Object Recognition based on Principal Component Analysis to Image Patches

R.Ahilapriyadharsini
Mepco Schlenk Engineering College,
Sivakasi, India

S.Arivazhagan
Mepco Schlenk Engineering College,
Sivakasi, India

M.Gowthami
Renganayagi Varatharaj College of Engineering, Salvarpatti,
Sivakasi, India.

Abstract— The proposed method is to recognize objects based on application of Principal Component Analysis (PCA) to the image patches. In order to represent the local properties of the images, patches are extracted where the variations occur in an image. To find the interest point, Wavelet based Salient point detector is used. In order to reduce dimensionality Principal Component Analysis is applied to the image patches and finally the principal components are classified using Support Vector Machine (SVM) Classifier. Bench mark database used here is UIUC car database and the results obtained are satisfactory.

Index Terms- Object Recognition, Patch, Principal Component Analysis, Salient Point Detector, Featrure Extraction,UIUC.

1 INTRODUCTION

Natural images which are not limited to any size and which show arbitrarily complex scenes are classified according to whether they contain a certain object or not, this is Generic Object Recognition [1]. Visual systems effectively distinguish objects. In same way computer system must also recognize objects at any position, size, and appearance. The proposed method allows for recognizing objects (car) under such circumstances and shows excellent results in UIUC car database. Generic object recognition systems do not include any information about specific objects rather learn to recognize objects by inspecting training images and train the model and recognize objects in unseen images[2].For each training image, features are derived. Using these features and the trained model recognition system outputs whether the object is present or not.

Global features describe image as a whole and are less successful in recognition. Salient points are the points which maximize the discrimination between the objects. The characteristics of salient points as proposed by Haralick and Shapiro [3] are: Distinctness, Invariance, Stability, Uniqueness and Interpretability.

Earliest method for interest point detector is Harris Corner Detector, but this seems to be rotationally invariant but not Scale invariant [4]. Though there are numerous interest point detectors Wavelet based salient Point extraction seems to be the best approach [5]. Local Patch based approaches have shown to have benefits over global techniques.

The advantages of patches are 1.Reduction of the amount of data to be processed, 2.Robustness to background clutter 3.Robustness to occlusion, variability in object shape [1].

The paper is structured as follows. The next section discusses the outline of the proposed method. In Section III, Salient point detection, in particular the advantages of using Wavelets for Salient Point Detection are discussed. Section IV deals with Feature Extraction such as Patch extraction and PCA.

Section V gives the results for single scale (SS) and Multi scale (MS) images in UIUC Database. Finally Section VI gives the conclusion of the proposed method.

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2 OUTLINE OF THE PROPOSED METHOD

The first step is to detect the salient points using salient point detector. The interest points are formed in the region of high variance. The patches are extracted around each of these salient points. The retained patches are manipulated by computing PCA to extract the appropriate feature from the patches. Then the PCA components are classified using SVM classifier.

(a) (b)

Fig.1.(a) Input car image (b) Salient points extracted

3 SALIENT POINT DETECTION

In this method, the salient points can be detected based on wavelets [1]. The wavelet used here is the Haar wavelet, since it is the simplest wavelet and fastest in execution.

The advantages of using wavelets are:

1. Wavelet transformed image is a multi resolution description of an image.
2. Visual artifacts introduced by wavelet transformed images are less evident.
3. Sub-band gives higher flexibility in terms of scalability in resolution and distortion.

The main steps involved in salient point detection are:

1. For each wavelet coefficient, find the maximum child coefficient.
2. Track it recursively in finer resolutions. Set the saliency value of the tracked pixel at the finer resolution level: the sum of the wavelet coefficients tracked.

