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PRIORITIZE ROADS ON THE BASIS OF SEVERE ANOMALIES

Rati Sharma
DIET, Shyampur
Rishikesh
rati_vce@yahoo.com

Kulvinder Singh
DIET, Shyampur
Rishikesh
Kulvindersing@dooninstitue.org

Laxmi Chand
NSIT, Delhi
Delhi
laxmisharma34@yahoo.co.in

ABSTRACT

In our daily life we have seen many of the road anomalies exist on the roads. Authorities are continuously working to get rid of those anomalies. Authorities need an inspection to checks various conditions of the roads. Currently these inspections are done manually which is a labor extensive job. This paper propeses a method to prioritize roads on the basis of severe anomalies present on roads. The technique used for prioritization is image processing and mathematics. Once prioritization is done, authorities can make a robust plan for the road maintenance.

General Terms
Road anomalies, prioritizing, image processing, manual inspection.

Keywords
Road anomalies, prioritizing, image processing, manual inspection.

1. INTRODUCTION

In the real time when road department want to do maintenance work on the road they need to plan a strategy. That strategy starts from inspecting all roads in the area allocated. That inspection starts with manually covering roads and identifying the number of road anomalies on each road. The inspection also includes checking severity of roads by identifying characteristics of anomalies detected. After doing all the inspection and writing down all details about the anomalies found on the road, the next step starts with setting up the priorities of the road on the basis of severe anomalies. Once anomalies found and prioritize is set up then, RD can start with the costing and planning of the maintenance work. Road anomaly detection is one of the important tasks for the proper planning of repairs and rehabilitation of asphalt pavements. When safety of commuters is on risk then road repair is necessary. This research paper proposes a visio based digital image processing methd to detect the road anomlaies and prioritize the roads on the basis of sever anomalies.

2. LITERATURE REVIEW

Threre are 3 approaches to detect the road anomalies: vibration based, laser based and vision based [1]. Vibration and laser based methods are highly expensive due to equipments used in it. In this research a new vision based method is proposed for detection of anomalies and prioritization of roads.

Pothole is a cavity on the road with having 150 mm diameter and 25mm depth [2]. An approach has been proposed [1] for identifying and extracting potholes usin spectral clustering and histogram. This method is successfully teste on Google image collection. [4] proposed a method of detecting pothole with help of optical device mounted on the vehicle to take input images. The optical device consists of optical part and GPS control part. Another paper, [5] proposed a method to detect road anomalies via digital image processing and k-mean clustering. It presents a way of processing road images to detect potholes with hough transform technique which can isolate a particular shape from an image. [6] proposed a vision based approach to identify the pothole using window mounted camera. Here is the method to detect the road anomalies on asphalt pavement digital image processing and convex hull. A study, [7] defines that area of an object can be calculated by counting the total number of pixels inside the object. Perimeter of an object can be calculated as the total number of pixels making the boundary of the object. Using a different approach [8] provides a vibration based a method to detect pothole using a commercial black box camera. The proposed system is mounted on the front windshield of a vehicle and can detect pothole. A pothole-detection algorithm is installed on an embedded board in the black-box camera. This algorithm collects information regarding the size of potholes and their location, and this information is stored in the black box

3. RSEARCH METHODOLOGY

3.1 Identification of a Problem

After reviewing different methods to detect the pothole a new visual based method is proposed to detect raod

anomalies. This approach requires to taked videos of roads instead of pictures from a specific segment. The road's conditions is then analysed to check whether roa d needs repair or reconstruction. The analysis and decision is done on the basis of the severity of road anomalies. Prioritization is present to user in order to make maintenance strategy.

3.2 Objective

The objective is specifically to take into account the vision base digital image processing techniques to detect the severe road anomalies from the real time images. The algorithm covers:

a) Number of anomalies on the road.
b) Severity of anomalies on the basis of their characteristics.
c) Prioritizing the roads on the basis of damage present on the road.

3.3 Methdology

This research provides a methodology to automate the process for road repair. This research proposes an algorithm named PRSA (Prioritize Road on the basis of Severity of Anomalies). PRSA prioritizes the roads according to the anomaly characteristics.

Figure 1 shows the block diagram of the proposed work.

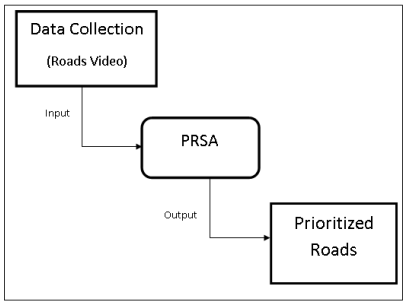


Figure 1. Block Diagram

The proposed research work starts with the data collection. The data collection is done by taking road videos on the vehicle. These roads video are then fed into the PRSA algorithm. The PRSA is an image processing system which works on the videos captured. The PRSA algorithm extracts road anomalies from road videos, characterize the anomalies on the basis of their area. The algorithm then, prioritizes the videos on the basis of severe anomalies present. The out put of the PRSA are prioritized roads. All the inspection, analysis, and decision making is converted from manual process to an automated process by proposed PRSA.

