International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Smart Highway Condition Monitoring using Raspberry-pi

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ABSTRACT

India has the second largest road network in the world which connect all rural road to the highways. Hence road surface condition plays an important role for road safety & transportation efficiency[1]. Therefore, data collection from indirect economical method is desired by road maintenance agencies. Recently IOT based road assessment become popular but the problem here is deploying IOT devices often comes with high time & money investment requirement. Many devices have a dependency on the internet and continuous power to function properly. Therefore, in this paper we propose a simple & cost-effective system that monitor road surface anomalies such as potholes, cracks and bumps in real time with the help of autonomous vehicle[2]. We are using conventional sensor such as ultrasonic sensor, Raspberry pi, GPS, Hotspot etc.Ultrasonic sensor is used to measured depth of pothole & height of hump. The data obtained from ultrasonic sensor is send through hotspot to mobile . The GPS obtain the location co-ordinates of the detected pothole & then transmits them to the micro controller[3].

Key Words: Pothole detection; Lane detection;TrafficSign detection; Animal detection; Raspberry Pi;

INTRODUCTION

According to statistics provided by World health organization (WHO), road accidents are 8th among top 10 major causes of death in the world[4]. The study[16] conducted by WHO shows that most road accidents are caused by poor road conditions. So there is an need for monitoring of road as well as analysis, evaluation and correction of work performed by road traffic control services[5]. Self driving car is used to monitor the road condition. The model is designed by using Raspberry Pi, sensors and Pi camera. Codes are written for detection of pothole, lane, animal and traffic signal. Using the GPS latitude and longitude of location of pothole was sent to database for road condition control device, which in turn to take necessary action to fill the pothole and to maintain good roads. The rest of the paper is organized as related works and research papers on this topic, methodology, implementation and results carried out about the project.

RELATED WORK

The author says that driver assistance system is used for lane detection using car's onboard camera. Previously detected lane feedback is compared to select best fitting line[6]. The difference between center of lane and borders give extent of lane departure and is used to give warning to driver about lane departure. Ruturaj Kulkarni mentions that deep neural network is proposed for self driving cars for detection and recognition of traffic lights using transfer learning[7]. It is a machine learning technique in which there is an enhancement in learning of new task that has been learned. The proposal describes a road condition monitoring and alert application using the in-vehicle Smartphone as connected sensors, which are connected to an Internet-of-Things platform over the Internet[8]. In addition to providing a generic Internet-of-Things based platform, the proposed solution brings in novel energy-efficient phone-orientation- accelerometer analytic in phone, reduces the data volume that needs be communicated between phone and the back- end over Internet. Mohammed Abdul Raheem presented fully automated road assessment methods using cellular based IOT platform[9]. The vibration data recorded from accelerometer attached to moving car is transmitted over internet via cellular network. This vibration signal is used to calculate international roughness index and its values are visualized on road map for different road segments.

In [10] paper, an advanced and reliable vehicle detection and tracking technique is proposed and implemented and given the name "Real-Time Vehicle Detection and Tracking" (RT_VDT). The RT_VDT is well suited for Advanced Driving Assistance Systems (ADAS) applications or Self-driving Cars (SDC). The main emphasis of the RT_VDT is the precision and fastness in identifying vehicles on the road and tracking them throughout the drive. In addition, the RT_VDT provides fast enough computation to be embedded in CPUs with affordable GPUs that are currently employed by ADAS systems. The RT_VDT is mainly a pipeline of reliable computer vision algorithms that augment each other and take in raw RGB images to produce the required boundary boxes of the vehicles that appear in the front driving space of the car. Development of a road surface condition monitoring and database system from federal university mentions that the development of a dedicated road surface condition monitoring device based on an accelerometer instrument Mykio board[11]. The design and development of an online database for storing accelerometer based road surface condition traces. This contribution can serve as a platform for a researcher who intend to study evaluate and compare related algorithm. Gaural Singhal used machine learning technology for the identification and patching of potholes[12].In the smartphone sensor such as accelerometer and is used to identify the potholes on road and GPS for the location of the pit.