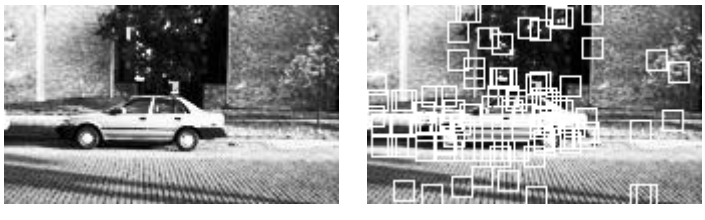
Most prominent points are finally chosen based on the saliency value.
This method leads to a more complete image representation than corner detectors [1]. Figure 1 shows the sample image from UIUC database and Salient point extracted image. For experimental purpose, 100 salient points are extracted.

4 FEATURE EXTRACTION

4.1 Patch Extraction

Objects of interests have little contribution to global properties as it occupies only a part of the image, hence Local descriptors are used. Patches are squared sub images extracted from the image over the Salient points [1]. Here patches of size 7x 7 are extracted over salient points. The result for Patch Extraction is shown in Figure 2.

For an $n \times n$ patch, n^2 dimensional feature vectors are obtained hence this step is desirable. A commonly used reduction method is Principal Component Analysis (PCA).



(a) (b)

(b)

Fig.2. (a) Input image (b) Patch Extracted image

4.2 Principal component Analysis

Descriptors obtained will be highly informative but when taken together tend to be over complete hence dimensionality reduction step is applied to retain only the salient characteristics of patch.

The steps involved in PCA transformation are,

1. Mean vector μ and covariance matrix ξ are computed for all the patches.
2. Find the Eigen values and Eigen vectors and sort it according to decreasing Eigen values.
3. Retain the topmost m values as the Principal Components.

5 EXPERIMENTAL RESULTS

The proposed method is evaluated using UIUC car dataset. It contains 1050 training images (550 positive car and 500 non-car images) and 170 single-scale test images, containing 200 cars roughly the same scale as in training images as well as 108 multi-scale test images, containing 139 cars at various scales [6].

The first step in the proposed methodology is the extraction of salient points. In this work 100 most prominent salient points are extracted using Wavelet

based salient point detector and patches of size 7×7 are extracted over each and every salient points. In order to reduce the dimensionality, the PCA is applied and the number of PCA components extracted is 4. The PCA coefficients are fed to the SVM classifier. The SVM used here is OSU-SVM [7].

The number of images used for training involves 550 positive images and 500 negative images and the number of

Fig 3. Misclassified Images

TABLE I

RECOGNITION RATE FOR SINGLE AND MULTI-SCALE TEST IMAGES

Number of images used for training		Number of images used for testing		Recognition rates (%)	
Positive images	Negative images	Single-scale images	Multi-scale images	Single-scale images	Multi-scale images
550	500	170	108	98.8	93.52

images used for testing involves 170 Single-scale test images and 108 Multi-scale test images.

The obtained result is compared with the various approaches using the UIUC Dataset and error rate performance for these approaches is compared.

Table II shows the error rate performance for various techniques which uses UIUC datasets .In [8], Objects are modeled as flexible group of similar parts. In [9], Image patches are extracted around interest points and compared to the codebook. Matching patches then cast probabilistic votes, which lead to object hypotheses. In [10], regions of homogeneity are extracted using Similarity- Measure segmentation and the region descriptors used are the intensity values. Finally Object categorization is done by Modified Adaboost algorithm. Mutch and Lowe (2008) investigated the role of sparsity and localized features in a biologically-inspired model of visual object classification and the classifier used is SVM [11] Our proposed technique gives error rate 1.2 when the patch size is 7×7.

6 CONCLUSION

It is concluded that the proposed method focuses on Object Recognition in Complex Images under varying illumination, rotation, scaling conditions. This method uses Image

TABLE II
ERROR RATES FOR VARIOUS APPROACHES ON THE UIUC DATASETS

Various Approaches on UIUC Datasets	Error rate (%)
[8]	11.5
[9]	6.1
[10]	0.0
[11]	0.06
Our method	1.2

Patches to extract the features and PCA transformation is applied to image patches. Concerning the patch locations, Wavelet based Salient points are used for better performance. Hence the proposed algorithm can be used for effectively recognizing objects under varying circumstances.

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