Real time intruder detection system using Arduino coupled with python and email cloud services

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ABSTRACT

Home security is an essential and integral part of our lives and upholding it by upgrading it through latest technology is very important. According to the data submitted by the Bureau of Justice Statistics, burglaries happen 10% more times in summer than winter. So when a person goes for shopping leaving their windows open to let fresh air in and the hoping that the closed and suffocated air is filtered, they indirectly let burglars in too. In this project we are introducing a cost effective and easily operatable solution where we use ultrasonic sensors to monitor the entry of an unknown person. We use face recognition module to perform face recognition on the person's face to match it with the owners' faces. In this paper, a notification process is also integrated. If the system detects an intruder, it notifies the owner immediately through an android application. The integral part of our system is that we have used cost effective equipment and serviced the protection of the household from outsiders. In this project we have used IoT components and were able to integrate it with python and cloud services to produce the results.

KEYWORDS

Internet of Things (IoT), Arduino UNO, face recognition model, EmailJS, Pushbullet, Home Secutiy System, Intruder detection system, Pymata4

INTRODUCTION

Security is an essential part of each and every one of our lives. It comprises of many different aspects of our lives ranging from physical security, security of our homes and assets, for a hospital the security of their medical records and patient info, for a bank the security of their assets and the customer's credentials and bank details. In this project we are focused on the security aspect of our house. Home security includes both the security hardware placed on a property and individuals' personal security practices. Security hardware includes doors, locks, alarm systems, lighting, motion detectors, and security camera systems. Personal security involves practices like ensuring doors are locked, alarms are activated, owning a Dog, windows are closed, and extra keys are not hidden outside.

According to an FBI report, 58.3% of burglaries in the United States involved forcible entry. Per the most recent statistics, the average burglary in the United States takes about 90 seconds to 12 minutes, and on average, a burglar will break into a home within 60 seconds. Most target cash first followed by jewels, drugs, and electronics [7]. Common security methods include never hiding extra keys outside, never turning off all the lights, applying small CCTV stickers on doors, and keeping good tabs with neighbours. Surveillance cameras play an important role in monitoring activities and are deployed in many households and offices to monitor the movements of people. Current cameras feature abilities such as motion detection and two-way audio, allowing users to receive notifications of activity and speak and listen through the camera. Home surveillance cameras used for security purposes have become more accessible, but have sparked security concerns from consumers [7].

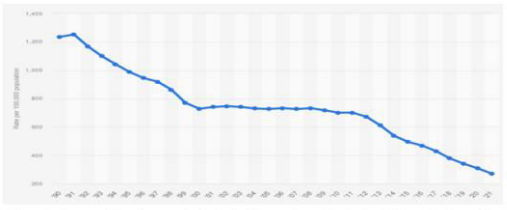


Figure 1: Reported burglary rate in the United States from 1990 to 2021 (per 100,000 of the population)

In figure 1, we can see that the rate of household burglary has decreased over the years because of the increasing security and advancement in technology. Here we can also see that the current number of house burglary incidents is stated to be 200 per 100,000 of the population.

The situation after COVID states that according to [8] on average, a burglary happens once every 30 seconds. According to reports submitted by the FBI, 3000 burglaries occur per day. Despite these stats only 25% of Americans have installed home security system to protect their property from damage. The average loss from a burglary is estimated to be $2,661. On top of the financial loss victims also suffer from emotional and mental breakdown as things are stolen from their households that are irreplaceable and hold a significant sentimental value to them. A survey was conducted by the team in [8] that stated that out of 700 people 50% of them informed that burglar stole or damaged items that held a significant value in their lives. 67% reported that their emotional and mental health took a significant hit and had trouble sleeping after the incident [9]

In this project we have used Arduino and integrated it with python through pyFirmata(specifically pymata4) to extend the usage of Arduino to a whole new level. After successfully completing the first step we used face recognition model from python to first store the faces of the owners. [10] The face recognition system also helps us to recognize the face of the intruder. [11] We also integrated email cloud services in our project to store the images of the intruder in the cloud. [12] The android application that has been implemented in our project is used to notify the owner in the event of burglary.

