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Real-time noise reduction and prediction of chaotic time series with Extended Kalman Filtering (EKF)

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A more valid and practical approach for real-time processing of noisy chaotic hydrological time series data is yet to be proposed. Kalman filtering and its variants have been successfully used in many different areas for real-time noise reduction applications. Ideally, EKF requires a perfect model. In the special case of chaotic time series, a perfect model may not give the best predictions for noisy data. This study uses EKF with imperfect state space models in prediction of noisy chaotic time series. The data driven model, ANN is used as the state space model. In the special case of imperfect data driven models, further prediction improvements may be possible through re-training the model once cleaned data is available. Therefore, secondly this study proposes the use of EKF estimates as cleaned data to further improve the prediction accuracy and the quality of the data driven model. The procedure proposed for real-time noise reduction is as follows. First, an optimal filter parameters and a re-trained data driven model are chosen off-line and then they are incorporated for real-time prediction. For comparison, prediction performance in terms of Mean Absolute Error (MAE) on a validation set using (1) ANN only (2) EKF predictions (3) EKF estimates with the proposed real-time prediction procedure (4) simple nonlinear noise reduction method [1] with the proposed procedure are given in Table 1 for 10% noisy chaotic Lorenz series. The prediction performance in terms of MAE is calculated with respect to both noisy values and noise-free values.
The superior performance of EKF in noise reduction and the suitability of proposed methods for chaotic time series are clearly evident. Performance improvement of river flow time series (not shown) was, however, not that significant.

Keywords: Chaos; noise; Kalman filtering; nonlinear noise reduction; Artificial Neural Network; prediction

Table 1: The MAE with respect to noisy observations and noise-free values

	ANN only (1)	EKF predictions (2)	Model trained with EKF estimates (3)	Model trained with nonlinear estimates (4)
Noisy values	1.2811	1.2640	1.2389	1.2668
Noise-free values	0.7786	0.6834	0.6447	0.7375

References

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