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An Experimental Study on Object Recognition Using Eigen Algorithm

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Abstract - **The paper presents the design of a vision system for an object recognition robot. The aim was to create a vision system that is able to view and track objects in the three dimensional world. The vision hardware consists of web camera and interface software. In this study we aim to devise computer vision software that identifies and memorizes the object in a given environment under similar conditions. Object recognition is achieved with a wide variety of algorithm; however for the purpose of this study we employ the various image processing techniques and Eigen method. Future works on the design of a vision system involve implementing vision system in the field of robotics.**

Index Terms - Eigen, Object recognition.

I. INTRODUCTION

As the holy grail of computer vision research is to tell a story from a single image or a sequence of images, object recognition has been studied for more than four decades. Significant efforts have been paid to develop representation schemes and algorithms aiming at recognizing generic objects in images taken under different imaging conditions (e.g., viewpoint, illumination, and occlusion). Within a limited scope of distinct objects, such as handwritten digits, fingerprints, faces, and road signs, substantial success has been achieved. Object recognition is also related to content-based image retrieval and multimedia indexing as a number of generic objects can be recognized. In addition, significant progress towards object categorization from images has been made in the recent years. Note that object recognition has also been studied extensively in psychology, computational neuroscience and cognitive science. Object recognition is concerned with determining the identity of an object being observed in the image from a set of known labels. Oftentimes, it is assumed that the object being observed has been detected or there is a single object in the image. Object recognition in computer vision is the task of finding a given object in an image or video sequence. Humans recognize a multitude of objects in images with little effort, despite the fact that the image of the objects may vary somewhat in different viewpoints, in many different sizes / scale or even when they are translated or rotated.

Over the last century, there has been an extensive study of eyes, neurons, and the brain structures devoted to processing of visual stimuli in both humans and various animals. This has led to a course, yet complicated, description of how "real" vision systems operate in order to solve certain vision related tasks. These results have led to a subfield within computer vision where artificial systems are designed to mimic the processing and behavior of biological systems, at different levels of complexity. Also, some of the learning-based methods developed within computer vision have their background in biology.

Central to object rcognition systems are how the regularities of images, taken under different lighting and pose conditions, are extracted and recognized. In other words, all these algorithms adopt certain representations or models to capture these characteristics, thereby facilitating procedures to tell their identities. In addition, the representations can be either 2D or 3D geometric models. The recognition process, either generative or discriminative, is then carried out by matching the test image against the stored object representations or models.

II. PROBLEM DESCRIPTIONS

Object recognition systems have recently achieved high detection rates and real-time performance. However, these methods usually rely on a huge training database (around 5,000 positive examples for good performance). While such huge databases may be feasible for building a system that detects a single object, it is obviously problematic for scenarios where multiple objects (or multiple views of a single object) need to be detected. In this work we focus on the problem of learning to detect objects from a small training database.

We show that performance depends crucially on the features that are used to represent the objects. Specifically, we show that using local edge orientation histograms (EOH) as features can significantly improve performance compared to the standard linear features used in existing systems. For frontal faces, local orientation histograms enable state of the art performance using only few hundred training examples. For profile view faces, local orientation histograms enable learning a system that seems to outperform the state of the art in real-time systems even with a small number of training examples.

Many of the methods used for recognition either require good whole-object segmentation, which severely limits their performance in the presence of clutter, occlusion, or background changes; or utilize simple conjunctions of low-level features, which causes crosstalk problems as the number of objects is increased.

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III. PROPOSED SYSTEM

Evaluation of object detection systems requires a set of test images with objects in heterogeneous scenes. Unfortunately, existing publicly available object databases provide few, if any, test images suitable for evaluating object detection systems. Here we present the an Object Recognition system, a software package for creating patterns suitable for evaluating object detection systems. These are created by superimposing objects from existing publicly available object databases onto heterogeneous backgrounds. It is capable of creating various patterns focusing, gray scale conversion. This software package is being made publicly available to aid the computer vision community by providing various patterns which will allow object detection systems to be systematically compared and characterized.

Appearance-based object recognition methods have recently demonstrated good performance on a variety of problems. However, many of these methods either require good whole-object segmentation, which severely limits their performance in the presence of clutter, occlusion, or background changes; or utilize simple conjunctions of low-level features, which cause crosstalk problems as the number of objects is increased. We are investigating an appearance-based object recognition system using a keyed, multi-level context representation, which ameliorates many of these problems, and can be used with complex, curved shapes. To recognize an object, that is to answer the question "what object is in this image?" key features together with their local contexts are extracted from the image, and fed into the associative memory. All matches are retrieved, and for each match, the associated information is used to compute a hypothesis about the identity, view, and configuration of a possible object. This hypothesis is fed to a second, "working" associative memory, where current hypotheses are stored. If any matches are found, the evidence associated with them is updated to reflect the new information. Otherwise a new hypothesis is entered. The accumulation is not a flat voting process, but depends on the frequency of occurrence of the feature, with uncommon features providing more evidence.

