IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	E. EDDIE BAKHASH	
U.S. Patent No.:	8,881,048	Attorney Docket No. 50095-0108IP1
Issue Date:	November 4, 2014	
Appl. Serial No.:	12/751,879	
Filing Date:	March 31, 2010	
Title:	SYSTEM AND METHOD FOR PROVIDING THREE-DIMENSIONAL GRAPHICAL USER INTERFACE	

DECLARATION OF DR. HENRY FUCHS

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LISTING OF CHALLENGED CLAIMS

Claim 1	
[1.pre]	A method for providing a three-dimensional (3D) graphical user interface, comprising:
[1.a]	receiving at least first and second inputs from an end user;
[1.b]	receiving first and second webpages from at least one server in response to said first and second inputs, wherein the first and second inputs are website addresses corresponding to said first and second webpages, respectively;
[1.c]	displaying at least a portion of the first webpage on a first object within a 3D space, and at least a portion of the second webpage on a second object within the 3D space, comprising;
[1.c.i]	rendering the first and second webpages;
[1.c.ii]	capturing first and second images of the at least a portion of the first webpage and the at least a portion of the second webpage, respectively; and
[1.c.iii]	texturing the first image on the first object and the second image on the second object, the first object being displayed in a foreground of the 3D space and the second object being displayed in a background of the 3D space; and
[1.d]	displaying additional information, comprising:
[1.d.i]	receiving an interaction by the end user on the first image;
[1.d.ii]	replacing the first and second objects within the 3D space with a window within a two-dimensional (2D) space in response to receiving the interaction, wherein the window includes the rendered first webpage;

[1.d.iii]	receiving an interaction by the end user on a link provided in the rendered first webpage, the link corresponding to the additional information;
[1.d.iv]	rendering the additional information; and
[1.d.v]	displaying the rendered additional information in said window within the 2D space.

Claim 2	
[2.pre]	The method of claim 1, further comprising:
[2.a]	capturing a third image of at least a portion of the rendered additional information;
[2.b]	texturing the third image on the first object, the third image thereby replacing the first image on the first object; and
[2.c]	replacing the window within the 2D space with at least the first and second objects within the 3D space, wherein the first object is displayed in the foreground of the 3D space and the second object is displayed in the background of the 3D space.

Claim 3	
[3.pre]	The method of claim 2, further comprising:
[3.a]	receiving a toggle interaction by the end user; and
[3.b]	replacing the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

Claim 4	
[4.pre]	The method of claim 2, further comprising:
[4.a]	receiving a navigation interaction by the end user; and
[4.b]	moving said second object from the background of the 3D space to the foreground of the 3D space in response to the navigation interaction.

Claim 5	
[5.pre]	The method of claim 1, further comprising:
[5.a]	receiving a toggle interaction by the end user; and
[5.b]	replacing the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

Claim 6	
[6.pre]	The method of claim 1, further comprising:
[6.a]	receiving at least a third input from the end user;
[6.b]	receiving a third webpage from the at least one server in response to the third input; and
[6.c]	displaying at least a portion of the third webpage on a third object within the 3D space, comprising:
[6.c.i]	rendering the third webpage;
[6.c.ii]	capturing a third image of the at least a portion of the third webpage; and
[6.c.iii]	texturing the third image on the third object, the third object being

	displayed in a further background of the 3D space, behind the second object.

Claim 7	
[7.pre]	The method of claim 1,
[7.a]	wherein the step of receiving the first and second webpages from the at least one server in response to said first and second inputs further comprises receiving the first webpage from a first server in response to said first input and receiving the second webpage from a second server in response to said second input.

Claim 8	
[8.pre]	A system for providing a three-dimensional (3D) graphical user interface, comprising:
[8.pre.i]	a display screen;
[8.pre.ii]	an input device for receiving at least one input from an end user
[8.pre.iii]	a processor module operatively coupled to the display screen and the user input device; and
[8.pre.iv]	a memory module operatively coupled to the processor module, the memory module comprising executable code for the processor module to:
[8.a]	receive at least first and second inputs from an end user;
[8.b]	receive first and second webpages from at least one source in response to said first and second inputs, wherein the first and second inputs are website address corresponding to said first and second webpages, respectively;

[8.c]	display at least a portion of the first webpage on a first object within a 3D space on the display screen, and at least a portion of the second webpage on a second object within the 3D space on the display screen, comprising;
[8.c.i]	rendering the first and second webpages;
[8.c.ii]	capturing first and second images of the at least a portion of the first webpage and the at least a portion of the second webpage, respectively; and
[8.c.iii]	texturing the first image on the first object and the second image on the second object, the first object being displayed in a foreground of the 3D space and the second object being displayed in a background of the 3D space; and
[8.d]	display additional information, comprising:
[8.d.i]	receiving an interaction by the end user on the first image;
[8.d.ii]	replacing the first and second objects within the 3D space with a window within a two-dimensional (2D) space on the display screen in response to receiving the interaction, wherein the window includes the rendered first webpage;
[8.d.iii]	receiving an interaction by the end user on a link provided in the rendered first webpage, the link corresponding to the additional information;
[8.d.iv]	rendering the additional information; and
[8.d.v]	displaying the rendered additional information on the display screen in said window within the 2D space on the display screen.

Claim 9	
[9.pre]	The system of claim 8, wherein said executable code is further

	configured to:
[9.a]	capture a third image of at least a portion of the rendered additional information;
[9.b]	texture the third image on the first object, the third image thereby replacing the first image on the first object; and
[9.c]	replace the window within the 2D space with at least the first and second objects within the 3D space, wherein the first object is displayed in the foreground of the 3D space and the second object is displayed in the background of the 3D space.

Claim 10	
[10.pre]	The system of claim 9, wherein said executable code is further configured to:
[10.a]	receive a toggle interaction by the end user; and
[10.b]	replace the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

Claim 11	
[11.pre]	The system of claim 9, wherein said executable code is further configured to:
[11.a]	receive a navigation interaction by the end user; and
[11.b]	move said second object from the background of the 3D space to the foreground of the 3D space in response to the navigation interaction.

Claim 12	
[12.pre]	The system of claim 8, wherein said executable code is further configured to:
[12.a]	receive a toggle interaction by the end user; and
[12.b]	replace the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

Claim 13	
[13.pre]	The system of claim 8, wherein said executable code is further configured to:
[13.a]	receive at least a third input from the end user;
[13.b]	receive a third webpage from the at least one server in response to the third input; and
[13.c]	display at least a portion of the third webpage on a third object within the 3D space, comprising:
[13.c.i]	rendering the third webpage;
[13.c.ii]	capturing a third image of the at least a portion of the third webpage; and
[13.c.iii]	texturing the third image on the third object, the third object being displayed in a further background of the 3D space, behind the second object.

Claim 14	
[14.pre]	A method for providing a three-dimensional (3D) graphical user interface, comprising:

[14.a]	receiving at least first and second website addresses from an end user;
[14.b]	using said first and second website addresses to retrieve first and second webpages from at least one source in response to said first and second inputs;
[14.c]	displaying at least a portion of the first webpage within a 3D space, and at least a portion of the second webpage within the 3D space, comprising;
[14.c.i]	generating first and second images of the at least a portion of the first webpage and the at least a portion of the second webpage, respectively; and
[14.c.ii]	displaying the first image and the second image in the 3D space, the first image being displayed in a foreground of the 3D space and the second image being displayed in a background of the 3D space; and
[14.d]	displaying additional information to said end user, comprising:
[14.d.i]	receiving an interaction from the end user with the first image;
[14.d.ii]	replacing the first and second images within the 3D space with a window within a two-dimensional (2D) space in response to receiving the interaction, wherein the window includes the first webpage;
[14.d.iii]	receiving an interaction by the end user on a link provided in the first webpage, the link corresponding to the additional information; and
[14.d.iv]	displaying the additional information to the user.

Claim 15	
[15.pre]	The method of claim 14,

[15.a]	wherein the additional information is displayed in the window, thereby replacing the first webpage in the window.

Claim 16	
[16.pre]	The method of claim 14, further comprising:
[16.a]	generating a third image of at least a portion of the additional information; and
[16.b]	replacing the window with at least the second and third images within the 3D space, wherein the third image replaces the first image in the foreground of the 3D space, and the second image remains in the background of the 3D space.

Claim 17	
[17.pre]	The method of claim 16, further comprising:
[17.a]	receiving a toggle interaction by the end user; and
[17.b]	replacing the window with at least the second and third images within the 3D space in response to the toggle interaction.

Claim 18	
[18.pre]	The method of claim 17, further comprising;
[18.a]	receiving a navigation interaction by the end user; and
[18.b]	moving said second image from the background of the 3D space to the foreground of the 3D space in response to the navigation interaction.

I, Henry Fuchs, PhD, declare as follows:

I. INTRODUCTION

1. I have been retained as a technical expert by counsel on behalf of Apple Inc. ("Apple"/"Petitioner"). I understand that Apple is requesting that the Patent Trial and Appeal Board institute an *inter partes* review ("IPR") proceeding with respect to U.S. Patent No. 8,881,048 ("the '048 patent") (EX1001).

2. I have been asked to provide my independent analysis of the '048 patent in light of certain prior art publications, and I have done so based on my personal knowledge and experience.

3. I am not, and never have been, an employee of Apple. I received no compensation for this Declaration beyond my normal hourly compensation based on my time actually spent analyzing the '048 patent, the prior art publications cited below, and various issues related thereto. I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the '048 patent.

II. QUALIFICATIONS

4. In formulating my opinions, I have relied on my knowledge, training, and experience in the relevant field. My education and experience are described more fully in the attached curriculum vitae (Appendix A). For ease of reference, I have highlighted certain information below.

5. I am the Federico Gil Distinguished Professor of Computer Science at the University of North Carolina at Chapel Hill. I head the UNC Graphics and Virtual Reality research group, supervising research scientists, engineers, PhD, MS, and undergraduate students.

6. I received a Bachelor of Arts degree in Information and Computer Science from the University of California at Santa Cruz in 1970, and a Ph.D. from the University of Utah in 1975.

7. I have over 50 years of experience working in the field of computer graphics. I have worked in the Imaging Lab of Caltech's NASA Jet Propulsion Laboratory, and have consulted for numerous organizations, including General Electric, the RAND Corporation, Mitsubishi Electric Research Laboratory, and Xerox Palo Alto Research Center. I have held visiting professorships at ETH Zurich and at TU Wien (the Vienna University of Technology).

8. My research in computer graphics has been supported by, among others, Cisco, DARPA, Google, Intel, Meta (fka Facebook), Microsoft, ONR, NIH, NSF, NVIDIA, U.S. Air Force, and Xerox. I have published about 250 papers, including some in the top journals, such as ACM SIGGRAPH, SIGGRAPH Asia, ACM Transactions on Graphics, and IEEE Computer Vision and Pattern Recognition (CVPR). As part of my research activities, I lead a research group at UNC Chapel Hill composed of senior researchers, PhD students, MS students,

undergraduates, and sometimes one or two high school students. Students I have advised have gone on to senior faculty positions at leading universities such as MIT, Stanford, and Georgia Tech, and leading research labs such as Google, Intel, Meta (fka Facebook), and Microsoft, as well as to smaller companies and startups around the world.

9. I have served on the program and papers committees of some of the top conferences in the field, such as ACM SIGGRAPH, ACM SIGGRAPH Asia, and Eurographics. I was instrumental in starting the conference series ACM Interactive 3D Graphics and Games, organizing the first conference in 1986. I helped with the founding of the ACM Transactions on Graphics, the top journal in computer graphics, by serving as the guest editor of its inaugural issue in 1982.

10. A number of ideas from my publications have been widely adopted in commercial products. For example, my introduction of Binary Space Partitioning Trees ("BSP Trees") in 1980 enabled real-time 3D games such as Doom and Quake to run on modest-sized PCs, and BSP Trees is now a standard rendering technique taught in major textbooks in computer graphics. The Pixel-Planes hardware graphics engines, which were developed in my UNC research group, pioneered several rendering techniques, for example, "tiled rendering", a method now adopted world-wide in the Graphics Processing Units (GPUs) in computers of all sizes. The Pixel-Planes 5 project validated the tiled approach, a method of parallel rendering of an

image in order of rectangular tiles, and introduced many of the techniques now standard for tiled renderers.

11. I have taught courses on computer graphics and related topics at UNC Chapel Hill, at University of Texas at Dallas, and at TU Wien. These courses often covered subjects such as stereoscopic displays and other 3D display technologies and applications. I am a named inventor on 20 patents and several pending patent applications, several of which involve stereoscopic display, autostereoscopic displays, and other 3D display technologies and applications. Examples of a few such patents are provided below.

12. US Patent No. 9,361,727 (issued June 7, 2016) to inventors H. Fuchs, L. McMillan, and A. Nashel, titled "Methods, systems, and computer readable media for generating autostereo three-dimensional views of a scene for a plurality of viewpoints using a pseudo-random hole barrier," describes a system for generating stereoscopic display for multiple users without the need for any special eyewear.

13. US Patent No. 8,896,655 (issued November 25, 2014) to inventors J. Mauchly, M. Marathe, H. Fuchs, and J. Frahm, titled "System and method for providing depth adaptive video conferencing," is about creating a combined image from panoramic image data of a conferencing room captured by a first camera and close-up image data of one or more conference participants captured through a second camera.

14. US Patent No. 5,870,136 (issued February 9, 1999) to inventors H. Fuchs, M. Livingston, T. Bishop, and G. Welch, titled "Dynamic generation of imperceptible structured light for tracking and acquisition of three dimensional scene geometry and surface characteristics in interactive three dimensional computer graphics applications," solves registration and occlusion problems in augmented reality systems.

15. U.S. Patent 4,607,255 (issued Aug. 19, 1986) to inventors H. Fuchs and S. Pizer, titled "Three dimensional display using a varifocal mirror," teaches a method for creating a true 3-D display which presents stereoscopic views to multiple users simultaneously using a vibrating varifocal mirror, a point-plotting CRT, and a conventional 2D color video system.

16. I have been honored with multiple awards, including the ACM SIGGRAPH Steven A. Coons Award, considered the highest award in the field of computer graphics. I am a member of the National Academy of Engineering, one of about 20 computer graphics specialists who are members. I am also a fellow of the American Academy of Arts and Sciences, a fellow of the ACM and IEEE. I received an honorary doctorate from TU Wien, the Vienna University of Technology, in 2018, one of two conferred that year.

17. I believe that I am qualified to opine as a technical expert in this proceeding. The '048 patent is about three-dimensional graphical user interfaces

("3D-GUIs"), and I have obtained ample knowledge and experience in this area over the years. Indeed, a portion of my work in the 1970s and 1980s focused on the computer graphics hardware improvements necessary to transform consumer-level 3D-GUIs from a theoretical concept to an obtainable reality. Since that time, I've led extensive research and development efforts on 3D-GUIs, generally and with a particular focus on virtual reality and augmented reality applications. Like 3D environments portrayed on conventional 2D screens, such as the '048 patent describes, augmented and virtual reality 3D-GUIs leverage depth cues (e.g., perspective, size, and occlusion) to create the illusion that virtual spaces and objects have real-world depth. Given this similarity, there is significant overlap between the various types of the 3D-GUIs, including from an underlying technology perspective and a design perspective.

18. I therefore believe that I have a detailed understanding of the state of the art during the relevant period, as well as a sound basis for opining how persons of skill in the art at that time would understand the technical issues in this case.

19. Additional details about my employment history, fields of expertise, and publications are included in my curriculum vitae (attached as Appendix A).

III. LEGAL PRINCIPLES

20. In forming my analysis and conclusions expressed in this Declaration, I have applied the legal principles described in the following paragraphs, which were

provided to me by counsel for the Petitioner.

A. Person of Ordinary Skill in the Art

21. I understand that the factors considered in determining the ordinary level of skill in a field of art include: the level of education and experience of persons working in the field; the types of problems encountered in the field; the teachings of the prior art regarding solutions to such problems; and the sophistication of the technology at the time of the alleged invention. I understand that a person of ordinary skill in the art ("POSITA") is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above and knowledge of all relevant prior art references, including the references I cite below.

B. Obviousness

22. I have been informed that a patent claim is invalid as "obvious" in light of one or more prior art references if it would have been obvious to a POSITA at the time of the alleged invention, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called "secondary considerations" of non-obviousness, which include: (i) "long-felt but unresolved need" for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) "copying" of the claimed invention by others.

23. While I do not know the exact date that the alleged invention of the '048 patent was made, I do know that the '048 patent's earliest claimed priority date is September 13, 2005. For purposes of my obviousness analysis, I have applied a date of September 13, 2005 as the date of the alleged invention ("Critical Date"), although in many cases the same analysis would hold true even if the date of the alleged invention were earlier or later.[1]

24. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason that would have prompted a POSITA to modify or supplement the single prior art reference, or to combine two or more references, in a manner that provides the elements of the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference(s) themselves, the knowledge or "common sense" of a POSITA, or from the nature of the problem to be solved, and this reason may be explicit or implicit from the prior art as a whole. I have been informed that, under the law, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield

[1] Note, however, that I do not concede that the '048 patent is entitled to its earliest claimed priority date.

predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

25. I understand that an obviousness determination also requires that a POSITA would have had a reasonable expectation of success. This concept has been explained to me as relating to the relative likelihood or predictability—from the perspective of a POSITA—of successfully modifying the prior art in a manner that would meet the claimed limitations of the patent being challenged (here the ’048 patent). I understand that the expectation of success need only be “reasonable” and, thus, does not require the absolute certainty gleaned from physically creating the proposed prior art modification.

C. Claim Interpretation

26. I understand that, for purposes of my analysis in this *inter partes* review proceeding, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and customary meaning, I understand that the words of a claim are first given their plain meaning that those words would have had to a person of ordinary skill in the art at the time of the alleged invention. I also understand that the structure of the claims, the specification and file history may be used to better construe a claim. Moreover, I understand that even treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a person of ordinary skill in

the art to a claim term.

27. I have been informed by counsel for Petitioner that the parties proposed constructions for certain claim terms in the ’048 patent in the co-pending litigation. I am not involved in the co-pending litigation and do not have direct knowledge of the events in that proceeding. Nor do I provide an opinion on claim construction in this proceeding. Note, however, that I have addressed the parties’ proposed constructions in my obviousness analysis below in Section VII and VIII.

IV. PERSON OF ORDINARY SKILL IN THE ART

28. Based on my knowledge and experience in the field and my review of the ’048 patent and its file history, I believe that a POSITA would have included a Bachelor’s of Science degree in computer science or a comparable field and at least two years of professional experience working with 2D and 3D graphical user interfaces. Such experience could be obtained through research and study in a graduate program or through comparable exposure through industry employment, and additional years of experience could substitute for the advanced-level degree.

29. Accordingly, my analysis and conclusions expressed in this Declaration are based on the perspective of a POSITA having this level of knowledge and skill. My education, technical expertise and personal knowledge discussed in Section II shows that I meet the qualifications of a POSITA.

V. MATERIALS CONSIDERED

30. My analysis in this Declaration is based on my knowledge and experience. Based on my above-described qualifications in Section II, the Patent Trial and Appeal Board should consider me to be an expert in the field. Also, based on my experiences, I understand and know of the capabilities of persons of ordinary skill in this field.

31. As part of my independent analysis for this Declaration, I have considered the following: the ’048 patent (EX1001) and its prosecution history (EX1002); the background knowledge/technologies that were commonly known to persons of ordinary skill; my own knowledge and experience gained from my work in the field; my experience in teaching and advising others in this field; and my experience working with others involved in this field. In addition, I have analyzed the following publications and materials:

EX1004	U.S. Patent No. 6,414,677 (“Robertson”)
EX1005	Preston Gralla, Que, HOW THE INTERNET WORKS (6th Ed. 2002) (“Gralla”)
EX1006	U.S. Publication No. 2005/0086612 (“Gettman”)
EX1007	U.S. Publication No. 2006/0230356 (“Sauve”)
EX1008	U.S. Patent No. 6,577,330 (“Tsuda”)
EX1010	Stuart K. Card, *et al.*, ACM Conference on Human Factors in Computing Systems (CHI), THE INFORMATION VISUALIZER, AN INFORMATION WORKSPACE (1991)
EX1011	Robertson, *et al.*, ACM Symposium on User Interface Software and Technology (UIST), THE DOCUMENT LENS (1993)
EX1012	Robertson, *et al.*, Communications of the ACM, Vol. 36, No. 4, INFORMATION VISUALIZATION USING 3D INTERACTIVE ANIMATION

	(1993)
EX1013	3D DESKTOP PROJECT BY SUN MICROSYSTEMS: A REVOLUTION EVOLUTION OF TODAY'S DESKTOP (2004)
EX1014	U.S. Patent No. 5,880,733
EX1015	European Patent Application No. 0 856 786
EX1016	U.S. Patent No. 6,909,443
EX1017	U.S. Patent No. 6,661,426
EX1018	U.S. Publication No. 2003/0142136
EX1019	U.S. Publication No. 2006/0107229
EX1020	U.S. Publication No. 2006/0161861
EX1021	U.S. Publication No. 2005/0057497
EX1022	Hideya Kawahara, *et al*., X Developer's Conference, PROJECT LOOKING GLASS: 3D DESKTOP EXPLORATION (2004)
EX1023	Andy Cockburn, *et al*., IT&Society, Volume 1, Issue 3, pp. 159-183, IMPROVING WEB PAGE REVISITATION: ANALYSIS, DESIGN AND EVALUATION (2003)
EX1024	Andy Cockburn, *et al*., WEBVIEW: A GRAPHICAL AID FOR REVISITING WEB PAGES (1999)
EX1025	Natalie Jhaveri, *et al*., ACM Conference on Human Factors in Computing Systems (CHI), THE ADVANTAGES OF A CROSS-SESSION WEB WORKSPACE (2004)
EX1026	Brian Amento, *et al*., ACM Symposium on User Interface Software and Technology (UIST), TOPICSHOP: ENHANCED SUPPORT FOR EVALUATING AND ORGANIZING COLLECTIONS OF WEB SITES (2000)
EX1027	Andy Cockburn, *et al*., BEYOND THE 'BACK' BUTTON: ISSUES OF PAGE REPRESENTATION AND ORGANISATION IN GRAPHICAL WEB NAVIGATION TOOLS (1999)
EX1028	U.S. Publication No. 2004/0001104
EX1029	Stuart K. Card, *et al.*, ACM Conference on Human Factors in Computing Systems (CHI), THE WEBBOOK AND THE WEB FORAGER: AN INFORMATION WORKSPACE FOR THE WORLD-WIDE WEB (1996)
EX1030	George Robertson, *et al.*, ACM Symposium on User Interface Software and Technology (UIST), DATA MOUNTAIN: USING SPATIAL MEMORY FOR DOCUMENT MANAGEMENT (1998)
EX1031	Mary P. Czerwinski, *et al.*, Human-Computer Interaction—INTERACT '99, THE CONTRIBUTION OF THUMBNAIL IMAGE, MOUSE-OVER TEXT AND SPATIAL LOCATION MEMORY TO WEB PAGE RETRIEVAL IN 3D (1999)

EX1032	U.S. Publication No. 2002/0054114
EX1033	U.S. Publication No. 2004/0109031
EX1034	U.S. Publication No. 2003/0164827
EX1035	U.S. Patent No. 6,229,542
EX1036	Alfred T. Lee, ACM Special Interest Group on Computer-Human Interaction (SIGCHI) Bulletin, Volume 31, Number J, WEB USABILITY (1999)
EX1037	Mark J. Kilgard, ACM Special Interest Group on Computer Graphics (SIGGRAPH) Eurographics Workshop, REALIZING OPENGL: TWO IMPLEMENTATIONS OF ONE ARCHITECTURE (1997)
EX1038	3B browser – 3B THE BROAD BAND BROWSER (2004), https://web.archive.org/web/20041208085023/http://www.3b.net/browser/index.html [accessed 9/28/2022]
EX1039	DICTIONARY OF COMPUTER SCIENCE, ENGINEERING AND TECHNOLOGY (2000) (excerpt)
EX1040	U.S. Appl. No. 09/152,712—File Wrapper Excerpts
EX1041	Robert Godwin-Jones, Language Learning & Technology, Volume 9, Number 2, EMERGING TECHNOLOGIES—AJAX AND FIREFOX: NEW WEB APPLICATIONS AND BROWSERS (2005)
EX1042	MOZILLA FIREFOX VS MICROSOFT INTERNET EXPLORER (2005), https://www.soundonsound.com/techniques/mozilla-firefox-vs-microsoft-internet-explorer [accessed 9/30/2022]
EX1043	X DEVELOPER'S MEETING 2004, https://www.x.org/wiki/Events/XDC2004/ [accessed 11/11/2022]

32. Note that my citations to non-patent literature throughout this Declaration reference the absolute page number added to the exhibit (as opposed to the original pagination of the document). For patent literature, I've used the column/line numbers or paragraph numbers. Note also that, unless I've indicated otherwise, all emphasis (bold/italics/underline) in any quoted text are ones I have added.

33. Although I cite and quote to selected portions of various references in this Declaration, the reader should understand that these citations are representative examples. A POSITA would have viewed each reference in its entirety and in combination with other references. Accordingly, I intend the references identified in this Declaration to be viewed as incorporated in their entireties.

VI. THE '048 PATENT

A. Background of the Technology

34. As I will explain in more detail below in Section VI.B, the '048 patent's inventor claims to have invented the notion of applying a three-dimensional graphical user interface ("3D-GUI") in the context of web browser tools for page revisitation. But the inventor was mistaken. This technology was not new or inventive by the 2005 Critical Date of the '048 patent. As I will show in the immediately following subsections, extensive development on 3D-GUIs and webpage revisitation tools took place long before the '048 patent, and those of skill in the art had already integrated these lines of development to create new and improved 3D-GUIs for web browsers.

35. I have cited numerous papers and patent documents that support my understanding, each of them preceding the '048 patent. A POSITA would have known of these references and considered them representative examples regarding the state of the art. Accordingly, my obviousness analysis below in Sections VII and VIII is informed by these references, as well as my personal knowledge and experience.

1. Three-Dimensional Graphical User Interfaces

36. Research and development on 3D-GUIs dates back more than a decade before the '048 patent's 2005 Critical Date, fueled by rapid advances in computer

"hardware technology." EX1012, p. 2. As summarized in a paper titled "Information Visualization Using 3D Interactive Animation":

> Processor and memory technology has far greater performance at far lower cost. Specialized 3D graphics hardware has made it progressively faster and cheaper to do 3D transformations, hidden-surface removal, double-buffered animation, antialiasing, and lighting and surface models. At the same time, software support for real-time operating systems and emerging industry standard open graphics libraries (e.g., OpenGL and PEX) are simplifying the 3D programming task. The trend will bring these technologies to the mass market in the near feature. EX1012, p. 2.

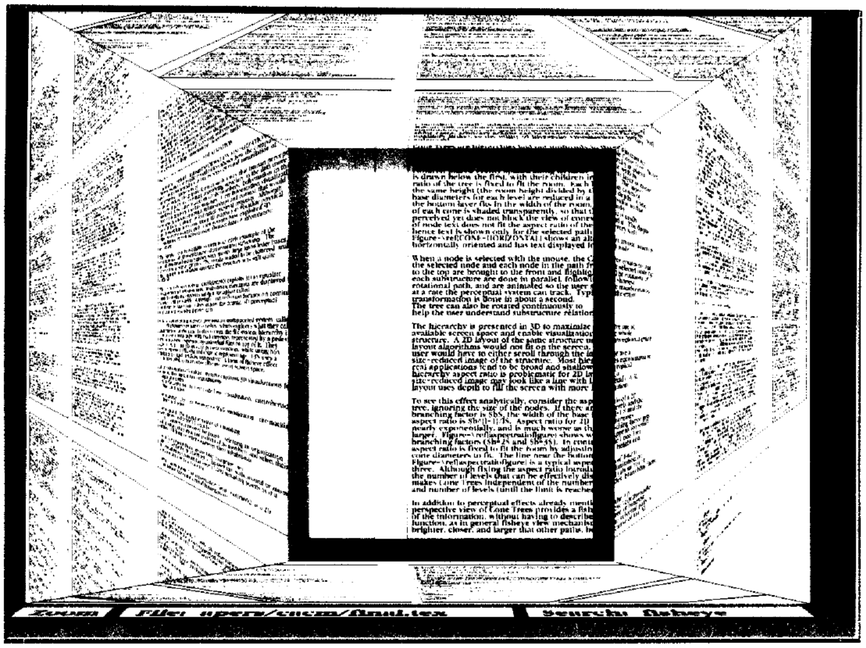
These technology advances "created many possibilities for user interface innovation," and there was "a great desire to explore new [user interface] paradigms." EX1012, p.2; *see also* EX1030 (a 1998 peer-reviewed paper explaining that "advances" in "[g]raphics technology, processor speed, and primary memory capacity" made it possible to build new systems based on 3D-GUIs).

37. For example, in 1991, Stuart K. Card, *et al.*, authored "The Information Visualizer, An Information Workspace," a peer-reviewed paper presenting an "experimental system, called the Information Visualizer." EX1010, pp. 1, 4. The Information Visualizer system was premised on the notion of using so called "3D/Rooms" to create a "3D workspace." EX1010, pp. 1, 4. According to the authors, employing "3D perspective graphics…allow us…to pack the space more

densely with information than would otherwise be possible." EX1010, p. 5 ("For example, in a companion paper [24], we describe a corporate organization tree requiring 80 pages on paper that has been displayed in a single 3D/Rooms screen.")[2].

38. In 1993, some of the same authors, Robertson, *et al*., presented another peer-reviewed paper titled "The Document Lens." EX1011, p.1. "The *Document Lens* is a 3D visualization for large rectangular presentations that allows the user to quickly focus on a part of the presentation while continuously remaining in context." EX1011, p.1. Like the Information Visualizer, one of the "basic goals" with the Document Lens was "to use 3D to make more effective use of available screen space." EX1011, p. 1; *see also* p. 3 ("In general, what we need is a way of folding or stretching that [large rectangular] region in 3D so that part of it is near you, but the rest is still visible[.]").

[2] The "companion paper [24]" refers to Robertson, G. G., Mackinlay, J. D., & Card, S, K. Cone Trees: Animated 3D visualizations of hierarchical information. ACM CHI '91: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems April 1991 Pages 189–194 https://doi.org/10.1145/108844.108883.

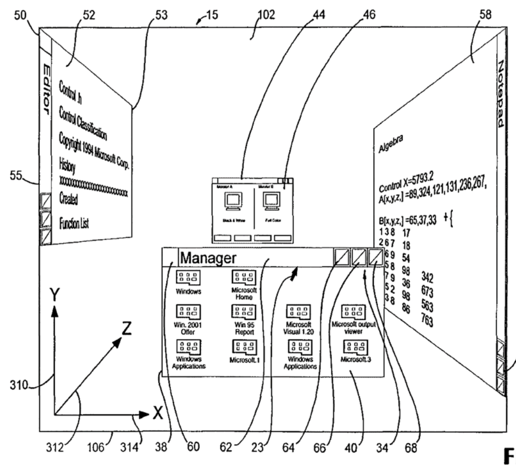
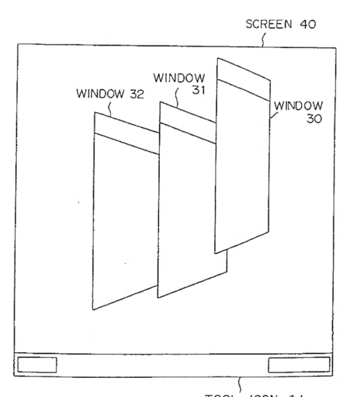


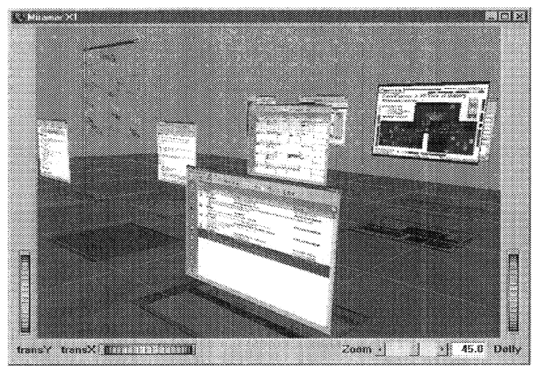
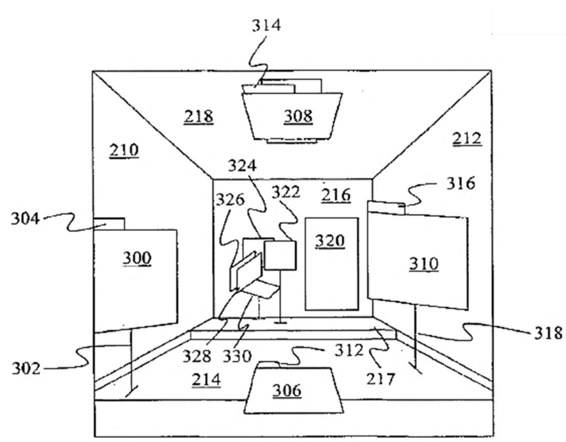
EX1011, p. 5 (Figure 3)

39. The Information Visualizer and Document Lens papers are illustrative of the active development within the community of skilled artisans on the subject of 3D-GUIs. And these are just a few examples of the numerous published papers, conference presentations, and software prototypes/products that were advancing this technology in the years before the Critical Date.

40. Given the active development of 3D-GUIs at the time, it is no surprise that the patent literature was also replete with disclosures on this subject. The table below catalogs several representative examples:

Document	Description
EX1014 US 5,880,733 Inventors: Horvitz, *et al.* Filed: Apr. 30, 1996	**EX1014** "provides a three-dimensional perspective, virtual workspace to window based display systems." [Abstract] The disclosed "isometric display system provides a display with monocular depth cues by making automatic sizing and geometric transformations

Document	Description
	on two dimensional rectangles that define traditional windows." [3:1-10] Figure 3 (below) provides an example of the 3D-GUI taught by EX1014.  FIG.3
EX1015 EP 0 856 786 Inventors: Negishi, *et al.* Filed: Jan. 8, 1998	**EX1015** "relates to a system for displaying windows of a window system in a virtual space (e.g., three-dimensional space) and to a method thereof." The disclosed technique features "a three-dimensional display unit that converts two-dimensional coordinates into three-dimensional coordinates." [5:7-8] By employing this coordinate conversion process, "the icons [in the displayed windows] can be operated in the same manner as those of the conventional window system." [5:9-12] Figure 5 (below) provides an example of the 3D-GUI taught by EX1015. 

Document	Description
EX1035 US 6,229,542 Inventors: Miller Filed: Jul. 10, 1998	**EX1035** describes a technique for "manag[ing] the transition between the 2D window state and the 3D window state to exhibit a 3D representation of traditional 2D windows, without modification of existing application programs." [3:26-29] Figure 5 (below) provides an example of the 3D-GUI taught by EX1035:  FIG. 5
EX1016 US 6,909,443 Inventors: Robertson, et al. Filed: Mar. 31, 2000	**EX1016** "provides a three-dimensional user interface for a computer system that allows a user to combine and store a group of windows as a task." [Abstract] "The image of each task can be positioned within the three-dimensional environment such that the user may utilize spatial memory in order [to] remember where a particular task is located." [2:1-4] Figure 6 (below) provides an example of the 3D-GUI taught by EX1016.  FIG. 6

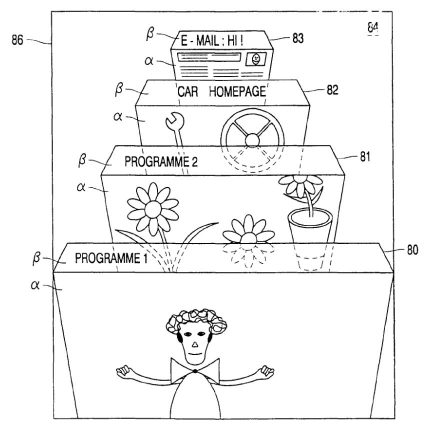
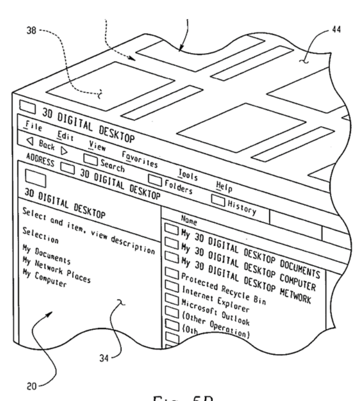
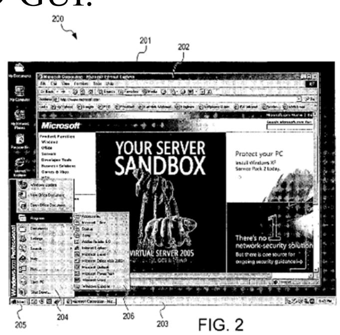
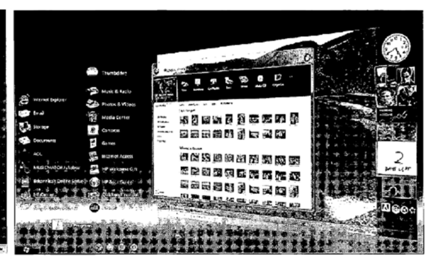
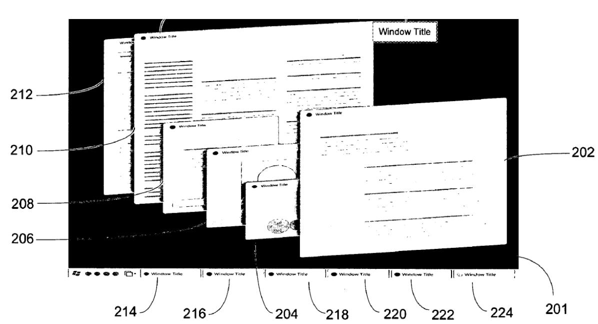
<table>
<tr><th>Document</th><th>Description</th></tr>
<tr><td></td><td></td></tr>
<tr><td>EX1017
US 6,661,426
Inventors: Jetha, et al.
Filed: Sep. 22, 2000</td><td>EX1017 “relates to apparatuses having display means operable to display data from two or more sources simultaneously, particularly but not exclusively in respective display panels or windows on a single screen.” [1:5-10] Figure 2 (below) shows an example of a 3D-GUI where “[t]he arrangement comprises four panels 80-83 arranged to simulate receding panels in parallel alignment, with one behind the other in a three-dimensional interface space 84.” [4:29-33]

</td></tr>
<tr><td>EX1018
US 2003/0142136
Inventors: Carter, et al.
Filed: Nov. 13, 2002</td><td>EX1018 describes “[a] 3D Desktop GUI based on [Non-uniform Rational B-Splines (NURBS)]” that “allows a user to [m]anage shortcut icons, files, [and] hard disks in a three-dimensional world.” [Abstract] Figure 5B (below) shows an example of a 3D-GUI where user-selectable windows and icons are presented on “a texture mapped cube 21.” [0049]


Fig. 5B</td></tr>
</table>

Document	Description
EX1019 US 2006/0107229 Inventors: Matthews, et al. Filed: Nov. 15, 2004	**EX1019** describes "[a] method and apparatus for transforming a work area and displaying an information component in a graphical user interface…The graphical user interface utilizes a three-dimensional transformation to move a presently displayed work area, for example a desktop with open windows, revealing a background presentation area behind it." [Abstract] Figure 2 (below, left) of EX1019 shows a conventional 2D GUI using the classic desktop metaphor, and Figure 3 (below, right) shows the new 3D-GUI.  FIG. 2 (PRIOR ART)  FIG. 3A
EX1020 US 2006/0161861 Inventors: Holecek, et al. Filed: Jul. 20, 2006	**EX1020** discloses a technique where, "responsive to a command" the open windows on a conventional desktop are moved into "a visual stack with the topmost window in the stack being in focus." [Abstract] "[T]he windows in the visual stack substantial retain their size…but are slightly scaled and skewed to provide a high fidelity three dimensional visual representation." [0041] Figure 2B (below) provides an example of the 3D-GUI taught by EX1020. 

41. US 2005/0057497 (EX1021) filed on September 15, 2003 by inventor Hideya Kawahara provides yet another exemplary 3D-GUI that predates the '048 patent. Mr. Kawahara's patent disclosure "provides a system that facilitates manipulating a 2D window within a three-dimensional (3D) display model." EX1021, Abstract. According to Mr. Kawahara, "the graphical processing power of personal computers and other high-end devices ha[d] increased dramatically" by 2003, leading to the development of "a number of 3D user interfaces." EX1021, [0006-0007]. In Mr. Kawahara's view, "[t]hese 3D interfaces typically allow a user to navigate through and manipulate 3D objects," and they could be improved by providing "a method and apparatus that supports legacy 2D window-based applications within a 3D user interface." EX1021, [0008]. By the mid-2000s, the field of 3D-GUIs had matured to a point where skilled artisans were delivering the kinds of usability and compatibility improvements (e.g., upgraded pointing and selecting interactions) that would support commercial adoption.

42. I've singled out Mr. Kawahara's patent application because of its resemblance to yet another 3D-GUI—in addition to the Information Visualizer (EX1010) and Document Lens (EX1011)—that was actually developed as a proof of concept demo and presented at the X Developer's Conference in 2004. *See* EX1043, p. 2. The 2004 X Developer's Conference was a meeting that "cover[ed] a wide variety of topics about X Window System technologies, and the as yet unmet

needs of the technologies that depend on the X Window System."[3] EX1043, p. 1.

43. As you can see from the comparison below, concepts of Mr. Kawahara's patent disclosure (EX1021) are demonstrated in Sun Microsystem's Project Looking Glass, a 3D desktop GUI that Mr. Kawahara was involved in developing. *See* EX1021, Code (76) (listing Mr. Kawahara has an inventor); EX1022, p. 1 (listing Mr. Kawahara as part of Project Looking Glass); EX1012, p. 1.

