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Pothole Detection Using Deep Learning Classification Method

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Abstract

Potholes on roads have been a primary reason for road disasters and damage to the vehicles. Currently due to heavy rains and poor structure accoutrements roads surface have flaws. Detecting the potholes manually is time consuming and will not be detecting the flaw impeccably. The proposed system aim is to recognize potholes on muddy roads and high way roads[1] pictures in order to avoid disasters and damage to the vehicles. Deep learning algorithms are used to classify image dataset in order to determine whether the roads are plain or have potholes. Images are collected from internet sources,(muddy roads) dataset and another dataset is taken from Kaggle (highway roads) dataset. Pretrained models Resnet50, IncepectionV2 and VGG19 are used for training the model. Web application is implemented for testing the model to identify the roads whether there is a pothole or plain based on the selected models like Resnet50, InseptionResNetV2, and VGG19 models are trained for the system.The model performances are analysed for better accuracy, precision and recall.Compare to Resnet50 ,IncepetionResNetV2 models.VGG19 model has given the best accuracy with 97 percentage for highway roads and 98 percentage for muddy roads.

Keywords:
Deep learning;Pothole classification; Pretrained models,Highway roads,Muddy roads

1. Introduction

Potholes are the most prevalent bowl-shaped holes road defects of varying diameters on the pavement surfaces. Potholes are produced on the road surface by a multitude of factors. The road's wear and tear, heavy rains, materials, climate change resiliency, extrinsic issues such as the use of poor building materials and a clogged sewer, and inadequate construction management . One of the most serious issues in emerging countries is effective road surface upkeep road maintenance and agencies still face a significant problem in tackling this issue. The study of automatic methods for detecting and identifying distress has garnered a lot of attention in recent decades, and there have been

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several automated distress analysis systems developed. Pavement damage and pothole detection is critical for evaluating the road's impact and road repairs are required. Road surfaces deteriorate with time, transportation and safety are two crucial issues to be consider. Visual pavement distress diagnosis by humans is a slow process, high-cost, and work-intensive. One of the most essential responsibilities for good road surface repair and rehabilitation planning is the detection and assessment of potholes. For a preliminary estimate of road damage, road maintenance firms now require several working hours. Material, labour, and equipment expenses all influence the total cost-effectiveness of the patching process. The assessment of damage from the obtained data is crucial to future decision-making for rebuilding. To anticipate future degradation rates and budgets, an automated method is required. The demand for quick, precise, non-subjective examination of road distresses is growing. In this paper , we are comparing the muddy and

Fig. 1. Pothole

highway roads images for classifying the potholes and plain .1000 images are used to trained the pretrained models like Resnet50,InceptionResNetV2 and VGG19 .Web application is implemented for testing the model based on the selected models and classfiying the images and predicating the accuracy.The objectives of this work will use hierarchical features learned from labelled inputs to train the convolution neural network after preprocessing the input picture. The project goal is to fine-tune the network's hyper parametersand also adding the muddy roads dataset. By adding a subsampling layer after each convolution layer, the final goal is to reduce the network's training time and computation complexity.

2. Related Worked

According to the literature review that was done, there are various methods for identifying potholes. The tendency of cars to slow down when they encounter potholes causes accelerometer data to be unreliable. In addition, potholes were being used to describe speed bumps. The R-CNN-based algorithm requires a lot of processing time and takes a while to detect potholes. There is no dataset and the potholes have not been detected for muddy roads.
Surekha Arjapure[1] in this paper shows how different algorithms affect the performance of the model. Photos were captured manually under a variety of lighting settings and wide range of image features of a pothole. To classify the potholes and comparing the result with different models, five convolution layers are used in models with Relu activation function. Data split is taken as 72 percentage for Training and 28 percentage for testing. Three metrics were used to evaluate the suggested method's performance: precision, recall, and accuracy. Resnet, Inception and DenseNet models are used and among these models InceptionResNetV2 and DenseNet201 model have given the best classification with accuracy of 89.66 percent when compared to other models.
Abhishek Kumar's [2] in proposed system transfer learning method are used to detect potholes for real time photos

and video clips captured by camera. Transfer learning can save the time by selecting pretrained model and performing the fine tuning on the dataset. Here object detection API tensor flow model is used for detecting the potholes which can be used to detect objects in image. Advance CNN models like F-RCNN, Inception v2, Inception v1 models are used to detect the potholes. After detecting the pothole by using the android app it will notify the driver if there is a pothole on the road.Disadvantage of R-CNN-based models is that they take more time to forecast. Furthermore, models trained on other countries roads for identifying potholes function poorly on Indian roads due to the vastly differing damage circumstances.

