

DETECTING POTHoles USING IMAGE PROCESSING TECHNIQUES AND REAL-WORLD FOOTAGE

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree

in

Computer Science and Engineering

by

Naman Rathore R (38110350)

Naman N Jain(38110349)



DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

SCHOOL OF COMPUTING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI,

CHENNAI – 600 119

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SATHYABAMA

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Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in



DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Naman Rathore R (38110350), Naman N Jain 38110349** who carried out the project entitled “**DETECTING POTHOLE USING IMAGE PROCESSING TECHNIQUES AND REAL-WORLD FOOTAGE**” under my supervision from **NOVEMBER 2019** to **APRIL 2020**.

Internal Guide

Dr. V. Nagarajan

Head of the Department

Dr. S. VIGNESWARI, M.E., Ph.D.,

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I Naman Rathore R (38110350) hereby declare that the Project Report entitled “**DETECTING POTHoles USING IMAGE PROCESSING TECHNIQUES AND REAL-WORLD FOOTAGE**” done by me under the guidance of Dr. V . Nagarajan is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Computer Science and Engineering.

DATE:

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Roads are the main mode for transportation, now a days. As we use roads heavily and frequently it sometimes leads to potholes. Environmental factors also leads to potholes in several ways. These potholes are main reason for many accidents. A Scheduled and proper maintenance is required where we need to monitor each and every road. AS this maintenance of all the roads at a time is not possible because it is not easy to monitor every single place or just because people ignore to check which causes formation of potholes that causes unnecessary traffic and many of accidents. To monitor all the roads this project for pothole detection using image processing techniques implemented. To test the performance of the proposed system is going to be implemented in a linux environment using Open CV Library. Techniques of Image processing which detects the potholes on roads and save the data of pothole for road maintenance department. This helps in keeping manual labour to the minimum number. Canny Edge Detecting technique and alone with the Contour Detecting Technique are techniques of Image Processing we use in the proposed system. Hough transformation technique in the end gives effective output of potholes, very accurately.

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CHAPTER 1

INTRODUCTION

1.1 POTHOLE DETECTION

Potholes are bowl-shaped openings on the road that can be up to 10 inches in depth and are caused by the wear-and-tear and weathering of the roads. They emerge when the top layer of the road, the asphalt, has worn away by lorry traffic and exposing the concrete base. Once a pothole is formed, its depth can grow to several inches, with rain water accelerating the process, making one of the top causes of car accidents. Potholes are not only main cause of car accidents, but also can be fatal to motorcycles. Potholes on roads are especially dangerous for drivers when cruising in high speed. At high speed, the driver can hardly see potholes on road surface. Moreover, if the car passes potholes at high speed, the impact may rupture car tires. Even though drivers may see the pothole before they pass it, it is usually too late for drivers to react to the pothole. Any sharp turn or suddenly brake, may cause car rollover or rear-end. Motivated from above reasons, we decided to investigate a system to detect potholes on roads while driving and the proposed system will produce the 3-dimensional information of potholes and determine the distance from pothole to car for informing the driver in advance. Also Currently, the main methods for detecting potholes still rely on public reporting through hotlines or websites, for example, the potholes reporting website in Ohio². However, this reporting usually lacks accurate information of the dimensional and location of potholes. Moreover, this information is usually out of date as well. A method to detect potholes on road has been reported in a real-time 3D scanning system for pavement distortion inspection³ which uses high-speed 3D transverse scanning techniques. However, the high-speed 3D transverse scanning equipment is too expensive. Rajeshwari Madli et al. have proposed a cost-effective solution to identify the potholes on roads, and also to measure the depth and height of each pothole using ultrasonic sensors.

All the pothole information is stored in database (cloud). Then alerts are provided in the form of a flash messages with an audio beep through android application. To detect the depth of pothole correctly, the ultrasonic sensor should be fixed under the car, which means the car should pass the pothole first. 2D

vision-based solutions can detect potholes as well. Regions corresponding to potholes are represented in a matrix of square tiles and the estimated shape of the pothole is determined. However, the 2D vision-based solution can work only under uniform lighting conditions and cannot obtain the exact depth of potholes. To remove the limitations of the above approaches, we propose a detection method based on computer stereo vision, which provides 3-dimensional measurements. Therefore, the geometric features of potholes can be determined easily based on computer vision techniques.

1.2 OBJECTIVE

To Identify the Pothole detection in real time. Lot of accidents are occurred by potholes, so this project objective is to detect the potholes and reduce accidents.

1.3 MOTIVATION

With the increase in world's population, there has been increasing load on the infrastructure. Roads have been flooded with the vehicular traffic. It has become increasingly difficult to manage this traffic. This is the prime motivation behind making a vehicle intelligent enough to aid driver in various aspects. One of the increasing problems the roads are facing is worsened road conditions. Because of many reasons like rains, oil spills, road accidents or inevitable wear and tear make the road difficult to drive upon. Unexpected hurdles on road may cause more accidents. Also because of the bad road conditions, fuel consumption of the vehicle increases; causing wastage of precious fuel.

Because of these reasons it is very important to get the information of such bad road conditions, Collect this information and distribute it to other vehicles, which in turn can warns the driver. But there are various challenges involved in this. First of all there are various methods to get the information about the road conditions. Then this information must be collected and distributed to all the vehicles that might need this information. Lastly the information must be conveyed in the manner which can be understood and used by driver. We in this project try to design and build such a system. In this system the access point collects the information about the potholes in the vicinity and store the information about the

potholes for the future use. Ideally the vicinity is every rout till the next access point.

CHAPTER 2

LITERATURE SURVEY

2.1 AUTOMATIC POTHOLE DETECTION

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. Many techniques have been proposed in the past to detect these problems using image processing methods. But there has been little work specifically carried out for detecting such issues of Indian roads. Potholes can generate damage such as flat tire and wheel damage, impact and damage of lower vehicle, vehicle collision, and major accidents. Thus, accurately and quickly detecting potholes is one of the important tasks for determining proper strategies in ITS (Intelligent Transportation System) service and road management system. Several efforts have been made for developing a technology which can automatically detect and recognize potholes. In this project, a pothole two dimensional (2D) images based pothole detection method is used for improving the existing method. This system proposes a system Automatic detect the number of recently published papers dealing with crack detection and characterization of pavement surface distresses shows an increasing interest in this area. A recent publication a hierarchical method present in [1], which deals with detection of roads and slopes. In this paper, a novel framework is proposed for segmenting road images in a hierarchical manner that can separate the following objects: road and slopes with or without collapse, sky, road signs, cars, buildings and vegetation from the images. The experiments show that the approach in this paper can achieve a satisfied result on various road images. The roads are unstructured, which are more complex than the structured roads. In [2] multi scale approach based on Markov random field is proposed to segment fine structures (cracks) in road pavement surface images. Cracks are enhanced using a 1-D Gaussian smoothing filter and then processed by a 2-D matched filter to detect them. A total of 64 road pavement surface images representing several crack types are considered for experimentation, producing a qualitative evaluation. Details on image characteristics or the type of sensor used to capture them are not provided. Another paper [3] evidences the difficulty of

detecting cracks of less than 3 mm width when using edge detectors. A non-sub sampled contourlet transform is adopted in [4] to detect cracks, wherein a limited set of experimental results is presented. A complete methodology to automatically detect and characterize pavement defects is proposed in [5], using gray scale images captured by line scan cameras illuminated by lasers during road surveys performed using a high-speed image acquisition system. Crack detection uses a conditional texture anisotropy measurement to each image, and defect characterization uses a multilayer perceptron neural network with two hidden layers. The results presented are promising, but the experimental evaluation does not support the distinction of multiple cracks in the same image. In paper [6], Neural network method is used. The automated pavement defect detection can only identify crack type defects. To classify defect, a multi layer perceptron neural network (MLPNN) is used. Neural network is used to classify the images into four classes: defect-free, crack, joint and bridged. Experimental results are performed on real road images which are labelled by human operators. There are more additional filters required for this system. In paper [7], Vision-based approaches are used to address functionalities such as lane marking detection, traffic sign recognition, pedestrian detection, etc. This system is possible to detect the free road surface ahead of the ego-vehicle using an on board camera. Novelty Method is used for both Shadowed and unshadowed regions which provide highest performance. Road detection algorithm is devised by combining the illuminant invariant feature space and likelihood based classifier. The defect of this system is under saturation by improving image acquisition system. In paper [8], A neural network based technique for the classification of segments of road images into cracks and normal images. The features are passed to a neural network for the classification of images into images with and without cracks. Another approach [9] extracts linear features (cracks) using two methodologies: one based on holistic thresholding and the second employing the Otsu algorithm.

2.2 AUTOMATIC DETECTION AND NOTIFICATION HUMPS ON ROADS

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 helps drivers to avoid accidents or vehicle damages, but also helps authorities to

Maintain roads. This paper discusses previous pothole detection methods that have been developed and proposes a cost-effective solution to identify the potholes and humps on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. Ultrasonic sensors are used to identify the potholes and humps and also to measure their depth and height, respectively. The proposed system captures the geographical location coordinates of the potholes and humps using a global positioning system receiver Taehyeong Kim and Seung-Ki [1] Ryu proposed a detection system 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. Sudarshan Rode [2] proposed a pothole detection system which is divided into 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. Eriksson et al. [3] studied mobile sensing of roads to monitor and report any potholes. The system used accelerometer and GPS for detection and location respectively. Cars give detections which are fed to a central server.

