Efficient Path Finding for Emergency Vehicles: A Comparative Exploration of Sparrow, Monkey and Frog Search Algorithms

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ABSTRACT: Efficient path finding for emergency vehicles is essential for saving lives by taking the optimal path from source to destination point that takes less time and covered less area by avoid traffic and any obstacles. There has been a lot of research is completed for finding optimal routes for emergency vehicles using different algorithms like Dijkstra, A* and genetic algorithms. In this research work has been done by using three bio-inspired algorithms such as Sparrow, Monkey and Frog search Algorithms for finding optimal ambulance routes. The objective not only to find the optimal routes but also presents a performance comparison graph of these path planning algorithms, where it finds the most efficient algorithms in terms of path length and time-taken efficiency of these three algorithm and shows the strengths and weakness of each methods in the ambulance routing and any emergency system.

Keywords: Emergency services, Path Finding, Ambulance routing, Sparrow search algorithm, Monkey search algorithm, Frog search algorithm.

INTRODUCTION

In today's traffic areas, where emergency medical services (EMS) are important in various sectors where quick response is needed for saving human life. In past years, bio-inspired algorithms are using for optimal path finding from source to destination points. Our research paper performs an efficient path finding using these three algorithms- Sparrow, Monkey and Frog search algorithms. These algorithms are used for path planning in any scenario. The foraging behavior of sparrows, it is an effective optimization technique. Monkey search changes its paths depending on the nature and where frog search is more interested in fast exploration and adapting to changes. By implementing these three bio-inspired algorithms, it can offer various optimal routes in emergency medical services. Also, we define the comparative results of these algorithms, where get the efficient algorithm from these algorithms. This proposed paper aims to discover the optimal path for an ambulance to destination (hospital), in the grid map graph that gives the user to reach their point in shortest possible time.

2 BACKGROUND AND MOTIVATION

In urban areas, where emergency medical services are crucial where people in need to must be reached by ambulances as soon as possible in a quick response time, especially in crowded areas and unpredictable traffic conditions. By using inspiration from nature, we used the bio-inspired algorithms for ambulance routing. These algorithms present to find an optimal path solution in an emergency scenario. The purpose this work is to show comparison of each algorithm and to determine which is the most-effective algorithm for finding the optimal solution. Overall, we find the effective solution by applying these three algorithms in terms of time taken, and compare each individual result which algorithm work is most efficient for finding path from source to destination points.

3 LITERATURE SURVEY

He et al. (2024) introduced the advanced chaos sparrow search algorithms, especially for the planning complexities in hard areas, with a focus on unnamed aerial automobiles (UAVs). The experiment of UAV path planning is applied in simple and complex maps. The author shows the result of CSSA, PSO AND SSA algorithms with an improvement in time i.e., 22.4%, 46.8% and 28.8% in urban environments. The main conclusion is to show the usefulness and superior performance that exhibits the high convergency accuracy in the complex environments.

Wei et al. (2023) proposed the advanced sparrow search algorithm that aims to define the path route. By adding the Golden Sine Algorithm for searching globally, it integrates with the sparrow search algorithm. In this paper, Gaussian-Cauchy perturbation is also applied to enhance accuracy and address the nearby optimal path. It primarily focuses on optimized path length and ignoring the various objective optimization problem in the three-dimensional graph map.

Zhang et al. (2024) proposed an improved Sparrow search algorithm by integrates the chaotic cube mapping initialization, firefly set of rules and tent chaos mapping perturbation search. It uses to improve the capability of search and the various optimal solutions. Six methods were used to find the best optimization result of the proposed firefly set of rules. In conclusion, it shows the efficiency and optimal result of CFSSA algorithm and simulated the other four SSA techniques.

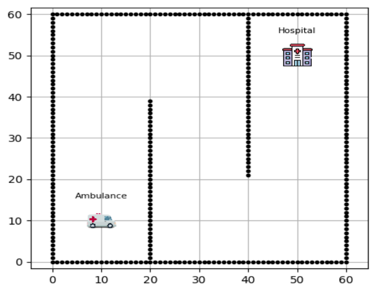
Saitou et al. (2024) introduced a novel swarm intelligence algorithm to integrate with Frog-Snake Prey-Predation Relationship optimization (FSRO). The main purpose of this approach is to adapt the nature of the snake i.e., find, approach, and seize and other to use the frog's nature-inspired optimization method operating within solution spaces. Overall, it shows that proposed algorithm is well-maintained search algorithm and has the capibilty of properly-balanced seek, reaching the two targets of improving accuracy and decreasing records.

Faujdar et al. (2023) suggested an innovative algorithm Hybrid Swarm-Intelligent Frog Jumping Optimization (HSIFJO) algorithm for finding the problems with Vehicle Routing with Time Windows (VR-TW). In VR-TW problems, the Hybrid Swarm-Intelligent Frog Jumping Optimization (HSIFJO) algorithm performs better than the traditional heuristics by utilizing new techniques. In summary, HSIFJO algorithm displays inspiring potential for resolving the problems in VR-TW and represent helpful in addition to the current methods of optimization for this issue.

