International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-6, April 2020

Automated Locking based on Thermal Camera and Artificial Intelligence

Arnab Dey, Sudhanshu Jain

Abstract*: In the fast lifestyle of today where work and learning consumes most of people's time. We through this paper look forward to providing further convenience to people through automated locking of house doors on detecting no person inside the house. This will ease pressure on the mind to lock or unlock the gate and carry keys or keep track of the digital system installed in the required events of leaving home or coming back. We recommend a thermal camera along with artificial intelligence means to detect humans inside the house and take action accordingly. If no human is found inside the house and no member(s) are facing the door then lock doors immediately. System of face detection and recognition of member(s) to unlock the house in the event of returning or going back inside the house is to be incorporated as well.

Keywords* : *Automatic locking, Thermal camera, Human detection, Artificial Intelligence, door locking.

I. INTRODUCTION

Keeping in mind the convenience that the paper intends to provide recommends using an automated system of locking doors and unlocking doors using artificial intelligence and thermal cameras that are expected to detect humans through face or temperature. For detecting humans effectively the research work which has already been published is understood to be best suited for this purpose. [5]

Functionality recommended is to detect humans inside the home. If the subject, that is human in this study, is found to be missing; whether infant, child, adult or elderly, then lock the doors immediately. Locking of doors can be through a digital medium that also incorporates a manual system of keys to lock and unlock for reliability and unlocking doors in unwanted circumstances of dysfunctional digital systems.

There may be an event when a person goes out of house and would come back immediately in such a scenario, we are recommending that person need not take any action to unlock it. It should be through pre-trained FaceNet based Face Recognition with Artificial Intelligence that a member is recognised through face detection facing towards the door and door unlocks. A system to light up the near door area in instance of darkness should also be incorporated to successfully do face recognition in light.

Revised Manuscript Received on April 30, 2020.
***** Correspondence Author
Arnab Dey*, Computer Science and Engineering, Kalyani Government Engineering College, Kalyani, India. Email: arnabdey120@gmail.com
Sudhanshu Jain, Research Department, Nandyavart Consultancy Services, Chandigarh, India. Email: sudhanshu@nandyavart.in

Member(s) of the house can simply walk out of the house and get the doors locked. On returning, that is facing towards the door, doors automatically get unlocked without key or any digital imprints like voice or fingerprint detection. Doing so would release any pressure of action to be made by members of the house. We do not require cameras to scan through walls as this would lead to problem statements such that a person within house boundaries and outside house walls would have to be differentiated. It would only make system implementation more complex. Thus, general thermal cameras will do that work during less no light well to detect humans through temperature.

II. LITERATURE SURVEY

Surveillance based on computational approach has become a major necessity in present generation. It is required to have a system that detects humans not only in daylight or tube light but also during faded and dark times. With the aid of FLIR (Forward Looking Infrared) camera paper recommends humans detected in low light as well. HOG (Histogram of Oriented Gradients) feature extraction technique along with adaptive background subtraction algorithm is introduced and it is the primary approach to detect humans. It works in association with the HOG approach. With the aid of the said procedure the precision, execution time, and other parameters can be minimized which result in improvement of overall accuracy of the human detection system.

The study deals with a night time surveillance system that is dependent on processing of thermal images which are taken from a FLIR camera. The proposed feature fulfils the necessity as using this system will give increase the precision, allowing the camera some freedom of movement and also by minimizing the processing duration of the system. [1]

In this study Doppler radar technology is utilized is a microwave sensor module which can particularly recognize moving objects and also the humans. The said module has many benefits such as wide sensing angle, high sensitivity, high reliability, long distance sensing, huge range of operating voltage. Here, a multi frequency radar system is used for detecting humans and classifying their activities at both long and short ranges. The short-range radar and the long-range radar system through light foliage work by selection and switching to work. It makes use of a mixed multimodal signal which is having two waveforms, an embedded single tone and wide-band noise waveforms which are added up and send simultaneously. The received single is utilized for the Doppler analysis. The matched filtering of transmitted and the received noise signals are carried out for detecting targets with the high-range resolution.

