NEURAL NETWORK BASED AUTOMATIC THRESHOLD SELECTION FOR AN INDUSTRIAL VISION SYSTEM

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ABSTRACT

Automatic threshold selection is one of the most important processes in industrial vision systems. In this study, a neural network is designed to select the threshold value automatically for an industrial vision system. A conveyor, which consists of a camera and a capture card, is designed for experimental study. The system has been tested for different objects, which are selected in a database. The online working feature of neural network makes this solution popular unlike the highly mathematical structure and time-consuming feature of conventional threshold selection methods. The results of experimental studies have been presented with their results.

1. INTRODUCTION

The problem of segmenting an object from a given field of view is basic to many image processing applications. Examples of such objects include lung tumours in chest radiographs, nuclei of blood cells and chromosomes in microscope images, solid in range images, or even military targets, in infrared and visible images. The digitisation of such images in image space might have a poor target/background contrast and unwanted background clutters may make segmentation difficult [1].

Threshold selection is one of the most important processes in image processing. Thresholding is widely used technique for image segmentation. It is based on the assumption that object and background can be distinguished by their intensity value. Many thresholding approaches have been studied in the literature. The best way to pick the threshold T is to search the histogram of grey levels, assuming it is bimodal, and find the minimum separating the two peaks. Finding the right valley between the peaks of a histogram can be difficult when the histogram is not smooth function. Smoothing the histogram can help but does not guarantee that the correct minimum can be found. An elegant method treating bimodal images assumes that the histogram is the sum of the composite normal functions and determines the valley location from the normal parameters [2][3].

Recently, with the developments in artificial intelligence; researchers have done some studies on threshold selection. Cheng and his co-workers have used maximum entropy principle and fuzzy c-partition method to select the threshold value (s) associated with the maximum entropy of the fuzzy c-partition [4]. Another study again using fuzzy has been done by Ramar and with his co-workers. In their paper, fuzzy measures are to be computed for a number of gray levels in the threshold range [5].

In this paper, we have designed a neural network to select threshold value automatically using frequency values on the histogram curve for each gray level value. The designed neural network has been used in a real-time vision based object recognition system. Threshold values are successfully obtained for each object in different situations.

II. THRESHOLD SELECTION

Many applications require the differentiation of the objects from background in the captured image data. Thresholding is most trivial and easily applicable method for this purpose. Thresholding is choosing a threshold value and assigning 0 to the pixels with values smaller or equal to T and 1 to the ones with greater values than T. We are interested in dark objects on a light background, the parameter T, called the brightness threshold, is chosen and applied to the image f (x,y) as follows:

If $f(x, y) \geq T \quad f(x, y) = \text{background}$

Else $\quad f(x, y) = \text{object}$

Thresholding is a technique widely used in image segmentation [6][7]. In the industrial vision based systems, threshold value should be computed, automatically.

III. NEURAL NETWORK DESIGN

In this section, the design of an artificial neural network (ANN) is given. Firstly, the data preparation for training and test set is explained. Then, the training and test procedure is given with its all details.

DATA PREPARATION

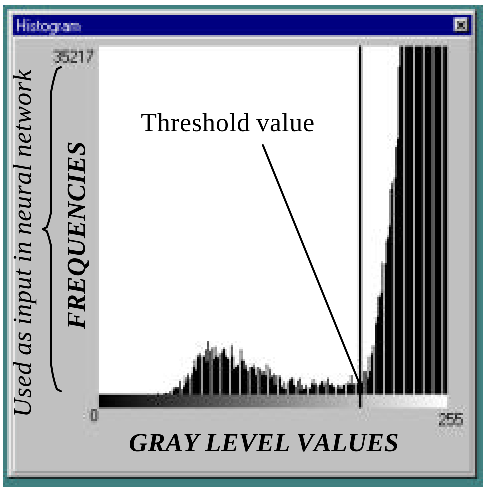
To prepare data for neural networks training set, the images are pre-processed. 8-bit quantizing is used. So that, grey level values changes from 0 (black) to 255 (white). 256x256 image. The size of image is 256x256 pixels. A median filter is used to eliminate the undesirable effects due to the noise and other effects. Then, histogram curves are obtained using median filtered images. A sample image and histogram curve is given in figure 1. For data extraction to for input and output of ANN; firstly, many different threshold values are obtained for different objects in different lighting conditions manually. For each sample, the frequencies for each grey level are recorded in a file to form the input data of ANN. Also, the threshold values for each input data vector set is matched in the file. The training set contains 250 data for 10 different objects in different conditions. Then, due to the feature of sigmoid activation, these obtained values are normalized between 0 – 1. Same maximum and minimum values are used in normalization for input and output data.

