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# Fire Detection System using Infrared Sensor and Camera

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# Abstract

The last decades has seen the rise of digitization and automation of certain tasks at dangerous work environments though this has not yet affected the firefighting profession. With sensors and remote vehicles it is possible to aid the firefighters in analyzing a situation and aid them in the extinguishing efforts which reduces risks and time spent finding the fires. This thesis proposes a solution to such a problem by designing and implementing a case study. The test system was tested in a controlled environment to verify the functionality of the system. The results show that this is possible using low resolution thermal imaging equipment. The case study also shows that standard imaging equipment is a useful tool to determine the severity of the scene as well as searching for people.



## Keywords

Infrared Sensor, Fire, Fire Detection, Sensor Based Systems, Wireless Communication

# Abstrakt

Under de senaste decennierna har digitaliseringen och automatisering av uppgifter i farliga arbetsmiljöer ökat, detta har inte ännu påverkat brandkåren. Med hjälp av sensorer och fjärrstyrda fordon kan detta göra det möjligt att hjälpa brandmän att analysera en situation och hjälpa till med brandsläckning vilket reducerar riskerna och tid att hitta bränder. Denna avhandling framför en lösning till ett sådant problem genom att skapa och implementera en fallstudie. Testsystemet var testat i en kontrollerad miljö att verifiera funktionaliteten av systemet. Resultaten visar att det är möjligt att använda sig av en lågupplöst värmekamera. Fallstudien visade även att bildutrustning är ett användbart verktyg för att bestämma allvarlighetsgraden av miljön och för att söka efter människor.



## Nyckelord

Infraröd Sensor, Eld, Elddetektering, Sensor Baserade System, Trådlös Kommunikation

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# Contents

# 1 Introduction

Building safety always include a fire code to make sure that all buildings produced are up to a certain standard, so that fire hazards are both minimised and likely to cause minimal damage. Although the field is old, it is a constantly updating set of rules that causes problems when older buildings are not updated to the same level of standards as expected from newly built buildings. As any other safety protocol it isn't a perfect set of rules that will remove any fire risk and you still need fire fighting equipment in place in case of a fire. This usually is done by a sprinkler system. The sprinkler system is a firefighting tool that can extinguish smaller fires by spraying large amounts of water over the entire room[1]. Usually they are hooked up to a sector system so that only the affected area of the building will have the sprinklers activate, instead of dousing the entire building when a fire may be several hundred meters away.

Fire detection methods normally employed is by using carbon monoxide and carbon dioxide readers, that after a certain threshold parts per million reading will trigger. This is a very imprecise reading, as it can be falsely triggered by even a certain amount of candles underneath it. Fires usually produce a lot of long wave infrared waves in their heat, meaning that it can be measured using other means, that also give information on where the source of the heat is in relation to the reader.

Firefighting is a very hazardous job as you would need to dive into a highly toxic environment to extinguish fires directly either through a hose or handheld extinguisher, though these both pose a significant risk for permanent damages. These environments often include dense black smoke that can hinder vision entirely and cramped spaces, as the building may be partially or fully collapsing during the firefighting effort. These environmental factors are highly unsuitable for humans to be in but less so for robotic actors, meaning that it may be beneficial to send in a robotic actor, at least for initial extinguishing efforts.

## 1.1 Background

The field of fire safety has been stagnant in relations to the digitisation of the world and still uses older methods to detect fires breaking out. This system is quite reliable, but has inherent flaws that makes it unsuitable for detecting smaller fires and fires in well ventilated spaces[2]. This, coupled with the traditional firefighting methods, means that fire safety can benefit a lot from a digitalized solution. Fire sprinklers themselves have been around for far longer than the current way of fire detection and is also in need of a context shift. Traditional fire sprinklers cause a lot of equipment damage when either falsely triggered or when triggered in areas yet untouched by the fire in a building.

By both digitising the detection system and the firefighting system, we can both make work spaces safer and minimize damage to equipment brought by the firefighting effort. Firefighters can also benefit from the improved job safety.

## 1.2 Problem

The main problem that this project aims to solve is fire detection, which is a complex topic and whose attribute in this study will be the long wave infrared radiation (IR). The firefighting will be coupled with understanding long distance remote communication means in hostile environments. This is to answer how we can effectively detect fires using a well characterized sensor and effectively communicating through harsh environments to a control center. In addition, it will also use itself of a camera which will help to show the environment to survey obstacles and detect if there are any people alive.

