Master thesis topic

Predicting Organ Failure for ICU Patients Using Recurrent Neural Networks

Context

Anaemia is a common condition in critically ill patients that occurs when the body does not have enough healthy red blood cells to carry sufficient oxygen to the body's tissues. Haemoglobin (Hb) is the major oxygen transport protein in the human body. Acute anaemia is typically treated with red cell transfusion to help maintain adequate oxygen delivery. Currently, haemoglobin level is the major trigger of red blood cell transfusion. At very low levels of haemoglobin (<7 g/dl) every patient will receive RBC transfusion. However, oxygen delivery and oxygen consumption not only depend on the haemoglobin level, but also on the clinical condition of the patient. Therefore, current guidelines recommend modifying the transfusion threshold (the haemoglobin level at which you would transfuse a patient) based on the clinical factors of the patient. These factors are often described in general terms.

Goal

The goal of this project is to build a recommendation system that provides personalised recommendations on whether to transfuse red blood cells or not for individual ICU patients, based on predicted Sepsis-related organ failure assessment *(SOFA) scores.* The SOFA score is used to track a person's status during the stay in an intensive care unit (ICU), to determine the extent of a person's organ function or rate of failure. The score is composed of six individual scores, one each for the respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems.

Data and approach

Clinical data gathered during an ICU stay is of temporal nature since it is collected at various time points. To avoid complexity, however, it is common practice to collapse all temporal data to one single data point and make a predictive model based on the simplified, flat dataset. In such an approach, there is a potential loss of valuable information. In this project, we propose to use Recurrent Neural Networks (RNN) to explicitly consider the temporal nature of the ICU data to predict the SOFA score. RNNs were designed to process sequential data. A key feature is a feedback loop which allows integration of information from previous steps with newly acquired data. Thus, they provide an elegant infrastructure to process evolving streams of clinical data.

Expected outcomes

1) A model, i.e., a recurrent neural network, that uses the Hb level and other clinical parameters to predict the likelihood that a critically ill, anemic patient will profit from blood transfusion.

2) A ‘decision support tool’ which, as an output, predict the patient’s SOFA score when the red cell transfusion is (or is not) administrated. The tool should take advantage of time as an important feature. It should allow the practitioners to specify how long into the future predictions are for. Each output vector contains forecasts such as SOFA score at the specified future time. This output in return facilitates the prediction of SOFA score increase/decrease trend.

Realisation

- Literature study
- Define the predictive model
- Validate the model
- Compare with existing algorithms
- Evaluate the results, derive recommendations
- Write report / thesis

Note that a large dataset is readily available for the project, which will be performed in collaboration with medical experts from LUMC/Sanquin (who will also be available to help interpret the results). Experiments will be performed on-site at LUMC/Sanquin.

Student profile

Good understanding of deep learning problems and algorithms; programming experience in Python.

Supervisors

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Relevant literature

[1] Aczon, M., Ledbetter, D., Ho, L., Gunny, A., Flynn, A., Williams, J. and Wetzel, R., 2017. Dynamic Mortality Risk Predictions in Pediatric Critical Care Using Recurrent Neural Networks. arXiv preprint arXiv:1701.06675.

[2] Caballero Barajas, K.L. and Akella, R., 2015, August. Dynamically modeling patient's health state from electronic medical records: a time series approach. In Proceedings of the 21th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (pp. 69-78). ACM.

[3] Morid, M.A., Sheng, O.R.L. and Abdelrahman, S., 2017. PPMF: A Patient-based Predictive Modeling Framework for Early ICU Mortality Prediction. arXiv preprint arXiv:1704.07499.

[4] Vincent, J.L., 2012. Indications for blood transfusions: too complex to base on a single number?. Annals of internal medicine, 157(1), pp.71-72.

[5] Vincent, J.L., 2015. Which carries the biggest risk: Anaemia or blood transfusion?. Transfusion Clinique et Biologique, 22(3), pp.148-150.