A Review on Automatic Traffic Monitoring System

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Abstract - *In this paper we have reviewed different automated traffic monitoring systems. The continuous and automatic processing of data as it occurs in order to generate systematic output used to analyze system functions and ongoing procedures. Real time processing is critical to maintain proper functionality of automated or continuously operated systems. The user interface of a real-time system may use specialist input devices to provide data input. For example, a car driver will be providing input data to the onboard computer with throttle and brake pedals. A gamer may be using a joystick or hand held control to interact with the real-time game. Video sensors become particularly important in traffic applications mainly due to their fast response, easy installation, operation and maintenance, and their ability to monitor wide areas. Two of the most demanding and widely studied applications relate to traffic monitoring and automatic vehicle guidance.*

Key Words: *Automatic Lane Finding, Video Sensor, edge-detection, real time processing, traffic monitoring.*

1. INTRODUCTION

The application of image processing and computer vision techniques to the analysis of video sequences of traffic flow offers significant improvements over the existing methods of traffic data collection and road traffic monitoring. Other methods suffer from serious drawbacks in that they are expensive to install and maintain and they are unable to detect slow or stationary vehicles. Video sensors provides wide area monitoring allowing analysis of traffic flows and turning movements, speed measurement, multiple point vehicle count. Image processing also finds wide applications in the related field of autonomous vehicle guidance, mainly for determining the vehicle's relative position in the lane and for obstacle detection. In this study we survey of algorithms and tools for the two major subtasks involved in traffic applications, i.e. the automatic lane finding (estimation of lane and/or central line) and vehicle detection (moving or stationary object/obstacle).

1.1 Automatic Lane Finding

Stationary Camera: [8] A serious objective in the development of a road monitoring system based on image analysis is flexibility. The ability of the system to react to a changing scene while carrying out a variety of goals is a key issue in designing replacements to the existing methods of traffic data collection. This flexibility can be achieved only by a generalized approach to the problem which includes little or no a priori knowledge of the analyzed scene. Such a system will be able to adapt to 'changing circumstances', which may include the following: changing light levels, i.e. night–day, or sunny–cloudy; deliberately altered camera scene, perhaps altered remotely by an operator. Automatic lane finding (ALF) is an important task for an adaptive traffic monitoring system. ALF can assist and simplify the installation of a detection system. It enables the system to adapt to different environmental conditions and camera viewing positions. It also enables applications in active vision systems, where the camera viewing angle and the focal length of the camera lens may be controlled by the system operator to find an optimum view.

Moving Camera: [1][9][10][11][12][13]In the case of automatic vehicle guidance, the lane detection process is designed to (a) offer estimates for the position and orientation of the car within the lane and (b) conclude a reference system for locating other vehicles or obstacles in the path of that vehicle. Certain assumptions facilitate the lane detection task and/or speed-up the processing:

i) Instead of processing entire images, a computer vision system can analyze specific regions (the 'focus of attention') to identify and extract the features of interest.

ii) The system can assume a fixed or smoothly varying lane width and thus limit its search to almost-parallel lane markings.

iii) A system can abuse its knowledge of camera and an assumption of a precise 3D road model (for example, a flat road without bumps) to localize features easier and simplify the mapping between image pixels and their corresponding world coordinates.

1.2 Vehicle Detection

[8]In road traffic monitoring, the video acquisition cameras are stationary. They are placed on posts above the ground to obtain optimal view of the road and the passing

vehicles. In automatic vehicle direction, the cameras are moving with the vehicle. In these applications it is essential to analyze the dynamic change of the environment and its contents, as well as the dynamic change of the camera itself. Thus, object detection from a stationary camera is simpler in that it involves fewer estimation procedures.

[1][9][10][11][12][13]Independent vehicle guidance requires the solution of different problems at different concept levels. The vision system can support the accurate localization of the vehicle with respect to its environment, by means of matching observations (acquired images) over time, or matching a single observation to a road model or even matching a sequence of observations to a dynamic model. We can identify two major problems with the efficient recognition of the road environment, namely the restricted processing time for real-time applications and the limited amount of information from the environment.

2. DIFFERENT LANE FINDING APPROACHES

Automatic lane finding approaches are classified into lane-region detection, feature driven and model driven approaches.

