A Deep Learning Approach For Pothole Detection

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Abstract
Road accident detection and avoidance are a more difficult and challenging problem in India as poor quality of construction materials get used in road drainage system construction. Due to the above problems, roads get damaged early and potholes appear on the roads which cause accidents. According to a report submitted by the Ministry of Road Transport and Highways transport research wing New Delhi in 2017, approximately 4,64,910 accidents happen per year in India. This paper proposed a deep learning-based model that can detect potholes early using images and videos which can reduce the chances of an accident. This model is basically based on Transfer Learning, Faster Region-based Convolutional Neural Network(F-RCNN) and Inception-V2. There are many models for pothole detection that uses the accelerometer (without using images and videos) with machine learning techniques, but a less number of pothole detection models can be found which uses only machine learning techniques to detect potholes. The results of this work have shown that our proposed model outperforms other existing techniques of potholes detection.

Keywords: Deep learning, F-RCNN, Inception-V2, machine learning, accelerometer, Road Transport, potholes detection

INTRODUCTION

India is the second-largest road network in the world. Therefore, 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. According to statistics submitted by the government of India from 2013 to 2016 potholes claimed 11,836 lives and 36,421 people got injured. Pothole problems cannot be resolved easily because every year almost all the places suffer from floods, disasters, heavy rainfall, etc. Though we cannot maintain the road, we can reduce the number of accidents which are getting increased every year. The Regions-CNN method was developed in 2014. The processing of a R-CNN can be divided into three steps [8]. Firstly, an algorithm called selective search generates approximately 2,000 region proposals (or regions of interest). These region proposals are independent divisions of the image where an object could be located. Secondly, a CNN extracts features individually from each region proposal. Finally, the object is classified using a Support Vector Machine (SVM) methodology. Region proposals are considered as positive when their Intersection over Union (IoU) measure against the ground truth exceeds an arbitrary value. Later, the object bounding box localization is calculated by overlapping the selected region proposals.

One of the main disadvantages of the R-CNN was its slow execution time. Fast R-CNN was proposed in 2015 as an improvement of R-CNN [7]. Fast R-CNN is twenty five times faster than its predecessor mainly due to two modifications. Feature extraction is performed using a CNN on the whole input image. Region proposals are selected as in the R-CNN approach by an external selective search method and included in the last layers of the network as projections on the feature map. The SVM classifier in this approach is replaced by a soft max layer. Although the Fast R-CNN was a breakthrough compared to the R-CNN, it still relied on algorithms such as the selective search that formed bottlenecks and slowed down the execution time of the detector In 2016 the Faster R-CNN method introduced a new region proposal extraction method called Regional Proposal Network (RPN) [15]. The idea of a RPN is to take advantage of the convolutional layers to obtain region proposals directly. Consequently, a sliding window is applied on the CNN feature map in order to extract

region proposals of different sizes. The RPN is not responsible for classifying localized objects, this task is subsequently carried out by a Fast R-CNN. Therefore, a Faster R-CNN is a Fast R-CNN plus a RPN.

