ACW-RNN: Adaptive Clockwork Recurrent Neural Networks for Early Warning Systems in Hospitals

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Abstract

Early Warning Systems (EWS), which use physiological datastreams to timely predict clinical deterioration for patients in regular wards and Intensive Care Units (ICUs), have been shown to have life-saving impact. We propose a novel Recurrent Neural Network (RNN) architecture that can address the unique challenges of implementing EWS in hospitals: 1) learning from multi-variate physiological datastreams spanning long periods of time; 2) learning from imbalanced data, where only a small percentage of patients are experiencing adverse events; 3) learning from the multi-variate physiological datastreams in different hospital settings (regular wards as compared to ICU), where more types of measurements are collected and more frequently, and the patterns of clinical deterioration often differ. Our model is based on Clockwork RNN (CW-RNN), which effectively captures temporal correlations by learning multi-resolution representations, but goes one step further. While CW-RNN learns only fixed multi-resolution representations, our proposed model, dubbed Adaptive Clockwise RNN (ACW-RNN) can learn adaptive multi-resolution representations based on the temporal correlations between physiological datastreams and their impact on clinical deterioration. This enables ACWRNN to effectively learn various patterns of deterioration from small and imbalanced datasets. We show that ACW-RNN can effectively operate in both regular wards and ICUs, and that it achieves large performance improvements over state-of-the-art deep learning models as well as existing clinical risk scores. To the best of our knowledge, this is the first deep learning solution which has been shown to issue timely and accurate predictions for clinical deterioration in both regular wards and ICU.

Keywords: *Early Warning Systems (EWS), Clinical Decision Support Systems (CDSS), Intensive Care Units (ICUs), Recurrent Neural Networks (RNN), Clockwork RNN (CW-RNN)*