**Professional Research Practice Task 3**

**A1 : Problem Statement And Project Aims**

*Drones for surveying terrain and aiding search and rescue teams in earthquake scenarios.*

Earthquakes are natural disasters which often result in toppled buildings, landslides and damage to infrastructure. During these events, there can be many casualties especially in countries such as Haiti where sufficient mitigation strategies may not be observed. Issues may include: people trapped under rubble, essential supplies being cut and loss of communication.

For our project, we will be attempting to provide a platform for rescuers during earthquake situations to help save human lives. Our main aim would be delivering an improved solution to the problem of detecting victims under deep rubble, along with finding survivors in isolated areas where immediate rescue may be scarce so we will be creating drones that will essentially act as flying scouts which would allow search and rescue teams to spot survivors, examine terrain and thus, plan their response appropriately. As a result of better responses, we can increase the number of lives saved hence, achieving our original aim.

**Objectives:**

A1.1 To have the drone ping the location of survivors during its scouting missions so that an appropriate response can be made by rescue teams.

A1.2 To utilise a HD camera that would retain it`s focus while travelling at high speeds to find survivors or record changes in the terrain

A3. To utilise a speaker and microphone system so communication between survivors and rescuers can occur, ensuring coordination between survivors needs and the tasks performed by rescue services

**A2 : Ethics, Feasibility, and Sustainability**

**Ethics**

The ACM code of ethics is a set of guidelines that should be followed by computer scientists and electronics engineers to ensure products are safe and ethical. The ACM code of conduct can be found here: <https://www.acm.org/code-of-ethics>

A section of the ACM code that needs to be fulfilled wholly is section 2.1 as the main aim is to save lives so the task at hand holds high importance and requires a high level of technical expertise. There also needs to be a deep understanding of the social environment in which our drones may be used.

There is also a potential to cause a breach of section 1.6 as the victim's privacy could be violated if personal information and data is not handled properly. When drones are used and are actively searching for victims using cameras and other technology, personal information may be monitored, collected, and exchanged. This may be without the knowledge of those who are being helped. Personal information should only be used for lawful and good purposes and without infringing on the rights of people affected. This necessitates the need to take care when handling personal data in order to prevent unwanted data collection or re-identification of anonymised data, as well as ensuring data accuracy and securing data from unauthorised access.

**Feasibility**

A feasibility study of this project is important as it dictates whether the project is possible to do under given conditions such as: the budgeting, market threats and the limits of technology available.

**Costs and pricing -**

In terms of costs and pricing, the drones need to be affordable to the rescue services who will be using them during emergency situations.

The volume of drones purchased should be large enough to create a worthwhile increase to the lives saved.

Furthermore, the costs to produce these drones should also be low enough so that the production of these drones can be continued with support and availability.

In 2019, The Red Cross spent a total of around £20 million to fund crisis responses, however this figure is spread throughout multiple different crises. Consequently, this figure is not restricted to an individual crisis. The Red Cross also spent an extra £3 million on the financing of new equipment.

Taking this information into consideration, we will aim to create a fleet of drones capable of aiding search and rescue for the cost of 1% of the Red Cross’ expenditure on equipment

£30,000. (Red Cross Trustee’s Report, 2019). We believe this figure is a reasonable price for a fleet of drones.

We plan for one fleet to contain roughly between 20 to 30 drones. This results in each drone having a budget of approximately £1000 to £1500. This is a competitive price as many drones equipped at this calibre often cost around upwards of £2000.

**Market threats -**

As with all products being produced, there will be competition between other drone manufacturers over who can make the more compelling product. The project will fail if the charities we are aiming to supply these drones to, opt to use something from another company (such as parrot).

**Technological limits -**

The limits of technology will also play a role in the effectiveness of the drone’s capabilities, these include: the battery life and the distance each drone can cover per day. A drone with equipment that falls short in its capabilities will be received negatively resulting in charities being less willing to purchase our product again.

