A Performance Evaluation of a Quadtree Eigenspace Technique for Automatic Target Recognition

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Abstract

Eigendecomposition-based techniques are popular for a number of computer vision problems. These techniques are purely appearance based and require few on-line computations. Unfortunately, they typically require an unobstructed view of the object to be detected. The presence of occlusion precludes the use of the normalizations that are typically applied and significantly alters the appearance of the object under detection. There is a need to modify conventional eigendecomposition methods to better handle the difficulties that are created by the presence of occlusion. In this work a particular eigendecomposition-based algorithm for detecting occluded objects was evaluated. The algorithm is based on applying eigendecomposition to a quadtree representation of the image dataset used to describe the appearance of an object.

1. Introduction

Eigendecomposition-based techniques are an important class of techniques for computer vision. These techniques are variously referred to as eigenspace methods, principal component analysis, and singular value decomposition. They are based on taking advantage of the fact that a set of highly correlated images can be approximately represented by a small set of eigenimages [2] and represent a computationally efficient approach for object recognition and localization. Unfortunately, one of the drawbacks associated with using eigendecomposition based-approaches is that they are very sensitive to occlusion. The presence of occlusion complicates the use of eigendecomposition in several ways. The location of the object in the test image cannot be easily determined, scale normalization cannot be performed on the test image, and brightness normalization is not effective. Furthermore, the occluded region will alter the projection into the eigenspace. Some of these problems can be addressed by using a hierarchical eigenspace approach [3]. Alternatively, one can apply an "eigen window" approach [4]. Unfortunately, this approach relies on appropriate feature selection as well as detection, and thus loses the advantages associated with purely appearance-based techniques.

This work is an evaluation of a recently proposed algorithm that is based on modifying the conventional eigendecomposition method to better handle the difficulties that are created by the presence of occlusion [1]. In the next section, the approach of this algorithm is briefly described. Conclusions appear in Section 3.

2. Approach

To apply the proposed algorithm, there is first an off-line training process in which a quadtree decomposition of the reduced eigenspace for the desired target object is calculated (see Fig. 1). The eigenspace decomposition is then used in the target recognition process to determine the target object's location and pose in a test image. First, likely candidate locations of the object are determined in the test image. These are determined based on both how well the candidate location is represented by the reduced eigenspace and how quickly that representation degrades as the location is perturbed slightly. The likely candidate locations are then evaluated to determine if the target object is located in the test image, and if so, in what pose. This process begins by projecting the portion of the test image around the candidate location that corresponds to the size of an entire training image into the eigenspace and computing the distance to the manifold composed of all the training images. If this distance is very small, then the

target object has been identified and the closest point on the manifold determines its pose. If this distance is very large, then the target object is not present at this candidate location. If the distance to the manifold is somewhere in between, then that portion of the test image is divided into four subimages and the process is repeated recursively, using the quadtree decomposition of the eigenspace. For those cases where multiple sub images identify the location of the target object, its pose is determined by considering the relative size of the portion of the target object in each subimage as well as a more refined measure of the distance to the manifold created using the training images.

3. Conclusions

This work has evaluated an algorithm for pose detection in the presence of occlusion. The algorithm is based on representing a desired target object using a quadtree decomposition of its reduced eigenspace. Because the algorithm relies purely on the appearance of the objects in the training set of images, it is very general and easy to apply. The difficulties that are created due to the presence of occlusion, i.e., the inability to easily locate the desired object and apply the appropriate normalizations, are efficiently overcome by the recursive quadtree procedure. While on-line detection times can be an order of magnitude larger that for unoccluded images, the amount of work is proportional to the difficulty of the problem, i.e., the extent of the occlusion. In addition, the algorithm rarely makes an error in detecting the location and pose of the desired object, preferring to declare the detection problem too difficult when too much information is occluded.

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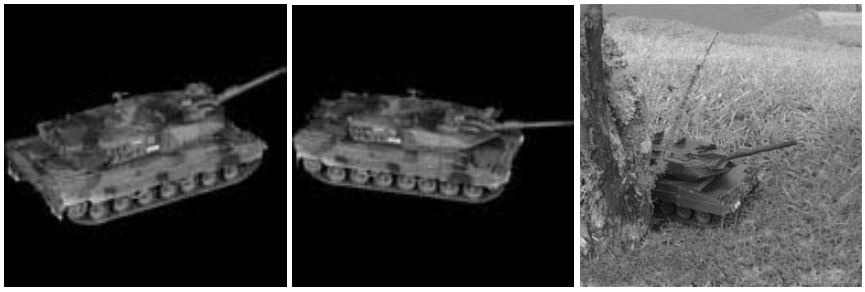

Figure 1 The first two images show examples of the different orientations of a model tank used to generate the reduced eigenspace for the tank. The third image is an example of a test image for which the proposed algorithm identified the partially occluded tank.

References

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