MACHINE LEARNING BASED APPROACH FOR POTHOLE DETECTION

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ABSTRACT
Potholes in roads constitute a major problem for both citizens and the government. Governments’ employee engineers and workers to detect damages to roads, distress, etc. This is highly time consuming and requires a lot of manpower. This paper explains the method used in the automatic detection and classification of damages to roads, potholes and cracks. In this process the types of damages like potholes, cracks and subsistent depressions are framed. The captured images of road and preprocess the data have been taken by converting the image into HSV color space, sample patching for image mask and applying contour detection, convex hull calculation and a final extraction of image. Feature selection is done and based on that feature selection and machine learning algorithms are used for classification.

Keywords: Decision trees, Image processing, Naïve Bayes, Potholes, K-Means.

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1. INTRODUCTION
Government needs accurate information for effective road maintenance at regular intervals. But, road inspection requires enormous of man power every year. This obviously slows down the process due to the distance involved. Automation technique for road damage detection and classification is highly effective in road management. Machine learning algorithm for classification and convex hull for image processing have used for the addition of weightage for the automation. Usually the images obtained from the data do not completely suit the purpose of analysis. Pothole is the kind of damage in roads which is caused as a result of
cracks and by water and traffic. There are many kinds of textures that found from the road and arising from many factors like different zones of the image. Hence it is quite difficult to categorize the damage to the road. Each road image has exclusive features like the shape of the road and width of the road making it difficult to apply defect detection process. Multiple image processing techniques and multiple types of features have been used for overcoming this problem and for the application of the machine learning techniques.

![Figure 1 Sample Image](image)

Detection methods for the crack in roads, experimental setup, methods for implementation and the machine learning techniques to be used for classification are subjects discussed in this paper which concludes with the results seen in the application of various machine learning techniques.

2. RELATED WORK

Many works based on this pothole detection have been carried out using different algorithms and various image processing techniques. The authors [1] proposed a paper based on crowd sourcing technique. The author has developed a crowd sourcing system for detecting and localizing potholes in various road conditions using accelerometer data obtaining from sensors. This crowd sourced system reduces the required network bandwidth by determining road incline and bank angle information in each vehicle to filter acceleration components that do not correspond to pothole conditions. The system on simulated and real-world data has been evaluated in the number of vehicles and the amount of bandwidth required for accurate detection analysis, and the results have been compared with those from the simpler single lane detection scenario. In [2], the authors have proposed a pothole detection technique by capturing data from 2D lidar and cameras. The main usage of these lidar cameras lies in its ability to capture a wide area with high accuracy. After the data capturing, various algorithms like filtering, classification and line extraction and gradient of data function are used. Pothole detection from video data and the combination with 2D lidar provided a more accurate pothole detection performance.

In [3] authors have proposed a methodology with various image processing techniques for this pothole detection done by evaluating and comparing the performance. Among all those methods, K-Means clustering technique has been found to be the best considering its fast computing time and segmentation based on edge detection preferred for its specificity. This author proposed future work will be in different classifiers like Neural Networks and fuzzy rule creating a standalone application for this detection. V Rishiwal has proposed that the importance of road surface surveillance. This is discussed in this paper for the safety of the travelers. Potholes are detected by vibrations based on severity levels. This method can be
easily installed on any smart phone. The acceptance of this proposal is directly proportional to the results of this paper. Results seen from the author’s proposed work can be tested using different algorithms under different road conditions.

3. METHODOLOGY

Pothole detection is being carried out using two techniques namely image processing and machine learning techniques. Those two techniques are used for a study of the detection and occurrence of potholes. The HD image has been captured from the Indian roads and used for analysis. The authors [4][5] proposes a method for the identification of potholes from the images. Visualization approach is also used for feature selection. The use of the previous mentioned methods helps isolation of the roads from the image and its extraction. The extraction process is followed by processing on it for pothole detection.

![Figure 2 Before applying HSV](image1)
![Figure 3 After applying HSV](image2)

This section provides a brief description of the pothole visualization. In method 1 morphological transformation is applied followed by contour detection. In method 2 the extraction of image is done with the help of convex hull algorithm.

3.1. Morphological Transformation

Morphological transformation is the technique which is based on the shape of the image. It is usually applied on a digital image. The two important morphological operations are erosion and dilation. Operation with these methods helps analysis of the data for future visualization of potholes in a specific region.

![Figure 4 Capturing Region of Interest](image3)

3.2. Contours and Convex Hull

Good visualization requires capture of the area of interest from the image. This operation of capture is done by selecting the largest contour from the images. After the selection of the largest contour, convex hull algorithm is used for drawing the convex hull. Selection of the area of interest helps prevention of unwanted data that has an effect on the identification of
pot holes. The image processing techniques can be applied for contour detection, edge detection and blob detection for drawing the box which surrounds the area of pothole.

![Magnified Region of Interest](image1.png) ![Masking the Region of Interest](image2.png)

**Figure 5** Magnified Region of Interest  **Figure 6** Masking the Region of Interest

### 4. POT HOLE DETECTION USING MACHINE LEARNING

Application of machine learning technique requires during feature extraction. This can be accomplished in two ways namely downs caling the image and color histogram. The later represents the different colors seen in the image. It projects the different colors and total count of pixels in each color. Histogram is the perfect summarization of the variety of data from the image. The color histogram suits that image being unvaried with rotation and translation from viewing axis and only with angle of view. Comparison between the two histogram patterns and both with color content assists classification of the position of an object and its notation. The presence of potholes in different shaped and colors makes figuring the unique feature a different job.