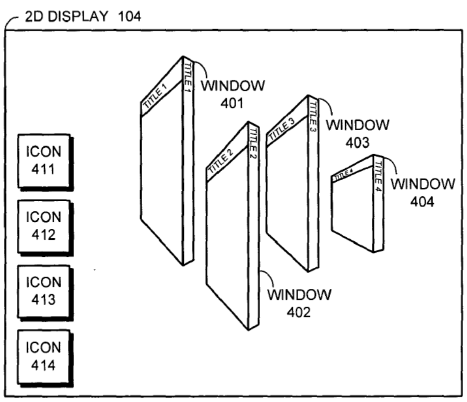
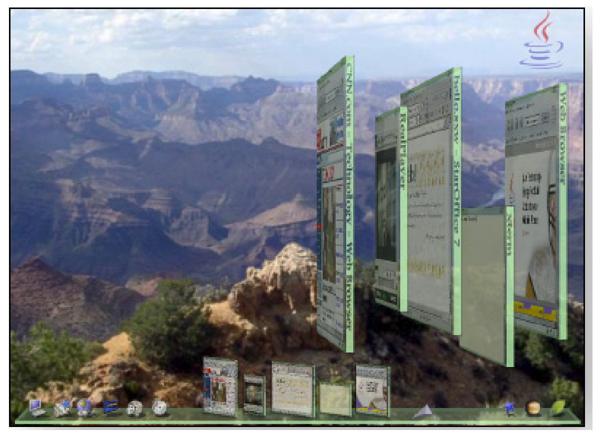


FIG. 4B

EX1021 (Kawahara Pat. Pub.), FIG. 4B



EX1013 (Project Looking Glass), p. 1

[3] The X Window System is a windowing system supported by the X.Org Foundation. A windowing system is computer software that draws and manages the windows of a graphical user interface.

2. Alternative Web Browser Tools

44. A 2003 paper authored by Andy Cockburn, *et al*., and titled "Improving Web Page Revisitation[4]: Analysis, Design and Evaluation" observed the following: [1] "Several years of research suggest improvement is needed in how people return to their previously visited Web pages"; and [2] because "Web page revisitation is one of the most frequent actions in computer use," "any interface improvement in this area can have a very large effect." EX1023, pp. 1-2, 4-6 (finding "the probability that any URL visited is a repeat of a previous visit" as "approximately 60%" historically and up to "81%" in later studies); *see also* EX1024, p.1 ("In our previous related work we have shown that page revisitation—the act of returning to previously seen pages—is a fundamental part of web navigation."); EX1025, p. 1 ("[R]eturning to previously visited web pages, known as the act of web page revisitation, plays an important role in information gathering. Past research, which shows web page revisitation to be the most common user action in web navigation [5, 14], is consistent with this suggestion.").

45. Consistent with these observations, and because current solutions were not optimal, skilled artisans in the 1990s and 2000s sought to answer the question of

[4] The term "page revisitation" used by some authors simply means revisiting a web page that one has previously visited.

"how the next-generation of Web browsers could integrate and enhance the diverse tools for revisitation that are available in current browsers." EX1023, p. 2, 9 (noting "indications that users find bookmark management troublesome"). Specifically, skilled artisans of the time were exploring improvements to conventional bookmark, history, and favorites lists that typically presented users with nothing more than representative *text* from corresponding web pages (e.g., titles and/or URLs). I provide a bulleted list specific examples below:

- **EX1023**, p. 2 (noting "bookmarks, and history lists" as a subject for improvement);
- **EX1026**, p. 1 ("[B]ookmarks, the most common form of keeping track of web sites, are a fairly primitive organizational technique."), p. 2 ("Bookmarks consisting of lists of URLs; typically the title of the web page is used as the label for the URL.");
- **EX1027**, p. 5 ("Titles, extracted from the <Title> tag in the page's source, are often poor identifiers of page contents.");
- **EX1028**, [0006] (explaining that, with conventional page revisitation tools, "the user typically obtains only a URL or a title of the resource" but "the user is often unaware of the URL of the site that they previously browsed" and "the title of the resource is frequently uninformative or inaccurate.");

- **EX1030**, p. 6 ("The list is text only, so [it] does not allow users to leverage other channels of information that may also be effective when attempting to retrieve web pages[.]").

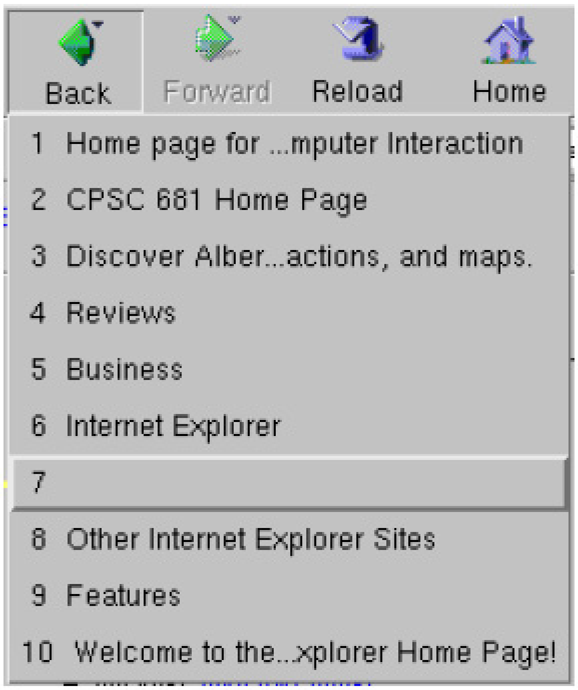
46. A common theme among multiple solutions to the page-revisitation problem was the introduction of representative webpage *images* to replace or accompany representative text, e.g.:

- **EX1023**, p. 19 ("The common features of all WebView prototypes are…[t]hey display zooming thumbnail representations of all pages visited in the browser.");
- **EX1024**, p.3 ("WebView combines thumbnails with bookmarking cues through a 'dogears' metaphor.");
- **EX1025**, p. 2 ("a thumbnail image of the web page is added to the end of the chronological list");
- **EX1026**, p. 2 ("Each site is represented by a large thumbnail image and the site title.").

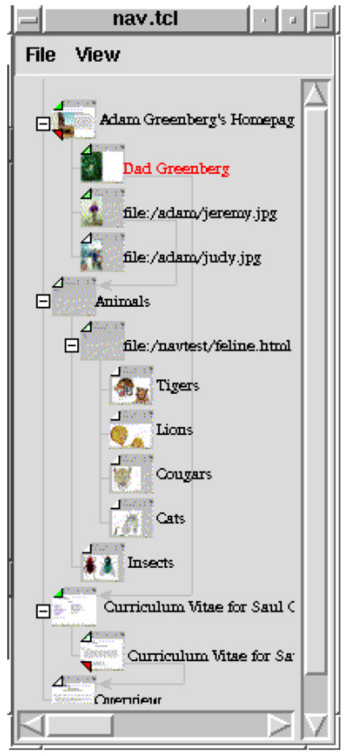
47. Representative webpage images emerged as a common solution because, e.g.,:

- **EX1023**, p. 19: "[P]eople are able to identify pages more accurately from thumbnail images than from titles or URLs"; "It seems reasonable to expect that automatically captured, [sic] Web page thumbnails, such as these, will soon appear in commercial Web browsers."

- **EX1026**, p. 3: "Thumbnail images also serve as effective memory aids to help users identify sites they already have visited."



EX1027, p. 5 (Figure 4)
A conventional browser tool with only representative text



EX1027, p. 8 (Figure 6)
A prototype browser tool with representative text and images

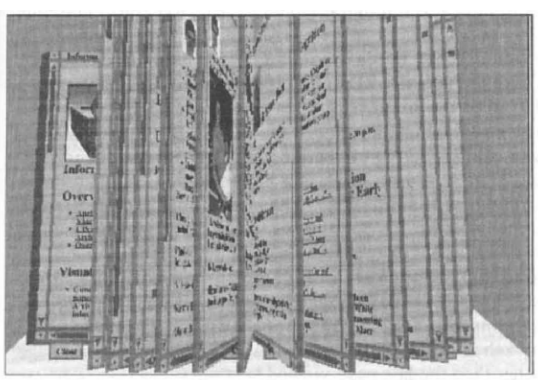
3. Applying Three Dimensional Metaphors to Web Browser Tools

48. As I explained above in Sections VI.A.1 and VI.A.2, many of those skilled in the 1990s and 2000s were developing 3D-GUIs and others were developing next-generation web browser tools. Some skilled artisans had also taken the further step of integrating these two lines of development, employing 3D-GUIs to improve web page revisitation. For example, in 1996, Stuart K. Card, *et al.*,

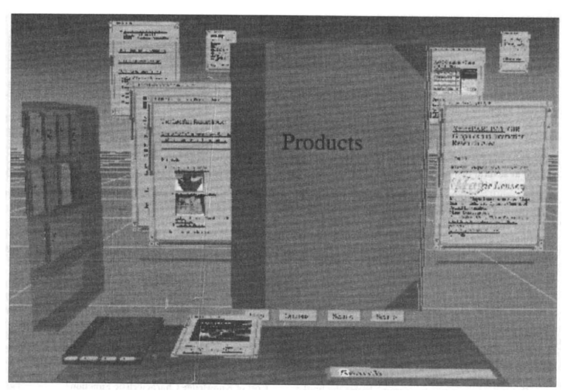
authored "The WebBook and the Web Forager: An Information Workspace for the World-Wide Web," a paper that "presents two related designs with which to evolve the Web and its clients." EX1029, p. 1.

> The first is the WebBook, a 3D interactive book of HTML pages. The WebBook allows rapid interaction with objects at a higher level of aggregation than pages. The second is the Web Forager, an application that embeds the WebBook and other objects in a hierarchical 3D workspace. Both designs are intended as exercises to play off against analytical studies of information workspaces. EX1029, p. 1.

Notably, Mr. Card, *et al.*, made clear that the extensive prior work on 3D-GUIs—including the Document Lens (EX1011) and Information Visualizer (EX1010) papers that I discussed above at Section VI.A.1—formed the building blocks for their WebBook and Web Forager prototypes. *See* EX1029, p. 3 (citing reference [19], the Document Lens), p. 5 (citing reference [21], the Information Visualizer).



EX1029, p. 3 (Figure 3)
The WebBook



EX1029, p. 5 (Figure 5)
The Web Forager

49. Like their peers, Mr. Card, *et al.*, recognized that "[t]he major effort to allow users to organize their workspaces [on the Web] has been the development of variants of the 'hotlist'"—e.g., history, favorites, bookmark lists. EX1029, p. 2. But "these mechanisms are very slow to use and do not work well with more than a couple dozen entries." EX1029, p. 2. The WebBook and Web Forager 3D-GUIs were developed to address these (and other) page revisitation problems. *See* EX1029, p. 4 ("Our system can read any user's Netscape hotlist and automatically fashion it into a set of WebBooks."), p.5 ("The page turning of a book conveys information about the relationship of pages, the direction you are moving in the book, the size of the book, and the contents of the book."), p. 6 ("The Web Forager workspace is intended to create patches from the Web where a high density of relevant pages can be combined with rapid access.").

50. Two years later, in 1998, George Robertson[5], *et al*. authored a paper titled "Data Mountain: Using Spatial Memory for Document Management." EX1030. The Data Mountain paper is particularly relevant here because it corresponds to the Robertson (EX1004) prior art reference that I discuss in my obviousness analysis in Section VII below. Robertson is an issued patent based on

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[5] Robertson was also a contributing author to the Document Lens (EX1011), Information Visualizer (EX1010), and Web Forager (EX1029) papers.

the Data Mountain prototype.

51. The Data Mountain paper explored "a new technique for document management called the *Data Mountain*, which allows user to place documents at arbitrary positions on an included plane in a 3D desktop virtual environment using a simple 2D interaction technique." EX1030, p. 1 (original emphasis). In more detail:

> The Data Mountain (Figure 1) is a novel user interface for document management designed specifically to take advantage of human spatial memory (i.e., the ability to remember where you put something). In our current prototype, the user freely arranges document thumbnails on an inclined plane textured with passive landmarks. We use 3D visual and audio cues to enhance the similarity to realworld object arrangement, yet use simple 2D interaction techniques and common pointing devices (like the mouse) for all interactions. The system is designed with a fixed viewpoint, so users need not navigate around the space. Users can identify and distinguish documents both through their thumbnail representation and through popup titles.

EX1030, p. 1

EX1030, p. 1 (Figure 1)

EX1030, p. 4 (Figure 5)

52. The "primary motivation" for the Data Mountain prototype was the "desire to leverage natural human capabilities, particularly cognitive and perceptual skills." EX1030, p. 3. Accordingly, Data Mountain uses "3D perception…to allow

for the representation of a large number of web page thumbnails with minimal cognitive load." EX1030, p. 3. By employing "simple 3D depth cues (like perspective views and occlusion)," the user is able to "place pages at a distance (thereby using less screen space) and understand their spatial relationships without thinking about it." EX1030, p. 3.

53. Like the Web Forager paper (EX1029), the Data Mountain paper (EX1030) builds on prior work regarding 3D-GUIs, such as the Information Visualizer paper (EX1010). *See* EX1030, p. 2 (citing reference [4], the Information Visualizer paper (EX1010)). The Data Mountain paper also recognizes the problem of webpage revisitation that I discussed above at Section VIA.2:

> Usage tracking shows that hotlists, bookmarks and Favorites folders are the navigation tools most frequently utilized by users for locating information on the web [20].
>
> Hence, web browser designers need to provide their users with mechanisms for creating personal web information spaces that can reliably and efficiently return the user to their favorite web sites. Implementing such mechanisms relaxes the cognitive and temporal demands of hypertext navigation [1]. Usability studies, as well as basic research, however, indicate that the current designs for navigating the web are still sub-optimal in supporting users' cognitive models of web spaces and the amount of information they need to repeatedly consume [1][24]. EX1030, p. 5.

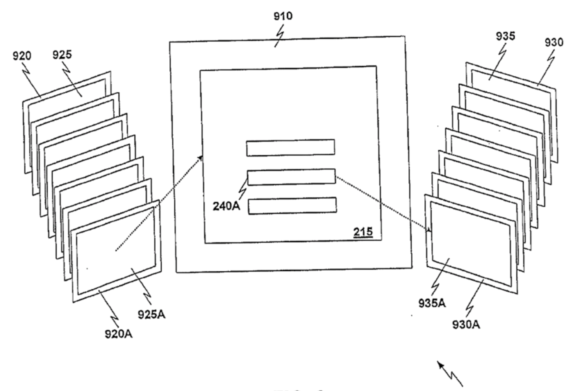
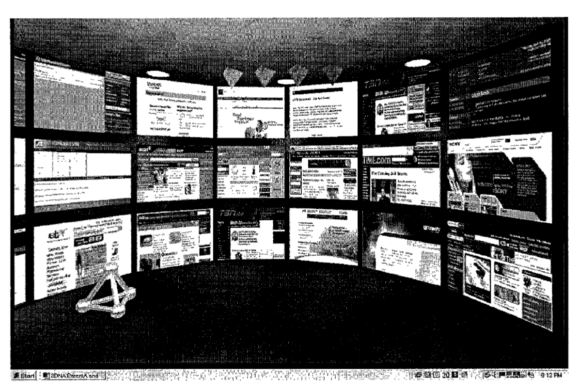
The authors sought to solve this problem of webpage revisitation by spreading the webpages across a 3D mountain landscape environment—the Data Mountain. *See* EX1030, p. 1.

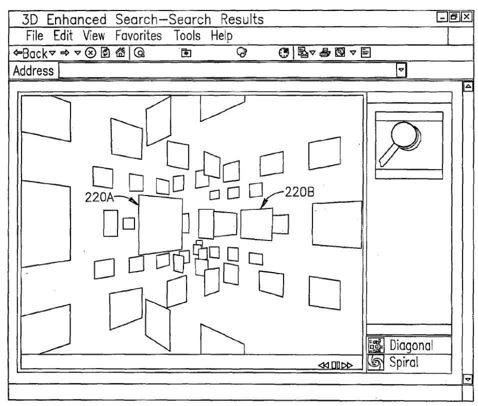
54. For the authors, the "question of interest" was "how effective is the Data Mountain for leveraging all aspects of memory during the retrieval of a web page in Favorites?" To answer this question, the authors conducted a controlled user study comparing Data Mountain prototypes against a state of the art web browser, Microsoft Internet Explorer. EX1030, pp. 5-9. The study involved three groups of users directed to conduct various web page revisitation tasks. EX1030, p. 6. The first group used the standard Microsoft Internet Explorer (IE4) Favorites mechanism; the second group used a first version of the Data Mountain prototype; and the third group used a second version of the Data Mountain prototype that was modified based on suggestions from users in the second group. EX1030, pp. 5-6. One "main finding" was that "the Data Mountain reliably facilitated speedy retrieval of web pages when compared to IE4, allowing users to leverage visual as well as textual cues in finding document locations in 3D space." EX1030, p. 8 (The group using the second Data Mountain version "was as fast or faster than the first Data Mountain group and IE4 group in all cueing conditions."). "The two Data Mountain groups were [also] reliably more likely to retrieve a web page within the time limit than the IE4 group." EX1030, p. 8. Finally, when asked "whether they would prefer

to use IE4 or the Data Mountain software," most users in the third group using the second version of Data Mountain "said they would prefer to use the Data Mountain over IE4." EX1030, p. 9. Thus, the user study "demonstrate[d] that the Data Mountain is an effective alternative for current web Favorites mechanisms, even in its preliminary prototype form." EX1030, p. 9. A follow-up study "brought back a group of subjects to re-experience their spatial layout of web pages that they themselves manually arranged in [the Data Mountain] 3D environment approximately 6 months earlier" and found that "[t]here was no significant change in their speed at retrieving web pages at that time, compared to the session in which the subjects created their layouts." EX1031, p. 1-2.

55. In addition to numerous published papers, the patent literature also was replete with relevant disclosures. The Robertson (EX1004), Gettman (EX1006), and Tsuda (EX1008) references that I discuss below as part of my obviousness analysis in Sections VII and VIII are all examples of applying the 3D-GUI concept to web browsers. Additional examples include:

Document	Description
EX1032 US 2002/0054114 Inventors: Shuping, *et al.* Filed: November 2, 2001	**EX1032** describes "a system and method for web browsing" that "contemporaneously displays multiple web pages," and "[p]referably," does so in "a three-dimensional space." [Abstract] In the example of Figure 9 (below), "a three dimensional environment includes a current panel 910, a plurality of past panels 920 and a plurality of future panels 930," where the user "may navigate through

Document	Description
	the three-dimensional environment of web browser 900 to view any of the web pages included therein." [0064] The past and future panels contain past and future webpages, respectively, arranged in a background-to-foreground stack. [0066-0068]  FIG. 9
EX1033 US 2004/0109031 Inventors: Deaton, *et al.* Filed: May 13, 2002	**EX1033** presents "a new 3D graphical user interface (3D GUI) technology that seamlessly integrates personal computer (PC) desktop, web portal, and data visualization functions in an intuitive 3D environment." [Abstract] In the example of Figure 4 (below): "Many websites can be seen at a single glance in the 3D Desktop's 'browser bay'. Each What You See Is What You Get or WYSIWYG Icon is a screen capture of the actual website. Clicking on any of the WYSIWYG Icons launches the corresponding web site." [0030]  FIG 4

Document	Description
EX1034 US 2003/0164827 Inventors: Gottesman, *et al.* Filed: February, 3, 2003	**EX1034** discloses "[a] system and method for presenting search and/or data query results within a virtual three-dimensional environment." [Abstract] "[T]he search results may be URL links resulting from an Internet search engine query, and the parameter update module 460 may assign a thumbnail or snap shot of the web page associated with each URL as a display parameter to one or more data containers 220." [0049] "FIG. 1A [below] is a diagram showing a computer screen with one possible virtual three-dimensional environment" contemplated by EX1034. [0017] 

B. Description of the '048 Patent (EX1001)

56. The '048 patent "is directed toward graphical user interfaces for operating and accessing information on a computer, and more particularly, to a three-dimensional ('3D') interactive computing interface." EX1001 ('048 patent), 1:28-31. Specifically, the '048 patent's graphical user interface (GUI) "uses the two-dimensional display of an end user's computer to display information (*e.g.*, webpages and other information mapped onto 3D objects) in a simulated real-time

3-D immersive Cartesian space." EX1001 ('048 patent), 7:59-63. In the embodiment of Figure 11 (below), the 3D-GUI "draws [a new] HTML page…into the 3D virtual space" when the user types a URL web address into the command line followed by a carriage return. EX1001 ('048 patent), 29:23-42.

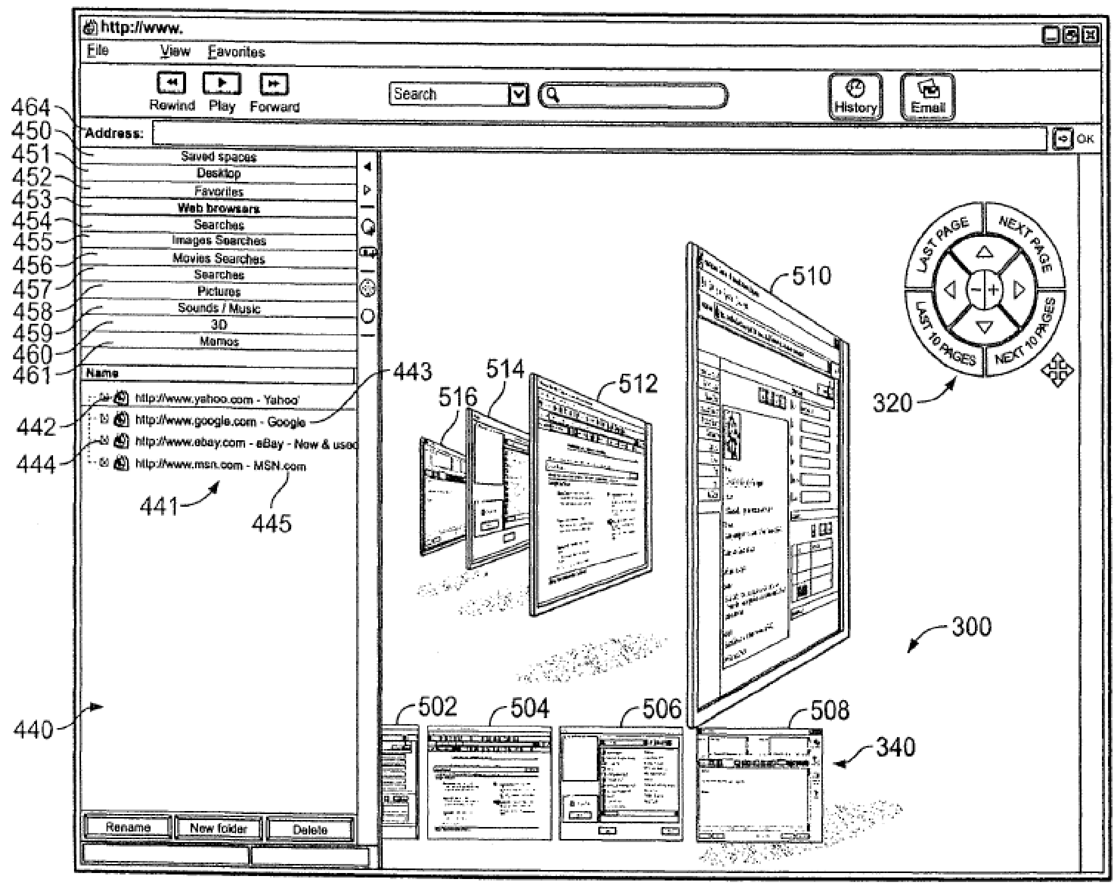


FIG. 11

EX1001 ('048 patent), Figure 11

57. But, according to the 048 patent, there is a problem with this approach: "it may be difficult to interact with" objects in the 3D space "if the end user is occupying an unfavorable viewpoint…where objects are drawn in skew." EX1001 ('048 patent), 21:20-24. The '048 patent offers two solutions. First, as shown in

Figure 13B (below), the ’048 patent proposes to equip the 3D-GUI with an explorer pane 441 indexing the various objects in the 3D space. EX1001 (’048 patent), 21:5-19. “Clicking one of these indexed names…will bind the end user to a viewpoint” where the content of the webpage is easy to read and interact with, as shown below in Figure 13B. EX1001 (’048 patent), 21:5-19.

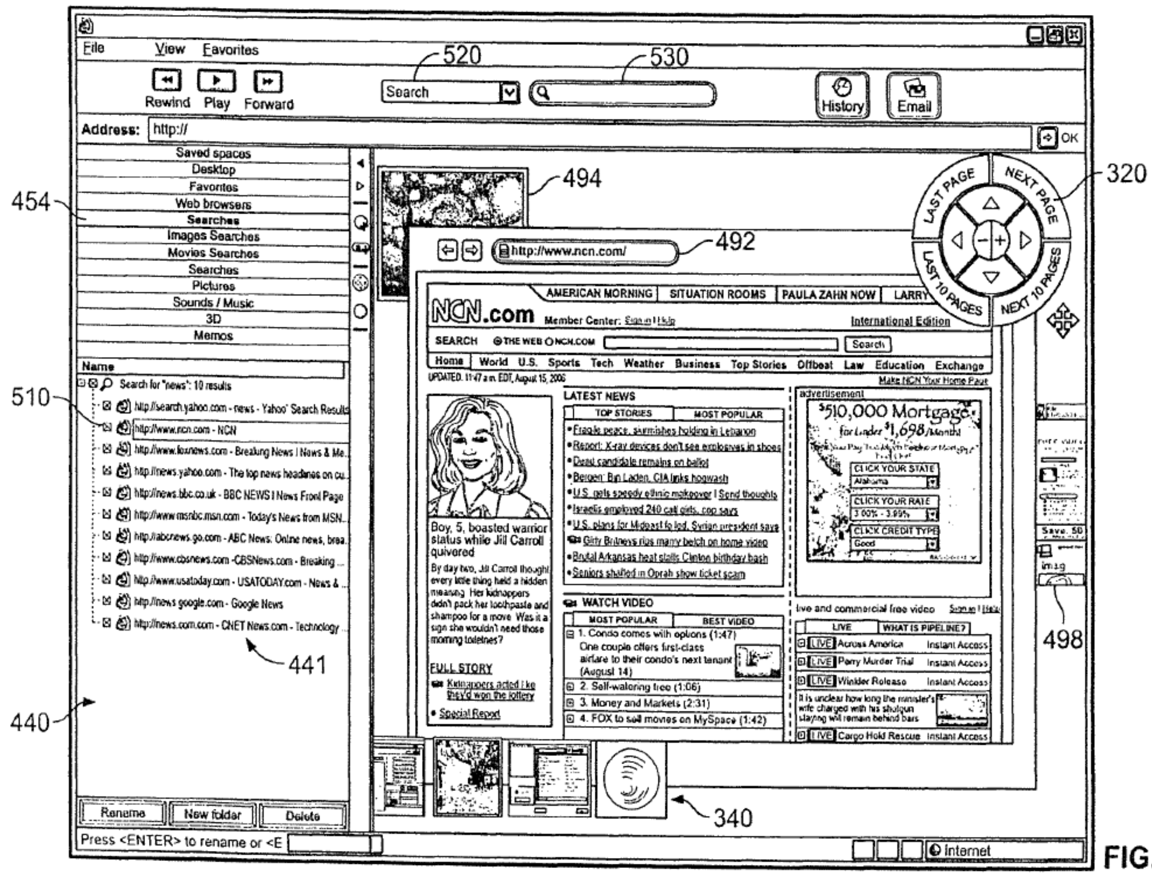


FIG. 13B

EX1001 (’048 patent), Figure 13B

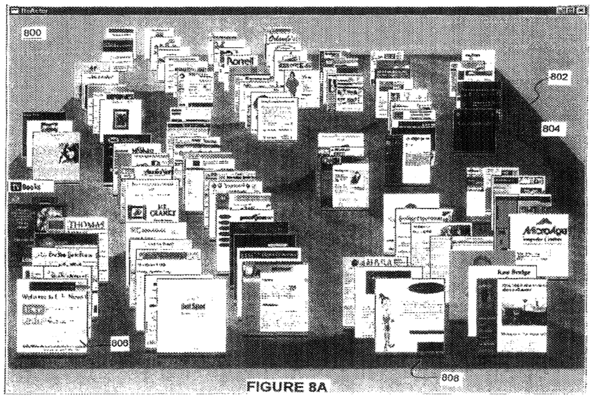
58. Second, the ’048 patent proposes a “Bind to the HUD” (heads-up-display) feature that involves “revealing the 2D version of the webpage that was initially hidden or drawn off screen and positioning it in a layer that is in front of the

3D virtual space such that the end user can interact with this layer in 2D." EX1001 ('048 patent), 21:36-58; *see also* 30:33-38 ("the Internet Explorer window will open in front of the 3D virtual space in a 2D window"). This second option corresponds to Element [1.d.ii] of the Challenged Claims, which calls for ***replacing the first and second objects within the 3D space with a window within a two-dimensional (2D) space***.

VII. GROUND 1: ROBERTSON, GRALLA, AND GETTMAN

A. Robertson (EX1004)

59. Recall from my earlier discussion that Robertson is an issued patent based on the prototypes developed and tested by the authors of the Data Mountain papers (EX1030 & EX1031). While the papers summarized the functionality of the Data Mountain prototypes and reported various testing results, Robertson's 80-page patent disclosure is broader and more detailed in multiple respects. For example, Robertson presents a variety of additional diagrams (FIGs. 1-2, 22-23B, 25-26), data structures (FIGs. 3-7, 24), and flow charts (FIGs. 19A-21C) that expound on the underlying technology. Additionally, while Robertson's disclosure includes the prototypes from the paper (e.g., FIGs. 8A-10B), it also includes a number of additional embodiments (FIGs. 11A-18).



EX1004 (Robertson), FIG. 8A

EX1030 (Data Mountain), p. 3 (FIG. 3)

60. A POSITA reading Robertson would have been aware of the Data Mountain papers, and the papers would have informed the POSITA's interpretation of Robertson. Accordingly, I cite to the papers in my obviousness analysis involving Robertson.

61. The explosive popularity of the Internet led more and more "people [to] us[e] computers to access information…created by unrelated third parties (or content providers)." EX1004 (Robertson), 2:26-65. From this premise, Robertson reasoned that "[n]ew GUIs should therefore help people find information that they want." EX1004 (Robertson), 2:66-67. For example, a user may want to "'go back' to (or 'relocate') information (or content), to revisit that information or to revisit a familiar content provider to view new information (or content)" without "navigating through a hierarchy of menus, or entering a search query." EX1004 (Robertson), 3:36-46. These observations by Robertson are consistent with a number of references that I discussed in Section VI.A.2 on the subject of page revisitation. *E.g.*, EX1023, pp.

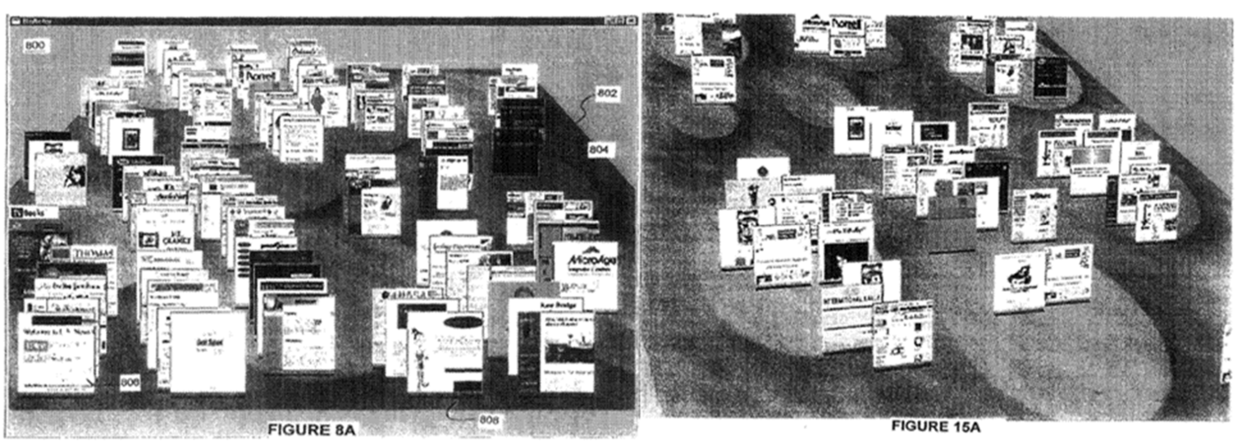
1-2 (“Web page revisitation is one of the most frequent actions in computer use”); EX1024, p.1; EX1025, p. 1; EX1030, p. 5.

62. While “[s]ome so-called ‘Internet browser’ program services, such as Microsoft’s Internet Explorer” help with relocating information or content providers by “permit[ting] people to create lists of favorite Internet locations…represented by bookmarks,” the “person’s ability to find a desired bookmark becomes more difficult” when “the number of bookmarks in a list increases.” EX1004 (Robertson), 3:47-66. Here again, Robertson echoes various contemporaneous references from my discussion in Section VI.A.2. *E.g.*, EX1023, p. 2; EX1026, p. 1 (“[B]ookmarks, the most common form of keeping track of web sites, are a fairly primitive organizational technique.”); EX1028, [0006] (explaining that, with conventional page revisitation tools, “the user typically obtains only a URL or a title of the resource” but “the user is often unaware of the URL of the site that they previously browsed” and “the title of the resource is frequently uninformative or inaccurate.”); EX1030, pp. 5-6 (“The list is text only, so [it] does not allow users to leverage other channels of information that may also be effective when attempting to retrieve web pages[.]”).

63. To improve upon these and other GUIs for accessing information over the Internet, Robertson proposed an interface that “exploit[s] spatial memory” by “simulat[ing] three dimensions” and representing webpages in the 3D space as

object thumbnails bearing a low resolution image of the corresponding content. EX1004 (Robertson), 6:15-28; *see also* 6:30-67, 9:11-50, 12:54-13:4 ("the object thumbnails 806 represent web (or hypertext markup language or 'HTML') pages"). The thumbnails "can be added, moved, or deleted from [the] simulated three-dimensional environment" at will by the user. EX1004 (Robertson), 6:34-40; see also 6:20-22 ("the user interface should…permit continuous movement in the simulated space"); 6:56-61 ("As object thumbnails are moved about the landscape…").

64. Figures 8A and 15A (below) are two of several exemplary 3D-GUIs proposed by Robertson where webpages are represented by object thumbnails on a simulated 3D landscape. EX1004 (Robertson), 12:54-13:4, 17:21-45, Figures 8A-18.



EX1004 (Robertson), Figures 8A & 15A

65. Like the '048 patent, Robertson recognized that it may not be feasible to interact with web content in the form of relatively small object thumbnails. Thus,

"for editing or otherwise working on a selected object," Robertson provides "'live' objects within an associated application"—i.e., actual HTML webpages within a web browser, such as Internet Explorer. EX1004 (Robertson), 13:55-67. Accordingly, when a user selects a thumbnail, "the Internet Explorer browser…render[s] [the corresponding] web page, with the [3D] user interface…in the background." EX1004 (Robertson), 13:67-14:14. In other words, selecting the thumbnail causes Internet Explorer to retrieve, render, and display the webpage represented by thumbnail. The webpage is presented in the foreground and "can be maximized…to substantially fill the screen of the video monitor," while the 3D space remains in the background. EX1004 (Robertson), 13:67-14:14.

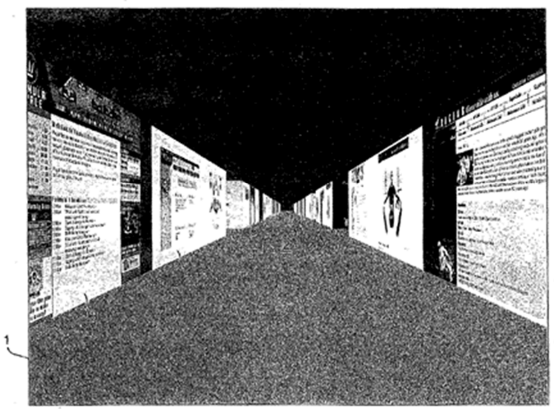
66. Robertson's disclosure of clicking a thumbnail/icon in a 3D-GUI to launch a webpage in a standard browser was not an isolated occurrence in the prior art. This functionality also disclosed by Gettman (EX1006), which I discuss below, and others. *E.g.*, EX1033, [0030] ("[c]licking on any of the WYSIWYG Icons launches the corresponding web site"); EX1034 ("[W]hen a viewer clicks with his or her mouse on a container shown within [the three-dimensional space of] FIG. 1C, a link to a search result associated with the container may be executed and the search result may be downloaded to the viewer's computer.").

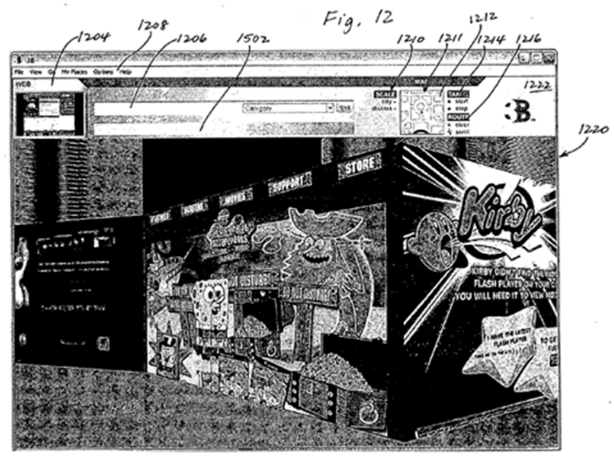
B. Gralla (EX1005)

67. Gralla is the sixth edition of a textbook entitled How the Internet Works. As its title suggests, Gralla teaches a variety of foundational principles regarding the Internet, including chapters on how webpages work (pp. 132-139) and how web browsers work (pp. 140-145), and including information about Microsoft's Internet Explorer (pp. 130, 133, 138, 141).

C. Gettman (EX1006)

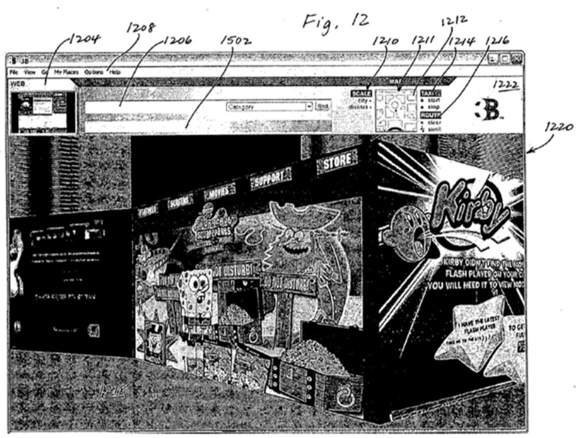
68. Like Robertson, Gettman describes a 3D-GUI for presenting web content. In Gettman, the 3D space is a virtual city, where each building comprises a "virtual display window[]" that "shows a page of content retrieved from an Internet HTML page." EX1006 (Gettman), ¶¶0076-0079, Figs. 1, 12 (below). To create these virtual display windows, webpages are rendered by "an adapted HTML page-rendering engine" and "bitmap screenshots of [the] HTML pages…are cached in local memory," where they are "stored as textures…used to populate the display windows." EX1006 (Gettman), ¶0082, ¶0112; *see also generally* ¶¶0108-0121, ¶0164 ("display windows 644, 646 display textures rendered from HTML documents of online [w]eb sites").

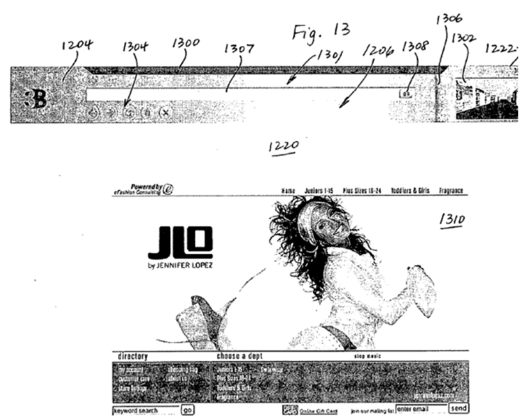




EX1006 (Gettman), Figures 1 & 12

69. When the user interacts with a display window in the virtual 3D city—*e.g.*, by clicking on it—"the target [w]eb site [will] open in a conventional two-dimensional web browser," such that "the user switches to an alternate two-dimensional view of the web page." EX1006 (Gettman), ¶0164; *see also* ¶¶0198-0202, Figures 12-13.





EX1006 (Gettman), Figure 12: 3D Virtual City (left) & Figure 13: 2D Browser Window (right)

70. Gettman further parallels Robertson in that the principles of its disclosure were literally put to practice. Where Robertson's disclosure was

embodied by the Data Mountain prototypes, Gettman's disclosure was deployed on a commercial product called the "3B Browser." EX1038; *see also* EX1006, Figure 18(c) (referencing "the 3B browser")[6].

EX1038 (3B Browser)

D. The Robertson-Gralla-Gettman Combination

71. The Robertson-Gralla-Gettman Combination integrates Robertson's 3D-GUI into the web browser described by Gralla as an upgrade to the conventional bookmark/favorites tools for revisiting webpages. As I explained above in Section VI.A, extensive development on 3D-GUIs and webpage revisitation tools took place long before the '048 patent, and those of skill in the art had already integrated these lines of development to create new and improved 3D-GUIs for web browsers. Thus, the integration of Robertson and Gralla tracks the broad development trends in the

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[6] I have also confirmed through the USPTO's Patent Center that Gettman is a patent publication assigned to THREE-B INTERNATIONAL LIMITED.