IV. EIGEN FACES

Eigenfaces are a set of eigenvectors used in the computer vision problem of human face recognition. The approach of using eigenfaces for recognition was developed by Sirovich and Kirby (1987) and used by Matthew Turk and Alex Pentland in face classification. It is considered the first successful example of facial recognition technology. These eigenvectors are derived from the covariance matrix of the probability distribution of the high-dimensional vector space of possible faces of human beings.

4.1 Eigen Face Generation

A set of eigenfaces can be generated by performing a mathematical process called principal component analysis (PCA) on a large set of images depicting different human faces. Informally, eigenfaces can be considered a set of "standardized face ingredients", derived from statistical analysis of many pictures of faces. Any human face can be considered to be a combination of these standard faces. For example, one's face might be composed of the average face plus 10% from eigenface 1, 55% from eigenface 2, and even -3% from eigenface 3. Remarkably, it does not take many eigenfaces combined together to achieve a fair approximation of most faces. Also, because a person's face is not recorded by a digital photograph, but instead as just a list of values (one value for each eigenface in the database used), much less space is taken for each person's face.

The eigenfaces that are created will appear as light and dark areas that are arranged in a specific pattern. This pattern is how different features of a face are singled out to be evaluated and scored. There will be a pattern to evaluate symmetry, if there is any style of facial hair, where the hairline is, or evaluate the size of the nose or mouth. Other eigenfaces have patterns that are less simple to identify, and the image of the eigenface may look very little like a face.

The technique used in creating eigenfaces and using them for recognition is also used outside of facial recognition. This technique is also used for handwriting analysis, lip reading, voice recognition, sign language/hand gestures interpretation and medical imaging analysis. Therefore, some do not use the term eigenface, but prefer to use 'eigenimage'.

4.2 Practical Implementation

To create a set of eigenfaces, one must:

1. Prepare a training set of face images. The pictures constituting the training set should have been taken under the same lighting conditions, and must be normalized to have the eyes and mouths aligned across all images. They must also be all resample to the same pixel resolution. Each image is treated as one vector, simply by concatenating the rows of pixels in the original image, resulting in a single row with $r \times c$ elements. For this implementation, it is assumed that all images of the training set are stored in a single matrix **T**, where each row of the matrix is an image.

2. Subtract the mean. The average image **a** has to be calculated and then subtracted from each original image in **T**.

3. Calculate the eigenvectors and eigenvalues of the covariance matrix **S**. Each eigenvector has the same dimensionality (number of components) as the original images, and thus can itself be seen as an image. The eigenvectors of this covariance matrix are therefore called eigenfaces. They are the directions in which the images differ from the mean image. Usually this will be a computationally expensive step (if at all possible), but the practical applicability of eigenfaces stems from the possibility to compute the eigenvectors of **S** efficiently, without ever computing **S** explicitly, as detailed below.

4. Choose the principal components. The D x D covariance matrix will result in D eigenvectors, each representing a direction in the $r \times c$-dimensional image space. The eigenvectors (eigenfaces) with largest associated eigenvalue are kept.

V. EXPERIMENTAL STUDY

We now consider some simple experiments which illustrate the matching performance of eigenface technique for object recognition. We compute the performance of these techniques when the background is known and the lightning conditions remains almost unchanged. The experiment consist of two phases

1. Training phase
 Here we prepare a training set of objects.

2. Recognition phase
 Here the trained objects are recognized.

The experiment consist a trial set of 5 different objects. The experiment was conducted with 100 trials and the accurate trials are noted down. We considered 5 different sample objects including a pen, a toy car, a disc, a cell phone, and a flash drive. Three tables are given here with the experiment results. The Table 1 records the details in which training is done only once whereas in Table 2 the training is done 4 times and in Table 3 the training set is 8.