$$X_{Normalized} = \frac{X_{Real} - X_{Min}}{X_{Max} - X_{Min}}$$

Here;

Xreal	:	Real value of the sample
Xmin	:	Minimum value in data set
Xmax	:	Maximum value in data set
Xnormalized	:	Normalized value for a number

(a)



(b)

Figure 1. (a) Sample object image
(b) Histogram curve of object

TRAINING NEURAL NETWORK

Multi-layer Perceptron (MLP) trained using the back-propagation algorithm has been used in this study. Learning in an MLP model involves using an iterative gradient descent algorithm to minimize the mean square error between the actual outputs of the network and the desired outputs in response to given inputs. Training in an MLP network is performed by forward and backward operation, the network produces its actual outputs for a certain input pattern using the current connection weights. Subsequently, the backward operation is carried out to alter the weights to decrease the error between the actual and desired outputs. The alteration of weights is affected by two parameters, namely learning rate and momentum coefficient. The learning rate defines the range of the changes in the connection weights. The momentum coefficient is introduced to improve the learning process and it works by adding a term to the weight adjustment that is proportional to the previous weight change [8][9].

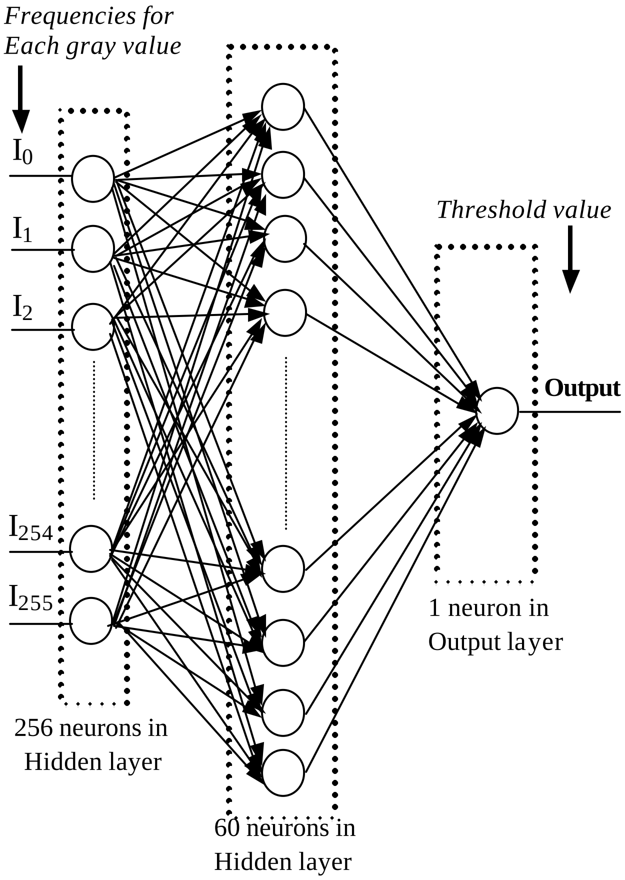


Figure 2. Topology of designed neural network for automatic threshold selection

In off-line training of BP neural network, 250 input and output vector sets are generated for 10 different objects in different conditions. 200 of these are used as learning set, and others are used in test. Outputs are coded in binary. It is a known fact that binary codes are strong through the noise. Due to the characteristic of sigmoid activation function, the training set is scaled between 0 and 1. Learning rate and the momentum rate are experimentally chosen as 0.3 and 0.7, respectively. Error at the end of the learning is 0.02784. Error is computed using mean square algorithm.

