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Computerized Object Recognition System using Undecimated Wavelet Transform and Nearest Neighbour Classifier

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ABSTRACT

Object recognition is one of the main functions in human visual system. The recognition of categories of objects in images has become a central topic in computer vision. However it is a technically challenging and most important problem in computer vision due to various illuminations, size, and colour. In this paper, a robust and automated objects recognition system is presented using Undecimated Wavelet Transform (UWT) and K-Nearest Neighbour (KNN) classifier. To extract features from the given images, UWT decomposition is taken place at a predefined level of decomposition. Then, energy features are computed from all UWT sub-bands. To facilitate the recognition process, KNN classifier is employed. In order to assess the performance of the proposed approach, experiments are carried out using COIL database images. It provides satisfactory recognition accuracy of over 80% at 6th level of UWT decomposition.

INTRODUCTION

The recognition of categories of objects in images has become a central topic in computer vision. Automatic visual recognition systems are rapidly becoming central to applications such as image search, robotics, vehicle safety systems, and image editing. A multi-linear supervised neighbourhood embedding for discriminant feature extraction for object recognition is described in (Ha, X.H., 2012). A local descriptor tensor is used to represent an image and used for subject or scene recognition. An efficient model that captures the contextual information among more than a hundred object categories using a tree structure (Choi, M.J., 2012). This tree based context model improves object recognition performance and provides a coherent interpretation of a scene, which enables a reliable image querying system by multiple object categories. New data sets with images that contain many instances of different object categories are used.

An approach to measure the similarity between shapes and exploit it for object recognition is presented in (Belongie, S., 2002). The measurement of similarity is preceded by two methods; solving for correspondences between points on the two shapes and using the correspondences to estimate an aligning transform. A validation and rotation invariant object recognition is described in (Kim, K., 2012). By using difference of Gaussian filter and local adaptive binarization, a binary image reserving spotless object boundaries is achieved. An object region from surroundings is extracted with remunerated edges that reserves geometry information of object. Neural network is used to recognize the object.

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A method for object category recognition by improving the popular bag-of-words methods is presented in (Wang, M., 2010). To obtain the global spatial features, a fast method is applied to generate the semantic meaningful object parts by exploiting the geometric position distribution of the local salient regions. The multi kernel learning framework is adopted to integrate the extracted features in an optimal way. Multiple Kernel Learning (MKL) based object recognition is illustrated in (Bucak, S., 2013). It selects and combines kernel for recognition task. To recognize the object, each image is represented by multiple sets of features and MKL is applied to combine different feature sets.

Discriminative parts based object recognition is presented in (Liu, Y.H., 2012). It is composed of three stages; retrieval and feature extraction of number of local parts from each model object, modelling the objects by feature vectors and similarity measurement. An approach for moving object detection and tracking is developed in (Tao, G., 2009). It detects the moving objects in the redundant Discrete Wavelet Transform (DWT) domain. An improved adaptive mean-shift algorithm is used to track the moving object in the follow up frames.

Distinct multicoloured regions are detected using edge maps and clustering. Invariant object recognition is introduced in (Kyrki, V., 2004) using simple Gabor features. By exploiting Gabor feature space, illumination, rotation, scale, and translation invariant recognition of objects can be realized within a reasonable amount of computation for object recognition task. Local affine frames based approach for object recognition is implemented in (Obdrzalek, S., J. Matas, 2006). The local appearance is expressed in terms of affine-covariantly detected local coordinate systems.

In this paper, an approach for object recognition based on UWT and KNN is presented. The rest of the paper is structured as follows: The brief descriptions of the mathematical backgrounds of UWT and KNN classifier are explained in section 2. The proposed object recognition system is described in section 3. Experimental results and conclusions are discussed in section 4 and 5 respectively.

Mathematical Background:

The proposed object recognition system is built using UWT and KNN classifier. The mathematical background of the above mentioned approaches are discussed in this section

UWT Decomposition:

The main drawback of DWT is lack of translation invariant. The translation of an image by DWT leads to down-sampled version of low and high frequency sub-bands. UWT is used to overcome this and more comprehensive feature of the decomposed image is obtained. The concept behind the undecimated wavelet transform is no decimation (Starck, J.L., 2007). Fig.1. (a) and (b) show the DWT and UWT decomposition respectively where LP and HP are low pass and high pass filters.

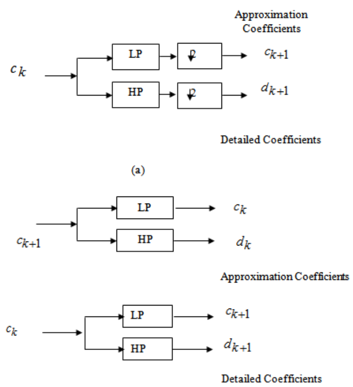

Fig. 1: (a) Filter bank for DWT (b) Filter bank for UWT.