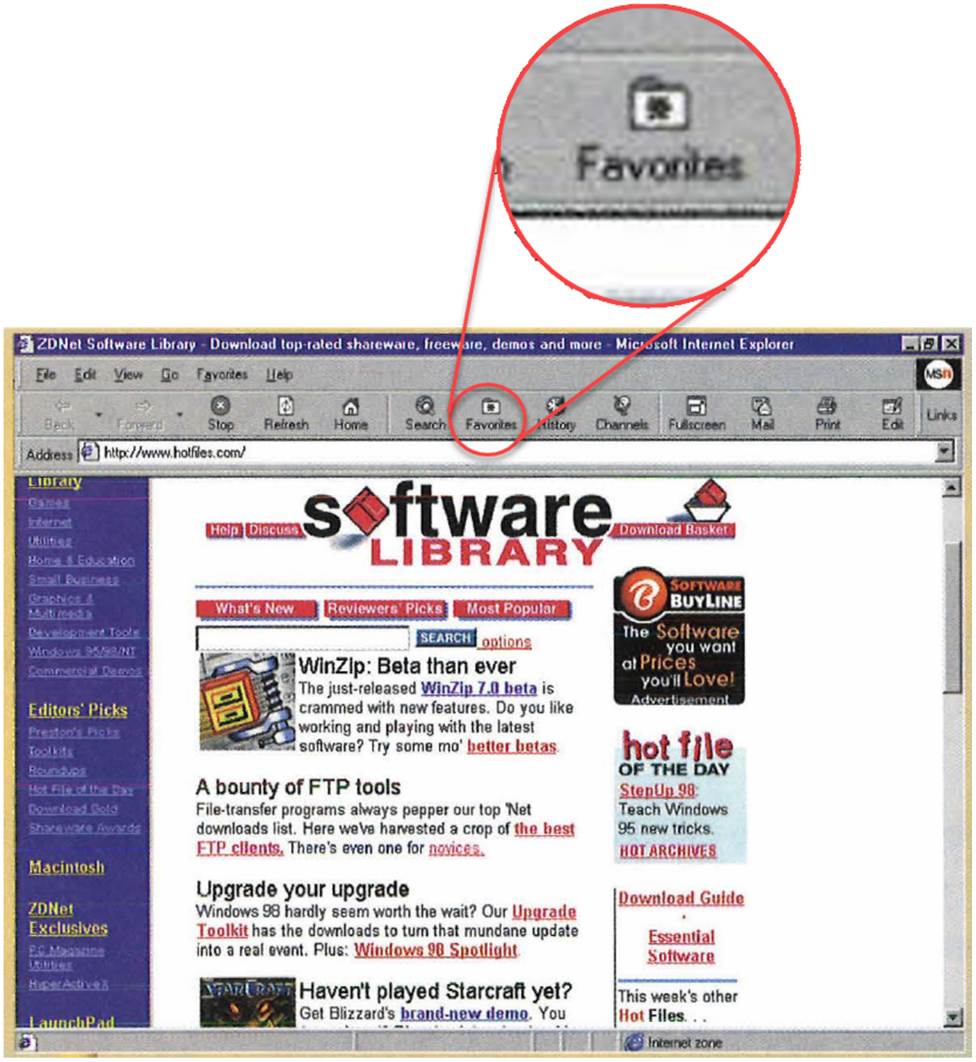
prior art.

72. Adding to the Robertson-Gralla combination, Gettman bolsters Robertson's disclosure on creating objects in a 3D space by articulating additional implementation details and also provides a desirable alternative approach to launching a 2D browser window.

1. Reasons to Combine

(i) Integrating Robertson's 3D-GUI into Gralla's web browser

73. First, Robertson makes clear that its 3D-GUI is an improvement over the Favorites tool employed in Microsoft's Internet Explorer, a featured web browser in Gralla. EX1004 (Robertson), 3:55-4:3 ("so-called 'Internet browser' program services, such as Microsoft's Internet Explorer…"); EX1005 (Gralla), 133-134 ("You run Web client browser software, such as Netscape Navigator or Microsoft's Internet Explorer…").



EX1005 (Gralla), 134—Annotated

74. Internet Explorer's **Favorites** tool allows users to organize webpage entries into hierarchical lists, which, according to Robertson, places a "cognitive load" on users each time they search for a desired entry. EX1004 (Robertson), 3:55-4:3. Hierarchical lists also fail to "fully exploit the spatial memory (This concept has also been referred to as 'where it is is what it is'.) of people." EX1004 (Robertson), 3:55-4:3. Robertson and his co-authors made similar observations in

the initial Data Mountain paper[7], noting that current tools for page revisitation, including "Favorites folders," were "still sub-optimal." EX1030, p. 5. Even beyond Robertson and the Data Mountain papers, my prior discussion at Section VI.A.2 details various other papers that expressed a similarly dim view of conventional page revisitation tools (e.g., bookmarks, history, and favorites lists). *E.g.*, EX1023, p. 2 (noting "bookmarks[] and history lists" as a subject for improvement), p. 9 (noting "indications that users find bookmark management troublesome"); EX1026, pp. 1-2 ("fairly primitive organizational technique"); EX1027, p. 5 ("poor identifiers of page contents"); EX1028, [0006] ("frequently uninformative or inaccurate").

75. Unlike hierarchical lists, Robertson set out to provide a 3D-GUI that "exploit[s] spatial memory" by "simulat[ing] three dimensions" and representing webpages in the 3D space as movable object thumbnails bearing a low resolution image of the corresponding content. EX1004 (Robertson), 6:15-28 (stating design goals), 9:14-50 ("To achieve these goals…"); *see also* 6:51-67; EX1030, p. 1 (explaining that "spatial memory" refers to "the ability to remember where you put something"). A prototype employing these principles was shown in the Data

[7] As I've explained, the Data Mountain papers (EX1030 & EX1031) describe prototypes of the technology disclosed in Robertson (EX1004) and should be read in tandem with Robertson.

Mountain papers to improve users' ability to quickly and reliably retrieve webpages, as compared to the Internet Explorer (IE4) **Favorites** tool. EX1030, pp. 8-9 (noting a Data Mountain user group that "was as fast or faster than the…IE4 group in all cueing conditions"); *see also* p. 1 ("The Data Mountain …takes advantage of human spatial memory."). The Data Mountain prototype was also preferred by multiple users over the Internet Explorer (IE4) **Favorites** tool. EX1030, p. 9 (noting users that "said they would prefer to use the Data Mountain over IE4"). These improvements were reaffirmed six months later by follow-up testing that showed "no significant change in [the users'] speed at retrieving web pages." EX1031, p. 2.

76. By noting the downsides of the hierarchical lists used in Internet Explorer's **Favorites** tool and proposing its 3D-GUI as a needed improvement, Robertson expressly encourages the POSITA to combine the teachings of Robertson and Gralla. These teachings from Robertson are reflected and substantiated by the Data Mountain papers and other corroborating evidence that I discussed previously in Section VI.A.

77. <u>Second</u>, design incentives and market forces would have prompted a POSITA to pursue a combination of Robertson and Gralla. As I've explained (*see* Section VI.A), significant development work on 3D-GUIs and next-generation tools for webpage revisitation took place long before the '048 patent, and those lines of development had also been combined, resulting in disclosures like Robertson (and

others) that proposed implementing page revisitation tools as 3D-GUIs. *E.g.*, EX1029 (WebBook and Web Forager); EX1030 (Data Mountain); EX1032 (US 2002/0054114); EX1033 (US 2004/0109031). A POSITA aware of this advanced state of the art and the known problems with page revisitation tools that employ hierarchical lists would have been incentivized to explore and implement Robertson's teachings as an alternative to the conventional Internet Explorer Favorites tool disclosed by Gralla. *E.g.*, EX1030, p. 9 (The user study "demonstrate[d] that the Data Mountain is an effective alternative for current web Favorites mechanisms, even in its preliminary prototype form.").

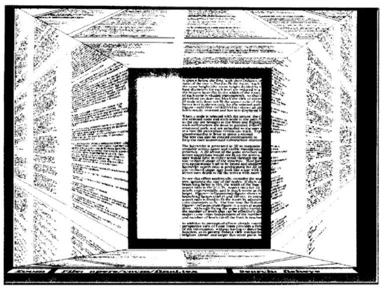
78. Moreover, the POSITA would have appreciated the commercial benefit of pursuing such a combination of Robertson and Gralla. For example, the POSITA would have known that page revisitation tools—such as the Favorites tool—were some of the most frequently used navigation features in commercial web browsers. Per my earlier discussion at Section VI.A.2, studies had shown that "the probability that any URL visited is a repeat of a previous visit" was "approximately 60%" (and even as high as "81%"). EX1023, 4-6; *see also* EX1024, p.1 ("In our previous related work we have shown that page revisitation—the act of returning to previously seen pages—is a fundamental part of web navigation."); EX1025, p. 1 ("[R]eturning to previously visited web pages, known as the act of web page revisitation, plays an important role in information gathering. Past research, which

shows web page revisitation to be the most common user action in web navigation [5, 14], is consistent with this suggestion."). Accordingly, it was well-known that "any interface improvement in this area can have a very large effect." EX1023, pp. 1-2.

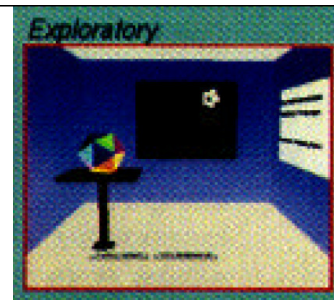
79. For at least these reasons, the POSITA would have sought usability improvements to this aspect of Internet Explorer, such as offered by Robertson (e.g., reduced cognitive load by exploiting spatial memory), in an effort to distinguish over competitor products in the marketplace. As the POSITA would have known, usability in this context—*e.g.*, the degree to which a given web browser efficiently facilitates the user's task of locating and consuming web content—was a key differentiator amongst competing web browsers. EX1036, p. 1 ("Paraphrasing the definition supplied by the ISO [1], Web usability is the efficient, effective and satisfying completion of a specified task by any given Web user."). While the same web content could be accessed on two competing web browsers, differences in the user interface could make accessing that content more efficient on one of the two. The browser with a superior interface from a usability standpoint would be more desirable by consumers.

80. <u>Third</u>, at the time of the '048 patent, the scientific and patent literature was replete with proposals to incorporate 3D-GUIs into commercial products like operating systems and web browsers. I cited numerous papers and patents

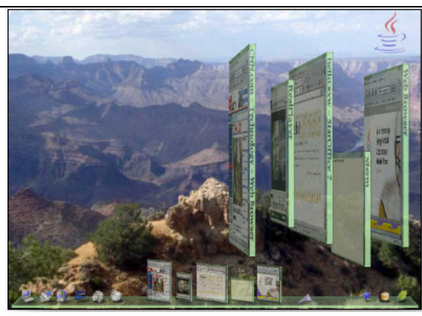
establishing this fact in Section VI.A, including the Information Visualizer (EX1010), the Document Lens (EX1011), Project Looking Glass (EX1012 & EX1022), the WebBook and Web Forager (EX1029), and the Data Mountain (EX1030 & EX1031), and more than ten documents from the patent literature (EX1014 through EX1021 and EX1032 through EX1035).



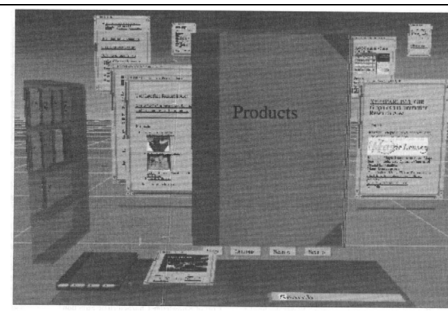
EX1011, p. 5 (Figure 3)
The Document Lens



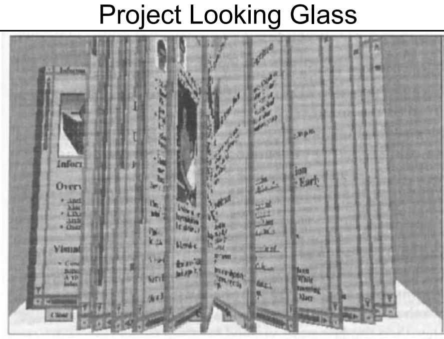
EX1010, p. 7
The Information Visualizer



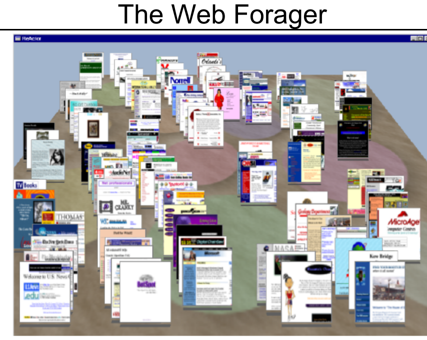
EX1012, p. 1
Project Looking Glass



EX1029, p. 5 (Figure 5)
The Web Forager



EX1029, p. 3 (Figure 3)
The WebBook



EX1030, p. 1 (Figure 1)
Data Mountain

81. A POSITA would have been motivated by this contemporaneous design and research trend to incorporate Robertson's 3D-GUI into a commercial web

browser like Microsoft's Internet Explorer. Indeed, it is telling that Robertson's disclosure is the product of research conducted by people at Microsoft—Microsoft Research. It is also telling that a number of other documents I've cited in this Declaration are likewise associated with Microsoft. *E.g.*, EX1014 (US 5,880,733); EX1016 (US 6,909,443); EX1019 (US 2006/0107229); EX1020 (US 2006/0161861); EX1035 (US 6,229,542). This ample R&D and intellectual property investment by a market leader in the computer software space—the proprietor of Internet Explorer—supports my view that the art was trending in the direction of 3D-GUIs.

(ii) Incorporating Gettman's implementation details on creating 3D objects

82. A POSITA would have understood Robertson to teach that object thumbnails in the 3D landscape are comprised of low-resolution images—"bitmaps"—obtained from corresponding webpages. EX1004 (Robertson), 6:30-50 ("low resolution image"), 9:10-35, 12:54-13:4 ("low resolution images," for example, "64 pixel by 64 pixel bitmaps having 24 bit color"), 18:1-5 (similar), 28:1-16 (similar), Figures 2, 4, 8A-18. And while a POSITA would have known the implementation details required to obtain and apply such bitmaps, Gettman provides more guidance on this subject by explaining that: **(i)** bitmaps are obtained by rendering the webpages and capturing screenshots of their content, and **(ii)** the

obtained bitmaps are applied to objects in a 3D space using a well-known technique called texturing. EX1006 (Gettman), ¶0082, ¶¶0108-0121, ¶0164.

83. First, Robertson's instruction to provide webpage images on objects in a 3D space would have prompted a POSITA to seek out and apply teachings from references in the same field, like Gettman, that provide relevant implementation details. I know from personal experience that people of skill in the art often rely on supplemental references in the same field to expand on rudimentary topics introduced in a primary reference of interest. The impetus for doing so is simply that the primary reference acts as a cue for the person of skill to consult the implementation details of the secondary references. Such a rationale is particularly strong in this context, where, as I have been informed my counsel, the POSITA is aware of all prior art. Thus, a POSITA considering Robertson would have known exactly where to look for additional disclosure on the subject of using bitmaps in a 3D-GUI for web browser—namely, Gettman.

84. Second, the rendering, capturing, and texturing steps taught by Gettman were all known techniques that were commonly applied in 3D-GUIs. In fact, Robertson and his co-authors described them in their Data Mountain paper. EX1030, p. 5 ("The 100 pages used in the study below are screen snapshots of actual web pages in 24-bit color. We employ two bitmap sizes of each page for texture mapping…"). Additionally, the Data Mountain paper and Robertson both reference

the "OpenGL" graphics library, which was known to support texturing. EX1004 (Robertson), 17:49-67 (identifying "OpenGL"); EX1030 (Data Mountain), p. 5 (explaining that the Data Mountain prototypes use "OpenGL as the underlying graphics library"); EX1037, p. 1 ("The OpenGL Graphics System provides a well-specified, widely accepted dataflow for 3D graphics imaging"), p. 3 (explaining OpenGL's "texturing" functionality); EX1012, p. 2 ("software support for real-time operating systems and emerging industry standard open graphics libraries (e.g., OpenGL and PEX) are simplifying the 3D programming task"). The following citations and parentheticals provide additional examples of the ample teachings in the prior art on this subject of rendering, capturing, and texturing steps:

- **EX1016**, 27:48-63 (from a patent filed in 2000: "In particular, the three-dimensional shell defines a three-dimensional polygon on which the image of a window is applied as texture.");
- **EX1018**, [0049] (a patent application filed in 2002 referencing a 3D-GUI where user-selectable windows and icons are presented on "a texture mapped cube 21");
- **EX1019**, [0055] (a patent application filed in 2004 explaining that "a process called texture mapping" can be employed to create a "3D scene" using "low level graphics APIs, such as Direct3D® or OpenGL®");

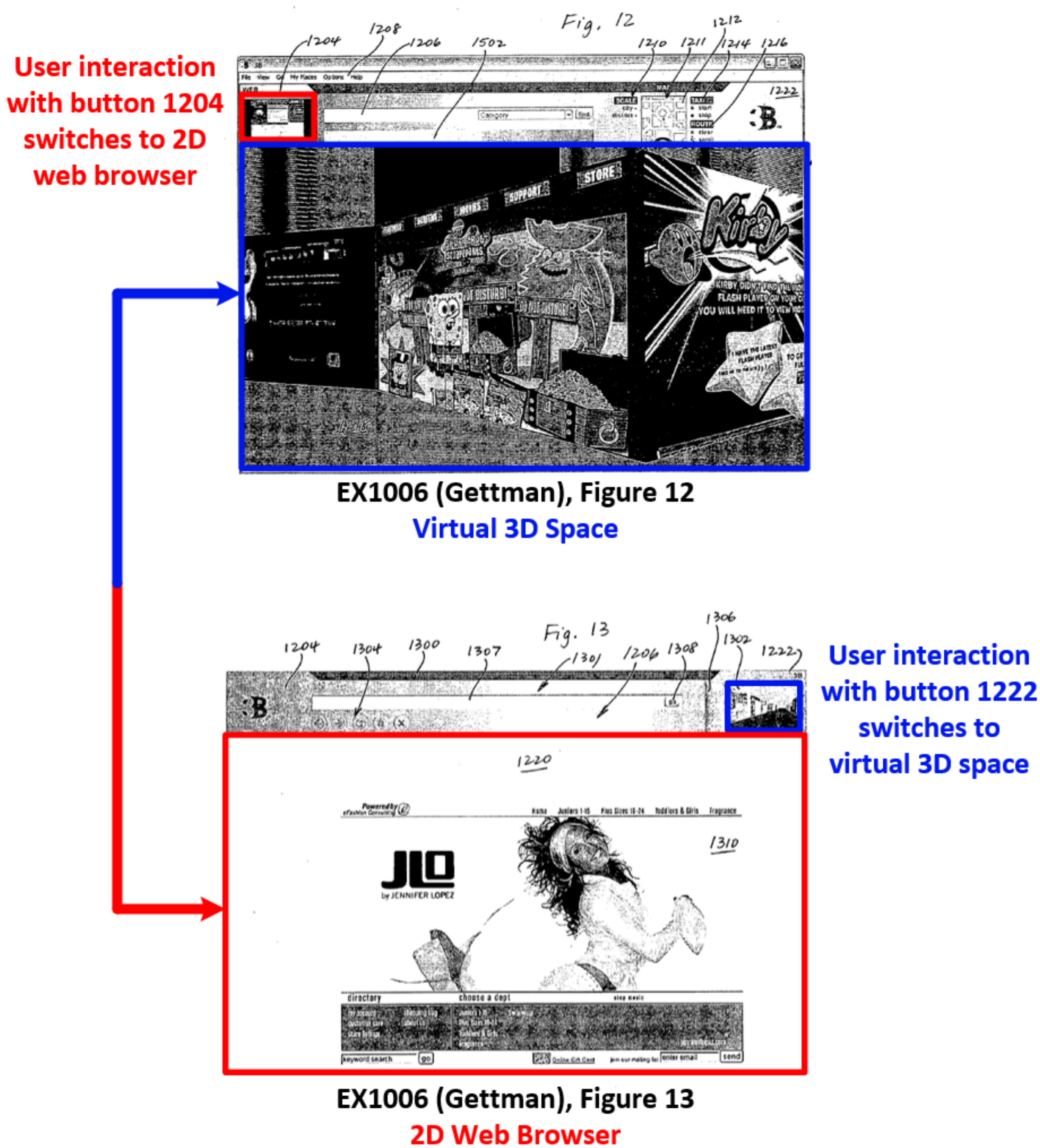
- **EX1021**, [0058] (a patent application filed in 2003 discussing how "output bitmaps" are generated and stored), [0059] (explaining that the "bitmaps" are retrieved from storage and "convert[ed] into a texture," which is then "displayed on the front face of [a] window" in the 3D space);
- **EX1022**, p. 15 (a 2004 developer's conference presentation describing a 3D graphics platform featuring a "3D Display Server" that "Loads pixmap [i.e., a grid of pixels] into texture"), p.23 (disclosing that "OpenGL" is used to perform a "Direct Render-to-Texture" process).
- **EX1035**, 6:7-31 (a patent filed in 1998 stating: "the pixel contents of the 2D shape, applied to the 3D shape as a 'texture'"), 6:66-7:19 ("At block 202, a 'snapshot' of the selected window is taken. That is, the pixels making up the selected window to be pushed back are captured in a data structure by the graphical user interface. At block 204, the snapshot data as a texture is applied to a display object in the 3D desktop window having the same shape as the selected window.");

85. In sum, rendering webpages, capturing images of those webpages, and texturing the captured images on objects in a 3D space were well known techniques employed throughout the 3D-GUI prior art. Applying these known techniques in the context of a similar reference like Robertson (which also teaches a 3D-GUI) to obtain a substantially similar result (an image textured onto an object in a 3D space)

would have been obvious to a person of skill.

(iii) Employing Gettman's alternative approach to launching a 2D browser window

86. Robertson and Gettman both describe 3D-GUIs with functionality to launch 2D browser windows that facilitate conventional user interaction with webpages (e.g., web surfing). EX1004 (Robertson), 13:55-14:11; EX1006 (Gettman), ¶¶0198-0202. In Robertson, the 2D browser window is "maximized, as is known to those skilled in the art," to replace the 3D space on the display. EX1004 (Robertson), 13:55-14:11. In Gettman, the GUI switches between the 3D space and the 2D browser window, replacing one with the other when the user makes the corresponding selection in the user interface, as shown in the visual aid below. EX1006 (Gettman), ¶¶0198-0202, Figures 12-13.



EX1006 (Gettman), Figures 12 & 13—Annotated

87. First, one advantage that a POSITA would have gleaned from Gettman's browser-window technique is the ability for the user—with a single interaction—to switch between the 2D browser and the 3D space. The POSITA

would have understood that this aspect of Gettman—i.e., an efficient mechanism for switching between the 2D browser and the 3D space—would predictably improve Robertson's GUI from a usability perspective. For example, Robertson does not detail the specific series of steps that the user must perform to obtain the "maximized" view of the 2D browser or to revert back to the 3D space. Gettman, on the other hand, demonstrates that the interface should be designed to facilitate switching between 3D and 2D with a minimal number of user interactions.

88. As the POSITA would have known, usability in this context—*e.g.*, the degree to which a given web browser efficiently facilitates the user's task of locating and consuming web content—was a key differentiator among competing web browsers. EX1036, p. 1 ("Paraphrasing the definition supplied by the ISO [1], Web usability is the efficient, effective and satisfying completion of a specified task by any given Web user."). While the same web content could be accessed on two competing web browsers, differences in the user interface could make accessing that content more efficient on one of the two. The browser with a superior interface from a usability standpoint would be more desirable by consumers. Thus, a POSITA looking to enhance Robertson's GUI, would have pursued the predictable usability improvement provided by Gettman.

89. Second, this predictable combination of Robertson and Gettman resembles the familiar pattern of merely substituting one element for another known

in the field to obtain predictable results. The facts I've laid out above support this reasoning. Robertson and Gettman both describe 3D-GUIs for viewing collections of webpages. In both disclosures, the user can launch from the 3D space a 2D browser for interacting with selected webpages in the conventional manner. The material difference between them in this context is simple—Robertson discloses maximizing the 2D browser window by some unstated series of steps, while Gettman efficiently "switches" between the 3D space and the 2D browser with a single user interaction. Bolstering Robertson's 2D browser technique based on Gettman's teachings would not have disturbed the other aspects of Robertson's 3D-GUI, and it would have produced substantially similar functionality to what Robertson described—i.e., an interface where the user can view several webpages (as thumbnails textured onto objects) in a 3D space and then select one of the webpages (objects) to launch a conventional 2D browser for interaction with the selected webpage.

2. Reasonable Expectation of Success

90. A POSITA would have reasonably expected a successful outcome from the above-discussed combination of teachings from Robertson, Gralla, and Gettman. GUIs, web browsers, and simulated 3D environments were all well-known technologies at the time of the '048 patent in 2005, and these technologies had been successfully demonstrated in the real-world by then. My extensive discussion on

the background of the technology establishes and supports these facts by identifying specific prototypes (e.g., the Information Visualizer [EX1010], the Document Lens [EX1011], the WebBook and Web Forager [EX1029], Data Mountain [EX1030]) and distributed software (e.g., Project Looking Glass [EX1012] and 3B Browser [1038]) that resulted from extensive research and development that predates the '048 patent. More specifically, and as I've also mentioned, the user interfaces of Robertson (Data Mountain, EX1030), Gralla (Internet Explorer), and Gettman (3B Browser, EX1038) were not just hypothetical, all had been developed and deployed for use by users. Having seen these disclosures implemented in the real-world, a POSITA would had confidence that their principles were sound and could be combined in the logical manner that I've proposed in this Declaration. Thus, the result of the Robertson-Gralla-Gettman Combination would have been predictable to a POSITA, and the POSITA would have expected it to work.

E. Claim Element Analysis

1. Claim 1

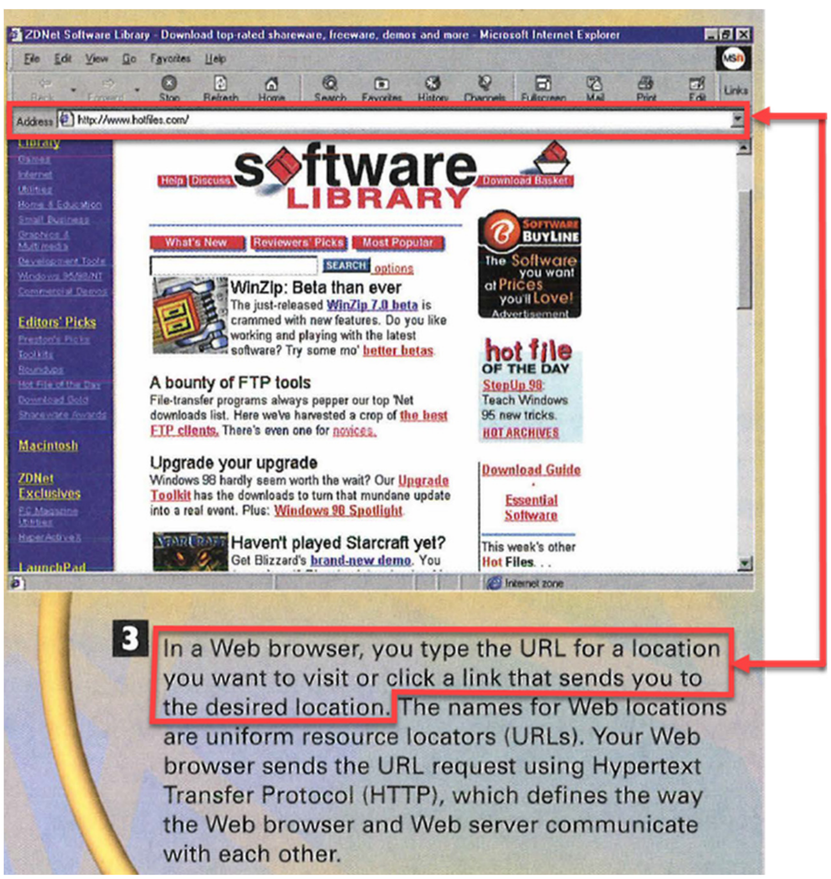
Element [1.pre]: A method for providing a three-dimensional (3D) graphical user interface, comprising:

91. The Robertson-Gralla-Gettman Combination satisfies Element [1.pre]. For example, Robertson describes "[a] ***graphical user interface*** in which object thumbnails are rendered on a simulated ***three-dimensional*** surface which (i) exploits

spatial memory and (ii) allows more objects to be rendered on a given screen." EX1004 (Robertson), Abstract; *see also* 6:30-67, 9:10-50, 15:46-16:2, 28:1-30, Figures 8A-18.

Element [1.a]: receiving at least first and second inputs from an end user;

92. The Robertson-Gralla-Gettman Combination satisfies Element [1.a]. As I explained earlier at Section VII.D, the Combination involves Robertson's 3D-GUI integrated within Gralla's web browser. Gralla shows that the web browser ***receives inputs from an end user***, for example, when the user "type[s] the URL for a location [they] want to visit" in an address bar. EX1005 (Gralla), 134.



EX1005 (Gralla), 134—Annotated

93. A POSITA would have understood and found it obvious that a user would visit multiple Internet locations (*e.g.*, webpages and websites) during one or more browsing sessions and, accordingly, provide multiple (***first/second***) uniform resource locator (URL) ***inputs***. Any person who has used the Internet can attest to this indisputable fact.

94. Moreover, this understanding is consistent with Robertson's teaching of favorites lists including "Internet locations (as located by a Uniform Resource Locator or 'URL') represented by [multiple] bookmarks." EX1004 (Robertson), 3:58-63. In other words, each item in a collection of bookmarked or favorited webpages typically represents a distinct URL, one for each webpage that the user previously visited and added to the collection. There are typically multiple (at least ***first/second***) bookmarks or favorites in the collection of a given user. *E.g.*, EX1023, p. 4 ("Some 84% of his respondents had more than eleven bookmarks[.]"). Thus, Robertson's teaching of collecting bookmarked/favorited webpages suggests that the user previously visited those webpages, such as by entering the URLs into the address bar of a web browser, as taught by Gralla.

Element [1.b]: receiving first and second webpages from at least one server in response to said first and second inputs, wherein the first and second inputs are website addresses corresponding to said first and second webpages, respectively;

95. The Robertson-Gralla-Gettman Combination satisfies Element [1.b].

the first and second inputs are website addresses corresponding to said first and second webpages

96. As discussed at Element [1.a], the Combination incorporates Gralla's teaching of receiving ***first and second inputs*** when a user types URLs (***website addresses corresponding to webpages***) into the address bar of a web browser. EX1005 (Gralla), 134, 153 ("…a URL, or Web address, indicates where the host computer is located, the location of the Web site on the host, and the name of the Web page and the file type of each document…").

receiving first and second webpages from at least one server in response to said first and second inputs

97. As discussed immediately above and at Element [1.a], "[i]n a Web browser, you type the URL for a location you want to visit" (***first and second inputs***). EX1005 (Gralla), 134. "Your Web browser sends the URL request using Hypertext Transfer Protocol (HTTP), which defines the way the Web browser and Web server communicate with each other." EX1005 (Gralla), 134. "When the server finds the requested home page, document, or object, it sends that home page, document, or object back to the Web browser client. The information is then displayed on the computer screen in the Web browser." EX1005 (Gralla), 134. In

short, after (***in response to***) the user types a URL (***website address***) into the address bar (***first/second inputs***), the browser sends a request to the ***server*** and receives a response from ***server*** including the (***first/second***) ***webpage*** that corresponds to the URL.

Element [1.c]: displaying at least a portion of the first webpage on a first object within a 3D space, and at least a portion of the second webpage on a second object within the 3D space, comprising;

98. The Robertson-Gralla-Gettman Combination satisfies Element [1.c]. To start, Robertson's 3D-GUI ***displays first/second objects within a 3D space***.[8]

99. As to the ***3D space***, a POSITA would have understood and found it obvious that Robertson's repeated discussion of positioning and moving thumbnail objects in a "simulated three-dimensional environment"[9] implicates a virtual space defined by a three-dimensional coordinate system.[10] EX1004 (Robertson), 6:30-50,

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[8] The colors in the text correspond to the annotated figure of Robertson's Figure 4 below. The colors do not change or impact the meaning of the text.

[9] The term "three-dimensional environment" is used synonymously in Robertson with "three-dimensional space," "three-dimensional landscapes," and "three-dimensional plane."

[10] I have been informed by counsel for Petitioner that the parties agreed in the co-pending district court litigation that the term ***3D space*** should be construed as "a

9:14-50, 12:54-13:27; 15:59-63 (discussing how the "virtual three-dimensional location" of the cursor and objects is tracked). In other words, the POSITA would have appreciated the well-known fact that coordinate systems were (and are) routinely used to establish the size, shape, and orientation of an object in a virtual space. EX1004 (Robertson), 12:54-13:27 (explaining how objects are appropriately scaled and oriented based on their location in the three-dimensional space). Coordinate systems were (and are) also used to track the location of such an object as it is moved throughout such a space. EX1004 (Robertson), 15:59-63 (discussing how the "virtual three-dimensional location" of the cursor and objects is tracked). In the context of a three-dimensional space, as Robertson teaches, the POSITA would have known that the appropriate coordinate system is a three-dimensional coordinate system.

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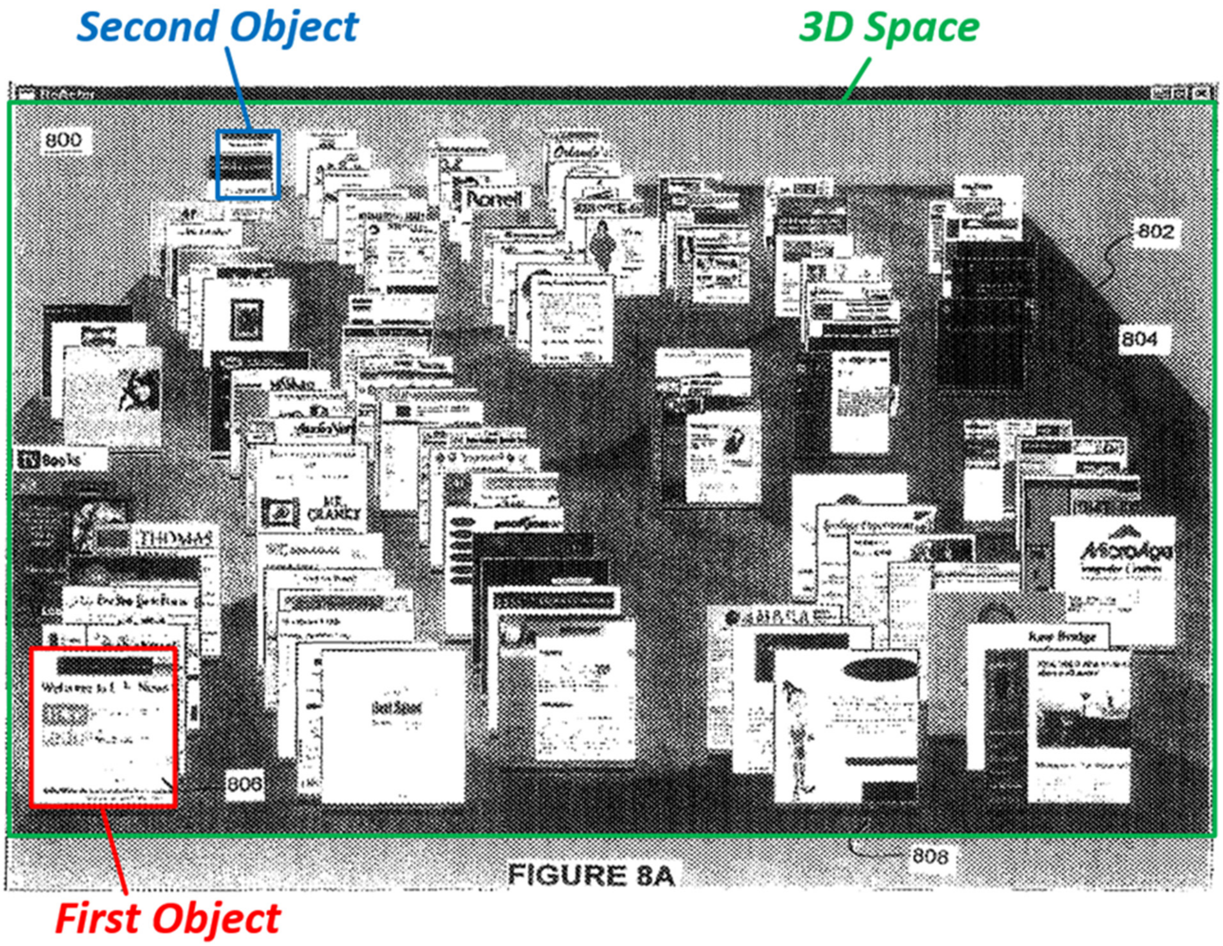
virtual space defined by a three-dimensional coordinate system." I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

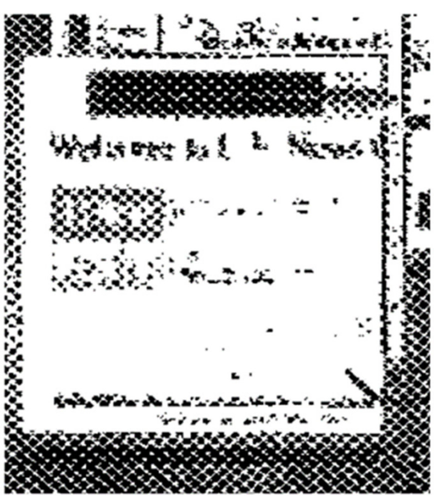


EX1004 (Robertson), Figure 8A—Annotated

100. Additionally, Robertson provides that its 3D-GUI "may (i) represent, visually, objects using object thumbnails and (ii) may simulate a three-dimensional plane, or other three-dimensional landscape on which the object thumbnails may be manipulated. FIG. 8A is a display 800 which illustrates an inclined…plane 802…having low resolution images…or object thumbnails 806." EX1004 (Robertson), 12:54-13:4, Figure 8A (annotated below). Robertson further teaches that, "[i]n the display 800, the object thumbnails 806 represent web (or hypertext

markup language or 'HTML') pages." EX1004 (Robertson), 12:54-13:4, Figure 8A (annotated below).

101. As I've explained, the Combination employs Robertson's 3D-GUI to present webpages previously visited and added to the **Favorites** tool by a user of Gralla's web browser. *See also* Elements [1.a-1.b] (discussing Gralla's web browser). Accordingly, in the Combination, the ***first/second object*** thumbnails of Robertson represent the ***first/second webpages*** of Gralla (per Element [1.b]). And Robertson shows that the ***object*** thumbnails comprise visual representations—images (***displaying at least a portion***)—of the ***webpages***. EX1004 (Robertson), 6:30-50 ("low resolution image"), 9:10-35, 12:54-13:4 ("low resolution images," for example, "64 pixel by 64 pixel bitmaps having 24 bit color"), 18:1-5 (similar), 28:1-16 (similar), Figures 2, 4, 8A-18.



"low resolution images...represent web (or hypertext markup language or 'HTML') pages"

EX1004, 12:54-13:4

EX1004, FIG. 8A (cropped)

EX1004 (Robertson), Figure 8A—Cropped to Show Detail

102. The companion Data Mountain paper, which describes prototypes implementing Robertson's (EX1004) teachings, supports my view that Robertson's (EX1004) object thumbnails comprise images of corresponding webpages. For example, Robertson and his co-authors explained in their paper:

> The 100 pages used in the study below are screen snapshots of actual web pages in 24-bit color. We employ two bitmap sizes of each page for texture mapping: a small 64x64 pixel version (12KB each) for the thumbnails on the Data Mountain surface, and a 512x512 pixel version (768 KB each) for the close-up view.

EX1030, p. 5

EX1030, p. 3 (Figure 3)

103. If there is any doubt about Robertson's disclosure on this feature (***displaying at least a portion of the first/second webpages on first/second objects***), Gettman's disclosure is a sufficient supplement. Recall from my earlier discussion at Section VII.D that a POSITA would have turned to Gettman for additional implementation details on this subject. For example, as discussed below at [1.c.i] through [1.c.iii], Gettman supplements Robertson with express teachings about saving bitmap screenshots (***at least a portion***) of ***webpages*** and ***displaying*** them in a 3D-GUI.

Element [1.c.i] rendering the first and second webpages;

104. The Robertson-Gralla-Gettman Combination satisfies Element [1.c.i]. A POSITA would have understood that Robertson's 3D-GUI ***renders the*** (***first/second***) ***webpages*** to obtain the webpage images on the object thumbnails. *See* Element [1.c]; EX1004 (Robertson), 6:30-50, 9:10-35, 12:54-13:4, 18:1-5, 28:1-16, Figures 2, 4, 8A-18. For example, the POSITA would have known that webpage ***rendering*** was a ubiquitous process for converting raw HTML code received from a web server into visible content.

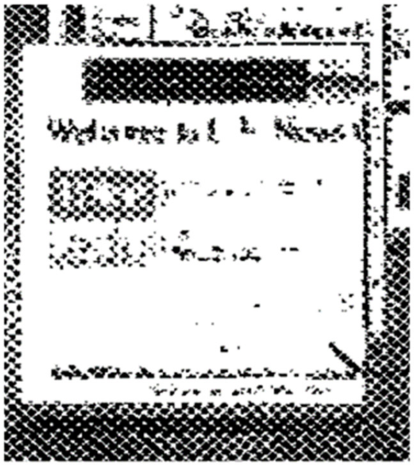
105. Webpage ***rendering*** is a core functionality of virtually all web browsers, and it would have been obvious to a POSITA that rendering is a prerequisite step to obtaining "screen snapshots of actual web pages," as explained in Robertson's companion Data Mountain paper. EX1030, p. 5. Moreover, the '048 patent supports my view about a POSITA's knowledge on ***rendering*** webpages. Indeed, the '048 patent concedes that webpage rendering was well known: "The name of one such control is called MSHTML/web browser control for rendering HTML webpages[.]" EX1001 ('048 patent), 23:4-6. "MSHTML" was the rendering engine used in the Internet Explorer browser at the time of the '048 patent in 2005.

106. Regardless, if there is any doubt about Robertson's disclosure on this ***rendering*** feature, the Combination incorporates the implementation details provided by Gettman for displaying webpages in a 3D-GUI and applies those details

to Robertson's disclosure on object thumbnails. Gettman's technique involves "cach[ing]" "bitmap screenshots" of ***webpages*** in local memory using a "HTML page-***rendering*** engine"—a software application for ***rendering*** (the ***first/second***) ***webpages***. EX1006 (Gettman), ¶0082; *see also* ¶¶0108-0121, Figure 2 ("Generate invisible window from source data").

