SCAAT: Incremental Tracking with Incomplete Information

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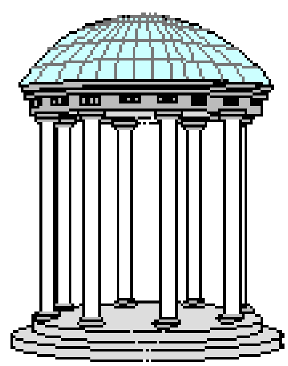
Gregory F. Welch

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



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SCAAT: Incremental Tracking with Incomplete Information

by

Gregory Francis Welch

A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Computer Science.

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Approved by:

Dr. Gary Bishop, Adviser

Dr. Henry Fuchs

Vernon Chi, Reader

Dr. Anselmo Lastra

Dr. Russell Taylor, Reader

Dr. John Poulton

ABSTRACT

Gregory Francis Welch
SCAAT: Incremental Tracking with Incomplete Information
(Under the direction of T. Gary Bishop)

The Kalman filter provides a powerful mathematical framework within which a minimum mean-square-error estimate of a user's position and orientation can be tracked using a sequence of *single* sensor observations, as opposed to *groups* of observations. We refer to this new approach as *single-constraint-at-a-time* or SCAAT tracking. The method improves accuracy by properly assimilating sequential observations, filtering sensor measurements, and by concurrently *autocalibrating* mechanical or electrical devices. The method facilitates user motion prediction, multisensor data fusion, and in systems where the observations are only available sequentially it provides estimates at a higher rate and with lower latency than a multiple-constraint approach.

Improved accuracy is realized primarily for three reasons. First, the method avoids mathematically treating truly sequential observations as if they were simultaneous. Second, because each estimate is based on the observation of an individual device, perceived error (statistically unusual estimates) can be more directly attributed to the corresponding device. This can be used for concurrent autocalibration which can be elegantly incorporated into the existing Kalman filter. Third, the Kalman filter inherently addresses the effects of noisy device measurements. Beyond accuracy, the method nicely facilitates motion prediction because the Kalman filter already incorporates a model of the user's dynamics, and because it provides smoothed estimates of the user state, including potentially unmeasured elements. Finally, in systems where the observations are only available sequentially, the method can be used to weave together information from individual devices in a very flexible manner, producing a new estimate as soon as each individual observation becomes available, thus facilitating multisensor data fusion and improving the estimate rates and latencies.

The most significant aspect of this work is the introduction and exploration of the SCAAT approach to 3D tracking for *virtual environments*. However I also believe that this work may prove to be of interest to the larger scientific and engineering community in addressing a more general class of tracking and estimation problems.

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