NewGen Navigation : Alerting System using Vehicle to Vehicle Communication

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Abstract—

Todays navigation systems are capable of suggesting routes to optimize time taken and distance covered. Maps come with a graphical interface which gives us access to real-time data on traffic conditions in the form of speech and text. Our system aims to notify users about hazard signs, hit-and-run accident situations, roadblocks due to natural disasters and ongoing constructions. We use multi-purpose camera placed at the front of the vehicle to capture and analyze real time events. This information is shared with other vehicles and collector stations. We utilize the video stream captured by these cameras and process them on MATLAB using the Computer Vision System Toolbox, Image Acquisition Toolbox and Image Processing Toolbox. A GPS module will be used to detect the coordinates of the hazardous zone which will finally be communicated to other vehicles on the road via Vehicle to vehicle communication.

Index Terms—Image Processing, Navigation, Computer Vision System Toolbox.

1 Introduction

The intelligent driving systems, aimed for collision avoidance and self-navigation, is mainly based on environmental sensing via radar, lidar and/or camera. While each of the sensors has its own unique pros and cons, camera is especially good at object detection, recognition and tracking. Our system makes use of cameras placed in the car to record live footage of real data. The video recording is processed on MATLAB to detect road signs, hit and run scenarios and accident situations. Image processing is a form of signal processing where the input signals are images such as photographs or video frames. The output could be a transformed version of the input image or a set of characteristics or parameters related to the image. The computer revolution that has taken place over the last 20 years has led to great advancements in the field of digital image processing. This has in turn, opened up a multitude of applications in various fields, in which the technology could be utilized.

One of the key features of the system is that it detects fire due to accidents at the particular location and intimates other drivers on the same route. Most of the available sensors for fire detection have longer response time, need to carefully placed and are unsuitable for open spaces. Due to rapid developments in video processing techniques,conventional fire detection technique is not going to be preferred as compared to computer vision based systems. Current vision based techniques mainly follow the color clues, motion in fire pixels, edge detection of flame and gray cycle pixel detection. Fire detection method can be made robust by identifying the gray cycle pixels nearby to the flame and measuring flame area dispersion.

Another important feature is detection and recognition of sign boards along the route. The information contained in them, such as signs and text, is useful for navigation. This is achieved by processing the video footage using fixed-point Blob analysis and the coordinates of the location of the recognized sign boards are obtained from the GPS.

2 Background / Formulation

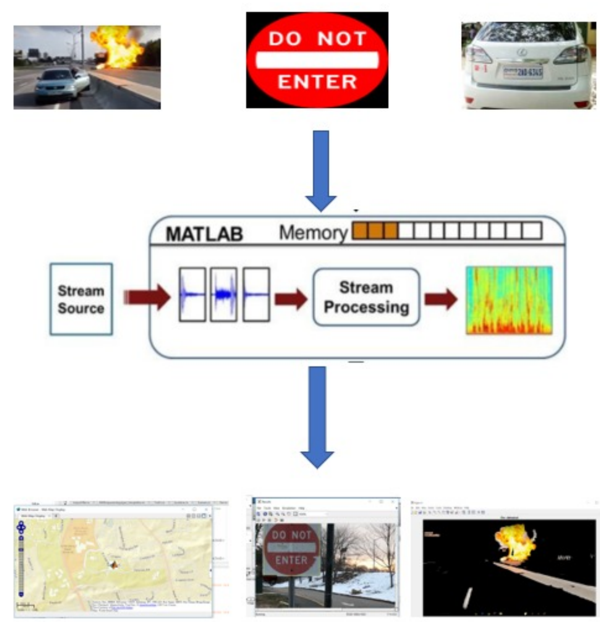
To solve the concerns over road and transportation safety, we employ the traffic sign detection and recognition feature of our project. It can detect and recognise traffic signs from and within images captured by cameras or imaging sensors. In adverse traffic conditions, the driver may not notice traffic signs, which may cause accidents. In such scenarios, our system comes into action. Robust and efficient sign board detection, as well as intimating drivers about accidents on the route is a tedious job given the continuous changes in the environment and lighting conditions. Among the other issues that also need to be addressed are partial obscuring, multiple traffic signs appearing at a single time, and blurring and fading of traffic signs, which can also create problem for the detection purpose. For applying these in real-time environment, a fast algorithm is needed, and we also need to minimize the use of hardware like sensors that would be affected by external factors. For the above reasons, image processing is an ideal approach. Image processing is an important part of the computer vision that has a fundamental impact on the field of mobile robotics because vision- based techniques are key components to obtain information about the robot motion and its surroundings. Extractors of salient points are popular image processing techniques that forms crucial building blocks for implementing navigation systems; however, the feature extraction process is usually computationally very demanding. An Automatic Traffic Sign Detection and Recognition System Based on Color Segmentation, Shape Matching, and SVM is a work from 2015 developing a system which contains an enriched dataset of traffic signs. The developed technique is invariant in variable lighting, rotation, translation, and viewing angle and has a low computational time with low false positive rate.Lazrus et al. [4] proposed an algorithm for vehicle number plate detection and recognition using segmentation and feature extraction using template matching. Koval et al. [5] proposed a method for deblurring the number plate images and recognizing them using feed forward neural network technique. Fire Detection using Wireless Sensor Networks: an approach based on statistical data modeling proposes an innovative architecture for fire detection, using a Wireless Sensor Network. This scheme is based on the statistical modeling of the Angstrom Index, and thus is hardware dependent. Fire Detection in the Buildings Using Image Processing is a fire detection system based on light detection and analysis is proposed in the paper. This system uses HSV and YCbCr color models with given conditions to separate orange, yellow, and high brightness light from background and ambient light. These works throw light on some of the trending technology in the field.

