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Real Time Detection of Potholes using Image Processing

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ABSTRACT: In today's world, there is an increase in road accidents due to their regularity maintained on roads, especially in countries like India. In rainy season, the roads become slippery, and potholes tend to take away the maximum road areas which causes in damage of vehicle or ruin to the outer parts of the vehicle such as flat tire, damage to lower body parts rising the accidents etc. As a result, if the potholes are detected, the drivers must be warned to take an action. The location can be logged, and an alert message can be sent to the drivers. Pothole detection is one of the fundamental jobs for the systematic planning and reconstruction of the potholes. Detection and estimation of potholes using existing methods were based on traditional equipment and perform variational in-depth tasks. The proposed system uses a prototype-based image processing perspective to identify potholes using a single camera and sensors. A distinguishing feature of this proposed system is to create an image processing approach of the potholes under various conditions and used in an algorithmic approach that merges various pre-processing steps with simple visualization technique such as a Canny edge detection.

KEYWORDS: Canny Edge detection, Counter Filter, Window-Mounded Camera, Computer Vision Approach, Ultrasonic Sensor, Pi Camera, Image Processing, Infrared sensor.

I. INTRODUCTION

Most countries are in development race. Road transportation is utmostimportant in country like India among other systems due to which there is an increase in the number of vehicles. As a result, pothole is considered as one of the fundamental criteria for the motorist. Accidents are also increasing due to increase in vehicles on roads [7]. So, sustaining the roads is important to recover humans' life. To repair the location of the pothole, the accurate position must be recognized. To enhance the efficiency, an automatic detection of potholes is required. Moreover, the condition of the potholes must be identified and the best way to perform is to use reports of human to primary government [5]. The proposed system uses image processing where image is processed to get a better visualized image with the Pi Camera, Infrared sensor, and Ultrasonic Sensor to detect potholes using Internet of Things. The Internet of Thingsdescribes connecting the unconnected things and discusses a method for detecting potholes that does not require training the model but is based on an algorithmic approach such as Canny edge detection [6]. Canny edge detection is an algorithm that is applied to an image to extract the edges of the pothole and to remove noise Gaussian filter is used. In canny edge detection converting from RGB to grayscale, blur or smoothening of an image takes place [4]. Due to the image captured by the camera, the solution is based on lighting conditions, hinderance, rain and any other factors that cause a destruction to see potholes [1]. As per the World health organization, road transport vehicle destructions lead to more than millions of deaths around worldwide leaving a negative impact on health. To reduce the lives lost during the accidents, driving rules and preventive measures were proposed [4].

In [1], The blood vessels of humans are compared with infrastructure of roads. Continuous monitoring and repairing are necessary to check the road status. Participatory sensing is an optimistic viewpoint for the data collection. Road irregularity detection using Android OS based mobile sensing

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system and selected data processing algorithms are proposed, and their evaluation is presented with positive rate as true as 90%. Android Features get overlapped in different functions and sensors are very Sensitive to Extreme Environmental Changes.

In [2], The proposed system uses Gap Trap implementation and for reporting the potholes. Gap Trap uses Client-Server architecture. Client device uses Android with GPS Sensor, accelerometer, and internet connection. Accelerometer continuously finds the force of velocity felt on all the 3 dimensions (g-force). The proposed system differentiates Gap Trap with correspondingly designed systems and discusses the usefulness of the idea. Accelerometer does not measure a constant velocity and theaccuracy of GPS depends on sufficient signal quality.

In [3], The existing system discusses safety as an important factor in saving human lives and existent methodsfor detection of potholes uses traditional tools and impose variational in-depth tasks. The proposed system uses a new unsupervised vision-based method, which does not require expensive tools, additional filtering and training phase establishing image processing and spectral clustering for identification of potholes. Accuracy is calculated manually.

In [4], The proposed system collectsdifferent road image samples and applied various pre-processing steps such as blur, smoothening, morphological operations, canny edgedetection and decision tree to detect potholes. After the road images with potholes are detected, they made a dataset, extracted features and giving it to deep neural network to process further and output is obtained in the form of linear regression. Real-time detection of potholes is necessary.

In [5], The proposed system detects potholes based on camera, sensors, and pothole characteristics such as dark region and round shape. By image processing, images are detected, and live captures are taken from camera sensor using cluster algorithm to make outlines of cells called super pixels. Using wavelet energy field, the system with the accuracy of 93% was obtained. The preceding system had an automatic delay. Here the high cost and normal car doesn't have automatic suspension system (black box).

