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Smart Door for Handicapped People via Face Recognition and Voice Command Technique

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K E Y W O R D S

Smart home, Face recognition, face detection, handicapped people, Raspberry Pi.

A B S T R A C T

Smart home indicates an application for different technological implementations, it could indicate any system which controls the door lock and several other devices. Facial identification which is an important section to achieve surveillance and safety, especially for handicapped people, can be considered as one of the ways that deal with biometrics and performed to identify facial images via utilizing fundamental features of the face. A Raspberry Pi-based face recognition system using conventional face detection and recognition techniques is going to be supplied, so the method in which image-built biometrics uses a Raspberry Pi is described. The aim of the paper here can be considered as transferring face recognition to a level in which the system can replace the utilizing of RF I-Cards and a password to access any system of security and making the system alive and protect the door from being open by hackers, especially by using the picture of an authorized person, we make the raspberry pi turn off and cannot turn on only by a command from the authorized person's mobile. The result of the presented proposal is a system that uses face recognition by utilizing OpenCV, Raspberry Pi, and it functions on an application of Android, and this system percentage becomes 99.63%. It should be cost-effective, of high performance, secured, and easy to use, which can be used in any smart home application.

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1. INTRODUCTION

It is very beneficial for a large rate of people such as handicaps and aged ones to get domestic appliances in hand by utilizing the smart type of technological techniques. A large number of those appliances have not been made for those who have some physical disorders. It is agreed that "handicapped persons suffer from a lot of daily issues indoors and outdoors specifically as no one accompanies them in their houses" [1]. Observing as well as dominating some missions at home could give the best state of safeness [2]. Thus, a framework with safety and accuracy in an exceeding

way must be outlined imperatively. Open CV 'open-source PC vision library' can be expressed as an open library of source picture preparing kind. OpenCV requires some compiler such as Dev C++, code squares, visual C++. The raspberry pi can be considered as a small Mastercard measured PC, the Raspberry Pi3 Model B can be a PC the same size as a credit card which can be connected to the television, as well as a mouse and keyboard [3]. The Camera Module can be considered as a little PCB that supplies connection for a camera that is connected via cable for shooting fixed pictures or videos and it gives voice commands, which is suitable for real-time [4], applications of smart home [5].

2. RELATED WORK

Some old studies connected to the paper explain as follows:

Some literature review concerning this paper: Hana'a Salman (2006) [6] gives information concerning automatic speech recognition by machine for man-machine communications in the voice command technique. Olegs Nikisins et al (2015) [7] introduced a system for face-recognizing established on a PC of a single board quality of Raspberry Pi. This system comprised detecting of the face as well as localizing them by utilizing the cascade classifier of Haar established on features. The features of faces were extracted utilizing measured an algorithm of Local Binary Pattern. The enhanced system performed an analysis for a complete face in 110 ms. Comparing a couple of biometric examples was performed in 2 ms. The suggested installed face-recognizing system had been tested on FERET collection of information as well as accomplished accurateness for CMC: 99.33% as well as EER: 1%. Ishita Gupta et al (2016) [8] introduced recognizing of face besides they said it was a significant section of securing and observing aim. Their target was to browse the potentiality to implement Raspberry Pi established on the system of face-recognizing utilizing traditional face detecting as well as recognizing mechanisms like PCA as well as Haar detecting. That paper aimed at transferring the recognizing of faces towards some level where this system would have the ability to substitute the utilizing of RF I Cards as well as passwords towards high securing systems as well as premises. Shrutika V. Deshmukh et al (2017) [9] introduced how many thefts were there as well as ID forgery that had become a matter of importance. For avoiding those issues, a system of recognizing faces was to be installed. The features that are similar to Haar were utilized to detect faces as well as the algorithm of HOG +SVM that was utilized to recognize faces. For achieving superior accurateness as well as impact they utilized the libraries of OpenCV as well as python. Identifying as well as training were done in an embedded gadget called Raspberry Pi. Shakir Fattah Kak et al (2019) [10] used the application of smart homes effectively for developing the control managing for securing of houses, securing, raising comfort, as well as declining consuming of energy utilizing a biometric mechanism as well as the services of cloud. Initially, the suggested system functioned for identifying an identification of members via utilizing the method of recognizing faces as some equipment for enhancing the securing of houses, as well as the control managing of houses. The procedure of recognizing captured an image of the face for some member within a systematic atmosphere utilizing a digital camera as an image for testing. The AdaBoost mechanism was used for detecting as well as extracting faces of members for the train, and member images for tests. The ways of DWT with PCA are utilized for extracting the features as well as dimension reducing for images. Alina Munir et al (2019) [11] envisioned some kind of smart homes established on both of the separate as well as arising technologies via the recognizing of faces, for aims of securing, as well as recognizing of speech, for aims of automating. Furthermore, the most modern work accomplished was taken into consideration in a brief way as well as the reason of an offline system had been a requirement for filling the blank within the current technology protocols explained within the field that belonged to the same topic. A system of securing ensured the functioning of smart homes via shooting a picture of a bell ringing and making a comparison to it with the saved collected owners' information in a strong as well as credible manner throughout Raspberry Pi microcontroller OpenCV.

