 Introduction:

Unmanned Aerial Vehicles, also known as UAVs, are drones which have many uses such as cargo delivery, surveillance, agriculture. However, they also have another use which is extremely helpful, and it is that they can extend the range of cell towers and/or increase the speed of the network.

UAVs have many use cases. A cell tower that is malfunctioning and needs to be repaired is one such instance where UAVs can be used. UAVs are also used when climate catastrophes such as earthquakes or landslides occur, where building infrastructures are not physically possible nor are they economically viable.

In densely populated areas, such as concerts, sport events, or any other densely populated area where there will be more demand for data usage, UAVs can also increase the network speed and cater to the high demand in those areas.

However, the problem is that these UAV-BSs can only be in the air for a limited amount of time

before they return to their depot to charge again. The typical flying time for a flying base station is

less than an hour. Besides, these drones cause significant noise pollution, especially when there are

multiple of them in the same region. When hovering, the noise can reach 85dB, which is around the

same amount of noise a leaf blower, or a lawn mower makes. Fortunately, these problems can be

solved by attaching effectors which can grasp onto urban structures such as lamp posts in an energy

neutral manner. This could increase the duration of service from less than an hour to several hours.

Robotics airborne base stations, or commonly referred to as RABS, are a modified version of the

standard UAV. Aside from operating silently, RABS also has another advantage which really

distinguishes it from ABS. It is the fact that it is weatherproof, specifically rainproof. Hovering during

rainfall is incredibly difficult for drones to perform, regardless of the weight of the drone. RABS

solves this problem permanently since it uses its grapplers. From previous research. The

average energy consumption of a normal ABS (4kg) while hovering is 320J/s, whereas in that same

time frame, a RABS which is grasping on to an object will only consume 15J/s, increasing the total

service time by about 35 fold

In this project, I will investigate the factors that affect the energy consumption of UAV-BS, and how

efficient robotic airborne base stations (RABS) are from standard hovering. I will also find the

optimum path trajectory of the base station depending on the number of nodes, the distance between

the nodes, and the service time in each of the node regions.

Gannt Chart from November-April

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| Tasks | Nov | | | Dec | | | Jan | | | Feb | | | Mar | | | Apr | | |
| Deeper Research |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Simulation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Simulation II  ML |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Final Analysis and Conclusion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Drafting Thesis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Final Corrections |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Video Presentation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Implementation:

The code will be written in MATLAB with the help of 2-opt algorithms. 2-opt algorithms are useful

in solving trajectory problems. The most famous one is the travelling salesman problem, where the

salesman must find the optimum path to different locations before the salesman returns to the starting

point. This problem can be used in other situations as well, such as the optimum path for a bus when

dropping students, deliveries by courier companies and of course, drones.

The full simulation will be implemented through MATLAB. The environment will start from the most basic case: one node. This will ensure that the environment is running correctly and that all the calculations are correct. Then the RABS factor will be added and compared to a nominal ABS. After this, the problem will get progressively more complex to calculate as there will be more nodes added and the distance between those nodes will be a determining factor as well.

I will also go beyond the scope and attempt to incorporate machine learning as well. This will be in the lines of genetic algorithms as they are one of the best when it comes to solving optimisation problems. The overview of implementing the genetic algorithm is as follows:

1. Creating initial population – There will be multiple species (in this case the drones) which will start from the depot. All
2. Initialise the fitness variable – This is relatively straightforward. The drone with the least amount of energy consumed after returning to the depot will receive the highest fitness score.
3. Mutations – The best species from the current generation will be mutated randomly and will become the population for the next generation

This process will repeat for multiple generations until the energy consumption of the drone has reached an optimum result. With this training, the fittest drone will then be validated with a new random path

All the steps done so far are in 2-Dimensional. If these simulations are successful, then I will move on to the 3-D version of this model where there will be more factors included. This includes obstacles and changes in weather patterns.

In summary, here are the tests I will perform and the factors I will add as the project progresses:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No.\Factor | No. of Nodes | Optimisation Algorithm | ABS | RABS | Wind | Rain |
| 1 | 1-5 | 2-Opt | Yes | Yes | No | No |
| 2 | 2-Opt | Yes | Yes | Yes | No |
| 3 | 2-Opt | Yes | Yes | Yes | Yes |
| 4 | 5+ | 2-Opt | Yes | Yes | Yes | Yes |
| 5 | 2-5 | ML | Yes | Yes | No | No |

The results from the ML model to the 2-Opt model will be compared

All simulations will be recorded and will be available in the final report in the appendix.

Monitoring Project Risks

Ethics:

Drone laws are generally strict all over the world. There are many laws that have restricted drone usage. In fact, almost all countries in the MENA (Middle East/North Africa) region have either banned UAV usage or have made it close to impossible to fly drones without getting the required licence. There are multiple reasons to this, such as:

1. Instability of the political climate of the country. Drones are seen as a threat in such countries.
2. Security and surveillance reasons
3. Wildlife protection

Drone laws in the UK are strict as well. You must have a licence to operate a drone in London and this can only be obtained from the Civil Aviation Authority (CAA). Drones can’t be flown over crowded areas. Unfortunately, this happens to be the primary use case for the UAV. The drone must not be over 500g. This also interferes with the preferable weight of the UAV. Therefore, this simulation cannot be conducted in real life, or at least in the UK unless the UAV operator has a special permit to use the UAV.

Health and Safety:

COVID-19 is not fully eradicated yet, and it is unlikely that it ever will. Although the symptoms of the more recent mutations of COVID-19 are milder this does not mean that the precautions can be dropped. That being said, the circumstances of COVID-19 do not affect the progress of this project since this project is fully simulation based.

Citations:

https://arxiv.org/pdf/1901.06637.pdf