This thesis aims to answer the following research question: *How can infrared sensors and cameras be used for fire detection?*

## 1.3 Purpose

The purpose of this thesis is to contribute to increased safety in firefighting efforts, by examining the effectiveness of long-wave infrared sensors as a fire detection tool and means of communicating this information, alongside a camera feed, to relevant authorities. The aim is to present the concept of digitized firefighting framework.

## 1.4 Goal

The project goal is to create a system that in hostile environments such as a smoke filled room has the capability to detect fires and distinguish them from hot objects. This is done by using a sensor that is characterized and has the ability to transfer that data alongside a camera feed so that the data can be compiled and acted upon.

## 1.5 Methodology

The project uses a literature study to gather the necessary knowledge to answer the research question. The studies goal is to get information about thermal radiation, in particular in the infrared spectrum. Also the knowledge is needed about how Wi-Fi that uses 2.4 GHz performs in adverse indoors conditions. Data will be collected from relevant Swedish authorities and fire departments and a case study will be conducted based on information gathered.

Secondly a qualitative research method have been used by creating a form that will be filled in by Swedish fire departments to gather the information from field experience.

Finally a case study has been made to gather data on the topic. A course in sensor based systems and a course in embedded systems has been taken by both students to prepare for the case study.

## 1.6 Limitations

The only fire detection used in the project is done by long-wave infrared radiation, no other means of fire detection has been used. More over only Wi-Fi on the 2.4 GHz band will be analyzed as the transmission means.

The survey will be limited in scope for gathering information on standard firefighting procedures and what is felt as needed to supplement the efforts.

The case study itself will be limited in most aspects, primarily the locomotion will be an off-the-shelf remote controlled car. Secondarily, it will only evaluate temperature sensing in the long-wave infrared spectrum. Thirdly, limited information will be transmitted to the control station.

## 1.7 Structure of the thesis

In chapter 2, relevant theoretical background will be introduced about what sensor based systems are, what characteristics that are looked into when constructing one, how specifically infrared sensors works and what related work have been done before. Chapter 3 presents the methodology used in the project. It gives a description of the different methodologies, such as literature study, quantitative study, qualitative study and a case study. Chapter 4 explains the conducted case study in detail such as finding out what needed to be done before making it using a survey, what had to be configured with the sensor before testing it and the results from the tests. Chapter 5 is conclusions made from this thesis, discussions that came up and future work of how this thesis can be useful for expanding it.

# 2 Theoretical Background

This chapter introduces relevant theory to increase understanding of the topic in order to answer the research question. Some areas that will be included are what sensor based systems are, what characteristics that are looked into when they are created, how wireless communications are used. In addition, related work is also presented in order to get a view of what has been tested before.

## 2.1 Sensor based systems

Embedded systems are systems that usually use a micro-controller (which usually consists of a processor, memory and different general input and output peripherals) that is programmed with software in order to do a certain function[3].

Sensor based systems are embedded systems that integrates sensors as its primary function. In today's society, sensor based systems are used everywhere on a daily basis. Some examples are in computers and smartphones. The purpose of the sensors themselves are that they are taking a physical property. A basic example would be measuring the temperature in a room, where the measurement will be converting into an electrical signal, such as voltage or resistance[4]. To have a great sensor, there are certain preferences that have to be checked in order to get great performance and good data coming out from them.

## 2.2 Sensor characteristics

One of the primary problems when it relates to sensors are noise, as it will make it difficult to get representative data. To measure noise, there are different signal characteristics that are being used to determine how much noise you have. The typical characteristics of a sensor are accuracy, precision and resolution[5].

Accuracy is the characteristic that measures how the value from the sensor represents the ”true” value. For example, is the value of the temperature in the sensor the same value as the real temperature?

Precision is about measuring consistency in the sensor, how repeatable the measurement is with the same value. For the temperature sensor, revisiting the same area that is getting measured, gets the same amount of degrees every time you measure it?

Resolution is related to how the output value from the sensor differs to the true value. For a temperature sensor, if the room is 10° Celsius, if it has higher resolution, it can for example output that the room is 10.001° Celsius. Resolution is important depending on how precise the value wants to be for the application.

## 2.3 Infrared sensors

All bodies above zero Kelvin emit a thermal radiation[6]. To measure this phenomena the measured spectrum taken can be compared to a black body emitter. This comparison produces an estimation of the temperature of an object as the black body emitter is an estimated zero (K).

