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An Overview of Image processing for traffic applications

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Abstract: - The frequent traffic jams at major junctions call for an efficient traffic management system in place. The resulting wastage of time and increase in pollution levels can be eliminated on a city-wide scale by these systems. In this paper we present an overview of image processing and analysis tools used in these applications and we relate these tools with complete systems developed for specific traffic applications. More specifically, we categorize processing methods based on their input data as feature-driven, area-driven, or model-based and the domain of processing as spatial or temporal frames.The image sequences from a camera are analyzed using various edge detection and object counting methods to obtain the most efficient technique. Subsequently, the number of vehicles at the intersection is evaluated and traffic is efficiently managed. The paper also proposes to implement a real-time emergency vehicle detection system. In case an emergency vehicle is detected, the lane is given priority over all the others.

Keywords: - Traffic monitoring, automatic lane finding, Object detection, Emergency vehicles, Image Processing.

I. INTRODUCTION

The application of image processing and computer vision techniques to the analysis of video sequences of traffic flow offers considerable improvements over the existing methods of traffic data collection and road traffic monitoring. Existing methods include the detectors such as loop, radar, infrared, ultrasonic, and microwave detectors which are expensive with limited capacity and involve installation, maintenance, and implementation difficulties. Image processing offer a relatively low installation cost with little traffic disruption during maintenance. Also they provide wide area monitoring allowing analysis of traffic flows and turning movements, speed measurement, multiple-point vehicle counts, vehicle classification and highway state assessment (e.g. congestion or incident detection).

Image processing also finds extensive 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 section2 traffic analysis can be done using automatic lane finding. In section 3 object detection discussed in detail and in section 4 emergency vehicle detection system is explained.

II. AUTOMATIC LANE FINDING

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 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. Based on the two features namely lane marking and road edges, lane finding is characterized into two classes [5]

2.1 LANE REGION DETECTION

This class relates the detection of the lane with the changing intensity distribution along the region of a lane. This class considers just the changes in the gray-scale values within an image sequence, without addressing the problem of motion estimation which causes classification problem which labels image pixels into road and non-road classes based on particular features. A typical classification problem involves the steps of feature extraction, feature de-correlation and reduction, clustering and segmentation.

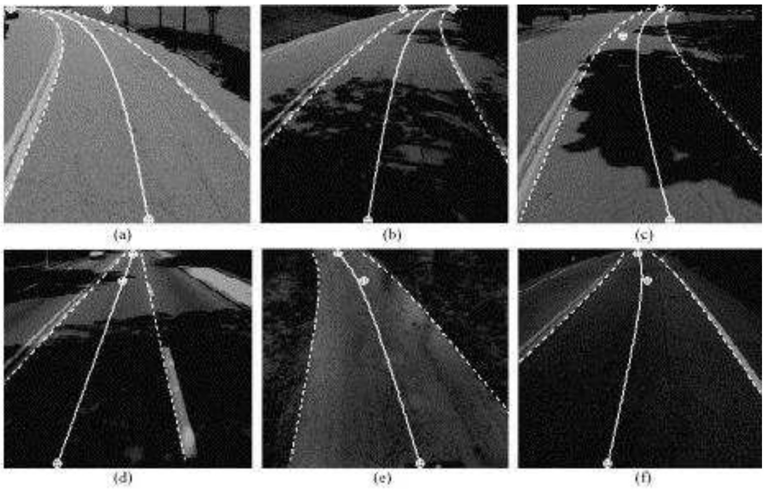
2.1.1 COLOR BASED SEGMENTATION

In this case, the features are defined by the spectral response of the illumination at the red, green and blue bands. At each pixel, the (R, G, B) value defines the feature vector and the classification can be performed directly on the (R, G, B) scatter diagram of the image.