4 METHODOLOGY

4.1 *Experimental Setup*: In our research for finding efficient path from source to destination point, we used the grid map graph with dimensions of 61*61, where ambulance is representing source point and hospital is destination point. In this graph, we also make some obstacles for finding the optimal routes in any scenarios like heavy traffic, rainfall, road closures etc. By using these setup, we applied these algorithms for showing how it works for finding the best optimal routes in the shortest possible time.

Figure 1. Grid Map Graph



4.2 *Data Collection*: By using the path planning algorithms- Sparrow, Monkey and Frog search algorithm, where each algorithms representing the results in graph using matplotlib library where it's easy to understand the path to the destination.

4.3 *Evaluation Metrics*: In evaluating the pathfinding algorithms, we focused on two key assessment metrics:

4.3.1. *Time Efficiency*: This metric gauges the computational time each algorithm consumes to identify the best route from the starting point to the destination. We logged the execution time for each algorithm across diverse scenarios and conducted an analysis to establish their average performance.

4.3.2. *Path Length Efficiency*: This metric quantifies the effectiveness of the paths produced by each algorithm in terms of the distance traveled by the emergency vehicle. We computed the total path length for every scenario and algorithm, comparing them to evaluate their efficacy in minimizing travel distance.

4.4 *Implementation*: Developing the pathfinding algorithms required converting abstract ideas into Python code that could be executed. To ensure clarity and promote reuse, we have developed improved modular versions of the Sparrow, Monkey, and Frog Search algorithms while keeping to the standards of object-oriented programming. We used blanket randomization approaches to simulate the stochastic decision-making processes included in the Frog and Monkey Search algorithms. We implemented visualization features with ease by employing the Matplotlib tool to show the global grid and the pathways created by the algorithms. We assured the accuracy and efficacy of our trials by carefully including these implementation details, which allowed for a thorough assessment of pathfinding algorithms customized for emergency vehicle routing scenarios.

5 PATH FINDING ALGORITHMS

5.1 *Sparrow Search Algorithm*: The Sparrow Search Algorithm (SSA) uses the natural methods to solve the problem in a way that seems similar to how sparrows feed. It finds the best possible result by continuously modifying a set of probably solutions. Every possible answer has an efficiency value that determines how efficient it is. The three main steps of the algorithm are modifications, extraction, and research. Like sparrows, which are experts at finding food, SSA seeks to effectively find optimal solutions by maintaining a balance between search and capture.

5.2 *Monkey Search Algorithm*: The Monkey Search Algorithm offer an innovative method to finding suitable solutions to difficulties. It was motivated by the way monkeys seek for food. This method uses a bunch of "monkeys," which are merely potential solutions for the issue. These monkeys investigate the problem field for evidence of the optimal answer. These solution monkeys move freely, just like monkeys in their natural environment. The same way that actual monkeys search for food, they are seeking to locate the optimum site. Our algorithm's monkeys continue working on their answers until they're close to optimal. In general, the Monkey Search Algorithm is an effective solution to issue solutions since it maintains a balance between examining various choices and exploring further into those that sound good in order to identify the optimal answer.

5.3 *Frog Search Algorithm*: The Frog Search Algorithm is a nature-inspired optimization technique that performs within solution spaces and is inspired by the effective exploring strategies of frogs. By using, this algorithm slowly improves possible answers in an effort to find the best answer for a particular problem. By combining these ideas, the Frog Search Algorithm efficiently explores and improves upon answers, taking direction from the quick and flexible foraging behaviors that frogs use in their native conditions.

6 RESULTS AND DISCUSSION

6.1 *Time Efficiency Results*

Comparing the Sparrow, Monkey, and Frog Search algorithms, notable differences in time efficiency are observed. Monkey Search stands out as the most time-efficient, with an average computation time of 5.12 seconds. Sparrow Search, due to its deterministic movement pattern, takes longer, averaging 15.62 seconds. Frog Search shows intermediate efficiency, with a processing time of 5.28 seconds. In situations requiring quick pathfinding, Monkey Search appears to be the preferred option due to its higher time efficiency.

6.2 *Path Length Efficiency Results*

Analysis of path length efficiency highlights variations in the efficacy of generated paths. Monkey Search demonstrates the most efficiency, with an average path length of 11462.37 units. Sparrow Search and Frog Search produce longer paths, averaging 16935.95 and 23811.07 units, respectively.

```
Time taken: 15.624670267105103 seconds
Time taken: 5.129509687423706 seconds
Sparrow Search Time Taken: 15.627015352249146 seconds
Sparrow Search Path Length: 16935.95583136935
Monkey Search Time Taken: 5.129735231399536 seconds
Monkey Search Path Length: 11462.377336282903
Frog Search Time Taken: 5.280786752700806 seconds
Frog Search Path Length: 23811.077615781414
```

Figure 2. Path length and time taken results

6.3 *Comparative Exploration Findings*

Upon comparative exploration, it becomes evident that Monkey Search yields the most efficient results overall. It generates shorter paths and achieves faster computational times compared to Sparrow and Frog Search algorithms, making it the preferred option for emergency vehicle routing in populated areas.