**Sustainability**

There are 3 factors that must be considered when judging the sustainability of drones in earthquake disaster scenarios. The first factor is environmental. One issue arises from the manufacturing of parts needed to build the drones: For example, Lithium batteries and carbon fibres are seen to have major environmental impacts such as being contributors to ‘human toxicity, freshwater aquatic ecotoxicity and marine aquatic ecotoxicity.’ (Koiwanit, 2018). Furthermore, the impacts of drones on airborne wildlife should not be ignored.

Research shows that birds, especially, are known to be easily disturbed by drones merely due to their presence, along with the sounds they emit. The number of bird-drone interactions have also increased with one example being an eagle “mistaking a drone for food” (EEA, 2020). Therefore, Wildlife in locations near the earthquake disasters could be heavily affected. We would need to take precautions with how waste material is being produced so that environmental damage is kept to a minimum. We can also minimise the impact of drones on animals by providing teaching resources to rescue teams, these resources would allow teams to learn to use their drones in a less environmentally damaging manner.

The second factor is economics, LIDCs (Low Income Developing Countries), are most likely in need of rescue drones however this may not be feasible as purchasing a large proportion of drones will come at the cost of potential development. It is in these countries where buildings are not pre fortified, alert systems are scarce and education is lacking compared to advanced countries therefore a dilemma arises when prioritising between safety systems and development. This is due to the poor economic status of these countries. However, we plan to solve this predicament by marketing to charities who can manoeuvre these drones to the countries that need it after a disaster.

Finally, there are two social problems we must avoid when outsourcing the manufacture of our design: Slavery, and Poor Factory Conditions. Although slavery was abolishised during the 19th century, there are often cases of the crime occuring privately within factories of less developed nations. Around the world, there are an estimated 12.3 million people in forced labour (Johannes Koettl, 2009) with most instances occurring within Asia and the pacific. Poor working conditions are another problem that must be considered when researching where to outsource production, terrible conditions can often have negative impacts on the mental and physical health of workers which as a consequence lead to tragic cases of death and suicide such as that seen in shenzen during 2010 (Occup Environ Med). With this in mind, we must perform background checks on the working conditions of our factories at least once a year to prevent exploitation.

**A3 : User Requirements**

Pilots of our drones will most likely be using them to scout terrain and find survivors in earthquakes and other natural disasters so our drones will be expected to perform these tasks:

A3.1 The drone must be capable of running for a minimum of an hour with fully charged batteries. This allows a significant number of potential survivors to be found before each recharge

A3.2 The drone will be intelligent enough to identify potential humans from images it has captured from surveying and relay these images to a “pilot” who will confirm or deny the presence of a human in distress and make the drone return its GPS position accordingly.

The ability to use GPS keep track of survivors allows rescuers to plan the most effective route to saving each survivor

A3.3 The drone will be able to hover independently, regardless of altitude and wind conditions. This allows for easier control of the drone by the pilot.

A3.4 The drone will be able to read data from its sensors, to detect where a human might be before further investigation. This data includes audio picked up with a microphone, to listen for yelling and other sounds of distress and thermal imaging to detect bodies of heat. The drone will then relay this information to the pilot who can better interpret the information

A3.5 The drone should be able to travel a significant distance and still be able to send and receive information across that distance in a secure way.

A3.6 The drone will be capable of complete 3D flight, both autonomously and with RC input.

A3.7 Upon running low on battery, or loss of connection, the drone will automatically, slowly and safely descend before battery power dies to prevent damage. The last known location of the drone will be saved to the controller so that it can be found

A3.8 The drone will be able to connect to satellites and cell towers to provide a signal to the device, alongside being able to ping nearby phones to check for any survivors in the area using aforementioned cell towers.

**A4 : Constraints**

Problems which may prevent the development/use of this product may include:

A4.1: Be able to withstand hitting objects such as trees with minimal damage so we will need sturdy materials which may increase cost and increase weight.

