Detection of Different Classes Moving Object in Public Surveillance Using Artificial Neural Network (ANN)

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***Abstract*— Public surveillance monitoring is rapidly finding its way into Intelligent Surveillance Systems. Street crimes such as snatch theft is increasing drastically in recent years, cause a serious threat to human life worldwide. In this paper, a moving object detection and classification model was developed using novel Artificial Neural Network (ANN) simulation with the aim to identify its suitability for different classes of moving objects, particularly in public surveillance conditions. The result demonstrated that the proposed method consistently performs well with different classes of moving objects such as, motorcyclist, and pedestrian. Thus, it is reliable to detect different classes of moving object in public surveillance camera. It is also computationally fast and applicable for detecting moving objects in real-time.**

Keywords*— object detection; public surveillance; street crime; rate of occurrence; neural network*

I. INTRODUCTION

The public surveillance field has founded into interest to many researchers in the past recent years. The increasing number of street crime cases has demanded more accurate and reliable public surveillance system. Crime activity such as snatch theft is increasing drastically, especially in the global economic downturn. There seems to be a worrying trend culture of crime permeating throughout the nation. According to the Department of Statistic Malaysia, there are 26664 cases of street crimes have been reported in 2011 [*1*]. In 2012, the statistic shows that the number of the cases reported has been decreased only by 15.3%. This worrying figure proves that the problem is still far from being solved. Having thousands of cases reported in a year has caused a worry to the public. Therefore, the Malaysian government has taken an initiative in reducing crime through Government Transformation Plan (GTP) 1.0.

Extensive research has been carried out into the detection of moving objects in both developed and developing countries using various training-based techniques. However, numerous variables between complex scene and the characteristic of moving objects require analytical techniques rather than conventional. A recent approach to analyse these relationships is the Artificial Neural Network (ANN) which has been proposed and employed successfully by many scientists as an alternative to the conventional background subtraction approach where the foreground and the background need to be identified beforehand. This paper presents and discusses the development of object detection and classification model for different classes of moving objects using ANN approach.

II. ARTIFICIAL NEURAL NETWORKS AND THEIR APPLICATIONS

Artificial Neural Network (ANN) is a tool to process a set of information, represent the complex relationship into a manner similar to the human brain. It is a part of artificial intelligence system which has been used recently to solve a wide variety of computer vision problems. ANN is known to be an algorithm that capable to exploit non-linear relationships between variables. Neural networks are a flexible non-linear regression and discriminate models, data reduction models, and non-linear dynamical systems [*2*]. They consist of a large number of 'neurons', usually organized into layers to form a network.

It is a network of artificial neurons connected in such a way that enables it to store information and model input-output of a process. The key element of this model is the novel structure of the information processing system.

The typical artificial neural network is composed of three main components, which are the neurons, layers and activation functions [*3*].

The large network is built by many artificial neurons. Each neuron has an input value (x), weight (w) and a bias value (b) where shown in Equation 1. The value of each neuron is the value of the input multiply by the weight, plus the bias. Figure 1 shows a single neuron with multiple inputs and one output.

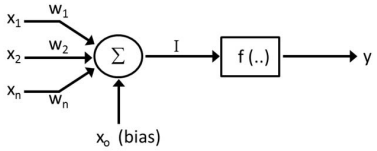

Figure 1. Single neuron

$$Neuron\ value, y = f(I) = \sum_{i=1}^{n} w_i x_i + b \quad (1)$$

The general neural network consists of 3 basic layers. There are input layer, hidden layer, and output layer. Each layer has several neurons connected to the other neurons from the previous layer. The input layer is where the data being supplied to the network. They act as independent variables given by the user. One or more hidden layer will do the processing, depends on its activation function. While, the

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output layer contains the outputs which are the dependent variables.

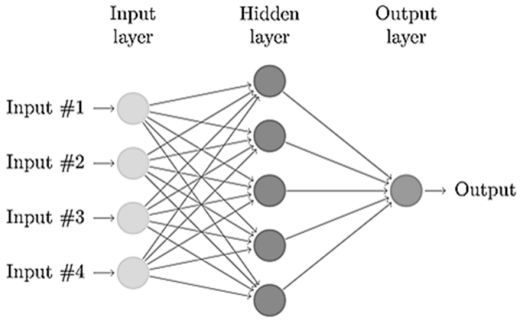

Figure 2. Typical layers in artificial neural networks [*4*]

Activation functions is the process where inputs being manipulated to obtain the desired output. These are also called transfer functions that define the mappings from input layer to hidden layer, and from hidden layer to output layer.

ANN has been deployed successfully in solving engineering problems related to classification of object, prediction of a pattern, and function approximation. In the public surveillance area, ANN has many applications.

Karthigayani et al. [*5*] was using Back Propagation Neural Network (BPNN) to predict human age. From the research, it was revealed that better result obtained compared to the common ANN. The quality of photos, glass appearance, and facial hair changes were taken as the features. However, the combination method between BPNN and Decision Tree will produce high computational cost. Maddalena et al. [*6*] used ANN to model the foreground for stopped object detection, as this research intended to be used for abandoned objects in train and airport stations. Based on their experimental result, for indoor environment, the objects are successfully detected. However, for outdoor environment, the algorithm need to be improved as some of the foreground are blended with the background. It happens mostly at occluded objects. Plus, this approach required additional steps which are background modeling.

Further applications include the work of Hafiz et al. [*7*] who used the ANN in classification of face recognition. It relies on the discriminant vectors learned by the network. The method is ideal for frontal face recognition as it has clear distinctive features at one side angle. In order to use it for street object classification, it may require large amounts of computing resources. On the other hand, Jadaan et al. [*8*] used ANN in the application to predict the probability of road accident.

