Artifact Removal from Intracranial Pressure Monitoring Signals: A Solution based on Robust Statistics & Empirical Mode Decomposition

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Background & Motivation. Intracranial Pressure (ICP) monitoring signal collected in Neuro Intensive Care Units (NICU) are often contaminated by large amount of artifacts. The artifacts not only directly lead to false alarms in automatic Intracranial Hypertension (IH) alert systems, and they also severely contaminate the characteristics of the underlying signal, which makes accuracy forecasting of impending IH impossible. Therefore, in this paper, we propose a novel solution to effectively remove artifacts from ICP monitoring signals.

Materials & Method. ICP monitoring signals of 53 patients, who were admitted between January 2009 to December 2010, are used for the study. ICP levels are invasively measured with a fibre-optic intraparenchymal gauge (Codman and Shurtleff, Taynham, MA). Measured ICP levels were sampled and recorded every 10 seconds with a bedside computer system.

The proposed method effectively detects artifacts by decomposing the ICP monitoring signal with Empirical Mode Decomposition (EMD) method. An iterative filtering method is also proposed to extract artifacts from the decomposed components of ICP signals. The proposed filter is "robust", i.e. instead of classical statistical tools, parameters of the iterative filter are estimated with "robust statistics". This ensures the performance of the proposed filter will not be unduly affected by artifacts. The detected artifacts are then imputed based on the Auto-Regressive Moving Average (ARMA) model to preserve the characteristics of the ICP signal.

Results & Conclusion. On average, the proposed method achieves 100% precision and 80.2% recall (F-score = 0.88) in identifying the positions of artifacts. In terms of estimating the exact number of artifact data points, the proposed method, on average, achieves 83.2% precision and 97.3% recall (F-score = 0.89). In short, the proposed method is empirically demonstrated to be an effective solution to remove artifacts in ICP monitoring signals.