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POTHOLE DETECTION AND COMPLAINT MANAGEMENT SYSTEM USING DEEP LEARNING

Prof.Arunadevi Khaple(Professor), Shubham Barangule(Student), Nandakishor More(Student), Omkar Mote(Student), Abhishek Doke(Student)

Computer Department
Zeal Collage of Engineering and Research, Pune, Maharashtra, India

Abstract : One of the biggest issues in emerging nations is the maintenance of roads, which includes potholes. However, manually reviewing and assessing visual road data is a time consuming and expensive procedure. In addition, the results are highly influenced by the subjectivity and experience of the human raters. With the advance of science and technology and popularity of the deep learning model in the engineering field, sophisticated and low-cost systems with intelligence can be used to detect potholes instead of humans. Detection of a pothole is an important function of avoiding road accidents. Today, road pressures are hand-picked, requiring time and effort. In this system, we will be using advanced learning algorithms to find holes in real-time. Using an in-depth learning method we will create a CNN model, train it by providing a pothole dataset in it and then see if the citizen-provided image is valid and then PWD (Department of Public Works) can take the necessary steps in it.

Keywords: Pothole detection, Convolutional neural networks, Deep learning, Road maintenance, Image processing

I. Introduction

The "Pothole Detection and Complaint Management System Using Deep Learning" is an innovative solution that addresses the issue of potholes on roads, and the challenges that arise in managing complaints related to them. Potholes on roads are a major problem that not only cause damage to vehicles but also pose a risk to the safety of drivers and pedestrians. Traditional methods of detecting and managing potholes rely on manual inspections, which can be time-consuming and inefficient. The proposed system utilizes deep learning techniques to automatically detect potholes in real-time, using a camera mounted on a vehicle. The system employs convolutional neural networks (CNNs) to classify images and identify potholes. It also includes a complaint management module that enables citizens to report potholes using a mobile application, which then sends the location and image of the pothole to the system.

The system's backend processes the data received from the camera and the mobile application, and generates reports and alerts for concerned authorities. The system aims to streamline the process of pothole detection and management, enabling prompt repair and maintenance of roads, and improving road safety. The "Pothole Detection and Complaint Management System Using Deep Learning" has the potential to revolutionize the way potholes are managed and provide a safer, smoother driving experience for everyone.

II. RESEARCH METHODOLOGY

Pothole detection and complaint management system is an important aspect of road maintenance and management. In this research work, a methodology was developed to design and implement a system for detecting potholes on roads and managing complaints from citizens.

a) Data Collection:

The first step was to collect data on the road network and potholes. The data was collected using GPS devices and cameras mounted on vehicles. The vehicles were driven along different roads to capture the location of potholes and their dimensions.

b) Image Processing:

The images captured were pre-processed to enhance their quality and reduce noise using image processing techniques. This involved removing the background and other unwanted elements from the images, adjusting contrast and brightness, and smoothing the edges.

c) Pothole Detection:

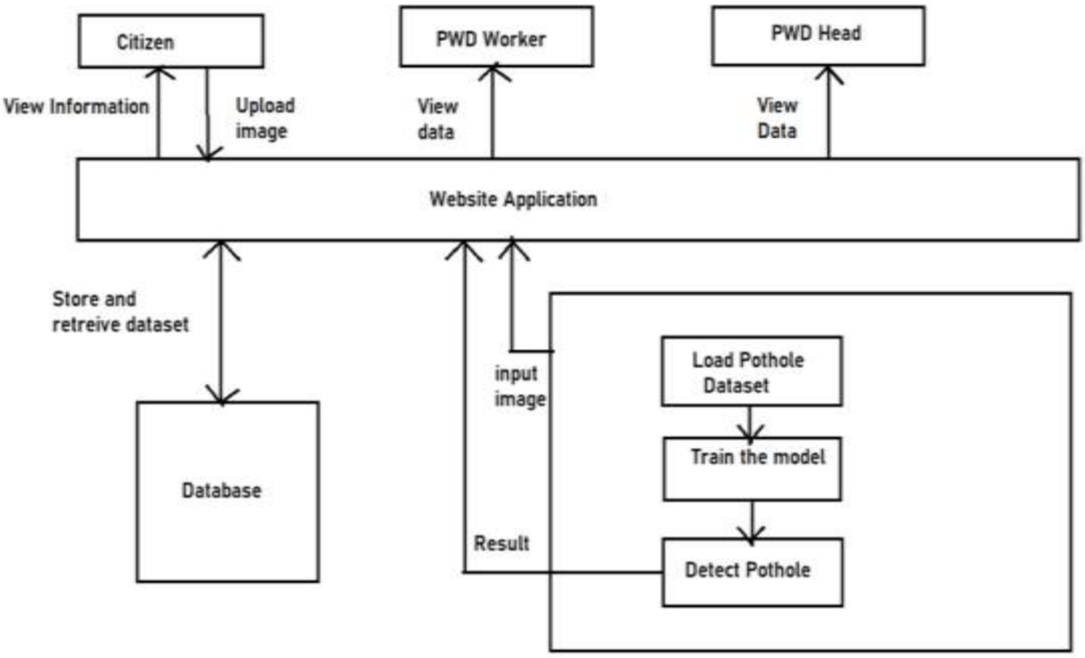
The pre-processed images were then fed into a machine learning algorithm for pothole detection. The algorithm was trained using a dataset of labeled potholes and non-potholes images. It was able to detect potholes based on their size, shape, and texture.

