An Image Processing Based Approach for Real-Time Road Traffic Applications

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Abstract— **Traffic engineers require various types of road traffic data to manage the traffic. The current sensors (inductive loops and axle sensors etc.) cannot collect all the data that are of interest to traffic engineers. Most important of all, if the data is to be collected at a different location, the installation of these equipments, which needs to be buried beneath the road, creates serious traffic disturbances. In order to overcome the above problems, many researchers have used vision-based system for collecting and analysing road traffic data. However, these techniques have not yielded good results due to various problems such as inefficiency of background updating, selection of a threshold value, change in ambient lighting etc. In this paper we describe a novel neural network and window-based image processing technique for road traffic applications. We use morphological edge detection techniques to detect vehicles. Once the vehicles have been detected, a back-propagation neural network is used for calculating various traffic parameters. This novel method has been implemented on a Pentium-based microcomputer system and the results are reported online in real-time. We also have compared our system with traditional image processing based systems and the results indicate that our proposed system provides better results than the traditional image processing based systems.**

Index Terms—mage Processing, Morphological Edge Detection, Neural networks, Transportation

I. INTRODUCTION

In recent years, laying new pavement or adding more lanes is becoming less feasible, particularly for big cities around the world and densely populated countries like Singapore, Hong Kong etc., where land is limited. One of the realistic solutions is to use the existing infrastructure intelligently and efficiently. Thus, road traffic management and control is the essential component of this solution. To manage and control the road traffic, it is necessary to obtain and analyse road traffic data in real-time. Although there are several techniques used for gathering traffic information such as magnetic inductive loops, radar, infra red ultrasonic [1], video image processing technique seems to be more efficient and flexible for computing broad range of traffic parameters [12]. However, there are many problems associated with this method due to diverse lighting and weather conditions.

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To overcome these problems, many techniques and algorithms have been proposed [1-9] and some of them even have been implemented [10-12]. Although some of these techniques have been able to overcome some of the above-mentioned problems, there is no complete system which can intelligently collect and analyse road traffic data in real-time [10, 12]. The system described in this paper is able to provide the collection and analysis of road traffic data in real-time, which can be considered a step closer in realizing the dream of modern intelligently transportation system

II. THE VEHICLE DETECTION PROCESS

The algorithm used for vehicle detection is based on applying low pass filtering and edge detection operations on windows located across the roads (figure 1). The edge detection has better performance than the background differencing operations as colours of vehicles and the ambient lighting changes in traffic scenes are less sensitive to edge detection [10]. Following the application of edge detection operation, the number of pixels having greater value than the threshold is used to recognise a vehicle. The threshold value is automatically determined by analysing histogram of the image [8].

Figure 1 Defining and Placing of Windows

A. *Selection of Edge Detector*

Edges are significant local change in the image and are important features for analysing images. They are usually found at the boundary between two different regions in an image. In our case, the edges are found in between the vehicle and the background. Many edge-detection algorithms based on gradient operators or statistical approaches have been developed. The gradient operators are usually sensitive to noise and are used with filtering operators to reduce the effect of noise [8]. Statistical approach is unable to detect thin edges, which are very likely to occur at a window of an image. The morphological-based edge detectors have proved to be more effective than conventional gradient-based techniques 910]. We have studied 4 commonly used edge detectors namely morphological edge detector called SMED, Krish, Prewitt and Sobel edge detectors. The algorithms were tested under various traffic and lighting conditions. As it can be seen (figure 2), SMED, morphological edge detector can detect vehicles passing through the windows nearly free of errors. The other edge detectors produced errors in the range of 3 - 7%.

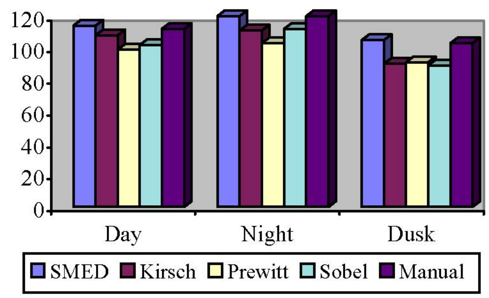

Figure 2 Result of Counting Vehicles

III MEASUREMENT OF TRAFFIC PARAMETERS

The traffic parameters such as vehicle count, vehicle speed, traffic congestion and vehicle movements at traffic junctions are extracted via vehicle detection operation. In the following sections, we describe the algorithms for calculating various traffic parameters.

A. *The Queue Detection*

The vehicle detection operation along with a motion detection operation is used to detect and measure the length of the queue [8]. In this case the window is located along the road direction. The algorithm used to detect and measure queue parameters consists of two operations, one involving motion detection and the other vehicle detection. These operations are applied to a window to detect the size of the queue. The method used for motion detection is based on differencing two consecutive frames. The vehicle detection algorithm is only applied when no motion is detected by the motion detection algorithm.

