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Novelty Detection in Stored Video Stream

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Abstract: This paper aims at developing a new framework for novelty detection. The framework evaluates neural networks as adaptive classifiers that are capable of novelty detection and retraining on the basis of newly discovered information. Apply the newly developed model to the application area of object recognition in stored video. This framework model is trained on input video stream and tested on the video stream with some novel objects. This proposed paper enhances the existing work by following ways: i) Novel objects can be reliably detected when they partially enter the frames. ii) Illumination changes in outdoor video recordings do not effect the novelty detection. In this paper a new method of novelty detection have been developed. This methodology is significantly different to the use of other novelty detection techniques like novelty detection with softmax, novelty detection with auto-associator [1].

Key words: Video analysis · Neural networks · Adaptive classifiers · Novelty detection · Data mining

INTRODUCTION

Novelty detection [2] is aimed at finding novel events or data from a stored video stream. Novelty detection can be based on the difference between actual and perceived external stimulus [3]. Novelty detection is mainly used in the following area I) In military applications novelty detection is used to find a new object in protected area ii) For security applications using robotic vehicles with vision capabilities, novelty detection is used to find new events or objects which may represent intrusion. iii) Novelty detection in video can also be applied to a range of problems within the smart rooms technology to determine abnormal visual behavior of people [4].

In data mining techniques neural network is an appropriate approach for recognizing novelty in a frame of video sequence. This approach attempts to make the process mostly independent of any parameter setting to generate robust solution. Neural network and competitive learning are the powerful data mining tools that have the ability to learn a set of data to represent the learning process. The data mining technique is primarily beneficial in improving the novelty detecting efficiency by detecting novel object when 50% of the object enters the video frame.

For novelty detection, a description of normality is learnt by fitting a model to a set of normal examples and previously unseen patterns are then tested by comparing their novelty score (as defined by the model) against some threshold. The main challenge is the determination of appropriate threshold with which outliers can be detected for a given application. A number of methodologies for novelty detection have been developed. Almost all of the developed methods so far have the following weaknesses: i) difficulty in automated threshold determination; ii) failure to specify a generic methodology that is applicable across applications without *a* priori knowledge of known data distributions and iii) failure to specify an effective incremental classifier re-training procedure.

The proposed model of the system was designed and implemented in MATLAB6.5 under Windows XP operating system.

This paper is organized as follows: In section2 model of novelty detection is described. Methodology used is presented in section3 .In section4 the neural network approach for detecting the novel object in stored video stream is described and in section5 results are discussed with concluding remarks in section6.

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A Model of Novelty Detection: The proposed model of novelty detection consist of two phases i) Training Phase and ii) Testing Phase which are shown separately. In the training phase, a neural network is trained on a given set of features extracted from video sequence. In the context of recognizing natural objects in video streams, the training features are generated as follows: Training video frames which can be derived from training videos is converted into images.

For every image its raw pixel values on the basis of which color and texture features were extracted and ground-truth (label) data to known classes was stored. Neural network was trained on the training data and their architecture (number of hidden units, learning parameters).

The testing phase consists of following steps: Frame splitting which split the video into frames. Feature extraction which extract the features like color and texture. Euclidean distance was found between the cluster labels of training video frames and feature vectors of testing video frames. Automatic threshold was found from this distance and euclidean distance of each testing video frame was compared with threshold to detect novel object [4].

MATERIALS AND METHODS

Frame Splitting: Frame splitting is the process of splitting the video sequence into frames so that features can be extracted from each frame and processed easily. Both training and testing video sequence was splitted into frames.

Feature Selection: Features like correlogram features [5], color moment features [6], color space features [7], texture features and wavelet features are used in image processing and video analysis applications. It was found that the neural network works better with a reduced set of selected features rather than the complete set. As taken video sequence contains only natural and synthetic objects only color and texture features were selected.

Feature Extraction: The objective of feature extraction is to obtain information about the texture and color present in the image under analysis. The feature extraction process produces a set of features that, taken together comprise the feature vector [8, 9]. This drastically reduced the amount of information compared to the original image. The feature vector represents all the knowledge upon which the subsequent classification decisions could be based.