Infrared [”IR”] sensors are a subset of sensors that measure the physical phenomena of thermal radiation within a given spectrum of wavelengths[7]. This is most often done by an increasing resistance in the element when the given spectrum hits the resistive element. Often these sensors requires tuning, which can be achieved by taking an object with a known temperature and using it to calibrate the readings. If the values are not matching what the known temperature is, then it can be adjusted using voltage offsets.

## 2.4 Wireless communications

Wireless communications can be done using a multitude of different protocols. Often consumer devices communicates using Bluetooth connections in a direct within line of sight communications[8]. There are also other protocols over the same channels of 20 MHz, which has different more or less desirable traits depending on what the desired outcome is. For this thesis, we decided to use the Wi-Fi protocol which has a high data rate and in the 2.4 GHz frequency it has desirable wall penetration which is needed when using this system. WiFi also allows the unit to act as a simple data bridge over standard interfaces, which allows for flexibility on the receivers side[9].

Wireless communications are based on radio waves at a set frequency. As with all waves, it will propagate until it encounters a block in its way in a vacuum but will start to lose energy over distance within the earths atmosphere. This behavior is labeled as path loss and stands as the limit on ranges for radio communications. When modeling a wireless system it can be advantageous to model the path loss accurately. This is a challenge as it is a complex topic and needs a complex model to accurately describe how the system will perform. There are many models that exist on this topic and work for different frequencies and environments[10].

## 2.5 Robot locomotion

Robot locomotion is a group of different type of robots that have the purpose of transporting itself to different places. It can do so in different ways, like moving through robotic legs, wheels, or as a drone. All of these different moving mechanisms have different advantages and there is no clear winner so it all depends on what terrain it will be used[11].

## 2.6 Related work

Prior to this thesis and within the fire detection field, there was one related work that was made about using infrared sensors for fire detection[12].

### 2.6.1 Thermal Infrared Sensing for Near Real-Time Data-Driven Fire Detection and Monitoring Systems

In this paper a study is conducted on the viability of using a high resolution IR camera and machine learning to detect fires in the wilds. This study shows the viability in using IR sensors to detect fires in the wilds with the focus on early warning systems for wildlife wardens. Our study will differ by attempting to use a low resolution IR camera and to deploy the system in a indoors environment instead.

# 3 Methodology

This chapter will give an overview of what research methodologies that were applied in this thesis. It will introduce the methods used to answer the research question.

## 3.1 Literature study

A literature study is the academic paper reviews done before a project is started to gain an understanding of already existing area of expertise and knowledge on the subject that the paper will cover. When conducting such a study, sources that are used are academic papers, articles and case studies.

In the beginning of this project we explored if there was any previous work related to our research question. We wanted to know if there have been similar projects from the past and to find out what barriers have been in similar projects. In addition, since this thesis is focused around embedded systems, we had to do some research on different data sheets from different micro controllers, in order to find out what was the most fitting tools and equipment in order to answer our research question.

## 3.2 Qualitative study

The qualitative study will be focused on doing interviews with relevant authorities. This will make it easier for us to understand what have been tested before, what barriers there are at the moment and what would like to have as solutions for the future. The way we decided to do it was by creating a survey that had a set of questions that we wanted to know more about. The results will be discussed and the questions and answers can be viewed in Appendix A.

## 3.3 Quantitative study

The quantitative study will be focused on data that is received from the system in order to satisfy the sensor characteristics. This will make it easy to understand how effective the sensors are for the thesis and define minimum specifications. This will be helpful in order to combat the different sensor characteristics as mentioned in 2.2.

Before starting, we had to get certain material in order to see how it affects. We decided to choose to test with wood and coal to fire up. The reason for choosing wood was because it is quite common that a lot of material in an indoor building is represented by wood. Coal is an excellent material to get a long duration of ember burn which will be helpful when doing multiple tests. When burning these materials, it will be used together with and without using lighter fluid. In addition before starting the test, we decided to create a table to check the precision and accuracy from the sensor.

## 3.4 Case study

In order to perform the quantitative study, a case study is designed to see how it performs in a practical context. The advantage of using it is that the results from executing the case study is that you can base the results from performing it instead of focusing on other metrics such as reading properties[13]. Two separate case studies where performed, one for the sensor and one for the camera.