LITERATURE SURVEY

In paper [1], facial image for face recognition and video frames for intruder detection are used as input. These are captured from Raspberry Pi Camera and Web Camera. The Intruder detection Module builds up on frame subtraction approach. In this approach we build a model of static scene (i.e., without moving objects) Called background and compare every subsequent frame of sequence to background frame in order to identify regions of motions called foreground. The intruder detection module after activation starts capturing live video frames. Whenever an intruder is detected by the web camera, it starts capturing images, attach these images to the mail and sending it to concerned police department mail Id and also SMS alert to the owners.

In paper [2], facial recognition is designed integrated with IoT to perform smart home security system. The prototype is built by combining the two components. For the facial recognition images are collected as the training set and then later tested with other new images. On the IoT end, the Blynk app is used. Blynk start online as the Raspberry Pi connected to the internet over Wi-Fi. For condition where face cannot be recognized, that person can press the doorbell and notifications are sent to smartphone of house owner. Hence, live streaming video will appear to identify the person trying to unlock the door. When person face can be recognized by the system, the door will open automatically. If face cannot recognize by the system, door will remain closed. Door access can also be controlled through IoT using Blynk app.

In paper [3], Design and implementation of security systems for smart home based on GSM technology, using a web camera system that detects motion and sends emails to users. GSM-based systems can send SMS when detecting flames or rising temperatures, but the time spent sending SMS depends on the specified cellular network coverage. If the phone is coverage networking, then the SMS will be sent within 25-30 seconds.

In paper [4], Every family member or house holder has RFID as an access card to enter the house. If the RFID owner enters the house, the system will send a notification via email to other family members. However, if there is an intruder detected by the PIR sensor, the system will send an email to the user indicated an intruder, then the buzzer will be sounded. This prototype also can monitor the flames on the kitchen stove and the system will send a notification through cell phone that connected in the Blynk application every 10 minutes. Users can turn off the stove by closing the gas line through the solenoid valve manually or automatically remotely.

In paper [5], the design of an Internet of Things (IoT)-based home security monitoring system that can track the

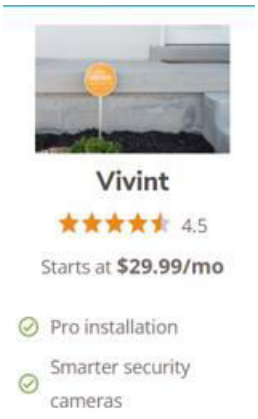
protection of homes from intruders and criminals, provide temperature alerts, and detect smoke or gas is presented. It is anticipated that it will be able to keep an eye on the condition of the home and alert the owner if there is any disturbance. Their objective is to create a simple-to-design device that can monitor the state of the home. The following components, which are readily available, are used: PIR sensor, temperature sensor, smoke sensor, and raspberry pi.

Paper [6] offers two IoT-based approaches for implementing home security. One method is to use web cameras so that if the camera detects motion, it sounds an alarm and emails the owner. Despite being rather expensive due to the cost of the cameras used, this method of detecting incursion is highly effective. The cameras must be of good quality in order to be able to detect movement. This means that they must have a wide field of view. Additionally, mobile cameras like dome cameras would cost even more than fixed ones if you choose them.

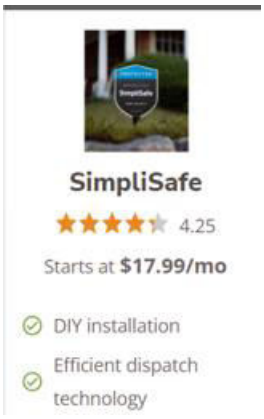
EXISTING TECHNOLOGY

The existing technology installed in homes to prevent intruders from entering include mostly CCTVS, physical locks and alarm systems.

