RAT Trap: Home Surveillance System Using IoT & AI

Raj Chauhan[1], Aditya Gidh[1], Trisha Gupta[1], Dr. Sanjay Sharma[2]

[1]Graduate Student, Dept. of Computer Engineering, New Horizon Institute of Technology and Management Mumbai, India
[2] Head Of Department, Dept. of Computer Engineering, New Horizon Institute of Technology and Management Mumbai, India

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Abstract - *We live in a world where breaking and entering, burglary and trespassing are increasing day by day. Keeping a check at home while giving security measures to the homeowner and complete control of what is happening in and around the house is very important at this time. Because of the increasing number of threats and disruptions that occur in the community, all residential households need a security plan to live a better life with safety. Home automation is about comfort, efficiency, and savings, improving one's standard of living. Home security has made major changes in the last few decades and will continue to improve gradually in future. Previously home security systems meant having an alarm sounded when someone broke in but a smart secure home does more than that. The proposed system comprises a combination of a unique wedge lock mechanism, a Linear Actuator, Raspberry Pi, Camera Module attached to it. The system will help users to protect their homes with facial recognition by installing it on doors or windows and monitor activities with their smartphones. Using the concept of Internet of Things (IoT), we can develop a Smart Home Security System, which would be efficient enough and take necessary actions accordingly. The proposed system can be the first step towards safer housing facilities.*

Key Words: *Raspberry Pi, IoT, Facial Recognition, Wedge Lock Mechanism, Linear Actuator, Camera Module*

1. INTRODUCTION

Smart Homes is the beginning of a new era in the field of home Security. With an integrated alarm system, the user can easily arm and disarm the home to the convenience of their smartphones no matter where the user is. Automating the tasks or jobs without human intervention is needed these days. With the recent invention of the voice assistants and the flexibility, it is providing us to connect any electronics things have become popular these days. The Internet of Things can be used to describe physical objects (or groups of such objects) embedded with sensors, processing ability, and software. A good locking mechanism makes the house more secure for any Intrusion as well as loss. A huge advantage of linear actuator design is that when a perpendicular external force is applied the actuator doesn't feel any kind of force as the cosine component of that force becomes zero.

Artificial Intelligence plays a prerequisite role in smart homes. Specific applications of AI include expert systems, natural language processing, speech recognition and computer vision. It is the venture to clone or simulate human intelligence in machines. AI algorithm is an extended subset of machine learning that informs the computer how to learn to operate on its own. In turn, the device continues to acquire knowledge to improve processes and run tasks more efficiently. AI allows organizations to make better decisions at identifying the intruder, improving core security by increasing both the speed and accuracy of strategic decision-making processes.

Facial recognition is one of the advanced forms of authentication capable of identifying and verifying a person using facial features in an image or video from a database. Modern facial recognition algorithms approach the problem of one-shot learning via face recognition by learning a rich low-dimensional feature representation, called face embedding, that can be calculated for faces smoothly and compared for verification and identification tasks.

2. LITERATURE SURVEY

Xin Zhang, Won-Jae Yi and Jafar Saniie introduced a home surveillance system that utilizes computer vision techniques to recognize intrusions and detailed threat information including classifying types of trespassers and specific weapons used. Process of identifying intrusions is achieved by our Smart Intruder Detection and Surveillance System (SIDSS) which involves 3-stages of computer vision algorithms.3-stage SIDSS includes an optimized convolutional neural network (CNN) for threat and intrusion detections, cascading classifiers for locating any potential intruders with correcting mechanism to overcome undetected threats from the previous stage, and principal component analysis (PCA) to efficiently train the facial recognizer to accurately differentiate passersby from potential intruders. Our system is scalable for various surveillance events and can be expanded with additional pre-processed datasets added to the SIDSS model to manage greater surveillance areas. Through this enhanced configuration, the system can achieve enhanced accuracy of recognizing broad range of weapons used and intruders. [1]

