Real-Time Predictive Analytics for Sepsis Level and Therapeutic Plans in Intensive Care Medicine

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ABSTRACT

Optimal treatments for patients with microbiological problems depend significantly on the ability of the attending physicians to predict sepsis level. A set of Data Mining (DM) models has been developed using forecasting techniques and classification models to aid decision making by physicians about the appropriate, and most effective, therapeutic plan to adopt in specific situations. A combination of Decision Trees, Support Vector Machines and Naïve Bayes classifier were being used to generate the DM models. Confusion Matrix, including associated metrics, and Cross-validation were used to evaluate the models. Associated metrics used to identify the most relevant measures to predict sepsis level and treatment procedures include the analysis of the total error rate, sensitivity, specificity, and accuracy measures. The data used in DM models were collected at the Intensive Care Unit of the Centro Hospitalar do Porto, in Oporto, Portugal. Encapsulated within a supervised learning context, classification models were applied to predict sepsis level and direct the therapeutic plan for patients with sepsis. This work concludes that it was possible to predict sepsis level (2nd and 3rd) with great accuracy (accuracy: 100%), but not for the therapeutic plan (best accuracy level: 62.8%).

Keywords: Classification Models, Data Mining, INTCare Project, Intensive Care, Sepsis Level, Therapeutic Plans

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1. INTRODUCTION

Each and every day, new patients in critical health conditions get admitted to the Intensive Care Units (ICUs). A major challenge faced in Intensive Medicine has to do with therapeutics; more specifically, when, how and what procedures should be administered to particular patients? In this context, Information Technology (IT) can often play a key role in supporting the quality and efficiency in healthcare services delivery; fundamentally, the ability to provide the right information at the right time for the right person (Handel & Hackman, 2008; Nowinski et al., 2007).

As it is a non-trivial assignment for healthcare professionals to take good care of their patients, while simultaneously, document the ongoing operations (Häyrinen, Saranto, & Nykänen, 2008; Mador & Shaw, 2009), the INTCare project (Breiman, Friedman, Olshen, & Stone, 1984; Tamayo et al., 2005) was developed to make available pertinent information about the patient anywhere, anytime (Filipe Portela, Filipe Pinto, & Santos, 2012; Portela et al., 2011) in order to overcome the challenging tasks. During the course of this project, a massive amount of data such as patient vital signs, laboratory results, fluid balance, ventilation and ICU scores were converted into digital form, thereby enabling automatic real-time patient data acquisition. Put simply, this new reality allows for the gathering of fundamental and timely knowledge needed to treat the patient under intensive care.

During the early stages, a set of procedures is often expected from caregivers in order to reduce sepsis mortality. It is purported that survival medium probability decreases 7.6% for each hour of delay in the presence of an effective antibiotherapy. The elaboration of a therapeutic plan for sepsis may result not only in the reduction of mortality, but also in the substantial decrease of operating costs for the caring institutions as a result of the possible improvement in the usage of existing resources (Shorr, Micek, Jackson Jr, & Kollef, 2007). Consequently, a quick interpretation and precise evaluation of physiological data of the patient status while remaining in intensive care are going to be crucial for a more efficient and effective decision-making by the medical staff. The objective of the INTCare project is to predict the patient sepsis level in real-time, determining whether the patient is in the second or third level of the scale (João M. C. Gonçalves et al., 2013). Additionally, making use of the same input variables, a set of models can be derived to predict the therapeutic plan.

The reported work here transpired in an environment using real-time data obtained from the ICU of Centro Hospitalar do Porto, in Oporto, Portugal. The organization of this paper is as follows. After the introduction, the background and related work are presented. Next, the data used by the DM Models are detailed and the developed DM models and resulting variables discussed. A presentation of the study results followed. Finally, certain conclusions about the work are drawn with highlights on future work.

2. BACKGROUND

2.1. Surviving Sepsis Campaign

A Surviving Sepsis Campaign (SSC) provides the international guidelines for the treatment of sepsis, severe sepsis and septic shock (Delinger et al., 2008). SSC is a program led by the ESICM (European Society of Intensive Care Medicine), ISF (International Sepsis Forum) and SCCM (Society of Critical Care Medicine). SSC aims to improve the survival diagnostic and the management of patients with sepsis, resolving the challenges associated with it, and having the following as a mission (SSC, 2010):

- Increasing the awareness, comprehension and knowledge;
- Altering perceptions and behaviors;
- Increasing the rhythm of change in care standards;
- Defining the care standards for severe sepsis;
Trends in Information Systems and Long-Term Care: A Literature Review
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