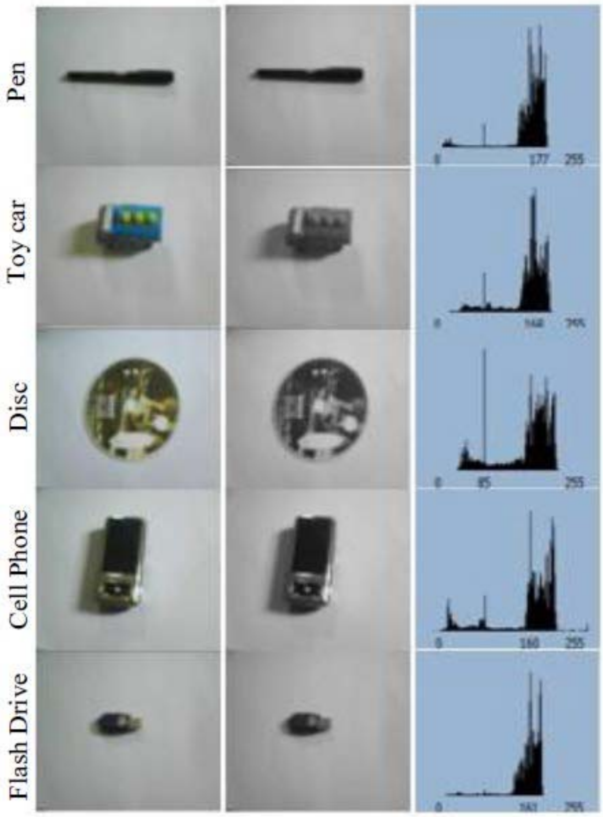

Figure 1: a view of object used for trial along with grayscale converted image and histogram.

Object Name	Number of training performed	Number of trials Conducted	Number of Success trial	Percentage of accuracy
Pen	1	100	53	53%
Toy Car	1	100	37	37%
Disc	1	100	72	72%
Cell Phone	1	100	74	74%
Flash Drive	1	100	53	53%

Table 1: Result of trial 1, where number of training performed is one.

Object name	Number of training performed	Number of trials Conducted	Number of success trial	Percentage of accuracy
Pen	4	100	90	90%
Toy Car	4	100	73	73%
Disc	4	100	100	100%
Cell Phone	4	100	90	90%
Flash Drive	4	100	70	70%

Table 2: Result of trial 2, where number of training performed is four.

Object name	Number of training performed	Number of trials Conducted	Number of succeeded trial	Percentage of accuracy
Pen	8	100	96	96%
Toy Car	8	100	92	92%
Disc	8	100	100	100%
Cell Phone	8	100	100	100%
Flash Drive	8	100	93	93%

Table 3: Result of trial 3, where number of training performed is eight.

Figure 2: sample training of pen with 8 training set.

We can infer that as the number of training has increased, it in turn increases the accuracy of recognition. In Table No. 1 we can see the no. of training is just 1 and the accuracy is too low. But in the succeeding ones theaccuracy has increased considerably. The comparison is between these 3 trials are plotted in the graph that follows:

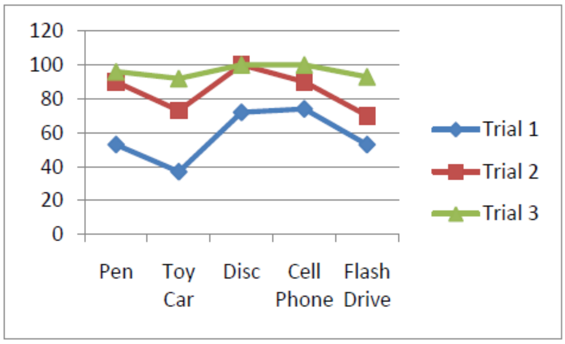

Figure 3: Graphical representation of accuracy.

X axis - Object name
Y axis - Number of success trial

Trial 1 consist of recognition with number of training is 1. Trial 2 consist of recognition with number of training is 4. Trial 3 consist of recognition with number of training is 8.

VI. Conclusion

In this work we tried to experiment object recognition using Eigen method. We conducted the method using different training set and accuracy was noted. Finally we inferred that the accuracy of recognition is increasing as the train input increases. Moreover the accuracy rate almost touched the maximum even the training set number is low for example, almost 8 as in the case of cell phone in this experiment. In brief this method can be utilized for object recognition.

With more reliable representation schemes and recognition algorithms being developed, tremendous progress has been made in recognizing objects under variation in viewpoint, illumination and under partial occlusion. Nevertheless, most working object recognition systems are still sensitive to large variation in illumination and heavy occlusion. In addition, most existing methods are developed to deal with rigid objects with limited intra-class variation. Future research will continue searching for robust representation schemes and recognition algorithms for recognizing generic objects in varying environment.

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