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Finding the Optimal Path using anytime Repairing A* Algorithm in Dynamic Environment

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ABSTRACT

This research builds the heuristic function utilized in the conventional A-star method to introduce a path-planning planning algorithm. The reduction in the number of nodes investigated is the primary justification for switching from the Dijkstra algorithm to the A-star method. This project's major goal is to minimize the number of nodes examined and the turning angles. The features are established using the grid technique. Instead of maintaining a search graph, this approach maintains a search tree. Hence, nodes that have already been studied along a different path can be avoided via Anytime Repairing A-star (ARA).In order to do this, a method known as "incremental heuristic search" is used, in which the heuristic function is modified throughout the search to include information about the cost of travelling to the target from the current node. This enables the algorithm to proceed in the desired direction even if the cost of travelling between nodes fluctuates, or in the presence of dynamic impediments.. By utilizing Octile distance as a heuristic function, the number of nodes studied is reduced by around 56% to 81% and the number of turns is decreased by 50% to 75%. Additionally to deal with dynamic environments in which the obstacles itself has dynamic behavior may cause more colliding perspectives and increase the percentage of colliding with the mobile robot, to overcome that the dynamic window approach (DWA) is majorly introduced with two major approach within it, which prevents collision and also to reach its goal destination with optimal solution. As this DWA is proposed to be a collaboration with A-star which was introduced earlier, it basically take the path which is generated previously by A-star and accomplishes it into DWA as reference path in a dynamic environment.

KEYWORDS: Anytime repairing A (ARA), Octile Distance, DWA, trajectories.*

1. INTRODUCTION

Anytime repairing A* (ARA), Chebyshev Distance, Octile Distance, DWA, optimal path finding, trajectories, mobile robot. reduction in time to respond to any deductions without impact to payment for the invoice and unpredictability in working capital planning.

Anytime repairing A* (ARA), Chebyshev Distance, Octile Distance, DWA, optimal path finding, trajectories, mobile robot.

It is possible to use both local and global route planning techniques in the process of path planning. Using projected positions of both static and moving obstacles, DWV developed options for obstacle-avoidable paths. Simulators and tests were used to show how the suggested strategy worked. The dynamic window technique is utilized to simulate three grid settings with dynamic obstacle distribution, and the enhanced DWA with adaptive output evaluation function weights may smooth out the planning path at the turning points without altering the initial path planned by the A algorithm. Along with halting in front of obstacles, spinning close to the target point, and having a poor obstacle avoidance path, the new fusion algorithm also helps to address these issues.

STRUCTURE OF PAPER

The paper is organized as follows: In Section 1, the introduction of the paper is provided along with the structure, important terms, objectives and overall description. In Section 2 we discuss related work and the complete information about algorithms used. Section 3 tells us about the methodology and the process description. Section 6 tells us about the future scope and concludes the paper with acknowledgement and references.

OBJECTIVES

The Aim of this proposed system is to build an optimal path in a known environment and plan a path accordingly when dynamic obstacles are generated. Initially, path need to be planned in a known environment using Improved A star algorithm which reduces the number of nodes from start to destination, which in-turn reduces the path length and number of turns. Then build a local path based on dynamic obstacles generated in the environment using Dynamic Window Approach while the robot is moving in the global path.

2. RELATED WORK

There are numerous works that have been done related to the Optimal path .

The Dijkstra algorithm [1] and the A-star algorithm [2] are the two most widely used path search algorithms included in the search algorithms. By going through every node, the Dijkstra algorithm determines the shortest path. Although obtaining the path is frequently successful, computing efficiency is generally poor. The A-star algorithm is simpler and more direct than the Dijkstra algorithm in solving the shortest path issue, but it also has a higher propensity to enter the local optimum.

Nonetheless, a cross path and sawtooth path will be produced when the A-star method is applied for path planning in complicated situations [3]. The A-star algorithm's efficiency will be significantly impacted by excessively big or complex environments.

