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Literature Review

Introduction

The issues surrounding path planning algorithms, or algorithms that enable for navigation from two locations through a variety of obstacles, have long been discussed. The reason being the potential wide variety of applications for these algorithms. These include traversal through “industrial, military, hospital, school, and office” settings (Martins). What makes for an efficient algorithm is the number of states that have to be explored, the time taken to calculate the best path, and whether or not the path generated is even the best path. Since each algorithm has it's pros and cons, the decision has to be made for which algorithm to be implemented in which scenario. This decision is not simple however, as all the factors need to be considered against each other.

Literature review

However, When looking at the current research, suggestions are made that neural networking algorithms are the most efficient across the board (Martins, Zhang). However, there

are a few disagreements amongst researchers as some claim that the efficiency of an algorithm will depend on the factors surrounding said algorithm (obstacles, local or global path, etc.). There are many trends presented in this paper including agricultural studies regarding path planning algorithms as well as studies regarding neural networks. There are also multiple miscellaneous studies regarding each individual path planning algorithm. However, there is little to no research regarding the combination of neural networks and path planning algorithms.

Review of Path Planning Algorithms

The age-old problem of attempting to traverse a finite distance in the shortest possible time has yet to be fully solved. There have been potential solutions, but they do not work for all circumstances (**Martins**). An example of this was in the study conducted by Garip regarding the use of multiple robots working in tandem with each other. It was discovered that there is not one possible solution to the problem and that depending on the variables presented alterations had to be made to the solution. **This confirms the work of Zhang in a study detailing the impacts of specific planning algorithms upon each other**. In this study, Zhang explains that planning algorithms work by taking all the destinations adjacent to the current location and then calculating the efficiency of each traversal. After calculating that, the algorithm will continue to explore until it either reaches its destination or to a state where there are no more nodes available to explore. If there are none to explore, the algorithm will continue to explore from the last place that contains possible destinations to traverse. However, these algorithms use different types of data structures, changing the efficiency and accuracy of the algorithm.

Machine learning

To begin, a majority of the work being done in the field of computing is with the use of machine learning and neural networks. Machine learning is teaching a computer to be able to think and behave like a human, in that the machine will "learn" with the experiences it will receive. The "learning" is done by training the network by presenting it with thousands of data points such that the computer will be able to determine patterns based upon the data it is receiving. As the computer runs through the data, it will update weights in a function so that a line of best fit is determined. The current literature also discusses the method of training a neural network. Leenings, in her 2021 paper, discussed the work her and her team were doing regarding making model training much more efficient. They discussed their novel software, Photonapi. This piece of software enables efficient model training and development such that the user can quickly use the model for further applications. **The work done by Leenings and her colleagues draws a parallel with the work done by Stimberg**. In his paper, Simberg discusses the development of the spiking neural network, Brian 2. A spiking neural network is a network that is developed specifically to mimic central nervous systems of living organisms. The implications of this are vast as being able to mimic biological creatures will enable humans to be able to better understand how biological systems work, such as the brain and the nervous system. There are also studies in the current body of knowledge that deal with neural networks in a different application. That being the training of an industrial robotic arm (Solovyeva and Abdullah). In the manufacturing industry, robotic arms are used in order to automate a majority of the required tasks. To learn the tasks that they need to perform, these robotic arms are given a machine learned algorithm to follow which is what is conveyed by Solovyeva and Abdullah. In their

study, they manage to **build the conceptual framework** for machine learning model application and clearly details the entire process including model training, dealing with errors in testing, and finally producing a working solution.

Agricultural Studies

In addition, the body of knowledge presents a vast quantity of past applications with neural networks. A large subset of these applications include agricultural based studies. The reasoning behind this is that the global population has been increasing, yet agricultural production has not been able to keep up, leaving millions starving across the globe. This led researchers to using mathematical models to estimate the best circumstances (weather, water consumption, planting density etc.) to produce more crops (Dong). A forerunner in the current body of knowledge is the work presented by **Eski and Zeynel** in their 2019 study regarding agricultural production. They present the idea of using a robot, in tandem with a neural network, to perform the actions normally done by humans, for example hoeing, seeding, watering. This study established a connection between robotic efficiency and neural networking solutions. The work presented led to further research being done by Zhao and colleagues. In their study, Zhao discovered that apple harvesting done by a robot can make the process more efficient, yet further innovation and technology is needed. The current body of work presented in this area of study suggests that machine learning is able to revolutionize the agriculture industry, provided the right parameters are considered and proper testing is done.

Further Studies with Planning algorithms

Researchers are also currently looking into the potential of path planning algorithms being used in a wide variety of studies as well. Most notably, is the work done by Wu. In his 2021 study regarding photovoltaic power generation panels (solar panels), Wu came across a problem with how to arrange said panels. This led to the experimentation of using a path planning algorithm to lay out the best possible grid of solar panels. Throughout the study, Wu presented a clear evaluation of the Hybrid Bird Swarm algorithm that was implemented as well as potential improvements to the current solution. This is similar to work done by Wang in his 2021 study regarding the use of the popular Dijkstra's algorithm to be able to develop a parking layout. The similarity being that both instances looked at the best possible solution to a problem. However, this is a more unique situation to use a planning algorithm in, due to the lack of a clear path that it is trying to follow. There is also a robotic study done by Marin-Plaza detailing the use of global and local path planning algorithms in an ROS platform. ROS stands for Robot Operating System and is the industry standard for robotics software. The importance of this study can not be understated as Marin-Plaza manages to bring abstraction layers upon the standard path planning algorithm. Ultimately, there are many uses for machine learning, highlighting it's potential benefits to many industries, the usage of these models should be implement in more areas.

Individual Path Planning Algorithms

In order to thoroughly evaluate all the path planning algorithms against each other, researchers are attempting to implement studies around each individual algorithm in order to test

the algorithms' limits. A novel study conducted discusses the speedup of the popular A* algorithm. Speeding up an algorithm is a technique done in order to make an algorithm more efficient by allowing the algorithm to run in less time (Liang and Ming). The reason that this study is one of a kind is that most algorithms were considered to be the most efficient in their current state and making them more efficient has not really been seen. Another study that has been seen is that conducted by Li-Xin and Wang. Their study addressed the use of a path planning algorithm, Sampling-Based Model Predictive Control, in a search-and-rescue application which is the one of the most important applications of this technology. These studies contrast that conducted by Liu which details a page ranking algorithm, algorithm used by google in order to rank different web-pages for usage by the search engine, executed by using a minimax comparison algorithm. Minimax is an algorithm that is used to determine the best possible outcome by ranking every outcome and comparing them against each other. This is different from the current body of knowledge as a majority of the work already deals with algorithms that might potentially produce an incorrect solution while minimax does not and can therefore be beneficial in instances where time is not of the essence. There is also a study done by Zhong which details the use of the popular Djikstra's algorithm in a seaport in order to find the most efficient navigation path through the port. The importance of this study is vast as Zhong details pseudocode examples and detailed outlines of the entire project.

Gap in the Current Literature

Though there has been extensive research done regarding path planning and machine learning, there has been little to no research done about the implementation of both in order to

increase efficiency. It is vital that this question be addressed as resources could be saved with the development of this study. This raises the question, to what extent can path planning algorithms be used with machine learning algorithms in order to increase their efficiency? Across smaller scale environments, the neural network model will have little to no effect as there will be less states to explore therefore rendering the time saved to be less. However, across larger scale environments with multiple paths to follow, the neural network will be able to deduce the best possible algorithm to follow and how exactly to solve problem.

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