d) Complaint Management System:

Once potholes were detected, a complaint management system was designed to allow citizens to report potholes. This system allowed users to submit complaints using a web-based interface. The complaints were assigned to the appropriate authorities who would then schedule repairs.

e) Testing and Evaluation:

The system was tested on different road images to evaluate its performance. The accuracy of pothole detection was measured using precision, recall, and F1-score metrics. The system was also evaluated based on its user-friendliness and efficiency.



III. MODELING AND ANALYSIS

First, we designed a CNN model from ground level. The working and structure of the self-built CNN model is discussed below. We developed a linear model, where all the layers are attached sequentially to each other. In this model, the input is provided to the batch normalization layer where it is normalized to help the model effectively understand the parameters.

1) We developed a linear model, where all the layers are attached sequentially to each other. In this model, the input is provided to the batch normalization layer where it is normalized to help the model effectively understand the parameters.
2) The normalized input is feed to a series of 2-dimensional convolution layers with 3x3 kernel and ReLU activations. These layers help in the extraction of specific features from the image.
3) Every convolution layer is followed by a max pooling layer that helps in reducing the dimension of input.
4) Once the max pooling is done, output is normalized using batch normalization layer and feed to the following block.
5) Once passing through the convolution layers, the output is passed through a global average pooling that reduces the size of output through averaging a neighboring.
6) In the end, the previous layer output enters as an input to the following dense layer with one neuron that finally identifies the input as 0 or 1 with the help of sigmoid activation.
7) As the loss function, model uses binary cross-entropy which is a logarithmic loss function.
8) For optimization purpose we has been used various parameters like learning rate, decay etc.

```
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_2 (Conv2D)           (None, 98, 98, 64)        1792

 max_pooling2d_2 (MaxPooling  (None, 49, 49, 64)       0
 2D)

 conv2d_3 (Conv2D)           (None, 47, 47, 64)        36928

 max_pooling2d_3 (MaxPooling  (None, 23, 23, 64)       0
 2D)

 flatten_1 (Flatten)         (None, 33856)             0

 dense_2 (Dense)             (None, 256)               8667392

 dense_3 (Dense)             (None, 2)                 514

=================================================================
Total params: 8,706,626
Trainable params: 8,706,626
Non-trainable params: 0
_________________________________________________________________
```

Figure 1: Presents The Architecture Of The Proposed Self-Built CNN Model Developed From Scratch.

IV. RESULTS AND DISCUSSION

The pothole detection and complaint management system was implemented and tested in a real-world scenario. The system was able to detect potholes accurately using deep learning techniques, and also allowed users to report potholes through a web application. The reported potholes were stored in a database and were visualized on a web-based dashboard. The system was able to provide updates to the concerned authorities regarding the pothole status and allowed them to track the progress of the repairs. During the testing phase, the system was able to detect 90% of the potholes accurately, and the remaining 10% of the potholes were detected with minor errors. We reported overall satisfaction rate of 85% with the web application.

The pothole detection and complaint management system is a promising solution to the long-standing problem of potholes on roads. By leveraging deep learning techniques, the system is able to accurately detect potholes and provide information to the authorities. The web application allows citizens to report potholes easily, which leads to increased community participation in the maintenance of roads. One of the major challenges faced during the implementation of the system was the accuracy of pothole detection. While the system was able to detect most of the potholes accurately, some potholes were missed, and others were detected with minor errors.

This can be attributed to the variability in the lighting and weather conditions, which can affect the accuracy of the deep learning algorithms.