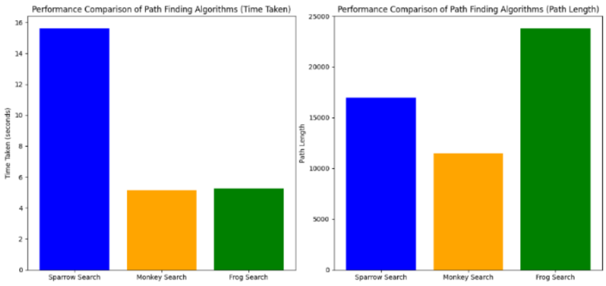


Figure 3. Performance Comparison Graph

6.4 *Discussion on Algorithm Efficiency and Suitability*

By defining each algorithms individually, we discuss the most efficient and suitable algorithm in the emergency navigation systems:

6.4.1 *Sparrow Search Algorithm*: In Sparrow search algorithm, it takes the highest time for finding route from source (ambulance) to destination (hospital) but its path length is less as compared to Frog search algorithm. Sparrow search is less efficient by taking the more time where in emergency scenarios each second's count.

6.4.2 *Monkey Search Algorithm*: The Monkey Search algorithm is the most efficient algorithm in both the efficiency results. It takes the shortest route from source (ambulance) to destination (hospital) point i.e., 5.12 units at 11462.37 seconds. By comparing the other three algorithms, it's more suitable and efficient for finding an efficient path find in emergency areas.

6.4.3 *Frog Search Algorithm*: Frog search is less efficient as compared to Sparrow and Monkey search algorithms. It takes the longest route from source (ambulance) to destination (hospital) point i.e., 23811.07 units, but it's quick in time i.e., 5.28 seconds as compared to Sparrow search Algorithm i.e., 15.62 which is the highest time taken to the destination.

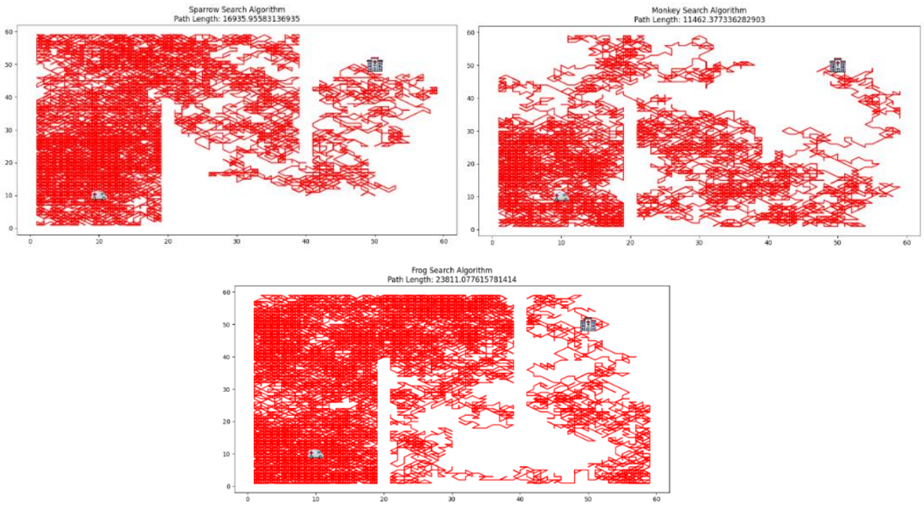


Figure 4. Path Finding using Sparrow, Monkey and Frog Search Algorithms

In the above results of each algorithm, shows the path finding results from source to destination point by using Matplotlib library to define the efficient path length in the grid map. Each algorithm is defining path length from moving to destination(hospital), where Monkey search is the most efficient algorithm by taking less time as compared to other algorithms. Below represent the table of each algorithm's performance summary of how each algorithms works:

Table 1. Algorithm Performance Summary.

Algorithm	Time Taken (seconds)	Average Path Length (units)
Sparrow Search	15.62	16935.95
Monkey Search	5.12	11462.37
Frog Search	5.28	23811.07

7 FUTURE SCOPE

In future these algorithms can be implemented by finding an optimal path in critical situation. We make efforts to improve and optimize existing algorithms to work better in urban environments. Furthermore, these algorithms can also be used by combining different algorithms to create more advanced solutions that can help people to reach their destination points in an efficient time. It's important to continue developing and researching these algorithms, that improve the urban traffic or emergency problems which will lead to optimal and user-friendly results.

8 CONCLUSION

The purpose of this research was to find an efficient path for emergency vehicle navigation by using Sparrow, Monkey and Frog Search Algorithms and compared the efficiency of these three algorithms in terms of path length and time taken results. Among the three algorithms is tested, the Monkey Search Algorithm is the most efficient algorithm for finding optimal path from source point to destination point with a duration of 5.12 seconds and with an average path length of 11462.37 units. It's the best suited algorithm when both efficient path and time are essential for saving some lives.

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