International Journal of Engineering Research and Science & Technology

RAILWAY OBJECTS DETECTION BY USING IMPROVED YOLO ALGORITHM

SHAGAM GEETHA [1], SHAIK UMAR [2], MUDUTHANAPALLI SRI CHARAN [3], PACHIPALA VINAY YADAV[4], SHAIK SHARUK[5]

[1]Assistant Professor, Dept. of CSE, Guru Nanak Institutions Technical Campus**,** Ibrahimpatnam, Telangana, India

[2, 3, 4, 5] B.Tech, Dept. of CSE, Guru Nanak Institutions Technical Campus**,** Ibrahimpatnam, Telangana, India

ABSTRACT— The efficient and accurate detection of foreign objects on railway tracks is critical to ensuring the safety and smooth operation of train systems. This work addresses the limitations of existing foreign object detection methods, including low efficiency and suboptimal accuracy, by proposing an enhanced railway foreign object intrusion detection framework leveraging YOLOv8 and Overhaul Knowledge Distillation. The proposed method consists of a two-stage architecture. In the first stage, a lightweight image classification network quickly determines whether a railway image contains foreign objects. This stage minimizes reliance on computationally intensive object detection models, thereby enhancing detection speed. In the second stage, YOLOv8 is employed to precisely detect and localize foreign objects in images flagged by the classification network. The choice of YOLOv8 provides notable improvements in accuracy and inference speed over previous versions such as YOLOv3. Additionally, the Overhaul Knowledge Distillation algorithm is applied to train the lightweight classification network under the supervision of a larger, more robust network, ensuring competitive classification performance while maintaining efficiency. Experimental results demonstrate that the proposed method achieves state-of-the-art performance in both detection accuracy and speed, with significant improvements in FPS and detection robustness compared to earlier approaches.

Index Terms – Railway intrusion detection, foreign object detection, YOLOv8, knowledge distillation, Overhaul Knowledge Distillation, deep learning, object detection, image classification, railway safety,

computer vision, real-time detection, intelligent transportation systems.

I. INTRODUCTION

The detection of foreign objects on railway tracks plays a crucial role in maintaining the safety and smooth operation of train systems. Such objects, whether they be debris, fallen trees, or other obstructions, present significant dangers. They can lead to accidents, derailments, train delays, and damage to railway infrastructure, all of which pose severe risks to public safety and financial losses. Traditional detection methods, relying on basic image processing algorithms or older deep learning models, have limitations in terms of real-time processing, computational load, and the ability to detect objects accurately in varying environmental conditions. These systems often struggle with maintaining high detection accuracy while ensuring efficient processing speeds in dynamic environments, where rapid response times are essential. To address these challenges, this project introduces a cutting-edge framework that incorporates YOLOv8, a state-of-the-art object detection algorithm, and an innovative Overhaul Knowledge Distillation technique. YOLOv8 is a next-generation deep learning model that offers enhanced performance in terms of speed and accuracy over its predecessors, such as YOLOv3 and YOLOv4. By employing this advanced model, the proposed system can detect and localize foreign objects on railway tracks with greater precision and in less time. Additionally, Overhaul Knowledge Distillation allows for the training of a lightweight classification model under the supervision of a larger, more powerful network. This technique ensures that the classification network retains high accuracy, while keeping the computational requirements minimal, making the system ideal for real-time applications where low latency and high throughput are essential.

The proposed solution focuses on developing a two-stage architecture for foreign object detection. In the first stage, a lightweight image classification model quickly identifies whether a railway image contains foreign objects, thus reducing the computational load on the detection system. In the second stage, YOLOv8 is employed to detect and precisely locate the foreign objects in the images flagged by the classification network. This combination of lightweight classification and high-performance object detection significantly reduces the time needed to analyze images, ensuring that detection happens swiftly and accurately. Furthermore,

the use of Overhaul Knowledge Distillation optimizes the training process, enabling the lightweight model to perform efficiently without sacrificing performance.