4. SOLUTION APPROACH (PRSA)

Figure 2 represernts the approach for PRSA. The algorithm is described below:

4.1 Video creation

A digital camera is used for image acquisition. The digital camera captures 2D images. Which is fitted at the rear of the vehicle which should be running are the speed of 10KM\H. The camera should be in sync with vehicle's reading to capture the distance covered on the road while capturing the video. Video coverage should be 1.462M X 0.925M (Length X Width) per video frame. The screen resolution is 1280 X 720 pixels (RGB). The video creation on road is done in natural light during the day time, not in rainy day.

4.1.1 Preprocessing

Preprocessing starts with retrieving frames from video followed by grayscale conversion. The conversion is done using weighted of RGB components0.3R + 0.59G + 0.11B [37].

Median 5X5 filter is used to remove noise from the images [9]. Normalization of pixel intensity value is done by replacing pixels intensity values with average intensity value of image [10]. The normalization removes some unwanted features (i.e road marks) form image which were not addressed by median filter.

4.1.2 Binarization

Thresholding is used to convert gray scale image to a binary image. Static thresholding is very common method for Binarization. This research uses dynamic thresholding since these image have got uneven light and shadows effect[10]. Below are steps used for thresholding:

a) Create a mean filter of window size 120.
b) Apply this mean filter to the input grayscale image.
c) Subtract the grayscale image (output of step3) from the filtered image.
d) Threshold the difference image with a constant 0.002.

4.1.3 Anomalies recognition and extraction

The black an white image contains Area Of Intereset (AOI) in form of black pixels background is represented as white pixels [10]. Probable AOI which can be anomalies and relates to this thesis can detected by Morphological image processing. Morphological erosion-dilation-erosion is used for anomalies detection. A square 3x3 kernel is used for morphological operations. Erosion operation adds some more black pixels to black and white image. The addition of more black pixels can connect those regions pixels which may be part of single anomaly.

Some unwanted and isolated black pixels might added to image as a result of erosion openratio. Thes black pixels needs to be removed as precation of wrong identification of anomalies. Dilation needs to be done to remove these black pixels in an image. Morphological operations creates the group of black pixel (which can be road anomalies) in the image.

Now anomalies extractions needs to be performed. Connected component labeling is done to label the groub of black pixles uniquely [10]. Boundary of these

group of lebel black pixels can be extracted by boundary extraction with 8 -neighbours.

4.1.4 Anomalies characteristics calculation

The above step gives the imformation about boundaries and group of labeled black pixels. Since we are working on the fact that

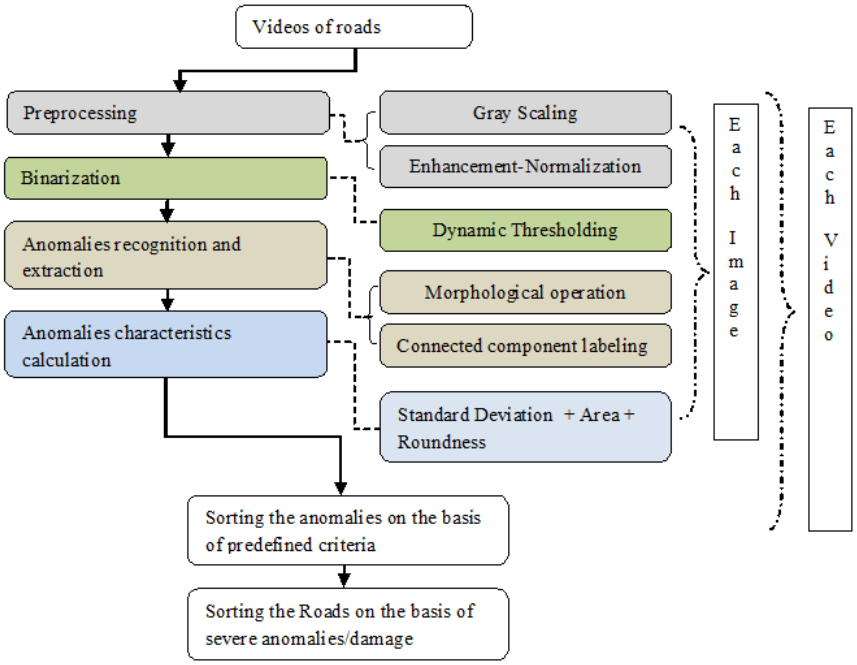


Figure 2. PRSA

anomalies have darker intensity values over an image. To make sure that these group of white pixels are anomalies in actual or not, some characteristics of these group of pixels needs to be identified. These are:

4.1.4.1 Perimeter

The Perimeter of a region is defined as total number of pixels in boundary image [11].

