UNIVERSITI TEKNOLOGI MARA

# HEART SOUND DIAGNOSIS USING NONLINEAR ARX MODEL

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# ABSTRACT

This thesis presents a research work on a diagnosis system for heart sound based on nonlinear ARX (NARX) model. The system uses neural network for model estimation and classification of several heart diseases. Six NARX models which represent Normal and other five categories of heart diseases such as Atrial Septal Defect (ASD), Pulmonary Stenosis (PS), Patent Ductus Arteriosus (PDA), Ventricular Septal Defect (VSD) and Mitral Regurgitation (MR) are estimated. A Lipschitz method and Levenberg Marquardt algorithm is used to determine the model order number and train the network respectively. The R-square value of the OSA prediction of the signal is above 99% for all heart sound signals. The best network architecture for modeling the heart sounds is 2-4-1.

As for classification, the features are extracted and selected from the modeled signals and their distinctive patterns are used as inputs to the classifier. To make the system more robust, the background SNR ranging from 3dB to 20dB is injected to the modeled signal. The Resilient Backpropagation (RPROP) algorithm is used to train the network. The optimized learning parameter used is 0.07 and the network has best performance when hidden neurons equal to 220. The architecture of the network is 32-220-6. The accuracy of the network when validated with the diagnostic test is found to be above 97% which suggests that the network performs well and is doing as 'gold standard'.

The classification result is further improved to 100% when overall testing is performed. This result has surpassed the result of heart sound classification based on linear model. The accuracy of the linear approach to analyse certain heart diseases varies from 88.5 to 91.6%. The nonlinear approach has successfully estimated the sounds from the heart such that the heart diseases are classified accordingly.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Cardiovascular diseases (CVDs) are among the most serious threats to human health. As the leading cause of death worldwide, CVD has a major impact not only on the wealthy, industrialized nations but also on the developed nations [1-3]. In the United States, the mortality data of 2006 shows that CVD accounted for 34.3% of all deaths while in the developed nations, particularly low and middle income countries, CVD accounted for nearly 30 percent of all deaths [1][4]. The increase prevalence of risk factors of CVDs is tobacco and alcohol use, high blood pressure, high cholesterol, diabetes, family history and obesity [5-6].

In Malaysia, cardiac disease is the number one killer as recorded in most of the government hospitals [7-8]. According to Department of Statistics, over 12% of total deaths in 2006 were due to complications related to heart disease while 1.2% of total deaths were attributed to reasons from strokes [9]. It was reported that each year, over 150,000 total heart patients are treated at the National of Heart Institute (IJN). The average rate of patient growth from year 2002-2006 is 5.5% [10]. As the number of patients suffering from heart disease has been considerably increasing every year, it is important to have a proper diagnostic tool for heart disease that may help patients to survive from fatal consequences. Early screening of the disease by a support tool could help the physicians know the condition of heart in times which enable them to decide on surgery or non-invasive treatment well before the disease may prove fatal.

Conventional method used for diagnosing heart disease is through auscultation system, studying Electrocardiogram (ECG) and Echocardiogram. Through auscultation system, a physician uses a stethoscope by listening to the heart sounds in