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Pothole Detection Using Deep Learning

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ABSTRACT

Connecting lines between different places are roads.There are over 64 or more millions kilometers of road in the world. India is the second-largest road network in the world.Potholes are not a new issue. All countries almost have the similar problem. One of the major problems in countries is maintenance of roads include potholes. Detecting and reporting the existence of potholes to responsible departments can save the roads from getting worse.However Detecting potholes manually is a labor-intensive and time-consuming task as well as expensive procedure.In order to solve this problem, various techniques have been implemented ranging from manual reporting to authorities to the use of vibration-based sensors to 3D reconstruction using laser imaging. But all these techniques have some drawbacks such as the high setup cost, risk while detection or no provision for night vision. Because of this we designed a smart pothole reporting system, so that all the problems could be reported to the concerned authorities as soon as the problem arises.In this paper we present our approach to building a generalized learning model for pothole detection. We apply four data-sets that contain a range of image and environment conditions. Using the Faster RCNN object detection model, we demonstrate the extent to which pothole detection models can generalize across various conditions. Our work is a contribution to bringing automated road maintenance techniques which helps for citizens and the government.

Index Terms—Pothole detection, Deep Learning, Transfer Learning, Deep Learning, Tensor flow API, Accelerometer, Image Labelling, F-RCNN, inception-v2

I. INTRODUCTION

There is close relationship between the accident and road condition including a pothole, Road accident detection and avoidance is a more difficult and challenging problem in India. The road network plays an important role in Indian economic development and social functioning. According to the report in the last ten years, the Road Transport sector GDP grew at an annual average rate close to 10% compared to the overall annual GDP growth of 6%. Nowadays road construction is done very rapidly by the government of India. But road maintenance is a challenging task because of the poor drainage system and overloaded

vehicles. Due to poor maintenance of roads, potholes get appeared on the road which causes road accidents. The first step toward prompt repair of the road surface is to get known the condition of the road in terms of defects. The most common defect on road surfaces are potholes, bowl-shaped holes of various sizes in the pavement surface . On road surface potholes are formed by a variety of reasons namely wear and tear of the road, age of the road, heavy rainfall, materials responsiveness to climate change, bad construction material used and external factors such as poor drain and quality construction management. Recently, damaged roads surface with potholes as shown in Fig. 1, are increasing in India, and thus complaints related to potholes are also increasing. Road with good condition always contributes a major portion to the country's economy.

Fig. 1. Damaged roads surface with potholes.

There are many models and methods for pothole detec-tion.The vibration method, which is based on an accelerometer sensor, can't predict potholes ahead of time. This is because the vehicle should pass over the pothole for detection. This method cannot differentiate between potholes and other arti- facts on the road like bridge joints and road reflectors. Laser scanning systems are classified among the 3D reconstruction methods. This system can detect potholes in real-time. How- ever, such a type is costly and has a short range of detection. Likewise, stereo vision methods are used in pothole detection. The drawback of this method is the high computational effort for pavement surface reconstruction,vibration sensitivity, and the need for perfect alignment of cameras. Kinect sensor, based on infrared technology, is developed by Microsoft.

The sensor is regarded to be costly and necessitates a close distance to the pothole. Finally, the vision based approaches that make use of monocular camera along with some object detection algorithms showed an improvement in real-time pothole detection.

The captured images of the road are fed into a Convolutional Neural Network (CNN). The paper tested different models of CNN: Self-built CNN models and CNNbased ResNet models. The system with ResNet152 achieved an accuracy of 95.98%. Another deep learning algorithm is used to detect potholes . 900 images with potholes were used to train Faster-RCNN. After detecting a pothole, the image of the pothole is saved. The collected data are saved in a server.The neural network consisted of four convolutional and pooling layers and one fully connected layer. The team captured images from different places and had variant conditions, like dry, wet, and shady potholes. The images collected were resized to 200x200 pixels and cropped to remove unwanted parts of the image, they only kept the pothole. After data augmentation is used to get a larger dataset for training with 13244 images, 3250 images for validation, and 500 images for testing. The system achieved 98.9% accuracy, 100 precision, and 99.7% recall.Thus our model performed better than the other models and methods.