The proposed system of this paper has been for building a face recognition real-time system for the handicapped for the door lock, via utilizing the software and hardware, and the percentage of the system is equal to 99.63 percent if detecting the face is correct. That should be of high-performance, cost-effective, secured, and simple, that could be utilized in all smart home applications.

3. OBJECT DETECTION FRAMEWORK

A way that is proposed by Jones and Viola in the year 2001 for supplying detection of objects quickly [12]. It can be considered as a way for speedy as well as the right detection of objects via utilizing the machine learning of Adaboost. The major characteristics of the algorithm of Viola-Jones can be:

1) *Integral image:* Needed for quick object detection that requires computing of Haar characteristics, and for computing them, an integral image has been gained utilizing some processes per pixel. After the calculating here, in fixed time Haar characteristics of any kind being calculated.
2) *The Adaboost Learning algorithm:* It made more than one skillful classifier from a set of extraction related visual characteristics. Learning has to eliminate a large number of characteristics that existed in the image for quick classifying. Critical characteristics extracted via the algorithm here as dismissing the other characteristics that are not significant.
3) *The cascade classifier:* Is focused on objects like portions and dismisses the background as Figure 1, it can be considered as a type of technique which familiar with its territory of interest and refused areas cannot possibly be for including any object. This could be quick in instant detection [13].

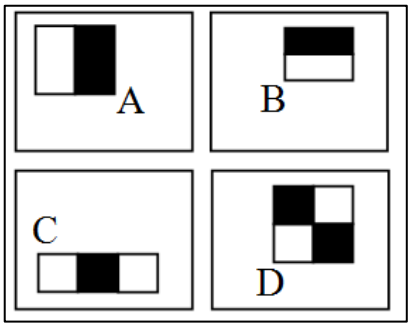

Figure 1: Haar cascade classifier

4. ALGORITHM

For researching the algorithm completely, the start is going to be with the properties of the images for classifying the task: -

I. Haar-like features

The algorithm of Viola-Jones uses Haar-like features, which means, a scalar article among a few Haar-like templates and images. All the more definitely, let Img and Pn give the meaning of image and pattern, the two are the same size G × G (As G=24) the feature linked to pattern Pn of image Img can be featured via:

$$\sum_{1\le i\le G}\sum_{1\le j\le G}\mathrm{Img(i,j)1Pn(i,j)is\ white}-\sum_{1\le j\le G}\sum_{1\le i\le G}\mathrm{Img(i,j)1Pn(i,j)is\ black} \quad (1)$$

For compensating for the affecting of various lighting terms, every image ought to be mean, and the difference normalized previously. These images with variance less than one, possessing a little interesting information in the beginning, have been concerned.