A4.2 Large batteries that hold large voltages may be needed to provide enough power for the large motors needed to carry the whole system, this adds weight and cost whilst being a fire hazard to the drone

A4.3 We will need a thermal camera capable of generating a heatmap to pick out crowded areas, which will increase the cost by a lot and the weight of the drone.

A4.4 Needs to be fitted with a GPS tracking device which will take up a sum of the budget but will not increase the weight by a noticeable amount.

A4.5 People may be uncomfortable with a drone that has a camera as they may not want their body to be seen by it and have private preferences that might include being seen while not wearing certain clothes such as a hijab.

A4.6 Must be able to be controlled from a long distance away such as from an international country in order to increase its usability in different scenarios.

**B1 Input/Output Requirements**

B1.1 Image inputs to the drone are provided using a Camera that would provide high quality imagery of the surroundings to scope the extent of the predicament – and allows drone operators to avoid obstacles while flying.

B1.2 This can be implemented by a gimbal that allows movement of the camera and attachment to our drone – Gimbal allows the camera to rotate smoothly across the axis – grants smoother and clearer imagery.

B1.3 Another input is a wind sensor that would be attached to the drone – picks up wind speeds which may affect manoeuvrability and overall control of the drone.

B.4 This data could be used to change propeller speed to match the wind and withstand varying wind pressures, this data could be fed to the interface to allow mode change.

B1.5 Another input is audio picked up through a sensitive microphone to pick up quiet noises around the drone.

B1.6 This will make it easier to locate frailties or people in need of aid as their voices may be heard even if they are trapped in rubble, permitting easier discovery of their location.

B1.7 Our drone will be managed using a remote controller handled by trained professionals.

B1.8 It will have a simple interface with multiple features such as changing mode for example into Hibernation mode when not in use.

B1.9 Another input is an infrared scanner designed to scan the environments for heat signatures of people in the midst of rubble or other debris.

B1.10 NDIR CO2 sensor which would pick up CO2 releases from the nearby locations - useful as People would emit Carbon Dioxide during Respiration. Allows easier detection of hidden victims – Provides a long term and low-cost strategy. Uses NDIR technique which is particularly suited for CO2 sensing as it “relies on the very high absorption coefficient of CO2 in the mid-infrared wavelength range around 4.26 μm.” (Jia et al., 2021)

B1.11 Phone detection pinging service which sends out signals from the drone – would be recognised by mobile devices in the local area – if signals are received, device sends signal back to the drone – allows co-ordinates to be roughly found.

B1.12 Image output for the drone controller to see that is sent from the Drone using the cameras – allows the drone controller to traverse towards locations that may be hot spots for victims such as towers, large buildings etc.

B1.13 GPS output from the drone to local search and rescue teams – GPS pings sent when victims are found to the teams so they can pinpoint the exact location of victims and the extent of damage. Allows more rapid aid – saves lives.

B1.14 Confirmation outputs therefore the trained professionals can discover which drone belongs to which controller in the fleet and allows them to check whether a drone is already connected to another controller – Prevents unneeded confusion.

B1.15 Sound outputs to the environments near the drone –signifies the drone`s presence and allows the pilot to communicate with survivors – would calm injured people as they would recognise that aid is incoming. Another sound output to the drone controller to allow the drone operators to hear the sound emanating from the area – such as people shouting for assistance.

**B2 : Operational Requirements**

B2.1: The drone will require a switch for it to be able to turn off or on,

B2.2 Must be equipped with idle mode, where the drone will remain neutral in a set location on the ground while the controller is not being used for a period of time

B2.3: The drone will include features such as a thermal camera to detect people and any potential dangerous objects that may cause the drone damage.

B2.4 Drone will be fitted with the ability to produce an SOS signal in case of an emergency crash landing.

B2.5 The drone will go under calibration to tell the user the precise distance of where people may be in danger.

B2.6 The drone will undergo sleep/charging for roughly 3 hours a day in order to insure its lifespan for the next 24 hours will not undergo any issues.

**B3: Functional Requirements**

The drone will need to be able to perform certain functions in order to perform its duties. These include:

Connection Checks- since the drones are likely to be handled in many different situations with many different people, the drones will feature a connection check when connecting to a remote allowing a user to identify that they are taking the right drone.

