Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 11s (2025)
https://www.jneonatalsurg.com

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Real-Time Detection and Alert System for Construction Worker Safety Gear Using YOLOv5

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.Cite this paper as: D. Ferlin Deva Shahila, Lincy Annet Abraham,C. N Vanitha, A.Dharani, Mary Jasmine, (2025) Real-Time Detection and Alert System for Construction Worker Safety Gear Using YOLOv5. *Journal of Neonatal Surgery*, 14 (11s), 792-803.

ABSTRACT

An inventive way to improve safety procedures on building sites is presented by the "Real-time Construction Worker Safety Gear Detection and Alert System using YOLO5" initiative. The technology uses real-time camera feeds and the cutting-edge YOLO5 object identification algorithm to identify and categorise critical safety equipment worn by construction workers. This involves identifying tools that are essential for reducing occupational risks, such as masks, vests, and helmets. Through ongoing video stream analysis, the technology makes sure that employees follow safety protocols by instantly notifying managers of any inconsistencies or lack of safety gear. The system's strong safety product detection module is its fundamental component. It uses YOLO5's sophisticated object detection capabilities to precisely identify safety equipment in the face of shifting worker motions and ambient circumstances. The model gains a high level of precision in identifying safety equipment through rigorous training on annotated datasets, allowing for dependable identification even in dynamic building site situations. Additionally, a built-in email alert mechanism guarantees supervisors are notified right away of any safety gear violations, allowing for prompt action to address the issue and maintain safety regulations. All things considered, the YOLO5 project's Real-time Construction Worker Safety Gear Detection and Alert System offers a complete answer to safety issues in the building sector.

Keywords: *Object Detection, YOLOv5 (You Only Look Once), Computer Vision, Deep Learning, Safety Gear Classification*

1. INTRODUCTION

One of the most innovative uses of computer vision technology in the construction sector is the "Real-time Construction Worker Safety Gear Detection and Alert System using YOLO5" project. The system can identify and categories crucial safety equipment worn by construction workers by using the YOLO5 object detection model to watch live camera feeds in real-time. By improving safety procedures on building sites, this creative strategy makes sure that employees have the tools they need to reduce occupational risks.

Wearing the proper safety gear is crucial for workers' safety on construction sites, which are dynamic settings with numerous risks. However, because it involves ongoing attention to detail and is subject to human error, manual monitoring of safety gear compliance is difficult. By employing computer vision to automate the monitoring process, our technology tackles these issues and lowers the possibility of mishaps and injuries on building sites. The initial goal of this initiative is to create a dependable and effective system for identifying and classifying safety equipment worn by construction workers in real time. This involves identifying products that are essential to worker safety, such as masks, vests, and helmets. The device seeks to increase safety compliance on construction sites and lower the risk of accidents by precisely recognizing protective gear in real-time. Creating a software system that can analyses real-time video feeds from building site cameras is part of the project's

scope. The system will identify and categories safety equipment in real-time using the YOLO5 object detection paradigm.

Furthermore, in the event that safety gear is violated, the system will promptly notify supervisors, allowing for prompt action to guarantee safety compliance. The technology will be scalable and flexible enough to adjust to various construction site conditions, making it a flexible way to improve safety in the building sector. A machine or computer program's potential for thought has been termed as artificial intelligence (AI). and learn. Another area of research that aims to make computers "smart" is this one. Mental facilities that were previously believed to need intelligence are eliminated from the definition as computers grow more and more capable.

2. LITERATURE SURVEY

[1] For workers in the industrial, electricity, and construction industries, wearing a safety helmet is essential. Employees expose themselves to additional risks when they often take off their helmets out of inconvenience and a lack of security awareness. Workers who don't wear helmets are more likely to get hurt in situations like falls, electrical shocks, and losing big objects. Therefore, it is imperative that all managers have the ability to quickly and accurately recognize safety helmets. Employee supervision in a big population is challenging and time-consuming with traditional human monitoring. The traditional helmet identification system used by the industry is not advised for usage due to its low accuracy and poor robustness. Consequently, this study provides a deep learning method for accurately detecting the use of safety helmets. The Kaggle website is used to gather the necessary photos. [2] On a building site, safety is the most crucial factor. Every everyone working in a building site is required to wear a safety helmet, which significantly lowers the number of accidents and fatalities. Even if employees recognize the dangers of not wearing safety helmets, a large number of people could fail to do so, which could result in serious security risks. The model based on YOLO is used, and the parameters are adjusted appropriately. The suggested model has an accuracy rate of 20 ms and a precision of 78.3%. The outcomes show that the suggested model is a relatively quick and efficient technique for real-time helmet detection identification and localization. [3] In order This study offers strategies based on You Only Look Once (YOLO) architectures for six classes to train and evaluate eight deep learning detectors for real-world applications, including vests, people, and four-colored helmets. In the meanwhile, 1330 photos from a specific high-quality dataset called CHV are created by considering the background of a genuine work site, various movements, a range of angles and distances, and many PPE classes. [4] This study introduces a real-time computer vision-based inherent safety helmet detection system at a construction site that depends on the You Only Look Once (YOLO) principle. YOLO-based designs' high processing speed (45 frames per second) may be used for real-time safety helmet identification. This study employed a benchmark dataset of 5000 hard hat photos, which was further split into training, testing, and validation in a 60:20:20 (%) ratio. According to the trial findings, the YOLOv5x architecture