II. Integral image

Instead of calculating every pixel in a rectangular window, the strategy here opposites the use of every total distributing function. The identified image IImg of Img could be the details of contact as:

$$\mathrm{IImg(i,j)}=\{\sum_{0,}^{1\le si\ image(es,t),1\le i\le G\ and\ 1\le j\le G}\ \text{otherwise}. \quad (2)$$

Is for that given a definition as the equation below: -

$$\sum_{G\le i\le G2}\sum_{G3\le j\le G4} \mathrm{Img(i,j)} = \mathrm{IImg(G2,G4)} - \mathrm{IImg(G2,G3-1)} - 1\mathrm{IImg(G1-1,G4)} + \mathrm{IImg(G1-1,G3-1)} \quad (3)$$

Holds for all G1 ≤ G2 and G3 ≤ G4.

Consequently, calculating an image's rectangular domestic sum needs mostly four plain processes given its integral image. Furthermore, gaining the integral image on its own could be performed in linear time:

Setting G1 = G2 and G3 = G4 in (eq.3), find that:

$$\mathrm{Img\,(G1,G3)} = \mathrm{IImg\,(G1,G3)} - \mathrm{IImg\,(G1,G3-1)} - \mathrm{IImg\,(G1-one,G3)} + \mathrm{IImg\,(G1-one,G3-1)} \quad (4)$$

III. Features scaling

Scaling for Haar-like features is utilized instead of scaling image sub-windows for getting a system of fast detecting. The feature (1x2) as the white rectangle is over the black one for the 24x24 sub-window matrix (x1 to x23, y1 to y23), the feature here begins at the position x1,y1, add up the pixel in white rectangle and taken away from the amount of the pixel of in the black one, after that the feature number one can be gained. Every calculation can be built on the classifier here. After scanning, the entire 24x24 sub-window, the feature here has been scaled and forwarded to the next feature size, which is going to be (1x4) in (x1, y1) position, the feature is going to continue increasing in size. It is going to be (1x8), (1x16), etc.; it is not cross the sub-window size. After a full scan for every 24x24 sub-window, another Haar-like feature can be utilized in the same steps. For every sub-window 24 × 24 images, feature (1x2) there have been forty-three thousand and two hundred features, and the feature (1x3) as the black rectangle can be considered as the two-weight rectangle just like it is illustrated in Fig. (1) (b) category (b) and (d). For every sub-window (24 × 24) image, there have been twenty-seven thousand six hundred features as in feature (1x4) as there have been two black rectangles and two white ones just like it is illustrated in Fig. (1) category, there have been twenty thousand seven hundred and thirty-six features, thus sixteen one hundred sixty-two thousand three hundred thirty-six features.

IV. Feature Selection with AdaBoost

For face detection, it presumes the kind of f: Rdn {-1,1}, as 1 suggests that there has been a face and -1 the opposite, and N is the Haar-like features number taken off an image. Given the probabilistic weights, wg ϵ R+ relegated to a training set talked about up of n pairs of observation-label (xi; yi).

$$\sum_{l=1}^{n} \mathrm{wg1yi} \neq \mathrm{f(xi)} \quad (5)$$

The building block of the face detector of Viola-Jones can be a depth one decision tree or a decision stump, parameterized by a feature f ϵ {1; ….. d}, a threshold t ϵ R and a toggle to ϵ {−1; 1}.

Given an observation β ϵ Rdn, a decision stump C makes predictions to its label utilizing the rule as follows: -

$$\mathrm{C(\beta)} = (1\pi f\,\beta \ge t - 1\pi f\,\beta < t)\mathrm{to} = (1\pi f\,\beta \ge t - 1\pi f\,\beta < t)\,\mathrm{to} = 1 + (1\pi f\,\beta < t - 1\pi f\,\beta \ge t)1\,\mathrm{to} = -1 \in \{-1;1\} \quad (6)$$

As πf β: The feature vector's f-the coordinate. Imagine a threshold put a place the original line, if the toggle has been set to 1, the outcoming rule is going to pronounce an instance β positive if πf β is bigger than the threshold and negative on the other hand. That allows us to evaluate the state's empirical error herewith choosing the toggle which suits the dataset. As margin: -

$$\min_{i:y_{i=-1}} |\,\pi f\beta - t| + \min_{i:y_i=1} |\,\pi f\beta - t| \quad (7)$$