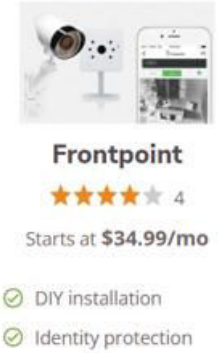
The latest technology used in the current scenario of home security system include –



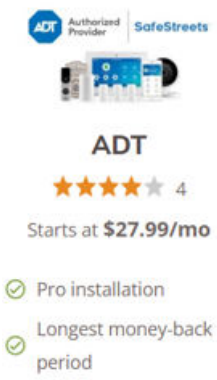
The stand out feature of Vivint is that it uses security cameras with Smart Deter lurked detection. Vivint shows a lot of competence with its three security cameras: the Vivint Indoor Camera, the Vivint Outdoor Camera Pro (Gen 2), and the Vivint Doorbell Camera Pro (Gen 2). Vivint also uses Car Guard which is a GPS vehicle tracker connection to smart home system, and diagnostic wizard all in one device. The Car Guard shows the location of the vehicle and any dangerous driving habits like hard braking and speeding. The Vivint mobile app for iPhone, iPad, Apple Watch, and Android devices serves as your direct line to the Vivint smart home security system.



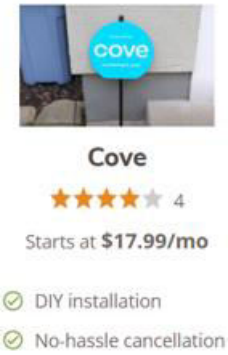
SimpliSafe features RapidSOS (only one other system has this security monitoring feature) to speed up help in an emergency. It skips sending information to a monitoring center and sends it directly to 911 dispatchers so first responders get to you (wherever you are) faster.SimpliSafe also has an outdoor camera



Frontpoint uses **Frontpoint ID Protect** powered by AllState Identity Protection. This smart security system protects one's home and thier identities. Frontpoint has a hefty roster of equipment and accessories that covers almost any security situation, from break-ins to fires and everything in between. It also connects with Alexa, Google Home, and Z-Wave devices for a complete home automation experience. The Frontpoint app wrangles the security system's devices and compatible smart home gadgets and makes them work together in a symphony of convenience.



ADT Home Security has more monitoring centers than any other security company. If one monitoring station goes down, your home's protection transfers to another center.



Cove offers a few good features:

- **Large 7-inch touchscreen panel** that comes with every package
- **InstaText** service that lets one confirm an emergency through a quick text message
- **LiveAssist** service that calls one through the control panel (no phone needed!)
- **RapidSOS** to get one help sooner
- **Cove Equipment Rewards** that lets one to upgrade to the newest equipment for free
- **Rate-lock guarantee** that keeps the monitoring price the same

PROPOSED MODEL/SYSTEM

The requirements for the given project can be underlined as –

Hardware requirements –

- Ultrasonic sensors
- Arduino UNO
- Camera (here webcam)
- Buzzer

Software requirements –

- Python 3.7-10
- Pymata4
- Email Services
- Pushbullet

Methodology and Implementation –

We now implement the circuit diagram as follows –

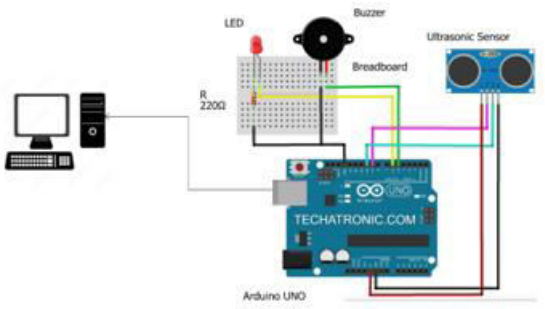


Figure 1: Circuit Diagram

In Fig 1, we connect the trigger pin and echo pin to digital pins 9 and 10 of the Arduino UNO respectively, for the convenience of detection we use 2 ultrasonic sensors in our project so we connect another ultrasonic sensor whose trigger pin and echo pin will be connected to 11 and 12 of Arduino UNO.

After the implementation of the circuit diagram, we upload the **"Firmata Express"** sketch available in the Arduino IDE -> Files -> Examples. This sketch helps the pymata library in python to connect the Arduino device. When the successful connection is secured between Arduino and python, we start our system and start taking input from ultrasonic sensors.

