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REAL-TIME HEALTH MONITORING VIA ECG ANALYSIS

In this paper we describe the range of use cases of medical wearable IoT devices for monitoring health state in real-time. We propose approaches for analysis the dynamic analogous but digitized electrocardiogram in combination with other personal data like age, gender, medical card and some sensors like GPS and accelerometer by neural network or some other machine learning method. It should be trained on classified dataset and then be adjusted for specific person to monitor and classify in real-time his or her health state whether he or she is healthy or if some abnormality detected. This paper is the declaration of our research and its development which is at the data gathering and preparation stage.

Keywords: machine learning, ECG, cardiovascular disease, time series analysis & forecast, health monitor, medical wearable device, IoT.

Introduction

There are lots of medical problems in the world and new scientific results in different fields can solve fully or partially some of them. Researches in usage of statistical and machine learning methods in medicine are very important for humanity, because in general the treatment of diseases depends on it. There are plenty of diseases and body's indicators to monitor, but we will concentrate at heart and cardiovascular system monitoring because of more than 30% of all global people death reason is cardiovascular disease in the whole world by statistics [1]. An important field of applications of the methods mentioned above is the analysis of electrocardiogram (ECG) to classify the person's health state in real-time or online mode, or, as a minimum, at regular rate – to check whether the one's cardiovascular system state is healthy or to detect the abnormality in time. At the best, the solution of such task could help people to control their health in real time.

Many new technologies appear nowadays particularly in medical IoT such as different gadgets for mass use like fitness trackers and different wearable wireless sensors that can read and analyze different health marks. Such devices give cheap opportunities for people to care about their health by themselves. And real time analysis of ECG can become one of the major directions for researches in the field as it provide lot of important information about the person. There are many start-ups developing now in this direction and this fact emphasizes the huge interest to achieve the goal of health self-monitoring.

The Task

Suppose we have a fixed sample of patients with known ECG and general medical and personal data (age, gender, medical card etc.). This information is already classified as healthy or with the heart attack or other known diseases. Also we have current person with the analogous data set (ECG as time series) which is dynamic but without classification. The task is to predict the person's state in online mode, namely healthy or abnormality detection.

Related Works

Classification of heartbeats is difficult and vital problem that is being explored for many years. The interest in medical IoT has increased for the last years [2] and as a result researches in this area become more popular and easier. And one of the most important reasons for such studies is to give people the cheap opportunity to monitor their health state and take care about it. Most of the previous researches were oriented to process static datasets so there were no opportunities to explore dynamic data. These methods are aimed

to decrease data dimensions and increase prediction accuracy for different illnesses. But some researches for real-time data appear recently. They are modelling dynamic processes for ECG with second order ordinary differential equation to classify normal and abnormal QRS complexes in the electrocardiogram, which is of great clinical values in diagnosis of cardiovascular diseases [3], find smaller subsets of features sufficient to detect arrhythmias with high accuracy using electrocardiogram signals [4], simultaneously capture morphological and dynamic feature of highly correlated ECG signals using second order ordinary differential equation [5], extract features from electrocardiogram signal using Huang Hilbert Transform and Wavelet Transform [6].

The Goals

The main purpose of our research is to create a methodology to classify the person's heart health state in the real time via the ECG and also using some general personal and medical information (gender, age, accelerometer & gyroscope sensors, temperature, medical card records etc).

We have some hypotheses which can be confirmed or declined through our research. They can be formulated like the following questions.

1) Is it possible to detect the deviation in cardiovascular system in time via the ECG sensors in combination with other sensors mentioned above?

2) Is it possible to predict some or any cardiovascular disease and/or deviation of health parameters after the regular monitoring through our (or any other) wearable ECG-device?

3) Is there exists some self-trained neural network (or some kind of machine learning tool) that can adjust itself (or being adjusted by some "tutor") to the ECG of any given person and give us the precise signals when some attributes of ECG goes to deviate from the normal for this person range?

The algorithm, as we see it the most probably, should check the obvious deviations at the first stage and then moves to self-trained neural network (or something similar formalism):

a) to train the network by the new data

b) to recognize the health parameters deviation in time.

The Current State of Research

First of all, there is no open data set of ECG in free access. So, the first task is to create this marked data set. The IoT wearable 1-channel cardiograph was made for this and now we are gathering the real ECG time series from the humans interested in experiment.

Secondly, gathered data should be analyzed from the cardiologist point of view, marked and accomplished by new data from the recommended patients (most probably with proven or suspected diseases).

The third task is to analyze the data in two ways: to train some neural network for self-diagnostics, self-monitoring, self-training and to check (approve) the hypotheses posted at the start of this paper.

Conclusions and Perspectives

Results of this research – namely, of the goals and tasks stated here – can be used in:

1) online/real-time diagnostics of cardiovascular system diseases,

2) health self-monitoring to prevent diseases,

3) sport medicine,

4) developing and using the existing wearable devices to analyze the person's health state for informing interested people (relatives, doctor etc.) in timely fashion,

5) monitoring of elder persons, probably with disabilities and/or some serious diseases or which are in high risk group of patients,

6) continuous monitoring and analysis of the health in real-time mode in special cases (new treatments, non-standard illness, high (sport) loads etc).

The evidence of the proposed plan is that similar ideas have been successfully used in other areas like preventive maintenance of wind turbines (and other engines) using machine learning [7].

Now we are at the stage of collecting the real-time information from the sensors from the group of patients to make starting classification and making first conclusions about the data quality and precision.

Perspectives in developing new wearables, from small on-wrist devices to fully-functional cardiographs, as well as new usage for the existing ones will appear for the wide range of potential and real use cases, some of which were shown here.

The main outcome will be in some machine learning mechanism or algorithm (neural network etc.) and/or expert system, which will be able to inform about some or any heart's health changes online and real-time.

These products potentially will be of interest by:

1) persons with cardiovascular diseases (or in the group of risk),
2) children of elder person as well as the latter themselves,
3) clinics and personal doctors,
4) insurance companies,
5) any human interested it his/her health monitoring.

Moreover, these devices and systems can be potentially used for life security and – who knows whatever – other cases.

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