T.O.O.F.A.N.

Complete Documentation

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What is this project about?:

As people who originate from countries which are notorious for their vast variety of natural disasters, such as earthquakes, floods, and landslides, we are no strangers to the negative effects that can come from these intense events. We also look at how negatively people can be effected from these catastrophes. Some may lose properties, some may even lose their lives unfortunately. As 4 driven Engineers representing the University of Western Ontario, we believe it is our responsibility to use our skills for the betterment of the world. So we thought of how we can create something which could really have a large impact on these people, and potentially create something which could save the lives of people in danger after the incident. We know it is unreasonable to try and avoid natural disasters, instead we wan't to improve the recovery process, and minimize the impact as soon as it is over with!

Simple Problems we aim to address:

1. ***Search and Rescue Operations***

Rovers equipped with cameras, sensors, and communication systems can assist in locating and rescuing survivors trapped in debris or hard-to-reach areas. Their ability to navigate rough terrain and access confined spaces makes them invaluable in urban search and rescue efforts.

2. ***Hazard Identification and Mapping***

Rovers can be used to map and identify hazardous areas, such as unstable structures, chemical spills, or radiation hotspots, without putting human responders at risk. Their data can guide safe evacuation routes and inform cleanup efforts.

3. ***Environmental Monitoring***

Rovers with specialized sensors can monitor air and water quality, detect contaminants, and assess the extent of environmental damage caused by natural disasters. This information is vital for planning recovery strategies and mitigating long-term health risks.

Infrastructure Inspection

Rovers can inspect and assess the condition of critical infrastructure, such as bridges, roads, and power lines, after a disaster. Their mobility and imaging capabilities can identify structural weaknesses or damage, enabling targeted repairs and preventing further deterioration.

4. ***Delivery of Supplies***

In areas with limited access or unsafe conditions, rovers can be used to deliver essential supplies, such as food, water, and medical aid, to affected populations. Their ability to traverse challenging terrain makes them suitable for last-mile delivery in disaster zones.

5. Aftermath Search and Analysis

In the aftermath of a disaster, deploying a rover for search operations can often save additional human lives.We can often save lives by providing medical attention to those trapped at disaster sites.

The T.O.O.F.A.N. Rover:

Our rover is a very simple design, A powerful all wheel drive bluetooth enabled car which has many features, and has potential for so much more! We have created a prototype model of this car, we aim to deploy our car into an area struck by either war, or .natural disaster. Our vision is to make this car reliable, and able to use the provided physical and AI tools to help people. It can be controlled via bluetooth connectivity (we opted for bluetooth over wifi since generally WiFi towers are broken down in areas hit by disaster).

- **Remote Controlled:** Our rover can navigate rough terrain and can withstand blunt force, all while being controlled by a bluetooth controller from an Open-Source app on your phone!
- **AI Controlled:** A feature which we aspire to add is AI controls, we have the camera and the radar, so in theory it would not be hard to incorporate AI Controls on the car in the event that the Bluetooth connection malfunctions, or even when operators aren't available to drive the car, an Artificial Intelligence Model can kick in and continue searching for and helping civilians.
- **Other Tools On The Car:** The following tools will cover all the physical, and software tools that the car possess (or will posses in an ideal model)

Camera AI Detection:

Currently it is being used to detect different objects, specifically humans. We used AI Libraries in order to have detection software. The purpose of this is to deployed into a given area, where it will be able to identify (and travel towards people in need). Of course at the moment, we are simply working with a prototype, but the applications of this technology are endless!

- **Facial Recognition:** If we were to implement some kind of facial recognition software, we could make our search for people a lot more targeted. If there are missing persons, we can apply our software to go and look for people in specific, this of course can be applied to missing objects and other things as well! It is all about how fine-tuned our software is!
- **Thermal Cameras:** With a higher budget, our camera can very easily be upgraded to a thermal camera, which would be an incredibly powerful tool when combined with our detection software! We know it would be able to find people in harder to find spots (such as in bunkers or under rubble). And having thermal sensing would make our tool more accurate, and able to detect people much more easily.
- **Weather Detection:** We can use a photoresistor (a light sensor), along with our AI camera to try and detect weather, we have forecasts of course, but an on-site weather detector housed by our car can also provide helpful data to personnel.
- **Warning Signals:** Upon finding something it finds concerning/can't help with, it sends a distress signal to the operators (our prototype sends these signals when it sees a phone)

Safe and Danger Zone Detection:

We trained a Neural Network with a dataset of over 2000 images! This is meant to distinguish between different zones impacted by Natural Disaster. We mainly trained and tested it using the earthquake crises of 2023 in Turkiye. We fed it satellite images of buildings that are broken, and buildings that are still standing. Upon our testing, our AI was approximately 96% accurate when automatically tested with 400 pictures, and identified broken buildings from built ones 10/10 times in our manual tests.

- **Rover-View Training:** Unfortunately there aren't any datasets of buildings from the ground view, so we had to settle with the satellite images to train our model. This however can easily be changed if we were to deploy our cars. We can set our cameras to take pictures of buildings (whether they be broken or built up), and train itself over time. Of course, having a model that determines a broken building from ground level is more applicable, but our satellite-based model is an excellent proof of concept! It also can easily be used for a drone if necessary.
- **Distress Signals:** We already mentioned distress signals with the AI operated camera, but it can just as easily be tied in here. We can send signals to nearby civilians when safe-spots are found so people can make it to safe-zones if they aren't in one already.
- **Selective Travel:** Our model allows for the rover to distinguish between safe-zones and danger-zones, this inherently means we can save time. It would be in our best interest to send the rover to areas where danger is more imminent.

Radar Detection:

Simply a way that our car can detect nearby objects, its a simple but effective RADAR system! We used a servo motor which rotates a supersonic sensor, which in turn sends feedback to our laptop.

Helper Chatbox

The integration of a chatbox into the T.O.O.F.A.N. Rover system is designed to facilitate real-time communication between the rover operators, emergency response teams, and potentially even disaster victims. This feature aims to enhance the overall efficiency and responsiveness of the rover during its deployment in disaster-stricken areas.

- Allows for quicker and more communication. This feature is crucial in high-stress situations where typing might not be feasible. Our technology enables real-time voice communication with minimal latency
- Integration with Google Cloud Translation API that ensures that language barriers do not hinder communication. This feature automatically translates messages into the preferred language of the user.
- Include a set of automated responses for common queries, such as directions to safe zones, basic first aid instructions, or reassurance messages. This speeds up communication and helps manage the load on operators
- Displays real-time GPS coordinates of the rover, allowing users to share precise location data easily. This feature is crucial for directing rescue operations to specific locations.