Kanushka Gajjar [3] proposed system image processing and deep learning technique are used to detect potholes on the road for virtual pictures and video clips. Image processing techniques are used to annotate labels and crop the images for the dataset. SDD with inception v2 backbone model, RCNN model with inception v2 as backbone and YOLOv3 models are used. The IOT system will accumulate the position of the potholes on roads, GPS location is send to the cloud system to store the information and display the potholes on roadmap web application. Yolov3 model has given the system a best accuracy rate.

Vijayalakshmi B [4]This technique proposes detecting potholes using machine learning and image processing [4]. Gathering pictures from the camera and images are stored in database to train the model. Image preprocessing methods like denoising, Frame extraction, and grey scaling Blurring and Edge Detection on the image are used. Raspberry pi hardware component is used to detect potholes.

Poonam Kushwaha[5] the proposed study has built a Graphical user interface is built to identify potholes for users and administrators with the help of deep learning CNN model and a basic image processing mechanism, is used to determine the state of the road. PyQT module will have all Graphical user interface design methods like dropdown, screen display, textbox, etc.MySql database is used to store the user details for validate users to access the application. Image preprocessing is done by using the image processing methods like contour image, smoothen image and converting image into gray scale image. CNN model is used to predicate the potholes for the good accuracy. The aim of this system is to evaluate the road condition by analyzing the pictures. If the road is in poor condition, system will send information to the government site requesting for work to be done on roads.

Lim Kuoy Suong[6] proposed a work based on methods to identify potholes in which pictures are collected from a wide range of real-world scenarios such as random-bump potholes, under a variety of circumstances, shape and size of the pothole images are taken as dataset. Yolov2, F2-ANCHOR, DEN-F2-ANCHOR models [6] are used to evaluate the model and modifying the parameters by a massive margin to get the best accuracy. Anchor box model is used to detect the objects of dissimilar ratios and sizes.

Roopak Rastogi,[7] Distinct instances of data were collected to test different types of images like bright, dry, overcast, and wet days to detect the objects at Electronics city Phase, Bangalore. Labeling is tool used to annotate with bounding boxes for pictures to detect the objects in the image. The purpose of this research [7] is to assess the performance of turning deep learning models like Resnet18, YOLOV2 and faster RCNN with vgg16 for detecting the pothole.YOLOV2 model has better accuracy comparing with all models with the lowest no.of parameters. System is integrated with the mobile camera using raspberry pi and by using the vehicles we can take real time images for detecting the potholes.

Pranjal A. Chitale [8], This paper mainly focus on dimension estimation and pothole detection on the images. Triangular Similarity metric is used to construct a pothole dimension estimating method based on image processing.YOLOV3 and YOLOV4 models are used to detect the potholes. YOLOV3 model is used mainly for class prediction, bounding box prediction.YOLOV4 model optimizes parallel computation and object detection for proposed system. mAP and IOU are used to compare the validation set for the obtained results. The identified potholes dimensions are calculated with high precision and a low error rate. YOLOv4 has a higher IOU, it can estimate the size of potholes more precisely.

Ping Ping [9] Pothole detection method based on deep learning techniques are used to identify holes on the roads using camera mounted on a car's dashboard and connected to the internet. The classification process dataset is used to train and evaluated with CNN models like Faster R-CNN, YOLOV3, SSD and HOG with SVM. Data which is currently accessible will convert into tagged picture file for training dataset that will be utilized as input by the models. Hyper parameters are tweaked for the selected models to calculate the size of a pothole for getting the good results. Yolov3 model got good accuracy when compare with other selected models.

Dharneeshkar J [10] proposed a system based annotated images are used for training and testing dataset. K-mean

clustering method is used to determine number of bounding boxes in image. Deep learning architectures like YOLOV3, tiny YOLOV3 and YOLOV2 are used .The aim of detecting the pothole in the proposed system is to speed up the computation process and effective usage of CUDA. Darknet53 pre trained CNN model is used for YOLOV3 and Darket19 is used for YOLOV2. Comparing this models by using map, precision and recall, yolov3 model has got the reasonable accuracy.

Shebin Silvister[11] has proposed work based on deep learning-based This system was proposed an android application to identify pothole, they used the accelerometer and gyroscope sensors as well as camera on the android handset, in a two-step cross verification process. Tensor Flow object identification, custom trained API is used for camera-based detection on images. Support vector model from machine learning algorithm and SSD model from deep learning techniques are used. Tensor Flow Lite was used to merge two trained models into a single android application.In this application real time images are captured from camera and object detection model is used to detect the potholes. After detecting the potholes the data will be updated in database and also it will show the detected pothole on location map. When compared to machine learning technique, SSD delivers quick real time identification of pothole, while the DNN model provides superior accuracy.

