IRS-HD: an Intelligent Personalized Recommender System for Heart Disease Patients in a Tele-health Environment

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Abstract. *The use of intelligent technologies in clinical decision making support may play a promising role in improving the quality of heart disease patients' life and helping to reduce cost and workload involved in their daily health care in a tele-health environment. The objective of this demo proposal is to demonstrate an intelligent prediction system we developed, called IRS-HD, that accurately advises patients with heart diseases concerning whether they need to take the body test today or not based on the analysis of their medical data during the past a few days. Easy-to-use user friendly interfaces are developed for users to supply necessary inputs to the system and receive recommendations from the system. IRS-HD yields satisfactory recommendation accuracy, offers a promising way for reducing the risk of incorrect recommendations, as well saves the workload for patients to conduct body tests every day.*

1 Introduction

The chronical diseases such as heart disease have become the main public health issue worldwide accounting for 50% of global mortality burden [1]. Today, the survival rates have been increased partially due to technological advancements in disease prediction. Extensive research work has been carried out on data mining and analytic in various medical domains [2].

One of the important problems in medical science is accurate prediction of disease based on analysing historical data of patients. The data mining techniques and statistical analysis have been extensively used to reduce various healthcare and medical issues. They have provided major assistance to experts in disease prediction [5], which can help in minimizing medical errors and providing more detailed data analysis in a shorter time. There are various predictive data mining techniques such as classification by decision tree induction, Support Vector Machine (SVM), Neural Networks, Bayesian classification, and classification based on association that are accepted for disease risk assessment and prediction in medical domain [3-7]. Intelligent technologies can particularly be developed

to greatly facilitate the development and deployment of tele-health systems for patients including those who suffer from chronical diseases such as heart disease and require continuous monitoring of their heart-related medical measurements.

When performing remote continuous monitoring of patients' key measurement readings, an abundance of time series data are generated. Most of the existing predictive analytic methods on medical time series data are used to predict the long-term risk (e.g., the chance of survival) or the diagnosis of diseases. Nevertheless, it turns out that short-term prediction is more difficult than long-term projection due to a higher level of short-term uncertainty existing in the readings of various medical measurements. In addition, short-term recommendations are equally useful for patients as they provide guidance as to what the patients need to do within a short timeframe.

Motivated by the need of a strong intelligent prediction system, this demo proposal presents an intelligent recommender system we developed, called IRS-HD (stands for Intelligent Recommender System for Heart Disease patients). The system is supported by several predictive algorithms for short-term risk assessment on patients in telehealth environment based on analysis of a patient's historical medical data. On the basis of assessment results, the system provides personalized recommendations to patients suffering from heart diseases in relation to the necessity of medical tests taken on a daily basis.

2 Proposed Recommendation System

In this demo proposal, we present an intelligent recommendation system equipped with an array of predictive algorithms to analyze the medical data of heart disease patients, assess their risk and provide them with appropriate recommendations regarding the necessity of taking a medical test in the following day based on the outcome of the prediction.

Easy-to-use user friendly interfaces are developed for users to supply necessary inputs to the system and receive recommendations from the system. IRS-HD involves human computer interaction to receive input from human users concerning the values of the parameters that are used in the algorithm of the system. The recommendations generated by IRS-HD will be returned back to users through different channels and platforms including desktops, laptops and even tablets to embrace the latest technological advancement for quick information dissemination. Besides returned back to the patients, the results can also be sent remotely to medical practitioners such as doctors and nurses so that they can be informed and keep track of the physical checkups and overall health conditions of the patients.

The demonstration system utilizes heterogenous prediction algorithms, including Basic Heuristic Algorithm (BHA), Regression-Based Algorithm (BRA), Hybrid Algorithm (HA), Neural network (NN), Least Square-Support Vector Machine (LS-SVM), Naive Bayes (NB) and K-Nearest Neighbor (KNN), for conducting predictive analysis and produce for ensemble-based recommendations to patients.

Specifically, there are three parameters in the recommendation system requiring configuration before use. The first parameter is the medical measurement (e.g., heart rate, blood pressure, etc.) that the prediction is working on. The minimum (min) and maximum (max) normal values for the selected medical measurement are also specified to establish its normal range. The second parameter is the length of the sliding time window k which determines the historical data to be utilized for prediction and recommendation. The final parameter is p for determining the minimum percentage of days when physical test is conducted by the patient for the measurement in the past k days.

All phases of IRS-HD were implemented using Matlab. The user must enter the three parameters to the system and then the predictive analytic methods for prediction. Users can choose one or multiple different analytical methods and, if multiple methods are selected, IRS-HD utilizes ensemble-based method to produce the prediction and recommendation. Through this function, IRS-HD can assess the patient's status and then generate recommendations based on the analysis of his/her measurement readings for the past k days and decide whether a given patient needs to take a medical measurement such as the heart rate test today or not.

Here, if the patient does not need to take the test on the following day for a selected medical measurement, a recommendation of "no test needed" will be generated and presented on the interface, and stored as well into the backend database as a part of the patient's historical records, as shown in Fig. 1. Otherwise, a recommendation of "test required" will be generated and the patient is suggested to take the medical test on the following day. Then, the recommendation system will ask the user to enter the his/her test value for today which will be stored into the system as a historical record, as shown in Fig. 2.

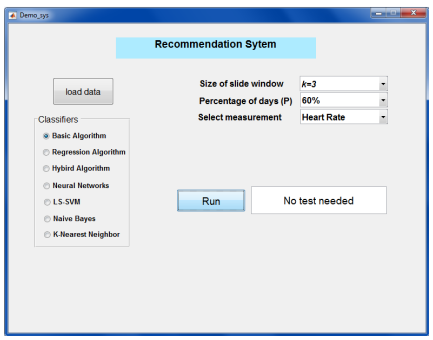

Fig. 1. Generation of the recommendation "No test needed" in IRS-HD

Fig. 2. Generation of the recommendation "Test required" in IRS-HD

3 Demonstration Plan

This section presents the detailed plan for our demonstration, which consists of the following parts:

First, we will describe to the audience the limitation in the existing predictive algorithms used to various healthcare and medical issues which motivates the development of our intelligent recommender system. We demonstrate the prototype of an intelligent recommendation system that is supported internally by innovative prediction and recommendation algorithms and feature intuitive user friendly system interface;

Second, we will display the system architecture of IRS-HD. The technical detail of the system will be introduced for its components and how connect each other in the recommendation system. We will also present to the audience how the ensemble-based prediction is performed within the system;

Finally, we will present the interactive interfaces developed for our recommendation system and how they significantly facilitate receiving input from human users concerning the values of parameters that are used in the algorithm of our system. Experimental evaluation results will be presented to the audience to show the performance of IRS-HD in terms of recommendation accuracy and workload saving (That is the percentage of days when the physical medical test is not required based on the recommendation).

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