

DETECTING POTHoles USING SIMPLE IMAGE PROCESSING TECHNIQUES AND REAL-WORLD FOOTAGE

Submitted in partial fulfillment of the requirements for the
award of Bachelor of Engineering degree in Electronics

Communication Engineering

By

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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MAY -2022



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafede work of **CHANDU BALLA (38130024)** who have done the Project work as a team and carried out the project entitled “**DETECTING POTHOLE USING SIMPLE IMAGE PROCESSING TECHNIQUES AND REAL-WORLD FOOTAGE**” under my supervision from December 2021 to May 2022.

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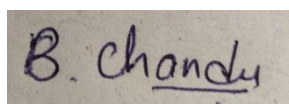
Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I, **B. chandu (38130024)** hereby declare that the project report entitled “**DETECTING POTHOLE USING SIMPLE IMAGE PROCESSING TECHNIQUES AND REAL-WORLD FOOTAGE**” done by me under the guidance of **Dr. BALAMURUGAN SIR**, (internal), is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering Degree in electronic communication and Engineering.

A photograph of a handwritten signature in blue ink on a light-colored piece of paper. The signature reads "B. chandu" with "chandu" underlined.

1)

DATE: 7-5-2022

Chandu Balla (38130024)

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ABSTRACT

India recorded that over 9,300 people had been killed and nearly 25,000 were injured in road accidents as a result of potholes. This is a serious concern over increasing accidents due to potholes on roads and these are much more than deaths due to terror attacks. It is unacceptable that such a large number of deaths take place on roads due to potholes and humps. A constant detection and repair in proper time can not only result in ensuring road surface quality but can also save many lives.

Many Proposals are collected from the standard journals, and it is first reviewed chronologically to find out the contributions in potholes and hump detection techniques. After reviewing, the various challenges addressed in the road maintenance is discussed. The various approaches used in the detection of potholes and humps are discussed and reviewed. The approach such as a vibration based for automatic detection of potholes and speed breakers along with their coordinates, a stereo vision system which detects potholes during driving, an internet of things based road monitoring system (IoT-RMS) is proposed to identify the potholes and humps in the road, Ultrasonic sensors are used to identify potholes and humps and also to measure their depth and height respectively, Computer vision approaches are generally based on either 2D road image analysis or 3D road surface modeling. As the research outcome, case studies are taken and reviewed.

One of the major problems in developing countries is maintenance of roads. Poor road conditions cause discomfort to the passenger, damage to vehicles, and increase the chances of road accidents. Therefore, it is desirable to have a mechanism to report potholes on a large scale occurring in the routes on which people wish to take in real time. Also understanding conditions of road surface is very important for road maintenance and management. To ensure road surface quality it should be monitored continuously and repaired as necessary. This paper proposes a cost-effective solution to identify the potholes on roads and provide timely alerts to drivers to avoid accidents or vehicle damages.

A connected technology is developed which will allow a vehicle to gather data about the location and severity of potholes. It will allow vehicles to receive warnings allowing the driver to slow down, smooth the ride, with the aim of reducing the potential for punctures, wheel and vehicle damage.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

India, the second most populous Country within the earth and a quick growing economy, is understood to possess an infinite network of roads. Roads are the dominant means of transportation in India today. They carry almost 90 percent of the country's passenger traffic and 65 percent of its freight. However, most of the roads in India are narrow and congested with poor surface quality and road maintenance needs don't seem to be satisfactorily met.

No matter where you're in India, driving may be a breath-holding, multi-mirror involving, potentially life-threatening affair. The bad road condition is the main reason for all the truck accidents, per the survey in. The weakened road system increases the upkeep cost and the negative effects on the axle and mechanical system of the vehicles. Various factors which affect the performance of the road are: -

- 1) Heavy traffic which causes the repetition of the load.
- 2) low-quality materials and inappropriate moisture condition at construction.

Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. Road surfaces can be classified into different categories such as smooth roads, potholes, bumps, contraction joints, manholes, expansion joints etc. The surfaces where one has to slow down his speed are potholes and bumps (also known as speed breakers). Fig 1 represents the statistical data of Indians killed in pothole related accidents over the past four years and shows top states in pothole deaths. Following is the report by the ministry of road transport.