Ben Luetkevich says that Hands-free staring centres the car without the driver hands on the wheel[13]. Lane centering steering intervenes when the driver comes Lane marking by automatically nudging the vehicle towards the opposite lane marking. An automated driving system can perform all driving task under certain circumstances such as parking the car. In the circumstances the human driver must be ready to retake control and is still required to be the main driver of the vehicle. Road surface monitoring is an essential problem in providing smooth road infrastructure to commuters[14]. This proposed an efficient road surface monitoring using an ultrasonic sensor and image processing technique. A novel cost-effective system, which includes ultrasonic sensors sensing with GPS for the detection of the road surface conditions, was designed and proposed. Dynamic time warping (DTW) technique was incorporated with ultrasonic sensors to improve the classification and accuracy of road surface detecting conditions. Road surface condition monitoring system that used acceleration sensors mounted on public transport buses to monitor the road surface condition with only a few sensors[15]. These bus mounted sensors gathered vertical and horizontal acceleration data on its route together with the GPS coordinates of the data collection points.

OBJECTIVES

First we will be detecting lane, animal and traffic signal. Next step is to detect pothole and sending location to phone through message and finally monitoring road condition based on information collected.

TOOLS USED

HARDWARE COMPONENTS

Raspberry Pi :

The Raspberry Pi is a computer that runs on Linux, but it also provides a set of GPIO (general purpose input/output) pins, allowing you to control electronic components for physical computing and explore the online of Things (IoT). There are many generations of the Raspberry Pi line: from Pi 1 to 4, and even a Pi 400. Generally there are two models of most generations i.e Model A and Model B . Model A has been a less expensive variant, and tends to possess reduced RAM and fewer ports (such as USB and Ethernet). The Pi Zero canbe a by-product of the primary (Pi 1) generation, made even smaller and cheaper.

Specifications:

CPU: 4x ARM Cortex- A53, 1.2 GHz
GPU: Broadcom Video CoreIVRAM: 1GB LPDDR2(900MHZ)
Networking: 10/100 Ethernet,2.4 GHz 802.11n wirelessBluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy Storage:micro SD
GPIO: 40-pin header, populated

Ports: HDMI, 3.4mm analogue audio-video jack, 4x USB 2.0 Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI).

Pi Camera :

Pi camera is great gadget to capture time-lapse, slow motion with great video clarity. It connects to Raspberry Pi via a flexible elastic cord which supports serial interface. The camera image sensor has a resolution of five megapixels and has a focused lens.The camera provides a great support for security purpose. Various characteristics of the camera are it supports 5MPsensor, Wide image, capable of 2592x1944 stills, 1080p30 video on Camera module v1.
Specifications:
Camera Module:5Megapixel Omnivision 5647.Photo Resolution:2592 x 1944 Pixels.
15-pin MIPI Camera Serial Interface - Plugs Directly into theRaspberry Pi Board.

UV Sensor :

Ultrasonic Distance Sensor provides very short (2CM) to long-range (4M) detection and ranging. The sensor provides precise and stable non-contact distance measurements from about 2cm to 4 meters with very high accuracy. It can be easily interfaced to any micro-controller. This ultrasonic sensor module can be used for measuring distance, object sensor, motion sensors etc. High sensitive module can be used with micro-controller to integrate with motion circuits to make robotic projects and other distance, position & motion sensitive products. The module sends eight 40Khz square wave pulses and automatically detects whether it receives the returning signal. If there is a signal returning, a high level pulse is sent on the echo pin. The length of this pulse is the time it took the signal from first triggering to the return echo.

Battery :

A battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, thin cells used in smartphones, to large lead acid batteries or lithium-ion batteries in vehicles, and at the largest extreme, huge battery banks the size of rooms that provide standby or emergency power for telephone exchanges and computer datacenters.

