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Monitoring of Automobiles using Vision System

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ABSTRACT: This study to create a vision system for objects that would prevent onward clash. The system is more of an aid to the driver, giving declarations whenever there is a chance of clash. With the use of a camera, this system is able to get sequence of images that would undergo processes of revealing and distance designs. And by using OpenCV, credit of objects through sensor and distance measurement by view point deforming have been probable. Critical distances comparative to the current speed of the system's object is the point of judgment that would result to proper notification of HMI display, buzzer. The On-board plc terminal of original objects enables input of speed to the system. And complete, the processes happen in an plc system that allows stand- alone operation, thus making a system that works while on the conveyor.

KEYWORDS: Blackfin, Digital Signal Processing, ELM327, On-board Diagnostic 2, OpenCV, Vehicle Vision System, uClinux, Warp Perspective, Haar, AdaBoost, Car, ADSP 537, PIC16F877A.

I. INTRODUCTION

In the Philippine setting, the number of car accidents as of 2007 reached a total of 4287 casualties according to NSO which includes 7267 vehicles involved. This resulted to 718 deaths which increased compared to 2006 with 578. These numbers, although not that high, are very striking because it represents the number of people who are injured or died in the incident. 13% of these accidents are actually caused by over speeding. Over speeding is a big issue on the road, many Filipinos make themselves believe that they are the kings of the road. The faster they are, the less the reaction time they can have when they are about to collide with another vehicle. Distracted driving could part of the reasons why these mistakes happen. It is a dangerous activity during road trips since the attention on the road is diverted to texting, eating or other activities. A few seconds of distraction may change the lives of the drivers. That is why drivers cannot fully rely on their vision and decision-making alone since they just humans; but an added eye on the road would definitely help. The idea is to create a car vision system that would aid the driver to avoid impending collision with other vehicles in front. It can solve the problem by detecting vehicles in front and monitoring its distance relative to the vehicle. Basically, the farther the car in front gets, the smaller it becomes to the vision of the reference. These ideas when put together constitutes this study; to be able to apply digital signal processing to make an intelligence system at will enable a car to monitor other vehicles and make proper action or notification to the driver. This technology would help increase the reaction time of drivers handling the vehicle with this device on-board since it would give the driver important information about possible vehicle collision.

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II. SET-UP DESIGN

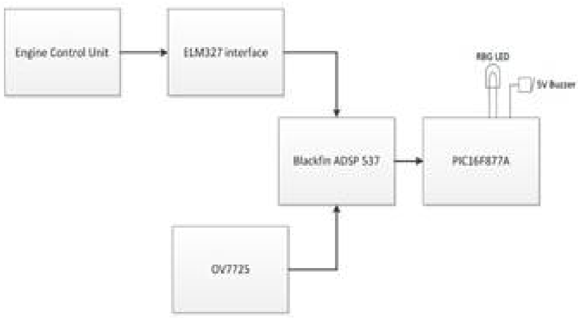

Figure 1. System Block Diagram

Figure 1 shows the System block diagram of how the system gathers the data, processes it and outputs the necessary warning signal. The Embedded System, Blackfin ADSP 537, will have two inputs coming from the image acquisition device, OV7725, and the engine control unit (ECU). The image acquisition device will be the one responsible for the images that will be processed by the Embedded System. The ELM327 interface, on the other hand, will be the one communicating with the ECU to monitor the speed of the car which will be fed to the Embedded System. The speed of the vehicle will be the basis of the 3-second rule which will be applied to the detected cars. The timing for both the data must be equal to ensure accuracy. Once all the data are processed, it will output a warning signal that generally depends on how the data is interpreted. The embedded system will contain two algorithms – the detection algorithm and the distance estimation algorithm. This is where the image files and the speed monitoring will be handled. After which, the embedded system will send a signal via UART to the PIC16F877A for the output of the system. A green LED lit on denotes that the system is running and may detect cars that are at safe distance. A red LED lit on means that the car is touching the 3-second rule and therefore the driver must be cautious enough in this situation. A red LED lit on and a buzzer alarms indicates that a car is at hazardous distance.

A. *Blackfin ADSP537*

ADSP 537 is a member of the Blackfin family processors that is capable of real-time image processing. The board will be used as the main interfacing circuit for the input camera and the alarm output.

The processor also provides a parallel peripheral interface (PPI). This supports variety of general-purpose and ITU- R 656 modes of operation. The three modes of operation for general purpose are input mode, frame capture and output mode. Input mode allows the video to serve as an input to the PPI continuously. Frame capture mode reads the data from the video depending on processors control. Output mode allows transmitting of video to another device. Basically, the researchers will use input mode for general purpose operation since they would need an infinite feed of data from the image acquisition device. ITU-R 656 operation supports sub-modes of active video only mode, vertical blanking only mode, and entire field mode. These are basically video data formats that the board provides. The researchers prefer the usage of entire field mode. This mode basically encapsulates the other two modes together. This mode allows transfer of data from start to active video up to the end active video. All other algorithms such as filtration, edge detection, and distance estimation will be embedded in the processor to provide image processing.