A random search algorithm known as a "bionic algorithm" mimics the biological evolution of living things or group social behavior. Path search procedures have been subjected to a number of algorithms, including the particle swarm optimization (PSO) algorithm [4], genetic algorithm (GA) [5], and ant colony (AC) algorithm [6].

An arrangement of continuous polygons composed of vertical bisectors that join two adjacent straight lines make up a Voronoi diagram. A path to avoid obstacles was generated by Candeloro et al. [7] using a Fermat spiral after they partitioned a scene including obstacles using a Voronoi diagram. The created path is relatively safe thanks to a Voronoi diagram. The majority of algorithms, however, use a lot of storage space and cannot ensure an ideal path length.

In reference paper [8] Path planning based on the improved A* algorithm belongs to the query phase of the probabilistic roadmap planner. The probabilistic roadmap planner consists of two phases: a preprocessing phase and a query phase. In the preprocessing phase, collision less sampling points are generated randomly in robotic configuration space and detected by Hybrid Bounding Volume Hierarchy Tree algorithm and also be called nodes during the query phase of the probabilistic roadmap planner, and then a local safety and collision less path was built between the sampling points b local path planner.

The DWA algorithm[9] aims to avoid obstacles in the dynamic environment by focusing on the speed and length of the path where mobile robots go. This has become increasingly important in recent years, as autonomous dynamic environments need to work in uncontrolled environments with dynamic goals. Simulation experiments have shown that the proposed DWA has better performance than original DWA.

DWA is a path planning method composed of a VM for static and dynamic obstacle avoidance[10], generated by variable velocities to determine the path candidates. It considers kinematics and dynamics constraints. A VM for static and dynamic obstacle avoidance, produced by varying velocities to identify potential paths, makes up the DWA path planning approach. Kinematics and dynamical restrictions are taken into account.

By combining global planning and local planning, the suggested approach[11] is intended to increase the smoothness and effectiveness of robot path planning in complicated situations. The enhanced A-star algorithm and the flexible Dynamic Window Approach make up this system (DWA). The algorithm successfully increases the path's smoothness and safety, and the evaluation function's weight is changed to prevent being stuck in a local optimal solution. To further enhance the path's smoothness and to avoid obstacles in real time, the evaluation function with a smoothing effect is created.

The line acceleration and rotational acceleration of a robot are used in the widely used DWA path planning method to create the trajectories[12], with the optimum trajectory being selected using an evaluation function. We provide an efficient algorithm to shorten the intended path, improve it, and still leave the robot with ample safe space. The outcomes of the simulation demonstrated that the optimization algorithm is capable of planning a shorter path with a minimal amount of processing time.

The suggested mobile robot navigation algorithm employs the A star algorithm to plan the course to avoid static obstacles, a stage target selection strategy, and an upgraded dynamic window approach with the speed obstacle method to address the issue of colliding with moving objects. The simulation outcomes demonstrated that the suggested algorithm[13] compared the global path's optimality while providing real-time obstacle avoidance, simplifying motion control and navigating shifting obstacles.

For USV (Unmanned Surface Vehicle) applications[14], path planning is a crucial problem that often incorporates both global and local path planning techniques. DWA is suggested as a hybrid algorithm that combines global and local path planning in order to get over the drawbacks of individual global path planning algorithms. Using the local goal point as a guide, the dynamic window algorithm (DWA) tracks the global path while avoiding the dynamic impediments. As the level of the sea state rises, the security of USV can be ensured by decreasing the weight of velocity and raising the body weight of distance by adding the weight coefficient taking sea state into account. To create a global path for USVs on the world map, A* and DWA are employed.

