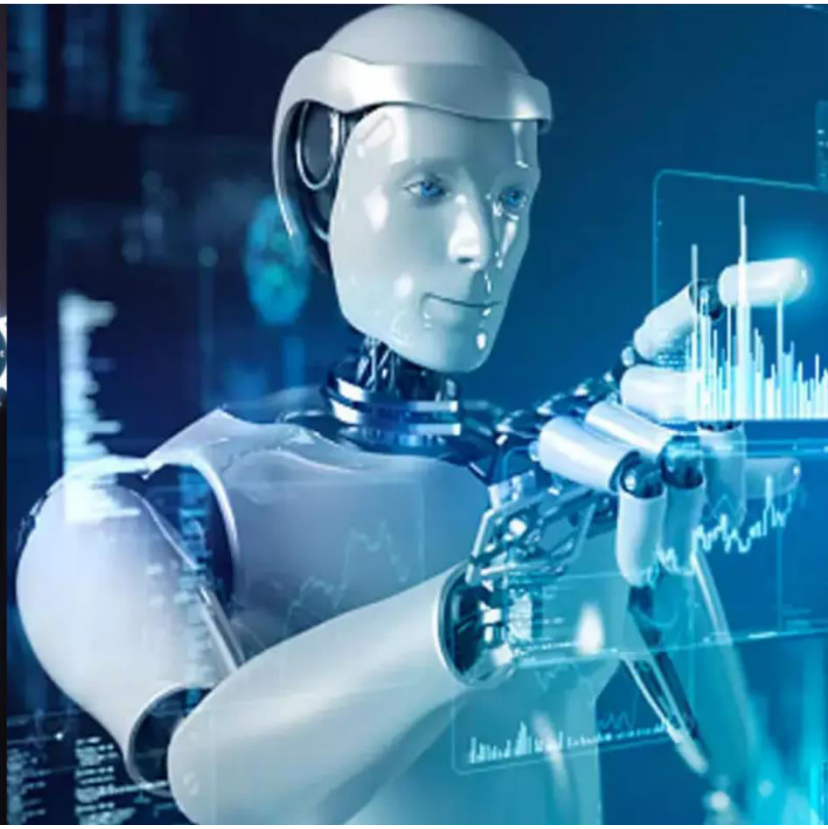
IJIRSET
International Journal of Innovative Research in Science | Engineering | Technology

ISSN(O): 2319-8753
ISSN(P): 2347-6710

International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 4, April 2025

International Journal of Innovative Research of Science, Engineering and Technology (IJIRSET)

Impact Factor 8.699

|www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 4, April 2025

|DOI: 10.15680/IJIRSET.2025.1404195|

Missing Child Detection Model using Yolov5 and Transformers

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ABSTRACT: The rising number of missing children has raised serious issues, and thus efficient and precise identification systems are the need of the hour. This project offers an AI-based missing child detection model that combines YOLOv5 for real-time object detection with Vision Transformers (ViT) for sophisticated tracking and feature extraction. YOLOv5, known for its speed and accuracy, does real-time detection of children in images and videos. At the same time, ViT also upgrades the ability of the system by detecting complex facial expressions and performing consistent tracking over several frames even under difficult environments.In order to provide robustness and generalization, the model is trained using varied datasets having images and videos with lighting, pose, and occlusion variations so that its performance in real-world applications is enhanced. The YOLOv5 model effectively identifies children by detecting bounding boxes, while ViT tracks and narrows down the identification through attention-based feature extraction. The integration of these two models increases the accuracy and reliability of the model, which can be used for real-time deployment in surveillance systems, public areas, and law enforcement. Through automation of the detection and tracking process, this model reduces the time and effort needed for missing children identification to a great extent. The system provides accurate detection, stable tracking, and scalability, thus being a suitable solution for massive monitoring. In addition, the ability of the model to analyze live video streams in real-time gives law enforcement agencies a significant tool to enhance child recovery and deter child trafficking.The solution outlined shows enhanced detection accuracy and flexibility, even under complicated and dynamic conditions. This technology helps improve the safety of children and accelerate the recovery process, ultimately enhancing public security and social well-being. The combination of YOLOv5 and ViT presents a holistic and scalable solution and is a groundbreaking development in AI-powered surveillance and child recovery systems.