## 3.5 Case study limitations

Due to limited usage of space, in the case study for the sensor testing, the burning will be done outdoors because we did not have any indoor area to produce the fire. This can affect the results as it is done outdoors. Factors like wind can affect the output noise from the sensor.

# 4 Detecting fire using sensor and camera

The case study in this thesis is designed to answer the research question using multiple tests. Each test was designed to characterize part of the system and its related part of the research question. The tests are separated between the thermal sensor and the camera with WiFi.

## 4.1 System Specification

The system is required to show a low resolution camera feed in near real time alongside the heat sensor output. To achieve this goal the system has to use a WiFi transceiver to establish a live information feed with minimal delay that can easily interface with standard computational equipment such as a smartphone, laptop or personal computer. It needs to be able to detect in the wavelength spectrum of 3 µm to 15 µm and it needs to be able to sense up to 1 meter. A camera would be needed to allow remote operation, a resolution of 480p (4:3) and refresh rate of 30 Hz. All of this needs to operate on a video link of a maximum delay of less than 100 ms as beyond that it is greater than what a large proportions of TVs manage and becomes noticeable. To keep the unit safe in case of a battery pack fire, the batteries would necessarily need to be in a reduced capacity and size and the unit may not consume to much power in that case. For this it would necessitate that the unit may not consume more than 1 W. The power consumption puts a barrier for low cost of each unit as not anything is efficient enough to fit under this requirement thus requiring a budgetary consideration for that. As firefighting equipment already requires stringent and costly testing generally a relatively high price is acceptable for such applications [14] so a 10 unit pricing we would ideally be looking at under 2000 SEK.

## 4.2 Hardware Architecture

Before starting the case study for testing the sensor and the camera, we had to create a circuit board in order to communicate with the micro controller and the other components. It communicates with the sensor through an i2c interface. It connects the battery with two 2N2219 transistors in order to control the motor that is being used. In figure 4.1 below the full schematic for the system is shown.

