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Research paper

Computer Vision Based Pothole Detection and Notification

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Abstract

Potholes on the road cause accidents and lead to traffic congestion. If left unresolved, the damage worsens and time taken to fix it also increases. We aim to develop an automated pothole detection and alert system which can detect potholes and also its location. In this paper, we propose a prototype for a computer vision based pothole detection system. Blob detection is used where the potholes are assumed to be a blob. The potholes are determined by the algorithm that is embedded in the Pi, which captures live images using the Pi camera. The OpenCV library is utilized for accomplishing the detection.

Keywords: *Blob detection; Computer vision; GPS; Pi camera; Potholes; Raspberry Pi*

1. Introduction

The presence of potholes causes major road accidents. It is hard for the driver to recognize and react accordingly at high speed. The potholes even cause damage to vehicles and discomfort to the passengers. There are several methods to detect potholes on the road such as vibration based detection, 3D reconstruction-based detection, and visual-based detection.

Prototype proposed in this paper detects potholes using visual based method. A pothole has few characteristics of visual appearance which differentiates it from other objects, like the shape of a pothole is likely to be an ellipse to a circle and the texture inside the potholes is much coarser and grainier than the surface of the surrounding area near the potholes, which is smooth. With these characteristics, vision based algorithm is developed and implemented on the device.

The main idea of this study is to develop an automated system which does not require any human intervention for detecting and raising a notification. The proposed prototype can be implemented in appropriate locations on highways and damage prone roads to immediately detect and alert the local corporation. It contains a Raspberry Pi 3 which is integrated with a GPS module and Pi camera. This system will immediately send an e-mail along with the location of the affected area. The algorithm is implemented on the Raspberry Pi in Python programming language, using the OpenCV library. The captured image is filtered to eliminate noise and then converted to grayscale. The blobs are detected and eliminated based on the fixed blob detector parameters.

2. Related work

Some of the existing methods to detect potholes on the road include image processing methods, vibration based methods and 3D reconstruction based methods.

Pothole detection using simple image processing techniques and real world footage was done. Based on the contour and color of the road, the road region is extracted. Canny edge detection was used to get the pothole contour since the algorithm defines a pothole as a region with a dark edge. To reduce noise effect, convex hull algorithm is used to decrease the effect of noise. The system was tested by using a GoPro camera fixed at the front windscreen of the car. This yielded an accuracy of 81.8 % [1].

The CDDMC algorithm was developed and analyzed the frames from videos. The frames were classified into distress and non-distress frames. The algorithm classifies distresses into three categories, potholes, cracks and patches. It was found to achieve an overall accuracy of 97% with 95% precision and 81% recall [2].

A low-cost pothole detection method using Field Programmable Gate Arrays (FPGA) was proposed [3]. Three edge detection techniques namely Sobel, Prewitt, and Canny are the main algorithms utilized to detect potholes. This technique is processed in parallel threads by FPGA. Hence, there is difficulty in achieving real-time detection. However, this methodology has achieved a good result for detection.

Vibration based methods make use of accelerometers, either external [4] or those which are a part of smartphones [5]. The main disadvantage of these methods is that they require that the vehicle be driven over the pothole, which causes discomfort to driver and damages the vehicle.

Methods based on 3D reconstruction [6] have managed to achieve good accuracy, in addition to estimating their volume. However, they are expensive to implement.

3. Methods

3.1 Hardware Design

In our proposed method, a Raspberry Pi model 3 is used as the main processor. A 5MP Pi Camera is interfaced with it, for the purpose of monitoring the road by capturing the road image which

will be processed. A Neo6Mv2 GPS module is interfaced with the Pi in order to send the location details of the pothole. A Raspberry Pi is a series of small single-board computers developed in the United Kingdom. Processor speed ranges from 700 MHz to 1.2 GHz for the Pi 3 on-board memory is 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory.

3.2 Software Development

The OpenCV library is used to perform the processing. It is an open-source image processing library which is used as the frame work for developing the algorithm. It supports a Linux OS. The OS used for Raspberry Pi is Raspbian, which is built on Linux and hence OpenCV is suitable for use in Pi. Programming can be done is C, C++, Java and Python.

The flowchart in Figure 1 illustrates the flow diagram of the proposed computer vision based pothole detection system.

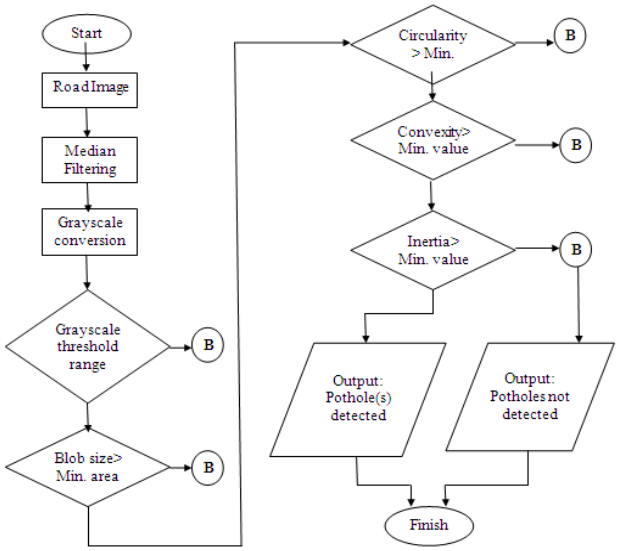

Fig.1: Flow diagram of the pothole detection system

For the purpose of detection, blob detection technique is employed. It scans an entire image searching for blob shapes. It works on edge detection using LoG (Laplacian of Gaussian), which convolves a Laplacian Gaussian function with the 2D value of the input image.