Element [1.c.ii] capturing first and second images of the at least a portion of the first webpage and the at least a portion of the second webpage, respectively; and

107. The Robertson-Gralla-Gettman Combination satisfies Element [1.c.ii]. A POSITA would have understood that Robertson's 3D-GUI ***captures images*** of the rendered (***first/second***) ***webpages*** to obtain the webpage images on the object thumbnails. EX1004 (Robertson), 6:30-50, 9:10-35, 12:54-13:4, 18:1-5, 28:1-16, Figures 2, 4, 8A-18; EX1030, p. 5 ("screen snapshots of actual web pages"). Robertson shows the webpage images in its figures (*e.g.*, Figure 8A, below) and explains that they are saved in memory as low-resolution bit maps (*e.g.*, 9:10-35, 18:1-5). Robertson also distinguishes the still images on the object thumbnails from a "live" object containing a dynamic instance of the actual webpage. EX1004 (Robertson), 9:103-35. Storing a low-resolution still image of a webpage in memory demonstrates to a POSITA that the ***image*** was ***captured***.



EX1004, FIG. 8A (cropped)

"low resolution images...represent web (or hypertext markup language or 'HTML') pages"

EX1004, 12:54-13:4

EX1004 (Robertson), Figure 8A—Cropped to Show Detail

108. Regardless, if there is any doubt about Robertson's disclosure on this ***capturing*** feature, my discussion above at Element [1.c.i] shows that Gettman's technique involves "cach[ing]" "bitmap <u>screenshots</u>" (***captured first/second images***) of rendered (***first/second***) ***webpages*** in local memory. EX1006 (Gettman), ¶0082; *see also* ¶¶0108-0121. First, a POSITA would have understood that Gettman's reference to a "screenshot" teaches that the contents of the screen—here, a rendered ***webpage***—are ***captured*** in a file saved ("cached") in memory. Second, the POSITA also understood that Gettman's reference to a "bitmap" teaches that the captured contents are ***images***. A "bitmap" is "strictly a one-bit-per-pixel representation for a defined area of a display." EX1039, p. 3. The term is also used

more generally when there is more than one bit per pixel.[11] Here, what is being represented is a rendered webpage. Thus, the "bitmap" provides a representative image of the webpage.

Element [1.c.iii] texturing the first image on the first object and the second image on the second object, the first object being displayed in a foreground of the 3D space and the second object being displayed in a background of the 3D space; and

109. The Robertson-Gralla-Gettman Combination satisfies Element [1.c.iii].

110. Per Element [1.c], Robertson provides (***first/second***) ***object*** thumbnails comprising low resolution bitmap ***images*** representing (***first/second***) ***webpages***. EX1004 (Robertson), 6:30-50, 9:10-35, 12:54-13:4, 18:1-5, 28:1-16, Figures 2, 4, 8A-18. According to Robertson (EX1004), for each object:

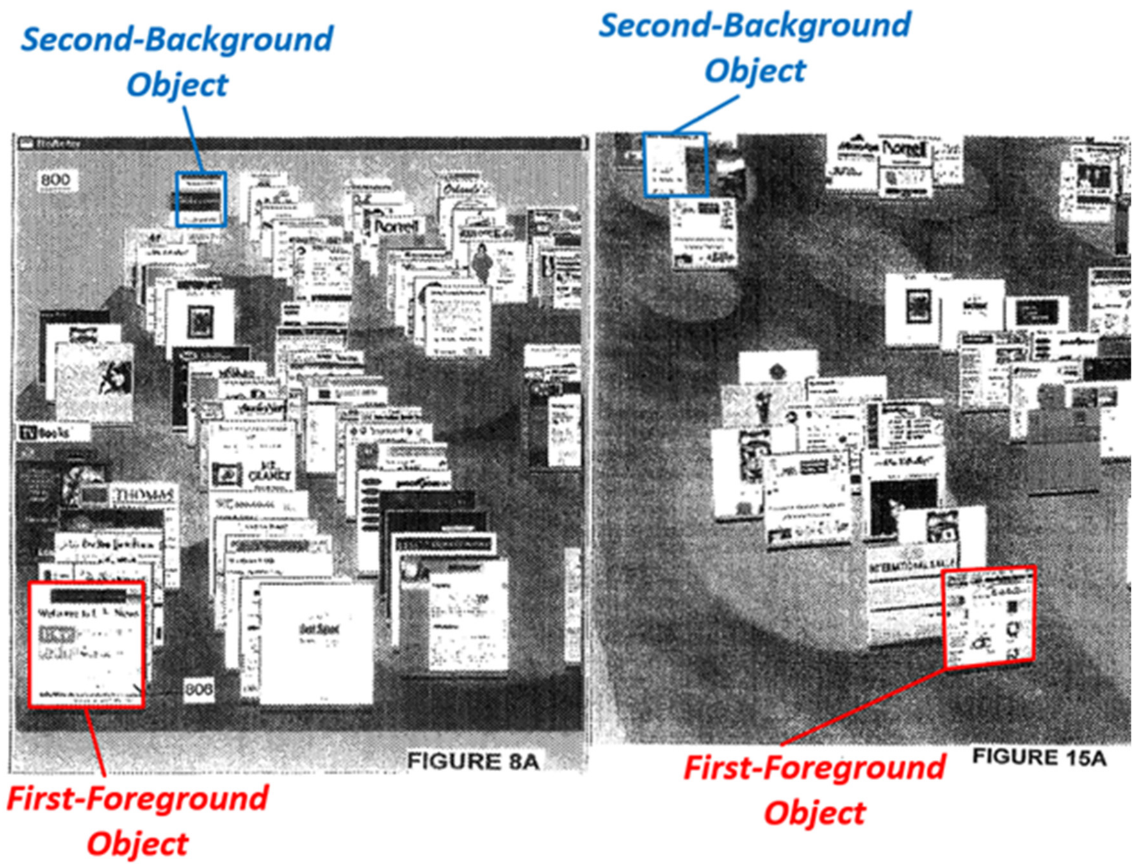
1. the "object's location" in the 3D space is retrieved from "storage means" (17:49-67, Figs. 2, 4, 8A-D, 25; *see also* 14:61-63 ("The location information field 308 may include…a location in the simulated three-dimensional environment."));
2. a "perspective view process" portrays the object on a "display plane" based on its location, such that objects "appear larger if located in the ***foreground***…and appear smaller if located in the

[11] For example, the Data Mountain paper references "two bitmap sizes" and "screen snapshots of actual web pages in 24-bit color." EX1030, p. 5.

background" (17:49-67);

3. an optional "parallax simulation process" applies an off-center effect to the object (17:21-48, 18:6-13, Figs. 15A-B, 23A-B); and
4. the "low resolution image" is retrieved from "storage means" and drawn/mapped (***textured***) on the object (17:49-67, Figs. 2, 4, 8A-D, 25).

111. Robertson's figures demonstrate how the webpage ***images*** are drawn/mapped (***textured***) based on the size and shape the ***object*** thumbnail—*e.g.*, larger in the foreground, smaller in the background, and optionally with a parallax effect. A POSITA reading Robertson would have understood that the webpage ***images*** are ***textured*** onto the object thumbnails. In other words, the pixel values from the bitmap representations of the webpages are mapped to the coordinates of the object in the virtual 3D space.



EX1004 (Robertson), Figures 8A & 15A—Annotated

112. As I've explained (and will repeat here), texturing (or "texture mapping") was a well-known technique commonly used in 3D-GUIs. Robertson and his co-authors described texturing in their Data Mountain paper (EX1030), which embodies the teachings of Robertson (EX1004). EX1030, p. 5 ("The 100 pages used in the study below are screen snapshots of actual web pages in 24-bit color. We employ two bitmap sizes of each page for texture mapping…"). Additionally, the Data Mountain paper and Robertson both reference the "OpenGL" graphics library, which was known to support texturing. EX1004 (Robertson), 17:49-67 (identifying "OpenGL"); EX1030 (Data Mountain), p. 5 (explaining that

the Data Mountain prototypes use "OpenGL as the underlying graphics library"); EX1037, p. 1 ("The OpenGL Graphics System provides a well-specified, widely accepted dataflow for 3D graphics imaging"), p. 3 (explaining OpenGL's "texturing" functionality); EX1012, p. 2 ("software support for real-time operating systems and emerging industry standard open graphics libraries (e.g., OpenGL and PEX) are simplifying the 3D programming task"). The following citations and parentheticals provide additional examples of the ample teachings in the prior art on this subject of texturing (or "texture mapping"):

- **EX1016**, 27:48-63 (from a patent filed in 2000: "In particular, the three-dimensional shell defines a three-dimensional polygon on which the image of a window is applied as texture.");
- **EX1018**, [0049] (a patent application filed in 2002 referencing a 3D-GUI where user-selectable windows and icons are presented on "a texture mapped cube 21");
- **EX1019**, [0055] (a patent application filed in 2004 explaining that "a process called texture mapping" can be employed to create a "3D scene" using "low level graphics APIs, such as Direct3D® or OpenGL®");
- **EX1021**, [0058] (a patent application filed in 2003 discussing how "output bitmaps" are generated and stored), [0059] (explaining that the "bitmaps" are retrieved from storage and "convert[ed] into a texture," which is then

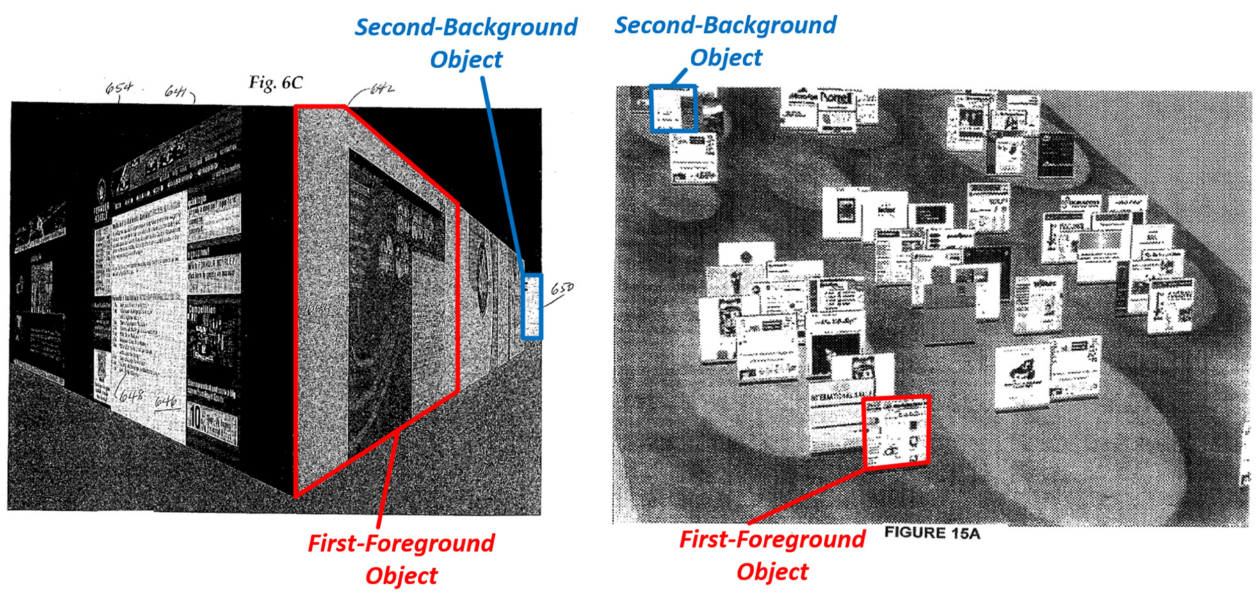
"displayed on the front face of [a] window" in the 3D space);

- **EX1022**, p. 15 (a 2004 developer's conference presentation describing a 3D graphics platform featuring a "3D Display Server" that "Loads pixmap [i.e., a grid of pixels] into texture"), p.23 (disclosing that "OpenGL" is used to perform a "Direct Render-to-Texture" process); and
- **EX1035**, 6:7-31 (a patent filed in 1998 stating: "the pixel contents of the 2D shape, applied to the 3D shape as a 'texture'"), 6:66-7:19 ("At block 202, a 'snapshot' of the selected window is taken. That is, the pixels making up the selected window to be pushed back are captured in a data structure by the graphical user interface. At block 204, the snapshot data as a texture is applied to a display object in the 3D desktop window having the same shape as the selected window.").

113. This is all more supporting evidence that texturing was well-known before the Critical Date in 2005; Robertson's disclosure uses texturing; and a POSITA would have understood that Robertson uses texturing.

114. Gettman's teachings reinforce the POSITA's understanding that Robertson's disclosure about mapping webpage images onto objects in a 3D space uses ***texturing***. According to Gettman, "cached HTML pages" (***captured images***, per Element [1.c.ii]) are "stored as ***textures*** in the client computer memory" and "used to populate the display windows" (***objects***) in ***the 3D space***. EX1006

(Gettman), ¶0112, ¶0163 ("a first virtual building 642…in a ***foreground***…a second virtual building 650…in a ***background***[.]"); *see also* ¶0113-0121, Figure 6C. As shown below, Gettman and Robertson similarly provide 3D spaces with objects bearing images of webpages. While Robertson does not use the exact term, Gettman confirms that a POSITA would have understood Robertson's technique to use ***texturing***.



Gettman (EX1006), Figure 6C (left); Robertson (EX1004), Figure 15A—Figures Annotated

115. Going back to the subject of "texturing," I have been informed by counsel for Petitioner that the parties have proposed the following two different constructions for this term in the co-pending district court litigation.[12]

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[12] I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

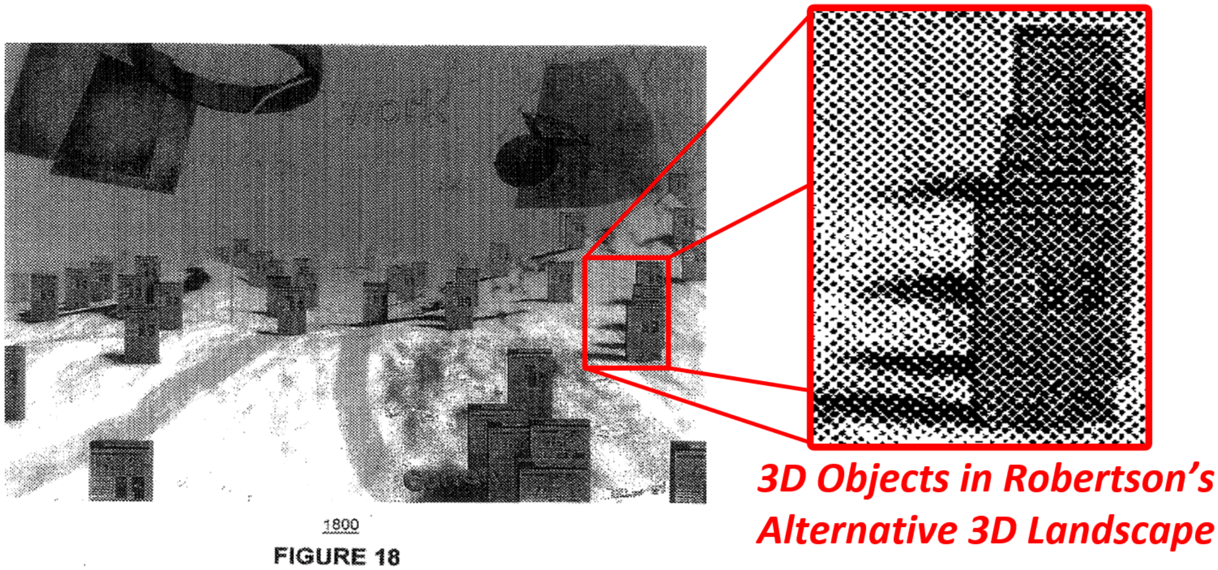
Term	Petitioner	Patent Owner
"texturing" Claims 1, 8	"drawing or mapping an image onto a 3D object"	No construction necessary; plain and ordinary meaning applies. Alternatively: drawing or mapping [the first image on the first object and the second image on the second object].

116. My analysis above satisfies Element [1.c.iii] under Patent Owner's proposed district court construction of ***texturing*** because that construction does not limit the claims to texturing on any particular kind of object. Petitioner's proposed construction, on the other hand, requires that the claimed ***objects*** on which the ***webpage images*** are ***textured*** must be ***3D objects***. In my view, the Robertson-Gralla-Gettman Combination satisfies Element [1.c.iii] under Petitioner's construction as well.

117. For example, Robertson discloses a variety of "alternative landscapes," where the object thumbnails textured with webpage images are depicted as rectangular prisms (***3D objects***) having a height in the Y-dimension, a width X-dimension, and a depth in the Z-dimension. [EX1004, 13:5-7, 27:45-67, Figures 16-18; *see also id.*, 22:31-55, Figures 13A-13D].[13] This is evident in the annotated

[13] I note that the quality of the images in the underlying Robertson patent application

figure shown below. As you can see in the figure, the left edge and side surface of the rectangular prisms (or "slabs") are darkened because they are in shadow based on the simulated location of the light source (up and to the right). Notice that the right edges of the "slabs" do not exhibit this darkening because they are not in shadow from the light that is up and to the right.



EX1004 (Robertson), Figure 18—Annotated

118. The '048 patent's preferred embodiments involve thin rectangular prisms that resemble those shown in Robertson's Figure 18. EX1001, 18:46-56,

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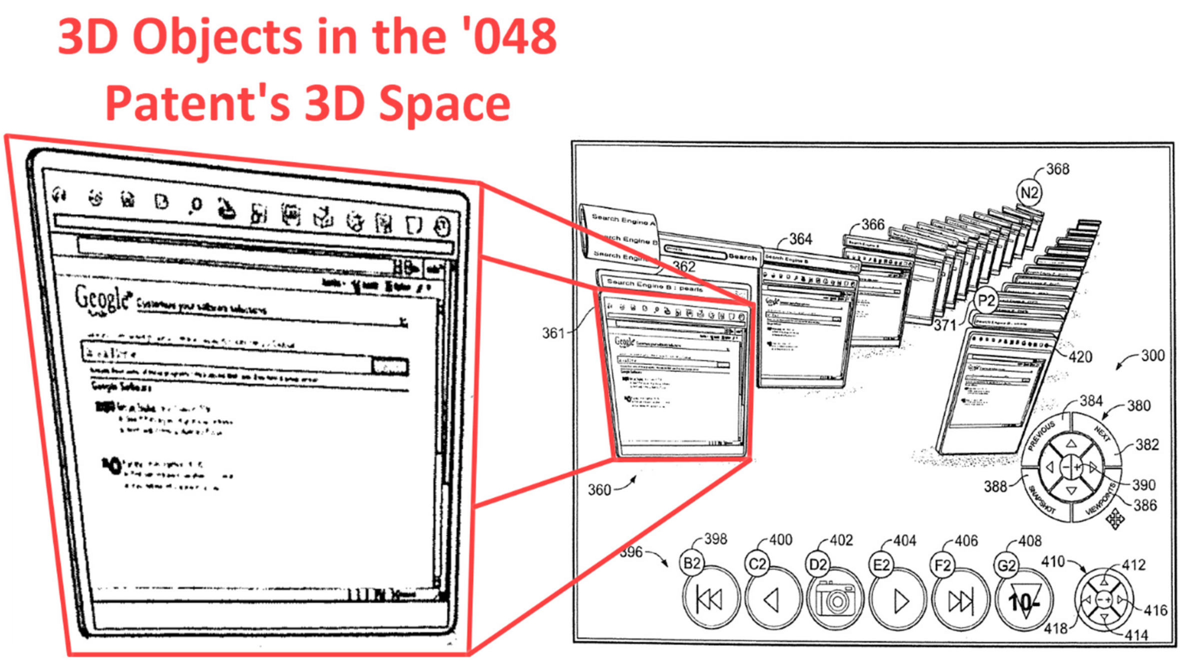
(EX1040) is superior to that of the Robertson patent (EX1004). The Robertson patent application's figures show the 3D rectangular prisms even more clearly. EX1040, pp. 124-127, 132-134.

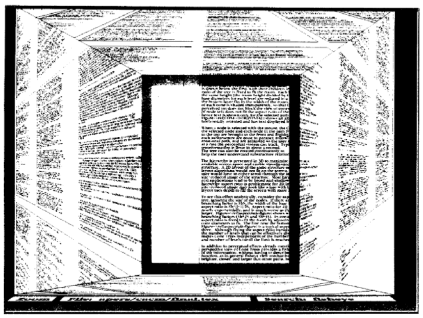
Figure 10 (annotated below). This fact supports my understanding that Robertson teaches texturing on 3D objects in the same manner disclosed and claimed by the '048 patent.



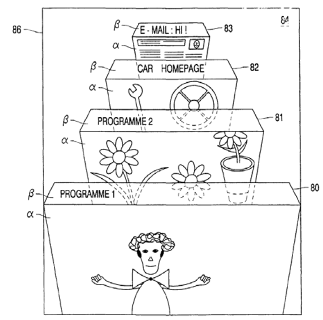
EX1001 ('048 patent), Figure 10—Annotated

119. A POSITA would have appreciated that utilizing the rectangular prisms (***3D objects***) from Robertson's alternative landscapes would have been a predictable variation from the embodiments discussed earlier in Robertson that employ flat rectangles without depth in the Z-dimension. This simple substitution of one virtual object for another within the scope of the same disclosure would have been readily apparent to the POSITA, especially when the two are described as "alternatives." When a document describes alternatives techniques, the person of skill tends to think about how those alternatives might be implemented. Here, the implementation is

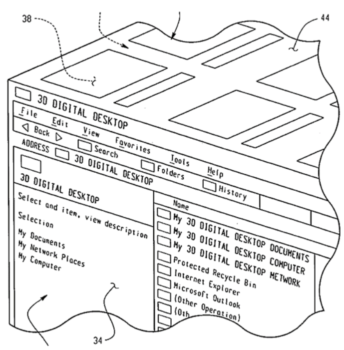
just a matter of adding depth to a virtual object. As I've explained at length in this Declaration, 3D graphics and GUIs involving 3D objects in 3D environments were all very well known by the '048 patent's Critical Date in 2005 (see examples below). It would not have been difficult, novel, or inventive for a POSITA to employ 3D objects in a 3D environment.



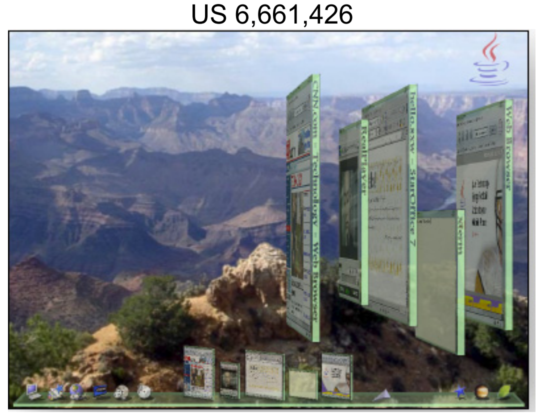
EX1011, p. 5 (Figure 3)
The Document Lens



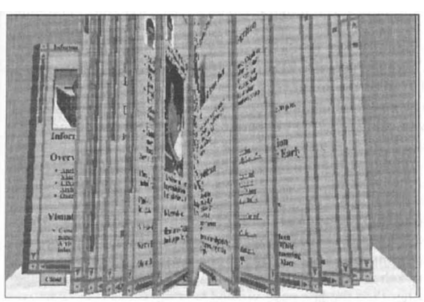
EX1017, Figure 2
US 6,661,426



EX1018
US 2003/0142136



EX1012, p. 1
Project Looking Glass



EX1029, p. 3 (Figure 3)
The WebBook

EX1038, p. 1
3B Browser

120. In fact, the notion of adding depth to Robertson's objects would have been intuitive to the POSITA given that the surrounding three-dimensional environment naturally allows three-dimensional objects. In some sense, one would expect to see 3D objects in a 3D space. Thus, even without Robertson's express teaching of alternative landscapes, it would have been obvious to employ 3D objects in the context of Robertson. Finally, the POSITA would have understood that using 3D objects would provide the predictable advantage of improving the realism and immersive effect of the Robertson-Gralla-Gettman 3D-GUI.

Element [1.d] displaying additional information, comprising:

121. The Robertson-Gralla-Gettman Combination satisfies Element [1.d] for all the reasons below regarding Elements [1.d.i] through [1.d.v].

Element [1.d.i] receiving an interaction by the end user on the first image;

122. The Robertson-Gralla-Gettman Combination satisfies Element [1.d.i]. For example, Robertson's 3D-GUI uses "'live' objects within an associated application for…working on a selected object." EX1004 (Robertson), 13:55-14:21. In one example, "the Internet Explorer™ Internet browser…may be rendering a web page, with the user interface of the present invention in the background." EX1004 (Robertson), 13:55-14:21. The selection is made when the ***end user*** inputs, and the 3D-GUI ***receives***, a predetermined ***interaction***, such a "mouse click," on the (***first***) ***image*** of the object thumbnail. EX1004 (Robertson), 16:3-17, Figure 22; *see also*

15:45-68 ("a user may interact with the user interface…using a pointing device, such as a mouse") ("[T]he pointer input management process…provides user inputs, from the pointing device, to the input management process…").

Element [1.d.ii] replacing the first and second objects within the 3D space with a window within a two-dimensional (2D) space in response to receiving the interaction, wherein the window includes the rendered first webpage;

123. The Robertson-Gralla-Gettman Combination satisfies Element [1.d.ii]. For example, per Element [1.d.i], when the user selects an object thumbnail, Robertson's 3D-GUI presents a "'live' object" that is "in its associated application," such as "the Internet Explorer™ Internet browser…[for] ***rendering a [first] web page***." EX1004 (Robertson), 13:55-14:14, Figure 9. The browser can be "maximized…to substantially fill the screen of the video monitor" while the 3D-GUI is "in the background." EX1004 (Robertson), 13:55-14:14.

124. In other words, the (***first/second***) ***object*** thumbnails ***in the 3D space*** of Robertson's GUI are ***replaced*** by a full-screen ***window in the two-dimensional space*** of a conventional Internet Explorer web browser. In the context of a Microsoft Windows-based system[14], Robertson's "substantially fill[s] the screen" statement means that the browser window is maximized to a full-screen view that takes up the

[14] Recall that Robertson (EX1004) is assigned to Microsoft Corporation and Internet Explorer is a Microsoft product.

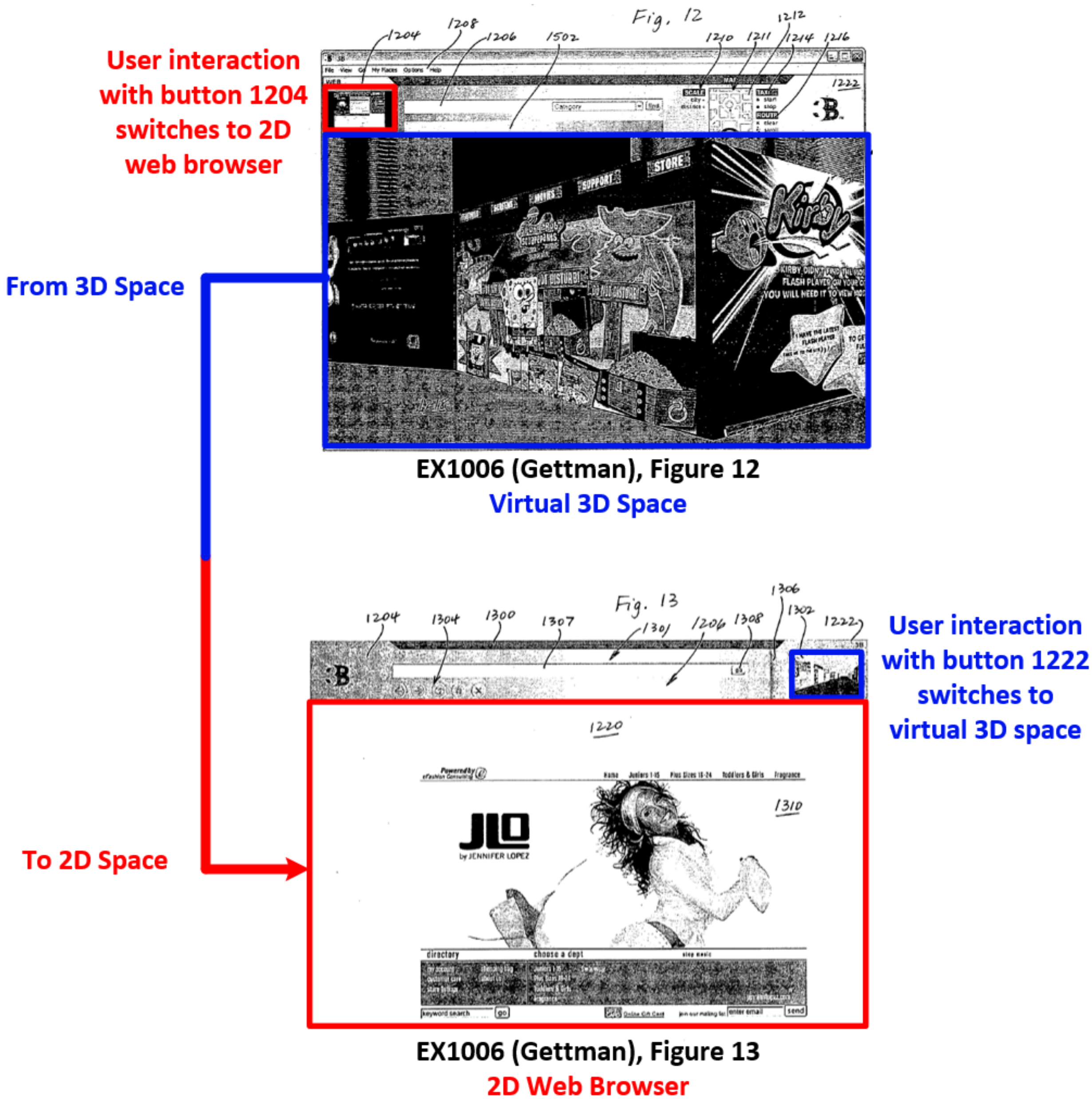
entire screen and effectively replaces the 3D space, both from the user's perspective of what content is viewable (only the 2D browser window) and from the computer's standpoint in terms of what content is being displayed (only the 2D browser window). In this way, Robertson's disclosure is similar to the '048 patent's preferred embodiment, which involves a "heads-up-display" feature where "the 2D version of the webpage…[is] position[ed] in a layer that is in front of the 3D virtual space such that the end user can interact with this layer in 2D." EX1001 ('048 patent), 21:20-53.

125. Briefly, I have been informed by counsel for Petitioner that the parties agreed in the co-pending district court litigation that the term ***2D space*** should be construed as "a finite graphical area defined by a two-dimensional coordinate system."[15] Robertson's disclosure of launching an Internet Explorer web browser is consistent with the parties' construction. Internet Explorer was a well-known web browser with which a POSITA would have been familiar. The POSITA would have known that Roberton's reference to Internet Explorer suggests a 2D space in the sense that Internet Explorer was designed to render webpages using 2D coordinate systems (e.g., Cascading Style Sheets (CSS)). In other words, most Internet

[15] I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

webpages were coded in 2D layouts and, thus, conventional web browsers like Internet Explorer were built to render those webpages in 2D spaces defined by 2D coordinate systems.

126. If there is any doubt about Robertson's disclosure on this ***replacing*** feature, Gettman's disclosure effectively supplements Robertson. For example, Gettman describes an embodiment where "the result of the interaction [with a 3D display window in the virtual city] may cause the target [w]eb site to open in a conventional two-dimensional web browser." EX1006 (Gettman), ¶0164; *see also* ¶¶0200-0201. In this way, "the user switches to an alternate two-dimensional view of the web page." EX1006 (Gettman), ¶0164; *see also* ¶0200. With reference to Figures 12 (left) and 13 (right), Gettman explains how the user interface "switches" between (***replaces***) **(i)** "a virtual ***3D space***" with "display windows" (***first/second objects***) showing images of corresponding (***first/second***) ***webpages***; and **(ii)** a "web view" comprising a "conventional ***two-dimensional*** browser" (*e.g.*, Mozilla) that loads the webpage "linked to a display window…on which the user has clicked." EX1006 (Gettman), ¶0200.

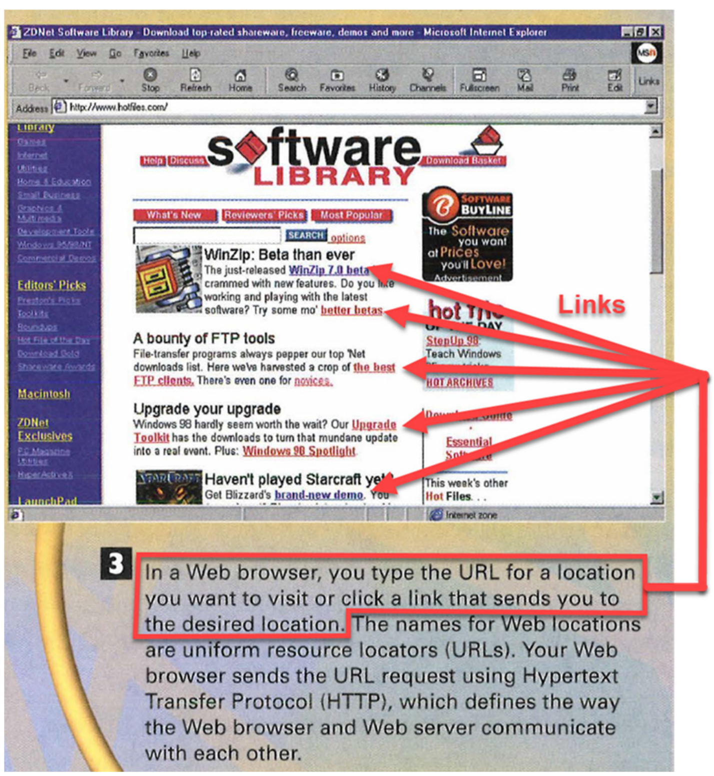


EX1006 (Gettman), Figures 12 & 13—Annotated

127. As I explained earlier at Section VII.D, a POSITA would have been motivated to employ Gettman's above-discussed teaching of toggling between "a virtual 3D space" and "a two dimensional browser" in response to an end user interacting with and selecting an object thumbnail.

Element [1.d.iii] receiving an interaction by the end user on a link provided in the rendered first webpage, the link corresponding to the additional information;

128. The Robertson-Gralla-Gettman Combination satisfies Element [1.d.iii]. As discussed at Element [1.d.ii], Robertson and Gettman teach the concept of launching a web browser (*e.g.*, Internal Explorer or Mozilla) for the user to interact with in a conventional way—i.e., in a 2D window instead of a virtual 3D space. And Gralla explains that the conventional functionalities of such a web browser involve ***receiving an interaction by the end user***—a "click"—***on a link provided in the rendered (first) webpage, the link corresponding to the additional information***. EX1005 (Gralla), 134.



EX1005 (Gralla), 134—Annotated

Element [1.d.iv] rendering the additional information; and

Element [1.d.v] displaying the rendered additional information in said window within the 2D space.

129. The Robertson-Gralla-Gettman Combination satisfies Elements [1.d.iv] and [1.d.v]. As discussed at Element [1.d.ii], Robertson and Gettman teach the concept of launching a web browser (*e.g.*, Internal Explorer or Mozilla) for the user to interact with in a conventional way—i.e., in ***a 2D window*** instead of a virtual 3D space. And Gralla explains that the conventional functionalities of such a web browser involve ***rendering*** and ***displaying the additional information***—i.e., content from the URL location of the link. EX1005 (Gralla), 142-143 ("A web browser ***displays information*** on your computer by interpreting the [HTML] that is used to build home pages on the Web."). As I explained above (*see* ¶¶104-105), ***rendering*** is a ubiquitous process for converting raw HTML code received from a web server into visible content. Web browsers ***render information*** by interpreting HTML code and ***displaying*** the corresponding content. Webpage ***rendering*** is a core functionality of virtually all web browsers.

2. Claim 2

Element [2.a] capturing a third image of at least a portion of the rendered additional information; and

Element [2.b] texturing the third image on the first object, the third image thereby replacing the first image on the first object;

130. The Robertson-Gralla-Gettman Combination satisfies Elements [2.a] and [2.b]. These elements require repeating the ***capturing*** and ***texturing*** steps of Elements [1.c.ii] and [1.c.iii] for the ***additional information rendered*** and ***displayed*** in Elements [1.d.iv] and [1.d.v], which yields ***a third image on the first object*** in the 3D space. More specifically, Elements [2.a] and [2.b] are about replacing the first webpage image on the first object in the 3D space with a third image, where that third image corresponds to some additional information, such as a new webpage, loaded in response to a user interaction with the first webpage. One way to view these elements is that they capture the notion of updating the 3D space to reflect the user's interaction with the 2D browser.

131. Repeating Elements [1.c.ii] and [1.c.iii] is taught by Robertson's instruction to perform its 3D-GUI processing steps "as a sequence of <u>cycles</u>" where "inputs are accepted" and "states are <u>updated</u>" based on "user inputs." EX1004 (Robertson), 14:25-34 ("[T]he processing by the present invention may be thought of as a sequence of cycles."), Figure 2. It would have been clear to a POSITA that the notion of "updat[ing]" the "states" applies throughout Robertson, and thus

includes the obvious functionality of updating the images on the object thumbnails in the 3D space to reflect updates in the 2D browser window based on the user's inputs and interactions with the 2D browser. Accordingly, during a subsequent processing cycle, the ***first image*** is replaced by a ***third image*** on the ***first object*** thumbnail to reflect the user input conducted using the browser application (navigating to a ***third webpage***).

132. Even without this teaching by Robertson, repeating Elements [1.c.ii] and [1.c.iii] for the additional information of Elements [1.d.iv] and [1.d.v] would have been obvious to a POSITA using common sense and ordinary creativity. Cycling through and repeating the steps of a known process flow is not novel or inventive to a person of skill. It is an age-old principle. And updating the information displayed through a GUI to reflect actions and input by the user was likewise well known and very common. Indeed, one purpose served by a GUI is to keep the user informed as to the current state of the system.

133. Moreover, the POSITA would have been motivated to incorporate such "updating" functionality in Robertson's 3D-GUI to promote Robertson's stated goal of improving the spatial/visual recognition of web pages. EX1004 (Robertson), 3:36-45, 6:15-23, 9:10-25. To provide a concrete example, the POSITA would have understood that within a particular browsing session, updating object thumbnail images would help users re-locate those thumbnails. Consider a scenario where the

user navigates from **Page X** to **Page Y** and then turns away from this line of browsing (e.g., to take a break or pursue some other online research). The lasting image in the user's mind would be that of **Page Y**. Accordingly, it would be useful from the user's perspective if the Robertson-Gralla-Gettman 3D-GUI were updated to reflect the image of **Page Y**. This way, if the user chooses to revisit the line of web browsing that left off at **Page Y**, it would be natural to spot the image of that webpage in the 3D-GUI.

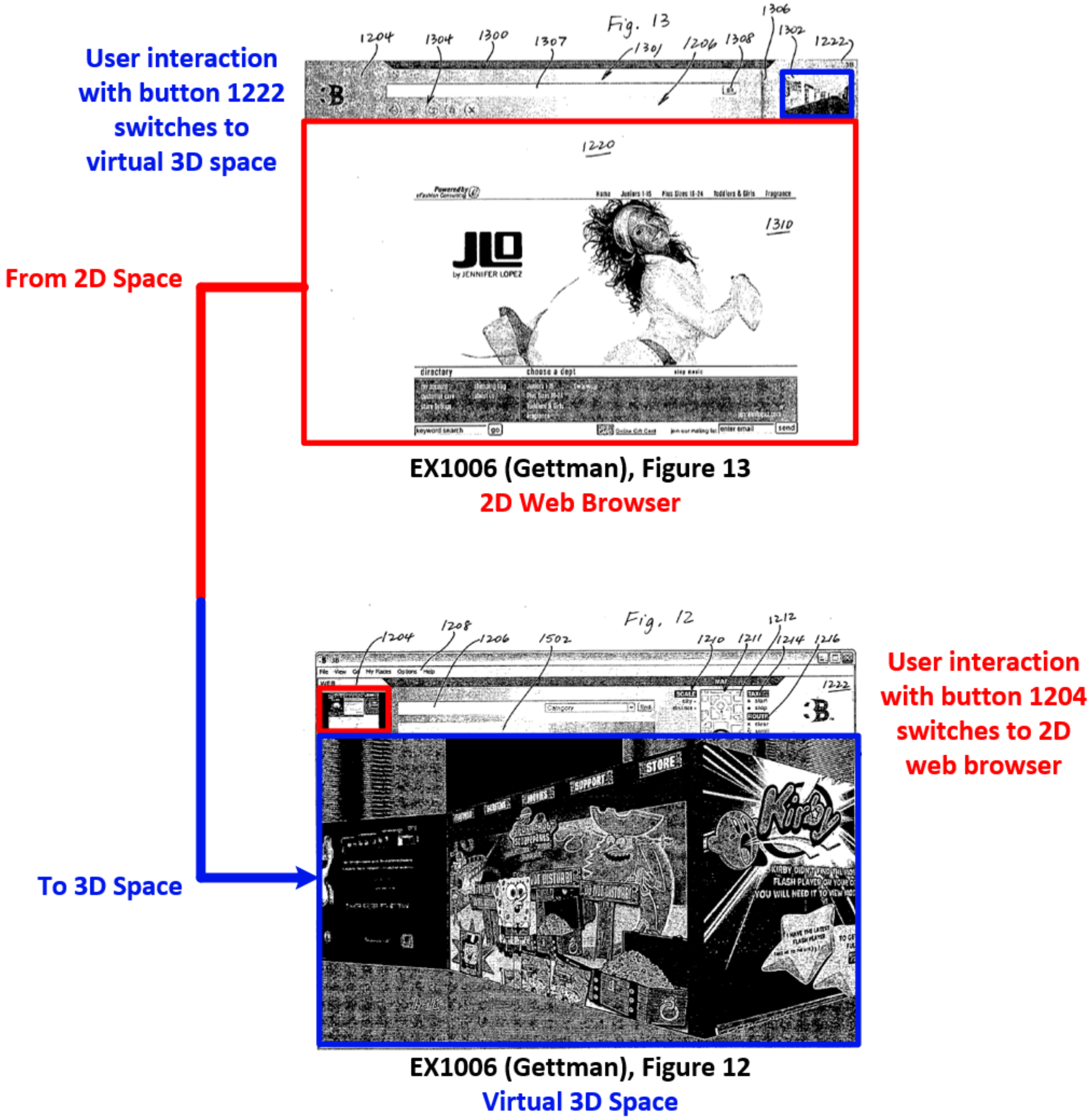
134. Another example that a POSITA would have contemplated is updating the URL associated with a particular entry in a collection of favorites or bookmarks, a well-known and common task performed by users. In the Robertson-Gralla-Gettman 3D-GUI,

- the user would select the object thumbnail in the 3D space corresponding to the old URL,
- navigate to the new URL in the 2D browser window, and
- establish the new URL as the favorite/bookmark, thus prompting an update of the thumbnail object in the 3D space to reflect an image of the webpage at the new URL.

