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DETECTION OF POTHOLES AND ROAD SURFACE CONDITIONS USING DEEP LEARNING

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Abstract: The preservation of roads is one of the most important issues in emerging nations. The economy of the nation is significantly boosted by well-maintained roadways. Finding pavement problems like potholes helps drivers prevent collisions or vehicle damage and also aids in road maintenance. Numerous ongoing efforts in the field of transport networks aim to give drivers pertinent information about the roads and traffic patterns. Indian secondary roads frequently have potholes, some of which may be wet or dry. Therefore, it is crucial to spot potholes and gauge their depths in both situations to ensure safe driving. A cost-effective automated method for identifying potholes and other issues with the road's surface is therefore becoming increasingly necessary. In this project, we create a sensing model that uses cameras to identify potholes in real time.

IndexTerms **– Deep Learning, Pothole detection, YOLO v7.**

I. INTRODUCTION

The Indian transportation and highway department has recognized road deterioration, such as potholes and cracks, as a significant contributing factor in accidents. Since it is essential for many applications, detecting such anomalies on highways has been the focus of research in a variety of fields. To improve road safety, automated techniques for monitoring abnormalities in the road surface, notably potholes, have been proposed. The manual examination of recorded videos used in conventional methods takes time. The potential of recent developments in anomaly identification to describe complicated interactions, which are frequently represented as networks or graphs, has piqued curiosity. Preventive maintenance is the most advantageous and cost-effective method of road maintenance. Deep Learning models outperform Machine Learning models, according on analysis of existing road quality measuring architectures and model comparisons. With the help of various feature extraction techniques, deep learning architectures, datasets, pre-processing techniques, segmentation, feature extraction, and classification methods, this project aims to create a model that can automatically evaluate road quality.

II. OVERVIEW

India's roads are poorly built and neglected, which results in dangerous potholes and damage that contributes to accidents. Negative road anomalies like potholes and cracks, which offer a serious risk because to their unpredictable shapes and placements, are the main barrier to effective obstacle avoidance. Finding and fixing these dangerous road abnormalities is essential for maintaining roads, improving autonomous driving, and lowering accident chances. By reducing possible concerns, such as health risks to drivers and damage to car tires from vibrations induced by navigating these anomalies, it broadens the scope of vehicle navigation.

For drivers' safety, the condition of the road infrastructure is essential, and potholes present a serious threat, especially during the rainy season. Cracks and potholes on the road cause discomfort for passengers, harm to vehicles, and increase the risk of accidents all over the world. Potholes are a significant contributor to accidents and wear and strain on vehicles. Roads are a crucial component of public infrastructure, which has a significant impact on cities' economics. Road efficiency, driver safety, and vehicle value are all adversely impacted by a variety of circumstances, including rain and ageing. Although human visual inspection is the best monitoring approach, it is not feasible due to labor, expense, and time issues. Therefore, the goal is to create an effective deep learning algorithm employing neural networks to identify potholes and other types of road damage, enabling efficient road maintenance and enhancing daily commute experiences. Through this project, our system recognizes the damages on roads through deep learning by using the YOLO v7 algorithm and the dataset was created using images of roads in India.

III. Related Work

Wang, [1] A new architecture for real-time object detectors and an associated model scaling technique are given as an approach. It is also discovered that when object detection technologies advance, new study areas emerge. They discovered the replacement problem of re-parameterized modules and the allocation challenge of dynamic label assignment during the study procedure. They have suggested the trainable bag-of-freebies method to improve item detection accuracy in order to address the issue. Based on the aforementioned, they created the YOLOv7 family of object detecting systems, which produce cutting-edge outcomes. Between 5 and 160 frames per second, YOLOv7 outperforms all other object detectors in terms of speed and accuracy, and it has the best real-time object detector accuracy.

L. Tianjiao and B. Hong, [2] In this study, the original Yolov3 model has been changed to reflect the actual circumstances surrounding car wheel weld. The paper builds on the original model's structure and layers by using Distance-IoU (DIoU) loss to enhance Yolov3's loss function and Distance-IoU-NMS to get rid of redundant candidate bounding boxes, which further speeds up the loss function's convergence and increases object detection accuracy. They contend that these techniques can be used to achieve the goals of reducing time and effort in comparison to manual approaches while also having high accuracy and stability in any specific setting that requires target identification. Certain parameters, such as establishing a better neural network to optimize the model, finding a more acceptable loss function, and determining whether the network can be further optimized to attain a higher FPS, were to be improved during the model training process.