4.1.4.2 Area

The Area of region is defined as total number of black pixels exists in the region [11].

4.1.4.3 Roundness

Roundness: Since mostly, potholes are circular in shape roundness of a region can be defined as the below equation 3.1 [11]

$$\text{Circularity}(\mathcal{R}) = 4\pi \cdot \frac{A(\mathcal{R})}{P^2(\mathcal{R})},$$

Where, A is Area of the region and P is Perimeter if the region.

4.1.4.4 Standard Deviation

Standard Deviation: The standard deviation of pixel intensities in the region tells how the intensities are spread in the region. To calculate the standard deviation of intensity values mean and variance of intensity values need to be calculated first. After that below formula would work to calculate the standard deviation [11]:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where, N is total number of intensity values, x is intensity value, μ is mean of intensities.

The group of these black pixels are said to be road anomalies if the characteristics for potholes are :

a) Standard Deviation is in between 28 and 40.
b) Area is greater than 177 square cm
c) Roundness is greater than 0.2.

Below characteristics should be checked for patch detection.

a) Standard Deviation is in between 20 and 26.
b) Area is greater than 300 square cm. Since patches are bigger in size, this parameter is obtained by doing a survey on pune roads to get an average minimum surface area of patches.
c) Roundness is greater than 0.05.

Previous step gives the diameter of AOI in terms of pixels but this need to be converted into mm for the categorization. The conversion requires calibration factor. Calibration factor is the ratio of the actual dimension (cm/mm) of the object and the number of

pixels captured by the object in the image [11]. PRSA uses video frame of 1280 X 720 pixel over the area of 180 X 120 cm. To calculate the calibration factor for PRSA a ruler has been placed over the road surface. Fig.2 shows the placement of the ruler over the surface. The actual area of this ruler is 126 square cm. The pixels covered by the ruler in the image are 8575 pixels. So, calibration factor for area is:

(Actual area of ruler (cm)/no. of pixels occupied by the ruler)

Figure 2: Ruler

= 8575/126 = 0.014694 (square cm)

= 0.14694(square mm)

Hence, area of 1 pixel = .014694 cm.

Now, this calibration factor would be used to measure the anomalies characteristics in cm/mm.

4.1.5 Sorting the anomalies on the basis of predefined criteria

When all the frames are processed and all anomalies are detected sorting needs to be done to detect the sever anomalies. Severity of anomaly is checked on the basis of its area. The more the area occupied by the anomaly the more severe it is. Get top 5 anomalies of the each road which needs to be prioritied. This step also calculates the % damage on the road as

(Sum of area of anomalies/Total area of road) * 100.

4.2 Sort the roads on the basis of severe anomalies

Input to this step is top 5 anomalies and % damage of all videos. This step again subdivided into:

a) Get top 5 severe anomalies from all road videos and puts to this step. Prioritize the road according to the top 5 severe anomalies.
b) Prioritize the road according to the % damage on the road mentioned in section 4.1.5.

5. IMPLEMENTATION AND RESULTS

Matlab 2015 is used to implement and test the results of proposed algorithm.

5.1 Results

The method has randomly selected 3 input videos captured while data collection. V1.mp4, V2.mp4 and V3.mp4 are the road videos.

Table 1. Total anomalies found on roads

Video	Anomalies found	Duration (processing)
V1.mp4	8	25 min
V2.mp4	5	30 min
V3.mp4	12	20 min

Table 2. Results in Images.

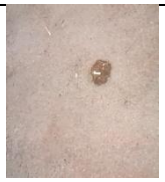
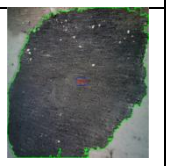
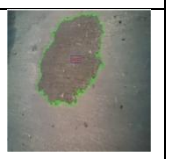
S. No	Input Image	Preprocessing	Output Image. Anomaly present in green boundary.
1			
2			
3			

Table 1 lists the total number of anomalies found per video. Table 2. shows the results of some images retrieved from the input videos. Ther first row shows the pothole while other rows shows the patch detection.

The sorted anomalies from V1.mp4, V2.mp4, V3.mp4 roads are lists in Table 3, Table 4 and Table 5 respectively.