The fusion method, an improved A* algorithm[15], was developed to address the issue of global path planning by enhancing the heuristic function, removing the global ideal key path intersections, and condensing the search directions. It performs better in terms of distance than the conventional A' algorithm and smoothens the path by taking into consideration the particularities of the marine environment. Based on the improved dynamic windowing method and the optimized A * algorithm, the fusion algorithm has a stronger anti-disturbance ability and higher stability when travelling in both the same direction and the opposite way. Global dynamic path planning fusion algorithms will be created in the future.

This study suggests an enhanced dynamic window strategy[16] that takes into account the classic DWA algorithm's properties for UAV formation and obstacle avoidance. The focus of the suggested approach is on the azimuth angle evaluation function for the target distance correction, the A-star algorithm, a novel rotation cost and penalty for large rotation angles to guarantee a smooth trajectory, and a leading-following consistent creation algorithm. To confirm these effectiveness of the modified algorithm for Multi-UAV formation cooperative obstacle avoidance, simulation experiments and verification are carried out.

3. METHODOLOGY

The A-STAR approach, which combines the advantages of Best First Search and Dijkstra algorithms, can guarantee that the ideal path will be discovered in a static environment and can also boost efficiency through heuristic search, making it suitable for accurate demand planning. In a 2D grid map, the A-STAR algorithm selects the next node based on the evaluation function:

f (n) is $f(n) = g(n) + h(n)$ (1)

The formula (1), where h (n) represents the anticipated cost from the current node to the target point and g (n) represents the cost from the start point to the current node; Manhattan distance and Euclidean distance are factors in the distance computation heuristic function of the A-STAR method.

$$\sqrt{((X1 - Y1) * (X1 - Y1) + (X2 - Y2) * (X2 - Y2))} \quad (2)$$

$$Abs(X_1-Y_1)+Abs(X_2-Y_2) \quad (3)$$

Chebyshev Distance:

$$MAX(abs(X_1-Y_1),abs(X_2-Y_2)) \quad (4)$$

Octile Distance:

$$(1.414 * (min((X_2-Y_2) + abs(X_2-Y_2)) \quad (5)$$

Where the target point G's coordinates are , The coordinates of the current node are (Xg,Yg) (Xn,Yn). Equation (2) represents the Euclidean distance, while equation (3) depicts the Manhattan distance. Equation (4) indicates the Chebyshev distance, while Equation (5) illustrates. In this study, all of the heuristic functions are used to test the algorithm.

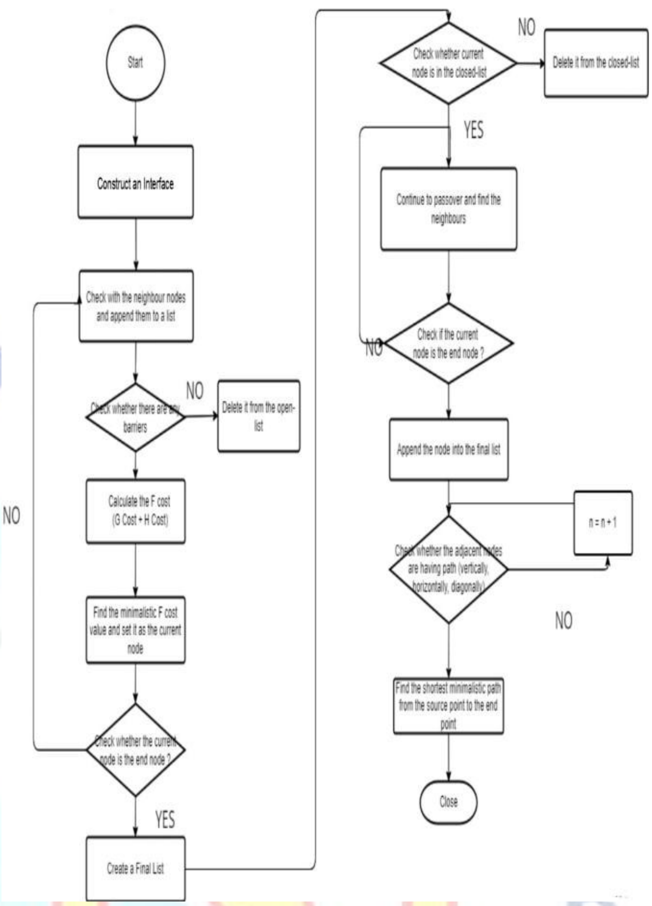
ARA Algorithm

The operating phases for the ARA algorithm are as follows, and Table 1 depicts the method's flow First, add the eight nodes near the start point to the open-list.

