An Object Recognition Scheme Using Knowledge and the Hausdorff Distance

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Abstract

In this paper we show how we can use a priori *knowledge from our environment in order to build a robust and efficient recognition scheme. The knowledge we use comes from physical constraints and the camera geometry. The recognition process is based on the* Hausdorff distance *transform. We propose a modification to the algorithm described in [6] that accomplishes the elimination of the scaling variance.*

Keywords: *distance transforms, perspective geometry, object recognition*

1 Introduction

The geometric comparison of contours is a very favorable approach in the object recognition community. Most of the model-based schemes in object recognition use distance measurements between the model features and the image features in order to extract a correspondence between them ([1], [11]).

The *Hausdorff distance* is a distance transform that has been widely used for such comparisons with successful results ([5], [6]). It provides a measure of the similarity between two sets of points and copes robustly with noise, too. In [7] the Hausdorff distance is further applied to the tracking of non-rigid objects in image sequences. In the rule two-dimensional models are extracted from the image data and matched to sucesive frames of the image sequence according to this distance measure. In general the search space consists of all the possible affine transformations (translation, scaling and rotation) that the model has to undergo in order to fit into the scene.

However, in these aproaches the camera is static. If *ego-motion* exists and without knowledge about the form and the expected size of the model, the separation of a moving object from its background will be quite difficult. Furthermore, the algorithm proposed by Huttenlocher ([6]) works efficiently in the case where the size of the object is expected to vary over a known small range of scales. Otherwise, the search space explodes and the search becomes inefficient.

In our case now, we apply the Hausdorff transform to the analysis of traffic scenes. The scenes were acquired from a camera installed in a vehicle while driving on a highway. The goal is to detect foregoing vehicles and identify them. So the objects we want to recognize are rigid (e.g. cars). The rotation factor in our samples is very small, so that it can be ignored. We actually have to cope with all possible translations and scalings that can bring our model near to an object in the scene so that it fits it. But still the dimensions of the search space can be prohibiting for the aim of a real time application. We need some cues that will reduce the complexity of our task.

In the next section we give the mathematical definition of the Hausdorff distance and briefly present the *distance transform* which is used for the computation of the Hausdorff distance. A detail description of the distance and its properties can be found in [5]. In section 3 we describe our system's geometry and explain which kind of knowledge we use in order to shrink our search space. We also provide a solution for the estimation of the size of an object in the image. The search algorithm that calculates the Hausdorff distance over one frame is presented in section 4, and we conclude with some results and the discussion.

2 The Hausdorff distance

Given two finite point sets $P = \{p_1, \ldots, p_m\}$ and $Q = \{q_1, \ldots, q_n\}$, the Hausdorff distance is defined as

$$H(P,Q) = \max(h(P,Q), h(Q,P))$$

where

$$h(P,Q) = \max_{p \in P} \min_{q \in Q} \|p - q\|$$

and $\|\cdot\|$ can be any norm (usually the *Euclidean* norm is used).