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R&D Project Proposal

Robot motion planning in dynamic environment: A comparative study

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May 2018

1. Introduction

- Mobile robot needs a plan to reach to its desired goal. This plan is provided by motion planning algorithms.
- Robot motion planning (RMP) for static environment is not sufficient for most of the application.
- Take for example, a robotic wheel chair or robot carrying hospital bed. These robot needs to tackle moving obstacle like patients, other wheel chairs, hospital beds, etc. while safely moving towards its goal.
- This type of problem applications need RMP for dynamic environment.
- By solving this problem, we can ensure
  - Safe environment for humans and for robots
  - Cost effective trasportation of goods

1.1. Problem Statement

- RMP in dynamic environment needs to perform the following task
  - Reach the desired target
  - Avoid static and moving obstacle
- It needs to perform these tasks in *fast* and *efficient* manner.
- This work will provide a comparative study on existing approaches for RMP in dynamic environment.
- This comparative study will include
  - An in depth literature review of existing approaches
  - Identifying top solutions

- Evaluating these candidates on various benchmark practical test on a real and simulated environment
- Identifying the best solution based on the performance measure

2. Related Work

- All the existing approaches have tested their efficiency on different robots and in different test environment.
- As the measuring criterion for each of them is different, it becomes an impossible task to determine a clear winner.
- There are several existing survey article:
  - Mohanan et al. [20] covers 101 research papers that were published between 1985 and 2016 in the field of RMP in dynamic environment. They have addressed all the approaches but a comparative analysis of all the aproaches with their contributions and deficiencies is left to be desired.
  - Hoy et al. [11] provides a survey for algorithms which provide collision free navigation for robots. This survey is not only detailed but also quite broad as it covers obstacle avoidance algorithm as well. Eventhough it provides a comparision between main approaches based on numerous criterion, it still does not evaluate these approaches on a standard uniform test.
  - Keshmiri et al.[13] provides a survey specifically for RMP in dynamic environment. It covers all the approaches presented in research papers published between 1986 and 2008 totalling upto 150 papers. They have provided a comparision on how much contribution has been made in RMP field based on different approach but regarding the actual approaches itself, only a summary of at most 2-3 sentences for each approach is provided.
  - [8] and [32] are quite dated and does not cover any state of the art approaches in RMP for dynamic environment.
- Existing approaches generally provide critique and deficiencies on their previous works. These are generally helpful but they mostly compare their approach with the existing solutions and only point out the deficincies that

they have addressed. Therefore, though these comparisions are helpful, they might not be completely reliable.

2.1. Approaches in RMP for dynamic environment

2.1.1. Velocity based

- *Dynamic window approach*: Fox et al. [6] proposed the original idea for simply optimizing a function which balances robot's distance from goal, distance from nearest obstacle and current velocity. This approach, despite being robust, simple and fast did not work for dynamic environment. Later, Brock et al. [2] extended this approach for global path planning and for dynamic environments by combining it with NF1 algorithm. This eradicated the problem of local minima. It has been since extended in [29] and [22]

- *Velocity obstacle (VO)*: Originally developed by Fiorini et al.[5], this approach proposes to avoid obstacles by choosing velocity outside *collision cone*. This approach unfies the representation for avoiding static and dynamic obstacles. This idea has since been transformed to incorporate many scenarios[31][24][23][10]. For multi robot systems, Van den berg et al.[34][35][33] have extended VO approach.

- *ICS based approach*: Inevitable collision states (ICS) [7][25][18] have proposed a solution to avoid states that has no outcome other than collision. They propose that this states if avoided will ensure that the robot will never collide. They have approached this problem in a mathematical way. They provide a very fast and almost infite look ahead option[20].

2.1.2. Roadmap based

- *Randomized kinodynamic planning*: Hsu et al.[12] provides an extension of probabilistic roadmap approach by considering kinodynamics of the robot before choosing a motion control.
- Van den berg et al.[36] provides an extension on roadmap based motion planning for static and dynamic obstacles.

2.1.3. Other

- *Nearness diagram*: [19] proposes a *divide and conquer* strategy for RMP in dynamic environment using a geometry based implementation of their approach.

3. Project Plan

3.1. Work Packages and milestones

The bare minimum will include the following packages:

Work packages	**Milestones**
Literature search	Gather literature
Literature review	Create review criteria and use case Compare different approaches Create annotated biliography Exclude approaches based on review criteria Create summary of review
Experiments	Choose approaches to test Implement approaches Perform experiments and gether results Evaluate results
Documentation	Document conclusion and review Refine report for better readability

Table 3.1: Work packages and milestones

3.2. Project Schedule

3.3. Deliverables

3.3.1. Minimum

- Annotated bibliography on RMP for dynamic environment
- Analysis of state of the art

deliverable_timeline.jpg

Figure 3.1: Gannt chart of milestones

- Description of review criteria
- Demonstration of 3 approaches in simulation
- Demonstration of 3 approaches on a real robot
- R & D report

3.3.2. Expected

- All items in minimum deliverable
- Description of use cases
- Demonstration of 1 additional approach in simulation

3.3.3. Desired

- All items in expented deliverable
- Detailed analysis of the result
- Demonstartion of 1 additional approach in simulation

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