Automated Email and SMS Notification System for Unauthorized Entry using Yolov9

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***Abstract*— Security breaches present a serious risk in a variety of settings, thus strong detection and alerting systems are required to efficiently reduce risks. This study proposes a novel way for developing an Automated Email and SMS Notification System customized for unauthorized entrance detection using the YOLOv9 object identification model. By utilizing the capabilities of YOLOv9, the system quickly detects unwanted people or things in the monitored areas and sends out automatic emails and SMS notifications to selected stakeholders. Our technology improves security measures by combining cutting-edge machine learning techniques with communication technologies. This allows for the rapid response to possible attacks through real-time notifications. Test results show that the system is effective in identifying unwanted entries and reducing false positives, strengthening security protocols in many contexts.**

Keywords— detection, real-time, unauthorized, automatic

I. INTRODUCTION

There is a rise in smart home technologies for which we need an advanced security solutions that has the potential to offer both accuracy and speed in detections. The integration of YOLO (You Only Look Once) algorithm, mainly the latest version i.e. 9, into home security systems would lead to immediate and precise authorized entry. Traditional home security systems often suffer from inaccurate and delayed intrusion detection that generally leads to false alarms or unauthorized entry. This system aims to overcome these issues.

Our main objective that is discussed in this paper is to enhance precision of facial recognition to maximize true positives and minimize false positives. For immediate response we can achieve an accurate intrusion detection using yolov9. How can we integrate yolov9 model for home security measures and implement automated email and SMS alerts using python. To use this in real world application for home security we have to introduce hardwares like motion detection sensors and camera for detecting entry and the camera to check whether the person entered is known or not. But this paper's primary focus is to show about the working of yolov9 model that can be further use for advance security measures in industries, home, campuses and so on. The reason why we are using yolo model instead of other face recognition models is, [4] for relatively small dataset Faster R-CNN model can be used but for more larger datasets or live video feed we should use yolo model. In this paper we are using yolo of version 9 that was recently launched during last week of February.

Training deep neural is tough,[15] traditionally people thought that the problems like vanishing gradients and saturations were the main issues but newer techniques like normalization and activation functions have helped a bit but still deep neural networks often take a long time to learn or don't learn well enough. So yolov9 model deals with solving the issue regarding information bottleneck. Information bottleneck refers to information getting lost as data moves through layers of deep learning networks. Crucial information gets lost at early stages in deep networks which makes it harder for them to learn properly. This idea was tested and was found that simple neural networks tend to lose more important information in the deeper layer, on the other hand more advanced networks like resnet and cspn-net they do a better job at keeping important information which help them learn better. To tackle these kind of problems, reversible networks approach is introduced. Reversible architecture maintain complete original information within each layer by enabling the operation units to convert inputs back to their original form. This ensures each layer of network retains complete original information.

About fifteen papers are discussed in related work section. It includes about the history of yolo, why yolo should be considered, explaining all versions and comparing each one of them. Then we have briefly discussed about the two modules that is Facial recognition module and the other is Email/SMS Notification module in proposed system section. We have also discussed how we have trained custom dataset. Then in result section, we have figure of mail and sms notification, a comparison graph showing why yolo should be considered for real time applications, a performance model plots that includes ten plots showing box_loss, cls_loss, dlf_loss, recall, precision and mean Average_Precision (mAP) and also a figure of f1-confidence curve. At the end we have discussed about the conclusion and how we can improve our project.