2.3 SMART SENSING OF POTHOLES AND OBSTACLES

Byeoung-ho-Kang and Su-il-choi proposes the concept of sensing potholes by using 2d lidar method. It is a sensing method which uses light pulses to ascertain the surface of earth. The major drawback in this method is, it is highly affected by heavy rain, fog, etc. Also does not work well at huge reflections. The operating cost for this approach is comparatively high. The proposed the 3d laser method to detect potholes and obstacles. The 3D laser checking is one of the outstandingly flexible and productive advances for precisely catching extensive arrangements of 3D facilitates. This method uses laser pulses to detect the irregularities in road surfaces. It is applicable to 2d and 3d surfaces. The disadvantage of this approach is that it requires post-processing to produce a usable output i.e., the output requires manipulation. And high end hardware is

required. AmilaAkagic, Emir Buza and Samir Omanavic used the RGB image processing technique, complex figuring devices that consolidate programming and equipment to process the pothole pictures are required in this technique. It is also consumes more time when compared to other methods. Also the accuracy rate is low in this approach. Moreover it needs prior knowledge of the images i.e., a large quantity of training sets have to be given. Wang didnt attainability concentrate to lead the comprehensive review of asphalt conditions by methods for of stereovision innovation. In this strategy, two advanced cameras are appended to the vehicle, which is utilized to cover an asphalt surface. The initial step is to dissect 2D pictures from every one of the two cameras to recognize and order any splits. To recuperate the 3D properties from given sets of 2D pictures on a similar asphalt surface, the succession of steps, for example, camera alignment, twisting right, coordinating stereo focuses, 3D recreate, and profile report ought to be performed. It needs complex computation capabilities when compared to other methods. Kana Azhary, FeerdMurtaza, Muhammad Herboon mohammed and Hafed Adman Habit stated an approach of finding and localizing the potholes based on computer vision in asphalt pavement images. Histograms from the input images are classified using naïve bayes classifier using normalized graph cut segmentation scheme. This experimentation showed 90% accuracy on localizing the potholes from the pothole images.

2.4 DETECTION AND NOTIFICATION OF POTHOLE AND HUMPS

Vigneshwar. k et al. [1] has done Image pre-processing based on difference of Gaussian-Filtering and clustering based image segmentation strategies are actualized for better outcomes. The primary objective of this paper was to recognize a superior technique which was exceedingly productive and precise compared to the conventional techniques. Different image pre-processing and segmentation techniques for pothole identification where looked into utilizing execution measures. The Identification of various image processing strategies for pothole recognition was finished by comparing performance measures for various image segmentation strategies. Detriment of this paper, executing these image segmentation strategies utilizing hybrid classifiers like neural network and fuzzy rule base and to develop a standalone product for pothole detection. I Schiopu et al. [2] proposed a low complexity technique for identification and tracking of

potholes in video sequences taken by a camera placed inside a moving car. The region of interest for the detection of the potholes is chosen as the picture territory where the street is seen with the highest resolution. The paper proposed an algorithm for pothole detection and tracking. The region of interest (ROI) was chosen off-line and candidate regions were produced utilizing a threshold based algorithm. The upsides of this paper, great accuracy and a little runtime. Vinay Rishiwal et al. [3] shows a vibration based approach for programmed location of potholes and speed breakers alongside their co-ordinates. In this approach, a database is kept up for every street, which is made accessible to the general population with the assistance of worldwide database or through an entry. The proposed favourable circumstances are cost effective and extremely successful for street surface checking. discuss about the significance of street surface monitoring in terms of comfort and security required by the street travellers. This approach can be advantageously for secure travelling particularly in obscure street conditions. The demerits are more complex. Rajeshwari S. et a. [4] displays an intelligent traffic control framework to pass crisis vehicles easily. Each individual vehicle is equipped with special RFID tag (placed at a key area), which makes it difficult to remove or destroy. This paper utilizes RFID peruse, NSK EDK-125-TTL and PIC16F877A framework on-chip to peruse the RFID labels attached to the vehicle. As the whole framework is computerized, it requires less human intercession. With stolen vehicle exploration, the signal naturally swings to red, so that the cop can make fitting move, on the off chance that he/she is available at the intersection. From literature survey we can conclude that, Potholes can be detected by using image pre-processing, segmentation and ultrasonic sensor techniques for pothole identification. Location of potholes and speed breakers alongside their coordinates can be detected by using vibration based approach.

2.5 AN APPROACH FOR REAL-TIME ROAD DEFORMATION DETECTION

The study conducted for structuring this project focuses on the application of image processing for segmentation for differentiating of road defects from plain road and other surrounding objects. As mentioned earlier other two approaches are with the use of expensive stereo cameras and laser scanners for 3D reconstruction which have computing complexity and vibration based which has a few drawbacks like only the cracks and potholes will get logged from where

vehicle wheels traverse through the deformities and not the ones which pass between the two side wheels. As described in paper by Emir Buza where Otsu thresholding method is used which segments images to obtain binary images from gray scale. Spectral clustering is then employed for determining shapes of irregular objects like road deformities from the selected images. In this shadows of surrounding objects and manhole covers can also get tagged as potholes and may not perform well in low light conditions[2]. Ajit Danti and Seungkiryu presented a novel approach by first using lane detection, then mapping a virtual polygon considering the lanes as sides of the polygon and then defined it as Region of Interest thus extracting a small part of the incoming video to reduce the processing load on the system and then by inspecting various features, such as the length, area, variance, and trajectory pothole extraction has been carried out. The important part in this is that not all roads have lane lines are present and in such situation by fixing lane vanishing point the unknown lane line is plotted virtually. They have implemented this is a commercially available black box camera embedded system; due to which this implementation technically faces limitation of the processing capabilities of that embedded system and also future modifications may not be possible[2 & 3]. In paper by Christoph Mertz, another novel approach by using line laser light projected on the road surface that helps in two ways: one for highly detailed 3D profiling of the road damages and other for plotting basic 2D graphical representation of the road deformations which can be well be used for filtering shadows and other objects that may get tagged as deformities which would be an improvement over the use of simple spectral clustering method [4]. But use of this system may not work effectively while in broad daylight but will generate one of the best results at night time. Thus this paper presents a combination of lane detection, laser and spectral clustering of the road for accurate detection of potholes and cracks well in advance before the vehicle passes over it.

2.6 POTHOLE DETECTION BASED ON BLOB DETECTION METHOD

Some existing methods to detect pothole, such as; vibration-based methods, 3D reconstruction-based methods, and vision-based methods [5]. Varadharajadan et al. [6] introduces potholes inspection system using vision-based methods. Smart camera from a smart phone captures road images for

segmentation. For detecting cracks on road or other road damage, Super pixel SLIC variation algorithm is utilized. Road damages are confirmed using Multiple Instance Learning Algorithm. The result shows the system is able to detect road cracks, and has potential to detect potholes, patches, etc. Koch and Ioannis [5] classifying a road based on its defect and non-defect regions for potholes detection. The algorithm consists of three stages which is image segmentation, shape extraction, and texture extraction and comparison. Image segmentation accomplished by using histogram shape-based thresholding algorithm. There are two procedure to detect a pothole in elliptical shape based on the detected shades. First is morphological thinning to minimize the cracks effect from the potholes. The second one is elliptic regression to approximate an ellipse. A remote-controlled robot was used to collect the data and simulate a high speed vehicle. The data is classify by a high variety potholes such as by shapes and sizes, non-defect asphalt pavements and other defect such as cracking and patching, and shadows that caused by lighting condition. This method has 85.9% accuracy and 81.6% precision. Although it is inefficient for the computation due the redetected pothole from processing every single image of the road pavement videos [7]. Buza et al. [8] provides another option for pothole detection by utilize image analysis and spectral clustering. Data is collected by mounting the system on passenger vehicles. The defects region are detected from every frame, then being analyzed later. Spectral clustering is used on the shape extraction process. This method adds Otsu Image Thresholding to automatically decide threshold values every image with internal algorithms either. The estimation accuracy of potholes detection by this algorithm is around 81%. Pawade et al. [9] have presented a low-cost potholes detection method with Field Programmable Gate Arrays (FPGA). FPGA is a digital devices with simply design [10]. The main algorithms to detect potholes by using three edge detection technique which is Sobel, Prewitt, and Canny. The pre-processing using canny method as it is one of the best efficient noise removal technique. The three edge detection technique is processed in parallel threads by FPGA, which caused real-time detection is hard to be achieved. Nevertheless, this system has good result of the amount of potholes on the pavement road and can also alert the driver about location of the potholes via GPS technology. Simple image processing technique to detect some potholes in real world footage has been proposed by Nienaber et al. [1]. The road

region is extracted based on the contour and colour of the road itself. The algorithm defines a pothole as shape which has strong dark edge, so canny edge detection method was capable to get potholes contour. Convex hull algorithm was applied to decrease the noise effect and a Gaussian filter is used to increase edge detection result. This pothole detection system method is tested by using a Go Pro.

CHAPTER 3

METHODOLOGY

3.1 EXISTING SYSTEM

In an existing system a detection which starts with noise removal, followed by brightness adjustment and rendition of video by doing the process of binarization. Then, removal of noise is applied to the binarized image. After noise removal, the process of extracting the framework or outlines for the objects that are segmented is carried out. Extraction is followed by selection, square zoning for the objects. After all these processes, desired pothole area information is returned. And another system that detects pothole.

It is categorised in to 3 subsystems. The encountered potholes are sensed by this first subsystem namely sensing subsystem, by using accelerometer or by camera which scans the road. Both are mounted on the car. Then there is another subsystem that is used to transfer the data between WiFi access points to the mobile nodes. The data about potholes is broadcasted by access point in its area. In the existing system, the pothole is detected using the accelerometer sensor in smart phone. This system is not automotive in nature. The complaints if needed to be posted or to be informed to any governmental authority it will be done only with human intervention. This process may not provide the complete efficiency as many people may ignore the issue and will not post them. Even if people sends the complaint to an admin many pothole image may be repeated and thus it may cause a huge confusion. In this case, if prioritization has been done then it would be an optimized way to collect the frequent places that is being affected by potholes.

3.1.1 Disadvantages

- GSM technology has been used which causes delay in message delivery.
- It is a paid message service.
- The severity is less estimated.
- It is exceptionally costly in nature and it can't be connected to working class level vehicles.

3.2 PROPOSED SYSTEM

In this proposed system 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. The image is firstly blurred using aver aging then it goes through Gaussian filet technique and lastly through median blur for removing unnecessary noise in the image. We modified the process with morphological operations just for achieving the most approximate detection of edge from the depth image. In general, these operations are a group of nonlinear operations that are carried out analogously on ordering of pixels without stirring their numerical values. Erosion, Dilation are morphological key operators. We have used erosion after blurring operations which is followed by two iterations of dilation. The pothole detection is utilizing canny edge detection technique. Detection techniques are multi - stage method to detect wide ranges of edges in images.

3.2.1 Advantages

- Easy to Replacement and maintenance.
- Fast in Identifying the potholes.
- Very cost efficient product.
- Simple method and Improves efficiency.