Extraction of Color Feature: Color is a prominent attribute considered in image processing applications and one of few that most researchers use. Color histogram is most widely used technique for extracting color features. This show the proportion of pixels of each color within the image. The color histogram for each image is stored in the matrix for object recognition image retrieval. A color histogram [9] refers to the probability mass function of the image intensities. This is extended for color images to capture the joint probabilities of the intensities of the three color channels. More formally, the color histogram is defined by,

$$h_{A,B,C}(a, b, c) = n . prob(A=a, B=b, C=c)$$

where A , B and C represent the three color channels (R,G,B or H,S,V) and N is the number of pixels in the image. Computationally, the color histogram is formed by discretizing the colors within an image and counting the number of pixels of each color. Algorithm to form color histogram is given below:

Algorithm: Construct Color Histogram from Video Frame:

Step1: Convert video frame into image. Step2: Convert image into RGB image.

Step3: Identify Red, Green and Blue colors from the RGB image

Step4: Similarly find Hue-Saturation-Luminance value by converting RGB image into HSY image.

Step5: Form color histogram for Red, Green, Blue, Hue, Saturation and Luminance.

Once color histogram was formed it represents the histogram counts. Lorenz Information Measure (LIM) was used to find the maximum value among this count.

Extraction of Texture Feature: Texture represents the characteristics of images. Texture is a key component of human visual perception. Like color, this makes it an essential feature to consider object recognition. Everyone can recognize texture but, it is more difficult to define. Unlike color, texture occurs over a region rather than at a point. It is normally defined purely by grey levels. Discrete Cosine Transform (DCT)is a feature extraction technique suggested by Ng *et al.* [9]. DCT is described as follows:

y = dct(x) returns the unitary discrete cosine transform of extract texture feature the dct value of red, green, blue, hue, saturation and luminance were found using above mentioned method and color histogram was formed for each dct value.

Neural Network Classification

Self-Organizing Network (SOM): Self-organizing in networks is one of the most fascinating topics in the neural network field. Such networks can learn to detect regularities and correlations in their input and adapt their future responses to that input accordingly. The neurons of competitive networks learn to recognize groups of similar input vectors. Self-organizing maps learn to recognize groups of similar input vectors in such a way that neurons physically near each other in the neuron layer respond to similar input vectors. Particularly competitive layer network was used for classification.

Neural Network for Novelty Detection: Neural network is a modeling technique based on the observed behavior of biological neurons and used to mimic the performance of a system.

The Self-Organizing Map *(SOM)* is a clustering algorithm that is used to map a multi-dimensional dataset onto a (typically) two-dimensional surface. SOM is an unsupervised learning network. For an unsupervised learning rule, the training set consists of input training patterns only. Therefore, the network is trained without benefit of any teacher. The network learns to adapt based on the experiences collected through the previous training patterns. As the output pattern of testing data is not known unsupervised learning network was used to train the video sequence.

It is used in applications such as robotics, diagnosing, forecasting, image processing and pattern recognition.

Competitive Learning: If a new pattern is determined to belong to a previously recognized cluster, then the inclusion of the new pattern into that cluster will affect the representation (e.g., the centroid) of the cluster. This will in turn change the weights characterizing the classification network. If the new pattern of inputs and outputs determined to belong to none of the previously recognized cluster, then (the structure and the weights of) the neural network will be adjusted to accommodate the new class (cluster).

