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Snavely et al.

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(45) **Date of Patent:** **Apr. 17, 2012**

(54) **NAVIGATING IMAGES USING IMAGE BASED GEOMETRIC ALIGNMENT AND OBJECT BASED CONTROLS**

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(73) Assignee: **Microsoft Corporation**, Redmond, WA (US)

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G06K 9/54 (2006.01)
G06K 9/46 (2006.01)

(52) **U.S. Cl.** **382/305**; 382/100; 382/154; 382/190; 382/201; 382/206; 707/E17.029

(58) **Field of Classification Search** 382/100, 382/154, 190, 201, 206, 214, 216, 305, 325; 707/E17.029
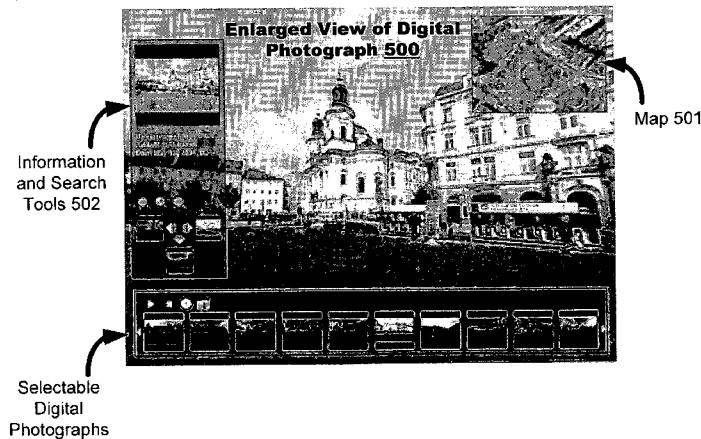See application file for complete search history.

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(57) **ABSTRACT**

Over the past few years there has been a dramatic proliferation of digital cameras, and it has become increasingly easy to share large numbers of photographs with many other people. These trends have contributed to the availability of large databases of photographs. Effectively organizing, browsing, and visualizing such .seas. of images, as well as finding a particular image, can be difficult tasks. In this paper, we demonstrate that knowledge of where images were taken and where they were pointed makes it possible to visualize large sets of photographs in powerful, intuitive new ways. We present and evaluate a set of novel tools that use location and orientation information, derived semi-automatically using structure from motion, to enhance the experience of exploring such large collections of images.