But the Doppler measurements are utilized for characterizing different gestures and movements of human beings. These measurements build the ability of this system for detecting human in a particular range and for characterizing various human movements at different ranges. [2]

In the software testing, automation testing plays a vital role for increasing the test efficiency of the testing team. Sometimes manual testing may not be effective due to its inconsistency, lack of coverage and non- repeating in nature. To overcome this Test automation is used in the software industry. Software testing is a set of methods that is performed for finding errors in software. This process is used to determine the quality of the software. Test automation process is used to minimize the cost and the rest of the overhead. Automation reduces the time spent on regression tests and provides a scope for organizations to improve the quality of their software products as we know that automation tools can perform tests faster than humans. [3] [11]

Thermal imaging is a method which utilizes the heat produced by an object for generating an image of it or for locating the object. The modern thermal imaging technologies are utilized for segmentation, detection and unique feature extraction and also for the measurement of the human physiological biometrics. The study also examines a specialized algorithm which fetches information and also creates a thermal signature that helps to recognize the individual. The accurate outcome found by the algorithms utilized, clearly showcases the ability of the thermal infrared systems to extend in application to other thermal imaging based systems. As we identify that thermal images don't require any special method for processing.

Various image processing methods which can be used are Training classifiers like Ada-boost and Bayesian, Edge detectors like Canny & Sobel filters, Multi-resolution screening, Morphological operators, Features matching and Finding interest points and centroids and others.

Recent studies have showcased that thermal imaging has performed better in the domain of biometrics in many other challenges. [4]

This study shows that human beings even across clothes can be detected by means of a thermal camera. Heat emitted by the person can be captured by a thermal camera. Infrared radiation (IR) is issued during the process of detection of humans. Major outcome of YOLO Convolutional Neural Networks (CNN) model is that under various weather conditions it can detect humans for example rain, snow etc. Keeping in view that face recognition would be of a person outside the house this model is best suited for implementation of human detection and face identification through images passed to artificial intelligence. [5]

Using mono static radar mode many sets of measurements were taken to detect human beings using UWB radar. Mainly 3 types of interference were studied.

- Wooden doors
- Gypsum
- Brick Walls

One of the 3 methods to detect humans was to do it through heart beat using a Doppler approach but it did not work through thick concrete walls. Second approach was to use singular value decomposition to reduce clutter but this too did not work on concrete walls. Next approach using the STFT and SVD method too did not show complete success. After study, it concluded that a new approach is required to make effective detection even through all types of walls. But it should be noted that our system is not required to detect humans through walls. To keep it simple, each room would have an independent thermal camera. Choosing any method proposed in this paper would be a solution to detection of humans but each of the methods has some hurdles. [6]

New pixel values and temperature values relationship of heat models for thermal image sensors is worked on during this research. Through these models and relationships human detection is studied. During the finding thermal cameras ought to be recommended for use of detection. Results of up to 90% were perceived. 4 types of models are studied with

- No background
- Hot model,
- Normal model
- Cold model.

Based on these 4 models classification was done to reduce the number of inaccuracies human detection. [7]

Digital locks can be based on various techniques such as:

- Secret code
- Semiconductors,
- Smart card
- Finger prints

Any of the methods stated above may be used for authentication purposes. The ZigBee model suggested in this paper indicates a centralized system to control the digital lock system. It can provide convenience and ease of installation and control over the system.

Through remote access to centralized systems digital locks can be managed. [8]

Fingerprint based systems are able to recognize unique fingerprints and take action accordingly. Various advantages and disadvantages are discussed in this paper of fingerprint based digital lock systems. Some advantages include are:

- It is customizable and quick.
- Provide ease.
- Has a high accuracy rate.
- Feasible to both large and small organizations.
- System is secure.

Some of disadvantages include:

- It is power dependent.
- Requires high power to operate.

The need for high power to operate so providing continuous power through batteries is a challenge sometimes. A power failure will make it unworkable. In that case, we can connect the system with an IPS or add rechargeable batteries to the system. [9]

Testing is an essential approach of Software Engineering. There are a huge number of open source software testing tools which are Selenium, Sikuli and Watir. These are used as open source automated testing tools.

