The Blue Ship Routing Problem

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M.Sc. ISoSySc, WiSe 22/23

Ethics of Intelligent Vehicles

February 8, 2023

Otto-Friedrich-Universität Bamberg

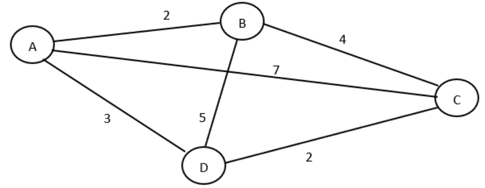
Outline

Motivation and Problem Statement

- Large number of marine life are killed yearly due to direct ships related accidents.
- Water pollution, sound pollution, Sulfur emission, etc from the ships have a major impact on marine life.
- Modern technology can be of great help as we have a vast amount of data.
- Focus of this project is to find the optimal route from the initial port to the destination port while avoiding the major marine life's habitat.
- For this task, we are using a Genetic Algorithm to compute the route for the dynamic obstacles.

Application

- Traveling salesman problem (TSP).



- Vehicle routing and Telecommunications problems.
- Gaming Field.

Computation of Factors

- Euclidean distance is used as the base for the fitness function.

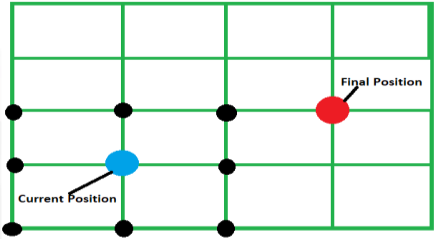
$$d(\mathbf{p},\mathbf{q}) = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

p, q = two points in Euclidean n-space

q_i, p_i = Euclidean vectors, starting from the origin of the space (initial point)

n = n-space

- Initial population will be generated using neighborhood coordinates that give the shortest distance.



Computation of Factors

- Haversine formula is used to calculate a length of the route.

Haversine: $d = sin^2\left(\frac{\Delta\emptyset}{2}\right) + \cos(\emptyset_1).\cos(\emptyset_2).sin^2\left(\frac{\Delta\beta}{2}\right)$

With: $c = 2.arctan2\left(\sqrt{d},\ \sqrt{1-d}\right)$

And: $a = R.c$

Where:

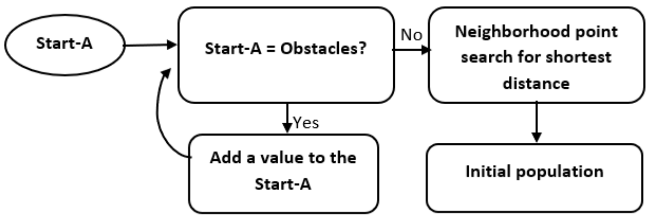
$\emptyset = Latitude$

$\beta = Longitude$

$R =\ Earths\ mean\ radius\ in\ Km\ (6371)$

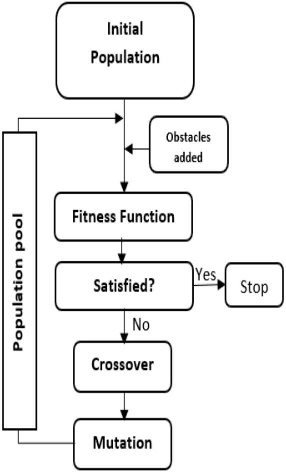
Genetic Algorithm: Process 1

- Function will take start point-A and end point-B as an argument.
- While the condition is true.
  - For each point-A will be recursively checked if there is an obstacle.
    - If point-A is equal to the position of obstacles then we will add a random value to point-A.
  - For new point-A we will check for the shortest distance between the neighborhood point of point-A and point-B.
- If point-A is equal to point-B then the loop condition will be false.



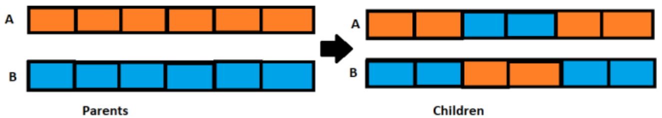
Genetic Algorithm: Process 2

- Obstacles are added in each cycle of the generation. Obstacles can be both static and dynamic types.
- Fitness score is calculated for every population and the best fittest individuals are selected.
- The crossover and mutation are applied over the selected population and reproduced for the next generation.

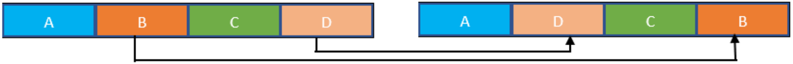


Genetic Algorithm: Process 3

- 2-point crossover operator: The routes of two random individuals from the current population are combined into a single new route. This process will reproduce two new individuals for a new generation.

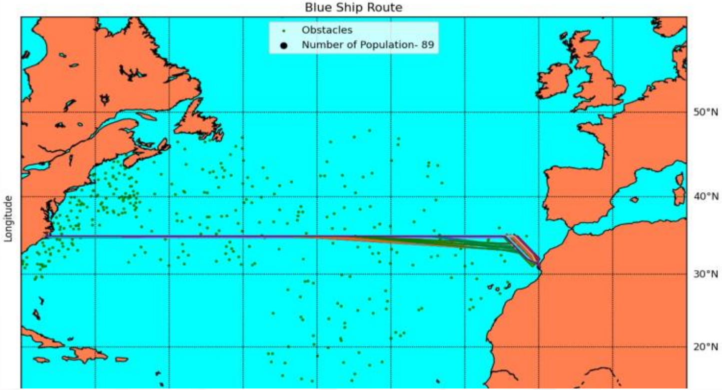


- 2-point mutation operator: Operators are used to making different changes to random coordinates of individuals or on the obstacles point.