Arshith Suresh, Aina P Subeer, Ann Mary Philip, Jini Shaji Varughese and Er. Justin Mathew proposed a system which

featured a system having a frontal face recognition at door step that assists in monitoring who and when someone has visited the house with alerts being sent if an unknown person is found to be at the doorstep. Algorithms that are fast and accurate are used for this purpose. This paper also introduces a feature that enables the user(owner) to control the entry of vehicles by adding a RFID based authorization of vehicles and allowing the user to add and delete authorized vehicles. The system also presents a motion detection sensing device that is efficient and accurate by using Passive Infrared Radiation Sensor and assisted by a machine learning algorithm to detect if a person has entered the house premises during security hours. The whole system is controlled and monitored via a mobile app that features facilities to get Alerts, monitor activities and other functions mentioned in this paper. The system thus provides automation with security focused to elderly people residing in the house.[2]

S.Srikanth, SK.saddamhussain and P.Siva Prasad put forward that now a day to secure your home using voice commands alexa can be used. It is widely used to control home appliances, background lights and colors .If you often worry that you forgot to lock your front door, a smart lock is one way around the problem. You can check the status of the door lock if your phone door is locked or unlocked remotely and let your dog walker, delivery service, or friend inside when you're not around. Also unknown persons haven't come far enough in terms of security, so beware of the pros and cons before you ditch your analog lock. Several smart lock manufacturers are making devices that integrate with alexa and voice commands. So you can call "Alexa lock my front door" and your Echo would connect to your device or reply with a status update is useful. If you're in the shower and you suddenly can't remember if your front door is locked or not.[3]

Anitha A proposed a system which will inform the owner about any unauthorized entry or whenever the door is opened by sending a notification to the user. After the user gets the notification, he can take the necessary actions. The security system will use a microcontroller known as Arduino Uno to interface between the components, a magnetic Reed sensor to monitor the status, a buzzer for sounding the alarm, and a WiFi module, ESP8266 to connect and communicate using the Internet. The main advantages of such a system includes the ease of setting up, lower costs and low maintenance.[4]

Rohan Namdeo, Sahil Sharma, Varun Anand and Chanchal Lohi proposed an IoT based surveillance security system that can be accessed remotely with the use of the internet. This framework can be used in homes and personal offices. The framework works best in confined spaces and when the space in which it is being used has the absence of the owner. This is because the system will detect any movement occurring in the space.[5]

Jessamyn Dahmen, Diane J. Cook, Xiaobo Wang and Wang Honglei proposed robust smart home technologies that are commonly used by large segments of the population in a variety of settings. Recent smart home applications are focused on activity recognition, health monitoring, and automation. In this paper, we take a look at another important role for smart homes: security. We first explore the numerous ways smart homes can and do provide protection for their residents. Next, we provide a comparative analysis of the alternative tools and research that has been developed for this purpose. We investigate not only existing commercial products that have been introduced but also discuss the numerous research that has been focused on detecting and identifying potential threats. Finally, we close with open challenges and ideas for future research that will keep individuals secure and healthy while in their own homes.[6]

Qasim Mahmood Rajpoot and Christian Damsgaard Jensen presented a general model of video surveillance systems that will help identify the major security and privacy requirements for a video surveillance system and we use this model to identify practical challenges in ensuring the security of video surveillance data in all stages (in transit and at rest). Our study shows a gap between the identified security requirements and the proposed security solutions where future research efforts may focus in this domain.[7]

3. PROPOSED SYSTEM AND METHODOLOGY

This system can be divided into four phases:

Phase 1: It is the initial phase in which the device is ON, but there is no face in front of the camera. The locking mechanism is also in its unlocked state.

Phase 2: A person enters the room by opening the door. The camera module captures the face of the person entering. The Raspberry Pi performs face detection and recognition of the face captured and classifies if the person entered is an intruder or not.

Phase 3: Depending on the condition, the locking mechanism is turned ENABLED. If the person is an intruder, the locking mechanism is ENABLED, 10-second video evidence is captured and uploaded to the cloud storage and the owner and the security guard are notified about the event.