This paper presents the comparative study of these different tools in terms of their data driven testing, efficiency, recording capabilities, code reusability and portrays the effectiveness of testing tool with these parameters. [10]

FaceNet uses a directly trained deep convolution neural network that optimizes the embeddings directly. An exclusive facial identification performance is accomplished with 128 bytes per face data. Just after the creation of Euclidean space steps such as face recognition, clustering and verification can easily be implemented using standard techniques with FaceNet embeddings as feature vectors. We recommend using FaceNet to implement member(s) identification at the time of facing doors from outside the house. [12]

III. SYSTEM MODEL

The model we designed showcases how thermal cameras along with artificial intelligence perform modularly to get desired results as intended in this research.

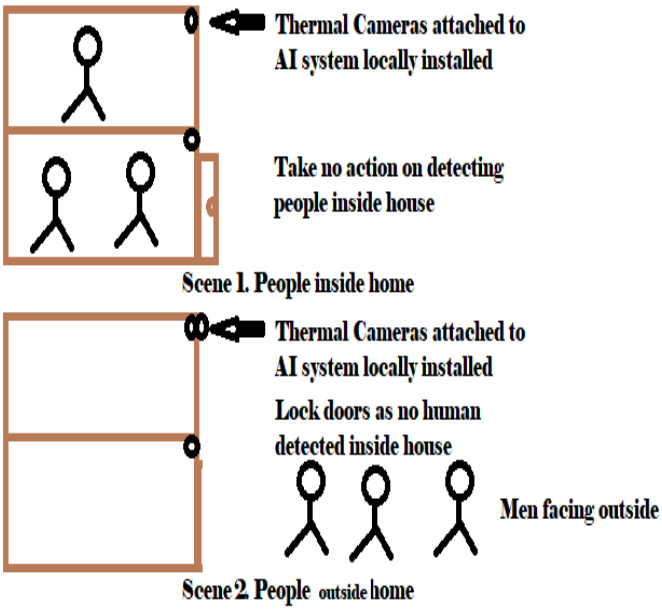

Fig. 1: Showing various Scenarios of Automatic Locking

Here in Scene 1 no action is taken if people inside the house detected and Scene 2 shows that it will lock the house if no human are detected inside the house.

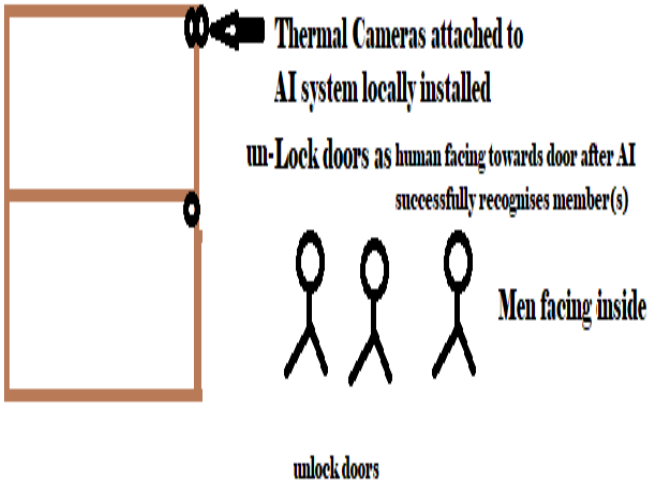

Fig. 2: Unlock doors after successfully identifying member(s) facing towards the doors.

If a member is found to be facing towards doors and no man is inside the house then unlock the house. After 30 seconds the system should recheck whether there is anybody inside the house or not to lock and unlock the house accordingly.

Study on human identification and face recognition has already been done before and this paper takes advantage of those research and recommendations. The integration of the two methods which are human identification and face recognition is required which is recommended in this research.

It is to be noted that manual method of key unlock remains in scenario of overriding the automated system is required. Our method introduces automation and Artificial Intelligence based locking systems in combination with the manual way of unlocking through key.

Various case studies are done to see how much our research is able to automate the thing correctly and efficiently at various situations. One case study involves understanding a scenario where 2 people sleeping inside the house and 3 people outside the house going to a party or an event would like to have the house locked. Thus in such scenarios, the recommended system should not take any action. This further eases the understanding of the system recommended here. If it is required to lock the doors then it will have to be done through the key manually.

