Optical Sensor Traffic Monitoring Using Analog Image Processing Techniques

M.Balakarthikeyan[1], G.Arunprasad[2], Dr.B.Chidhambararajan[3]

[1,2]Asst.Prof, Department of Electrical and Electronics Engineering,
VelTech MultiTech Dr.R.R & Dr.S.R.Engineering College, Avadi, Chennai.
[3]Principal
Madurai Institute of Engineering & Technology, Madurai, Tamil Nadu, India.

ABSTRACT

Governments worldwide are investing much time and effort into developing efficient traffic-management capabilities to overcome growing problems with traffic congestion, accident rates, long travel times, and air pollution from auto emissions. One approach is to use optical sensors to monitor traffic and establish a dynamic road traffic-management system that operates in near real time. Such a system requires the design of new software and hardware components for signal processing. Traffic-data measurement systems often used today are induction loops embedded in the pavement and the so-called floating-car-data technique, in which the desired data such as the position and velocity of the vehicles--are collected by several mobile units at the same time and transmitted to a central system via mobile communication. These types of systems have disadvantages, including the inability to calculate all the necessary traffic parameters, such as object-related features (location, speed, size, and shape) and region-related features (traffic speed and density, queue length at stop lines, waiting time, and origin-destination matrices), or to evaluate the behavior of nonmotorized road users. Optical systems can overcome these limitations and thus optimize traffic flow at intersections during busy periods, identify accidents quickly, and provide a forecast of changes in traffic patterns.

***Keywords*: monitoring traffic, air pollution, Optical sensor, Image Processing.**

I.INTRODUCTION

Sustainable urban development requires a modern transportation management. Especially cities have distinct transportation problems. Like many cities in the world they suffer from severe traffic congestion, air pollution, high accident rates, slow traffic and long overall travel times. An efficient transportation management system has to be developed to overcome these world wide problems. This includes reliable traffic observation, traffic control, and dynamic road traffic management in real time.

Traffic accident detection employing computer vision and image processing on freeways has attracted much attention recently. Kimachi focus on abnormal vehicle behaviors causing incidents (e.g., a traffic accident), traffic jams, fallen-down obstacles, etc. They propose a method that employs image-processing techniques and fuzzy theory to predict an incident before it happens. The judgment of whether an incident has happened or not is made using the “behavioral abnormality” of some continuous images. Michalopoulos carried out an autoscope video-detection system to detect incidents. This system is able to detect incidents almost 2 miles away. Yong-Kul Ki proposed a Accident Detection System using Image Processing and MDR. He proposed an algorithm includes three steps: vehicle extraction, feature extraction of a moving vehicle (MV), and accident detection.

II. HARDWARE AND SOFTWARE COMPONENTS

The system we have developed consists of mechanical and optical components, an image-acquisition system, a hardware-based image-processing unit, and image-processing software implemented in a standard microprocessor (see Fig. 1). There are three different levels of image and data processing: the processing in the camera itself (detection and extraction of traffic objects), the further processing as tracking and calculating features for describing the actual traffic flow, and the fusion of all these information and additional data to evaluate the overall situation.

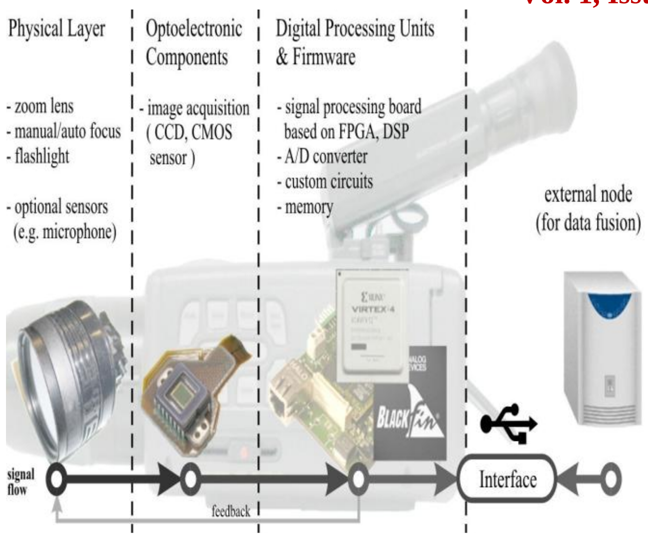

FIGURE 1.