Element [2.c] replacing the window within the 2D space with at least the first and second objects within the 3D space, wherein the first object is displayed in the foreground of the 3D space and the second object is displayed in the background of the 3D space.

135. The Robertson-Gralla-Gettman Combination satisfies Element [2.c]. This element requires the 3D-GUI to revert the ***replacing*** step of Element [1.d.ii] to re-enter the 3D space, which Robertson and Gettman both teach. EX1004 (Robertson), 16:15-17 ("If the object is deselected, for example by another mouse click," the prior state is "reentered."), 22:67-23:4, Figure 22; EX1006 (Gettman), ¶¶0200-0201 ("3B Button area 1222 [in the 2D browser window of Figure 13]…when selected by a user, cause[s] the browser to display the 3B view [comprising the 3D-GUI of Figure 12] in the main pane 1220.").

136. The visual aid below, illustrates Gettman's teaching about switching (***replacing***) the 2D space with the 3D space. Moreover, my analysis here taken together with my prior analysis at Element [1.d.ii] above shows how Gettman teaches toggling back and forth between 3D and 2D spaces.



EX1006 (Gettman), Figures 12 & 13—Annotated

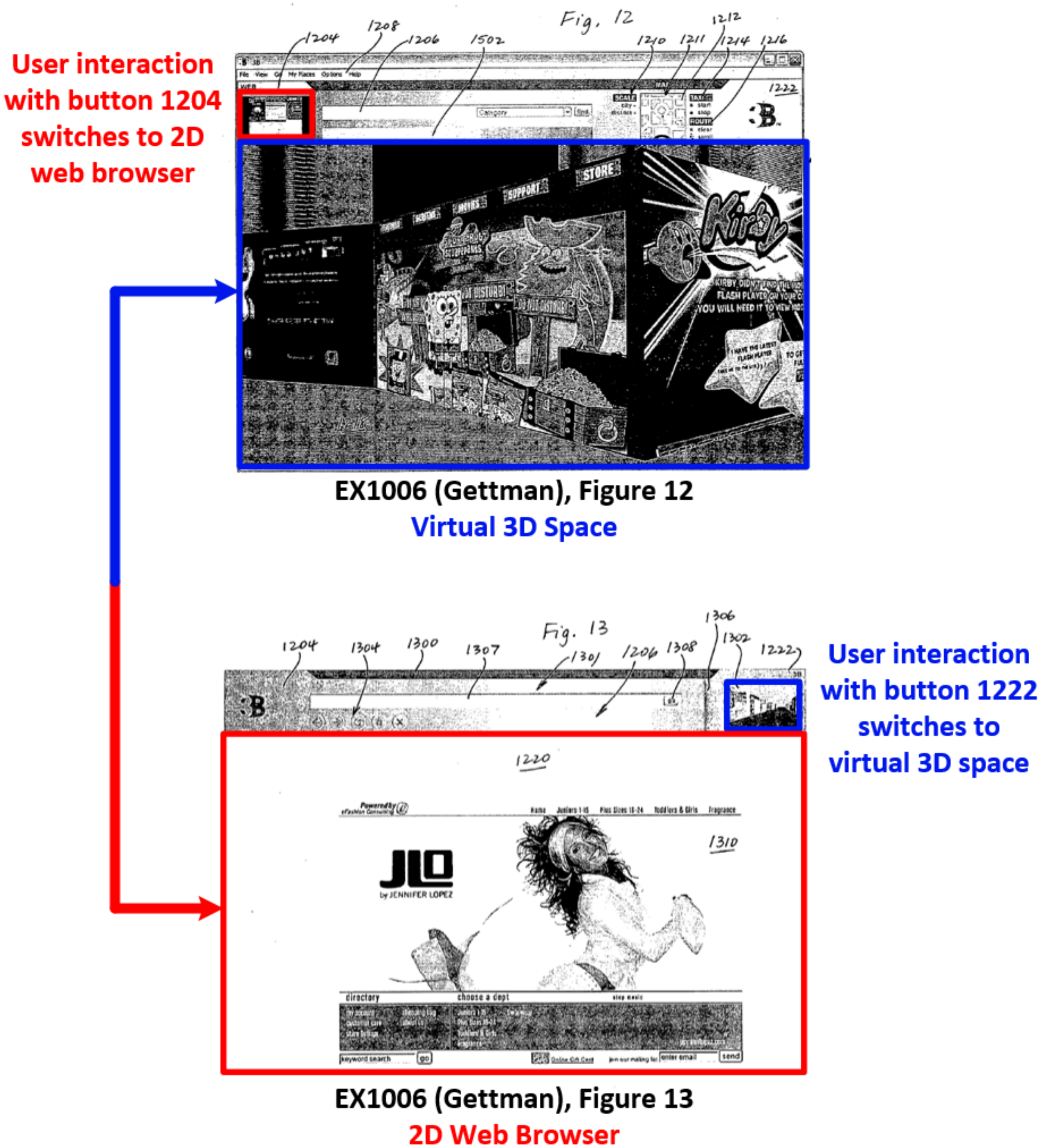
3. Claim 3

Element [3.a] receiving a toggle interaction by the end user; and

Element [3.b] replacing the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

137. The Robertson-Gralla-Gettman Combination satisfies Elements [3.a] and [3.b] for the same reasons discussed at Element [2.c]. Robertson and Gettman both teach reverting the replacing step of Element [1.d.ii] in response to a ***toggling interaction*** (*e.g.*, a mouse click or button selection) ***received*** from the ***end user***. EX1004 (Robertson), 16:15-17, 22:67-23:4, Figure 22; EX1006 (Gettman), ¶¶0200-0201, Figures 12-13. In other words, Robertson and Gettman both teach replacing the 2D window with the 3D space in response to an interaction from the user, like a mouse click or button selection.

138. The visual aid below illustrates Gettman's teaching about toggling back and forth between 3D and 2D spaces.



EX1006 (Gettman), Figures 12 & 13—Annotated

4. Claim 4

Element [4.a] receiving a navigation interaction by the end user; and

Element [4.b] moving said second object from the background of the 3D space to the foreground of the 3D space in response to the navigation interaction.

139. The Robertson-Gralla-Gettman Combination satisfies Elements [4.a] and [4.b]. For example, in Robertson, "***object*** thumbnails are ***moved*** about the landscape" using "inputs from a familiar input device such as a mouse" (***in response to receiving a navigation interaction***). EX1004 (Robertson), 9:36-63; *see also* 6:32-40. A POSITA would have appreciated that Robertson's teaching of moving the object thumbnails "about" the simulated three-dimensional landscape (***3D space***) entails moving them from ***background to foreground*** (and vice versa).

5. Claim 5

Element [5.a] receiving a toggle interaction by the end user; and

Element [5.b] replacing the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

140. Elements [5.a] and [5.b] are the same or substantially similar to Elements [3.a] and [3.b]. Accordingly, the Robertson-Gralla-Gettman Combination satisfies Elements [5.a] and [5.b] for the same reasons discussed at Elements [3.a] and [3.b].

6. Claim 6

Element [6.a] receiving at least a third input from the end user;

Element [6.b] receiving a third webpage from the at least one server in response to the third input; and

Element [6.c] displaying at least a portion of the third webpage on a third object within the 3D space, comprising

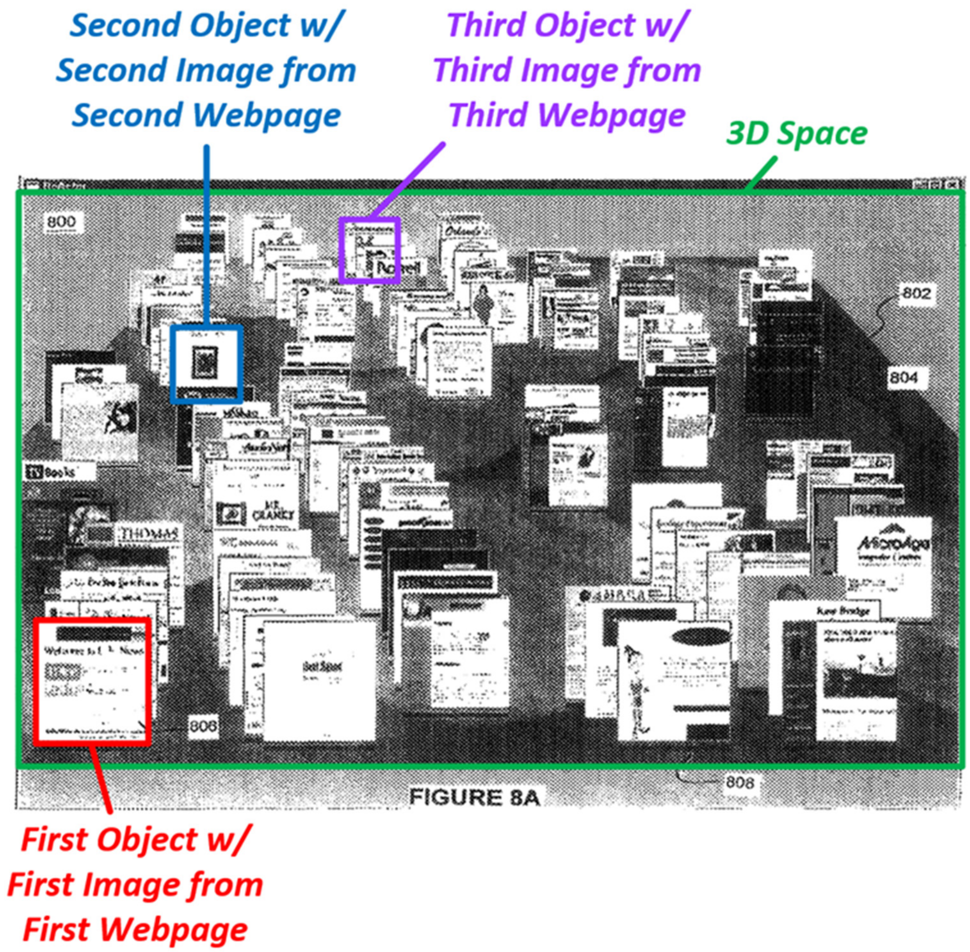
Element [6.c.i] rendering the third webpage;

Element [6.c.ii] capturing a third image of the at least a portion of the third webpage; and

Element [6.c.iii] texturing the third image on the third object, the third object being displayed in a further background of the 3D space, behind the second object

141. The Robertson-Gralla-Gettman Combination satisfies Elements [6.a] through [6.c.iii] for the same reasons discussed at Elements [1.a] through [1.c.iii]. The elements of Claim 6 merely require repeating the steps of Claim 1 a ***third*** time to create a ***third object*** bearing a ***third image*** from a ***third webpage***. In other words, Elements [6.a] through [6.c.iii] are about adding a third object with a third webpage image to the 3D space using the same ubiquitous rendering, capturing, and texturing techniques discussed above. These elements do not introduce new material from a technical perspective. They just repeat what has already been stated in earlier steps.

142. Robertson teaches this feature by showing that the processing steps of its 3D-GUI are repeated many times over (and thus a third time) to create a multitude of object thumbnails with webpage images. EX1004 (Robertson), 17:21-67, 18:6-13, Figures 2, 4, 8A-18, 23A-B, 25.



EX1004 (Robertson), Figure 8A—Annotated

7. Claim 7

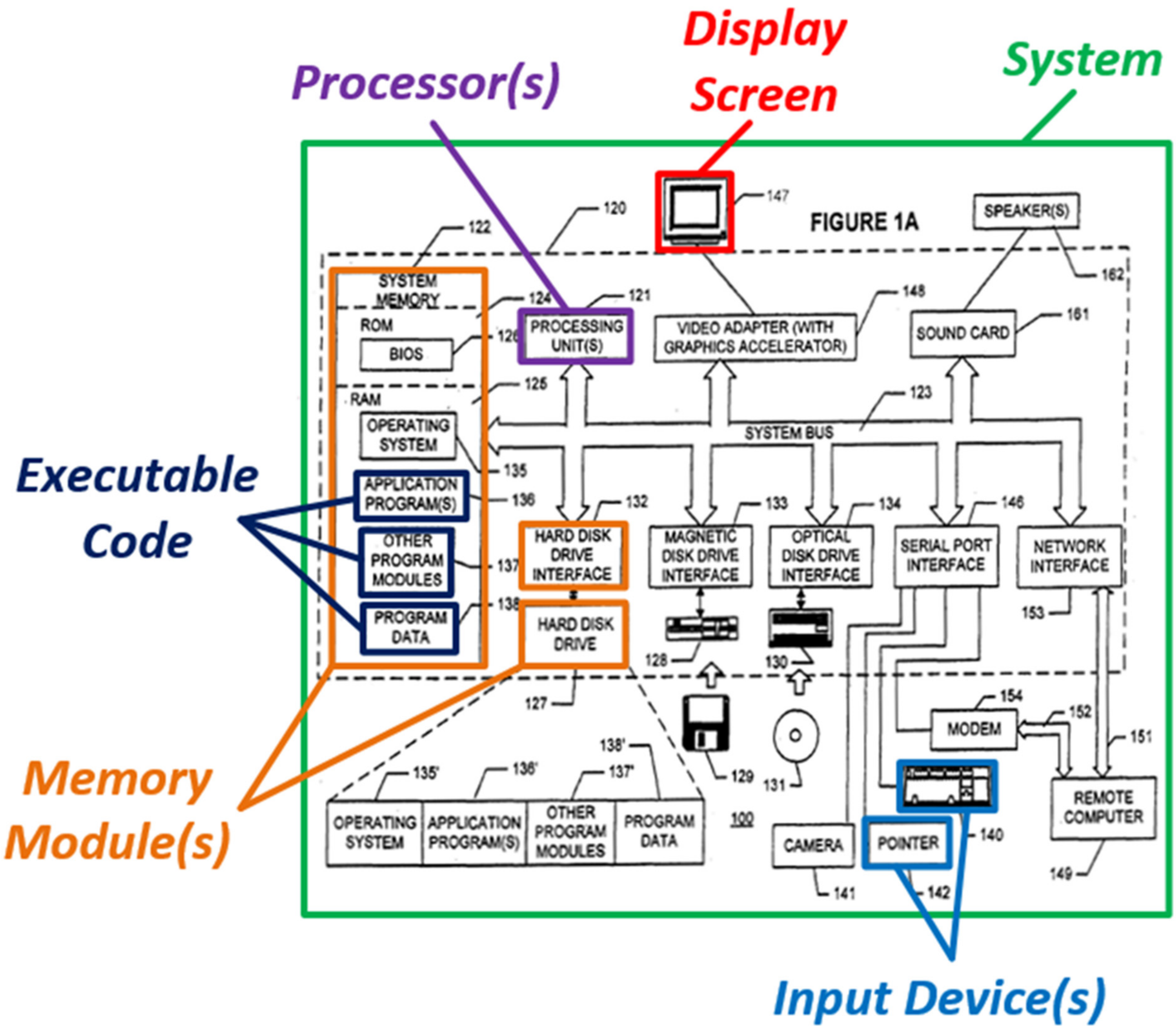
Element [7.a] wherein the step of receiving the first and second webpages from the at least one server in response to said first and second inputs further comprises receiving the first webpage from a first server in response to said first input and receiving the second webpage from a second server in response to said second input.

143. The Robertson-Gralla-Gettman Combination satisfies Element [7.a]. To start, Robertson teaches and suggests that different (***first/second***) ***webpages*** are ***received*** from different (***first/second***) ***servers***. For example, Robertson explains that the Internet allows "users [to] seamlessly transition from various resources, even

when such resources were stored at geographically remote resource servers." EX1004 (Robertson), 2:27-34. Similarly, Gralla teaches that a conventional URL web address "refers to the specific host [or 'server'] computer on which the document resides." EX1005 (Gralla), 155; *see also* 31, 141. The fact that URLs identify the host where a webpage resides shows that two different webpages can be (and often are) hosted by two different servers.

8. Claims 8-13

144. Claims 8-13 are substantially similar to Claims 1-6, reciting a similar series of steps with generic preamble language identifying conventional computer system components. Robertson (EX1004) plainly provides the ***system*** [8.pre] (11:7-10), ***display screen*** [8.pre.i] (12:3-12), ***input device*** [8.pre.ii] (11:54-66), ***processor*** [8.pre.iii] (11:10-14), and ***memory module*** storing ***executable code*** [8.pre.iv] (11:10-54) recited in the preamble elements of Claim 8, as shown below. *See generally* EX1004 (Robertson), 11:7-12:51, Figures 1A-1B.



EX1004 (Robertson), Figure 1A—Annotated

145. The Robertson-Gralla-Gettman Combination satisfies the remaining elements of Claims 8-13 for the same reasons discussed above regarding Claims 1-6. Identification of the relevant discussion for each step is provided below.

Claim 8	
[8.a]	*See* [1.a]
[8.b]	*See* [1.b]
[8.c]	*See* [1.c]
[8.c.i]	*See* [1.c.i]
[8.c.ii]	*See* [1.c.ii]
[8.c.iii]	*See* [1.c.iii]
[8.d]	*See* [1.d]
[8.d.i]	*See* [1.d.i]
[8.d.ii]	*See* [1.d.ii]
[8.d.iii]	*See* [1.d.iii]
[8.d.iv]	*See* [1.d.iv]
[8.d.v]	*See* [1.d.v]

Claim 9	
[9.a]	*See* [2.a]
[9.b]	*See* [2.b]
[9.c]	*See* [2.c]

Claim 10	
[10.a]	*See* [3.a]
[10.b]	*See* [3.b]

Claim 11	
[11.a]	*See* [4.a]
[11.b]	*See* [4.b]

Claim 12	
[12.a]	*See* [3.a]/[5.a]
[12.b]	*See* [3.b]/[5.b]

Claim 13	
[13.a]	*See* [6.a]
[13.b]	*See* [6.b]
[13.c]	*See* [6.c]
[13.c.i]	*See* [6.c.i]
[13.c.ii]	*See* [6.c.ii]
[13.c.iii]	*See* [6.c.iii]

9. Claims 14-18

146. The elements of Claims 14-18 recite language that is substantially similar to Claims 1-4. Accordingly, the Robertson-Gralla-Gettman Combination satisfies the elements of Claims 14-18 for the same reasons discussed above regarding Claims 1-4. Identification of the relevant discussion for each step is provided below.

Claim 14	
[14.pre]	*See* [1.pre]
[14.a]	*See* [1.a] (receiving inputs), [1.b] (inputs are website addresses)
[14.b]	*See* [1.b] (receiving webpages)
[14.c]	*See* [1.c]
[14.c.i]	*See* [1.c.ii]
[14.c.ii]	*See* [1.c.iii]
[14.d]	*See* [1.d]
[14.d.i]	*See* [1.d.i]
[14.d.ii]	*See* [1.d.ii]
[14.d.iii]	*See* [1.d.iii]
[14.d.iv]	*See* [1.d.v]

147. I note that Element [14.b] deviates from Element [1.b] in the following way: Element [1.b] recites "receiving first and second webpages from at least one server," while Element [14.b] recites "retriev[ing] first and second webpages from at least one source."

148. To start, Element [14.b] is broader than Element [1.b] in terms of generically reciting a ***source*** instead of specifying that the source is a ***server***. Accordingly, on this point, my analysis applied to Element [1.b] necessarily satisfies Element [14.b]. Additionally, in this context, there is no practical difference between ***receiving*** webpages, as stated in Element [1.b], and ***retrieving*** webpages, as stated in Element [14.b]. As I explained at Element [1.b] with reference to Gralla, after the user types a URL web address into the address bar, the browser sends a request to the server and receives a response from server including the webpage that corresponds to the URL. This process involves ***retrieving*** the webpage because the browser requests it from the server.

Claim 15	
[15.a]	*See* [1.d.ii]/[1.d.v]

Claim 16	
[16.a]	*See* [2.a]
[16.b]	*See* [2.c]

Claim 17	
[17.a]	*See* [3.a]
[17.b]	*See* [2.c]/[3.b]

Claim 18	
[18.a]	*See* [4.a]
[18.b]	*See* [4.b]

VIII. GROUND 2: SAUVE AND TSUDA

A. Sauve (EX1007)

149. Sauve "relates to browsing software, and more particularly, to tabbed-browser software." EX1007 (Sauve), ¶0001. "Tabbed browsers load web pages in 'tabs' within the same browser window." EX1007 (Sauve), ¶0004. According to Sauve, "[t]abbed browsing makes it easier and more convenient to view multiple web pages" but, "when multiple tabs are open, users may experience difficulty switching between them." EX1007 (Sauve), ¶0004. Sauve sought to solve this problem by enhancing the user experience "with selecting one out of a large set of open tabs." EX1007 (Sauve), ¶0005.

150. Sauve's solution is "[a] quick pick user-interface…that visually displays a rich set of information, such as thumbnails, meta-data describing each tab (*e.g.*, title) and the like. The thumbnails may be selected and/or moved within the quick pick user interface. Upon switching back to the tabbed window view, the tab row and contents of the tabbed window are modified based on the interactions that occurred in the quick pick user interface." EX1007 (Sauve), ¶0018. The progression of Figures 3-5 show how Sauve's quick pick user interface helps the user switch between different tabs.

151. In Figure 3, the user is viewing a webpage #6 ("content of current tab 360") in the window of tab 336. EX1007 (Sauve), ¶¶0037-0041.

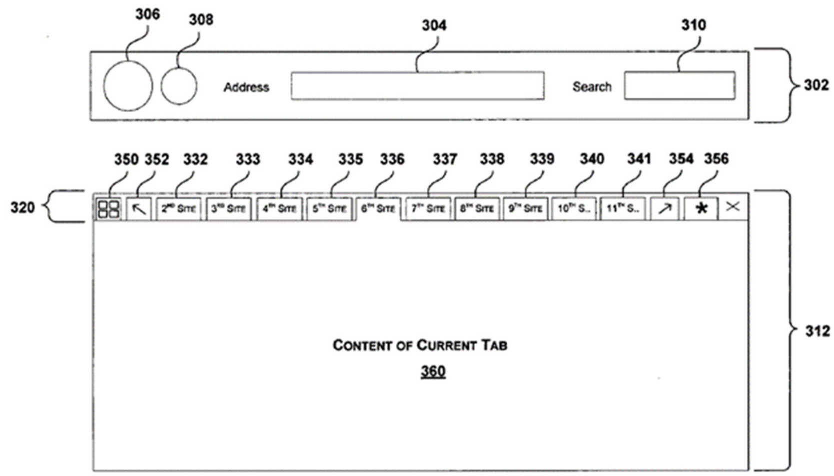


Fig. 3

EX1007 (Sauve), Figure 3

152. In Figure 4, the user toggles from the browser view to the quick pick user interface, where all of the open tabs are presented for selection as thumbnails displaying the content of the corresponding webpages. EX1007 (Sauve), ¶¶0042-0042.

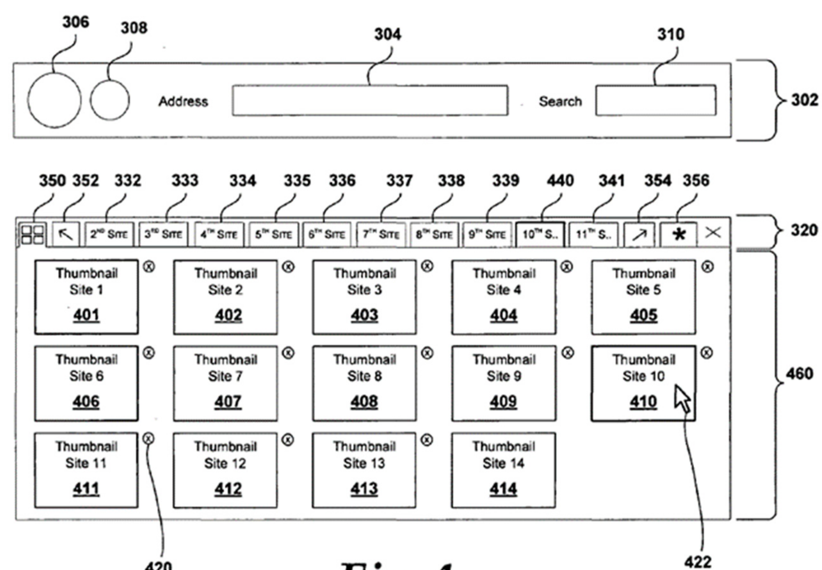
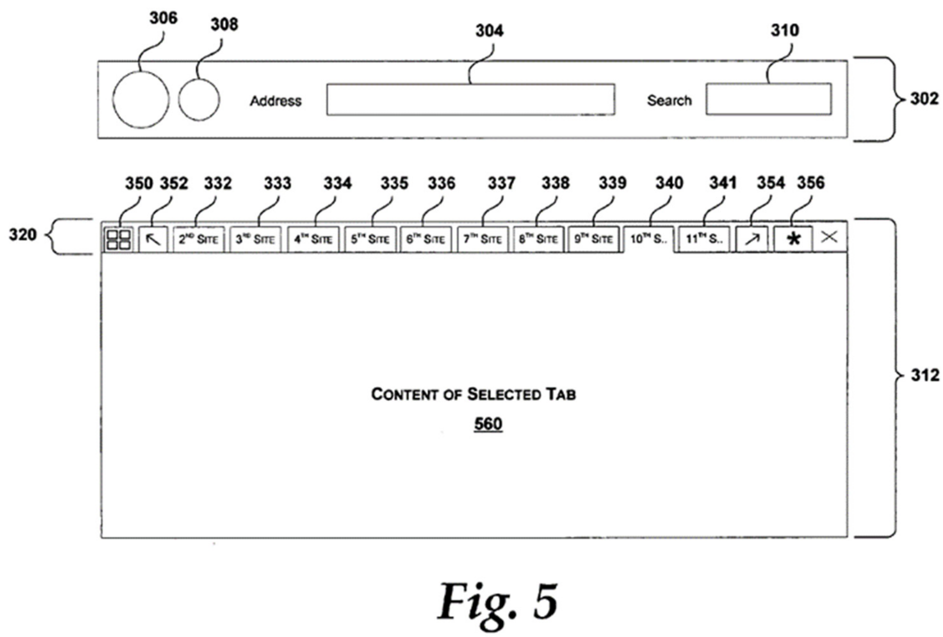


Fig. 4

EX1007 (Sauve), Figure 4

153. In this example, the user selects thumbnail 410, which shows an image from webpage #10, and this selection prompts the browser to display webpage #10 ("content of selected tab 560") in the window of tab 340, as shown in Figure 5. EX1007 (Sauve), ¶¶0043-0044.



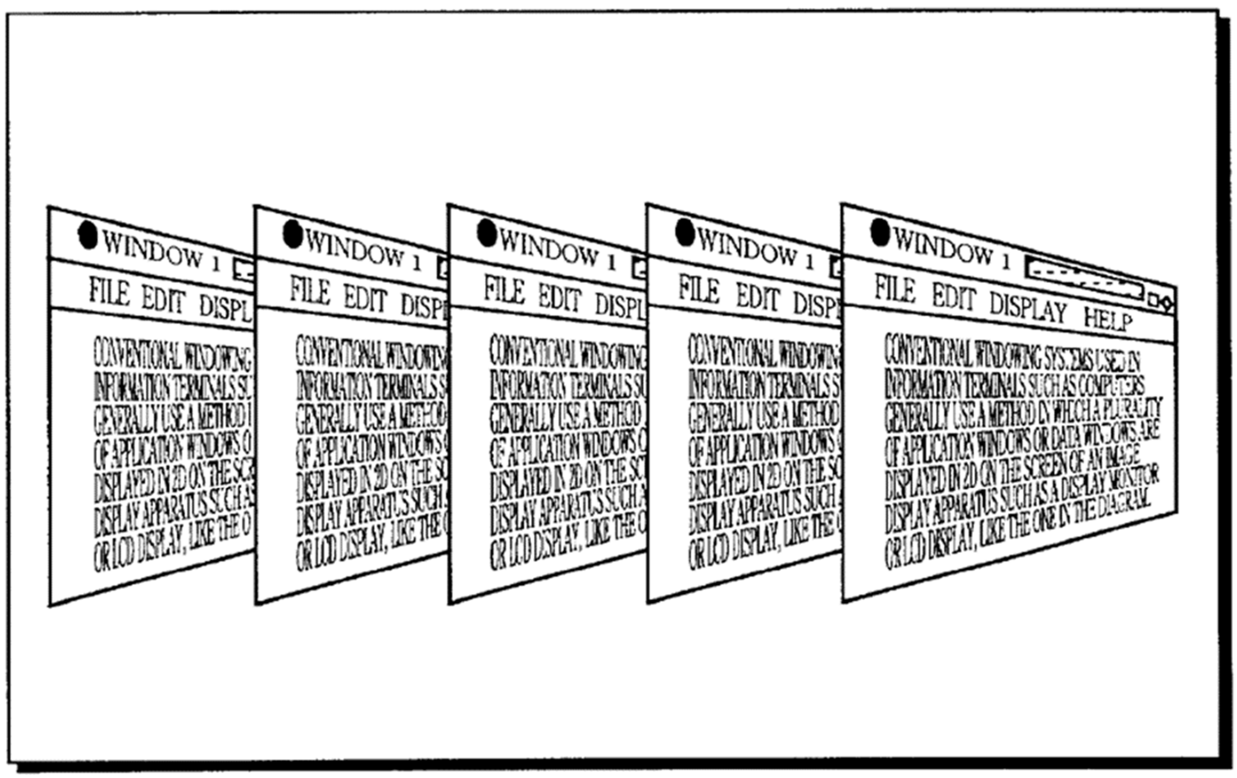
EX1007 (Sauve), Figure 5

B. Tsuda (EX1008)

154. Tsuda describes "a device for displaying windows in a virtual three-dimensional (3D) space." EX1008 (Tsuda), 1:5-12. In the example of Figure 11B, the windows are arranged in a horizontally stacked configuration that "eliminates wasted area on the screen and enables the position and content of all the windows to be grasped at a glance." EX1008 (Tsuda), 18:1-24. While Tsuda's disclosure is not tied to any particular application, web browsers are a contemplated use case.

EX1008 (Tsuda), 14:24-27 ("This invention may also be effective for desktop computers, if a user is browsing various homepages on the Internet…").

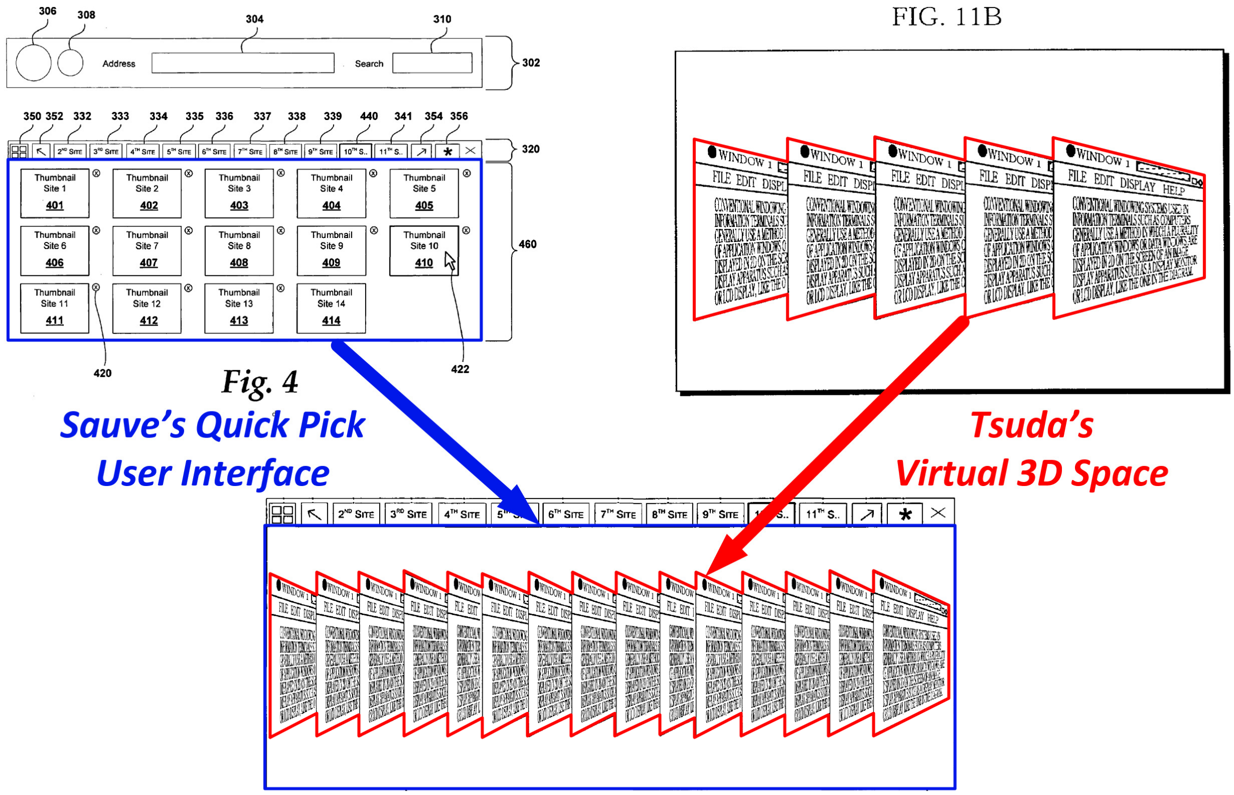
FIG. 11B



EX1008 (Tsuda), Figure 11B

C. The Suave-Tsuda Combination

155. The Sauve-Tsuda Combination applies Tsuda's teachings on a user interface featuring a virtual 3D space to Sauve's task of arranging graphical representations in a quick pick user interface for a tabbed browser. The visual aid below demonstrates how the 2D thumbnails disclosed by Sauve are replaced by Tsuda's 3D windows.



EX1007 (Sauve), Figure 4; EX1008 (Tsuda), Figure 11B; Combined Visual Aid

1. Reasons to Combine

156. First, a POSITA would have been motivated to pursue the Sauve-Tsuda Combination based on Tsuda's statement that "[t]his invention may also be effective for desktop computers, if a user is browsing various homepages on the Internet." EX1008 (Tsuda), 14:24-26. In other words, Tsuda made clear that web browsers were a preferred use case for its 3D user interface. EX1008 (Tsuda), 14:24-26. And a POSITA looking to improve Sauve's tabbed web browser would have acted on Tsuda's suggestion by contemplating the above-discussed Sauve-Tsuda Combination. EX1008 (Tsuda), 14:24-26.

157. The quick pick user interface would have been the natural place to apply Tsuda's teachings in Sauve's tabbed browser. For one, the POSITA would have recognized that Tsuda's 3D windows are analogous to Sauve's 2D thumbnails in the quick pick user interface. After all, a "thumbnail" is simply a graphical representation of a file, document or object, and Tsuda's 3D windows serve the same purpose. Indeed, both objects comprise graphical representations reflecting the content of an underlying application—namely, a web browser.

158. The POSITA also would have appreciated that Tsuda's stated advantage of using screen space efficiently by depicting 3D windows in perspective view is particularly beneficial in the context of Sauve quick pick user interface, which faces the difficulty of fitting numerous 2D thumbnails on the same screen. EX1008 (Tsuda), 14:16-24. The benefit of improved space efficiency in a user interface would have been evident to a POSITA. In particular, the POSITA would have understood that arranging more objects on the screen allows the user to digest information at a glance—e.g., without an additional scrolling or panning interaction. I note that multiple contemporaneous references on the subject of 3D-GUIs highlighted this space efficiency advantage:

- **EX1004** (Robertson), 6:65-68: "An ancillary advantage of using a simulated three-dimensional landscape is that more objects can be represented, at one time, on a single display screen."

- **EX1010** (Information Visualizer), p. 5: "3D perspective graphics…allow us…to pack the space more densely with information than would otherwise be possible."
- **EX1011** (Document Lens), p. 1: One of the "basic goals" was "to use 3D to make more effective use of available screen space."
- **EX1014** (US 5,880,733), 10:19-40: "By providing three-dimensional graphics to the windows/objects created and managed by an operating system, the computer workspace is effectively enlarged…"
- **EX1029** (WebBook and Web Forager, p. 6: "The purpose of the workspace is to allow a number of objects to be displayed together (mitigating the limitations of the small screen space)…"
- **EX1030** (Data Mountain), p. 4: "the user gets the advantages of a 3D environment (better use of space, spatial relationship perceived at low cognitive overhead, etc.)…"
- **EX1035** (6,229,542), 3:5-11: "This depth dimension addresses the window overcrowding problem."

159. Second, a POSITA would have been motivated to pursue the Sauve-Tsuda Combination to predictably improve Sauve's quick pick user interface through the known benefits of 3D-GUIs. For one, as noted in Tsuda (and the other

references in the bulleted list above), depicting thumbnail images in a perspective view within a 3D space is more space efficient than a conventional 2D front view. Additionally, the added depth dimension enables the arrangement of thumbnails to have structure, which can convey meaning to the user. For example, in the Sauve-Tsuda Combination, the thumbnail windows in the 3D space are arranged in a stack, where the relative position in the stack conveys order (e.g., position in the row of tabs, order of importance, etc.) more clearly than an array of 2D thumbnails. Further still, the POSITA would have expected the stack "metaphor" used in Tsuda's 3D space to add an element of realism to Sauve's quick pick user interface and, as a result, exploit the spatial location abilities of human users. I note that multiple contemporaneous references recognized the spatial memory and location advantage associated with 3D-GUIs:

- **EX1004** (Robertson), 6:51-55: "The user interface of the present invention exploits spatial memory by, for example, simulating a plane located and oriented in three-dimensional space, or other three-dimensional landscape on which the object thumbnails may be manipulated."
- **EX1016** (US 6,909,443), 2:1-4: "The image of each task can be positioned within a three-dimensional environment such that the user may utilize spatial memory in order remember where a

particular task is located."

- **EX1030** (Data Mountain), p. 1: "We describe a new technique for document management called the *Data Mountain*, which allows users to place documents at arbitrary positions on an inclined plane in a 3D desktop virtual environment…We also describe a user study that shows that the Data Mountain does take advantage of spatial memory"

160. Third, design incentives and market forces would have prompted a POSITA to pursue a combination of Suave and Tsuda. As I've explained (*see* Section VI.A), significant development work on 3D-GUIs and next-generation web browser tools took place long before the '048 patent. *E.g.*, EX1029 (WebBook and Web Forager); EX1030 (Data Mountain); EX1032 (US 2002/0054114); EX1033 (US 2004/0109031). A POSITA aware of this advanced state of the art would have been incentivized to explore and implement Tsuda's teachings regarding a 3D-GUI as an alternative to the conventional 2D-GUI disclosed by Suave, particularly regarding Sauve's quick pick interface.

161. Moreover, the POSITA would have appreciated the commercial benefit of pursuing such a combination of Sauve and Tsuda. For example, a POSITA would have known that users viewed tabbed browsing, such as disclosed by Sauve, as a desirable and important web browser functionality. *E.g.*, EX1041, p. 1 ("But

[Mozilla Firefox's] attractiveness is also due to features not found in IE such as integrated newsfeeds, advanced tabbed browsing, and customizable contextual menus."); EX1042, p. 1 (touting "tabbed browsing" as "[t]he most obvious" feature contributing to an "easer to use" web browser interface).

162. For at least these reasons, the POSITA would have sought usability improvements in this area, such as offered by the Sauve-Tsuda combination (e.g., exploiting spatial memory and more efficient use of screen space), in an effort to distinguish over competitor products in the marketplace. As the POSITA would have known, usability in this context—*e.g.*, the degree to which a given web browser efficiently facilitates the user's task of locating and consuming web content—was a key differentiator among competing web browsers. EX1036, p. 1 ("Paraphrasing the definition supplied by the ISO [1], Web usability is the efficient, effective and satisfying completion of a specified task by any given Web user."). While the same web content could be accessed on two competing web browsers, differences in the user interface could make accessing that content more efficient on one of the two. The browser with a superior interface from a usability standpoint would be more desirable by consumers.

2. Reasonable Expectation of Success

163. A POSITA would have reasonably expected a successful outcome from the above-discussed combination of teachings from Sauve and Tsuda. GUIs, web

browsers, and simulated 3D environments were all well-known technologies at the time of the '048 patent in 2005, and these technologies had been successfully demonstrated in the real-world by then. My extensive discussion on the background of the technology establishes and supports these facts by identifying specific prototypes (e.g., the Information Visualizer [EX1010], the Document Lens [EX1011], the WebBook and Web Forager [EX1029], Data Mountain [EX1030]) and distributed software (e.g., Project Looking Glass [EX1012] and 3B Browser [1038]) that resulted from extensive research and development that predates the '048 patent. Having seen the 3D-GUI technology mature into real-world implementations, a POSITA would had confidence that the underlying principles were sound and could be integrated with systems and disclosures based on conventional 2D-GUIs, as I've explained in this Declaration. Thus, the result of the Sauve-Tsuda Combination would have been predictable to a POSITA, and the POSITA would have expected it to work.