It is learnt that not under all scenarios automation would work to lock and unlock doors. As in the scenario stated above, the manual method will have to be in place. Whenever required, the manual system could be activated from inside house on button press on digital hardware.

To lock and unlock digital hardware locking systems is required that embeds logic presented in this paper. The way logic recommended can be implemented by digital hardware lock manufacturers is left to the choice of manufacturing and developing company.

IV. PROBLEM STATEMENT

Providing ease of locking and unlocking based on automated systems through means of detection and identification is what we have achieved through this research. Automation is provided by detection of humans through thermal cameras inside the house and identification with Face recognition using 3 side face profile matching based FaceNet implementation of Artificial Intelligence from outside the house.

V. PROBLEM SOLUTION STATEMENT

Thermal cameras detecting heat emissions from human beings will indicate to the local Artificial Intelligent System installed whether a person is present inside the house or not. In instances where no human is inside home and no member(s) is facing doors, doors are to be locked. If a member is found to be facing doors from outside then this recommended system would use Advanced FaceNet method to recognize the face and then unlock systems. It is important to implement that if a person is facing doors and no person is inside home then deadlock conditions should not happen. The system should unlock doors for 30 seconds and again check after 30 seconds whether people inside the home exist or not to lock or unlock the doors. This way it is made security hardened that when no member is inside the house,

the house can stay open for maximum 30 seconds. Our system doesn't fall into deadlock conditions.

To do effective member(s) identification we suggest 3 face profile scan based face recognition. The front profile, left profile and right profile face scan will have to be done to make sure images are not put up to mimic human faces by miscreants. It will also prevent any other person except the house member(s) to unlock the door just by showing a picture of the house member through a mobile or any other device. It is only after all 3 cameras enabled with AI will give a positive signal after matching that the doors will be unlocked unless done manually through key.

VI. RESULT, ANALYSIS AND DISCUSSION

Three cases to be evaluated when manual system is not active:

- If the video finds no human being inside the house then pass value 1 to the AI system. AI in action will then check for another condition that is to see that no member(s) of the house are facing the door from outside. If no member(s) found facing doors then indicate it through value 1. On both values being 1 lock the doors.
- If no one inside the house and members facing the camera from outside home and manual system is not active then unlocks the door.
- If any of the values is 0 that the member is facing the door or the human being is inside the house and the manual system is not active then do have doors locked in unlocked condition.

The Case 2 and 3 both will have doors unlocked but there is a difference in action which is to be taken. Case 2 requires unlocking the doors by taking action while Case 3 will be valid during most of the time with no action of locking or unlocking action taking place. Order of case execution is important. Below is pseudo code that gives clear implementation logics.

Main Program Logic is defined here that is to be part AI system with control logic system. Overall the below 3 mentioned system integration is required along with an AI sub-system of the first one.

- AI along with control logic system and AI Sub system
- Digital lock and
- Thermal Camera.

Pseudo code:

The code is divided into various sections A, B, C and D.

A. AI along with control logic system:

Step 1: BEGIN
Step 2: Loop executes Step 3 every 30 seconds by Setting setinterval = 30 in JavaScript code.
Step 3: If Manual_Button_Pressed == 1 Then
SET State = 1 // meaning withdrawal of AI system.
ELSE If Manual_Button_Pressed == 0 AND
Electricity found supply == 1 Then
DECLARE and INITIALIZE Global variables
Thermal-Camera logic = 0
L_State in Digital-Lock = 0
No_Member_Facing_OutsideDoorCamera = 0
If Human_Being == 0 AND
No_Member_Facing_OutsideDoorCamera == 0 Then
Digital Lock L_State = 1 //meaning lock. Make hardware to action lock.
Else If Human_Being == 0 AND No_Member_Facing_OutsideDoorCamera != 0 Then
Digital Lock L_State = 0 //meaning unlock. Make hardware to action unlock
Else If Human_Being != 0 AND No_Member_Facing_OutsideDoorCamera == 0 Then
Digital Lock L_State = 0 //meaning unlock state No action required.
Step 4: Go to step 2 again.