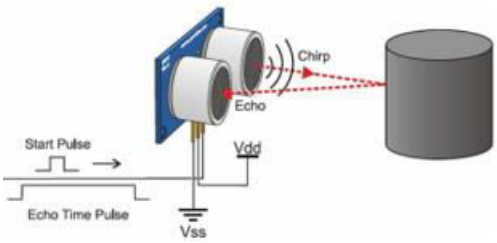


Figure 2: Ultrasonic sensor

The time elapsed between the trigger pulse (start pulse) and the receiving echo pulse is calculated as the ultrasonic distance as shown in Fig 2.

Once we start receiving the input from the ultrasonic sensors, we set some parameters and conditions in which we confirm that somebody has entered the room. We use the threshold value as when the ultrasonic distance is less than 100 the detections are confirmed.

If a person entering the premises is confirmed by the ultrasonic sensors we switch on our camera and take 3 pictures of the person. Before moving onto the next step, we set the owners' faces as the database to be compared with. For this project we use the picture –

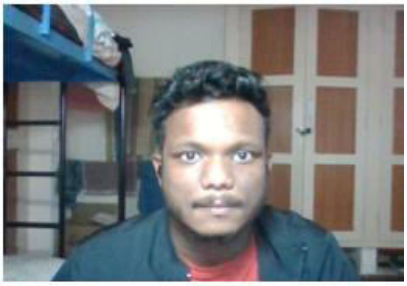


Figure 3: Undetected face

If we apply our face recognition model on the face in Fig 3, which we label as "Pratyush" (name of the owner) we get –

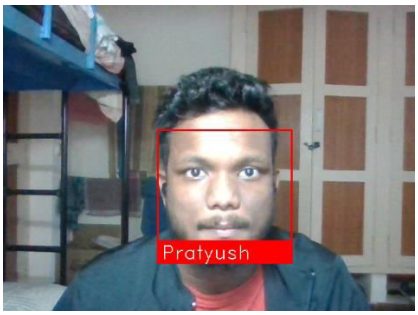


Figure 4: Detected/Recognized face

Any other face other that Fig 4, is declared as "Unknown" by the model

Now, when an unknown person enters our premises his/her 3 pictures are taken and are matched with the database. Since the face is not recognized he/she is declared as "Unknown". The proposed model then integrates with a local server that has been setup to attach the image of the unknown person with an email sent to the owner's mail. Along with the image a notification

is also sent to the owner through pushbullet API to a mobile app.