In [6], The proposed system uses a prototype-based image processing perspective to identify potholes using a single camera and sensors. An algorithmic approach that merges various pre-processing steps with simple visualizationtechnique such as a Canny edge detection. The proposed system does not reply on training the model and the speed of execution are manageable given the speed of vehicle is less than 60 km/hr. The proposed system is not able to detect potholes which contains sand and dirt edges.

In [8], The proposed system uses new forms of telemetry data such as digital images, detection of light and ranging, acquired by unmanned aerial vehicle (UAV) were used to distinguish between damage and normal pothole using support vector machine, Artificial neural network, and random forest Machine Learning Algorithms. The asphalt pavement was monitored which provides the best tool for remote sensors merged with UAV platform. Studies show that resolution should not be greater than the minimum scale of pavement. Cracks with the width less than 13.54 mm cannot be captured.

In [10], The proposed system analyses detection of pothole methods developed are either Vibration based, Stereo Vision method or Vision based 2D image. The system proposed are cost-effective compared to 3D reconstruction. Distorted signal generated by noise may be difficult to accurately detect a pothole by these methods.

II. METHODOLOGY

This part discusses the following: A: System Components B. System Overview, C. Automatic detection of potholes, D. Proposed Algorithm, E. System Integration, F: Detection of potholes.

System Components

Raspberry-Pi- It is a microcontroller handling all the processing activities. It acts as a microcomputer where several components such as Ultrasonic Sensor, Pi camera and L293 Driver motor is connected.

Figure 1: Raspberry Pi

Ultrasonic sensor- It is an IOT object where sound waves are used to detect the objects based on depth distance.

Figure 2: Ultrasonic Sensor

Pi- Camera- Once the object is detected, Camera captures the images for further image processing to get a final image.

Figure 3: Pi Camera

L293D Motor Driver- It is a driver used for controlling the vehicle movement using Direct control motors. It is connected to Raspberry-Pi for further processing.

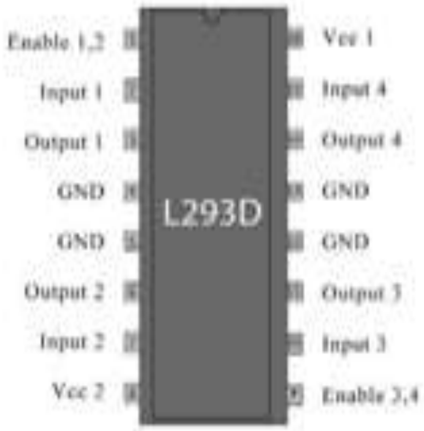

Figure 4: L293D Motor Driver

Wi-fi Module- It is connected to Raspberry Pi for receiving Wi-fi network for locating an object using GPS Tracker.

Figure 5: Wi-fi Module

GPS Tracker- Geo Positioning system is linked to Wi-fi module to track the location of the object.

Figure 6: GPS Tracker

Infrared sensor- It is a sensor linked to Wi-fi Module to detect the pothole using Infra-red rays based on distance.

Figure 7: Infrared Sensor

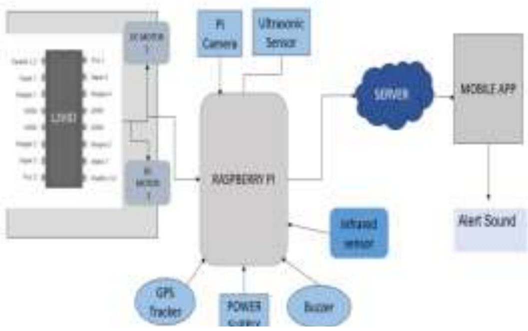

Figure 8: System Overview

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Overview of the system

The proposed system was outlined to gather a road profile through a device which is installed on a vehicle and pothole is detected from the gathered data using the proposed algorithm. Figure 8 shows the system overview process between medium and microcontroller. The system comprises Raspberry Pi Microcontroller, Ultrasonic sensor to detect the potholes, Infrared sensor connected to Wi-fi module used to send data to the mobile application, Pi Camera to capture the images, GPS tracker to track the location of the potholes, Wi-Fi module to connect the server of the database and L293D Motor driver was constructed for vehicle movements using Direct control motors. Once pothole is detected, an alert in the form of buzzer is beeped, location and depth distance are reported to the motorist through mobile application.

