Improving Cardiology-Rehospitalization Prediction Through the Synergy of Process Mining and Deep Learning: An Innovative Approach

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Abstract. Nowadays, hospitals are facing the need for an accurate prediction of re-hospitalizations. Rehospitalizations, indeed, represent both a high financial burden for the hospital and a proxy measure of care quality. The current work aims to address such a problem with an innovative approach, by building a Process Mining-Deep Learning model for the prediction of 6-months rehospitalization of patients hospitalized in a Cardiology specialty at San Raffaele Hospital, starting from their medical history contained in the Patients Hospital Records, with the double purpose of supporting resource planning and identifying at-risk patients.

Keywords. Rehospitalization prediction, Process Mining, Deep Learning, Neural Networks, Cardiology, hospital planning, patient identification

1. Introduction

Hospitals are facing the need for an accurate prediction of rehospitalizations, as they are considered a proxy measure of care quality. Moreover, they represent a high financial burden on the hospital, as they require a vast deployment of resources.

This work addresses the problem under an innovative perspective, recently developed to answer to some common research questions (i.e. short-term readmission [1] and survival [2]). The novelty consisted in the use of Process Mining (PM) to introduce in the model, next to the traditional features (e.g. demographics, lab results), new variables, called Timed State Samples (TSSs), derived from the clinical history of the patients, embedding time information related to the hospital events into the predictive model. It was the first time that PM was used on the clinical path of patients as the core of the process, with a predictive purpose regarding the patient outcome. The current work has the purpose to build a Process Mining-Deep Learning (PM-DL) model for the prediction of 6-months rehospitalization, by using the medical history recorded within San Raffaele

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Hospital (HSR), with the aim of supporting resource planning and identifying at-risk patients. We focused on Cardiology specialty, as cardiovascular diseases are the most common cause of death and hospitalization in the world.

2. Methods

We applied a PM-DL approach for the prediction of rehospitalization at HSR within 6 months from the first discharge from a Cardiology-related departmentWe obtained a final dataset of 4761 patients from Regione Lombardia hospitalized in 2018 or 2019. The Patient Hospital Records (PHRs) were converted into event logs that were used to discover a process model. Time information related to the hospital events, in the form of TSSs, was extracted using the DREAM (Decay Replay Mining) algorithm [3]. The TSSs obtained in the PM phase were then combined with more traditional features (demographics, laboratory results, baseline hospitalization features and past history features) and fed to a 5-layer Fully Connected Neural Network.
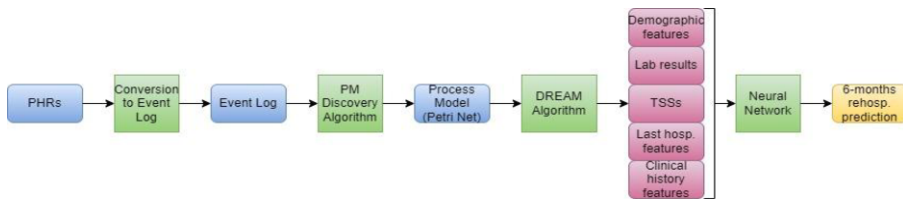

Figure 1. Steps of the work.

3. Results, Discussion and Conclusions

Together with the PM-DL model, we also performed the analysis using some more traditional ML models (i.e. Logistic Regression and Random Forest), that did not use time as a variable. The results showed that the innovative PM-DL approach provided a significant improvement in the prediction of the outcome compared to the more traditional ones, yielding promising results in terms of precision, accuracy and AUC. The latter, specifically, was equal to 0.738. This proved the importance of including time information in models for rehospitalization prediction, opening new scenarios for the use of PM and DL in the healthcare domain, to improve hospital resource planning as well as care quality. This work could help clinicians in identifying patients at-risk of rehospitalization, allowing a more patient-focused follow-up and, simoultaneously, it can help hospital resource planning, giving an indication on the load of rehospitalizations produced by the Cardiology-related specialties, allowing a better management of those resources.

References

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