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Detection of Pothole by Image Processing Using UAV

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Abstract: *Potholes on road can generate costly damage to flat tire or can cause wheel damage of motor cycle. Especially in India vehicle collision and major accidents happens due to immense depth of pothole on road. Thus, detecting and repairing of potholes on road is major challenge for in ITS (Intelligent Transportation System) service and road management system. In order to enhance the efficiency of pavement inspection,currently some new sorts of remote sensing methods without any physical damage to the pavements is possible. In our study the pavement images captured by the unmanned aerial vehicle are collected and distinguish the pavements with the pothole from the normal pavements by performing the Morphological Operations on the images. UAV is new tool under the Remote sensing technique for the pavement inspection with more efficiency as it is usable in hard to reach places also where road maintenance is difficult. Through large transport surveillance, we built a method that can detect pothole using various algorithms of image processing for time optimization of surveillance. A model of potholes is constructed using the image library, which is used in an algorithmic approach that combines a live road footage and simultaneously detection of potholes using simple image processing techniques such as a medium filter and edge detection. Using this approach, it was possible to detect potholes with a precision of 80% and recall of 74.4.%. Using UAV, we can reach in remote places and specially to National Highways, detection of pothole and collecting all database become very easy and time saving. With more advanced technologies such as Artificial Intelligence and Machine Learning algorithms can be used for surveillance of road with more precise results with automatic repairing robots or machines.*

Keywords: *Unmanned Aerial Vehicle, Morphological Operation, Dilation, Erosion, ITS, Feature Detection*

I. Introduction

Potholes are terribly huge drawback in country like India. Potholes are merely areas of paved surface that have cracked, worn away, and eventually shaped a hole. They begin out as small cracks. India has large network of road transportation therefore various individuals travel through roads. Potholes are main reason for inflicting accidents on roads.UAV technique for hole discovering is employed to detect the potholes from any inaccessible and long pavement place. Projected system uses UAV to flow on road to capture image of road. It's live streaming during which video is unceasingly transmitted to laptop and thru software package potholes are detected and knowledge is hold on for future reference. It's terribly straightforward and advanced technique to discover potholes with less use of force and additional precise work with less time consumption. The continual examination and assessment of physical and practical condition of civil infrastructure is crucial for safety, utility and rideability. Currently, the manual visual examination at regular intervals is that the main variety of conditions assessment in most countries. Sadly, because of shy examination and condition assessment this technique had some tragic consequences in India. Automatic examination uses specialized vehicles or drones that are mounted with cameras, pavement profilers, image and positioning systems. Example of Potholes inspection strategies have many

restrictions, adore the quantity of defects they will discover, the value of sensing element instrumentality and also the level of detail they will attain.