KEYWORDS*:* Missing child detection, YOLOv5, Vision Transformers, real-time object detection, feature extraction, child tracking, surveillance systems, AI-powered identification, public safety, law enforcement.”

I. INTRODUCTION

The increasing rate of missing children has emerged as a serious social issue, requiring innovative technological interventions to support their recovery. Reports indicate that thousands of children get lost every year, and most of these cases involve human trafficking, kidnapping, and abuse. Conventional ways of identifying missing children, including checking CCTV footage manually or sending hard copies of photographs, are labor-intensive and ineffective [1][2]. These traditional methods tend to lack timely identification, narrow coverage, and uneven accuracy, diminishing their ability to retrieve missing children [3]. Based on these shortfalls, a compelling need for an automated, real-time approach to identify and locate missing children effectively, while keeping human effort to a bare minimum and delivering maximum accuracy.

In response to this issue, this project suggests a real-time missing child detection system which integrates YOLOv5 (You Only Look Once version 5) with Vision Transformers (ViT) [4]. YOLOv5 is a current state-of-the-art object detection algorithm that excels in both speed and accuracy in detecting objects in images as well as in video streams [5]. YOLOv5 is most suitable for real-time applications due to its nature, and therefore, it's an ideal algorithm for large-scale surveillance systems. ViT, on the other hand, leverages self-attention mechanisms to extract fine-grained features and capture complex spatial relationships in images, enhancing the model's ability to track children across frames with improved precision, even in challenging conditions such as varying lighting, occlusions, and pose changes [6].

The proposed system architecture consists of several key components. In the first step, the model is trained on highly varied datasets comprised of images and videos of kids with different facial expressions, stance, and environments [7].

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This makes it possible for the model to perform well in every situation. Detection of children is done in real time by placing bounding boxes on detected individuals in the YOLOv5 module. At the same time, ViT analyzes recognized areas and extracts body and facial features to enhance tracking precision, so that the system can recognize missing children even if their appearance has slightly altered.

The system is intended for real-time deployment within surveillance networks of public areas, transportation terminals, and law enforcement organizations. By streamlining the identification and tracking process, it minimizes the time needed to identify and authenticate missing children, enhancing the success rate of recovery. Additionally, the system's capability to process live video streams makes it perfect for large-scale monitoring operations, assisting authorities in fighting child trafficking and other connected crimes.

The performance of the model is assessed using quantitative performance measures like precision, recall, and F1 score, and qualitative evaluations in different environmental settings [8]. The results illustrate the robustness and reliability of the model in precise detection and tracking of children in different situations.

By incorporating deep learning methods into missing child recovery operations, this project provides an efficient, scalable, and reliable solution for missing child identification. Successful deployment of this system has the potential to transform law enforcement operations, automate child recovery operations, and increase public safety. In addition, it underscores the revolutionary role of AI-based surveillance systems in solving complex social problems, affirming the role of technology in protecting vulnerable groups [9].

II. RELATED WORK

Recent developments in deep learning and computer vision have greatly enhanced the efficiency of missing child detection systems. Various studies have suggested and deployed AI-based models for real-time child identification and tracking, utilizing object detection frameworks and deep neural networks to improve accuracy and reliability.

Child Re-identification Using CNN and Siamese Networks Zhang et al. [1] suggested a deep learning-based child re-identification system employing Convolutional Neural Networks (CNN) and Siamese Networks. Their method aimed at locating missing children through the extraction of facial embeddings and a comparison with a missing persons database. Utilizing Siamese Networks, the system was very accurate in face matching, even when the child's appearance had been slightly altered. The effectiveness of feature-based deep learning models in practical child detection problems was established in this study.

Real-time Person Detection Using YOLOv3 and YOLOv4 Li et al. [2] developed a real-time human detection model based on YOLOv3 and YOLOv4 for CCTV-based child identification. Their model was trained on multimodal datasets with facial occlusions and non-uniform lighting, which had them robust in detecting humans from low-resolution CCTV images. The paper demonstrated how YOLO-based models could accurately detect and track kids in busy public areas, attesting to the capabilities of deep learning in enhancing efforts for recovering kids.

