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IoT and object identification enabled Smart Home Security System.

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Abstract: With the help of Internet of Things (IoT), we can setup our own smart home with high security and we can have decided by Smartphone and web application that will enter in our smart home. For identifying genuine object used object identification techniques in this application and we can easily be monitoring our home from anywhere and anytime, it is very simple through this application. But traditional or regular home security systems are outdated and breakable. In this case, can be more chances of robbery and utilized this approach for home security it's costly. To overcome this problem, we proposed our security system for home that is based on IoT and object identification technique. In our proposed home security system used ESP32 camera that connect with raspberry pi follows by PIR sensors and digital door lock. The enabled ESP32 camera of our proposed system is captured real-time person image by IoT and object identification techniques and if the capture images followed by object identification algorithm confirm the entered living thing is a person and if door is locked. System notifies the owner about the stranger entering in the house by SMS and Emails. And also send the person image on the IoT base application installed in the owner mobile phone. Therefore, we can fulfil the home security requirements by this application. This proposed system based on battery powered and if power is fails then owner can track the system through raspberry pie using internet by own smart phone. This application provides the facility to owner can add new person's images into the repository by own smart phone.

Keywords: IoT, Raspberry pi, smart phone, Object identification algorithm, PIR sensors, ESP32 camera.

Introduction: Need of home security to safe valuable assets and family from antisocial elements and thief. There are representing some valuable statistics for United States according litleture, in US 5 every second happen, 15 burglaries in minute, 300 an hour and approximately 6700 a day. Some statistics shown the nature of burglaries 88% are residential, 78% crime related to property crimes and 36% robbery crimes which is committed by gun. The thief crime is growing faster in United States, United Kingdom and Canada [13].

Overcome home security related problems by our proposed system, which is provide the efficient solution in respect to cost and service performance for home security. It is developed by using IoT and face recognition. The work of IoT in our proposed system is enabling the sensors and triggers the system using sensors. This system calculating position and measure distance of person which are stand in front of enable camera and gap between person and camera should be less than 240 cm, if person covered face then not able to access. We used object identification algorithm in proposed system that have accuracy more than 90% to detecting the real-time images or objects [2][8][9]. If we applicable our proposed system to any home so can be check it working procedure such as person or any objects stand in front of camera and those person or object identified then model will compare from store images or objects in database. If it is matched the door will opened otherwise remain lock.

Literature Review:

As per availability of different technologies such as One Time Password based system, Radio Frequency Identification card-based system, Cryptography based system, and Biometric based system and so on. This system is applicable for distinct field based on uses of technologies with security approach but not possible to provide full security in system [10]. Moreover, Number of authors already talks about these issues and also proposed some techniques, which are mostly face recognition-based approach it's really good for removing home security problems.

For home security, we can use the face detection and recognition related system for recognized the captured images. When processing the captured images using MYRIO 1900, it is a controller that holds in images for detection. But disadvantage of MYRIO is more costly than raspberry pi [1].The system explained here how works local binary pattern does in face recognition system with support vector machine but in term of power fails nothing worked [2].When we used face recognition approach with IoT for smart home security purpose, its working quite well for door lock and unlock but there is some limitations of wifi, in which case homeowner cannot accessed remotely to applicable system [3].

Working algorithm:

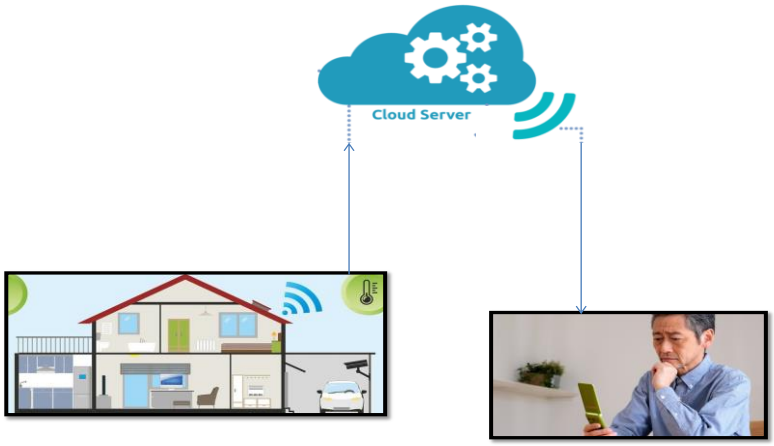

Fig. 1 User and smart home connectivity via cloud server

PIR Sensor: The PIR Sensor made up of two slots and each slot is made of special material which is sensitive to IR. A lens is used to improve its performance. These two slots are absorbing the same amount of radiation from the outside like room wall, furniture and electronic equipment etc and remain idle until and a worm body like human and animal (cat, dog, mice). When a worm body passes the sensor a pulse is generated which can be sensed with the help of microcontroller board like raspberry pi or Arduino.

