

**FAULT DETECTION AND DIAGNOSIS OF AIR-
CONDITIONING SYSTEM USING CONVOLUTIONAL NEURAL
NETWORK**

ROHAIZAH BINTI RAMLAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**FAULT DETECTION AND DIAGNOSIS OF AIR-
CONDITIONING SYSTEM USING CONVOLUTIONAL
NEURAL NETWORK**

ROHAIZAH BINTI RAMLAN

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Alamat Tetap: No 15 Jalan
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10, 62250
Putrajaya,

Tarikh : 30/5/2019

NOOR ASYIKIN BINTI SULAIMAN
Pensyarah
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh : 30/5/2019

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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.

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DEDICATION

To my beautiful parents, Ramlan bin Mohamed and Rosimah binti Sukur

ABSTRACT

Fault diagnosis plays a vital role for large system in this modern industry. In general, faults are deviations from normal behavior of the system that indicates something is going wrong in the monitored system. Improving this system contributes great energy savings and avoid total system breakdown. One of the large systems that is commonly used in most of the building is heating, ventilation and air- conditioning (HVAC) system. Therefore, this project attempts to identify faulty as well as to monitor the HVAC system and diagnose fault within the chiller of the HVAC system. (The purpose of the proposed project is to ensure the satisfactory thermal comfort among users). This project uses convolutional neural network (CNN) for faults classification. The data is fed to CNN and undergoes training and testing processes by using splitting method and k-fold cross validation. The accuracy of CNN on air-conditioning system fault data is tested and analysed, by varying the configurations. The results show that CNN is able to classify all faults with more than 97% accuracy.

ABSTRAK

Diagnosis kerosakan memainkan peranan penting untuk sistem yang besar dalam industri moden ini. Secara umum, kerosakan merupakan sisihan daripada sifat biasa dalam sesebuah sistem yang melambangkan sesuatu tidak kena berlaku pada sistem pengawasan. Penambahbaikan pada sistem tersebut menyumbang penjimatan tenaga yang banyak dan mengelak sistem rosak sepenuhnya. Salah satu sistem yang lazim digunakan pada kebanyakan bangunan adalah sistem heating, ventilation and air conditioning (HVAC). Justeru, projek ini mencadangkan sebuah sistem yang mengenalpasti jenis kerosakan dan juga mengawas sistem HVAC dan diagnos kerosakan dalam sistem penyejuk HVAC. Projek ini bertujuan untuk memastikan kepuasan persekitaran dalaman. Kaedah klasifikasi menunjukkan potensi dalam pelaksanaan objektif projek dan kaedah dicadangkan adalah convolutional neural network (CNN). Data yang diperolehi dimasukkan dalam CNN dan seterusnya ke proses 'train and test' melalui kaedah 'splitting' 80:20. Ketepatan CNN dalam data kerosakan sistem penghawa dingin dikaji dan analysis dilakukan, dengan pelbagaikan konfigurasi.

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TABLE OF CONTENTS

Declaration	
Approval	
Dedication	
Abstract	i
Abstrak	ii
Acknowledgements	iii
Table of Contents	iv
List of Figures	vii
List of Tables	ix
List of Symbols and Abbreviations	xi
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	2
1.2 Problem Statement	3
1.3 Objectives	3
1.4 Scope of Project	3
1.5 Thesis Outline	4

CHAPTER 2 BACKGROUND STUDY	5
2.1 Heating, Ventilation Air-Conditioning System	6
2.1.1 Cooling Tower	6
2.1.2 Chiller	7
2.1.3 Air Handling Unit	7
2.2 Fault Diagnosis and Detection	8
2.3 Convolutional Neural Network Overview	9
2.3.1 Pre-Processing	10
2.3.2 Input	11
2.3.3 Convolution	12
2.3.4 Pooling	13
2.3.5 Backpropagation	14
2.4 Fault Diagnosis and Detection Using Convolutional Neural Network	15
2.5 Multi Layer Perceptron	17
CHAPTER 3 METHODOLOGY	18
3.1 Introduction	18
3.2 Data Collection	21
3.3 Data Classification	24
3.4 WEKA toolkit	25
3.5 Pre-processing Data	27

	vi
3.5.1 Data Normalization	28
3.6 Classifier	29
3.7 Evaluation/Validation Criteria	30
3.7.1 Holdout: Train and Test	30
3.8 K-Fold Cross Validation	31
CHAPTER 4 RESULTS AND DISCUSSION	33
4.1 Introduction	33
4.2 Fault Detection and Diagnosis	34
4.3 Holdout: Train and Test	34
4.4 K-Fold Cross Validation	50
4.5 Overview of Fault Detection and Diagnosis	66
CHAPTER 5 CONCLUSION AND FUTURE WORKS	67
5.1 Introduction	67
5.2 Conclusion	67
5.3 Future work	68
REFERENCES	69

