Chapter 77
Collaborative Exploration based on Simultaneous Localization and Mapping

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ABSTRACT

This chapter focuses on the study of SLAM taking into account different strategies for modeling unknown environments, with the goal of comparing several methodologies and test them in real robots even if they are heterogeneous. The purpose is to combine them in order to reduce the exploration time. Indubitably, it is not an easy work because it is important to take into account the problem of integrating the information related with the changes into the map. In this way, it is necessary to obtain a representation of the surrounding in an efficiently way. Furthermore, the author is interested in the collaboration between robots, because it is well-known that a team of robots is capable of completing a given task faster than a single robot. This assumption will be checked by using both simulations and real robots in different experiments. In addition, the author combines the benefits of both vision-based and laser-based systems in the integration of the algorithms.

INTRODUCTION

During the last decades the robotics field has provided solutions to problems that were difficult to solve some years ago or simply performs the tasks in faster and simplest way that facilitates the life for human beings. Thus, when a problem has to be solved implies that challenges have to work out. In this sense, one of the most well-known challenges in the robotics field is related to Simultaneous Localization and Mapping problem (SLAM).

Many applications depend on a team of robots being able to navigate in real world environments without human intervention. In order to navigate or path plan, robots often need to consult the representation of their surroundings and sometimes it is the only way to achieve their goal.

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Therefore, when a robot is located in an unknown environment, the SLAM solutions conduct to build a map while at the same time the robot is able to determine its location using the map. Thus, to give a solution to the SLAM problem we need to perform the task of integrating the information related with the changes into the map and it becomes more difficult in the design part, as we also have to choose appropriately the tools that were used in the real world.

In this sense, the SLAM problem has become central for the researchers during the last years. For this reason, different proposals have been presented in order to solve it, such as: Extended Kalman Filter, Rao-Blackwellized, FastSLAM, etc. In which the probability theory plays an important role in the whole research related to SLAM.

Until now, we can think that SLAM is only about theoretical part. However, it can be applied in different domains such as indoors, outdoors, underwater or even in the air. However, it leads us to exploration tasks conducting to discover unknown spaces during the time. In this sense, one point that we want to cover in this chapter is related to compare the advantages of both single and multi-robot exploration, but it is well-known that increasing the number of robots also increases the complexity for managing those tasks in an optimal way. It is interesting for several reasons, for instance, tasks may be inherently too complex for a single robot to accomplish, or performance benefits can be gained from using a team of robots, or several robots give us more flexibility and more fault-tolerance than having a single robot for each separated task.

In addition, we want to show that is more advantageous a coordinated exploration in contrast to an uncoordinated exploration. Different benefits can be found: overlapping information which can help to compensate for sensors uncertainty, robots can localize themselves more efficiently, increased robustness or higher quality solutions. However, a set of aspects to consider during the tasks that must be taken into account are: risk of possible interferences between robots, limited communication range, limited energy, computation and mobility or dynamic events.

Furthermore, during an exploration task we expect that robots acquire as much information as possible, this meaning to get both idiothetic information (that corresponds to odometry) and allothetic information (provided by laser range finders, sonars or vision) and, then, combine them for a good representation of the surrounding. Consequently, in order to build reliable maps and to navigate for long periods of time the allothetic information must compensate for idiothetic information drift, while idiothetic information must allow perceptually aliased allothetic information to be disambiguated. Of course, for archive a mathematical model of the sensors, we have to take into account that we use both camera and laser based systems and, then, processing the information for representing the results in an understandable way.

On the other hand, it is necessary to bear in mind the two fundamental paradigms for modeling robot environments: the grid-based (metric) paradigm and the topological paradigm. We want to compare the advantages and disadvantages of both. In addition, solve the assignment problem and compare well-known algorithms, as for instance the frontier cells, based on structure environment using the segmentation of the space or using clustering, etc.

In this chapter, we want to give to the reader a framework related to Simultaneous Localization and Mapping including the dependent tasks: motion control, exploration and improvement of the pose estimated along the time for obtaining a consistent representation of the environment. Moreover, we will discuss the factors that have to bear in mind in the real world, and finally offer a set of results in both simulation and real world for making a comparison between the most well-known approaches. In this sense, we will give a global idea about the existing work and the future of this important research line.

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