M. Suganthi and J. G. R. Sathiaseelan, [3] In this publication, the research's goal was to identify an appropriate hybrid classification system. Additionally, this survey offered several machine learning facets and described the Convolutional Neural Network architecture's guiding principles. This paper discusses the development of CNN for image classification applications. This hybrid CNN is thought to be more effective than a standard CNN by researchers from several domains. Better accuracy was obtained by combining the CNN model with RNN, GA, KNN, MLP, and LSTM than by repeatedly stacking the same building blocks. The hybrid CNN model underwent a comparison examination, and it was discovered that CNN-LSTM gave superior results. As a result, the deep learning model received favorable feedback from all academic domains. Because of its sensitivity and specificity, deep learning will have limited application in the agriculture sector in the future. Thus, researchers must identify high-quality pre-existing concerns.

R. Rastogi, [4] In this research, the authors have concentrated on testing the performance of cutting-edge neural network algorithms for rapid and accurate pothole identification, including YOLO and Faster R-CNN using VGG16 and ResNet-18 architectures. In order to test different object detection techniques, 1300 photos of potholes were gathered. When used to solve the "pothole" and "normal road" class imbalance problem, a customized version of YOLOv2 performed better than the YOLOv2 base model and Faster R-CNN architectures. The outcomes demonstrated that the modified YOLOv2 architecture outperformed all the models that were taken into consideration with the fewest parameters. With regards to its high accuracy, the suggested architecture can be put on the dashboard of manual and autonomous vehicles for real-time pothole identification, providing drivers and commuters with warnings for safe driving. It can also be combined with a smartphone camera using a Raspberry Pi.

Dib, J. & Sirlantzis, [5] In order to improve the detection of negative surfaces, they have compiled the currently available methods in this study with an eye towards their relative strengths and limitations. Techniques were examined. Based on their inadequacies and with the aid of specific performance metrics, their limitations have been discovered and evaluated. Deep Learning techniques, which rely on deep learning and neural networks to assure the detection of the negative road anomalies, and Non-Deep Learning Techniques, which do not use deep learning, are the two primary types of currently accessible technologies. They have discovered that for their project, a deep learning model performs better than a machine learning model. Deep learning algorithms are more effective and produce outcomes that are more accurate. In most circumstances, the system's ability to be mass produced could be controlled, but the consumers might pay a large price for it.

IV. Methodology

In this project, a method for utilizing deep learning algorithms to find potholes and damaged road conditions is presented. The deep learning model is initially loaded with datasets of images of potholes and plain roads that have been divided into training and test sets. The YOLOv7 image classification algorithm is then trained on the datasets and tested to determine its efficacy. Fig 4.1 shows the system architecture of the proposed system.

Dataset Design: Our dataset consists of 3198 images with YOLO v7 PyTorch format annotations of potholes. The dataset is separated into train, validation, and test categories where 90% of the dataset is utilized for training and validation, and 10% is used for testing.

The YOLO v7 Algorithm:

"You Only Look Once" refers to a family of well-liked real-time object detection methods. YOLOv7 provides a greatly improved real-time object detection accuracy without increasing the inference costs. Modern real-time object detections can be effectively reduced using YOLOv7 by roughly 40% parameters and 50% computation, leading to faster inference times and better detection accuracies. Model Scaling for Concatenation-based Models and Extended Efficient Layer Aggregation Network (E-ELAN) are components of the YOLO v7 architecture. By employing "expand, shuffle, merge cardinality" to accomplish the capacity to constantly increase the learning ability of the network without breaking the original gradient route, the YOLOv7 E-ELAN architecture helps the model learn better. Compound model scaling for a concatenation-based model is introduced in

YOLOv7. The model's original design qualities can be preserved by using the compound scaling method, keeping the ideal structure intact. With a range of 5 FPS to 160 FPS, YOLOv7 outperforms all prior object detectors in terms of both speed and accuracy. While obtaining 30 FPS or more utilizing a GPU V100, the YOLO v7 algorithm achieves the highest accuracy among all other real-time object detection models.