3.3 FLOW CHART

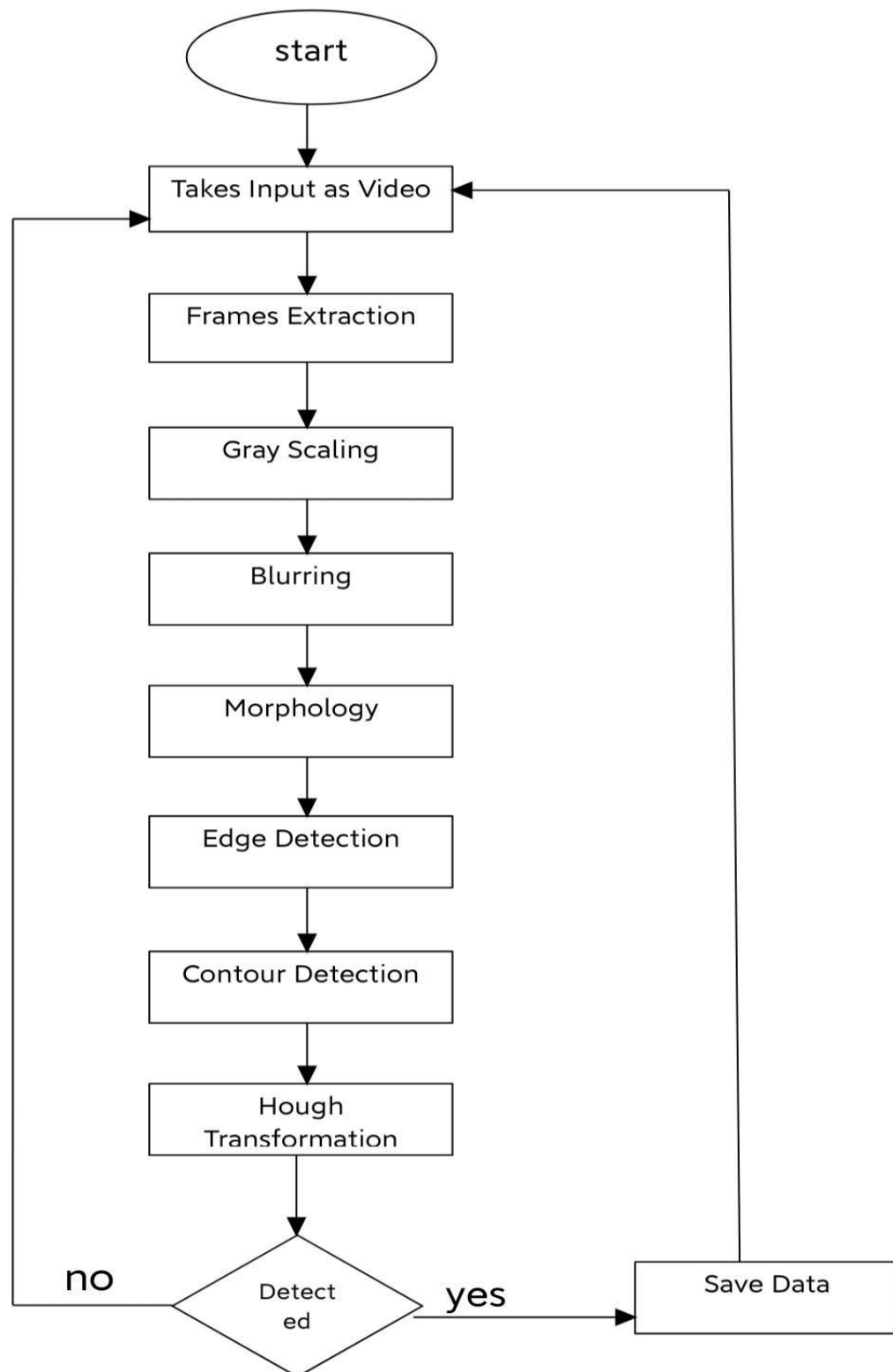


Fig 3.1 Flow Chart

3.4 HARDWARE REQUIREMENTS

- Raspberry pi
- Motor driver
- Motor
- Buzzer

3.5 SOFTWARE REQUIREMENTS

- Linux OS Ubuntu
- Python Programming

3.5.1 *Linux*

Linux is a family of open source Unix-like operating systems based on the Linux kernel, an operating system kernel first released on September 17, 1991, by Linus Torvalds. Linux is typically packaged in a Linux distribution. Distributions include the Linux kernel and supporting system software and libraries, many of which are provided by the GNU Project. Many Linux distributions use the word "Linux" in their name, but the Free Software Foundation uses the name *GNU/Linux* to emphasize the importance of GNU software, causing some controversy.

Popular Linux distributions include Debian, Fedora, and Ubuntu. Commercial distributions include Red Hat Enterprise Linux and SUSE Linux Enterprise Server. Desktop Linux distributions include a windowing system such as X11 or Wayland, and a desktop environment such as GNOME or KDE Plasma. Distributions intended for servers may omit graphics altogether, or include a solution stack such as LAMP. Because Linux is freely redistributable, anyone may create a distribution for any purpose. Linux was originally developed for personal computers based on the Intel x86 architecture, but has since been ported to more platforms than any other operating system. Linux is the leading operating system on servers and other big iron systems such as mainframe computers, and the only OS used on TOP500 supercomputers (since November 2017, having gradually eliminated all competitors). It is used by around 2.3 percent of desktop computers. The Chrome book, which runs the Linux kernel-based Chrome OS,

dominates the US K-12 education market and represents nearly 20 percent of sub-\$300 notebook sales in the US.

Linux also runs on embedded systems, i.e. devices whose operating systems is typically built into the firmware and is highly tailored to the system. This includes routers, automation controls, televisions, digital video recorders, video game consoles, and smart watches. Many smart phones and tablet computers run Android and other Linux derivatives. Because of the dominance of Android on smart phones, Linux has the largest installed base of all general-purpose operating systems. Linux is one of the most prominent examples of free and open-source software collaboration. The source code may be used, modified and distributed—commercially or non-commercially—by anyone under the terms of its respective licenses, such as the GNU General Public License.

3.5.2 *Ubuntu*

Ubuntu is a free operating system that uses the Linux kernel. The word "ubuntu" is an old African word meaning "humanity to others". It is pronounced "oo-boon-too". It is one of the most popular Linux distributions and it is based on Debian Linux computer operating system. The goal with Ubuntu is to make it easy to use and install onto a computer. Ubuntu can be used on all types of personal computers (and even devices such as robots) including in Windows 10. Ubuntu is downloaded as a DVD, which is free to download on the Ubuntu website. It can be installed or tested by running the DVD. Ubuntu is released every six months, with long-term support (LTS) releases every two years. The latest release is 19.10 ("Eoan Ermine"), while the most recent long-term support release (what most users may want to choose) is 20.04 LTS ("Focal Fossa"), which is supported until 2028. Started in 2004, Ubuntu has been developed by Canonical Ltd., a company owned by a rich South African man named Mark Shuttleworth.

3.5.3 *Ubuntu Variants*

Ubuntu is available in many different variants, e.g. because there are several options for which desktop environment to use.

The official sister distributions which are fully supported by Canonical are :

- Ubuntu Kylin, an official derivative aimed at the Chinese market.

- Kubuntu, a desktop distribution using KDE rather than GNOME.
- Ubuntu Server Edition, which is mainly used on servers to provide services. This version only comes with a command line interface, but a graphical user interface can be installed.
- Xubuntu, a "lightweight" distribution based on the Xfce desktop environment instead of GNOME, designed to run better on low-specification computers.
- Lubuntu, a desktop using the LXDE desktop environment.
- Ubuntu Budgie, a desktop using the Budgie desktop environment.
- Ubuntu MATE.
- Ubuntu studio, a multimedia - creation form of Ubuntu.
- Edubuntu, a distribution designed for classrooms using Unity

3.5.4 Python

Python is an interpreted, high-level, general-purpose programming language. Created by Guido van Rossum and first released in 1991. Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly, procedural), object-oriented, and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library.

Python interpreters are available for many operating systems. A global community of programmers develops and maintains CPython, an open source reference implementation. A non-profit organization, the Python Software Foundation, manages and directs resources for Python and CPython development. Python is meant to be an easily readable language. Its formatting is visually uncluttered, and it often uses English keywords where other languages use punctuation. Unlike many other languages, it does not use curly brackets to delimit blocks, and semicolons after statements are optional. It has fewer syntactic exceptions and special cases than C or Pascal.

Python uses whitespace indentation, rather than curly brackets or keywords, to delimit blocks. An increase in indentation comes after certain statements; a decrease in indentation signifies the end of the current block. Thus, the program's visual structure accurately represents the program's semantic structure. This feature is sometimes termed the off-side rule, which some other languages share, but in most languages indentation doesn't have any semantic meaning.

3.6 SYSTEM DESIGN

The most frequently mounting problems of the roads are facing is Damaged road conditions. For many reasons like earth quakes, accidents on roads, wear and tear of top layers of roads make the drivers to drive on those roads. Unexpected Obstacles on roads may cause number of accidents. Also because of worse road conditions, the vehicles consumes a lot of fuel unnecessarily. For these are the reasons it is very significant to get the data of such damaged roads. POTHOLEs are the crack-up's on roads that are formed on the roads for many reasons where the top road layers will get tattered by heavy traffic. Once after formation of pothole the size of hole will keep increasing till we ready that road or repair the pothole, which is main causes for Road mishap's. Potholes on roads are particularly affects for drivers rushing at high speed. At high speeds a driver almost inconceivably can notice the potholes on road surface. None the less the drivers may see the potholes before they cross it, it normally will be too late for a driver to respond to the pothole. A sudden turn or sudden braking will mostly causes car roll-over. Triggered to the above reasons, we introduced a system that detects potholes and the proposed system will produce the three dimensional data of potholes and save data information data and we can retrieve that data and get pothole image. In this paper we use different edge detection techniques to detect potholes on road. Canny edge detection technique, the most important algorithm we used here to detect potholes. It detects potholes very accurately and stores the data for future maintenance of roads. We use a web camera to record the roads and click the images because comparing to the costly high speed Three Dimensional traverse scanning equipment, web camera is cheap and expensive.

3.7 ALGORITHM

In the proposed system video has been captured using a camera module and Frames of the video are extracted and the individual frame is considered as an image. We use canny edge detection technique for pothole detection which is a multi-stage method used to detect wide range of images. The image is blurred using Gaussian filter and median blur to remove unwanted noise from image. Morphological operations are used to achieve more accurate edge detection from the depth image. 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.

