Towards a Data Fusion Model for Predicting Deterioration in Haemodialysis Patients

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Patients with Chronic Renal Failure are given three 4-hour haemodialysis treatments per week in order to maintain fluid and biochemical homeostasis. The accumulation and relatively rapid removal of fluid is often accompanied by adverse events, the most prominent of which is hypotension. Current patient monitoring during dialysis treatment includes intermittent measurements of tympanic temperature, blood pressure and haematocrit. However, this information is mostly used retrospectively rather than as a means for preventing adverse events.

We continuously monitored the vital signs of 40 haemodialysis patients during 8 sessions over a 6-month period in the Oxford Renal Unit in order to establish whether data fusion techniques could assist in predicting hypotension and which parameters would be most suitable for this purpose. The study involved non-invasively monitoring the ECG, heart rate, blood oxygen saturation and photoplethysmograph (PPG) waveform, as well as the haematocrit and tympanic temperature throughout each dialysis session.

The 4-dimensional vital sign data (heart rate, blood pressure, oxygen saturation and tympanic temperature) was initially visualized on 2D maps using the Neuroscale algorithm. The training data consisted of a data subset acquired from patients labelled by clinicians as physiologically stable patients and therefore considered to reflect normal physiology during dialysis. The maps show a clear distinction between unstable from and stable patients, with adverse hypotensive events outside the region corresponding to normal physiology.

A data fusion model based on a Parzen windows estimator of the probability density function of normal data was then created using the same training data. With this model, instabilities in patient physiology can be identified with, in some cases, the adverse event being predicted ahead of time.