II. RELATED WORK

There are many works based on this pothole detection have been carried out using different algorithms and various image processing techniques,from the literature survey carried out, there are different methods for pothole detection.In [1] the authors proposed a deep convolutional neural network (CNN) based on YOLOv2 approach. In this method, the author discussed a significant increase in performance over YOLOv2 from 60.14% to 82.43% average

precision. Proposed F2- Anchor and Den-F2-Anchor models achieved better results. In [2] the authors proposed a way to implement detection of pothole using a smart phone, and classification is performed using Transfer Learning. 70% data (70 instances) is used for training and 30% data (30 instances) is used for testing. Proposed method recognized correctly all of the instances showing 100% of classification rate.In [3]the authors proposed a paper based on crowd sourcing technique. The author has developed a crowd sourcing system for detecting and localiz- ing 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[4] the authors detected potholes by using smart phone camera and image classification method based on the deep convolutional neural network models and obtained the classification accuracy rate of 97% using colored images and 97.5% using gray-scale images.In [5] 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 [6] authors compared results with self-built CNN architecture by changing some parameters twice and achieved test accuracy of 64.42% and 73.06%. Authors also tried different pre-trained ResNet model. Authors obtained results on image size 224 using ResNet101 pre- trained model and achieved validation accuracy of 97.08%.

III. PROPOSED METHODOLOGY

Design a smart pothole reporting system, so that all the problems could be reported to the concerned authorities as soon as the problem arises.The main motivation,objective of this paper work is to develop a system that can detect potholes from images.For this, a deep learning-based approach has been used. A convolution neural network (CNN)-based model i.e faster-RCNN has been designed that takes as input-images of potholes and non-pothole roads. After training the model on this data, the model predicts if the input image is of a pothole or non-pothole.

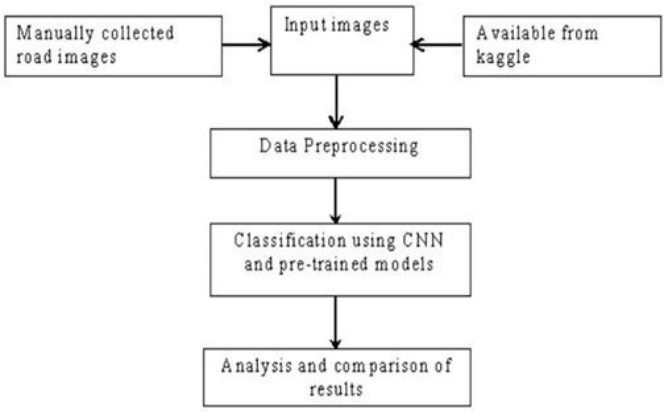

Fig. 2. Proposed Methodology used for pothole classification and detection.

IV. IMPLEMENTATION

A. Data Acquisition

This is first and important step.In this step many photos of pothole is taken from various angles and all these contribute to a data-set. This data-set contain both potholes and non- potholes images.Some road images are manually collected and some from Kaggle. Potholes are identified by considering following factors-:

1) According to potholes size there are Low, high and medium type of potholes.
2) According to potholes shallowness there are non-shady and shady type of potholes.
3) According to moisture presence there are dry and wet type of potholes.

B. Data Prepossessing

It is also most important steps in which we perform the various prepossessing technique on the data-set. The following operations are -

1) Capturing of photo: Photos are captured in such a way that the camera labels do not hinder photo-processing methodologies.
2) Images re-sizing: Images are re-sized to half before training to avoid a case in which hardware is unable to handle the processed images.
3) Zooming of image: Zooming means changing the mag- nification of the image this can be useful when the image is taken far from potholes.
4) Rotation of the image: The pivot point of the image changes during the rotation of the image. An image containing potholes and non-potholes when rotated will look as if the different image was taken from a different angle.
5) Mirroring of image:: The mirror image of potholes means replicating or making multiple copies of the data, this will increase the size of the training data-set.
6) Blurring of image:: Decreasing the sharpness of sharp elements of an image such as edges, corners are known as Image blurring. Blurry image decreases the size of the image which will increase the size of the data-set and leads to better training of the data model.
7) Improvement of comparison:: Image contains more in- tensity when the contrast of the image is increased and thus improves the training of the model.

