Road Accident Avoidance System using FAsT match algorithm and Raspberry Pi

Mr. Arun Kumar
Professor,
SRMIST

Ganesan S
SRMIST

Abstract—The rise in number of vehicles along the years has been a double edged sword. On one side, it facilitates comfortable transportation but on the other end, it contributes to increase in road accidents. This demands, a technological solution that works real time and at the same time remains accurate. By harnessing the power of real-time image processing, the amount of accidents that happen can be reduced. Road Accident Avoidance System is a solution that is designed to make this possible. This system employs a camera on the dashboard of a vehicle which takes live feed as input and puts out necessary warning signs to alert the driver of imminent danger. This system can recognize traffic signs, pedestrian crossing and safe distance maintenance between vehicles and warn the driver about the issue found. The goal of this solution is to do pattern matching faster since it must be used in real time. So , the entire focus is on the faster and accurate performance of the algorithm. The Road Accident Avoidance System is done using the FAST-match template matching algorithm. The algorithm is run on a Raspberry Pi system - a single board computer that is capable of doing the processes that a normal desktop can do.

I. Introduction

Accidents are one of the major cause of deaths in the world. Every year around 1.3 million people die from road accidents, which averages to around 3287 deaths per day. One of the major causes of such road accidents is the negligence of road signs intentionally or the lack of observation of road traffic signs . The driver may not be totally conscious or observant throughout the journey. So, even the slightest amount of distraction may put the person's life in danger. An example would be a driver not observing a road sign of a "speed breaker ahead" and driving at a high speed onto the speed breaker resulting in an aerial lift and crash of the vehicle. On the other hand, an example of negligent driving is not obeying the traffic signs and speeding beyond the speed limit. Mobiles are also a common source of distraction that ruins the concentration of the driver on a road. Companies like Google, Uber and Apple are working on automated cars that could drive to the destination without human aid. But not everyone can afford such technologies. So we require a cost-efficient and a reliable system that could be devised in order to minimize road accidents.

So we require a system that could succour the driver and recognize the road signs, pedestrians crossing and alert the driver on time to avoid an accident. This paper presents a comprehensive solution to prevent the occurrence of road accidents due to lack of concentration or negligence by devising a reliable system that assists the driver when needed.

II. Background

1) Image Processing Based Traffic Sign Detection and Recognition with Fuzzy Integral: In this study, some image processing techniques were used to detect traffic signs and Fuzzy Integral was used for recognition. Both accuracy rate and low computational cost were obtained in the recognition stage by using positive aspects of algorithms taken as input parameters with Fuzzy Integral in the traffic sign recognition system. Experimental results showed that proposed method gave highly accurate results in a reasonable time.

2) Traffic Sign Recognition Using SURF: Speeded Up Ro-bust Feature Descriptor and Artificial Neural Network Classi-fier: Traffic Sign Recognition (TSR) system was a vital com-ponent of intelligent transport system. It played an important role by enhancing the safety of the drivers, pedestrians and vehicles as traffic signs provide important information of the traffic environment of the road and assist the drivers to drive more safely and easily by guiding and warning. This paper rep-resented road sign detection and recognition system based on speeded up robust feature (SURF) descriptor that was invariant to rotation, skew and occlusion of the sign and artificial neural network (ANN) classifier . The proposed system consisted of three steps. In the first step the road scene image was segmented using color based thresholding algorithm followed by some post processing like morphological analysis and
filtering using region properties to extract the road sign as a blob of region. Next, shape verification was carried out by using translation, scaling and rotation invariant features vector named Distance to Borders (DtBs) of the segmented blob. Finally the recognition of the traffic sign was implemented using an ANN classifier with the training of SURF descriptor. The proposed system simulated on offline road scene images showed a high success rate in the recognition stage. The performance of the classifier was illustrated in terms of cross entropy, confusion matrix and receiver operating characteristic (ROC) curve.

3) A Collision Avoidance System at Intersections using Robust Model Predictive Control: In the United states of America, the collisions at intersections were found to cause around 20 % of the car accidents and around 40 % of fatalities. The reason was found to be human error in making quick decisions and erroneous judgments. Because of this, Active safety systems were developed that had a great chance of reducing such accidents at intersections. They were made to

issue warnings to the driver and would also take control at critical situations. In this system a single test vehicle that was controllable was made to be along with a number of uncontrollable vehicles with no communication between them. Only a map with the current position and velocity of the target vehicles were assumed to be known, but no predefined crossing order was given. A Robust Model Predictive Control strategy was designed for finding safe gaps in the crossing traffic, and for planning optimal trajectories to maximize the test vehicles efficiency and driver comfort. The Affine Disturbance feedback enhanced the performance of the system. The system was tested in several simulation scenarios and was also implemented on a test vehicle to validate the results.