ANN is widely used in surveillance monitoring. ANN is able to construct a suitable relationship between input data and the target responses without any need for a theoretical model to determinedly working.

III. DEVELOPMENT OF ANN DETECTION MODEL

Developing the ANN model for moving object detection and classification involved the following parameters and processes.

Data collection phase obtained from Royal Malaysia Police (RMP) is in the form of recorded CCTV footage. Each video will be converted to image sequences which will be analysed further.

The data is divided into three sets, which are training data (60% of total data), validation data (20% of total data), and testing data (20% of total data).

The network training, validation, and testing phase was performed using MATLAB software.

The network properties includes the need to be set beforehand to create sufficient size of network. The input data will be in the following parameters: T: type of moving objects, L: length, W: width, V: velocity in m/s. Selected transfer functions set to process the data are hyperbolic-tangent at the input hidden layer and linear transfer function at the output hidden layer.

The output value will be between [0,1] for each class. For the first object, if pedestrian is detected, the output is '1'. For the second detection, if motorcycle is detected, the output will be yield as '0'.

The neural network used in this research is based on a specific class of network, which referred as multilayer feed-forward network as shown in Figure 3.

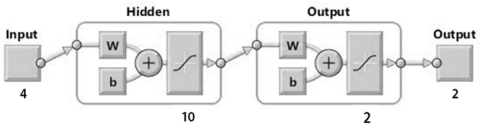

Figure 3. Architecture of the network

The training process started with setting the initial weights. Then, the output were evaluated based on initial weights considered at the beginning. From this values, Mean-Square Error (MSE) were calculated. The weights were then adjusted using learning rate, η. The weights adjusting were repeated until the MSE is small acceptable value or the desired output is obtained.

In the validation phase, no weight adjustment was done. Validation phase is necessary to determine whether the network satisfies the specified requirement to detect pedestrian and motorcycle. The validity can be improved by combining with training process to improve the performance of the model.

In the testing phase, the output values from the network are compared with the input values using testing data. Like previous phase, no adjustment occurs to the weights. This phase will use the test data which provides a completely independent measure of network accuracy.

IV. RESULTS

The neural networks allow the development of different alternatives by changing the number of hidden layers. Five alternative models with different number of hidden layers were considered as shown in TABLE 1.

TABLE 1. DIFFERENT ALTERNATIVES OF ANN MODEL

Model No.	No. of hidden layers	r (Training)	r (Testing)	r (Validation)	Correct classification (%)	Incorrect classification (%)
1	1	0.9811	0.9966	0.9819	46.6667	53.3333
2	2	0.9984	0.9814	0.9877	83.3653	16.6347
3	3	0.9614	0.9576	0.9966	93.3333	6.6667
4	4	0.9917	0.9991	0.9983	93.3333	6.6667
5	5	0.9970	0.9998	0.9993	94.6777	5.3223

** 'r' is the correlation coefficient between actual and output values of the network

The fifth model was found to be the best model with the highest correct moving object detection and classification. The result were found to be satisfactory with small mean-squared-error which reflects the network is able to produce detection and classification close to the actual data. Figure 4 shows the continuous process of the outputs which consist of Receiver-Operating Curve (ROC) for each phase: training phase, testing phase, validation phase, and overall phase.

The accuracy of the network depends on how well it can separates the tested images into pedestrian and motorcyclist groups. Accuracy is measured by the area under ROC curve. An area which close to 1 means it is accurate, while an area of below than 0.5 represents a worthless test.

In the training and validation phase, it yields to mostly perfect classification. However, at the testing and final phase, it performs at successful rate with the area under the curve with a slight incline, 0.9984 and 0.9995 respectively.

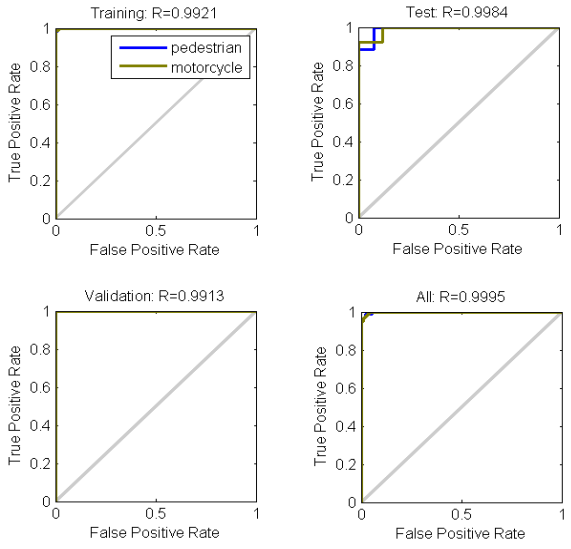

Figure 4. The network ROC curve for the outputs

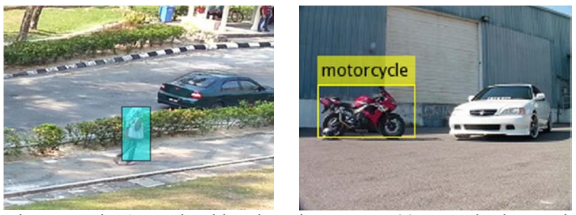

Figure 5. The ANN algorithm detection output : (a) Dense background (b) Less Dense Background

V. CONCLUSION

The increasing number of street crime cases has demanded more accurate and reliable public surveillance system. Artificial Neural Network (ANN) is a novel approach which proved to be successful in solving computer vision problem in term of detection and classification of different objects.

A moving object detection and classification model was developed using ANN approach through analysing relationship between all input features of the intended object to be detected. The proposed model was validated using street surveillance camera obtained from Royal Malaysia Police (RMP). It has produced satisfactory results in detecting different classes of objects which are the pedestrian and motorcycle under complex street scene condition.

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