



Faculty of Information and Communication Technology

**THE DEVELOPMENT OF AN INTELLIGENT FIRE ALARM
DETECTION SYSTEM USING FUZZY LOGIC:
A CASE STUDY**

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Masters of Computer Science (Software Engineering and Intelligence)

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ABSTRACT

Fire is very dangerous and life threatening. Fire detection and alarm system are designed to provide warning about the outbreak of fire and allow appropriate fire fighting action to be taken before the situation gets worse and out of control. At the preliminary stage, this research reviews the current practice of detecting fire at a manufacturing company in Melaka. It is a well-known fact that high risk, damage and losses of capital will be the consequences of fire. In the fire alarm and monitoring system, the fire detector is provided with various functions. Unfortunately, the traditional fire detector does not react in the early stage of fire and is not able to differentiate between false alarm and true alarm. Due to that, fire cannot be controlled effectively and this leads to heavy losses. Therefore, through this research, the new development of intelligent fire alarm detection system using fuzzy logic has been proposed. The integration of new technologies and concepts will improve the capability of fire detection systems and enable users to discriminate between fire and non-fire threats. This will increase the time available for property and life protection.

ABSTRAK

Kebakaran adalah membahayakan dan mengancam nyawa. Pengesanan kebakaran dan sistem penggera dicipta untuk memberi amaran apabila berlaku kebakaran dan membenarkan tindakan sewajarnya untuk memadamkan kebakaran sebelum keadaan menjadi lebih berbahaya dan di luar kawalan. Pada peringkat awalnya, kajian ini mengulas pelaksanaan terkini yang dilaksanakan dalam sektor perkilangan di Melaka. Adalah menjadi sedia maklum fakta sebenar mengenai kebakaran iaitu risiko yang tinggi, kerosakan dan kerugian modal merupakan kesan yang timbul dari kebakaran. Di dalam sistem kebakaran dan pemantauan kebakaran, alat pengesanan kebakaran mempunyai pelbagai fungsi. Malangnya, alat pengesanan kebakaran tersebut tidak bertindak pada awal kebakaran dan tidak mampu membezakan antara kebakaran palsu atau kebakaran sebenar. Oleh sebab itu, kebakaran tidak dapat dikawal dengan berkesan dan menyebabkan kerugian yang besar. Menerusi kajian ini, satu pembangunan baru untuk sistem pengesanan kebakaran yang cerdas dicadangkan dengan menggunakan *fuzzy logic*. Integrasi teknologi baru dan konsepnya akan mempertingkatkan kebolehan sistem pengesanan kebakaran untuk membezakan antara ancaman kebakaran sebenar dan palsu. Ia juga akan meningkatkan masa yang diperlukan untuk melindungi peralatan dan nyawa.

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DEDICATION

To

my beloved husband; Zaharudin Bin Ahmad,
my children; Muhammad Zafri, Nurzahirah Dinah and Nurzarifah Irdina,
as well as
my father and mother; Abu Samah Bin Mamat and Maritah Binti Ros

Thank you for being my inspiration and the full support given.

Khyrina Airin Fariza Binti Abu Samah

DECLARATION

I declare that this thesis entitle “*The Development of An Intelligent Fire Alarm Detection System Using Fuzzy Logic: A Case Study*” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

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LIST OF ABBREVIATIONS

COG	Centre of Gravity
FLV	Fuzzy Linguistic Variable
GUI	Graphical User Interface
MATLAB	Matrix Laboratory
MF	Membership Function

CHAPTER 1

INTRODUCTION

1.0 Introduction and Background of Study

Fire is rapid oxidation, usually with the evolution of heat and light; heat fuel, oxygen and interaction of the three (National Wildfire Coordinating Group [NWCG], 2008, p. 71). Another definition of fire is referring to the combination of the brilliant glow and large amount of heat released during a rapid, self-sustaining exothermic oxidation process of combustible gases ejected from a fuel. The fire itself is a body of gas that releases heat and light. It starts by subjecting the fuel to heat or another energy source, e.g. a match or lighter, and is sustained by the further release of heat energy.

