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Hospital Readmissions and Machine Learning

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The need to improve the efficiency of the healthcare services has emerged over recent decades and, especially, during the last few years with the economic and financial crisis, developed countries have been suffering

The ageing population, the sector most affected by chronic diseases, is seeking better results when they need the healthcare services and, in particular, hospital services.

Hospital services account for 40 to 60 percent (OECD, 2015) of healthcare costs, even increasing to 75 to 85 percent (Centres for Medicare and Medicaid Services, 2012) in the cases of chronic diseases like CHF, COPD, mainly because of the high costs of readmissions. Co-morbidities added to the main health problem can create a more complex scenario.

Moreover, we have to consider the quality of life of the patient who suffers frequent readmissions: nobody likes to be admitted to hospital and facilities are sometimes unsafe. The inconvenience and the direct and indirect costs for patients and caregivers are huge.

Finally, from the clinical point of view, treating these cases do not give any special added value to the knowledge of clinicians attending to such patients. Normally the process is repetitive with similarities to the Taylor model of production (New England Journal of Medicine, 2016).

For all reasons, the vision of the hospital of the future is a facility that will have inpatient services, mostly for people undergoing an important surgical procedure (even in this case, the length of stay of most of the procedures has decreased dramatically). As far as other reasons for occupying a hospital bed are concerned, we can refer to emergency services for critically-ill patients suffering a non-preventable, life-threatening episode. Finally, some complex diagnostic procedures - most of them linked to radio diagnostics - may require a reduced stay at the hospital.

Variables

The main pressure on reducing the readmission rates has come from the payers and financing bodies of the healthcare systems, public or private, of which perhaps the most known are Medicare and Medicaid, established by CMS from 2014 for US hospitals.

The model has been followed as an example in many health systems across the world. This is the case of Catsalut, the public Catalan Health Care payer, where if a patient is readmitted for the same reason during the next month, the hospital only receives 0.4 percent of the established fee. Furthermore, through reducing readmissions a hospital can attend to more patients, increasing the productivity from the population management point of view.

The question is: how can we reduce our readmissions? If we explore the literature, mostly published in the last five years, we cannot find a simple explanation and we observe that different publications are studying diverse factors affecting the development of a particular illness. Moreover, as we know, the factors that can affect the illness are not only clinical, but also environmental, including social.

Between most referred variables are: demographics, socioeconomic conditions, vitals, co-morbidity, discharge/ admission parameters, length of stay, lab tests, procedures, medications, previous inpatient, outpatient and emergency services attended.

We can conclude that a lot of work has to be done but, as the topic is so complex, no single human brain can process the information needed. This situation requires and reinforces the use of computers and especially the machine learning approach to help us manage the situation. The published results are encouraging.

The use of sophisticated algorithms is not new. Twenty years ago, most disease management companies began to use them as a basis of the work done at call centres, especially in the U.S. Initial predictive models also pointed in this direction. Actually, with the high computing capabilities, the use of predictive analytics has been exploited and it is used on accuracy of diagnosis of preventive medicine, personalised medicine, research on medications and health outcomes among others topics.

Hospital Readmission Prevention

Our solution, from a technological point of view, can be included in the field of machine learning (ML), but what does machine learning mean?

Machine learning is the part of computer science that allows machines or software, to learn by themselves from the information (data) they are analysing. In other words, they can self-configure in order to find the answer to a logical problem.

But ML is not only a computational tool, it also involves its own operative methodology, different from that of traditional software tools. This method is an iterative process by which the investigators can reach the solution of a given case of analysis, following a set of logical steps repeatedly until they find a satisfactory explanation of it.