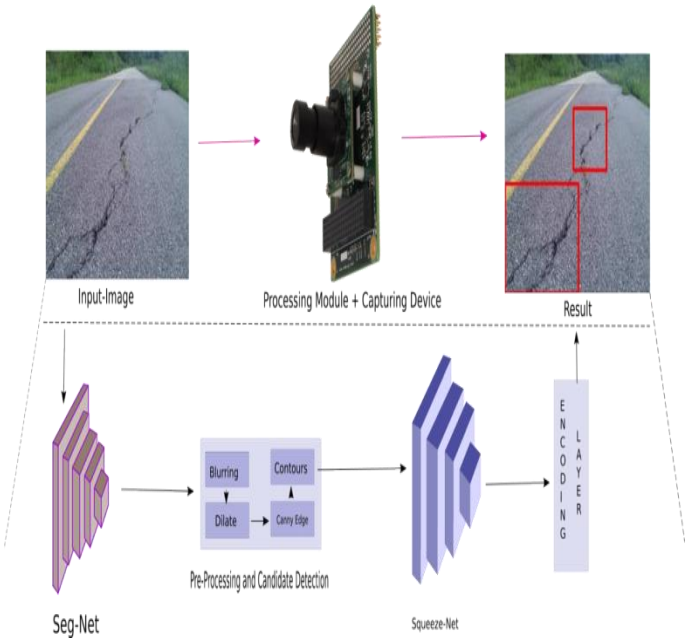

Fig1: Concept of Pothole Detection

Currently, with the support of computer and remote sensing technologies, many forms of remote sensing data and advanced pattern recognition algorithms have been introduced into the automated detection of pavement damages without doing harm to the road pavement. Pavement friction measurements are often tested by lateral force apparatus instrument [7]. Obviously, this type of strategies is time consuming and labor intensive, most of that are even damaging to the paved surface meantime [8].

Especially, in the previous studies, the digital pictures or videos with solely single or RGB channels captured, supported the mobile vehicle, are the most frequently used information sort to mechanically find the pavement damages [2], [13]. As for digital pavement pictures, image process and machine learning algorithms are the 2 primary methods to extract the surface defects [13]. Image process can be wont to isolate the defects from the background and build a binary image, akin to bar chart thresholding, morphological algorithms (opening, closing, dilation, and erosion), wavelet, and Fourier transformation [14].processing and machine learning algorithms are the 2 primary methods to extract the surface defects [13]. Image process can be wont to isolate the defects from the background and build a binary image, akin to bar chart thresholding, morphological algorithms (opening, closing, dilation, and erosion), wavelet, Fourier transformation [14]. To resolve the preceding issues of current vehicle platform, the versatile UAV platform configured with one multispectral imaging system was chosen to collect the road pavement image information in our experiment.

The central objective and contribution of this study is to analyse the practicableness of the projected model and supply a brand new tool for observance asphalt road pavement condition to boost the potency of road maintenance follow.

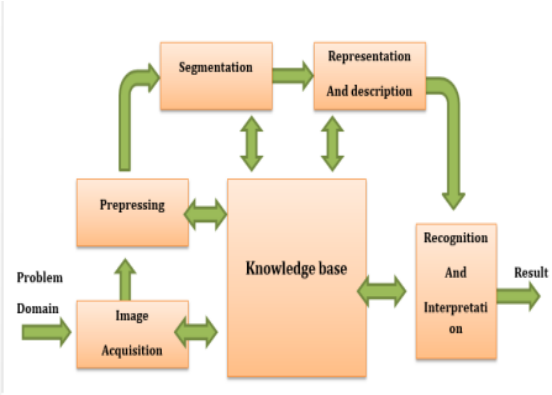

Fig.2: Image Processing Techniques

By implementing UAV for detecting potholes on surface reduces workload at a time and necessity towards Intelligent Transportation System in smart cities.

II. UAV System and Sensors

1. Frame of Drone

We have designed frame for drone using wood by using drone calculations. Total weight of drone is expected to 1.215 Kg by considering all equipment weight and Power to Weight ratio is 2:1 hence with thrust per motor is expected to be 607.5gm.
We are using Strong Magnetic 716 Coreless DC Motor with 48000 RPM is used for UAV design and propellers has the dimensions of 45mm. the frame is designed with lifting capacity up to 1000 gm.

2. Flight Controller

We are using kk 2.1.5 multi rotor flight control of size 50x5012 mm has inbuilt IC of Atmega 644 PA. This controller is is controlled though remote transmitter and receiver module FLYSKY CT6B 6CH.

3. Image Processing Unit

The 1200 TVL cmos mini high definition camera is perfect for image capturing and mounted on drone .it has the 2.8MM lens.
Also the transmitter module TS835 module is set up on the UAV for transmitting the image capture by the camera to the receiver section

III. Feature Extraction

1. Gray conversion

I= rgb2gray(RGB) converts the true color image rgb to the grayscale image I. the rgb2gray function converts RGB image to grayscale by eliminating the hue and saturation information while retaining the luminance.