4) Appearance-Based Brake-Lights Recognition Using Deep Learning and Vehicle Detection: Vehicle following is one of the fundamental functions of an autonomous driv-ing system. Detection and recognition of tail light signal is important to prevent an autonomous vehicle from rear-end collisions or accidents. Although sensors like acoustic sonar or commercialized Advanced Driving Assistance System (ADAS) products such as mobileye could be used for rear-end collision warning, a cost-effective approach is expected. In this paper, we have developed a novel two-stage approach to detect vehicles and recognize brake lights from a single image in real-time. Unlike previous approaches where pair taillight has to be extracted explicitly, we use vehicle rear appearance image instead. On a large database, Brake Lights Patterns (BLP) were learned by a multi-layer perception neural network. Given an image, the vehicles could be classified as brake or normal using the deep classifier. The vehicle could be detected quickly and robustly by combining multi-layer lidar (IBEO Lux fusion system) and a camera. Road segmentation and a novel vanishing point Region of Interest (ROI) determination method were explored to further speed up the detection and improve the robustness. The experimental results conducted on some real on-road videos have shown the robustness and efficiency of the proposed approach.

III. Proposed System

In order to develop a well performing system that can avoid road accidents, it should be stable and must deliver high performance at low cost.The recognition should be done in a fast paced manner in order to cope up with the real time situation. So, the Raspberry Pi should be able to process data in a balanced flow and the algorithms that recognize the signs and the pedestrians should be equally faster and be quick in processing of the images rendered from the cam to get the pattern matched correctly.

By the proposed system, the images that have been rendered into the system by the mini cam that has been placed inside the vehicle is being sent into the Raspberry pi system that has the FAST-Match algorithm inserted to it via the SD card. The Fast-match algorithm would ultimately take the images and match the pattern with the existing templates that are in the data base. For the identification of the road signs is done in two cruical stages such as the detection and recognition. The detection part is done in order to find the road signs, pedestrians or any other occlusion within the image that is being captured. The recognition system is done to get the type of the roadsign or the occlusion that has been detected. In order to perform this efficiently, the Fast-Match algorithm is used that can be of a leap in the performance speed.

A. Capturing Image

In the proposed system, a micro camera is placed on the dashboard of the vehicle. This cam would look for the roadsigns, pedestrians as well as any other obstacles that are present in the road. Whenever a roadsign is being detected, it would automatically take a picture of it and send the image to the recognition system for the pattern to be matched and the result to be displayed on the driver's monitor.

The video capture port is utilized in the Raspberry Pi system using a JPEG encoder.Since this is a video recording, the images that are being rendered from it could be distorted or blurred and also the resolution of the images could not be always expected to be in the desired format . Since the images that are captured by the video port could be fragmented, it has to undergo certain techniques which use algorithms that could remove noise from the images.

As the I/O bandwidth of the Raspberry Pi is very lim-ited,there limits the efficiency of capturing images onto the system.And also,the size of the SD card should be relatively higher in order to store data in high volumes so that it could be compared with the template matching algorithms.

B. Image recognition

The images that are received from the camera are being recognized and identified by the image processing and recog-nition system with the help of the Fast match algorithm.Fast match algorithm can be run using the OpenCV platform. The OpenCV platform is the best for the purpose of image recognition.

1) Template Matching: Template Matching is used in dig-ital image processing as a technique to find a match between small parts of an image and another which is used as a reference which is called as a template.The source image is compared with the template image by sliding it with one another and the metric is stored in a matrix which is called as result matrix. There are a lot of approaches done within the Template matching depending on the scenario on which it is applied.For this accident avoidance subject matter, Fast Match algorithm emerges to be the best.

2) FAsT Match algorithm: FAsT Match algorithm is the best performed algorithm for template matching under the 2D affine transformations.The algorithm has to work on 2D affine transformations in order to capture road signs that could be of any tilted position too. For all possible transformations that are taken, the Sum-of-Absolute-Differences (SAD) is approximated and only a small number of pixels is taken for the examination process in order to make the process quicker because the algorithm could work on any initialization and does not require an exact template to match with it.A desired

Fig. 1. Examples of Road Sign templates 1

Fig. 2. Examples of Road Sign templates 2

accuracy value of is set and each transformations SAD error is made sure that it does not differ more than from that of the net.If the is small, then we apply branch and bound approach.Fast match does not rely on initial guess and hence does not get trapped in the local minimum.Fast match algorithm would work even with a less accurate initialization.