V. Classifier Cascade

The powerful classifier categorizes every sub-window. But we possess a lot of robust classifiers. That gets the image processing time to be longer. For improving the time of detecting along with skillful computing, a robust classifiers' cascade can be utilized. The notion is constructing tinier and

skillful classifiers built on the sub-windows in the input image. Here the powerful classifier can be classified from the most superior classifier to the worst one. The most superior classifiers which possess great features are going to refuse the negative sub-windows, noise, and rotation. Extra negative sub-windows, noise, and rotation can be removed completely via the following layers named (stages) as needing extra computing. Every stage has more than one classifier. In the project here, twenty stages of the cascade which have been yielded by Open CV and dataset are utilized, began from the more powerful classifiers and finished with lacking power ones. Thus, the sub-windows are assumed to be decreased fast after many processing stages and this yields a fine accurateness and a little time to process. In every stage, Haar-like features of the sub-window can be counted, after that those functions can be matched with the threshold for seeing whether it can be a face or not. The value of the threshold can be obtained from the powerful classifier. Besides, it is likely to alter the threshold here until gaining the face. If features met the needs of the condition of the threshold, the sub-window moves toward the following stage of the cascade for doing the same operation. If features do not treat the condition of threshed at any of the stages, the sub-window could be refused. If the sub-window passes every stage of the cascade, the sub-window can be pointed at as the face image.

5. PROPOSED SYSTEM

The suggested system designed for the paper here can be for building a real-time face recognition system which could be beneficial for the handicapped concerning door locks via utilizing software and hardware, the percentage of the system is 99.63 percent if faces are detected correctly. it ought to be worth paying for as well as its efficiency, easiness, and safety, which could be utilized for any application that deals with smart homes.

The system designing includes modules of PI camera which are going to be utilized to instant video stream, capture frames of input, and forward the frames towards the Raspberry PI. The Raspberry PI is going to perform detection and recognition for every face in the frame with the eventual output being illustrated in an instant video streaming on online appliances, the Raspberry PI can be connected to Wi-Fi. The system work can be as the following:

1) Raspberry PI camera linked to the Raspberry PI video of a live stream.
2) The Raspberry PI detected faces from captured frames, calculates face embeddings, and matches the vector output with the renowned database, and labels the face that is most matched.
3) If the face cannot be identified, an anonymous label is illustrated for the face detected.

And the components we used:

Hardware: Has Raspberry PI 3 Model B, Raspberry PI model of camera v1, Wi-Fi, and a device that supplies power. Raspberry PI can be a tiny and cheap PC that is connected to an LCD or monitor and is utilized within a mouse and a keyboard. Raspberry PI can be utilized for projects which do not need a lot of storage space of processing power.

Software: Python language has been utilized to program face recognition, Haar cascade classifier, Viola and Junes suggested an algorithm of machine learning object detecting renowned as Haar cascade, for identifying the object in videos as well as images built on the principle of the features. The function of the cascade can be trained on a huge dataset of negative and positive pictures. For face detecting, the algorithm needs positive images that had faces and negative ones that do not have faces for training the classifier, which can be utilized for extracting the form of features. All features can be a single value gained by computing the variance among the summations of the intensifiers of pixels in every territory. Because of the number of features utilized, the principle of the integral image can be applied for preventing a rise in the time of computing. It as well assists in simplifying the computing of pixels.

Adaboost can be utilized for selecting features, decreasing the complication of every classifier, and train them. After that, every feature can be applied to every training image and for each feature, the most superior threshold could be found for classifying the faces as negative or positive. Anyway, as it is not skillful and takes too much time, cascading classifiers can be utilized for obtaining the most superior features from faces via chunking them into a classifiers' stage and processing or dismissing the face territory regarding the past stages of features.

Open Source Computer Vision Library (Open CV) can be a library of machine learning along with functions of programming for instant PC vision and image processing. This library comprises a

lot of built-in packages for face recognition. It contains linear and non-linear image filtering, transforming of the geometric image, alter color spaces, smoothing images, thresholding of images, histograms, etc. Via utilizing the operation of classifier cascade, the fastness and accurateness of the system of face detection can increase just like Figure 2, which illustrates the classifier of open CV.