Final image of the model –

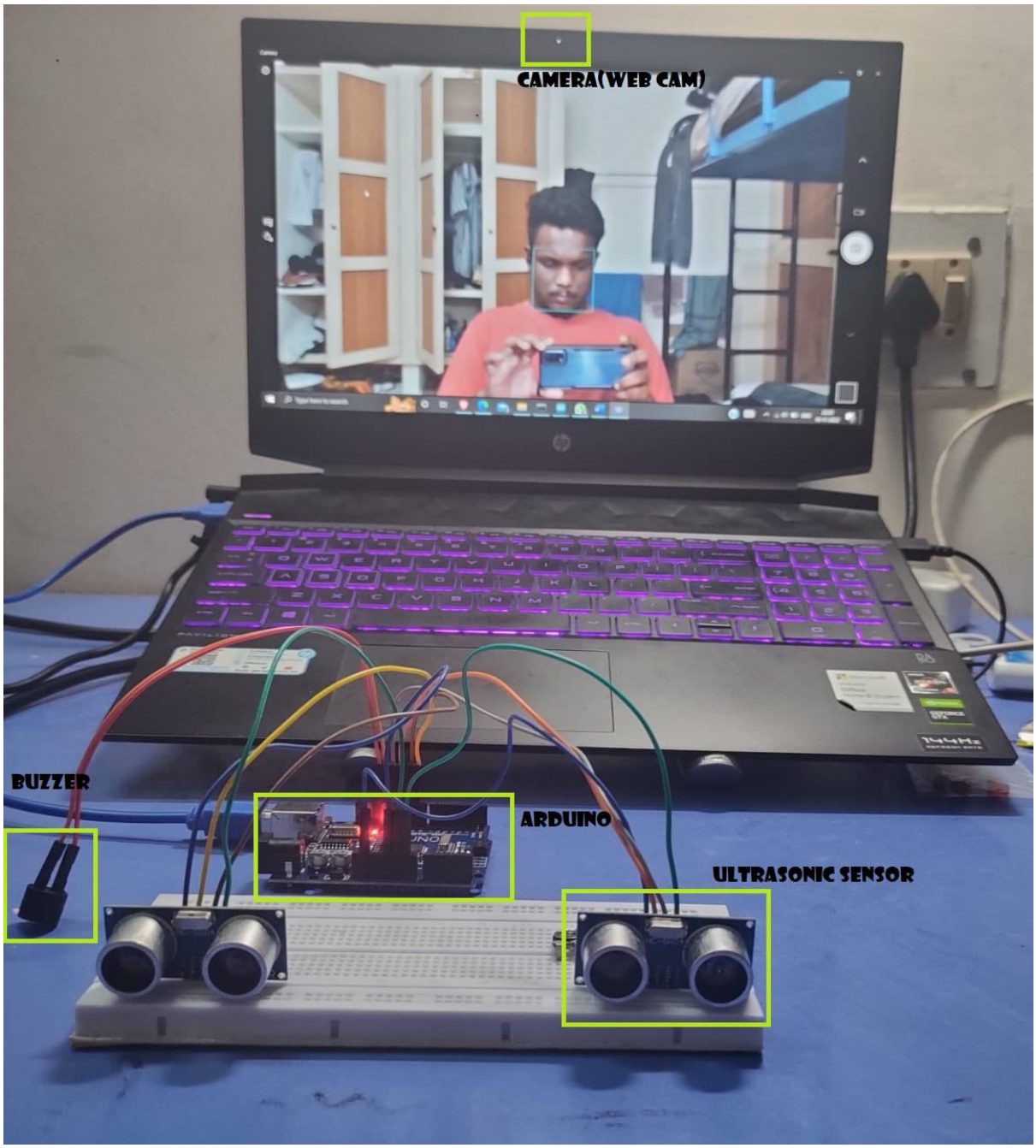


Figure: Final Components distribution of the model

Workflow of the model –

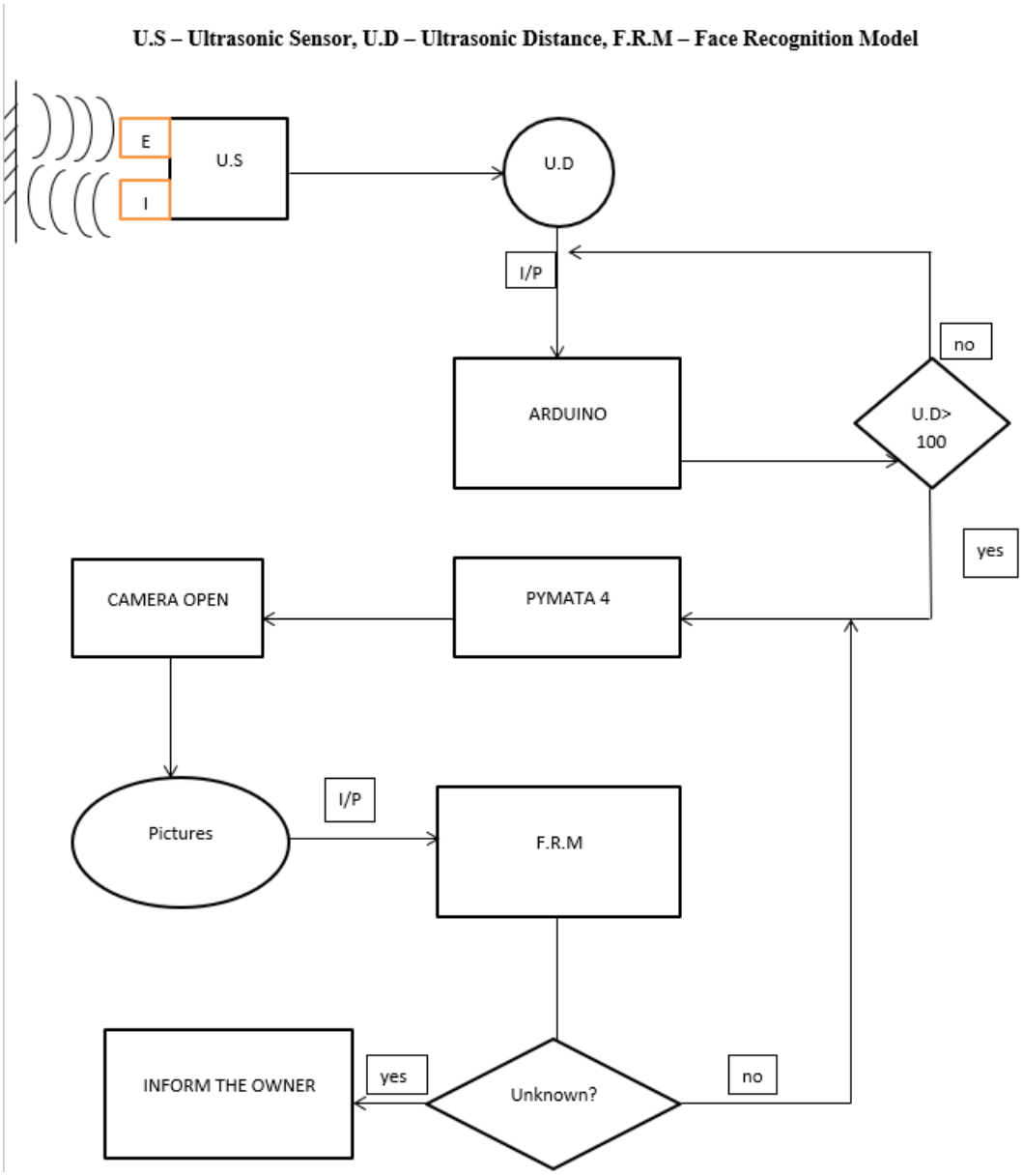


Figure 5: Workflow Block Diagram

The whole methodology and the functional aspect of the working of the project is depicted in Fig 5.

RESULTS AND DISCUSSION:

During the detection of an unknown intruder in the room or premises. The image of the unknown person is emailed to the owner of the house. The email sending process includes making an account in gmail services provided by google to allow python to send email.

After that we create a local SMTP server through which we send the email using the credentials set during account formation in the format followed by official gmail servers attached along with it the image of the intruder.