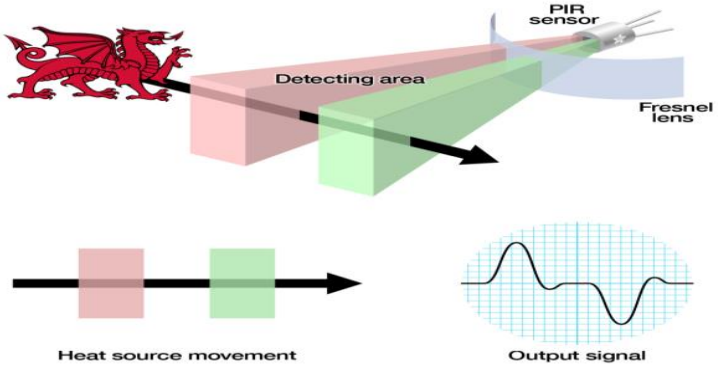

Fig. 2 Sensitivity of PIR sensor

Object Identification:

According to the system algorithm it is essential to identify the worm body sense by PIR Sensor whether it is Cat, Dog and human. To accomplish this job an object identification system is used to identify the worm body. Object identification system work in five steps, which are collecting as much as image of object, create database, pre-processing of images, train model and test model.

First Step: Capture 100 images of each Dog, Cat and human with different position and variety and make folder each category.

Second Step: Crate Database of these folders.

Third Step: Pre-processing of images by changes the pixel size of the image, brightness, colour, intensity and angle.

Forth Step: Train Convolutional Neural Network (CNN) Model by defining the number of neuron in Hidden layer, number of hidden layer and activation function.

Fifth Step: Test the CNN Model by capturing new images of objects.

Entire process of the proposed algorithm:

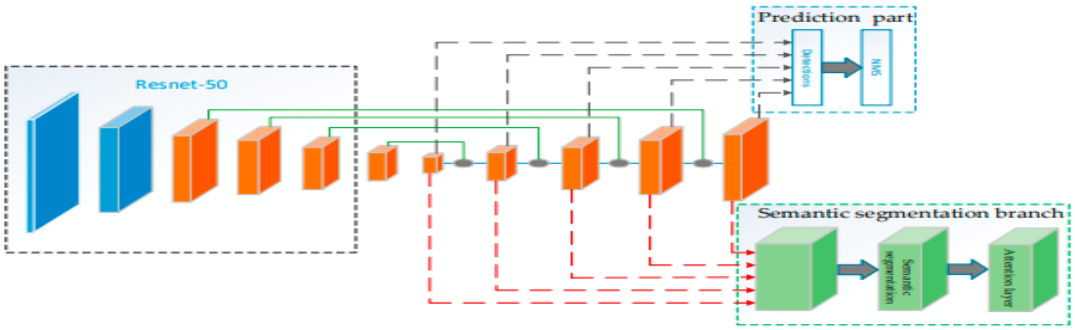

Fig. 3 Work flow of proposed algorithm

Semantic segmentation branch: Loss function: $L_{seg}(X, C; \theta_{seg}) = -\frac{1}{|B|.H.W} W_{seg} \sum_{k\epsilon|C|} \sum_{i\epsilon P} \log[Softmax(a_k^i)]$ (1)

|B| = Image batch size

H = Height (No. of Pixels)

W = Weight (No. of Pixels)

P = Whole images set of pixels

$a_{k=\ Mark\ Score}^{i}$

i = Pixel images

k = Images Categories

C = No. of total Categories

θ_{seg} = Semantic segmentation parameters

W_{seg} = Semantic segmentation weight and offset

Loss function: prediction part $L(x, c, l, g; \theta_{pre}) = \frac{1}{N} W_{pre} \left(L_{conf}(x, c; \theta_{pre}) + \alpha L_{loc}(x, l, g; \theta_{pre})\right)$ (2)

N = No. of matched detection box

x, y = Box coordinates (height, width)

Positioning error:

$L_{loc}(x, l, g; \theta_{pre}) = \sum_{i,j,u\epsilon\{x,y,w,h\}} x_{ij}^{k}\ smooth_{L1}(l_i^u - g_j^u)$ (3)

$x_{ij}^{k} = Detection\ algorithm$

i, j = Detection box and real box

$\theta_{pre} = Pridection\ parameters$

$$smooth_{L1}(x) = \begin{cases} 0.5x^2 & if\ |x| < 1, \\ |x| - 0.5 & other \end{cases} \quad (4)$$