D. Claim Element Analysis

1. Claim 1

Element [1.pre]: A method for providing a three-dimensional (3D) graphical user interface, comprising…

164. The Sauve-Tsuda Combination satisfies Element [1.pre]. For example, Sauve describes a "tab UI" that "provide[s] a quick pick ***user-interface***" where each

web browser tab is displayed "as a ***graphical*** representation." EX1007 (Sauve), [0035], [0042], Figures 2, 4. The integrated teachings of Tsuda convert Sauve's 2D-GUI into a ***3D-GUI***. EX1008 (Tsuda), Abstract, 1:5-12, 14:16-27, Figures 1, 5, 11B, 12A-C.

Element [1.a] receiving at least first and second inputs from an end user;

165. The Sauve-Tsuda Combination satisfies Element [1.a]. For example, Sauve's web browser ***receives input*** when the ***end user*** enters a web address into the address bar. EX1007 (Sauve), ¶0002, ¶¶0004-0005, ¶0040, Figure 3. As shown below, a POSITA would have understood that in Sauve's tabbed browser, the user would provide different (***first***/***second***) web address ***inputs*** with respect to different tabs.

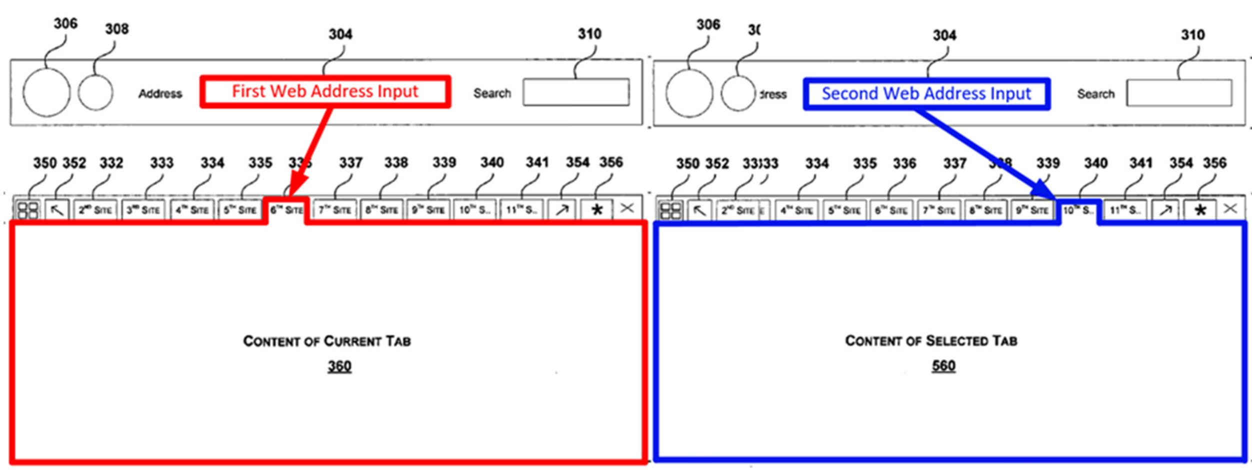


Fig. 3 Fig. 5

EX1007 (Sauve), Figures 3 & 5—Annotated

166. Additionally, even without Sauve's disclosure on this point, the notion of receiving user input in the form of web addresses was foundational to many (if

not all) web browsers at the time of the '048 patent, and a POSITA would have understood Sauve's tabbed browser to operate in the conventional manner. This fact would explain why Sauve did not provide an extensive explanation on the subject—web browsers, including tabbed browsers, were already well known. *See* EX1007 (Sauve), ¶¶0003-0004. It would have been redundant and unnecessary to provide such an explanation to the person of skill.

Element [1.b] receiving first and second webpages from at least one server in response to said first and second inputs, wherein the first and second inputs are website addresses corresponding to said first and second webpages, respectively;

167. The Sauve-Tsuda Combination satisfies Element [1.b]. Per Element [1.a], the (***first/second***) ***inputs*** comprise ***web addresses*** entered into the address bar of Sauve's browser. And Sauve further teaches:

> Upon entering a web address or URL of a particular website, the browser requests web pages from a web server hosting that website. The browser then interprets the web pages and displays the content on a display. EX1007 (Sauve), ¶0002.

In other words, when (***in response to***) the user enters the (***first/second***) ***web address***, Sauve's web browser requests and ***receives*** the corresponding (***first/second***) ***webpage from the server*** specified in the address.

168. Additionally, the notion of retrieving webpages from servers was foundational to many (if not all) web browsers at the time of the '048 patent, and a

POSITA would have understood Sauve's tabbed browsers to operate in the conventional manner. This fact would explain why Sauve did not provide an extensive explanation on the subject—web browsers, including tabbed browsers, were already well known. It would have been redundant and unnecessary to provide such an explanation to the person of skill.

Element [1.c] displaying at least a portion of the first webpage on a first object within a 3D space, and at least a portion of the second webpage on a second object within the 3D space, comprising;

169. The Sauve-Tsuda Combination satisfies Element [1.c]. As I explained earlier at Section VIII.C, the Combination applies Tsuda's teachings regarding a virtual 3D space to Sauve's quick pick user interface, which "visually ***displays*** a rich set of information, such as thumbnails…describing each tab." EX1007 (Sauve), ¶0018; *see also* ¶0042 ("The tabbed browser scales the thumbnails so that the content of each tab can be viewed in the quick pick window."); cl.3 ("a thumbnail displaying the portion of content"), cl.13 ("the thumbnail displaying a screen shot of content").

Sauve's Quick Pick User Interface

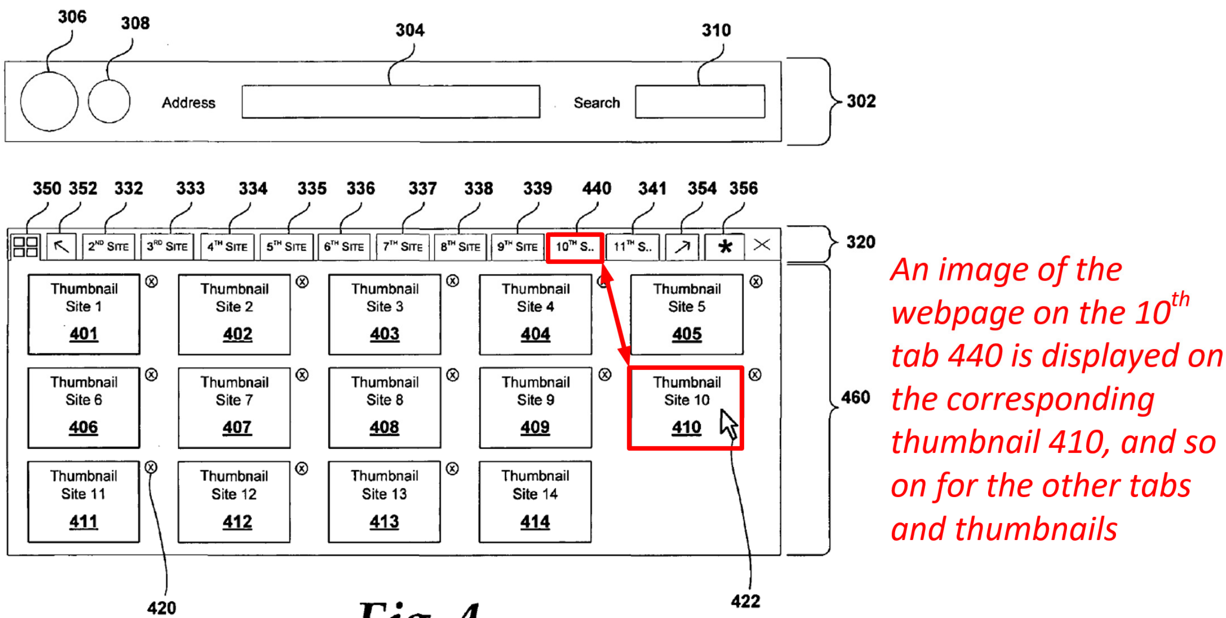


Fig. 4

EX1007 (Sauve), Figure 4—Annotated Text in Red

170. Accordingly, in the Sauve-Tsuda Combination, the visually displayed information comprises windows "placed in a virtual ***3D space***." EX1008 (Tsuda), 10:50-62. Regarding the "***virtual 3D space***," Tsuda makes clear that it is defined by a three-dimensional coordinate system.[16] *E.g.*, EX1008 (Tsuda), 11:27-31 ("The 3D

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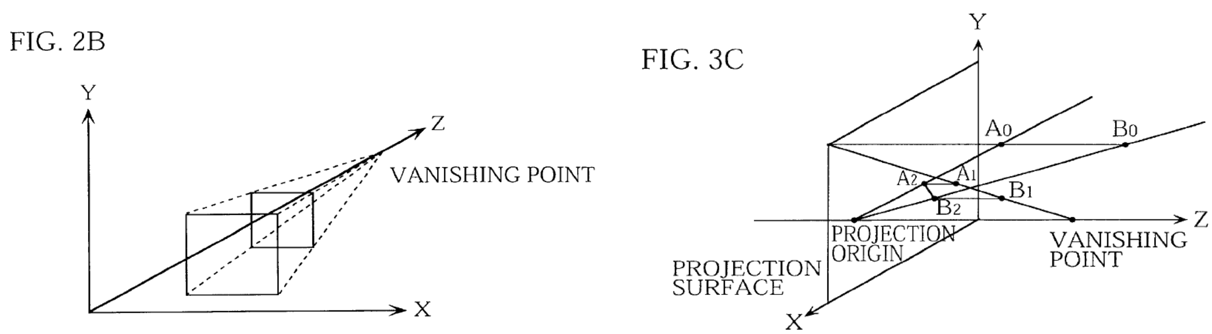
[16] I have been informed by counsel for Petitioner that the parties agreed in the co-pending district court litigation that the term ***3D space*** should be construed as "a virtual space defined by a three-dimensional coordinate system." I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

position calculating unit calculates a position (coordinates for the four vertices of the window) in the 3D space for a window stored in the storage unit 5201 and stores the result according to a notification from the program execution unit 5101 or the input unit 5103."); 11:59-12:4 ("In other words, image data is converted from a virtual 3D coordinate system to a screen coordinate system."), 12:8-67, 13:15-43 ("The coordinate system used [by the 3D position calculating unit] is the one shown in FIG. 3C."), 21:5-25 ("[A] method in which the window itself is presumed to be a 3D object and, when the window is in perspective, the title bar and the menu bar are displayed on a side surface of the object that is adjacent to the near edge of the window surface, may also be used."), Figures 2B, 3C, 4, and 5.

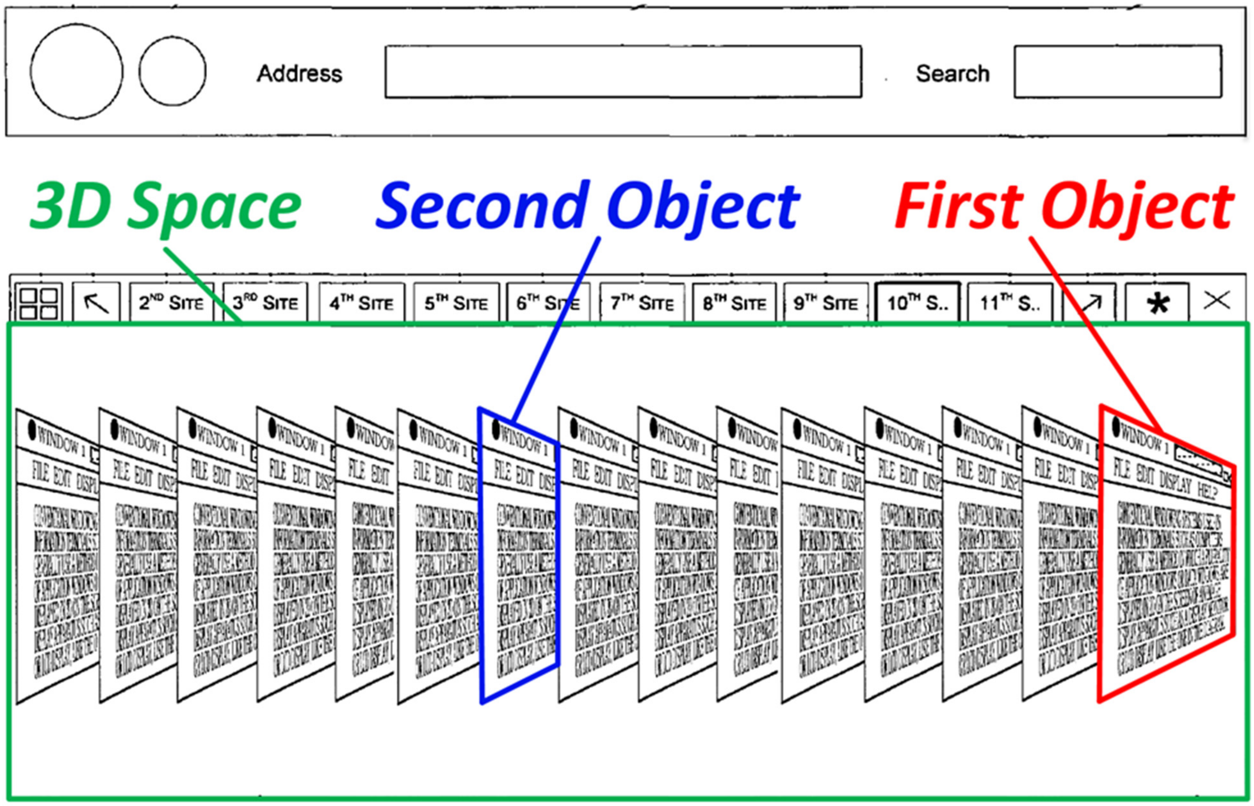


EX1008 (Tsuda), Figures 2B and 3C—Illustrating a 3D Coordinate System

171. I would still hold the same opinion regarding Element [1.c] even without Tsuda's express disclosure about using a 3D coordinate system to define a 3D space. For one, Tsuda's disclosure of a "3D space" implicates a virtual space defined by a three-dimensional coordinate system. In other words, the POSITA would have appreciated the well-known fact that coordinate systems were (and are)

routinely used to establish the size, shape, and orientation of an object in a virtual space. Coordinates and coordinate systems were (and are) used to keep track of the location of such an object as it is moved throughout such a space. In the context of a 3D space, as Tsuda teaches, the POSITA would have known that the appropriate coordinate system is a three-dimensional coordinate system. Moreover, the notion of defining a "3D space" using a three-dimensional coordinate system would have been obvious to a POSITA applying mere common sense and ordinary creativity to a routine design challenge. That is, a POSITA looking to implement Tsuda's 3D space would have understood and been motivated to do so by employing a 3D coordinate system. As was typical by the 2005 Critical Date, the 3D coordinate system would facilitate positioning virtual objects/windows within the 3D space.

172. Finally, Tsuda's windows (***first/second objects***) in the ***3D space*** include texture-mapped ***images*** of the application content—here, the (***first/second***) ***webpages*** retrieved by Sauve's tabbed browser—as shown in the visual aid below. EX1008 (Tsuda), 11:4-17, 13:10-46, Figures 1, 4-6, 9, 11-12C.



Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)

Element [1.c.i] rendering the first and second webpages;

173. The Sauve-Tsuda Combination satisfies Element [1.c.i]. For example, Sauve's browser performs HTML ***rendering*** for each (***first/second***) ***webpage*** of its various tabs. EX1007 (Sauve), ¶0002 (web browsers "interpret[] the web pages and display[] the content on a display"), ¶0004 ("Tabbed browsers load web pages in 'tabs'…"), ¶¶0026-0027 (threads handle "HTML rendering"), ¶0041 ("content 360 may be a web page").

174. As I've explained above (*see* ¶¶104-105), webpage ***rendering*** is a core functionality of virtually all web browsers. Thus, even without Sauve's express

teachings on this subject, Element [1.c.i] would have been obvious to a POSITA. The ’048 patent supports my view about a POSITA’s knowledge on ***rendering*** webpages. Indeed, the ’048 patent concedes that webpage rendering was well known: “The name of one such control is called MSHTML/web browser control for rendering HTML webpages[.]” EX1001 (’048 patent), 23:4-6. “MSHTML” was the rendering engine used in the Internet Explorer browser at the time of the ’048 patent in 2005.

Element [1.c.ii] capturing first and second images of the at least a portion of the first webpage and the at least a portion of the second webpage, respectively; and

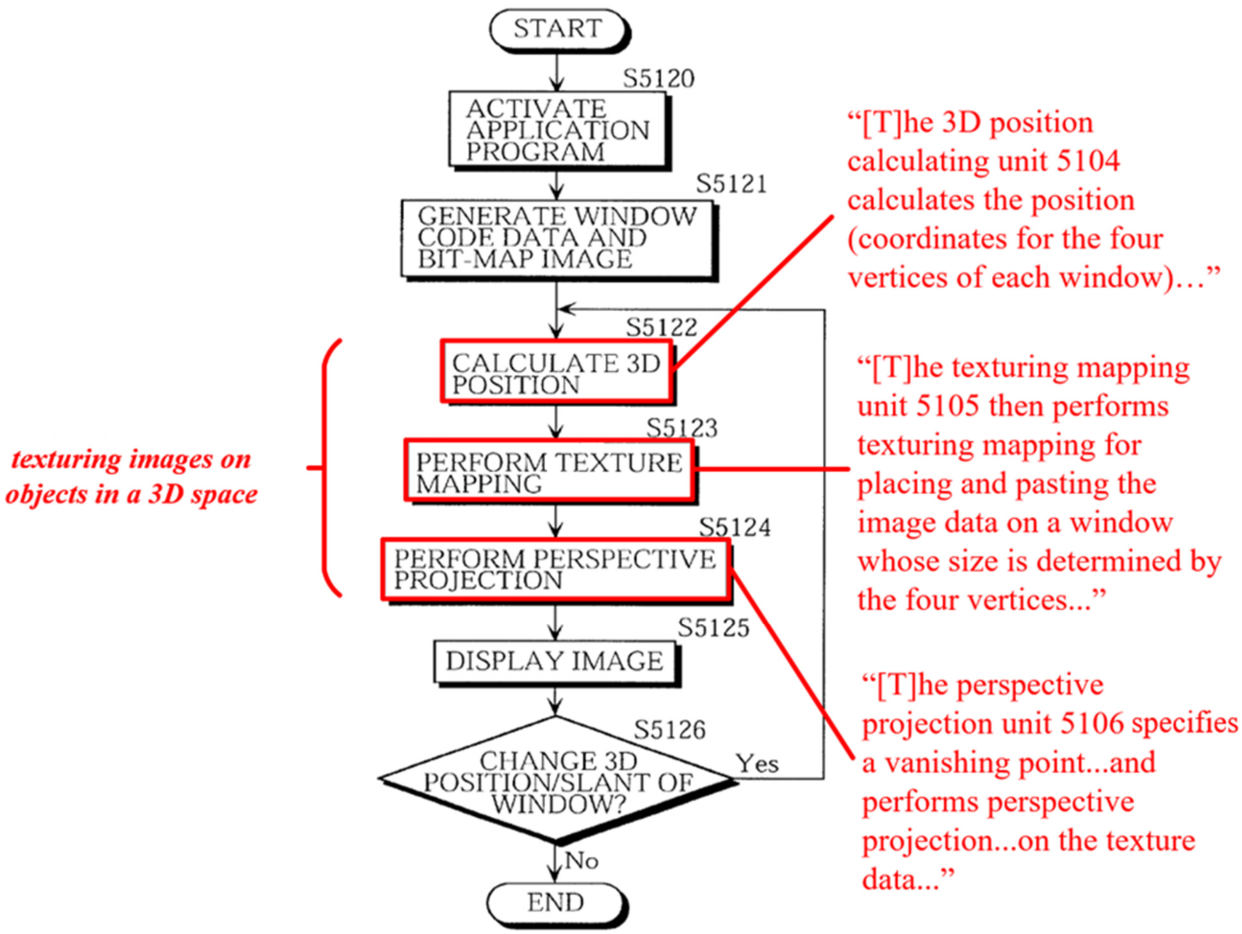
175. The Sauve-Tsuda Combination satisfies Element [1.c.ii]. For example, Sauve suggests ***capturing first and second images of the first and second webpages*** by explaining that the thumbnails shown in the quick pick window are scaled “so that <u>the content</u> of each tab <u>can be viewed</u>.” EX1007 (Sauve), ¶0042; *see also* ¶0041 (“content 360 may be a web page”), cl.3 (“each graphical view comprises a thumbnail <u>displaying the portion of content</u>”), cl.13 (“the thumbnail <u>displaying a screen shot of content</u>”). Sauve’s reference to “<u>the</u> content” of the tab indicates to a person of skill that the thumbnail is showing a captured image of the webpage.

176. Tsuda is even more direct on this point, stating expressly that “display data” from “application programs that interact with users by displaying conventional two-dimensional (2D) windows”—here, Sauve’s (***first/second***) ***webpages***—is stored

in computer memory. EX1008 (Tsuda), 11:4-12; *see also* 13:10-46, Figures 1, 4-6, 9, 11-12C. And Tsuda goes on to explain that "display data" includes "code data specifying window display content (documents, characters, graphics etc.) and ***image*** data expressing the objects as bitmap ***images***." EX1008 (Tsuda), 11:4-12; *see also* 13:10-46, Figures 1, 4-6, 9, 11-12C.

Element [1.c.iii] texturing the first image on the first object and the second image on the second object, the first object being displayed in a foreground of the 3D space and the second object being displayed in a background of the 3D space; and

177. The Sauve-Tsuda Combination satisfies Element [1.c.iii]. For example, Tsuda describes a three-step process that demonstrates ***texturing*** (***first/second***) ***images*** from content on a 2D application, such as Sauve's webpages, ***on the*** (***first/second***) windows (***objects***) in the 3D space. EX1008 (Tsuda), 13:15-43 (quoted below), Figure 4 (annotated below). In short, Tsuda's process: calculates the four vertices for the window in the 3D space; texture maps the image data according to the location-based size of the window; and performs a projection on the texture data to impart a perspective view. These steps would have been consistent with a POSITA's understanding of ***texturing***.



EX1008 (Tsuda), Figure 4—Annotated

178. As I've explained (and will repeat here), texturing (or "texture mapping") was a well-known technique commonly used in 3D-GUIs. *E.g.*, EX1030, p. 5 ("The 100 pages used in the study below are <u>screen snapshots</u> of actual web pages in 24-bit color. We employ two bitmap sizes of each page for <u>texture mapping</u>…"); EX1004 (Robertson), 17:49-67 (identifying "OpenGL"); EX1030 (Data Mountain), p. 5 (explaining that the Data Mountain prototypes use "OpenGL as the underlying graphics library"); EX1037, p. 1 ("The OpenGL Graphics System

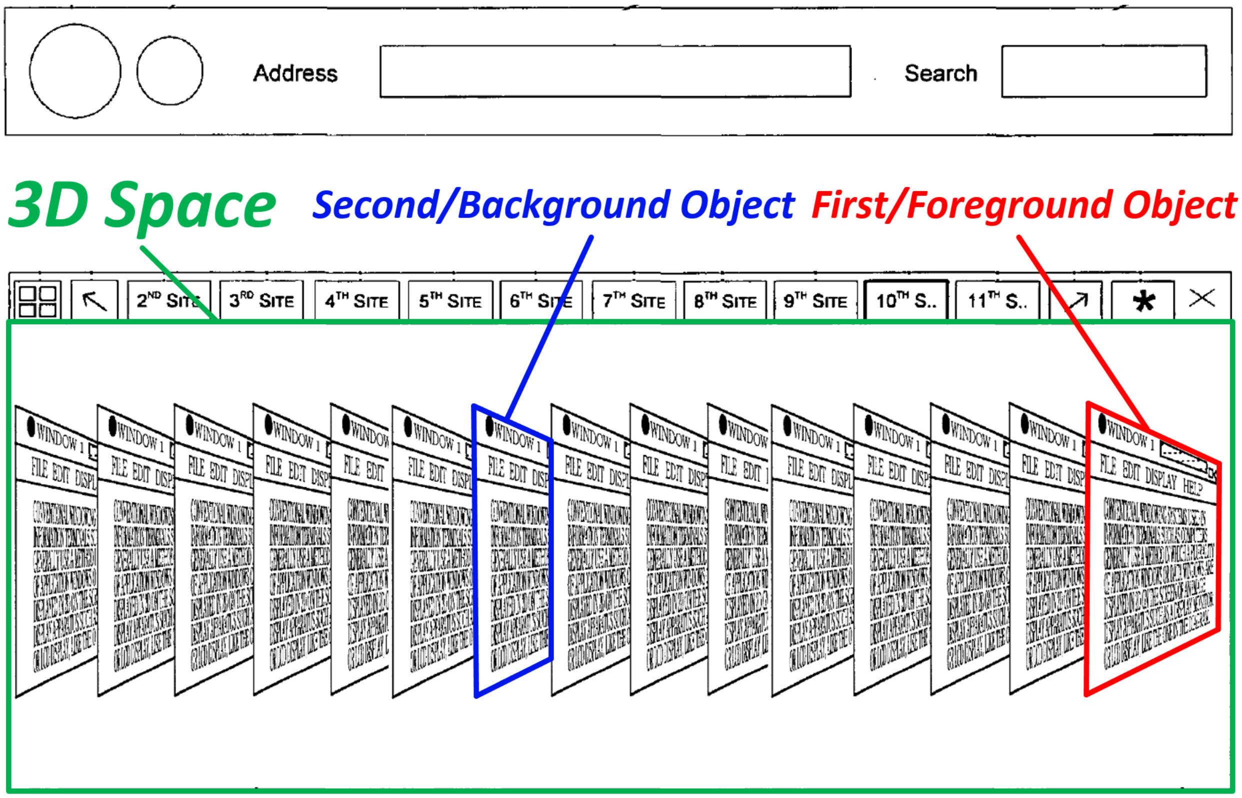
provides a well-specified, widely accepted dataflow for 3D graphics imaging"), p. 3 (explaining OpenGL's "texturing" functionality); EX1012, p. 2 ("software support for real-time operating systems and emerging industry standard open graphics libraries (e.g., OpenGL and PEX) are simplifying the 3D programming task"). The following citations and parentheticals provide additional examples of the ample teachings in the prior art on this subject.

- **EX1016**, 27:48-63 (from a patent filed in 2000: "In particular, the three-dimensional shell defines a three-dimensional polygon on which the image of a window is applied as texture.");
- **EX1018**, [0049] (a patent application filed in 2002 referencing a 3D-GUI where user-selectable windows and icons are presented on "a texture mapped cube 21");
- **EX1019**, [0055] (a patent application filed in 2004 explaining that "a process called texture mapping" can be employed to create a "3D scene" using "low level graphics APIs, such as Direct3D® or OpenGL®");
- **EX1021**, [0058] (a patent application filed in 2003 discussing how "output bitmaps" are generated and stored), [0059] (explaining that the "bitmaps" are retrieved from storage and "convert[ed] into a texture," which is then "displayed on the front face of [a] window" in the 3D space);

- **EX1022**, p. 15 (a 2004 developer's conference presentation describing a 3D graphics platform featuring a "3D Display Server" that "Loads pixmap [i.e., a grid of pixels] into texture"), p.23 (disclosing that "OpenGL" is used to perform a "Direct Render-to-Texture" process);
- **EX1035**, 6:7-31 (a patent filed in 1998 stating: "the pixel contents of the 2D shape, applied to the 3D shape as a 'texture'"), 6:66-7:19 ("At block 202, a 'snapshot' of the selected window is taken. That is, the pixels making up the selected window to be pushed back are captured in a data structure by the graphical user interface. At block 204, the snapshot data as a texture is applied to a display object in the 3D desktop window having the same shape as the selected window.").

179. This is all more supporting evidence that texturing was well-known before the Critical Date in 2005; Tsuda's disclosure uses texturing; and a POSITA would have understood that Tsuda uses texturing.

180. In Figures 11B-12C, Tsuda's windows (***objects***) are stacked horizontally from right to left, such that the rightmost window in the stack occupies a plane that is forward in the stack (***first object*** in a ***foreground***) relative to the plane of a window further to left (***second object*** in a ***background***). EX1008 (Tsuda), 8:3-14, 17:25-32, 18:8-18. The visual aid below demonstrates a horizontal stack of Tsuda's windows applied in the context of Sauve's quick pick user interface.



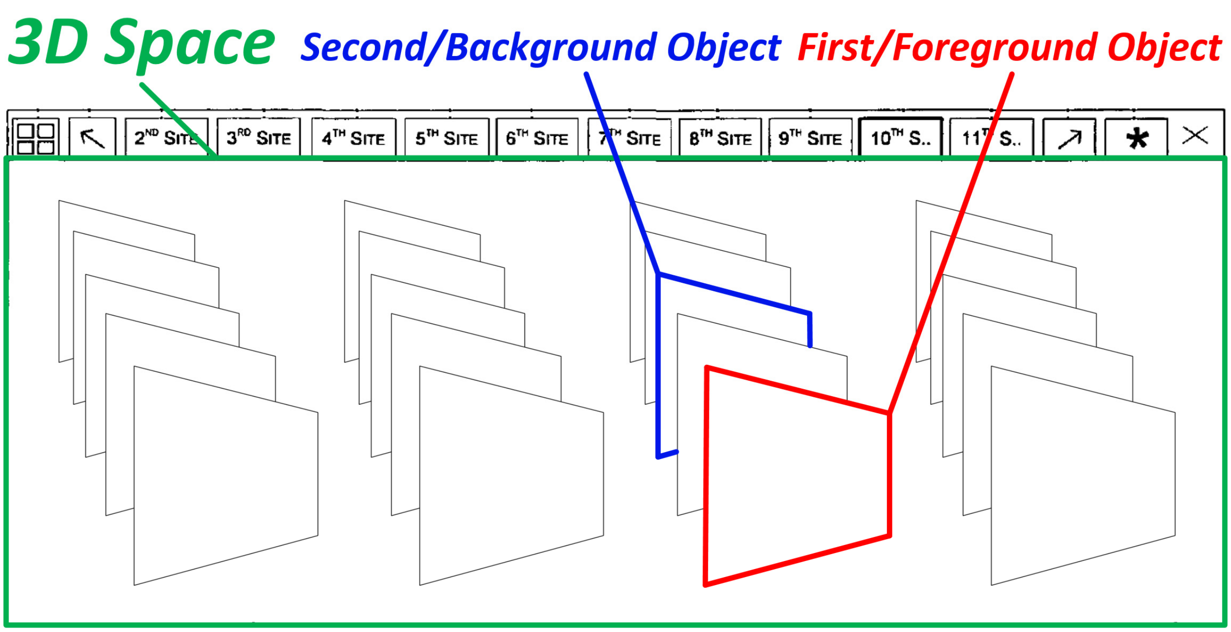
Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)

181. Note that my analysis above regarding Tsuda's horizontal stack is based on my understanding from Petitioner's counsel that Patent Owner has apparently alleged in the co-pending litigation that objects at the same depth along the Z-dimension can satisfy the foreground/background requirement of Element [1.c.iii].[17] For example, here in Tsuda, the position of each window relative to the foreground/background can be expressed by the fact that objects closer to the

[17] I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

foreground partially occlude (obstruct the view of) objects closer to the background.

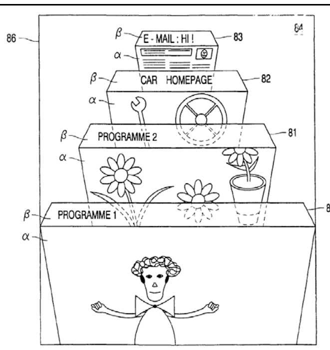
182. Additionally, a POSITA exercising common sense and ordinary creativity would have appreciated that an obvious variant of Tsuda's embodiment with horizontally stacked windows would have been to stack the windows in the Z-dimension and in the X/Y-dimensions (to reduce occlusion), as shown in the visual aid below.



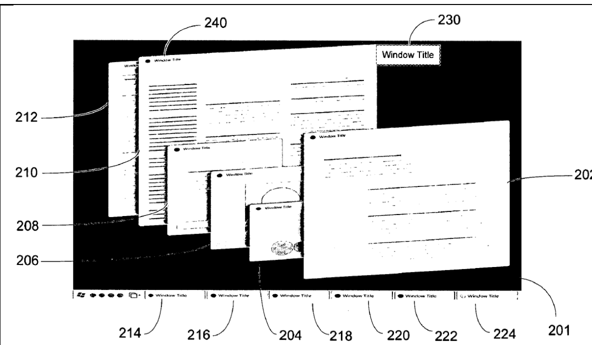
Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)

183. Conceptually, changing the orientation of the stack from horizontal to front-to-back would have been a trivial modification. For one, in a virtual 3D environment, the orientation of virtual objects is a flexible property, just like position, size, color, etc. Indeed, it is telling that Tsuda's three-step process discussed above can be used to produce a stack of windows in essentially any

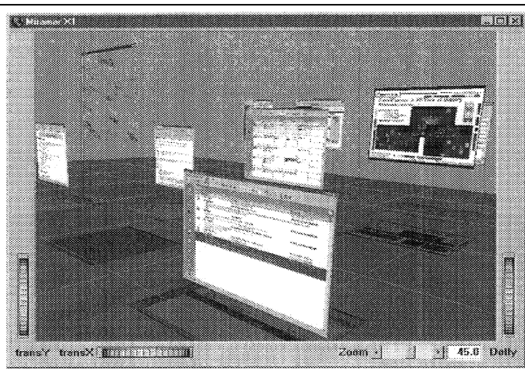
orientation. Moreover, stacking 3D objects front-to-back was a known configuration with which a POSITA would have been familiar (see examples below).



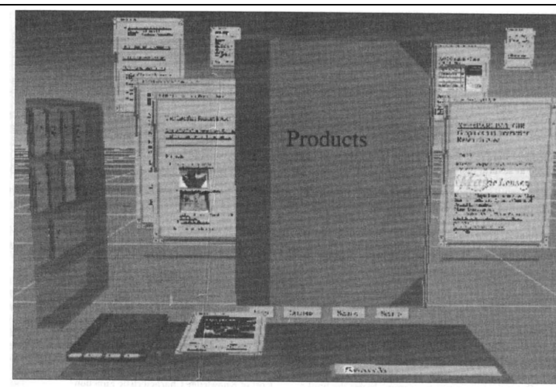
EX1017, Figure 2
US 6,661,426



EX1020, Figure 2B
US 2006/0161861

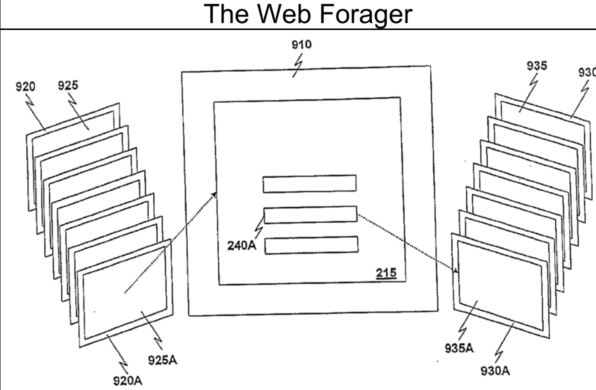


EX1035, Figure 5
US 6,229,542



EX1029, p. 5 (Figure 5)
The Web Forager

EX1030, p. 1 (Figure 1)
Data Mountain



EX1032
US 2002/0054114

184. Finally, a POSITA would have been motivated to incorporate functionality for different types of stacked orientations to enable users to customize

the layout of the user interface according to their preferences. Layout customization options of this sort would have improved user satisfaction with the interface.

185. Going back to the subject of "texturing," I have been informed by counsel for Petitioner that the parties have proposed the following two different constructions for this term in the co-pending district court litigation.[18]

Term	Petitioner	Patent Owner
"texturing" Claims 1, 8	"drawing or mapping an image onto a 3D object"	No construction necessary; plain and ordinary meaning applies. Alternatively: drawing or mapping [the first image on the first object and the second image on the second object].

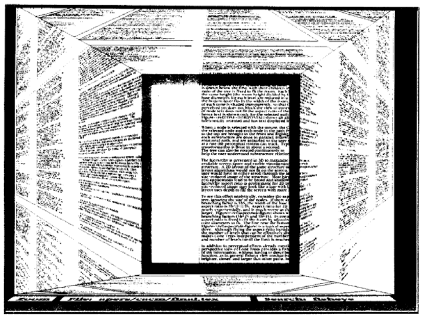
186. My analysis above satisfies Element [1.c.iii] under Patent Owner's proposed district court construction of ***texturing*** because that construction does not limit the claims to texturing on any particular kind of object. Petitioner's proposed construction, on the other hand, requires that the claimed ***objects*** on which the ***webpage images*** are ***textured*** must be ***3D objects***. The Sauve-Tsuda Combination satisfies Element [1.c.iii] under Petitioner's construction as well.

[18] I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

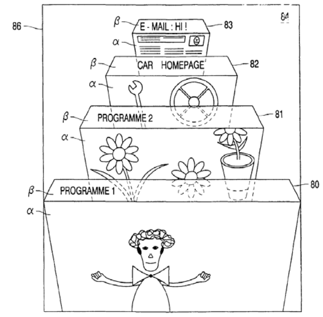
187. For example, Tsuda describes alternative embodiments where the 3D window is "a ***3D object***." EX1008 (Tsuda), 21:5-25. Tsuda goes on to provide a motivation for using such 3D objects—it (A) "makes windows more visually appealing"; and (B) "enabl[es] the window surface to be utilized more effectively" because basic information about the window (e.g., title and menu bar) can be displayed elsewhere (e.g., "on a side surface"). EX1008 (Tsuda), 21:5-25.

> [A] method in which the window itself is presumed to be a 3D object and, when the window is in perspective, the title bar and the menu bar are displayed on a side surface of the object that is adjacent to the near edge of the window surface, may also be used. EX1008 (Tsuda), 21:8-11.

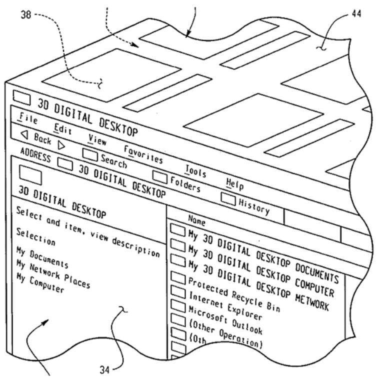
188. Additionally, as I've explained at length in this Declaration, 3D graphics and GUIs involving 3D objects in 3D environments were all very well known by the '048 patent's Critical Date in 2005 (see examples below). It would not have been difficult, novel, or inventive for a POSITA to employ 3D objects in a 3D space like Tsuda's. In fact, using 3D objects in a 3D space would have been intuitive to the POSITA, requiring no more than the exercise of basic common sense and ordinary creativity. Thus, even without Tsuda's express teaching of 3D objects, it would have been obvious to employ them.



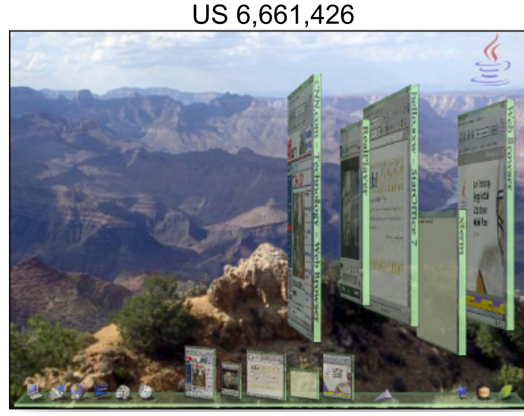
EX1011, p. 5 (Figure 3)
The Document Lens



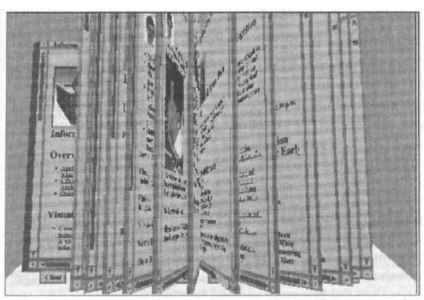
EX1017, Figure 2
US 6,661,426



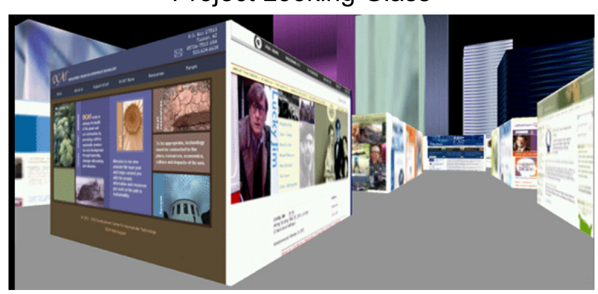
EX1018
US 2003/0142136



EX1012, p. 1
Project Looking Glass



EX1029, p. 3 (Figure 3)
The WebBook



EX1038
3B Browser

Element [1.d] displaying additional information, comprising:

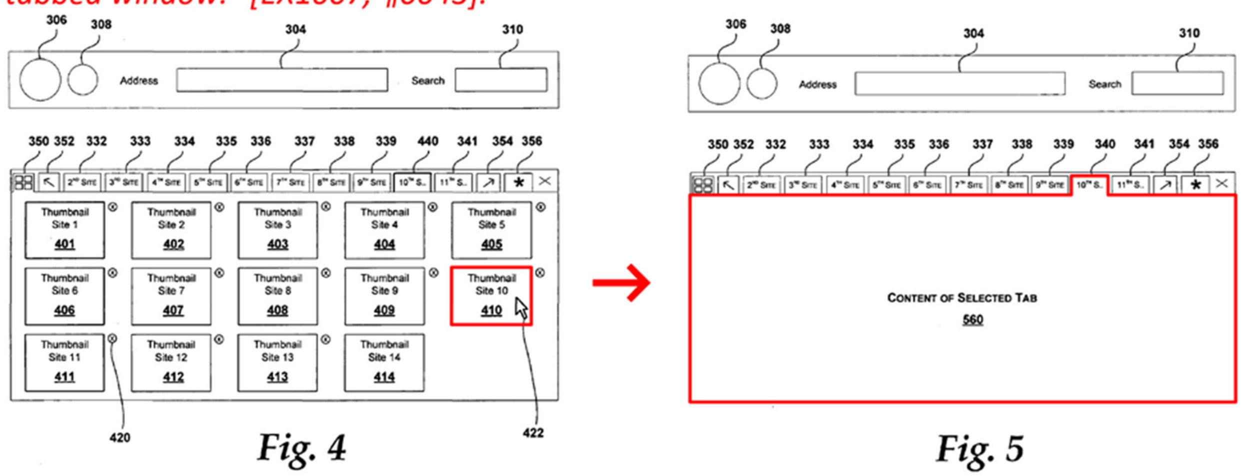
189. The Sauve-Tsuda Combination satisfies Element [1.d] for all the reasons below regarding Elements [1.d.i] through [1.d.v].