3. Proposed Methodology

An image datases are taken as input parameter for the models shown below Fig 2, In data preprocessing model images are converted into a readable format and also images are resized to fit into input model. Dataset is divided into training and testing data. Creating advance CNN models with different layers and tuning the parameters. Evaluation metrics are calculated such as accuracy, precision, recall .Finally,will save all in one file as h5 and then creating the gui application and selected the images and model for predicting the output based on the selected model the metrics and image classification is predicted. The implementation is done by using pretrained modules of deep learning

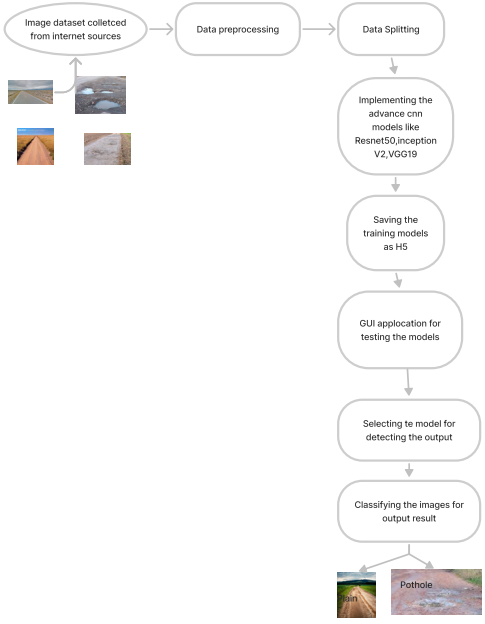

Fig. 2. System implementation

algorithms which are used to predict the features taken for the datasets.Implementation is done with 3 deep learning models those are Resnet50, vgg19, Inception-ResNet-v2. Dividing the data into training and testing then fit the model and evaluating to get the accuracy.The image datasets are used to compare the models and also the datasets whether for muddy roads or highway roads are giving the best result for the pretrained models.Vgg19 has given the best result because the architecture has 19 layers and also by hyper tunning the parameters this model work better compare to others models.

Data gathering The dataset is collected from internet sources where images are high resolution for highway roads and muddy roads. Images are collected one dataset images are gathered from internet sources, muddy roads dataset and another dataset is taken from Kaggle[1] highway roads dataset.Images are classified into two labels Plain and Pothole. Total dataset contains around 1000 images fig 2 shows some sample images from datasets.

Data Pre-processing The image data taken as the input will have huge dataset with a lot of images.Resize the images into 256*256 to bring those images into a common format. All the images are made transformed through the label encoder. Defining the plain and pothole trained data as input for the models.

Data Splitting Data is divided into two categories: training and testing. We must divide the entire data set into proportions. 65 percent will most likely be used for training, while 35 percent will be used for testing for highway road dataset and for muddy road dataset 60 percentage data for training and 40 percentage data for testing has taken . The training dataset is a subset of the larger dataset that is used to train the model. Testing dataset is a subset of the training dataset that is used to test learned models.

Advance CNN models Deep learning models are used to predict the accuracy of the features which are taken to analyze. The models are Resnet50, InceptionResnetV2 and VGG19.First, we have selected each model one by one and trained the model using training data with that model. After successful training, the trained model is saved as h5. Then the prediction is done with each model and then it is evaluated with test dataset for accuracy.

Architecture of models The models consists of five phases each with a convolution and Identity block. Each convolution blocks includes 3 convolution layers and each identity block comprises three convolution layers. We used Dropout, 3 dense layers with Relu and one dense layers with Softmax to fine tune the model parameters are used:

Epoch: 5 or 6
Batch size: 2 or 3
Total dataset images: 1000
Image size for input: 256 * 256
Optimizer: Adam
Loss function: Categorical cross entropy

The ResNet-50 model consists of five phases each with a convolution and Identity block. Each convolution blocks includes 3 convolution layers and each identity block comprises three convolution layers. The ResNet-50 has nearly 23 million trainable parameters. We used Dropout, 3 dense layers with Relu and One dense layers with Softmax to fine tune the model.

