FAULT DETECTION AND DIAGNOSIS FOR WATER-COOLED CHILLER SYSTEM

CHAN KAI YANG

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAULT DETECTION AND DIAGNOSIS FOR WATER-COOLED CHILLER SYSTEM

CHAN KAI YANG

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Fault Detection and Diagnosis for Water-Cooled Chiller System

Sesi Pengajian : 2017/2018

Saya CHAN KAI YANG mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **SULIT*** (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ **TERHAD*** (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.

☐ **TIDAK TERHAD**

Disahkan oleh:

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: No. 4, Jln Wawasan 3/3, Bandar Baru Ampang, 68000, Selangor.

Tarikh : 01 June 2018 Tarikh : 01 June 2018

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this report entitled "Fault Detection and Diagnosis for Water-Cooled Chiller System" is the result of my own work except for quotes as cited in the references.

Signature : ……

Author : ……Chan Kai Yang……

Date : ……01 June 2018...……

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature	:	……..
Supervisor Name	:	…Noor Asyikin binti Sulaiman…
Date	:	……01 June 2018…….

DEDICATION

To My Beloved Father and Mother

ABSTRACT

There are many types of air conditioner such as the split unit air conditioner, the package unit air conditioner and the chiller system which is widely used in modern commercial building. The demand of indoor air quality, heating, ventilation and air conditioning (HVAC) systems especially the chiller system of a HVAC system has been continuously increasing from years to years. The HVAC system has become more and more complex to provide a comfortable indoor environment as well as to provide energy management in modern building. However, an operating system with unidentified fault may lead to high energy consumption and system failure. As a result, a fault detection and diagnosis system which is able to identify fault as well as to monitor and diagnose faults within the HVAC system is required. Principal Component Analysis (PCA) is a Fault Detection Method based on data and parameters. It is used to reduce the dimensionality of data and detect faults based on data. On the other hand, a trained model with the implementation of the K-Nearest Neighbor (KNN) algorithm is used to diagnose faults based on input data. Fault detection and diagnosis system is essential in detecting and diagnosing faults to prevent system failure.

ABSTRAK

Terdapat banyak jenis penghawa dingin seperti penghawa dingin unit perpecahan, penghawa dingin unit pakej dan sistem penyejuk yang banyak digunakan di bangunan komersial moden. Permintaan sistem pemansan, pengudaaan dan penghawa dingin (HVAC system) terutamanya sistem pengyejuk telah meningkat secara berterusan. Sistem HVAC telah menjadi lebih kompleks untuk menyediakan persekitaran dalaman yang selesa. Walaubagaimanpun, sistem HVAC terutamanya sistem penyejuk yang beroperasi dengan kerosakan sistem yang tidak dapat dikenal pasti akan mengakibatkan pembaziran tenaga dan kegagalan sistem. Oleh itu, sistem pengesanan dan diagnosis kerosakan sistem penyejuk yang dapat mengenal pasti dan menentukan kerosakan sistem serta memantau kerosakan dalam sistem HVAC terutamanya sistem penyejuk amat diperlukan. Principal Component Analysis (PCA) adalah kaedah yang digunakan untuk mengenal pasti kerosakan di dalam sistem penyejuk berdasarkan data dan paramenter. Ia digunakan untuk mengurangkan dimensi data dan menentukan kerosakan sistem berdasarkan data. Sebaliknya, model berdasarkan algoritma K-Nearest Neighbor (KNN) digunakan untuk menentukan kerosakan dalam sistem penyejuk. Oleh itu, sistem pengesahan dan diagnosis amat diperlukan untuk menggelakkan kegagalan sistem.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for giving me the chance to undertake my Final Year Project in partial fulfilment for Bachelor of Electronic Engineering with Honours.

I would like to thank my supervisor, Madam Noor Asyikin binti Sulaiman who guide me through my Final Year Project. A lot of advises and guidances throughout the projects and advise in working attitudes, discipline in life and knowledge related to engineering field has been given to me and accompany me till the end of this Final Year Project and maybe the rest of my life.