demonstrated exceptional performance in recognizing safety helmets, acquiring the highest mean average accuracy (mAP) of 92.44% even in dimly lit circumstances. [5] Based on the You-Only-Look-Once (YOLO) architecture, this study proposes three deep learning (DL) models to figure out if a worker is wearing a hard helmet, vest, or both. These models are used to analyses images and videos in real time. In the first method machine learning model (such a decision tree or neural network) determines if each approved worker is adequately wearing a vest or hat. once the algorithm has discovered workers, hats, and vests. In the second method. The system employs the use of one convolutional neural network (CNN) structure to both recognize individual personnel and declare PPE compliance. [6] A well-known yearly competition in The ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in computer vision assesses techniques for large-scale object recognition and picture categorization. It makes use of the ImageNet collection, which has thousands of categories and millions of labelled pictures. Deep learning has advanced significantly as a result of the challenge, especially with the creation of models like AlexNet, VGG, and ResNet.[7] A Method for Stochastic Optimization" presents Adam (Adaptive Moment Estimation), a popular optimization approach for deep learning model training. Adam combines the advantages of two approaches: RMSProp, which use exponential moving averages of gradients, and Aderid, which modifies learning rates for particular parameters. The approach works well for issues with big datasets or parameters, is memory-efficient, and takes less memory. [8] The "Realtime Multi-Person 2D Pose Estimation utilizing Part Affinity Fields" paper describes a technique for real-time human stance detection for numerous people in a picture. It presents Part Affinity Fields (PAFs), which enable the system to group parts that belong to the same individual by encoding the associations between bodily parts. The method is effective, scalable, and maintains real-time performance while achieving high accuracy on pose estimation tasks. [9] A. PPE detection on big construction sites using a layered network Utilizing segmenting frames. [10] The "Identification System of Personal Protection Items Using Convolutional Neural Network (CNN) Method" was delivered at the 2020 Creative Construction e-Conference held at Budapest University of Technology and Economics. article describes a method for identifying and categorizing PPE (such as vests, gloves, and helmets) in pictures. It uses CNNs to identify if people are wearing the necessary safety gear with great accuracy. This technology is essential for automating compliance monitoring, lowering the need for manual inspections, and guaranteeing workplace safety. [11] CNNs are investigated in the publication ""A Convolutional Neural Network-Based Solution Towards Real-Time Hard Hat Detection" in order to identify hard hats in live video streams. By automatically detecting people in dangerous situations who are not wearing the appropriate protective gear, it seeks to improve workplace safety. Because of its excellent detection accuracy, the suggested approach may be used in real-time industrial safety monitoring applications. [12] The paper "You Only Look Once: combine, Real-Time Object Detection" introduces the YOLO (You Only Look Once) algorithm, a novel method for object identification in real time. In contrary to prior approaches that perform object detection in multiple stages, YOLO frames the problem as a single regression task, improving speed and efficiency[13]. The method achieves impressive real-time performance while maintaining high accuracy, making it highly suitable for applications requiring fast object recognition.

3. METHODOLOGY

The goal of the suggested system is to use YOLOv5 (You Only Look Once version 5) to create a reliable and effective safety product detection system for building sites. The technology will automatically recognize and recognize safety gear worn by construction workers using deep learning and computer vision techniques. The trained YOLOv5 model will be used by the system to interpret input photos or videos taken at construction sites. It will recognize safety gear like a helmet, mask, and safety vest by analyzing the visual data. Real-time detection will enable prompt and precise identification of the use of safety products.