An integrated optical system for monitoring via image analysis includes mechanical and optical components, an Image-acquisition system, a hardware-based image-processing unit, and image processing software.

The sensor system combines complementary technologies (stereo camera, infrared and visible sensors) that offer a variety of radiometric and geometric resolution and spectral sensitivity. The sensors are connected within a network; the availability of specific hardware solutions at low-cost allows special image processing and avoids some basic bottlenecks. One possibility of a flexible hardware design is the implementation of image-processing procedures on a field-programmable gate array (FPGA). The advantages of FPGA solutions are a high degree of parallelism, a flexible structure, low clock frequency, and low power loss. The programmability makes it possible to adapt the structure to the problem (especially the degree of parallelism in the limit of available gates). A high-density FPGA provided by Altera or Xilinx, for example, includes more than 1 million gates as well as embedded 32-bit processor cores.3 An important step in implementing this system is to build up the hardware accelerator code, which is located in the programmable logic storage of the FPGA. We found that memory-mapped communication gives the best performance and lowest cost. If the system is intended to use FPGA structures for real-time signal processing, algorithms that are suitable for parallel processing should be used. The degree of parallelism is determined by the amount of hardware resources (gates, slices, and modules), so algorithms have to be adapted to these hardware resources for fast operation. In addition, the use of programmable hardware and software allows an early system test without increasing hardware costs, which means the same platform can be used from prototype to full-scale implementation[7].

In addition to the sensor system and other hardware and networking components, low- and high-level image-processing algorithms are needed to enable the traffic-management system to operate intelligently. The performance of the system depends on the reliable recognition of all road users, their adequate description, and the knowledge of how to combine these parameters with information from other sources to solve the problems of traffic management.

III. EXTRACTION OF TRAFFIC OBJECTS

Robust segmentation of the images is crucial for traffic surveillance. Objects of interest are pedestrians, motorized and non-motorized vehicles. One well-known method for initial segmentation is the calculation of the difference between the current image and an estimation of the background. In general, the algorithms for background estimation have to deal with a vast number of different lighting conditions. Rapid changes of image intensity due to clouds, rain or automated exposure control of the camera itself have to be taken into account.

All these problems have to be addressed; otherwise the background update will be trapped in a vicious circle: false background estimation will lead to false segmentation. False segmentation will lead to a false update of the background image. After the background image was initialized the difference image between the background and the current image is calculated using the color model. Differences are calculated independently for each channel. An adaptive threshold is applied to the difference images. The two resulting binary images are merged with a logical OR operation.

A connected component analysis and the calculation of the convex hull of each object provide the traffic objects. The set of convex hulls is also used for masking the regions that are excluded from the update of the background image.

Image processing includes the search for shadow, histogram calculation and morphological operations. Tracking of objects in an image sequence is done with Kalman filtering. This approach allows the tracking of objects. Tracking is a necessary task for instance to determine the origin-destination relations at intersections.

IV. VEHICLE EXTRACTION AND TRACKING

Vehicles are extracted by detecting moving parts in each frame based on a difference equation. This process consists of taking the difference of two continuous frames, binarization, and horizontal and vertical projection, and then extracting parts which exceed the threshold value. For the extraction of moving regions in a video sequence, an input image, a pair of gray-level images acquired at successive time instants. The output is the moving regions in which significant changes have been detected. For the extraction of moving regions, the difference image is computed[2].

V. FEATURE EXTRACTION

Depending on the tracking result, the Accident Recording and Reporting System extracts features for accident detection. Features such as the acceleration, position, area (size), direction of the moving vehicle are used for accident detection. Rapid velocity variation is a useful descriptor of a traffic accident. In general, a traffic accident causes rapid change to vehicle speeds. Hence, we used the variation rate of vehicle speed (acceleration and retardation) for accident detection. In the tracking process, the speeds of the moving vehicle's, calculated the positive or negative accelerations of the vehicles, and used them for accident detection. Positions are useful descriptors of objects within images. An image that represents an object consists of positive valued pixels that are set against a background of 0-valued pixels. Position refers to the location of the object in the plane. The object's centroid (or center of mass) is the point that is used to specify its position. Area is a commonly used descriptor for regions in the plane. Let R denote the region whose points have pixel value 1. One way to calculate the area (S) is simply to count the number of points in R. This can be accomplished with the image algebra statement $S = \Sigma s$. When the vehicle moves away from the camera, the size of the moving vehicle decreases and as it moves towards the camera, the size of the moving vehicle increases; however, its variation rate is small. On the other hand, the accidents cause rapid change to the size of the MV. Therefore, we used the variation rate of area as a factor for traffic accident detection.