The procedure for decomposing an image by UWT is same as DWT. However, the main difference of UWT is it omits both down-sampling in the forward and up sampling in the inverse wavelet transform. Hence, the size of all sub-bands does not reduce from level to level.

KNN Classifier:

K-Nearest neighbor classifier is one of the simplest instance based learning algorithm. Based on the distance function, KNN classifier assigns the class of the unknown object into one of the known training object's class. It requires training samples with class label. It calculates the distances between the unknown object and training samples. Then, it assigns the class label of the training samples which is nearest to the unknown object.

In this study KNN classifier is adopted with Euclidean distance measure. The Euclidean distance measure in eqn. 1 is used in the proposed method. Let us consider $a = (x_1, y_1)$ and $b = (x_2, y_2)$ are two points. Then, the Euclidean distance between these two points is given by

$$D(a,b) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (1)$$

Proposed Methodology:

The aim of the proposed system is to design an automated and reliable object recognition approach against various illumination, rotations and size. The design of the proposed object recognition system is comprised of two modules; feature extraction and recognition. Fig. 2 shows the schematic model of the proposed object recognition system.

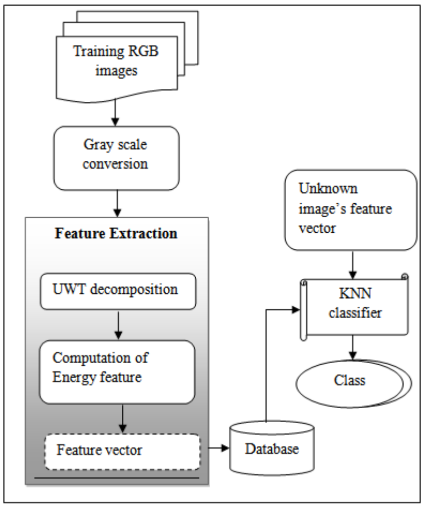

Fig. 1: Schematic model of the proposed object recognition system.

Feature Extraction:

Feature extraction is an important preprocessing step in any type of machine learning and computer vision algorithms. It reduces the amount of redundant data presented in a given image sample despite the fact that retaining discriminative image information. On account of feature extraction in this study, UWT is adopted at various decomposition levels. Initially, the given image undergoes into UWT decomposition. It provides multi resolution representations of the input image based on the level of decomposition. This representation contains one approximation sub-band and 3*k* detailed sub-bands for *k* level decomposition. Since UWT is achieved by removing the up samplers and down samplers in the DWT, the output of UWT contains the same number of coefficients which is equal to the number of pixels in the input image at each step. This may consume more memory and will take more computation time. To avoid this problem, the high dimensionality UWT coefficients space is reduced by computing energy features from each and every sub bands. The process of energy computation is repeated for all training images and corresponding features are stored in database for later recognition process.

Recognition:

The second stage of the proposed system is recognition or classification. The unknown image undergoes into the feature extraction steps as same as the feature extraction of training images. Then, the computed energy features and stored feature database are fed into the KNN classifier, whereas minimum distance between feature spaces is computed and the corresponding class of the unknown object is classified.

RESULTS AND DISCUSSIONS

In order to assess the performance of the proposed object recognition system, Columbia Object Image Library Dataset (COIL-100) (Nene, S.A., 1996) images are used for experimental evaluations. The accuracy obtained by the proposed approach is shown in Table 1. On account of training and testing process, COIL database images are divided based on the angles of object rotation.

It is observed form the Table 1 that the proposed system achieves maximum classification accuracy of 82.94% at 6^{th} level of decomposition. It is also noted from the Table 1 that the accuracy of the proposed system increases with respect to level of UWT decomposition while using objects that are captured at every 10^0 rotation. The detailed information produces in the higher level decomposition increases the performance of the system.

Table 1: Results for object recognition.

Level	*Recognition accuracy (%)*					
	10^0	*20^0*	*30^0*	*45^0*	*60^0*	*90^0*
2	*64.31*	*56.02*	*51.68*	*46.27*	*40.47*	*38.41*
3	*70.06*	*61.80*	*57.07*	*51.77*	*45.94*	*42.82*
4	*75.44*	*68.37*	*63.78*	*57.33*	*52.27*	*48.07*
5	*79.97*	*73.46*	*68.05*	*62.86*	*56.76*	*52.31*
6	*82.94*	*77.44*	*72.17*	*66.45*	*60.30*	*55.25*

Conclusion:

In this study, an automated object recognition system is presented based on UWT and KNN classifier. It is designed by constructing two stages. In the first stage, the given images are decomposed by UWT which is a frequency domain analysis. While using UWT coefficients directly, it may complicate the system performance. Hence, to train the classifier in ease manner, energy is computed from the decomposed UWT coefficients. Then, KNN classifier is adopted for object classification by using Euclidean distance measure. Experimental results show that the proposed object recognition system achieves better classification accuracy over 82%.

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