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Norfolk and chance IN620001 Embedded Systems Report

# Executive Summary:

Fire safety in industrial settings is a widespread issue that causes many injuries and deaths throughout the world; this effect is especially pronounced in developing nations. This report describes and evaluates a potential solution to this issue, which aligns with the UN Sustainable Development Goals 8 and 9. During our research before our proposal, we found that commercially available solutions to this problem were prohibitively expensive; this makes good fire safety a potentially unattainable goal for many workplaces in developing nations. Our solution aims to solve this by creating a cheap automated solution that will improve fire safety in the workplace. The proposed solution is a small robot that is equipped with sensors and warning devices that will allow it to detect and warn people of potentially dangerous temperatures in the workplace. This solution could also be applied to currently existing automated robots. It will carry out these tasks automatically without the need for human intervention. Our solution to the problem does have some shortcomings when compared to other options. However, our solution aims to be cheaper than currently commercially available solutions, this will allow it to be accessible in developing nations. While our solution is not the only available option to this problem its main feature is its cost and therefore its accessibility. This will allow it to better meet the requirements of UN SDG 8 and 9

# Introduction:

When researching for a solution to one of the UNSDGs we found concerning statistics around fire-related injuries and deaths in the workplace (Ahrens & Evarts, 2021). These findings gave us the motivation to propose a potential solution to the issue. With that in mind, we began designing a fire safety robot that could automatically detect and warn people of fire within the workplace. We found that this would align with the UN Sustainable Development goals 8 and 9. So we planned to optimize our solution to suit these goals better. This refined our motivation as we now knew that our solution would need to be better suited for developing nations, therefore we decided to optimize our solution for cost. How we went about this is further outlined in the report below.

# Problem/Solution:

The problem we found was high amounts of fire-related injuries in the workplace in both developing and developed nations. The reasons for this are many but one of them was lack of proper safety equipment or more importantly lack access to safety equipment particularly in developing nations (Tatham, 2018). While the human injury aspect of fires in the workplace is certainly the most important there is also a large financial impact from workplace fires (Cost of Fire to a Business 2020). Damage to industrial equipment and infrastructure can have a major impact on the ability of companies to continue their work and develop their businesses. This is compacted with the impact on human resources that workplace injuries can have on a business. These issues will negatively affect the achievement of UN SDGs 8 (Decent work and economic growth) and 9 (Industry, Innovation, and Infrastructure).

Our solution is one that aims to address this issue and promote the development of UN SDGs 8 and 9, it does this by providing a cheap alternative to existing fire safety solutions. The solution is a fire safety robot. This robot is equipped with a small infrared temperature sensor and an array of warning devices. These warning devices are as follows: an RGB light, an LCD screen, and a buzzer. The robot will automatically patrol an area constantly taking readings of ambient temperature and object temperature of nearby equipment. When the robot detects a temperature reading above the pre-determined safe levels it will begin to make noise, change its light from green to red and display a warning message on its LCD screen. The design of this robot is one that is modular, as its sensor and warning device cluster is separate from the part of the robot that controls its movements. This will allow it to be added to existing automated robots or to be used in a static use case where the movement of the robot is not required. The potential scope of our solution is large and could be applied in a variety of use cases, this is due to the small form factor and modularity allowing it to be quite flexible in its fire safety abilities.

This solution aims to meet the UN SDGs of 8 and 9, while the solution is primarily for UN SDG goal 9.2 which focuses on improving industrialization in developing nations it could also have beneficial effects on UN SDG goal 8. The way our solution does this is by reducing fire-related accidents in an affordable way. This will allow companies to channel all their resources towards industrializing which will allow them to contribute more to employment and GDP. As less of their resources will be spent on recovering from fire-related incidents. This solution could also have flow-on effects to UN SDG 8 (Decent work and economic growth) as if industrialization is improved through increased fire safety, economic growth will also increase. While our solution is primarily focused on UN SDG 9 it is important to consider other potential benefits.

# Concepts used:

Modularity concept: By designing our solution using two separate microcontrollers we have a degree of modularity. This gives the solution a wider scope of potential applications and allows it to be potentially cheaper where only one part of it is required. Our solution makes use of two separate Arduinos that communicate with each other. However, if for example you already had some sort of automated robot or another locomotion device you could remove the automated robot part of our solution and just make use of the sensor cluster. Or even just use the sensor cluster by itself statically.

We looked at existing automated systems in the real world and noted that they did not eliminate humans from the workplace in even the most heavily automated workplaces.

In both situations, robots work alongside people. In the case of the port at Qingdao(Peng, 2017), containers still need to be driven to the port from the wider area by human-operated vehicles. With MIR(Robots, Optimize your workflows with the mobile robots from MiR), they have a host of features built into the robots that allow them to operate in a workplace alongside human workers. In both cases, each robot in the system has a host of sensors that allows them to “see” their environment using lasers, Object Recognition systems, and ultrasound distance/collision sensors. It stands to reason that these robots can also have some safety features added, such as poisonous gas detectors, temperature sensors, and windspeed detectors (for the case of the very tall robotic gantry cranes).