The pushbullet API aids developers to send message/notification to any application through python. For this action we first create a simple mobile application which only receives notification then we connect the pushbullet API to the application generating an access token that serves secure communication between the two domains, the we simply declare the message as a notification and send it to the application.

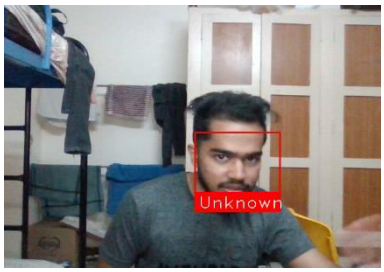


Figure 6: Unknown person detected

In Fig 6, an unknown person is detected

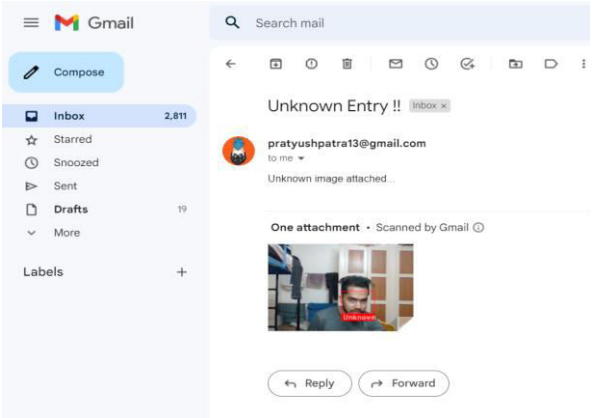


Figure 7: Email attached along with the image

In Fig 7, the email is being sent successfully.