Phase 4: It is the final phase where the owner can disable the locking mechanism, in case a known person who is authorized by the owner but not the system is trapped or when the owner is there with the police and wants to open the door and confront the thief.
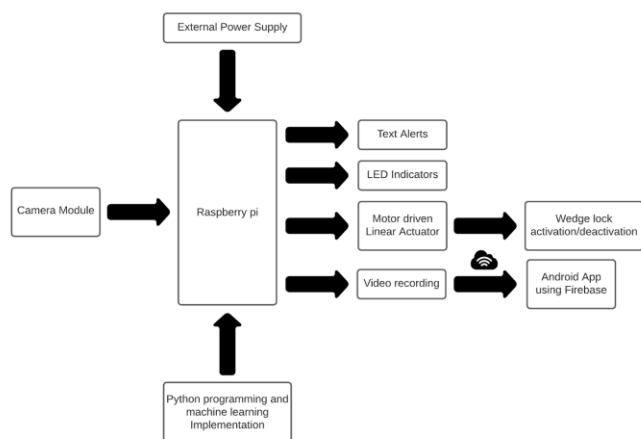
Fig -1: Proposed System Architecture

Raspberry Pi 4B - The Raspberry Pi is a small single-board computer. It is based on Broadcom BCM2711, quad-core Cortex-A72. It supports various types of Operating Systems like RaspbianOS, Linux and Windows as well as high-level programming languages like Python, which makes it suitable to run ML applications. It has various connectivity options like Gigabit Ethernet, 802.11 LAN, Bluetooth 5.0, USB 2.0 and 3.0 and two micro HDMIs.

Linear Actuator - This Miniature Linear Actuator is an electric push rod and an ideal solution for industrial, agricultural machinery, construction, clean sweeping vehicles, vessels, cargo and many other applications. This electric push rod is a kind of electric driving device which transforms the rotary motion of the motor into the linear reciprocating motion of the pushrod. It can be used in various simple or complex processes such as executive machinery to realize remote control, centralized control or automatic control. The electric push rod is composed of the drive motor which operates on 12V DC, reduction gear applying 100N of force with a speed of 90 mm per second, screw, nut, guide sleeve, pushrod of 50mm, sliding seat, shell, micro-motion control switch, etc.

Fig -2: Raspberry Pi 4B

Fig -3: Linear Actuator

Locking Mechanism - The locking mechanism is designed in house by us. It is a simple yet effective method to lock the door. It is constructed by using 2 prism-shaped pieces of wood, locally machined and strategically assembled such that when the linear actuator pushes the bottom prism horizontally, the other prism is pushed vertically. This results in the door being locked and can't be unlocked unless the lock is disabled. The best part about this is that even with a lot of force applied the mechanism doesn't fail as virtually no force is applied to the linear actuator as it is perpendicular to the force applied onto the vertically moving prism lock.

Fig -4: Locking Mechanism (Unlocked)

Reinforced Door - The door is reinforced with steel at the bottom which makes it harder to break the door, which in turn increases the time required for the intruders to escape the scene. This time is sufficient for the security guard to come to the scene and call law enforcement if required.

Fig -5: Reinforced Door

Camera Module - The C270 HD Webcam gives you sharp, smooth conference calls (720p/30fps) in a widescreen format. Automatic light correction shows you in lifelike, natural colors. We use this to capture facial information which helps the Raspberry Pi to make decisions based on the face detected and recognized. Otherwise any camera module can be used that supports USB, Ethernet or Wireless Connectivity.


Fig -6: Camera Module

Dual Channel Relay Module - This module contains two relay switches that are electrically isolated from the controlling input. The relays can be used to switch higher voltage and current loads than a microcontroller can traditionally accomplish. Here we are using it to switch the polarity of the motor. It is powered from 5V. Each relay has 1 input and receives from the microcontroller. There are 2 pairs of switching ports Normally Open(NO) and Normally Closed (NC) which provide the current to be switched in the relay. A comm port (COM) is connected to the linear actuator.

