

Research Question: To what extent can neural networks be used with path planning algorithms to increase the overall efficiency of autonomous robots.

Annotated Bibliography

Bayraktar, Ertugrul, et al. "Object Manipulation with a Variable-Stiffness Robotic Mechanism Using Deep Neural Networks for Visual Semantics and Load Estimation." *Neural Computing & Applications*, vol. 32, no. 13, July 2020, pp. 9029–9045. *EBSCOhost*, doi:10.1007/s00521-019-04412-5.

This study looks at manipulating a robotic arm with different weighted masses using a neural network in order to get the best results. The study was a success as the arm was successfully able to manipulate the weights without failure. This source is in fact credible. This is due to the fact that Ertugrul Bayraktar and his colleagues conduct research for the prestigious Yildiz Technical University. Their work was also published in the peer reviewed journal called *Neural Computing & Applications*. This study pointed out some key information. Bayraktar and his colleagues hypothesized that implementing a neural network would increase the productivity of the robot. This in fact connected to the body of knowledge as a majority of these robotics applications mention that neural networks increase efficiency. This study will be used in order to convey some more important information about how to utilize neural networks in robotical applications in my study.

Chaves-Osorio, J. A., et al. "Two Agents with GBFS Algorithms Working Cooperatively to Get a Shortest Path." *Scientia et Technica*, vol. 25, no. 3, July 2020, pp. 448–454.

EBSCOhost, doi:10.22517/23447214.24341

This article discusses the effects of Greedy Best First Search, a path planning algorithm, on both the target and starting node. The study addresses the use of collaboration in path planning and it concludes that collaborating will produce the best results in terms of efficiency of the path. This study developed the conceptual framework for the use of GBFS in a planning algorithmic study. The lead researcher, J.A Chaves-Osorio, conducts research for the prestigious Universidad Tecnológica de Pereira located in Pereira, Colombia. He also managed to publish his research in the peer-reviewed journal called *Scientia et Technica*. This confirms the credibility of the work presented in this paper. This work presents similar results to those discussed in the body of knowledge. Therefore, it will be used in the introductory piece of the paper. The research presented will most likely be use to contextualize and corroborate all the different types of planning algorithms.

De-An, Zhao, et al. "Design and Control of an Apple Harvesting Robot." *Biosystems*

Engineering, vol. 110, no. 2, Oct. 2011, pp. 112–122. *EBSCOhost*,

doi:10.1016/j.biosystemseng.2011.07.005.

This article discusses the application of robots in using an apple harvesting robot. This robot will be able to automatically harvest apples using a neural network to locate the apples and the success rate was 77 percent. The credibility of this source can not be put into question as De-An conducts research for the prestigious Electrical and Computing College at Jiangsu University. Also, their study was published in the peer-reviewed journal called Biosystems Engineering. The work presented advanced the notion of neural network integration in an agricultural environment. This study however, specifically concentrated on the use of an apple harvesting device. This relates to the body of knowledge as this is an example of a specific agricultural study. This source will be used as a quantitative review of an application of a neural network. The work presented in this source will be used in the body of knowledge to better contextualize the problem.

Dong, Fuhong, et al. "Development of a Row Guidance System for an Autonomous Robot for White Asparagus Harvesting." *Computers & Electronics in Agriculture*, vol. 79, no. 2, Nov. 2011, pp. 216–225. *EBSCOhost*, doi:10.1016/j.compag.2011.10.002.

This article discusses the use of an autonomous robot in harvesting white asparagus. This study attempts to help make the task of harvesting much more efficient. The study concludes that the harvesting happened to a margin of error of ± 0.5 cm. The main author of this source, Fuhong Dong, conducts research for the Otto von Guericke Universitaet Magdeburg, a prestigious institute located in Germany. Also, he and his team managed to get their work published in the

peer-reviewed journal called Computers & Electronics in Agriculture. This confirms the credibility of Dong and his colleagues. The work published in this journal managed to establish a connection between another agricultural study, the one conducted by De-an Zhao relating to apple-harvesting. This study will relate to the existing agricultural studies and will build upon the existing literature. The agricultural applications are quite important to the study and will be sprinkled throughout the paper.