Fig (1): color based segmentation [3, 5]

2.1.2 TEXTURE BASED SEGMENTATION

In this case, the texture of the image has been used as a feature for classification. The texture of the road is normally smoother than that of the environment, allowing for region separation in its feature space. The texture calculation can be based on the amplitude of the gradient operator at each image area which uses a normalized gradient measure based on a high-resolution and a low-resolution (smoothed) image in order to handle shadow interior and boundaries. [5]



Fig(2): texture based segmentation[5]

2.2 FEATURE-DRIVEN APPROACH

This class of approach 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 two levels of processing like feature detection and feature aggregation.

2.2.1 FEATURE DETECTION

This part aims at extracting intensity discontinuities. To make the detection more effective, image enhancement is performed followed by a gradient operator. The dominant edges are extracted based on thresholding of the gradient magnitude. At this stage, the direction of edges at each pixel can be computed based on the phase of the gradient and a curvature of line segments can be estimated based on neighborhood relations. [6]

2.2.2 FEATURE AGGREGATION

This process 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. Thus gross road boundaries and markings must be directed towards a specific point in the image, the focus of expansion (FOE) of the camera system. Along these directions, it detects lane markings through a horizontal (linear) edge detector and enhances vertical edges via a morphological operator. For each horizontal line, it then forms correspondences of edge points to a two-lane road model (three lane markings) and identifies the most frequent lane width along the image, through a histogram analysis.

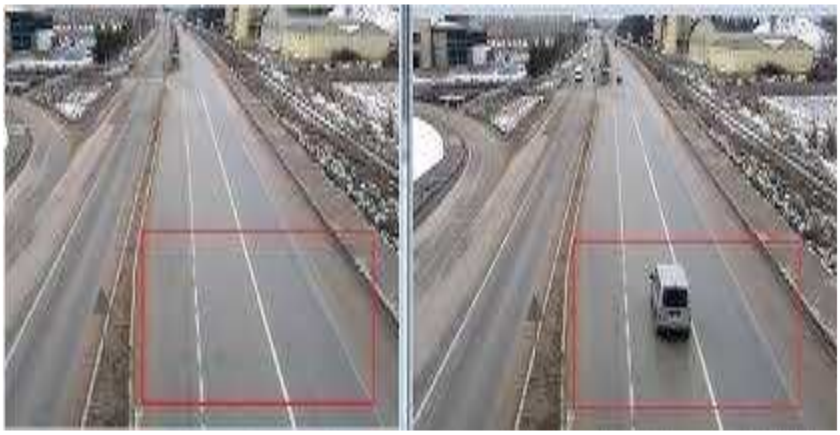
In general, feature driven approaches are highly dependent on the methods used to extract features and they suffer from noise effects and irrelevant feature structures. Often in practice the strongest edges are not the road edges, so that the detected edges do not necessarily fit a straight-line or a smoothly varying model. Shadow edges can appear quite strong, highly affecting the line tracking approach.[3,6]

III. OBJECT DETECTION

Some fundamental issues of object detection are considered in this section. Different approaches have been categorized according to the method used to isolate the object from the background on a single frame or a sequence of frames.

3.1 THRESHOLDING

This is one of the simplest, but less effective techniques, which operates on still images. It is based on the notion 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. Adaptive thresholding can be used to account for lighting changes, but cannot avoid the false detection of shadows or missed detection of parts of the vehicle with similar intensities as its environment. To aid the thresholding process, binary mathematical morphology can be used to aggregate close pixels into a unified object. Furthermore, gray-scale morphological operators have been proposed for object detection and identification that are insensitive to lighting variation.[1,3,5]



