8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

COMPARISON OF KALMAN FILTER ESTIMATION APPROACHES IN THE FIELD OF GEOMECHANICS

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Key Words: *Kalman Filter, Inverse Modelling, Parameter Estimation*

ABSTRACT

The Extended Kalman Filter (EKF) has been used in the field of geomechanics standard for nonlinear state space estimation (Murakami, 1991). However a couple of alternative approaches have emerged over the last few years, namely the Ensemble Kalman filter (EnKF) and the Unscented Kalman filter (UKF).

Evensen introduced the EnKF in 1994 and the theoretical formulations as well as an overview of several applications are described in Evensen (2003). The EnKF was designed to resolve two major problems related to the use of EKF. The first problem relates to the use of an approximate closure scheme in the EKF, and the other one to the huge computational requirements associated with the storage and forward integration of the error covariance matrix *P*. For further details, the reader is referred to the references. In the Ensemble Kalman filter, an ensemble of possible state vectors, which are randomly generated using a Monte Carlo approach, represents the statistical properties of the state vector. The algorithm does not require a tangent linear model, which is required for the EKF, and is very easy to implement.

The UKF was first proposed by Julier and Uhlman (1997) and further developed by Wan and Van der Merwe (2001). Instead of linearizing the functions, as is done in the EKF, this transform uses a set of points and propagates them through the actual nonlinear function. The points are chosen such that that their mean, covariance and possibly also higher order moments match the Gaussian random variable. The mean and the covariance can be recalculated from the propagated points, yielding more accurate results compared to the ordinary function linearization.

The EnKF and the UKF have both their advantages and disadvantages. The good performance of the EnKF in geomechanical problems has been shown in Hommels *et al.* (2005). However the UKF has not been introduced in the field of geomechanics.

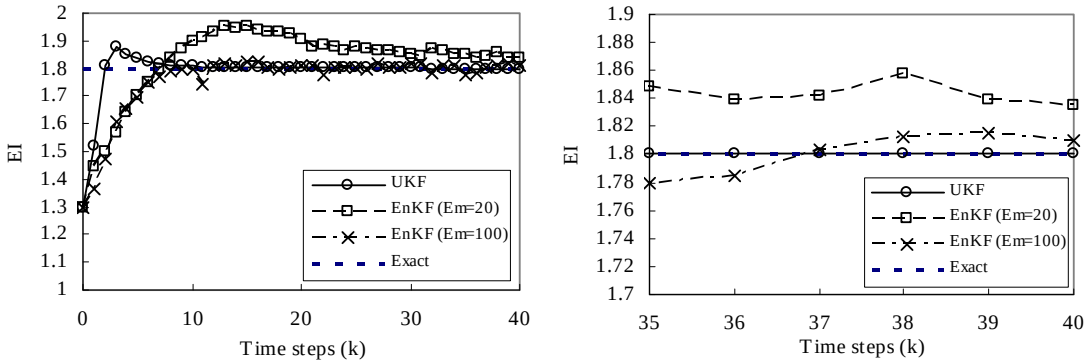

Figure 1: Comparison of the performance of the EnKF and the UKF over a longer time period (left) and zoomed in at a shorter time period.

In Figure 1, the results are shown of a simple linear case study (loading of an axially loaded rod) to compare the performance of the EnKF with the UKF. In the left of Figure 1, there is hardly any diference in the performance of the EnKF and UKF as long as the the number of ensemble members is high enough. However, if we look in detail (right part of Figure 1), we can see that the UKF is more accurate than the EnKF in simple linear case study.

However, this is still an linear case study. The authors are working on an a nonlinear case study of the construction of a road embankment, for which the performance of the EnKF will be compared with the UKF. During the presentation the first results will be shown.

Acknowledgements: The authors aknowledge the important contribution in numerical computation of Mr. Satoshi Kasamatasu who is a graduate student of Okayama University.

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