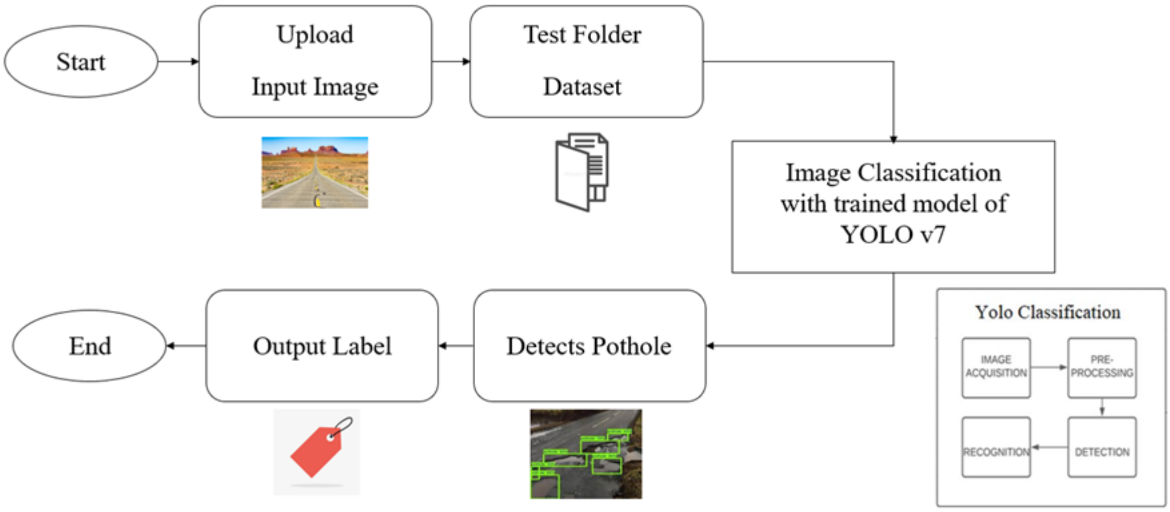

Fig 4.1: Architectural Design

Fig 4.2 shows the Dataflow diagram of the proposed system where the process involves collecting and annotating a dataset of pothole and non-pothole images and videos, training a YOLOv7 object detection model using transfer learning and data augmentation. Then the model is evaluated and fine-tuned, deploying it with a front end for real-time pothole detection using webcam data, and implementing an alert system to indicate the presence of potholes.

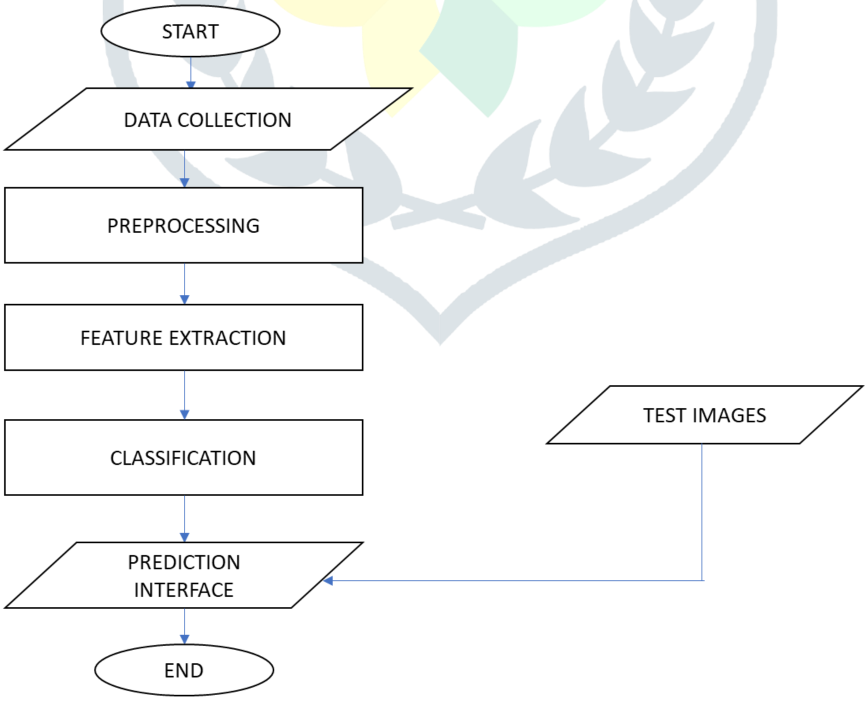

Fig 4.2: Dataflow Diagram

Fig 4.3 shows the Use Case diagram of the proposed system where the system model gathers the data from the user's visual input. Data pre-processing, feature extraction, categorization, and detection are the next phases. The user is informed if a pothole has been discovered through an alert voice note that the model produces after detecting a pothole or damaged road condition.