V. IMAGE CLASSIFICATION: POTHOLE DETECTION WITH FASTER-RCNN

For solving the object detection problem for pothole de- tection we have trained a s object detection model i.e Faster R-CNN.Faster R-CNN has two stages for detection. In the first stage,images are processed using a feature extractor called the Region Proposal Network (RPN) and simultaneously, intermediate level layers are used to predict class bounding box proposals.Faster R-CNN stands for "Faster Region-based Convolutional Neural Network". Before talking about Faster R-CNN we should know about Fast R-CNN. Fast R-CNN is a detector that uses an external proposal or external selective search. It consists of External selective search, CNN with max pooling, ROI (Region of Interest) pooling layer, fully connected layers, and output layers. Fast R-CNN takes an input image and then with the help of CNN max-pooling layers, a convolutional feature map is extracted from the image. The ROI pooling layer performs a very important task here. We know that fully connected layers can accept only certain sizes, So ROI pooling layers converts the output of the CNN into certain fixed sizes.After putting Fast RCNN with the RPN(Region proposal network),it becomes Faster R- CNN.So,basically, the difference between Fast R-CNN and Faster R-CNN is the Region proposal. In Fast R-CNN,there is an external selective search whereas in Faster R-CNN RPN is combined with the Architecture.

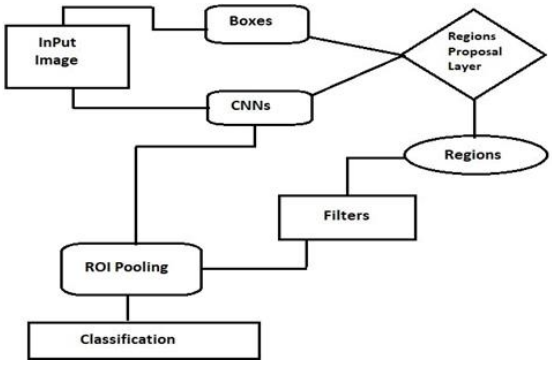

Fig. 3. The Architecture of F-RCNN.

In order to get a trained working Faster R-CNN architecture, we need to perform the following steps –

- For training of RPN – first of all, we need to Train the RPN architecture with the data-set so that it can propose the expected region.
- Training of Faster R-CNN – As we know, Faster R-CNN is a combination of RPN and Fast R-CNN. So, we've to train a Fast R-CNN with the proposals obtained by RPN (after training) in order to make a Faster R-CNN.

- For fixing Convolutional layers, fine-tuning unique layers to RPN.
- Fixing Convolutional layers, fine-tuning fully connected layers of Fast R-CNN.

VI. RESULT AND ANALYSIS

By using the neural network configurations our model was based on the deep learning and image processing was completely developed. We compared [Fig 4] SSD ,YOLO and Faster R-CNN,While comparing YOLO achieve 67% accu- racy and SSD achieve 88.78% accuracy.Most Important our proposed model i.e Faster R-CNN achieves 98.9% accuracy. "Single Shot Detector" achieves a good balance between speed and accuracy.However if you are strapped for computation SSD is good recommendation ,if accuracy is not to much important and you want go super fast then YOLO(You Only Look Once) is better recommendation. But if you want both best speed and accuracy then Faster R-CNN is best choice.

The proposed system for finding holes using a Faster R- CNN-based model can achieve high accuracy.This method has several advantages over other techniques such as greater accuracy, lower cost, less complexity, can work at night and in foggy weather, and also does not cover the risk of overcrowding.