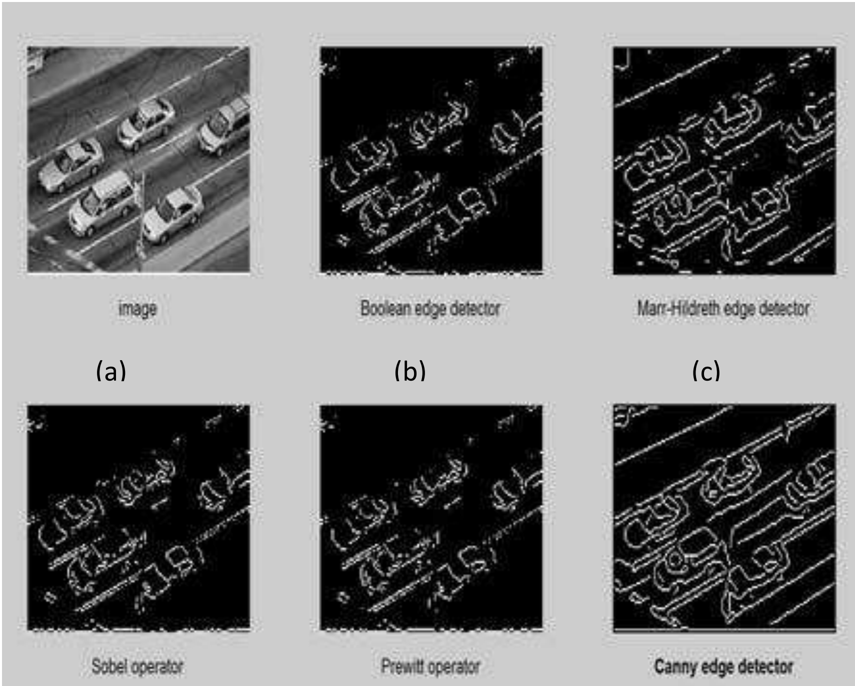
Fig(3): Object detection done using thresholding[3]

1.1.1 MULTI GRID IDENTIFICATION OF REGIONS OF INTEREST

This method first generates a hierarchy of images at different resolutions. Subsequently, a region search begins 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 variations 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. Each pixel of interest is selected according to some interest function which may be a function of the intensity values of its adjacent pixels, edge strength, or successive frame differencing for motion analysis.[4]

3.2 EDGE-BASED DETECTION (SPATIAL DIFFERENTIATION)

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 exhibit superior performance. In traffic scenes, the results of an edge detector generally highlight vehicles as complex groups of edges, whereas road areas yield relatively low edge content. Thus the presence of vehicles may be detected by the edge complexity within the road area, which can be quantified through analysis of the histogram. Alternatively, the edges can be grouped together to form the vehicle's boundary.[2,6]



(d) (e) (f)

Fig(4): object detection done using different edge detection algorithm[6]

Fig.(4.a) input image is given. In Fig (4.b), Boolean edge detector is used to perform a decent job of marking the locations of edges; however it failed to complete the edges making object detection difficult. In Fig (4.c), Marr-Hildreth detector is applied since it is susceptible to noise and gave a lot of false results. In Fig (4.d) and (4.e), Sobel and Prewitt operators are used for recognizing edges that are horizontal or vertical and are susceptible to noise. And Fig,(4.f) Canny edge detector is used which basically uses two thresholds which used for detecting true weak edges, providing a better and fairly noise resistant output.[6]

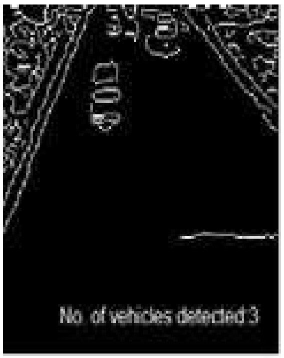
3.3 BACKGROUND FRAME DIFFERENCING

This method is based on forming a precise 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. The background can change significantly with shadows cast by buildings and clouds, or simply due to changes in lighting conditions. With these changing environmental conditions, the background frame is required to be updated regularly. There are several background updating techniques. The most commonly used are averaging and selective updating. In averaging, the background is built gradually by taking the average of the previous background with the current frame. In selective updating, the background is replaced by the current frame only at regions with no motion detected; where the difference between the current and the previous frames is smaller than a threshold. Selective updating can be performed in a more robust averaging form, where the stationary regions of the background are replaced by the average of the current frame and the previous background. [4, 6]