9 Claims, 10 Drawing Sheets

Enlarged View of Digital Photograph 500

Map 501

Information and Search Tools 502

Selectable Digital Photographs
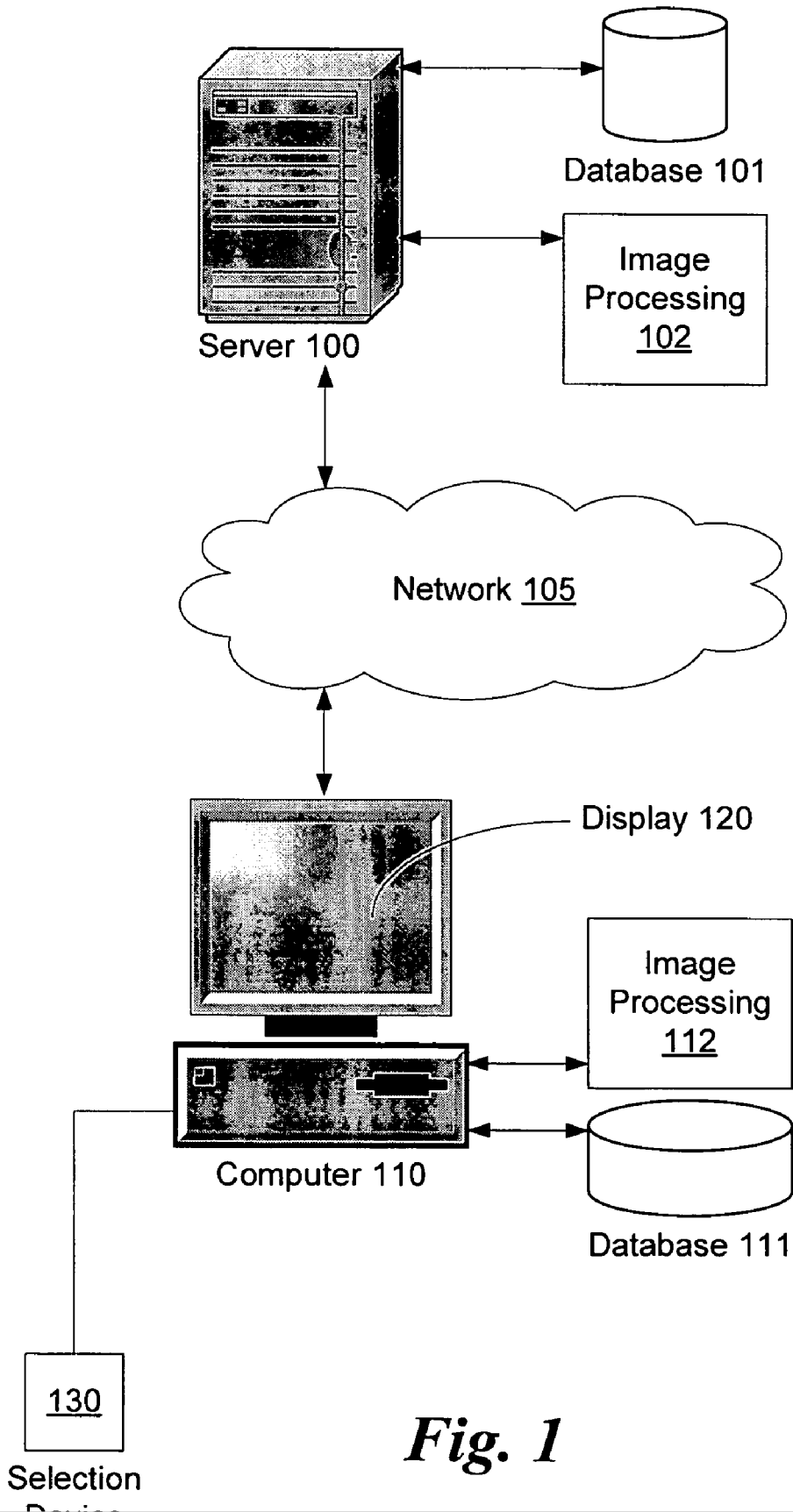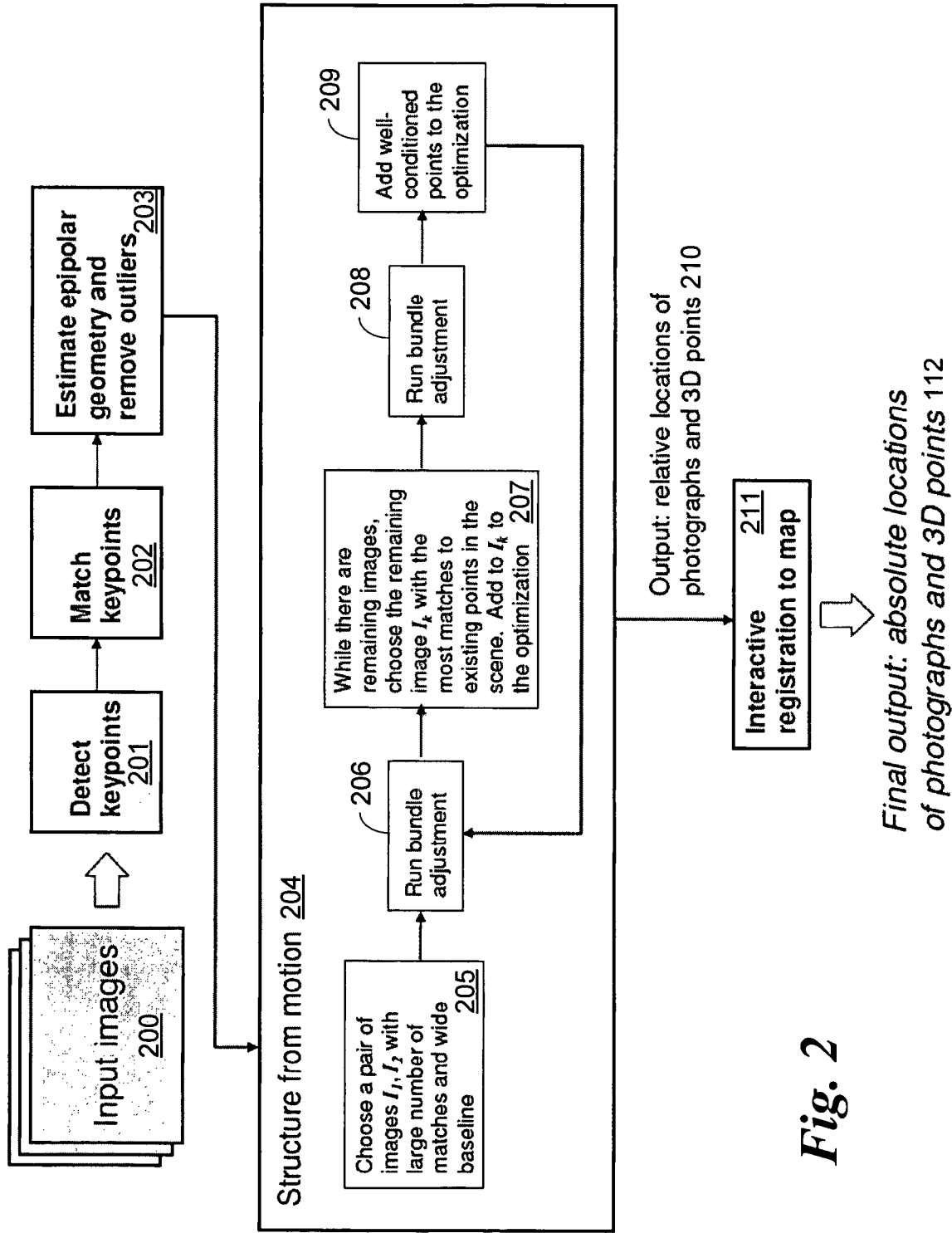
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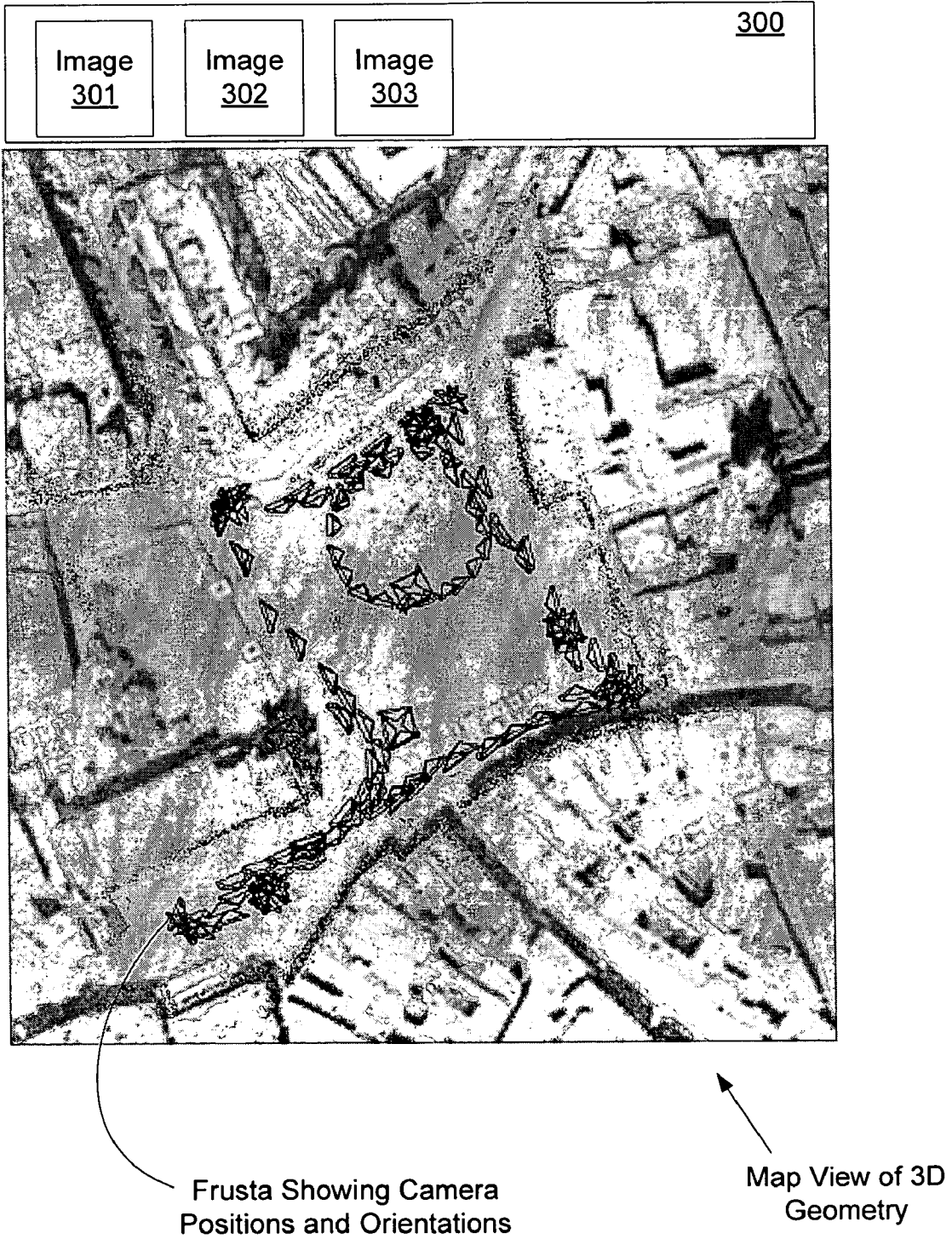Yeh, T. et al., "Searching the web with mobile images for location recognition," *CVPR* (2), 2004, 76-81.

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Database 101

Image
Processing
102

Server 100

Network 105

Display 120

Image
Processing
112

Computer 110

Database 111

130

Fig. 1

Selection
~~Device~~

Input images 200

Detect keypoints 201

Match keypoints 202

Estimate epipolar geometry and remove outliers 203

Structure from motion 204

Choose a pair of images I_1, I_2 with large number of matches and wide baseline 205

Run bundle adjustment 206

While there are remaining images, choose the remaining image I_k with the most matches to existing points in the scene. Add to I_k to the optimization 207

Run bundle adjustment 208

Add well-conditioned points to the optimization 209

Output: relative locations of photographs and 3D points 210

Interactive registration to map 211

Final output: absolute locations of photographs and 3D points 112

Fig. 2

Frusta Showing Camera
Positions and Orientations

Map View of 3D
Geometry

Fig. 3

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