B. Setting Value of Human_Being variable in software embedded thermal camera hardware logic:

Step 1: BEGIN
Step 2: Set Human_Being = 1 on no human detection
Step 3: Set Human_Being = 0 on Human detection
Step 4: Stop
Detection of Value Digital Lock L_State variable in software embedded digital lock hardware logic:
Step 1: BEGIN
Step 2: If L_State == 1 // Move hardware to lock
Step 3: else If L_State == 0 // Move hardware to unlock
Step 4: Stop.

C. Set value from AI FaceNet based system with 3 cameras:

Step1: BEGIN
Step2: If Members_Left_FaceProfile_Match AND Members_Right_FaceProfile_Match AND Members_Front_FaceProfile_Match Then
Set No_Member_Facing_OutsideDoorCamera = 1
Else
Set No_Member_Facing_OutsideDoorCamera = 0;
Step3: Stop

Logics in B, C and D can be set in different systems that pass values to the main control logic system A with AI as global variables.

No_Member_Facing_OutsideDoorCamera variable is dependent on 3 way profile identification left, right and center. It is only after all 3 matches or not match that this variable is assigned a value.

Analysis:

Cyclomatic Complexity based on path, nodes and edges shown in graph below:
Part a) Main control system

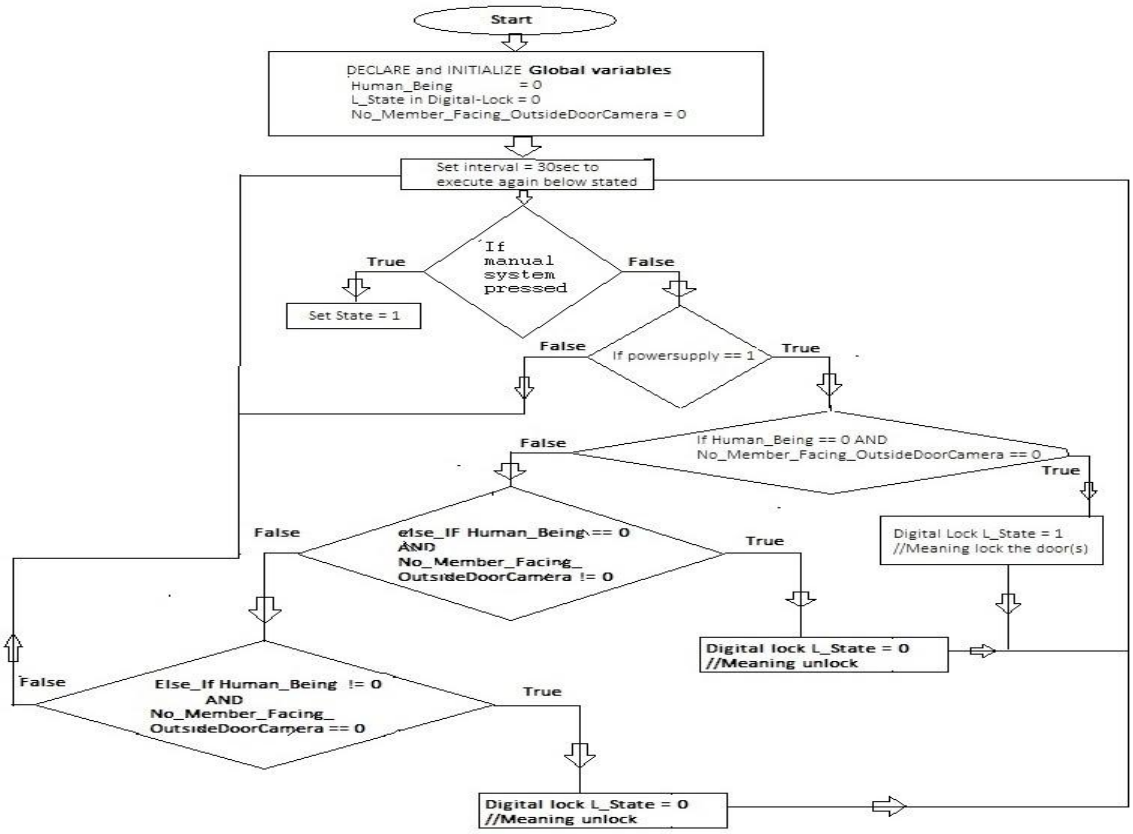

Fig. 3: Flowchart of Control system

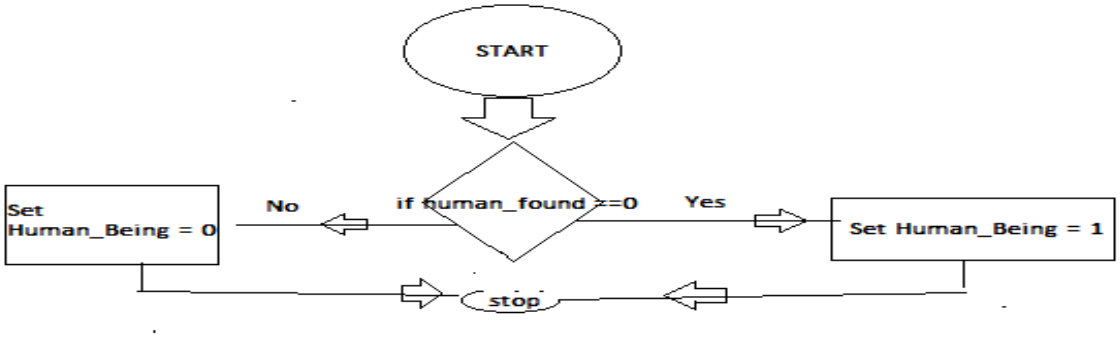

Fig. 4: Flowchart of Thermal Camera

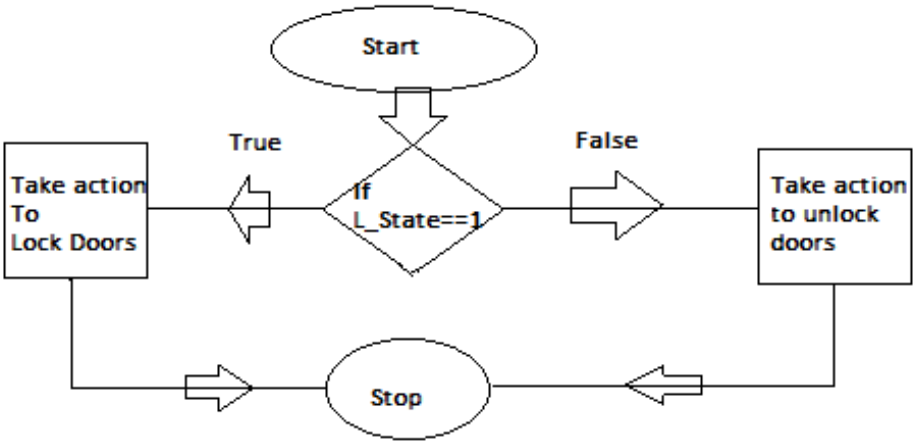

Fig. 5: Flowchart of Digital lock

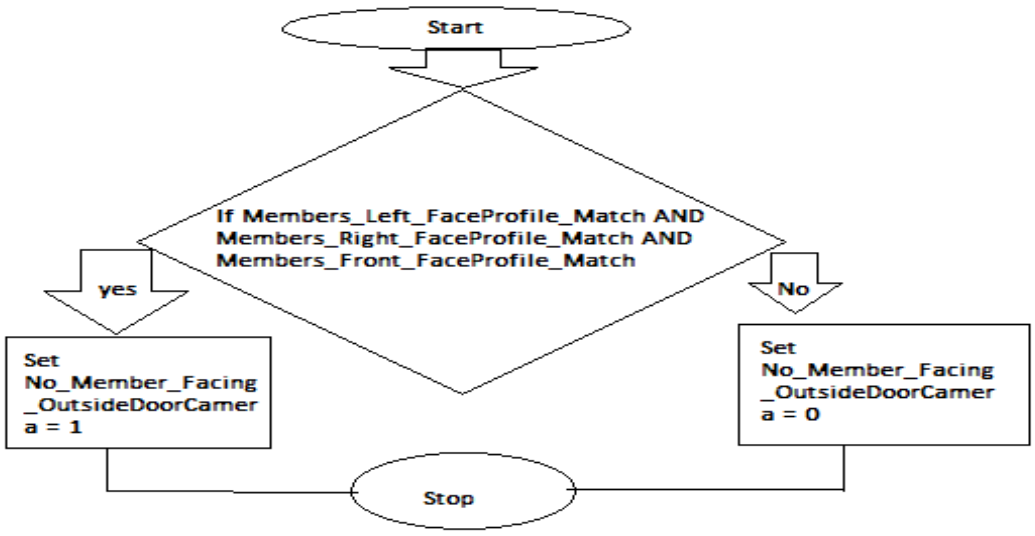

Fig. 6: Flowchart of AI Sub system

Action count on voice digital system

Action name	Count of actions
Walk closer to voice recognition device	1
Speak password or code or name etc	2

Action count on fingerprint scanner system

Action name	Count of actions
Walk closer to fingerprint scanner	1
Take action to place finger on fingerprint scanner	2