Dusseault, Bernard, and Philippe Pasquier. "Efficient G-Function Approximation with Artificial Neural Networks for a Varying Number of Boreholes on a Regular or Irregular Layout." *Science & Technology for the Built Environment*, vol. 25, no. 8, Sept. 2019, pp. 1023–1035. *EBSCOhost*, doi:10.1080/23744731.2019.1634932.

This article commented on a potential application of a neural network regarding bore holes. The study specifically looks at predicting the mean temperature of these boreholes using the network. Bernad and Pasquier, both researchers from Polytechnic Montreal, one of the premier universities in Canada, managed to get their study published in one of the best peer reviewed journals. This being the Science & Technology for the Built Environment. This study connects to the current literature as it describes a potential application for neural networks that is apart from robotics. The information in this study relates to the body of knowledge as it shows the extent to which neural networks can increase the efficiency of an application. This study is relevant as it highlights the potential of

neural networks in an application apart from robotics, therefore allowing comparisons with a robotics application. It will be used in my study to contextualize neural networks and their usage.

Eski, İkbāl, and Zeynel Abidin Kuş. “Control of Unmanned Agricultural Vehicles Using Neural Network-Based Control System.” *Neural Computing & Applications*, vol. 31, no. 1, Jan. 2019, pp. 583–595. *EBSCOhost*, doi:10.1007/s00521-017-3026-4.

This paper discusses the use of neural networks in agricultural robots. The authors of this paper used a neural network to allow for an unmanned agricultural vehicle to perform farming tasks such as seeding, hoeing, weeding, etc. The researchers measured the performance by looking at things such as rise time, peak time, settling time etc. These metrics allowed for the conclusion to be generated that the control system produced the best results. İkbāl Eski and her colleagues are from the prestigious Erciyes University located in Turkey. They were also able to publish their study in the *Neural Computing & Applications* peer reviewed journal. This study focused on an agricultural application of a neural network. This study cited the need for using neural networks in order to automate the agricultural process and increase the efficiency of robots. This connects with the information in the body of knowledge as many researchers based their work off of this specific study. Those researchers on the other hand, looked into specific plant applications such as apples and asparagus. This study is key for my study as it is one of the cornerstone sources that can illustrate some facts about the existing

literature.

GARIP, Z.BATIK, et al. "Path Planning for Multiple Mobile Robots Using A Algorithm." *Acta Physica Polonica, A*, vol. 132, no. 3, Sept. 2017, pp. 685–688. *EBSCOhost*, doi:10.12693/APhysPolA.132.685.

This source is another detailed look at how path planning algorithms work and how they can interact with robots. This study also looks into multiple robots running in the same environment and how exactly to prevent the robots from impeding each others' progress. Professor Garip and his colleagues are credible researchers as they work in the distinguished Sakarya University in Turkey. Also, their study was published in the peer reviewed journal *Acta Physica Polonica A*. This Polish journal is considered to be one of the premier peer reviewed journals in Europe. The research presented in this paper affirms the work of Oluwaesun Martins and Han-ye Zhang. But, this source identified and reported a unique perspective that was not considered before. The mention of using the A and A* family of algorithms was not explored and the study concluded that these algorithms are in fact efficient. The relevance of this source is quite large as it provides some of the background information about path planning algorithms as well as their implementation in an environment with other robots.

Guo, Na, et al. "A Fusion Method of Local Path Planning for Mobile Robots Based on LSTM Neural Network and Reinforcement Learning." *Mathematical Problems in Engineering*, June 2021, pp. 1–21. *EBSCOhost*, doi:10.1155/2021/5524232.