We are given two gray scale images S1 and S2 of dimensions m1*m1 and m2*m2 respectively, with pixel values in the range [0, 1]. We will refer to S1 as the template and to S2 as the image. The total variation of an image S, denoted by V(I), is the sum over the entire image of the maximal difference between each pixel p and any of its eight neighbors q 2 N(p) (we omit the dependence on I as it is always clear from the context).

The Branch and Bound scheme

"To achieve an additive approximation of O( ), the complete net of transformations N must be tested. Achieving a satisfactory error rate would require using a net N where is small. The rapid growth of the net size with the reduction in the value of (linear in 1/ ^{6}) renders the algorithm impractical, despite the fact that the testing of each transformation is extremely efficient. To overcome this difficulty, a branch-and-bound scheme was devised, using nets of increasing resolution while testing small fractions of the transformations in the rapidly growing nets. This improvement was possible with virtually no loss in precision, based on the theoretical results. As a result, the number of transformations tested in order to achieve a certain precision is reduced dramatically. "[3]

Algorithm

"Input is Gray scale images s1, s2 and a precision parameter . The output is a transformation T.

1) Let S_0 be the complete set of transformations in the net N_0 (for initial precision $_0$)
2) Let i = 0 and repeat while i >
   a) Run algorithm 1 with precision $_i$, but considering only the subset S_i of N_i
   b) Let T^{Best}_i be the best transformation found in S^i
   c) Let Q^i = q 2 S_i : q(s1, s2) - T^{Best}_i (s1, s2) < L($_i$)
   d) Improve precision: $_{i+1}$ = fact $_i$ (by some constant factor 0 < fact< 1)
   e) Let S^{i+1} = T 2 Net $_{i+1}$: 9q 2 Q_i s.t. `$_1$(T,q) < $_{i+1}$. n_1
3) Return the transformation T^{Best}_i " [3]

Algorithm description :

RF based detection : On top of the recognition applied to the system above, we also focus on implementing the Radio Frequency based detection to avoid accidents. With the use of the ultrasonic sensors, the distance between the vehicles is calculated and hence collision between cars is avoided.The input being the ultrasonic sensors, the display monitor is used as the output to alert the driver.

Eye Blinking based detection :

It cannot always be assumed that accidents only happen because of not concentrating on roads.Many accidents happen because of the drowsiness of drivers which inhibits their concentration and their ability to make rational decisions..Eye blinking detection is employed to measure the driver drowsiness. The blinking period and closure period is calculated for the detection.There are two states by which the situation can be classified as either normal or abnormal. If the closure period of the eye is for 2 seconds, then it is considered to be normal.If the closure period is more than 2 seconds, then it is considered to be abnormal behaviour.This method also uses a camera to occupy the video to get the face movements and the blinking time of the driver to avoid accidents at any cause.

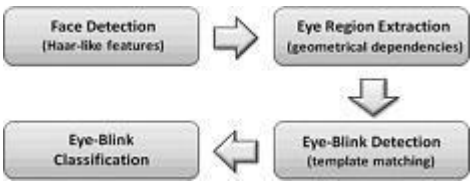

Fig. 3. Process of Blink detection

C. Noise prevention

Noise in images is an imbalance in brightness and color information within the image that diminishes the quality of the image.In order to prevent the noise from damaging the image and producing wrong results, the noise is being reduced to a certain amount of degree by smoothing the image by applying a Noise removal filter to the image. Although there are various noise filtering algorithms that are

available, Gaussian filter works best for this context.

Gaussian filter

Gaussian filter is a linear filter whose impulse response is the Gaussian function and is much faster than the median filtering. A Gaussian filter typically modifies the signal that is given as input using a Gaussian function and this modification of the input signal is called as the Weierstrass transform.So the Weierstrass transform is done over the images that are procured and the noise is being removed from the series of images that have been procured from the camera feed.

