iCreate cafe

4F, Fisher Mall, Quezon City
Metro Manila

Project S.O.A.R - Smart Operations And Rescue Drone

Prepared by

Almond Rose Obedoza

Grant Travis Wong

Owen Justin Gocheco

CHAPTER ONE

INTRODUCTION

It was several years ago when drones started helping out in emergency response situations, conducting surveillance and locating structural damage. Today, almost every agency involved in disaster responses may somehow deploy a drone as a primary tool, to assess damage, search for victims, make 3D maps to track changes to certain areas over time, and more.

After search and rescue operations, which can take up to several weeks, rescuers have to focus on treating and taking care of the survivors they have already found.

If the search and rescue period were shorter, the survivors could be treated sooner. If it were more effective, more victims could be found and treated before it is too late.

To sum it up, several lives could be saved if we could somehow make the search and rescue phase quicker and more efficient. But how? Perhaps it would help if the rescuers had an eye in the sky…

STATEMENT OF THE PROBLEM

In 2018, one of the biggest disasters was a 7.5 earthquake that struck Palu, Indonesia, causing a tsunami that killed 2,256 people. In 2017, disasters cost $306,000,000,000 in losses.

According to data from the United Nations Office for Disaster Risk Reduction, natural disasters from 2005 to 2014 cost 1.4 trillion in damage, impacted 1.7 billion people, and killed 0.7 million.

And those 0.7 million people also include rescuers, who go to remote and inaccessible areas to save lives, often putting themselves directly in harm's way in the process. The rescue crews that assist in search and rescue operations and damage assessments often find themselves around hazards like unstable buildings, broken electrical lines, dangerous water and flooding conditions, and more.

The search and rescue period can last for hours or even days after the disaster. Only after this can rescuers focus on treating the survivors they have already found, which can be a problem in situations like Hurricane Katrina (2005), wherein the process lasted for several weeks.

As disasters all over the world claim the lives of disaster victims and rescuers alike, the question is – what can be done to make the search and rescue period shorter and more effective, ultimately saving the lives of millions?

PURPOSE

The Smart Operations and Rescue Drone (SOAR) will be equipped with Edge Artificial Intelligence (Edge AI), thereby giving it the ability to scan an area from above and detect ongoing calamities, in order to help inform rescuers. After that, the rescue teams can decide which situation to help out with first. Would they rush to evacuate the damaged building that is still relatively stable or the burning building with hundreds of people trapped inside? Would they help out with the flood in an abandoned warehouse or in a mall filled with dozens of people? SOAR can assess situations, as well as send pictures and information about the disaster, to help rescuers make an informed decision.

SIGNIFICANCE OF THE STUDY

The SOAR Drone saves lives through 3 key actions:

(1) By the time rescuers get informed of calamities happening in distant locations, it would likely be too late to save most of the victims. SOAR uses artificial intelligence to detect ongoing disasters within the area. Rescuers can view pictures of these disasters to help inform them about potential crises, near or far, and decide which calamity to attend to first. Our robot is also a drone, which enables it to fly over debris and quickly locate disasters.

(2) SOAR helps rescuers save resources. Typically, rescuers would deploy rescue trucks and helicopters to search for victims and locate places that need attention such as burning buildings and flooded villages after a natural disaster. However, these vehicles are expensive. Our robot is a drone, which would typically cost only 75 cents per hour. SOAR can also fit through small spaces and fly over debris, thereby enabling it to quickly reach disasters and victims. It can legally soar up to one hundred meters high to scan more terrain at once and detect disasters that rescuers could not see at eye level. Thus, our robot can make search and rescue operations more efficient and inexpensive.

(3) Rescuers normally treat the survivors they have already found *after* they conduct search and rescue operations. Since our robot makes the search and rescue phase quicker, rescuers and doctors can take care of the victims sooner, thereby increasing the chance that they will live.

CHAPTER 2

RELATED LITERATURE

Drones for Assessing Structural Damage

Rescuers sometimes encounter gas leaks when conducting rescue operations in areas that are critically damaged. However, there are drones nowadays that are equipped with “sniffers,” or basically sensors that can detect high levels of methane, to help rescuers locate broken gas lines. After that, workers would shut down these lines and fix any breaches, thereby preventing explosions from occurring.