(a) Real-time image [6]

(b) Background image[6]

(c) Subtracted image[6]



(d) No. of vehicles = 3[6]

II. EMERGENCY VEHICLE DETECTION

Fig(5): Emergency vehicle detection[7]

The various steps of detection system are shown in following flow-chart. In case of normal regulation the image is subjected to adaptive background subtraction, edge detection, and object counting methods. Using this, the number of vehicles is calculated and traffic is regulated as per the congestion in each lane. [4,7]

2.1 FLOWCHART FOR EMERGENCY VEHICLE DETECTION

In case a red beacon is detected, the next step is to identify whether it is from an emergency vehicle or not. This is done by identifying the blinking frequency of red light detected in the image sequence and comparing it to the standard used by the emergency vehicles as shown in the above flow chart. This system will override the normal regulation system and will change light to green till emergency vehicle is exited. Then system wiil start running for normal regulation.

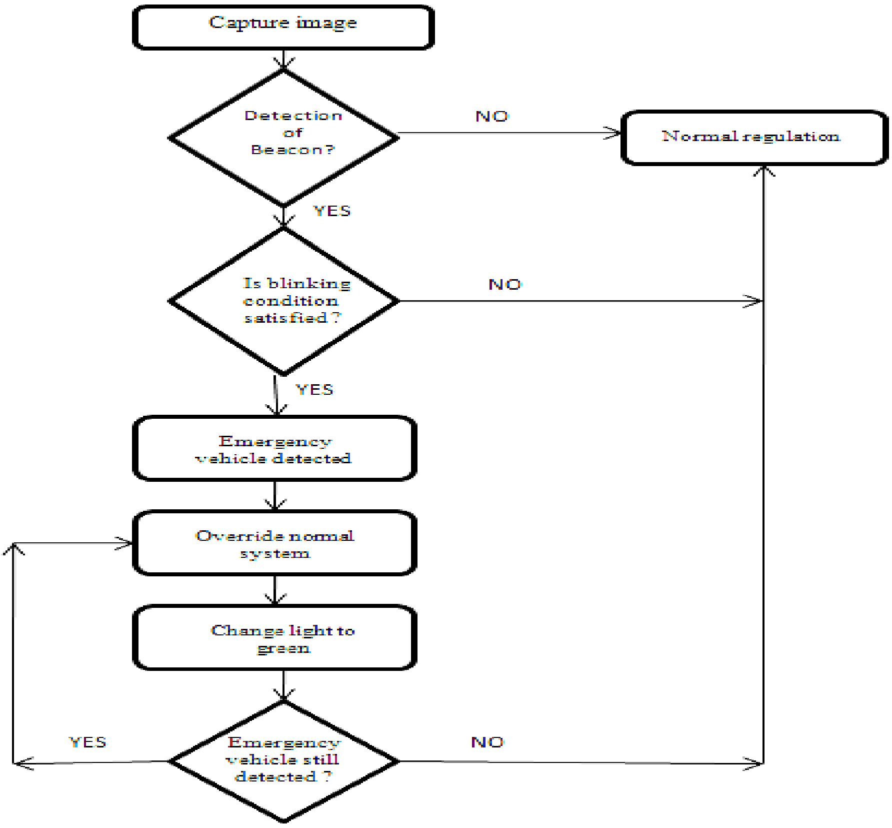


Fig (6): Flowchart for emergency vehicle detection [7]

IV. CONCLUSION

In this paper, we have studied different parameters which are used in traffic scene analysis. Automatic lane detection based on region and texture .In object detection we have studied Thersholding, Background Subtraction, Boolean Edge Detector, Sobel & Prewitt operator and Canny Edge Detector . Of all studied methods Canny Edge Detector is gives error free output even in noise and for weak signals .Thus Emergency vehicle Detection can be well implementated using Canny Edge Detector which tracks the red beacon signal for more accurate detection.

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