LIST OF FIGURES

Figure 2.1 : Schematic of cooling tower	7
Figure 2.2 : Overview of CNN architecture	10
Figure 2.3 : Input Image for the network [10]	11
Figure 2.4 : CNN architecture of [10]	13
Figure 2.5 : Output layer error formula	14
Figure 2.6 : Hidden layer error signal formula	14
Figure 2.7 : Illustrates of perceptron network with three layers	17
Figure 3.1 : Flowchart	19
Figure 3.2 : Schematic diagram of sensors distribution in HVAC system	23
Figure 3.3 : WEKA logo	25
Figure 3.4 : Data in form of '.csv' file	26
Figure 3.5 : Dataset in '.arff' file	26
Figure 3.6 : Result of Normalization	28
Figure 3.7 : WEKA Layout in Classifier	31
Figure 3.8 : K-Fold Cross Validation Illustration	32
Figure 4.1 : Confusion Matrix for Split Data 80:20	35
Figure 4.2 : Detailed Accuracy for Split 80:20	40
Figure 4.3 : Confusion Matrix for Split Data 70:30	41

Figure 4.4 : Detailed accuracy of Split Data 70:30	46
Figure 4.5 : TP Rate for Split Train and Test	46
Figure 4.6 : FP Rate for Split Train and Test	47
Figure 4.7 : Precision for Split Train and Test	47
Figure 4.8 : Recall for Split Train and Test	48
Figure 4.9 :Confusion Matrix for 10 Folds	50
Figure 4.10 : Detailed Accuracy for 10 Folds	55
Figure 4.11 : Confusion Matrix for 5 folds	56
Figure 4.12 : Detailed Accuracy for 5 Folds	61
Figure 4.13 : TP for K-Fold Cross Validation	61
Figure 4.14 : FP for K-Fold Cross Validation	62
Figure 4.15 : Precision for K-Fold Cross Validation	62
Figure 4.16 : Recall for K-Fold Cross Validation	63

LIST OF TABLES

Table 3.1 : Type of parameters detected by sensors	22
Table 3.2 : Types of Condition	24
Table 3.3 : Classifier configurations	29
Table 4.1 : Summary of Fault Diagnosis for Normal Operation	36
Table 4.2 : Summary of Fault Diagnosis for Cooling Tower Fan Faulty	36
Table 4.3 : Summary of Fault Diagnosis for Compressor Malfunction	37
Table 4.4 : Summary of Fault Diagnosis for Damper Stuck	38
Table 4.5 : Summary of Fault Diagnosis for Supplied Chilled Water Clogging	38
Table 4.6 : Summary of Fault Diagnosis for Air Ducting Leakage	39
Table 4.7 : Summary of Fault Diagnosis for Normal Condition (70:30)	42
Table 4.8 : Summary of Fault Diagnosis for Cooling Tower Fan Faulty (70:30)	42
Table 4.9 : Summary of Fault Diagnosis for Compressor Malfunction (70:30)	43
Table 4.10 : Summary of Fault Diagnosis for Damper Stuck (70:30)	44
Table 4.11 : Summary of Fault Diagnosis for Supplied Chilled Water Clogging (70:30)	44
Table 4.12 : Summary of Fault Diagnosis for Air Ducting Leakage (70:30)	45
Table 4.13 : Output Model	49
Table 4.14 : Summary of Fault Diagnosis for Normal Condition (10 folds)	51
Table 4.15 : Summary of Fault Diagnosis for Cooling Tower Fan Faulty (10 folds)	52

Table 4.16 : Summary of Fault Diagnosis for Compressor Malfunction (10 folds)	53
Table 4.17 : Summary of Fault Diagnosis for Damper Stuck (10 folds)	53
Table 4.18 : Summary of Fault Diagnosis for Supplied Chilled Water Clogging (10 folds)	54
Table 4.19 : Summary of Fault Diagnosis for Air Ducting Leakage (10 folds)	55
Table 4.20 : Summary of Fault Diagnosis for Normal Condition (5 folds)	57
Table 4.21 : Summary of Fault Diagnosis for Cooling Tower Fan Faulty (5 folds)	57
Table 4.22 : Summary of Fault Diagnosis for Compressor Malfunction (5 folds)	58
Table 4.23 : Summary of Fault Diagnosis for Damper Stuck (5 folds)	59
Table 4.24 : Summary of Fault Diagnosis for Supplied Chilled Water Clogging (5 folds)	59
Table 4.25 : Summary of Fault Diagnosis for Air Ducting Leakage (5 folds)	60
Table 4.26 : Output Model for K-Fold Cross Validation	64

LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

- ARFF : Attribute-Relation File Format
- CNN : Convolutional Neural Network
- FDD : Fault Diagnosis and Detection
- WEKA : Waikato Environment for Knowledge Analysis
- HVAC : Heating, Ventilation, Air-Conditioning

CHAPTER 1

INTRODUCTION

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

1.1 Introduction

There are various types of air conditioner available in the market and chiller system is one of them. It is commonly used in modern commercial building. The chiller system of the heating, ventilation and air conditioning (HVAC) systems is a complex system to provide a comfortable indoor environment and energy management in that particular building. Problems such as equipment fault, inaccurate detection of sensors, wrong installation, lack of maintenance can cause negative effects on the chiller system and eventually affect the indoor environment air quality. As a result, a system to identify fault as well as to monitor the HVAC system and diagnose fault within the air-conditioner is required.