Automatic detection of potholes

As an automatic prototype, the system was installed. This vehicle has the size necessary to identify all forms of potholes. The position and placement of the Ultrasonic sensor and camera module were critical in determining the potholes correctly. The sensor and camera module were facing towards the road with the constant distance between the road and the prototype to obtain good results.

For the pothole detection, the Ultrasonic sensor would capture the depth distance up to a threshold from 1 centimeter to 1 meter. Figure 9 shows the measured distance to detect the pothole. In our system, if the threshold is more than 20 centimeters, the pothole is detected. In this design, the vehicle part is constructed where the Bridge Motor driverL293D is connected to raspberry pi. Raspberry pi and motor is connected for vehicle movements. Ultrasonic sensor detects the pothole based on depth distance using ultrasonic sound waves. Once the pothole is detected, Pi-camera is activated to capture the images of pothole in Raspberry pi. The images captured are processed by image processing usingedge detection and a series of pre-processing techniques is carried out. In canny edge detection converting from RGB to grayscale, blur or smoothening of an image removes outlier pixels that may be noise in the image. Certain steps such as gaussian blur, medium blur and erosion takes place. Image processing is carried to check again if the captured image is a pothole or not. The image processing is done by first cropping the captured image, to adjust the image contrast, the algorithm would detect the edges based on its intensity gradient removing the weak edge pixels.

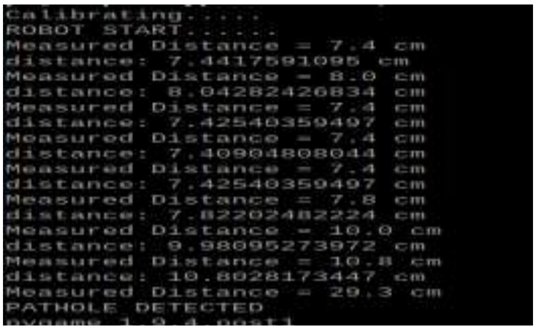

Figure 9: Detection of pothole

III. ALGORITHM

The captured image is transferred for image processing in Raspberry Pi. The process was created to stack directories containing images into arrays after the dataset is stored in a variable. Then next is to crop an image obtaining the starting and ending index of the captured image. Newly created image with the size will be defined. The image's starting point is determined, as well as the percentage of the image's overall height and breadth. The image's ending point is obtained in a similar method. The values have now been mapped to the original image. As a result, the output is a cropped and original image.The resizing of an image occurs during pre-processing. The number of rows and columns that tell the size of the image can be defined using the x and y axes values in the resize method. After resizing, image contrast and brightness is done. Equation 1 does the same.

$$newimage=a*actual\_image+b \quad (1)$$

where a is the alpha value that determines the image's contrast.

If a is greater than 1, there will be a lot of contrast. Lower contrast is obtained if the value of an is between 0 and 1 (smaller than 1 but bigger than 0). When a is 1, there is no contrast effect on the image. The letter b stands for beta. b's values range from -127 to +127.

After pre-processing, algorithm is applied. Algorithm extracts useful structural information from different vision objects and dramatically reduce the amount of data to be processed. The algorithm applies Gaussian filter to remove the noise, intensity gradients of the image is found, gradient magnitude thresholding or lower bound cut-off suppression to get rid of spurious edges, edge detection is applied, then threshold is doubled to determine potential edges. Final step is to track the edge by conquering all the other edges that are weak and not connected to strong edges.

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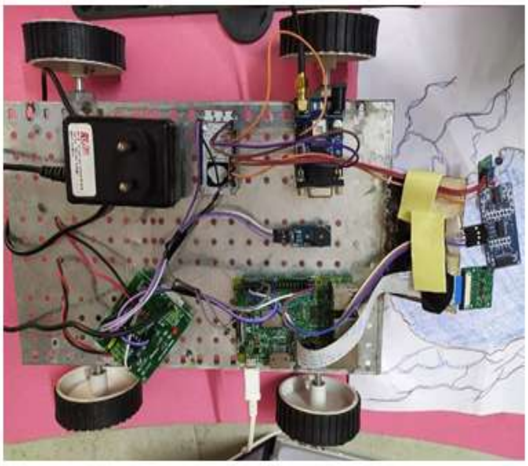

Figure 10: Prototype

System Integration

The main process of the system focuses on detecting of potholes and at the same time reporting its exact location to the main module. The prototype is shown on Figure 10. The process is composed of two parts, automatic detection, and reporting of potholes. As the pothole is detected, the camera would start to capture images in front of the moving prototype. The microcontroller processes the captured images and image processing is analysed. Once detected, the Wi-Fi module connects to the GPS module to obtain the location of the pothole and a buzzer is beeped.

