Landscape Simulation in Outdoor Settings using Stereoscopic Augmented Reality

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This poster reports on an Augmented Reality system that handles virtual realizations of buildings and civil engineering structures at real scale in outdoor settings. This system consists of a Real-Time Kinematic GPS and a 3DOF inertial measurement unit. With additional software, these diveces improve the precision in computing camera position and orientation. Moreover the system uses a 3D head-mounted display rendering shadowing of all virtual buildings to achieve a real-world look. The system enables practical AR landscape simulations for architectural design to be made.

1. Introduction

Although advanced information technologies have been introduced in architectural design and building construction, more effective simulation methods are currently required. Conventional methods, such as photo montage and virtual reality, are inadequate in giving realistic simulations in exterior settings. With AR technology, we can freely move camera position to borrow real-scene backdrops that can be added to a simulation. Similar systems from previous research focused primarily on portability. In contrast, we emphasis performance over portability aiming for a stereoscopic AR that can handle large and complicated 3D shapes.

2. System Architecture

2.1. Hardware

We use a Real Time Kinematic (RTK)-GPS and a 3DOF inertial measurement unit (Sensor) to obtain camera position and orientation. In addition, we employ a 3D-Head Mounted Display (HMD) and two cameras to develop stereoscopic views for more realistic simulation. We have packed these devices into a compact portable unit suitable for outdoor use.

GPS

Hemisphere GPS A100 Smart Antenna
specifications
- Update Rate: 20Hz
- Horizontal Accuracy: 20mm

Sensor

Trivisio Colibri
specifications
- Update Rate: 100Hz
- Orientation Accuracy: Pitch/Roll: 0.5°| Yaw: 1.0°
- Accelerometer: Scale±16g | Resolusion 13-bit
- Gyroscope: Scale±1500º/s | Resolusion 13-bit

Cameras & HMD

POINT GREY Flea2
specifications
- Maximum Resolution : 1288×964
- Maximum Framerate: 1288×964 at 30FPS

eMagin Z800 3D Visor
specifications
- Resolusion: 800×600

Device Package

Desktop PC
specifications
- CPU: Intel(R) Core(TM) i7 -2600 3.40GHz
- GPU: NVIDIA Quadro 2000
- RAM: 8GB

2.2. Software

We developed a Virtual Reality Modeling Language (VRML) parser to ease loading of 3D models into the system.

Because the devices generate small errors that betray a real-world appearance, we implemented five functions.

Functions

Jitter Reduction

These functions resolve the slight shaking in the rendering of virtual buildings even if a camera is at rest.

Function 1. Sensor jitter reduction

Ignores Sensor outputs if euclidean norm of angular velocities vector fall below a threshold value.

Function 2. GPS jitter reduction

Ignores GPS outputs if euclidean norm of acceleration vector fall below a threshold value.

Low-pass filter

We use Low-pass filter to smooth the devices outputs.

$$C_t = rC_{t-1} + (1 - r)C$$

Where C_t is the filtered value, r is the smoothing factor, C is the previous filtered value, and C_{t-1} is the raw value.

Sensor Outputs Correction

These functions improve the precision in computing camera orientation.

Function 3. Pitch/Roll angle correction by using accelerations due to gravity

If Sensor is at rest, accurate Pitch/Roll angle can be calculated from the following equation:

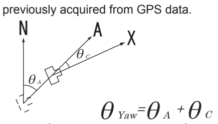
$$\theta_{pitch} = Tan^{-1}\left(\frac{-A_y}{\sqrt{A_x^2 + A_z^2}}\right)$$

$$\theta_{Roll} = Tan^{-1}\left(\frac{-A_x}{A_z}\right)$$

where A_x, A_y, and A_z are the values of accelerations due to gravity.

Function 4. Yaw angle correction by using GPS data

We can correct Sensor output (Yaw angle) by using a series of locations previously acquired from GPS data.

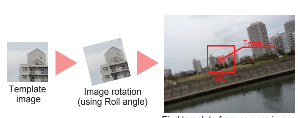


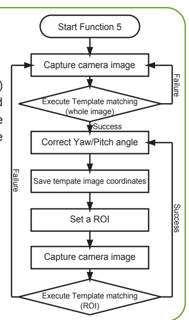
$$\theta_{Yaw} = \theta_A + \theta_C$$

Where $\vec{N}$ is the true north vector, $\vec{A}$ is the direction vector of a series of locations previously acquired from GPS data, and $\vec{X}$ is the direction vector of the Sensor's X-axis.

Function 5. Yaw/Pitch angle correction through template matching

We can correct Sensor outputs (Yaw/Pitch angle) through template matching from previously-captured landscape images. For improvement in the speed, we employ a small Region Of Interest(ROI) on template matching.



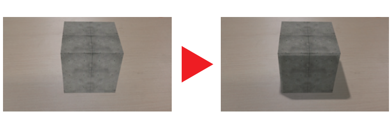


3. Rendering

High quality rendering is required in architectural design simulations.

3.1. Shadow Mapping

Ground surface can be calculated by using Sensor outputs and camera height. We achieve a realistic rendering by shadowing the virtual buildings.



3.2. Real-time Processing

To preserve realtime performance, our program was developed with multithreading to ensure the functions run concurrently and smoothly.

3.3. Stereoscopic Rendering

To improve reality, we achieve stereoscopic AR simulation by using 3D-HMD and two cameras.

Cross-eye view