What if we used raw biomedical signals and deep neural networks to predict mortality?

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In her master’s thesis, Joanna Haahti, from Aalto University Department of Computer Science, presents a novel approach for predicting mortality with non-invasive biomedical signals measured from intensive care patients. The thesis was done at GE Healthcare. Long windows of high-frequency signals, such as ECG, are the source of information, presenting the state of the patient. The prediction is created by a convolutional recurrent neural network, which combines the capabilities of two popular architectures: convolutional and recurrent neural networks. The deep learning model, utilizing commonly measured signals, provides superior predictive quality compared to corresponding vital signs from the electronic health records.

Traditionally, scoring systems predicting patient deterioration are based on a small set of vital signs. Commonly used vital signs are heart rate, respiration rate, blood pressure and peripheral oxygen saturation. These scoring systems are based on a relatively small set of variables making them general tools that are not able to consider characteristics of an individual patient. Additionally, these scores create only snapshots of patients’ states and don’t take the temporal changes into account.

In her thesis, Joanna presents a deep learning approach to predict mortality by using the raw high-frequency measurements, biomedical signals, instead of vital signs. Such high-frequency data has not been used for prediction tasks before. Such measurements are challenging to analyze by a human, due to the amount of data and the raw signal format. Novel deep learning methods have enabled the extraction of information from such data in various domains. The proposed deep learning approach utilizing high-frequency data gives great value to data that cannot be easily analyzed in its raw format.

Due to the length of the signals, the size of the input to the neural network is enormous. A carefully designed neural network architecture is required for processing such large data. The proposed model is a combination of convolutional and recurrent neural networks. The first layers of the network are convolutional layers, enabling local feature learning simultaneously reducing the temporal dimensionality. In the last layers of the network, a recurrent structure is included, learning the temporal dependencies of the data. This structure enables the utilization of very large signals as input to the neural network.

The proposed model provides superior predictive quality compared to a model utilizing corresponding vital signs. The results indicate that signal data contains additional information to predict mortality. Utilizing signals can enable more accurate predictions since individual characteristics and high-frequency structures are present in the morphology of the signals and can be taken better into account. Therefore, such utilization of data can introduce new possibilities for prediction tasks in clinical decision-making.

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