3 System Overview

The system overview of our project focuses on video processing using MATLAB. The video captured by the cameras in the car is processed to extract information. Since the data is live and large, we need to sample it and for this we make use of stream processing, which is a memory-efficient technique for handling large amounts of data. Stream processing fully processes the frame before the next one arrives. This kind of processing is important for applications where object detection and tracking is concerned. The just-in-time and memory-sensitive nature of stream processing presents special challenges. Streaming algorithms must be efficient and keep up with the rate of data updates. To handle large data sets, the algorithms must also manage memory and state information, store previous data buffers only as needed, and update each buffer and state frame-by-frame.

The flowchart of our system is shown in the figure below:

Fig. 1. System Design



The steps involved in this process are explained as: 1. We set up a database containing images of road signs, hit and run scenarios and accident(fire) situations.

2. The stream collected by the camera is processed in MATLAB, frames are extracted from the incoming video and compared with the images in the database.

3. Location coordinates are recorded when any such situation arises.

To achieve the above mentioned goals, we make use of the Computer Vision System Toolbox provided by Mathworks Inc. It provides algorithms, functions, and applications for designing and simulating computer vision and video processing systems. We can perform feature detection, extraction, and matching, as well as object detection and tracking. We make use of the object detection and recognition feature of the computer vision system toolbox which provides us with a comprehensive suite of algorithms and tools. Object detection is a key process in our project. It is the process of finding instances of real-world objects such as faces, bicycles, road signs and buildings in images or videos. Object detection is commonly used in applications such as image retrieval, security, surveillance, and advanced driver assistance systems (ADAS).

Object Recognition and Detection methods in Computer Vision: Object Recognition and Detection methods in Computer Vision Object recognition is a process for identifying a specific object in a digital image or video. Object recognition is useful in advance driver assistance systems. Object detection is used to determine the location of an object in an image. The system toolbox provides several algorithms and techniques to detect objects, including pre-trained detection models, as well as functions and an app to train object detectors.

In case of a hit and run situation, the camera records the event and the number plate of the vehicles involved will be extracted and this information can be used for further investigation and assistance. We make use of a feature called Optical Character Recognition (OCR) for extracting number plate from the image and convert it into text format. MATLAB contains a rich library functions for image processing and data analysis, this makes MATLAB an ideal tool for faster implementation and verification of any algorithm before actually implementing it on a real hardware. Sometimes, debugging of errors on actual hardware turns out to be a very painful task. The algorithm uses various inbuilt functions and implements few user defined routines related to image processing. It was verified with multiple input images containing car number plates. The input images contained number plates that were aligned horizontally as well as at some angle from horizontal axis. Once the algorithm was completely verified, the in-built functions of MATLAB were replaced by user defined functions. The input image is a colored image represented by 3-dimensional array in MATLAB, it is converted to a 2-dimensional gray image before further processing. Using dilation, the noise with-in an image can also be removed, and by making the edges sharper, the difference of gray value between neighboring pixels at the edge of an object can be increased. This enhances the edge detection for Number Plate Detection. Next, the algorithm has used horizontal and vertical histogram, which represents the column-wise and row-wise histogram respectively. These histograms represent the sum of differences of gray values between neighboring pixels of an image, column-wise and row-wise. Out of all the regions, the one with the maximum histogram value is considered as the most probable candidate for number plate. All the regions are processed row-wise and column-wise to find a common region having maximum horizontal and vertical histogram value. This is the region having highest probability of containing a license plate.

