Incorporating Pathophysiological Knowledge into a Time-Aware Long Short-Term Memory for the Early Prediction of Sepsis

Marcus Vollmer, Christian F. Luz, Philipp Sodmann, Maarten W. N. Nijsten, Bhanu Sinha, Sven-Olaf Kuhn

Institute of Bioinformatics, University Medicine Greifswald
Greifswald, Germany

Motivation: This contribution relates to the *PhysioNet/CinC Challenge 2019* on real-time early detection of sepsis from bedside monitoring and laboratory parameters. Accounting for complex clinical dynamics in sepsis patients while aiming at an automated analysis of hourly (non-)validated data is challenging. The algorithm has to deal with imprecise, incorrect and incomplete data in addition to being time aware.

Methods: We aim to use a Time-Aware Long Short-Term Memory (T-LSTM), a recurrent neural network for handling irregular time intervals, in longitudinal patient records. Our Python-implemented open-source algorithm aims at the integration of laboratory parameters, continuously measured vital signs, and pathophysiological knowledge in the architecture of the T-LSTM model. Missing data in hourly-measured variables is handled with multiple imputations using credible intervals.

The T-LSTM is trained on an 80% validation split of 40,336 ICU patients. The sepsis prediction will be externally validated on the hidden test set of the *2019 PhysioNet/CinC Challenge*. The performance is based on the utility functions that reward a prediction between 12 hours before and 3 hours after the sepsis onset (as defined by the Sepsis-3 guidelines) with a defined optimum at 6 hours before. Furthermore, results will be compared with an ordinary LSTM.

Results: A T-LSTM was developed for the early prediction of sepsis in ICU patients processing hourly measurements of vital signs and irregular time intervals of laboratory parameters together with medical knowledge. A normalized utility score of 0.30 can be reported for a LSTM submitted during the unofficial phase evaluated with the training data set. Further preliminary results are reported in the table below.

Performance of an early stage LSTM

	AUROC	AUPRC	Accuracy	F-measure	Utility
Training set	0.86	0.27	0.98	0.35	0.30