3.8 CANNY EDGE DETECTION ALGORITHM

The Canny Edge Detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. It was developed by John F Canny in 1986. Canny also produced a computational theory of edge detection explaining why the technique works. The Process of Canny edge detection algorithm can be broken down to 5 different steps :

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

3.8.1 Gaussian Filter

Since all edge detection results are easily affected by the noise in the image, it is essential to filter out the noise to prevent false detection caused by it. To smooth the image, a Gaussian filter kernel is convolved with the image. This step will slightly smooth the image to reduce the effects of obvious noise on the edge detector. The equation for a Gaussian filter kernel of size $(2k+1) \times (2k+1)$ is given by :

$$H_{ij} = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(i - (k + 1))^2 + (j - (k + 1))^2}{2\sigma^2}\right); 1 \leq i, j \leq (2k + 1)$$

Here is an example of a 5×5 Gaussian filter, used to create the adjacent image, with $\sigma = 1$. (The asterisk denotes a convolution operation.)

$$\mathbf{B} = \frac{1}{159} \begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * \mathbf{A}.$$

It is important to understand that the selection of the size of the Gaussian kernel will affect the performance of the detector. The larger the size is, the lower the detector's sensitivity to noise. Additionally, the localization error to detect the edge will slightly increase with the increase of the Gaussian filter kernel size. A 5×5 is a good size for most cases, but this will also vary depending on specific situations.

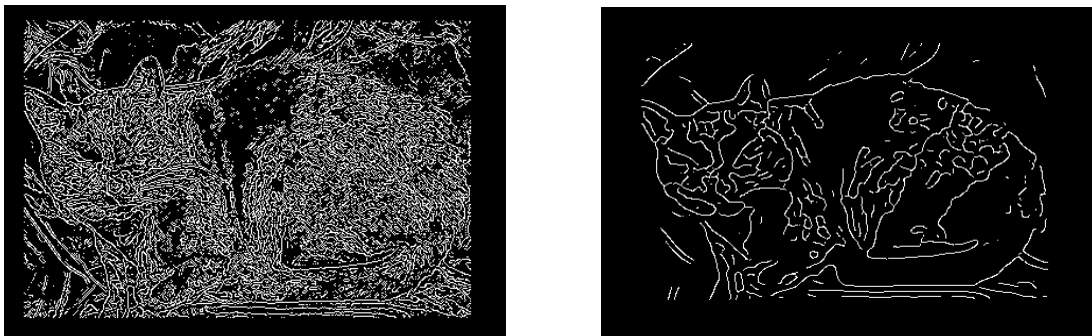


Fig 3.2 Gaussian smoothing

3.8.2 Intensity Gradient

An edge in an image may point in a variety of directions, so the Canny algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image. The edge detection operator (such as Roberts, Prewitt, or Sboel) returns a value for the first derivative in the horizontal direction (G_x) and the

vertical direction (G_y). From this the edge gradient and direction can be determined :

$$G = \sqrt{G_x^2 + G_y^2}$$

$$\Theta = \text{atan2}(G_y, G_x),$$

where G can be computed using the hypot function and a atan2 is the arctangent function with two arguments. The edge direction angle is rounded to one of four angles representing vertical, horizontal and the two diagonals (0° , 45° , 90° and 135°). An edge direction falling in each colour region will be set to a specific angle values, for instance θ in $[0^\circ, 22.5^\circ]$ or $[157.5^\circ, 180^\circ]$ maps to 0° .

3.8.3 Non-Maximum Suppression

Non-maximum suppression is an edge thinning technique. Non-maximum suppression is applied to find “the largest” edge. After applying gradient calculation, the edge extracted from the gradient value is still quite blurred. With respect to criterion 3, there should only be one accurate response to the edge. Thus non-maximum suppression can help to suppress all the gradient values (by setting them to 0) except the local maxima, which indicate locations with the sharpest change of intensity value. The algorithm for each pixel in the gradient image is:

1. Compare the edge strength of the current pixel with the edge strength of the pixel in the positive and negative gradient directions.
2. If the edge strength of the current pixel is the largest compared to the other pixels in the mask with the same direction (e.g., a pixel that is pointing in the y-direction will be compared to the pixel above and below it in the vertical axis), the value will be preserved. Otherwise, the value will be suppressed.

In some implementations, the algorithm categorizes the continuous gradient directions into a small set of discrete directions, and then moves a 3x3 filter over the output of the previous step (that is, the edge strength and gradient directions). At every pixel, it suppresses the edge strength of the center pixel (by setting its

value to 0) if its magnitude is not greater than the magnitude of the two neighbours in the gradient direction. For example,

- If the rounded gradient angle is 0° (i.e. the edge is in the north-south direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the **east and west** directions.
- If the rounded gradient angle is 90° (i.e. the edge is in the east-west direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the **north and south** directions.
- If the rounded gradient angle is 135° (i.e. the edge is in the northeast-southwest direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the **north west and south-east** directions.
- If the rounded gradient angle is 45° (i.e. the edge is in the north west-south east direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the **north east and south west** directions.

In more accurate implementations, linear interpolation is used between the two neighbouring pixels that straddle the gradient direction. For example, if the gradient angle is between 89° and 180° , interpolation between gradients at the **north** and **north east** pixels will give one interpolated value, and interpolation between the **south** and **south west** pixels will give the other (using the conventions of the last paragraph). The gradient magnitude at the central pixel must be greater than both of these for it to be marked as an edge.

Note that the sign of the direction is irrelevant, i.e. north-south is the same as south-north and so on.

3.8.4 Double Threshold

After application of non-maximum suppression, remaining edge pixels provide a more accurate representation of real edges in an image. However, some edge pixels remain that are caused by noise and colour variation. In order to account for these spurious responses, it is essential to filter out edge pixels with a

weak gradient value and preserve edge pixels with a high gradient value. This is accomplished by selecting high and low threshold values. If an edge pixel's gradient value is higher than the high threshold value, it is marked as a strong edge pixel. If an edge pixel's gradient value is smaller than the high threshold value and larger than the low threshold value, it is marked as a weak edge pixel. If an edge pixel's value is smaller than the low threshold value, it will be suppressed. The two threshold values are empirically determined and their definition will depend on the content of a given input image.

3.8.5 Edge Tracking By Hysteresis

So far, the strong edge pixels should certainly be involved in the final edge image, as they are extracted from the true edges in the image. However, there will be some debate on the weak edge pixels, as these pixels can either be extracted from the true edge, or the noise/colour variations. To achieve an accurate result, the weak edges caused by the latter reasons should be removed. Usually a weak edge pixel caused from true edges will be connected to a strong edge pixel while noise responses are unconnected. To track the edge connection, blob analysis is applied by looking at a weak edge pixel and its 8-connected neighbourhood pixels. As long as there is one strong edge pixel that is involved in the blob, that weak edge point can be identified as one that should be preserved.

The Canny algorithm is adaptable to various environments. Its parameters allow it to be tailored to recognition of edges of differing characteristics depending on the particular requirements of a given implementation. In Canny's original paper, the derivation of the optimal filter led to a Finite Impulse Response filter, which can be slow to compute in the spatial domain if the amount of smoothing required is important (the filter will have a large spatial support in that case). For this reason, it is often suggested to use Rachid Deriche's infinite impulse response form of Canny's filter (the Canny-Deriche detector), which is recursive, and which can be computed in a short, fixed amount of time for any desired amount of smoothing. The second form is suitable for real time implementations in FPGAs or DSPs, or very fast embedded PCs. In this context, however, the regular recursive implementation of the Canny operator does not give a good approximation of rotational symmetry and therefore gives a bias towards horizontal and vertical edges.

3.9 IMAGE THRESHOLDING

- We use Otsu's method for reduction of a grey level image to a binary image.
- The system then uses contour detection technique. For better accuracy, use binary images. So we have applied threshold and canny edge detection.
- While capturing video the hassle of adjusting speed is eliminated. Hence, the images give a clear view.

3.9.1 Otsus's Method

In computer vision and image processing, **Otsu's method**, named after Nobuyuki Otsu, is used to perform automatic image thresholding. In the simplest form, the algorithm returns a single intensity threshold that separate pixels into two classes, foreground and background. This threshold is determined by minimizing intra-class intensity variance, or equivalently, by maximizing inter-class variance.^[2] Otsu's method is a one-dimensional discrete analog of Fisher's Discriminate Analysis, is related to Jenks optimization method, and is equivalent to a globally optimal k-means performed on the intensity histogram. The extension to multi-level thresholding was described in the original paper, and computationally efficient implementations have since been proposed. The algorithm exhaustively searches for the threshold that minimizes the intra-class variance, defined as a weighted sum of variances of the two classes :

$$\sigma_w^2(t) = \omega_0(t)\sigma_0^2(t) + \omega_1(t)\sigma_1^2(t)$$

Weights ω_0 and ω_1 are the probabilities of the two classes separated by a threshold 't', and σ_0^2 and σ_1^2 are variances of these two classes. The class probability $\omega_{0,1}(t)$ is computed from the L bins of the histogram :

$$\omega_0(t) = \sum_{i=0}^{t-1} p(i)$$

$$\omega_1(t) = \sum_{i=t}^{L-1} p(i)$$

For 2 classes, minimizing the intra-class variance is equivalent to maximizing inter-class variance :

$$\begin{aligned}\sigma_b^2(t) &= \sigma^2 - \sigma_w^2(t) = \omega_0(\mu_0 - \mu_T)^2 + \omega_1(\mu_1 - \mu_T)^2 \\ &= \omega_0(t)\omega_1(t)[\mu_0(t) - \mu_1(t)]^2\end{aligned}$$

which is expressed in terms of class probabilities ω and class means μ , where the class means $\mu_0(t)$, $\mu_1(t)$ and μ_T are :

$$\mu_0(t) = \frac{\sum_{i=0}^{t-1} ip(i)}{\omega_0(t)}$$

$$\mu_1(t) = \frac{\sum_{i=t}^{L-1} ip(i)}{\omega_1(t)}$$

$$\mu_T = \sum_{i=0}^{L-1} ip(i)$$

The following relations can be easily verified :

$$\begin{aligned}\omega_0\mu_0 + \omega_1\mu_1 &= \mu_T \\ \omega_0 + \omega_1 &= 1\end{aligned}$$

The class probabilities and class means can be computed iteratively. This idea yields an effective algorithm.