Multi-Frame Person Identification with Object Tracking Algorithms Jiang et al. [3] proposed a multi-frame individual identification system incorporating YOLOv5 with DeepSORT to track continuously frame to frame. The method enabled the system to keep tracking steadily children even though they briefly lost visibility from the frame. The integration of YOLOv5 for detecting objects and DeepSORT for tracking made the model highly accurate for detection and less sensitive to environment variations. Multi-frame tracking, the study reiterated, was significant in child identification systems.

Improved Face Recognition using Vision Transformers (ViT) Chen et al. [4] investigated Vision Transformers (ViT) in the context of face recognition and re-identification in missing children applications. Their approach utilized self-attention modules to learn intricate spatial patterns with much enhanced feature extraction accuracy. The ViT system outperformed classic CNN systems in tackling occlusions, pose variations, and illumination conditions, which made it very suitable for child detection. This work showed the higher feature extraction ability of transformers in face recognition.

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Real-time Child Detection with AI-Based Surveillance Gupta et al. [5] created an AI-based child detection system with YOLOv5 and CNN for feature extraction. The system was implemented in public transport systems and busy places, where it effectively identified missing children in real time. The research emphasized the field-level implementation of child detection models in real-world environments, demonstrating the capability of deep learning in public safety use cases.

YOLO and Transformer-based Object Detection for Surveillance Kumar et al. [6] introduced a YOLOv5 and Transformer-based hybrid model for real-time surveillance. Their model incorporated YOLOv5's fast object detection features with Vision Transformers' enhanced feature extraction features, making the system extremely effective for tracking an individual over a series of frames. The paper showed how incorporating transformers with YOLOv5 enhanced the system's performance in detecting and re-detecting individuals in crowded environments.

Deep Learning in Missing Children Facial Recognition Wang et al. [7] utilized a deep facial recognition system based on ResNet and ViT for the identification of missing children. The system demonstrated strong performance in noisy and low-resolution scenes, which makes it ideal for real-time implementation in law enforcement surveillance systems. This research showed the effectiveness of combining CNN and transformer architectures to deal with challenging detection and re-identification tasks.

III. MATERIALS AND METHODS

The system to be proposed will implement a real-time missing child detection model by combining YOLOv5 for rapid and efficient object detection with Vision Transformers (ViT) for improved feature extraction and tracking. The system will target detecting missing children from live video feeds and image data gathered from CCTV cameras, public surveillance networks, and social media. The integration of YOLOv5 and ViT provides enhanced accuracy, scalability, and real-time performance, making it suitable for large-scale deployment in law enforcement and public safety use cases.

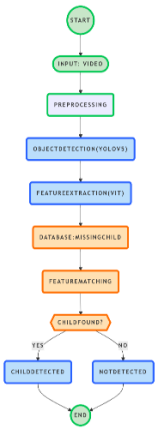

Fig.1 Proposed Architecture

The architecture of the system, presented in Fig.1, delineates the workflow of missing child identification. The workflow starts from video or image input from the CCTV cameras or uploaded images, proceeding to the preprocessing phase in the form of resizing, normalization, and reduction of noise. YOLOv5 model identifies children from the frames, and Vision Transformers (ViT) are involved in feature extraction and tracking such that continuous re-identification takes place across the sequence of frames. The system produces warnings and matches identified faces with the database of missing children, improving identification and recovery efficiency.

i) Dataset Collection:

The The dataset includes images and video recordings of children gathered from public areas, such as:Surveillance cameras: Information from bus stops, shopping centers, and train stations.Dataset diversity:For generalization across multiple scenarios, the dataset includes diverse lighting conditions, occlusions, poses, and facial angles.