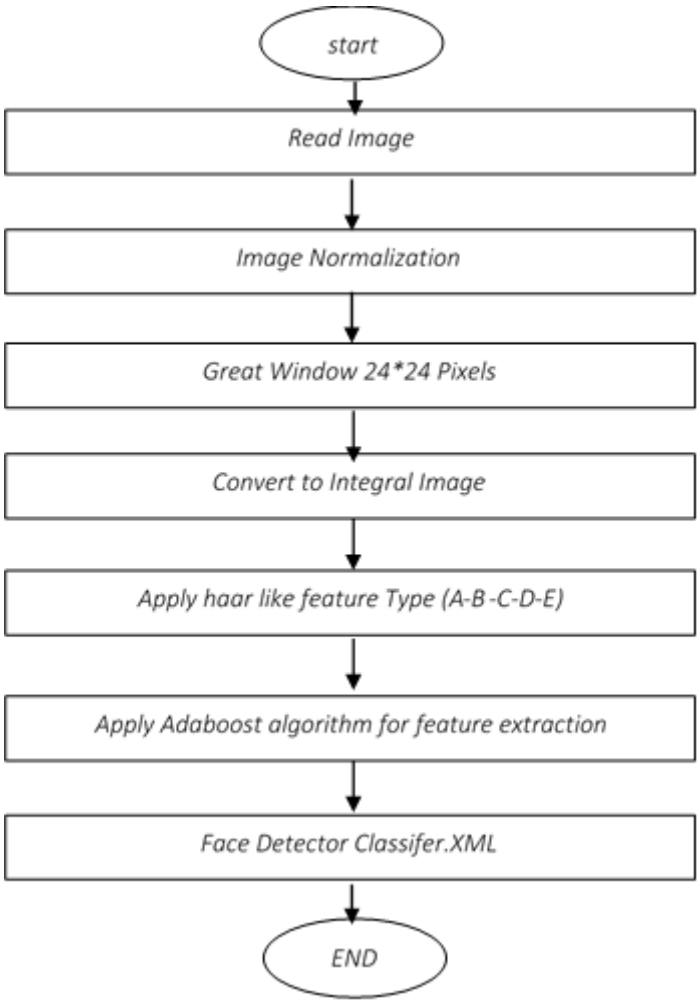

Figure 2: Flow chart the open CV classifier

6. EXPERIMENT AND RESULTS

For estimating the suggested face detection & recognition method performing, several checks have been accomplished, when the raspberry pi is opened by a command from the authorized person's mobile-only. If the face is recognized correctly then the locked door is open and reads the name of the person. and the outcomes have been as the following:

Stage 1: - The camera of the raspberry pi trained with the owner's face as Figure 3.

Figure 3: Trained with Owner's Face

Stage 2: - The person looks at the camera for identification. detecting the position of faces effectively, the following operation can be face recognition as Figure 4.

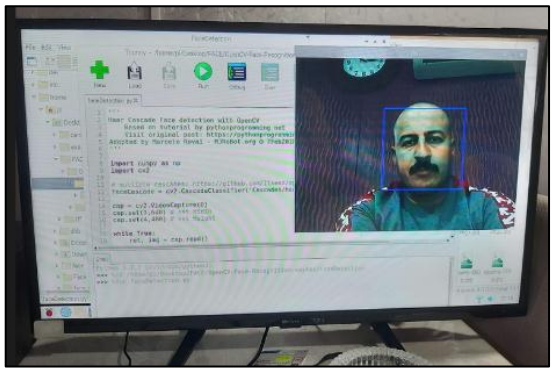

Figure 4: Face detection

Stage 3: - Throughout face the algorithm of detection and recognition, it distinguishes the individual whether he/she is an unknown person or the person who owns the place. For applying the systems of face detection as well as face recognition in every actual system concerning securing houses, the individual whose status is correct is going to be permitted to go through the door or open it for getting in. As an individual who is not identified cannot be allowed to get in

Stage 4: - If the individual has been distinguished as the person who owns the place, the door is going to open and a voice message is going to appear, otherwise go to Stage 5 as Figure 5.

