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RASPBERRY – PI BASED COST EFFECTIVE VEHICLE COLLISION AVOIDANCE SYSTEM USING IMAGE PROCESSING

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ABSTRACT

Highway obstacle detection is one of the most challenging task in real time for autonomous vehicle navigation system. The basic idea is to design an effective system for real time environment, which detects the presence of obstacles in the track of the vehicle. In the proposed work Raspberry Pi Camera module is employed for object detection and image acquisition. A thorough investigation is performed on a test image in order to validate the best algorithm suitable for edge detection of images. Sufficient analysis is performed to consolidate the results.

Keywords: raspberry –Pi, canny edge detection, sobel edge detection, laplacian edge detection, Open CV, collision avoidance.

1. INTRODUCTION

In India most of the people are killed in road accidents rather than by diseases. According to a survey near about 45% of persons are died in road accidents in a year. Highway obstacle detection is one of the most difficult and challenging task in real time systems in vehicles. In 1988 Delco System Operations in Goleta, California was the first who developed the first obstacle detection system which detects and warns the driver about the obstacles on the road. After few years Santa Barbara Research and Corp. (SBRC), California first introduced the obstacle detection techniques which uses impanation of ultrasound, infrared lasers and radars.

In the past decades many driving assistance systems were designed to enhance the safety of the driver and passengers. Many obstacle detection systems were introduced which adopt different active sensors like millimeter wave radar [4], LIDAR sensor [9, 16], infrared laser sensor [7] and ultrasonic sensor [10]. Embedded technology has gained tremendous impetus in automotive industries. In order to provide safety and transport efficiency, intelligent automotive vehicles are used nowadays. The obstacle detection system is designed to reduce the detrimental effects of the accident. This can be done efficiently by using new technologies like radar, lasers, cameras and ultrasonic sensors to detect obstacles in the front side or rear side of the vehicle. United Nations General Assembly affirmed the period of 10 years from 2010 to 2020 as the decade of action which should be undertaken for road safety measurement.

In the proposed work ultrasonic sensors are employed to detect the motion of the object [10]. The sensor measures the distance between the object and vehicle and relays the information to the driver who can act accordingly in order to avoid collision. The sensors are implanted in such a way that it can efficiently detect objects in the front side as well as in the rear side of the vehicle. Mainly the ultrasonic sensors are incorporated to detect objects in blind zone [6] of the vehicles.

The work is proposed by analyzing the Indian road conditions [1] and densely populated areas which the main factors contributing to this theory. For example, when the vehicle is traversing through a narrow street the factors like population i.e. people moving around acts as an obstacle as well as stationary objects present on the path. These obstacles are alerted to the driver for easy navigation.

Previously various obstacle detection system in automotive systems employed infrared sensors [7] widely as proximity sensor for obstacle avoidance. Since IR sensors have a non linear behaviour and its basic concept depends on the reflection from surrounding object, some error always creeps in thereby making it unsuitable for applications which demand acute precision.Thus these sensors are recommended only for short distance measurement upto 25 cms.

The table image/vision technology used to detect the presence of pedestrian is a most challenging task. In this fast processing is quintessential to alert the driver as soon as possible. But the system using image/vision sensing technologies have some drawbacks. The system fails in unfriendly weather conditions like foggy, harsh and extreme rainy enviornment. Sometimes this system produces error in differentiating between shadows and pedestrian. This system requires high resolution cameras and implementation of such system is a difficult task as it produces error due to damping and vibrations of the vehicles.

Recently ultrasonic sensors and downward looking radar sensors are used for obstacle detection system in automobiles. Obstacle detection techniques based on RADAR are used in advanced driver assistance systems due to its advantages in longer detection range and higher reliablility. But it has high implementation cost associated with it. Moreover measurements obtained from ultrasonic sensors are usually adulterated with vibrations which thereby depriciates the result. As a result of which image based obstacle detection technique is adopted here which is a cost effective methodology and consumes less power.

Withthe new enhancement in the technology and the increasing demand of the consumer electronics, a vision based sensor is implanted for detecting the obstacle and avoiding collision [2, 3]. In 2006, Volvo introduced a

Collision warning and Brake support system that could help driver to avoid accidents at low speed or in traffic conditions. In 2008, BMW introduced Lane Departure Warning System, which uses a vibrating steering wheel to warn the driver. Several vision based lane detection and object detection has been developed in last few years.