Classification loss

$$L_{conf}(x, c; \theta_{pre}) = -\sum_{i,j} x_{ij}^{k} \log\left(c_i^{\hat{k}}\right) - \sum_i log\left(c_i^{\hat{k}}\right) \quad (5)$$

$$\left(c_i^{\hat{k}}\right) = Predected\ probability$$

Loss function of the prediction module and the semantic segmentation branch

$$L_{loss} = L(x, c, l, g; \theta_{pre}) + L_{seg}(X, C; \theta_{seg}) \quad (6)$$

Algorithm:

I: Trained the all images dataset and building the model

II: Used gradient function and reduce the loss by Neural Network

III: Select the object by highest accuracy using model with validation set

IV: Through shallow feature, we can predict object and also achieve deep features

V: Capture the full semantic information of objects by semantic segmentation mechanism

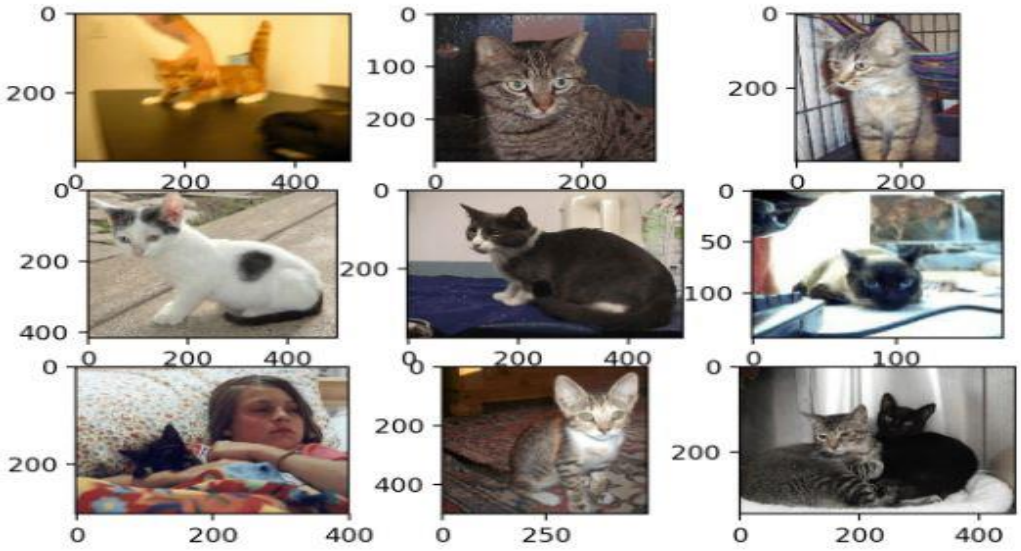

Fig. 4 Representation of labelled images

Fig. 5 CNN Object detection model

Deep learning: Object identification system use deep learning method using CNN technique. A CNN Architecture as shown in below figure is used to train the model. The architecture used is the deep learning is AlexNet which consist of eight layers. This architecture builds with layers of Convolution, Maxpooling, Flatten, Dense, Activation and Dropout. Then define the different activation function and train the architecture and check the accuracy the model. The entire CNN model is implemented in python language and keras library. The training involves 100 epochs at first and repeated with 20 epochs after testing. When training is completed system is tested with 10 images of each Dog, Cat and human. (Fig 6)