2. Median Filtering

J = medfilt2 performs median filtering of the image I in two dimensions each output pixel contains the median value in a 3x3 neighborhood around the corresponding pixel in the input image. You optionally can compute the normalized cross correlation using a GPU

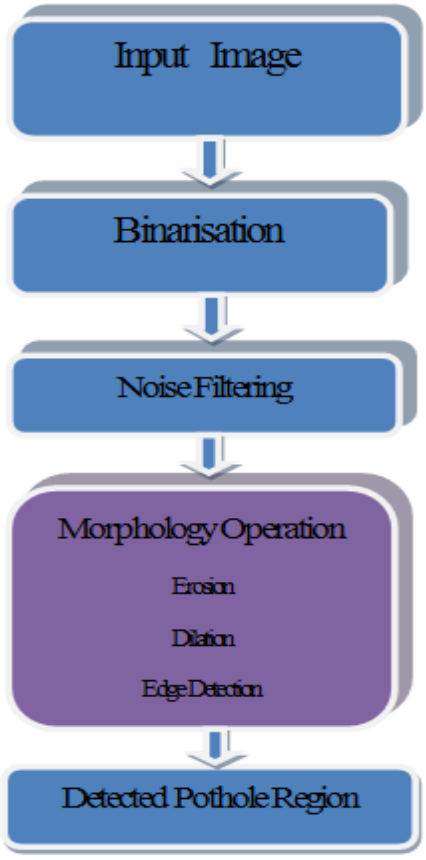

Fig.3: Methodology

3. Morphology operations

Morphology is a broad set of image processing operations that process images based on shapes. In a morphological operation, each pixel in the image is adjusted based on the value of other pixels in its neighborhood. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image.

A. Erosion

The price of the output picture element is that the minimum value of all pixels within the neighbourhood during a binary image, a picture element is about to zero if any of the neighbouring pixels have the worth 0.Morphological erosion removes islands and little objects in order that solely substantive objects stay.

B. Dilation

Morphological dilation makes objects a lot of visible and fills in tiny holes in objects. The price of the output constituent is that the most value of all pixels within the neighbourhood during a binary image, a constituent is about to one if any of the neighbouring pixels have the worth 1.

Dilation and erosion are usually utilized in combination to implement image process operations.

As an example, the definition of a morphological gap of a picture is associate degree erosion followed by a dilation, and by exploitation constant structuring part for each operations. Mix dilation and erosion to get rid of little objects from a picture and swish the border of huge objects.
Dilation adds pixels to the limits of items in a picture, while erosion evacuates pixels on object limits. the quantity of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image

C. Edge detection

Edge detection is a picture process technique for locating the boundaries of objects inside pictures.
It works by police work discontinuities in brightness. Edge detection is employed for image segmentation and knowledge extraction in areas corresponding to image process, laptop vision, and machine vision.
Common edge detection algorithms embrace Sobel, Canny, Prewitt, Roberts, and formal logic ways