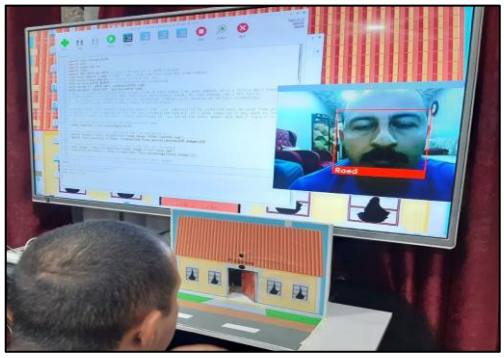

Figure 5: Face recognition

Stage 5: - If the individual has been distinguished as being an unknown person, the door is not open, and warning message will appear as Figure 6.

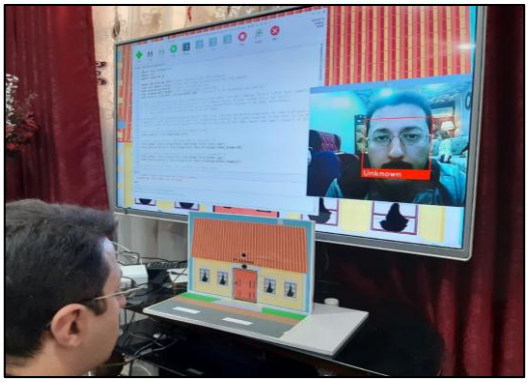

Figure 6: Stranger person, the face is not recognized.

Stage 6: - The entire system has been integrated on Raspberry Pi 3 by utilizing a camera attached to it.

The accuracy of the performance of the proposed system using the application of statistical methods has been presented. Assessment methods are a measurement to verify the operational efficiency and performance of any facial recognition system.

Table I show the result of the evaluation frames for detection and recognition of four people and each one of them makes the test four times, and the time required for identifying the case in seconds. And the system identifies them whether they wear glasses or hijab or mask or in right view face or left view face.

TABLE I: Results of the evaluation by using a camera of Raspberry pi

Person ID	Time of detected face	Time of Face with glasses	Time of Face with hijab	Time of Face With medical mask	Time of Right-view face	Time of Left –view face
P1	2.36	2.90	2.10	4.92	3.08	2.82
	2.40	2.00	2.40	6.10	2.75	3.99
	2.60	2.24	2.30	5.06	2.76	4.02
	2.66	2.69	2.90	4.91	3.73	2.60
P2	2.33	2.85	2.11	4.77	3.22	2.83
	2.43	2.22	2.44	6.56	2.45	3.90
	2.55	2.55	2.23	5.46	2.65	3.99
	2.54	2.57	2.77	4.30	3.64	2.53
P3	2.30	2.90	2.10	4.92	3.08	2.82
	2.40	2.00	2.40	6.10	2.75	3.99
	2.60	2.24	2.30	5.06	2.76	4.02
	2.66	2.69	2.90	4.91	3.73	2.60
P4	2.36	2.90	2.10	4.92	3.08	2.82
	2.40	2.00	2.40	6.10	2.75	3.99
	2.60	2.24	2.30	5.06	2.76	4.02
	2.66	2.69	2.90	4.91	3.73	2.60

Table II shows the accuracy and error rate, Precision, Recall, F1 measure, false positives (FP), false negatives (FN), and true positives (TP) cases. And the accuracy of the proposed system was very high.

TABLE II: Accuracy of nine people in the training phase

Person ID	TP	FP	FN	Precision	Recall	F1	Accuracy	Error
1	38	0	0	1.000	1.000	1.000	100%	0%
2	56	0	0	1.000	1.000	1.000	100%	0%
3	35	0	0	1.000	1.000	1.000	100%	0%
4	50	1	0	0.980	1.000	0.990	98%	2%
5	48	0	0	1.000	1.000	1.000	100%	0%
6	50	0	0	1.000	1.000	1.000	100%	0%
7	30	0	0	1.000	1.000	1.000	100%	0%
8	49	0	0	1.000	1.000	1.000	100%	0%
9	47	0	0	1.000	1.000	1.000	100%	0%
Average				99.8%	100.0%	99.9%	99.8%	0.2%

7. CONCLUSIONS

The system could recognize every face in the video stream in real-time, so their labeling was performed rightly. Via getting Raspberry Pi embedded with every method of image processing, it is possible to illustrate the position via opening the LED of the area of variation where it is possible to locate faces.