Element [1.d.i] receiving an interaction by the end user on the first image;

190. The Sauve-Tsuda Combination satisfies Element [1.d.i]. For example, Sauve teaches that the ***end user*** can switch from the quick pick user interface (Figure

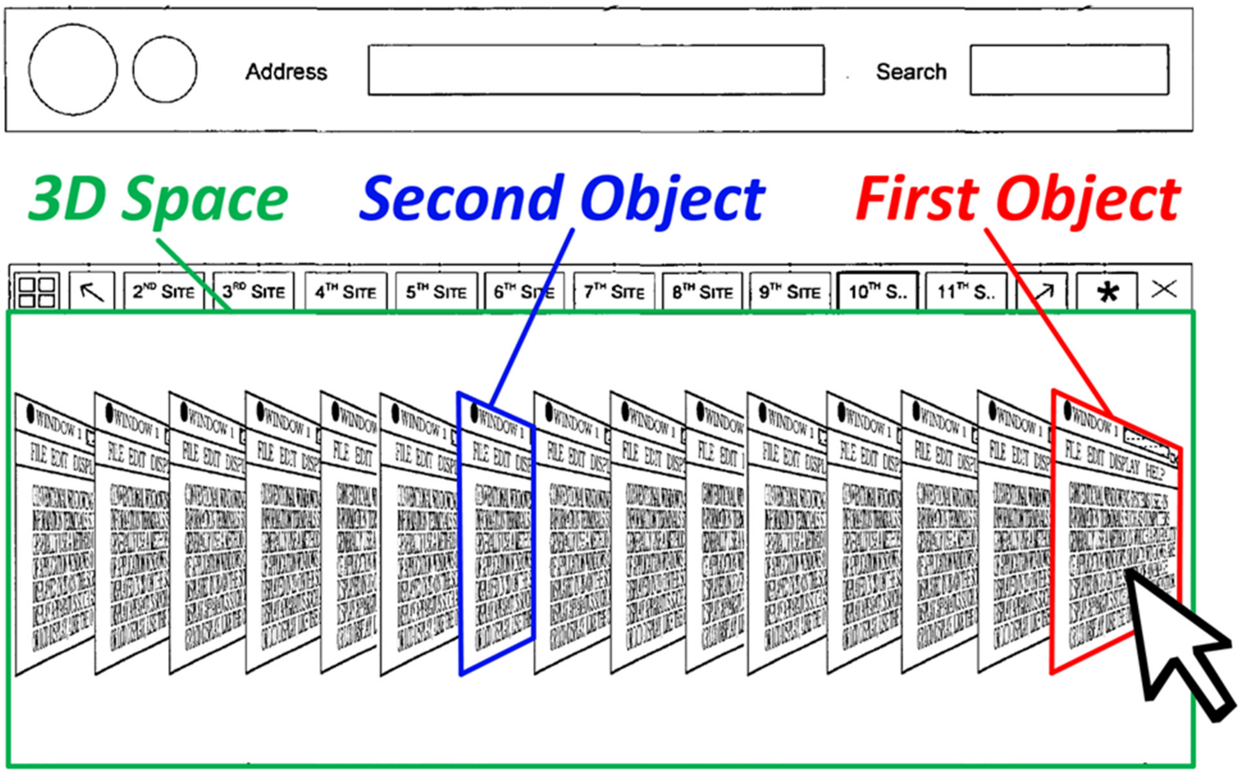
4 below) and a tabbed window showing the webpage content for an in-focus tab (Figure 5 below) by "select[ing] any one of the thumbnails to view its corresponding content." EX1007 (Sauve), ¶¶0043-0044. As illustrated in Figure 4, the action of making a "select[ion]" involves the user moving a pointer to the thumbnail, which bears an image of the corresponding webpage (***interacting on the first image***). EX1007 (Sauve), ¶¶0043-0044; *see also* ¶0018, ¶0042.

"The user may select any one of the thumbnails to view its corresponding content in the tabbed window." [EX1007, ¶0043].



EX1007 (Sauve), Figures 4 and 5—Annotated

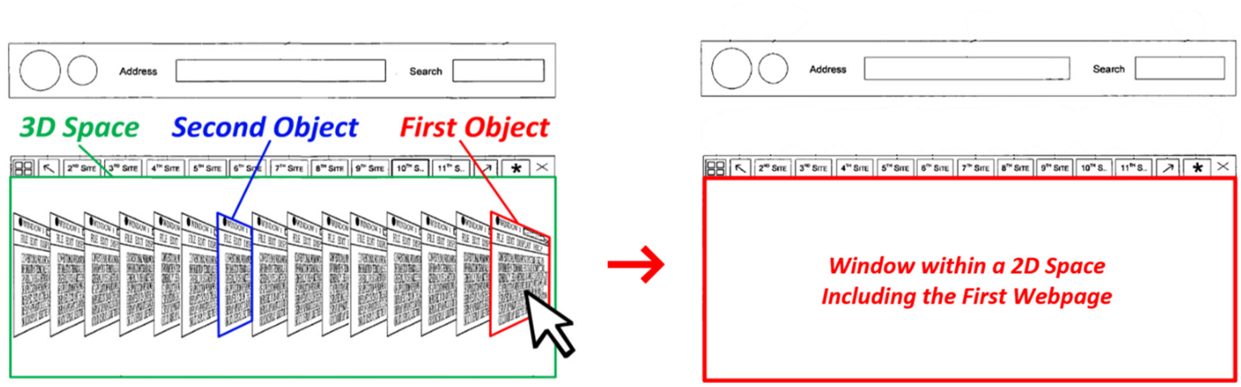
191. Applying Sauve's teaching to the Combination (*e.g.*, as discussed at Elements [1.c] through [1.c.iii]) yields an ***interaction*** by the end-user on a 3D window (***first object***) bearing an ***image*** of a webpage, as shown in the visual aid below.



Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)

Element [1.d.ii] replacing the first and second objects within the 3D space with a window within a two-dimensional (2D) space in response to receiving the interaction, wherein the window includes the rendered first webpage;

192. The Sauve-Tsuda Combination satisfies Element [1.d.ii]. As discussed at Element [1.d.i], the web browser of the Combination ***replaces*** the ***3D space*** of the quick pick user interface, which includes the (***first/second***) virtual 3D windows (***objects***), with a ***window within a 2D space*** including the (***first***) ***webpage*** of the selected tab, as shown in the visual aid below. EX1007 (Sauve), ¶0018, ¶¶0042-0044.



Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)—Annotated

193. Briefly, I have been informed by counsel for Petitioner that the parties agreed in the co-pending district court litigation that the term ***2D space*** should be construed as "a finite graphical area defined by a two-dimensional coordinate system."[19] Sauve's disclosure of switching to a "tabbed window" showing webpage content is consistent with the parties' construction. *See* prior discussion at Element [1.d.i]. As I've explained, a POSITA would have understood that Sauve's tabbed browser operates in a conventional manner in terms of loading webpages. This conventional manner of operation connotes a 2D space. At the time of the '048 patent, virtually all web browsers were designed to render webpages using 2D coordinate systems (e.g., Cascading Style Sheets (CSS)). In other words, most Internet webpages were coded in 2D layouts and, thus, conventional web browsers

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[19] I am not involved in the district court litigation and have no direct knowledge of the events in that proceeding.

were built to render those webpages in 2D spaces defined by 2D coordinate systems.

Element [1.d.iii] receiving an interaction by the end user on a link provided in the rendered first webpage, the link corresponding to the additional information;

Element [1.d.iv] rendering the additional information; and

Element [1.d.v] displaying the rendered additional information in said window within the 2D space.

194. The Sauve-Tsuda Combination satisfies Elements [1.d.iii] through [1.d.v]. For example, once transitioned from the quick pick user interface (*e.g.*, Figure 4) to the tabbed window (*e.g.*, Figure 5), as discussed above at Element [1.d.ii], Sauve's tabbed browser provides conventional point-and-click web surfing functionality. EX1007 (Sauve), ¶¶0002-0005, ¶¶0025-0027, ¶¶0042-0044. And this conventional functionality includes: ***receiving*** a mouse click ***interaction by the end user on a link provided in the rendered (first) webpage, the link corresponding to*** a new webpage (***additional information***), per Element [1.d.iii]; ***rendering the*** new webpage (***additional information***), per Element [1.d.iv]; and ***displaying*** the rendered webpage (***additional information***) ***in said window within the 2D space***, per Element [1.d.v]. EX1007 (Sauve), ¶0002 ("a web browser…provides <u>an easy-to-use point-and-click interface</u> for accessing various content on the web"), ¶0003 (the conventional functionality of a web browser includes "[e]ach time one of the hypertext or <u>hyperlinks is selected</u>, the new content is downloaded into the current window"), ¶¶0004-0005 ("Tabbed browsers <u>load web pages</u> in 'tabs' within the

same browser window”), ¶¶0025-0027 (explaining with reference to Figure 2 that each content window 202 of the tabbed browser “may be a web browser”); *see also* Element [1.c.i] (discussing webpage rendering).

195. Additionally, the notion of receiving a user interaction on a hyperlink and rendering/displaying a new webpage associated with the link was foundational to many (if not all) web browsers at the time of the ’048 patent, and a POSITA would have understood Sauve’s tabbed browser to operate in this conventional manner. This fact would explain why Sauve did not provide an extensive explanation on the subject—web browsers, including tabbed browsers, were already well known. It would have been redundant and unnecessary to provide such an explanation to the person of skill.

2. Claim 2

Element [2.a] capturing a third image of at least a portion of the rendered additional information; and

Element [2.b] texturing the third image on the first object, the third image thereby replacing the first image on the first object; and

196. The Sauve-Tsuda Combination satisfies Elements [2.a] and [2.b]. These elements require repeating the ***capturing*** and ***texturing*** steps of Elements [1.c.ii] and [1.c.iii] for the ***additional information rendered*** and ***displayed*** in Elements [1.d.iv] and [1.d.v], which yields ***a third image on the first object*** in the 3D space. More specifically, Elements [2.a] and [2.b] are about replacing the first

webpage image on the first object in the 3D space with a third image, where that third image corresponds to some additional information, such as a new webpage, loaded in response to a user interaction with the first webpage. One way to view these elements is that they capture the notion of updating the 3D space to reflect the user's interaction with the 2D browser.

197. Sauve suggests repeating Elements [1.c.ii] and [1.c.iii] in this manner by specifying that images shown in the quick-pick user interface match the webpage content from the corresponding browser tabs. *E.g.*, EX1007 (Sauve), ¶0041 ("content 360 may be a web page"), ¶0042 ("the content of each tab can be viewed in the quick pick window"), cl.3 ("each graphical view comprises a thumbnail displaying the portion of content").

198. A POSITA would have appreciated that users of the Sauve-Tsuda tabbed browser would toggle back and forth between the quick pick user interface and the tabbed browser view multiple times during a web browsing session. EX1007 (Sauve), ¶0039 (discussing a "button" or "hot key" to access the quick pick-user interface). Indeed, the purpose of the quick pick user interface is to help users navigate between different tabs. *E.g.*, EX1007 (Sauve), ¶¶0004-0005, ¶0018. Accordingly, it would have been understood by the POSITA, especially based on Sauve's suggestion noted above, that the ***capturing*** and ***texturing*** steps of Elements [1.c.ii] and [1.c.iii] are executed anew each time the user calls forth the quick pick

user-interface. Without this functionality, the effectiveness of the quick pick user interface would be diminished. That is, it would be more difficult for users to associate the thumbnails/windows in the quick pick user interface with corresponding web browser tabs. Thus, even without Sauve's disclosure on this subject, a POSITA would have been motivated to repeat the capturing and texturing steps of Elements [1.c.ii] and [1.c.iii].

Element [2.c] replacing the window within the 2D space with at least the first and second objects within the 3D space, wherein the first object is displayed in the foreground of the 3D space and the second object is displayed in the background of the 3D space.

199. The Sauve-Tsuda Combination satisfies Element [2.c]. This element requires the 3D-GUI to revert the ***replacing*** step of Element [1.d.ii] to re-enter the 3D space. As discussed above regarding Elements [2.a] and [2.b], a POSITA would have appreciated that users of the Sauve-Tsuda tabbed browser would toggle back and forth between the quick pick user interface and the tabbed browser view multiple times during a web surfing session. EX1007 (Sauve), ¶¶0004-0005, ¶0018, ¶0039.

3. Claim 3

Element [3.a] receiving a toggle interaction by the end user; and

Element [3.b] replacing the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

200. The Sauve-Tsuda Combination satisfies Elements [3.a] and [3.b] for the same reasons I discussed at Elements [2.a]-[2.c]. To reiterate: a POSITA would

have appreciated that users of the Sauve-Tsuda tabbed browser would toggle back and forth between the quick pick user interface and the tabbed browser view multiple times during a web surfing session. EX1007 (Sauve), ¶¶0004-0005, ¶0018, ¶0039.

4. Claim 4

Element [4.a] receiving a navigation interaction by the end user; and

Element [4.b] moving said second object from the background of the 3D space to the foreground of the 3D space in response to the navigation interaction.

201. The Sauve-Tsuda Combination satisfies Elements [4.a] and [4.b]. For example, Sauve teaches that the graphical representations in the quick pick user interface—the virtual 3D windows (***objects***) taught by Tsuda, per Elements [1.c] though [1.c.iii]—are "re-positioned" (***moved***) in response to ***receiving*** a "drag-drop operation" (navigation interaction) by the end user. EX1007 (Sauve), ¶¶0047-0048, Figure 8. Sauve makes clear that this functionality allows the user to place the graphical representations in whatever location and order the user desires. EX1007 (Sauve), ¶¶0047-0048, Figure 8. Accordingly, in the Combination's quick pick user interface, the user can ***move*** Tsuda's 3D windows (***first/second objects***) forward (***foreground***) or backward (***background***) through the horizontal or front-to-back stacks of the ***3D space*** discussed at Element [1.c.iii].

5. Claim 5

Element [5.a] receiving a toggle interaction by the end user; and

Element [5.b] replacing the window within the 2D space with at least the first and second objects within the 3D space in response to the toggle interaction.

202. Elements [5.a] and [5.b] are the same or substantially similar to Elements [3.a] and [3.b]. Accordingly, the Sauve-Tsuda Combination satisfies Elements [5.a] and [5.b] for the same reasons discussed at Elements [3.a] and [3.b].

6. Claim 6

Element [6.a] receiving at least a third input from the end user;

Element [6.b] receiving a third webpage from the at least one server in response to the third input; and

Element [6.c] displaying at least a portion of the third webpage on a third object within the 3D space, comprising:

Element [6.c.i] rendering the third webpage;

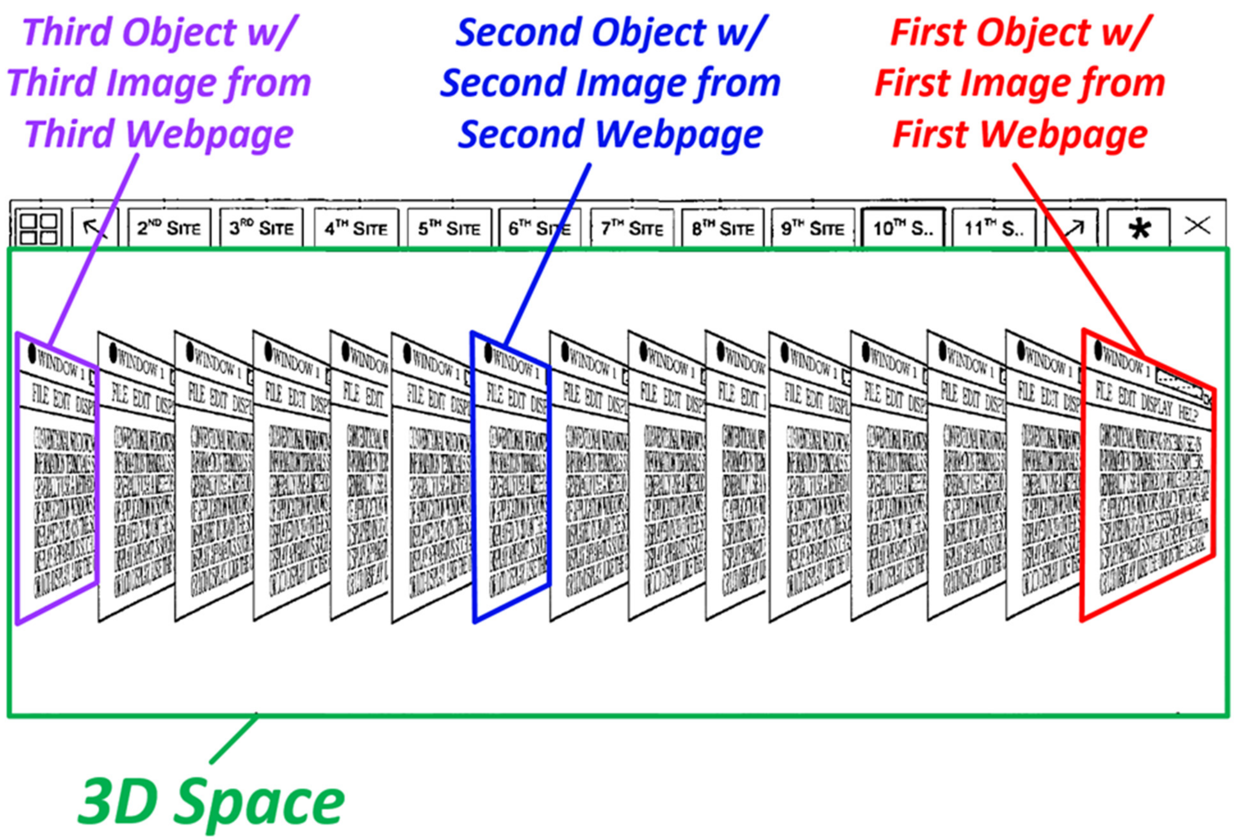
Element [6.c.ii] capturing a third image of the at least a portion of the third webpage; and

Element [6.c.iii] texturing the third image on the third object, the third object being displayed in a further background of the 3D space, behind the second object.

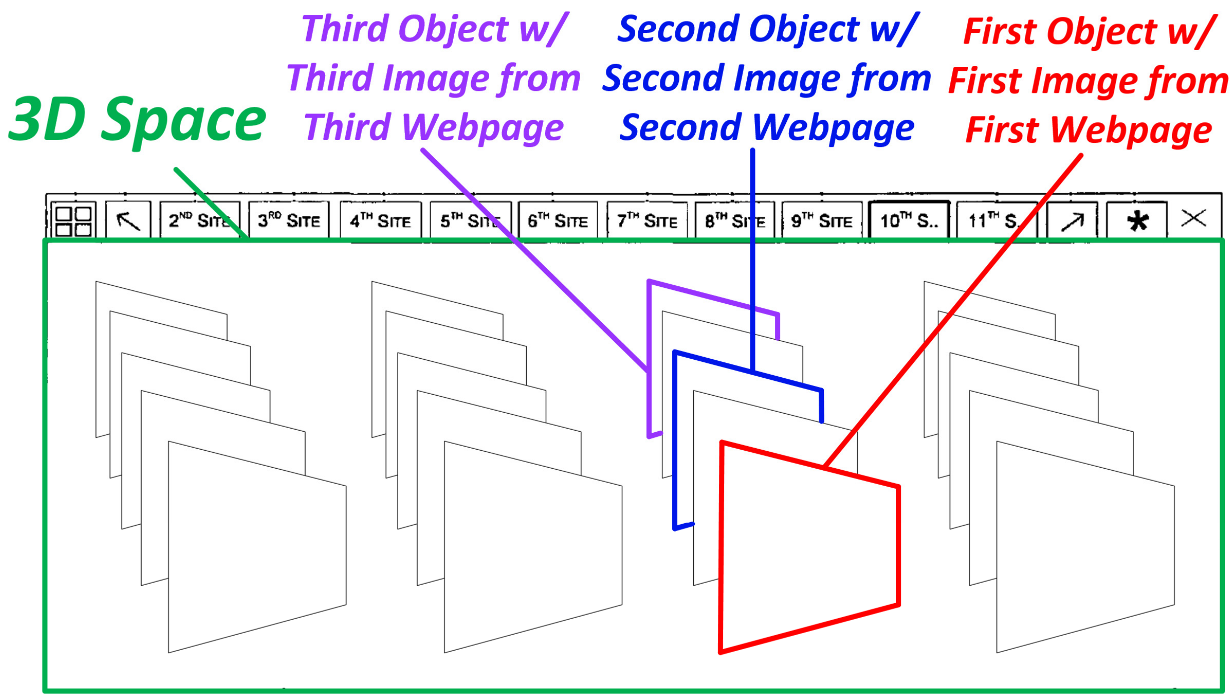
203. The Sauve-Tsuda Combination satisfies Elements [6.a] through [6.c.iii] for the same reasons discussed at Elements [1.a] through [1.c.iii]. The elements of Claim 6 merely require repeating the steps of Claim 1 a ***third*** time to create a ***third object*** bearing a ***third image*** from a ***third webpage***. In other words, Elements [6.a] through [6.c.iii] are about adding a third object with a third webpage image to the 3D space using the same ubiquitous rendering, capturing, and texturing techniques

discussed above. These elements do not introduce new material from a technical perspective. They just repeat what has already been stated in earlier steps.

204. Sauve and Tsuda teach this feature by showing in their figures that the processing steps are repeated multiple times over to create several thumbnails/windows. EX1007 (Sauve), Figures, 4, 6, 8; EX1008 (Tsuda), Figures 5, 8, 11B-12C. The visual aids below demonstrate how the quick pick user interface of the Combination provides a ***third object*** bearing a ***third image*** from a ***third webpage***.



Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)



Visual Aid Combining EX1007 (Sauve) and EX1008 (Tsuda)

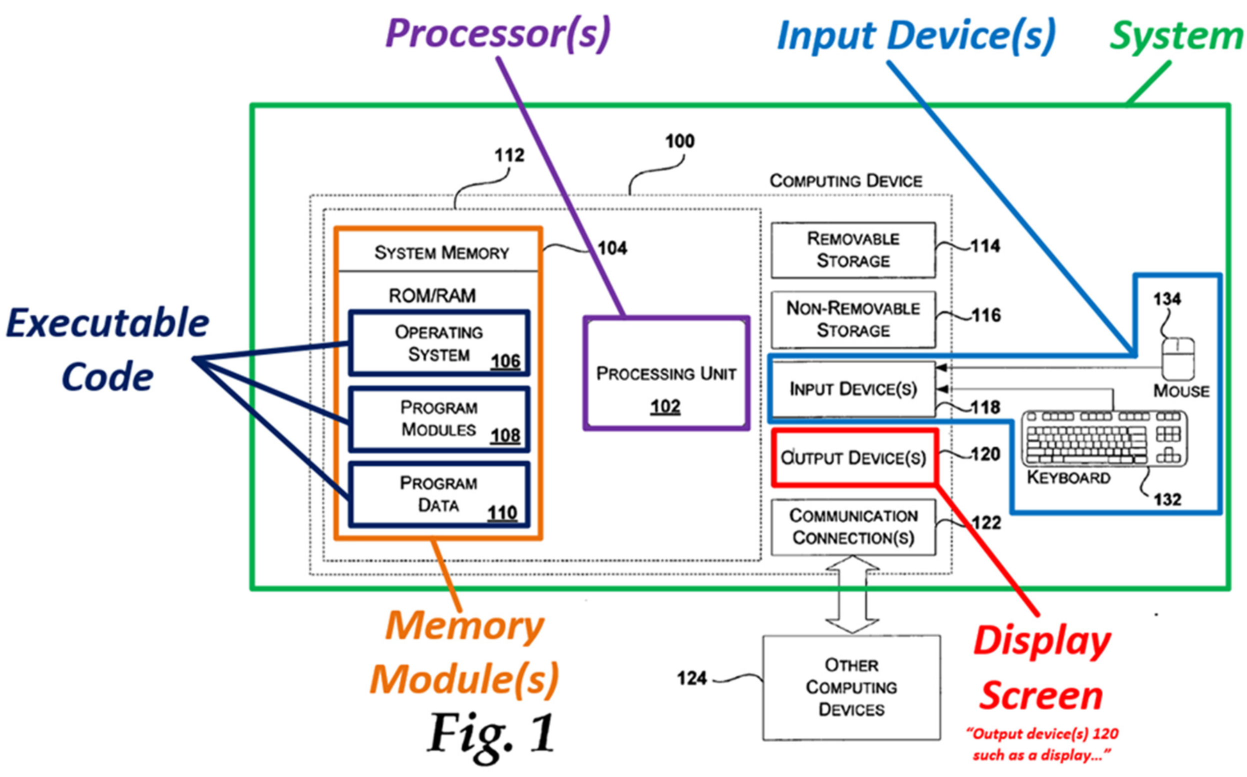
7. Claim 7

Element [7.a] wherein the step of receiving the first and second webpages from the at least one server in response to said first and second inputs further comprises receiving the first webpage from a first server in response to said first input and receiving the second webpage from a second server in response to said second input.

205. The Sauve-Tsuda Combination satisfies Element [7.a]. Consistent with the discussion at Element [1.b], Sauve discloses that "[u]pon entering a web address or URL of a particular website, the browser requests web pages from a web server hosting that website." EX1007 (Sauve), ¶0002. As Sauve suggests, and as a POSITA would have known, URLs identify the host server where a webpage resides, and this identification requirement in the syntax indicates that different (***first/second***) ***webpages*** are commonly hosted on different (***first/second***) ***servers***.

8. Claims 8-13

206. Claims 8-13 are substantially similar to Claims 1-6, reciting a similar series of steps with generic preamble language identifying conventional computer system components. Sauve (EX1007) plainly provides the ***system*** [8.pre], ***display screen*** [8.pre.i], ***input device*** [8.pre.ii], ***processor*** [8.pre.iii], and ***memory module*** storing ***executable code*** [8.pre.iv] recited in the preamble elements of Claim 8, as shown below. *See generally* EX1007 (Sauve), ¶¶0019-0021.



EX1007 (Sauve), Figure 1—Annotated

207. The Robertson-Gralla-Gettman Combination satisfies the remaining elements of Claims 8-13 for the same reasons discussed above regarding Claims 1-

6. Identification of the relevant discussion for each step is provided below.

Claim 8	
[8.a]	*See* [1.a]
[8.b]	*See* [1.b]
[8.c]	*See* [1.c]
[8.c.i]	*See* [1.c.i]
[8.c.ii]	*See* [1.c.ii]
[8.c.iii]	*See* [1.c.iii]
[8.d]	*See* [1.d]
[8.d.i]	*See* [1.d.i]
[8.d.ii]	*See* [1.d.ii]
[8.d.iii]	*See* [1.d.iii]
[8.d.iv]	*See* [1.d.iv]
[8.d.v]	*See* [1.d.v]

Claim 9	
[9.a]	*See* [2.a]
[9.b]	*See* [2.b]
[9.c]	*See* [2.c]

Claim 10	
[10.a]	*See* [3.a]
[10.b]	*See* [3.b]

Claim 11	
[11.a]	*See* [4.a]
[11.b]	*See* [4.b]

Claim 12	
[12.a]	*See* [3.a]/[5.a]
[12.b]	*See* [3.b]/[5.b]

Claim 13	
[13.a]	*See* [6.a]
[13.b]	*See* [6.b]
[13.c]	*See* [6.c]
[13.c.i]	*See* [6.c.i]
[13.c.ii]	*See* [6.c.ii]
[13.c.iii]	*See* [6.c.iii]

9. Claims 14-18

208. The elements of Claims 14-18 recite language that is substantially similar to Claims 1-4. Accordingly, the Sauve-Tsuda Combination satisfies the elements of Claims 14-18 for the same reasons discussed above regarding Claims 1-4. Identification of the relevant discussion for each step is provided below.

Claim 14	
[14.pre]	*See* [1.pre]
[14.a]	*See* [1.a] (receiving inputs), [1.b] (inputs are website addresses)
[14.b]	*See* [1.b] (receiving webpages)
[14.c]	*See* [1.c]
[14.c.i]	*See* [1.c.ii]
[14.c.ii]	*See* [1.c.iii]
[14.d]	*See* [1.d]
[14.d.i]	*See* [1.d.i]
[14.d.ii]	*See* [1.d.ii]
[14.d.iii]	*See* [1.d.iii]
[14.d.iv]	*See* [1.d.v]

209. I note that Element [14.b] deviates from Element [1.b] in the following way: Element [1.b] recites "<u>receiving</u> first and second webpages from at least one

server," while Element [14.b] recites "retriev[ing] first and second webpages from at least one source."

210. To start, Element [14.b] is broader than Element [1.b] in terms of generically reciting a ***source*** instead of specifying that the source is a ***server***. Accordingly, on this point, my analysis applied to Element [1.b] necessarily satisfies Element [14.b]. Additionally, in this context, there is no practical difference between ***receiving*** webpages, as stated in Element [1.b], and ***retrieving*** webpages, as stated in Element [14.b]. As I explained at Element [1.b] with reference to Sauve, after the user enters a URL web address, the browser sends a request to the server and receives a response from server including the webpage that corresponds to the URL. This process involves ***retrieving*** the webpage because the browser requests it from the server.

Claim 15	
[15.a]	*See* [1.d.ii]/[1.d.v]

Claim 16	
[16.a]	*See* [2.a]
[16.b]	*See* [2.c]

Claim 17	
[17.a]	*See* [3.a]
[17.b]	*See* [2.c]/[3.b]

Claim 18	
[18.a]	*See* [4.a]
[18.b]	*See* [4.b]

IX. OVERVIEW OF CONCLUSIONS FORMED

211. This Declaration explains the conclusions that I have formed based on my independent analysis. To summarize those conclusions:

- Based upon my knowledge and experience, and my review of the materials listed above, I believe that Claims 1-18 of the ’048 patent are obvious in view of Robertson (EX1004), Gralla (EX1005), and Gettman (EX1006). *See* Ground 1—Section VII.
- Based upon my knowledge and experience, and my review of the materials listed above, I believe that Claims 1-18 of the ’048 patent are obvious in view of Sauve (EX1007) and Tsuda (EX1008). *See* Ground 2—Section VIII.

X. CONCLUSION

212. I declare that all statements made in this Declaration of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both (under Section 1001 of Title 18 of the United States Code).

Executed this 21st day of November, 2022.

Henry Fuchs, PhD

APPENDIX A

HENRY FUCHS

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Education

1975 Ph.D, Computer Science, University of Utah

1970 B.A., Information and Computer Science, University of California at Santa Cruz

Positions Held

2017-2018 Guest Professor, TU Wien

2003-2004 Guest Professor, ETH Zurich

1978 - present University of North Carolina at Chapel Hill
- Federico Gil Distinguished Professor (1988-present)
- Adjunct Professor of Biomedical Engineering (2000-2019)
- Adjunct Professor of Radiation Oncology (1988-2008)
- Professor of Computer Science (1983-1988)
- Associate Professor of Computer Science (1978-83)

1975 -1982 University of Texas at Dallas, Programs in Mathematical Sciences
- Adjunct Associate Professor (1978-82)
- Computer Science Coordinator (1977-78)
- Assistant Professor (1975-78)

1979 -1982 University of Texas Health Science Center at Dallas, Southwestern Medical School
- Adjunct Associate Professor of Medical Computer Science

1970 - 1974 University of Utah, Department of Computer Science
- Research Assistant and Teaching Fellow

1976 - Present Former consulting and advisory board memberships (selected):
- Expert witness, various law firms
- Fraunhofer: IGD, Darmstadt, Germany; and CRCG, USA
- Harvard Neuroimage Analysis Center
- Lockheed-Georgia

Mersive Technologies
Mitsubishi Electric Research Lab
RAND Corp.
Research Triangle Institute
ShoGraphics
Stellar Computer
Thomson Corp.
Xerox Palo Alto Research Center

1968 - 74 Caltech / NASA Jet Propulsion Lab
Engineer and Consultant (mostly summers)

1968 - 70 University of California at Santa Cruz
Programmer and Consultant, Computer Center
Undergraduate Research Assistant for Prof. Harry Huskey

Honors

- Fellow, Eurographics, European Association for Computer Graphics, 2020 (two or three fellows elected each year)
- Career Impact Award, ISMAR 2018 (“Based on the profound impact that he has continued to have on AR/MR for well over forty years and on ISMAR since its inception”)
- Honorary doctorate (Dr. h.c.), TU Wien, 2018.
- ACM SIGGRAPH Academy - Inaugural Class, 2018 (“For contributions to augmented and virtual reality, telepresence and graphics hardware, and for educating the leaders in the field of computer graphics.”)
- The 2015 ACM SIGGRAPH Steven A. Coons Award (Considered the most prestigious award in the field of computer graphics; awarded once every two years.)
- Fellow, IEEE 2015 (“For contributions to computer graphics, virtual and augmented reality”)
- The 2013 IEEE VGTC Virtual Reality Career Award (“In recognition of his lifetime contributions to research and practice of virtual environments, telepresence and medical applications”).
- Fellow, American Academy of Arts and Sciences, 1997.
- Member, National Academy of Engineering, 1997.
- The 1997 Satava Award, Medicine Meets Virtual Reality Conferences. ("For your commitment to the transformation of medicine through visionary applications of interactive technology").
- ACM Fellow, 1994. (“For distinguished contributions in the field of computer graphics”).
- The 1992 Computer Graphics Achievement Award, ACM/SIGGRAPH. ("In recognition of his outstanding contribution to high-performance, parallel display architecture”).
- The 1992 National Computer Graphics Association (NCGA) Academic Award. ("For his outstanding leadership in the development and promotion of computer graphics applications in the academic community").

Patents Awarded

20. H. Fuchs, A. Lastra, J. T. Whitted, F. Zheng, A. State, G. Welch, "Minimal-Latency Tracking and Display for Matching Real And Virtual Worlds in Head-Worn Displays," US Patent No. 11,049,476 (June 29, 2021).

19. H. Fuchs, M. Dou, G. Welch, J. M. Frahm, "Methods, Systems, and Computer Readable Media for Unified Scene Acquisition and Pose Tracking in a Wearable Display," US Patent No. 10,365,711 (July 30, 2019).

18. H. Fuchs, G. Welch, "Methods, Systems, and Computer Readable Media for Improved Illumination of Spatial Augmented Reality Objects," US Patent No. 10,321,107 (June 11, 2019).

17. P. K. Chakravarthula, H. Fuchs, "Methods, Systems, and Computer Readable Media for Dynamic Vision Correction for In-focus Viewing of Real and Virtual Objects," US Patent 10,319,154 (June 11, 2019).

16. H. Fuchs, D. Dunn, C. Tippets, "Wide Field of View Augmented Reality Head- Mounted Display with Distance Accommodation," US Patent No. 9,983,412 (May 29, 2018).

15. H. Fuchs, N. Dierk, J. M. Frahm, A. Lastra, D. Perra, "Low-Latency Stabilization for Head-Worn Displays," US Patent No. 9,898,866 (Feb. 20, 2018).

14. A. Maimone, H. Fuchs, "Methods, Systems, and Computer Readable Media for Generating an Augmented Scene Display," US Patent No. 9,858,721 (Jan. 2, 2018).

13. G. Welch, K. Keller, A. State, H. Fuchs, R. Schubert, "Methods, Systems, and Computer Readable Media for Utilizing Synthetic Animatronics", US Patent No. 9,792,715 (Oct. 17, 2017).

12. G. Welch, H. Fuchs, P. Lincoln, A. Nashel, A. State, "Methods, Systems, and Computer Readable Media for Shader-Lamps Based Physical Avatars of Real and Virtual People", US Patent No. 9,538,167 (Jan. 3, 2017).

11. H. Fuchs, L. McMillan, A. Nashel, "Methods, systems, and computer readable media for generating autostereo three-dimensional views of a scene for a plurality of viewpoints using a pseudo-random hole barrier," US Patent No. 9,361,727 B2 (June 7, 2016).

10. H. Fuchs, H. Yang, T. Peck, A. Bulysheva, A. State, "Methods, systems, and computer readable media for image guided ablation," US Patent No. 9,265,572 B2 (Feb. 23, 2016).

9. J. M. Frahm, H. Fuchs, M. Marathe, B. Mauchly, "System and Method for providing depth adaptive video conferencing," U.S. Patent No. 8,896,655 (Nov. 25, 2014).

8. K. Keller, H. Fuchs, L. McMillan, L. Vicci, "Methods, systems, and computer program products for full spectrum projection," U.S. Patent No. 8,152,305 (April 10, 2012).

7. H. Fuchs, D. Cotting, M. Naef and M. Gross, "Methods, systems and computer program products for imperceptibly embedding structured light patterns in projected color images for display on planar and nonplanar surfaces," U.S. Patent No. 7,182,465 (Feb. 27, 2007).

6. K. Keller, J. Ackerman, M. Rosenthal, H. Fuchs and A. State, "Methods and systems for real-time structured light depth extraction, and endoscope using real-time structured light depth extraction," U.S. Patent No. 6,503,195 (Jan. 7, 2003).

5. H. Fuchs, M. Livingston, T. Bishop, and G. Welch, “Dynamic generation of imperceptible structured light for tracking and acquisition of three dimensional scene geometry and surface characteristics in interactive three dimensional computer graphics applications,” U.S. Patent No. 5,870,136 (Feb. 9, 1999).

4. H. Fuchs, “Image buffer having logic-enhanced pixel memory cells and method for setting values therein.” U.S. Patent No. 4,827,445 (May 2, 1989).

3. H. Fuchs and J. Poulton, "VLSI Graphic Display Image Buffer Using Logic Enhanced Pixel Memory Cells," U.S. Patent No. 4,783,649 (Nov. 8, 1988).

2. H. Fuchs and S. Pizer, "Three Dimensional Display Using a Varifocal Mirror" U.S. Patent No. 4,607,255 (Aug. 19, 1986).

1. H. Fuchs, "Graphics Display System Using Logic-Enhanced Pixel Memory Cells," U.S. Patent No. 4,590,465 (May 20, 1986).

Recent Grants & Contracts (Selected)

1. National Institutes of Health: “SCH: An Augmented Reality Neurorehabilitation System for Monitoring and Management of Motor Symptoms of Parkinson's Disease” R01HD111074, July 2022- June 2026 (Fuchs, PI).
2. National Science Foundation: “HCC: Medium: Deep Learning-Based Tracking of Eyes and Lens Shape from Purkinje Images for Holographic Augmented Reality Glasses,” IIS-2107454, Oct. 2021 - Sept. 2024 (Fuchs, PI).
3. Facebook/Meta: “Towards a Physics-based Understanding of Holographic Image Quality,” Dec. 2020 - July 2022 (Fuchs, PI)
4. National Science Foundation: “FW-HTF: Collaborative Research: Enhancing Human Capabilities through Virtual Personal Embodied Assistants in Self-Contained Eyeglasses-Based Augmented Reality (AR) Systems,” CMMI-1840131, Sept. 2018 - Aug. 2022 (Fuchs, PI)
5. National Science Foundation: “CHS: Small: Collaborative Research: 3D Audio Augmentation for Limited Field of View Augmented Reality Systems for Medical Training," IIS-1718313, Sept. 2017 - Aug. 2021 (Fuchs, UNC PI; collaboration with University of Florida)
6. National Science Foundation: “SCH: INT: Collaborative Research: Computer Guided Laparoscopy Training” IIS-1622515, Aug. 2016 - July 2021 (Fuchs, UNC PI; collaboration with University of Arizona)
7. National Science Foundation: “EAGER: Wide Field of View Augmented Reality Display with Dynamic Focus” IIS-1645463, Aug. 2016 - July 2018 (Fuchs, PI)
8. National Science Foundation: “CHS: CGV: Small: Minimal-latency Tracking and Display for Matching Real and Virtual Worlds in Head-worn Displays” IIS-1423059, Sept. 2014 – Aug. 2017 (Fuchs, PI)
9. National Science Foundation: “II-New: Seeing the Future: Ubiquitous Computing in EyeGlasses” CRI-1405847, Sept. 2014 – Aug. 2017 (Fuchs, Co-PI)
10. National Science Foundation: “HCC: CGV: Small: Eyeglass-Style Multi-Layer Optical See-Through Displays for Augmented Reality” CHS-1319567, Sept. 2013 - Aug. 2016 (Fuchs, PI).
11. NVIDIA Research: Cooperative Agreement & Support (Fuchs, PI) ca. 2013 - current

12. Cisco Systems: "Telepresence Systems," 2006 – 2015; 2017 (Fuchs, PI).
13. National Science Foundation: "II-NEW: A Robot Testbed for Real-time Motion Strategies and Autonomous Personal Assistants" CRI-1305286, Sept. 2013 - Aug. 2015 (Fuchs, co-PI)

OTHER FORMER GRANTS AND CONTRACTS (selected): DARPA (Defense Advanced Research Projects Agency), DOE (U.S. Dept. of Energy), NIH (National Institutes of Health), NCI (National Cancer Institute), NSF (National Science Foundation), ONR (Office of Naval Research); U.S. Air Force.