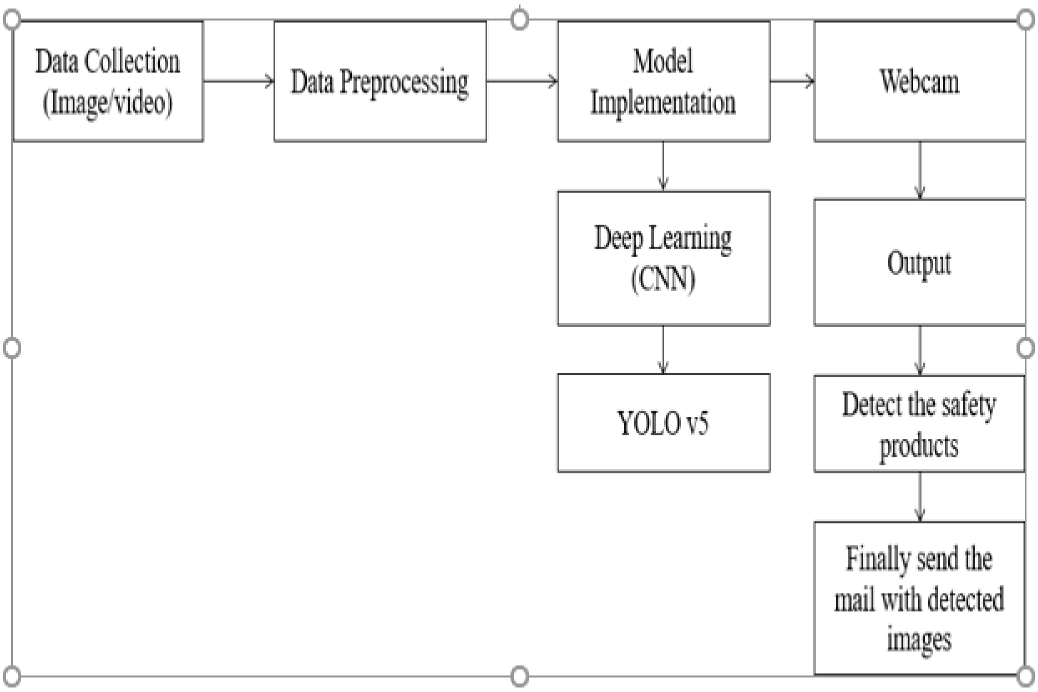

Fig : 1 Architecture diagram for Worker Safety Gear Detection

3.1 Input Module:

The input module is at the forefront of innovations in occupational safety. This system uses camera feeds to monitor construction sites in real-time, utilizing YOLO5, a powerful object identification model. It quickly identifies workers and makes sure they are wearing necessary safety equipment, such as masks, vests, and helmets. The technology instantly notifies supervisors in the case of any inconsistency or lack of safety equipment, allowing them to take swift action and enforce safety regulations, hence reducing the likelihood of mishaps and injuries. In addition to creating a safer workplace, this technology expedites monitoring procedures, opening the door for preventative safety measures on building sites

3.2 Preprocessing Module:

Incoming camera footage for this project passes through a number of important processes to guarantee precise and effective safety gear detection. In order to analyses individual images, the raw video input is first recorded and transformed into frames. After that, these frames are normalized and scaled to a format that is accepted by the YOLO5 model. Additionally, methods like picture improvement and noise reduction may be used to increase the quality of the input data, which will help the model recognize safety gear more correctly under a variety of environmental elements and lighting circumstances. Additionally, to diversity the training dataset and enhance the extrapolation abilities and durability of the model, data augmentation methods like random cropping, rotation, and flipping may be used. The solution guarantees that the YOLO5 model receives high-quality input data through careful preprocessing, enabling dependable real-time identification of safety gear on construction workers.

3.2 Safety Product Detection Module:

The YOLO5 object detection model is trained to precisely identify and categories critical safety equipment worn by construction workers in the Safety Product Detection module of the "Real-time Construction Worker Safety Gear Detection and Alert System using YOLO5" project. This session focusses on using webcam footage to detect important safety items including masks, vests, and helmets in real time. Utilizing the effectiveness and precision of the YOLO5 architecture, the model examines every video frame to identify if safety equipment is worn by construction workers and where it is located. The model gains the ability to identify safety gear with high precision and recall by means of prolonged training on annotated datasets that comprise a variety of instances of the equipment in a range of orientations and environmental conditions. This module's ability to detect safety equipment in real time is crucial for guaranteeing that construction workers are appropriately protected. It also makes it possible to act quickly when safety equipment is lost or worn incorrectly, which improves workplace safety procedures.