RAT TRAP App - For remotely controlling the device and accessing the video recordings uploaded to the cloud storage by the Raspberry Pi. The cloud storage used is Google Firebase. Firebase also provides authentication for the users. The app is built using the Flutter framework, which makes it usable on Android as well iOS. Fig. 8 and 9 shows the user interface of the application with firebase authentication.
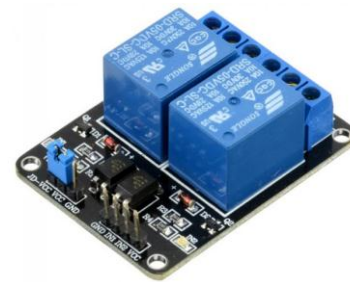
Fig -7: Dual Channel Relay Module
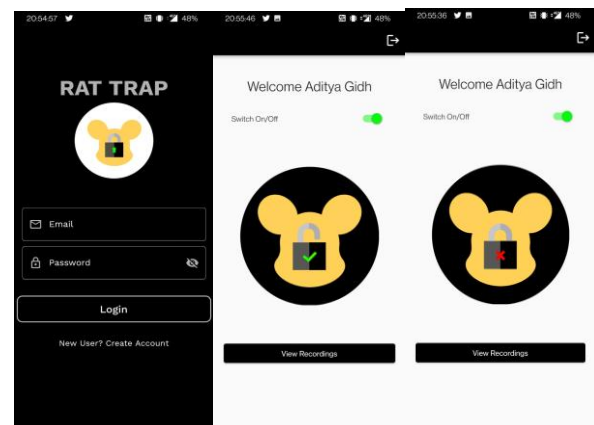
Fig -8: Login Screen of Application (Left) System is enabled with no intruder (Middle) and when intruder is trapped (Right)

4. PROPOSED SYSTEM AND METHODOLOGY

When an intruder is detected, the following operations perform simultaneously:

a) The locking mechanism instantly gets enabled, locking the exit routes. Fig. 11 shows the enabled locking mechanism

b) A 10 second video evidence is captured and is uploaded to Firebase Storage. This step is done even if the person entered is not an intruder.

c) An alert sent to the owner's and security guard's phone via SMS using Twilio about the incident.

The owner can then check the "View Recordings" section, which shows him who has entered. If the person trapped is an actual intruder, the owner can contact the law enforcement. If the person trapped is a known person and is not an intruder, the owner can disable the system by switching the toggle switch off. Same can be done when the police arrive to nab the intruder, the locking mechanism can be disabled so that the police can open the door and get hold of the intruder for further investigation.

Fig -9: Enabled Locking Mechanism
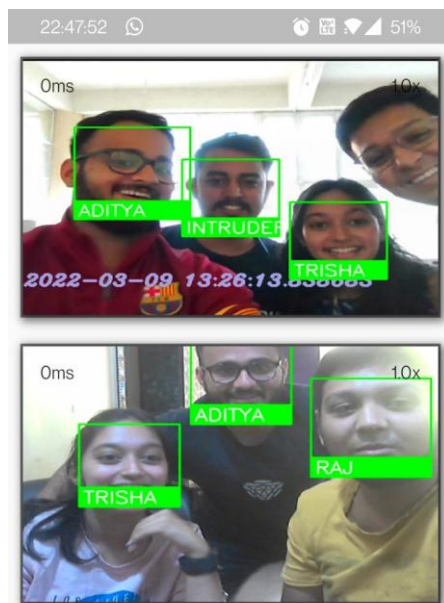
Fig -10: Video Uploaded on the Firebase Storage shown in the RATTRAP app

Networkability plays a vital role. Due to the complete installation of the operating system on raspberry pi, there comes the division on the processing power but if only there could be a dedicated unit only made for facial recognition and GPIO, it can be more efficient such that the entire power of the system is concentrated on the facial recognition model and there would be less load and more accuracy. Once the lock is activated the surfaces of the wedges are thrusted with the help of linear actuator and due to controlled speed the friction created is of adequate amount and there is no wear and tear of the wedges.