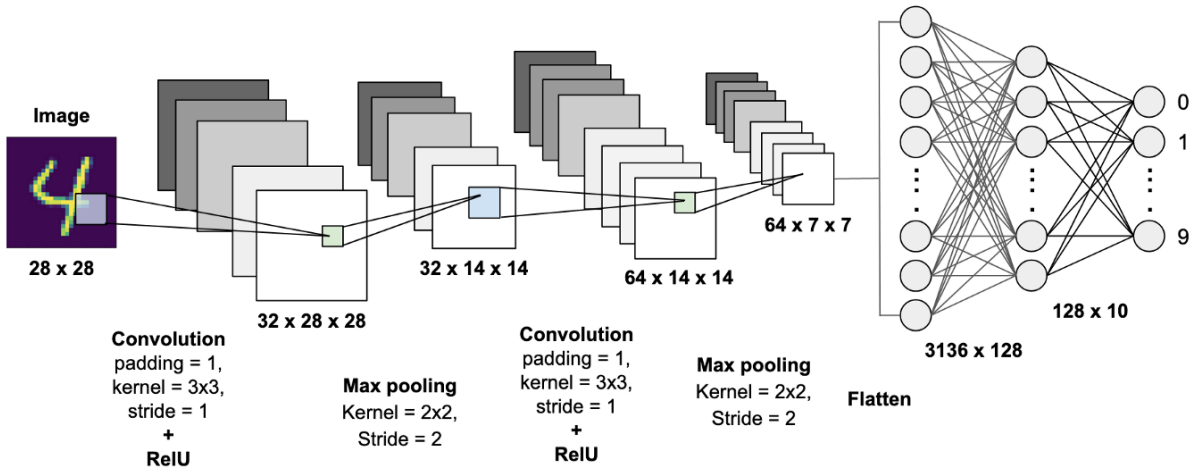

Fig. 6 Network Architecture

Trained model identifies each object and labelled in the image whether it is human, Dog and Cat as shown in the below figure.

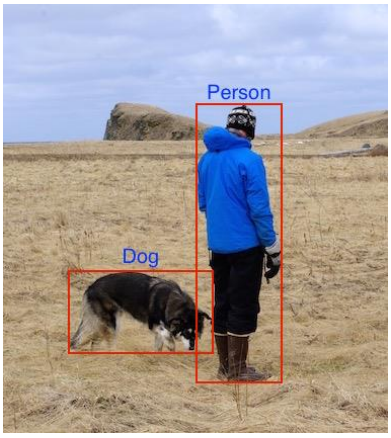

Fig. 7 Identify the actual objects

Methodology: In this Project IoT and Image processing both technologies are used to develop the home security system which can protect the home from any stranger in absence of any home users. In this project PIR Sensor, ESP32 Camera and raspberry pi board are used to develop the prototype of the system. PIR sensor and ESP32 camera are installed at every entrance of the house. The working principle of the project is, when all users are out of the home and home is locked. If any stranger living thing get into the house PIR sensor and ESP32 camera and raspberry pi and detect that object using object identification algorithm and send API to the user and alarm him about the presence of strange person. Then stranger can view the stranger using live Camera Recording and can take respective action. (Fig 8)

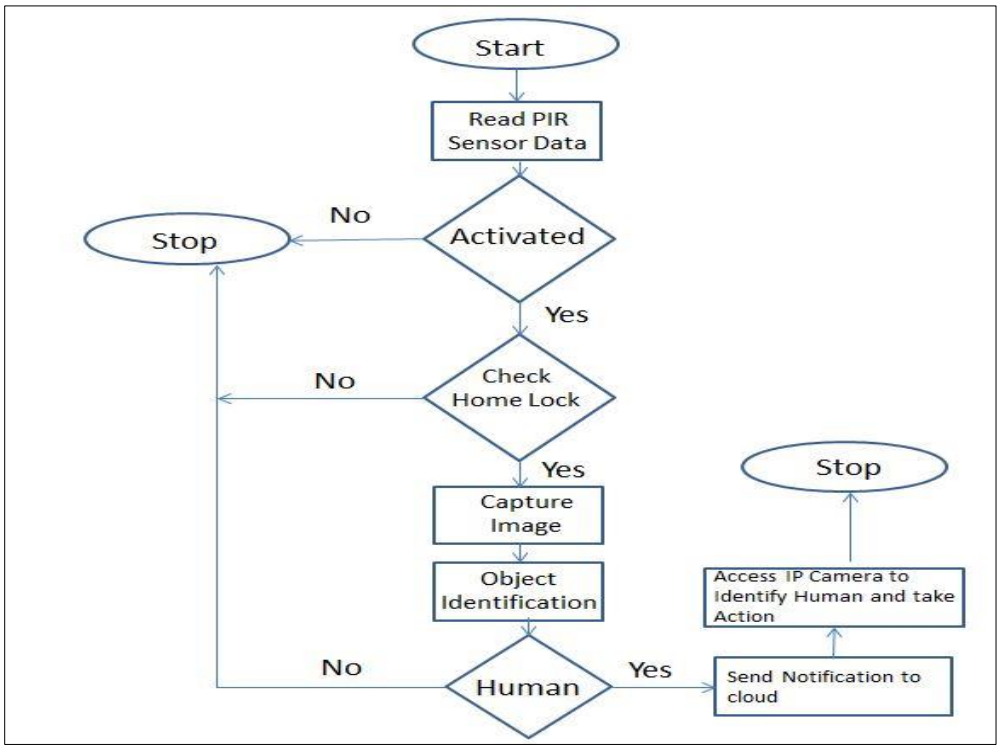

Fig. 8 Architecture of proposed model

Detail Description:

In this project following whole system is working on the following algorithm:

PIR sensor and ESP32 Camera data are sent to blynk cloud with the help of Wi-Fi which is open source. Blynk app is installed at every user of the house which gets the data from the cloud. When a strange living thing get into the house, System is continuously check the data of PIR sensor and if sensor is activated algorithm check the position of door lock if door is unlock system does not do any activity and if door is locked capture the image using ESP32 camera and start identify the object using object identification algorithm and if object is not human system does not do any activity and if abject is human or any person system send API to the cloud and notify the user about security threat in the house. User opens the blynk app where he can see the person in the house and can take required action.(Fig 9)

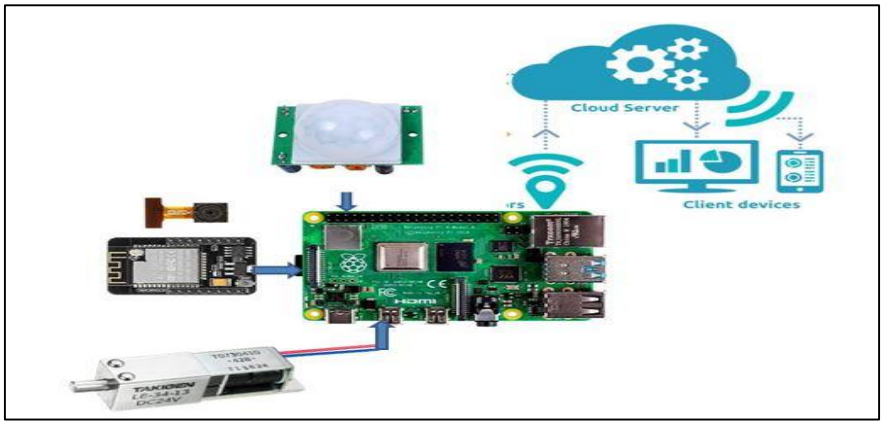

Fig. 9 Work Flow of designed model

Comparison:

1. IoT based facial recognition door access control home security system using raspberry pi:
In this article author use the face recognition system to identify that person entering in the house is member of the house or not. But in this article, system does not provide security in the case of a stranger enter in house except the main door.

2. Smart Home Security using IoT and Face Recognition
In this paper author use the PIR sensor and face recognition system to identify the person weather the person belong to the family or not but in the article, system does not provide security in the case of a stranger enter in house except the main door.

RESULT AND ANALYSIS:

For testing the project dog, cat and person are put one by one in front of the camera. As we already discuss that system algorithm will activate only if a person is found in the camera. Therefore, when a person come in front of the camera system send data to the cloud and image of the person is found in the blynk app. The tests are done with ten different cat, dog and human and check the object identification ability if the system. System shows the 89% accuracy in the bright light. System shows the poor performance of 55% in dim light.

The IoT and image processing based home security system is shown in below figure. Image of the test with a person is also shown below.

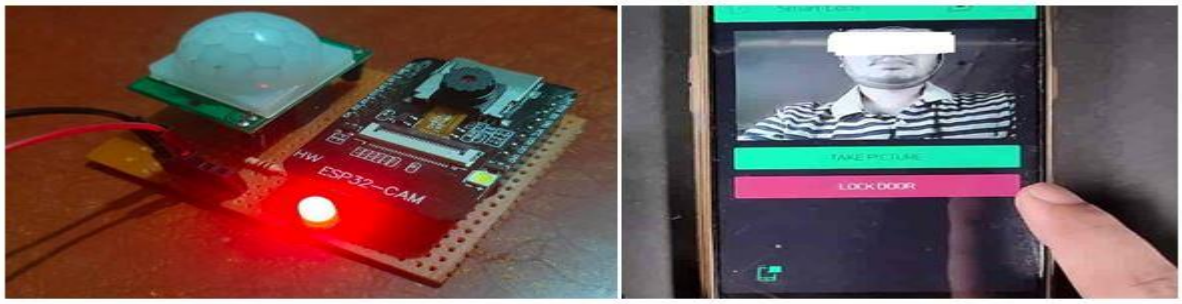

Fig. 10 Developed smart home security application

Conclusion and Future Work:

In this research we designed one of optimal module which is providing highly home security in very less cost because of developing the system using IoT and object identification. Through this system we can identified unknown person or objects and give the warning and forward the details to homeowner via SMS, Emails and IoT Mobile Application. These techniques are representing more growing nature for smart home security it is combined with IoT and Object identification algorithm. Future scopes of the system will have used more relevant and accurate face recognition algorithm and economical sensors for updates the system's precision. For example, video streaming, remote control, digital assistance and surveillance system will be applicable in home.

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