Step 2: Ascertain the nearest nodes' cost functions, f (n). If the node is an obstacle grid, the start point is added to the close-list, and the node with the smallest substitution value is selected as the grid for the subsequent pass.

Step 3 involves adding the node that is next to the current node n but not in the close-list to the open-list. The current node will then serve as the parent of the newly generated node. Use that node as the parent node of the newly added node and recalculate the node value's f(n) to see whether the distance g(n) from the start point to the current node is smaller if the nearby node already exists in the open-list;

Step 4: Step 3 must be repeated in order to add the goal point to the close-list. Start your search from the goal point and go along the parent node to establish a path that connects the start point and the goal point;



Step 5: All nodes on the close-list are evaluated once the goal point is added using the functions P (x, y) and W (x, y), and any that fail muster are removed;

Step 6: After Step 5, determine if there is a decrease in the number of nodes in the close-list. If so, continue to Step 5; if not, exit the loop, add the final few nodes to the list, and make a final decision.

Step 7: Connect the remaining nodes to form a new path and smooth the turning path at the same time.

Dynamic Window Approach

Dynamic Window Approach (DWA) is a popular and widely used local based path planning algorithm used to plan the path of a mobile robot in a Pygame environment. It is divided into two parts: global path planning and local path planning. DWA generates paths by considering the robot's configuration and the kinematics of the robot, and it also avoids dynamic obstacles. The DWA planner is efficient and mostly used for mobile robots, as it considers the robot's configuration and kinematics. The DWA planner uses a mathematical model to generate candidate trajectories for the robot's motion, which can be discredited based on time intervals. These trajectories are represented by the equations X = x + (u cos (theta) + v cos (pi/2 + theta)) dt, Y = y + (u sin (theta) + v sin (pi/2 + theta)) dt, and Theta = theta + omega * dt.

Those that do not satisfy the velocity limits are simply discarded, and the candidate trajectories that pass through any obstacle are also rejected.

From these remaining candidate trajectories, we select the best trajectory based on an optimization function. The target heading term gives more value to those trajectories that follow the global path and helps the robot reach its final goal. The clearance term of the optimization function penalizes those candidate trajectories that are in close proximity to the different obstacles. The velocity term in the optimization function rewards those candidate trajectories that help the robot move faster.

4. FUTURE SCOPE AND CONCLUSION

The Anytime repairing A-star method, which is described in this paper, is a new path planning algorithm with a distinct heuristic function. Its goal is to improve the erroneous path produced by the conventional A-star algorithm and decrease the number of nodes the algorithm explores. The studies demonstrate that our approach has a high success rate, provides feasible pathways, and the screening time is relatively quick when combined with the benefits of an interpolation algorithm. The A-star method first generates a viable path, after which a screening function optimizes the irregular path.The hybrid path planning method is suggested in this research based on the advancement of A*. In order to make up for the A* algorithm's lack of timeliness, it incorporates the DWA algorithm for real-time obstacle avoidance. To achieve the optimization of route length, smoothness, and safety performance, the global path-related information is combined to plan the ideal path. The suggested fusion algorithm of improved A* and DWA's real-time, validity, and security are confirmed by contrasting the simulated experiments.

The path planning of mobile robots in multi-task difficult settings will be further investigated by fusing deep learning and machine vision in the future. Robot path planning algorithms will be studied in a variety of areas and scenes.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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