Finally, yet importantly, I would like to express my heartfelt thanks to my parents for their blessings, my friends or classmates for their wishes and helps for the successful completion of my Final Year Project. No man walks alone throughout the journey of life. Without the help from everybody, I could not complete my Final Year Project successfully. Once again, thank you everyone and I am grateful for your help and support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

HVAC	:	Heating, Ventilation, Air Conditioning
PCA	:	Principal Component Analysis
KNN	:	K-Nearest Neighbor
GUI	:	Graphical User Interface
EMC	:	Electromagnetic Compatibility
ANN	:	Artificial Neural Network
SPM	:	Statistical Process Monitoring

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter, the motivation, problem statement, objective and scope of work will be discussed. Discussion of all subtopics in this chapter will be the initiative for this project.

1.2 Motivation

As shown in Figure 1.1, there are many types of air conditioner in the market, such as the split unit air conditioner which consists of one outdoor unit and one indoor unit air conditioner that is commonly used in most of the residents, the package unit air conditioner which consists of one outdoor unit and multiple indoor units air conditioner that is commonly used in small commercial building, and the chiller

system which is widely used in modern commercial building. The demand of indoor air quality, heating, ventilation and air conditioning (HVAC) systems especially the chiller system of a HVAC system has been continuously increasing from years to years [1]. The chiller system of the HVAC system has become more and more complex to provide a comfortable indoor environment as well as to provide energy management in modern building [2]. The chiller system of the HVAC system is commonly equipped with power and control system, and several component and elements of the chiller of the HVAC system itself which makes the system complex. When all these things, together with the chiller of the HVAC system are installed in the building, problems such as equipment fault, inaccurate detection of sensors, wrong installation, lack of maintenance can cause negative effects on the chiller system of the HVAC system and eventually affect the indoor environment air quality. As a result, a system which is able to identify fault as well as to monitor the HVAC system and diagnose fault within the chiller of the HVAC system is required.

1.3 Problem Statement

The chiller system of a HVAC system is a large system and it involves lots of elements as well as components. As a result, it is difficult to identify the fault when something goes wrong within the system. It has come to a solution where sensors are installed within the chiller system of the HVAC system to detect the parameters of the system such as the temperature sensors are installed in the test room to detect the temperature in the rooms. As the system is complex, it is difficult to identify the fault based on the complex and multiple variables data obtained from the sensor. An operating system with fault may leads to high energy consumption as well as system

failure. Therefore, it is very important to locate the fault within the system as fast as possible to avoid energy wastage and system failure.

1.4 Objectives

1. To identify fault on chiller system by using Principal Component Analysis (PCA) and K-Nearest Neighbor (KNN).
2. To develop a Fault Detection and Diagnosis System.

1.5 Scope of Work

As mentioned in Subtopic 1.1, there are many types of air conditioner in the market such as the split unit, package unit and the chiller system. As a result, this project is limited to the water-cooled chiller system which has two test rooms. The data and parameters obtained from the system are simulated with PCA Algorithms in MATLAB.