B. *Traffic Movements at Junctions*

The first step to measure the TMJ (traffic movements at junctions) parameters is to cover the boundary of the junction by a polygon in such a way that all the entry and exit paths of the junction cross the polygon [10]. However, the polygon should not cover the pedestrian marked lines as shown in figure 3.

The second step of the algorithm is to define a minimum numbers of key regions inside the boundary of the polygon, covering the junction. These key regions are used for detecting vehicles entering and exiting the junction based on First-Vehicle-In First-Vehicle-Out logic

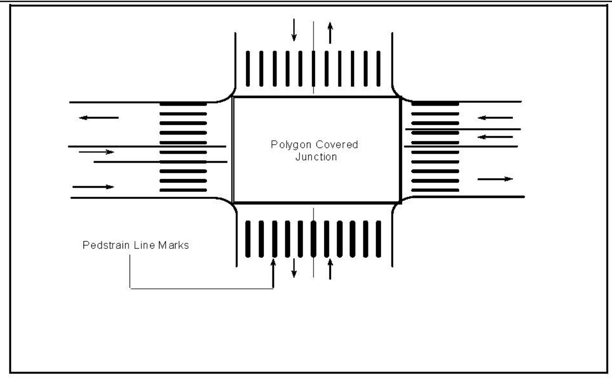

Figure 3 The Polygon Covering the Junction

IV USING NEURAL NETWORKS

In order to analyse the status vector for each window; a neural network with 10 inputs, 7 outputs and a hidden layer was used for pattern recognition and traffic analysis. In this method, the pattern vector of 10 consecutive frames is applied to a back propagation network and the number of passed vehicles is computed by neural networks. Each input of neural network is the percentage of white points in that frame and each output represents the number of passed vehicles in 10 frames.

The training of neural network is done for each road separately. In our approach, 200 samples are used for training and the network has produced designed response after 100K training. Following the training of the network, the computed weights (*W*ij) are extracted and are used for vehicle detection program to compute the outputs as follows:

$$Sj = \sum_j Wij * Xi \quad i = 0 \ \text{input} \quad j = 1 \ \text{hidden} \qquad \text{(i)}$$

Where, input and hidden are the numbers of inputs and hidden layers in our system. These values are constant and equal to 10. The output of each hidden layer is computed using signed function as follows:

$$hj = (1 + e^{-sj})^{-1} \qquad j = 1 \ldots\ldots \text{hidden} \qquad \text{(ii)}$$

Where Sj is obtained from equation (i). The main output of neural network is computed as follows:

$$Sj = \sum_j Wij * hi \quad i = 0 \ . \ \text{hidden} \quad j = 1 \ \text{Output} \qquad \text{(iii)}$$

When hj is computed from (ii) and output is constant value equal to 6. The output of network is given as:

$$Oj = (1 + e^{-sj})^{-1} \qquad j = 1 \ldots\ldots \text{output} \qquad \text{(iv)}$$

V RESULT

The algorithms were tested under various traffic and lighting conditions using an Intel Pentium-based computer system operating at a clock speed of 2 GHz together with a frame grabber. We have conducted extensive experiments for a continuous period of 6 - 8 hours. The result of counting vehicles by heuristic method is shown in figure 4, while figure 5 shows the results using neural network approach. It is clear that the neural network approach has provided better results than the traditional approach.

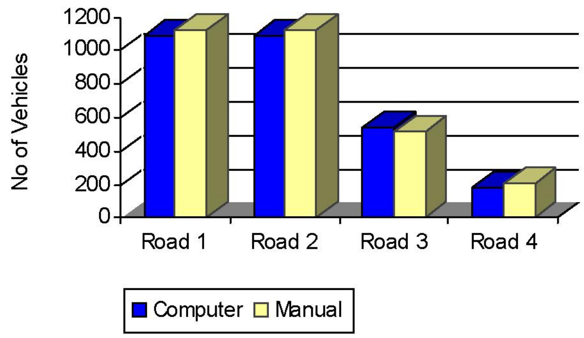

Figure 4 Counting Vehicles

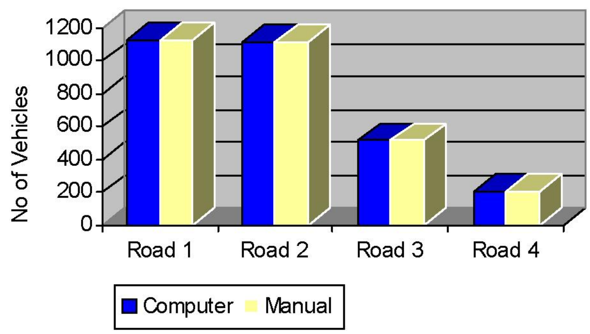

Figure 5 Counting Vehicles (Neural Network)

The results of queue parameters by both approaches are shown in figures 6 and 7. From the results it is obvious that neural network approach provides better results. The result of the TMJ parameters by using traditional image processing algorithms is shown in figure 8, while figure 9 shows the result of TMJ parameters by using neural network approach. As it can be seen, there are up to 15 % overall errors in measuring the TMJ parameters using the traditional methods. This error is reduced to 1.5% when the neural network technique is used.