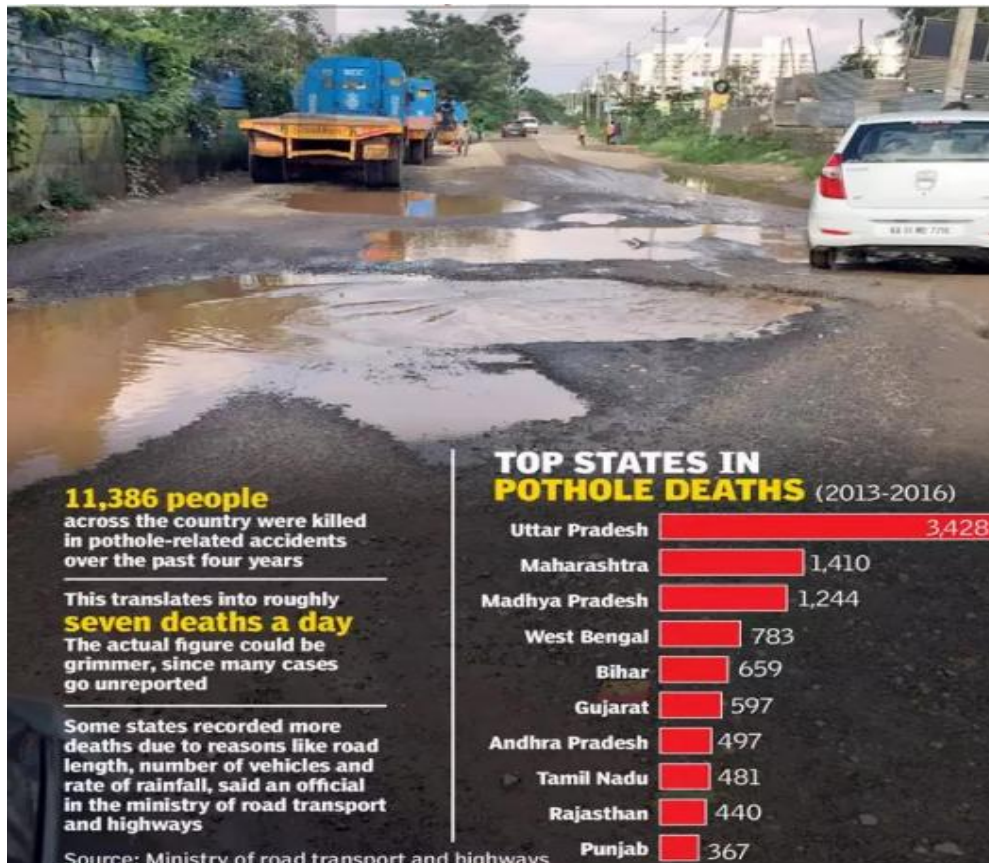


Fig 1.1: Statistic Report by Government representing road accident from the above data.

we can see Pothole-ridden roads have taken 11,386 lives across India in the last four years, which interprets into roughly seven deaths each day. These dangerous road conditions are a distraction for all the commuters; hence detection of these potholes plays a major role in fixing them on time and can prevent many road accidents. For pothole detection many approaches are preexisting but each of them has their own drawbacks. This paper analyses the related work and proposes an efficient solution which may prove to be a great help to the commuters. In this paper the Related work and their analysis is presented in Section 2 followed by the conclusion in Section 3.

India has the second largest population in the world with one of the fastest growing economies. As the population rises, the need for well-maintained roads is also increasing as road transport is one of the most primary means of transport in the country. However, most of the roads in the country are narrow, congested and of very poor quality. Dangerous road surface conditions are major distraction for safe and comfortable transportation. Driving a vehicle in India is potentially life taking. Pothole is a depression in the road surface caused by wear or subsidence. Potholes are formed because of substantial downpours and poor drainage framework in urban areas. Research for the Department for Transport has shown

that the public's main concern on roads is potholes. Potholes stand out above all other defects as the most unacceptable of all conditions.

Nearly everyone has this at the top of their scale. Potholed roads are a common sight across rural and urban India especially during and after monsoons. Every year crores and crores of rupees are spent by the highway agencies in extensive pothole patch repairs. Because of adverse media coverage these agencies do patch repairs of main streets in urban areas and main highways in rural areas after the monsoon season is over. By lanes in towns and cities and some secondary roads in rural areas usually remain neglected for years. This ritual is repeated year after year even though several lakhs of people are involved in accidents due to potholes causing serious injuries and in many cases fatalities. Both drivers and road maintainers are interested in fixing the potholes as soon as possible. However, they must be identified first.

According to the survey report "Road Accidents in India, 2011", by the ministry of road transport and highways, a total of 1,42,485 people had lost their lives due to fatal road accidents. Of these, nearly 1.5 per cent or nearly 2,200 fatalities were due to poor condition of roads. According to most recent figures by a few state governments, potholes across the nation has claimed 3,597 lives in 2017, an over half ascent in the toll than a year ago. Around 30 deaths happen day by day on streets because of potholes.

The simplest method to detect potholes is collecting photos of road damage and hazards taken by the participants and uploading them to a central server. However, it requires strong participation from the users. An automated approach to detect potholes with little or no human interaction is more promising. This would ensure more comprehensive survey data with fewer errors caused by human factors than generated by mere enthusiasm of the participants. Some pothole detection methods have been proposed previously and they can be classified into two groups: Image recognition method and mobile sensing method. Image recognition methods include image processing techniques to collect and analyze the road information to detect potholes. In mobile sensing methods, accelerometers and gyro sensors are incorporated and the data processing center analyses these data to check whether the data exceed the thresholds for pothole detection.

CHAPTER 2

LITERATURE SURVEY

2.1 OVERVIEW

Pothole detection being a noteworthy subject of research, specialists are taking an effort at various pothole detection methods. a number of the pothole detection methods are referenced underneath. In this section we'll analyze each of those approaches.