Vision based techniques for collision detection [2] becomes a wide area of interest in the field of autonomous intelligent vehicles. A number of vision based techniques are used for detection purpose [14-18]. The rear light detection techniques were also implied to detect the vehicles and measure the distance between them [18]. In this paper several algorithms for efficient edge detection is employed and a comparative analysis is carried out.

2. SYSTEM REQUIREMENTS

The hardware part of the system consists of Raspberry – Pi B+ board, a USB webcam and power supply.

a) Raspberry – Pi Model B+

Raspberry Pi is a small sized single board computer like credit card with a basic size of 85mm x 56mm developed by Raspberry Pi Foundation. The raspberry pi is mainly depended on Broadcom BCM2835 SoC (system on chip) with a core architecture of 32-bit ARM11 processor, CPU ARM1176JZFS having an operating frequency of 700MHz. The B+ model has a memory of 512 Mb SDRAM, 40 GPIO pins, 4 USB-2.0 ports, one Ethernet socket, video output, audio output, 15 pin MIPI camera serial interface with a micro SD card slot.

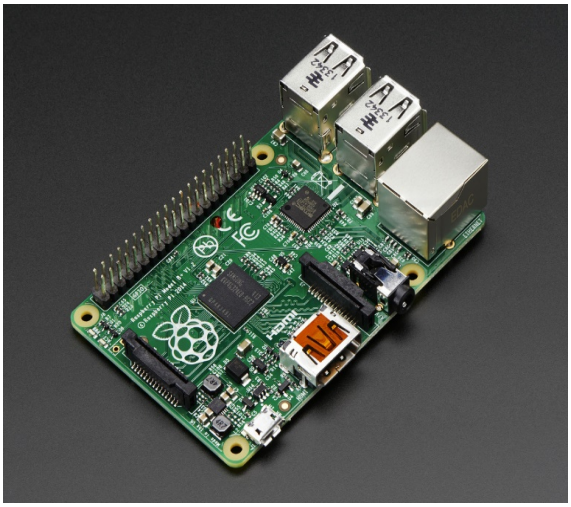

Figure-1. Raspberry – Pi Model B+.

The raspberry pi works has power consumption of 5v, 2A. The operating system boots from micro SD card with a current version of Linux operating system such as Raspbian, Debian, NOOBS, and Fedora etc. The basic software tool needed for Raspberry – pi is OpenCV with any of the programming language like python, C/C++, Java, Ruby and Pearl.

b) USB webcam

The webcam used to detect the objects and capture images is a Logitech USB webcam. The webcam has a still sensor image resolution of 5 megapixel, image capture resolution 640 x 480, the frame rate is 30 fps with video capture resolution of 1024 x 768. The camera is easy to plug in raspberry pi board and supports all Linux based OS.

Figure-2. USB webcam.

3. SOFTWARE REQUIRED

Thebasic software required for this work in Raspberry – Pi is OpenCV and the programming language adopted here is Python.

OpenCV (Open Source Computer Vision) is an open source machine learning and computer vision software library of programming functions in real time. It was officially launched in 1999 by Intel Research and currently supported by Willow Garage and Itseez. OpenCV is free for use for both commercial and academic use and is released under open source BSD licence. It was developed to provide basic infrastructure for computer vision applications and to enhance the use of mechanical perception for commercial products. The modification of code is easily done in OpenCV. The OpenCV library contains more than 2500 optimized codes and algorithms such as face detect, tracking movements, video capturing, extraction of 3D model of objects, produce 3D points clouds from stereo camera, Hough transform etc.

The primary interface of OpenCV is written in C++ but it supports other interfaces also such as C, Python, Java and MATLAB/OCTAVE. The operating systems which support OpenCV are Linux, Windows, Android, FreeBSD, OpenBSD and Mac OS.

In this system the programming language used is Python. It is a high level programming language which allow to express the concept with the help of inbuilt libraries.

4. EXPERIMENTAL SETUP

The whole system is implemented using Raspberry Pi board. A USB camera is used to detect and capture images. These images are saved in system memory and basic edge detection operations are performed on the test images captured by the camera. OpenCV serves as the interface on which edge detection algorithms are allowed to run and perform basic image processing functions. The OpenCV provides several inbuilt libraries for image processing.

