# Machine Learning Engineer Nanodegree

# (Robot Motion Planning)

## Capstone Proposal

Daiki Matsunaga

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## Proposal

*(approx. 2-3 pages)*

### Domain Background

*(approx. 1-2 paragraphs)*

*In this section, provide brief details on the background information of the domain from which the project is proposed. Historical information relevant to the project should be included. It should be clear how or why a problem in the domain can or should be solved. Related academic research should be appropriately cited in this section, including why that research is relevant. Additionally, a discussion of your personal motivation for investigating a particular problem in the domain is encouraged but not required.*

In this capstone project, I will tackle the difficult problem of robot mapping and motion planning. To put simply, this is the problem of programming robots that can map out its environment, plan a optimum path and take action in accordance with that path. Robots have been a topic of interest for decades, notably in science fiction films. While robots were often depicted as autonomous creatures, who can become threats to human existence, the co-existence of sophisticated robots and humans has been merely a topic for thought experiments. However, with increased computing capabilities, greater amounts of data and improved algorithms, the field of robotics has suddenly emerged as a real tool in helping humans work and live more efficiently. For example, autonomous vehicles, drones, disaster relief robots and cleaning robots are some of the many applications of robotics, which are already starting to make

an impact on today's world. In this project, a simpler version of the problem will be used to explore the world of robot mapping and motion planning. In particular, the robot will explore a maze, map out the surrounding environment and find the fastest path to the destination. This seems simple at first glance but I believe the core essence of the problem is similar to more complicated problems that are being researched by large corporations and universities. My goal here is to get a glimpse of the exciting world of robotics and hopefully use this as a stepping-stone to tackle large-scale problems in the future.

## Problem Statement

*(approx. 1 paragraph)*

*In this section, clearly describe the problem that is to be solved. The problem described should be well defined and should have at least one relevant potential solution. Additionally, describe the problem thoroughly such that it is clear that the problem is quantifiable (the problem can be expressed in mathematical or logical terms) , measurable (the problem can be measured by some metric and clearly observed), and replicable (the problem can be reproduced and occurs more than once).*

This problem, in essence, is how to program a robot that can map out the environment and make rational decisions in accordance with the inputs to achieve a certain goal. In this case, the robot's goal is to understand the structure of the maze and make the correct decisions (go straight, go backwards) in order to reach its destination. The solution, then, would be to have the robot reach its destination in the shortest amount of time for different types of environments. Also, the time it takes for mapping is a part of the solution that needs to be considered. Therefore, it can be said that a solution to this problem is to build a robot that maps its environment quickly and reaches its destination quickly as well. This performance can be measured simply by how many steps it takes to map out its environment as well as the number of steps taken to reach a destination from the starting point.

## Datasets and Inputs

*(approx. 2-3 paragraphs)*

*In this section, the dataset(s) and/or input(s) being considered for the project should be thoroughly described, such as how they relate to the problem and why they should be used. Information such as how the dataset or input is (was) obtained, and the characteristics of the dataset or*

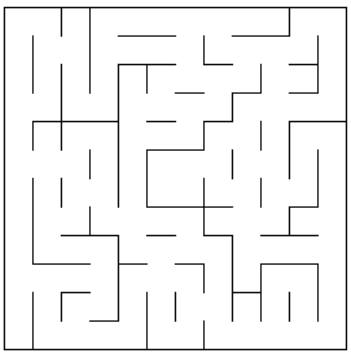
*input, should be included with relevant references and citations as necessary It should be clear how the dataset(s) or input(s) will be used in the project and whether their use is appropriate given the context of the problem.*

The datasets used in this project are three text files used to create a maze. For example, Figure 1a shows an example of a text file, which has the first row show the number of rows in each dimension, and the subsequent numbers showing whether or not each side has a wall (on the top, right, left and bottom). The visual demonstration of the text file can be shown in Figure 1b.

