Ph.D. project, Cotutelle 2019

Diagnosis and prognosis of heart disease

Diagnostic et pronostic de maladies cardiaques

Supervisor: Farah CHEHADE

farah.chehade@utt.fr

Université de Technologie de Troyes, Institut Charles Delaunay, M2S

1 – Context

Nowadays, heart disease is the leading cause of death in the world. It touches all ethnicities, sexes and ages, but it increases with age. Heart disease refers to complications that affect heart functions, including cardiovascular diseases, such as heart attack, arrhythmias, heart failure, or pulmonary diseases, such as acute respiratory distress syndrome. Some of these pathologies are given in Figure 1- Some types of heart disease. Heart disease has different symptoms, such as shortness of breath, chest pain, sweating and nausea. It also has several risk factors, like smoking, hypertension, diabetes and obesity. Occurrence of heart disease may lead to mortality, disabilities or functional declines. Besides the degradation of life quality, it imposes a huge burden in terms of healthcare costs. An essential strategy to overcome these heavy consequences is to anticipate the occurrence of heart disease by predicting it and providing the surveilled subject the required treatment.

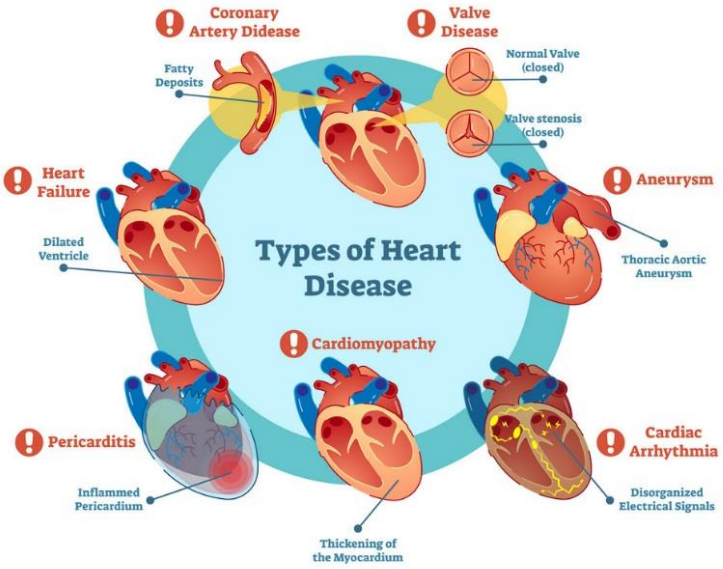

Figure 1- Some types of heart disease

2 – Objective

The objective of this Ph.D. project is to develop methods for predicting a heart disease. This is done by analyzing vital signals of subject, extracting significant information from these signals, diagnosis the current state and forecasting eventual degradation to generate an alert.

2.1 – Extracting signals and parameters

The Ph.D. student will first handle the public database MIMIC III that includes a large amount of vital records of patients having different pathologies [1]. Signals, like heart rate, respiratory rate, airway blood pressure and oxygenation saturation, will be needed from this database, to be used afterwards in surveillance [2]. An illustration of heart rate signals of a healthy subject and an ill subject is given in Figure 2- Heart rate signals of a healthy subject (at left) and an ill patient (at right).

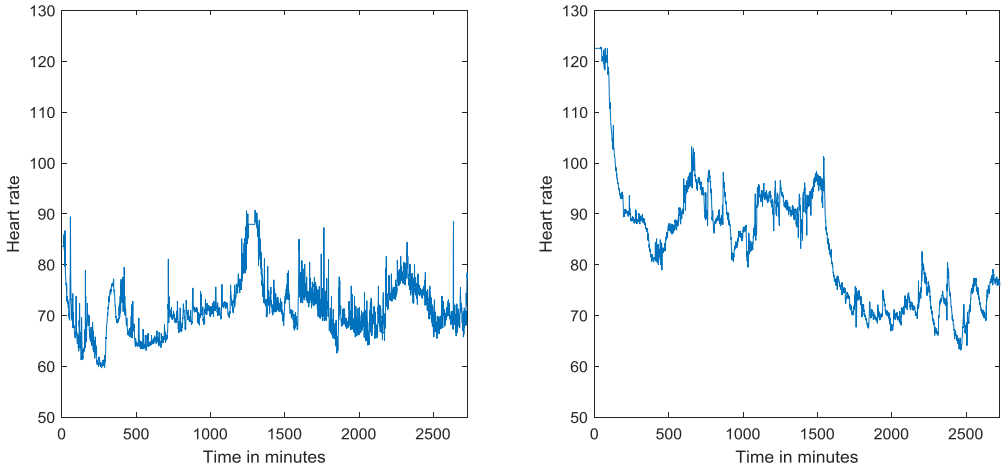

Figure 2- Heart rate signals of a healthy subject (at left) and an ill patient (at right)

The extraction of signals will be followed by an extraction of significant parameters from these signals. Parameters could be statistical, such as the mean, the standard deviation, the kurtosis, the skewness, frequency parameters, or without physical definitions, based on nonparametric methods [3], [4].

2.2 – Diagnosis and prognosis

Having a considered heart disease, a health state of a patient could be at different levels of degradation going from normal state to severe illness, as shown in Figure 3- Levels of degradation. First of all, the objective of the Ph.D. work is to diagnose where the state of the surveilled patient falls, using its real-time extracted parameters [5], [6], [7]. It consists of developing classification methods, using machine learning, that take the parameters as input and yield the state level as output.

Figure 3- Levels of degradation

Afterwards, the Ph.D. student will work on developing an evolution model between the state levels, based on stochastic processes, such as Hidden Markov Models [8], [9], or others [10], [11]. This part of the study allows to predict the remaining time for the patient state to reach the final level and thus its severity. An alert, for the doctor, is then generated to take care of the patient.

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