One of the advantages of this mechanism is that any force applied is nullified as its vertical component gets absorbed in the ground and horizontal component by the reinforced door.

Out of a total 2000 test runs the system passed 1902 times. The face recognition had an accuracy of around 95.1%. The remaining 4.9% unsuccessful test cases are due to certain conditions and circumstances like darkness near the detection and recognition zone. In these cases, the lock will be activated but can be manually deactivated by the owner.
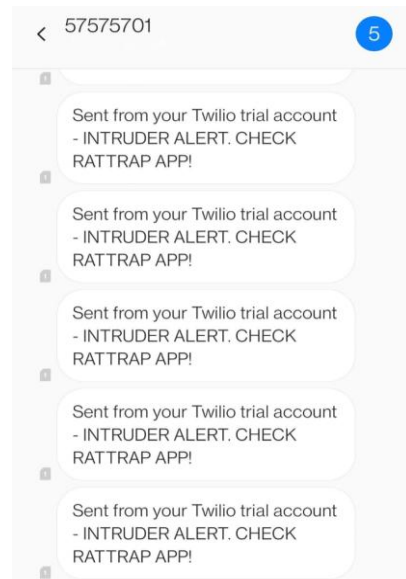
Fig -9: SMS Alert on the phone via SMS using Twilio

5. CONCLUSIONS AND FUTURE SCOPE

The purpose of the system is to provide a measure of security to avoid burglary or trespassing. Based on the results, it is concluded that the system assures the bifurcation between an intruder and an authorized person. Also, it creates a confinement area preventing the intruder from fleeing. The algorithm and method are independent of both the application and the backend domain. An integrated approach to the hardware and the software has been developed. The application would greatly benefit the development of such systems, which have widespread applications.

The developed system can also be used in industrial and commercial applications such as offices, warehouses and other areas where some areas are reserved for authorized personnel only such as the internet server room of Multinational Companies. The system can also be easily upgraded to add extra safety features such as iris and motion detection sensors and a robust processing unit for increased safety. The system can also further be developed by adding an Radio Frequency Identity (RFID) scanner so that the authorized users need only to carry an RFID tag with them. The RFID scanner will work by scanning the tag wirelessly and if the user is authorized to enter, the alarm system will be disabled for some time so that the user can enter.

ACKNOWLEDGEMENT

REFERENCES

[1] Xin Zhang, Won-Jae Yi and Jafar Saniie,"Home surveillance system using Computer Vision and Convolutional Neural Network", 2019 IEEE International Conference on Electro Information Technology (EIT), 10.1109/EIT.2019.8833773.

[2] Arshith Suresh, Aina P Subeer, Ann Mary Philip, Jini Shaji Varughese, Justin Mathew,"Comprehensive home security for elderly people using IoT and Artificial Intelligence",2020 IEEE International Conference for Innovation in Technology (INOCON),10.1109/INOCON50539.2020.9298445.

[3] S. Srikanth, SK. Saddam Hussein, P. Siva Prasad,"Home anti-theft powered by Alexa", 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN), 10.1109/ViTECoN.2019.8899464.

[4] A Anitha,"Home security system using internet of things",IOP Conference Series: Materials Science and Engineering, Volume 263, Issue 4.

[5] Rohan Namdeo, Sahil Sharma, Varun Anand, Chanchal Lohi, "Smart Automated Surveillance System using Raspberry Pi",International Journal of Recent Technology and Engineering (IJRTE).

[6] Jessamyn Dahmen, Diane J. Cook1, Xiaobo Wang, Wang Honglei,"Smart secure homes: a survey of smart home technologies that sense, assess, and respond to security threats", Journal of Reliable Intelligent Environments volume 3, pages83–98 (2017), 10.1007/s40860-017-0035-0.

[7] Qasim Mahmood Rajpoot, Christian Damsgaard Jensen,"Security and Privacy in Video Surveillance: Requirements and Challenges", IFIP Advances in Information and Communication Technology book series (IFIPAICT,volume 428). M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.