Minimum values for the blob detector parameters are set to detect potholes. The parameters that are considered are:

- Grayscale threshold level
- Pixel Area
- Circularity
- Convexity
- Inertia

First, the image of the road is captured by the Pi camera and then processed for detection. Median filtering is applied on input images to remove salt and pepper noise and then converted to grayscale image. Then, the various parameter thresholds of the blob detector are applied to the image. If the blob fails to meet any of the set parameters, it is not considered to be a pothole.

Once the pothole is detected, the number of potholes and their coordinates with respect to the image are displayed. Further, using GPS module, the location of the pothole is obtained. Based on the detection, an email is sent to alert the maintenance authorities.

4. Implementation Results

Testing is done for the algorithm using sample images downloaded from the internet (Source: Google Images). Figure 2 shows the hardware connections for the proposed system. Figure 3 shows the mail received after potholes were detected.

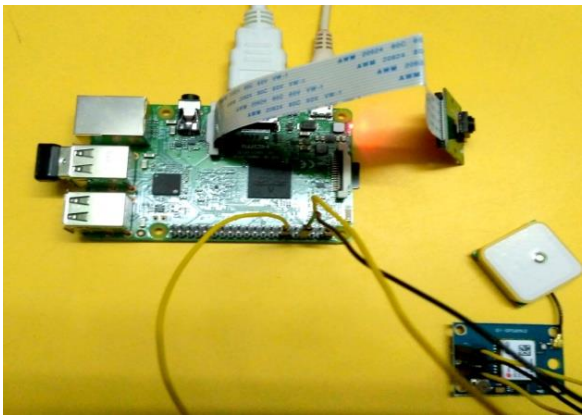

Fig.2: Hardware connections

Fig.3: Mail output

Figure 4 shows the intermediate and final detection outputs of the proposed algorithm for five images taken from Google images containing varying number of potholes.

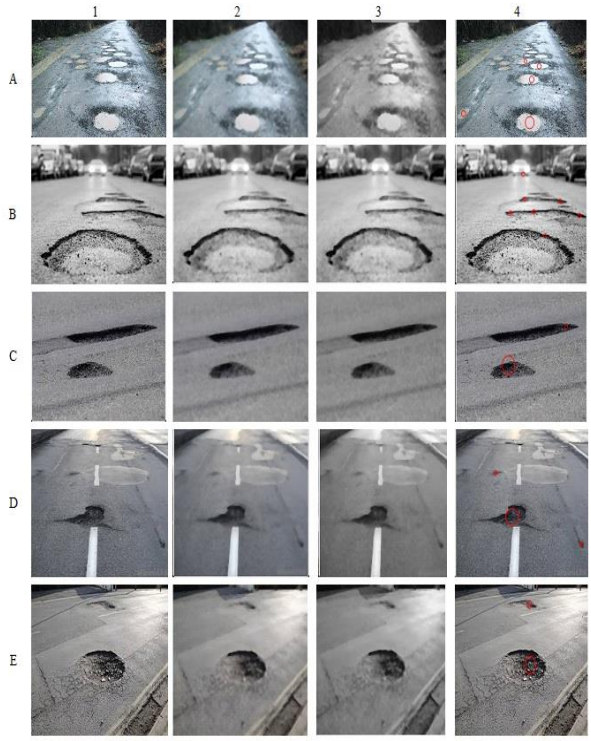

Fig. 4: Outputs of the proposed blob detection algorithm

The image columns are described as follows:

Column 1: Original image. This is the input image to be processed and detected.
Column 2: Enhanced image. This is the output image obtained after median filtering the image.
Column 3: Grayscale image, obtained by converting the enhanced image from RGB to grayscale.
Column 4: Key point image. This is the final output image obtained after pothole detection

5. Conclusion

One of the main causes of most road accidents is the presence of potholes on the road. It could also damage vehicles and cause discomfort to commuters. Presently, potholes are detected and treated manually by technicians of the road maintenance department or reported by the citizens. An automatic pothole detection system can be a good solution, since manual supervision and reporting is time consuming and tedious. This paper explains the prototype which uses blob detection to automatically detect the potholes present on the road. It also sends the location where the potholes are present via e-mail to the respected authorities. Raspberry Pi, Pi camera and GPS module are used for the functionality of this prototype. This prototype can be extended to make use of high definition cameras to monitor over a long range. A database can be created using the Node Red application, where the data sent can be sent, stored and viewed. Further, the application can be directly deployed on the IBM Bluemix cloud platform. For the system to work more accurately, an effective algorithm can be used to detect the potholes even on a flooded road, on potholes with same color, or potholes that are covered by the shadows of trees or buildings, which does not depend on the color difference and a more adaptive thresholding method.

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