II. RELATED WORK

A. A review of knowledge distillation in object detection

Accurately detecting active objects undergoing state changes is essential for comprehending human interactions and facilitating decision-making. The existing methods for active object detection (AOD) primarily rely on visual appearance of the objects within input, such as changes in size, shape and relationship with hands. However, these visual changes can be subtle, posing challenges, particularly in scenarios with multiple distracting no-change instances of the same category. We observe that the state changes are often the result of an interaction being performed upon the object, thus propose to use informed priors about object related plausible interactions (including semantics and visual appearance) to provide more reliable cues for AOD. Specifically, we propose a knowledge aggregation procedure to integrate the aforementioned informed priors into oracle queries within the teacher decoder, offering more object affordance commonsense to locate the active object. To streamline the inference process and reduce extra knowledge inputs, we propose a knowledge distillation approach that encourages the student decoder to mimic the detection capabilities of the teacher decoder using the oracle query by replicating its predictions and attention. Our proposed framework achieves state-of-the-art performance on four datasets, namely Ego4D, Epic-Kitchens, MECCANO, and 100DOH, which demonstrates the effectiveness of our approach in improving AOD.

B. Detection of foreign objects intrusion into transmission lines using diverse generation model

As a critical component of the electric power transportation system, overhead transmission lines confront various risks, including foreign object intrusion. To tackle this issue, this paper proposes an enhanced target detection model, named KM-YOLO, aimed at effectively detecting foreign object intrusion on overhead transmission lines.The KM-YOLO model builds upon the improved YOLOv5s algorithm as its foundation. It introduces the fusion of the GC module and the C3 module to create the C3GC attention mechanism, which is integrated into the backbone network. Additionally, the paper

introduces the WZ Dynamic DeCoupled Head as a decoupled detection head and adopts the SIoU loss function for the model. Experimental evaluation conducted on the home-made dataset KC-dataset reveals that the average accuracy of the KM-YOLO model improves from 0.845 to 0.894. This improvement demonstrates the significant enhancement of the model's capability in detecting foreign object intrusion on overhead transmission lines. The research methodology presented in this paper offers a practical solution to the safety detection problem associated with overhead transmission lines and has yielded substantial progress in experimental results. These findings possess considerable reference value and can offer insights and inspiration for research and practical applications in related fields.

C. SDRC-YOLO:A novel foreign object intrusion detection algorithm in railway scenarios

Foreign object intrusion detection is vital to ensure the safety of railway transportation. Recently, object detection algorithms based on deep learning have been applied in a wide range of fields. However, in complex and volatile railway environments, high false detection, missed detection, and poor timeliness still exist in traditional object detection methods. To address these problems, an efficient railway foreign object intrusion detection approach SDRC-YOLO is proposed. First, a hybrid attention mechanism that fuses local representation ability is proposed to improve the identification accuracy of small targets. Second, DW-Decoupled Head is proposed to construct a mixed feature channel to improve localization and classification ability. Third, a large convolution kernel is applied to build a larger receptive field and improve the feature extraction capability of the network. In addition, the lightweight universal upsampling operator CARAFE is employed to sample the size and proportion of the intruding foreign body features in order to accelerate the convergence speed of the network. Experimental results show that, compared with the baseline YOLOv5s algorithm, SDRC-YOLO improved the mean average precision (mAP) by 2.8% and 1.8% on datasets RS and Pascal VOC 2012, respectively.

D. RTIDS: A robust transformer based approach for intrusion detection system

Due to the rapid growth in network traffic and increasing security threats, Intrusion Detection Systems (IDS) have become

increasingly critical in the field of cyber security for providing secure communications against cyber adversaries. However, there exist many challenges for designing a robust, efficient and accurate IDS, especially when dealing with high-dimensional anomaly data with unforeseen and unpredictable attacks. In this paper, we propose a Robust Transformer-based Intrusion Detection System (RTIDS) reconstructing feature representations to make a trade-off between dimensionality reduction and feature retention in imbalanced datasets. The proposed method utilizes positional embedding technique to associate sequential information between features, then a variant stacked encoder-decoder neural network is used to learn low-dimensional feature representations from high-dimensional raw data. Furthermore, we apply self-attention mechanism to facilitate network traffic type classifications. Extensive experiments reveal the effectiveness of the proposed RTIDS on two publicly available real traffic intrusion detection datasets named CICIDS2017 and CIC-DDoS2019 with F1-Score of 99.17% and 98.48% respectively. A comparative study with classical machine learning algorithm support vector machine (SVM) and deep learning algorithms that include recurrent neural network (RNN), fuzzy neural network (FNN), and long short-term memory network (LSTM) is conducted to demonstrate the validity of the proposed method.