3.10 HOUGH TRANSFORM

The **Hough transform** is a feature extraction technique used in image analysis, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. The classical Hough transform was concerned with the identification of lines in the image, but later the Hough transform has been extended to identifying positions of arbitrary shapes, most commonly circles or ellipses. The Hough transform as it is universally used today was invented by Richard Duda and Peter Hart in 1972, who called it a “generalized Hough transform” after the related 1962 patent of Paul Hough. The transform was popularized in the computer vision community by Dana H. Ballard through a 1981 journal article titled “Generalizing the Hough transform to detect arbitrary shapes”.

3.10.1 Theory

In automated analysis of digital images, a sub problem often arises of detecting simple shapes, such as straight lines, circles or ellipses. In many cases an edge detector can be used as a pre-processing stage to obtain image points or image pixels that are on the desired curve in the image space. Due to imperfections in either the image data or the edge detector, however, there may be missing points or pixels on the desired curves as well as spatial deviations between the ideal line/circle/ellipse and the noisy edge points as they are obtained from the edge detector. For these reasons, it is often non-trivial to group the extracted edge features to an appropriate set of lines, circles or ellipses. The purpose of the Hough transform is to address this problem by making it possible to perform groupings of edge points into object candidates by performing an explicit voting procedure over a set of parameterized image objects (Shapiro and Stockman, 304).

The simplest case of Hough transform is detecting straight lines. In general, the straight line $y = mx + b$ can be represented as a point (b, m) in the parameter space. However, vertical lines pose a problem. They would give rise to unbounded values of the slope parameter m . Thus, for computational reasons, Duda and Hart proposed the use of the Hesse normal form.

$$R = x \cos \theta + y \sin \theta$$

where 'r' is the distance from the origin to the closest point on the straight line, and θ (*theta*) is the angle between the x axis and the line connecting the origin with that closest point.

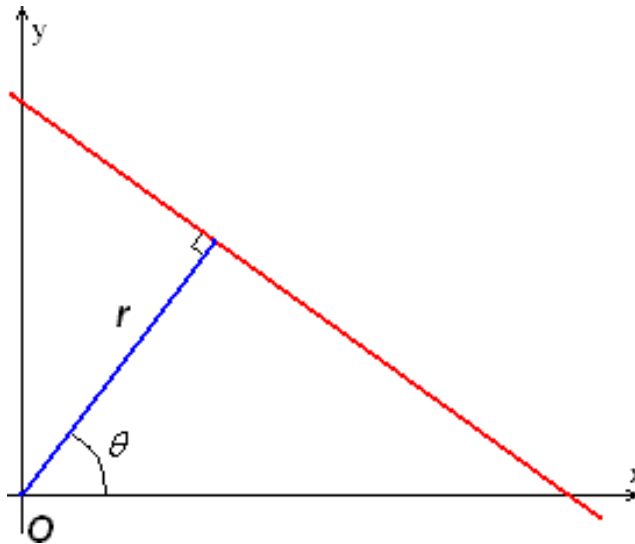
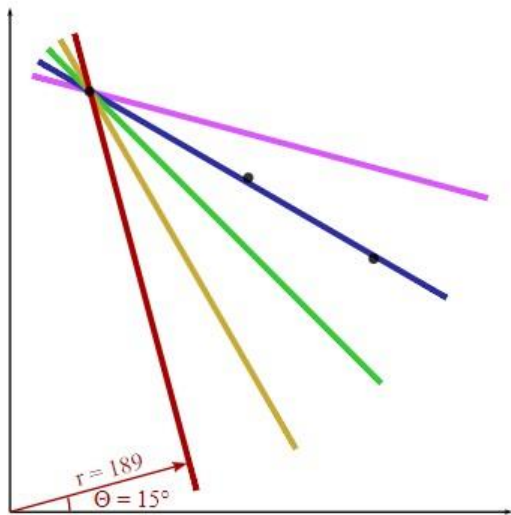


Fig 3.3 Hough Transform

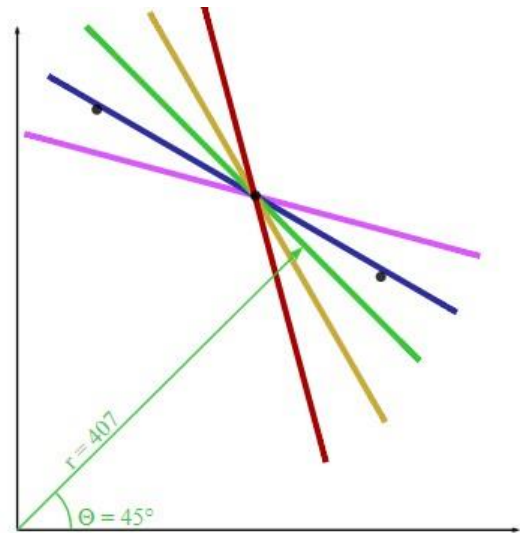
It is therefore possible to associate with each line of the image a pair (r, θ) . The (r, θ) plane is sometimes referred to as *Hough space* for the set of straight lines in two dimensions. This representation makes the Hough transform conceptually very close to the two-dimensional Radon transform. In fact, the Hough transform is mathematically equivalent to the Radon transform, but the two transformations have different computational interpretations traditionally associated with them.

Given a *single point* in the plane, then the set of *all* straight lines going through that point corresponds to a sinusoidal curve in the (r, θ) plane, which is unique to that point. A set of two or more points that form a straight line will produce sinusoids which cross at the (r, θ) for that line. Thus, the problem of detecting collinear points can be converted to the problem of finding concurrent curves.

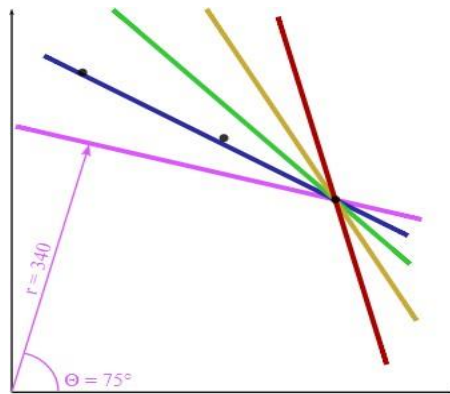
3.10.2 Example 1



Θ	r
15	189.0
30	282.0
45	355.7
60	407.3
75	429.4



Θ	r
15	318.5
30	376.8
45	407.3
60	409.8
75	385.3



Θ	r
15	419.0
30	443.6
45	438.4
60	402.9
75	340.1

Fig 3.4 Example 1

- For each data point, a number of lines are plotted going through it, all at different angles. These are shown here in different colours.

- To each line, a support line exists which is perpendicular to it and which intersects the origin. In each case, one of these is shown as an arrow.
- The length (i.e. perpendicular distance to the origin) and angle of each support line is calculated. Lengths and angles are tabulated below the diagrams.

From the calculations, it can be seen that in either case the support line at 60° has a similar length. Hence, it is understood that the corresponding lines (the blue ones in the above picture) are very similar. One can thus assume that all points lie close to the blue line.

3.10.3 Example 2

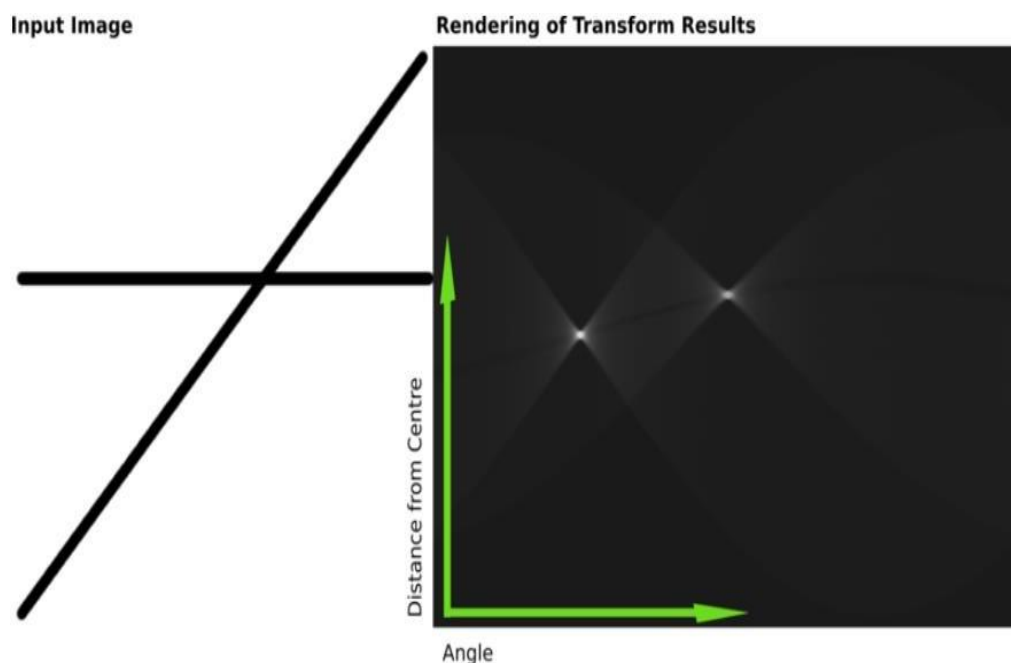


Fig 3.5 Rendering of Transform Results

The results of this transform were stored in a matrix. Cell value represents the number of curves through any point. Higher cell values are rendered brighter. The two distinctly bright spots are the Hough parameters of the two lines. From these spots' positions, angle and distance from image center of the two lines in the input image can be determined.