There are also existing drones with high-zoom sensors to assess damage and locate places where it may be dangerous for people to venture.

SOAR uses Artificial Intelligence to identify disasters and structural damage. However, in the future, our robot can be equipped with both AI and sensors to help it recognize calamities with more accuracy.

3D Mapping

Some drones are used to create 3D maps. These drones have high quality cameras and are used to take several pictures of a certain building. Researchers then use these pictures to make 3D maps of the building. They use these maps to read geometric information about it, and track changes to certain areas over time. Some maps are also created using LiDAR, an instrument that uses laser beams to provide a precise 3D model of an object.

Drones with Thermal Sensors

Some drones use thermal sensors to detect human body heat. This helps rescuers locate and identify survivors in the aftermath of a disaster. It also helps them find people trapped under piles of debris.

Google AIY Vision Kit

The Google AIY Vision Kit is basically a kit that lets people build a smart camera with a Vision Bonnet and Raspberry Pi. This smart camera uses Edge AI to classify images.

Inference, or running an image or text through an AI model to output a result, is usually done on the Cloud. However, with Edge AI, inference is run on a device like the Vision Bonnet included in the AIY Vision Kit.

The Google AIY Vision Kit has pre-trained AI models that can classify faces as happy or sad, detect different types of food, and identify different objects in an image. We once tried experimenting to see if it could detect disasters with its image classification model, and it identified fires as fireboats, torches, stoves, candles, and fire screens. It also identified floods as bathtubs, boathouses, lakes, and amphibious vehicles.

CHAPTER 3

METHODOLOGY

PROCEDURE AND TIME FRAME

In 2018, we interviewed Dino Juan, a former military man who works on rescue missions, to get his thoughts on a prototype robot that we were proposing to help during floods. He mentioned that it would be helpful for his team if drones could be used to assess an area before his men were deployed.

Earlier this year, we learned about Edge AI through the Google AIY Vision Kit, which demonstrates how inference could be done locally, without the need to connect to a cloud service via the Internet. We realized the potential of applying this new technology to a drone to help in disaster rescue and risk management.

We continuously sought to improve our proposed solution based on inputs from experts on drones and artificial intelligence. Here are some of the important things that we have learned from the interviews:

INTERVIEW INFORMATION

Helicopters Versus Drones

Normally, rescuers would send out big rescue trucks and helicopters to find victims *and* rescue them. However, these are really expensive. A helicopter could cost around two thousand dollars per hour. It is better to use drones to search for victims and ongoing disasters, because they only cost around seventy-five cents per hour and they can fit through tight spaces, thereby making the search and rescue phase quick, efficient, and inexpensive. After SOAR locates some disasters and the rescuers have decided which one to attend to first, they can use rescue trucks or helicopters to do the actual rescue operations.

Rescue Vehicle

Drones run on lithium batteries, which have a short lifespan. This could be a disadvantage in rescue operations. To solve this issue, SOAR will be attached to a small vehicle with rescuers and a computing device such as a computer or laptop. Our robot can be connected to the computing device in order to sustain its power. In addition, it is advantageous to have the drone tethered to prevent it from being stolen. The rescue team would be able to plan and communicate with others based on the drone's bird's-eye view of the area, which enables it to scan more terrain and identify key crisis locations in a short amount of time. Ideally, several such vehicles and drones can be deployed in strategic locations to cover a particular region and determine the best place for deployment of the main rescue team and vehicles.

Sending Back Coordinates

Once a calamity is detected, the computer inside the vehicle attached to the drone can send the disaster coordinates back to the rescue office. SOAR can also have lights that can flash a distress signal as well as its location in Morse code, in case connectivity is down after a disaster. Since our robot is a drone, the rescue team back at the police or fire station should be able to see it in the air.

Drones

Drones are ideal for disaster recovery because they can pass through areas that are difficult to access. They are small, which helps them get through tight spaces, and they can legally fly up to a hundred meters high, which lets them soar over debris and locate disasters happening far away. This helps them find disasters and victims in a shorter amount of time.