2.2 SURVEY OF PREVIOUS WORKS

The existing methods for pothole detection can be divided into 3D reconstruction based, Sensor based, Vision based methods. In this section we present few methods that are relatively close to our work in this paper. Most of the systems used ultrasonic sensor to measure the height and depth of the potholes. In microcontroller processes this information and triggers GPS module to send the location to the cloud database. Other vehicles are alerted via android app with an audio beep. Magnitude of reflected signal from the ultrasonic sensor decreases due to roughness of the surface and signal amplitude is difficult to analyze. So, accelerometer is used to optimize these variations present in the signals. It is difficult to classify large and small potholes using the weak signal from this sensor. The information about the pothole presence is transmitted to other vehicles in the vicinity via ZigBee module. The transmitting vehicle speed is directly controlled by the microcontroller acting on the motor drivers. In vehicle mounted accelerometer sensor is used. The sensor data and the location from the GPS are pre-processed and then passed to machine learning based damage detection method.

In 2D LiDAR (Light detection and ranging) and Camera are used. LiDAR obtains the angle and distance information's. Image based detection improve the accuracy, the algorithm includes noise filtering, brightness control, binarization, additive noise filtering, edge extraction, object extraction and pothole detection. Image based detection methods have the advantage of not being affected by electromagnetic waves and road surface state. Video processing-based road crack recognition method was simulated in MATLAB. Here the video images are processed by grey transformation and image smoothening techniques. Mathematical morphology methods are used to classify cracks into categories like transverse, longitudinal and turtle crack.

In other vision-based methods an optical device is mounted at a height of rear-view mirror of

a survey vehicle to obtain the video data. Histogram and closing operation are used to separate image from background and further noise is removed by median filtering. This proposed method has a better performance for bright images, rather than dark images. Another approach based on pothole texture extraction and comparison. The system is trained based on the existing number of pothole texture samples such that it detects the potholes based on this training result. In a method based on wavelet energy field has been implemented as a MATLAB prototype, that achieves a high detection and segmentation accuracy. Here, the wavelet energy field of the pavement image is constructed to detect the pothole by morphological processing and geometric criterions. And the detected pothole is segmented by Markov random field model and the pothole edge is extracted accurately. In the proposed system makes use of both vision and sensor-based methods, where an accelerometer identifies the pothole and mobile application is developed to capture the pothole image and sent to the cloud.

2.2.1 Automatic Detection of Potholes and Humps on Roads to Aid Driver.

- In a year of publish in 2020.
- Author of it was Prof. R. M. Sahu, Mayank Kher, Nurul Hasan, Laxmi Panchal.
- Content of the project was One of the major problems in developing countries is maintenance of roads. Well maintained roads contribute a major portion to the country's economy. Identification of pavement distress such as potholes and humps not only help drivers to avoid accidents or vehicle damages.
- Problems are also identified where it is not an cost efficiency product.

2.2.2 Automatic Pothole Detection System using Laser

- In a year of 2015.
- Author was S. Yamuna, S. Raja Pavithra. M, Rajitha. M, Subhashini. R, Sneha. S
- Identification of pavement distress such as potholes and humps not only helps drivers to avoid accidents, but also helps authorities to maintain roads. This project discusses previous pothole detection methods that have been developed.
- Complex method to Improve the efficiency.

2.2.3 Detection of Potholes using Image Processing Techniques

- in a year of 2020.
- Author of this was Akshata Bhat, Pranali Narkar, Divya Shetty, Ditixa Vyas.
- Roads are considered to be the main mode of transportation. But due to this heavy

use of roads and environmental factors, these roads need a scheduled maintenance

- Hard to replacement and maintenance.

2.2.4 AUTOMATIC POTHOLE DETECTION

- In a year of 2019.
- Author of it was Chaitali S Poyekar, Asma S. Shaikh, Harshita D Shah, M.John Kenny.
- Most of the Indian rural and sub urban roads are not ideal for driving due to faded lanes, irregular potholes, improper and invisible road signs. This has led to many accidents causing loss of lives and severe damage to vehicles
- Low efficiency when compared to the existing system.

2.2.5 PROTOTYPE OF VEHICLES POTHOLE DETECTION BASED BLOB DETECTION METHOD

- In a year of 2017
- DEWIANI DJAMALUDDIN, ANDANI ACHMAD, RIVANTO PARUNG
- Potholes on road causes majority of traffic incidents. It happens with driver's unawareness to potholes on the road, while pothole's location data mining is still performed manually by technician nowadays
- Very long time to detect the potholes.

2.2.6 Real-Time Pothole Detection Using Deep Learning

- In a year of 2021.
- Anas Al shaghouri, Rami Al khatib, Samir Berjaoui
- Roads are connecting line between different places and used daily. Roads' periodic maintenance keeps them safe and functional. Detecting and reporting the existence of potholes to responsible departments can help in eliminating them. This study deployed and tested on different deep learning architecture to detect potholes.
- It is difficult work out because here they used tensor flow, the installation process is very difficult.