2.1 Lane-region detection

[4]One method of automatic lane finding with stationary camera can be based upon collecting a map of significant scene change. The so-called activity map, distinguishes between active areas of the scene where motion is occurring (the road) and inactive areas of no significant motion (e.g. verges, central reservation). To prevent saturation and allow alteration to changes of the scene, the map generation also includes a simple decay mechanism through which previously active areas slowly fade from the map. Once formed, the activity map can be used by a lane finding algorithm to extract the lane positions.

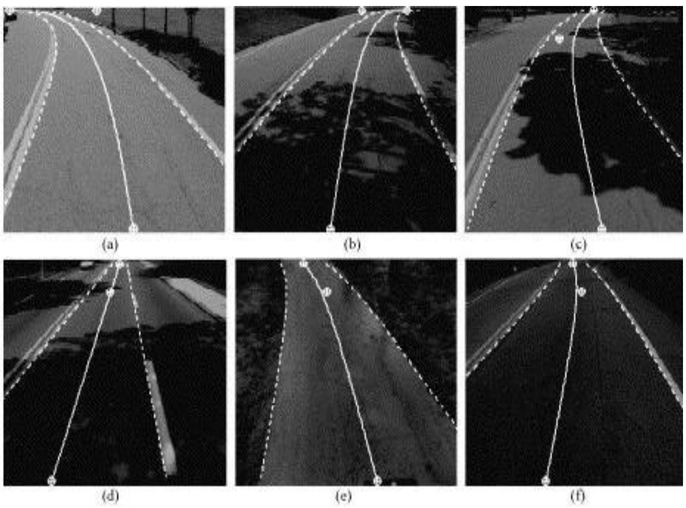


Fig- 1: Texture based segmentation

2.2 Feature-driven approaches

[6][4]This class of methodologies is based on the detection of edges in the image and the organization of edges into meaningful structures (lanes or lane markings). This class involves, in general, two levels of processing, i.e. feature detection and feature aggregation. The feature detection part aims at extracting intensity discontinuities. To make the detection more effective, a first step of image enhancement is performed followed by a gradient operator. Feature aggregation organizes edge segments into meaningful structures (lane markings) based on short-range or long-range attributes of the lane. Short-range aggregation considers local lane fitting into the edge structure of the image. Long-range aggregation is based on a line intersection model, based on the assumption of smooth road curvature.

Disadvantage: Feature driven approaches are highly dependent on the methods used to extract features and they suffer from noise effects and unrelated feature structures. Often in practice the strongest edges are not the road edges, so that the detected edges do not necessarily fit a straight-line or a smoothly varying model. Shadow edges can appear quite strong, highly affecting the line tracking approach.

2.3 Model-driven approaches

[3][2]In model-driven approaches the aim is to match a deformable template defining some scene characteristic to the observed image, so as to derive the parameters of the model that match the observations. The pavement edges and lane markings are often approximated by circular arcs on a flat-ground plane.

Disadvantage: Model-driven methods provide powerful means for the analysis of road edges and markings. However, the use of a model has certain drawbacks, such as the difficulty in choosing and maintaining an appropriate model for the road structure, the inadequacy in matching complex road structures and the high computational complexity.

3. DIFFERENT VEHICLE DETECTION APPROACHES

Approaches have been classified according to the method used to isolate the object from the background on a single frame or a sequence of frames.

3.1 Thresholding

[14]This is one of the simplest, but less effective techniques, which operates on still images. It is based on the concept that vehicles are compact objects having different intensity form their background. Thus, by thresholding intensities in small regions we can separate the vehicle from the background. This approach depends heavily on the threshold used, which must be selected appropriately for a certain vehicle and its background.

Fig- 2: Object detection done using thresholding

3.2 Multigrid identification of regions of interest

This method first produces a hierarchy of images at different resolutions. Consequently, a region search starts at the top level (coarse to fine). Compact objects that differ from their background remain distinguishable in the low resolution image, whereas noise and small intensity differences tend to disappear at this level. Thus, the low resolution image can immediately direct attention to the pixels that correspond to such objects in the initial image.