This paper discusses the use of long term and short-term memory neural networks to develop an algorithm that locally plans a path. This article discusses another method used for path planning and they mention that the LSTM methodology is more unique in this aspect. The local planning is cheaper and is based on input data from external sensors attached to the robot. Na Guo, an esteemed researcher at the National University of Singapore, managed to publish his paper in the *Mathematical Problems in Engineering* journal. This prestigious peer-reviewed journal confirms the credibility of Guo and his colleagues. This study attested to the work presented by Han-ye Zhang and Oluwaseun Martins. This study also developed a conceptual framework for understanding how neural networks can be used with path planning algorithms. This source is extremely relevant to the research question as this study presents a similar topic to path planning manipulation with neural networks. However, this study is a bit more specific than the one to be conducted.

Leenings, Ramona, et al. "Photonapi—A Python API for Rapid Machine Learning Model Development." *PLoS ONE*, vol. 16, no. 7, July 2021, pp. 1–19. *EBSCOhost*, doi:10.1371/journal.pone.0254062.

This study details the use of an API, application programming interface, used in to rapidly train neural networks. Ramona Leenings and her colleagues discussed the flexibility of this model, that it can be used with keras and other pipelining software, in order to effectively create and train neural networks. The lead researcher for this paper, Leenings, is a current PhD student at the esteemed University of Munster, located in Germany. This combined with the fact that her study was published in the peer-reviewed journal PLOS one, confirms the credibility of this source. The work presented by Leenings, attested to the arguments made by Solovyeva in her study, that neural network training does increase the performance of the task. But this study elaborated further and revealed that the current technology for training neural networks is inefficient and that Photonapi does in fact improve the performance of current neural network solutions. The use of this study will be vast as Photon api might be in order to train the neural network in this project. In order to better understand the software, this source presents important information about the work that needs to be done.

Liang Zhao, and Mingji Gao. "Node Early-Fixing: A Practical Speedup Technique for A* Algorithms." *GSTF Journal of Mathematics, Statistics & Operations Research*, vol. 1, no. 1, May 2013, pp. 98–102. *EBSCOhost*, doi:10.5176/2251-3388_2.1.39.

This study looks a speedup technique for A* Algorithms (family of algorithms that Dijkstra's algorithm belongs to). The study is first explained and then the results of an application to a real algorithm are presented towards the end of this

study. This study advanced the notion of the use of A* software in a speedup application. This study pointed out that this method of speedup does increase the potential of the algorithm and allows it to find the shortest path much quicker. The credibility of this source can not be questioned as the authors managed to get their work published in GSTF Journal of Mathematics, Statistics and & Operations Research, a highly respected peer-reviewed journal. This study presents a new look that is apart from the current body of knowledge. The reason being that a majority of the current literature looks into just the algorithms themselves, instead of improving or making these algorithms faster and more efficient. This study will be used to better understand how the A* algorithm works and how to make improvements upon the current path planning algorithms.

Marin-Plaza, Pablo, et al. "Global and Local Path Planning Study in a ROS-Based Research Platform for Autonomous Vehicles." *Journal of Advanced Transportation*, Feb. 2018, pp. 1–10. *EBSCOhost*, doi:10.1155/2018/6392697.

This study looks into the main software used to manipulate robots, Robot Operating System. This study also discusses the use of path planning algorithms as well such as Dijkstra's algorithm. This study gave attention to ROS, a lower level application that interacts directly with robots. Pablo Marin-Plaza, the lead researcher conducts research for the prestigious University Carlos III de Madrid, located in Madrid, Spain. Marin-Plaza also managed to get his work published in the peer-reviewed Journal of Advanced Transportation. The work presented in

this study is unique compared to the literature in the body of knowledge. The reason being that not many studies reference an ROS based platform with planning algorithms. This study will be used in order to better understand the low-level applications of this study and how it can be potentially used in the real world. Relating to the paper, it will most likely be addressed in the contextualization and introduction section of the paper.

Martins, Oluwaseun Opeyemi, et al. “Quantitative Performance Review of Wheeled Mobile Robot Path Planning Algorithms.” *Gazi University Journal of Science*, vol. 34, no. 3, Sept. 2021, pp. 765–784. *EBSCOhost*, doi:10.35378/gujs.792682.