II. RELATED WORK

Anjeana and K. Anusadha [1] showed how yolo algorithm is used for facial recognition and why yolo better from other recognition models. They uses ArcFace loss, a specific loss function, which minimizes the distance between same face embeddings while maximizing the distance between different face embeddings. Gudala and Sagar [2] describes the main advantages of using yolo in real world application. By comparing to other algorithms, it performs at much fast-running rate of 45 frames per second, it has a high prediction capability and also has high-resolution classifier. Anita A [3] showed about home security system. The system informs the owner for any unauthorized entry or any door opening using Arduino UNO and a magnetic reed sensor. Shrey and other authors [4] compared some CNN-based object detection models like FRCNN, YOLO, SSD on famous COCO dataset. They concluded that even though yolo and SSD are fastest, Faster RCNN still gives the better accuracy. So for relatively small dataset FRCNN can be used but for larger datasets or live video feed we should use YOLO. Dr.Pravin Futane, Dr.Priya Shelke, Aditya Khedkar [5] provides us a foundation in facial recognition for future work. They showed how Local Binary Pattern Histogram (LBPH) algorithm achieved high accuracy for facial recognition. Juan R. Terven, Diana M. Cordova-Esparaza [6] provides us a complete journey of yolo algorithm from Yolov1 to Yolov8. They explains all versions and also compares all of it that gave us a depth knowledge of Yolo Algorithm. Asif Rahim, Yanru Zhong, Tariq Ahmad, Sadique Ahmad, Paweł Pławiak and Mohamed [7] showed the using of CNN models in smart home Iot devices for face recognition and anomaly detection. They gives us the knowledge of how to use CNN models for real-time application. Dweepna Garg and Parth Goel [8] showed how we can use yolo algorithms. They gives us in-depth knowledge about yolo for face detection and also showed a proper analysis of Yolo algorithm. They provide us that the learning rate should be kept small, shows that for data overfitting issue, the size of epoch should be a optimal number. Nur Widiyasono1, Alam Rahmatulloh and Helmi Firmansah [9] basically gives us on how to trigger email system for security measures. In this when PIR sensor detects any human presence, the developed system automatically send email alerts attached with images. Femi Emmanuel Ayo [10] describes the system that is able to predict the genders and ages of the detected face using YOLO algorithm using geometric analysis. The system also gives us the emotions. They showed implementation of quickly and accurately detecting faces using YOLO. Models Zhong Qu, Leyaun Gao, Shengye Wang [10] discusses about Hierarchical Detection Structure. For prediction feature layer it introduces a grid on yolov3 that achieves a better accuracy. Michel Owayajn, Amer Dergham, Gerges Haber, Nidal Fakih, Ahmad Hamoush and Elie Abdo deals with security system using face recognition on their paper [12]. It completely describes a solution with hardware and software. For hardware it includes camera and for software it includes face-recognition algorithms. Peiyuan Jiang, Daji Ergu, Fangyao Liu, Ying Cai and Bo Ma [13] briefly described on how yolo algorithm has developed over the years. It discusses about the features, comparison with other versions of yolo. HaitongLou, XuehuDuan, JunmeirGuo, HaiyingLiu and JasonGu [14] proposes a object detection algorithm by combining camera sensor and AI. It discusses about the working of yolov8 and also shows that it is better detector than other object detectors in both speed and accuaracy. In contrast to conventional camera sensors, the algorithm for small-scale object detection proposed in this research combines artificial intelligence with a camera sensor. Next, a few issues with the recently published YOLOv8 and the current small-size object identification methods are examined and resolved. Proposed are novel techniques for feature fusion and network designs. It significantly enhances the network's capacity for learning. The datasets from PASCALVOC2007, Tinyperson, and Visdrone are used for the test and comparison. The viability of every component of the optimisation is demonstrated through analysis and experiments. The DC-YOLOv8 performs better than other detectors in terms of speed and accuracy. It is simpler to catch small targets in a variety of complex settings. Chien-Yao Wang, I-Hau Yeh, and Hong-Yuan Mark Liao gives a brief explanation of yolov9 on their paper [15]. It discusses the differences between other versions of yolo. It has discussed the main special feature of yolov9 i.e. programmable gradient information that is used to reduce the information bottleneck which refers to loss of information. In this paper, we suggest using PGI to address the issues of information bottleneck and deep supervision mechanism's unsuitability for lightweight neural networks. We created the extremely effective and lightweight neural network known as GELAN. GELAN performs strongly and steadily in object detection across a range of depth settings and computing blocks. It can, in fact, be extensively extended to provide a model appropriate for a range of inference tools. The addition of PGI enables notable accuracy gains for both deep and lightweight models for the aforementioned two problems. The YOLOv9, which was created by fusing GELAN and PGI, has demonstrated significant competitiveness.

