Funding Proposal

Comparing the Performance of Depth First Search and Breath First Search for a Robot with Energy Constraints Exploring an Unknown Environment

PROJECT DESCRIPTION

1 Introduction

There are many instances in which we must rely on robots to explore environments which humans cannot. A couple of examples would be deep ocean floor mapping and terrestrial object explorations (such as Mars). Robots are also helpful in solving problems closer to home as searching for missing persons in disaster zones. However, considering the expenses necessary to carry out such operations, we must make sure that the robots search their environments in the most efficient and cost effective manner possible.

There are many algorithms that can be used to help a robot traverse an unknown environment but when selecting an algorithm for a robot to use in big operations we would like to pick the one which performs the best. In order to do this there must be a standard evaluation metric which we should use to compare the performance between different algorithms.

In this proposal, we ask for funds to help evaluate and compare searching algorithms in real-world environments as we believe this is the optimal to get a true reading of an algorithm's potential.

Comparing and creating new algorithms to search an unknown environment is not new but hardly has it been done with a robot's energy capacity kept in mind. However, in a real world environment, a robot would not have an infinite energy supply so it is prudent for us to consider this constraint when comparing algorithms.There have been a few studies where researchers evaluate the performance of their algorithms when a robot is given this energy constraint, but their performance metrics vary which makes it difficult to asses which algorithm actually performs better.

In the short term, we hope that the work we do will help revolutionize the searching capabilities of robots in disaster recovery efforts. In the long term, we hope that robots will be more broadly and effectively used in searching hazardous and unknown environments such as the deep ocean floor and terrestrial objects.

In the remainder of the proposal we will discuss work done by fellow researchers in the field as well as discuss our own work. We will then outline the evaluation metric we plan to use to compare different algorithms, and discuss our management plan, significance of our proposed word, its intellectual merits as well as the broader impact it will have.

2 Initial Work

In our initial work, we have wrote a paper that compared different methods of searching an unknown environment, namely Depth First Search (DFS) and Breadth First Search (BFS). In our simulations, the robot which will be searching the unknown environment will have an energy constraint which requires it to return to a charging station to recharge its battery before it continues its exploration. Though this research we looked to compare two widely know methods (DFS and BFS) to help serve as a base of comparison for other algorithms.

3 Past Work

While few in number there has been research done by other scholars in this topic. For instance, Strimel and Veloso used a boustrophedon decomposition to cover an unknown environment [1]. In this method, the robot returns to the charging station when its energy level is too low to continue the coverage. Mishra *et al.* designed a coverage planning algorithm which uses multiple robots to traverse the unknown environment [2]. This method involves splitting the robots into two groups, workers and helpers. When a worker needs to recharge its battery, an associated helper will continue the worker's coverage. Though these studies added useful information to the topic, neither of them formally analyzed their algorithms and instead only looked to prove that their methods correctly covered every point in the environment. Through our research, we have set a precedent of comparing algorithms based on the same parameters. This will help decide which algorithms are superior so that they can be used practically.

4 Methodology and Evaluation

The goal of this project is for a robot to traverse every point in an unknown environment while having to return to a charging station (which will be placed at the robot's starting point) whenever its battery runs low. Thus the starting point and end point will be the same as the robot must return to its charging station once its traversal is complete. The input for this project was a grid environment with a random distribution of obstacles which will be traversed using DFS and BFS. The grid environment here was simply a graph with nodes and edges that resembles a square grid. Depth First Search (DFS) is an algorithm for traversing or searching tree or graph data structures. The algorithm starts at the root of the tree and traverses as far as possible down the tree's branch before backtracking. The time complexity for this algorithm is $O(b^d)$ where b is the branching factor, in this case two, and d is the depth of the tree. Breath First Search (BFS) is similar to DFS except it traverses all the nodes at the present depth of the tree before going to the next depth level. The time complexity for this algorithm is also $O(b^d)$. The environment can be traversed in all four cardinal directions and each node in the grid has a maximum of two parents and two children. The output here will be the path/paths taken by the robot to traverse the entire unknown environment. Three environments were created: a

100x100 environment, a 200x200 environment, and a 300x300 environment. Each environment had a random obstacle distribution where the obstacle percentage can be either 10%, 20%, or 30%. The environments were created using Graph Stream, an open source Java graph handling package available online [3]. The two unique data sets that were collected are time taken to search the environment, and the length of the path taken by the robot to search the environment. This data will help serve as a simple evaluation metric to compare the two searching algorithms.

5 Time Line and Management Plan

January 2021: Procure the necessary equipment needed to test the algorithms in a real-world environment.

Feburary 2021: Test the DFS and BFS algorithms in the real-world environment, and identify ad resolve any bugs in the testing environment.

March 2021: Test other algorithms in this environment.

April 2021: Test various real-life scenarios that may occur while traversing an environment and see how each search algorithm adjusts to these different scenarios.

May 2021: Compile the results of the various algorithms and deduce any conclusions that can be drawn from them.

June 2021: Compile and submit a paper that contains the various findings of our research.

6 Summary: Significance of proposed work

6.1 Intellectual Merit

Robots are increasingly becoming more prominent in our lives. There is a need by researchers to optimize the algorithms used by these robots in order to produce the best results. Searching/traversal problems has long been a prominent issue in robotics specifically and artificial intelligence more broadly. As robots become more commercialized, our research hopes to put in place a standardized evaluation metric to help compare various algorithms so that the best one may be chosen and ultimately implemented.

6.2 Broader Impacts

Our evaluation metric hopes to help pick the most optimal algorithms so that they may be used by robots in industry. We hope that this will serve as a precedent and that similar steps will be taken in other fields where robots are becoming more prominent such as in healthcare. In short, we hope that our work in the long run allows robots to be more effectively and broadly used in our society.

7 References

[1] Grant P. Strimel and Manuela M. Veloso. 2014. Coverage planning with finite resources. *2014 IEEE/RSJ International Conference on Intelligent Robots and Systems* (2014), 2950–2956
[2] Saurabh Mishra, Samuel Rodríguez, Marco Morales, and Nancy M. Amato. 2016. Battery-constrained coverage. In *CASE*. IEEE, 695–700.
[3] GraphStream - A Dynamic Graph Library.[online] Available at: https://graphstream-project.org/