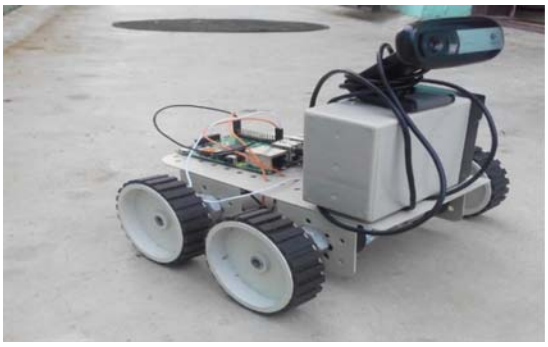

Figure-3. Demonstration model.

Here, basically three operations are performed on images viz. Laplacian operator, Sobel operator and Canny operator for performing edge detection of the images. Figure-4 shows the basic flow of the system.

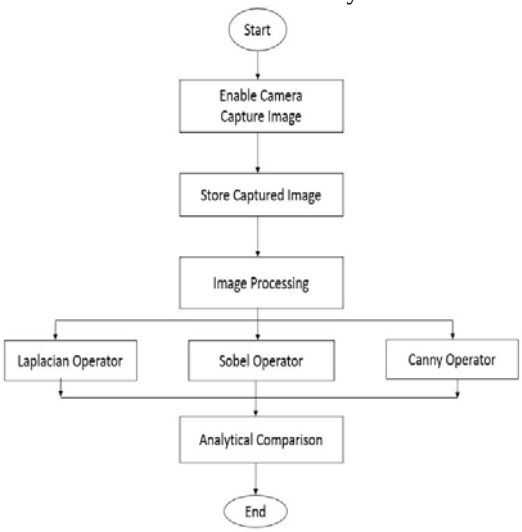

Figure-4. Basic flow diagram.

5. METHODOLOGY

This system is used to detect the objects in front of the vehicle by using a camera module. The USB camera is connected to Raspberry Pi board which serves as the basic module followed by a webcam which is attached with the board to take the picture and capture video. The camera detects the picture and operation is performed in OpenCV to detect the edge of the detected picture. Here mainly three algorithms are employed for efficient edge detection viz. Laplacian, Sobel and Canny Edge Detection Technique [8, 13]. An illustrative comparative analysis is carried out demonstrating each technique and the best method is adopted.

Figure-5 shows the test image on which these various algorithms are applied and the results so obtained are analysed.

Figure-5. Test image.

a) Laplacian edge detection

The Laplacian operator is the second derivative operator used in the edge detection. The laplacian edge detector uses only one kernel [5]. The laplacian operator in OpenCV is implemented by the function laplacian. This algorithm is used to find the edges of the target image.

Figure-6 shows the result obtained after applying l0aplacian operator to the test image.

Figure-6(a). Laplacian edge detection.

Figure-6(b). Laplacian edge detection.

b) Sobel edge detection

The sobel edge detection method is a gradient based method which calculates the first order derivative of the image on X axis and Y axis separately. This is the most commonly used edge detection algorithm due to its simplicity [11].

Figure-7 shows the result obtained after applying sobel operator to the test image.

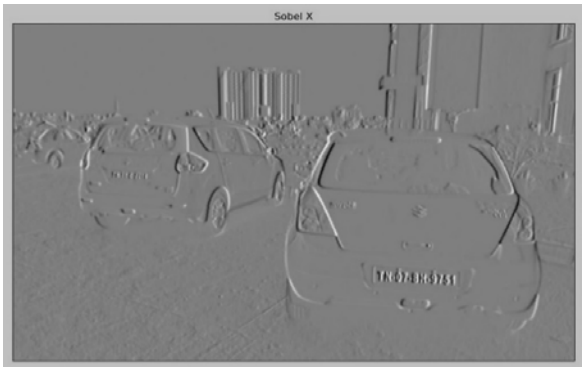

Figure-7(a). Sobel edge detection X – axis.