SOFTWARE COMPONENTS

VNC Viewer: VNC Viewer is employed for native computers and mobile devices you wish to regulate from. a tool like a pc, tablet, or good phone with VNC Viewer software package put in will access and take charge of a pcin another location.

BLOCK DIAGRAM

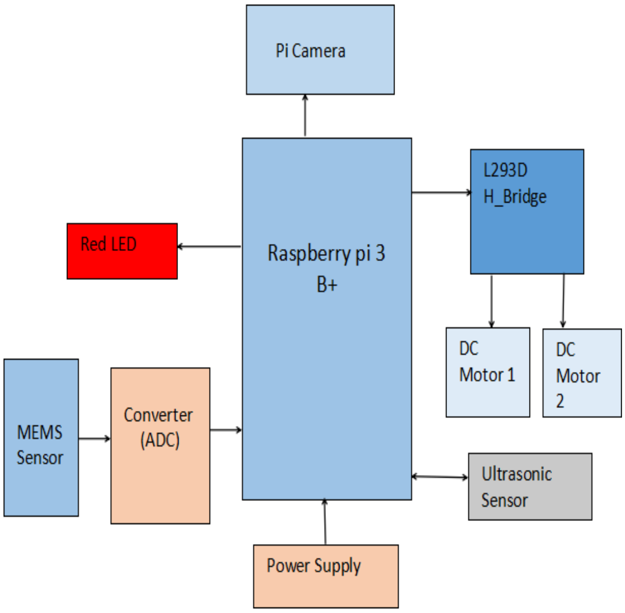

Fig-1: Block-diagram of the proposed methodology

When the self-driving car is started the pi-cam captures images /video of the road for maintaining road conditions (i.e., it detects potholes, lanes on the road, traffic signals), ultrasonic sensor is used for measuring the depth of a pothole to detect animals on the road, whether the traffic signs are present, and lanes are properly marked. The ultrasonic sensor measures the distance in analog format which is then converted into digital format using the ADC, to transfer the collected data to the PIC micro-controller. The pothole detection system is based on IoT and distance sensor which is ultra-sonic sensor. The data obtained from ultrasonic sensor is sent alert to authorized mobile through SMS and to the PIC micro-controller. The circuit works on a 5V power supply to power the PIC micro-controller. The GPS receiver obtains the location co-ordinates of the detected pothole and then transmits them to the micro-controller. The location of all the detected potholes is then stored in the database. Same way the remaining detections are done when the animals are detected on the road the car stops and then moves and even the car detects the traffic signs and follows the traffic rules when red signal is detected it stops and when the green signals is detected car moves and follows the traffic signal. Below all detection are explained clearly.

METHODOLOGY

Pothole detection :

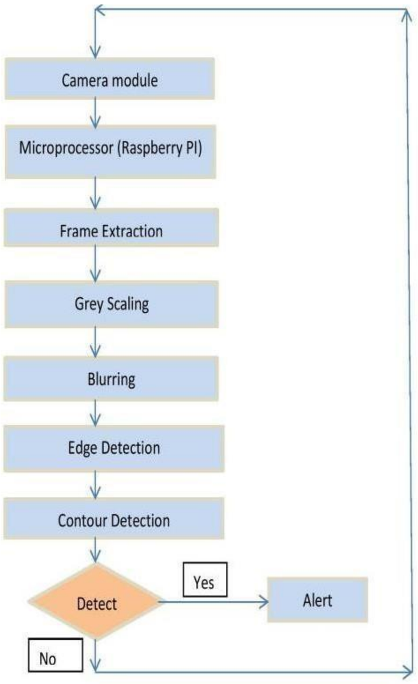

Fig-2: Flow-chart of the Pothole detection

Flow chart for pothole detection is shown in fig 2. First images is collected from the camera module, then it is sent to Raspberry Pi for performing image processing then extracted RGB images converted to grayscale image the canny edge detection is performed on extracted road image can you edge detector produces black and white image open CV is utilized as framework for image processing development . Then image is blurred to remove unwanted noise from image contour detection is used for shared analysis object detection and recognition if portal is detected information is sent to phone as message.

