DEVELOPMENT OF OBJECT RECOGNITION SYSTEMS USING INVARIANT FEATURE BASED INDEXING

by

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Submitted

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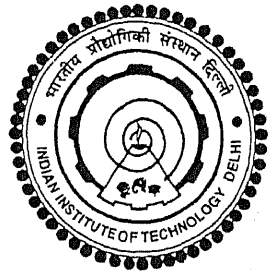

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Certificate

This is to certify that the thesis entitled "*Development of Object Recognition Systems Using Invariant Feature Based Indexing*," which is being submitted by Mr. Navin Rajpal to the Department of Computer Science and Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of bonafide research work, he has carried out under our supervision and guidance, and, in our opinion, it has reached the standard fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted to any other university or institute for the award of a degree or a diploma.

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Navin Rajpal

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DEDICATED TO MY PARENTS AND WIFE

Abstract

In this thesis we have considered two recognition problems:

1. Recognition of Partially Occluded 2D objects.

2. Recognition of 3D objects from Image Sequences.

For both the recognition problems, we have investigated different issues related to the design of recognition systems using indexing invariants. We have looked into the problems of developing robust indexing schemes using known invariants. We have also considered the problem of developing reliable verification schemes. In addition, we have examined the problem of combining shape and colour based cues for obtaining reliable recognition results.

The main contributions of this thesis are:

Recognition of Partially Occluded 2D objects

A new neural network based indexing scheme has been proposed for recognition of 2D objects. Local contour based invariants have been used for indexing. Object contours have been obtained using an algorithm which combines the advantages of region growing and edge detection. The contour obtained

is decomposed into curve segments using dominant points extracted by applying a curvature guided polygon approximation technique. For extracting local similarity/affine transformation invariant features from these curve segments we have used a canonical frame construction scheme. Two types of networks, one based on supervised and other based on unsupervised learning have been trained using these invariant features. We have compared the performances of both these networks with that of the conventional geometric hashing method. Experimental results on real images of varying complexity with a reasonably large data-base of objects have established the robustness of the method.

We have presented a feature based hypothesis filtering and verification scheme for 2D Object Recognition. The neural network based indexing scheme produces a number of competing hypotheses. These hypotheses are first ranked using neighbourhood constraints and local colour invariant features to reduce the search space. The competing hypotheses set is then verified using two strategies. In the first strategy we have used a simple alignment method and used a distance transform measure for computing the verification score. We have also proposed a hypotheses verification scheme using relaxation labeling. The initial probability assignments for mapping of object labels to model labels are done on the basis of the output of the neural network and local region based colour invariants. The recognition results on scenes consisting of multiple overlapping objects have demonstrated the effectiveness of the system. We have shown that the relaxation labeling based scheme provides a better pose estimate than a simple alignment based verification scheme.

Recognition of 3D Objects from Image Sequences

We address the problem of extraction of 3D geometric invariants from image sequences for the purpose of recognition of 3D objects. We consider colour image sequences of multiple independently moving objects in a scene. It is assumed that the objects are undergoing affine motion and therefore, the affine camera projection model is used for extraction of 3D invariant features. Optic flow based segmentation technique is used to isolate the independently moving objects in the first few frames of a sequence. Corners are detected in rectangular regions around object using the Plessey corner detector. Interframe corner correspondences and invariant 3D affine coordinates are obtained using a affine structure based tracker. Even though the 3D structure invariants of corner features can be extracted with high accuracy, it is still preferable to use line features for the purpose of object recognition. A novel algorithm, therefore, has been developed for line correspondence and tracking of line segments along long image sequences.

We present a complete 3D object recognition system from image sequences. We have shown that colour based features extracted from image sequences provide a stable indexing scheme. For verification of the composite hypotheses and object localization we use two alignment based methods. The first one is based on linear combination of affine views and the second one is a method of repeated random alignments based on relaxation labeling. We present detailed experimental analysis of the methods used on real image sequences. Experimental results have established effectiveness of the approach.

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