III. PROPOSED METHODOLOGY

The Proposed System, on the other hand, introduces several advancements to address these limitations. Instead of YOLOv3, it utilizes the more advanced YOLOv8, which offers improved accuracy, speed, and real-time performance. The system retains the two-stage approach, where the first stage is still a lightweight classification network to quickly identify foreign objects. In the second stage, YOLOv8 performs the detection and localization of the objects flagged by the classification network, benefiting from YOLOv8's enhanced architecture. Furthermore, the Overhaul Knowledge Distillation technique is employed to train the lightweight classification network under the supervision of a larger network, ensuring that the classification performance is on par with heavier models while maintaining computational efficiency. Experimental results show that the proposed system significantly improves FPS by 50-70 units and offers enhanced detection accuracy,

making it a more effective solution for real-time railway foreign object detection.

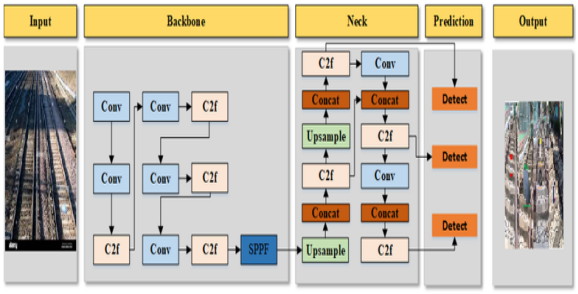


Fig. 1: System Overview

1. Data Collection

The first step in building the foreign object detection system is to gather a diverse and comprehensive dataset of railway images. These images should cover a variety of environmental conditions such as different lighting, weather, and track types. The dataset should include both "normal" images (no foreign objects present) and "intruded" images (with foreign objects on the tracks). Data can be collected from railway surveillance cameras, public datasets, or simulated environments. The diversity in the dataset ensures that the model is trained to generalize well across different real-world scenarios.

2. Annotations

Once the data is collected, the next step is to annotate the images. In this stage, each image is labeled as either "normal" or "intruded" based on the presence of foreign objects. For the "intruded" images, further annotations are made to identify the specific type and location of the foreign objects within the image. This could involve drawing bounding boxes around the foreign objects and labeling them accordingly. The accuracy and quality of these annotations are crucial, as they directly impact the performance of the trained model.

3. YOLOv8 Model Building

With the annotated dataset ready, the next step is to build the YOLOv8 model for object detection. YOLOv8 is an advanced deep learning model designed for real-time object detection. It is known for its high speed and accuracy, making it ideal for dynamic environments like railway tracks where timely detection is essential. The YOLOv8 model is built and configured to detect and localize foreign objects in the images. This involves selecting the appropriate architecture, defining the input and output layers, and configuring hyperparameters for optimal performance.

4. Feature Engineering

Feature engineering involves identifying and selecting the most relevant features from the data that will help the model make accurate predictions. For object detection, this

includes preparing the input images, ensuring they are resized and normalized, and possibly applying data augmentation techniques such as rotation, flipping, and zooming to create a more robust model. Additionally, features like texture, shape, and color patterns that are relevant to foreign object detection can be considered for enhancement.

5. Model Training

The next step is to train the YOLOv8 model using the annotated dataset. During training, the model learns to identify patterns in the images that correspond to foreign objects and how to classify and localize them accurately. The training process includes backpropagation and optimization algorithms to minimize the loss function, iterating through many epochs to ensure that the model learns the relationships between the input data and the target outputs (object classification and localization). The Overhaul Knowledge Distillation technique is applied here to improve the efficiency and accuracy of the lightweight ResNet-tiny classification network, which is trained under the guidance of a larger, more robust network.

6. Model Evaluation

After training, the model undergoes rigorous evaluation using a separate validation or test dataset. The goal is to assess how well the trained model generalizes to new, unseen images. Metrics such as accuracy, precision, recall, and F1-score are used to evaluate the classification performance, while mean average precision (mAP) is typically used for object detection tasks. Evaluation metrics like FPS (frames per second) and inference speed are also crucial to ensure that the model performs efficiently in real-time scenarios.