The designing of the system of recognizing faces utilizing raspberry pi can create the tinier, lighter as well as with consuming less electricity, so it can be more comforting than the system of face-recognizing based on a face. To make the system alive and protect the door from being open by hackers, especially by using the picture of an authorized person, we make the raspberry pi turn off and cannot turn on only by a command from the authorized person's mobile.

If any person steals the authorized person's mobile and unlocks it, and gets a picture of that person, only then the door can be unlocked. and we are about to deal with this case.

The system suggested can be non-expensive, configured plainly, as well as simple in a reasonable way. It can specifically assist the old and disabled persons living by themselves in their homes. The collected data for the status of devices at a certain time was improved.

In the future, the android app ought to show back up in getting more doors, windows, and basic home electronic devices in hand. A report that is auto-triggered for the try to steal can send towards the closest police station with the local address. This notion is to be taken into account for making the suggested system more superior.

REFERENCES

[1] Mtshali, P. and Khubisa, F., " A Smart Home Appliance Control System for Physically Disabled People", Information Communications Technology and Society Conference (ICTAS) (pp. 1-5) IEEE, 2019.

[2] Hussein, N.A. and Al Mansoori, I., "Smart Door System for Home Security Using Raspberry pi3", International Conference on Computer and Applications (ICCA) (pp. 395-399) IEEE, 2017.

[3] Abdulhamid, M., Odondi, O. and AL-Rawi, M., "Computer Vision Based on Raspberry Pi System", Applied Computer Science Journal, 2020 | Vol. 16, no 4 | 85—102.

[4] Abd Ali, A., Ali, A.H. and Al-Askery, A.J., "Design and Implementation of Smart E-Health System Based on Cloud Computing to Monitor the Vital Signs in Real-Time and Measurements Validation", IOP Conf. Ser.: Mater. Sci. Eng. 745 012097, 2020.

[5] Mohammed, M.N., Desyansah, S.F., Al-Zubaidi, S. and Yusuf, E., "An internet of things-based smart homes and healthcare monitoring and management system", Journal of Physics: Conference Series (Vol. 1450, p. 012079), 2020.

[6] Hana'a M. Salman," Design of a fuzzy system for autonomous mobile robot movement control", A dissertation submitted to the Department of Computer Science of the University of Technology, 2006 .

[7] Nikisins, O., Fuksis, R., Kadikis, A. and Greitans, M., Face recognition system on Raspberry Pi. Institute of Electronics and Computer Science, 14 Dzerbenes Street, Riga, LV 1006, Latvia, 2015.

[8] Suja, P. and Tripathi, S., Real-time emotion recognition from facial images using Raspberry Pi II. 3rd International Conference on Signal Processing and Integrated Networks (SPIN) (pp. 666-670). IEEE, 2016.

[9] Lu, J., Fu, X. and Zhang, T, August. A smart system for face detection with spatial correlation improvement in IoT environment. In 2017 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computed, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI) (pp. 1-4). IEEE, 2017.

[10] Kak, S.F. and Mustafa, F.M., April. Smart Home Management System Based on Face Recognition Index in Real-time, International Conference on Advanced Science and Engineering (ICOASE) (pp. 40-45). IEEE, 2019.

[11] Munir, A., Ehsan, S.K., Raza, S.M. and Mudassir, M., " Face and Speech Recognition Based Smart Home", In 2019 International Conference on Engineering and Emerging Technologies (ICEET) (pp. 1-5). IEEE,2019.

[12] Jones, M. and Viola, P. , "Rapid Object Detection using a Boosted Cascade of Simple Features. Computer Vision and Pattern Recognition", IEEE Computer Society Conference, 1(1), pp: 511-518, 2001.

[13] Paul V., Michael J. Jones., "Robust Real-Time Face Detection", International Journal of Computer Vision, 57(2): 137–154, 2004.