3.3 Edge-based detection

[1][6]Approaches in this class are based on the edge-features of objects. They can be applied to single images to detect the edge structure of even still vehicles. Morphological edge-detection schemes have been extensively applied, since they show superior performance. In traffic scenes, the results of an edge detector generally highlight vehicles as complex groups of edges, whereas road areas produce relatively low edge content. Thus the presence of vehicles may be detected by the edge complexity within the road area, which can be measured through analysis of the histogram.

Advantage: Edge-based vehicle detection is often more effective than other background removal or thresholding approaches, since the edge information remains significant even in variations of ambient lighting.

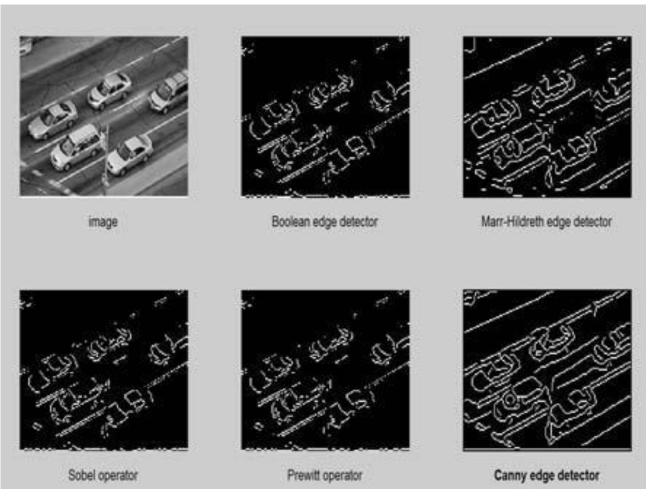


Fig- 3: Edge based Object detection

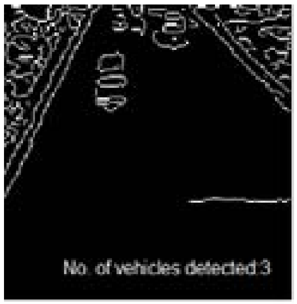
3.4 Background frame differencing

[1][15]This method is based on forming an accurate background image and using it for separating moving objects from their background. The background image is specified either manually, by taking an image without vehicles, or is detected in real-time by forming a mathematical or exponential average of successive images. The detection is then achieved by means of subtracting the reference image from the current image. Thresholding is performed in order to obtain presence/absence information of an object in motion.

(a) Real-time image

(b) Background image

(c) Subtracted image



(d) No. of vehicles = 3

4. REVIEW OF DIFFERENT SYSTEMS

Based on the previous classification of video analysis methods, we attempt a brief review of existing systems for traffic monitoring and automatic vehicle guidance. It should be mentioned that this review does not by any means cover all existing systems, but it rather considers representative systems that highlight the major trends in the area. We also attempt a categorization of these systems in terms of their area of operation, the basic processing techniques used and their major applications.

Table -1: Review Table of different Systems

System	Operating Domain	Processing Techniques	Major Applications
ACTIONS	Spatio-temporal	Optical flow field with spatial smoothness constraints	1.Traffic monitoring 2. Static camera
CCATS	Temporal-domain with spatial constraints	Background removal and model of time signature for object detection	1.Traffic Monitoring 2. Static camera
ARCADE	Spatial processing	Model-driven approach with deformable templates for edge matching	1.Automatic Lane finding 2. Static camera
LANA	Spatial processing	Model-driven approach exploiting features to compute likelihood. DCT features Deformable template models for priors	1.Automatic lane finding 2.Moving camera

5. FUTURE WORK

Towards the improvement of the image-processing stage itself, we can expect morphological operators to be used more widely for both the segmentation of smooth structures and the detection of edges. Such nonlinear operators provide algorithmic robustness and increased discrimination ability in complex scenes, such as in traffic applications.

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BIOGRAPHIES

Soumen Bhowmik completed his B. Tech from University of Kalyani and M. Tech from IIEST, Shibpur, India. He has published several research papers in different National and International Journals. His areas of research interest are image steganography, real time video data processing, network security, image processing, sensor network etc. He is the Life member of ISTE, IACSIT-Singapore, CSTA-ACM, ISOC-Switzerland etc.

Anirban Halder pursuing M. Tech in the CSE branch at BITM, Santiniketan under WBUT. He has completed his M. Sc (Computer Science) from Visva Bharati University. He has the interest in image processing, database management system, networking and automatic traffic control in real time application.