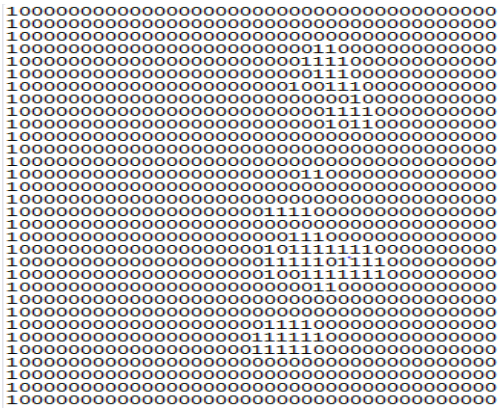

Fig.4: **Binarised form of original image**

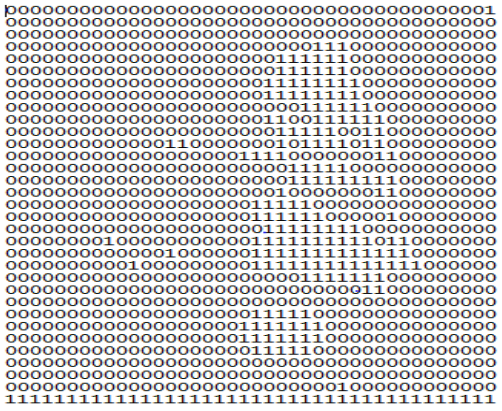

Fig.5: **Image after Erosion**

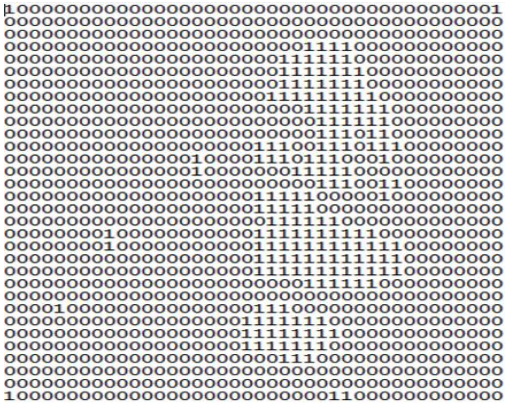

Fig.6: **Image after Dilation**

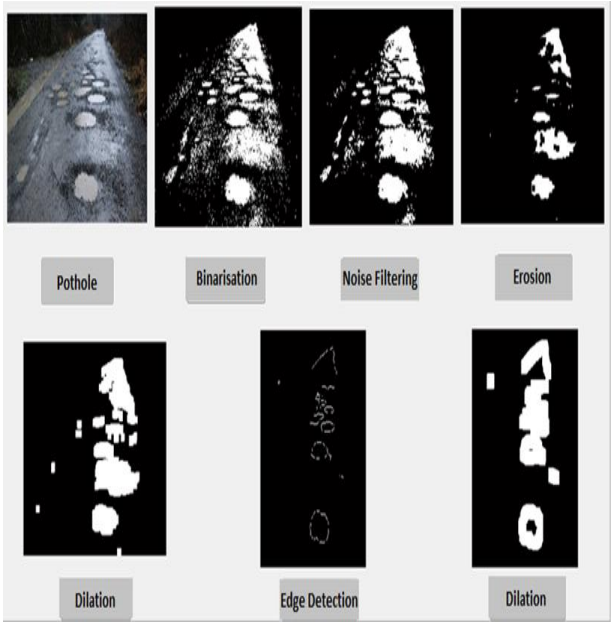

Fig.7: **Algorithm to detect pothole 1**

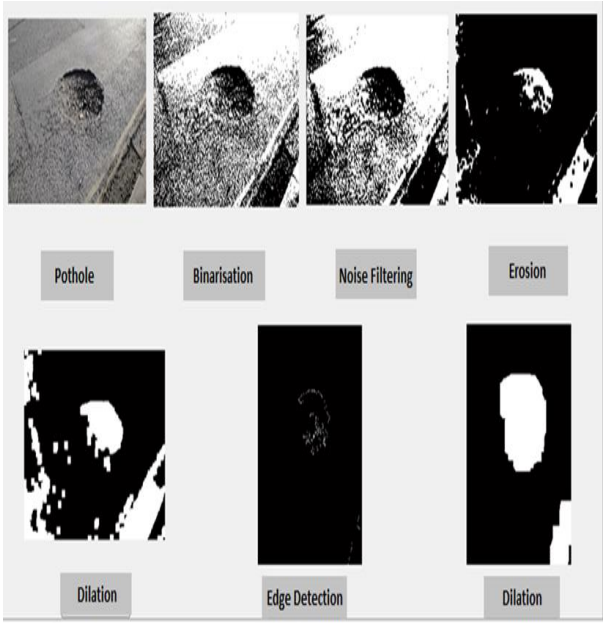

Fig.8: **Algorithm to detect pothole 2**

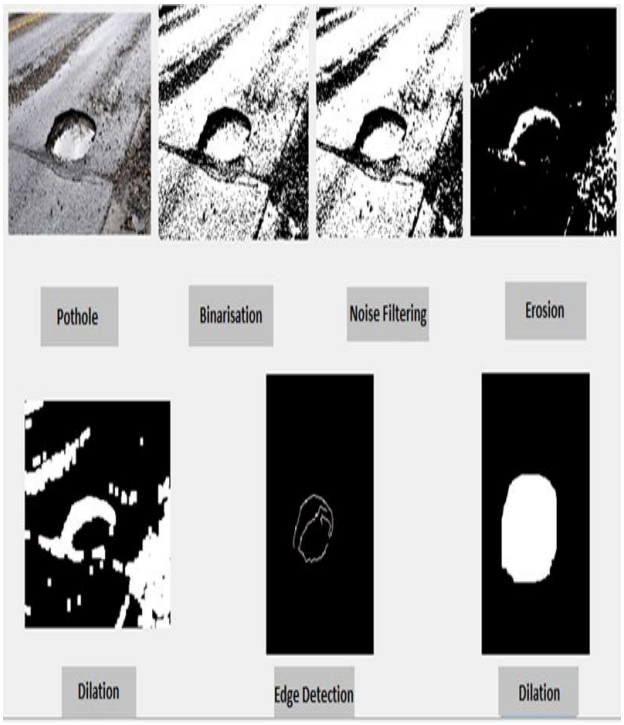

Fig.9: **Algorithm to detect pothole 3**