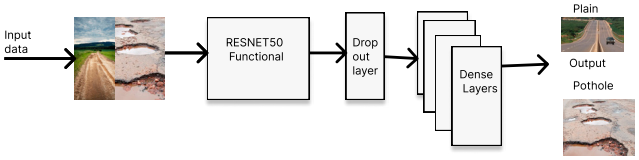

Fig. 3. Resent50 model

Inceptionresnet v2 mode use factorization to limit the channel size hence forth diminishing the overfitting issue the quantity of boundaries was additionally decreased the expansion in the quantity of leftover squares between beginning modules brings about countless commencement modules.We used Dropout, 2 dense layers with Relu and One dense layers with Softmax to fine tune the model.

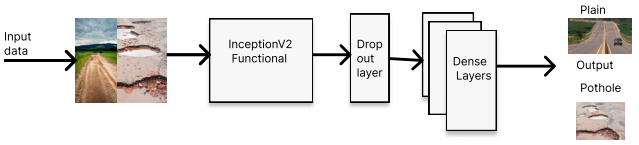

Fig. 4. Inceptionresnet v2 model

VGG19 is a convolutional neural network built around a million photos from ImageNet. There are 19 tiers in the network are classify photos into a variety of item groups. The layers are used input as image and vgg19 functional, Dropout, 2 dense layers with Relu and One dense layers with Softmax to fine tune the model.

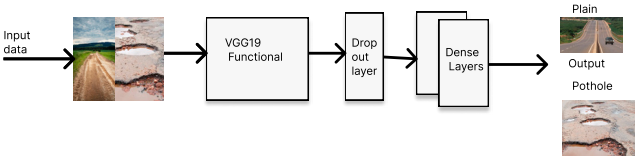

Fig. 5. VGG19 model

Using Flask model we created a user interface which include the space for the giving input data for prediction and output. The web app will work as the font end part of the project. The training, testing and prediction will be run in the backend. The input image is selected to predict the output based on the selected models the predicted accuracy will be displayed with the classifying type.

4. Experiments and results

The experiment of nice grained classification with dataset which generated by us within each class we try to group together the pictures representing the precisely purity results can be estimated further with huge set of data we decided to construct two parcels for this the first demonstrates the reliance on the number of epochs of the assessment precision the precision of the assessment was calculated using extra 550 images dataset the second plot demonstrates that the

number of epochs during the experiments depends on the precision and validation precision.
The high precision is accomplished after 6 epochs on the first plots shown in Fig 6 .The precision doesn't enhance in later epochs on the plot and even reduces in 2 -3 epochs intervals. If our training information accuracy continues to improve as your validation information precision deteriorates, you are likely to be in an overfitting scenario.

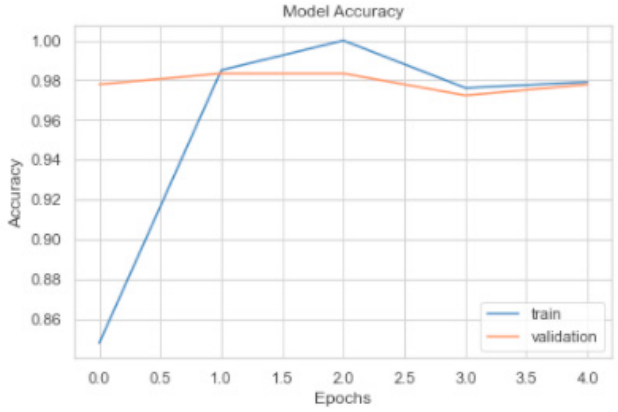

Fig. 6. Accuracy of the model for highway roads dataset

The high precision is accomplished after 6 epochs on the first plots shown in Fig 7 .The precision doesn't enhance in later epochs on the plot and even reduces at 2 epoch. If our training information accuracy continues to improve as your validation information precision deteriorates, you are likely to be in an overfitting scenario.

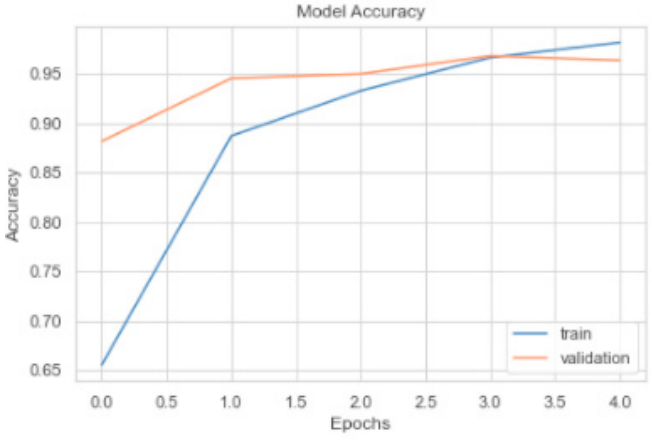

Fig. 7. Accuracy of the model for muddy roads dataset

Result:

My current experiment yields result for Highway roads as tabulate below. Epochs vs loss plots captured while building the models.VGG19 has given highest accuracy of 97.91 percentage and least error rate of 4.41 percentage compare with resent50 and Inception resnet V2 models.