CHAPTER – 4

RESULTS AND DISCUSSION

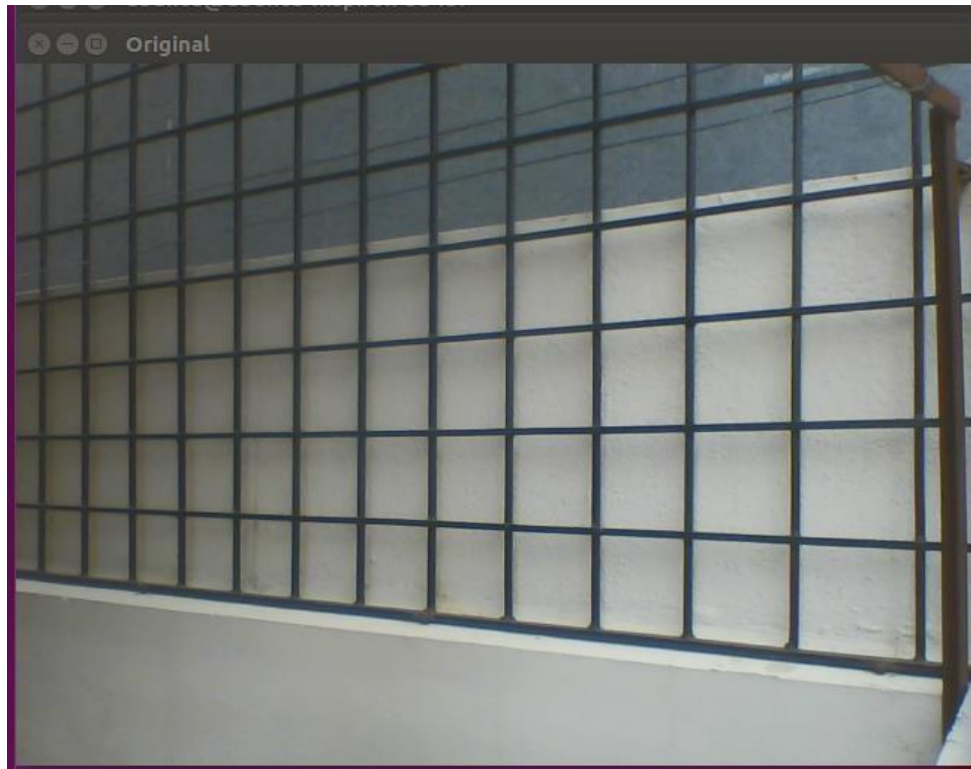


Fig 4.1 Original Image

The Video has been captured using a camera module and Frames of the video are extracted and the individual frame is considered as an image.



Fig 4.2 Preprocessing Image

The image is blurred using Gaussian filter and median blur to remove unwanted noise from image.

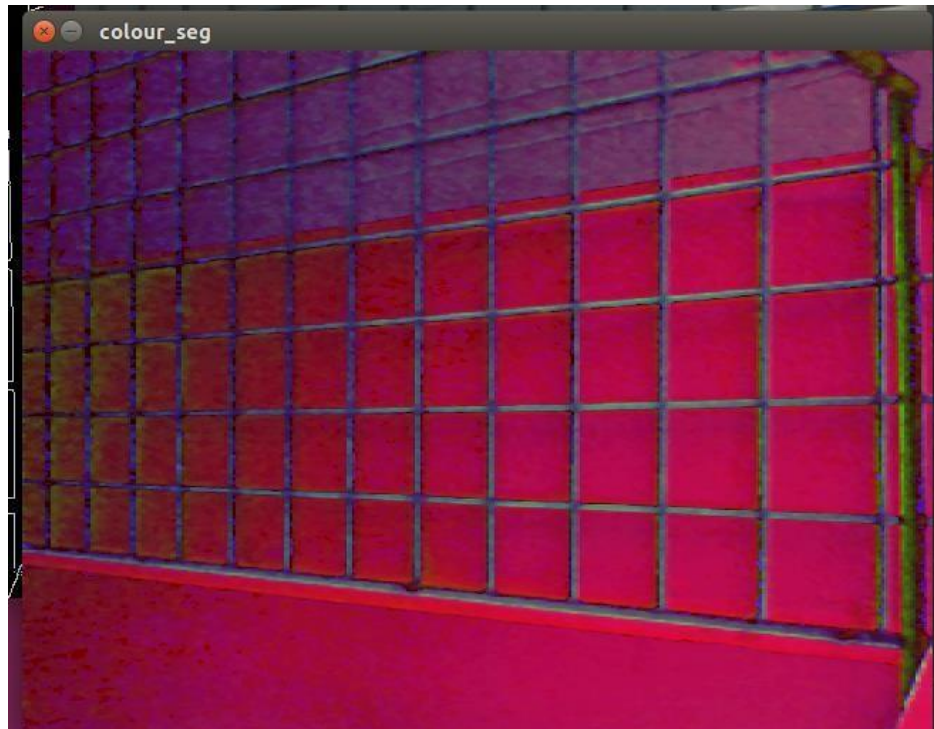


Fig 4.3 Color Segmentation Image

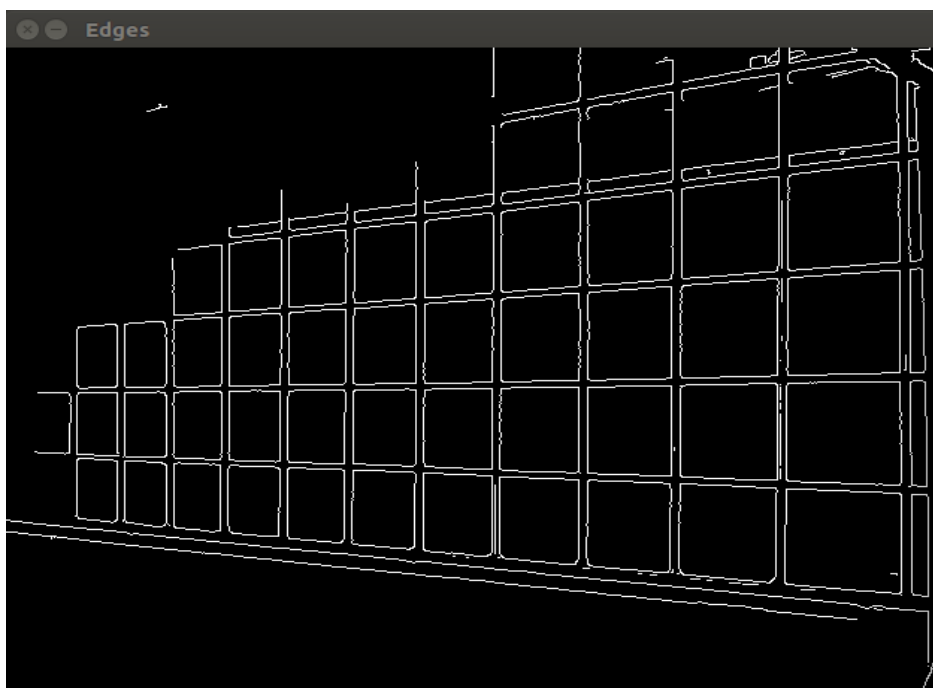
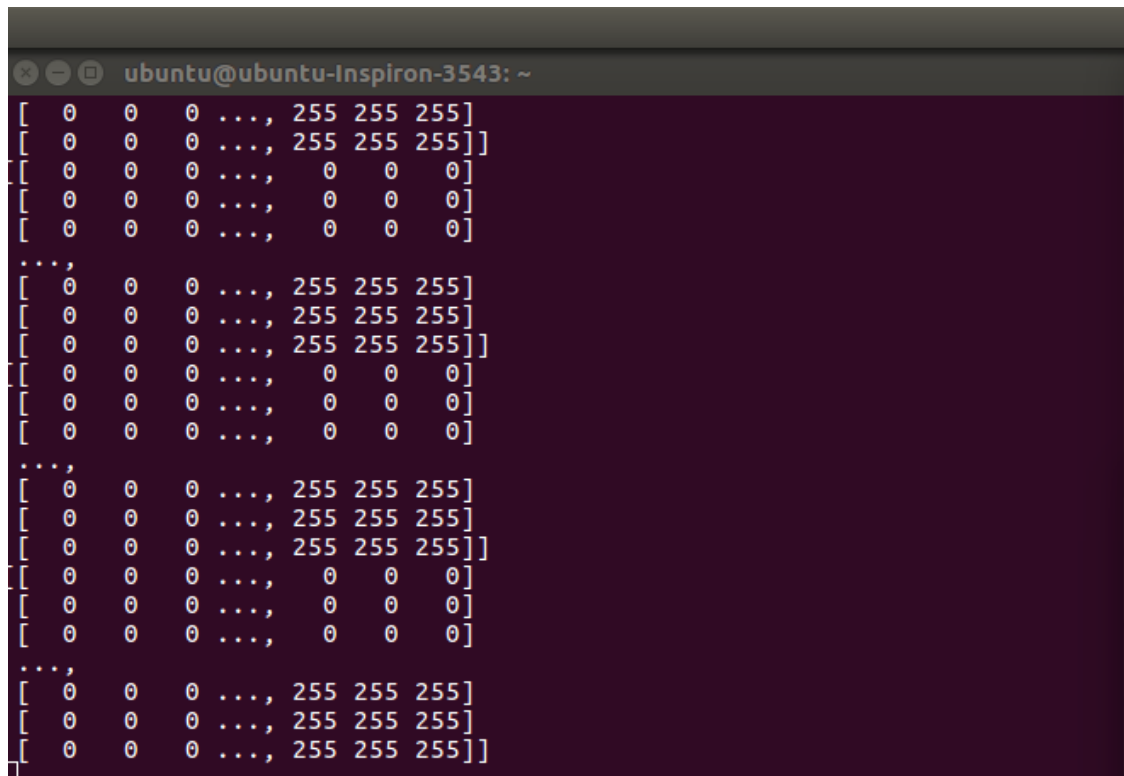


Fig 4.4 Edge Detection Image

Morphological operations are used to achieve more accurate edge detection from the depth image. 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.

A terminal window titled 'ubuntu@ubuntu-Inspiron-3543: ~' displays a matrix of numerical values representing an edge detection image. The matrix is organized into four distinct groups, each preceded by an ellipsis '...'. Each group contains six rows of data. The first three rows of each group consist of values 0, 0, and 0, followed by an ellipsis and three values of 255. The last three rows of each group consist of values 0, 0, and 0, followed by an ellipsis and three values of 0. This pattern suggests a binary edge detection result where edges are represented by 255 and non-edges by 0.

```
ubuntu@ubuntu-Inspiron-3543: ~  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
...  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
...  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
...  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]
```

Fig 4.5 Saved Data Image

The data of pothole saved in the matrix form after the pothole is detected for the future use.

CHAPTER – 5

CONCLUSION AND FUTURE ENHANCEMENT

5.1 CONCLUSION

Various choices for implementing the System have been studied. These choices were also compared to each other on various criterion. We have specified the High level design choices of the Subsystems and justified the corresponding selections. We did experiments on the platform called Firebird. We were also able to characterize road condition into categories like smooth, moderately uneven and highly uneven from the results of the experiments.

