T4

DEPLOYMENT OF UAV FLEETS IN HUMANITARIAN DISASTER RESPONSE LAST MILE LOGISTICS

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INTRODUCTION

A critical aspect of a humanitarian disaster response is delivery of aid to victims from local distribution centres: last mile logistics. Current terrestrial means used in last mile disaster response are fraught with difficulties. Autonomous fleets of small Unmanned Aerial Vehicles (UAVs) used in immediate disaster response for last mile distribution can circumvent these difficulties, providing wider relief, in less time, and using fewer resources.

Project aim: optimise the use of a UAV fleet in immediate aftermath of a disaster to minimise the unmet demand for medical aid in an area by producing an optimal itinerary for each UAV in the fleet.

METHODOOGY

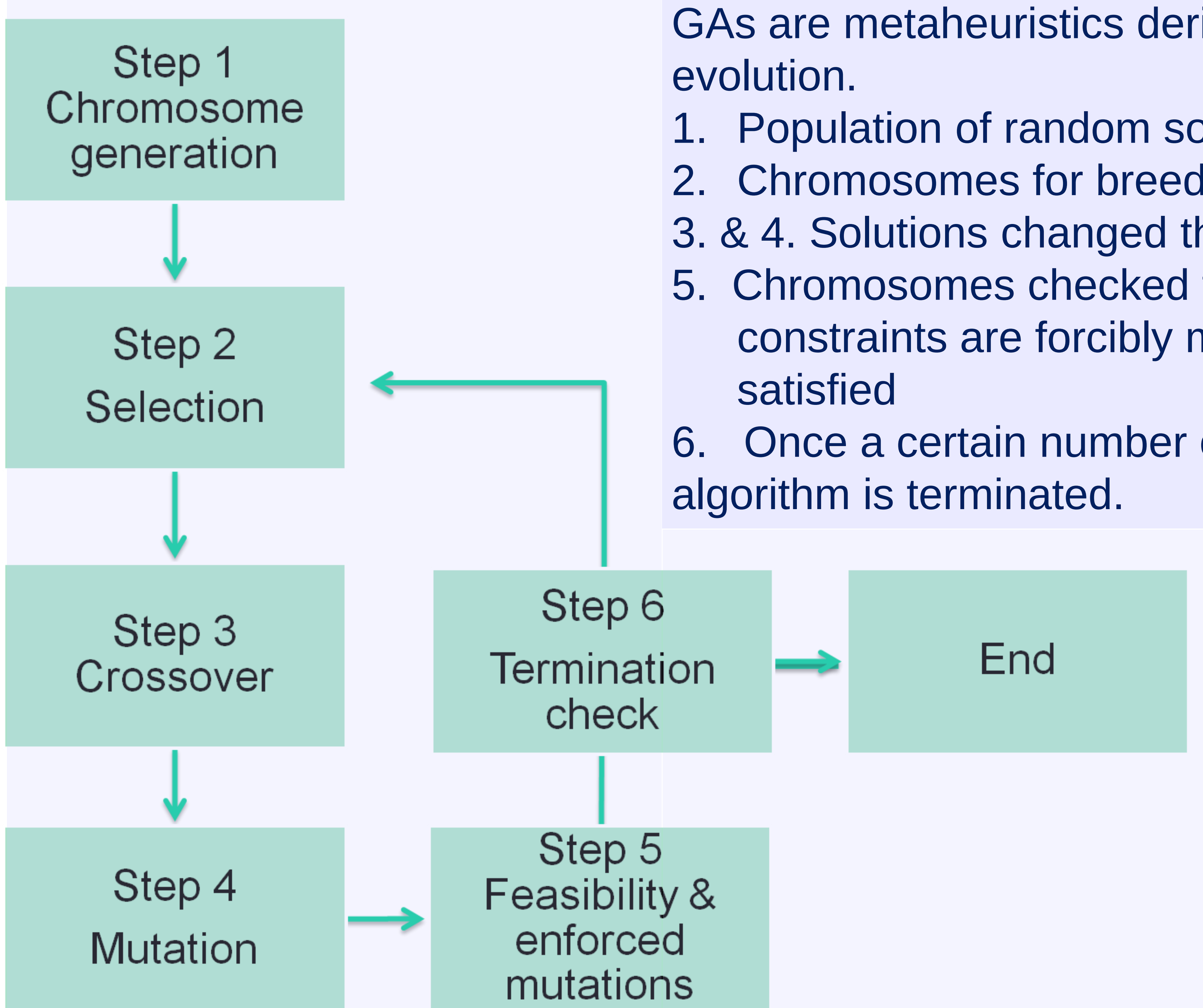
The problem in this project is expressed as a multi-hub, split delivery, recharge and stock replenishment vehicle routing problem (VRP) with multiple vehicles, and is the first to do so.

Network characteristics:
- Demand nodes are locations in need of disaster relief, and thus UAV demand.
- Hubs are locations where UAVs are docked, recharged, and restocked during disaster response.

Model dependencies:
- the battery capacity of each UAV
- the specified total mission time
- locations of demand nodes and hubs
- the number of UAVs in the fleet.