# Hardware/Software:

For this section, the hardware and software components will be in a list with a description beside the respected component.

## Hardware:

* IRF Sensor - This is an infrared sensor that we will be using to detect the temperature.
* Sparkfun Redboard – This is the microcontroller that everything runs off.
* BreadBoard – This is the piece of equipment everything plugs into.
* RGB light – This lights up depending on the situation green (safe) red (danger).
* Buzzer – Emits a sound when the robot is sensing danger.
* Jumper cables - These are used to connect components.
* Distance sensor – This is what we use to sense how far an object is from our robot.
* Hobby motors - What is used to make the tracks of our robot go.
* Motor driver - This is controlling the hobby motors.
* Switch – Simply used to change our bot from a stand still state to a moving one.
* LCD Screen – This is what the message of our choosing is displayed on.
* Resistors – Help manage the flow of electricity, so we prevented excess current reaching components.

## Software:

* Arduino IDE- For developing, testing and deploying the code to the robot.
* draw.io was used for any diagrams needed to be made.
* CURA was used to slice and produce the gcode for printing the robot parts.
* Adafruit MLX9016 Arduino library for use with the IR sensor

# Conclusion:

The problem of fire safety in the workplace is one that is widespread and all too common. While our solution to the problem is not infallible it aims to provide a start to a wider solution to fire safety that will allow for increased industrialization throughout the world. The design of the robot was influenced by the UN SDGs and its focus on developing nations this guided us towards optimizing our design for cost. This is an aspect that is important when regarding industrialization in developing nations where cost is paramount in the decision-making process. Overall, our prototype provides good proof of concept of the problem-solution showing that a cheap robot can be created to provide fire safety solutions to workplaces. There are many improvements that could be made to our design that would improve its efficacy, for example, better grip could be added to the tracks to make it more effective in traversing different terrains. The IR sensor could be attached in a way that allows it to be aimed making it more adaptable to different scenarios. The buzzer could be improved to be much louder making it better suited for loud industrial settings. Also, an enclosure could be 3D printed to reduce the size and make it more resilient to environmental factors. These all would improve our prototype greatly but unfortunately were not possible in the scope of this course. However, if this solution were ever iterated and scaled its efficacy could be greatly improved. With iterations of the design its resilience and use cases would further improve and with scaled production economies of scale would take effect and reduce costs further. In conclusion, our solution is one that has some drawbacks when compared to more advanced and more expensive solutions. Although this may be the case, we believe that at its core it the solution could have great benefits to achieving the UN SDGs and preventing fire-related injuries throughout the world.

# Self-report (Kaleb):

It went well I feel, I enjoyed working in the group I was in, though that is not saying it all went well, during the printing phase of the project there were a lot of problems such as things just would not print. Our team was lucky enough to have Conor on it as he has his own printer, and this helped with the problem of the Polytech’s printer always being used. At the start of this project, I was the prototype but as the project went on, we soon realized that that job was best left for Conor though I did help now and again with how the bot went together, I mainly focused on the documentation kind of side of things doing the finite state machine the report and collecting the datasheets for each component. Now for the development of the bot went quite well with the only big hiccup is that because we used two boards that talk to each other we must power them somehow and the battery packs made it too heavy and then the bot could not turn, if we were to continue this project elsewhere weight distribution would be something that would have to be investigated. If I were to do something different next time it would be not to leave gathering all the documentation we need at the last second we need it, this is to do with time management so next time I would manage my time better.

# Self-report (Conor):

I enjoyed this paper and the semester’s work laid out. Learning the new concepts presented was a thrill, and really tested my abilities for researching background, thinking of a solution, testing, and then executing that solution- and improvising solutions where needed. A massive boon was having my own 3D printer, which tested the limits of my abilities with this relatively new technology, with a fair bit of trial and error. I managed to adapt the Sparkfun Circuit 5c code provided to work with the directionally opposed hobby motor solution as they were aligned this way in the tank design. My teammates were conscientious and hard-working, and I could not have produced this robotic solution without them.

# Self-report (Ryan):

This project was one that provided many interesting challenges and techniques that were new to me. The use of microcontrollers and circuit boards was new to me, and it took some getting used to. Many times, throughout the design process I had issues with making sure all the components were functioning correctly. However, after some practice, it began to come more naturally, and eventually, I managed to get the prototype functioning as expected. Specifically, regarding getting our two Arduinos communicating. However, with some tinkering and testing, I managed to get the board communicating and working as expected. For the group aspect of the project, I thought we all worked well together and managed to naturally assign tasks that were suited to our skills and resources. Particularly Conor’s 3D printing gives our prototype a cool design which made it more satisfying when it all came together. Overall, I liked the project’s brief of trying to solve one of the UN SDGs as it gave our design process good focus and made it easier to make design decisions throughout the project.

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