Action count on thermal and AI based system recommended in this paper

Action name	Count of actions
Walk towards doors from outside house	1

Fig 7: It shows comparison between voices based and fingerprint based digital system with recommended solution

In Fig. 3 the flow of logic of pseudo code in section A which is the main control system of our proposed research is shown. This would direct the final outcome based on decision statements to part c to lock or unlock doors.

Analysis: 12(Nodes)-17(Edges)+10(path) = 5 Cyclomatic Complexity.

Part b) Human present global variable assignment using Thermal Camera

In Fig. 4 the flow of logic of pseudo code section B is shown. If the human being count is equal to 0 then set human_being global variable to 1 that means lock the door.

Analysis: 5(nodes)-5(edges)+2(paths) = 2 Cyclomatic Complexity.

Part c) Digital lock

Fig. 5 shows the flow of logic of pseudo code in section C. If L_State set by Part A is 1 then digital lock should lock doors else otherwise action to be taken based on further condition check.

Analysis: 5(nodes)-5(edges)+2(paths) = 2 Cyclomatic Complexity.

Part d) AI Sub System

Fig. 6 shows flow of logic of pseudocode section D. It sets global variable value that is part of conditional statements in part A logic. If member(s) all 3 profiles match, set value as 1 otherwise 0.

Analysis: 5(nodes)-5(edges)+2(path) = 2 Cyclomatic Complexity.

Total additional complexity 5(A) +2(B) +2(C) +2(D) = 11 Cyclomatic Complexity

Assuming existing systems' Cyclomatic Complexity be N then by adding recommended functionality as in this paper Cyclomatic Complexity is going to be N+11.

It is seen as a 50% action difference between 2 of existing systems of digital locks. We can say that convenience is provided with 50% less action required.