Table 3. Top 5 sorted anomalies of V1.mp4

Video	Anomaly	Area of anomaly(square cm)
V1.mp4	V1-A1	534
V1.mp4	V1-A2	500
V1.mp4	V1-A3	462
V1.mp4	V1-A4	387
V1.mp4	V1-A5	385

Table 4. Top 5 sorted anomalies of V2.mp4

Video	Anomaly	Area of anomaly(square cm)
V2.mp4	V2-A1	700
V2.mp4	V2-A2	576
V2.mp4	V2-A3	233
V2.mp4	V2-A4	219
V2.mp4	V2-A5	200

Table 5. Top 5 sorted anomalies of V3.mp4

Video	Anomaly	Area of anomaly(square cm)
V3.mp4	V3-A1	588
V3.mp4	V3-A2	278
V3.mp4	V3-A3	245
V3.mp4	V3-A4	211
V3.mp4	V3-A5	199

The road videos are sorted according to the area of anomalies. Table 6 shows the result of sorting the anomalies mentioned in Table 3, Table 4 and Table 5, extracting top 5 anomalies.

Table 6. Sorted Roads

Video	Anomaly	Area of anomaly(square cm)
V2.mp4	V2-A1	700
V3.mp4	V3-A1	588
V2.mp4	V2-A2	576
V1.mp4	V1-A1	534
V1.mp4	V1-A2	500

Table 7 shows the Prioritized roads according to sorted road anomalies in Table 6.

Table 7. Prioritize roads

Prioritized Roads	Priority
V2.mp4	1
V1.mp4	2
V3.mp4	3

The % damage of road can be calculated as:

(Sum of area of anomalies/Total area of road) * 100.

Table 8 shows the result of % damage found on roads.

Table 8. % Damage Road

Video	Area of Video(square m)	Area of anomalies (square m)	% Damage
V1.mp4	135.44	33.74	24.4
V2.mp4	140	22.3495	15.95
V3.mp4	192.33	28	14.58

Table 9 shows the priority of roads on the basis of % damage.

Table 9. Prioritized Roads(% Damage)

Prioritized Roads	Priority
V1.mp4	1
V2.mp4	2
V2.mp4	3

5.2 Performance Parameters

The performance of PRSA can be described by calculating accuracy, precision and recall.

Accuracy = (TP+TN)/(TP+TN+FP+FN)

Precision = TP/(TP+FP)

Recall = TP/(TP+FN)

Where, TP is True Positive : Anomalies area correctly detected. TN is True Negative: Non Anomalies area not detected as anomalies, FP is False Positive: Non

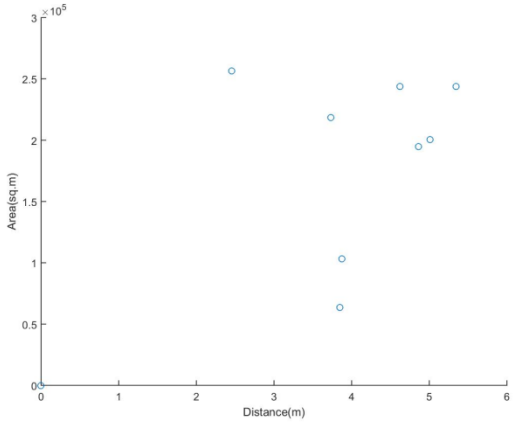
Anomalies area detected as anomalies and FN is False Negative: Anomalies area not detected as anomalies needs to be calculated. Table 10 shows the performace of PRSA.

Table 10. Performance Parameters

Parameter	Value
Total TP	18
Total FP	4
Total TN	17
Total FN	6
Accuracy	77.77%
Precision	81.81%
Recall	75%

7. GRAPHS

Graph 1 shows the anomalies and their distance from the starting point for road V1.mp4.



Graph 1. Anomalies and Distance

Analysis of graph concludes that the road V1.mp4 is majorly damaged in between 3.5 m to 5.5 m from the starting position. It also describes that the most severe anomaly is 2-3 m away from the starting point.

8. CONCLUSION AND FUTURE WORK

The PRSA takes videos of roads as input. It processes the video one by one and takes out the anomalies on the road with their area. PRSA calculates the % damage on the road as well. Once anomalies are found PRSA sorts it according to the severity. The bigger the area of anomaly the more severe it is. Once all anomalies are sorted PRSA prioritize the roads on the basis of severity of anomaly. PRSA helps in prioritizing the roads on the basis of % damage present on the road.

The research work can be extended to many aspects by using other techniques and methodologies which can make the anomaly recognition process more accurate when there is change in illumination. The FP and FN can also minimize in future work. The future work would require the analysis of these factors on the image processing techniques.

9. ACKNOWLEDGMENTS

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