This study is a quantitative study on the different types of path planning algorithms. They conducted a study on a variety of variables including having a global or local path, changing the amount and types of obstacles, and even having a dynamic or static environment. All of these studies proved that stand alone neural networks do in fact have the best performance. This is a peer reviewed study published in the Gazi University Journal of Science, with Gazi University being in the country of Turkey. Oluwaseun Martins and Adefemi Adeyemi, another co-author on this paper, are researchers at the Federal University Oye Ekiti in Nigeria. This is one of the most premier universities in Nigeria. This is a cornerstone source in the body of knowledge. A majority of the literature in the body of knowledge affirm the facts presented in this study. Also, a majority of other studies base their work off of the work presented in this study. This source

will be used as a foundation for the study I will conduct as it will help better understand the different variables involved within the study.

Solovyeva, E. B., and A. Abdullah. "Controlling System Based on Neural Networks with Reinforcement Learning for Robotic Manipulator." *Information & Control Systems / Informazionno-Upravlyaushie Sistemy*, vol. 108, no. 5, Oct. 2020, pp. 24–32. *EBSCOhost*, doi:10.31799/1684-8853-2020-5-24-32.

This source discusses the training of a robotic arm using a neural network, in order to allow the robotic arm to move autonomously. The information presented in this study gave attention to the process of how training of a neural network must be done, as well as a robotical application of a neural network. The credibility of this source can be clearly established as well. With this source being published in the peer reviewed journal, Information Systems Control. Also, Elena Solovyeva, the lead author of this paper, conducts research at the respected Saint Petersburg Electrotechnical Institute. This source introduces the idea of using neural networks in robotics applications. This is key as a majority of the current literature on neural networks relates to stand-alone neural networks, or neural networking technology working independent of a separate entity. This source will be used to provide background information about practical neural network applications.

Tian, Shasha, et al. "Robot Global Path Planning Using PSO Algorithm Based on the Interaction Mechanism between Leaders and Individuals." *Journal of Intelligent & Fuzzy Systems*, vol. 39, no. 4, Oct. 2020, pp. 4925–4933. *EBSCOhost*, doi:10.3233/JIFS-179978.

This study discusses the use of a specific algorithm, the particle swarm algorithm in a common application. A particle swarm algorithm works by creating a swarm around the starting node and then repeating itself until it reaches the finishing node. This study was also published in the *Journal of Intelligent & Fuzzy Systems*, a credible peer-reviewed journal. This study emphasized the plausibility of using a swarm algorithm in a robotics application. This study relates to the body of knowledge as it shows yet another way that a path planning algorithm can be used in a software application. Also, this study and one conducted by Dongchun Wu both address swarm planning algorithms. Except, this study addressed a more in-depth look into the algorithm specifically while Wu's work looked into a potential application of this work. This study will be used in order to contextualize yet another path planning algorithm and explain how that algorithm works in its specific circumstances.

Wang, H. "Urban Integrated Intelligent Parking Guidance Based on Dijkstra Algorithm." *Advances in Transportation Studies*, Mar. 2021, pp. 153–164. *EBSCOhost*, doi:10.4399/979128041436614.

This study looks at developing an algorithm to assist with parking using dijkstra's algorithm. The researchers elaborated further and revealed that running the program in a simulation, they were able to conclude that the algorithm did in fact increase the efficiency and they recommended that this algorithm be more frequently used. The information presented in this study should be considered as the research is in fact credible. This can be seen as Wang, the sole researcher of this paper, maintains credibility with the IEEE, the Institute of Electrical and Electronics Engineers. Also, he managed to get his work published in the peer-reviewed journal called Advances in Transportation Studies. The work published in this source established a connection between Dijkstra's and it's potential applications. Wang also mentions other studies in which Djikstra's was used in order to lay out road networks. This is similar to the current body of knowledge and claims made. This study will be used to contextualize Dijkstra's a little more and to better understand how this algorithm works.

Wang, Lin-Lin, and Li-Xin Pan. "Research on SBMPC Algorithm for Path Planning of Rescue and Detection Robot." *Discrete Dynamics in Nature & Society*, Nov. 2020, pp. 1–11. *EBSCOhost*, doi:10.1155/2020/7821942.

