

Thesis proposal

Title : Machine Learning and Big Data for innovative techniques to aid medical decision: application to remote monitoring

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General context

Both European Union and China is experiencing population ageing. This development will jeopardize the future balance of public finance, including that of health care. Life expectancy at birth continues to rise worldwide, and in Europe, it is approaching or exceeding 85 years for women and 80 years for men. The quality of life in these extra years, experienced after age 80 or 85, is of increasing concern to authorities seeking to delay the onset of chronic diseases, senescence, functional decline, frailty and loss of autonomy. The growing number of elderly people in the French population causes increased usage of the healthcare system. In 1997, people aged 60 and over represented almost one-third of the total medical expenditure and almost half of drug expenditure, while making up only 20% of the total population. These figures highlight the impact of the increasing number of elderly people in our country.

Data analytics consists in developing optimization and/or machine learning based algorithms that learn to recognize complex patterns within valuable and massive data. Challenges related to that topic are numerous, and many scientific fields are involved: computer science, data science, big data, operational research, process and data mining. When applied to health-care, the objectives are often summarized as improving quality and timeliness of care, quality of life, maximizing financial performance, and decreasing practice variability across organizations. It relies on the following tasks: (i) identify critical features that impact outcomes (allocation of limited resources/time for greater effect); (ii) seek greater use of treatment evidence to advance the quality and effectiveness of care delivery; (iii) rapid learning and best practice dissemination. Process mining is also a closely connected field of research.

The development of data analytics and information and communication technologies (ICTs) for the elderly is a promising venture. They create new opportunities to assist and care for elderly people at home or in specialized institutions, including nursing homes and hospitals. Grouped under the term gerontotechnology, the first analyses of their contributions to this field appeared in the mid-1990s. Gerontotechnology examines technology and aging in order to improve living conditions and working environments, as well as medical care for dependent seniors.

Preventive medicine

Telemedicine [1][2] has shown its effectiveness in the management of chronic diseases, such as heart failure and high blood pressure, among others. Monitoring patients with chronic diseases through the use of telemedicine is a way to optimize their care. It also offers a better quality of life for elderly patients. Telemonitoring could lead to a significant reduction in the number of readmissions, which would consequently result in lower costs for society. These solutions also encourage the accurate collection of medical data to enable improved monitoring of patient health. The objectives

are thus ambitious, ranging from improved rates of morbidity and mortality, to decreased readmissions, improved quality of life and reduced economic costs.

Machine Learning and Big Data

The use of computer science, especially machine learning [3], arrives as a solution to assist the practitioners. The literature presents different machine learning models that provide recommendations and alerts in case of anomalies, such as the case of heart diseases. The major problem of machine learning is the high dimensionality [4]. The key to the success of machine learning models is to select the best features. It can be observed in the literature that the use of feature selection techniques helped the performance of a classification algorithm in the prediction.

Expected contribution

The main objective of this thesis consists in developing, in a Big Data context, innovative optimization and machine learning techniques aid medical decision by improving early detection of decompensation in a patient. We'll use health databases coming from the experimentation of the E-care platform and its uses in different project since 2014. The E-care [5][6] intelligent telemedicine platform, winner of the Investissements d'Avenir (Future Investments) in 2012 and the Fondation d'Avenir (Future Foundation) in 2015 and 2017. The platform assists caregivers by automating the processing of information from sensors and questionnaires to detect anomalies and make early diagnoses of medically risky situations. The platform is currently deployed in the PRADO-INCADO project in Strasbourg (a collaborative project between the Strasbourg University Hospital, the Bas-Rhin Medical Insurance and the Grand-Est Regional Health Agency) to monitor heart failure patients where they live.

The volume of data is growing on a massive scale. E-care is also deployed in different other hospitals and for remote monitoring of various pathologies such as diabetes or the main geriatrics risks.

The work will be done in partnership with the CHRU of Strasbourg, the CHRU of Besançon in France and the hospital of rehabilitation No. 3 of Shanghai.

[1] Andrés E et al. "Telemedicine to monitor elderly patients with chronic diseases, with special focus on patients with chronic heart failure." J Gerontol Geriatr Res 2016, 5:311. <http://dx.doi.org/10.4172/2167-7182.1000311>.

[2] A. A. Zulfiqar et al. "Telemedicine and Cardiology in the Elderly in France: Inventory of Experiments", DOI: 10.1155/2019/2102156.

[3] A. K. Garate Escamilla, A. Hajjam El Hassani, E. Andres " A Comparison of Machine Learning Techniques to Predict the Risk of Heart Failure", in book: Machine Learning Paradigms: Applications of Learning and Analytics in Intelligent Systems, pp 9-26, DOI:10.1007/978-3-030-15628-2, SPRINGER, 2019.

[4] T. Lambachri, A. Hajjam El Hassani, E. Andres " Aligning Pattern Extraction Algorithms for the Lambda Architecture", in Proceedings of the 2018 9th IEEE International Conference on Information, Intelligence, Systems and Applications (IISA), DOI: 10.1109/IISA.2018.8633698, 2018.

[5] E. ANDRES et al. "E-Care Project: A Promising E-Platform for Optimizing Management of Chronic Heart Failure and Other Chronic Diseases." In Heart Research Open Journal, vol. 2(1), pp. 39-45, Openvention Publisher ISSN: 2377- 164X. 2015.

[6] Andrés et al. "E-care project: a promising e-platform for the optimizing management of chronic heart failure and other chronic diseases." Heart Res Open J 2015;1: 39- 45. <http://dx.doi.org/10.17140/HROJ-2-107>.