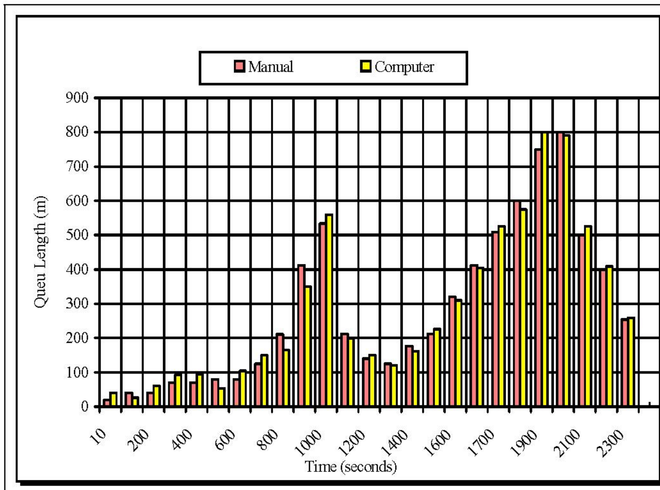

Figure 6 Queue Parameters

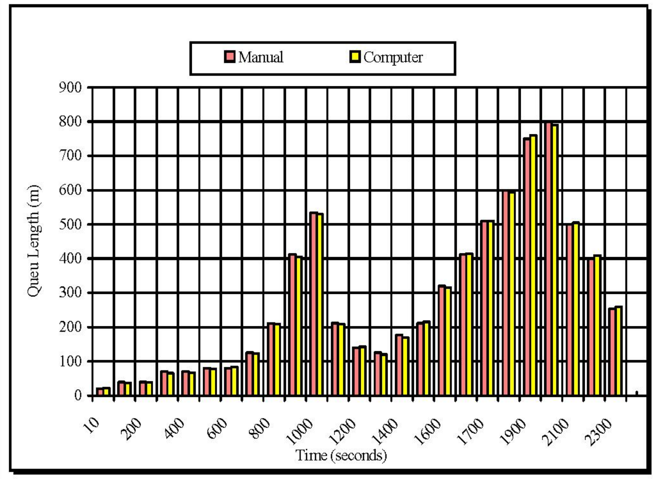

Figure 7 Queue Parameters (Neural Network)

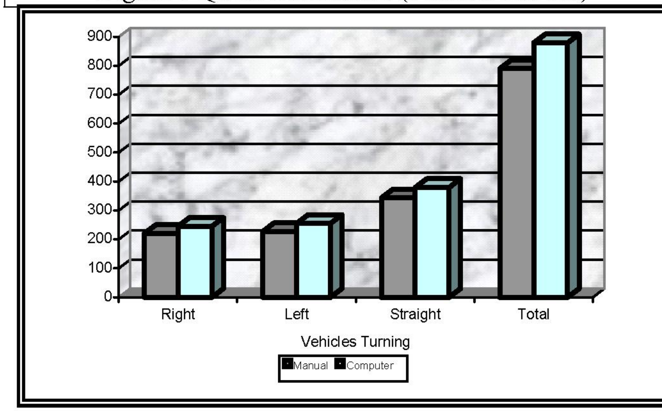

Figure 8 TMJ Parameters

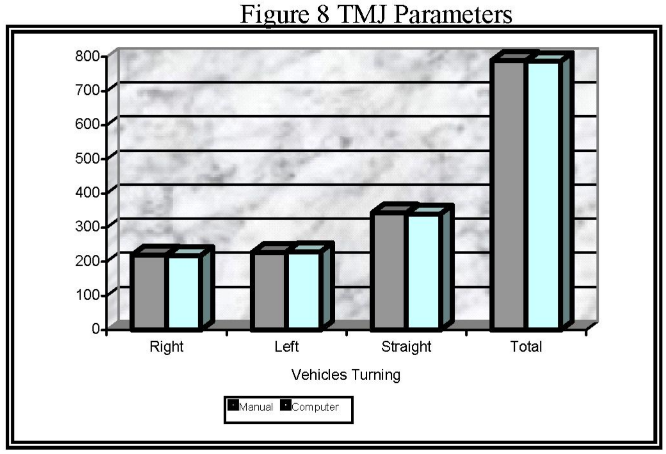

Figure 9 TMJ Parameters (Neural Network)

VI CONCLUSION

A new traffic parameter measurement approach by using neural network instead of heuristic approach was introduced to analyse the road traffic data. Neural network is more accurate than the heuristic approach as considering all patterns is difficult in real-world traffic scene because the vehicles move with different speeds and directions. In this case, an intelligent approach such as neural network, which is trained for various traffic scenes and situations, is able to compute the parameters more accurately. By using other networks with more hidden layers or other training approaches, it is possible to have a system that can respond to any traffic scene more accurately.

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