4. MAIL SHARING MODULE:

Using webcam footage, the YOLO5 object identification model is taught to recognize and categories vital safety equipment including masks, vests, and helmets with accuracy in real-time. This module quickly detects the presence and proper placement of safety equipment on construction workers by analyzing each frame of the video stream using the accuracy and efficiency of the YOLO5 architecture. An integrated Email Send module is activated when any inconsistencies or lack of safety equipment are detected. This module immediately notifies selected supervisors or safety officers of the particular problem that was noticed. These emails provide relevant information, such the incident's location and timing, which allows supervisors to respond quickly to address the issue and successfully enforce safety procedures. This module contributes to improved safety measures on construction sites by ensuring prompt response and intervention through the seamless integration of safety gear detection with automated email notifications.

3.5 YOLO (You Only Look Once):

When it comes to locating and recognizing things or entities of interest in multimedia data, such pictures or videos, the object identification method YOLO is essential. YOLO is used to identify and detect people, cars, or other pertinent things from surveillance film or photos in the context of suspect prediction from criminal networks. YOLO follow possible suspects by accurately and effectively processing incoming data in real-time, allowing law enforcement to act quickly.

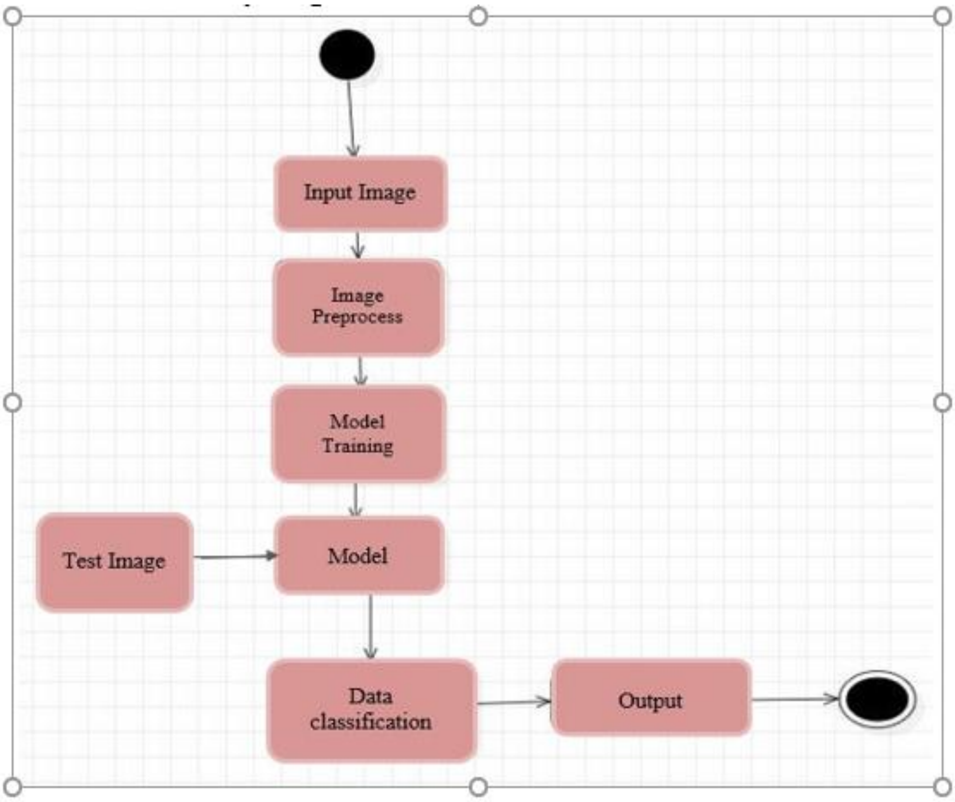

Fig: 2 Activity diagrams

CPU type	I5
Ram size	4GB
Hard disk capacity	80 GB
Keyboard type	Internet keyboard
Monitor type	15 Inch colour monitor
CD -drive type	52xmax

Table :1 Hardware Requirements

OpenCV: "OpenCV was created with real-time applications and computational efficiency in mind. OpenCV has been widely used, with a user base of worldwide installations of over 47,000 and an estimated 14 million. Applications include mine inspection, interactive art, online mapping, and sophisticated robots.