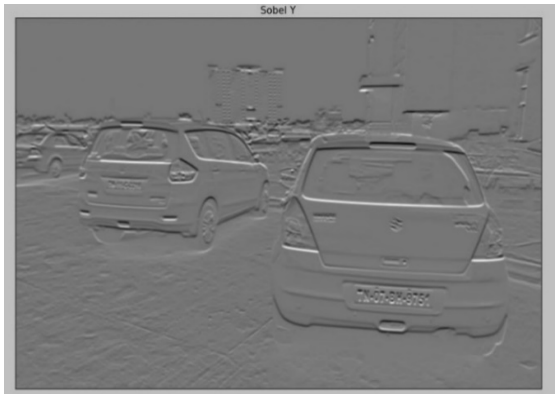

Figure-7(b). Sobel edge detection Y – axis.

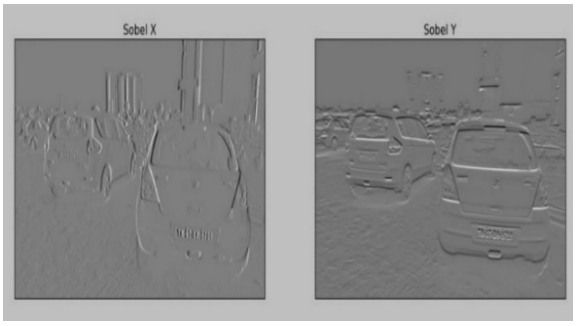

Figure-7(c). Sobel edge detection X and Y – axis.

c) Canny edge detection

The steps involved in canny edge detection.

Step-1: Smoothing of image with the help of Gaussian filter.

Step-2: Finding gradients: Edges are marked where gradients of images have lager magnitude.

Step-3: Non maximum suppression i.e. full scanning of the image to remove unwanted pixels which may not constitute edges.

Step-4: Two threshold are set viz. minimum threshold and maximum threshold values to detect the edges and link them. The canny edge detection method is the first order derivative of the Gaussian [12].

Figure-8 shows the result obtained after applying canny edge operator to the test image.

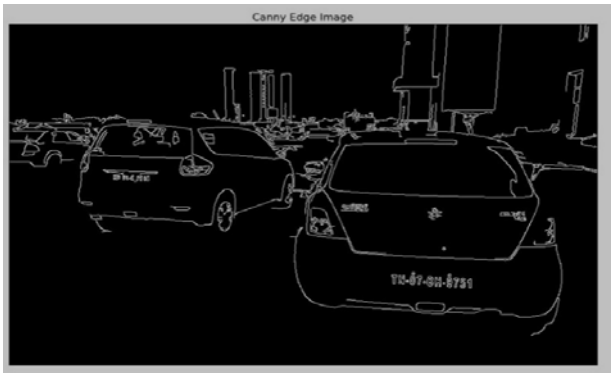

Figure-8(a). Canny edge detection.

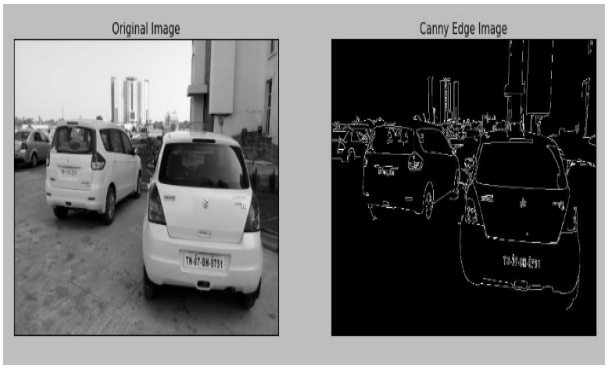

Figure-8(b). Canny edge detection.

6. CONCLUSIONS

In this paper, an illustrative comparative analysis is performed on the test image captured by USB webcam and the edge detection operations are performed in OpenCV on Raspberry – Pi board. Based on the results it can be concluded that canny edge detection technique provides better and legible edges than its other counterparts. This can be seen from the results that are obtained after performing canny edge detection the results of which leads to distinguish objects and better depth analysis of the image. This entire work has been performed in OpenCV by adopting python as the programming language.

The future scope of this above work is to a generate a novel distance measuring algorithm based on canny edge detection principle to measure the distance between the objects and vehicles and efficiently minimize the risk of accidents especially in areas densely infested with people.

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