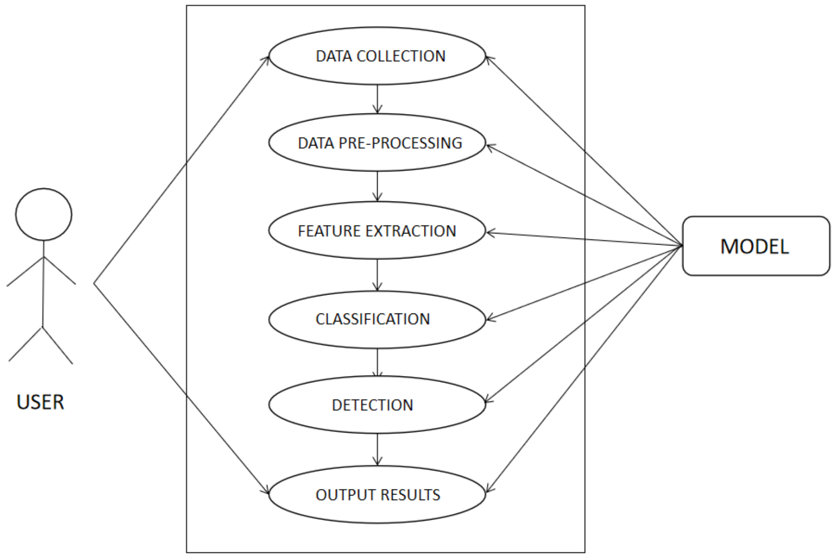

Fig 4.3: Use Case Diagram

V. Implementation

The accuracy of the deep learning model depends on the size of the dataset and the number of parameters or features taken into account when developing the model. The deep learning model is initially trained over a dataset and tested to achieve a specified accuracy score. Later, the model is changed into a pickle file. The pickle file operates on the necessary features extracted from the user's input in the front-end to produce the desired outcome.

The work has been split into the following modules:

Data Preprocessing: The dataset is pre-processed by resizing the images or videos to the desired input size after the necessary dependencies and frameworks have been installed.

Feature Extraction: The dataset is then divided into three sets: training, validation, and testing. By choosing the right pre-trained model and tweaking hyper-parameters like learning rate, batch size, and input size, the YOLOv7 model is configured.

Dataset Training: The YOLOv7 model is then trained using the supplied training script on the training dataset. By tweaking hyper-parameters and using methods like data augmentation, the model is refined. Analyze the validation dataset's performance using the trained model. As necessary, model or hyper-parameter adjustments are made.

Prediction Interface: The implementation of the real-time detecting system. The trained YOLOv7 model is used to detect potholes in real-time video or photos taken from a camera or other sources. Based on the information about the processed potholes, an alert system is put into place. To ensure precise real-time pothole recognition and proper operation of the alarm mechanism, we created a sound indicator and tested the system from beginning to end.

VI. Conclusion

The proposed system primarily has two functions where it automatically detects potholes as well as notifies vehicles of them so that they can avoid collisions. This is a pothole detection method that is economical. As the warnings are delivered from the recorded information in the server or database, this method is functional even in the rainy season when the roads are flooded with rain water and in the winter during low visibility. This method assists us in avoiding terrible potholes and, as a result, any unfortunate accidents brought on by poor road conditions. In order to maintain the roads, the government officials can also use the information.

Future Scope: The proposed system takes potholes into account. Using a Raspberry Pi, this can be done in real time. Additionally, it can be used to inform servers when potholes are present. The system can be further enhanced to take into account the mentioned fact and update server databases appropriately. The proposed system can incorporate SATNAV and Google Maps to enhance user experience. By warning the driver of speed bumps and other on-road obstructions, the system can be further enhanced.

REFERENCES

[1] Wang, Chien-Yao & Bochkovskiy, Alexey & Liao, Hong-yuan. (2022). YOLOv7: Trainable bag-of-freebies sets new state-of-the-art for real-time object detectors.

[2] L. Tianjiao and B. Hong, "A optimized YOLO method for object detection", 2020.

[3] M. Suganthi and J. G. R. Sathiaseelan, "An Exploratory of Hybrid Techniques on Deep Learning for Image Classification", 2020.

[4] R. Rastogi, U. Kumar, A. Kashyap, S. Jindal and S. Pahwa, "A Comparative Evaluation of the Deep Learning Algorithms for Pothole Detection", 2020.

[5] Dib, J. & Sirlantzis, Konstantinos & Howells, Gareth. (2020). A Review on Negative Road Anomaly Detection Methods.

[6] V. Sharma, M. Gupta, A. Kumar and D. Mishra, "Video Processing Using Deep Learning Techniques: A Systematic Literature Review", 2021.

[7] P. Ping, X. Yang and Z. Gao, "A Deep Learning Approach for Street Pothole Detection", 2020.

[8] D. J, S. D. V, A. S A, K. R and L. Parameswaran, "Deep Learning based Detection of potholes in Indian roads using YOLO", 2020.

[9] VP. A. Chitale, K. Y. Kekre, H. R. Shenai, R. Karani and J. P. Gala, "Pothole Detection and Dimension Estimation System using Deep Learning (YOLO) and Image Processing", 2020.

[10] J. -C. Tsai, K. -T. Lai, T. -C. Dai, J. -J. Su, C. -Y. Siao and Y. -C. Hsu, "Learning Pothole Detection in Virtual Environment", 2020.