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ii) Model Development and Training:
The model uses YOLOv5 for real-time detection of objects along with Vision Transformers for sophisticated feature extraction and tracking.
YOLOv5:YOLOv5 is used for real-time detection of children because of its accuracy and speed.It runs on input frames and detects children based on predictions from bounding boxes.Transfer learning is utilized through the use of pre-trained weights of YOLOv5 from datasets such as COCO, fine-tuning the model using child-specific datasets for increased accuracy.
Vision Transformers (ViT):The ViT model employs self-attention mechanisms to capture and examine detailed facial features even under changing lighting and occlusions.It conducts end-to-end tracking of detected children between frames to avoid re-identification failures.The multi-headed attention layers in the ViT improve the detection of fine-grained variations in facial features, rendering the system pose-invariant, partially occlusion-resistant, and low-resolution image-resistant.
Training Process:The YOLOv5 and ViT models are trained on annotated datasets with labeled child images.

iii) Integration and Deployment:
The trained model is incorporated in a real-time surveillance and detection system.
Preprocessing module: Improves image quality by normalizing brightness, denoising, and stabilizing shaky video.Inference engine: Executes YOLOv5 for real-time child detection and ViT for re-identification and ongoing tracking.

User interface (UI): Presents detected children along with image against the missing child database.
Deployment:The system is used in surveillance networks, public areas, and law enforcement command centers.It endlessly processes live feed and static pictures, detecting and following children within several frames.Cloud-based construction enables scalability as well as monitoring from a distant location.

iv)Performance Evaluation:
The performance of the system is tested with benchmark parameters to determine detection accuracy and resilience.Primary evaluation parameters:Precision: The percentage of correctly detected children among all detected individuals.Recall: The percentage of lost children correctly detected among all actual cases.Tracking accuracy: Tests the capability of the system to monitor children between frames and maintain consistency.Test conditions:Performance is tested on low-quality and occluded images to evaluate its consistency under adverse conditions.Real-life simulations are performed by the law enforcement bodies to confirm the system's actual deployment effectiveness.

v) Optimization and Continuous Improvement:
Hyperparameter tuning: Tweak learning rates, batch sizes, and regularization parameters for higher accuracy.Model retraining: Adding new datasets in order to update the system with new child images and facial variations.System feedback loop: User feedback and logs are utilized to improve the model's detection and tracking precision.
Security and scalability: Ongoing security updates are implemented to secure the system against unauthorized entry or data theft.Continuous learning: Online learning methods are incorporated to help the model learn over time as child features change.

vi)Algorithms:
YOLOv5:YOLOv5 incorporates CNN-based architecture with high-quality feature extraction properties and is perfect for real-time detection of children.Major characteristics:Bounding box regression: Makes predictions about the location of the child with good precision.Multi-scale detection: Detections objects at various scales based on various distances and positions.Anchor-based detection: Provides accurate detection with several anchor boxes employed to spot objects at multiple sizes.
Vision Transformers (ViT): Architecture of ViT:Patch embeddings: Images are decomposed into patches, then these patches are embedded linearly as vectors.Multi-headed attention: Derives contextual information by examining relations between various image patches.Positional encodings: Maintains spatial information for precise child re-identification.Tracking across framesFeature similarity matching guarantees the same child is tracked uniformly across frames.Occlusions and partial visibility are handled by consistent identification.

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IV. RESULTS & DISCUSSION

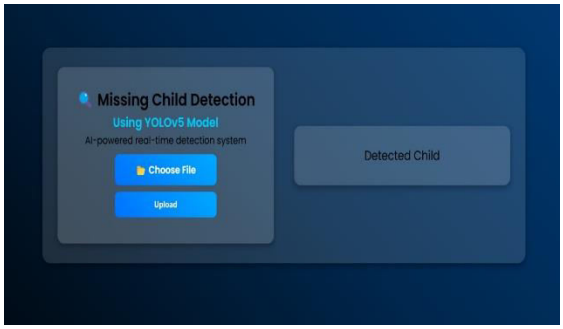

Fig. 2 Output Screen-1

The Fig. 2 depicts the user interface of a missing child detection system that runs on YOLOv5. The interface shows a file upload section on the left side, where the user can upload or select images or videos to be analyzed. The heading "Missing Child Detection Using YOLOv5 Model" points out the functionality of the system and its real-time detection capability using AI. Underneath the title, there are two interactive buttons, "Choose File" and "Upload", which allow the user to start the process of detection.