Edge AI

Our robot will use Edge AI to identify disaster zones. It can be given examples of calamities from different angles at different times of day, so SOAR can use artificial intelligence to accurately detect situations that need attention.

Inference is basically running an image or text through an AI model to get a result. This is normally done on the Cloud. However, with Edge AI, inference is run on a small device. This helps increase the privacy and speed of the AI model, and lessen its price.

Using Edge AI also means that rescuers do not have to pay to use online artificial intelligence services. In addition, they do not have to be dependent on to the Internet, which they may not be accessible in the aftermath of a disaster.

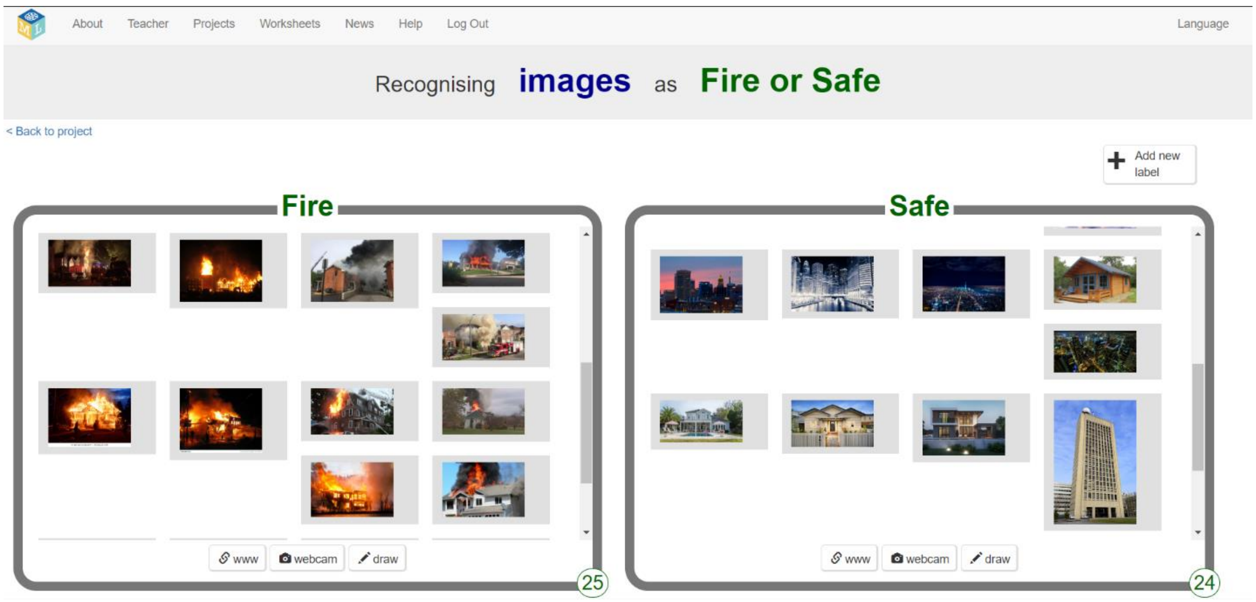
PROTOTYPE

We built a working prototype to simulate SOAR: a drone with a webcam connected to a small rescue vehicle, and a rescue truck that would follow the drone once a disaster was detected by the AI. We trained an AI model to detect burning buildings.