Path hole detection using RADAR: -

One of the major problems in developing countries is maintenance of roads. Poor road conditions cause discomfort to the passenger, damage to vehicles, and increase the chances of road accidents. Therefore, it is desirable to have a mechanism to report potholes on a large scale occurring in the routes on which people wish to take in real time. Also understanding conditions of road surface is very

important for road maintenance and management. To ensure road surface quality it should be monitored continuously and repaired as necessary. This paper proposes a cost-effective solution to identify the potholes on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. A connected technology is developed which will allow a vehicle to gather data about the location and severity of potholes. It will allow vehicles to receive warnings allowing the driver to slow down, smooth the ride, with the aim of reducing the potential for punctures, wheel and vehicle damage.

CHAPTER-3

Aim And Scope of the present investigation

3.1 Aim of the project

To identify the pothole detection in real time.

Pothole is a depression in the normal surface of the road.

Larger potholes sometimes cause breath holding accidents and loss of lives as they are not visible at night. Pathetic condition of roads is a boosting factor for traffic congestion and accidents. The driver must manually look for potholes on the road while driving sometimes, the driver encounters many risks such as he will be at a constant speed and suddenly there will be a pothole or hump on the way. At these times, the risks of accidents are more.

This paper presents a prototype which detects the pothole in the path of driving and update it to the cloud. A voice notification alerts the driver of the potholes ahead. Website is built which will be accessible by the authorities concerned so that they can take care of the potholes detected. This system will help in the maintenance of the roads.

3.2 EXCISTING SYSTEM

In an existing system a detection which starts with noise removal, followed by adjustment of brightness and simplification of video by binarization. Then, noise removal is applied to the binarized image.

After noise removal, the process of extraction of the outlines of the segmented objects is carried out. Extraction is followed by selection and square zoning for the objects. After all these processes, desired pothole area information is returned.

Another pothole detection system which is divided in to three subsystems. First is sensing subsystem which senses the potholes encountered by it, by using accelerometer or by camera which scans the road. Both are mounted on the car.

Then communication subsystem which transfers the information between Wi-Fi access point and mobile node. Access Point broadcasts the data about potholes in its area.

3.3 PROPOSED SYSTEM

Video has been captured and save in file format and the Frames of the video are extracted and the individual frame is considered as an image which is further processed.

The image is firstly blurred using aver aging then with Gaussian filter and lastly with median blur so to remove unwanted noise from the image.

To achieve more accurate edge detection from a depth image we have modified the process using morphological operations.

These operations are generally a collection of nonlinear operations carried out comparatively on the ordering of pixels without affecting their numerical values.

The key operators for morphological operations are erosion and dilation. We have used erosion after blurring operations which is followed by two iterations of dilation. The pothole detection is utilizing canny edge detection technique. The detection technique is a multi - stage method to detect a wide range of edges in images.

Canny edge detection goes through five stages as follows:

- Apply Gaussian filter to smooth the image in order to remove the noise.
- Find the intensity gradients of the image.
- Apply non-maximum suppression to get rid of spurious response to edge detection.
- Apply double threshold to determine potential edges.
- Track edge by hysteresis: Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

We use Otsu's method for reduction of a grey level image to a binary image.

The algorithm assumes that the image contains two classes of pixels following bi - modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra - class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter - class variance is maximal.

The system then uses contour detection technique. For better accuracy, use binary images. So, we have applied threshold and canny edge detection.

In this system, a database of road images and videos are collected. Videos are acquired from a roadside pole with a camera module interfaced with raspberry pi.

As the system is stationery, the hassle of adjusting speed etc. is eliminated. Hence, the images give a clear view of the road from the roadside pole.

These images go through image processing steps for detection.

CHAPTER 4

MATERIAL AND METHOD

4.1 SYSTEM REQUIREMENT

4.1.1 Hardware: -

The proposed system utilizes a Raspberry Pi, as the main processor for performing the image processing and detecting potholes. A Raspberry Pi is a development board embedded with ARM processor and capable running UNIX based operating system. The model used has an onboard 1GB of RAM, which will make it capable of performing the image processing along with the detection. It also has an interface which supports the raspberry pi to connect to a camera module. An additional 3G USB modem is utilized as the network interface so that Raspberry Pi is get connected to the internet. This modem is attached to Raspberry Pi; therefore, it can make the Raspberry Pi is able to transmit any defects or potholes presence on road in real-time. It also has a micro-SD card slot which will be used to temporarily store images.

4.1.2 Software: -

An open-source library of image processing called OpenCV is utilized as the framework for the image processing development. OpenCV is a library which is designed for a computational efficiency for image processing and manipulation. OpenCV supports Linux operating system which is suitable to be developed inside the Raspberry Pi. It also has interfaces to python, C, C++, and Java.