5.2 FUTURE ENHANCEMENT

In future we propose to do more experiments with variety of the scenario. Our next and immediate step is to use the Accelerometer on real vehicles and measure their response. Apply different scenarios like potholes on the slopes, turns and see how the accelerometer readings can characterize such condition. Along with that in remaining January and February we want to come up with and formalize the alternate solution for the Localization subsystem.

In next months we perform simulations for given scenarios in Communication subsystem. And we plan to come up with values for the related parameters. For example Loss in throughput because of increase in number of vehicle, Loss in vehicle throughput because of the increase in speed. In the later months we perform the more experiments regarding the Localization system. If we are not able to come up with alternate solution; Then we will perform the experiments regarding integration of the rest of the system with GPS.

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APPENDIX

A. SAMPLE CODE

```
import cv2
# np is an alias pointing to numpy library
import numpy as np
# capture frames from a camera
cap = cv2.VideoCapture(0)
# loop runs if capturing has been initialized
while(1):
    # reads frames from a camera
    ret, frame = cap.read()
    # converting BGR to HSV
    hsv = cv2.cvtColor(frame, cv2.COLOR_BGR2HSV)
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    # define range of red color in HSV
    lower_white = np.array([0, 0, 200])
    upper_white = np.array([145, 60, 255])
    # create a red HSV colour boundary and
    # threshold HSV image
    mask = cv2.inRange(hsv, lower_white, upper_white)
    # Bitwise-AND mask and original image
    res = cv2.bitwise_and(frame, frame, mask= mask)
    # Display an original image
    cv2.imshow('Original', frame)
    # finds edges in the input image image and
    # marks them in the output map edges
    edges = cv2.Canny(frame, 100, 200)
    # Display edges in a frame
    #cv2.imshow('input', frame)
    cv2.imshow('preprocessing', gray)
    cv2.imshow('colour_seg', hsv)
    cv2.imshow('Edges', edges)
    print mask
```

```
# Wait for Esc key to stop
k = cv2.waitKey(5) & 0xFF
if k == 27:
    break;
# Close the window
cap.release()
# De-allocate any associated memory usage
cv2.destroyAllWindows()
```

B. SCREENSHOTS



Fig 1 Original Image



Fig 2 Preprocessing Image

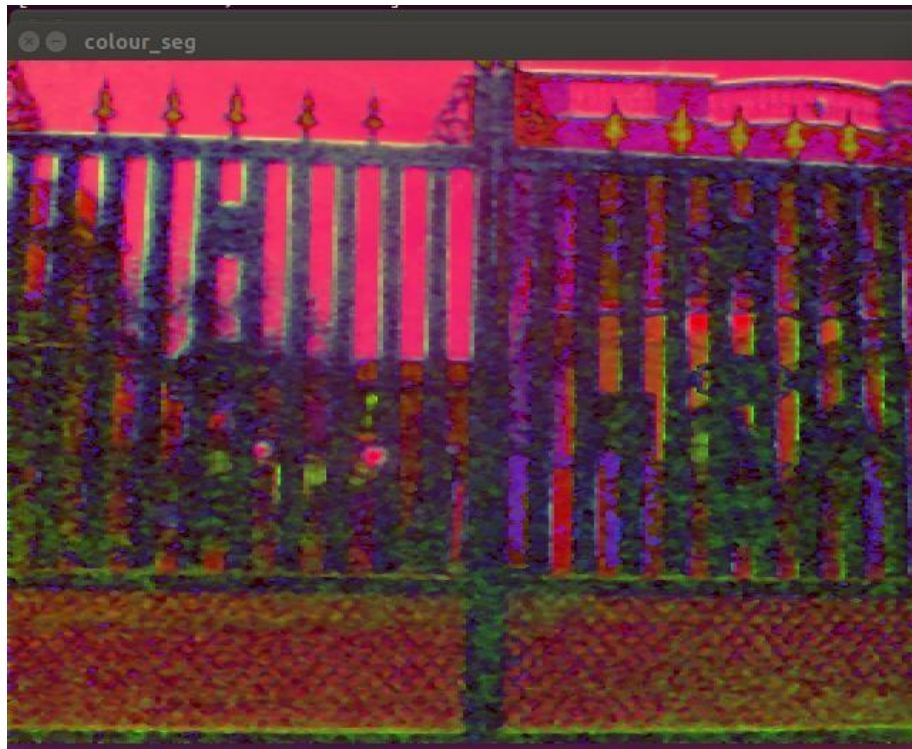


Fig 3 Color Segmentation Image



Fig 4 Edge Detection Image

```
ubuntu@ubuntu-Inspiron-3543: ~  
[[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
...  
[[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
...  
[[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
[ 0 0 0 ..., 255 255 255]  
...  
[[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]  
[ 0 0 0 ..., 0 0 0]]
```

Fig 5 Saved Data Image

C. PUBLICATION WITH PLAGIARISM REPORT



Detecting Potholes Using Image Processing Techniques and Real-World Footage

M. B. Sai Ganesh Naik^{1*}, V. Nirmalrani²

¹Sathyabama Institute of Science and Technology, Chennai, Tamilnadu, India

²Sathyabama Institute of Science and Technology, Chennai, Tamilnadu, India

^{1*}saiganesh121171@gmail.com, ²nirmalv76@gmail.com

Abstract :-Roads are the main mode for transportation, now a days. As we use roads heavily and frequently it sometimes leads to potholes. Environmental factors also leads to potholes in several ways. These potholes are main reason for many accidents. A Scheduled and proper maintenance is required where we need to monitor each and every road. AS this maintenance of all the roads at a time is not possible because it is not easy to monitor every single place or just because people ignore to check which causes formation of potholes that causes unnecessary traffic and many of accidents. To monitor all the roads this project for pothole detection using image processing techniques implemented. To test the performance of the proposed system is going to be implemented in a linux environment using Open CV Library. Techniques of Image processing which detects the potholes on roads and save the data of pothole for road maintenance department. This helps in keeping manual labour to the minimum number. Canny Edge Detecting technique and alone with the Contour Detecting Technique are techniques of Image Processing we use in the proposed system. Hough transformation technique in the end gives effective output of potholes, very accurately.

Keywords :- Image Processing, Canny Edge, Potholes Detection, Otsus's method, Gaussian filter.

1.1. Introduction

The most frequently mounting problems of the roads are facing is Damaged road conditions. For many reasons like earth quakes, accidents on roads, wear and tear of top layers of roads make the drivers to drive on those roads. Unexpected Obstacles on roads may cause number of accidents. Also because of worse road conditions, the vehicles consumes a lot of fuel unnecessarily. For these are the reasons it is very significant to get the data of such damaged roads. POTHOLEs are the crack-up's on roads that are formed on the roads for many reasons where the top road layers will get tattered by heavy traffic. Once after formation of pothole the size of hole will keep increasing till we ready that road or repair the pothole, which is main causes for Road mishap's. Potholes on roads are particularly affects for drivers rushing at high speed. At high speeds a driver almost inconceivably can notice the potholes on road surface. None the less the drivers may see the potholes before they cross it, it normally will be too late for a driver to respond to the pothole. A sudden turn or sudden braking will mostly causes car roll-over. Triggered to the above reasons, we introduced a system that detects potholes and the proposed system will produce the three dimensional data of potholes and save data information data and we can retrieve that data and get pothole image. In this paper we use different edge detection techniques to detect potholes on road. Canny edge detection technique, the most important algorithm we used here to detect potholes. It detects potholes very accurately and stores the data for future maintenance of roads. We use a web camera to record the roads and click the images because comparing to the costly high speed Three Dimensional traverse scanning equipment, web camera is cheap and expensive.

1.2. Related Work

1.2.1. Automatic Pothole Detection

This has crystal rectifier to several accidents inflicting loss of lives and severe injury to vehicles. several techniques are planned within the past to sight these issues victimization image process ways. however there has been very little work specifically dispensed for detective work such problems with Indian roads. Potholes will generate injury like pneumatic alloys injury, jolt and injury of bottom side of vehicles, car or bike destructions, and big mishap's. Hence, precisely and hastily detective work potholes should be one amongst all of the necessary processes of detecting correct methods in ITS services. Many attempts many efforts are created for progressing the technology which might mechanically sight and acknowledge potholes. during this project, a hole 2 dimensional (2D) pictures primarily based hole detection technique is employed for rising the prevailing technique. this method proposes a system Automatic sight the amount of recently revealed papers addressing crack detection Associate in Nursing classification of asphalt surface affliction displays an alluring interest during this space. A recent journal, a stratified gift in [1], that cope with disclosure of roads and inclinations. During this paper, unique groundwork is planned for separating roads pictures in an exceedingly stratified presence so that may divide the subsequent things. The analysis displays that the accession during this paper are able to do a glad output on the varied images of road. The lanes square measure disorganized, that square measures additional advanced more than the organized roads. In [2] the multi scale accession supported Andre Mark off odd field is planned to section adepts in road concrete surface pictures. Adepts square measure increased employing one dimensional filter of Gaussian used for smoothing and so handled by the filter that matches two dimensional to sight them. Complete sixty four road or lane asphalt layer pictures exhibiting many adepts sorts square measure thought of for experimentation, manufacturing a qualitative analysis. Characteristic details of image or sort detector accustomed will click them aren't given. Another paper [3] evidences the problem of detective work cracks of but three millimeter dimension once victimization edge detectors. A non-sub sampled contour let rework that has been ratified in [4] for sight adepts, whereby restricted collection of developmental outputs are conferred. A whole methodology to mechanically sight and characterize top surface defects are planned at [5], victimization gray scaled pictures that are clicked with line scanning cameras where lasers lit them throughout road analysis executed employing an image acquisition system with high speeds. Detection of Adepts uses tentative texture property activity for every picture. The outputs conferred square measure encouraging, however developmental analysis doesn't brace excellence of number of cracks within same picture. In paper [6], NN technique is employed. The machine-driven pavement defect detection will solely establish crack kind defects. To classify defect, a multi-layer perceptron neural network (MLPNN) is employed. NN is employed to segregate the pictures into four classes: defect-free, crack, joint and bridged. Experimental results square measure performed on real road pictures that square measure labeled by human operators. There square measure additional further filters needed for this method. In paper [7], Vision-based approaches square measure accustomed address functionalities like detection of marking lanes, recognition of traffic signals,

detection of pedestrians, etc. this method is feasible to sight the free paved surface before the ego-vehicle victimization Associate in Nursing on board camera. Novelty technique is employed for each shadowy and not shadowy regions which give highest performance. Detection of roads formula is hatched by combining the fuel constant feature area, probability primarily of classifier based. Defect of this method is below saturation by rising image acquisition system. In paper [8], A NN primarily based approach for the classification of sections of lane pictures into adepts and traditional pictures. The options square measure passed for the classification to NN into the pictures including and while not cracks.