An open-source platform that allows for applications in computer vision is called SimpleCV. Without having to initially understand matrix versus bitmap storage, bit depths, file formats, color spaces, buffer supervisors, or eigenvalues, you may use it to access a number of powerful computer vision packages, like OpenCV. Mahotas is a Python module for image refining and computer vision. It features a very tidy Python interface and several C++-implemented methods for speed when working with numpy arrays. At the moment, Mahotas offers more than 100 image processing and computer vision tasks, and it continues to expand.

Multidimensional array items and several processing procedures are included in the NumPy, or Numerical Python, package. Arrays may be subjected to logic and math operations using NumPy. The fundamentals of NumPy, including its environment and architecture, are covered in this lesson. The several array functions, indexing kinds, etc., are also covered. Additionally, an overview of Matplotlib is given. To aid with comprehension, examples are used to describe each of these points.

For people who wish to learn about the fundamentals and other features of NumPy, this lesson has been produced. It is very helpful for those who create algorithms. You will be at a moderate level of skill after finishing this tutorial, from which you can go to more advanced levels.You ought to be familiar with the fundamental terms used in computer programming. It is advantageous to have a basic grasp of Python and other programming languages.

NumPy is a Python package. And it signifies 'Numerical Python'. It is a library comprising multidimensional array objects and several array processing functions. Numeric, which was precursor to NumPy, was developed by Jim Hugunin. Another program with more abilities Numara, was also developed. In 2005, Travis Oliphant integrated the functionality of Numara with the Numeric package to create the NumPy package. There are many collaborators to this open source project.

In a broader sense, pictures can also be created by a combination of techniques, particularly in a pseudo-photograph, or manually, by sketching, painting, or carving; A rectangular grid of pixels is called an image. Its width, measured in pixels, and height are both fixed. On a certain display, every pixel is square and has a set size. However, pixel sizes may vary throughout computer displays. Each pixel in a picture is made up of integers that represent brightness and color magnitudes and are arranged in a grid (columns and rows).

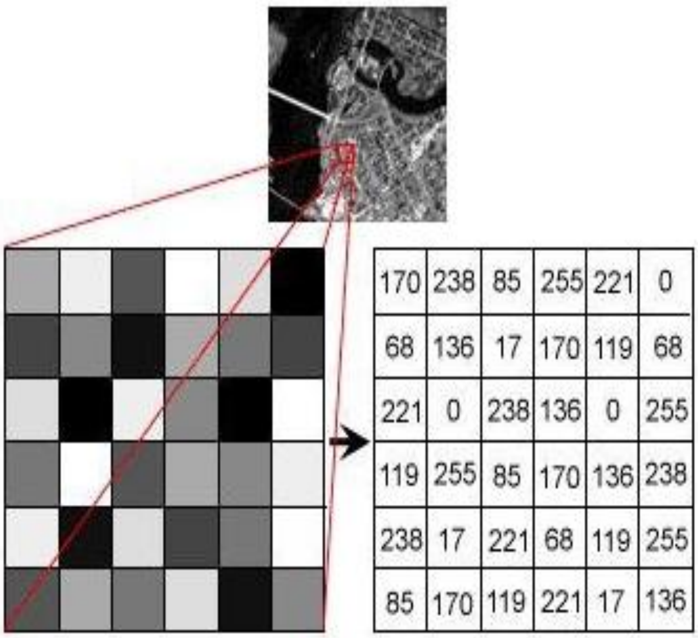

Fig : 3 Gray Scale Image Pixel Value Analysis

Every pixel has a distinct colour. The colour is an integer with 32 bits. The pixel's redness, greenness, and blueness are determined by the first eight bits, followed by the transparency and the following eight bits, respectively. The number of bytes that rises in proportion to the number of pixels that make up a picture and the colour depth of those pixels is the measure of the size of an image file. The image resolution increases with the number of rows and columns, and the file size also increases. Additionally, as an image's color depth rises, so does the size of each pixel of which is referred to as true colour.

