USC UNIVERSITY OF SOUTHERN CALIFORNIA | IMSC Integrated Media Systems Center

INTEGRATED MEDIA SYSTEMS CENTER
A National Science Foundation
Engineering Research Center at the
UNIVERSITY OF SOUTHERN CALIFORNIA

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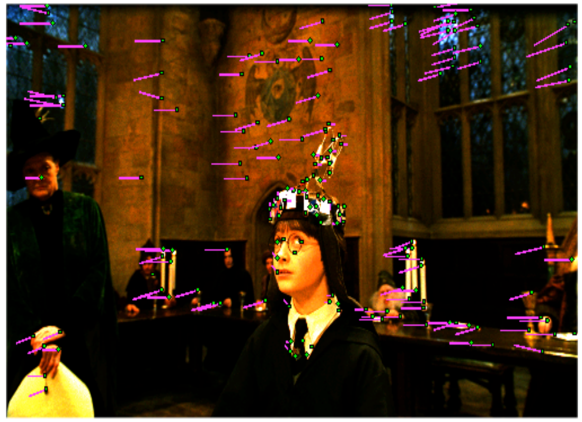
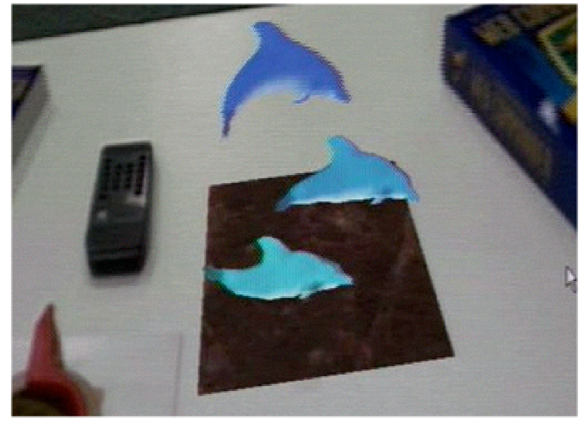
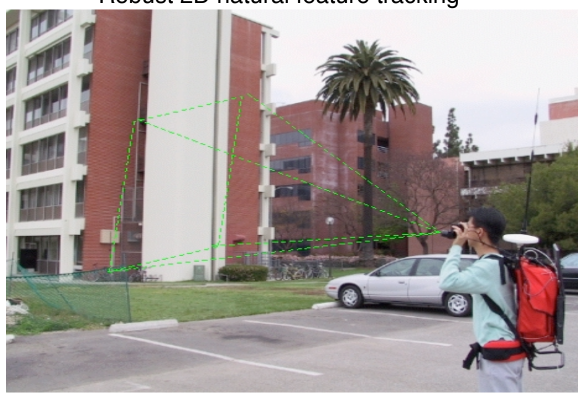
TRACKING AND DYNAMIC VISUALIZATION



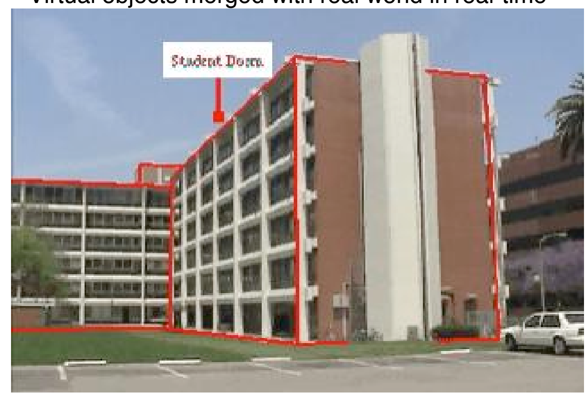
Robust 2D natural feature tracking



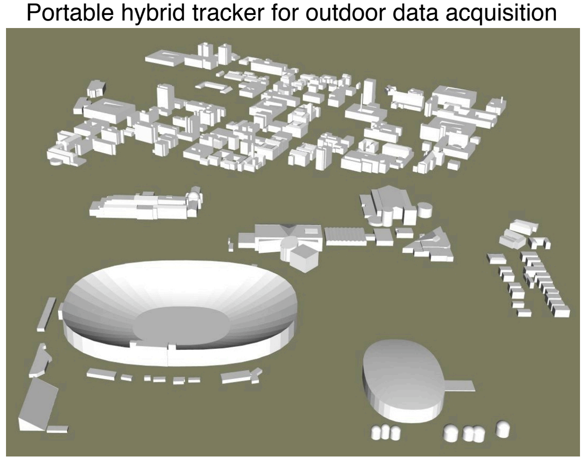
Virtual objects merged with real world in real-time