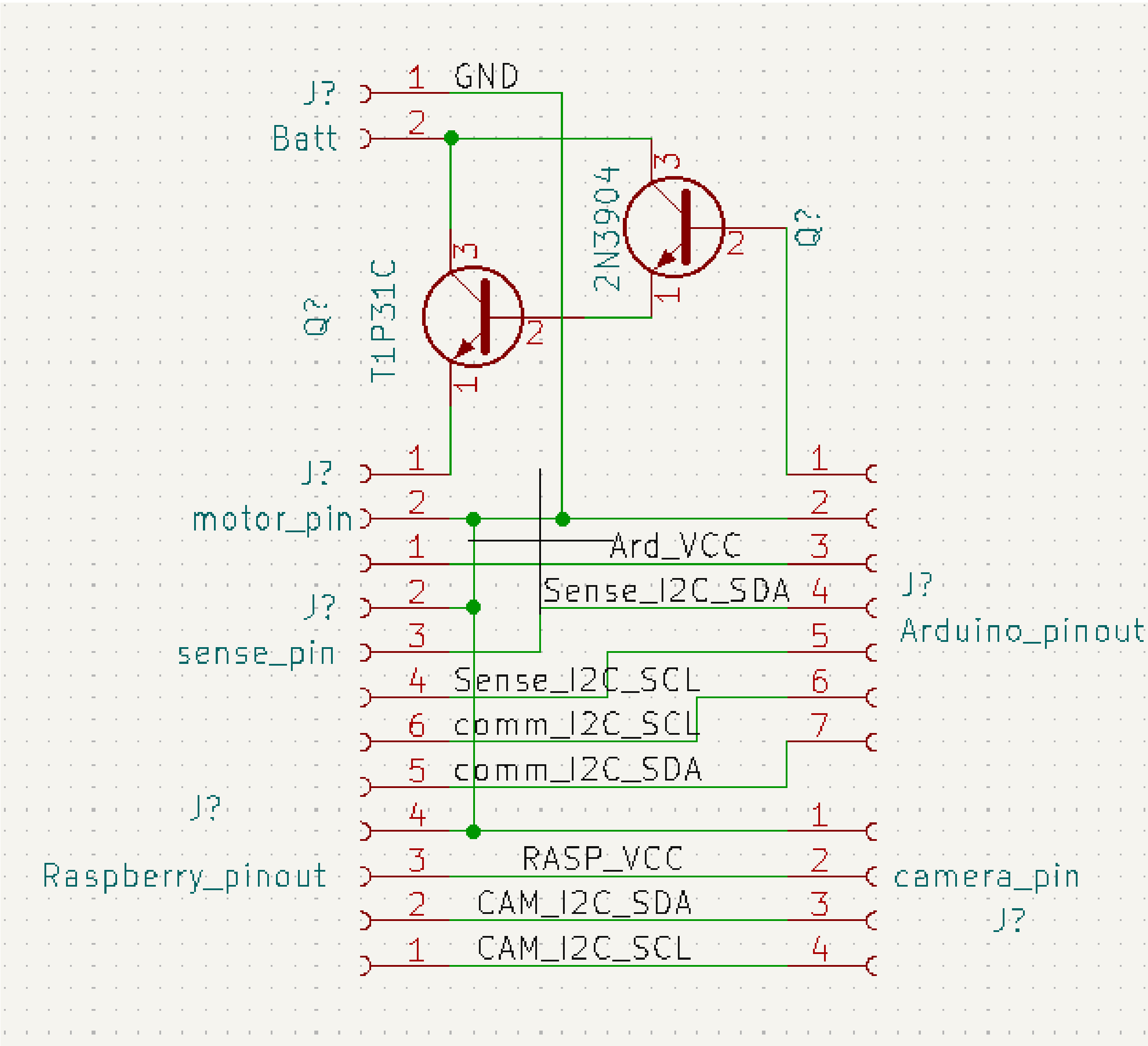


Figure 4.1: The schematic for the system

### 4.2.1 Sensor Test

In order to test the infrared sensor's performance, testing procedures had to be created. The sensor needs to be able to distinguish between the fire and ordinary background thermal radiation. The testing was done through two material groups, wood and paper, coal and wood. These groups were additionally tested once started by themselves and once started using Naphtha as a lighter fluid. The environment was two brick walls with large glass panes, wooden wind breakers on either side of the fire and mixed stone and grass flooring with no roof. The ambient temperature measured at the time of testing was 19.5°C, with minor fluctuations of ±1.5°C.

Around the fire three different common reflective materials were placed at 45° angle from the fire to the sensor. These three items were a polished piece of aluminum 10 cm by 10 cm with a thickness of 1 cm, a mirror 10 cm by 10 cm with a thickness of 5 mm and finally a polished piece of reflective plastic 10 cm by 10 cm with a thickness of 2 cm.

The sensor was mounted on a stable platform and locked in place on the same level as the fire. The platform was able to traverse in a direct line from the fire up to 1.5 m in 10 cm increments. The test was conducted by taking 10 readings and taking the average% of these readings. The averaging function was run 100 times and the average value was noted and the maximum deviation was also noted. These findings can be found in Table 4.1. After the 100 values were taken the second type of testing commenced. The data was compared to another IR thermal imager (Medisana A79) and the error is compared to the value recorded on the other device.

Table 4.1: Error variation based on temperature

| Degrees | Error Margin(deg) | Error Margin (percentage) |
|---|---|---|
| 19.5°C | ±1.5° | 7.7% |
| 230°C | ±10° | 4.34% |
| 260°C | ±15° | 5.76% |
| 390°C | ±25° | 6.41% |

The second testing type was to determine the maximum range when the fire can be distinguished from the ambient temperature noise. It was done by moving the platform used in the previous test 10 cm and taking five 10 value averages and comparing it to the background noise temperature. If the averaged value of the 5 averages is greater than 10°C above ambient temperature, it is considered distinguishable and noted down. The highest value reached for the sensor was 1.2 meters with high reliability though 1.3 meters had often the ability to distinguish the fire it sometimes got washed out by the background noise from gusts of wind making it too unreliable. The sensor could thus achieve up to 1.2 meters range and could with high precision distinguish the fire.

A reflexivity test was conducted to make sure that the sensor wouldn't be easily fooled by reflective materials often found in homes. The platform used in the previous two experiments was dismounted from the movement tray and set down 30 cm from both the reflective material and the fire. By taking 100 readings averaged together, then again averaged 100 times we get the estimated heat of the object. First the fire was measured and noted the value then the reflective materials temperature was noted. To consider the test a success the sensor would be able to have a temperature delta between the true fire and the reflected fire of at least 1°C.

Lastly a test was conducted to define the sensors field of view (FOV) by placing the sensor 50 cm from the flame. After moving the sensor, the platform was rotated in single degree increments using a protractor to make sure that the movement was as close to a degree as possible. Each movement incremented the rotational value by 1°. The sensor managed a precise 35° field of view at 50 cm distance. Though at the full 1.2 meter mark it could only claim a 36° field of view, which was slightly beyond the expected behavior according to the data sheet.