It can be noted from Fig. 7 above that at minimum 2 actions are required to be performed by member(s) when voice based or fingerprint based digital lock system is in place whereas by recommended method in this paper just 1 action of walking towards doors from outside the house is required by member(s) to unlock door(s).

This shows us efficiency of 50% achieved to member(s) in actions. Thus, it provides convenience and ease for human beings.

VII. CONCLUSION

It is successfully understood that the recommendation made in this paper of using human detection inside the house by means of thermal camera and identification done with 3 way face profiling face recognition can provide ease and convenience. Logic stated is simple that in a scenario of no human being detected inside the house and no members facing doors of present then the house doors should be locked. If a member is found facing the door from outside then unlock the house allowing 30 seconds to enter the house before re-checking. Manual method of key to unlock and lock the doors is not to be removed to keep as an alternative measure in case of system breakdown or non-functioning due to unavoidable situations such as no power supply.

The proposed method is better than all the existing methods as it involves a powerful face scanning and thermal camera is integrated for human identification. In voice or biometric based systems users are required to take certain actions but in this recommended research we state that no special action is required from member(s) of the house other than walking towards the door to enter the house. Benefits like no action other than walking towards the door, ease of lifestyle, much more secured, efficient stress free and convenience are extended to member(s) on implementation of this recommended method of auto locking system through automation.