4.1.3 PYTHON: -

- Python is a widely used high-level programming language for general-purpose programming, created by Guido van Rossum and first released in 1991.
- An interpreted language, Python has a design philosophy that emphasizes code readability (notably using whitespace indentation to delimit code blocks rather than curly brackets or keywords), and a syntax that allows programmers to express concepts in fewer lines of code than might be used in languages such as C++ or Java.
- It provides constructs that enable clear programming on both small and large scales

4.1.4 UBANTU: -

- Ubuntu is a Linux-based operating system. It is designed for computers, smartphones, and network servers. The system is developed by a UK based company called Canonical Ltd. All the principles used to develop the Ubuntu software are based on the principles of Open-Source software development.
- Ubuntu is having the better user Interface. Security point of view Ubuntu is very safe because of its less useful. Font family in Ubuntu is very much better in comparison of windows. It has a centralized software Repository from where we can download all required software from that.
- Linux is a Unix-like computer operating system assembled under the model of free and open-source software development and distribution. Ubuntu is a computer operating system based on the Debian Linux distribution and distributed as free and open-source software, using its own desktop environment.

4.2 BLOCK DIAGRAM

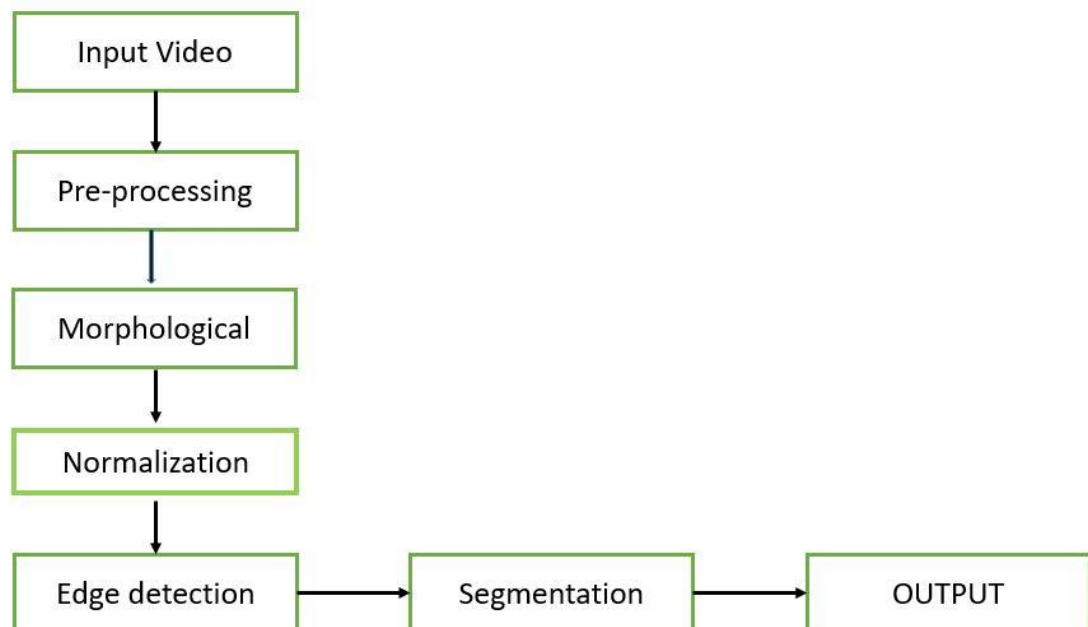


FIG 4.2: -BLOCK DIAGRAM

4.2.1 MODULES: -

- In first module we collect the video and going to pre-processing it. In pre-processing the video can be covert into frames and it will convert into grey scale
- In second module adding filtering techniques. In this module we can get what we want in the image, by using filters and morphological techniques.
- In third module we can detect the potholes. In this module for detecting the pothole, we are using edge detection, contour detection and segmentation
- In the final module get the alerts from mail. In this module pothole can detected by our system it will send mail alerts to the higher authorities

4.2.2 IMAGE PROCESSING: -

- Image Processing is a technique to enhance raw images received from cameras/sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-today life for various applications.
- Various techniques have been developed in Image Processing during the last four to five decades. Most of the techniques are developed for enhancing images obtained from unmanned spacecraft's, space probes and military reconnaissance flights. Image Processing systems are becoming popular due to easy availability of powerful personnel.
- computers, large size graphics software's etc. Image Processing is used in various Techniques

4.2.3 PRE-PROCESSING: -

- Pre-processing is a common name for operations with images at the lowest level of abstraction of both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortion

- Some of the point processing techniques include contrast stretching, global thresholding, histogram equalization, log transformations and power law transformations. Some mask processing techniques include averaging filters, sharpening filters, local thresholding... **etc.**

4.2.4 MORPHOLOGY: -

- Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image.
- morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images.
- Morphological operations can also be applied to greyscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.
- A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image.

4.2.5 NORMALIZATION: -

- To remove any non-uniformities, present in the imaging system, dark field image subtraction and bright field image normalization were performed.
- A dark field image (or background image) for each run was taken immediately before the laser was fired.

4.2.6 EDGE DETECTION: -

- Edge detection is an image processing technique for finding the boundaries of objects within images.

- It works by detecting discontinuities in brightness.
- Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.
- Edge detection allows users to observe the features of an image for a significant change in the gray level.

4.2.7 SEGMENTATION: -

- Image segmentation is a method in which a digital image is broken down into various subgroups called Image segments which helps in reducing the complexity of the image to make further processing or analysis of the image simpler.
- Segmentation in easy words is assigning labels to pixels.
- All picture elements or pixels belonging to the same category have a common label assigned to them.