### 4.2.2 Wireless Transmission and Camera Testing

To determine the wireless transmission performance and camera performance a test was conducted in cooperation with a local fire department. The indoors firefighting building was used to set up a test scenario, in which both the wireless capabilities were tested, as well as the cameras performance in a smoke filled environment.

The wireless test consisted of setting the unit in the middle of the room and measuring the distance between the wall and the transceiver. The wall thickness was then measured and added to get the length between the outer wall and the transceiver. Then a line was drawn 15 meters long, with notches at half meter increments.

The camera unit was placed in a controlled environment, measuring 10 meters wide by 10 meters long by 3 meters high. The area was enclosed with one meter thick reinforced concrete walls and a large metal door set in the center of one of the walls. Inside this room were multiple metal framed tables and chairs, as shown in Fig 4.2. The unit was then put in the center of the room as denoted by the blue circle in Fig 4.2 and a small fire consisting of three standard firewood logs and a starter was set in the location of the green star. Lastly the test unit had its video feed activated and the room was sealed.

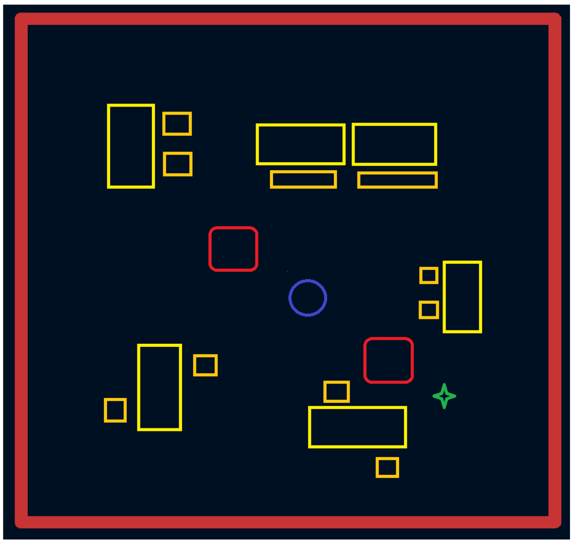

Figure 4.2: Diagram for the room

For the unit to be able to be considered successful in the test it would have to at least reach 3 meters from the wall. This would equate to a total reach of 9 meters from the unit through extremely thick walls. By stepping half a meter at a time the video stream was kept running up until the 11 meters mark. During the measurement time of 15 minutes, the camera allowed vision throughout the test and did not get residue stuck to the lens during the test.

## 4.3 Unit Cost and Power Consumption

When we calculated the price for producing the product, we assumed that in would be purchased in a batch of producing 10 units. As if this would be produced in a industry setting, it would decrease the price more as the parts would be purchased in a bulk. Below is a table of the cost of each component.

Table 4.2: Unit cost for production of 10 units, VAT included.

| Unit | quantity | price |
|---|---|---|
| cables | 10 cm | 3.534 SEK |
| perfboard | 1 | 82.45 SEK |
| battery holder | 1 | 35.34 SEK |
| Arduino Uno | 1 | 210.03 SEK |
| Raspberry Pi Zero WH | 1 | 232.05 SEK |
| Raspberry camera | 1 | 208.75 SEK |
| MLX90614 DCC IR Array | 1 | 335.86 SEK |
| Total cost | Single unit cost | 1108.014 SEK |
| Total cost | Total batch cost | 11080.14 SEK |

To determine the power consumption of the device a USB-A multimeter was used between the power supply and the device to measure voltage and current, this was done for each controller. The system power consumption is separated on the two different units, the main board managed to draw with the sensor a total of 206.8 mW and the camera board drew a total of 402.8 mW. Total system power draw would become 610.6 mW and given a typical AA batteries power rating of 3.9 W allows the system to run for 6 hours and 22 minutes continuously.

# 5 Discussion

This chapter will discuss the system as a whole, the efficiency cost for the system, the conclusions that were made from this thesis and what future work that can be done.

## 5.1 Cost Efficiency

As it is a add-on device to any already existing system locomotion is not considered into the total cost, it could be any cost from already existing commercial options. Compared to other compact firefighter assistance tools this is a little under eight times as cheap, whilst supplying vital information for the fire department on-scene.

