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Multi-model Short-term Prediction Schema for mHealth Empowering Asthma Self-management

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Abstract

Ambient intelligence and machine learning techniques are widely proposed by various eHealth and mHealth applications for home-care and self-management of various chronic health conditions. Their adoption for self-management of asthma, a multifactorial chronic disease, requires evaluation and validation in a real-life setups along with optimization at patient level to personalize predictions with respect to asthma control status and exacerbation risk. The current work proposes a novel short-term prediction approach for asthma control status, considering training of multiple classification models for each monitored parameters along with necessary pre-processing methods to enhance robustness and efficiency. The machine learning algorithms considered in this study are the Support Vector Machines, the Random Forests, AdaBoost and Bayesian Network. The Random Forests and Support Vector Machines classifiers demonstrated overall superior performance for the case studies (models) considered.

Keywords: asthma control, personalized self-management, short-term prediction, machine learning algorithms, decision support system, mHealth.

1 Introduction

The currently large amounts of data being automatically collected in various application domains, including health, requires also automatic processing means to extract meaningful high level information for health risk assessment. Artificial Intelligence (AI) and Machine Learning (ML) techniques are widely used to pre-process

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the data (e.g. optimize collection and transmission, de-noise and complete data), extract features and identify patterns in order to predict future behaviours and potential problems, thus allowing for decision support and preventive actions. In the health domain, the usage of mobile, wearable, pervasive and smart sensing technologies have boosted the implementation of eHealth and mHealth applications for home-care and self-management of various chronic health conditions (e.g. diabetes, cardiac diseases) [1] [2] [3], including asthma and other respiratory diseases [4], [5]. At global level, an increasing trend in the percentage of older population is observed (we live longer) [6], which is accompanied by an increased need for home-care health services and pro-active support and prevention (predict a potential problem early to avoid associated health complications, need of hospitalization and increased healthcare costs) [2], [3], [4]. Taking into account the increased prevalence of chronic diseases among the older adults and the long-term monitoring requirements, the proposed solutions must have the capability to: (i) cope with missing data (e.g. a sensor may fail to gather data or the user may forget to fill in a questionnaire) , (ii) efficiently transmit and store dense measurements (e.g. continuous monitoring of activity), (iii) process and interpret heterogeneous datasets, and (iv) personalize risk assessment, predictions and feedback to specific conditions and individual patients [7].

Asthma is a multifactorial, chronic inflammatory disease of the airways (breathing tubes), which has a high prevalence worldwide, and without adequate healthcare management can lead to death, especially for the older adults. Recent efforts have been oriented towards establishing guidelines and monitoring strategies to assess asthma severity and control, and have highlighted the importance of identification of future risk of deterioration in the management of asthma [8]. Various instruments are in place to identify and measure asthma symptoms and severity, along with well established therapies and self-management protocols [9], [10]. However, it appears that due to the heterogeneity and complexity of the disease, new holistic and personalized management approaches are needed [7] to increase efficiency of interventions. Furthermore, a large number of patients do not fully adhere to the self-management programme and their disease management is poor [11], thus requiring specific knowledge and understanding on what triggers their asthma attack and how to avoid these triggers in the daily management of the disease, while being supported and guided to respond quickly to worsening of their asthma in order to maintain a good quality of life and avoid hospitalization.

More specifically, previous works were focused on monitoring and assessing asthma control through a limited set of parameters, most of the times considering the Asthma Control Diary (ACD) or the Asthma Quality of Life Questionnaire (AQLQ) [12] [13], along with the Forced Expiratory Volume in the first second (FEV1) and/or the exhaled nitric oxide (FeNO) [14] [15]. Recently, an increasing number of mHealth applications are exploiting the advances of Information and Communication Technology (ICT) to deliver highly customizable, low-cost and easily accessible self-management interventions to asthma patients [5], [16], [17], [18]. Older studies indicated that there is no clear conclusion with respect to the effec-