III. PROPOSED SYSTEM

Our proposed system aims to automate email and SMS notifications for unauthorized home entry. The software will recognize the faces, triggering alerts for unauthorized access. Email notifications, via SMTP, will include details like time, location, and media. For instant alerts, SMS services like Twilio will be integrated. Recipients can manage preferences for both email and SMS notifications. The system will log entry activity for review and offer reporting features.

The Modules that are used are Face recognition, Automated Email/SMS Notification Module.

EMAIL/SMS NOTIFICATION

An Email and SMS notification system using Python can be developed to send automated messages to users based on certain events or triggers.

Here's a brief explanation of how such a system can be implemented:

Setting up Email Notification

For sending emails we are using python library called smtplib. We first import smtplib and then declare sender email and receiver email. After this we initialize subject and message and then we declare which server to use. And then with the help of server we use login method and then finally send mail. During login, there are two parameters that we have to use, email , and another app password that can be obtained from google.

Setting up SMS Notification

For sending SMS we are using Twilio service. It's a message service provider. By first installing and then importing Twilio in python, in Twilio we registered with our name, email and number. We then got Twilio phone number from the website itself and account SID and then we use create method to send the message to ourself via Twilio.

FACE RECOGNITION

A facial recognition system using python can be developed to detect a face and then recognize it. We are using Yolov9 as model to recognize face. We trained the model using custom dataset. Using Roboflow, a computer vision platform, we used 80 images and annotate each of them. Then we trained by 100 epochs and got the result. Following is the brief explanation about the model.

YOLOv9 (You Only Look Once version-9)

Information Bottleneck Principle

$$I(x, x) \geq I(x,f(x)) \geq I(x,g(f(x))) \quad (1)$$

The above formula [15] that is mentioned refers to the explanation of information bottleneck principle. *I(x,x)* represents the mutual information between the original data x and itself which is the maximum information available in the data. Then *I(x,f(x)),* this represents the mutual information between the original data and the transformed data after passing through the first transformation function. And then the last term represents the mutual information between the original data and the transformed data after passing through two consecutive transformation function which is f() and then g() where this represents the parameter for second functions. As mentioned earlier [15] yolov9 involves the use of reversible function architecture. So if we apply R to some data x and then apply v to the result i.e. R(x) and then applying v we get v(R(x)). After this we get original data x. Reversible function ensures no information is lost during transformation. The benefit of having same information is to obtain reliable gradients. These are important as they are needed for updating the model effectively during trainings. Some models do have this approach but while applying this to lightweight models there can be defects, some issues due to the model being underparameterized for handling large amount of raw data. This can lead to loss of important information during the forward pass through the network. For this Programmable Gradient Information method is introduced. It's a training method that mainly consists of three components i.e. main branch, auxiliary reversible branch, multi-level auxiliary branch. Main branch is the primary component used during the inference process, it does not require any inference cost that is additional. Auxiliary reversible branch is designed to address the issues caused by the deepening of deep neural network. When the network become deeper, they can suffer from an information bottleneck, so this aims to reduce the problem. Now the mutli reversible target the problem of error accumulation caused by deep supervision. In deep learning, with each training cycle (epoch), minor errors or noise may accumulate. If not appropriately addressed from learning the genuine patterns in the data, resulting in less accurate predictions.

In yolov9 auxiliary reversible branch in PGI is used to update network parameters and provide dependable gradients. By offering data mapping from targets to data.