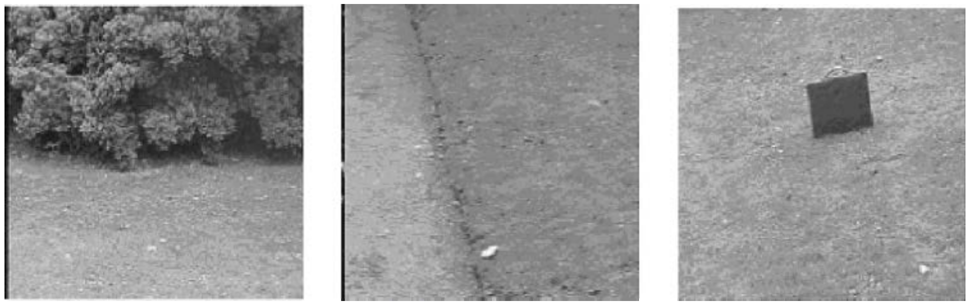
Training: A basic competitive learning network has one layer of input neurons and one layer of output neurons. An input given to neural network for classification was feature vector and network trained the video stream based on this feature vector. Cluster labels were produced as the output of training. The number of cluster label produced varies according to background of taken video sequence.

Testing: Once training video sequence was trained by using competitive learning network, features were extracted and distance was calculated between cluster labels of training video and feature vector of testing video. Automatic threshold was set as average of distance. Euclidean distance was used to calculate distance. Euclidean distance was calculated using the formula:

$$d = | x - y | = \sqrt{\sum_{i=1}^{n} | x_i - y_i |^2}$$

where x is cluster labels of training video stream and y is feature vector of testing video stream. For each video frame euclidean distance was calculated and compared with threshold for detecting novelty.

Implementation Result: This paper primarily focus on video sequences of outdoor environment. In order to understand what information is present in the video, it aims to train a classifier on naturally occurring objects and then by including a synthetic object in the outdoor environment, it test whether the proposed model can identify this novelty. The following objects from the outdoors were modeled: trees and road. An unseen set of samples from these known objects and two synthetic objects: briefcase and a piece of clothing (fleece) were taken in the video sequence. Two video sequences V1 (containing all known objects) for training and V2 (containing some of the known and one unknown object) for testing were taken. The aim was to find whether unknown objects in V2 can be detected. The video sequences were taken from the website http://www.dcs.ex.ac.uk/research/pann/master/web2/newisa.htm. Sample video frames are seen in Figure 1.



(a) Frame contain grass and tree (b) Frame contains grass (c) Frame with novel object

Fig. 1: Some example frames used in the proposed system

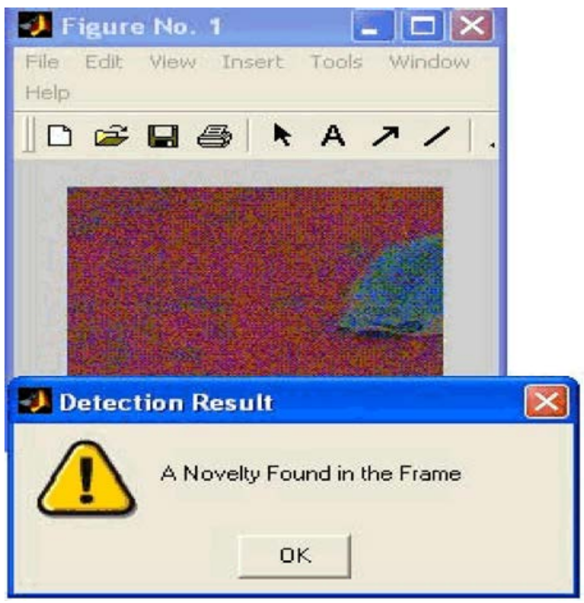


Fig. 2: Novelty detection result with novel object

Table 1: Novelty detection performance for varies frames based on portion of novel object enters the frame

No of Frame in Training video	No of Frames in Testing Video	Portion(%) of the Object Enters the Frame When Novelty Detected
35	112	50
105	259	80

It is clear from Table 1 that the proposed system effectively detected the novel object when only portion of the object entered the video frame.

As shown in Figure 2 novelty was detected when novel object entered the frames partially. Its also proved novelty detection was not effected when two video frames which were recorded under different lighting conditions were used.

CONCLUSION

In this paper a new method of novelty detection have been proposed. This method was based on the use of unsupervised clustering techniques. In this system a method to find the threshold automatically has been found and proved that novelty was detected when novel object partially enters the frame. Also proved that illumination changes in video frame does not effect the novelty detection.

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