Predictive Tracking for Augmented Reality

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by

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ABSTRACT

Ronald Tadao Azuma. Predictive Tracking for Augmented Reality

(Under the direction of T. Gary Bishop.)

In Augmented Reality systems, see-through Head-Mounted Displays (HMDs) superimpose virtual three-dimensional objects on the real world. This technology has the potential to enhance a user's perception of and interaction with the real world. However, many Augmented Reality applications will not be accepted unless virtual objects are accurately registered with their real counterparts. Good registration is difficult, because of the high resolution of the human visual system and its sensitivity to small differences. Registration errors fall into two categories: *static* errors, which occur even when the user remains still, and *dynamic* errors caused by system delays when the user moves. Dynamic errors are usually the largest errors. This dissertation demonstrates that predicting future head locations is an effective approach for significantly reducing dynamic errors.

This demonstration is performed in real time with an operational Augmented Reality system. First, evaluating the effect of prediction requires robust static registration. Therefore, this system uses a custom optoelectronic head-tracking system and three calibration procedures developed to measure the viewing parameters. Second, the system predicts future head positions and orientations with the aid of inertial sensors. Effective use of these sensors requires accurate estimation of the varying

prediction intervals, optimization techniques for determining parameters, and a system built to support real-time processes.

On average, prediction with inertial sensors is 2 to 3 times more accurate than prediction without inertial sensors and 5 to 10 times more accurate than not doing any prediction at all. Prediction is most effective at short prediction intervals, empirically determined to be about 80 milliseconds or less. An analysis of the predictor in the frequency domain shows the predictor magnifies the signal by roughly the square of the angular frequency and the prediction interval. For specified head-motion sequences and prediction intervals, this analytical framework can also estimate the maximum possible time-domain error and the maximum tolerable system delay given a specified maximum time-domain error.

Future steps that may further improve registration are discussed.

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