Using these and other inputs, model is solved using a genetic algorithm (GA) to provide an optimal itinerary for each UAV that minimises the unmet demand in an area by the end of the mission period.

GENETIC ALGORITHM



GAs are metaheuristics derived using techniques inspired by natural evolution.

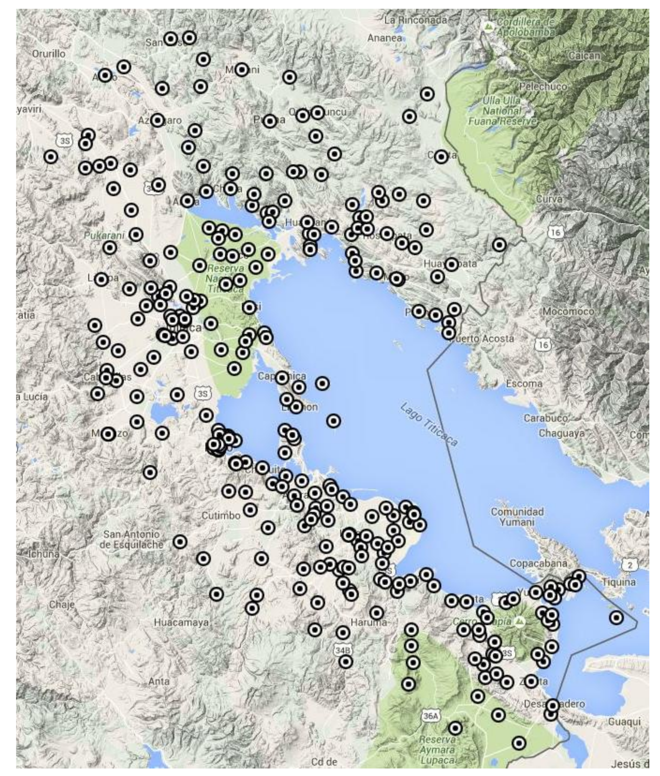
1. Population of random solutions created
2. Chromosomes for breeding selected
3. & 4. Solutions changed through evolutionary processes
5. Chromosomes checked for feasibility. Those that violate any constraints are forcibly mutated so that all constraints are satisfied
6. Once a certain number of generations has taken place, the algorithm is terminated.

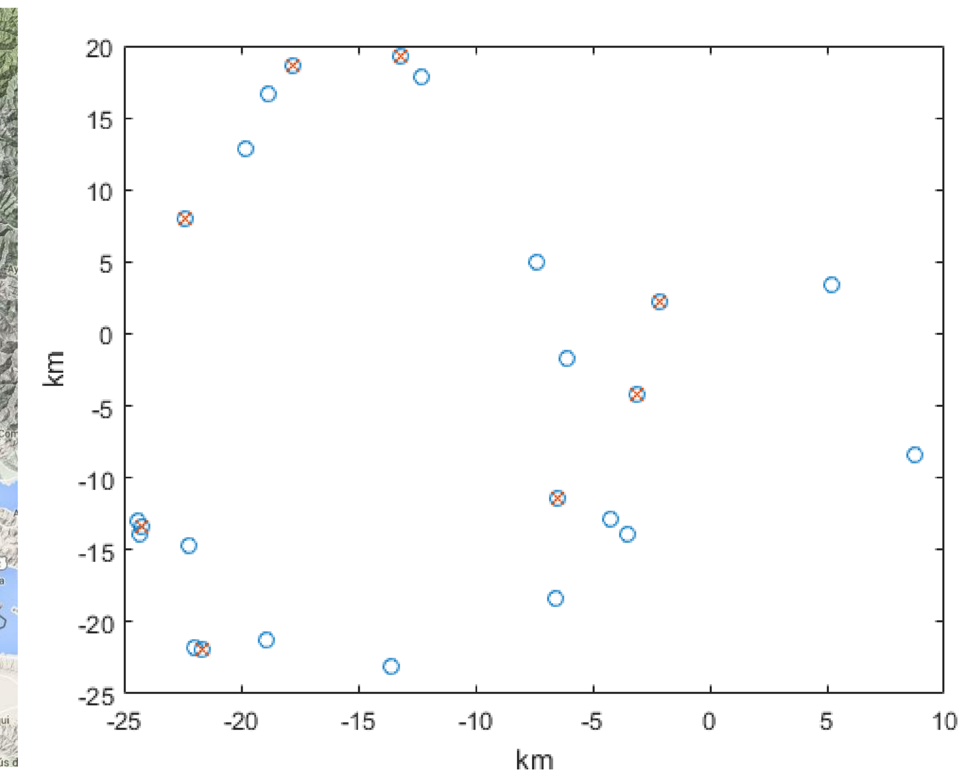
Given the pedigree of parent chromosomes, this evolutionary technique produces offspring, and hence solutions, of greater quality.

CASE STUDY

- Case study conducted on Lake Titicaca region of Peru. Lake Titicaca is situated between Peru (west) and Bolivia (east). Peru has a vast range of environments and one of the most vulnerable populations in the world to natural disasters.
- Peruvian Lake Titicaca network consists of 456 nodal coordinates that represent health stations, as seen in the figure below left.