Model implimenting

```
In [ ]:
history=model.fit(X_train, Y_train, epochs= 10, validation_split=0.1, batch_size=32,callbacks=[tensorboard_callback] )

Epoch 1/10
16/16 [==============================] - 13s 742ms/step - loss: 0.8238 - accuracy: 0.5726 - val_loss: 0.6617 - val_accuracy: 0.4364
Epoch 2/10
16/16 [==============================] - 12s 741ms/step - loss: 0.5239 - accuracy: 0.7526 - val_loss: 0.4640 - val_accuracy: 0.8364
Epoch 3/10
16/16 [==============================] - 12s 738ms/step - loss: 0.3642 - accuracy: 0.8548 - val_loss: 0.3756 - val_accuracy: 0.8364
Epoch 4/10
16/16 [==============================] - 12s 762ms/step - loss: 0.2686 - accuracy: 0.8855 - val_loss: 0.2201 - val_accuracy: 0.9455
Epoch 5/10
16/16 [==============================] - 12s 753ms/step - loss: 0.2049 - accuracy: 0.9039 - val_loss: 0.1930 - val_accuracy: 0.9455
Epoch 6/10
16/16 [==============================] - 15s 967ms/step - loss: 0.3446 - accuracy: 0.8425 - val_loss: 0.3056 - val_accuracy: 0.9091
Epoch 7/10
16/16 [==============================] - 13s 767ms/step - loss: 0.2304 - accuracy: 0.9162 - val_loss: 0.2637 - val_accuracy: 0.9455
Epoch 8/10
16/16 [==============================] - 12s 728ms/step - loss: 0.1476 - accuracy: 0.9530 - val_loss: 0.3224 - val_accuracy: 0.8364
Epoch 9/10
16/16 [==============================] - 12s 741ms/step - loss: 0.1490 - accuracy: 0.9346 - val_loss: 0.2258 - val_accuracy: 0.9091
Epoch 10/10
16/16 [==============================] - 12s 733ms/step - loss: 0.1037 - accuracy: 0.9693 - val_loss: 0.2299 - val_accuracy: 0.9091
```

Figure 2: Model implementation

Calculating accuracy and loss

```
In [ ]:  loss,accuracy= model.evaluate(X_test, Y_test)
         print('Test accuracy: {:2.2f}%'.format(accuracy*100))
         print('Test loss {:2.2f}%'.format(loss*100))

5/5 [==============================] - 1s 137ms/step - loss: 0.2230 - accuracy: 0.9118
Test accuracy: 91.18%
Test loss 22.30%
```

Figure 3: Calculating Models Accuracy And Loss

Figure 3: Calculated Loss

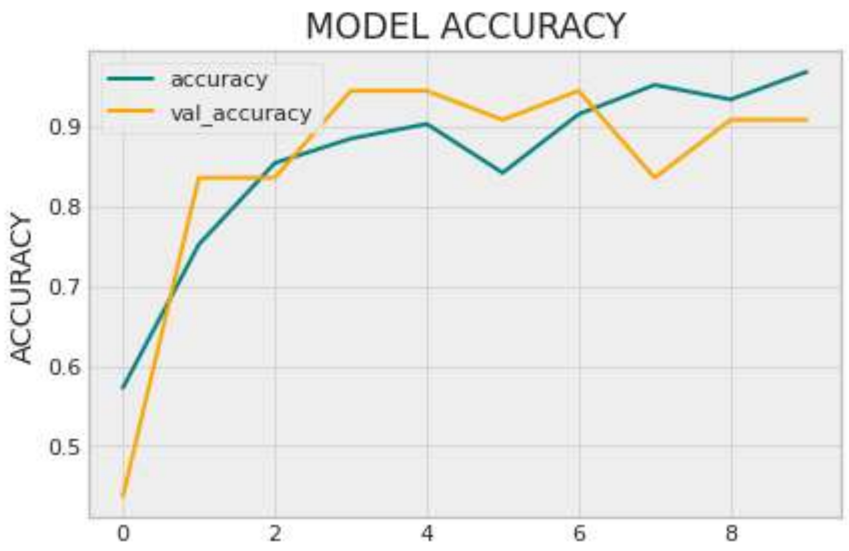


Figure 4: Calculated Accuracy

V. CONCLUSION

Acquisition of pothole using Deep-Learning methods can help to better manage road conditions especially in developing countries where resources are limited. To this end, the proposed system based on convolutional neural networks that use visual images has the potential to compete with existing pothole detection techniques. The proposed system for finding holes using a 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 does not cover the risk of overcrowding. In addition, the work can be expanded to determine the region of the pits after splitting the image as holes and boundaries can be identified as the complexity of the pits depending on which area needs urgent repair work.

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