Traffic Signal detection :

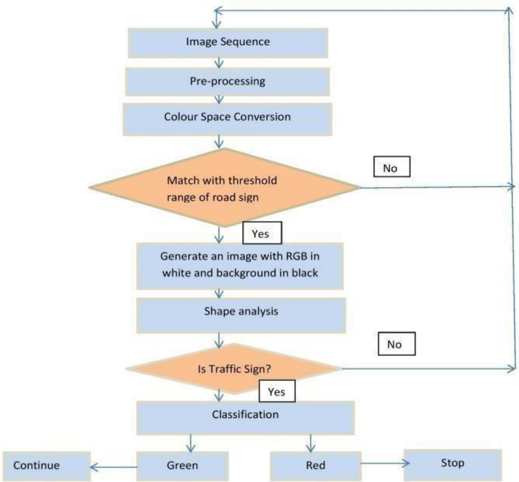

Fig-3: Flow chart of the Traffic Signal detection

Flow chart for Traffic detection Signal is shown in fig 3. HSV algorithm [HUE saturation value] color solution is achieved by extracting a particular HSV from an image.

I. RGB to HSV conversion

Here the Hue determines color we want Saturation determines how intense color isValue determines lightness of image .

II. Threshold mask is applied to isolation and detectssignal

For red - 0°,100,100

For yellow- 60°,100,100For green-60°,100,100

First image is preprocessed and it is converted into HSV conversion. Then it is matched with threshold range of road traffic light. then it is generates image with RGB in white and background is black. Then shape analysis is done to check whether it is traffic signal. If yes it classifieds it as red and green. if red vehicle will stop and if it is green vehicle will continue to move.

Animal detection :

Flow chart for animal detection is shown in fig 4. Open CVS deep neural network is used for pre-processing images and preparing them for classification via pre- trained deep learning models the first image is extracted from the camera next video is converted to frame ,each animal images are stored and which is used as trained dataset of our program. Camera capture frames and are compared with data set, in-read function is used to read the images and pre processing is done on that image . BLOB [binary large object] detection is performed on the framed and are compared with images with trained data set and we will check if it matches the datasets or not if it is matched vehicle is stopped.

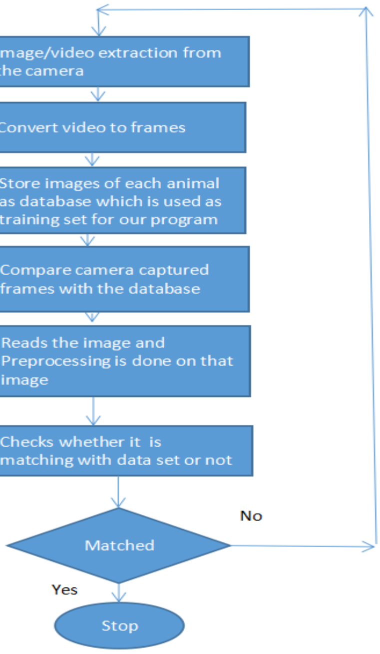

Fig -4: Flow chart of Animal detection

Lane detection :

Flow chart for lane detection is shown in fig 5. At first when the car is started pi cam starts captures the

Image / video of the road ,then the capture image/video is converted into tensors [Tensors are matrices with additional dimensions. (Scalar -> Vector -> Matrix -> Tensors)]. And then the image/video is converted into grayscale [We convert our image to grayscale so that we can abstract away from a Tensor to a Matrix and deal with raw pixel values. (960,540,3) -> (960,540)

Treat yellow or white lane lines the same Pixel list = color channel Average color channel values within the pixel list (R

+ G + B / 3)],then Gaussian blur is applied to reduce the noise in the image/video and canny edge method is applied after that the image/video is masked[Apply a trapezoidal mask over edges

Use bitwise AND to return image only where mask pixels are non-zero.] and then the masked image/video is given hough transform i.e.,[Goal: To identify straight lines.