4.2.8 TRESHOLDING: -

- Automatic thresholding is a great way to extract useful information encoded into pixels while minimizing background noise.
- This is accomplished by utilizing a feedback loop to optimize the threshold value before converting the original grayscale image to binary.
- The idea is to separate the image into two parts: the background and foreground.
- Select initial threshold value, typically the mean 8-bit value of the original image.
- Divide the original image into two portions.
 - => Pixel values that are less than or equal to the threshold, background
 - => Pixel values greater than the threshold; foreground
- Find the average mean values of the two new images.

- Calculate the new threshold by averaging the two means.
- If the difference between the previous threshold value and the new threshold value are below a specified limit, you are finished. Otherwise apply the new threshold to the original image keep trying.

4.3 METHODOLOGY

Video has been captured using a camera module interfaced with raspberry pi. Frames of the video are extracted, and the individual frame is considered as an image which is further processed.

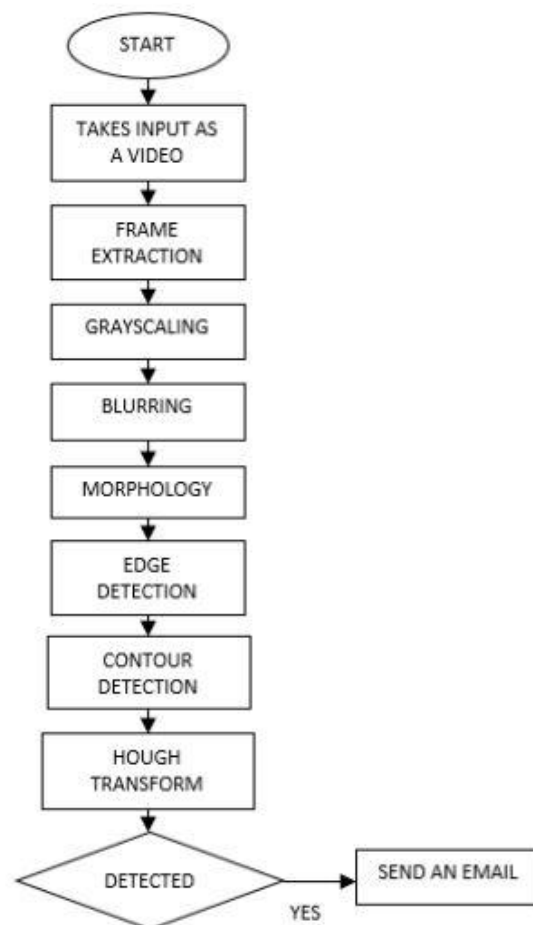


FIG.4.3. flowchart of image processing.

The first step after frame extraction was the conversion of the RGB image into grayscale

using standard techniques to make processing of image faster.

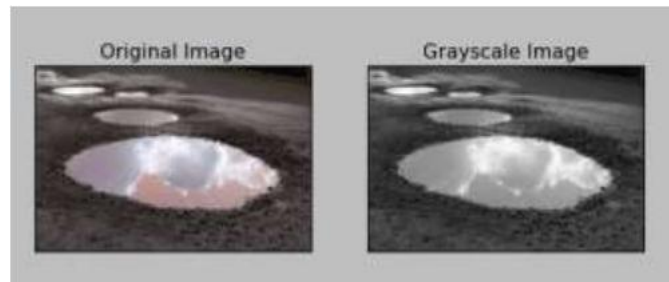


FIG.4.3 Example of gray scaling.

After gray scaling, we perform three different blurs on the image. The image is firstly blurred using averaging then with gaussian filter and lastly with median blur so to remove unwanted noise from the image.



FIG.4.3. Image after blurring

To achieve more accurate edge detection from a depth image we have modified the process using morphological operations. These operations are generally a collection of nonlinear operations carried out comparatively on the ordering of pixels without affecting their numerical values. The key operators for morphological operations are erosion and dilation. We have used erosion after blurring operations which is followed by two iterations of dilation. The pothole detection is utilizing canny edge detection technique. The detection technique is a multi-stage method to detect a wide range of edges in images.

Canny edge detection goes through five stages as follows:

- Apply Gaussian filter to smooth the image in order to remove the noise
- Find the intensity gradients of the image
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- Apply double threshold to determine potential edges
- Track edge by hysteresis: Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

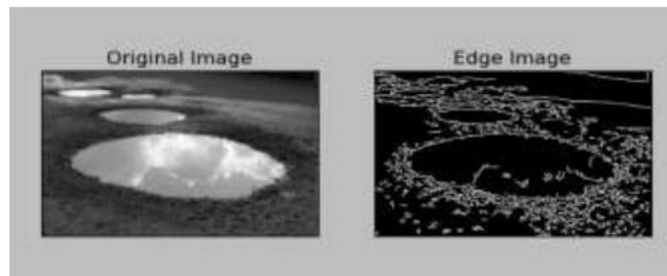


FIG.4.3. Example of canny edge detection.

- Edge detection is an image processing technique for finding the boundaries of objects within images.
- It works by detecting discontinuities in brightness.
- Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.
- Edge detection allows users to observe the features of an image for a significant change in the gray level.