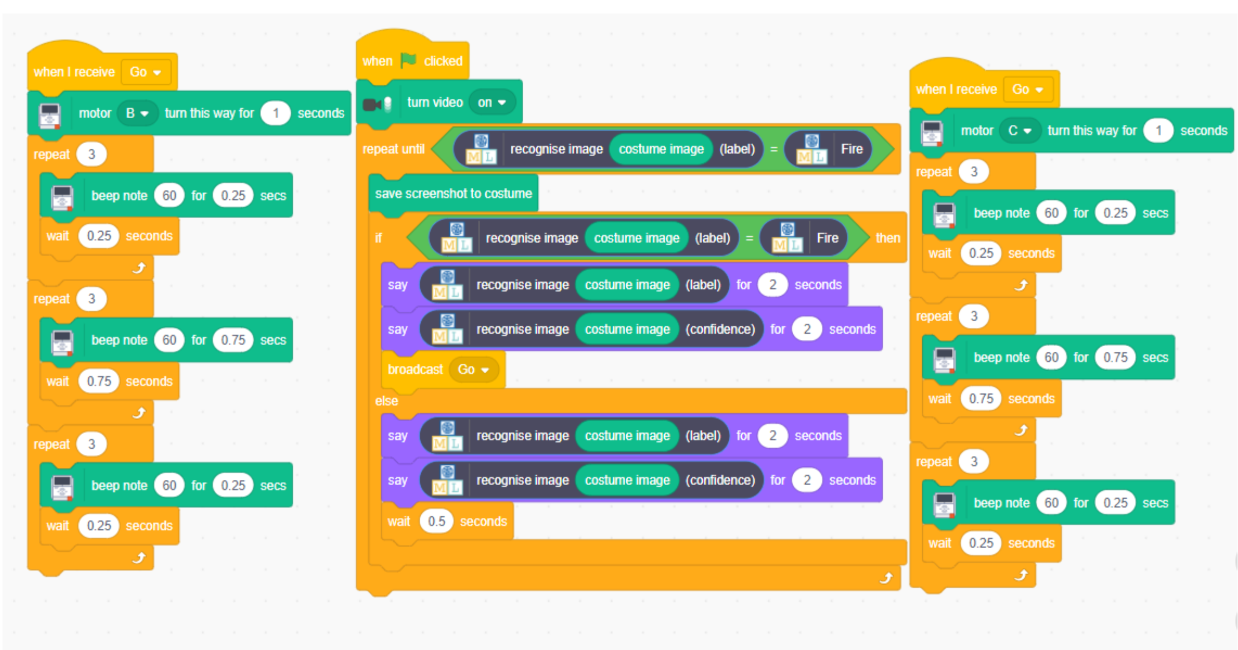
ANALYSIS PLAN

These are the pictures of our robot's code on EV3 and Scratch:

We used the machinelearningforkids.co.uk site to connect to IBM Cloud and train machine learning models. This is the AI model of our robot, which can detect burning buildings:



Below is our robot's Scratch code. It connects to the AI model using the extended blocks provided by the machinelearningforkids.co.uk website in order to detect a disaster.

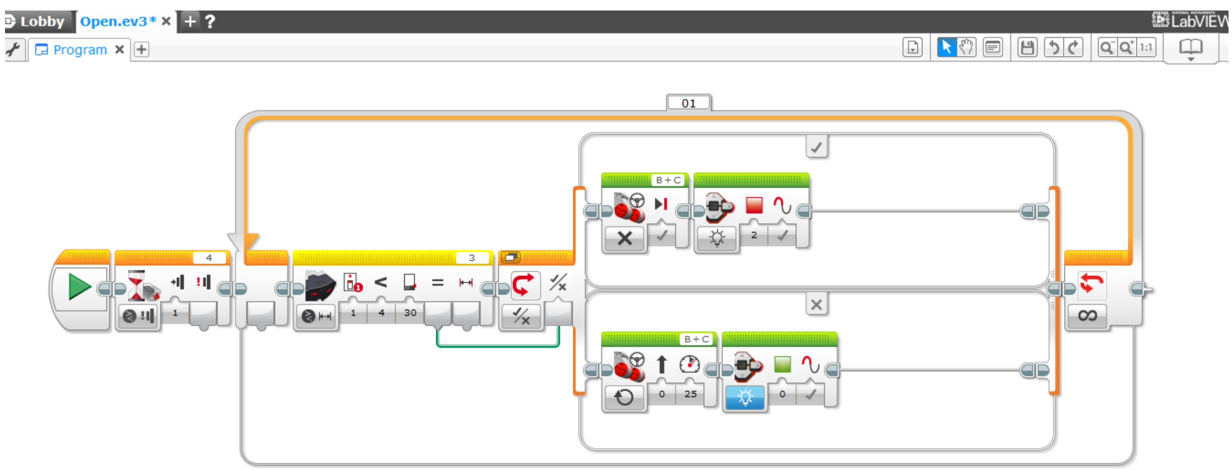


We have three different robots.