#### 4.1. Machine Learning Algorithms

Various machine learning algorithms have been used in this project. The extracted features have been trained into the model and analyzed.

##### 4.1.1. Support Vector Machine

Support Vector Machine (SVM) is a supervised machine learning algorithm which can be used for both classification and regression challenges. However, it is used in classification problems. In this algorithm, each data item is plotted as a point in n-dimensional space (where n is number of features you have) with the value of each feature being the value of a particular coordinate. Then, classification is performed by finding the hyper-plane that differentiates the two classes very well.

##### 4.1.2. Decision Tree

Decision tree is a type of supervised learning algorithm (having a pre-defined target variable) that is mostly used in classification problems. It works for both categorical and continuous input and output variables. In this technique, the population or sample is split into two or more homogeneous sets (or sub-populations) on the basis of most significant splitter / differentiator in input variables. The main part comes in following image preprocessing segment, namely analysis using machine learning algorithms. Different classifiers are trained and the data is tested to figure out the accurate detection of potholes from the image. In this segment the methods used for the pothole visualization and the detection techniques are discussed. The three segments in these projects are image processing-based visualization, feature extraction and finally machine learning algorithms.
4.2. POTHOLE VISUALIZATION

4.2.1. Morphological Transformation Method
The image taken from the camera is smooth handed using Gaussian blur and with the application of certain amount of threshold. Basic morphological operations such as opening and closing transformations are applied for removing noise from the image. The required area is then extracted. Edge detection methodology is used for detecting potholes from the image.

4.2.2. Visualization from isolated roads
The image which is captured from the camera is converted to its HSV channels as it finds the maximum variance from the image. Following the performance of HSV, the region of interest can be selected. The standard deviation and mean are calculated for each color channel from the region of interest. Each road color is modeled individually per channel which is in between three SD of mean in of every individual channel. This is done to avoid the problem of variation in color seen in roads. These are the threshold values which are used to be binaries of the image and for obtaining the mask. The average color model which does not match with complete roads is not included as the most of the areas are not be included after this operation. The next algorithm is contour detection applied on the mask. After many of these operations, the biggest contour of the image is considered and sent to the convex hull. The biggest contour of the road is extracted using the mask from the convex hull.

Figure 7 System Architecture

Figure 8 Convex Hull of Largest contour  Figure 9 Convex Hull Marking
4.2.3. Blob Detection Method

The road area is taken and put under analysis for the visualization of potholes. Basically, this blob detection method is used for identification of the regions from the image which differs in its properties such as contrast, brightness, etc. The potholes are assumed having different textures compared to road area mainly from dark areas. This blob detection is mainl used for distinguishing potholes from other factors.

![Result of Convex Hull Marking](image)

4.2.4. Contour Dilation Method

The captured road area can also be put under contour dilation and edge detection methods. This detected edge is enlarged for highlighting the presence of potholes. Potholes are in different shapes and color.

5. RESULTS AND DISCUSSION

The conventional image processing techniques provide results that are then insignificant. The first method prepared does not work well as the edges in the road create the needless contours which are indicated as potholes. Method 2 with contour detection does not work most of the time. So, identification of potholes using visualization does not ensure accuracy and does not have the ability to find the feature for the purpose of analysis. When training the models, the color histogram as a feature works better than a downscaled image. The DECISION TREE with the combination of color histogram provides the maximum accuracy but SVM, KNN and GAUSSIAN do not.

```plaintext
Extraction done
20
Extracted feature labels
Using Downscaled image features
['Y.JPG', 'N.JPG', 'Y.JPG', 'N.JPG', 'Y.JPG', 'N.JPG', 'Y.JPG']
Training Gaussian
Training KNN
Training SVM
Training Decision Trees
Prediction score for
SVM:91.6666666667
KNN:90.6666666667
Gaussian:61.6666666667
Decision Tree:66.6666666667
Using Color histogram features
['Y.JPG', 'N.JPG', 'Y.JPG', 'N.JPG', 'Y.JPG', 'N.JPG', 'Y.JPG']
Training Gaussian
Training KNN
Training SVM
Training Decision Trees
Prediction score for
SVM:58.3333333333
KNN:66.6666666667
Gaussian:83.3333333333
Decision Tree:91.6666666667
```
6. CONCLUSION

The conclusions reached are that a combination of machine learning and image processing techniques generates good performance in pothole detection and machine learning techniques provide better results than the usual image processing models. The paper provides a good description of the feature extraction methods and its performance. The current work is distracted by sense which has heavy shadows, lighting problem, etc. A good process which can detect potholes even in bad conditions such as uneven lights, shadows, etc. is required. The various methods in Deep learning can also be used for the analysis.

REFERENCES

[7] The annotated image dataset used in the pothole detection is freely available at: https://goo.gl/3QyeMs
[8] Open CV is used for Image processing and Machine Learning: http://docs.opencv.org