Detection of potholes

Once the pothole is detected, buzzer is alerted as well as location is sent to the motorist using Blynk Mobile Application. Figure 11 shows the Pothole report.

Figure 11: Pothole Report

IV. RESULTS

Figure 12 is the input image given for the detection potholes. Figure 13 is the captured image and outcome of image processing .Later after applying image processing operations such as smoothening filtrating of different kinds is fulfilled .After applying erosion operation image processing completes .Here is the final output of whole process and image processing output is shown in Figure 14 .In the figure each and every step of image processing from RGB to Grayscale , Blurred , Gaussian blur ,Medium blur , Erosion, Closing and finally edge detection .Then output image of the pothole clearly misaligning background and foreground to actually show it to canny edge detection.

Figure 12: Input image

Figure 13: Captured image

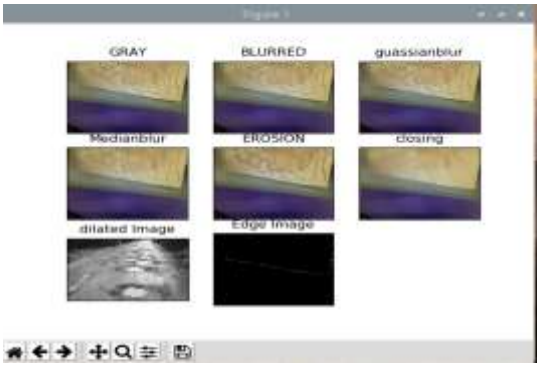

Figure 14: Final output

Source code for the micro processor:

```
import RPi.GPIO as GPIO
import time
#GPIO Mode (BOARD / BCM)
GPIO.setmode(GPIO.BCM)
#set GPIO Pins
GPIO_TRIGGER = 21
GPIO_ECHO = 20
```

```
#set GPIO direction (IN / OUT)
GPIO.setup(GPIO_TRIGGER, GPIO.OUT)
GPIO.setup(GPIO_ECHO, GPIO.IN)
def distance():
    # set Trigger to HIGH
    GPIO.output(GPIO_TRIGGER, True)

    # set Trigger after 0.01ms to LOW
    time.sleep(0.00001)
    GPIO.output(GPIO_TRIGGER, False)

    StartTime = time.time()
    StopTime = time.time()

    # save StartTime
    while GPIO.input(GPIO_ECHO) == 0:
        StartTime = time.time()

    # save time of arrival
    while GPIO.input(GPIO_ECHO) == 1:
        StopTime = time.time()

    # time difference between start and arrival
    TimeElapsed = StopTime - StartTime
    # multiply with the sonic speed (34300 cm/s)
    # and divide by 2, because there and back
    distance = (TimeElapsed * 34300) / 2
    return distance
```

```
if __name__ == '__main__':
    try:
        while True:
            dist = distance()
            print ("Measured Distance = %.1f cm" % dist)
            time.sleep(1)

        # Reset by pressing CTRL + C
    except KeyboardInterrupt:
        print("Measurement stopped by User")
        GPIO.cleanup()
```

SL.NO	DISTANCE MEASURED	RESULTS
1	7.4 cm	POTHOLE NOT DETECTED
2	8 cm	POTHOLE NOT DETECTED
3	10.8 cm	POTHOLE NOT DETECTED
4	29.3 cm	POTHOLE DETECTED

V. CONCLUSION

The system which uses single camera can detect potholes in a constant distance and will not relay on training any models.

The device was effectively used for detecting potholes, with image processing steps including cropping, re-sizing, and finally the Canny edge detection algorithm. The image processing reaction time was relatively quick. Therefore, the system was able to detect and notify potholes with extreme accuracy. Using ultrasonic sensor based on depth distance, pothole is detected and pi camera using image processing again checks if the captured image has a presence of pothole. Basically, the proposed system uses different methods to detect the pothole. Once the Infrared sensor detects the pothole connected to Wi-fi module, an alert beep sound and location of pothole is sent to the motorist using Mobile application. The proposed system can be used in real-time as it uses pi-camera to capture live images and processing speed was relatively high. It can be easily implemented. With more advanced technologies such as I Core microcontrollers this can be more efficient in terms of accuracy.

Some of the advanages from the above results

a) Real time implementation.
b) Processing speed is relatively high.
c) No training of models.
d)Pothole detection is checked with different methods
e) Robustness

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