An Architecture of Sensor Fusion for Spatial Location of Objects in Mobile Robotics

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Abstract. Each part of a mobile robot has particular aspects of its own, which must be integrated in order to successfully conclude a specific task. Among these parts, sensing enables to construct a representation of landmarks of the surroundings with the goal of supplying relevant information for the robot's navigation. The present work describes the architecture of a perception system based on data fusion from a CMOS camera and distance sensors. The aim of the proposed architecture is the spatial location of objects on a soccer field. An SVM is used for both recognition and object location and the process of fusion is made by means of a fuzzy system, using a TSK model.

1 Introduction

The field of mobile robotics has evidenced an enormous potential for research and real experiments. Mobile robots with intelligent behavior are constructed in various parts which by themselves show potential for study [1].

In particular, the sensing is responsible for supplying the robot with the necessary information for the construction of a representation of its surroundings, where the robot is placed, thereby allowing a dynamic description of the obstacles and useful landmarks for the orientation of the robot. Such a task must be made by computational methods whose objective is to reduce the inaccurate nature of the sensors. In order to do this, sensor fusion techniques have been applied successfully, providing a more suitable description of the surroundings due to both redundancy and complementation of data.

To evaluate a perception system and its architecture, it must be submitted to some specific task. For the proposed system, robot soccer is chosen and the Robocup rules for small size robots (F-180 league) are used for the local vision system constraints. For a team of robots to participate in a soccer match, various technologies must be present: principles of autonomous agent design, multi-agent collaboration, robotic and sensor fusion, among others. The main objective of the application of the mobile robot in a soccer environment is, therefore, the analysis of multiple areas of knowledge which serves to support socially significant problems as well as industry.

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For the perception system proposed in this work, a CMOS camera and infrared distance sensors are used. An SVM (Support Vector Machine) is applied for the classification of objects by a single color, without any image processing. Another SVM is used for obtaining the polar coordinates of the objects, by regression, from the image; for the sensor fusion, a fuzzy system using the TSK (Tagaki-Sugeno-Kang) zero order model integrates the information of angles of the objects with the data from the distance sensors, in order to refine the information obtained.

In Section 2, aspects of the classifier used are shown. Section 3 describes some architectures for sensor fusion. Section 4 describes the communication between the vision system and the robot. The architecture proposed, as well as its model, are presented in Section 5, while Section 6 presents general results obtained at each stage. To finish, Section 7 presents some conclusions.

2 Support Vector Machine

SVM is a hybrid technique of statistical and deterministic approaches. This means that to find the best space for classification hypothesis, a probability distribution is determined from the input space. The technique originated from the work of Vapnik on the Principle of Risk Minimization, in the area of Statistical Learning [2].

The technique is applied in the following way: in the case of linear space, determine the hyperplanes of separation by an optimization problem; in the case of non-linear space, a kernel function is applied and the new space obtained is denominated the feature space – now linearly separable, of a dimension greater than the original.

Fig. 1 illustrates the application of a kernel in the input space. In the feature space, a hyperplanes is obtained for separation.

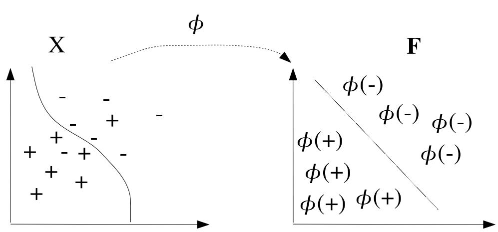

Fig. 1. Mapping of an input space non-linearly separable for a feature space

Another important aspect is the relationship between dimension VC (Vapnik-Chervonenkis), number of support vectors and generalization of the classification. To determine the dimension VC of a space, it is necessary to also determine the number of support vectors; in this case to find the oriented hyperplanes,