Split Package Chiller

Figure 1.1 Types of Air Conditioner

1.6 Research Methodology Flow Chart

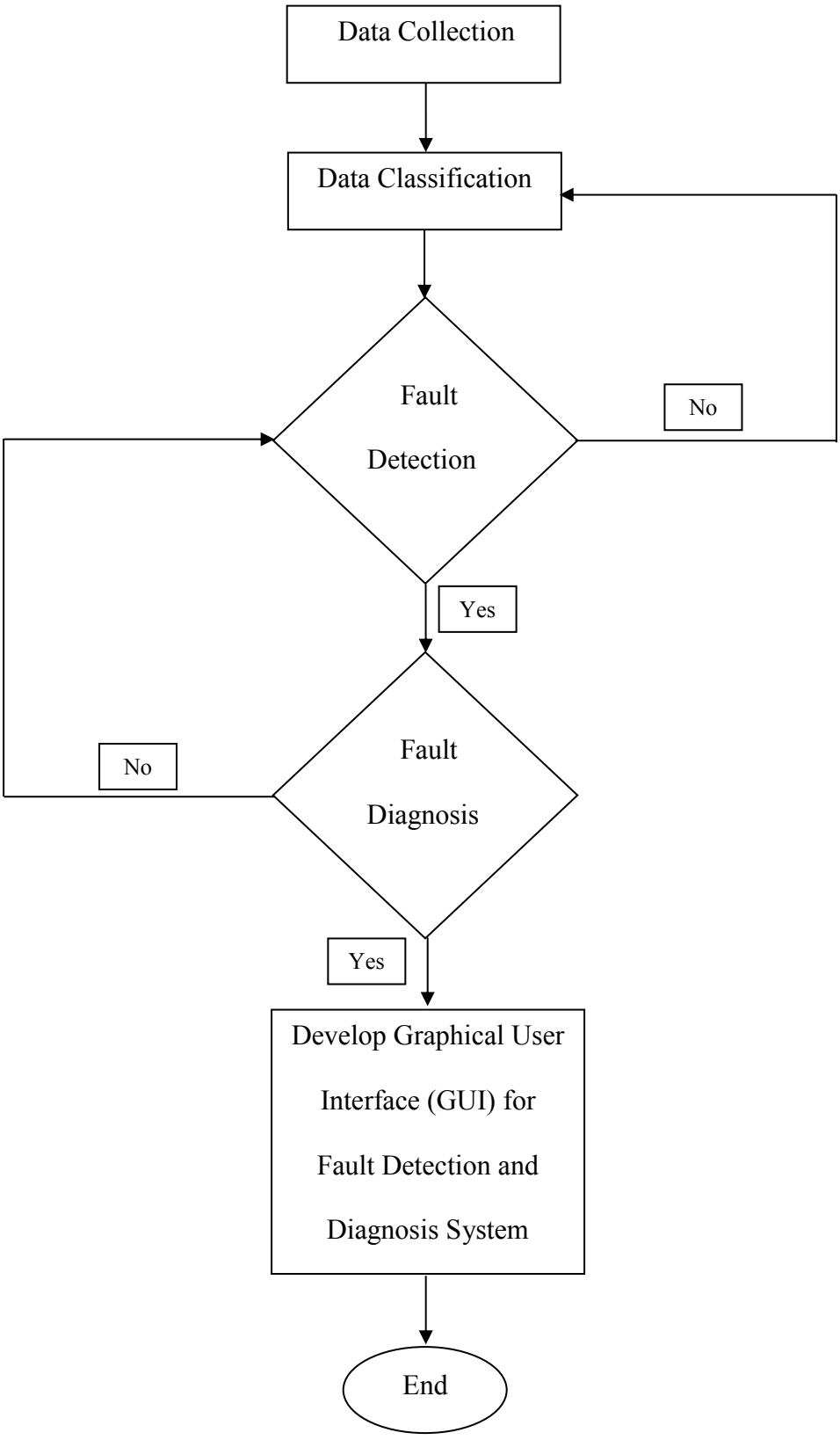

Figure 1.2 Research Flow Chart Methodology

By referring to referring to Figure 1.2, it shows the flow chart of this project. At the initial stage, sensors are fixed in the chiller system of the HVAC system to collect data from the chiller system. Once data is being collected, they are being classified to different categories for the preparation of development of the fault detection and diagnosis system. The fault detection system should be able to detect abnormal condition based on the data obtained from the sensor in the chiller system. If the fault detection system is not able to do so, it has to be returned to the previous step to examine problems that causes errors on the fault detection system and redevelop the fault detection system until it is able to detect abnormal condition based on the data. The next step is to develop a fault diagnosis system to diagnose the exact faults occurred in the system based on the data obtained. If the fault diagnosis system is unable to perform fault diagnosis, it has to be returned to the previous step to examine problems which causes errors on the fault diagnosis system. Once the fault diagnosis is being developed, the graphical user interface (GUI) for the fault detection and diagnosis system can be developed for the ease of the users.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

In this chapter, the background of the project will be explained briefly for better understanding of the research. A review of previous related works will be discussed to obtain some useful information by synthesizing their work to make this research successful.

2.2 Faults

A fault is an unpermitted deviation of at least one characteristics property (feature) of the system from the acceptable, usual, standard condition [3]. A fault is a condition of a state within the system. The difference between the identified fault value and the value that go against of a tolerance zone for its normal value is considered as