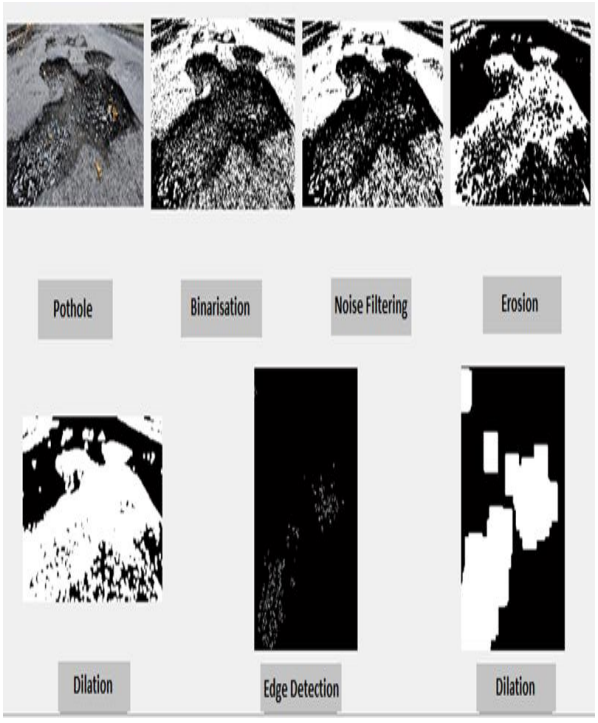

Fig.10: **Algorithm to detect pothole 4**

IV. Proposed System Methodology

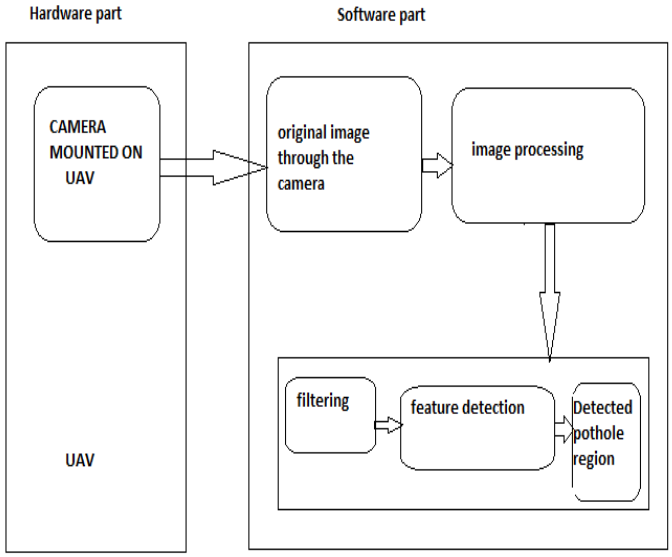

Fig.11: Proposed System Block diagram

As seen from fig.11, in our proposed system we used common Wifi network to transmit image from source to destination. In commercial projects, it is necessary to use RF TS835 transmitter and receiver module for image transmission using TVL high definition camera fixed at drone.