## 5.2 System Discussion

The system works as intended, but has a major limitation in that the camera is unable to see through the smoke when it has had a long time to fill the room and fall low enough to obfuscate the camera. Giving it issues navigating the room by the camera alone. As the locomotion system relies on the camera to avoid obstacles, a completely smoke filled room would cause the unit to only be able to move based on the heat output.

The system has a large effective aperture at longer ranges which allows for large data gathering, but it also can add a large amount of noise which cant reliably be accounted for. Though a general approach to finding fires or fire spread would be to always go after where the highest temperature value is found in relation to the unit. This was not attempted nor is in the scope of the work, but would make for an interesting test for future work.

An unintentional effect from the camera was the capabilities of detecting people inside the building that is in fire, on top of the intended ability to survey the environment it was in. On top of the fantastic results of the weak WiFi access point transferring the video feed means that the system performs to a satisfactory level for the intended purpose as shown in 4.2.2. By this performance it accomplishes another goal of the targeted market.

## 5.3 Conclusions

Our research question is: How can infrared sensors and cameras be used for fire detection? Our case study shows that infrared sensors and cameras can be used for fire detection. The error margin for detecting fires are quite low so it will detect a fire properly. The purpose was to discern what is an actual fire instead of extinguishing something that isn't a fire, which also was the disadvantage of sprinklers as was mentioned in the introduction. When taking the hottest direction has the ability to lead you directly to the fire. Taking this simple method alongside the visual camera stream a remote operator is able to reliably find any fires active in the building.

## 5.4 Future Work

In the future the sensor could be made to rotate in its own housing, thus gaining the capability to survey the entire space it is in and find the source of the fire much faster. This would necessitate that a housing was designed and produced. The ability to view the entire space it is in would likely improve accuracy of the fire prediction on top of the faster acquisition time.

As question 7 in Appendix A indicates, there was a large focus on being able to find people inside the burning building. To this end the camera was an unexpectedly effective tool for such an action. Though in the future, it would be preferable to use a separate sensor to detect living beings inside the burning building. A motion sensor can be used instead of the camera to improve power usage. It could also be used together with the camera to improve accuracy. The motion sensor may also help in settings where the camera lens may be covered by smoke or dust. By adding additional sensing options for such a vital task, not only does it add better accuracy but also allows for redundancy in case any other sensing capabilities are unable to function in the environment.

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# Appendix A: Interview with Sten

**1.Förekommer det ofta situationer vid rökdykning som kräver röjning för att ta sig vidare till branden?**

Normalt inte. Det går alltid att tänka sig ett sådant scenario t.ex. i samband med en gasexplosion i en lägenhet, men då är det en händelse på tio år.

**2. Finns det oftast någon större ingång eller är det helt avblockerat hela vägen? Exempelvis ras.**

De flesta bränderna har vi i bostäder där vi går in genom en dörr eller fönster så svaret blir ja.

**3. Vart brukar bränder oftast förekomma? Är det på markhöjd, bordshöjd eller på takhöjd?**

Initialbranden är alltid lägre än fortsättningen av brandförloppet eftersom branden sprider sig uppåt. Brand på spis är en vanlig orsak, typ bordshöjd. Vid utvecklade bränder så har vi oftast en brandspridning till taket i brandcellen. När branden inte har spridit sig så finns initialbranden oftast vid en lägre punkt.

**4. Vilken är den vanligaste typer av bränder? Några exempel kan vara elbrand eller oljebrand.**

Bostadsbränder är den vanligaste branden. Om jag tolkar din fråga rätt så är du ute efter orsakstyp då är några vanliga orsaker glömd spis och hantverkare. Några få procent är kopplade till elbränder där batteriladdning är en ökande orsak. Oljebränder (tror du menar matolja) händer men är ovanligt.

**5. Har ni prövat använda fjärrverktyg för att släcka bränder? Isåfall vilket?**

Det finns pulvergranater som vi kan använda när vi kommer fram med en första insatspersonal. Den kan man kasta in i brandcellen (vet inte om du räknar det som fjärrverktyg).

**6. Finns det en möjlighet att vi kan komma förbi för flera frågor?**

Det kan vi självklart fixa att ni kan få komma och prata med några brandmän.

**7. Vilka digitala verktyg hade ni viljat använda för ert framtida arbete?**

Vi skulle t.ex. ha nytta av olika sensorer för att få mer information om miljö och om det finns levande människor att rädda.

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