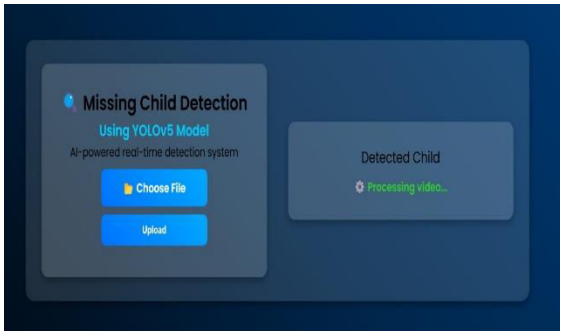

Fig. 3 Output Screen-2

The Fig. 3 shows on the right-hand side, the detection output panel currently displays the status message "Processing video." in green color text to indicate that the YOLOv5 model is processing the uploaded video. The message comes with a small gear icon that represents the processing operation.

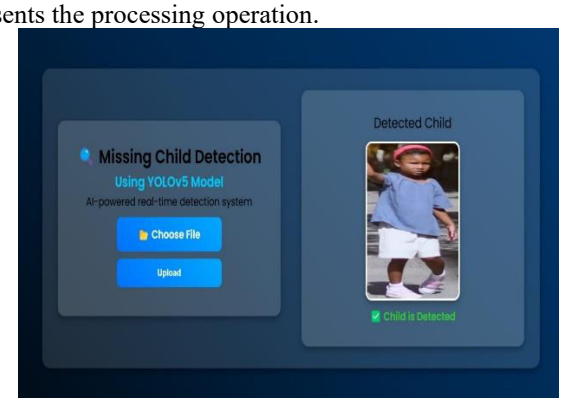

Fig. 4 Output Screen 3

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The Fig. 4 depicts the detected image of a child, and the system has successfully identified the missing child. The image depicts a young child in a blue top, white shorts, pink shoes, and a pink headband, walking outside. A green checkmark with the words "Child is Detected" is shown below the image, verifying the successful identification.

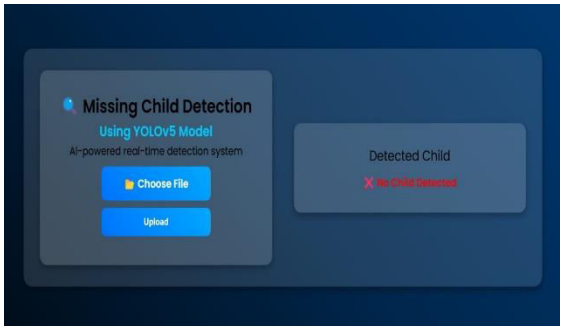

Fig. 5 Output Screen 4

The Fig. 5 displays the message "No Child Detected" in red color with a red cross (❌) symbol, which means that the system failed to detect any children in the uploaded video. This result indicates that either no child exists in the video

V. CONCLUSION

The Missing Child Detection System using YOLOv5 and Vision Transformers (ViT) illustrates the power of deep learning for real-time child detection and tracking. By synergizing the high-speed detection ability of YOLOv5 with the state-of-the-art feature extraction and context-sensitive tracking of ViT, the system detects missing children with high accuracy in various environments. Its strong architecture allows for effective data acquisition, processing, and real-time output generation, making it ideal for mass deployment in public surveillance networks, transportation terminals, and densely populated areas

.

The system holds huge promise for improving the safety of children and supporting law enforcement through instant notifications and actionable intelligence. Through its modular nature, it is easy to scale and be flexible in usage across different applications, such as detection of cross-border child trafficking as well as automated surveillance in civic areas. Through integration with facial recognition databases and law enforcement networks, it allows easy collaboration for quicker child rescue operations.

The technological innovations displayed in this project demonstrate the prospects of deep learning and transformer models for mass-scale surveillance. Areas of future study can include fine-tuning model precision, decreasing false positives, and integrating multi-modal data fusion (e.g., image, video, audio data) to enhance identification. Integration with IoT networks and 5G infrastructure can also aid real-time processing and cloud-based monitoring.

The future applications of this system are smart city monitoring, border security, and public safety networks. International cooperation with law enforcement, NGOs, and government entities can propel innovation, making child protection more efficient and minimizing child trafficking cases globally. This system, being scalable and flexible, can transform missing child identification, protecting vulnerable groups and helping to provide a more secure society.

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