We use Otsu's method for reduction of a gray level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal. The system then uses contour detection technique. For better accuracy, use binary images.

So, we have applied threshold and canny edge detection. Contours can be explained simply as a curve joining all the continuous points (along the boundary), having same color or intensity. The contours are a useful tool for shape analysis and object detection and recognition. Thus, it is very useful in pothole detection system.

In order to detect circles in images, we make use of the `cv2.HoughCircles` function by

making adjustments in the signature below: `cv2.HoughCircles(image, method, dp, minimum Dist)`

- **image:** It is the image obtained after contour detection.
- **method:** Defines the method to detect circles in images. We are using `cv2.HOUGH_GRADIENT` in our system.
- **dp:** This parameter is the inverse ratio of the accumulator resolution to the image resolution.
- **minimum Dist:** Minimum distance between the center (x, y) coordinates of detected circles.
- **param1:** Gradient value used to handle edge detection in the Yuen et al. method.
- **param2:** Accumulator threshold value for the `cv2.HOUGH_GRADIENT` method.
- **minimum Radius:** Minimum size of the radius (in pixels).
- **maximum Radius:** Maximum size of the radius (in pixels).

If circles are detected after all these steps, an email will be sent to respective officials using SMTP.

RESULTS

5.1 OVERVIEW



FIG.5.1. TUNING VIDEO INTO IMAGE FRAMES

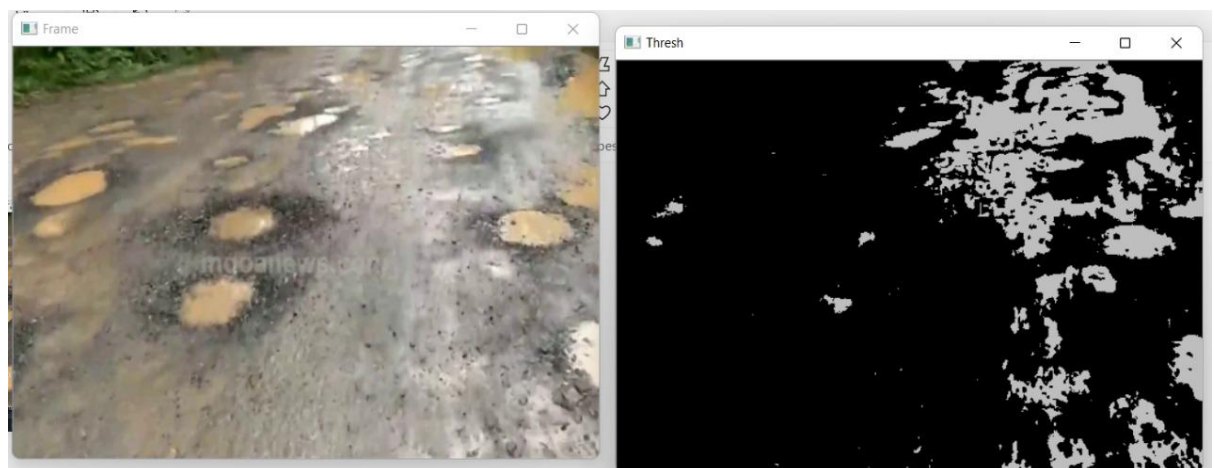


FIG.5.1.IMAGE TO GREY SCALING

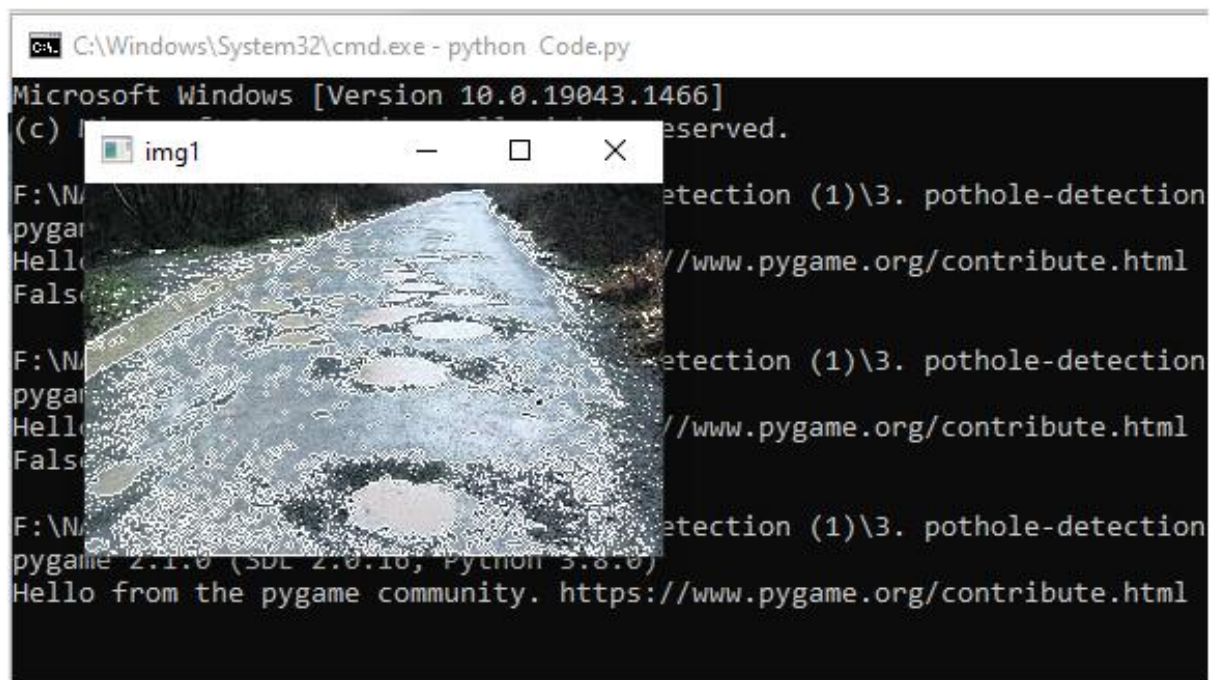


FIG.5.1. AFTER RUNNING THE CODE

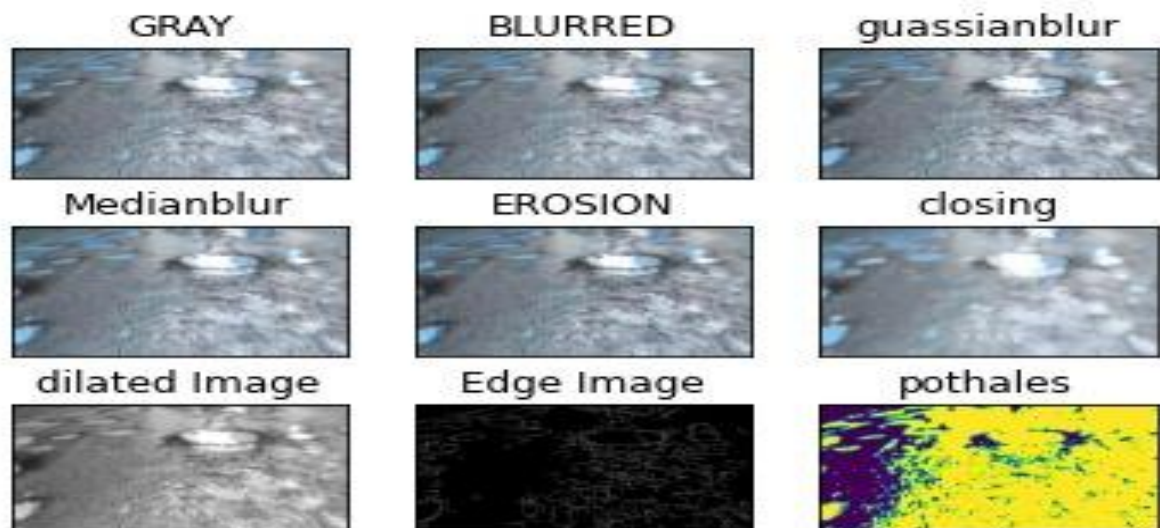


FIG.5.1.PROCESS OF DETECTION

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 CONCLUSION