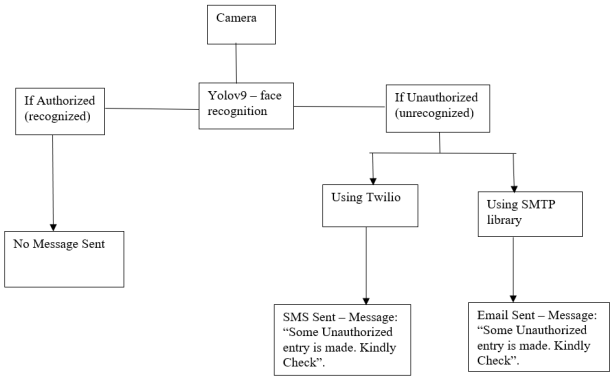

Figure 1. Flow Chart

Fig. 1 shows the flow chart for proposed system that refers, after camera, it undergoes yolov9 model for face recognition and if the face gets recognized (Authorized) then no notification would be received by owners but if it does not get recognized(Unauthorized) then SMS and email will be sent with the help of Twilio and SMTP Library respsectively.

The challenging part is to train yolov9 on custom dataset and then use it for real-time application. Since yolov9 is not available in ultralytics thus we cannot train like yolov8 locally on python environment. Following is the brief explaination about how we can train the model.

Training Yolov9 on Custom Dataset

As we know, for any object detection or recognition we need to annotate images. So we trained our model with one face but 80 images. Using roboflow, we annotate all 80 images and split seventy percent to train, twenty percent to validate and ten percent to test. After this we export the dataset and then a code is provided with an access key (so we can access the dataset). We use that code in google colab to access the annotated dataset and then we train the model. After training, we zipped the trained model file and saved it in google drive. From drive, model gets downloaded and was used on our local python environment.

IV. RESULT

We are successfully able to implement yolov9 model on real time, webcam in our computer for facial recognition and sending email and SMS alert messages if detected unauthorized. By training yolov9 with our own image, the model is able to detect whether the person is authorized or unauthorized. Based on confidence score, the model predicts. By analysing, we got that for authorized image the confidence score is always showing more than 80% and sometimes(rarely) the score gets around 60 to 80% based on environment and facial movements, so if confidence score is less than 60 then it is considered to be unrecognized. And based on that, as we can see from fig: 2 and 3, the system will send mail and sms.

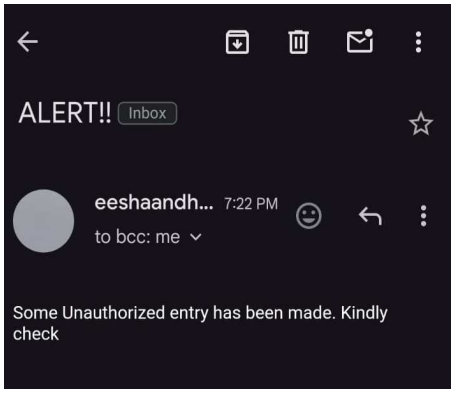

Figure-2 Email Notification

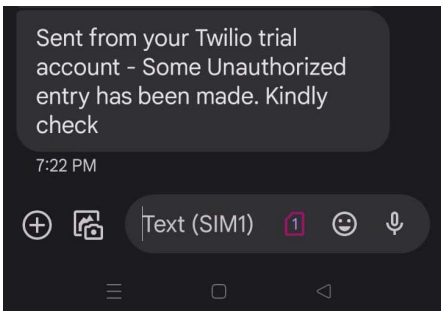

Figure-3 SMS Notification

As we can observe from fig. two and three, for unauthorized entry, email and sms has been sent.

We also got one comparison graph for different object detection models based on speed. On comparing Faster R-CNN, R-FCN, SSD and YOLO(You only look once) the best suitable fastest model we got was yolo. The main reason for this comparison is to show [4] why it is better to use yolo in real-time applications.