7. Object Detection:

Once the model has been successfully trained and evaluated, it is used for object detection on new images. In this final step, the trained YOLOv8 model takes in new railway images and identifies whether they contain foreign objects. For images classified as "intruded," the model not only classifies the object but also localizes it by drawing bounding boxes and categorizing the type of foreign object detected. The model is expected to perform in real-time, ensuring that it can continuously monitor and provide accurate results for immediate action on railway tracks. This process, from data collection to object detection, ensures that the proposed system is both accurate and efficient in detecting foreign objects on railway tracks, ultimately improving safety and operational efficiency.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

International Journal of Engineering Research and Science & Technology

The experimental results show that the proposed YOLOv8-based railway object detection framework achieves higher detection accuracy and faster inference than existing methods. The integration of a lightweight image classification network with Overhaul Knowledge Distillation reduces computational cost while maintaining high classification performance. The two-stage architecture improves detection robustness and significantly increases frames per second (FPS) for real-time monitoring. Overall, the proposed approach provides an efficient and reliable solution for railway foreign object detection and safety monitoring.

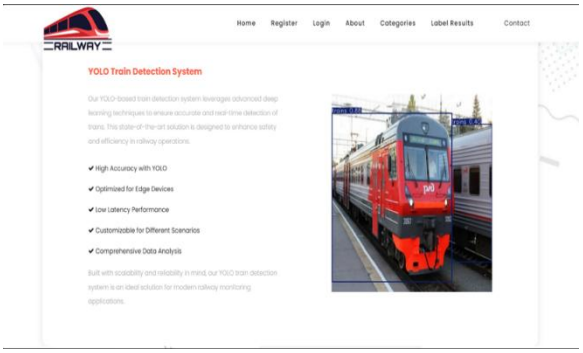


Fig. 2: Home Page

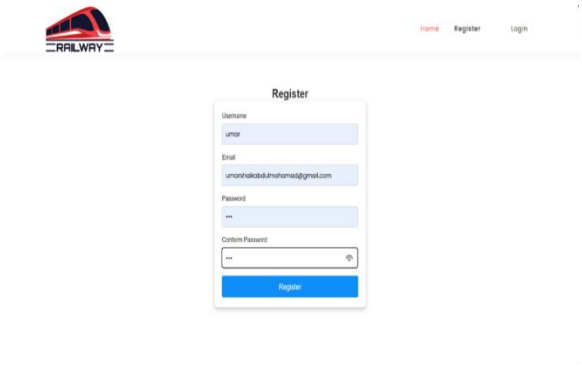


Fig. 3: Registration

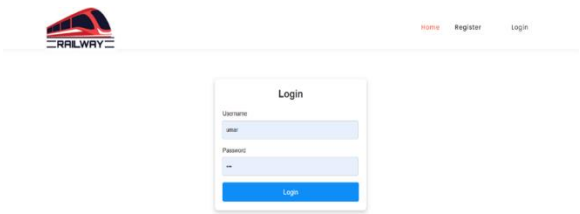


Fig. 4: Login

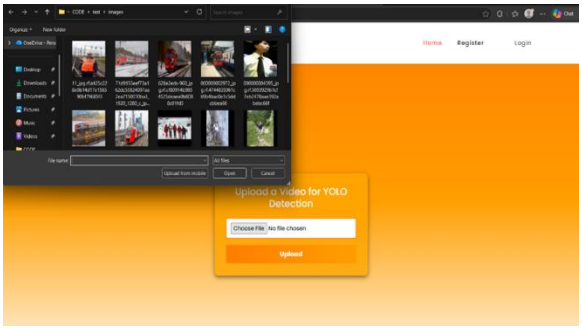


Fig. 5: Upload Images

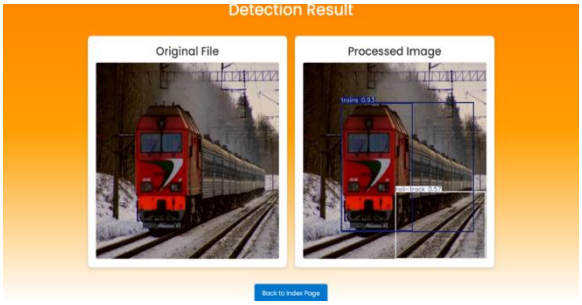


Fig. 6: Result

V. CONCLUSION

In conclusion, the proposed rapid railway foreign object intrusion detection system offers an efficient and accurate solution to the challenge of detecting foreign objects on railway tracks. The use of YOLOv8 for foreign object detection further ensures accurate localization and classification of detected objects, while omitting unnecessary detection steps for images classified as "normal." The experimental results confirm that the proposed system achieves comparable accuracy to traditional methods but excels in terms of processing speed and computational efficiency. This system provides a foundation for real-time railway monitoring, offering enhanced safety and faster response times. Future enhancements, including the adoption of newer models, multi-modal data integration, and scalability improvements, could further expand the system's capabilities, making it an even more robust solution for railway track safety monitoring.

REFERENCES

