

Research project proposition - ICU Prediction Using Deep Markov Models

Project Members:

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Background:

Clinical practice in intensive care units (ICUs) requires early warnings when a patient's condition is about to deteriorate so that preventive measures can be undertaken. To this end, prediction algorithms have been developed that estimate the risk of mortality in ICUs. One such model has recently been developed (Y Oezyurt, M Kraus, T Hatt, S Feuerriegel - Feb 2021) using a deep Markov model named AttDMM.

AttDMM uses a joined learning model: learning long-term disease dynamics (via attention) and different disease states in health trajectory (via a latent variable model). According to the manuscript, the AttDMM was superior to state-of-the-art baselines when tested on the standard baseline dataset (MIMIC-III) with 53,423 ICU stays.

However, from initial checks, it appears that AttDMM is not robust to different datasets. Such robustness is crucial when looking to implement the model in Israeli ICU's.

In addition, Medical prediction systems require a high level of interpretability to be deployed. For example, a mortality prediction without context of how the model achieved is of low value. Therefore in this project we seek to understand the key components of the system, identify which are the most important for predictions, and see if we can improve it.

The Questions:

1. Find the most pivotal components for predictions?
2. How robust are the hyper-parameters?
3. What additional components could improve the performance?

The Data:

MIMIC-IV is a retrospective medical data that was collected from digital health record systems in hospitals. This is one of the largest publicly ICU datasets, widely used for benchmarking. The data comes from two sources: wide EHR (Electronic Health Record) and ICU (Intensive Care Units) clinical information system.

The data is grouped into five categories:

- Core - includes general data about the patient demographic, hospitalization, and each ward stay within the hospitalization.
- Hospital - Includes data collected from the wide EHR, among other includes laboratory measurements, microbiology cultures, and medication administration.
- ICU - The most important for our project, which includes intravenous and fluid inputs, patient outputs, and other chart events. For each stay, the dataset includes a time series of different measurements like temperature, heart rate and blood pressure. Those time series are considered as a hard nut to crack.
- ED - The ED module contains data for emergency department patients collected while they are in the ED.
- Note - Contains deidentified free-text clinical notes for hospitalization.

In order to create a comparison, we are going to compare MIMIC-IV to eICU dataset, which contains the same kind of information like MIMIC-IV, but organized differently with other measurements.

Methods:

Inspired from the article mentioned above, we expect the use of the following methods:

1. Deep markov model
2. Latent variable models
3. Time series analysis methods.

AttDMM was developed in Python using PyTorch, and so will be most of our work. Training networks might require heavy computing resources.

Possible adversities:

- Uncharted territory - both of us lack experience in above mentioned methods. The first major challenge for us will be to learn those topics, and look for relevant materials to learn from.
- Difficulty improving the model - A lot of work was put into developing the AttDMM model, and we might fail making any improvements to the model.

Proposal schedule:

15.02.2022 - 07.03.2022 - Data exploration and deep dive to the research question

07.03.2022 - 14.04.2022 - Learning the above methods

14.04.2022 - 30.04.2022 - Analyze the components of the mentioned article

30.04.2022 - 21.05.2022 - Find the most pivotal components for predictions

21.05.2022 - 10.06.2022 - Check robustness of the hyper-parameters

10.6.2022 - 20.7.2022 - Search for additional components that could improve the performance

20.07.2022 - 31.8.2022 - Final conclusions and writing project report