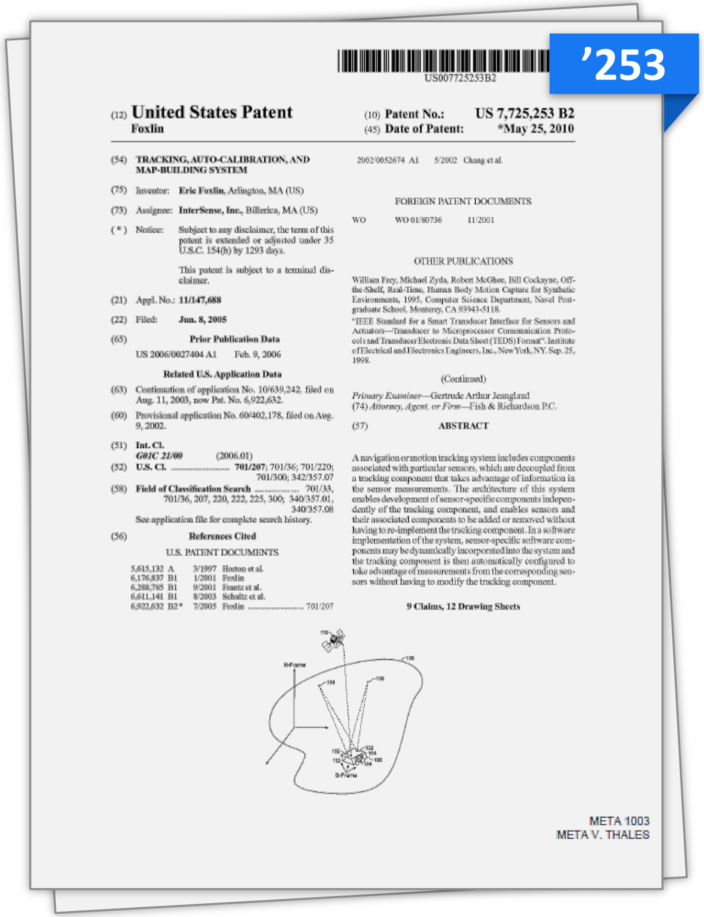
KIRKLAND & ELLIS LLP

U.S. Patent No. 7,725,253
IPR2022-01308
Petitioner's Demonstratives

META 1041
IPR2022-01305
META V. THALES

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

Sole Dispute Regarding Claim Is "Configuration Data"



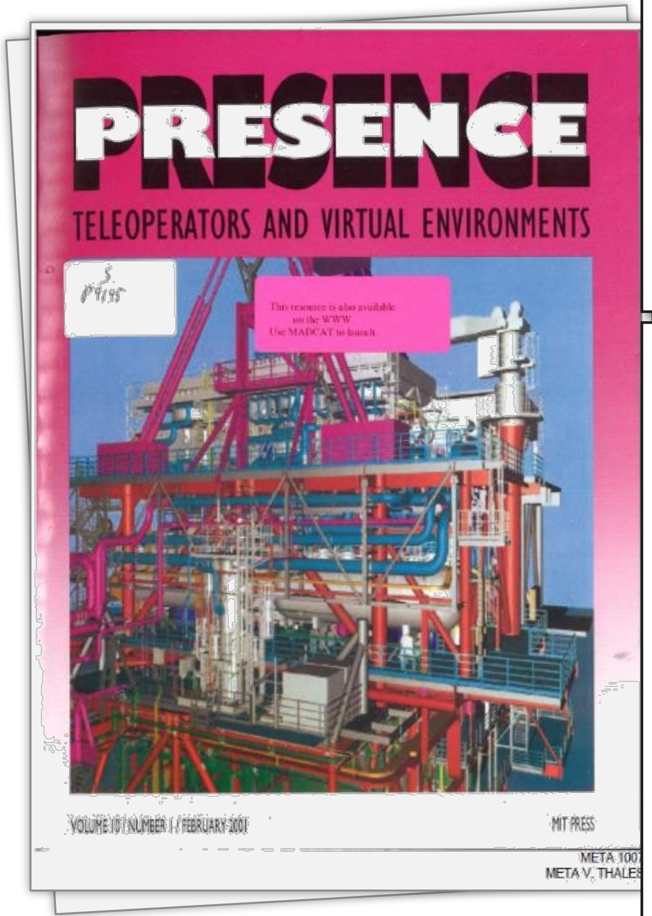
1. A tracking system comprising:
an estimation subsystem; and
a sensor subsystem coupled to the estimation subsystem and configured to provide **configuration data** to the estimation subsystem and to provide measurement information to the estimation subsystem for localizing an object;
wherein the estimation subsystem is configured to update a location estimate for the object based on configuration data and measurement information accepted from the sensor subsystem.

2. The system of claim 1 wherein the sensor subsystem includes one or more sensor modules, each providing an interface for interacting with a corresponding set of one or more sensing elements.

Ex. 1003 ('253 Patent) at cls. 1 and 2

Ground I: Welch-2001 + Welch-1997
See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1
See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

Welch's Offline And Online HiBall Measurements Are Used For "Calibration"



5 Methods

5.1 Bench-Top (Offline) HiBall Calibration

After each HiBall is assembled, we perform an off-line calibration procedure to determine the correspondence between image-plane coordinates and rays in space. This involves more than just determining the

To determine the mapping between sensor image-plane coordinates and three-space rays, we use a single LED mounted at a fixed location in the laboratory such that it is centered in the view directly out of the top lens of the HiBall. This ray defines the z or up axis for the HiBall coordinate system. We sample other rays by rotating the goniometer motors under computer control. We sample each view with rays spaced about every six minutes of arc throughout the field of view. We repeat each measurement 100 times to reduce the effects of noise on the individual measurements and to estimate the standard deviation of the measurements.

5.2 Online HiBall Measurements

Upon receiving a command from the CIB (section 4.3), which is synchronized with a CIB command to the ceiling, the HiBall selects the specified LEPD and performs three measurements, one before the LED flashes, one during the LED flash, and one after the LED flash. Known as "dark-light-dark," this technique is used to subtract out DC bias, low-frequency noise, and background light from the LED signal. We then convert the measured sensor coordinates to "ideal" coordinates using the calibration tables described in section 5.1.

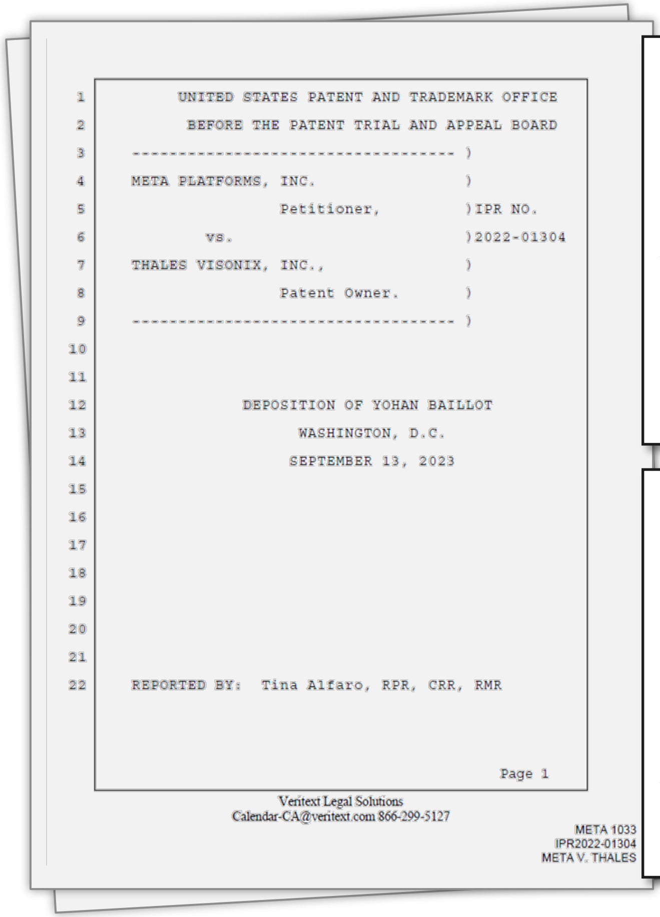
Ex. 1007 (Welch-2001) at 9-10

Ground I: Welch-2001 + Welch-1997

See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

Welch's "Calibration" Data Are Data Used To Configure The Estimation Subsystem ➔ "Configuration Data"


UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD
-----------------------------------)
META PLATFORMS, INC.)
Petitioner,) IPR NO.
vs.) 2022-01304
THALES VISIONIX, INC.,)
Patent Owner.)
-----------------------------------)

DEPOSITION OF YOHAN BAILLOT
WASHINGTON, D.C.
SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

META 1033
IPR2022-01304
META V. THALES

Q Do you agree that Kalman filters are configured at least according to the calibration parameters that they use?
A. **I think in some case, yes.** You might want to be more definitive on that. I don't have really an opinion right now as I stand.

Q. So in view of what the '632 Patent teaches, do you agree that Kalman filters are typically configured according to the calibration parameters that they use?
A. That's what it says here. **I would think in most instances they are.**

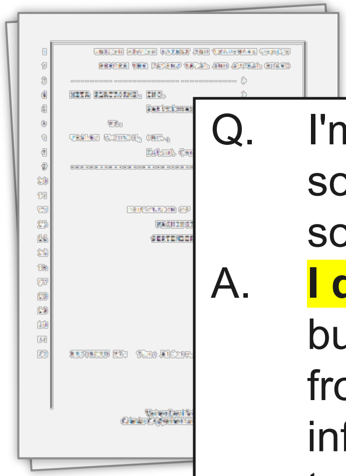
Ex. 1033 (Baillot Depo. Tr.) at 5:22-6:5, 7:6-11

Ground I: Welch-2001 + Welch-1997
See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1
See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

PO's Construction Of "Configuration Data" Is Not Supported

PO's Construction

"data describing characteristics or attributes of a sensor or set of sensors"



Q. I'm not able to find those specific words in the patent. And so did you find them in the patent or did you get them from somewhere else?

A. **I do not recall at this time.** I could scan the patent again, but it could be just also a way for me to define this further from reading the specification and seeing the type of information or data we are talking about. Basically I'm trying to say that it describes -- this information describes characteristics and attributes of a sensor.

Q. So you don't have an opinion as to whether this is the standard definition of the terms "configuration data" and "configuration information"?

A. **No.** I think "configuration data" and "configuration information" could be thought as many things, but for the purpose of this declaration I'm trying to define them further.

Ex. 1033 (Baillot Depo. Tr.) at 203:14-204:2, 205:1-8

Ground I: Welch-2001 + Welch-1997

See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

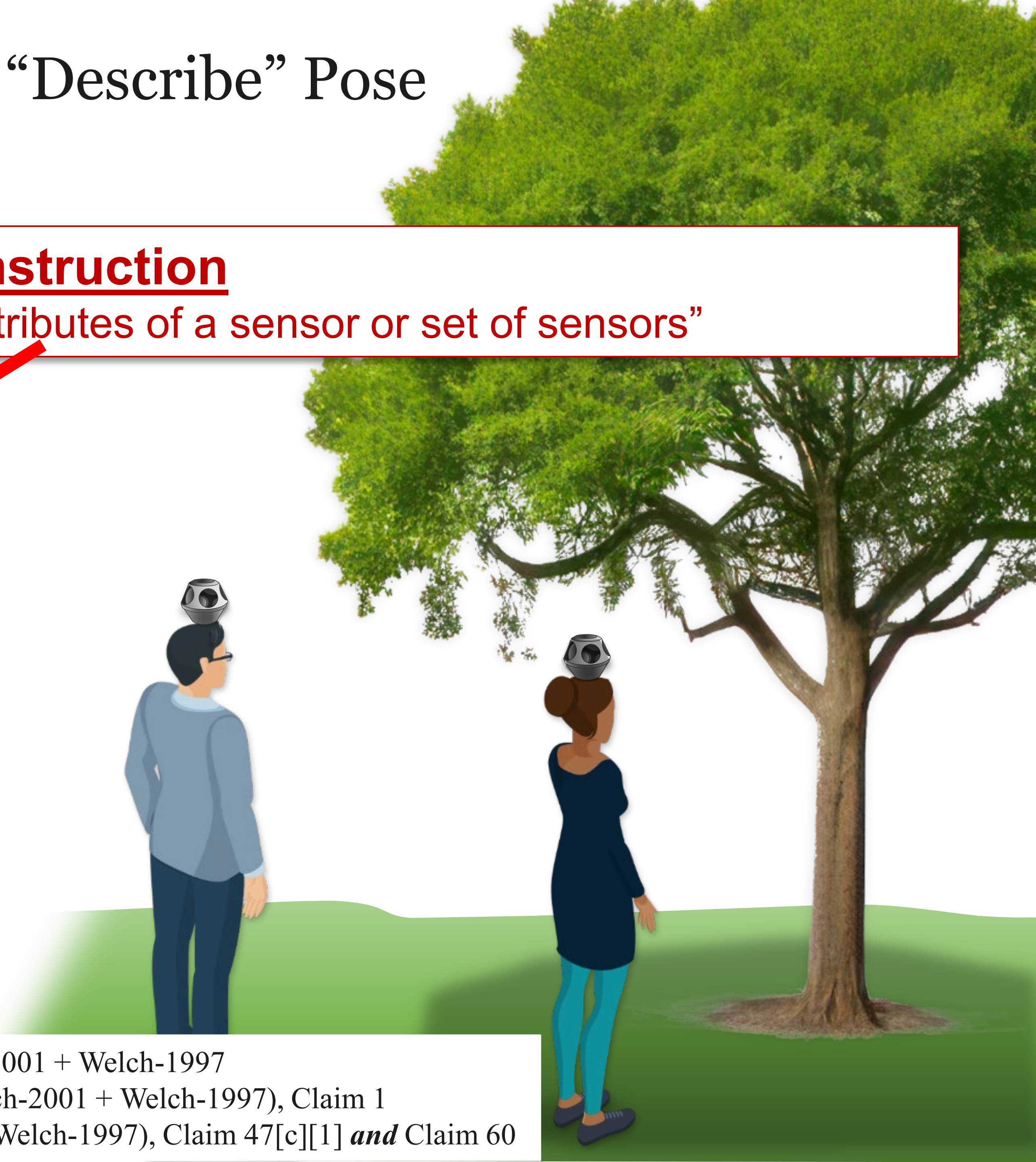
Welch’s Calibration Measurements “Describe” Pose And Satisfy PO’s Construction

PO’s Construction

“data describing characteristics or attributes of a sensor or set of sensors”

may be sensors or targets. Each PSE object has the following attributes:

(1) Pose (location and orientation) relative to the map of the environment or vehicle to which the PSE is attached.



Ex. 1003 (’253 Patent) at 30:3-6

Ground I: Welch-2001 + Welch-1997

See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1] ***and*** Claim 60

PO's Construction Of Its Own Construction Is Unsupported And Improper

PO's Construction

"data describing characteristics or attributes of a sensor or set of sensors"

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

THALES VISIONIX, INC.,
Patent Owner

U.S. PATENT NO. 7,725,253

IPR2022-01308

PATENT OWNER'S SUR-REPI

November 3, 2023

measurements can be configuration data under Patent Owner's construction. **The POSITA would not have understood Welch's raw measurements to "describe[e] characteristics or attributes of a sensor or set of sensors."** Patent Owner's Response

Paper 37 (PO's Sur-Reply) at 10

Ground I: Welch-2001 + Welch-1997
See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1
See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

Welch's Metadata Is Admittedly "Configuration Data"

PO's Construction

"data describing characteristics or attributes of a sensor or set of sensors"

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

THALES VISIONIX, INC.,
Patent Owner

U.S. PATENT NO. 7,725,253

IPR2022-01308

PATENT OWNER'S SUR-REPLY

November 3, 2023

Paper 37 (PO's Sur-Reply) at 11

does not provide any expert evidence that it is "configuration data." During system design, the Kalman filter would have been configured to work with the particular data type and format produced by the HiBalls. But that information is provided by the system designer; it is not "provid[ed]" by the "sensor subsystem." Ex.1033, 10:12-11:7, 12:4-13. Nor is the Kalman filter "configured" by receiving a

Ground I: Welch-2001 + Welch-1997

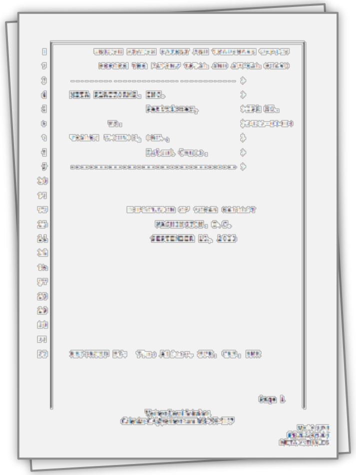
See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1] ***and*** Claim 59

PO's Expert Admitted Welch's Metadata Is Supplied By The HiBall Sensors

PO's Construction

"data describing characteristics or attributes of a sensor or set of sensors"



Q. And so I'd just like to confirm that Welch 2001's Kalman filters are configured according to the type and format of data **that it receives from the HiBall sensors**.

A. Again, no relationship with what I just read, but as **a general statement and understanding I would say it's correct** that it is done one time at the design stage of the system, and that system is not designed to ensure a configuration of those data of this Kalman filter that can be changed. So it has been done once, just to be clear.

Ex. 1033 (Baillot Depo. Tr.) at 10:12-22

Ground I: Welch-2001 + Welch-1997

See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

PO’s Complaints Regarding Allegedly New Argument Are Irrelevant In View Of PO’s Post-Institution Constructions

“We hold that where a patent owner in an IPR first proposes a claim construction in a patent owner response, a petitioner must be given the opportunity in its reply to argue and present evidence of anticipation or obviousness under the new construction, at least where it relies on the same embodiments for each invalidity ground as were relied on in the petition”

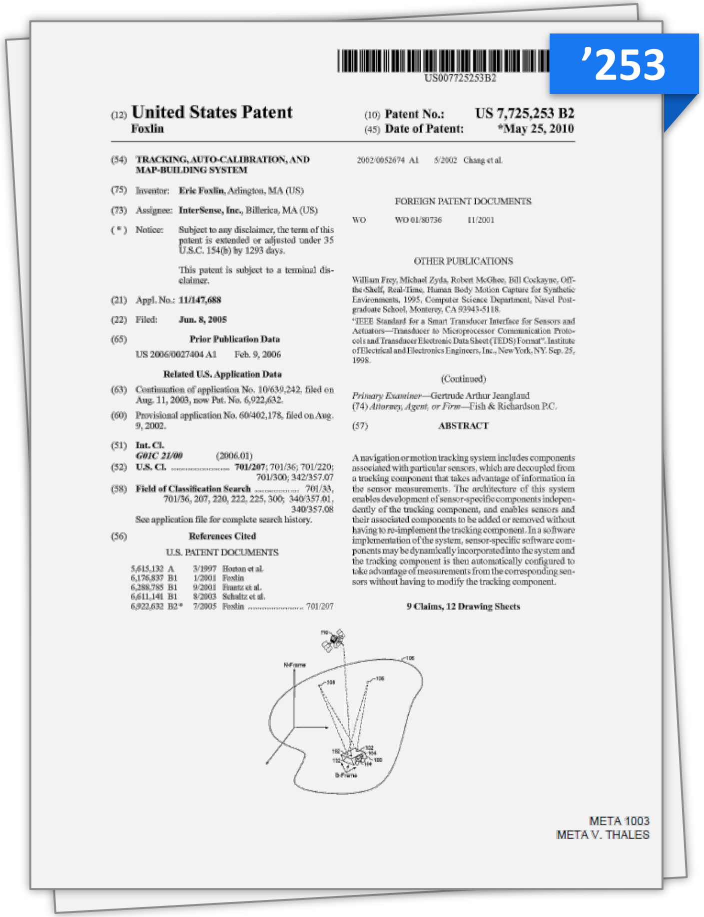
Axonics, Inc. v. Medtronic, Inc., 75 F.4th 1374, 1384 (Fed. Cir. 2023)

Ground I: Welch-2001 + Welch-1997

See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 1

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 47[c][1]

Claims 6 And 8


’253

US007725253B2

(12) **United States Patent**
Foxlin

(10) **Patent No.:** **US 7,725,253 B2**
(45) **Date of Patent:** ***May 25, 2010**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Billerica, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1293 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/147,688**

(22) Filed: **Jun. 8, 2005**

(65) **Prior Publication Data**

US 2006/0027404 A1 Feb. 9, 2006

Related U.S. Application Data

(63) Continuation of application No. 10/639,242, filed on Aug. 11, 2003, now Pat. No. 6,922,632.

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**
G01C 21/00 (2006.01)

(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07

(58) **Field of Classification Search** 701/33, 701/36, 207, 220, 222, 225, 300; 340/357.01, 340/357.08

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,615,132 A	3/1997	Horton et al.	
6,176,837 B1	1/2001	Foxlin	
6,288,785 B1	9/2001	Frantz et al.	
6,611,141 B1	8/2003	Schulz et al.	
6,922,632 B2*	7/2005	Foxlin	701/207
2002/0052674 A1	5/2002	Chang et al.	

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

William Frey, Michael Zyda, Robert McGhee, Bill Cockayne, Off-the-Shelf, Real-Time, Human Body Motion Capture for Synthetic Environments, 1995, Computer Science Department, Navel Post-graduate School, Monterey, CA 93943-5118.

"IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format", Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

(Continued)

Primary Examiner—Gertrude Arthur Jeanglaud
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

9 Claims, 12 Drawing Sheets

META 1003
META V. THALES

6. A method comprising:
enumerating sensing elements available to a tracking system that includes an estimation subsystem that estimates a position or orientation of an object; and
providing parameters specific to the enumerated sensing elements to the tracking system to enable the estimation subsystem to be configured based on the parameters specific to the enumerated sensing elements to enable the estimation subsystem to estimate the position or orientation of the object.

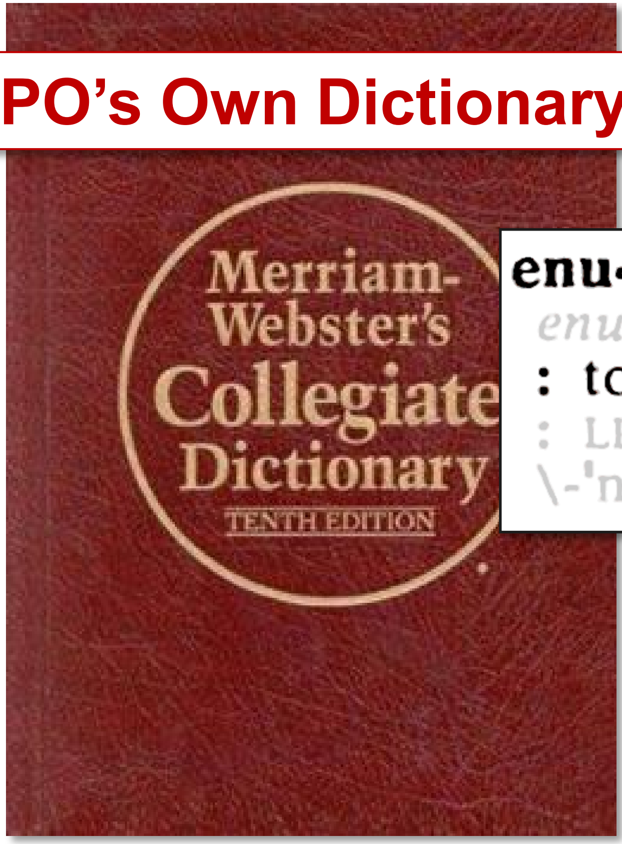
8. The method of claim 6 wherein the set of sensing elements comprises at least one sensor and at least one target, the sensor making a measurement with respect to the target.