Our first robot is the drone. Once it detects a disaster such as fire, it will send a SOS signal to our next robot, which is the trigger robot. The trigger robot is controlled by the Scratch code above. Its job is to move forward, hit a touch sensor, and activate our recue robot.

An EV3 brick lets us control a conveyor belt mechanism. The drone is suspended on the belt, which moves back and forth, to make the drone seem like it is flying in the air.

And finally, our last robot, the rescue robot, will follow the infrared beacon on the drone and head over to the site of the disaster. This is the code to control the rescue robot:



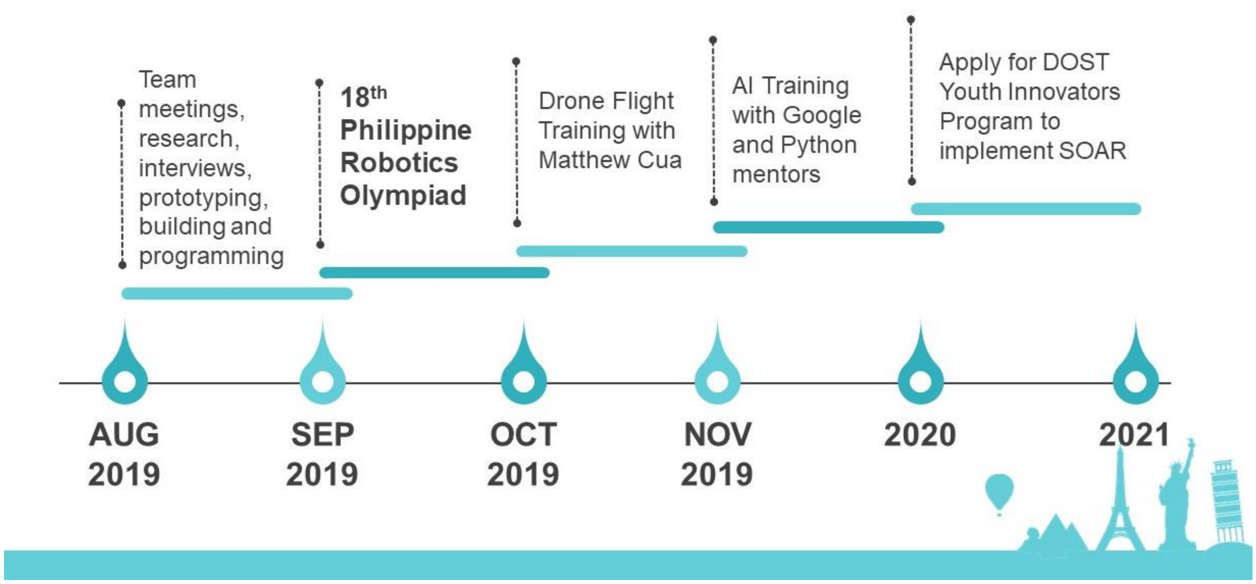
SCOPE AND LIMITATIONS

Some limitations were observed as part of the rules stated that we could only use what was available in our Lego sets and EV3 kits for our prototype:

1. We could not make an actual flying drone because we did not have the technical skills yet to create a flying drone out of Lego that could support the weight of the EV3 brick. Instead, we attached SOAR to a conveyor belt mechanism made of bricks in an EV3 kit. This helped

us make our robot go back and forth without touching the ground, to simulate a flying drone.