Model Evaluation and Comparisons

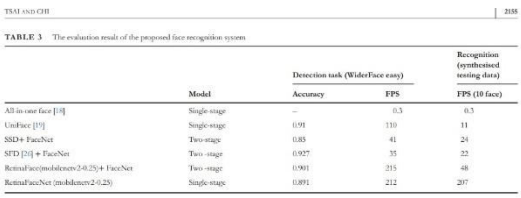


TABLE 3 The evaluation result of the proposed face recognition system

Model	Detection task (WiderFace easy) Accuracy	FPS	Recognition (synthesised testing data) FPS (10 face)
All-in-one face [18]	Single-stage	–	0.3	0.3
UniFace [19]	Single-stage	0.91	110	11
SSD+ FaceNet	Two-stage	0.85	41	24
SFD [20] + FaceNet	Two -stage	0.927	35	22
RetinaFace(mobilenetv2-0.25)+ FaceNet	Two -stage	0.901	215	48
RetinaFaceNet (mobilenetv2-0.25)	Single-stage	0.891	212	207

TABLE 4 Comparison with two stage network

Layer	Parameter	FLOPs
Retina Net	3.4 M	5.0 G
Proposed network	3.6 M	5.2 G
Difference	14.5 K	1 182 M
FaceNet (MobileNetV2)	3.3 M	133 M

TABLE 5 The result of different triple setup

Setup	Train Set accuracy	LFW accuracy
MobileNetV1, no dynamic triplet	93.2%	70.5 %
MobileNetV2, no dynamic triplet	96.1%	75.5 %
MobileNetV2, dynamic triplet	94.1%	92.4 %

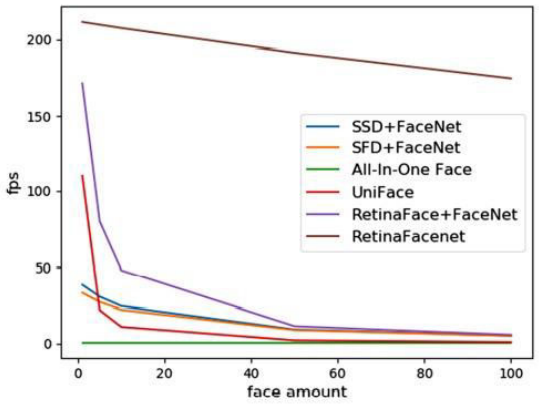


FIGURE 5 Inference speed comparison

Comparisons of MobileNet-SSD and YOLO v3 accuracy and detection speed

Result\Model	MobileNet-SSD	YOLO v3
mAP Overall	53.29%	NA
mAP (Large Object)	-1	NA
mAP (Medium Object)	58.33%	NA
mAP (Small Object)	53.34%	NA
mAP(0.5IOU)	97.8%	99.14 %
mAP(0.75IOU)	51.28%	NA
Detection Speed(ms)	135.5	497.5 1