This connection check will need the user to look at their screen where they will be presented with a video of the drones with its propellers spinning in a certain pattern.

The users drone will have its propellers spin in the same way,

The user will need to verify whether the drones spinning blades match that of the controller

Through pressing a button on that controller.

This simplifies the task of checking which remote is connected to what drone when dealing with multiple pilots and drones getting ready for take off

Switch to Emergency function- In the event the drone loses connection with its remote control, the drone enter into the emergency mode, the user should also be allowed to activate this feature through an emergency button on the controller, the drone is able to detect a connection loss through pinging the controller every few seconds

Human detection function- The drone may need a human recognition function which will detect people signalling for help in a disaster scenario. This may speed up the time it takes for people to be spotted by first responders to an earthquake scenario especially if the drone is high in the sky searching for people as small images will be hard for a human to pick up.

The most likely to be effective way to do this would be to have the on board camera footage go to an AI that is sensitive to objects in an image that are not moving with the rest of the image. The AI would then highlight these objects pointing them out to the drone user.

Sound Recognition function - the sound recognition function would allow the drone to pick up and isolate noises that humans would be able to verbally make such as screaming and crying. The drone can then measure how loud these screams are and highlight the sounds it is hearing to the user either visually or audibly notifying the rescuer that there are people nearby that may need help

Location lock- the drone should be able to control its altitude and position in the sky, this allows the users to keep track of the drone when not in use and simplifies other tasks such as assessing the damage caused by an earthquake as the controller when drone pilots would be more focused on what they are seeing than piloting.

One way this would be done is by allowing the drone to use gps data to keep track of its longitude and latitude, when the drone is holding its positions and detects that it is drifting off, the drone can actively make an attempt to move back to its original position.

Furthermore the system can use wind sensors to measure the strength the wind has on the drone, using this information the drone may then be able to tilt in accordance with this wind information allowing itself to hold its position against the wind

Zoom function - the drone is most likely going to need a zoom function for the camera to allow the user to look at images in greater detail. This will be done through ways: One will use a physical lens to help the camera zoom into objects. The other will be digital, enlarging an image so that smaller objects can be easier seen.

**B4 : Non Functional Requirements**

B4.1 The drone will be constructed of recyclable materials with a low environmental impact to obtain and process to be as eco and climate friendly as possible, alongside following all governmental regulations

B4.2 The materials used to create the drone will be lightweight and durable. Allowing for more flight time for each drone before repairs may be necessary.

B4.3 Each rotor will be made of an incredibly strong material, designed in a way to withstand forces occurring from high rpm. This ensures the drone will be very capable of flight

B4.4 The drone will be designed with aerodynamics in mind, so that less power is drained to fly the drone.

B4.5 The drone will be equipped with Several status lights. One indicates whether the drone is off, idle/starting up, and on varying between the colours red, yellow and green respectively. Another Light will indicate whether the drone is currently charging, and a third will indicate whether or not the drone has a signal and is connected to a controlling device.

B4.6 The drone will have 4 rotors, which provide a high degree of manoeuvrability, without going overboard on power consumption and size.

**C : Key Design Challenges**

C1 - Potential trade off in features and weight as features required as part of our design would increase weight – threatens drone balance and speed

C2 - Battery life – must be limited as if the battery size is increased, weight would also increase – Heavier drone requires bigger motors which would increase the design costs

C3 - Quality of materials – must be durable but also cost efficient

C4 - Heavier motors – more energy needs

C5 - Connectivity between Drone and controller over large distances – Emergency mode – Drone slowly descends to the ground if connectivity is lost then sends a signal of its location

C6 - Potential limitations in finding people through deep rubble – the thermal camera may not be able to scan through such dense material

C7 - General damage over time – for example Animal interactions, just general wear and tear

C8 - Drone may not perform in varying weather conditions such as during Rainfall, Heavy wind, storms etc.

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