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B. On-board Diagnostics

The OBD2 protocol is a useful tool in determining the speed of the vehicle being used. It is an important part of the study to include because the detection process is relative to the speed of the vehicle being driven. The idea is that a connection will be made between the OBD2 and the Blackfin DSP board using an ELM327 RJ10 interface. No matter how you physically connect to the ELM327, one will need a way to send and receive data. The simplest method is to use the 'terminal' programs that are available, hyper terminal can be used which is a freeware in windows. To use a terminal program, the user must first adjust several settings. The user must ensure that the software has the proper COM port and the proper data rate us chosen. The Blackfin will have the Proportional-integral-Derivative (PID) or in layman's term, commands, that will be sent to the OBD2 which will be explained later in the section. These commands are the ones that can
be sent in the hyper terminal, if using a computer, to instruct the Engine Control Unit (ECU) on what to do next. It is analogous to the command prompt of windows. These commands may vary from detecting the RPM of the engine to detecting the speed itself. The commands may also var y with the bytes being sent to the ECU but the researchers only need 2 bytes in the design because the syntax to get the speed will have a size of 2 bytes. After the command is sent by the Blackfin, the ECU will acknowledge and send data back. It must be noted that these data is in hexadecimal. A computation will be used for the data received which is based on the tabulation of PIDs found in several studies. After the computation, the speed can now be obtained which will be used for the early warning system of the study.

The sample rate of the On-board Diagnostic 2 to Blackfin connection is at 25 samples/sec (0.04 sec/sample). Using the basic acceleration formula in physics:

C. Haar Training

The training needs a database of thousands of images with and without the object of interest. This is called the as the positive and negative images, respectively. It is good to have at least 2000- 3000 positives and 4000 - 5000 negatives. Place all the positive images inside the folder "\temp\positive\rawdata". Once all positive images are placed inside the folder, execute the 'objectmarker.exe' program. It is a program that lets the user choose, by boxing, the object of interest for ever y positive image inside the folder. Every boxed region saves the X, Y, width, height of the image in a notepad that will be used later for the training. Haar training program is included in openCV. The Haar training program will output an 'xml' file that can be loaded into the program to serve as the reference for its detection.

D. Haar Detection

Using the .xml file output of the Haar training, detecting of vehicles in front of the reference vehicle is possible with the common characteristics of vehicles. All the vehicles detected by the system are boxed to have a good reference on what are being detected. The quality of detection is dependent on the number of stages and number of samples in the Haar training proper. Figure 2 shows the difference in detection process using different number of stages. It can be seen that training with higher stages gives a better output after detection process. Observing the boxes made by the system, the detection process is not a hundred percent accurate; and to be able to increase the accuracy of the system without undergoing more training, two error corrections were made – lane correction and small object correction

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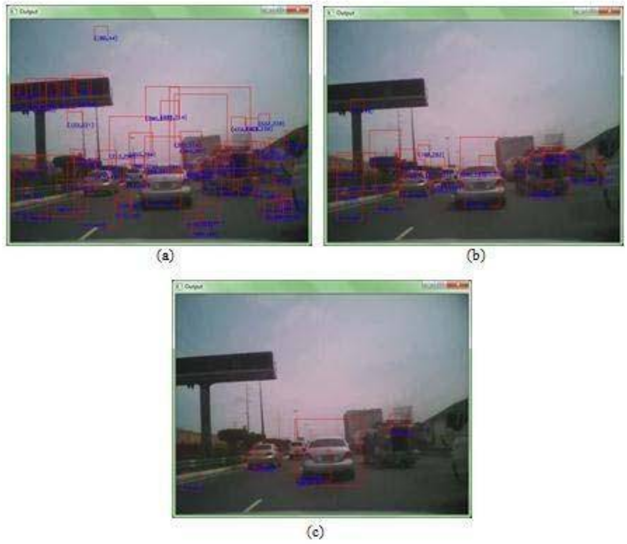

Figure 2. Detection using (a) 5 stages, (b) 15 stages, and (c) 20 stages

First correction is limiting the detection to vehicles in front. This could be thought of as creating an invisible lane that is a few cm wider than the vehicle. The result of this error correction is that only the nearest vehicle that could result in frontal collision is being passed on to the next process.

Second error correction is the small object correction. Based on the result of initial testing, there are a big number of errors from distances of 0-5m and these are actually false detections. Small objects are being detected as vehicles but looking into the size or area of the detected object, the possibility that it is a vehicle is almost zero percent since the nearer the vehicles get, the larger the area should be. With this, the system would get the next vehicle in all detections.