Matlab 2016a version is used as software part for image processing and feature extraction process to detect pothole.

Camera fixed on UAV will continuously stream the video and hence result will be simultaneously shown in GUI shown in simulations Fig .12 and Fig. 13

Using Pre-processing techniques in matlab, we capture images of road with live streaming of video using mobile camera with live streaming of road through transmitter and receiver modem, is continuously get converted to binary form using binarisation. Using HST for binarisation, we convert picture from color to RGB and suitable black and white form for separating and filtering out unnecessary 1's and 0's from captured image.

Filtering Process is done using edge detection and medium filter for cover out only ROI of pothole using image processing toolbox. It is feature based candidate extraction that is easily understandable to observe exact region of pothole on highways or main roads.

V. Simulations/Results

This is sample photo taken by drone at height about 20-25 meters above by camera. Using some image processing techniques. We can detect pothole live and send data to Municipal Corporation for database with location.

Sr. No.	Pothole Image s	True Positive (TP)	False Positive (FP)	Precision (%)	Recall (%)
1		72	14	80	73
2		79	18	92	81
3		80	20	94	83
4		73	13	78	69.8

Table 1. Precision Value of Detected Potholes

The key performance measures for this study are presented in Table 1. The sample study indicated a precision of our case study potholes are nearly by 78 % to 92%. It is possible to increase this accuracy by increasing the dilation process by several factors; however, this will lead to a loss of pothole detection, as more potholes likely merge with the outer road contour and other parameters like unwanted objects spread on road can also get included

The formulas to calculate the precision and recall are given in below Equations:

$$\text{Precision} = TP/(TP+FP)$$

$$\text{Recall} = TP/(TP+FN)$$

The values shown in GUI (Fig .7) in results that is 259.967 and 263.402 are pixel count in terms of area. This is calculated using formula a = W*L i.e. (Number of pixel in X-Axis * Number of pixels in Y-Axis)

Fig. 12: Live Detection of Pothole while Streaming Through UAV

Fig. 13: Live Detection of Pothole while Streaming Through UAV

VI. Conclusion

In this project the UAV used to examine road is to tackle a situation where administrator of road pavements cannot reach .In this project we proposed a method for automatic detection of potholes based on RGB color space image segmentation. Potholes are bowl-shaped depressions in the asphalt pavement, thus the region of interest was defined as asphalt pavement. Hence, we narrowed the search for potholes in this region only. The effectiveness of the method depends on the extraction of Region of interest accuracy. Once it is extracted, the potholes are detected by filtering pixels using medium filters and morphological operations in MATLAB. After all linear and image boundary shapes are filtered, the remaining portions are detected as potholes.

The proposed method was implemented in MATLAB and tested on 10 pothole images captured by the camera , the accuracy of estimation of pothole on pavement surface was about 78% to 92% which far better in this type of image processing technique. Therefore this method can be used for the repairing the pavements. True and False positives in table shows pixel values after binarisation and filtering process to calculate total precision of pothole detected. In Fig 12 and 13, Pixel count area helps to improvise detection process and helps to find approx area and width of pothole on road by unit Sq.Cm^2.

Using Artificial Intelligence and Machine Learning algorithms this can be more efficient in terms of accuracy and more precise image feature extraction of pothole to avoid unwanted things present on road. Also for depth calculation, Machine Learning algorithm can be used using stereo vision mode of depth estimation.

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