**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Volume 2, PP 52-56

# Detection of Potholes using Image Processing Techniques

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***Abstract:*** *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. Often this maintenance is not performed since it is not possible to monitor each and every place or simply because of ignorance. This leads to the formation of potholes which causes unwanted traffics and the majority of accidents. This paper discusses about the detection of potholes using camera installed on light poles of roads. Image processing techniques have been used which informs the BMC officials in a timely manner using email system, thus keeping manual labor to the minimum. For testing its performance, the proposed system has been implemented under a Windows environment using OpenCV library. Simple image processing techniques like canny edge and contour detection with hough transform is used for effective pothole detection.*

***Keywords -*** *canny, contour, detection, edge, pothole.*

## I. INTRODUCTION

India is one of the most populous country, roads are the main mode of transportation in this developing country. But due to the heavy use of roads, there is a high amount of wear and tear carried out. Since these roads cannot sustain itself for a long time, a timely maintenance is expected to be carried out in order to prevent the formation of potholes. The manner in which a pothole is formed depends on the type of bituminous pavement surfacing. The heavy traffic on the road is the primary reasons for the fatiguing of the road surface, resulting in the formation of the crack. These depressions collect water and allow the water to mix with the asphalt. When vehicles drive through such holes the water is expelled along with some of the asphalt, and this slowly creates a cavity underneath the crack. If a regular road maintenance is neglected, the road surface will eventually collapse into the cavity, resulting in a visibly huge pothole over the surface. In order to repair these roads in a timely manner, it is necessary that the entity knows which area is affected by the pothole or decaying road section is located and an automated process could assist with this.

All these reasons demand that it is important to collect information of the road conditions and through a series of processing and analyzing the obtained information, appropriate conclusions are derived which in turn, warn the officials of the respective area. The simplest and highest accuracy approach to this is to click and upload pictures to the interface provided by the official, but this involves a strong participation from the users as well as manual image analysis. Thus, an automated detection sounds more promising in this case.

Our approach includes the use of a computer vision based system. In this system, a two-dimensional image of roads is used. The digital images are captured by the camera and are processed to capture the information related to road anomalies. In a 2D image-based approach, the system extracts the texture measure based on the histogram as the features of the image region, and the nonlinear support vector machine was built up to identify a potential region is a pothole or not.

## II. RELATED WORK

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.

## III. MATERIALS AND METHODS

A. 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 [1].

B. 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 [1].

C. 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.

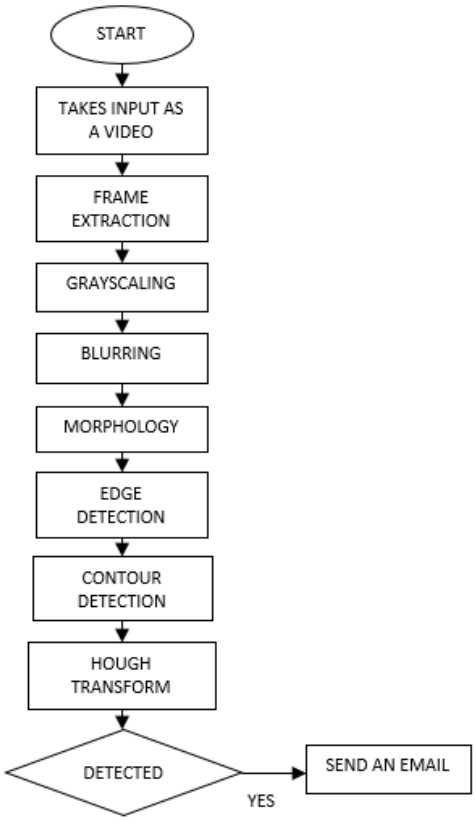


**FIG.1.** flowchart of image processing.

The first step after frame extraction was the conversion of the RGB image into grayscale using standard techniques to make processing of image faster [2]. An example grayscale image is shown in Figure 3.

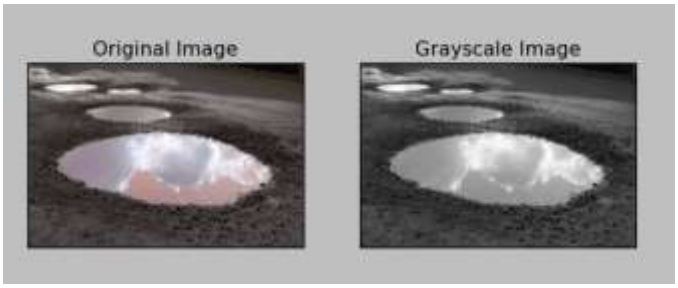


**FIG.2**. Example of grayscaling.

After grayscaling 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.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 [3].

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 [3].

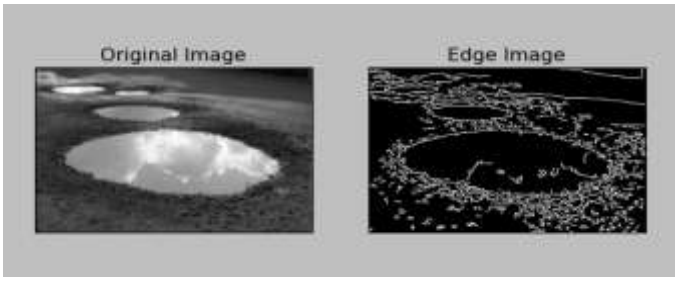


**FIG.4.** Example of canny edge detection.

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 [4].

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, minDist)

- 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.
- minDist: 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.
- minRadius: Minimum size of the radius (in pixels).
- maxRadius: 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

## IV. PROPOSED SYSTEM

A sample block diagram of the proposed system is represented in the figure as shown below.

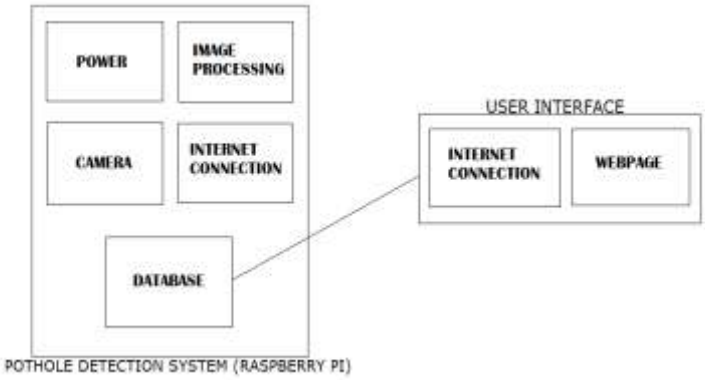


**FIG.5**. Generalized diagram of the proposed system.

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. If potholes are detected, the images and the locations are sent to the official with the use of emails.

## V. CONCLUSION

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.

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