The Gaussian form in a two dimensional space is given by

$$g(x,y) = \frac{1}{2\pi\sigma^2} \cdot e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Fig. 4. Gaussian noise reduction formula

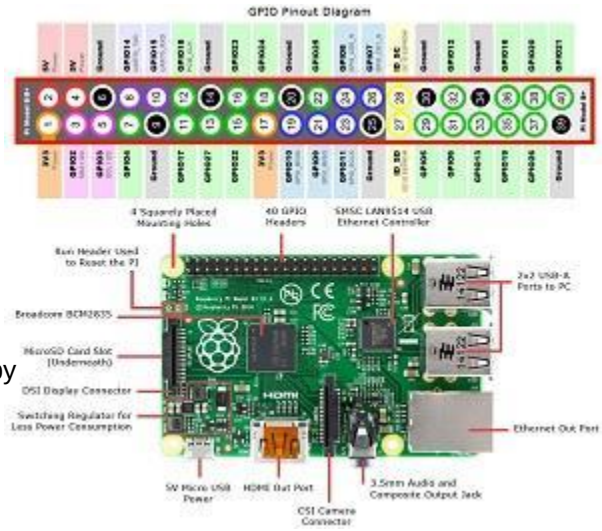

Fig. 5. Pin diagram of Raspberry Pi

Raspberry Pi

Raspberry Pi is a single board computer that could perform all operations that a normal computer can and contains a ARM processing chip. Raspberry Pi is the hardware that is used in this project to perform all the operations and produce results. The camera feed which is live is fetched by the raspberry pi system which does the template matching. The template matching algorithm is stored in the SD card and then executed in the Raspberry Pi system. Raspbian OS is set up on this hardware component and is made ready for the execution of the algorithm. The rendered output is displayed in a monitor screen or even can be connected to a voice feed that would say out the detected object or sign and would warn the driver about the upcoming obstacle.

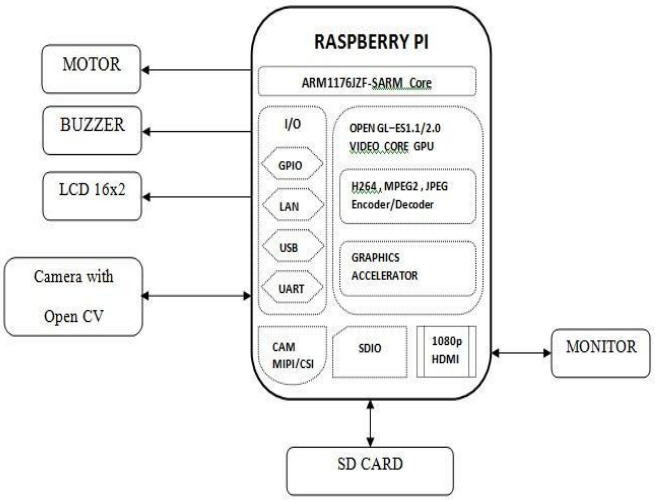

Fig. 6. Architecture of Raspberry Pi

Multithreading for Pre-processing :

As mentioned in the above sub-section the Raspberry Pi has a very limited I/O bandwidth. So multithreading has to be done for the pre-processing of the images and to successfully capture the images from the video-port . The important fact to be noted is that, the processing speed of the algorithm has to be much faster than the frame rates at which the image is being captured. Since this is going to be used in real-time , there shouldn't be any kind of delay in delivering the output to the driver.

IV. Performance Analysis

The system was built on a Raspberry Pi board which uses Raspbian OS which was chosen because of the extensively used GPIO pins for the purpose of linking the board with the camera feed. Raspbian is a Debian based Linux distributed operating system which comes with pre-installed libraries for Camera Module integration and GPIO. The system is loaded with Python/Open CV libraries for the algorithms used for template matching.

The templates for the matching of the pattern with signs were presented to the system and the system was loaded with varying ranges and sizes of templates for all kind of road signs and traffic signs. Using the FAsT match algorithm, the system is able to distinguish between different sets of obstacles and signs. The performance of the developed system is however affected by several parameters such as the lighting conditions, noise in the image etc. The signs are being processed and the output is generated by the system in the time range between 1 to 1.5 seconds. The blinking based detection is able to detect whether the driver is drowsy or not by implementing the face detection technique and extracting the eye region and evaluates the closure of the eye for effective analysis. Put together, the system reduces the risk of an accident by a significant amount.

Outcomes of the system :

The algorithm which was implemented is quite accurate and faster than all other algorithms for this application because it uses superior techniques for faster detection.

The detection phase is quite faster and in order to prevent errors caused by the prior images, the processor should be stalled for a small period of time.

Python - OpenCV is best in terms of image recognition and template matching.And the script for the Fast Match algorithm does not come with the OpenCV and has to be written for it.

V. CONCLUSION

We have presented a concept that uses the FAsT matching algorithm to detect the road signs and alerts the driver on the sign recognized. We have selected FAsT match as our algorithm as it's one of the most efficient algorithms in Image Processing. This speed is essential as the processing of these images has to be done in real time as fast as possible. We have also included the blink detection system to detect the driver's drowsiness. Furthermore, RFIDs can be used to detect the obstacles making the system much more reliable.

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