VI. ACCIDENT DETECTION ALGORITHM

The traffic accident will be detected by using the detection algorithm. The accident features in each image were calculated in the acceleration, position, and direction. Finally, considering the "Feature indexes" in the sequence, it was determined whether or not the traffic accident had occurred. The accident detection algorithm is summarized as follows:

ALGORITHM:

Step 1: extract the vehicle objects from the video frame

Step 2: track the moving vehicles by the tracking algorithm

Step 3: extract features such as variation rates of velocity, position, area, direction of the moving vehicle as the accident index

Step 4: estimate the sum of the accident index flags such as velocity, position, area and direction (VF+PF+SF+DF) and identify the accident [3].

VII. POLLUTION PREDICTION

Using the image processing techniques not only the traffic was monitored the pollution also predicted. Road traffic makes a significant contribution to the following emissions of pollutants: benzene(C_6H_6), 1,3~butadiene, carbon monoxide(CO), lead, nitrogen dioxide(NO_2), Ozone(O_3), particulate matter(PM_{10} and $PM_{2.5}$) and sulphur dioxide(SO_2). The impact of local air quality pollutants on the environment and health. The figure shows that, increased car ownership and use in urban areas (road traffic) generate some chemical emissions to the air to form the air pollution. With various weather conditions (effected by the temperature, wind, humidity, pressure, etc.), these pollutants pose different air qualities. When human beings expose to the polluted air (especially in the urban areas), driving in heavy traffic, near the highways or at the 'downwind' locations, with the dose-response, people may suffer breathing problems and asthma attacks, which will contribute to risk of heart attacks among people with heart disease [8].

Traffic parameters such as the number of trucks and cars and their average speed can be used to estimate the traffic related air pollution. Good prediction results require the classification of car types, especially of trucks, and the characterization of the traffic situation. After segmentation the front of each truck is extracted and normalized. Then potential positions of the manufacturer logo are searched. The two-dimensional cross correlation provides a similarity measure for truck classification.

The traffic related air pollution is acquired with a network of sensor units which are spread over the whole city. The concentrations of NO, NO_2, NO_X, SO_2, CO and PM_{10} are measured. A camera was installed above one of the sensor units to determine up to which degree the concentration can be estimated by simply counting cars and trucks. The first step was to look for a possible temporal shift between the data. As shift index the maximum of the normalized discrete cross correlation function was calculated. Then the Pearson correlation coefficients for the time-shifted curves were determined. Table 2 shows the correlation coefficients between air pollutant concentration and the number of trucks or the number of all vehicles, respectively.

The value of correlation indicates that the number of trucks is a better measure for traffic related air pollution than the number of all vehicles. However, additional parameters should be included. An appropriate model includes weather information, information about the sensor position and specifics of each estimated concentration. The information about the truck type can be used to incorporate type-specific emission characteristics. The amount of pollution is also sensible to the traffic situation. The consideration of average speed will allow applying the appropriate pollution model [5].

TABLE 1.
Correlation coefficients between air pollutant concentration and the number of trucks

Air pollutant	correlation coefficient (5 min sum of trucks)	correlation coefficient (5 min sum of all vehicles)
SO_2	-0.29	0.01
NO	0.22	0.10
NO_2	0.57	0.03
NO_X	0.27	0.10
CO	0.43	0.01
PM10	-0.03	-0.10