Our system is also capable of detecting fire hazards in forests, as well as fire caused due to accidents. We take inspiration from the idea of YCbCr color model, which uses statistical features of the fire image i.e, mean and standard deviation because in YCbCr color space, the relation between pixel is more compared to other color models. The center of the flame is white in color like cloud. This method detects fire with 99.2% true detection rate. The proposed method provides significant improvement over other methods used earlier. YCbCr color space is preferred as it separates luminance information from chrominance information than other color spaces. For fire pixel classification, four rules (Rule I, Rule II, Rule III, and Rule IV) are formed. The color of the fire in the region except the center region varies from red to yellow. Among the four rules used, Rule I and Rule II are used for the segmentation of fire flame region. Rule III and Rule IV are used for the segmentation of center fire pixels (high temperature region). Finally the image obtained by satisfying Rule I & 2 and the image obtained by satisfying Rule III & IV are added to get the true fire image. A pixel is classified as fire flame pixel if it satisfies Rule I and Rule II. However a pixel is classified as fire center pixel if it satisfies Rule III and Rule IV.

First segmentation is done for the true fire region. Each digital color image has three color planes: Red (R), Green (G) and Blue (B). Each color plane is quantized in to discrete levels, generally 256 (8 bits per color plane) quantization levels are used for each plane. White color is represented by (R,G,B)= (255, 255, 255). Black is represented by (R,G,B)= (0,0,0). A color image consists of h pixel is represented by spatial location in the rectangular grid. (R (x,y), G (x,y), B (x,y)) is the color vector corresponding to the spatial location (x,y).

We can expect that in the fire region of the digital fire image, the value of red channel(R) is greater than the value of green channel (G). Separating the R component, G component and B component in the real fire image, R component can be detected and then the mean values are calculated for the segmented fire region of the original images. There is a need for transforming RGB color space into one of the color space where the separation between intensity and chrominance is more discriminate. Based on the above concept we choose YCbCr color space for the classification of fire pixels. Also, conversion from RGB to YCbCr color space is linear. Similarly, segmentation is done for the fire flame region and also the fire center region.

Another feature of the system is to detect different sign boards on routes. In our implementation, we have attempted detection of STOP, YIELD and DO NOT ENTER sign boards. These road signs were captured in and around Stony Brook University campus. This method employs two set of templates - one for detection and the other for recognition.

Detection: Each video frame is analyzed in the YCbCr color space. It extracts the portions of the video frame that contain blobs of red pixels by thresholding and performing morphological operations on the Cr channel. The Blob Analysis block finds the pixels and bounding box for each blob. The example and then compares the blob with each warning sign detection template. If a blob is similar to any of the traffic warning sign detection templates, it is a potential traffic warning sign.

Tracking and Recognition: It compares the bounding boxes of the potential traffic warning signs in the current video frame with those in the previous frame and then the counts the number of appearances of each potential traffic warning sign. If a potential sign is detected in 4 contiguous video frames, it compares it to the traffic warning sign recognition templates. If the potential traffic warning sign is similar enough to a traffic warning sign recognition template in 3 contiguous frames, it considers the potential traffic warning sign to be an actual traffic warning sign.

Display: After a potential sign has been detected in 4 or more video frames, a Draw Shape block is used to draw a yellow rectangle around it. When a sign has been recognized, a Insert Text block is used to write the name of the sign on the video stream. The term 'Tag' is used to indicate the order in which the sign is detected.

We have incorporated location detection system whenever any of the above mentioned scenarios are encountered. For this purpose, we make use of MATLAB mobile application. This feature enables us to acquire sensor data from iOS/Android device which includes position information like longitude, latitude, altitude and speed. This data is sent to MATLAB session and can be used for further analysis and visualization. The data can be combined into a webmap display. The latitude and longitude data are processed to make up individual line segments to overlay on the map. The Mapping Toolbox provides a number of functions for working with web maps. The map displaying the location of the event opens in a browser.