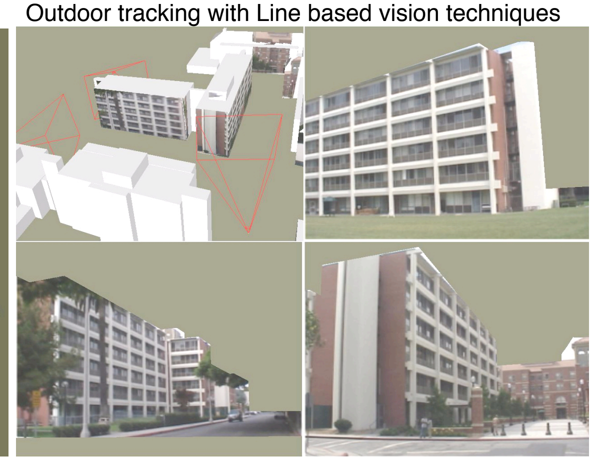
Portable hybrid tracker for outdoor data acquisition



Outdoor tracking with Line based vision techniques



Reconstructed USC campus and surrounding area



AVE: dynamic fusion of multi-sensor projections

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BRIEF DESCRIPTION OF DEMONSTRATION

Tracking camera pose (position and orientation) enables merging 3D graphics (virtual objects) in real scenes. The fusion of live or recorded imagery with a static virtual environment creates an Augmented Virtual Reality (AVE), enabling users to visualize and comprehend multiple streams of imagery in a four-dimensional context. Applications include engineering, mission planning, training simulations, environment monitoring, and security surveillance.

DISTINGUISHING CHARACTERISTICS RELATIVE TO STATE-OF-THE-ART

Indoor tracking (based on landmarks) is scaleable to both near and far fields. Outdoor tracking makes use of natural visual features and multiple sensor technologies including inertial, GPS, panoramic, and vision sensors. 3D modeling rapidly creates large-scale site models from LiDAR sensor. Dynamic visualization merges images and models seamlessly.

UNDERLYING TECHNOLOGIES

- Tracking from vision, GPS and inertial sensing
- Line and point feature auto-calibration
- Real-time image analysis & computing
- Large-scale environment modeling
- Dynamic fusion 2D data using 3D model
- 3D graphics & visualization
- Cognitive perception

APPLICATIONS

Typical applications include assembly, maintenance, and other tasks that require information about real objects and how to interact with them. Targets are industries with a need to visualize information in a spatial context to facilitate or speed up work, decrease errors, reduce training time. Military uses include navigation and iconic scene overlays to increase situational awareness of visualize battlefield environments. Entertainment applications include games or sports with real and virtual elements. Commerce and surveillance applications include security surveillance, environment monitoring, heath care, wildlife animal preserves, traffic measurement, tactical decision-making, and management of catastrophe response.

RECENT HIGHLIGHTS, LEVEL OF DEVELOPMENT, UPCOMING MILESTONES

Offline systems allow tracking objects and camera motion in arbitrary environments. A real time system uses a fiducials (color ring or square landmark) and auto-calibration (line and point) to allow extendible wide-area tracking for hand-held or head-mounted cameras. Panoramic imaging and inertial systems enable tracking in an uncalibrated outdoor environment. Research in multi-sensor dynamic AR visualization environment combines all manner of images, 3D models, video, and data in a coherent visualization that supports varied media types and layers of abstraction.

BRIEF DESCRIPTION OF UNDERLYING TECHNOLOGIES

1) Robust 2D Natural Feature Tracking

A software algorithm performs two-dimensional Natural Feature (NF) tracking in a sequence of images. Features are detected and tracked as they move due to camera or scene motions. The algorithm is unique in its integration of several features:

a) It selects scene features in an image that are most appropriate for robust tracking.

b) It verifies that features are correctly tracked from frame to frame.

c) It attempts to locate and track a selected number of “best” features regardless of image conditions.

The special effects house, Rhythm & Hues, has used the software for special effects for three new films—“Gigli,” “XMen II,” and “Daredevil”, reducing the time it takes for a key part of the process—feature tracking in image sequences—from minutes to seconds per frame. The software also reduces the need for hand-corrections by robust tracking of the features.

2) Real-time Landmark Detection and Identification

A software algorithm detects and uniquely recognizes a set of novel landmarks or fiducials that are easily reproduced on home computer printers. The landmarks are high contrast patterns printed on paper. Their detection is robust over a wide range of lighting and viewing conditions. An alphanumeric or symbol region embedded in their design facilitates unique fiducial recognition from sets of 50-100 different symbols. The detection and recognition is robust to viewing direction and range variations. The detection and recognition of landmarks executes in approximate real time (20-25Hz), depending on the number of landmarks in the scene and the contrast complexity of the scene.