[1] Z. Teng, F. Liu, and B. Zhang, ‘‘Visual railway detection by superpixel based intracellular decisions,’’ Multimedia Tools Appl., vol. 75, no. 5,pp. 2473–2486, Mar. 2016.

[2] T. Xiao, Y. Xu, and H. Yu, ‘‘Research on obstacle detection method of urban rail transit based on multisensor technology,’’ J. Artif. Intell. Technol., vol. 1, no. 1, pp. 61–67, Jan. 2021.

[3] Y.-R. Pu, L.-W. Chen, and S.-H. Lee, ‘‘Study of moving obstacle detection at railway crossing by machine vision,’’ Inf. Technol. J., vol. 13, no. 16, pp. 2611–2618, Aug. 2014.

[4] P. Felzenszwalb, R. Girshick, D. McAllester, and D. Ramanan, ‘‘Object detection with discriminatively trained part-based models,’’ IEEE Trans. Pattern Anal. Mach. Intell., vol. 32, no. 9, pp. 1627–1645, Sep. 2010.

[5] M. Ruder, N. Mohler, and F. Ahmed, ‘‘An obstacle detection system for automated trains,’’ in Proc. IEEE 4th Intell. Vehicles Symp., Jun. 2003, pp. 180–185.

[6] F. Auger, M. Hilairet, J. M. Guerrero, E. Monmasson, T. Orlowska-Kowalska, and S. Katsura, ‘‘Industrial applications of the Kalman filter: A review,’’ IEEE Trans. Ind. Electron., vol. 60, no. 12, pp. 5458–5471, Dec. 2013.

[7] H. Mukojima, D. Deguchi, Y. Kawanishi, I. Ide, H. Murase, M. Ukai, N. Nagamine, and R. Nakasone, ‘‘Moving camera background-subtraction for obstacle detection on railway tracks,’’ in Proc. IEEE Int. Conf. Image Process. (ICIP), Sep. 2016, pp. 3967–3971.

[8] S.-C. Oh, G.-D. Kim, W.-T. Jeong, and Y.-T. Park, ‘‘Vision-based object detection for Passenger’s safety in railway platform,’’ in Proc. Int. Conf. Control, Autom. Syst., vol. 2, Oct. 2008, pp. 2134–2137.

[9] H. Salmane, L. Khoudour, and Y. Ruichek, ‘‘A video-analysis-based railway–road safety system for detecting hazard situations at level crossings,’’ IEEE Trans. Intell. Transp. Syst., vol. 16, no. 2, pp. 596–609, Apr. 2015.

[10] Y. Xu, C. Gao, L. Yuan, S. Tang, and G. Wei, ‘‘Real-time obstacle detection over rails using deep convolutional neural network,’’ in Proc. IEEE Intell. Transp. Syst. Conf. (ITSC), Oct. 2019, pp. 1007–1012.

AUTHORS Profile



Mrs. SHAGAM GEETHA has received her B.Tech Computer Science and Engineering from Nagarjuna Institute of Technology, JNTUH in 2012, M.Tech-Vidya Vikas Institute of Technology, Computer Science and Engineering from JNTUH. She is dedicated to teaching field from the last 8 years. At present she is working as Assistant Professor in CSE Department at Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India.



Mr. SHAIK UMAR pursuing B.Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.



Mr. MUDUTHANA-PALLI SRI CHARAN pursuing B.Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.



Mr. PACHIPALA VINAY YADAV pursuing B.Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.



Mr. SHAIK SHARUK pursuing B.Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.