My current experiment yields result for muddy roads as tabulate below. Epochs vs loss plots captured while building the models.VGG19 has given highest accuracy of 98.17 percentage and least error rate of 1.24 percentage compare

Table 1. Result table updated with various pretrained model for Highway roads dataset

Model	Accuracy(%)	Validation Accuracy(%)	Loss(%)
Datamodel merged with Resnet50 model	91.94	92.82	17.95
Datamodel merged with InceptionResnetV2 model	90.15	94.48	7.16
Datamodel merged with VGG19	97.91	97.79	4.41

Table 2. Result table updated with various pretrained model for Muddy roads dataset

Model	Accuracy(%)	Validation Accuracy(%)	Loss(%)
Datamodel merged with Resnet50 model	93.29	95.91	13.51
Datamodel merged with InceptionResnetV2 model	91.77	90.45	5.87
Datamodel merged with VGG19	98.17	96.36	1.24

with resent50 and Inception resnet V2 models.

Confusion Matrix of plain, potholes roads were analyzed .VGG19 classified 89 of the plain as true positive, 88 of potholes as true positive.

	Predicted Plain	Predicted Potholes
Actual Plain	89	1
Actual Potholes	3	88

Fig. 8. Pothole Classifier Confusion matrix

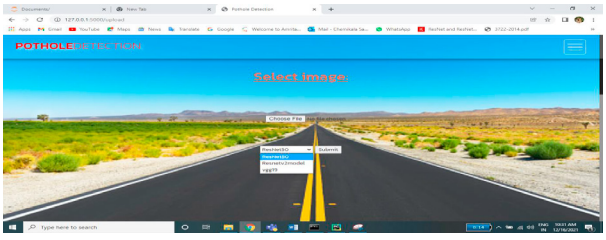

Fig. 9. Upload image page

Fig 9 shows the uploading image window for selecting the image and also models for predicting the image.

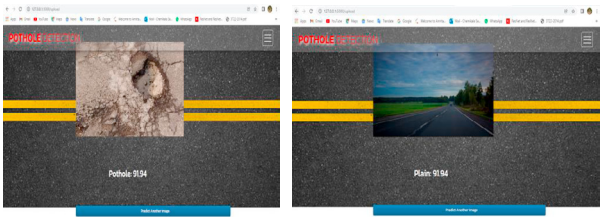

Fig. 10. Output Display for highway roads

After submitting below fig 10 shows the output prediction based on the selected image and model for highway roads.

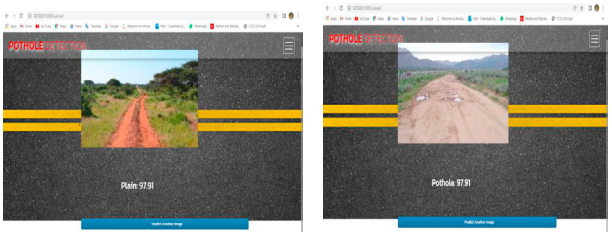

Fig. 11. Output Display for muddy roads

After submitting above fig 11 shows the output prediction based on the selected image and model for muddy roads.

5. Conclusion and Future Work

In conclusion ,this paper aim to identify the highway and muddy roads are plain or having potholes using photos was evaluated with variety of deep learning algorithms. Using tensor flow, keras pothole image is been trained and tested .Our model was trained for around 1000 images are collected from internet sources,(muddy roads)dataset and another dataset is taken from Kaggle(highway roads)dataset .The trained obtained models are saved as h5.py for testing the models on web application .The execution time differs from one image to other based on the image complexity. The designed application shows an accurate and promising result on the images for simple and too complex image.Web application is implemented for testing the model to identify the roads whether there is a pothole or plain based on the selected models like Resnet50, InseptionResNetV2, and VGG19 models are trained for the system. The performance is analysis on different metrics compare to Resnet50 ,InsepetionResNetV2 models VGG19 model has given the best accuracy with 97 percentage for highway roads and 98 percentage for muddy roads.

Future work of this paper is to implement on more data should be trained and tested in order to get the accuracy percentage high with less error and increase the speed of prediction .Complexity and accuracy are all time concerns for real time detected object .A high efficiency processor can be used in order to attend more accuracy. CNN structures like the most recent forms of origin (Xception and Mobile Net) for working on the performance and exactness.

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