Chapter 29
A Review of Registration Methods on Mobile Robots

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ABSTRACT

The task of registering three dimensional data sets with rigid motions is a fundamental problem in many areas as computer vision, medical images, mobile robotic, arising whenever two or more 3D data sets must be aligned in a common coordinate system. In this chapter, the authors review registration methods. Focusing on mobile robots area, this chapter reviews the main registration methods in the literature. A possible classification could be distance-based and feature-based methods. The distance based methods, from which the classical Iterative Closest Point (ICP) is the most representative, have a lot of variations which obtain better results in situations where noise, time, or accuracy conditions are present. Feature based methods try to reduce the great number or points given by the current sensors using a combination of feature detector and descriptor which can be used to compute the final transformation with a method like RANSAC or Genetic Algorithms.

INTRODUCTION

The task of registering three dimensional data sets with rigid motions is a fundamental problem in many areas as computer vision, medical images, mobile robotic, arising whenever two or more 3D data sets must be aligned in a common coordinate system. The registration problem is comprised of two related sub-problems: correspondence selection and motion estimation. In the former, candidate correspondences between data sets are chosen, while in the latter, rigid motions minimizing the distances between corresponding points are estimated.

In the robotic field, the registration problem can be used for a great variety of tasks: find the relative pose between two or more sensors, object reconstruction, object tracking or estimate the movement (translation and rotation) of a mobile robot.

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Our main goal is to use registration in order to help mobile robotics to solve the Simultaneous Localization and Mapping (SLAM) (Dissanayake et al., 2001) obtaining the egomotion at each step.

The remainder of this chapter is organized as follows; in the first section, we present the registration problem. Then, we describe the robot platforms and sensors we use. Next section reviews distance based registration methods, most of them based on the classical ICP. Then, some feature based registration methods are introduced, and finally, some experiments are done finishing by our main conclusions.

BACKGROUND

Registration problem is the process of transforming different sets of data into one coordinate system. On the field of mobile robotics, the registration problem is defined as the task of finding the transformation needed to fit one set called scene S (the set which its coordinate systems is unknown) to another set called model M (the set with the coordinate system known). Formally,

$$\mathrm{T} = \arg\min \sum_{s \in S} \sum_{m \in M} w_{ms} \left| m - \mathrm{T}(s) \right| \tag{1}$$

where $s \in S$ are points of the scene, $m \in M$ are points of the model, and w_{ms} if the probability that the point *m*matches with the point *s*.The problem can be simplified when the correspondence pairs between scene and model are known,

$$\mathrm{T} = \arg\min \sum_{i=1}^{N} \left\| m_i - \mathrm{T}\left(s_i\right) \right\|^2 \tag{2}$$

where N is the number of correspondence pairs, and m_i is the point of the model set which has a correspondence with the scene point s_i. In the field of mobile robotic, the transformation T usually is assumed to be an affine transformation, trying to solve registration on mostly static scenes and assuming the object are rigid bodies.

2D/3D DATA ACQUISITION

We have used several robot platforms, depending on the perception system used. In Figure 1, two of these platforms are shown. The left one is a Magellan Pro from iRobot used for indoor experiments. For outdoors we have used a PowerBot from ActiveMedia. Furthermore, PowerBot can carry heavy loads like the 3D sweeping laser unit. Both come with an onboard computer.

In our research, we manage 3D data that can come from different sensor devices. For outdoor environments we use a 3D sweeping laser unit, a LMS-200 Sick laser mounted on a sweeping unit. Its range is 80 meters with an error of 1mm per meter. The main disadvantage of this unit is the data capturing time: it takes about one minute to get a complete frame. For indoor environments we use another two sensors. The first one is a SR4000 camera from Mesa Imaging, which is a time-of-flight camera, based on infrared light. Its range is limited to 5 or 10 meters, providing gray level from the infrarred spectrum. Finally, a Kinect sensor has been included. This sensor provides 3D data together with RGB data, with a maximum range of 10 meters.

Figure 1. Mobile robots used for experiments. From left to right: Magellan Pro unit used for indoors; PowerBot used for outdoors. SR4000 camera used with both robots; Kinect sensor used in indoors.