Ex. 1003 (’253 Patent) at cls. 6 and 8

Ground I: Welch-2001 + Welch-1997
See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 33[a]

“E**numer**ating” = “Determining The Number Of”

PO’s Own Dictionary



enu•mer•ate \i-ˈn(y)ü-mə-ˌrāt\ *vt* **-at•ed; -at•ing** [L *enumeratus*, pp. of *enumerare*, fr. *e-* + *numerare* to count, fr. *numerus* number] (1616) **1 : to ascertain the number of** : COUNT **2 :** to specify one after another : LIST — **enu•mer•a•tion** \-ˌn(y)ü-mə-ˈrā-shən\ *n* — **enu•mer•a•tive** \-ˈn(y)ü-mə-ˌrā-tiv, -ˈn(y)üm-rə-, -ˈn(y)ü-mə-rə-\ *adj*

Ex. 2015

Welch “Enumerates” Under PO’s Express Construction

Declaration of Ulrich Neumann, Ph.D.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.
Petitioner

v.

THALES VISIONIX, INC.
Patent Owner

U.S. Patent No. 6,922,632
U.S. Patent No. 7,725,253

Cases IPR2022-01304, IPR2022-01305, IPR2022-01308

SUPPLEMENTAL DECLARATION OF DR. ULRICH NEUMANN IN SUPPORT OF PETITIONER’S REPLY TO PATENT OWNER’S RESPONSE TO PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NOS. 6,922,632 AND 7,725,253

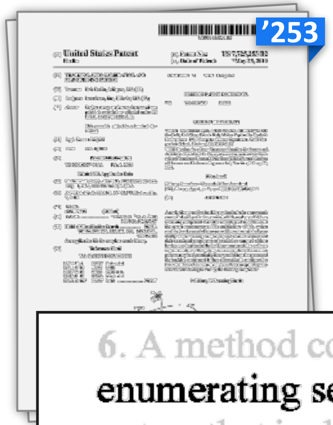
META 1038
IPR2022-01308
META V. THALES

16. In practice, a person of ordinary skill in the art would have recognized that this specifying process would be reflected in code as the instantiation of a module associated with each sensor. Even if each HiBall unit were instantiated with

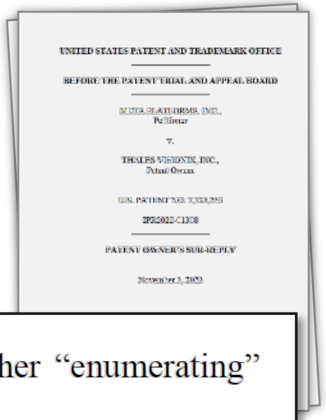
Ex. 1038 (Supplemental Neumann Declaration) ¶ 16

Ground I: Welch-2001 + Welch-1997
See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 33[a]

PO Adds Implied Requirements Beyond Its Express "Enumerating" Construction



6. A method comprising:
enumerating sensing elements available to a tracking system that includes an estimation subsystem that estimates a position or orientation of an object; and
providing parameters specific to the enumerated sensing elements to the tracking system to enable the estimation subsystem to be configured based on the parameters specific to the enumerated sensing elements to enable the estimation subsystem to estimate the position or orientation of the object.



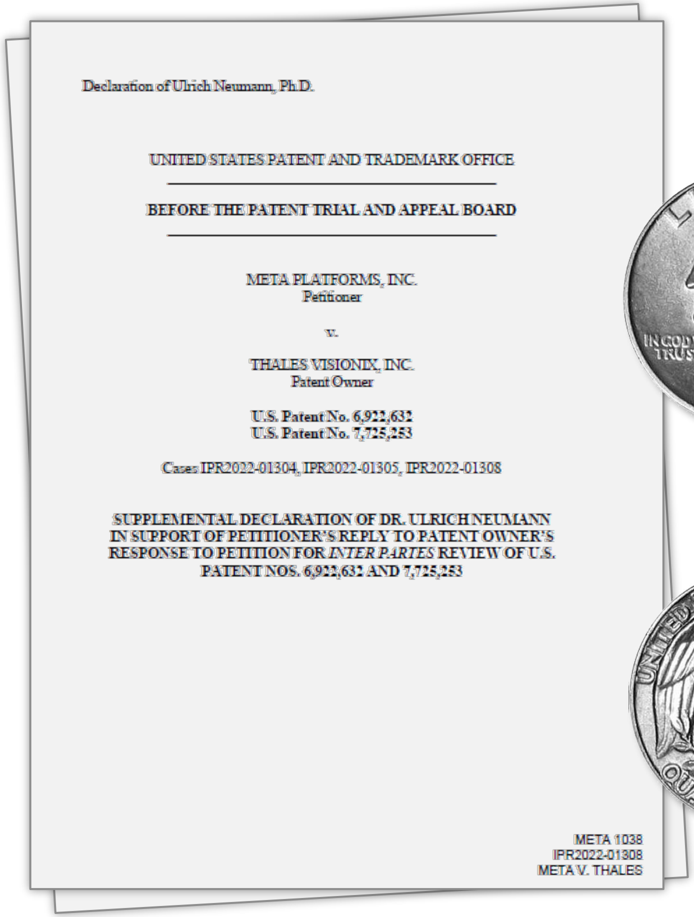
POR 23-24; Ex.2007 ¶74. Petitioner disputes (Reply 7) whether "enumerating" must involve specifying or listing each available sensor, or whether it can be satisfied by simply determining the number of sensors available, but does not contest that "enumerating," as claimed in the '253 patent, is a "process *performed by the system*." The patent repeatedly describes the system itself doing the enumerating, Ex.2007 ¶74, and never suggests that a human could satisfy this step at system design. Petitioner, however, relies on a human programming the sensors into the PC. Reply

Ex. 1003 ('253 Patent) at cl. 6; Paper 37 (PO's Sur-Reply) at 11

Ground I: Welch-2001 + Welch-1997

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 33[a]

Welch "Enumerates" Under PO's Express AND Implied Constructions


Declaration of Ulrich Neumann, Ph.D.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.
Petitioner

v.

THALES VISIONIX, INC.
Patent Owner

U.S. Patent No. 6,922,632
U.S. Patent No. 7,725,253

Cases IPR2022-01304, IPR2022-01305, IPR2022-01308

SUPPLEMENTAL DECLARATION OF DR. ULRICH NEUMANN IN SUPPORT OF PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE TO PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NOS. 6,922,632 AND 7,725,253

META 1038
IPR2022-01308
META V. THALES

15. Since "each" HiBall unit needs to be calibrated, and different embodiments of Welch-2001's system have different numbers of HiBall units attached to it, something must specify to the PC (which performs Welch-2001's tracking calculations) how many sensing elements are available to it, so that the system knows how many calibration procedures to perform.

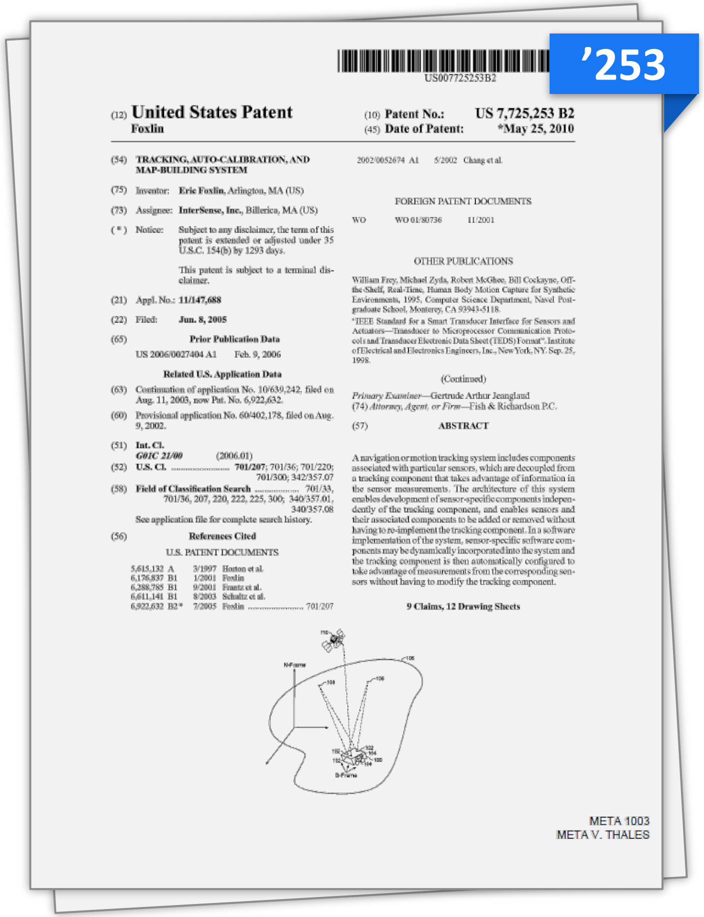
16. In practice, a person of ordinary skill in the art would have recognized that this specifying process would be reflected in code as the instantiation of a module associated with each sensor. Even if each HiBall unit were instantiated with

Ex. 1038 (Supplemental Neumann Declaration) ¶¶ 15-16

Ground I: Welch-2001 + Welch-1997

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 33[a]

Claim 7: “Highest Expected Utility”



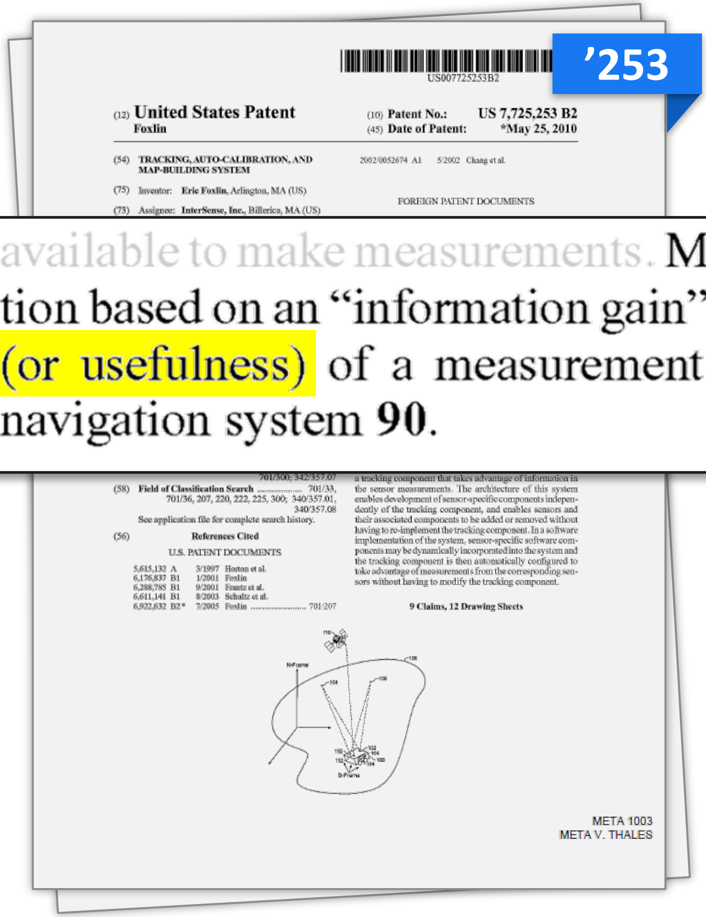
7. The method of claim **6**, further comprising selecting a pair of sensing elements from a sequence of candidates of pairs of sensing elements, the selected pair of sensing elements being ready to make a measurement at the time of selection of the pair or at a predefined time after the time of selection of the pair, the selected pair having a highest expected utility of a measurement among the sequence of candidates.

Ex. 1003 (US 7,725,253) at cl. 7

Ground I: Welch-2001 + Welch-1997

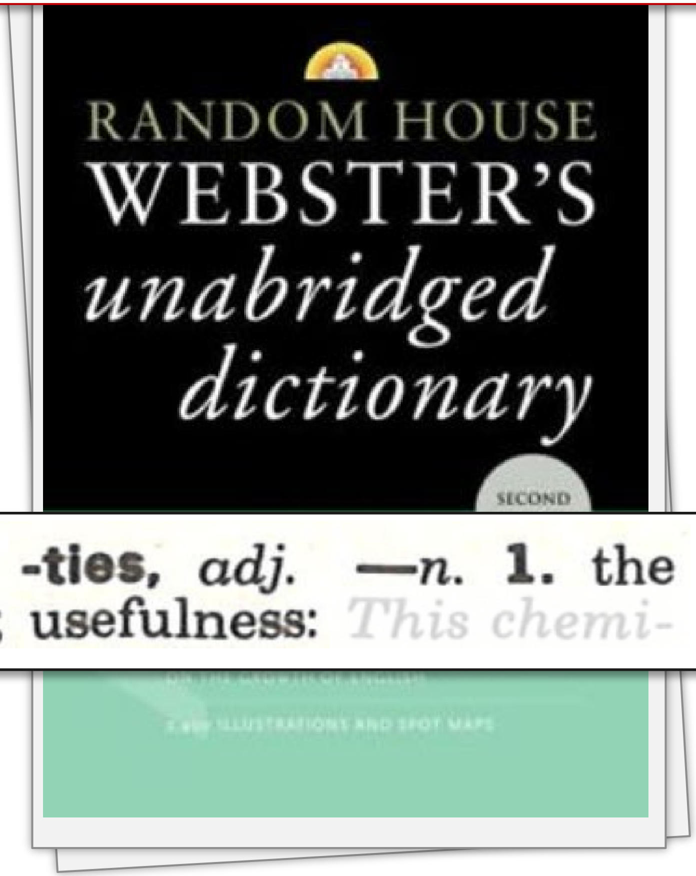
See also -01304 Ground I (Welch-2001 + Welch 1997) ***and*** Ground IV (Horton), Claim 33

Claim 7: “Highest Expected Utility” = “Highest Expected Usefulness”



available to make measurements. MMU **304** makes the selection based on an “information gain” that represents the utility (or usefulness) of a measurement by the pair of PSEs to navigation system **90**.

PO’s Own Dictionary



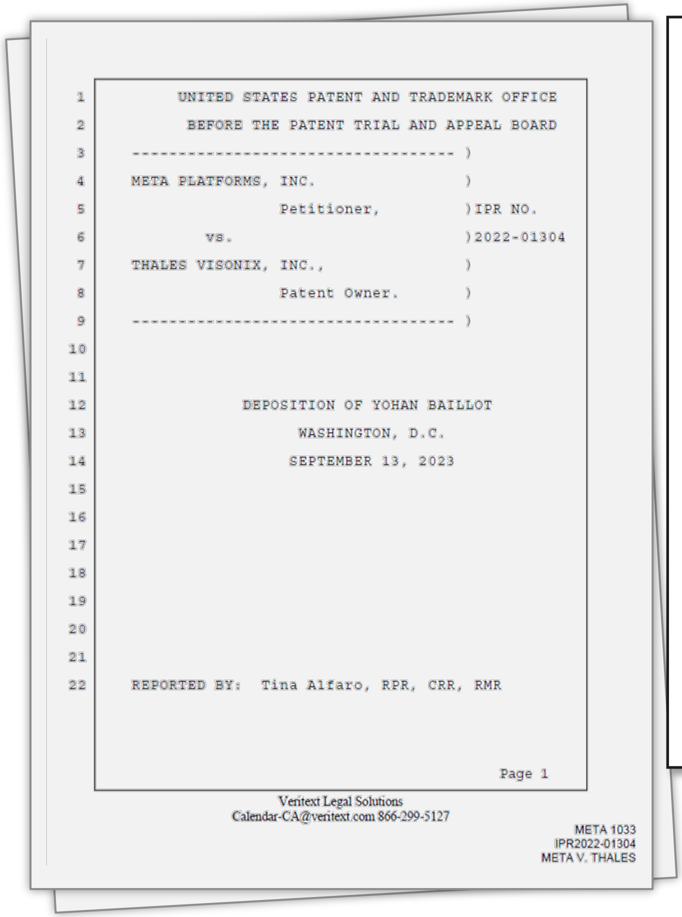
u•til•i•ty (yo͞o til′i tē), *n., pl.* **-ties,** *adj.* —*n.* **1.** the state or quality of being useful; usefulness: *This chemi-*

Ex.1003 (’253 Patent) at 19:9-12 ; EX1034

Ground I: Welch-2001 + Welch-1997

See also -01304 Ground I (Welch-2001 + Welch 1997) ***and*** Ground IV (Horton), Claim 33

PO Has No Evidence That Welch's "Least Recently Used" Heuristic Is Not The Most "Useful" Option


UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

-----------------------------------)
META PLATFORMS, INC.)
Petitioner,) IPR NO.
vs.) 2022-01304
THALES VISONIX, INC.,)
Patent Owner.)
-----------------------------------)

DEPOSITION OF YOHAN BAILLOT
WASHINGTON, D.C.
SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

META 1033
IPR2022-01304
META V. THALES

Q. Right. And so I just want to know if you have any reason to believe that when Welch chose to use the least recently used heuristic, did he expect it would be less useful than the alternative heuristics available to him?

A. I don't see any discussion of that in this paper or reference. I don't believe I have addressed that in my declaration. So without more detail I cannot really form a complete opinion on this today.

Ex. 1033 (Baillot Depo. Tr.) at 55:6-16

Ground I: Welch-2001 + Welch-1997
See also -01304 Ground I (Welch-2001 + Welch 1997), Claims 33-34

Welch's "Least Recently Used" Heuristic Would Admittedly Have A Highest Expected Information Gain At Least Some Of The Time

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner,
vs.
THALES VISONIX, INC.,
Patent Owner.

IPR NO. 2022-01304

DEPOSITION OF YOHAN BAILLOT
WASHINGTON, D.C.
SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

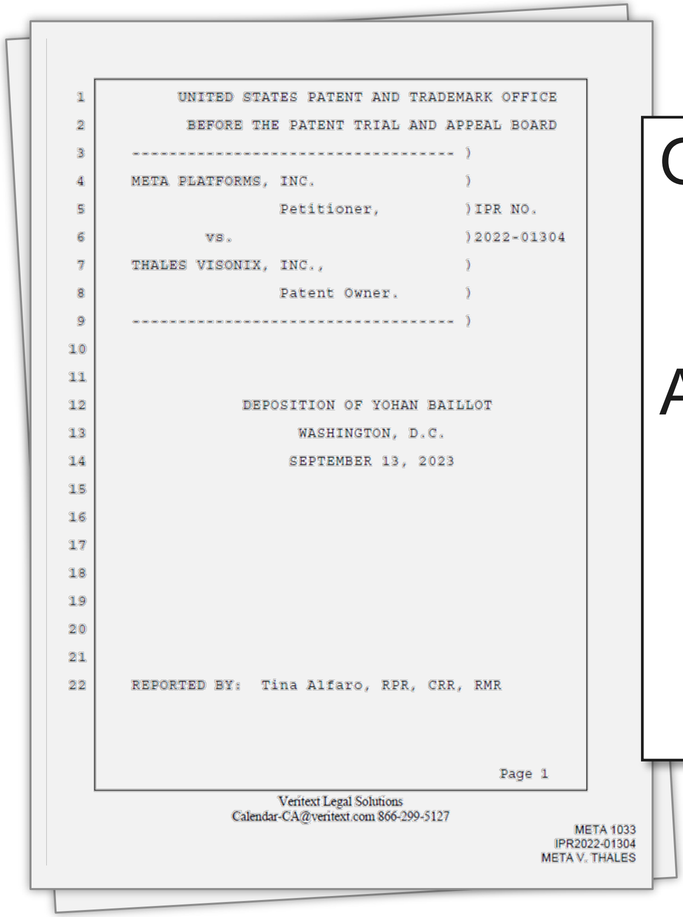
META 1033
IPR2022-01304
META V. THALES

Q. Are there scenarios where the least recently used LED would provide the greatest information gain?
A. I think there is some situation where the selected LED as per this process would lead to a greater information gain than another, yes.

Ex. 1033 (Baillot Depo. Tr.) at 56:8-13

Ground I: Welch-2001 + Welch-1997
See also -01304 Ground I (Welch-2001 + Welch 1997), Claims 33-34

Claim 9: Typical Camera Flash Can Replace Welch's "Dark-Light-Dark" Sequence



UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

----------------------------------)
META PLATFORMS, INC.)
Petitioner,) IPR NO.
vs.) 2022-01304
THALES VISONIX, INC.,)
Patent Owner.)
----------------------------------)

DEPOSITION OF YOHAN BAILLOT
WASHINGTON, D.C.
SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

META 1033
IPR2022-01304
META V. THALES

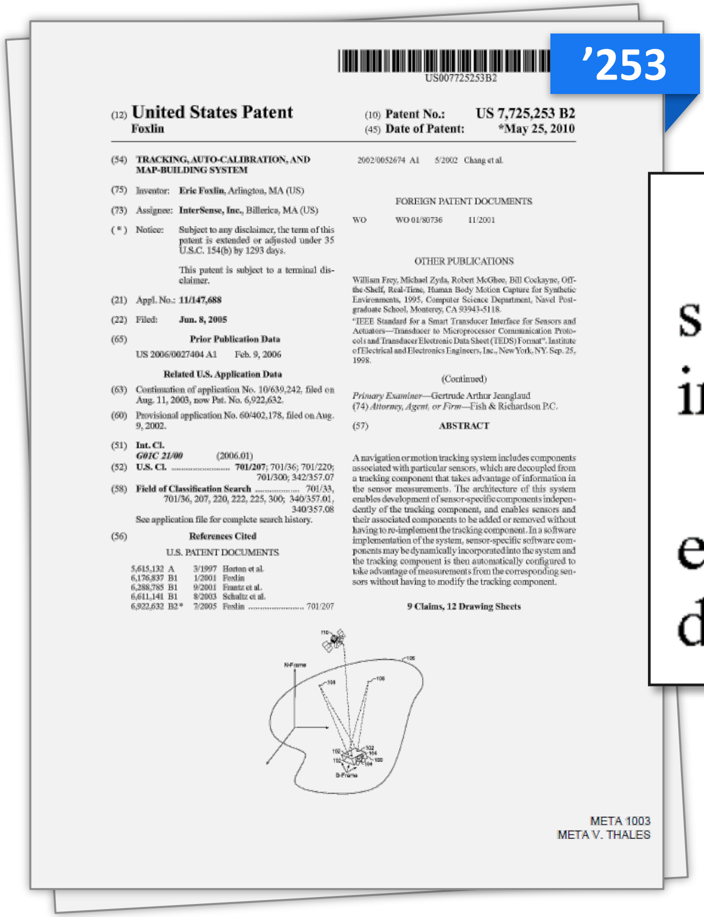
Q. So could this dark-light-dark process be performed instead with passive targets where the flash is emitted by the HiBall instead of by the LED target?

A. **I think there is probably some scenario, yes**, but it depends on how would you build such a system. Probably other factors to consider that are changing between using these LED's and using some other thing that can do what you are suggesting.

Ex. 1033 (Baillot Depo. Tr.) at 61:5-14

Ground I: Welch-2001 + Welch-1997
See also -01304 Ground I (Welch-2001 + Welch-1997), Claim 27

Claims 3-4: Only Unique Dispute Is Motivation To Combine



’253

US007725253B2

(12) **United States Patent**
Foxlin

(10) **Patent No.:** **US 7,725,253 B2**
(45) **Date of Patent:** ***May 25, 2010**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Billerica, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1293 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/147,688**

(22) Filed: **Jun. 8, 2005**

(65) **Prior Publication Data**

US 2006/0027404 A1 Feb. 9, 2006

Related U.S. Application Data

(63) Continuation of application No. 10/639,242, filed on Aug. 11, 2003, now Pat. No. 6,922,632.

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**
G01C 21/00 (2006.01)

(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07

(58) **Field of Classification Search** 701/33, 701/36, 207, 220, 222, 225, 300; 340/357.01, 340/357.08

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,615,132 A 3/1997 Horton et al.
6,176,837 B1 1/2001 Foxlin
6,288,785 B1 9/2001 Frantz et al.
6,611,141 B1 8/2003 Schultz et al.
6,922,632 B2* 7/2005 Foxlin 701/207
2002/0052674 A1 5/2002 Chang et al.

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

William Frey, Michael Zyda, Robert McGhee, Bill Cockayne, Off-the-Shelf, Real-Time, Human Body Motion Capture for Synthetic Environments, 1995, Computer Science Department, Naval Postgraduate School, Monterey, CA 93943-5118.

"IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format". Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

(Continued)

Primary Examiner—Gertrude Arthur Jeanglaud
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

9 Claims, 12 Drawing Sheets

META 1003
META V. THALES

3. The system of claim **2** wherein the interface enables the sensor module to perform computations independently of an implementation of the estimation subsystem.

4. The system of claim **2** wherein the interface enables the estimation subsystem to perform computations independently of an implementation of the sensor modules.

Ex. 1003 (’253 Patent) at cls. 3 and 4

Ground II (Welch-2001/1997 + Harris) and Ground III (Welch-2001/1997 + Reitmayr)
See also **-**01305 Ground III (Welch-2001/1997 + Harris)

Harris's And Reitmayr's "Distributed" Systems Increase Processing Speed, Which Increases Accuracy

United States Patent [19] — Harris

US005307289A

[11] Patent Number: 5,307,289
[45] Date of Patent: Apr. 26, 1994

[54] METHOD AND SYSTEM FOR RELATIVE GEOMETRY TRACKING UTILIZING MULTIPLE DISTRIBUTED EMITTER/DETECTOR LOCAL NODES AND MUTUAL LOCAL NODE TRACKING

[75] Inventor: James C. Harris, Vienna, Va.
[73] Assignee: Sesco Corporation, Vienna, Va.
[21] Appl. No.: 758,782
[22] Filed: Sep. 12, 1991
[51] Int. Cl.[5] G01S 13/06
[52] U.S. Cl. 364/516; 364/460
[58] Field of Search 364/460, 559, 516;

Acoustics, Speech, and Signal Processing, vol. ASSP-33, No. 4, Oct. 1985, pp. 1123–1128.

Primary Examiner—Jack B. Harvey
Assistant Examiner—Thomas Pesso
Attorney, Agent, or Firm—Hoffman, Wasson & Gitler

[57] ABSTRACT

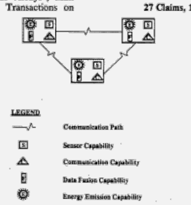
A method and system for tracking various objects utilizing a plurality of sensors. Separate locations or platforms are provided with a number of sensors collocated with an energy generation/ reflection device, and also a communication device. Each of the platforms is termed local nodes of a multi-sensor fusion system, and possibly

> The primary object of this invention is to provide a novel method for relative geometry and relative orientation state tracking which **can obtain much greater accuracies** than the prior art. An additional object is to

"Multiple Site Radar Tracking System", B. H. Cantrell and A. Grindlay, IEEE International Radar Conference, pp. 348–354 (1980) Apr.
"Decentralized Processing in Sensor Arrays", Mati Wax and Thomas Kailath, IEEE Transactions on

relative geometries are either range normalized or scaled with actual ranges depending upon sensor capabilities.

27 Claims, 11 Drawing Sheets



META 1011
META V. THALES

> 79. In my opinion, it would have been well-known to a POSITA that a distributed processing system would provide efficiency benefits. For example, a POSITA would have understood that implementing a distributed system would allow for increased processing speed, reduced need for communication between processors, the ability to balance the computational load on each processor, and smaller required memory or storage bandwidth and size. Specifically in the tracking

Ex. 1005 (Neumann Declaration) ¶ 79 (Harris) and ¶ 92 (Reitmayr); Ex. 1011 (Harris) at 4:14-17

PO's Contention That Using Distributed FPGAs Would Reduce "Flexibility" Is Factually False

intel®

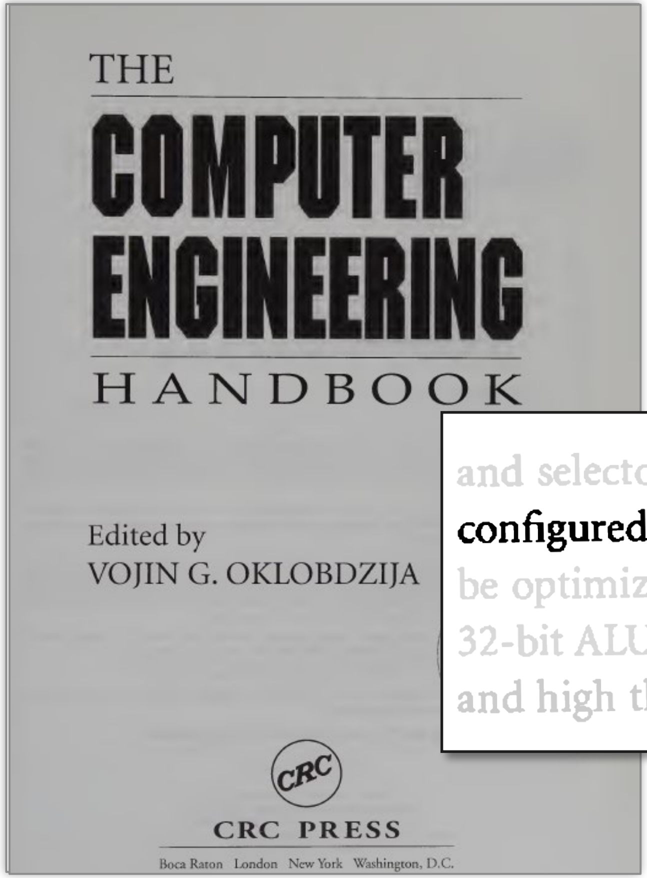
FPGA Advantages:

- Efficiency: Data processing pipeline tuned exactly to the needs of software. No need for control units, instruction fetch units, register writeback, and other execution overhead.
- Custom Instructions: Instructions not natively supported by CPUs/GPUs can be easily implemented and efficiently executed on FPGAs (e.g., bit manipulations).
- Data Dependencies across Parallel Work can be resolved without stalls to the pipeline.
- Flexibility: FPGAs can be reconfigured to accommodate different functions and data types, including non-standard data types.

No objection or response by PO

Ex. 1036 at 5; -01308, Paper 33 (Petitioner's Reply) at 16

PO's Contention That Using Distributed FPGAs Would Reduce "Flexibility" Is Factually False



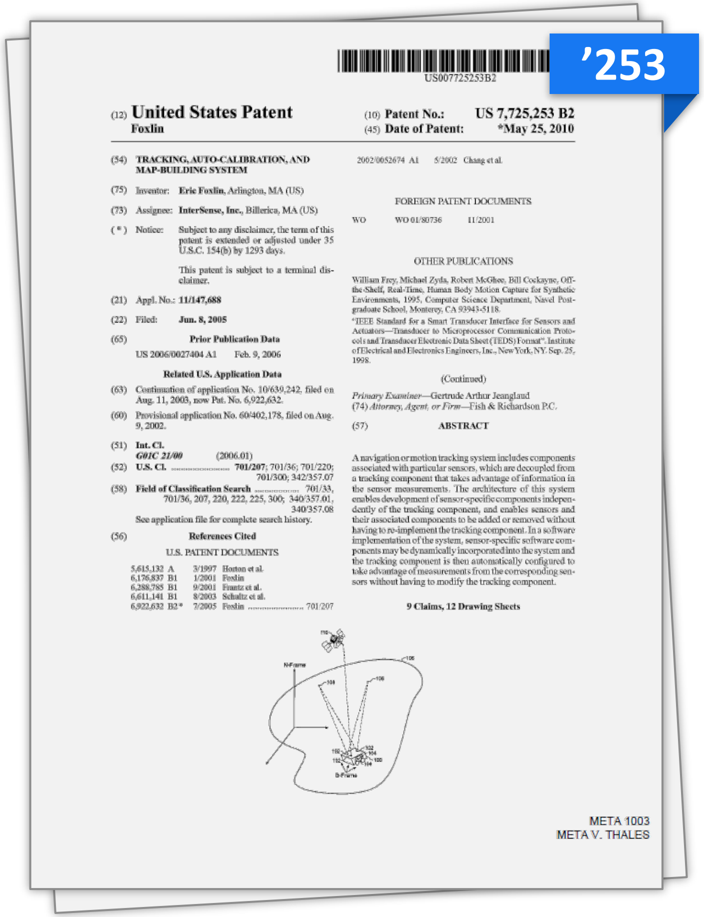
No objection or response by PO

and selectors as shown in Fig. 19.6. The features are: **(1) It is quite flexible. Basically, the FPGA can be configured to any dedicated function if integrated gate capacity is enough to map it;** (2) Structure can be optimized without being limited to prefixed data width and variation of function unit like a general 32-bit ALU of CPU. Therefore, FPGA is not used only for prototyping but also where high performance and high throughput are targeted. (3) It is very inefficient in power. Switch network for fine-grain level

Ex. 1035 at 5

Ground II (Welch-2001/1997 + Harris) and Ground III (Welch-2001/1997 + Reitmayr)
See also -01305 Ground III (Welch-2001/1997 + Harris)

Claim 1


US007725253B2

’253

(12) **United States Patent**
Foxlin

(10) **Patent No.: US 7,725,253 B2**
(45) **Date of Patent: *May 25, 2010**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Billerica, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1293 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/147,688**

(22) Filed: **Jun. 8, 2005**

(65) **Prior Publication Data**

US 2006/0027404 A1 Feb. 9, 2006

Related U.S. Application Data

(63) Continuation of application No. 10/639,242, filed on Aug. 11, 2003, now Pat. No. 6,922,632.

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**
G01C 21/00 (2006.01)

(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07

(58) **Field of Classification Search** 701/33, 701/36, 207, 220, 222, 225, 300; 340/357.01, 340/357.08

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,615,132	A	3/1997	Horton et al.	
6,176,837	B1	1/2001	Foxlin	
6,288,785	B1	9/2001	Frantz et al.	
6,611,141	B1	8/2003	Schultz et al.	
6,922,632	B2 *	7/2005	Foxlin	701/207
2002/0052674	A1	5/2002	Chang et al.	

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

William Frey, Michael Zyda, Robert McGhee, Bill Cockayne, Off-the-Shelf, Real-Time, Human Body Motion Capture for Synthetic Environments, 1995, Computer Science Department, Naval Postgraduate School, Monterey, CA 93943-5118.

"IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format", Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

(Continued)

Primary Examiner—Gertrude Arthur Jeanglaud
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

9 Claims, 12 Drawing Sheets

META 1003
META V. THALES

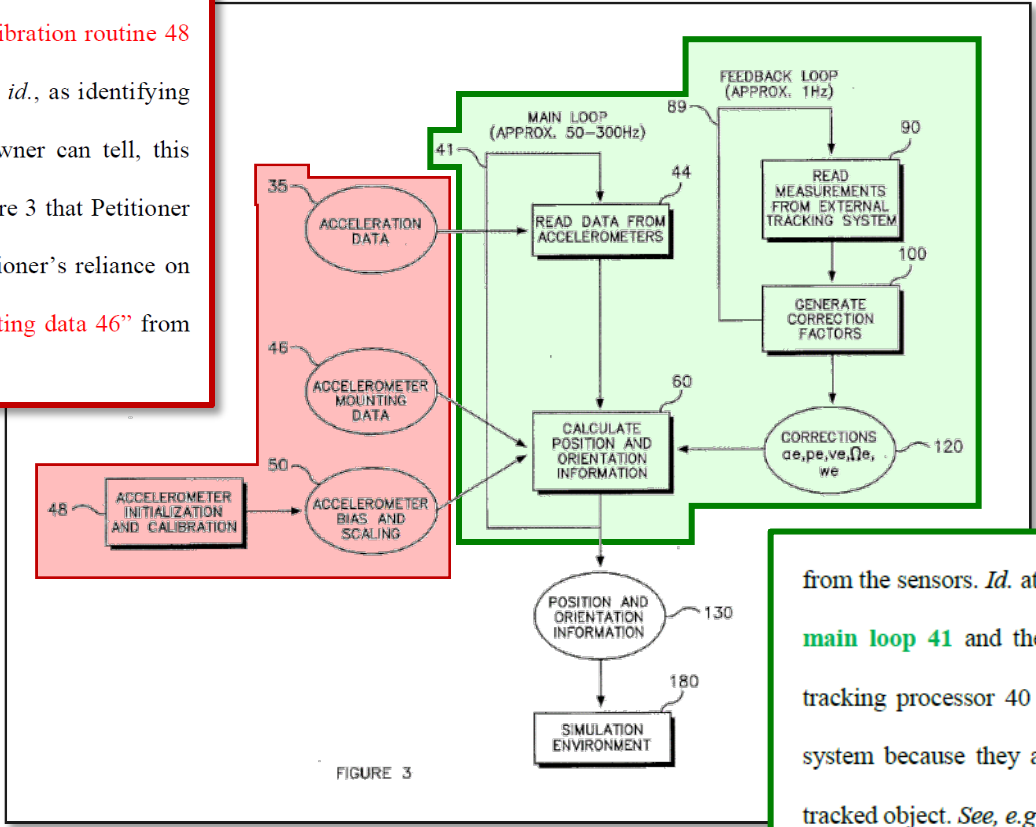
1. A tracking system comprising:
an estimation subsystem; and
a sensor subsystem coupled to the estimation subsystem and configured to provide configuration data to the estimation subsystem and to provide measurement information to the estimation subsystem for localizing an object;
wherein the estimation subsystem is configured to update a location estimate for the object based on configuration data and measurement information accepted from the sensor subsystem.

Ex. 1003 (’253 Patent) at cl. 1

Grounds IV (Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1

The Petition Identified Two Separate "Subsystems"

The Petition never expressly states which particular parts of the Horton system constitute the claimed "sensor subsystem." *See id.*, 60. The Institution Decision, however, credited the Petition's contention that "Horton discloses that the tracking system includes accelerometers 1-6 that are initialized using calibration routine 48 and provide acceleration data 35 to the estimation subsystem," *id.*, as identifying the "sensor subsystem," Paper 10, 30. As best as Patent Owner can tell, this appears to correspond with the red annotation of Horton's Figure 3 that Petitioner provides on page 59 of the Petition. *See also id.* (noting Petitioner's reliance on "accelerometer bias and scaling 50" and "accelerometer mounting data 46" from Figure 3); Baillot, ¶¶414-416.

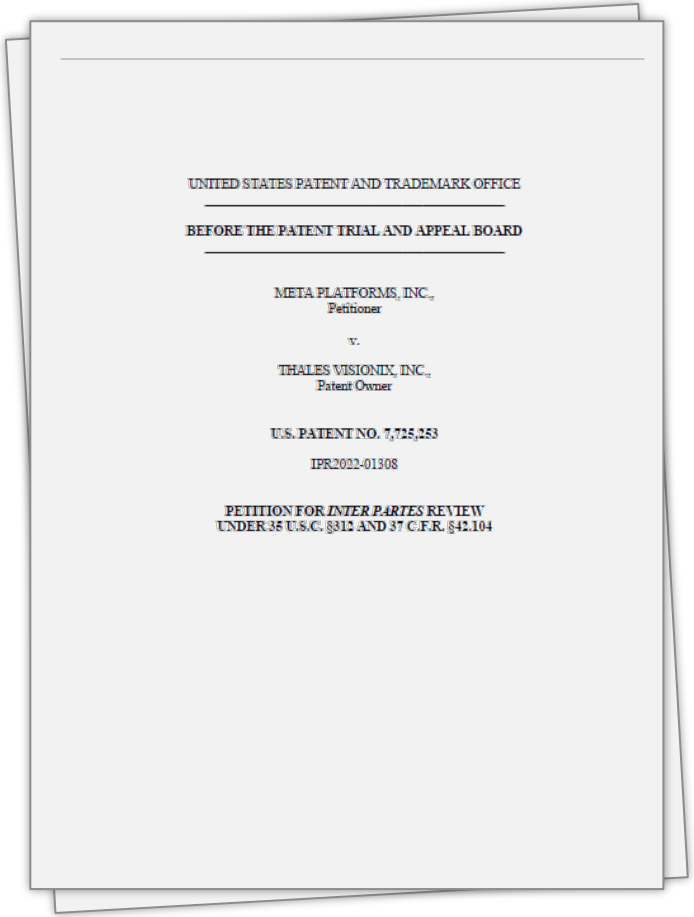


from the sensors. *Id.* at 2:25-30, 41-44. A POSITA would have understood that the main loop 41 and the Kalman Filter (i.e., feedback loop 89) executed by the tracking processor 40 constitutes an "estimation subsystem" within the overall system because they are used for estimating the position and orientation of the tracked object. *See, e.g., id.* at 7:56-64 (describing the processor's calculation of "an

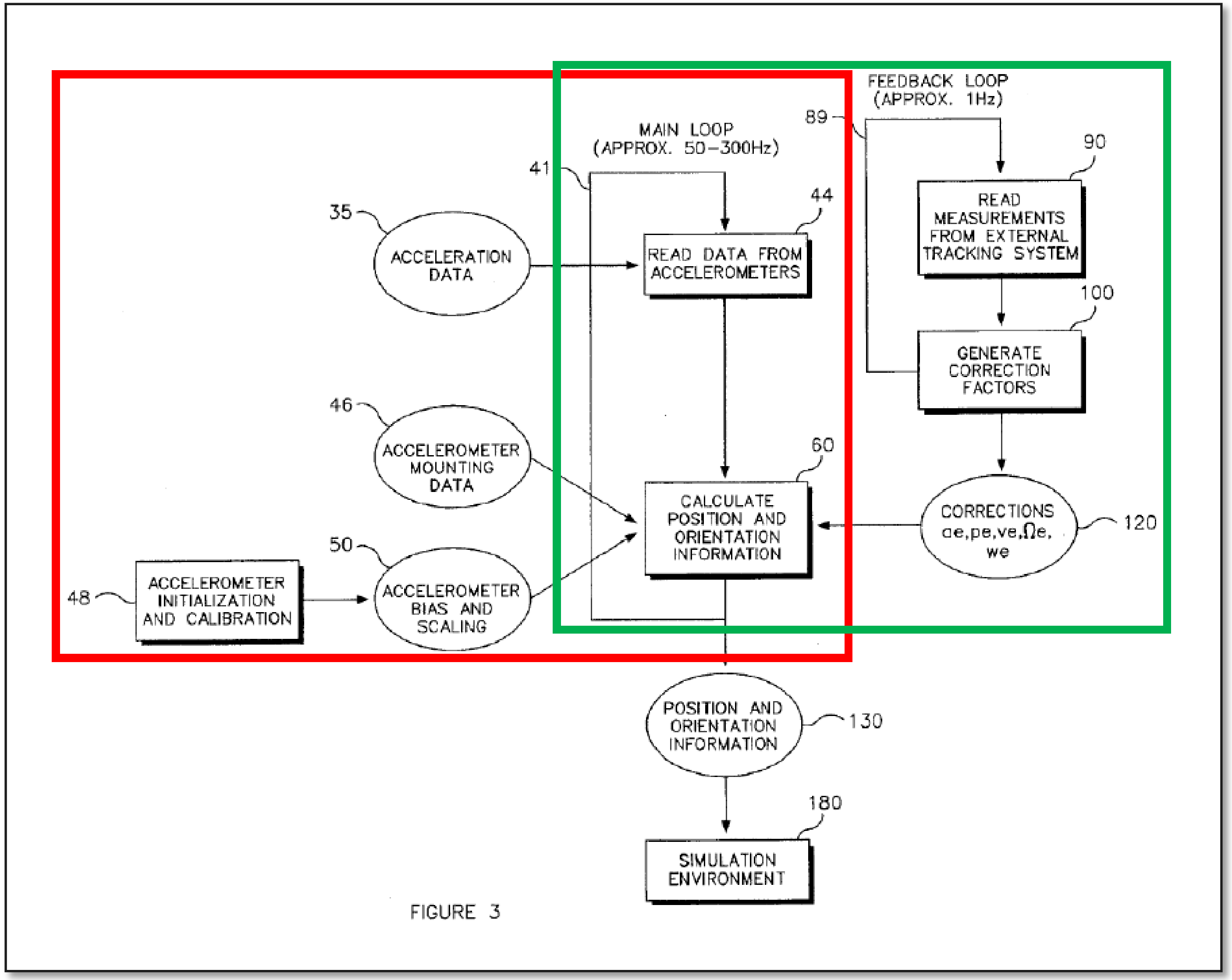
Paper 29 (Patent Owner's Response) at 48; Paper 01 (Petition) at 59; Ex. 1010 (Horton) Figure 3

Grounds IV (Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1

PO Misconstrues The Petition

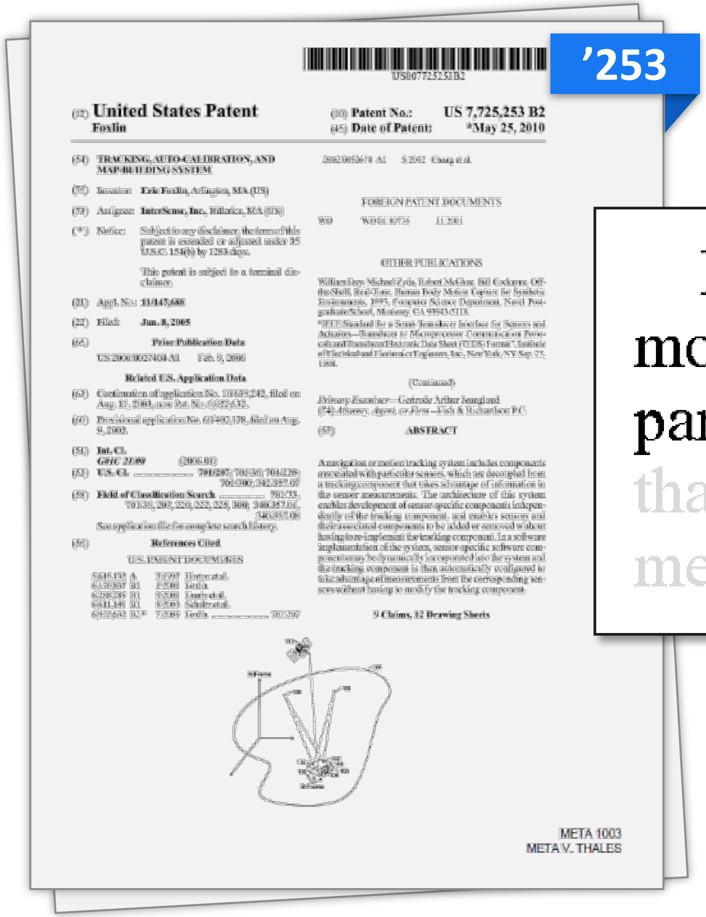


Paper 1 (Petition) at 59



Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1

PO's 100% Non-overlapping Construction Is Inconsistent With The Specification



In a general aspect, the invention features a navigation or motion tracking system in which ~~components associated with~~ particular sensors are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development

Ex. 1003 ('253 Patent) at 2:22-26

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1

At A Minimum, Petitioner's Reply Identified Two Separate "Subsystems" (*Axonics v. Medtronic*)

(most emphasis in original). And, the Petition identifies the claimed "sensor subsystem" as follows: "**accelerometers 1-6** that are initialized using **calibration routine 48** and provide **acceleration data 35** … [as well as] '**accelerometer bias and scaling 50**' and '**accelerometer mounting data 46**'…." *See* POR, 48 (color