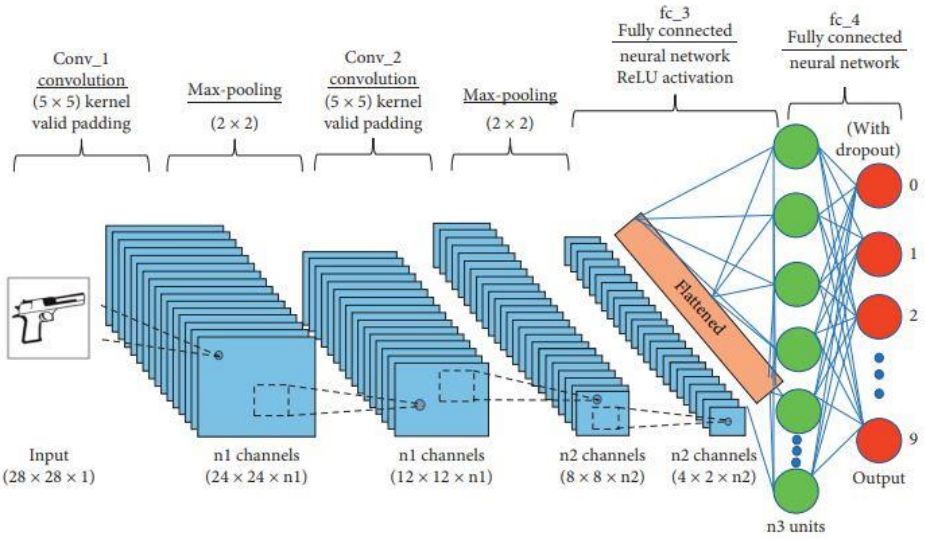

FiG 1 Fast R-CNN plus a RPN.

The CNN selected as Faster R-CNN base architecture should depend on its final purpose. Many CNNs employ a very deep architecture with the aim of obtaining a higher accuracy at a high computational cost. On the other hand, other architectures can be used that sacrifice precision in order to obtain models that can be integrated into embedded systems.

LITERATURE SURVEY

Artis M. et.al. Have proposed an accelerometer-based model that uses Z-THRESH, Z-DIFF, STDEV (Z) and G-ZERO algorithms and that can be deployed on any Android OS-based devices with limited hardware and software resources. They analyze the performance of the model with a 90% true positive value.

Lin, J. et. al. used a non-linear SVM model classification tool with a Gaussian radial basis function for the detection of a pothole. In this model, each image of 64×64 gets converted into grayscale and used for the experiment. Here for each grayscale eigenvalue is calculated and an average range of eigenvalue lie between 60 to 100 is searched before applying the SVM model. After this normalization of each image in the range is done using eigenvector.

Pereira, V. et. al. used Convolution Neural Network and compared the performance of their model with SVM and found that their model out formed SVM with 99.80% accuracy. They deployed the model using CNN, pooling, ReLU activation function, Adam Optimizer, and Sigmoid function. Here, convolution and pooling have been used for feature extraction. Adam optimizer is used to reduce the cost function and sigmoid function for output predicted values between 0 and 1.

PROPOSED METHODOLOGY

As mentioned above, the main objective of this work is the development of a Pothole detector that efficiently locates Pothole Detection in real-time video. For that purpose, an approach based on deep learning techniques and more specifically through the Faster R-CNN methodology will be adopted. This Pothole detection approach uses internally a CNN and a Regional Proposal Network (RPN) for the Detection and location processes respectively. Existing roadways gradually lead to wear and tear of the roads with the development of small, and medium to large size potholes. The presence of potholes on the roads not only increase the travel time and fuel consumption, thereby reducing the average speed of the traffic, but also lead to fatal accidents claiming lives and causing damages to vehicles. Monsoon season and excessive rainfall cause more distress to the commuters when potholes get filled with rainwater and sometimes sewage water in the absence of a proper drainage system. Therefore, along with the construction of new roads, timely maintenance of the existing roads is equally important.

A significant challenge towards the regular maintenance and repair of potholes is their timely and automatic detection. Pothole detection was classified into three categories namely

- Vibration
- 3D reconstruction
- Vision-based.

Among the vision-based methods, three visual specific characteristics of the pothole, namely, oval in shape, dark in color, and rougher surface than its surroundings were defined. These characteristics were used for shape extraction and image segmentation, and the extracted features were compared with the surroundings to determine a pothole.