The phases of this method comprise:

- Business Understanding: this initial phase focuses on understanding the project objectives and requirements from a business perspective;
- Data Understanding: the data understanding phase starts with initial data collection and proceeds to familiarising activities for the data;
- Data Preparation: the data preparation phase covers all activities connected with construction of the final dataset;
- Modelling: in this phase, various modelling techniques are selected and applied depending on the subject of study. Now is the time in which the input variables relevant to the case are selected, and the output variables are also defined;
- Evaluation: at this stage in the project you have built a model (or models) and you will compare them with the real data;
- Deployment: in this step the solution is delivered to the customer in the more adequate way depending on the project.

If we think of this, one could think that the ML process is very similar to scientific method itself. As it was explained by Richard Feynman in a rather humorous way in his lectures on physics; “first we guess” (understand the business aspects define the model and set the ML experiment) “calculate the consequences of our guess” (execute the ML process), and “compare the results with nature” (see if the results match the predictions provided by the ML experiment, evaluation step), then as we explained before, we can refine our model, to match the results with reality, in a more accurate way.

So this new generation of computer solutions implies a new way of working, and a new way of forming working teams. Technology can no longer operate in isolation from clinical knowledge, since they are explicitly involved in the same investigation process. This type of team will include typically (at least): A clinical expert, a data scientist (or person in charge of the ML development), a computer science professional and a data analysis coordinator.

Let's then take a closer look at a particular ML solution, to see an example of the ideas explained earlier: Bismart's Hospital Readmission Prevention.

Bismart is one of the world's most innovative companies in the data analysis sector and its solution for readmissions helps to explore the causes of this phenomenon; reducing clinical cost and improving patient healthcare quality. Bismart's Hospital Readmission Prevention tool provides the means necessary to locate where the readmissions of a hospital are occurring and find the reasons that are causing this undesired effect.

The tool uses machine learning techniques (clustering algorithms written in R language) that allow the user to discover groups of readmissions that may share a common cause.

From its component architecture's perspective, our Hospital Readmission Prevention solution is a cloud-based project, using mainly Microsoft's Azure Machine Learning and Power BI as main technological components. According to a previously defined statistical model, in the near future, this architecture will be combined with the interaction of wearables that will receive the prediction of readmission in a given time, by reading the vital constants of the patient and raising an alert whenever the health variables acquire certain values. This structure allows us to provide the ML functionality by means of subscriptions to our service (software as a service concept), letting the hospital pay only for the precise use of the solution it needs, reducing costs, and giving the chance to employ the resources with the investigation itself instead of doing it on the software development/licensing.

The tool provides three main perspectives:

• Detailed analysis: once we know where (in terms of the variables of the input model) the main concentration of readmissions are, this perspective allows us to explore the details of the clinical episodes, one by one. After studying the information regarding a particular case, we will be able to find out relevant clues about the underlying and undesired cause of the readmission;

• Group characteristics: this view provides the information that defines the aggrupation that later will be used for detailed analysis. We also can visualise the accuracy of the different clusters;

• Readmission geolocation: this view enables the user to study where the readmissions are happening using map visualisation controls. With this report the user will be able to ascertain if the reason for the readmission is related to the location of the patient (where he or she comes from in the surroundings of the hospital).

This knowledge is acquired thanks to modelling the globally- accepted "Integrated Care" approach. The next step, the emerging "Population Health Management" concept (use of data involved with the environmental and social determinants of health) is a good framework to allow clinicians, social workers or other professionals involved directly or indirectly in the health care to efficiently help patients.

Probably, we are now really at the beginning of the postindustrial era of health care services that are going to create dramatic changes in how we make health problems and their costs affordable. To this end, Parikh, Kakad and Bates have recently published an excellent approach introducing the concept "precision delivery" in JAMA (Bates, Kakad & Parikh, 2016).

Key Points

- Many diverse and complex factors lead to hospital readmissions. No single human brain can process the information needed to prevent it.
- Machine learning is a self-trained computer science solution that can help solve major health care issues such as the hospital readmissions.
- Machine learning projects transform the way the investigation teams work, their composition and the relationship among its members.
- This approach can be covered under the umbrella of the new concept "precision delivery".

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