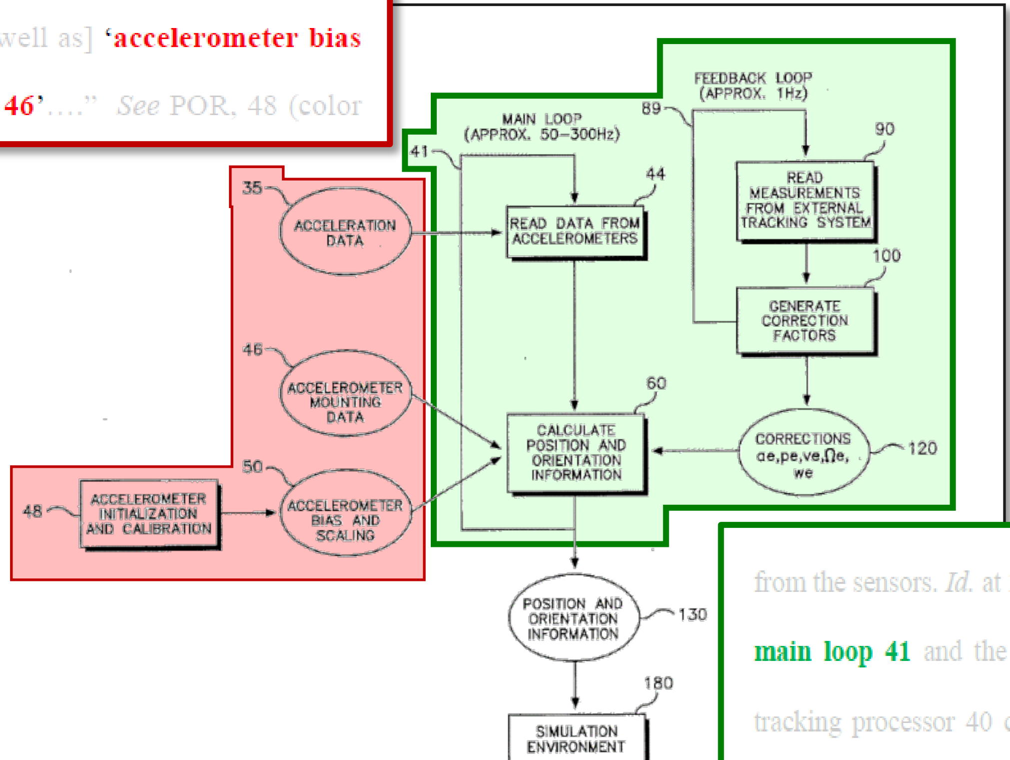


FIGURE 3

from the sensors. *Id.* at 2:25-30, 41-44. A POSITA would have understood that the **main loop 41** and the Kalman Filter (i.e., **feedback loop 89**) executed by the tracking processor 40 constitutes an **"estimation subsystem"** within the overall system because they are used for estimating the position and orientation of the tracked object. *See, e.g., id.* at 7:56-64 (describing the processor's calculation of "an

Paper 33 (Petitioner's Reply) at 19-20; Ex. 1010 (Horton) at Fig. 3

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1

The “Sensor Subsystem” Does ***Not*** Include Main Loop 41 (During Calibration Or During Tracking)

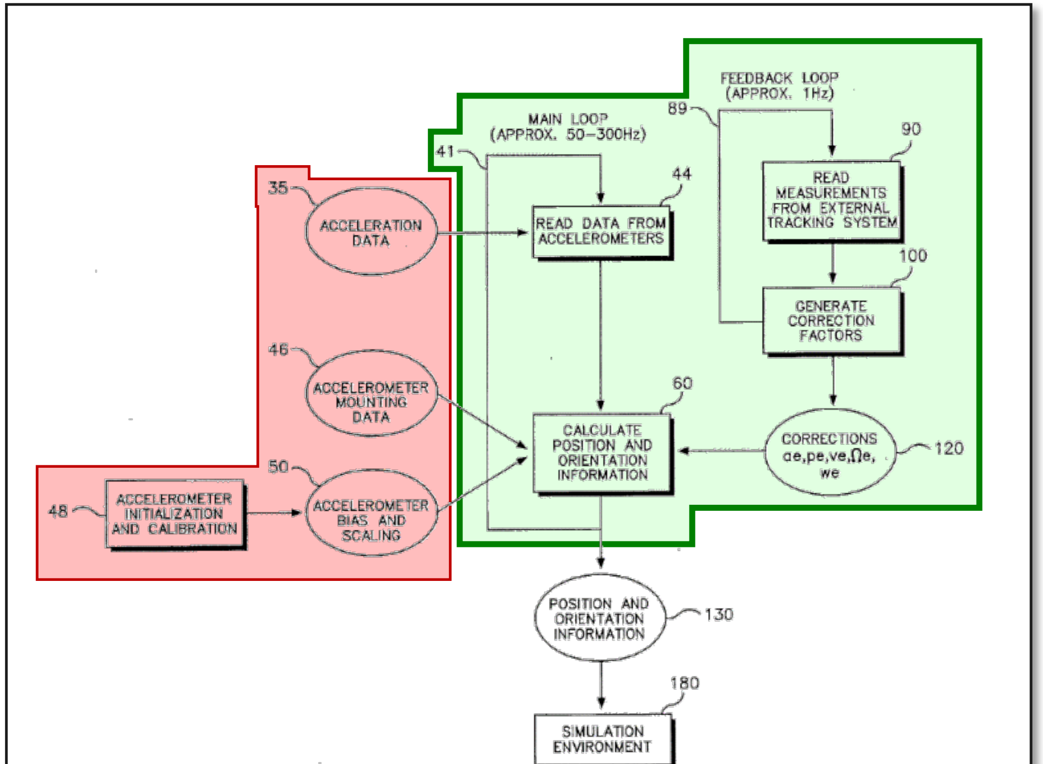


FIGURE 3

Ex. 1010 (Horton) at 5:64-6:3 and Fig. 3

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1

PO Improperly Attempts To Define ***Petitioner's*** Challenge. Petitioner Does Not Identify Horton's Main Loop 41 As Part Of The Claimed "Estimation Subsystem"


UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

THALES VISIONIX, INC.,
Patent Owner

U.S. PATENT NO. 7,725,253

IPR2022-01308

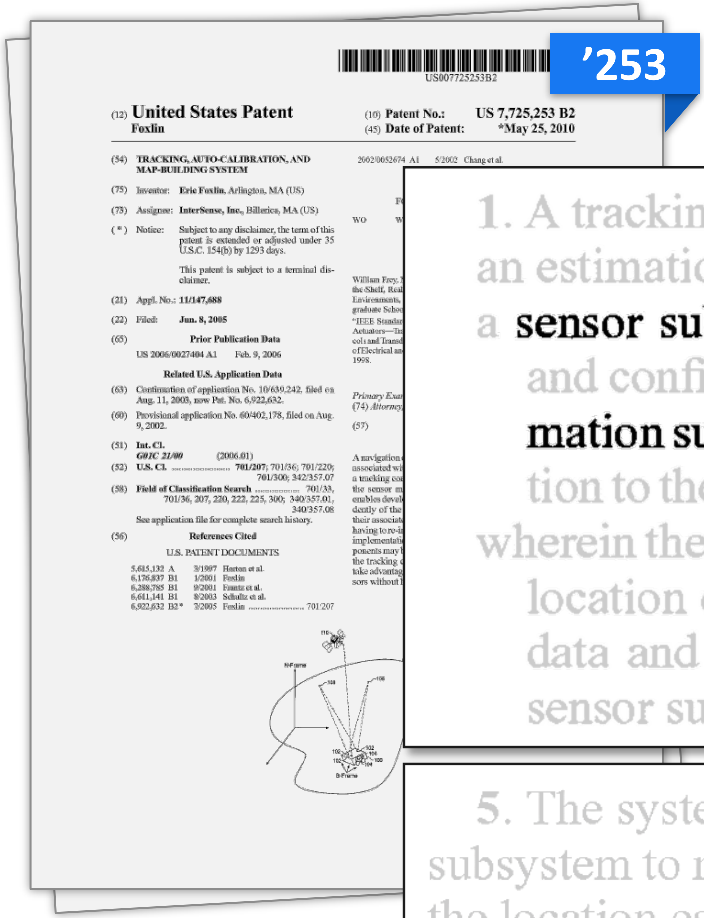
PATENT OWNER'S SUR-REPLY

November 3, 2023

> Horton does not match up with the claim. The main loop does not switch from being part of the sensor subsystem to being part of the estimation subsystem whenever it suits Petitioner; it is inherently part of both.

Paper 37 (PO's Sur-Reply) at 19 n.5

Claim 1: Horton Teaches Three Types Of "Configuration Data"


’253

(12) United States Patent
Foxlin
(10) Patent No.: US 7,725,253 B2
(45) Date of Patent: *May 25, 2010

(54) TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM
(75) Inventor: Eric Foxlin, Arlington, MA (US)
(73) Assignee: InterSense, Inc., Billerica, MA (US)
(21) Appl. No.: 11/147,688
(22) Filed: Jun. 8, 2005

1. A tracking system comprising:
an estimation subsystem; and
a **sensor subsystem** coupled to the estimation subsystem and configured **to provide configuration data to the estimation subsystem** and to provide measurement information to the estimation subsystem for localizing an object;
wherein the estimation subsystem is configured to update a location estimate for the object based on configuration data and measurement information accepted from the sensor subsystem.

5. The system of claim 1 further comprising a navigation subsystem to navigate the object in an environment based on the location estimate for the object.

Configuration Data

1. Calibration Measurements
2. Pre-specified bias
3. Mounting Data

Ex. 1003 (’253 Patent) at cls. 1 and 5

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1
See also -01305 Ground IV (Horton), Claim 47[c][1]

Calibration Measurements From The "Sensor Subsystem" Are "Load[ed]" Into The "Estimation Subsystem" During Calibration

1

mechanical jarring and the like. Accelerometers **1–6** are initialized **48** by loading the values of the accelerometer biases which are pre-specified at the factory or obtained from accelerometer specifications. Calibration **48** of accelerometers **1–6** is accomplished by running tracking system **15** while the object to be tracked **300** (e.g., head-mounted display (HMD) on a user) remains stationary. Position and

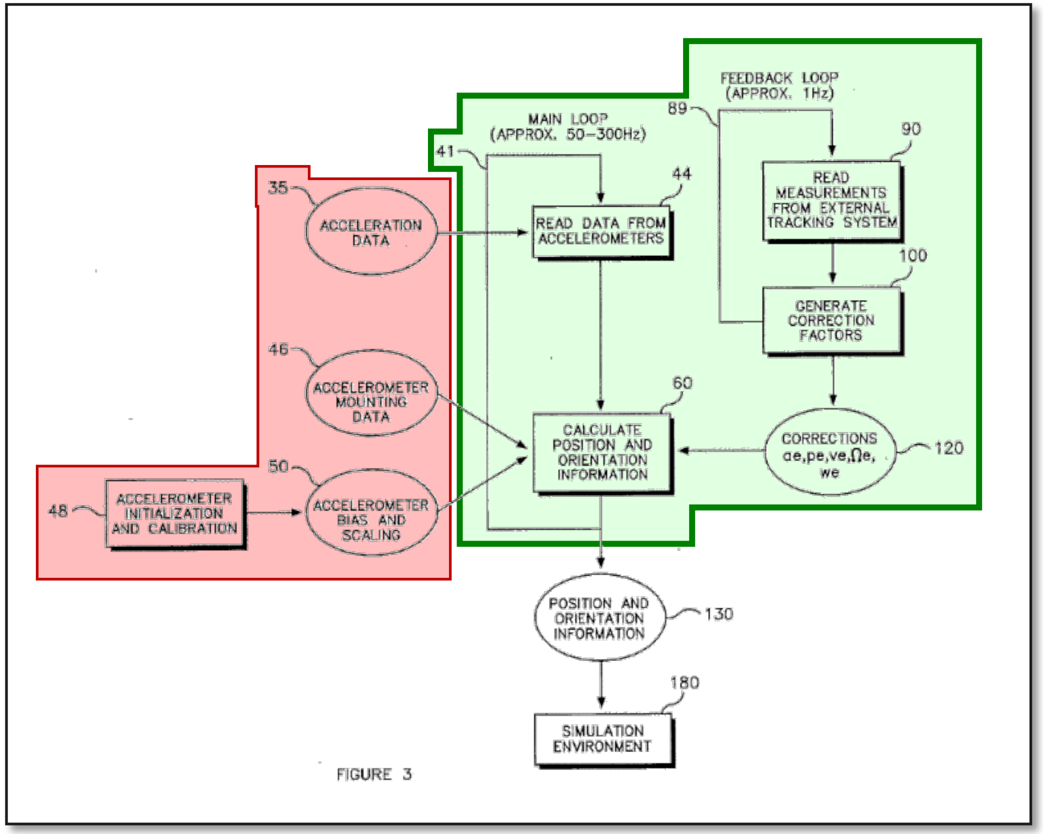


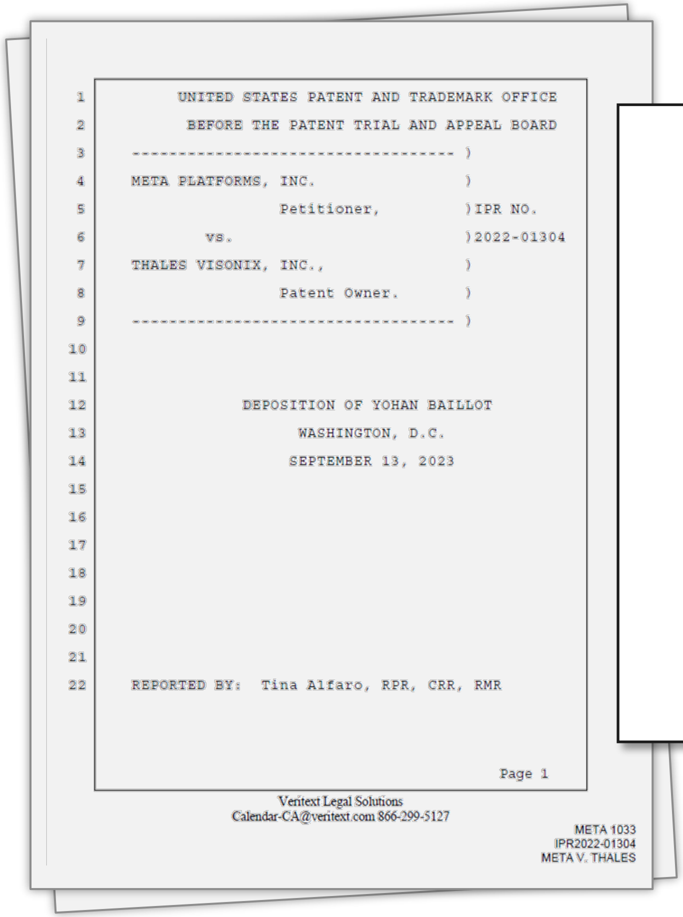
FIGURE 3

Ex. 1010 (Horton) at Fig. 3, 5:64-6:3

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1
See also -01305 Ground IV (Horton), Claim 47[c][1]

PO's Expert Admits "Pre-Specified Bias" Data Is Received By The Tracking System

2


UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD
-----------------------------------)
META PLATFORMS, INC.)
Petitioner,) IPR NO.
vs.) 2022-01304
THALES VISIONIX, INC.,)
Patent Owner.)
-----------------------------------)

DEPOSITION OF YOHAN BAILLOT
WASHINGTON, D.C.
SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

META 1033
IPR2022-01304
META V. THALES

Q. Do you agree that the tracking system receives these prespecified bias values for purposes of calibration?

A. That's what it says, yeah, here.

Q. And do you agree that that's what's happening?

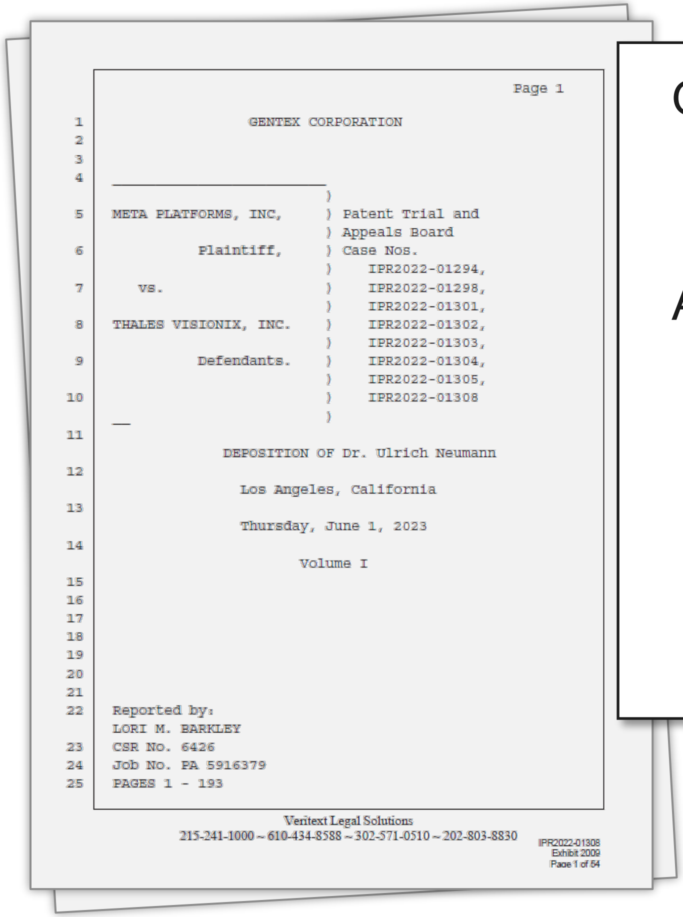
A. That's what I'm reading and that seems to be making sense.

Ex. 1033 (Baillot Depo. Tr.) at 131:19-132:4

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1
See also -01305 Ground IV (Horton), Claim 47[c][1]

The Designer Must Use A Sensor To Measure The Mounting Data, And That Sensor Is Part Of The "Sensor Subsystem" As Defined

3



Page 1

GENTEX CORPORATION

META PLATFORMS, INC.,) Patent Trial and
) Appeals Board
Plaintiff,) Case Nos.
) IPR2022-01294,
vs.) IPR2022-01298,
) IPR2022-01301,
THALES VISIONIX, INC.) IPR2022-01302,
) IPR2022-01303,
Defendants.) IPR2022-01304,
) IPR2022-01305,
) IPR2022-01308

DEPOSITION OF Dr. Ulrich Neumann

Los Angeles, California

Thursday, June 1, 2023

Volume I

Reported by:
LORI M. BARKLEY
CSR No. 6426
Job No. PA 5916379
PAGES 1 - 193

Veritext Legal Solutions
215-241-1000 ~ 610-434-8588 ~ 302-571-0510 ~ 202-803-8830

IPR2022-01308
Exhibit 2009
Page 1 of 54

Q. Okay. And the sensors don't determine -- like the accelerometer doesn't determine that mounting data itself, correct? It's the person who set up this system who determines that mounting data?

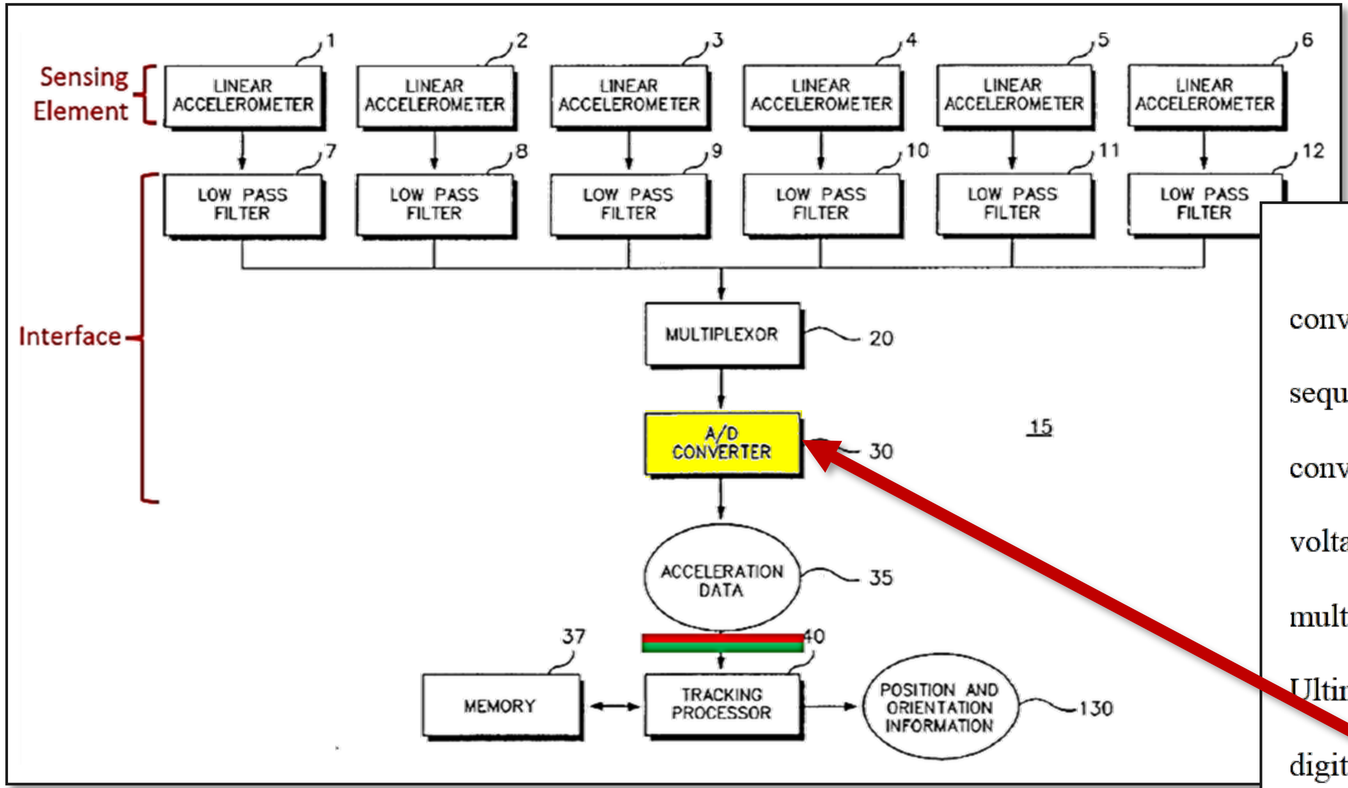
A. Yeah, it's a physical thing. They construct some sort of module that will hold the accelerometers. You have to mount them somehow so they don't move around.

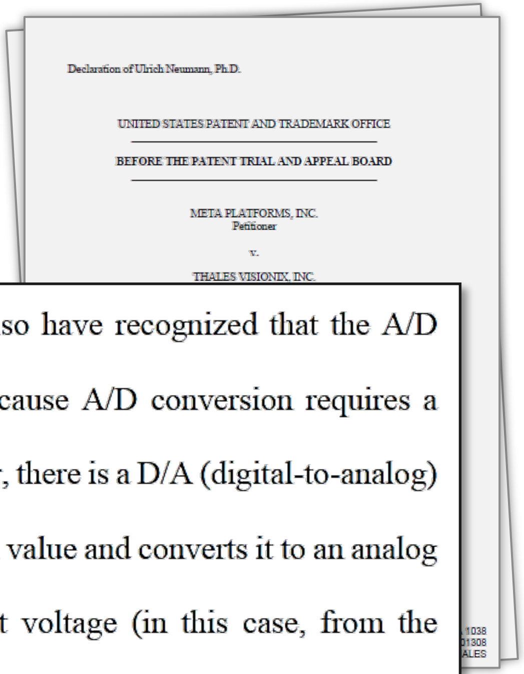
And you are make them as rigid and accurate as possible. You record the data as best as you can. **You measure it. And that becomes the mounting data.**

Ex. 2009 (Neumann Depo. Tr.) at 155:14-24

Grounds IV(Horton) and V (Horton + Welch 1997)
See also -01304 Ground III (Horton), Claim 1
See also -01305 Ground IV (Horton), Claim 47[c][1]

Claim 3: Dr. Neumann Confirms Horton Performs "Computations" (Ex. 1038 ¶¶ 19-25)




Declaration of Ulrich Neumann, Ph.D.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.
Petitioner

v.

THALES VISIONIX, INC.

22. A person of ordinary skill would also have recognized that the A/D converter is itself a small computing system because A/D conversion requires a sequence of computing steps. In an A/D converter, there is a D/A (digital-to-analog) converter that takes an internally generated digital value and converts it to an analog voltage. That voltage is compared to the input voltage (in this case, from the multiplexer) and a decision is made depending on which is the greater voltage. Ultimately, the D/A voltage is found that best matches the input voltage, and the digital value that creates that D/A voltage is the output of the A/D converter. Various computational algorithms may be used to find the digital value quickly, and that algorithm is embedded in the A/D converter and controls its operation.