4 RESULTS

Our programs were tested by capturing videos in and around Stony Brook University campus. For fire detection, we made use of an online video. For displaying the results, we developed a GUI which indicates the entire process of detection and identification. The videos are processed and results containing the information is displayed. The results for each phase are illustrated below:

Fire Detection:We tested our system by using 10 videos, out of which fire was successfully detected for 9 of them. This gives us an accuracy of 90%. If the model achieves to detect at least 10 pixels of a fire region in a given image, then it is assumed as a correct detection. Whenever fire is detected, our system locates the coordinates and displays it on a map. The following output images are displayed in the GUI:

Fig. 2. Fire Detection

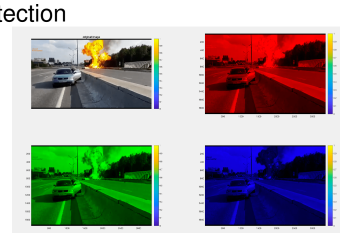
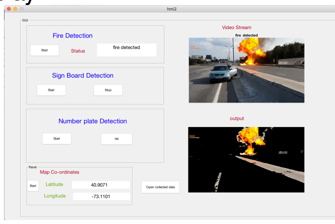


Fig. 3. Fire Detection

Fig. 4. GUI Display



Sign Board Detection:
We tested our system on 10 videos, out of which sign boards were successfully detected for 9 of them. This gives us an accuracy of 90%. We observed that the detection is inaccurate when video is captured in low light. The system maps the location of these sign boards. The following output images are displayed in the GUI:

Fig. 5. STOP Sign

Fig. 6. YEILD Sign

Fig. 7. DO NOT ENTER Sign

Number Plate Detection:
We tested our system on 10 videos, the system could read number plates for 8 of them, giving us an accuracy of 80%. We observed that the detection is inaccurate when video is captured in low light. The system maps the location of the particular vehicle. The following output images are displayed in the GUI:

Fig. 8. Number Plate Detection

Fig. 9. Horizontal Edge Processing Histogram

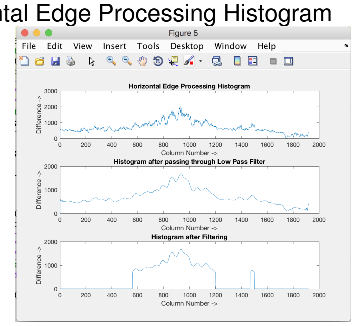


Fig. 10. Vertical Edge Processing Histogram

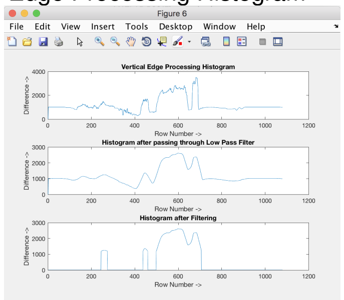
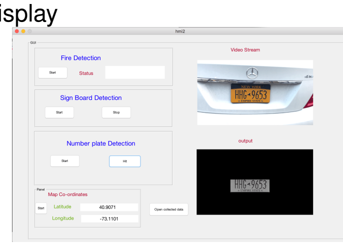


Fig. 11. GUI Display



5 FUTURE WORK

The full potential of this work will be realized if the coordinates of the hazardous zone can be communicated to other vehicles on the road via Vehicle to vehicle communication. Vehicle to vehicle communication is a major deal in the future of road safety. Safety benefits from this could minimize the dangers of accidents and warn drivers about oncoming obstacles. For Vehicle to Vehicle and Vehicle to Collector Station Communication we can use an Arduino board with in-built HC-12 Module. The HC-12 wireless serial port communication module is a new-generation multi-channel embedded wireless data transmission module. Its wireless working frequency band is 433.4-473.0MHz, multiple channels can be set, and there are totally 100 channels. The communication distance is 1,000m in open space. The vehicles which are in the scope of the wireless range will accept and transmit the data from other vehicles and collector stations. To ensure information security, every vehicle should be registered in the network and is given a specific identification number. The information will be exchanged only with vehicles with valid ID. Also, the data from collected stations will be backed up to the cloud.

6 CONCLUSION

This project incorporates the various navigation situations into an alerting system designed and implemented on MATLAB. It alerts drivers about hazard signs, hit-and-run accident situations and roadblocks due to natural disasters and ongoing construction. We utilize the video stream captured by these cameras and process them on MATLAB using the Computer Vision System Toolbox, Image Acquisition Toolbox and Image Processing Toolbox. The coordinates of the hazardous zone were also recorded and displayed on a MATLAB GUI. The project can also be extended by communicating these alerts to other drivers on the road via Vehicle to Vehicle communication.

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