5. SIMULATION RESULT

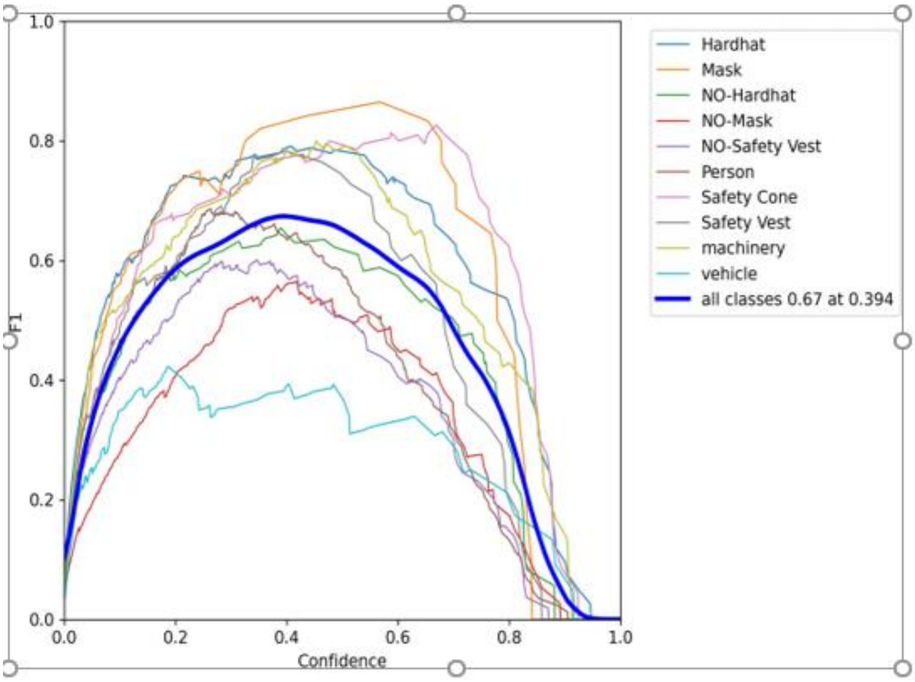

Fig : 4 F1 score

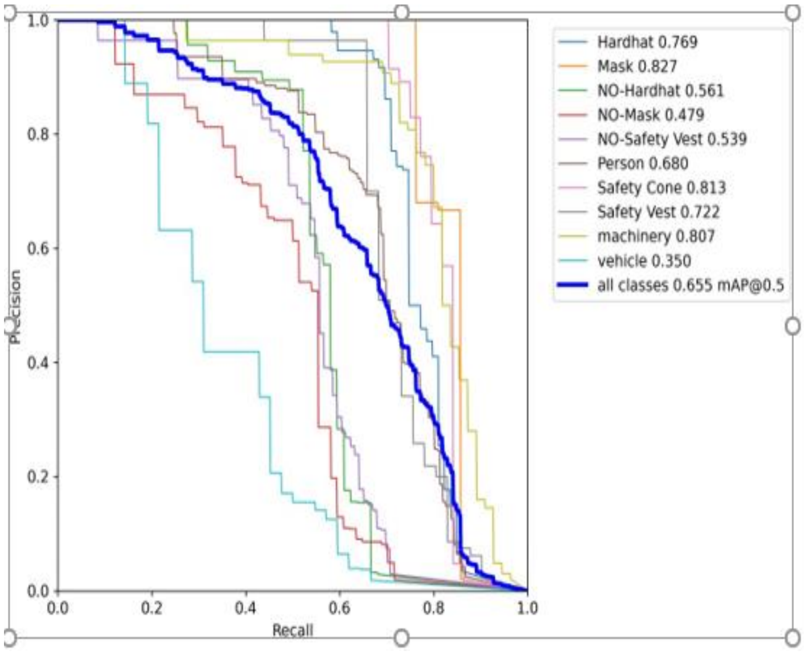

Fig : 5 Precision Recall Curve

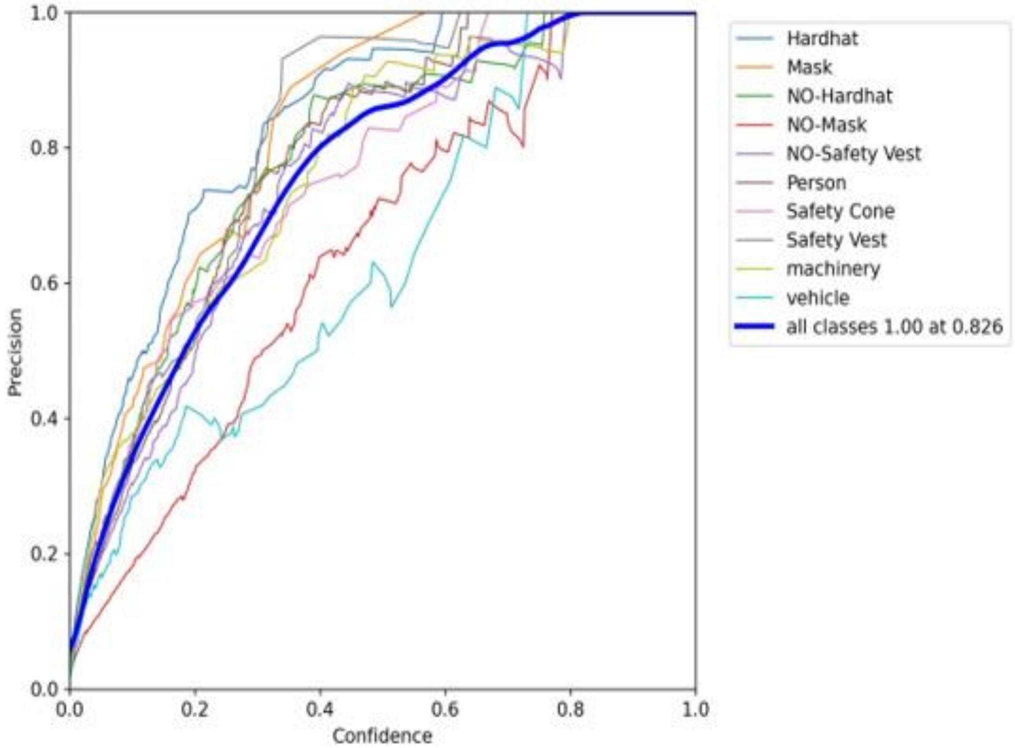

Fig : 6 Precision Curve

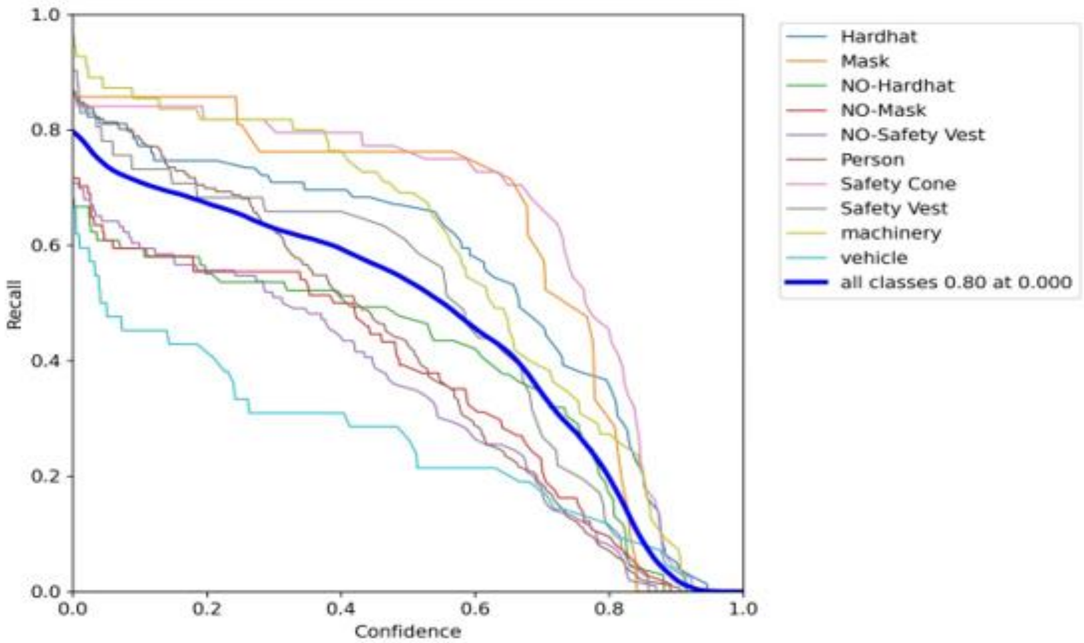

Fig : 7 Recall Curve

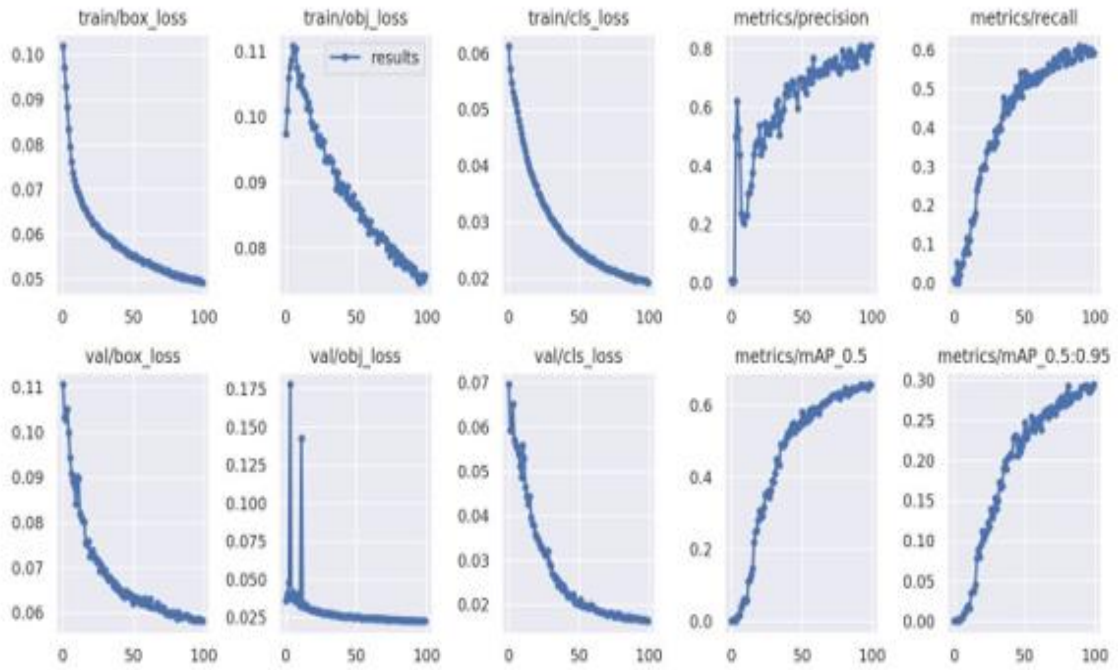

Fig : 8 Result Curve

6. CONCLUSION AND FUTURE ENHANCEMENTS

The "Real-time Construction Worker Safety Gear Detection and Alert System using YOLO5" project, in summary, represents a significant breakthrough in protecting the health and safety of construction workers. This system provides a complete solution to monitor and enforce safety gear compliance in real-time on sites by utilising YOLO5's sophisticated object identification capabilities. Supervisors may effectively identify and handle safety gear breaches by integrating webcam feeds and email alert modules, which reduces possible hazards and improves workplace safety procedures.

This project's use of YOLO5 technology offers a number of significant advantages, such as improved safety gear detection tasks' speed, accuracy, and adaptability. Even in demanding and dynamic construction site conditions, YOLO5's simplified architecture and optimised inference speed allow for quick and accurate recognition of safety equipment including masks, vests, and helmets. Additionally, the safety monitoring system can be seamlessly integrated and deployed