Paper 33 (Petitioner's Reply) at 26; Ex. 1038 (Supplemental Neumann Declaration) ¶ 22

Claim 6: Horton (At Least Obviously) "Enumerates"

Decl

28. Horton goes on teach that the system then initializes each of the six accelerometers in that embodiment. *See* EX1010, 5:64-6:3. A person of ordinary skill would understand that, as a result of specifying each of the six accelerometers available to the system during the process of initialization, Horton's main loop 41 is able to go through and read data from each accelerometer 1 through 6, because it knows that there are six accelerometers, and further knows that each accelerometer is an accelerometer (as opposed to another type of sensor taught by Horton, such as a magnetic sensor (*see* EX1010, claim 8)), and further knows what the proper correction calibration factors are for each accelerometer based on their pre-specified bias (EX1010, 5:64-67). *See* EX1010, 12:44-56.

META 1038
IPR2022-01308
META V. THALES

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

THALES VISIONIX, INC.,
Patent Owner

U.S. PATENT NO. 7,725,253

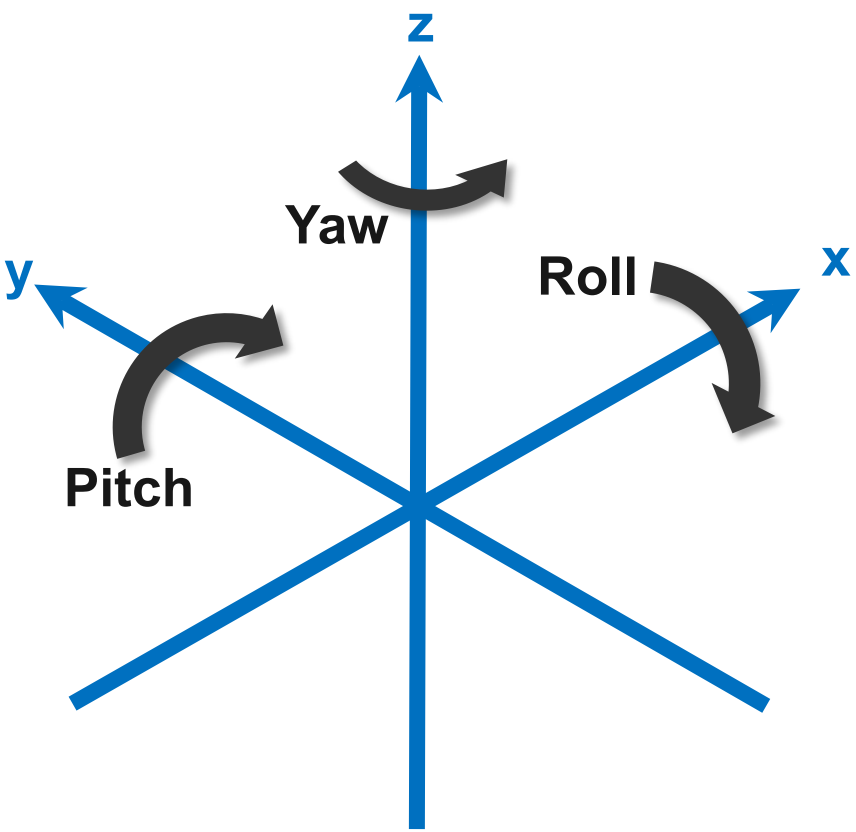
IPR2022-01308

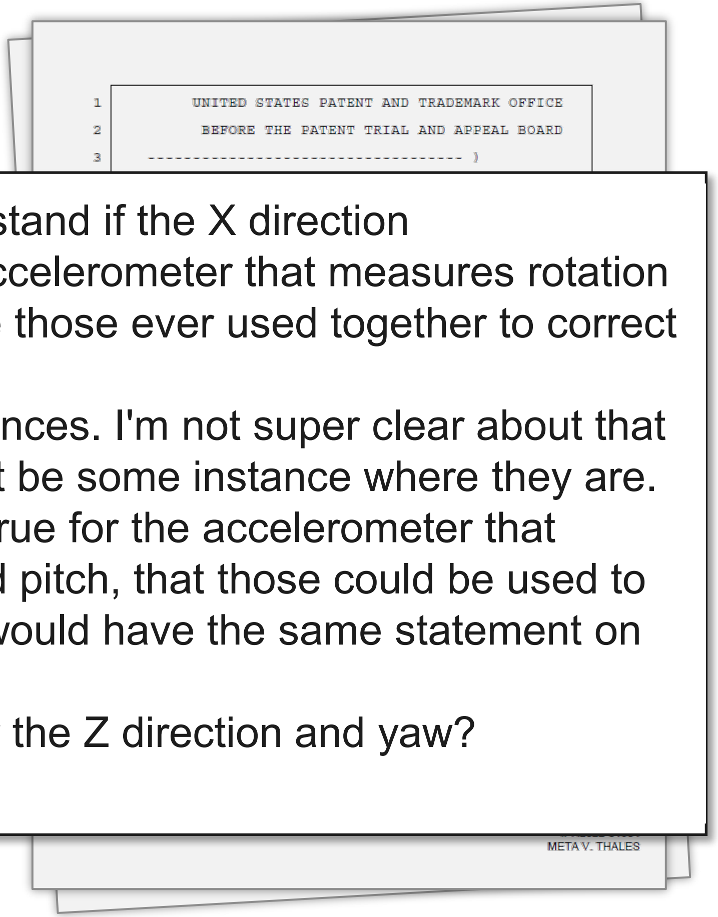
PATENT OWNER'S SUR-REPLY

Ex.1010, Table 1, 12:47-50 ("for i = 1 to 6"). All of that information is provided to the system by the designer; Horton suggests no mechanism by which the system does such specifying, listing, or even determining a number itself, as the claim requires. Petitioner also continues to point in passing to the accelerometer

Ex. 1038 (Supplemental Neumann Declaration) ¶¶ 26-30; Paper 37 (PO's Sur-Reply) at 22

Claim 7: Orientation (Roll-Pitch-Yaw) Accelerometers Are Obviously Paired With Translation (X-Y-Z) Accelerometers





Q. …I'm just trying to understand if the X direction accelerometer and the accelerometer that measures rotation about the X direction, are those ever used together to correct each other?

A. They might in some instances. I'm not super clear about that right now, but there might be some instance where they are.

Q. And would the same be true for the accelerometer that measures Y direction and pitch, that those could be used to correct each other? A. I would have the same statement on this.

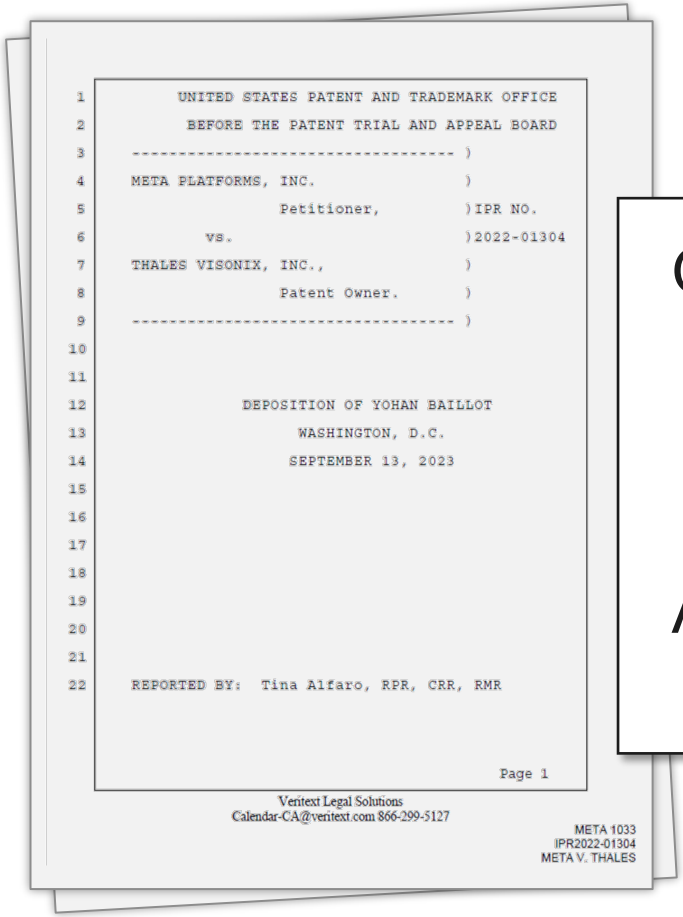
Q. And the same answer for the Z direction and yaw?

A. Yeah.…

Ex. 1033 (Baillot Depo. Tr.) at 154:2-17

Grounds IV(Horton) and V (Horton + Welch 1997)
See also **-**01304 Ground III (Horton), Claim 20

Claim 7: Position Accelerometers Would Obviously Have Been Paired With Orientation Accelerometers


UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

----------------------------------)

META PLATFORMS, INC.)

Petitioner,) IPR NO.

vs.) 2022-01304

THALES VISIONIX, INC.,)

Patent Owner.)

----------------------------------)

DEPOSITION OF YOHAN BAILLOT

WASHINGTON, D.C.

SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

META 1033
IPR2022-01304
META V. THALES

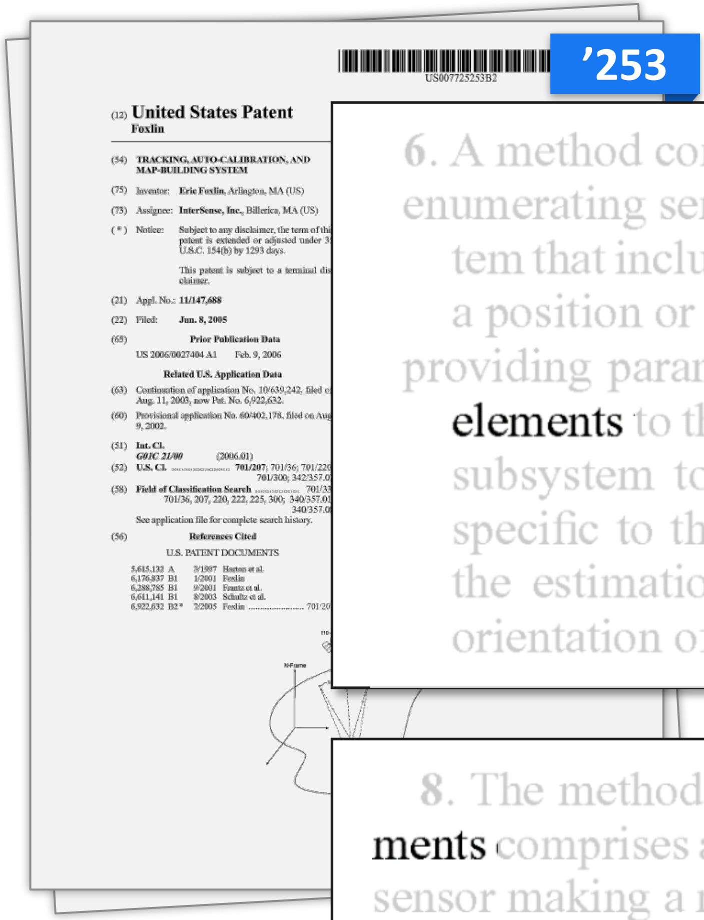
Q. I'm just asking generally if the translation accelerometer and the orientation about that axis accelerometer, meaning those two degree of freedom, if those are ever paired to correct for each other?

A. **They might be.** I'm not so clear about that. I'm not dealing with a scanning sensor in my current job.

Ex. 1033 (Baillot Depo. Tr.) at 155:2-10

Grounds IV(Horton) and V (Horton + Welch 1997)
See also **-**01304 Ground III (Horton), Claim 20

Claim 8: Two Errors That Require Expert Testimony To Correct According To PO ➔ NOT Correctible Per *Novo Industries*



6. A method comprising:
enumerating sensing elements available to a tracking system that includes an estimation subsystem that estimates a position or orientation of an object; and
providing parameters specific to **the enumerated sensing elements** to the tracking system to enable the estimation subsystem to be configured based on the parameters specific to the enumerated sensing elements to enable the estimation subsystem to estimate the position or orientation of the object.

Not referred to in Claim 6 as a “set”

8. The method of claim 6 wherein **the set of sensing elements** comprises at least one sensor and at least one target, the sensor making a measurement with respect to the target.

Not referred to in Claim 8 as “enumerated” sensing elements

Ex. 1003 (’253 Patent) at cls. 6 and 8

KIRKLAND & ELLIS LLP

U.S. Patent No. 6,922,632
IPR2022-01304
Petitioner’s Demonstratives

Claim 2: Kalman Filter Software Modules Are Coupled (By The CIB) To ***Each*** Sensor

’632

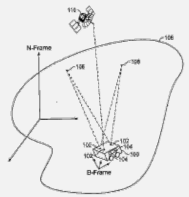
United States Patent
Foxlin

Patent No.: US 6,922,632 B2
Date of Patent: Jul. 26, 2005

(54) TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM

(75) Inventor: Eric Foxlin, Arlington, MA (US)

(73) Assignee: InterSense, Inc., Bedford, MA (US)



2. The method of claim 1 wherein coupling the sensor subsystem to the estimation subsystem includes coupling software modules each associated with one or more of the sensing elements.

SCAAT: Incremental Tracking with Incomplete Information

Greg Welch and Gary Bishop

University of North Carolina at Chapel Hill

3.2.1 Device Filters

For each device (source, sensor, landmark, etc.) we create a distinct device filter as follows. Let $\vec{\pi}$ represent the corresponding

Ex. 1001 (’632 Patent) at cl. 2; Ex. 1008 (Welch-1997) at 6

Claim 2: PO Misleadingly Quotes Dr. Neumann's Testimony

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

THALES VISIONIX, INC.,
Patent Owner

U.S. PATENT NO. 6,922,632

IPR2022-01304

to the sensor subsystem, as the claim requires. POR 33. Petitioner's expert acknowledged he did not "see a mention of a software module interacting with the sensor subsystem." Ex.2009, 101:6-6. Welch 2001 teaches a hardware connection

Page 1

GENTEX CORPORATION

Q. I see where you say, "each Kalman filter is performed in software in the PC estimation subsystem and in my opinion constitutes a software module," right? That's **in your opinion 68**.
A. Yes, I see that.
Q. I'm not seeing any other opinion about any other software module; is that correct?
A. Well, I'm talking about the sensors and the sensor elements, the ceiling and the HiBall. So the implication there is at minimum there should be some software that interacts with those and makes those work.
Q. But you don't offer an opinion in this claim 2 about any other software module other than the Kalman filter performed in software in the PC?
THE WITNESS: Yeah, I think I assumed it was understood it was there. I didn't explicitly mention it in this paragraph.
Q. So you don't mention anything else here **beyond that software module of the Kalman filter**?
A. **I don't see a mention of a software module interacting with the sensor system**.
Q. Okay.
A. It may be elsewhere. But I don't see it here.

Paper 39 (PO's Sur-Reply re 632) at 12; Ex. 2009 (Neumann Depo. Tr.) at 100:7-101:9

Claim 11: “Information ***Related To*** An Expected Sensor Measurement”

’632

US006922632B2

(12) **United States Patent**
Foxlin

(10) **Patent No.: US 6,922,632 B2**
(45) **Date of Patent: Jul. 26, 2005**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/639,242**

(22) Filed: **Aug. 11, 2003**

(65) **Prior Publication Data**

US 2004/0073360 A1 Apr. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**[7] **G01C 21/26**
(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07
(58) **Field of Search** 701/33, 36, 207, 701/220, 222, 225, 300; 342/357.01, 357.07, 357.08, 424

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,176,837 B1		1/2001	Foxlin	600/595
6,288,785 B1	*	9/2001	Frantz et al.	356/614
6,611,141 B1	*	8/2003	Schulz et al.	324/226
2002/0052674 A1	*	5/2002	Chang et al.	700/300

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

“IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format”. Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

Neal A. Carlson. “Federated Filter for Fault–Tolerant Integrated Navigation”. NATO Advisory Group for Aerospace Research and Development (AGARD) book “Aerospace Navigation Systems”, AGARD–AG–331, published Jun., 1995, pp. 265–280.

V. A. Tupysev. “A Generalized Approach to the Problem of Distributed Kalman Filtering”. AIAA–98–4309, pp. 1097–1116, Aug., 1998.

Donald T. Knight. “Rapid Development of Tightly–Coupled GPS/INS Systems”. IEEE, 1977.

Gudrun Klinker et al. “Distributed User Tracking Concepts for Augmented Reality Applications”. IEEE, pp. 37–44, 2000.

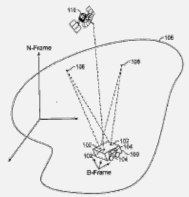
* cited by examiner

Primary Examiner—Gertrude A. Jeanglaude
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

69 Claims, 12 Drawing Sheets



META 1001
META V. THALES

11. The method of claim 1 wherein repeatedly updating the state further includes:

providing to the sensor subsystems information related to an expected sensor measurement; and

wherein accepting the measurement information from the sensor subsystem includes accepting information related to an actual sensor measurement.

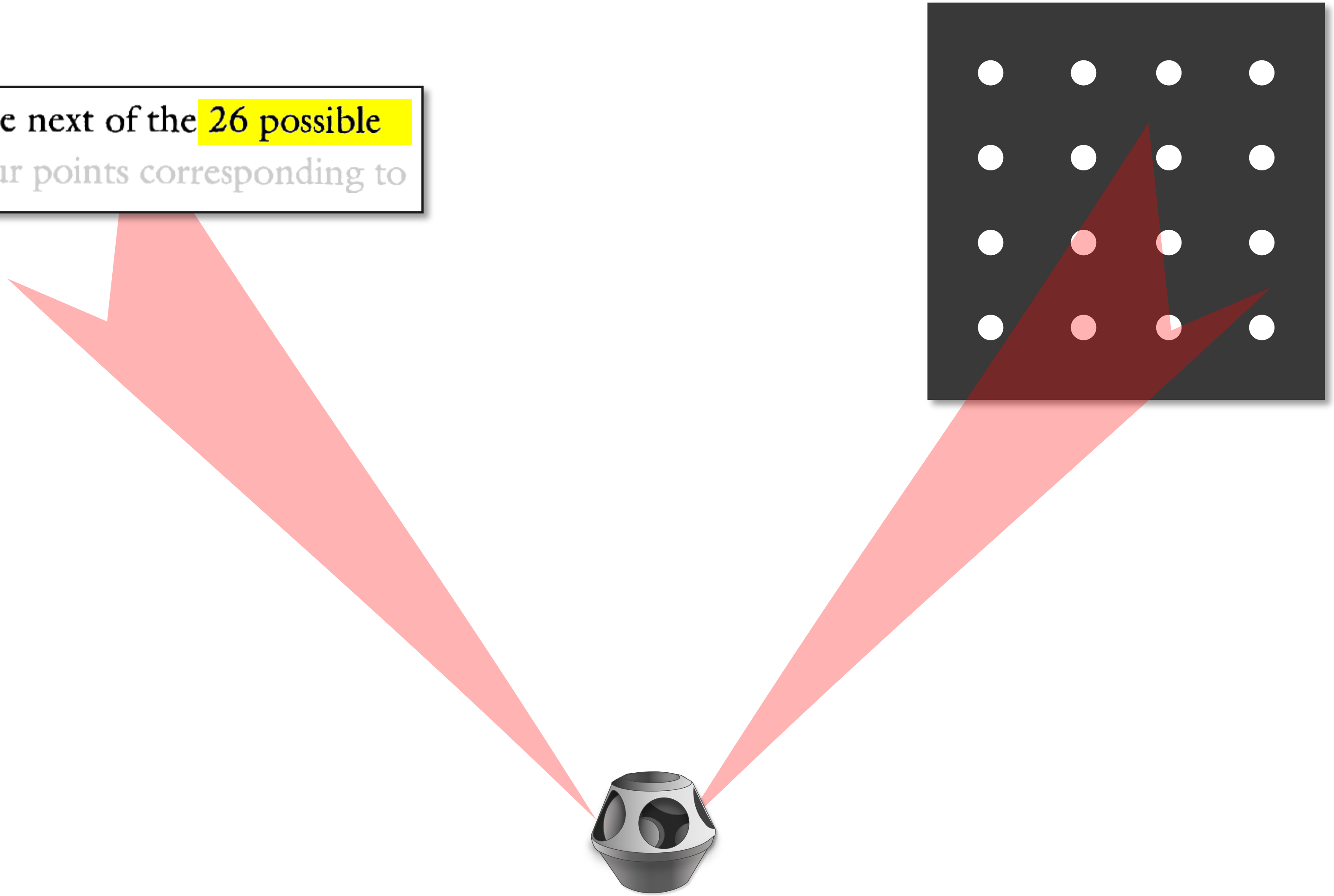
Ex. 1001 (’632 Patent) at cl. 11

Ground I: Welch-2001 + Welch-1997

See also -01305 Ground I (Welch-2001 + Welch-1997), Claim 30[c]

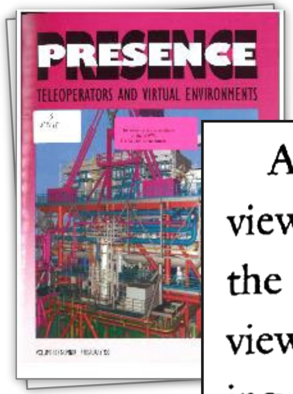
Claim 11: LED Selection Is Based On Predicted Pose

> At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to

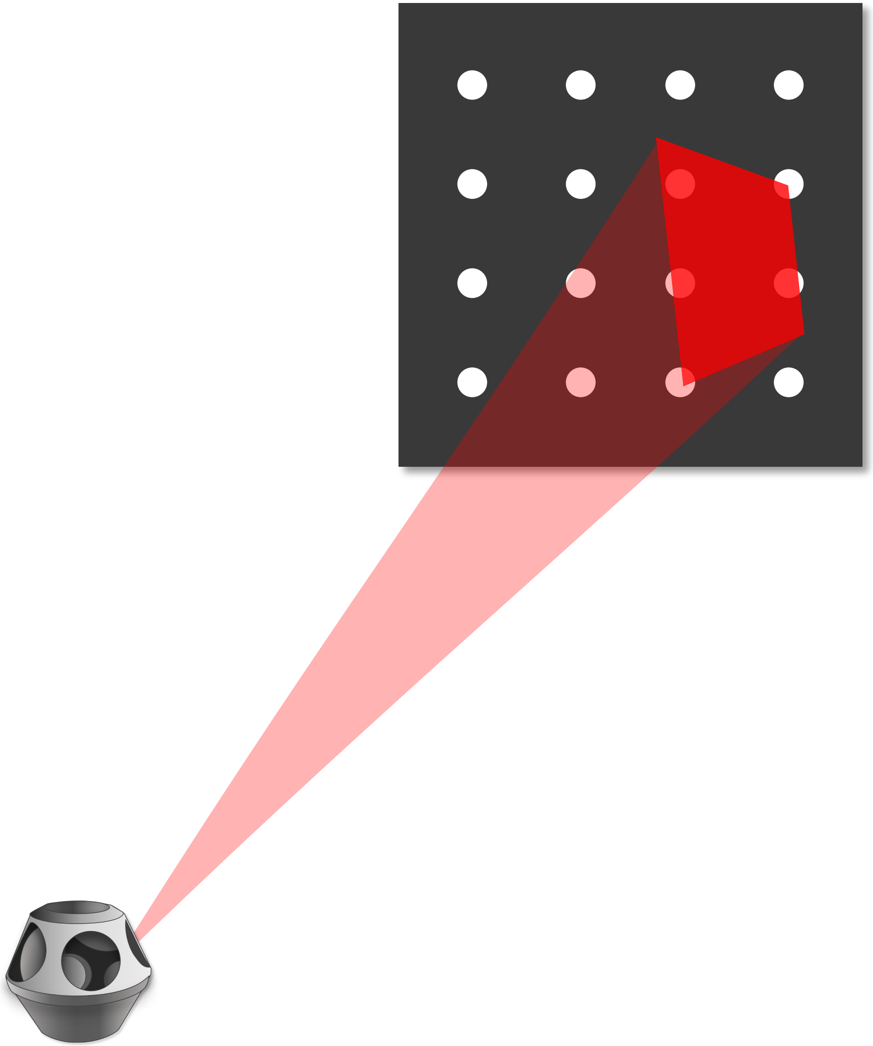


Ex. 1007 (Welch-2001) at 13

Claim 11: LED Selection Is Based On Predicted Pose

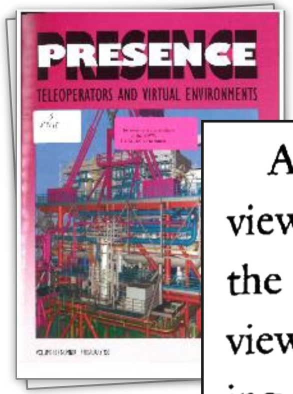


At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to the corners of the LEPD sensor associated with that view are projected into the world using the 3 × 4 viewing matrix for that view, along with the current estimates of the HiBall pose. This projection, which is the inverse of the measurement relationship described above, results in four rays extending from the sensor into the world. The intersection of these rays and the approximate plane of the ceiling determines a 2-D bounding box on the ceiling, within which are the candidate LEDs for the current view. One of the candidate LEDs is then chosen in a least-recently-used fashion to ensure a diversity of constraints.