E. Distance Estimation

Inverse Perspective Mapping offers faster and reliable method of determining distance in a single camera system. By transforming the road from an inclined view to bird's eye view, distance can be computed within the transformed range linearly similar to using a common measuring device. to bird's eye view, two matrices must first be determined – the Source Matrix and the Destination Matrix. The source matrix is a 4-point object that is a square or rectangle in real world. This matrix is stretched or shrunk to the destination matrix where the distance measurement will happen. The transformation matrix is the key to transforming all the points of the image/frame to bird's eye view.

The unit of this scaling factor is dependent on the length of the selected points in the source matrix which is most commonly in meters. This is determined by getting the quotient of the pixel length of the destination matrix and the length of the actual rectangle chosen in the source matrix. By doing this, the length of one pixel is already determined which should be used to calculate the distance.

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Figure 3. (a) Input to Warp Perspective (b) Output of Warp Perspective

Warp Perspective is done be transforming the original image/frame point by point using the transformation matrix generated earlier in the algorithm. As the points in the source image/frame were fitted into the destination matrix, the entire image/frame is also altered relatively. Figure 3 shows how the image looks like after doing warp perspective. After this process, the distance can now be computed.

By knowing the position in the transformed image/frame whose distance is to be measured, distance monitoring is possible. The scale factor is multiplied to the size of the object in pixels, from the lowest point of the destination matrix to the point of interest.

III. DATA AND RESULTS

To gather data, the image acquisition device was placed in the area where there is good angle of visibility – below the rear view mirror. The coordinates of first two points that is visible to the camera were taken to serve as a reference. After which, another two point coordinates were taken that is 50 meters away from the first two points. These coordinates were used as the coordinates needed for the source matrix for warp perspective algorithm. the system is highly accurate in city road testing. Figure 6b would refer to the total data gathered in highway road testing. It can be noted that in this graph, the system is more prone to bad is more prone to bad.

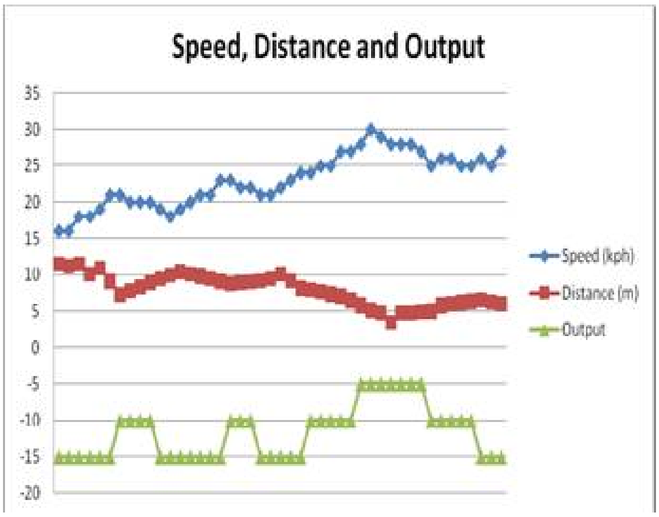

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Figure 5. Point-to-Point Relation of Speed, Distance and Output of (a) City Road Testing and (b) Highway road testing

Nevertheless, the system can still be considered reliable and highly accurate with an accuracy of 91.99%. Figure 6c shows a the graph of bad and good detections of the actual road testing taken as a whole. The system has an overall computed accuracy of 92.47%.

IV. CONCLUSIONS

The study was able to develop a system that can detect vehicles, monitor its distance and notify the driver when necessary. The system was implemented in a Blackfin ADSP 537 board using uClinux as its operating system. There were two algorithms used in the system – the detection algorithm and the distance estimation algorithm. Once a car is detected in front, its distance will be monitored and output a corresponding warning signal depending on the speed and distance measured by the system. Factors like vehicle height, length of the vehicle's hood, camera position and reach of camera's vision must all be considered in ensuring a more effective distance measurement.

Based from the results, the system is proven to be reliable with its detection and distance measurement through proper testing up to 80kph speed. Looking into the different tests conducted in different environments, the system is more efficient at day time compared to night time. The system is flawed in detecting vehicles at night due to the light illumination caused by headlights of the counter flowing vehicles. Through the system's smooth detection up to its driver notification, it is able to achieve reliability of 92.47% in majority of scenarios.

V.RECOMMENDATIONS

Future improvements in the system would include adding an external flash memory for Blackfin implementation. For the algorithm, a tracking system could be added after detection process to improve process time in using Haar detection each and every frame. Adding light compensation to the system can also be taken into consideration to allow almost the same reliability during night time.

Looking into a bigger picture, this vision system can be used as a reference in implementing a vehicle vision system that is capable of both forward and backward collision warning. Also, further study of such research may lead to the technology of adaptive cruise control for vehicles that is dependent on the vision system.

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