Case study specifications:
- Network of 25km radius chosen centred in Puno, Peru
- 16 demand nodes (blue circles) and 8 hubs (red crosses)
- Population of 107,020 in catchment, requiring 1244 UAV visits
- Fleet of 16 UAVs
- Mission time of 24 hours



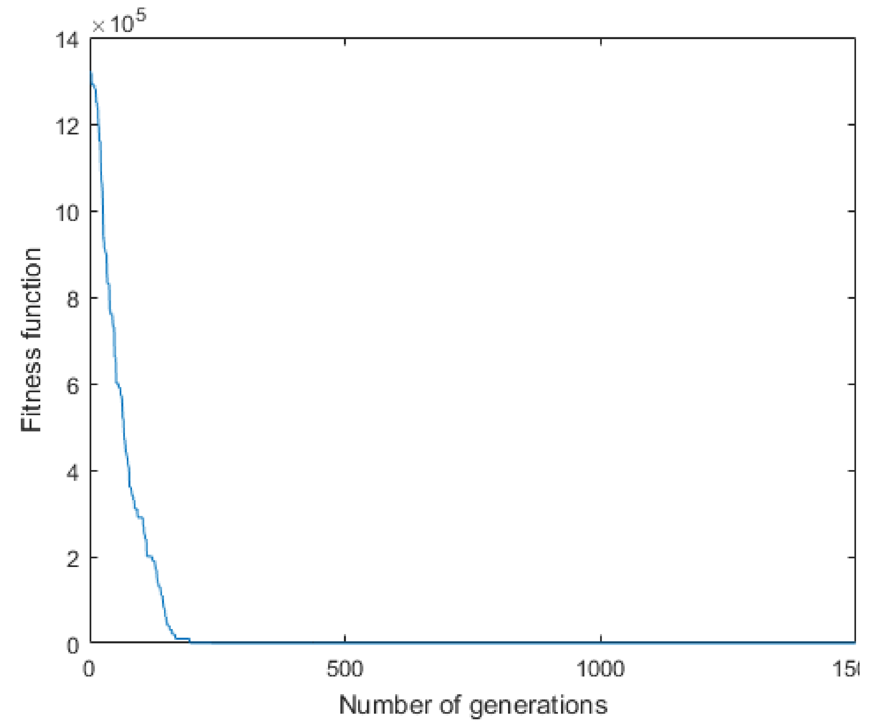


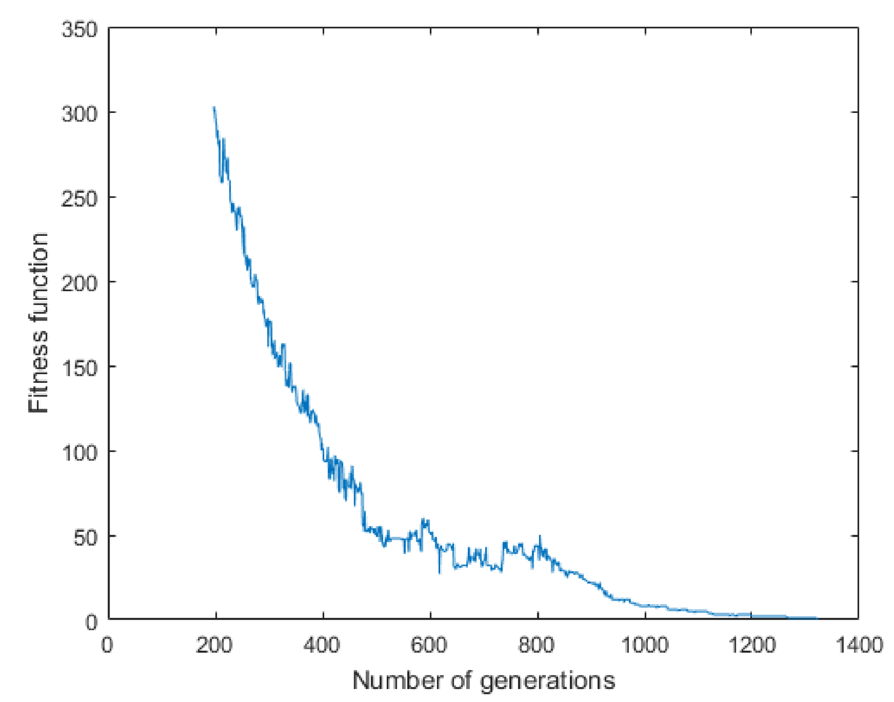
RESULTS AND CONCLUSIONS

Algorithm was experimented with different parameter sets. The optimal parameter set, and its fitness function variation, can be seen below.

Methodology provided a complete itinerary for each UAV which minimised unmet demand, hence the competency of the genetic algorithm was shown

Model performance:
- adequate - optimal computation time of 1920 seconds





Optimal Parameter Set	Population size	Crossover rate	Mutation rate
	100	0.8	0.6

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REFERENCES

Ascending Technologies. (2015) AscTec Pelican