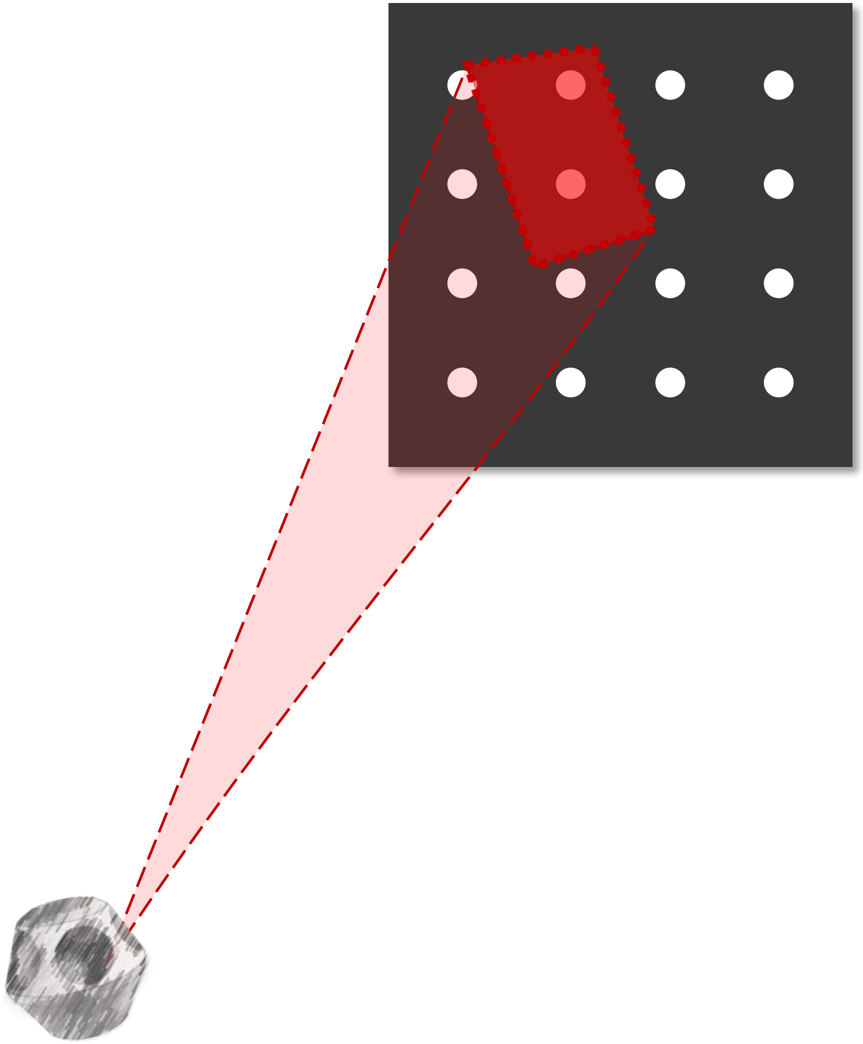


Ex. 1007 (Welch-2001) at 13

Claim 11: LED Selection Is Based On Predicted Pose

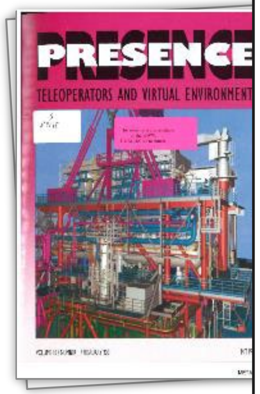


At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to the corners of the LEPD sensor associated with that view are projected into the world using the 3 × 4 viewing matrix for that view, along with the current estimates of the HiBall pose. This projection, which is the inverse of the measurement relationship described above, results in four rays extending from the sensor into the world. The intersection of these rays and the approximate plane of the ceiling determines a 2-D bounding box on the ceiling, within which are the candidate LEDs for the current view. One of the candidate LEDs is then chosen in a least-recently-used fashion to ensure a diversity of constraints.

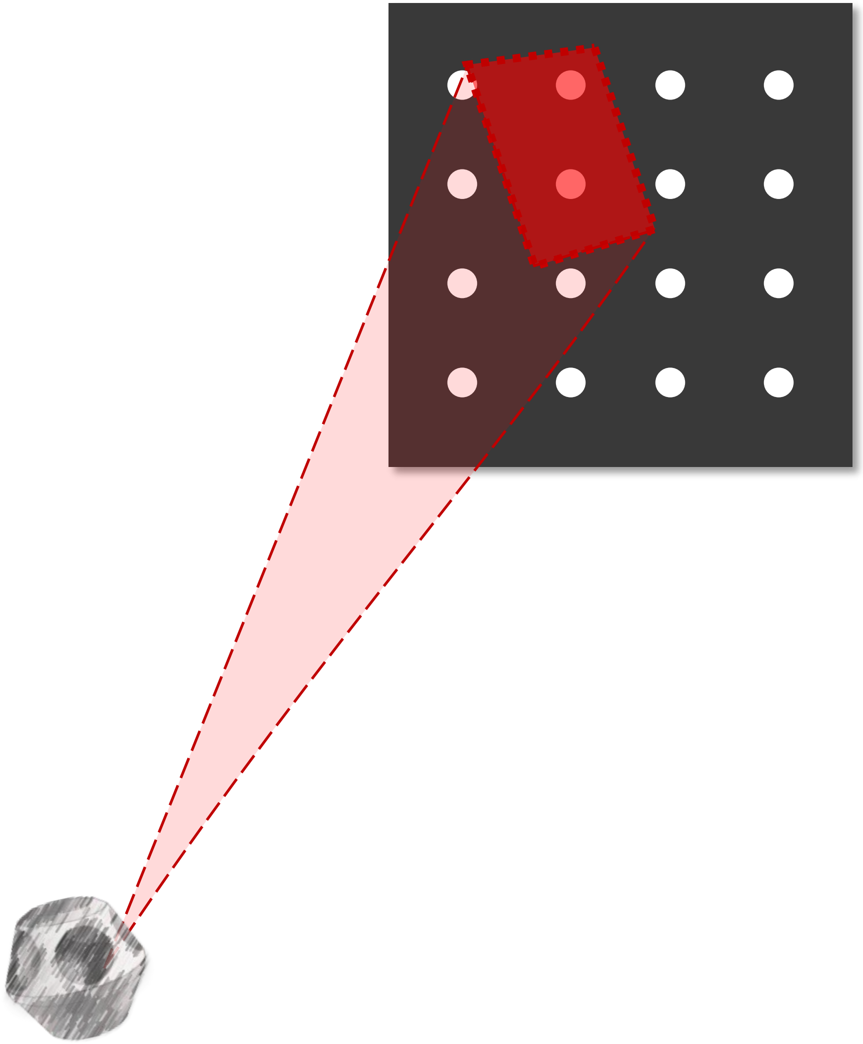


Ex. 1007 (Welch-2001) at 13

Claim 11: LED Selection Is Based On Predicted Pose

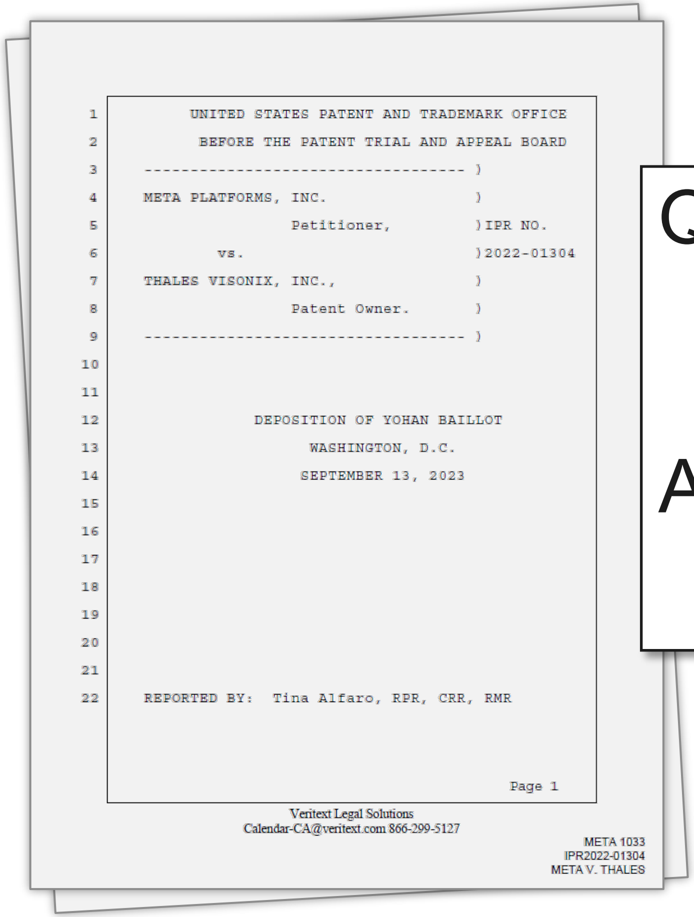


> At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to the corners of the LEPD sensor associated with that view are projected into the world using the 3 × 4 viewing matrix for that view, along with the current estimates of the HiBall pose. This projection, which is the inverse of the measurement relationship described above, results in four rays extending from the sensor into the world. The intersection of these rays and the approximate plane of the ceiling determines a 2-D bounding box on the ceiling, within which are the candidate LEDs for the current view. One of the candidate LEDs is then chosen in a least-recently-used fashion to ensure a diversity of constraints.
>
> Once a particular view and LED have been chosen in this fashion, the CIB (section 4.3) is instructed to flash the LED and take a measurement as described in section 5.2. This single measurement is compared with a prediction obtained using equation (3), and the difference (or *residual*) is used to update the filter state and covariance matrices using the Kalman gain matrix. The



Ex. 1007 (Welch-2001) at 13

Claim 11: PO's Expert Admitted LED Trigger Data Is Related To Predicted (="Expected" According To PO) Sensor Measurement


UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC., Petitioner, vs. THALES VISONIX, INC., Patent Owner.	) IPR NO.) 2022-01304

DEPOSITION OF YOHAN BAILLOT

WASHINGTON, D.C.

SEPTEMBER 13, 2023

REPORTED BY: Tina Alfaro, RPR, CRR, RMR

Page 1

Veritext Legal Solutions
Calendar-CA@veritext.com 866-299-5127

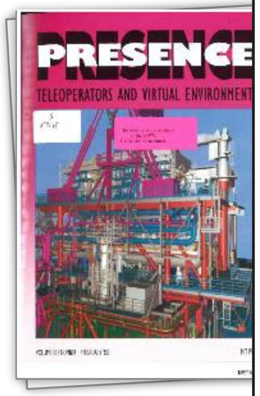
META 1033
IPR2022-01304
META V. THALES

Q. Would the decision of which LED to flash be based at all on the predicted sensor measurement?

A. **It can be dependent in part**, but it's not the only thing that will be involved.

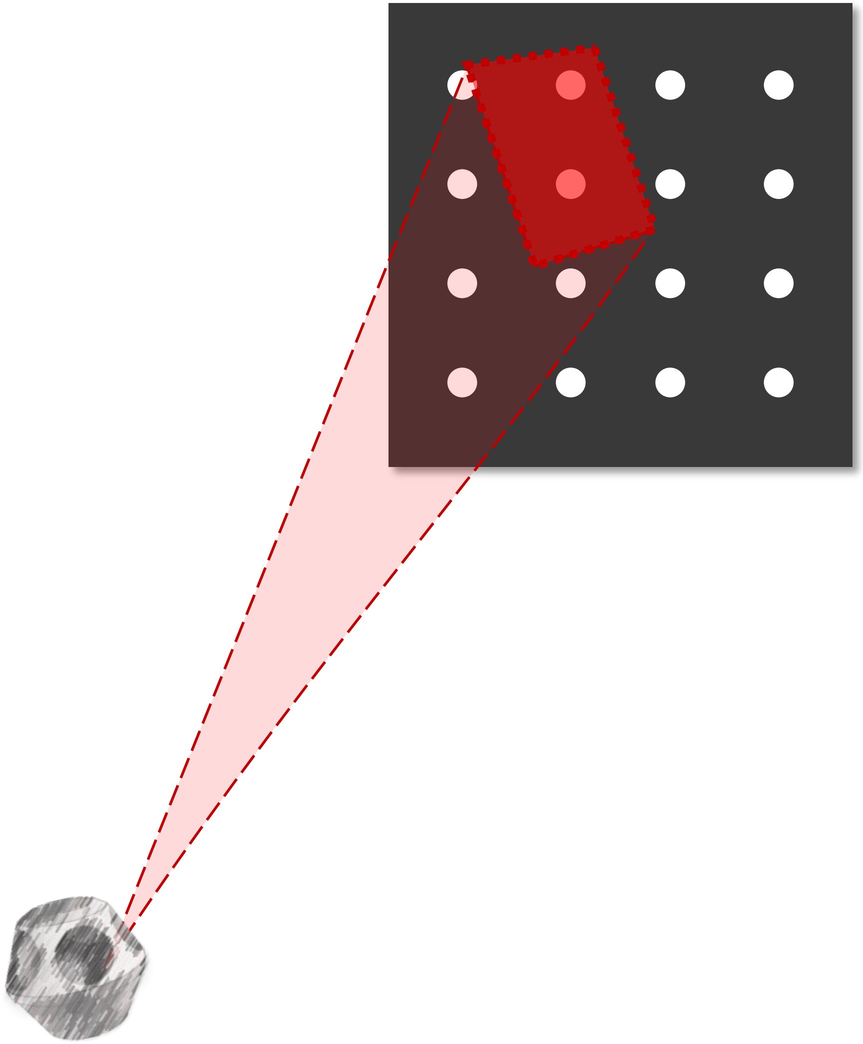
Ex. 1033 (Baillot Depo. Tr.) at 69:1-5

Claim 14: Welch Calculates The Difference Between Actual And Expected Measurements



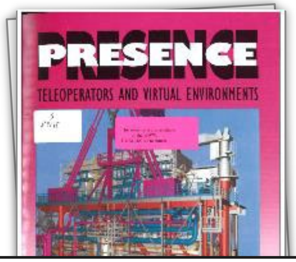
At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to the corners of the LEPD sensor associated with that view are projected into the world using the 3 × 4 viewing matrix for that view, along with the current estimates of the HiBall pose. This projection, which is the inverse of the measurement relationship described above, results in four rays extending from the sensor into the world. The intersection of these rays and the approximate plane of the ceiling determines a 2-D bounding box on the ceiling, within which are the candidate LEDs for the current view. One of the candidate LEDs is then chosen in a least-recently-used fashion to ensure a diversity of constraints.

Once a particular view and LED have been chosen in this fashion, the CIB (section 4.3) is instructed to flash the LED and take a measurement as described in section 5.2. This single measurement is compared with a prediction obtained using equation (3), and the difference (or *residual*) is used to update the filter state and covariance matrices using the Kalman gain matrix. The



Ex. 1007 (Welch-2001) at 13

Claims 12-13: LED Selection Related To Relative Geometric Configuration And Location Of Sensing Elements In The HiBall

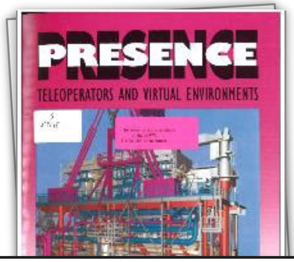


At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to

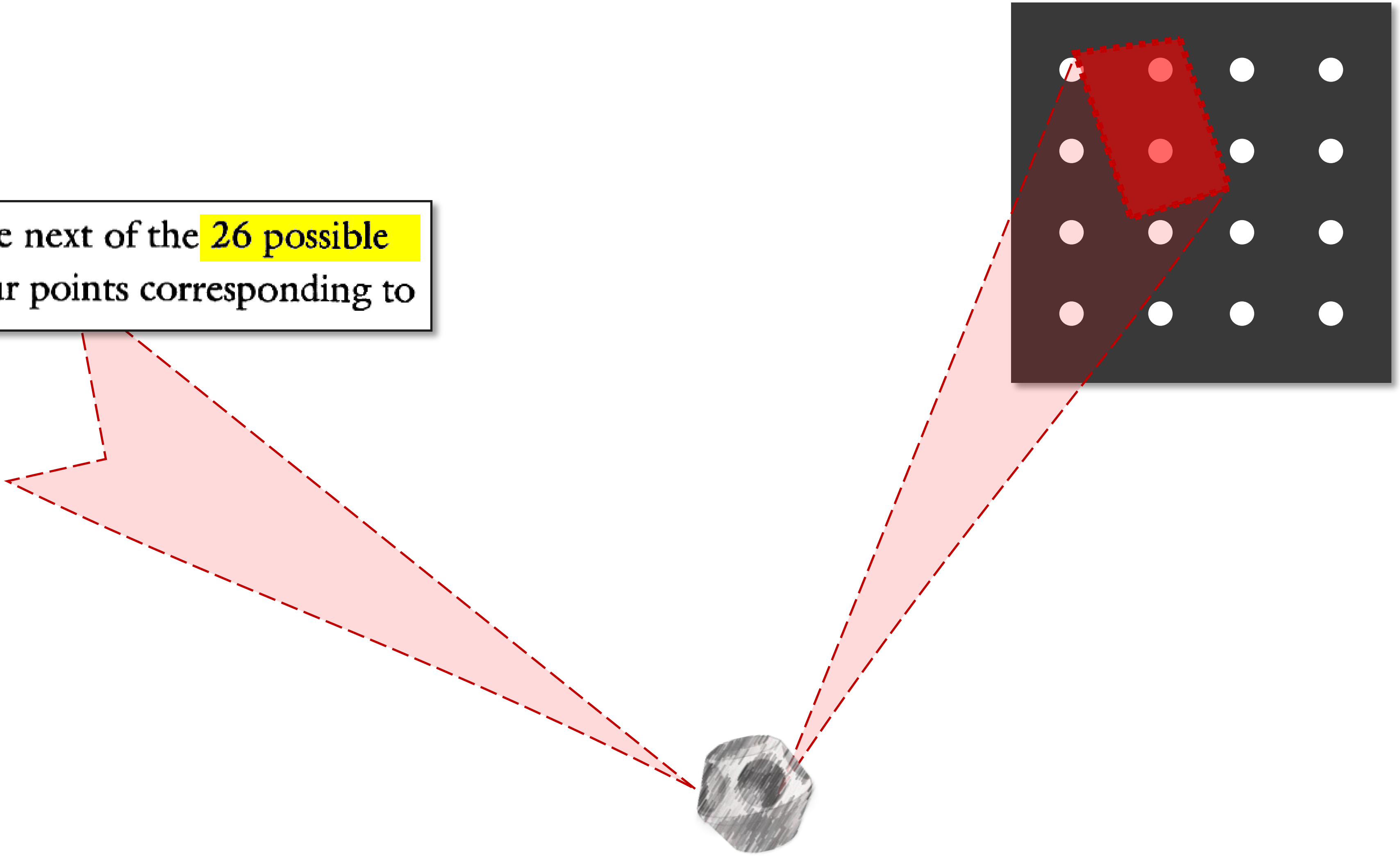
tion errors. In part to address this problem, the HiBall sensor unit was designed as a single, rigid, hollow ball having dodecahedral symmetry, with lenses in the upper six faces and LEPDs on the insides of the opposing six lower faces (figure 7). This immediately gives six primary "camera" views uniformly spaced by 57 deg. The views efficiently share the same internal air space and are rigid with respect to each other. In addition, light entering any lens sufficiently off-axis can be seen by a neighboring LEPD, giving rise to five secondary views through the top or central lens, and three secondary views through the five other lenses. Overall, this provides 26 fields of view that are used to sense widely separated groups of LEDs in the environment. Although the extra

Ex. 1007 (Welch-2001) at 13 (left) and 6-7 (right); -01304, Paper 34 (Petitioner's Reply) at 12 (section heading) and 13-14 ("The selection of which LED to flash")

Claims 12-13: LED Selection Related To Relative Geometric Configuration And Location Of Sensing Elements In The HiBall

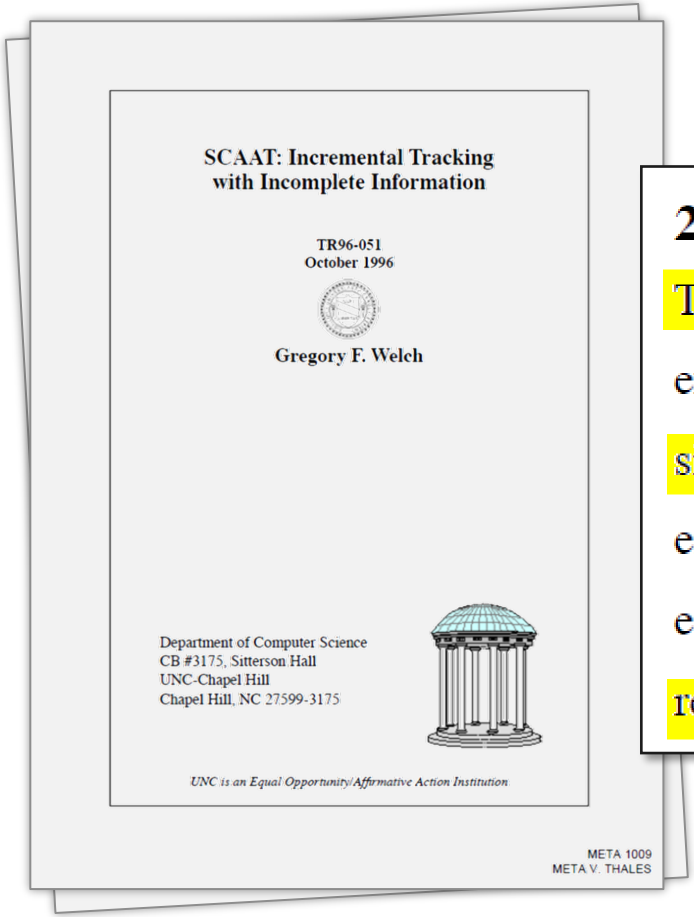


At each estimation cycle, the next of the 26 possible views is chosen randomly. Four points corresponding to



Ex. 1007 (Welch-2001) at 13; -01304, Paper 34 (Petitioner's Reply) at 12 (section heading) and 13-14 ("The selection of which LED to flash")

Claim 23: POSITA Motivated To Develop Hybrid Systems


SCAAT: Incremental Tracking
with Incomplete Information

TR96-051
October 1996

Gregory F. Welch

Department of Computer Science
CB #3175, Sitterson Hall
UNC-Chapel Hill
Chapel Hill, NC 27599-3175

UNC is an Equal Opportunity/Affirmative Action Institution

META 1009
META V. THALES

2.4.1 Hybrid Systems, the Past and the Future

Tracking systems that employ only one form of sensing all suffer inherent drawbacks. For example, purely inertial trackers suffer from drift, optical trackers require a clear line of sight, and magnetic trackers are affected by ferromagnetic and conductive materials in the environment [Raab79]. To maintain more consistent performance throughout a working environment, across the frequency spectrum, and over a wide range of dynamics, researchers have sought to develop *hybrid tracking systems*.