VIII. RECENT TRENDS:

Recently the optical image processing technique was used to identify the vehicle license plate and to monitoring the traffic. Optical systems have a multitude of advantages in traffic monitoring. First of all there is a variety of usable sensors which can be combined in different ways. Limitations from measurement principles in the spectral or resolution range can be compensated, if the combination is complementary. For example, the CCD-camera has a limited spectral range, but day and night vision is possible by combination of sensors for visible and infrared radiation. Several cameras with different views can also help to manage occlusions in the camera field of view caused by traffic signs, trees, or cars. From image sequences acquired by optical systems the automatic object extraction and tracking can be carried out by using corresponding object recognition and tracking algorithms. The traffic flow can be characterized by traffic object parameters and road or lane related amounts if each traffic objects is identified and specified. Typical object parameters are location, speed, size, shape, color of moving and non-moving traffic, distances to the traffic behind and ahead, as well as vehicle acceleration or location in object space. Typical lane related features are traffic speed and density, queue length at stop lines, waiting time, number of waiting vehicles, origin-destination matrices as primary values. Secondary values are derived statistical features related to the traffic object (average speed, traffic direction, travel time), to the region of acquisition (average density, average traffic speed, average queue length), or to the lane (number of objects). At least the object information can be combined with image information and geo-coded object description to get a user-friendly traffic characterization with GIS tools.

If objects could be extracted by hardware in the camera system itself, it would not be necessary to transmit the whole image, but only the object information. Image processing algorithms in the sensor system can be implemented in specially designed hardware (e.g. programmable logic) to support real time signal processing.

IX. CONCLUSION

Traffic monitoring by optical sensors provides the capability of real-time surveillance of large areas. The use of complementary sensors (stereo camera, IR and VIS sensors) provides a variety of images which can be processed to extract features and to track all kinds of observed objects. There are still problems with synchronizing the various images or finding spatial correlations in real-time. Future developments should deal with scalable procedures for time-consuming tasks and with methods for an optimal partitioning of hardware and software implementation of the developed algorithms. By using this optical sensor we can monitor the traffic at any type of roads. We can identify the accidents at any traffic levels. This optical sensor traffic monitoring systems will be able to provide real time accident prediction and warning system.

REFERENCES

[1] Dalaff, C.; Ruhé, M.; Reulke, R.; Schischmanow, A.; Schlotzhauer, G., "OIS - An optical information system for road traffic measurement and management", *Joint Workshop of ISPRS Working Groups IV/3, IV/6 and IV/7, University Stuttgart, Germany, 8. - 9. September 2003.*

[2] Y. K. Ki, D. Y. Lee, D. K. Baik. "Traffic Accident Detection Model at Intersections via Image Processing," Presented at *85th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 2006.*

[3] Meffert, B., Blaschek, R, Knauer, U., Reulke, 1 R., Winkler, F., Schischmanow, 1 A., "MONITORING TRAFFIC BY OPTICAL SENSORS", *Second*

International conference on Intelligent Computing and Information Systems, March 2005, pp. 9-14.

[4] I. Ohe, H. Kawashima, M. Kojima, Y. Kaneko. "A Method for Automatic Detection of Traffic Incidents Using Neural Networks," *In Proc. Of the IEEE Conf. Vehicle Navigation and Information Systems, 1995, pp. 231-235.*

[5] Reulke, R.; Börner, A., Hetzheim, H.; Schischmanow, A.; Venus, H., "A sensor web for road-traffic observation", *IVCNZ 2002, Proceedings, pp. 293-297.*

[6] Yong-Kul Ki., "Accident Detection System using Image Processing and MDR", *IJCSNS International Journal of Computer Science and Network Security, VOL.7 March 2007, No.3, pp. 35-39.*

[7] http://lfw.pennnet.com/display_article/282147/12/ ARTCL/none/WebX/TRAFFIC-MONITORING:-Optical-sensing-system- improves - traffic-flow-evaluation.

[8] Yajie Ma ,Mark Richards, Moustafa Ghanem, Yike Guo and John Hassard., "Air Pollution Monitoring and Mining Based on Sensor Grid in London", *Sensors 2008, 8, DOI: 10.3390/s8063601, pp. 3601-3623.*

[9] W. Hu, X. Xiao, D. Xie, T. Tan, S. Maybank.,"Traffic Accident Prediction Using 3-D Model-Based Vehicle Tracking", In Transactions on Vehicular Technology, IEEE
Vol. 53, May 2004, No 3, pp. 677-694.