We have demonstrated and tested the pothole and non-pothole detection using various deep learning classifier algorithms. The performance of these models are measured and compared using various parameters like accuracy, precision, and recall. We achieved an accuracy of 89.66% by InceptionResNetV2 and DenseNet201 which is higher as compared to other models.

Potholes have nothing but negative effects and hence it must be eradicated as soon as possible. The current system includes the use of manual detection by people who are willing to contribute for the betterment of the road. Thus, it is important that manual labor approach is kept to a minimum and switched to an automatic approach instead. The system will be installed in a fixed position on the light poles which ensures less handling. Also, this system keeps a track of the negligence and delay.

The system makes use of Raspberry Pi, which has a low cost and high compatibility with other interfaces, we also make use of 2D vision-based approach, this makes our system more affordable. The system also detects potholes in time without damaging the cars for potholes detection. Thus, making the system more feasible and favorable.

CHAPTER 7

REFERENCE

1. Dewiani, D jamaluddin , A ndani A chmad , R ivanto ,P arung, Prototype of vehicles potholes detection based blob detection method , Journal of Theoretical and Applied Information Technology , 15th June 2017. Vol.95. No 11.
2. Sudarshan, R. (2007) "A Pothole Detection System".
3. J. Eriksson, L. Girod and B. Hull, "The Pothole Patrol: Using a Mobile Sensor Network for Road Surface Monitoring,"
4. Samarth B, Grayscale in image processing,
<https://samarthbhargav.wordpress.com/2014/05/05/image-processing-with-python-rgb-to-grayscale-conversion/>
5. Syed Mohammad Abid, Hasan Kwanghee Ko, Depth edge detection by image - based smoothing and morphological operations, Journal of Computational Design and Engineering, July 2016 Volume 3, Issue 3.
6. Suganya, Menaka, Various Segmentation Techniques in Image Processing, International Journal of Innovative Research in Computer and Communication Engineering