Process: For each pixel at (x,y) the hough transform algorithm determines if there is enough evidence of a straight line at that pixel.Lines = cv2.Hough Lines P(canny_edges, rho, theta, threshold, min_line_length, max_line_gap).Rho: Distance of P(pixels). Minimum value of

1. Higher Rho = Increased distance resolution

Theta: angular resolution. Higher theta = higher angular resolution.Min_line_length: minimum length of a line in pixels you will accept in the output.Max_line_gap: max distance (in pixels) between segments that you allow to be connected into a single line] in hough transformation if the lane is detected car moves or else the stops.

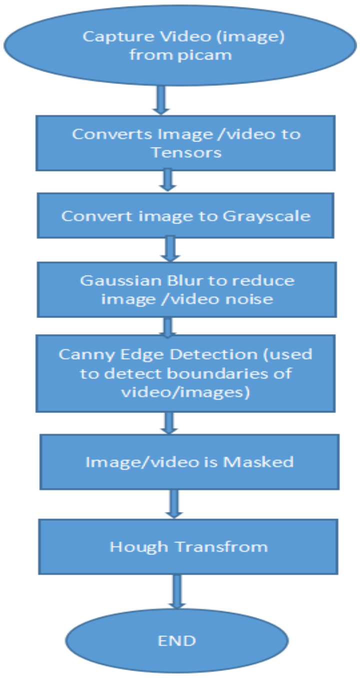

Fig-5:Flow chart of Lane detection

RESULTS

Pothole detection output :

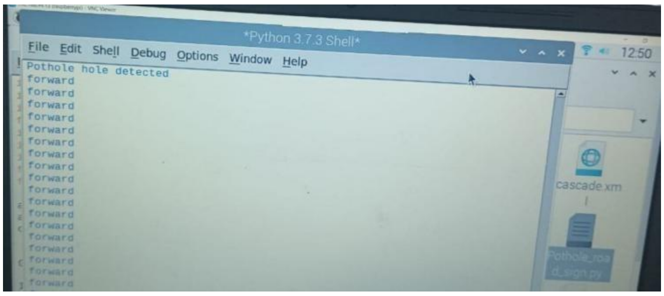

Fig – 6 Pothole detection in monitor

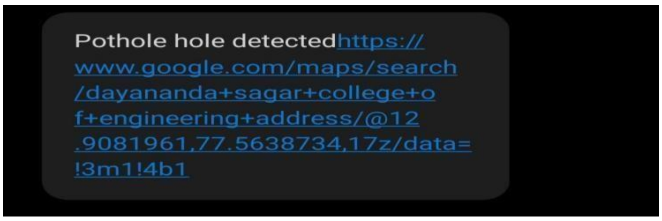

Fig-7 Message sent to phone about pothole

The autonomous car will detect pothole and stops. Pothole detection in monitor is shown in fig 6. The latitude and location of location of pothole is sent as message to user as shown in fig 7.

Animal detection output :

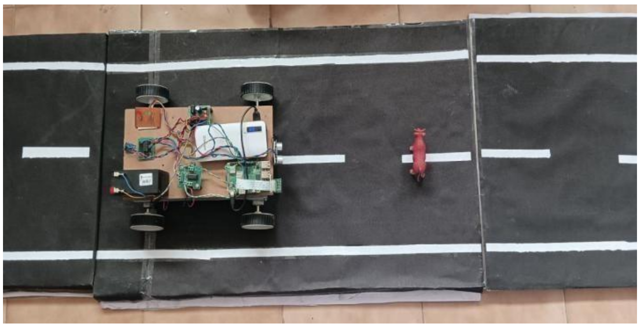

Fig-8 Animal detection

Fig-9 Animal detection in monitor

The autonomous car detects animal at a maximum distance of 30cm and minimum distance of 8cm and stops till animal moves as shown in fig 8. The monitor output of detecting cow is shown in fig 9.