Ex. 1009 (Welch-Thesis) at 56

Claim 2: Horton's Code Is Comprised Of Two Inextricably Linked Software Module**s** That Are Each Coupled To Sensors

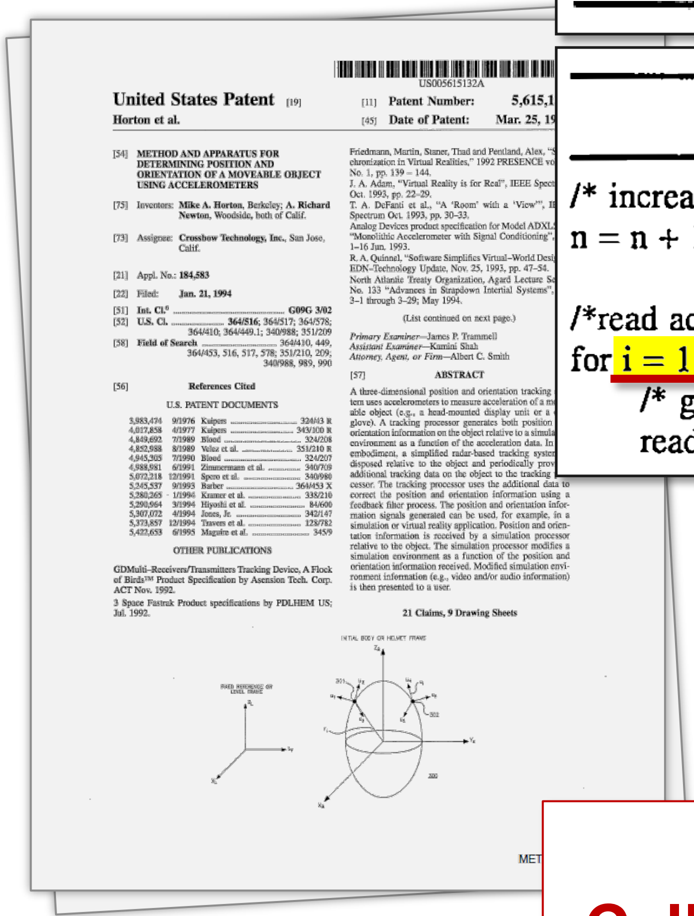

United States Patent [19]
Horton et al.
[11] Patent Number: 5,615,1
[45] Date of Patent: Mar. 25, 19
[54] METHOD AND APPARATUS FOR DETERMINING POSITION AND ORIENTATION OF A MOVEABLE OBJECT USING ACCELEROMETERS
[75] Inventors: Mike A. Horton, Berkeley; A. Richard Newton, Woodside, both of Calif.
[73] Assignee: Crossbow Technology, Inc., San Jose, Calif.
[21] Appl. No.: 184,583
[22] Filed: Jan. 21, 1994
[56] References Cited
U.S. PATENT DOCUMENTS
OTHER PUBLICATIONS
[57] ABSTRACT
21 Claims, 9 Drawing Sheets

TABLE 4

System Flow - MAIN LOOP

```
/* increase update counter */
n = n + 1

/*read accelerometer data */
for i = 1 to 6
    /* get new data from A/D converter */
    read v(i)
```

TABLE 1

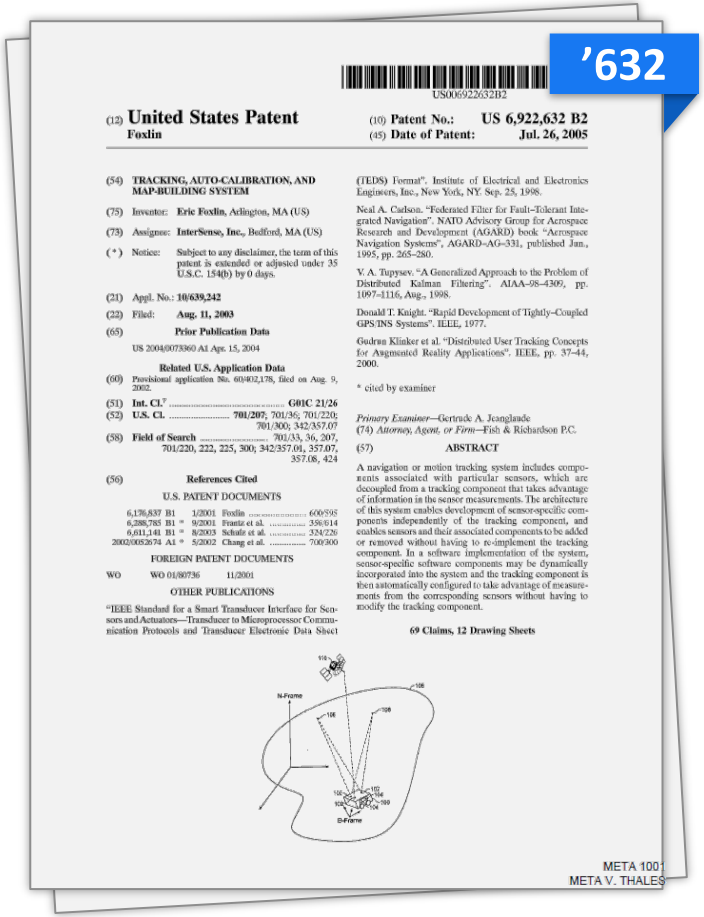
CONSTANTS - MAIN LOOP

Symbol	Dimension	Description
T	Scalar	Update period for main loop. 0.01 seconds
T_D	Scalar	Update rate of simulation software. Typ. 1/30 sec.
B	N/A	Body or helmet coordinate frame
L	N/A	Room or chair coordinate frame. Also referred to as Level or Reference frame.
i	Scalar	1,2, . . . , 6 accelerometer number . . . see schematic

Table 4 Module That Reads Accelerometers Calls Table 1 Module That Sets Number Of Accelerometers

Ex. 1010 (Horton) at cols. 11 and 12; -01304, Paper 34 (Petitioner's Reply) at 23 ("Table 1")

Claim 6: Directed To Iterative Refinement Of Configuration Information


’632

US006922632B2

(12) **United States Patent**
Foxlin

(10) **Patent No.:** **US 6,922,632 B2**
(45) **Date of Patent:** **Jul. 26, 2005**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/639,242**

(22) Filed: **Aug. 11, 2003**

(65) **Prior Publication Data**

US 2004/0073360 A1 Apr. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**[7] **G01C 21/26**
(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07
(58) **Field of Search** 701/33, 36, 207, 701/220, 222, 225, 300; 342/357.01, 357.07, 357.08, 424

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,176,837 B1		1/2001	Foxlin	600/595
6,288,785 B1	*	9/2001	Frantz et al.	356/614
6,611,141 B1	*	8/2003	Schulz et al.	324/226
2002/0052674 A1	*	5/2002	Chang et al.	700/300

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

"IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format". Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

Neal A. Carlson. "Federated Filter for Fault–Tolerant Integrated Navigation". NATO Advisory Group for Aerospace Research and Development (AGARD) book "Aerospace Navigation Systems", AGARD–AG–331, published Jun., 1995, pp. 265–280.

V. A. Tupysev. "A Generalized Approach to the Problem of Distributed Kalman Filtering". AIAA–98–4309, pp. 1097–1116, Aug., 1998.

Donald T. Knight. "Rapid Development of Tightly–Coupled GPS/INS Systems". IEEE, 1977.

Gudrun Klinker et al. "Distributed User Tracking Concepts for Augmented Reality Applications". IEEE, pp. 37–44, 2000.

* cited by examiner

Primary Examiner—Gertrude A. Jeanglaude
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

69 Claims, 12 Drawing Sheets

META 1001
META V. THALES

1. A method for tracking an object comprising:

coupling a sensor subsystem to an estimation subsystem, said sensor subsystem enabling measurement related to relative locations or orientations of sensing elements;

accepting configuration data from the sensor subsystem;

configuring the estimation system according to the accepted configuration data;

repeatedly updating a state estimate, including

accepting measurement information from the sensor subsystem, and

updating the state estimate according to the accepted configuration data and the accepted measurement data.

6. The method of claim 1 wherein the state estimate characterizes configuration information for one or more sensing elements fixed to the object.

Ex. 1001 ('632 Patent) at cls. 1 and 6

Claim 6: Directed To Iterative Refinement Of Configuration Information

’632

US006922632B2

(12) **United States Patent**
Foxlin

(10) **Patent No.: US 6,922,632 B2**
(45) **Date of Patent: Jul. 26, 2005**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/639,242**

(22) Filed: **Aug. 11, 2003**

(65) **Prior Publication Data**

US 2004/0073360 A1 Apr. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**[7] **G01C 21/26**

(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07

(58) **Field of Search** 701/33, 36, 207, 701/220, 222, 225, 300; 342/357.01, 357.07, 357.08, 424

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,176,837	B1		1/2001	Foxlin	600/595
6,288,785	B1	*	9/2001	Frantz et al.	356/614
6,611,141	B1	*	8/2003	Schulz et al.	324/226
2002/0052674	A1	*	5/2002	Chang et al.	700/300

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

"IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format". Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

Neal A. Carlson. "Federated Filter for Fault–Tolerant Integrated Navigation". NATO Advisory Group for Aerospace Research and Development (AGARD) book "Aerospace Navigation Systems", AGARD–AG–331, published Jun., 1995, pp. 265–280.

V. A. Tupysev. "A Generalized Approach to the Problem of Distributed Kalman Filtering". AIAA–98–4309, pp. 1097–1116, Aug., 1998.

Donald T. Knight. "Rapid Development of Tightly–Coupled GPS/INS Systems". IEEE, 1977.

Gudrun Klinker et al. "Distributed User Tracking Concepts for Augmented Reality Applications". IEEE, pp. 37–44, 2000.

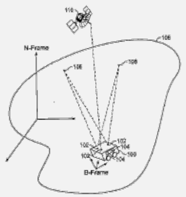
* cited by examiner

Primary Examiner—Gertrude A. Jeanglaude
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

69 Claims, 12 Drawing Sheets



META 1001
META V. THALES

In a second mode of operation, navigation system **90** performs simultaneous localization and calibration (SLAC), and updates vehicle state **202** and vehicle map **204** in the iterative process. In a third mode of operation, navigation system **90** performs simultaneous localization, mapping, and calibration, and updates the vehicle state **202**, vehicle map **204**, and the environment map **206** in the iterative process.

Ex. 1001 (’632 Patent) at 24:34-40

Claim 6: Horton's Iterative Refinement Of Configuration Information Is Exactly What Claim 6 Contemplates

Horton

US005615132A

United States Patent [19] — **Horton et al.**

[11] **Patent Number: 5,615,132**

[45] **Date of Patent: Mar. 25, 1997**

[54] **METHOD AND APPARATUS FOR DETERMINING POSITION AND ORIENTATION OF A MOVEABLE OBJECT USING ACCELEROMETERS**

[75] Inventors: **Mike A. Horton**, Berkeley; **A. Richard Newton**, Woodside, both of Calif.

[73] Assignee: **Crossbow Technology, Inc.**, San Jose, Calif.

[21] Appl. No.: **184,583**

[22] Filed: **Jan. 21, 1994**

[51] **Int. Cl.**[6] **G09G 3/02**

[52] **U.S. Cl.** **364/516**; 364/517; 364/578; 364/410; 364/449.1; 340/988; 351/209

[58] **Field of Search** 364/410, 449, 364/453, 516, 517, 578; 351/210, 209; 340/988, 989, 990

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,983,474	9/1976	Kuipers	324/43 R
4,017,858	4/1977	Kuipers	343/100 R
4,849,692	7/1989	Blood	324/208
4,852,988	8/1989	Velez et al.	351/210 R
4,945,305	7/1990	Blood	324/207
4,988,981	6/1991	Zimmermann et al.	340/709
5,072,218	12/1991	Spero et al.	340/980
5,245,537	9/1993	Barber	364/453 X
5,280,265	1/1994	Kramer et al.	338/210
5,290,964	3/1994	Hiyoshi et al.	84/600
5,307,072	4/1994	Jones, Jr.	342/147
5,373,857	12/1994	Travers et al.	128/782
5,422,653	6/1995	Maguire et al.	345/9

OTHER PUBLICATIONS

GDMulti–Receivers/Transmitters Tracking Device, A Flock of Birds™ Product Specification by Asension Tech. Corp. ACT Nov. 1992.

3 Space Fastrak Product specifications by PDLHEM US; Jul. 1992.

Friedmann, Martin, Staner, Thad and Pentland, Alex, "Synchronization in Virtual Realities," 1992 PRESENCE vol. 1, No. 1, pp. 139 – 144.

J. A. Adam, "Virtual Reality is for Real", IEEE Spectrum Oct. 1993, pp. 22–29.

T. A. DeFanti et al., "A 'Room' with a 'View'", IEEE Spectrum Oct. 1993, pp. 30–33.

Analog Devices product specification for Model ADXL50*, "Monolithic Accelerometer with Signal Conditioning", pp. 1–16 Jun. 1993.

R. A. Quinnel, "Software Simplifies Virtual–World Design", EDN–Technology Update, Nov. 25, 1993, pp. 47–54.

North Atlantic Treaty Organization, Agard Lecture Series No. 133 "Advances in Strapdown Intertial Systems", pp. 3–1 through 3–29; May 1994.

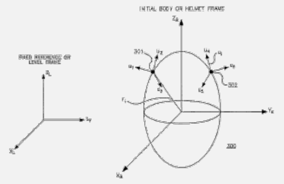
(List continued on next page.)

Primary Examiner—James P. Trammell
Assistant Examiner—Kamini Shah
Attorney, Agent, or Firm—Albert C. Smith

[57] **ABSTRACT**

A three-dimensional position and orientation tracking system uses accelerometers to measure acceleration of a moveable object (e.g., a head-mounted display unit or a data glove). A tracking processor generates both position and orientation information on the object relative to a simulation environment as a function of the acceleration data. In one embodiment, a simplified radar-based tracking system is disposed relative to the object and periodically provides additional tracking data on the object to the tracking processor. The tracking processor uses the additional data to correct the position and orientation information using a feedback filter process. The position and orientation information signals generated can be used, for example, in a simulation or virtual reality application. Position and orientation information is received by a simulation processor relative to the object. The simulation processor modifies a simulation environment as a function of the position and orientation information received. Modified simulation environment information (e.g., video and/or audio information) is then presented to a user.

21 Claims, 9 Drawing Sheets

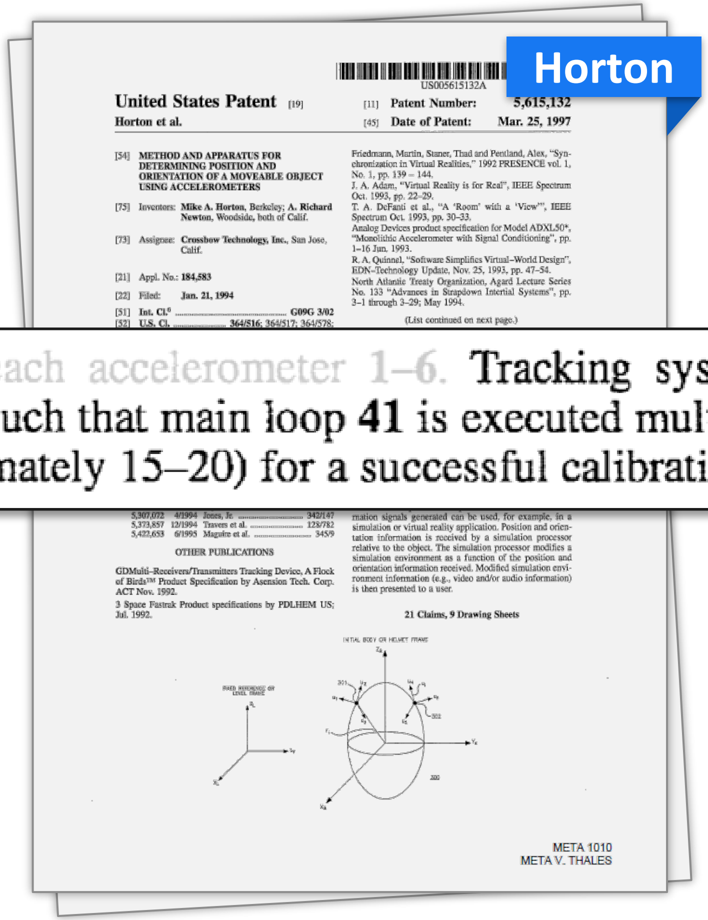


META 1010
META V. THALES

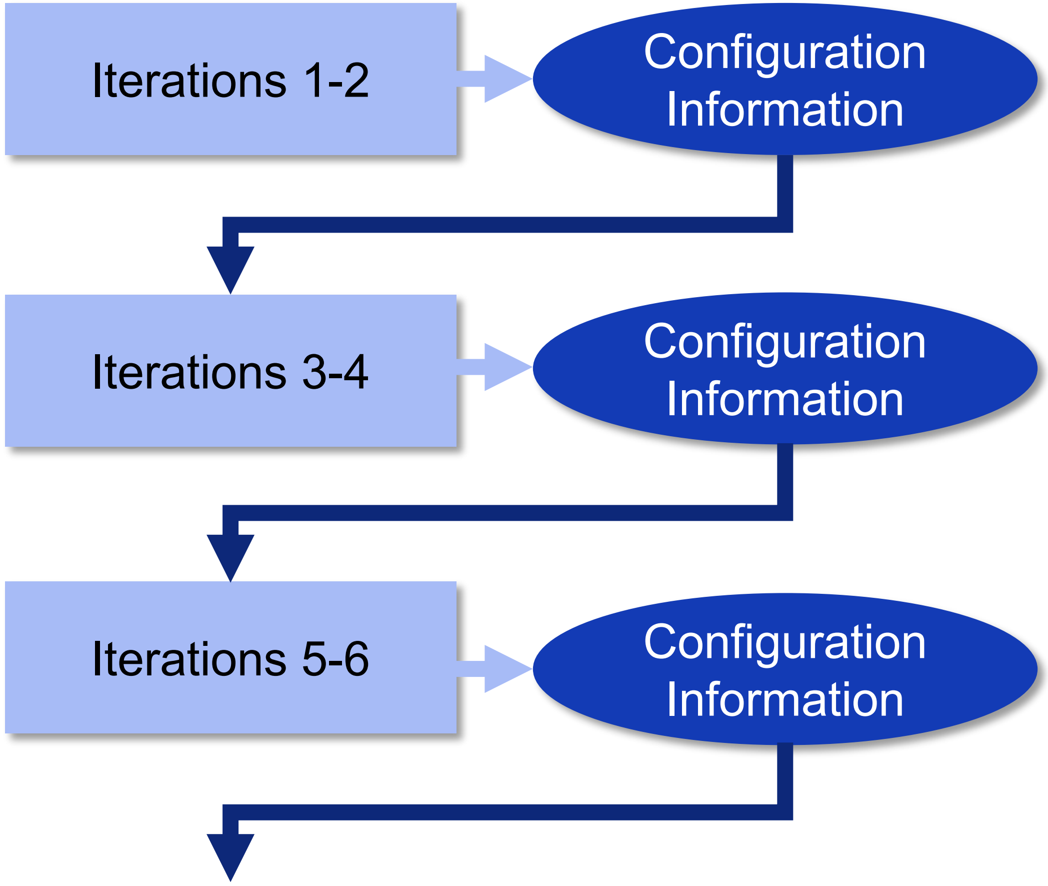
each accelerometer 1–6. Tracking system **15** is operated such that main loop **41** is executed multiple times (approximately 15–20) for a successful calibration **48**. Total calibra-

Ex. 1010 (Horton) at 6:12-14

Claim 6: Horton's Iterative Refinement Of Configuration Information Is Exactly What Claim 6 Contemplates



each accelerometer 1–6. Tracking system **15** is operated such that main loop **41** is executed multiple times (approximately 15–20) for a successful calibration **48**. Total calibra-

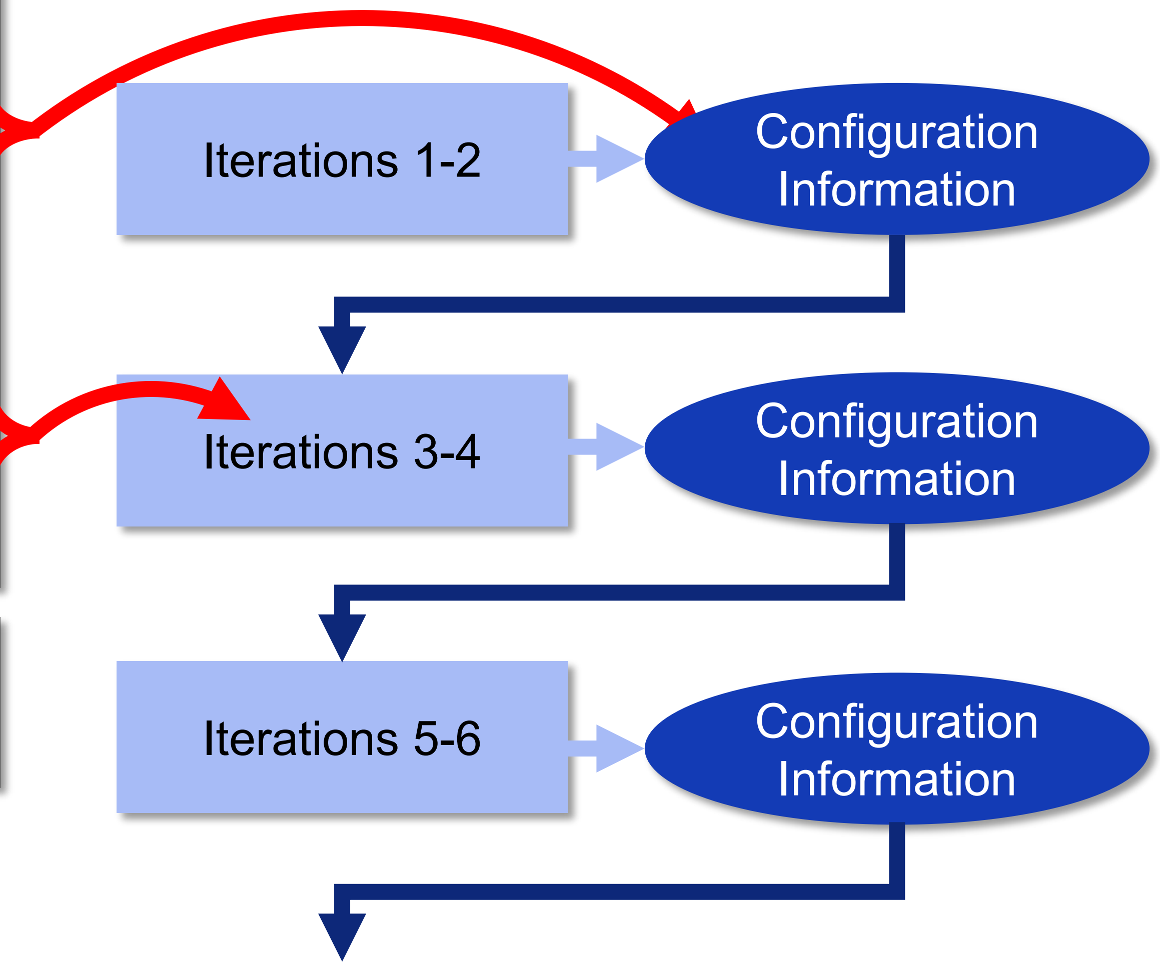


Ex. 1010 (Horton) at 6:12-14

Claim 6: Horton's Iterative Refinement Of Configuration Information Is Exactly What Claim 6 Contemplates

1. A method for tracking an object comprising:
coupling a sensor subsystem to an estimation subsystem, said sensor subsystem enabling measurement related to relative locations or orientations of sensing elements;
accepting configuration data from the sensor subsystem;
configuring the estimation system according to the accepted configuration data;
repeatedly updating a state estimate, including
accepting measurement information from the sensor subsystem, and
updating the state estimate according to the accepted configuration data and the accepted measurement data.

6. The method of claim 1 wherein the state estimate characterizes configuration information for one or more sensing elements fixed to the object.