3) 3D/6DOF Pose Estimation

A software algorithm estimates high-dimension parameters from multiple lower-dimension measurements. For example, the 3D position of a point can be estimated from a sequence of 2D images taken from cameras at known positions and orientations. This example describes the use of the filter for autocalibration, or modeling of the scene (see Autocalibration). Likewise, the position and orientation (6D pose) of a camera can be estimated from the positions of multiple 2D image features whose 3D positions are known. This latter example is exactly the calculation needed for tracking a camera’s pose (from known fiducials) in order to overlay 3D annotations on a scene. The pose filter executes in real time (30Hz), given the necessary input measurement data.

4) Point and Line Feature Autocalibration

A software algorithm simultaneously estimates 6D pose of a camera and 3D parameters of tracked features (points or lines) in the scene. An initial camera pose estimate is computed from a set of known calibrated features. Other features (intentional fiducials (IF) or natural features (NF)), at initially unknown positions, are tracked in the images produced as the camera moves. The IF or NF 3D positions are estimated (automatically calibrated) and their position estimates are used, in turn, to estimate the pose of the camera. This computation iterates and converges to produce both 6D camera pose and 3D IF or NF positions over a sequence of images. The iterative estimation executes in real time (30Hz), given tracked 2D feature positions in an image sequence.

5) Wide Area Tracking with Panoramic Imaging

A software algorithm estimates 6DOF (six-degree-of-freedom) camera pose in wide area (indoor or outdoor). By using the panoramic imaging sensor and our innovated tracking method, camera motion pose can be estimated robustly while required less 3D environment measurements or calibrations (normally 2 measurements are sufficient, which are used as reference images). The 6DOF camera pose is derived directly from a pair of 5DOF motion (orientation and translation direction) estimates measured between the two reference images and tracked images. The pose estimate algorithm executes in approximate real time (25Hz), given the 2D tracking data.

6) Inertial and Vision Fusion

A software algorithm integrates vision and gyroscope data from a rigidly connected camera and gyroscope assembly. The algorithm is a flexible framework with a two-channel complementary motion-filter structure that combines the low-frequency stability of vision sensors with the high-frequency tracking of gyroscope sensors, hence, achieving stable static and dynamic six-degree-of-freedom (6DOF) pose tracking. The complementary filter processes data independently, allowing for different sample rates of the sensor systems and reducing the end-to-end system delay. The fusion algorithm executes in real time (30Hz), given real time 3D gyro data and vision tracking data.

7) Large-scale Urban Site Modeling

A software technique extracts and models complex building structures with irregular shapes and surfaces. The modeling approach is based on the use of airborne LiDAR, which offers a fast and effective way to acquire models for a large urban environment. To verify and refine the reconstructed ragged model, a primitive-based model refinement approach is suggested that requires minor user assistance. Given the limited user input, the system automatically segments the building boundary, does the model refinement, and assembles the complete building model. By adapting a set of appropriate geometric primitives and fitting strategies, the system can rapidly and accurately model a range of complex buildings with irregular shapes.

8) AVE: Dynamic Fusion and Visualization of Imagery and 3D Models

A software technique combines all manner of images, video, 3D models, and data in a coherent visualization that supports varied media types and layers of abstraction. An Augmented Virtual Environment (AVE) fuses dynamic imagery with 3D models. The AVE provides a unique approach to visualize and comprehend multiple streams of temporal data or images. Models are used as a 3D substrate for the visualization of temporal imagery, providing improved comprehension of scene activities. Dynamic multi-texture projections enable real time update and “painting” of scenes to reflect the most recent visual scene data. The dynamic controls, including viewpoint as well as image inclusion, blending, and projection parameters, make for interactive real-time visualization of events occurring over wide areas such as a campus, airport, security infrastructure, or battlefield.

LIST OF PUBLICATIONS, REFERENCES, URLs

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- S. You, J. Hu, U. Neumann, and P. Fox, "Urban Site Modeling From LiDAR," *Second International Workshop on Computer Graphics and Geometric Modeling CGGM'2003*, Montreal, CANADA, 2003.
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- S. You, J. Hu, B. Jiang, J. Lee, and U. Neumann. "Creation of Augmented Virtual Environments by Dynamic Fusion of Imagery and 3D Models", *Workshop on Intelligent Human Augmentation and Virtual Environments*. DARPA/ARL/University of North Carolina at Chapel Hill, October 17-19, 2002, USA.
- J. Lee, S. You and U. Neumann. "Tracking with Omni-directional Vision for Outdoor AR Systems", *IEEE, ACM International Symposium on Mixed and Augmented Reality,* September 30 - October 1, 2002, Germany*.*
- Suya You and Ulrich Neumann, "Fusion of Vision and Gyro Tracking for Robust Augmented Reality Registration", *", IEEE Virtual Reality*, March, Japan, 2001
- Bolan Jiang and Ulrich Neumann. "Extendible Tracking by Line Auto-Calibration". *ISAR 2001*, USA.

http://graphics.usc.edu/~suyay/project.html

http://deimos.usc.edu/~bjiang

http://www.usc.edu/dept/CGIT (CGIT lab web pages)

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