Image processing techniques have also been used in detecting defects on the roads using texture, shape, and dimensions of the defective area. Further, pothole, crack, and patch area measurements were classified to identify the road distress. This existing system and disadvantages are Low Accuracy, High Computational Cost

The proposed modern based pothole detection method using the transfer learning technique detects potholes in videos/images in real-time. The method uses common techniques like "use of FRCNN", "inception v2 model" which are described below. The main advantage of this method is small training time with an easy training process and higher accuracy. In order to get a trained working Faster R-CNN architecture, we need to perform the following steps –Training of RPN – first of all, we need to Train the RPN architecture with the dataset so that it can propose the expected region.
Training of Fast 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. Fixing Convolutional layers, fine-tuning unique layers to RPN.
Fixing Convolutional layers, fine-tuning fully connected layers of Fast R-CNN. These proposed system and advantages are High mean average precision, Dynamic Feature Extraction and Scaling.
To run the project file you need to open the anaconda prompt and change the directory to the folder where the projects files are present as shown in below figure:

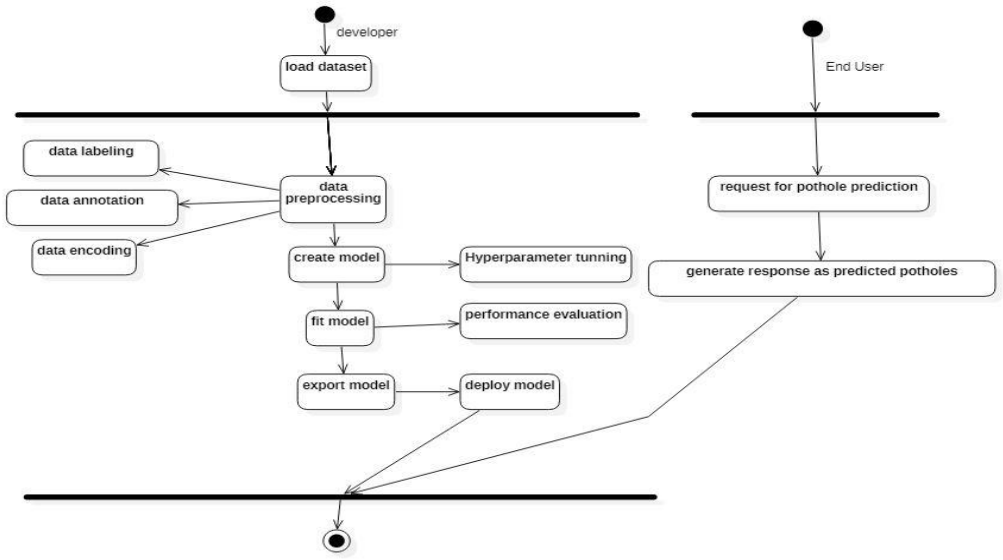

Fig. 2 ACTIVITY DIAGRAM

Activity diagram is another important diagram in UML to describe the dynamic aspects of the system. Activity diagram is basically a flowchart to represent the flow from one activity to another activity. The activity can be described as an operation of the system. The control flow is drawn from one operation to another. This flow can be sequential, branched, or concurrent. Activity diagrams deal with all type of flow control by using different elements such as fork, join, etc Potholes are very harmful road surface conditions that prevent a safe, secure and reliable transportation and movement of people, goods and services. Road surface obstacles such as potholes affect the safety and comfort of most road users and commuters. Bad road networks hampers the smooth movement of goods and services and contribute to the poor growth and development of the economy while good road networks provides access to markets and enable fast and smooth transportation of goods and services from producers to consumers. Early detection and maintenance of potholes helps to create a conducive and reliable road network that facilitates the smooth movement of people, goods and services.

Fig 3 results Screenshot

Fig 4 results Screenshot

CONCLUSION

In this project, we proposed a system to detect potholes in real-time in images/videos captured by a camera mounted on the vehicle and to give an alert to the driver about the pothole on road in front of the vehicle. Further, our system will detect the location of the pothole and upload the same on map (reflected in android app developed by us) so that other users who have no camera mounted on their vehicle can get alert about the pothole using the app only (however this is our future work). In this system, we used famous and complex CNN architectures like Inception v1 (GoogLeNet), inception v2 and finally select inception v2 in our system. In the experiment data, the system shows extremely good results. Our Future works include experiments for improving the system and making it simple for common/general use.

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