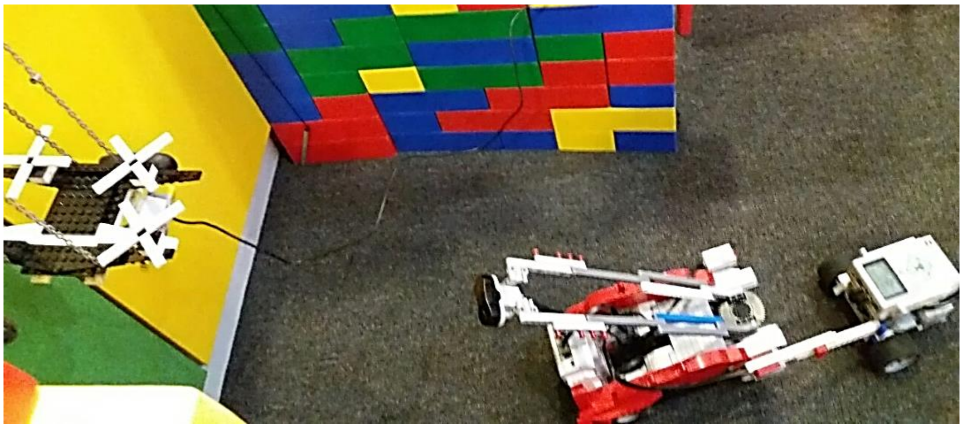
2. We did not have the time and knowledge to make an actual Edge AI model for our robot. Instead, we trained a Cloud AI model through the Machine Learning For Kids website to prove that such a model could be trained and downloaded into an Edge AI board in the future. We connected this model to Scratch, a programming language that also has some blocks of code to control EV3 robots.
3. Our team is composed of 10-year-olds. We still do not have the knowledge to fully explain how the prototype would be constructed in the real world and its actual cost. We could only do research to prove that it is possible and affordable. We aim to follow the timeline below in order to implement a more realistic prototype in the future:



CHAPTER 4

RESULTS

The prototype ran successfully, demonstrating how the robot could go around the area and identify pictures of burning buildings using IBM Cloud's visual recognition service. It signaled the rescue truck after detecting a crisis, enabling the rescuers to follow SOAR and arrive at the site of the disaster.



We also tried testing Edge AI through the Google AIY Vision kit by showing pictures of burning buildings, which were classified as torches, fireboats, stoves, candles, and fire screens. When we tried using the Vision camera to identify images of floods, it categorized these images as lakes, boathouses and amphibious vehicles. These results show that there is potential to detect disasters, but the model would have to be retrained for this particular purpose.

```
pi@raspberrypi:~/AIY-projects-python/src/examples/vision $ ./image_classificatio
n.py --input Flood1.jpg
Result 0: amphibian/amphibious vehicle (prob=0.591797)
pi@raspberrypi:~/AIY-projects-python/src/examples/vision $ ./image_classificatio
n.py --input Flood2.jpg
Result 0: lakeside/lakeshore (prob=0.166138)
Result 1: gondola (prob=0.154907)
Result 2: boathouse (prob=0.117859)
pi@raspberrypi:~/AIY-projects-python/src/examples/vision $ ./image_classificatio
n.py --input Fire1.jpg
Result 0: torch (prob=0.323730)
Result 1: stage (prob=0.159058)
pi@raspberrypi:~/AIY-projects-python/src/examples/vision $ ./image_classificatio
n.py --input Fire2.jpg
Result 0: church/church building (prob=0.511719)
Result 1: fireboat (prob=0.117798)
pi@raspberrypi:~/AIY-projects-python/src/examples/vision $
```

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

With this prototype, we have proven that it is possible to train an AI model to detect a disaster with image processing. In the future, we can apply this model to a drone camera to be used in disaster recovery and rescue operations. But what if we combine this with existing technology, such as thermal and gas sensors? Our robot would be able to help rescuers determine which disasters have higher risks. Calamities detected by both the AI and the sensors would be more accurate than the ones identified by only one of them.

SOAR would also be able to assist in the three phases of disaster recovery: rescue, or locating and rescuing people; after a disaster, such as when people re-enter buildings after an earthquake; and mitigation, or preventing disasters. For example, our robot can use facial recognition and thermal sensors to find people trapped in the waters after a tsunami or maritime disaster. Before people are allowed to go back inside a structure, our robot can search for damage inside, so that when the evacuees return to the building they will be safe and sound. Our future vision for the drone is for it to be able to go around an area daily to search for ongoing or potential disasters (such as damaged roads and structures), so that the local government can immediately attend to these.

This is more than a competition to us. Next month, we will learn how to fly drones and get certified with the help of Mr. Matthew Cua, an expert on drones. Our mentors from the Google and

Python Philippines communities will also teach us about Edge AI, the Python TensorFlow Library, and image processing. We are dedicated to making SOAR a reality, to help save lives.

Because together, we can change the world, with unity, teamwork, and of course, the power of technology. Together, we can SOAR.

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