Fire plays important roles for human's life. According to Vaux (n.d), fire has been called the foundation of human civilization that provides warmth and heat, protecting us from the ravages of the elements. Through fire, it gives us light to see in the dark and signal other people, who may looking for us. Fire enables us to cook and helps eliminate harmful bacteria besides improves the taste of foods. Similarly comments from Tristan (2000), fire helped the aborigines hunt for their food. In addition, fires promoted the growth of the edible parts of some plants that were eaten by the aborigines. Other

aboriginal uses of fire include defence, cooking, warmth, and to clear paths in the rainforest. Therefore, without fire, civilization would be radically different.

Nonetheless, Prashant (2007) cited that although fire can be a useful tool, but it can also be a deadly nightmare. As the old proverb states, it is a good servant but a bad master. Sustaining information from Frederick (2001) supports the statement from Prashant. Carbon monoxide (CO) is highly flammable; it has a wide explosive range (12.5% to 74%); it ignites at about 1,128 degrees Fahrenheit (a temperature quickly attained in many room fires). Although the lower explosive limit (LEL) of CO is high when compared to other flammable gases, once the LEL is achieved, CO remains within its flammable limits over a wide range of fire ground conditions.

According to Gan, Huang, Zhao, Xu and Liu (2005), fire is a terribly destructive disaster among the other disasters. The frequency of the occurrence of fire is not only very high but the damage caused by fire is in fact five times more than that of earthquakes. The effects of fire, more importantly lives are lost and people are injured. Fire alarm leaves an impact on all parties involving the employees. Besides, it also disrupts business in terms of time wasted, loss of revenue and productivity. Other impacts involve security issues, unnecessary risks during evacuation, and environmental disturbances e.g. unnecessary movements of appliances.

The increment of fire cases could due to the extensive use of expensive and hi-technology machines and materials. Several incidences of fire in factories include the explosion of a fire cracker factory at Sungai Buloh in 1991, fire at a Chemical Plant in Port Kelang in the year 1992 and Oil Refinery Plant in 2005, followed by explosion of VCM

vessel at Kerteh in 2007, dust explosion at Lumut in 2008 and fire in an oil tank at Port Tanjung Langsat in Pasir Gudang on the 17 August, 2008. Therefore, having effective fire safety procedures in our workplace is not only a matter of regulatory compliance, but also of conscience (Thomas, 2008).

The primary goal of fire safety is to preserve life; the safety of life without any permanent damage to health. In order to achieve the goal, fire management plays important roles to include early fire detection. This parallel as per cited by Shinji, Junji, Takashi & Mayumi (1991); the purpose of the fire warning system is to detect fire at an earlier stage and then to give a high reliable judgment result.

At present, the installation of fire detection and fire alarm system is built in the manufacturing building. Though it is considered to be an active detector and provides great functions, it does not have the ability to detect an early fire. Therefore, the fire alarm doesn't siren on time. It is also impossible to differentiate between real alarm and false alarm. Accurate early fire detection systems are crucial parts in order to save human life, their lives and provide early notification of fire and navigation to employees. Besides that, to save property such as manufacturing building that have been equipped with expensive machines and products also a part of the importance of accurate early fire detection. New technologies and concepts developed in manufacturing buildings, such as advanced multi-function sensors, computer vision systems and wireless sensors, real-time control via the Internet, and integrated building service systems, have also been reviewed and discussed (Liu, Makar and Kim, 2001). All these automatic systems have proved their capability to detect fires in practical applications but it also still shows some weaknesses including false alarm.

Frequent false alarms also affect employee's mindset and attitude. They may feel complacent – "it's just another false alarm", therefore this will reduce effectiveness of management plans. People who hear regular false alarms begin to ignore them, or react more slowly and at the end this may put them at significant risk in a real emergency. In the manufacturing area, false alarm can also be caused by the violation of the employees such as breaking the fire alarm break glass on purpose. Despite knowing the impact, it still happens and reoccurs. Some well known nuisance alarms are caused by cigarette smoke, smoke from bread toasting, dust, high humidity/condensing water vapor, pollen, baby powder, and smoke from heated cooking oil.