1.2.2.Smart Sensing Of Potholes and Obstacles In Automotive Applications Using Internet Of Things

It is a sensing method which uses light pulses to ascertain the surface of earth. The major drawback in this method is, it is highly affected by heavy rain, fog, etc. Also does not work well at huge reflections .The operating cost for this approach is comparatively high. The proposed the 3d laser method to detect potholes and obstacles. The 3D laser checking is one of the outstandingly flexible and productive advances for precisely catching extensive arrangements of 3D facilitates. This method uses laser pulses to detect the irregularities in road surfaces. It is applicable to 2d and 3d surfaces. The disadvantage of this approach is that it requires post-processing to produce a usable output i.e., the output requires manipulation. And high end hardware is required where others used the RGB image processing technically ,complex figuring devices that consolidate programming and equipment to process the pothole pictures are required in this technique. It is also consumes more time when compared to other methods. Also the accuracy rate is low in this approach. Moreover it needs prior knowledge of the images i.e., a large quantity of training sets have to be given. Wang didn't attainability concentrate to lead the comprehensive review of asphalt conditions by methods for of stereovision innovation. In this strategy, two advanced cameras are appended to the vehicle, which is utilized to cover an asphalt surface. The initial step is to dissect 2D pictures from every one of the two cameras to recognize and order any splits. To recuperate the 3D properties from given sets of 2D pictures on a similar asphalt surface, the succession of steps, for example, camera alignment, twisting right, coordinating stereo focuses, 3D recreate, and profile report ought to be performed.It needs complex computation capabilities when compared to other methods.

1.2.3. Detection, Notification of Potholes, Humps Using Android Application

In this System the process of image pre-processing is done by accomplishing the differences between Gaussian-Filtering to the Clustering Image segmenting strategies for best and clear fallout's. The main aspiration of this gazette was recognizing the principal technique which was enormously gratifying and actual correlated to traditional techniques. They used different types of image processing techniques and segmentation methods to detect the pothole where they follow up to take advantage of beheading measures. The recognition of different scenarios of image processing for detecting pothole was done by correlating measures of performance with different segmentation methods. Drawback with this system, assassinating and applying the neural networks which are hybrid classifiers like fuzzy rule base to advance place alone device to recognize pothole. And proposed a low complexity technique for analyzing and run down of potholes by the input source fixed inside a running vehicle. The interest for pothole detection is chosen as territory of picture and the area is seen with maximum resolution. The applicant fields were producedapplying threshold design. The asset of this journal was accuracy in detection.

1.3. Existing System

In an existing system a detection which starts with noise removal, followed by brightness adjustment and rendition of video by doing the process ofbinarization. Then, removal of noise is applied to the binarized image. After noise removal, the process of extracting the framework or outlines for the objects that are segmented is carried out. Extraction is followed by selection, square zoning for the objects. After all these processes, desired pothole area information is returned And another system that detects pothole which is categorised in to 3 subsystems. The encountered potholes are sensed by this first subsystem namely sensing subsystem, by using accelerometer or by camera which scans the road. Both are mounted on the car. Then there is another subsystem that is used to transfer the data between WiFi access points to the mobile nodes. The data about potholes is broadcasted by access point in its areaIn the existing system, the pothole is detected using the accelerometer sensor in smart phone. This system is not automotive in nature. The

complaints if needed to be posted or to be informed to any governmental authority it will be done only with human intervention. This process may not provide the complete efficiency as many people may ignore the issue and will not post them. Even if people sends the complaint to an admin many pothole image may be repeated and thus it may cause a huge confusion. In this case, if prioritization has been done then it would be an optimized way to collect the frequent places that is being affected by potholes.

1.3.1. Disadvantages Of Existing System

GSM technology has been used which causes delay in message delivery. It is a paid message service. The severity is less estimated. It is exceptionally costly in nature and it can't be connected to working class level vehicles.

1.4. Proposed System

In this proposed system 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. The image is firstly blurred using average filtering then it goes through Gaussian filtering technique and lastly through median blur for removing unnecessary noise in the image. We modified the process with morphological operations just for achieving the most approximate detection of edge from the depth image. In general, these operations are a group of nonlinear operations that are carried out analogously on ordering of pixels without stirring their numerical values. Erosion, Dilation are morphological key operators. We have used erosion after blurring operations which is followed by two iterations of dilation. The pothole detection is utilizing canny edge detection technique. Detection techniques are multi - stage method to detect wide ranges of edges in images.

1.4.1. Advantages of Proposed System

- Easy to Replacement and maintenance.
- Fast in identifying the pothole.
- Very cost efficient product.
- Simple method and Improves efficiency.

1.4.2. System Architecture:

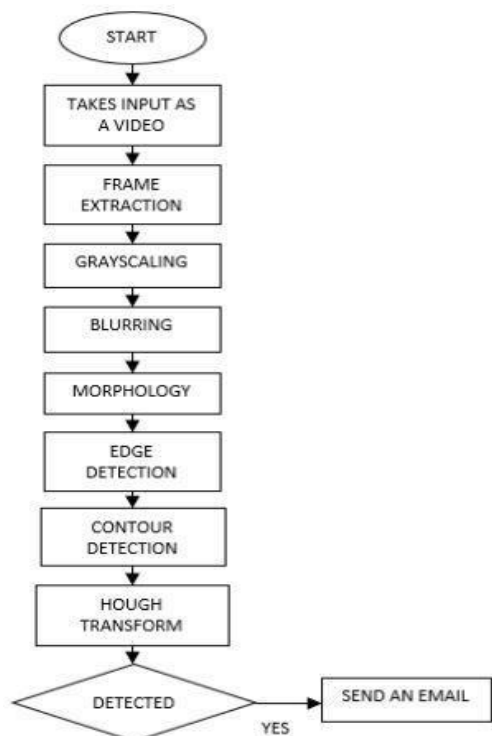


Fig 1.4.2.Overview of The Proposed System.

1.5. Implementation

1.5.1. Canny Edge Detection

Canny edge detection technique is a detection algorithm which uses multi stage algorithm undergoes five stages. It starts with applying Gaussian filter which is used for image smoothing and removal of unnecessary noise. Then as a second step it finds out the intensity angles of the image from the first step. Then it applies non-maximum suppression technique to dispose of false edges. Then to detect all possible edges it uses double threshold method. Finally it detects the proper edges by removing all the false edges which are not connected with strong edges.

1.5.2. Gaussian Filter

Gaussian filter, used to blur the image and cut down the noise which does unsharp masking that will blur the edges and cut down contrast.

1.5.3. Otsu's Method

We use Otsu's method for reducing the grey level image into a binary one. It assumes that the image or picture consists of two classes pixels that follows bi-modal histogram. Then it will calculate optimal edge value where two classes are separated and combined diffusion will at be minimum or equal and inter class deviation will at maximum. The system then uses contour detection technique. For better accuracy, use binary images. So we have applied threshold and canny edge detection. While capturing video the hassle of adjusting speed is eliminated. Hence, the images give a clear view.

1.6. Results



Fig 1.6.1.Preprocessing Image

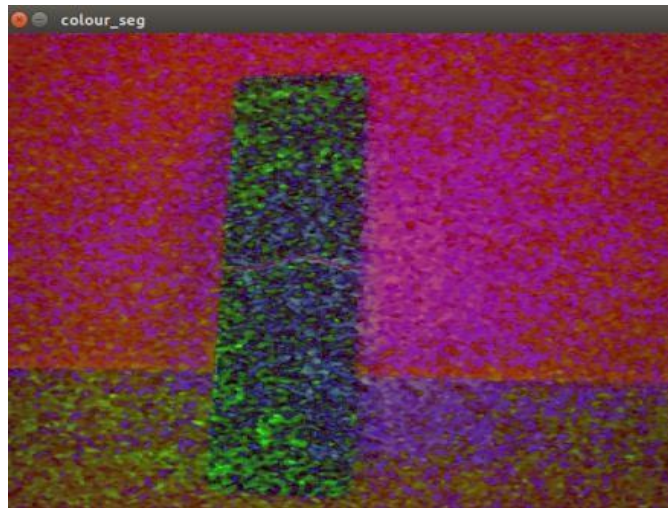


Fig 1.6.2.Color Segmentation

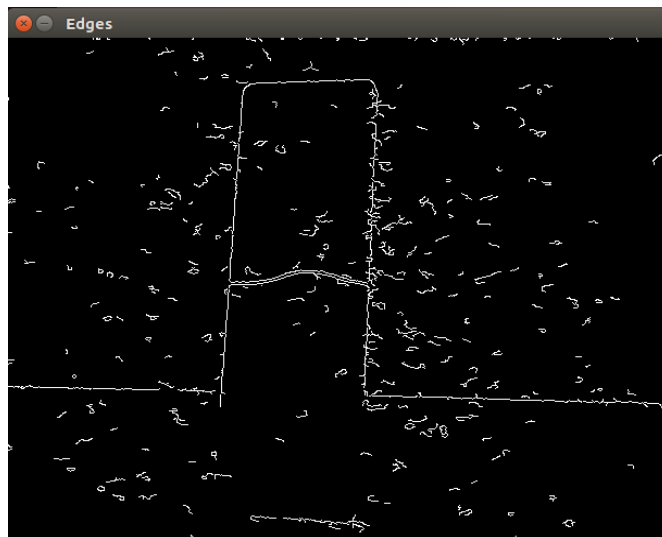


Fig 1.6.3.Edge Detection

1.7. Conclusion

The proposed method describes Image processing techniques for detection method and segmentation of potholes, accurately. For this process to happen and to achieve the accuracy we need to combine the texture with gray scale information. These processes to be applied in real world to avoid major accidents. In real world we have many cc cameras now a days on the roads which are used for traffic purpose and we can use the same cameras for maintenance of roads and detecting the potholes.

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