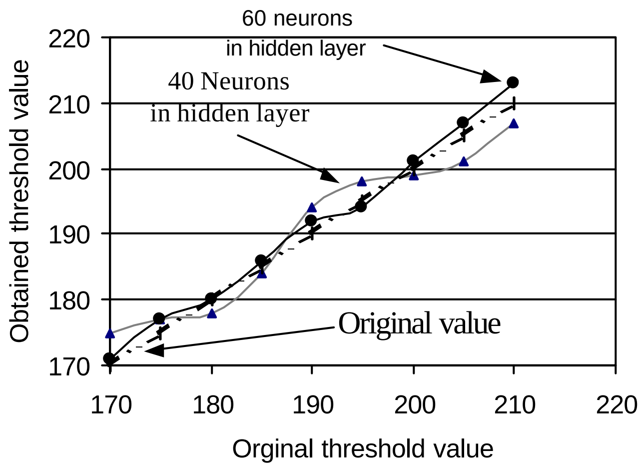


Figure 3. The results for different neurons in hidden layer in 250.000th iteration

The training process has been completed approximately in 250.000 iterations. When off-line training is completed, a neural network is designed using the obtained weights as seen in figure 2. The number of neurons in hidden layer is found experimentally. In figure 3, the curves for 60 and 40 neurons in hidden layer is given, graphically. Then, this neural network is also tested using a vision-based system. The set up of this system is explained below.

IV. EXPERIMENTAL SET-UP FOR TEST

The solution method is experienced on a vision based object classification system [10]. The system includes a camera, a capture card and a computer with a conveyor. A TV-capture card, which has a BT878 chipset, is used to capture image frames. Neural network and all image processing algorithms with real time capture process are implemented in Delphi Programming Language. To capture image frames we have used the drivers of the capture card (DLL File). Thus, TV-capture card is on-line controlled by prepared software.

We have made using the designed vision system an object position and analyses previously. This study has also includes recognition of objects. To mention about this system more; a work area is selected on the conveyor-moving surface. At the beginning of the conveyor we have captured images sequentially with intervals of 200 ms. by using these captured images we have computed the area of the object. We have compared the area changes to understand if the whole object image is ready to be captured or not in the work area. When the whole object is at the work area we have captured the image to be processed. Firstly, centroid is computed to have information about object position. The velocity of the conveyor is computed by using centroid changes. Using this velocity we have calculated the position of object after a certain time approximately at the end of the conveyor. The histogram curves are obtained for each object images. Here, the frequencies for each grey level value have been computed and given as an input to the designed neural network. The response of ANN is used threshold value of the processed object image.

The system has been implemented by using a Pentium III-750 computer. All processes have taken approximately 210 ms. In this duration, the neural network based threshold selection process has not taken a visible time.

V. RESULTS

In this is study; artificial neural network is used in automatic threshold selection. An ANN is firstly designed to select threshold value for a vision based object classification system.

The frequencies for each grey level are used as input in neural network, and the threshold value is used as output. In different conditions like lighting and other effects, the data preparation is realized for neural network. It was aimed to have an adaptive and automatic working threshold selection.
As a result, neural network is found successful in threshold selection for this system. Also, it may be generalized for different image processing systems. In this system, objects have been separated from the background and recognised successfully using proposed method. Traditional threshold selection methods include highly mathematical complex structures; therefore the online working feature of neural networks makes this method useful.

VI. REFERENCES

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