Recent Award-Winning Exhibits

Best in Show at Siggraph 2018 Emerging Technologies Exhibition (led by my student Kishore Rathinavel and NVIDIA's Kaan Aksit, in collaboration with NVIDIA Research) https://s2018.siggraph.org/conference/conference-overview/emerging-technologies/

DCExpo/DCAJ prize at Siggraph 2017 Emerging Technologies Exhibition (led by my student David Dunn, in collaboration with NVIDIA Research) http://s2017.siggraph.org/content/emerging-technologies.html

Professional Activities (Selected)

- Chair of VR Awards Program, IEEE VGTC (Visualization and Graphics Technical Community), 2020-present
- Member, Editorial Advisory Board, Computers & Graphics, 2013-present
- Member, Steering Committee, IEEE International Symposium on Mixed and Augmented Realities (ISMAR) 2008 - present.
- Member, External Advisory Board, Harvard's Neuroimage Analysis Center, 2004-2012.
- Member, External Advisory Board, Mersive Technologies. ~2008 - ~2010.
- Member, Dept. of Energy Blue Ribbon Panel for Evaluation of ASCI Program, 1998-1999.
- UNC Delegate, New Vistas in Transatlantic Science and Tech Cooperation, Washington D.C., 1998.
- Member, DARPA's Information Science and Technology Study Group, (Defense Advanced Research Projects Agency), 1994.
- Member, Computer Science and Telecommunications Board, National Research Council of the National Academies, 1993-1997.
- Co-Director (with Gary Bishop), NSF Invitational Workshop on Research Directions in Virtual Environments, Chapel Hill, NC, March 1992.
- Co-Director (with K.H. Höhne and Steve Pizer), NATO Advanced Research Workshop in 3D Imaging in Medicine, Travemünde, Germany, June 1990.
- Chairman, 1986 Workshop on Interactive 3D Graphics, UNC Chapel Hill, Oct. 1986 (the initial meeting of what has become the annual ACM Symposium on Interactive 3D Graphics and Games).
- Distinguished Visitor, IEEE Computer Society, 1985-1986.

- Chairman, 1985 Chapel Hill Conference on VLSI, May 1985. (7th Annual. All previous conferences held at Caltech and MIT). Conference now called S.I.S.
- Chairman, Tutorial on VLSI and Computer Graphics, SIGGRAPH'83, SIGGRAPH'84, SIGGRAPH'85.
- Associate Editor, ACM Transactions on Graphics, 1983-1988.
- Guest Editor, ACM Transactions on Graphics, Vol.1, No. 1, January 1982.
- Technical Program Chairman, SIGGRAPH'81.
- Member, Advisory Committee, National Science Foundation, Division of Microelectronic Information Processing Systems.
- Member, Special Study Sections, National Institutes of Health; Review Panels and Site Visit Committees, National Science Foundation: 1978-Present.

Program Committee Memberships (Selected)

- ACM SIGGRAPH Asia (2013)
- ACM SIGGRAPH (1979, 1980, 1981, 1985-1992, 1998-2001, 2005) Annual Conferences on Computer Graphics and Interactive Techniques
- Symposium on Interactive 3D Graphics, 2001 in Chapel Hill, N.C.
- Symposium on Interactive 3D Graphics, 1990 at Snowbird, Utah
- Workshop on Volume Visualization, 1989 at UNC-Chapel Hill
- Conference on Advanced Research in VLSI (1986 at MIT, 1987 at Stanford, 1988 at MIT, 1989 at Caltech)
- Eurographics, 1997
- International Electronic Image Week (CESTA, SIGGRAPH) FRANCE (1986 and 1987)
- Computer Graphics International (1987 in Japan; 1988 in Switzerland)

Publications

256. Praneeth Chakravarthula, Ethan Tseng, Henry Fuchs, Felix Heide, “Hogel-free Holography.” ACM Transactions on Graphics (TOG), March 2022 and ACM SIGGRAPH 2022, https://doi.org/10.1145/3516428.

255. Youngjoong Kwon, Stefano Petrangeli, Dahun Kim, Haoliang Wang, Vishy Swaminathan, Henry Fuchs. “Tailor Me: An Editing Network for Fashion Attribute Shape Manipulation.” IEEE WACV 2022.

254. C Lu, Q Zhang, K Krishnakumar, J Chen, H Fuchs, S Talathi, K Liu. “Geometry-Aware Eye Image-To-Image Translation.” 2022 Symposium on Eye Tracking Research and Applications.

253. Praneeth Chakravarthula, Zhan Zhang, Okan Tursun, Piotr Didyk, Qi Sun, Henry Fuchs, “Gaze-contingent Retinal Speckle Suppression for Perceptually-Matched Foveated Holographic Displays.” IEEE TVCG 2021.

252. Youngjoong Kwon, Dahun Kim, Duygu Ceylan, Henry Fuchs. “Neural Human Performer: Learning Generalizable Radiance Fields for Human Performance Rendering.” NeurIPS 2021. Spotlight presentation (Acceptance: < 3.0%)

251. Young-Woon Cha, Husam Shaik, Qian Zhang, Fan Feng, Andrei State, Adrian Ilie, Henry Fuchs. “Mobile. Egocentric Human Body Motion Reconstruction Using Only Eyeglasses-mounted Cameras and a Few Body-worn Inertial Sensors.” Proceedings IEEE Virtual Reality and 3D User Interfaces (27 March-1 April 2021) **Winner: A Best Conference Paper Award (1 of 3).**

250. P. Chakravarthula, Ethan Tseng, Tarun Srivastava, Henry Fuchs, Felix Heide. “Learned Hardware-in-the-loop Phase Retrieval for Holographic Near-Eye Displays.” SIGGRAPH Asia 2020.

249. X. Lu, Praneeth Chakravarthula, Yujie Tao, Steven Chen, Henry Fuchs. “Improved Vergence and Accommodation via Purkinje Image Tracking with Multiple Cameras for AR Eyeglasses.” Proceedings IEEE International Symposium on Mixed and Augmented Reality (ISMAR) 2020.

248. X. Xia, Yunqing Guan, Andrei State, Praneeth Chakravarthula, Tat-Jen Cham, Henry Fuchs, “Towards Eyeglasses-style Holographic Near-eye Displays with Static Expanded Eyebox.” Proceedings IEEE International Symposium on Mixed and Augmented Reality (ISMAR) 2020.

247.Youngjoong Kwon, Stefano Petrangeli, Dahun Kim, Haoliang Wang, Henry Fuchs, Viswanathan Swaminathan. “Rotationally-Consistent Novel View Synthesis for Humans.” Proceedings of the 28th ACM International Conference on Multimedia Oct. 2020.

246. Youngjoong Kwon, Stefano Petrangeli, Dahun Kim, Haoliang Wang, Eunbyung Park, Viswanathan Swaminathan, Henry Fuchs. “Rotationally-Temporally Consistent Novel View Synthesis of Human Performance Video” Proceedings of the European Conference on Computer Vision (ECCV) 2020. Spotlight Presentation (Acceptance: 265/5025 ≈ 5.3%)

245. Hanseul Jun, Jeremy N. Bailenson, Henry Fuchs, Gordon Wetzstein. “An Easy-to-use Pipeline for an RGBD Camera and an AR Headset” PRESENCE: Teleoperators and Virtual Environment 2020.

244. P. Chakravarthula, Yifan Peng, Joel Kollin, Felix Heide, Henry Fuchs. “Computing high quality phase-only holograms for holographic displays.” Optical Architectures for Displays and Sensing in Augmented, Virtual, and Mixed Reality *(AR, VR, MR)*. Vol. 11310. International Society for Optics and Photonics, 2020. **Winner: an Optical Design Award at SPIE Photonics West 2020.**

243. K. Rathinavel, Hanpeng Wang, Henry Fuchs, “Optical Calibration and Distortion Correction for a Volumetric Augmented Reality Display”, Emerging Digital Micromirror Device Based Systems and Applications XII, Photonics West 2020.

242. A. State, H. Towles, T. Johnson, R. Schubert, B. Walters, G. Welch, H. Fuchs. "The A-Desk: A Unified Workspace of the Future," IEEE Computer Graphics and Applications, vol. 40, issue 1, pp. 56-71, January 2020.

241. P. Chakravarthula, Y. Peng, J. Kollin, H. Fuchs, F. Heide. “Wirtinger Holography for Near-Eye Displays,” ACM Trans. Graph., Vol. 38, No. 6, Art. 13, Nov. 2019.

240. K. Rathinavel, G. Wetzstein, and H. Fuchs. “Varifocal Occlusion-Capable Optical See-through Augmented Reality Display based on Focus-tunable Optics,” IEEE Transactions on Visualization and Computer Graphics, Nov. 2019, vol. 25, issue 11, pp. 3125-3134, doi: 10.1109/TVCG.2019.2933120.

239. R. Chabra, J. Straub, C. Sweeney, R. Newcombe, H. Fuchs. “StereoDRNet: Dilated Residual Stereo Net”, in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) (pp. 11786 - 11795) 2019.

238. X. Xia, Y. Guan, A. State, P. Chakravarthula, K. Rathinavel, T.J. Cham, H. Fuchs. “Towards a Switchable AR/VR Near-eye Display with Accommodation-Vergence and Eyeglass Prescription Support,” in IEEE Transactions on Visualizations and Computer Graphics, Nov. 2019, vol. 25, issue 11, pp 3114-3124, doi: 10.1109/TVCG.2019.2932238.

237. A.S. Rose, H. Kim, H. Fuchs, J.M. Frahm. “Development of Augmented Reality Applications in Otolaryngology-Head and Neck Surgery,” The Laryngoscope, Jul. 2019.

236. K. Aksit, P. Chakravartula, K. Rathinavel, Y. Jeong, R. Albert, H. Fuchs, D. Luebke. “Manufacturing Application-Driven Foveated Near-Eye Displays,” in IEEE Transactions on Visualization and Computer Graphics, vol. 25, no. 5, pp. 1928-1939, May 2019. doi: 10.1109/TVCG.2019.2898781

235. H. Jiang, S. Xu, A. State, F. Feng, H. Fuchs, M. Hong, and J. Rozenblit. "Enhancing a Laparoscopy Training System with Augmented Reality Visualization," 2019 Spring Simulation Conference (SpringSim), 29 April - 2 May, 2019, Tucson, Arizona. doi: 10.23919/SpringSim.2019.8732876

234. A. Blate, M. Whitton, M. Singh, G. Welch, A. State, T. Whitted, and H. Fuchs. “Implementation and Evaluation of a 50 kHz, 28μs Motion-to-Pose Latency Head Tracking Instrument,” in IEEE Transactions on Visualization and Computer Graphics, vol. 25, 5 May 2019, pp. 1970-1980). doi: 10.1109/TVCG.2019.2899233

233. G. Song, J. Cai, T.J. Cham, J. Zheng, J. Zhang, H. Fuchs. “Real-time 3D Face-Eye Performance Capture of a Person Wearing a VR Headset,” Proceedings of the 26th ACM International Conference on Multimedia, Oct. 28, 2018. pp. 923-391. doi: 10.1145/3240508.3240570

232. D. Dunn, P. Chakravarthula, Q. Dong, H. Fuchs. “Mitigating Vergence-Accommodation Conflict for Near-Eye Displays via Deformable Beamsplitters,” SPIE Digital Optics for Immersive Displays 2018. **1st Place, DOID Student Optical Design Challenge.**

231. P. Chakravarthula, D. Dunn, K. Aksit, H. Fuchs. "FocusAR: Auto-focus Augmented Reality Eyeglasses for both Real and Virtual," Proceedings of ISMAR 2018 and IEEE Transactions on Visualization and Computer Graphics. **Best Paper Award.**

230. K. Rathinavel, H. Wang, A. Blate, H. Fuchs. "An Extended Depth-of-Field Volumetric Near-Eye Augmented Reality Display," Proceedings of ISMAR 2018 and IEEE Transactions on Visualization and Computer Graphics.

229. Y-W. Cha, T. Price, Z. Wei, X. Lu, N. Rewkowski, R. Chabra, Z. Qin, H. Kim, Z. Su, Y. Liu, A. Ilie, A. State, Z. Xu, J. Frahm, H. Fuchs. “Towards Fully Mobile 3D Face, Body, and Environment Capture Using Only Head-worn Cameras,” Proceedings of ISMAR 2018 and IEEE Transactions on Visualization and Computer Graphics.

228. K. Rathinavel, P. Chakravarthula, K. Aksit, J. Spjut, B. Boudaoud, T. Whitted, D. Luebke, H. Fuchs. “Steerable Application-Adaptive Near Eye Displays,” SIGGRAPH ‘18: ACM SIGGRAPH 2018 Emerging Technologies, August 2018, pp. 1-2. doi: 10.1145/3214907.3214911.**Best in Show Award.**

227. X. Xia, Y. Guan, A. State, T-J. Cham, H. Fuchs. “Towards Efficient 3D Calibration for Different Types of Multi-view Autostereoscopic 3D Displays,” Proceedings of Computer Graphics International, CGI 2018, June 11-14, 2018, Bintan Island, Indonesia, pp. 169-174.

226. K. Kroesl, D. Bauer, M. Schwarzler, H. Fuchs, G. Suter, M. Wimmer. “A VR-based User Study on the Effects of Vision Impairments on Recognition Distances of Escape-Route Signs in Buildings,” The Visual Computer, June 2018. Vo. 34, Issue 6-8, (Proceedings of Computer Graphics International, CGI 2018, June 11-14, 2018, Bintan Island, Indonesia), pp. 911-923

225. David Dunn, Praneeth Chakravarthula, Qian Dong, Kaan Aksit, Henry Fuchs. “Towards Varifocal Augmented Reality Displays using Deformable Beamsplitter Membranes,” SID Display Week 2018 Digest, pp. 92-95.

224. H. Chen and H. Fuchs. “Supporting Free Walking in a Large Virtual Environment: Imperceptible Redirected Walking with an Immersive Distractor,” Proceedings of Computer Graphics International (CGI ’17),

223. H. Chen and H. Fuchs. “Towards Imperceptible Redirected Walking: integrating a distractor into the immersive experience,” Proceedings of the 21st ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games (I3D 2017).

222. G. Avveduto, F. Tecchia, H. Fuchs. “Real-world Occlusion in Optical See-through AR Displays,” ACM Symposium on Virtual Reality Software and Technology 2017 (Gothenburg, Sweden, Nov. 8-10, 2017).

221. T. Arce, H. Fuchs, K. McMullen. “The Effects of 3D Audio on Hologram Localization in Augmented Reality Environments,” Proceedings of the Human Factors and Ergonomics Society 2017 Annual Meeting (Austin, TX, October 9–13, 2017) pp. 2115-2119.

220. R. Chabra, A. Illie, N. Rewkowski, Y. Cha, H. Fuchs. “Optimizing Placement of Commodity Depth Cameras for Known 3D Dynamic Scene Capture,” IEEE Virtual Reality 2017 (Los Angeles, CA, March 18-22, 2017).

219. D. Dunn, C. Tippets, K. Torell, P. Kelinhofer, K. Aksit, P. Didyk, K. Myszkowski, D. Luebke, H. Fuchs. “Wide Field of View Varifocal Near-Eye Display using See-Through Deformable Membrane Mirrors,” IEEE Virtual Reality 2017 (Los Angeles, CA, March 18-22, 2017). **Best Paper Award.**

218. P. Lincoln, A. Blate, M. Singh, A. State, M. Whitton, T. Whitted, H. Fuchs. ”Scene-Adaptive High Dynamic Range Display for Low Latency Augmented Reality,” ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games 2017 (San Francisco, CA, Feb. 25-27, 2017). **2nd-Best Paper Award.**

217. Y-W. Cha, M. Dou, R. Chabra, F. Menozzi, A. State, E. Wallen, MD, H. Fuchs. “Immersive Learning Experiences for Surgical Procedures,” Medicine Meets Virtual Reality / NextMed 2016 (Los Angeles, April 7-9, 2016).

216. Y. Ren and H. Fuchs. "Faster Feedback for Remote Scene Viewing with Pan-Tilt Stereo Camera," IEEE Virtual Reality 2016 Conference (Greenville, SC, March 19-23, 2016).

215. P. Lincoln, A. Blate, M. Singh, T. Whitted, A. State, A. Lastra, H. Fuchs. “From Motion to Photons in 80 Microseconds: Towards Minimal Latency for Virtual and Augmented Reality,” IEEE Virtual Reality 2016 Conference (Greenville, SC, March 19-23). **Best Paper Award.**

214. M. Dou, J. Taylor, H. Fuchs, A. Fitzgibbon, S. Izadi. “3D Scanning Deformable Objects with a Single RGBD Sensor,” CVPR 2015-Computer Vision and Pattern Recognition Conference (Boston, MA, June 7-12, 2015).

213. A. Ullah Naweed, L. Chen, M. Dou, H. Fuchs. “Enhancement of 3D Capture of Room-sized Dynamic scenes with Pan-Tilt-Zoom Cameras,” International Symposium on Visual Computing (ISVC) 2014 (Las Vegas, Nevada, Dec. 8-10, 2014).

212. F. Zheng, T. Whitted, A. Lastra, P. Lincoln, A. State, A. Maimone, H. Fuchs. “Minimizing Latency for Augmented Reality Displays: Frames Considered Harmful,” IEEE ISMAR, International Symposium on Mixed and Augmented Reality, September 2014.

211. H. Fuchs, A. State, J. Bazin. “Immersive 3D Telepresence,” IEEE Computer. Vol.47, No. 7, pp. 46-52. July 2014.

210. D. Sonnenwald, H. Söderholm, G. Welch, B. Cairns, J. Manning, H. Fuchs. “Illuminating Collaboration in Emergency Health Care Situations: Paramedic-Physician Collaboration and 3D Telepresence Technology,” Information Research, 19(2) paper 618, 2014.

209. C. Fleury, T. Popa, T. Cham, H. Fuchs. “Merging Live and pre-Captured Data to Support Full 3D Head Reconstruction for Telepresence,” Eurographics 2014, (Strasbourg, France, April 7-11, 2014), pp. 9-12, 2014.

208. A. Maimone, D. Lanman, K. Rathinavel, K. Keller, D. Luebke, H. Fuchs. “Pinlight Displays: Wide Field of View Augmented Reality Eyeglasses Using Defocused Point Light Sources,” SIGGRAPH 2014 (Vancouver, Canada, August 10-14, 2014)

207. M. Dou and H. Fuchs. “Temporally Enhanced 3D Capture of Room-sized Dynamic Scene with Commodity Depth Cameras,” IEEE Virtual Reality 2014 Conference. **Best Short Paper Award.**

206. A. Maimone, R. Chen, H. Fuchs, R. Raskar, G. Wetzstein. “Wide Field of View Compressive Light Field Display using a Multilayer Architecture and Tracked Viewers,” Society of Information Display Week 2014 (San Diego, CA, June 1-6, 2014)

205. T. Deng, H. Li, J. Cai, T. Cham, H. Fuchs. “Kinect Shadow Detection and Classification,” 2013 IEEE International Conference on Computer Vision Workshops (ICCVW) 2013 (Sydney, Australia December 1-8, 2013)

204. A. Maimone and H. Fuchs. “Computational Augmented Reality Eyeglasses,” International Symposium on Mixed and Augmented Reality (ISMAR) 2013 (Adelaide, Australia, October 1-4, 2013).

203. M. Dou, H. Fuchs, J.-M. Frahm. “Scanning and Tracking Dynamic Objects with Commodity Depth Cameras,” International Symposium on Mixed and Augmented Reality (ISMAR) 2013 (Adelaide, Australia, October 1-4, 2013).

202. A. Sadagic, M. Kolsch, G. Welch, C. Basu, C. Darken, J. Wachs, H. Fuchs, H. Towles, N. Rowe, J.-M. Frahm, L. Guan, R. Kumar, H. Cheng. “Smart Instrumented Training Ranges: Bringing Automated System Solutions to Support Critical Domain Needs,” The Journal for Defense Modeling and Simulation (JDMS), Vol. 10 No. 3, July 2013.

201. A. Maimone, G. Wetzstein, M. Hirsch, D. Lanman, R. Raskar, H. Fuchs. “Focus 3D: Compressive Accommodation Display,” ACM Transactions on Graphics. 32, 5. Article 153 (September 2013).

200. A. Maimone, X. Yang, N. Dierk, A. State, M. Dou, H. Fuchs. “General-Purpose Telepresence with Head-Worn Optical See-Through Displays and Projector-Based Lighting,” IEEE Virtual Reality 2013 (Orlando, FL, USA, March 16-23, 2013) **Best Short Paper Award.**

199. D. Rivera-Gutierrez, G. Welch, P. Lincoln, M. Whitton, J. Cendan, D. Chesnutt, H. Fuchs, B. Lok. “Shader Lamps Virtual Patients: The Physical Manifestation of Virtual Patients,” Medicine Meets Virtual Reality 19 – NextMed, Studies in Health Technology and Informatics, IOS Press, 2012, 173:372-378.

198. R. Schubert, G. Welch, P. Lincoln, A. Nagendran, R. Pillat, and H. Fuchs. "Advances in Shader Lamps Avatars for Telepresence," Proceedings of 3DTV-Conference 2012: The True Vision: Capture, Transmission and Display of 3D Video, (ETH Zurich, Zurich, Switzerland), October 15-17 2012.

197. A. Maimone and H. Fuchs. "Real-Time Volumetric 3D Capture of Room-Sized Scenes for Telepresence," 3DTV Conference: The True Vision - Capture, Transmission and Display of 3D Video (3DTV-CON) 2012 (Zurich, Switzerland, October 15-17, 2012). doi: 10.1109/3DTV.2012.6365430

196. A. Maimone, J. Bidwell, K. Peng, H. Fuchs. "Enhanced Personal Autostereoscopic Telepresence System using Commodity Depth Cameras," Computers & Graphics, Volume 36, Issue 7, November 2012, pp. 791-807.

195. T. Peck, H. Fuchs, and M. Whitton. "The Design and Evaluation of a Large-Scale Real-Walking Locomotion Interface," IEEE Transactions on Visualization and Computer Graphics 18(7), July 2012, 1053-1067.

194. A. Maimone and H. Fuchs. "Reducing Interference Between Multiple Structured Light Depth Sensors Using Motion," IEEE Virtual Reality 2012 (Orange County, CA, USA, March 4-8, 2012) **Best Short Paper Award.**

193. M. Dou, L. Guan, J.-M. Frahm, H. Fuchs. "Exploring High-Level Plane Primitives for Indoor 3D Reconstruction with a Hand-held RGB-D Camera," ACCV (Asian Conference on Computer Vision) Workshops (2) 2012.

192. M. Dou, Y. Shi, J.-M. Frahm, H. Fuchs, B. Mauchly, M. Marathe. "Room-sized informal telepresence system," IEEE Virtual Reality 2012 Conference (Orange County, CA, March 4-8, 2012), pp. 15-18.

191. A, Maimone and H. Fuchs. "A First Look at a Telepresence System with Room-Sized Real-Time 3D Capture and Life-Sized Tracked Display Wall," 21st International Conference on Artificial Reality and Telexistence (ICAT) (Osaka, Japan, November 28-30, 2011).

190. P. Lincoln, G. Welch, A. Nashel, A. State, A. Ilie, H. Fuchs. "Animatronic shader lamps avatars," Virtual Reality 15(2-3): 225-238 (2011).

189. C. Burke, J. Cullen, A. State, S. Gadi, K. Wilber, R. Michael, A. Bulysheva, A. Pease, M. Mauro, H. Fuchs. "Development of an Animal Model for Radiofrequency Ablation of Primary, Virally Induced Hepatocellular Carcinoma in the Woodchuck," Journal of Vascular and Interventional Radiology, 22(11), p. 1613-1618, November 2011.

188. A. Maimone and H. Fuchs. "Encumbrance-free Telepresence System with Real-time 3D Capture and Display using Commodity Depth Cameras," International Symposium on Mixed and Augmented Reality (ISMAR) 2011 (Basel, Switzerland, October 26-29, 2011).

187 P. Lincoln, G. Welch, H. Fuchs. "Continual Surface-Based Multi-Projector Blending for Moving Objects," IEEE Virtual Reality 2011 (Singapore, March 19-23, 2011).

186. T. Peck, H. Fuchs, M. Whitton. "An Evaluation of Navigational Ability Comparing Redirected Free Exploration with Distractors to Walking-in-Place and Joystick Locomotion Interfaces," IEEE Virtual Reality 2011 (Singapore, March 19-23, 2011).

185. G. Ye, A. State, H. Fuchs. "A Practical Multi-viewer Tabletop Autostereoscopic Display," Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR) 2010 (Seoul, South Korea, October 13 -16, 2010).

184. T. Peck, H. Fuchs, M. Whitton. “Improved Redirection with Distractors: A Large-Scale-Real-Walking Locomotion Interface and its Effect on Navigation in Virtual Environments,” IEEE Virtual Reality 2010.

183. P. Lincoln, G. Welch, A. Nashel, A. State, A. Ilie, H. Fuchs. “Animatronic Shader Lamps Avatars,” Virtual Reality (2010), Springer, London, pp. 10-14.

182. T. Peck, H. Fuchs, M. Whitton. “Evaluation of Reorientation Techniques and Distractors for Walking in Large Virtual Environments,” IEEE Transactions on Visualization and Computer Graphics, pp. 383-394, May/June, 2009.

181. A. Nashel and H. Fuchs. “Random Hole Display: A Non-Uniform Barrier Autostereoscopic Display,” 3DTV 2009 Conference: The True Vision - Capture, Transmission and Display of 3D Video.

180. G. Welch, D. Sonnenwald, H. Fuchs, B. Cairns, K. Mayer-Patel, H. Soderholm, R. Yang, A. State, H. Towles, A. Ilie, M. Ampalam, S. Krishnan, V. Noel, M. Noland, J. Manning. “3D Medical Collaboration Technology to Enhance Emergency Healthcare,” The Journal of Biomedical Discovery and Collaboration 4:4 (2009).

179. H. Towles, T. Johnson, H. Fuchs. “Projector Based Displays,” The PSI Handbook of Virtual Environments for Training and Education Vol. 2 (2009). D. Nicholson, D. Schmorrow and J. Cohn (editors), Westport, Praeger Security International. pp. 63-89.

178. A. Sadagic, G. Welch, C. Basu, C. Darken, R. Kumar, H. Fuchs, H. Cheng, J.-M. Frahm, M. Kolsch, N. Rowe, H. Towles, J. Wachs, A. Lastra. “New Generation of Instrumented Ranges: Enabling Automated Performance Analysis,” Interservice/ Industry Training, Simulation, and Education Conference (I/ITSEC-2009), Orlando, FL.

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46. J. Rosenman, E. Chaney, S. Pizer, G. Sherouse, H. Fuchs, “The Value of Three-Dimensional Display Techniques in Radiation Therapy Treatment Planning,” International Journal of Radiation Oncology and Biomedical Physics, vol. 13, pp. 198, 1987.

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42. H. Fuchs. “VLSI-intensive Graphics Systems,” NATO Advanced Study Institute: Mathematics and Computer Science in Medical Imaging, Il Ciocco, Italy, 1986.

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40. J. Goldfeather, J. Hultquist, H. Fuchs. “Fast Constructive-Solid Geometry Display in the Pixel-Powers Graphics System,” Computer Graphics, vol. 20, (Proceedings, SIGGRAPH 1986), pp. 107-116, 1986.

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38. D. Bourland, E. Chaney, H. Fuchs, S. Mahaley, J. Naves, S. Pizer, J. Rosenman, G. Sherouse, E. Staab, M. Varia, R. Whaley. “Planning Stereotactic I-125 Implants of the Brain Using Interactive 2D and 3D Graphics,” Twenty-Seventh Annual Meeting of the American Association of Physicists in Medicine, 1985.

37. E. Chaney, H. Fuchs, S. Pizer, J. Rosenman, G. Sherouse, E. Staab, M. Varia. “A Three-Dimensional Imaging System for Radiotherapy Treatment Planning,” XIV International Conference on Medical and Biological Engineering and the VII International Conference on Medical Physics, Medical Biological Engineering and Computing, Espoo, Finland, 1985.

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32. H. Fuchs and J. Poulton. “Parallel Processing In Pixel-Planes, a VLSI Logic-Enhanced Memory for Raster Graphics,” ICCD'85, The IEEE International Conference on Computer Design, Port Chester, New York, 1985.

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29. G. Abram and H. Fuchs. “VLSI Architectures for Computer Graphics,” NATO Advanced Study Institute on Microarchitecture of VLSI Computers, Sogesta-Urbino, Italy, 1984.

28. G. Bishop and H. Fuchs. “The Self-Tracker: A Smart Optical Sensor on Silicon,” 1984 MIT Conference on Advanced Research in VLSI, Artech House, Dedham, MA, 1984.

27. H. Fuchs and S. Pizer. “Systems for Three-Dimensional Display of Medical Images,” 1984 International Joint Alpine Symposium on Medical Computer Graphics and Image Communications and Clinical Advances in Neuro CT/NMR, 1984.

26. E. Heinz, D. Osborne, B. Drayer, A. Yeates, H. Fuchs, S. Pizer. “Examination of the Extracranial Carotid Bifurcation by Thin-Section Dynamic CT: Direct Visualization of Intimal Atheroma in Man (Part 2),” American Journal of Neuroradiology, American Roentgen Ray Society, vol. 0195-6108/84/0504-0361, pp. 361-366, 1984.

25. E. Heinz, S. Pizer, H. Fuchs, E. Fram, P. Burger, B. Drayer, D. Osborne. “Examination of the Extracranial Carotid Bifurcation by Thin-Section Dynamic CT: Direct Visualization of Intimal Atheroma in Man (Part 1),” American Journal of Neuroradiology, American Roentgen Ray Society, vol. 0195-6108/84/0504-0355, pp. 355-359, 1984.

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23. H. Fuchs, G. Abram, E. Grant. “Near Real-Time Shaded Display of Rigid Objects,” Proceedings of ACM SIGGRAPH, vol. 17, pp. 65-72, 1983.

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20. H. Fuchs, Guest Editor. ACM Transactions on Graphics, Vol. 1, No. 1 (premier issue), 1982.

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18. H. Fuchs, S. Pizer, E. Heinz, L. Tsai, S. Bloomberg. “Adding a True 3-D Display to a Raster Graphic System,” IEEE Computer Graphics and Applications, vol. 2, pp. 73-78, 1982.

17. H. Fuchs, J. Poulton, A. Paeth, A. Bell. “Developing Pixel-Planes, a Smart Memory-Based Raster Graphics System,” MIT Conference on Advanced Research in VLSI, Artech House, Dedham, MA, 1982.

16. S. Pizer, H. Fuchs, E. Heinz, S. Bloomberg, L. Tsai. “Varifocal Mirror Display of Organ Surfaces from CT Scans,” World Congress of Nuclear Medicine and Biology, Paris, France, 1982.

15. H. Fuchs and J. Poulton. “Pixel-Planes: A VLSI-Oriented Design for a Raster Graphics Engine,” VLSI Design (formerly called Lambda), vol. 2, pp. 20-28, 1981.

14. J. Rosenberg and H. Fuchs. “Survey and Evaluation of Color-Display Terminals for VLSI,” VLSI Design (formerly called Lambda), vol. 2, pp. 58-60, 1981.

13. H. Fuchs and J. Poulton. “Pixel-Planes: A VLSI-Oriented Design for 3-D Raster Graphics,” Proceedings of the Canadian Man-Computer Communications Society 7th Conference (Waterloo, Ontario, 10-12 June 1981), pp. 343-347.

12. H. Fuchs, Z. Kedem, B. Naylor. “On Visible Surface Generation by a Priori Tree Structures,” Proceedings of ACM SIGGRAPH '80, Seattle, Washington, 1980.

11. Z. Kedem and H. Fuchs. “On Finding Several Shortest Paths in Certain Graphs,” Eighteenth Annual Allerton Conference on Communication, Control, and Computing, Champaign-Urbana, IL, 1980.

10. J. Barros and H. Fuchs. “Generating Smooth 2-D Monocolor Line Drawings on Video Displays,” Proceedings of ACM SIGGRAPH '79, Chicago, IL, 1979.

9. H. Fuchs and B. Johnson. “An Expandable Multiprocessor Architecture for Video Graphics (Preliminary Report),” 6th Annual ACM-IEEE Symposium on Computer Architecture, 1979.

8. H. Fuchs, Z. Kedem, B. Naylor. “Predetermining Visibility Priority in 3-D Scenes (Preliminary Report),” Proceedings of ACM SIGGRAPH '79, Chicago, IL, 1979.

7. H. Fuchs, S. Pizer, J. Cohen, J. Brooks. “A Three-Dimensional Display of Medical Images from Slices,” VIth International Conference on Information Processing in Medical Imaging (Traitement Des Informations en Imagerie Medicale), Paris, France, 1979.

6. H. Fuchs, J. Duran, B. Johnson, Z. Kedem. “Acquisition and Modeling of Human Body Form Data,” 1978 NATO Symposium on Applications of Human Biostereometrics, Paris, France, 1978.

5. H. Fuchs and Z. Kedem. “The ‘Highly Intelligent’ Tablet as an Efficient Pointing Device for Interactive Graphics (Preliminary Report),” 1978 Annual ACM Conference, 1978.

4. H. Fuchs. “Distributing a Visible Surface Algorithm over Multiple Processors,” Proc. 1977 ACM Annual Conference.

3. H. Fuchs, J. Duran, B. Johnson. “A System for Automatic Acquisition of Three-Dimensional Data,” 1977 National Computer Conference, 1977.

2. H. Fuchs, Z. Kedem, S. Uselton. “Optimal Surface Reconstruction from Planar Contours,” Communications of the ACM, vol. 20, pp. 693-702, 1977. (One of only two papers from SIGGRAPH’77 Conference selected to be published in Communications of the ACM.)

1. H. Fuchs, “The Automatic Sensing and Analysis of Three-Dimensional Surface Points from Visual Scenes,” Ph.D. Dissertation, Department of Computer Science, University of Utah, Salt Lake City, 1975.

Technical Reports (Selected)

D. Cotting, I. Nebel, M. Gross, H. Fuchs, “Towards a Continuous, Unified Calibration of Projectors and Cameras,” Computer Graphics Laboratory, ETH Zurich, Switzerland, and University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 2011.

T. Johnson, H. Towles, A. State, F. Wu, G. Welch, A. Lastra, H. Fuchs. “A Projector- based Physical Sand Table for Tactical Planning and Reviewing,” UNC Department of Computer Science, Chapel Hill, NC, 2009.

D. Bandyopadhyay, R. Raskar, A. State, and H. Fuchs, “Dynamic Spatially Augmented 3D Painting,” UNC Department of Computer Science, Chapel Hill, NC, 2001.

R. Raskar, H. Fuchs, G. Welch, A. Lake, and M. Cutts, “3D Talking Heads: Image Base Modeling at Interactive Rates Using Structured Light Projection,” UNC Department of Computer Science, Chapel Hill, NC, 1998.

W. Dally, L. McMillan, G. Bishop, and H. Fuchs, “The Delta Tree: An Object-Centered Approach to Image-Based Rendering,” MIT Artificial Intelligence Laboratory, Technical Memo 1604, Cambridge, MA, May 1996.

U. Neumann, A. State, H. Chen, H. Fuchs, T. Cullip, Q. Fang, M. Lavoie, and J. Rhoades, “Interactive Multimodal Volume Visualization for a Distributed Radiation-Treatment Planning Simulator,” UNC Department of Computer Science, Chapel Hill, NC, 1994.

H. Fuchs, J. Poulton, “Supercomputing Power for Interactive Visualization,” Report of Research Progress October 1990 – March 1991, UNC Department of Computer Science, Chapel Hill, NC, 1994.

H. Fuchs, F. Brooks. “Advanced Technology for Portable Personal Visualization,” Report of Research Progress, April – December 1991, UNC Department of Computer Science, Chapel Hill, NC, 1991.

H. Fuchs, J. Poulton, A. State, E. Hill, and R. Brusq. “An Architecture for Advanced Avionics Displays,” Wright Research and Development Center, Wright Patterson Air Force Base, OH TR90-7006, May 1990. 1990.

Invited Talks (Selected)

60. Keynote, 2019 World Conference on VR Industry, Nanchang, China, October 2019.

59. Keynote, ISMAR 2018, Munich, Germany, October 2018.

58. Google, SF, Aug. 2018.

57. Disney Research, Zurich, Switzerland, May 2018.

56. Snap Research, Venice, CA, Feb. 2018.

55. Vuforia, Vienna, Austria, Jan. 2018.

54. Keynote, ACM Multimedia Systems 2017, Taipei, Taiwan, June 2017.

53. Keynote, Eurographics 2016, Lisbon, Portugal, May 2016.

52. Technical University of Vienna, Symposium of Visual Computing Trends, January 2015

51. Samsung Developer Conference, San Francisco, November 2014

50. University of Maryland, Department of Computer Science, Distinguished Colloquia, October 2014.

49. Keynote (1 of 4), 5th International Conference on Remote Sensing in Archeology, Duke University, October 2014.

48. Keynote, IEEE VR 2014, Minneapolis, MN, March 2014.

47. Keynote, BEAMING Workshop, Barcelona, Spain, June 2011, "Toward Improved Telepresence: BeingThere International Research Center for Telepresence and Telecollaboration…and related work."

46. Keynote, Japan VR, Tokyo, Japan, December 2010.

45. Keynote, ISMAR 2010, Seoul, Korea, October 2010.

44. Keynote, IEEE International Symposium on Multimedia (ISM2010), Taichung, Taiwan, December 2010, "Physical and Digital Media of Telepresence."

43. ISMAR Symposium Workshop, Orlando, Florida, October 2009.

42. AMI-ARCS Workshop, London, England, September 2009.

41. NAIST, Japan, July 2009.

40. Keynote, NOSSDAV, Williamsburg, Virginia, June 2009, "Experiences Building Telepresence Systems."

39. University of Pennsylvania, Franklin Institute Symposium, RoboFest: A Celebration of Robotics at the GRASP Laboratory, April 2009.

38. NASA Langley Research Center, Initiated the Speaker Series on Virtual Worlds, April 2009.

37. 9th Marconi Research Conference, Office Ergonomics Research Committee (OERC), Marconi Center, Marshall, CA, January 2009.

36. Keynote, Graphics Hardware 2008, Sarajevo, Bosnia and Herzegovina June 20, 2008.

35. Keynote, PROCAMS 2008, Los Angeles, CA, August 9, 2008.

34. Keynote (1 of 2), Eurographics 2004, Grenoble, France, September 2004.

33. J. Barkley Rosser Distinguished Lecture, University of Wisconsin, Madison, WI, March 2001.

32. Distinguished Lecture, National Science Foundation (NSF), February 2001.

31. Address, Sesquicentennial Anniversary, University of Rochester, October 2000 (1 of 2 in Computer Science).

30. Distinguished Lecture, Stanford University Department of Computer Science, June 2000.

29. Keynote Address, Virtual Reality Software and Technology (VRST ’99), London, England, December 1999.

28. Keynote, 1st International Symposium on Mixed Reality (ISMR’99), Yokohama, Japan. Mar. 9, 1999.

27. University of Utah Department of Computer Science Distinguished Lecture, December 8, 1998.

26. Invited Paper, Advanced Multimedia Content Processing (AMCP’98), Osaka, Japan. Nov. 9, 1998.

25. Keynote, Advanced School for Computing and Imaging (ASCI’98), Lommel, Belgium. June 11, 1998.

24. Fraunhofer Inauguration Symposium, Virtual Environments Panel, Darmstadt, Germany, Oct. 30, 1997.

23. Keynote, Eurographics ‘97, Budapest, Hungary, September 6, 1997.

22. Keynote, Computer Graphics International’97, Hasselt, Belgium, June 25, 1997.

21. Keynote, 2nd Visualization Conference, Technicon, Haifa, Israel, June 30, 1996.

20. Keynote, 1995 Symposium on Interactive 3D Graphics, Monterey, CA, April 10-12, 1995.

19. University of Southern California Department of Computer Science Distinguished Lecture, Los Angeles, CA, Dec. 2, 1994.

18. Invited talk, The London VR User Show, VR in Medicine Workshop, London, England, September 1994.

17. IEEE EMBS 1994 International Summer School on Three-Dimensional Biomedical Imaging, to teach course on Virtual Reality in Medical Imaging, July 7-8, 1994.

16. Invited talk, ATR Workshop on Virtual Space Teleconferencing Systems, Kyoto, Japan, Dec. 3, 1993.

15. Invited talk, Computer Graphics International '92 (CGI '92), Tokyo, Japan, June 24, 1992.

14. NATO Advanced Research Workshop, Travemünde, Germany, June 26, 1990.

13. Keynote, First Conference on Visualization in Biomedical Computing, Atlanta, Georgia, May 23, 1990.

12. Keynote Address, Computer Graphics International, Leeds, UK, June 1989.

11. World Congress on Medical Physics and Biomedical Engineering, San Antonio, Texas, August 1988.

10. Member of panel on "Parallel Processing for Computer Vision and Display" at SIGGRAPH'88, August 1988.

9. Member of panel on "3D Imaging in Medicine: Pitfalls and Possible Remedies" at the National Computer Graphics Association annual conference, Anaheim, California, March 1988.

8. International Conference and Exhibition on Parallel Processing for Computer Vision and Display (sponsored by IBM - UK Labs, Univ. of Leeds, British Computer Society, Computer Graphics Society, Eurographics), University of Leeds, UK (January 1988).

7. NATO International Advanced Study Institute on Theoretical Foundations of Computer Graphics and CAD, Il Ciocco, Lucca, Italy (July 1987).

6. NATO International Advanced Study Institute on Mathematics and Computer Science in Medical Imaging, Il Ciocco, Lucca, Italy, (September 1986).

5. International Summer Institute (British Computer Society), State of the Art in Computer Graphics, Stirling, Scotland (June 1986).

4. NATO International Advanced Study Institute on Fundamental Algorithms for Computer Graphics, Ilkley, England (April 1985).

3. Qualitative Changes in the Future of Interactive Graphics. COMPCON 1985, San Francisco, California (February 1985).

2. Eurographics'85, Nice, France (September 1985) (1 of 4 keynotes).

1. NATO International Advanced Study Institute on Microarchitecture of VLSI Computers, Urbino, Italy (July 1984).