This piece looks into the use of the Sampling-Based Model Predictive Control algorithm in a search and rescue bot. Through simulation, it is concluded that implementing this algorithm reaps many benefits for the researchers. They gave cognizance to a potential application of path planning, search and rescue. The

credibility of these researchers can not be put into question as both Lin-Lin Wang and her colleague Pan Li-Xin conduct research for the prestigious Beijing Institute of Technology. They also managed to get their work published in the Discrete Dynamics in Nature & Society Journal, a credible peer-reviewed journal. The work presented in this study is quite unique as not many other studies have been conducted regarding the SBMPC Algorithm and its potential applications. This source will be used to add additional information about one specific planning algorithm as well as seeing a similar study regarding planning algorithm and seeing how it works.

Wu, Dongchun, et al. "Hybrid Improved Bird Swarm Algorithm with Extreme Learning Machine for Short-Term Power Prediction in Photovoltaic Power Generation System." *Computational Intelligence & Neuroscience*, Aug. 2021, pp. 1–12. *EBSCOhost*, doi:10.1155/2021/6638436.

This article discusses the use of Swarm algorithms in predicting the short term power output for solar power generation. The study accurately predicted the implications of using Swarm algorithms in laying out the power grid. This study introduced the idea of a swarm algorithm in a practical application. A swarm algorithm is an algorithm that knows what the end node is and maps a best path by helping the starting node and end node find each other simultaneously. The credibility of this source can not be put into question as Dongchun Wu and his colleagues conduct research for the prestigious Yancheng Institute of Technology

located in Yancheng, China. Also, Wu and his colleagues managed to publish their work in the peer reviewed journal called Computational Intelligence & Neuroscience. Wu established a convincing case that swarm algorithms are efficient and in some instances are more appropriate than another algorithm such as a dijkstra's or breadth-first search for instance. This is a new look that is apart from the current views expressed in the body of knowledge. The information presented in this source will be used in order to present yet another study with a planning algorithm to better understand how it works.

Zhang, Han-ye, et al. "Path Planning for the Mobile Robot: A Review." *Symmetry* (20738994), vol. 10, no. 10, Oct. 2018, p. 450. *EBSCOhost*, doi:10.3390/sym10100450.

This study is an inclusive look into all the aspects of path planning. This study explored the subject of path planning. In this study, Zhang and his colleagues measure the impacts of different path planning algorithms and how they work. They explain how each specific algorithm works and explain how the algorithm will work with a robot. This study is more of a general overview of path planning, therefore there was not any specific data concluded. This study was published in *Symmetry*, a peer-reviewed journal sponsored by MDPI, a reputable publisher of peer-reviewed journals. This source is another cornerstone study that details how each path planning algorithm works. A lot of studies base their work on this study and try to emulate techniques discussed within this study. This study will be used

in order to convey some background information and will provide the baseline for the work that will be conducted in my study.

Zhong, Meisu, et al. "Priority-Based Speed Control Strategy for Automated Guided Vehicle Path Planning in Automated Container Terminals." *Transactions of the Institute of Measurement & Control*, vol. 42, no. 16, Dec. 2020, pp. 3079–3090. *EBSCOhost*, doi:10.1177/0142331220940110.

This article discusses the use of Dijkstra's algorithm in seaports. The authors attempted to see if using dijkstra's algorithm to automate some of the processes would increase the efficiency. According to their study, it was a success and the algorithm accurately predicted future data. Meisu Zhong, one of the lead researchers, conducts research for the prestigious Shanghai Maritime University. Zhong and his colleagues also managed to get their work published in *Transactions of the Institute of Measurement & Control*. This peer reviewed journal elevates the study and maintains Zhong's credibility. Zhong discovered in his studies that Dijkstra's algorithm can be used in any type of application. However, he specifically concentrated on the use of Dijkstra's in a seaport. This study agrees with a majority of the current body of knowledge about the fact that planning algorithms can in fact increase the efficiency of these tasks. This study will be used in order to build upon the existing literature on the topic and further explain it.

