

PREDICTIVE MODELING USING UBIQUITOUS MONITORING FOR PERSONALIZED PREVENTIVE HEALTHCARE SERVICES

ABSTRACT

The world's population is growing and simultaneously the expectations for effective treatments and improved quality of life are also increasing. At the same time, the worldwide rising burden of chronic non-communicable diseases (NCD) diseases is responsible for the increased mortality rate, morbidity rate, and healthcare cost. These factors are putting extreme pressure on the healthcare service industry. Therefore, providing healthcare to all is the most important social and economic challenge. The major risk factors for NCD are smoking, physical inactivity, an unhealthy diet, and excessive consumption of alcohol. These risk factors are purely behavioral and require promoting behavior change and living a healthy lifestyle.

Existing healthcare delivery follows the reactive sick-care approach. An episodic, and acute care-based reactive approach is taken when one gets sick. It has various limitations in terms of catering to the healthcare needs of different individuals, varying from a healthy individual to a chronically sick patient. Preventive treatment by proactively avoiding the risk factors and promoting healthy living is identified as one of the approaches to alleviate the burden of NCD.

So far, the role of information and communication technology (ICT) has been very instrumental in improving healthcare and its effectiveness be it the development of medical devices, diagnostic solutions, medicine, or vaccine development. The recent technological advances in ICT like Big Data Analytics, Predictive Analytics, IoT, and Artificial Intelligence are playing a major role in healthcare delivery and services. But it is not utilized that effectively in providing preventive healthcare. The effective utilization and applications of these technologies have become more relevant in the post-COVID-19 era. Several applications of IoT and ICT like contactless healthcare services, teleconsultation, personalized smart healthcare services, diagnosis, patient management, and operational processes are now more relevant than ever. The research work carried out in this thesis and the proposed solutions are highly relevant in post-COVID-19 scenarios and help towards enhancing the proactive and preventive healthcare management using predictive analytics.

The broader aim of this study is to explore how predictive modeling using ubiquitous monitoring can be utilized for enabling preventive healthcare services. The research objectives that have been studied in this thesis are the prediction of adverse events in clinical settings, real-time recognition of activities of daily living (ADL), the prediction of life outcomes, and designing a blueprint for preventive healthcare services.

An important application of preventive healthcare is in clinical settings where the healthcare professionals want to avert adverse events in the patients during critical clinical procedure like surgeries, hemodialysis, or organ transplant. Proactively predicting the adverse events in the patients during a clinical procedure can mitigate the risk. In this study, a non-contact sensor device has been used to monitor vital parameters of patients during hemodialysis (HD) sessions. Predictive models have been developed to predict the adverse events in HD patients. These models could assist healthcare professionals in taking proactive decisions and designing better care plans for patients by early detecting changes to the vital parameters.

Smoking is one of the major risk factors for NCD. Real-time recognition of smoking activity among the confounding ADL enables just-in-time interventions for smoking cessation. A multi-class classification-based predictive modeling framework to identify the smoking activity among other confounding ADL is developed in this study. The developed models obtained a very high predictive accuracy for predicting smoking activity.

The activities can be used to identify behaviors and further in the prediction of life outcomes. The next objective is to predict life outcomes using various types of activities and behavioral data gathered using continuous monitoring of individuals. To demonstrate, we have used the prediction of mental health using smartphone usage and sensor data as a use case in this study. The prevalence of mental health problems is rising worldwide especially in the young age population. We have utilized smartphone usage and sensor data to derive various mobility, sociability, and physical activity features. Further, these features are used for developing predictive models to predict mental health. A decent predictive accuracy has been achieved by the models. The implications of this research work for practice are developing a smartphone-based automated system for predicting mental health. It could be a useful tool for professionals, especially in academic institutions.

The study has been concluded by presenting a blueprint for preventive healthcare services. The key building blocks required for providing preventive healthcare services have been identified. The details of these components are explained in the proposed service blueprint. This blueprint can be utilized by entrepreneurs and industry players to design preventive healthcare services based on patient monitoring and predictive modeling.

Keywords: Ubiquitous Monitoring, Predictive Analytics, Clinical Decision Support Systems, Activity Recognition, Behavior Modeling, eHealth, Preventive Healthcare Services