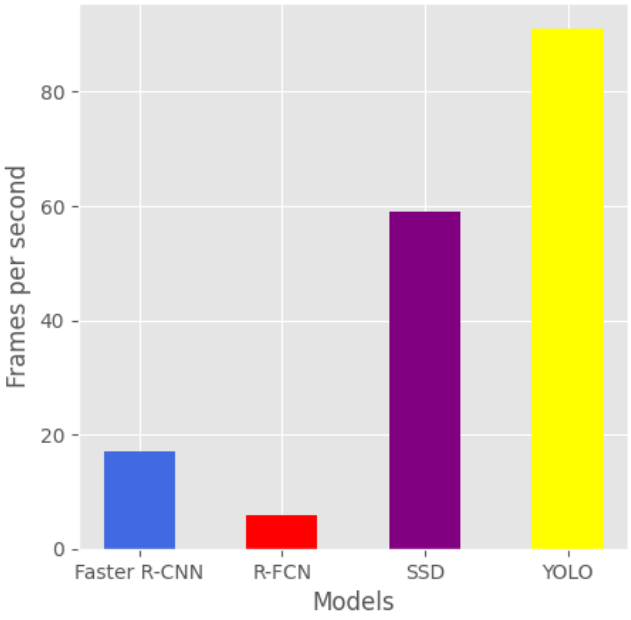

Figure-4 Graph based on speed

Fig. 4 compares models - Faster R CNN, R-FCN, SSD and YOLO based on frames processed per second (FPS) using input images with different resolutions.
As we can see yolo has the highest Speed among other models that is 91. To compare models we used MS-COCO-Dataset.