Traffic Signal output :

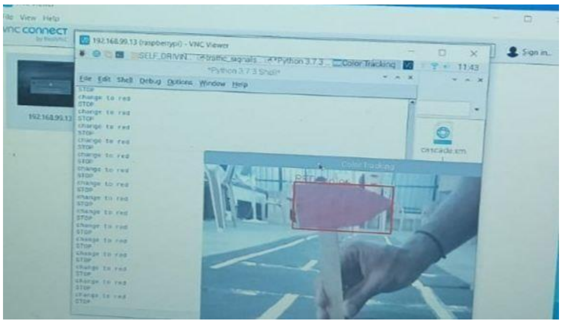

Fig10- Detecting Red Signal

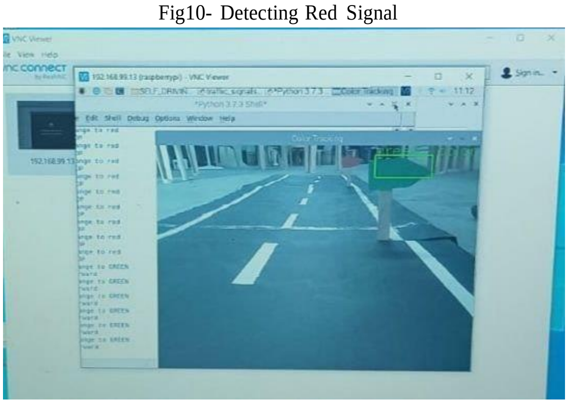

Fig-11 Detecting green signal

The autonomous car will detects traffic signal at maximum distance of 115cm and minimum distance of 10cm. The car will stops when red signal is detected as shown in fig 10 and car will move when it detects green signal.

Lane detection :

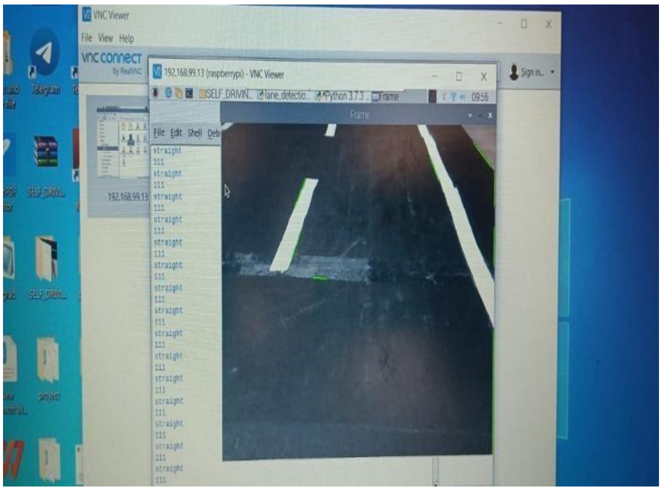

Fig-12 Lane detection

The autonomous car detects lane and it will not go out of lane. The monitor output of showing indication 'straight' when lane is detected is shown in fig 12.

CONCLUSION

The different hardware components along with software configuration are clearly described. Information collected regarding potholes are sent through message for maintenance purposes. This work illustrates the viability of an economic road safety monitoring solution through advances sensor (hardware components along with software). At this stage the basic part of the system is developed which correctly responds to change in the position & movement of the device. Such hardware in the future may increase it functionality. It serves as a helpful approach for the government authority. The long term benefit from this is performing of road network state comparison throughout various time interval and checking upon the road construction project whether or not they meet the assigned quality prerequisites.

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