thanks to YOLO5's user-friendly implementation choices, which provide supervisors the ability to proactively enforce safety laws and guarantee the wellbeing of construction workers. All things considered, the project "Real-time Construction Worker Safety Gear Detection and Alert System using YOLO5" is a prime example of how innovative technology and workplace safety measures may coexist. By using YOLO5's capabilities, this system promotes a proactive safety management culture on construction sites in addition to improving safety monitoring procedures. It therefore has enormous potential to lower the frequency of workplace mishaps and injuries, eventually resulting in safer working conditions for construction workers and advancing occupational safety regulations.

he "Real-time Construction Worker Safety Gear Detection and Alert System using YOLO5" project has a bright future ahead of it, with several opportunities for improvement and growth. The following are some possible future scope areas:

Enhanced Safety Gear recognition: To increase the precision and dependability of safety gear recognition, the object detection model may be further refined, maybe using more sophisticated YOLO versions or variations. To improve detection capabilities, this might entail adding more data sources or sensor inputs.

Wearable Technology Integration: By integrating the detection system with wearable technology, such as smart helmets or sensor-equipped vests, it will be possible to monitor the use of safety gear in real-time and provide supervisors and workers with feedback. This could improve safety protocols by giving workers proactive alerts and feedback. Multi-site Monitoring and Centralised Control: By expanding the system to monitor multiple construction sites at once and centralising control and monitoring in a command centre, it will be possible to improve safety management efficiency and facilitate better coordination of safety protocols across various sites. Data Analytics and Insights: Applying data analytics to examine patterns in safety gear compliance, spot possible safety risks, and offer suggestions for enhancing safety procedures. To anticipate trends in the use of safety equipment and improve safety procedures, machine learning algorithms may be used.

Building Information Modelling (BIM) Integration: The detection system is integrated with BIM technology to offer real-time safety information superimposed on the digital model of the building site. This has the potential to improve safety planning and coordination as well as supervisors' situational awareness.

Support for Augmented Reality (AR): Using AR technology to give workers visual overlays and guidance on how to use and comply with safety equipment. This might improve real-time worker awareness and adherence to safety procedures.

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