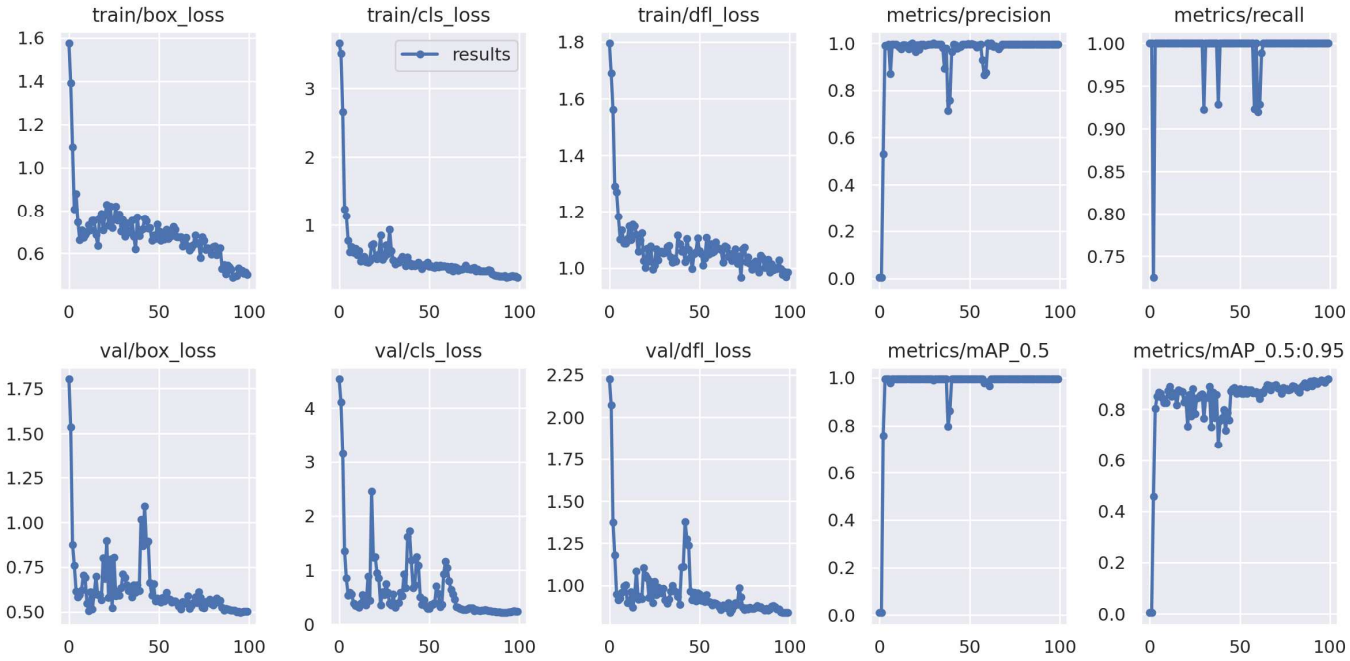

Figure-5 Performance_model_plots

As we can see that fig. 5 contains ten different plots. We have bounding box loss, classification loss, distribution focal loss then we have precision and recall. Each plot has its own significance. The box loss represents how well the predicted bounding box covers an object and how well the algorithm can locate the centre of an object. So, for train box loss we can see the graph is downward graph. That means there is very less error. All loss graphs are downward graphs which tells us that the training of model was good. We also have precision, recall which are upward graphs that again tells us the behavior of having a good trained model. The graphs are created from hundred epochs. It gives a general description of each epoch results.

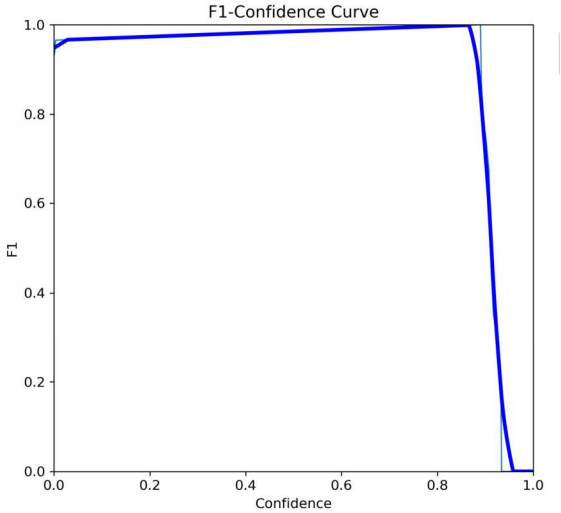

Figure-6 F1-Confidence Curve

Fig. 6 shows about the graph for f1 confidence which is the harmonic mean of precision and recall. This graph clearly shows how well trained the model is.

V. CONCLUSION

In conclusion for enhancing security measures automated email and sms notification for unauthorized entry using yolov9 gives us a tremendous solution. By using the capabilities of yolov9 integrating with automated communication channels like email and sms, organizations would be able to easily respond to any potential intruders or homes for any burglary, theft. The benefits of using this system includes the automation notification process enables security personnel to respond immediately threats to potential threats without any involvement of manual intervention. By actively detecting unauthorized entry, organizations can increase their security protocols, reducing any potential risks and minimizing the likelihood of security breaches. From small business to large organisations, the system has the potential to be easily scaled for accommodating varying levels of security needs and also can adapt to different environments. It can easily be integrated with existing security systems, CCTV Cameras and access control systems. To put it simply, the combination of automated email and SMS notifications and yolov9 for unauthorized entry detection is a proactive approach to security that enables organisations to strengthen their defences and react quickly to possible threats,

protecting people, property and any confidential data. Yolov9 helps to reduce the information bottleneck principle thus working with yolov9 provides us benefits of getting original information at the end process by introducing the concept of Programmable Gradient Information (PGI). This study shows very basic information about using yolov9 for real world applications. Only one face but 80 images was used to train but we can use thousands of faces and images to train the model and can have a lot more applications. We can also employ motion sensors or cameras for entry detection, feeding signals to a central hub like a Raspberry Pi. There are lot of works related to facial recognition using other object detection models but this new version of yolo opens up a lot of possibilities.

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