Figure 7: Comparison table between different models

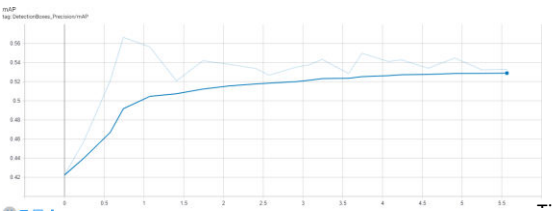


Figure 8: Overall mAP of MobileNet-SSD

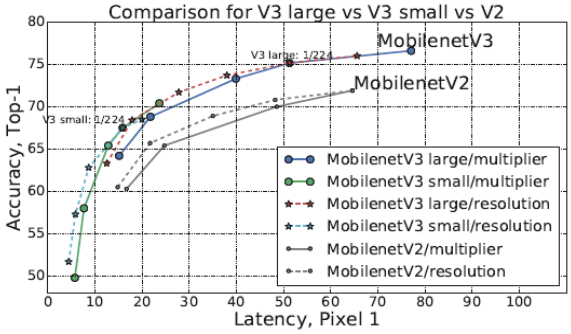


Figure 9: Comparison between v2, v3 of mobile net SSD

SSD	**YOLO**
It takes the input photos and performs single pass through a convolutional network, generating a feature map.	The open-source method of object recognition can quickly identify subjects in static images and moving footage.
SSD network could be a better alternative because we can run it on a video, and the real trade-off is very small. This makes the SSD a very viable option.	When exactness is not a significant source of disquiet, yet you still want to go very quickly, YOLO is a better choice.
When the object size is very small, there is a slight decrease in performance.	YOLO can be the better option, even if the object in question is relatively small.

Figure 10: Comparitive study between YOLO and SSD

REFERENCES

[1] Home Security System and Door Access Control Based on Face Recognition, R. Manjunatha1, Dr. R. Nagaraja2 1M. Tech student, Computer Network Engineering, Dept. of ISE, Bangalore Institute of Technology, Bangalore, Karnataka, India 2Professor and PG Coordinator, Dept. of ISE, Bangalore Institute of Technology, Bangalore, Karnataka, India

[2] IoT based facial recognition door access control home security system using raspberry pi, A. R. Syafeeza1 , M. K. Mohd Fitri Alif2 , Y. Nursyifaa Athirah3 , A. S. Jaafar4 , A. H. Norihan5 , M. S. Saleha6 1,3,4,5 Fakulti Kejuruteraan Elektronic and Kejuruteraan Komputer, Universiti Teknikal Malaysia, Malaysia 6 Fakulti Teknologi Kejuruteraan, Universiti Teknikal Malaysia Melaka, Malaysia 2 School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Malaysia

[3] Design and Implementation of an IoT-Based Smart Home Security System Mohammad Asadul Hoque1,*, Chad Davidson2 1 Department of Computing, East Tennessee State University, Johnson City, TN 37614, USA 2 Department of Electrical Engineering and Computer Science, University of Tennessee, Knoxville, Tennessee, USA

[4] Iot-based Integrated Home Security and Monitoring System Taryudi1 , Davin Bagas Adriano2 and Wahyu Apsari Ciptoning Budi3 1,2,3 Electronics Department Faculty of Engineering, Universitas Negeri Jakarta, Indonesia

[5] Home security monitoring system with IoT-based Raspberry Pi by Gusti Made Ngurah Desnanjaya Department of Computer System Engineering STMIK STIKOM Indonesia 80225 Tukad Pakerisan 97 Denpasar, Bali, Indonesia

[6] Home security system using internet of things Anitha A School of Information Technology and Engineering, VIT University, Vellore- 632014, Tamil Nadu, India.

[7] Home Security presented by Wikipedia. https://en.wikipedia.org/wiki/Home_security

[8] 8 Surprising Home Burglary Facts and Stats by Rebecca Edwards (Security Expert, Safety & Tech Reporter) in https://www.safewise.com/blog/8-surprising-home-burglary-statistics/

[9] Arduino with Python: How to Get Started by Renato Candido Oct 21, 2019 in https://realpython.com/arduino-python/

[10] Face recognition model using python and open CV in https://techvidvan.com/tutorials/face-recognition-project-python-opencv/

[11] How to Send Emails Using Python - Plain Text, Adding Attachments, HTML Emails, and More by Corey Schafer uploaded in https://www.youtube.com/watch?v=JRCJ6RtE3xU&t=1312s

[12] Python – Web App To Send Push Notification To Your Phone by Geeks for Geeks on 5th Oct, 2021 in https://www.geeksforgeeks.org/python-web-app-to-send-push-notification-to-your-phone/

[13] 10 Best Home Security Systems of 2022 by Alina Bradford (Senior Writer, Safety & Security Expert) in https://www.safewise.com/best-home-security-system/