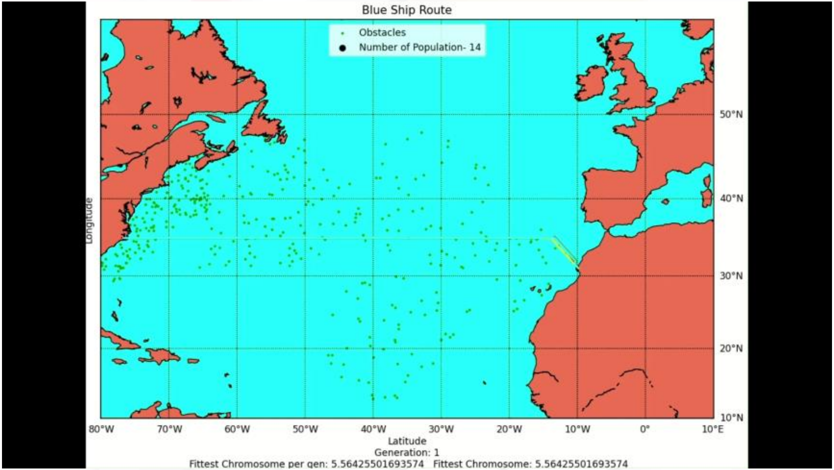


Results

- The algorithm is able to find the route while avoiding the obstacles.
- The Boolean function provides the presence of land so our algorithm can avoid it.

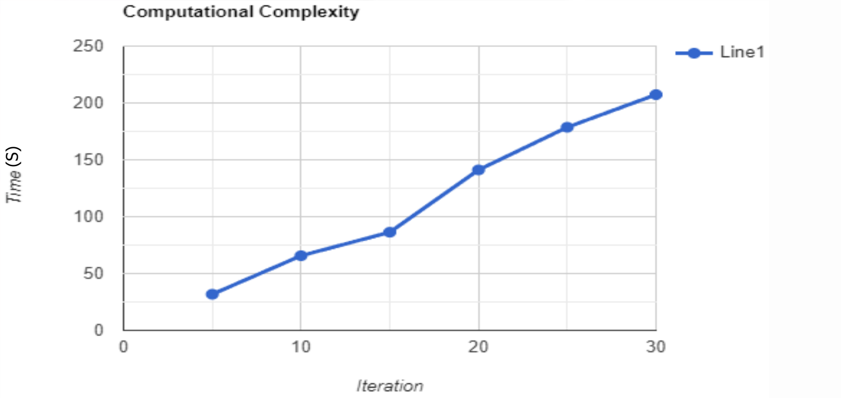


- The demo of the algorithm.



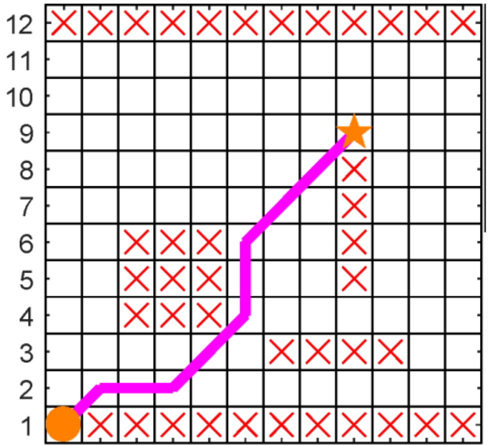
Limitation

- Computational Complexity
  - Calculation for generation 1 only.
  - Total population for each generation is *((Iteration * 3) -1)*.



Future Work

- Using AIS data for initializing the population.
- Implementation of the algorithm with density mapping for marine life habitat.
- Using A* and Dijkstra's algorithm for better-optimized results.



Conclusions

- Genetic algorithms (GAs) are a potent optimization technique that can be applied to solve a wide range of problems.
- Advantages of GAs include their ability to handle complex problems, their robustness to changing environments, and their ability to find good solutions even when they start with a poor initial population.
- GAs has some limitations, such as the need for extensive computations, the risk of premature convergence, and the difficulty in defining suitable representation and operators
- Optimized routes will save energy, the environment and will also increase the safety of ships.

References

- Kuhlemann, S., Tierney, K. A genetic algorithm for finding realistic sea routes considering the weather. J Heuristics 26, 801–825 (2020). https://doi.org/10.1007/s10732-020-09449-7.
- Otman, Abdoun Abouchabaka, Jaafar. (2012). A Comparative Study of Adaptive Crossover Operators for Genetic Algorithms to Resolve the Traveling Salesman Problem. 31.
- Haldurai, L., Madhubala, T., Rajalakshmi, R. (2016). A study on genetic algorithm and its applications. Int. J. Comput. Sci. Eng, 4(10), 139-143.
- Singh, S., Lodhi, E. A. (2013). Study of variation in TSP using genetic algorithm and its operator comparison. International Journal of Soft Computing and Engineering, 3(2), 264-267.

Thank you for your attention!
Questions?