Fault detection and diagnosis research has been actively done, which is an essential part of modern industries to ensure safety and product quality. Deep learning shows great potential to train and perform fault detection and diagnosis. Convolutional neural network is one type of deep and feedforward network that outperformed others in generalizing and training networks consisting of full connectivity across adjacent layer. It is constructed as a series of stages that plays their own role. CNN construct consists of four properties: multiple layers, pooling/subsampling, shared weights and local connection. [1]

1.2 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, identifying any fault within the system would be a difficult task. It has come to a solution where sensors are installed within the 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.

1.3 Objectives

1. To develop the fault detection of HVAC system
2. To analyse the performance of convolutional neural network

1.4 Scope of Project

There are many types of air conditioner such as split unit, package unit and chiller system. As for this project, it is limited to the water-cooled chiller system which has two test rooms. The data and parameters obtained from the system are simulated with CNN methods.

1.5 Thesis Outline

This thesis is organized into five chapters to cover the research work that is related to fault diagnosis and detection using convolutional neural network. The outlines of the thesis are described as follows. Chapter 2 presents the literature review of chiller system of HVAC system, fault diagnosis and detection and the using method, convolutional neural network. Chapter 3 is the research methodology of convolutional neural network method. Chapter 4 is the mainly focused on the analysis and discussion on the results of the research. Chapter 5 provides an overall conclusion.

CHAPTER 2

BACKGROUND STUDY

This chapter discusses about the air-conditioning system, fault diagnosis and detection, and convolutional neural network generally. The training process using CNN is explained further throughout this chapter.

2.1 Heating, Ventilation Air-Conditioning System

Heating, ventilation and air-conditioning (HVAC) system is commonly found in large building. It is a challenging task to monitor and control this modern and sophisticated HVAC under a wide variety of occupancy and load related operating conditions. This system consists a cooling tower, chiller and air handling unit (AHU). In [2] claimed that several failures caused by malfunctions in components, actuators and resulting unexpected interference or gradual aging system.

2.1.1 Cooling Tower

A cooling tower working as a primary system component of HVAC system performs the function of heat rejection from the chiller condenser. Heat rejection is achieved via heat and mass transfer occurring from direct contact between hot-water droplets from the chiller condenser water and relatively cool, ambient air. A cooling tower generally comprises fans, a hot-water distribution system, spray nozzles, fill (packing), a collection basin, and a condenser pump.[3]

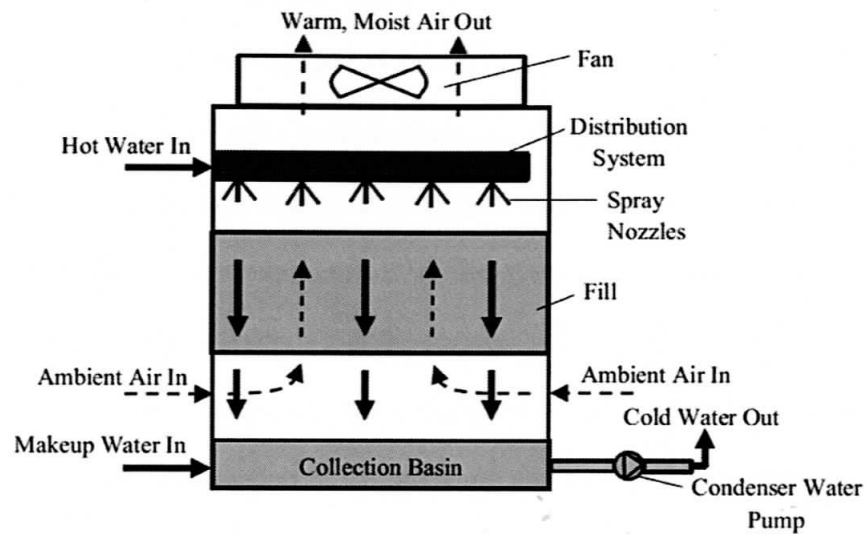


Figure 2.1 : Schematic of cooling tower

2.1.2 Chiller

Most of commercial buildings and also residential building used the common vapor compressor chiller. This chiller consisting evaporator, compressor, condensor and expansion valve. In [4], it defines chiller as a central equipment that provide the cooling to the conditioned buildings. The chiller is a primary system component of an HVAC system that rejects heat from a liquid through a vapor compression cycle or an absorption cooling cycle.[3]

2.1.3 Air Handling Unit

Heating and cooling are another essential element of HVAC system. In the AHU, heating and cooling coil act as heat exchangers where air loses or gains heat from water passing through the coil. [3]