Our future work will include a larger datase for training and it has more images for potholes from different roads, with several severities and different lighting and weather conditions

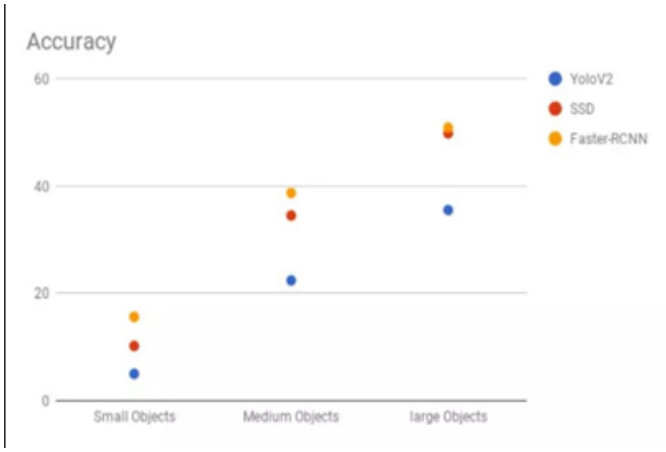

Fig. 4. The Compared Result.

VII. SYSTEM ARCHITECTURE

- Establish a request application where citizens can register a complaint for a given pothole and the relevant author- ities will assess the validity of the complaint and take action on it.
- The actors in the whole process are citizens, PWD staff, and the head of PWD.
- Citizens are given the option to log in / register in the app to register a complaint about the pit. After that, the complaint is found to be valid or not. A photo was uploaded by a citizen and tested by CNN's in-depth learning model. If the complaint is valid then forwarded to the PWD (Public Works Dept.) function.
- Database mines are easily accessible online.
- The employee receives new complaints according to the area where the complaint was reported by the citizen and refers the complaint to the Head of the Disabled. The PWD Head is responsible for receiving the appeal referred by the employee.

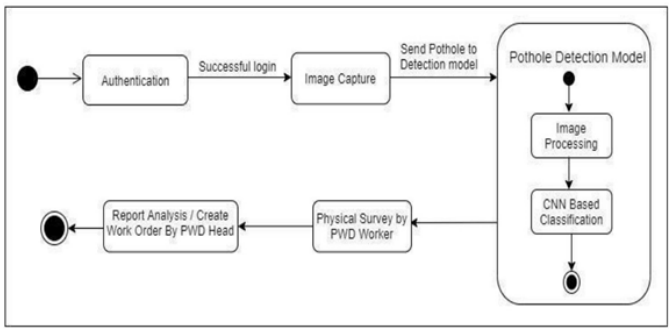

Fig. 5. System Architecture.

VIII. CONCLUSION AND FUTURE SCOPE

We developed an innovative system and method to find pot- holes easily using Faster R-CNN.From this work we analyzed the feasibility and accuracy of thermal imaging in the field of pothole detection. After collecting a suitable amount of data containing the images of potholes under various conditions. We trained an object detection model using the Kaggle pothole dataset. We used Faster RCNN with a variety

of conditions including small image sizes, different image types and lighting effects.

We have demonstrated and tested the pothole and non- pothole detection using various deep learning classifier algo- rithms. The performance of these models are measured and compared using various parameters like accuracy, precision, and recall. We achieved an accuracy of 98.9% which is higher as compared to other models.

Capturing potholes in a time-efficient and user-friendly way can be beneficial for the development of developing countries and for this purpose we are identifying potholes using deep learning which is far better than current techniques. Using this technique, we can find potholes with higher accuracy and this method can be used by any citizen with great ease and the user can track their complaint and check, if necessary, actions are taken for their complaint. Moreover, this technique will save a lot of time for PWD workers as now they don't have to find potholes manually.

We will be building a model that will predict the exact location of the pothole in real time and will be able to predict the location of the pothole, this model can be used in a self- driving car or can also be used to build an alert system for blind people. We will build a model which is mounted in traffic signal cameras and road side lights that will predict the exact location of pothole and capture image and able to send respective department.

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