REFERENCES

1. Ram M. Narayanan, Sonny Smith, and Kyle A. Gallagher, "A Multifrequency Radar System for Detecting Humans and Characterizing Human Activities for Short-Range Through-Wall and Long-Range Foliage Penetration Applications", International Journal of Microwave and scientific technology (IJMST), April 2014. DOI: 10.1155/2014/958905
2. Yash Khandhediya1, Karishma Sav, Vandit Gajjar, "Human Detection for Night Surveillance using Adaptive Background Subtracted Image", International Journal of Scientific and Engineering Research (IJSRD), May 2017, ISSN: 2321-0613.
3. Prasad Mahajan, Harshal Shedge, Uday Patkar , "Automation Testing In Software Organization", International Journal of Computer Applications Technology and Research (IJCATR), Vol. 5 Issue 4, pp 198 - 201, April 2016.
4. Nermin Kamal Abdel-Wahab Negied, "Human Biometrics: Moving Towards Thermal Imaging", International Journal of Recent Technology and Engineering (IJRTE), Volume-2 Issue-6, pp 73-77, January 2014.
5. Marina Ivašić-Kos, Mate Krišto and Miran Pobar, "Human detection in thermal imaging using YOLO", 5th International Conference on Computer and Technology Applications (ICCTA), April 2019. DOI: 10.1145/3323933.3324076
6. Singh, S., Liang, Q., Chen, D. et al., "Sense through wall human detection using UWB radar", EURASIP Journal on Wireless Communications and Networking, Article no. 20, June 2011. DOI: 10.1186/1687-1499-2011-20
7. Pei-Jun Lee,Trong-An Bui, Che-Chih Lo, "Temperature Model and Human Detection in Thermal Image", 2018 IEEE 7th Global Conference on Consumer Electronics (GCCE), October 2018. DOI: 10.1109/GCCE.2018.8574800
8. Yong Tae Park,Pranesh Sthapit, Jae-Young Pyun, "Smart digital door lock for the home automation ", TENCON 2009 - 2009 IEEE Region 10 Conference, IEEE, January 2009, DOI: 10.1109/TENCON.2009.5396038
9. Piash Paul, Md. Abdullah Al Achib, Hazrat Sauda Hossain, Md. Kaviul Hossain, "Smart Door Lock System with Fingerprint Interface", Technical Report, BRAC University, October 2019.
10. Inderjeet Singh, Bindia Tarika, "Comparative Analysis of Open Source Automated Software", International Journal of Information & Computation Technology (IJICT), Vol. 4, no. 15, 2014, pp. 1507-1518.
11. Milad Hanna, Amal Elsayed Aboutabl, Mostafa-Sami M. Mostafa, "Automated Software Testing Framework for Web Applications", International Journal of Applied Engineering Research (IJAER), Vol. 13, no. 11, 2018, pp. 9758-9767
12. Florian Schroff, Dmitry Kalenichenko, James Philbin, "FaceNet: A Unified Embedding for Face Recognition and Clustering", 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), October 2015. DOI:10.1109/CVPR.2015.7298682

AUTHORS PROFILE

Arnab Dey is currently pursuing Master's Degree in Computer Science and Engineering (CSE) from Kalyani Government Engineering College, Kalyani, India. He has completed his Bachelor's Degree in the same discipline under Maulana Abul Kalam Azad University of Technology in 2019. He has published 3 research papers and 4 Articles in various Journals, Newspapers and Conference Proceedings. He was associated with the Entrepreneurship Cell of Indian Institute of Technology, Kanpur for one year. He is a member of various bodies such as IEEE, ISTE, IAENG, ASTM International and ISRD. The author is also a Volunteer of IEEE. He also prepares project for various companies**.** His current research interests include Image Processing, Artificial Intelligence, Intelligent Systems, IoT, Machine Learning, Web development, Cloud Computing, Automation, Algorithms and Wireless Communication and Systems.

Sudhanshu Jain is currently working as Software Engineer in Nandyavart Consultancy Services, Chandigarh. He has completed his Master of Computer Applications (MCA) from Chitkara Institute of Engineering and Technology, Punjab in 2010. He has completed his Bachelor's Degree in the same discipline in 2007. He has 2 research paper publications. Currently he is holding a member position at IEEE Chandigarh section. He has been working in the field of Information Technology for more than 10 years. He has experience of working at MNC companies like Infosys and IBM**.** His current research interest includes Web Development, Artificial Intelligence, Browser Applications and Automation.