AA 222 Final Project Proposal

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May 20, 2018

Abstract

Path planning is a corner stone of Robotic Autonomy, as a robot has to be able to evolve in his environment to be considered truly autonomous. Our project aims at using genetic algorithms to solve the problem of optimal path planning for autonomous mobile robots. This approach was inspired by an article from Castillo et al [CTM06]. It would be part of a common project with the class AA203 (Optimal Control), in which both of us are enrolled, with the approval of Pr. Pavone. The part of the project relevant to AA203 would cover a different approach to the problem of optimal path planning.

1 Problem

The formulation of our problem is as follow : given a 2D occupancy grid, an initial cell and a final cell, the goal is to find an optimal admissible path between the initial and the final point. Each cell of the grid has a metric value between 0 and 1 characterizing its difficulty : 0 means no effort to pass through that cell, 1 means insurmountable barrier. This grid can for example be seen as a 2D map where the value in each cell would correspond to the average elevation gain at that particular point in space.

The optimality criterion would be dual: ideally we would like the shortest and easiest path. In a first approach, minimizing the total time would be equivalent to minimizing the length of the path (with the "length" being the number of cells crossed), if we assume that crossing any cell takes the same amount of time. The difficulty of the path can be seen as the "energy" consumed by the robot. This would be directly proportional to the value in each cell. In a second approach, we could think of adding a time penalty for crossing a difficult cell, in addition to the energy cost.

2 Approach

Our approach would be to use genetic algorithm strategies to make a population of m individuals, each individual representing a feasible path, converge to an optimal path. Different challenges would have to be addressed:

1. Initialization: how to initialize a population of feasible paths while keeping some controlled randomness ? (see [LK16])
2. Selection: which metric to consider ? Especially if we have a two-fold objective.
3. Cross-over: how to ensure path-feasibility at the next generation ?

To answer these problems, we will try to take inspiration from a few papers that have been published in the past years (see [RTL13], [GG03], [QXA13]).

3 Performance metric

The edge of our common project would be that we have all the tools to evaluate how well the genetic algorithm approach performs compared to traditional optimal control tools. This comparison was not done in [CTM06]. In particular, our first idea would be to compare the optimal path given by our genetic algorithm on a 2D occupancy grid, with the optimal trajectory found using calculus of variation for a continuous metric (height variation over the all map), and for varying parameters (discretization size for the GA approach, for instance).

References

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