Week 3 Report

1. Introduction

* Advancement in UAV tech has exponentially increased in the last decade
* New path planning algorithms are assuming a new role, as smart city management allow for better optimization of this technology
* Many suggestions for optimal methods, but the problem of collisions remain
* Metaheuristic algorithms have been used to solve this problem, but aren’t perfect
* Optimization is the choosing of certain variables and parameters to achieve the objectives
* Metaheuristic algorithms are simple (easy to understand), flexible (can be applied to and adapt to many different situations), derivation-free mechanisms (random solution optimization allows for even more reliability in a changing environment) and better at avoiding local optima (able to extensively search the entire area, avoiding stagnation in local areas)

1. Related Study

* Meta-heuristic optimization has gained recent awareness due to its capabilities in solving engineering problems (neural networking, path planning)
* Strong global minima capability in this optimization focuses on one particle to search for in a whole space
* In a case study, optimization of algorithms with more than one particle vs just one particle as undertaken. Having more than one particle decreased the overall effectiveness of the entire product (while making it much faster)
* Optimal path planning, linear scaling and communication can save energy and increase overall effectiveness

1. DGBCO Mathematical Modeling

* Different meta-heuristic algorithms will be utilized
* Dynamic group based Cooperative Algorithm: cooperation of singular entities towards a larger goal. Divide into sub-groups based on their certain task
* Initialization: DGBCO assigns particles in whole space area
* Exploration and Exploitative: Will be assigned 70% – 30%.
  + Exploration: Searches for optimal solution. Particle position is updated by both equations and a variable of “mutation” (allows for adaptability)
  + Exploitative: Finds the best group and converges on the correct answer, using mostly equations
* Pseudo Code: UAV population and # of iterations are considered input parameters. Maximize iterations of UAV. We then update the UAV position, exponentially increasing the number of focused particles. We consider both exploration and exploitation groups to update and follow the best solution

1. UAV Path Planning Methodology

* DGBCO (Dynamic Group Based Cooperative Algorithm)
* Flight space is defined in its workspace area and obstacles are placed in the workspace to act as hurdles for the UAV
* The pseudocode goes as this:
  + Iterates through possible solutions
  + If the pest solution doesn’t appear within 2 complete iterations, the number of nodes used in exploration is expanded
  + Elitism for the best solution is done and the best solution is then mutated
  + Best solution is then implemented
* The optimal path finding method searches within bounds such that the cost function of the path is minimized
* The task of primary importance is to include some vector that has a set of control points from the start to end
* The second task is to create a function that will determine the cost or loss of each path. This function will be used to minimize / optimize the path
  + This function is calculated through using the Euclidean method of determining the distance to a point
* Control points will be utilized at random time intervals in the search area. The cost function will then be used to calculate the loss and the position of the guiding control points
* Often times, the shortest path isn’t the most optimal so longer paths with less obstacles could then be chosen
* DGBCO searching is utilized over multiple iterations where control points are checked and adjusted with the net cost being the primary considering factor

1. Results and Discussion

* Here, the four primary searching algorithms are tested
* DGBCO (dynamic group based cooperative algorithm) is tested along with PSO (particle swarm operation), WOA (whale optimization algorithm), and GWO (grey wolf optimizer)
* Comparison factors are used to optimize cost and run time operations
* DGBCO had a far superior performance, as is observed later in the paper
* First, a general environment is simulated with few obstacles
  + DGBCO utilized its dynamic grouping method to quickly remove unsatisfactory paths and easily determine which set of routes would be the most optimal
  + DGBCO also achieved less cost and iterations compared to other techniques
* In the next scenario, the basic urban environment is simulated with several random obstacles like dense buildings, large vehicles, and random pedestrians
  + The UAV utilized the DGBCO searching and path planning method to effectively find a seamless path through urban areas
* The third scenario simulated a maze complex with defined paths
  + Here also, the DGBCO algorithm had a far better cost optimization
  + PSO and GWO both had random oscillations and path confusion when iterating
* Finally, a dynamic environment is tested where a complex mixture of prior cases is simulated
  + Here also, PSO, GWO, and WOA got stuck within their iterations while DGBCO determined a proper UAV path that passed optimization tests

1. Conclusion

* In this research, different metaheuristic algorithms were tested to determine which would calculate the most time efficient and collision free path for a UAV in a catastrophic situation
* Algorithms like PSO, GWO, WOA, and DGBCO were tested within static and dynamic environments that simulated environmental situations
* The simulation results determined that the DGBCO algorithm performed better than the other algorithms with 24.5% less travel time and obstacles and 13.3% less computing power used