Ex. 1001 ('632 Patent) at cls. 1 and 6

Claim 11: PO Adds Non-Existent Requirements

1. A method for tracking an object comprising:
coupling a sensor subsystem to an estimation subsystem, said sensor subsystem enabling measurement related to relative locations or orientations of sensing elements;
accepting configuration data from the sensor subsystem;
configuring the estimation system according to the accepted configuration data;
repeatedly updating a state estimate, including
accepting measurement information from the sensor subsystem, and
updating the state estimate according to the accepted configuration data and the accepted measurement data.

11. The method of claim 1 wherein repeatedly updating the state further includes:
providing to the sensor subsystems information related to an expected sensor measurement; and
wherein accepting the measurement information from the sensor subsystem includes accepting information related to an actual sensor measurement.

No requirement that this information is provided *by the estimation subsystem*

Ex. 1001 ('632 Patent) at cls. 1 and 11

KIRKLAND & ELLIS LLP

U.S. Patent No. 6,922,632
IPR2022-01305
Petitioner’s Demonstratives

Claim 30: Trigger For HiBall Sensor Is Tied To The LED Trigger, Which Is “Related To An Expected Sensor Measurement”

’632

US006922632B2

(12) **United States Patent**
Foxlin

(10) **Patent No.:** **US 6,922,632 B2**
(45) **Date of Patent:** **Jul. 26, 2005**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/639,242**

(22) Filed: **Aug. 11, 2003**

(65) **Prior Publication Data**

US 2004/0073360 A1 Apr. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**[7] **G01C 21/26**
(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07
(58) **Field of Search** 701/33, 36, 207, 701/220, 222, 225, 300; 342/357.01, 357.07, 357.08, 424

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,176,837 B1	1/2001	Foxlin	....	600/595
6,288,785 B1 *	9/2001	Frantz et al.	....	356/614
6,611,141 B1 *	8/2003	Schulz et al.	....	324/226
2002/0052674 A1 *	5/2002	Chang et al.	....	700/300

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

“IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format”. Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

Neal A. Carlson. “Federated Filter for Fault–Tolerant Integrated Navigation”. NATO Advisory Group for Aerospace Research and Development (AGARD) book “Aerospace Navigation Systems”, AGARD–AG–331, published Jun., 1995, pp. 265–280.

V. A. Tupysev. “A Generalized Approach to the Problem of Distributed Kalman Filtering”. AIAA–98–4309, pp. 1097–1116, Aug., 1998.

Donald T. Knight. “Rapid Development of Tightly–Coupled GPS/INS Systems”. IEEE, 1977.

Gudrun Klinker et al. “Distributed User Tracking Concepts for Augmented Reality Applications”. IEEE, pp. 37–44, 2000.

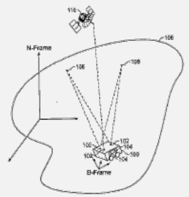
* cited by examiner

Primary Examiner—Gertrude A. Jeanglaude
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

69 Claims, 12 Drawing Sheets



META 1001
META V. THALES

30. A sensor module comprising:

a sensor interface for communicating with a measurement sensor;

a communication interface for communication with an estimation system;

wherein the sensor module is configured to

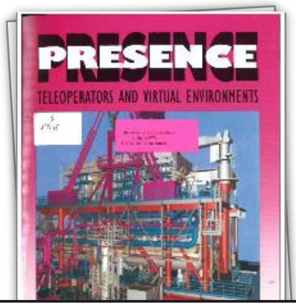
receive information related to an expected sensor measurement over the communication interface,

receive a measurement signal over the sensor interface,

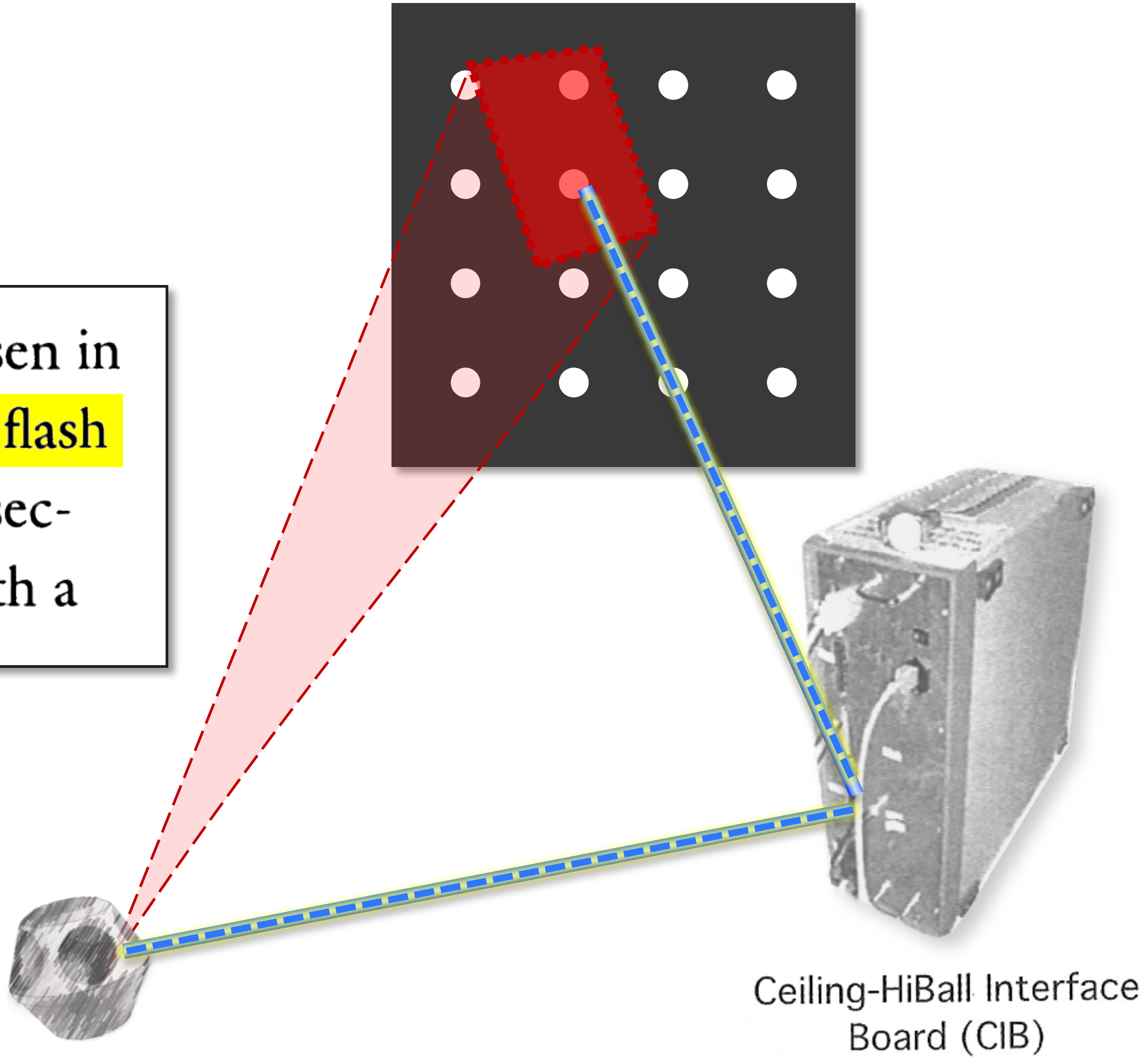
provide measurement information based on the measurement signal over the communication interface.

Ex. 1001 (’632 Patent) at cl. 30; -01305, Paper 2 (Petition) at 19 (“Once the view and LED are selected, the CIB flashes the selected LED and the HiBall takes a single measurement.”)

Claim 30: LED Selection Is Based On Predicted Pose, and HiBall Trigger Is ***Directly Connected*** To LED Selection Trigger

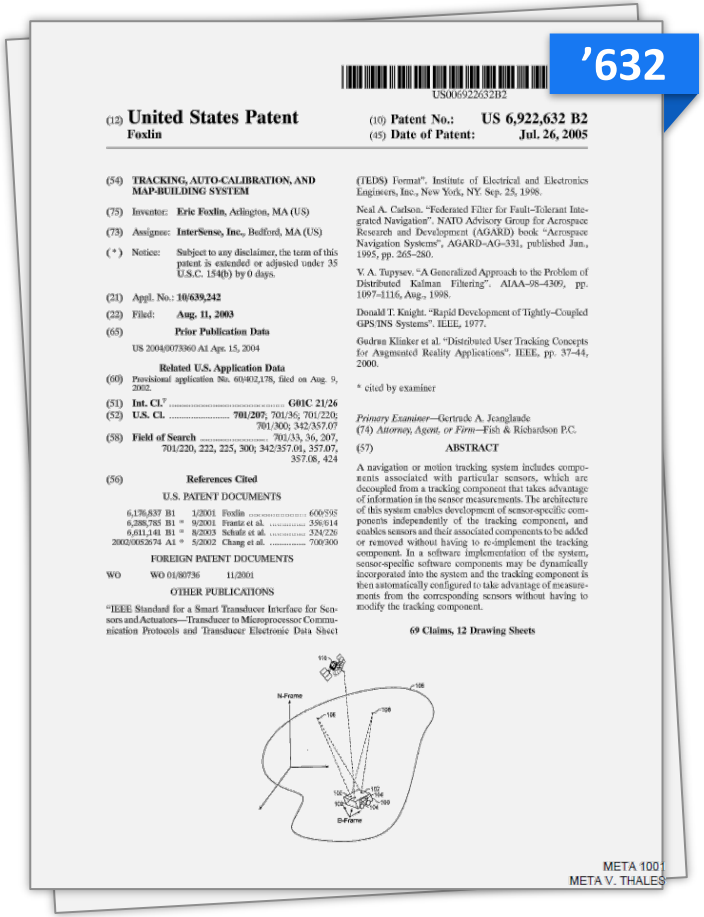


Once a particular view and LED have been chosen in this fashion, the CIB (section 4.3) is instructed to flash the LED and take a measurement as described in section 5.2. This single measurement is compared with a



Ex. 1007 (Welch-2001) at 13 and Fig. 6; -01305, Paper 2 (Petition) at 19 ("Once the view and LED are selected, the CIB flashes the selected LED and the HiBall takes a single measurement.")

Claim 33: Welch's "Reacquisition" Sequence Satisfies This Claim Element



US006922632B2

(12) **United States Patent**
Foxlin

(10) **Patent No.:** **US 6,922,632 B2**
(45) **Date of Patent:** **Jul. 26, 2005**

(54) **TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM**

(75) Inventor: **Eric Foxlin**, Arlington, MA (US)

(73) Assignee: **InterSense, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/639,242**

(22) Filed: **Aug. 11, 2003**

(65) **Prior Publication Data**

US 2004/0073360 A1 Apr. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) **Int. Cl.**[7] **G01C 21/26**
(52) **U.S. Cl.** **701/207**; 701/36; 701/220; 701/300; 342/357.07
(58) **Field of Search** 701/33, 36, 207, 701/220, 222, 225, 300; 342/357.01, 357.07, 357.08, 424

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,176,837 B1		1/2001	Foxlin	600/595
6,288,785 B1	*	9/2001	Frantz et al.	356/614
6,611,141 B1	*	8/2003	Schulz et al.	324/226
2002/0052674 A1	*	5/2002	Chang et al.	700/200

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

"IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format". Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

Neal A. Carlson. "Federated Filter for Fault–Tolerant Integrated Navigation". NATO Advisory Group for Aerospace Research and Development (AGARD) book "Aerospace Navigation Systems", AGARD–AG–331, published Jun., 1995, pp. 265–280.

V. A. Tupysev. "A Generalized Approach to the Problem of Distributed Kalman Filtering". AIAA–98–4309, pp. 1097–1116, Aug., 1998.

Donald T. Knight. "Rapid Development of Tightly–Coupled GPS/INS Systems". IEEE, 1977.

Gudrun Klinker et al. "Distributed User Tracking Concepts for Augmented Reality Applications". IEEE, pp. 37–44, 2000.

* cited by examiner

Primary Examiner—Gertrude A. Jeanglaude
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) ABSTRACT

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

69 Claims, 12 Drawing Sheets

META 1001
META V. THALES

'632

33. A method comprising:

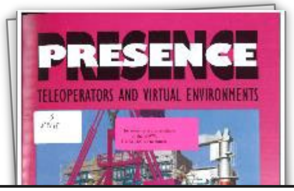
enumerating a set of sensing elements available to a tracking system that includes an estimation subsystem that estimates a position or orientation of an object;

providing parameters specific to the set of sensing elements to the tracking system to enable the estimation subsystem to be configured based on the parameters specific to the set of sensing elements; and

generating a sequence of candidates of pairs of sensing elements selected from the set of sensing elements, the sequence based on an expected utility of a measurement associated with said elements to the estimation subsystem.

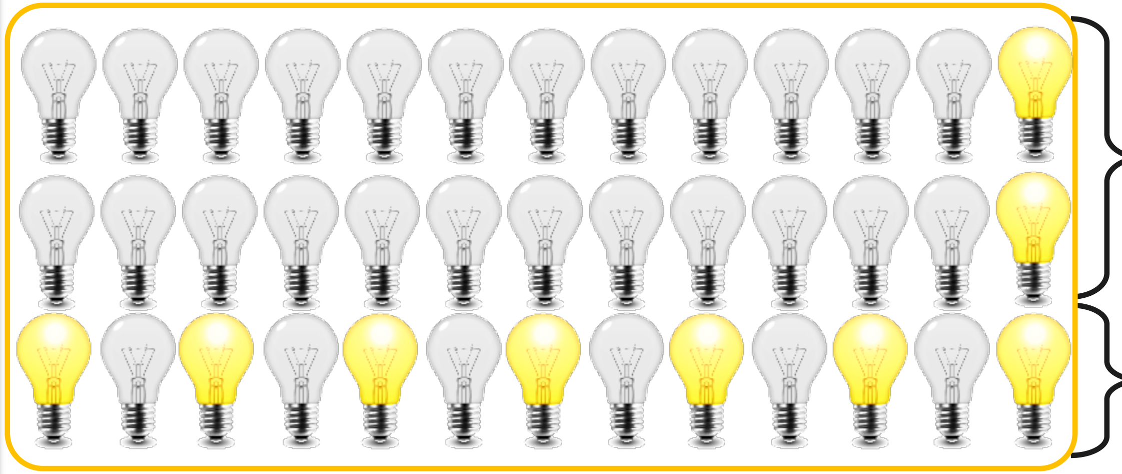
Ex. 1001 ('632 Patent) at cl. 33

Claim 33: Welch "Reacquisiton" Process Is ***One*** Sequence Of Candidates Where The Pairs In The Beginning Of The Sequence Have A Higher Expected Utility Than The Pairs At The End



> We begin with an exhaustive LED scan of sufficiently fine granularity to ensure that the central primary field of view is not missed. For the present ceiling, we flash every thirteenth LED in sequence, and look for it with the central LEPD until we get a hit. Then, a sufficiently large patch of LEDs, centered on the hit, is sampled to ensure that several of the views of the central LEPD will be hit. The fields of view are disambiguated by using the initial hits to estimate the yaw of the HiBall (rotation about vertical); finally, more-selective measurements are used to refine the acquisition estimate sufficiently to switch into tracking mode.

ONE Sequence

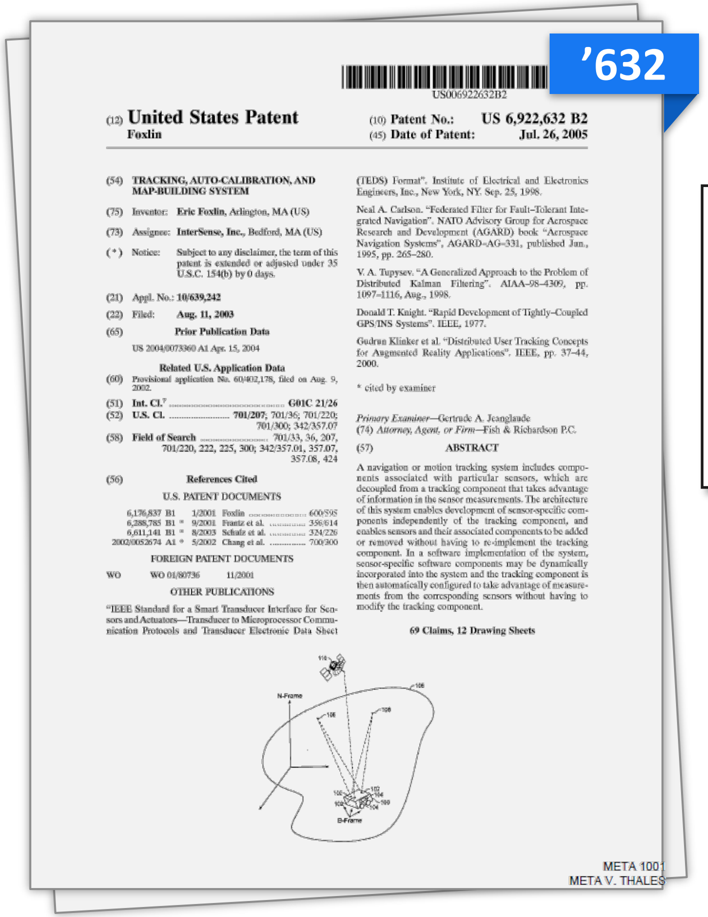


Higher expected utility portion of sequence

Lower expected utility portion of sequence

Ex. 1007 (Welch-2001) at 14

“Expected” = “Anticipated,” Not “Predicted Value” As PO Contends


(12) United States Patent
Foxlin

US006922632B2

(10) Patent No.: US 6,922,632 B2
(45) Date of Patent: Jul. 26, 2005

(54) TRACKING, AUTO-CALIBRATION, AND MAP-BUILDING SYSTEM

(75) Inventor: Eric Foxlin, Arlington, MA (US)

(73) Assignee: InterSense, Inc., Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 10/639,242

(22) Filed: Aug. 11, 2003

(65) Prior Publication Data

US 2004/0073360 A1 Apr. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/402,178, filed on Aug. 9, 2002.

(51) Int. Cl.[7] G01C 21/26
(52) U.S. Cl. 701/207; 701/36; 701/220; 701/300; 342/357.07
(58) Field of Search 701/33, 36, 207, 701/220, 222, 225, 300; 342/357.01, 357.07, 357.08, 424

(56) References Cited

U.S. PATENT DOCUMENTS

6,176,837 B1 1/2001 Foxlin 600/595
6,288,785 B1 * 9/2001 Frantz et al. 356/614
6,611,141 B1 * 8/2003 Schulz et al. 324/226
2002/0052674 A1 * 5/2002 Chang et al. 700/300

FOREIGN PATENT DOCUMENTS

WO WO 01/80736 11/2001

OTHER PUBLICATIONS

“IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format”. Institute of Electrical and Electronics Engineers, Inc., New York, NY. Sep. 25, 1998.

Neal A. Carlson. “Federated Filter for Fault–Tolerant Integrated Navigation”. NATO Advisory Group for Aerospace Research and Development (AGARD) book “Aerospace Navigation Systems”, AGARD–AG–331, published Jun., 1995, pp. 265–280.

V. A. Tupysev. “A Generalized Approach to the Problem of Distributed Kalman Filtering”. AIAA–98–4309, pp. 1097–1116, Aug., 1998.

Donald T. Knight. “Rapid Development of Tightly–Coupled GPS/INS Systems”. IEEE, 1977.

Gudrun Klinker et al. “Distributed User Tracking Concepts for Augmented Reality Applications”. IEEE, pp. 37–44, 2000.

* cited by examiner

Primary Examiner—Gertrude A. Jeanglaude
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) ABSTRACT

A navigation or motion tracking system includes components associated with particular sensors, which are decoupled from a tracking component that takes advantage of information in the sensor measurements. The architecture of this system enables development of sensor-specific components independently of the tracking component, and enables sensors and their associated components to be added or removed without having to re-implement the tracking component. In a software implementation of the system, sensor-specific software components may be dynamically incorporated into the system and the tracking component is then automatically configured to take advantage of measurements from the corresponding sensors without having to modify the tracking component.

69 Claims, 12 Drawing Sheets

META 1001
META V. THALES

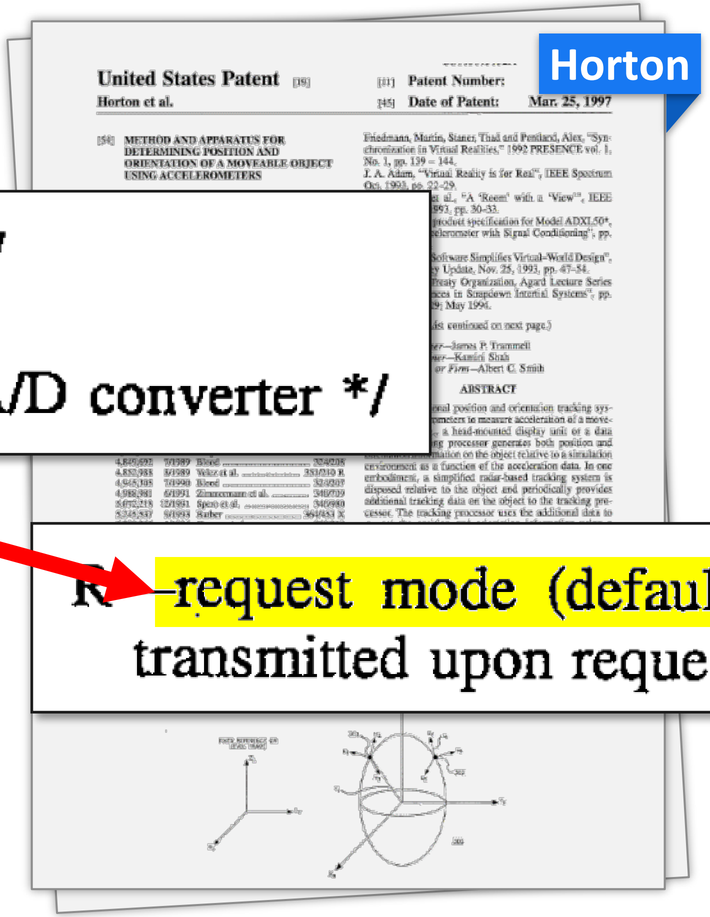
’632

The patent intentionally distinguishes between “expected” and “predicted”

> The received information related to an expected sensor measurement includes a predicted pose of a sensing element relative to the measurement sensor.

Ex. 1001 (’632 Patent) at 4:50-52

Claim 30: "Request Mode" At Least Obviously Applies To "Get" New Accelerometer Data When Helpful, Rather Than At Arbitrary Intervals




```
/*read accelerometer data */
for i = 1 to 6
      /* get new data from A/D converter */
```

R—request mode (default). Position and orientation is transmitted upon request.

Ex. 1010 (Horton) at 12:47-49; 4:60-61

Ground IV: Horton

See also Ground IV (Horton), Claim 47[d][1-2]

Claim 59: Ignoring PO's Unclaimed Requirements, Accelerometer Mounting Data Satisfies This Claim

’632

United States Patent
Foxlin

Patent No.: US 6,922,632 B2
Date of Patent: Jul. 26, 2005

No requirement to ***uniquely*** characterize a sensor

> **59**. The method of claim **47** wherein providing configuration information from the sensor modules includes providing information characterizing a type of a sensor associated with a sensor module.

No requirement that characterizing information is provided ***directly by*** the sensors

> **47**. A method of using multiple sensors in a tracking system comprising:
>
> . . .
>
> providing configuration information from each of the sensor modules to the estimation module regarding the characteristics of the sensors associated with the sensor module, and

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner,
vs.
THALES VISIONIX, INC.,
Patent Owner.

IPR NO. 2022-01304

Q. I guess would the mounting -- or would the typical mounting for a set of accelerometers expect it to be the same as a typical mounting for a set of ultrasonic sensors?

A. **It's a completely different setup. So there is no constraint that will apply from one to the other.**

Ex. 1001 (’632 Patent) at cls. 47, 59; Ex.1033 (Baillot Depo. Tr.) at 176:7-13