Figure 1a

```
12
1,5,7,5,5,5,7,5,7,5,5,6
3,5,14,3,7,5,15,4,9,5,7,12
11,6,10,10,9,7,13,6,3,5,13,4
10,9,13,12,3,13,5,12,9,5,7,6
9,5,6,3,15,5,5,7,7,4,10,10
3,5,15,14,10,3,6,10,11,6,10,10
9,7,12,11,12,9,14,9,14,11,13,14
3,13,5,12,2,3,13,6,9,14,3,14
11,4,1,7,15,13,7,13,6,9,14,10
11,5,6,10,9,7,13,5,15,7,14,8
11,5,12,10,2,9,5,6,10,8,9,6
9,5,5,13,13,5,5,12,9,5,5,12
```

Figure 1b



## Solution Statement

*(approx. 1 paragraph)*

*In this section, clearly describe a solution to the problem. The solution should be applicable to the project domain and appropriate for the dataset(s) or input(s) given. Additionally, describe the solution thoroughly such that it is clear that the solution is quantifiable (the solution can be expressed in mathematical or logical terms) , measurable (the solution can be measured by some metric and clearly observed), and replicable (the solution can be reproduced and occurs more than once).*

As written in the previous section, the solution to this model is one in which the robot maps the environment quickly and reaches its destination quickly. In the provided code, the robot's score is measured by "the number of time steps required to execute the second run, plus one thirtieth the number of time steps required to execute the first run." The first run refers to the robot roaming around the maze trying to map it out. Once the robot reaches its destination in this first run, it can go back to the starting point whenever the robot is ready. The second run, then, is the robot's real test where the robot starts in the left hand corner and goes for the destination, which is the 2x2 square in the middle of the maze.

## Benchmark Model

*(approximately 1-2 paragraphs)*

*In this section, provide the details for a benchmark model or result that relates to the domain, problem statement, and intended solution. Ideally, the benchmark model or result contextualizes existing methods or known information in the domain and problem given, which could then be objectively compared to the solution. Describe how the benchmark model or result is measurable (can be measured by some metric and clearly observed) with thorough detail.*

The benchmark model can simply be one in which a human (me) solves each maze and finds the optimum solution to get to the destination. We can then compare this result to the robot's performance and set a threshold e.g. within +10% of time steps compared to the shortest time solved by a human. For example, it seems that the shortest amount of steps taken to solve the maze in Figure 1b is 30 steps. If the robot solves it within 33 steps, it would have a very high performance. Note: this idea of a threshold will be reconsidered once the project is underway.

## Evaluation Metrics

*(approx. 1-2 paragraphs)*

*In this section, propose at least one evaluation metric that can be used to quantify the performance of both the benchmark model and the solution model. The evaluation metric(s) you propose should be appropriate given the context of the data, the problem statement, and the intended solution. Describe how the evaluation metric(s) are derived and provide an example of their mathematical representations (if applicable). Complex evaluation metrics should be clearly defined and quantifiable (can be expressed in mathematical or logical terms).*

The benchmark metric for this project is initially provided as "the number of time steps required to execute the second run, plus one thirtieth the number of time steps required to execute the first run."

## Project Design

*(approx. 1 page)*

*In this final section, summarize a theoretical workflow for approaching a solution given the problem. Provide thorough discussion for what strategies you may consider employing, what analysis of the data might be required before being used, or which algorithms will be considered for your implementation. The workflow and discussion that you provide should align with the qualities of the previous sections. Additionally, you are encouraged to include small visualizations, pseudocode, or diagrams to aid in describing the project design, but it is not required. The discussion should clearly outline your intended workflow of the capstone project.*

This project can be separated into two parts: mapping and motion planning. My first step is to review the course materials and other information about different algorithms for both parts. Then, I will use SLAM to program the mapping part for the robot. Finally, I will evaluate BFS, A* search and Dynamic Programming as some of the possible algorithms in finding the most optimal path. Of course, each step will be recorded in the form of a report.

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