G

A Comparison of Appearance–Based Descriptors in a Visual SLAM Approach

L. Fernández
Miguel Hernández University, Elche (Alicante), Spain

L. Payá
Miguel Hernández University, Elche (Alicante), Spain

F. Amorós
Miguel Hernández University, Elche (Alicante), Spain

O. Reinoso
Miguel Hernández University, Elche (Alicante), Spain

INTRODUCTION

The problem of Simultaneous Localization and Mapping (SLAM) has been studied thoroughly in the past decade in the field of mobile robotics. Taking into account the information that we can find on literature, it is possible to face the SLAM problem from three different points of view: the Metric SLAM, the Topological SLAM and the hybrid Metric-Topological SLAM. When we use the metric approach, we represent the environment and we compute the robot location through geometrical information with certain accuracy. On the other hand, when we face the problem using the topological approach, the objective is to represent the environment information by means of a list of locations within a graph, maintaining connectivity relationships between them. Finally, the metric-topological approach consists of a combination of the both techniques, trying to take advantage of both methods.

Nowadays, the use of computer vision is usual when we want to build a map and localize the robot in the map, because of several advantages (they are passive sensors, have a low cost and provide us with a great amount of information). When we use a vision sensor on a SLAM problem, we can approach the problem from two points of view: using the local appearance (landmarks) or using the global appearance to extract the necessary information from the scenes. The use of local appearance implies the extraction of distinctive landmarks from the images. When we use techniques based on local appearance, we typically need more computational time to build the map and locate the robot within the map. It is due to the fact that we need to extract the distinctive landmarks from each image and find each landmark extracted, in all images that compose the map. However, it presents an advantage: the possibility of including metric information to the system. Conversely, the global appearance methods need a lower time to work (they allow us to work in real time) but they do not directly include metric information in the map.

The main objective of this work is to build and test an algorithm to solve the SLAM problem using the global appearance of omnidirectional visual information and the robot internal odometry. Taking into account the advantages and disadvantages of the methods previously listed, we have decided to use a hybrid metric-topological approach to solve the SLAM problem.

BACKGROUND

The SLAM problem is a task studied extensively in the field of mobile robotics. One of the first works we find corresponds to Moravec and Elfes (1985), where a metric map is built by means of wide-angle sonar range measurements and a probabilistic approach.

DOI: 10.4018/978-1-4666-5888-2.ch313

Subsequently laser sensors are introduced to improve the accuracy and velocity in the algorithms created. For example, Thrun (2001) presents an algorithm for the SLAM problem in which a team of robots builds a map online using laser sensors and a Monte Carlo approach. However, the use of laser sensors implies an important contribution of radiation to the environment, and the laser sensors also use mechanical systems, which introduce errors.

Later, due to the numerous advantages offered (passive sensors, low cost, large amount of information, low power consumption, etc.), the use of cameras in the field of mobile robotics became widespread. For example, Murillo et al. (2007) make use of omnidirectional images to localize a robot within a previously created map, using SURF (Speed Up Robust Features) (Bay et al., 2006). Nevertheless, in most cases, when a robot needs to perform a task it does not possess any information about the environment and therefore the robot must build a map while it is located in it (SLAM). In this line, Gil et al. (2010) present an algorithm for the visual SLAM problem in which a robot builds a map online using a stereo-camera and SURF features. The main problem presented by the use of the extraction of distinctive landmarks corresponds to the high computational cost required. As a feasible alternative, the use of topological approaches is a field of great interest in the construction of maps by means of the global appearance of visual information, due to the numerous advantages it presents in terms of simplicity and computational cost. For example, Menegatti et al. (2004) carried out a study on robot navigation using the omnidirectional visual information captured from the environment, by applying a global appearance descriptor. In this work, they carried out a task of mapping and localization, without conducting a close loop, where the authors claim not high accuracy. In this sense, Werner et al. (2009) carried out a task of topological SLAM using vision-based techniques and global appearance. They also make use of omnidirectional images, and furthermore they propose a Bayesian approach that combines the odometry information of the robot with the visual information to improve the accuracy.

In this work we present a comparison of three global appearance descriptors in a process of robotic mapping, using a hybrid topological/metric SLAM.

APPEARANCE-BASED SLAM

In the approach we present in this work, we have decided to fuse the metric and the topological approach, with the goal of getting the advantages of each method. The topological method allows us to build a global compact representation of the environment and the metrical approach uses the information provided from the topological method to detect loop closures, so that it is possible to correct the possible errors in the position of the robot.

Constructing a Topological Map

Since we have decided to work with the global appearance of the images, we need to represent the global information that each image has, building a specific descriptor. The descriptor should retain the information in a compact and efficient manner, it must be computed quickly and it must be robust against changes in the environmental lighting conditions. In this work we make use of and compare three different global image descriptors: Fourier Signature (FS) (Payá et al., 2009), Gist-Gabor (Friedman, 1979) and Histogram of Oriented Gradient (HOG) (Amorós et al., 2010).

With the objective of representing the environment, we have used a graph, so that, each node of the graph represents an area of the environment with similar visual appearance (containing one or more images), and each edge indicates the connectivity relationships between the nodes (Romero et al., 2010). Taking into account that each node can contain one or more images, we have decided to compute the most representative image of each node. With this objective we use the following equations to compute the similarity between every two images in the node $S(i,j)$:

$$S(i,j) = 1/D(i,j)$$
$$D(i,j) = \sqrt{\sum_m \sum_n \left(Des_i(m,n) - Des_j(m,n)\right)^2}, \quad (1)$$

where Des_i represents the descriptor of the panoramic image I_i, and m and n are the number of

Related Content

The FBI Sentinel Project
Leah Olszewskiand Stephen C. Wingreen (2013). *Cases on Emerging Information Technology Research and Applications (pp. 298-322).*
www.irma-international.org/chapter/fbi-sentinel-project/75865

Crisis Informatics
Christine Hagar (2015). *Encyclopedia of Information Science and Technology, Third Edition (pp. 1350-1358).*
www.irma-international.org/chapter/crisis-informatics/112534

Software Development Life Cycles and Methodologies: Fixing the Old and Adopting the New
Sue Conger (2011). *International Journal of Information Technologies and Systems Approach (pp. 1-22).*
www.irma-international.org/article/software-development-life-cycles-methodologies/51365

Query Languages for Graph Databases
Kornelije Rabuzin (2018). *Encyclopedia of Information Science and Technology, Fourth Edition (pp. 2031-2042).*
www.irma-international.org/chapter/query-languages-for-graph-databases/183916

Reusing the Inter-Organizational Knowledge to Support Organizational Knowledge Management Process: An Ontology-Based Knowledge Network
Nelson K. Y. Leung, Sim Kim Lauand Joshua Fan (2010). *Ontology Theory, Management and Design: Advanced Tools and Models (pp. 142-161).*
www.irma-international.org/chapter/reusing-inter-organizational-knowledge-support/42888