Therefore, this project by using multi sensor system is intended to minimize and reduce false alarm by developing an intelligent fire alarm detection system using fuzzy logic approaches. Hopefully by reducing the occurrence of false alarm and establishing an accurate early fire detection is able to reduce unforeseen consequences.

1.1 Problem Statement

Muller and Fisher (1995) and Avon Fire & Rescue (n.d) define it as unwanted alarms or any alarm given by a fire detection system but in actual situation there is no fire. This may be due to failures of some component in the detection system, misuse by personel or misinterpretation of the current environmental condition based on the monitored signal(s). "A false alarm is when a detector goes off due to dust, steam, fibers, or other non-smoke phenomena" (Mike, 2004). The Hampshire Fire and Rescue Service (n.d.) reports the following: "False alarm diverts us away from our primary role of

preventing fires and attending real emergencies, additionally they cost millions of pounds to commerce, through disruption to work and business continuity”.

System reliability can be a problem when it causes nuisance alarms, false alarms, or fails to alarm when called for. In all three circumstances, the source of the problem should be immediately found and fixed, so that responders will not lose confidence in the alarm reports.” (GBRK Glass Break, 2007). In addition, an article “An inside look at Smoke Detectors: Featured Articles” (2004) by Mike did support the same information as GBRK Glass Break regarding the false alarm. Although most smoke detectors work very well in many circumstances, they are prone to false alarms and nuisance alarms.

Despite having used the standard microelectronics technology, Pfister did propose: a cost-effective fire alarm system with high detection intelligence, application-specific detection characteristics, application problem warning, self-diagnosis and problem indication, and automatic reconfiguration after maintenance”. (Pfister, 1997).

Information gained from BFPE International: Fire Alarm also support Pfister’s proposal whereby normally the testing frequencies for fire alarm system devices (heat and smoke detectors) only will be done on an annual basis and needs monthly maintenance in order to ensure that it’s free from dust.

In order to overcome the problem, we have to use intelligent approaches that will provide additional information on the environmental condition and help us differentiate between real fire and no-fire or false alarm cases. The intelligent detection provides the highest probability to detect all smoldering and the highest immunity to false alarming in

response to deceptive smoke and temperature phenomena. By overcoming the problem of false alarm, indirectly we would be able to avoid the consequences of false alarm as mentioned before.

1.2 Research Questions

Based on the problem definition as presented in earlier section has led to the following research question:

- 1) Is there any way to minimize the occurrence of false alarm?
- 2) What are the parameters involved in developing the intelligent fire alarm detector?
- 3) How is the effectiveness of the intelligent detector measured?

1.3 Objectives

The main objective of this research is to develop an intelligent fire detection using a combination of Fuzzy Logic and Neural Network, which increases the fire detection system's reliability on "early detection of fire", "decreases false alarms", and "simple management of the system". In order to achieve the aforementioned issues we need to:

- 1) Determine sensor's value to a group of membership functioning.
- 2) Produce an alternative decision for the membership functioning.
- 3) Optimize solutions for the alternative decision rules.

1.4 Hypotheses and Assumptions

The purpose of this research is to identify and conduct a test on the relationship between dependent and independent variables. Below are the hypotheses of the proposed study:

Hypothesis 1:

The membership function of sensor detector algorithm using multi sensor input manages to detect real fires early.

Hypothesis 2:

The intelligence fire detection system manages to reduce false alarm and avoid unnecessary evacuation.

1.5 General Methodology

Figure 1.1 describes the general overview of the method and techniques used in this study. It was conducted through several stages. Firstly, the sensor values are defined and used as an input for fuzzy logic sets and MF during the second steps. Thirdly, suitable MF types are chosen followed by the structuring of the fuzzy inference. MATLAB application is used to provide an easy way to get the results' from the set input. Lastly, rules reduction techniques provide the way on how to optimize or choose the best and relevant rules instead of using the newly constructed rules.

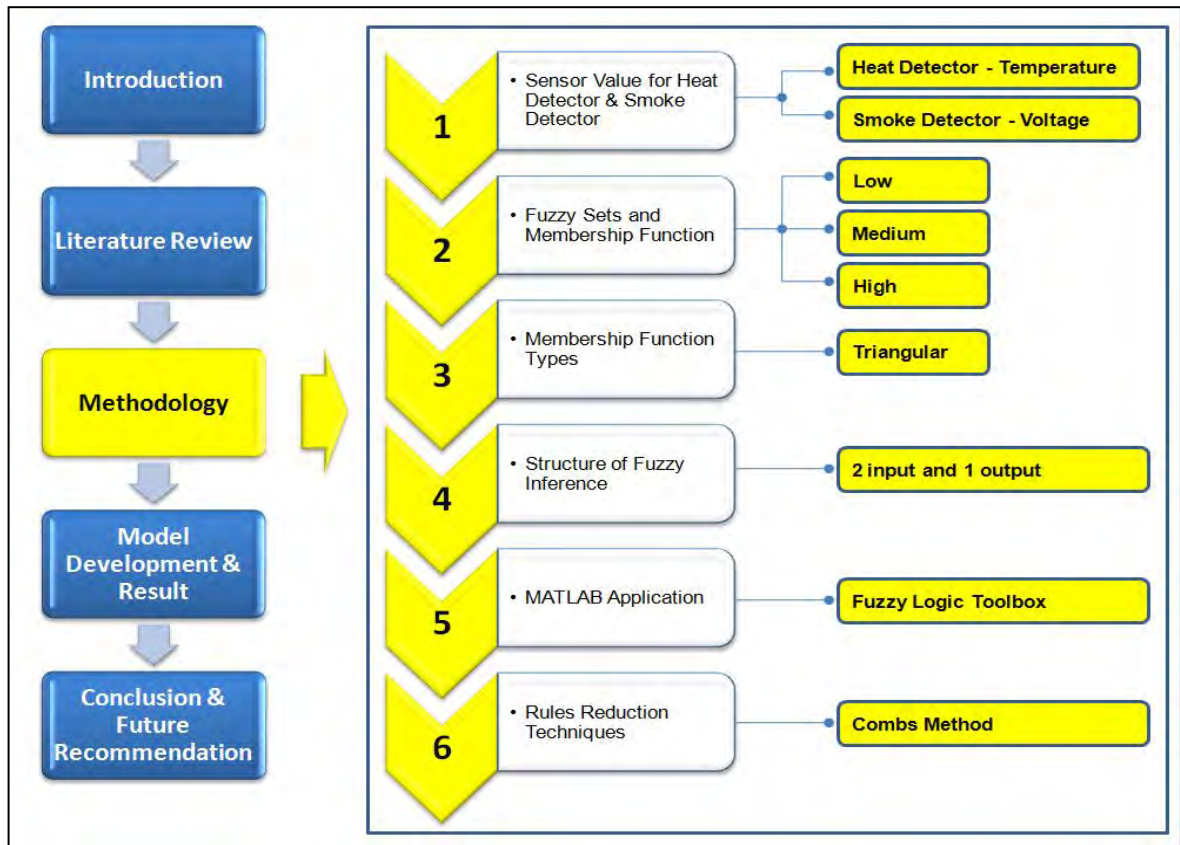


Figure 1.1: General Overview of the Methodology

1.6 Scope of Study

This research will focus on a manufacturing company in Melaka that is Infineon Technologies (M) Sdn. Bhd. The reason for choosing the company is because it involves more than 500 employees and despite having a good detection system for fire alarms. When it comes to false alarms, it will definitely affect the employees and the company's productivity.

The different technologies of fire detector used, might provide different results and it also depends on the size of the areas inside the building, the material used in the