Smart Home Security System using Emotion Detection

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Abstract - *The propagation of Internet of Things (IoT) devices, which is used to collect sensitive and confidential information on a regular basis is on a surge. However many of these devices are unable to provide adequate security. Such flaws are needed to be addressed to a variety of products. One such device is a home security camera which can be used to lock or unlock the main door whenever a person enters. This paper proposes on enhancing the security of such devices, by introducing the emotion detection which can be used to analyse the behaviour of an individual. Based on this mechanism, we can stop the intruders, who vandalize or steal the valuables, from entering into the premises. The effectiveness of the proposed mechanism will help in reducing the theft that is happening in a locality. The accuracy of this system can go from 92 to 95 percent.*

Key Words: Smart Home Security, Machine Learning, Deep Learning, Classification, OpenCV, Haarcascades, Python.

1. INTRODUCTION

The demand of IoT devices has augmented significantly. This is due to the fact that the devices are able to connect easily and one can retrieve information and share it with other technologies. Some of them even have the ability to make decisions and invoke actions, thereby providing seamless user experience. There are a plethora of applications where IoT is used such as industries, medical field and in government infrastructures to name a few. Various governments are taking an effort in upbringing of IoT such as introduction of smart vehicles, home automation, smart medical healthcare systems and many more. Also the organizations along with the government are tirelessly working to provide better technologies to make it stand out from rest of the countries. Nevertheless, these technologies have helped humans relying on the machines, but then there is always some void in the system that has made the industries and organization lose millions of money. One of them is the security risk.

This paper proposes on how one can enhance security of a door lock system by facial recognition. A simple door lock is used by introducing a solenoid motor and a camera, which is integrated to Arduino board, where the software is loaded to control the door lock. However this system is flawed as the system detects the known person and remaining persons are considered as intruders. So to avoid that certain measures are taken so that the security aspect of home surveillance system is amplified.

2. LITERATURE SURVEY

The paper[1] proposed on the idea of how face recognition has become an integral part in real time application [1]. It mentions the role of OpenCV in detecting the face with the help of haarcascades; a tool used for detecting various parts of a body. It also explains how one can use OpenCV tool to detect faces. OpenCV uses haarcascades which can be used for detecting faces. However the use of haarcascades in deep learning isn't acknowledged.

While ,the paper[2] proposed on an idea of a door locking system which uses the radio frequency identification (RFID) for user authentication, an LCD panel and a DC motor for opening and closing the door [2].It uses ZigBee, a module which is embedded in the digital lock and uses smart card. The drawback that was identified in this system was that RFID tags could be easily accessed by anyone, by adjusting the radio frequency and getting code . Sometimes these RFID could also contain confidential information and getting these information could lead to violation of privacy.

The paper[3] gave a preview on how door locking system can be introduced by using face recognition instead of key identification card or password. It makes use of OpenCV and rationalizes on the usage by explaining that it makes use of Eigen vectors in the face which helps in reducing the scale factor of faces in an image. However, face recognition, when used solely, makes this system deficient.

The paper[4] proposes on the idea of two stage door locking mechanism; one using fingerprint and other using radio frequency identification (RFID) or a Bluetooth master key [4]. The paper claims that it can protect from the unauthorized access. However, these biometrics can be easily extracted by using tape and as mentioned earlier, information can be tapped easily with the help of RFID, thereby making this system vulnerable

3. PROPOSED SYSTEM

In order to overcome such flaws a behavioral system is introduced. This involves detection of emotion of an individual. This process involves detecting the emotion of an individual by creating the dataset of an individual's emotion using deep learning. Thousands of dataset are created based on the emotion which includes the following – happy, sad, surprise, angry, neutral and scared. Based on these behavior the system will grant access to the house.

This system will work mostly for unknown faces. In case of a known face the face recognition algorithm using OpenCV will work. The video recorder will first check the behavior of an individual. It checks whether an individual is happy or not. If he is happy then he is granted access to the house and if not then based on the other emotions various decision takes place. In case of a neutral expression, an image is captured and is sent to the administrator of the house (owner by default) via an e-mail. Then the administrator takes decision whether or not to grant access. In case if the person shows any sign of anger then a notification is sent to the local police station and the admin is alerted immediately. In the next stage, the person enters the compound and then the face recognition takes place. In case of known person he door opens and in case of unknown person the door remains locked.

The algorithm works based on deep learning which involves introduction of behavioral datasets and implementation of VGG network architecture which is an integral part in deep neural networks.

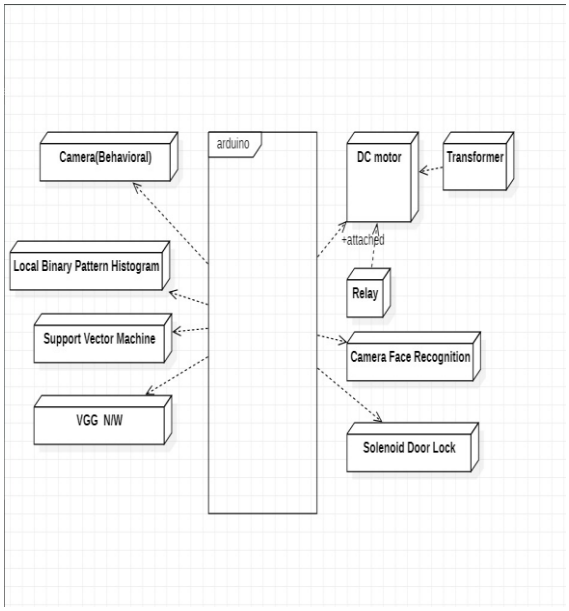

Fig -1: Structure of a door lock

For this proposed system to work, the device uses various hardware and software which could be seen in the diagram given below:

The hardware component consists of a solenoid lock which is coupled to a DC motor. The DC motor, is in turn coupled with a step-down transformer to reduce the load upon the relay. The motor is also coupled with relay that acts as a switch[5]. The relay has binary values 0 and 1. If the face is recognized then it gets the value as 1 and instructs to open the door via Arduino Uno, else it enters zero and locks the door. All these are attached to Arduino Uno board. This board is preferred over others, as to make the device cost-efficient. To this board cameras are attached, one is for facial recognition and other for behavioral analysis. The software that is used for both facial recognition and behavioral analysis is Python 3.0+ (i.e. Version 3 or higher) while to send a multimedia messages Twilio, a communication API, is used[6].

There are various algorithms and used for this project. Some of them are –

3.1 Haar Cascades

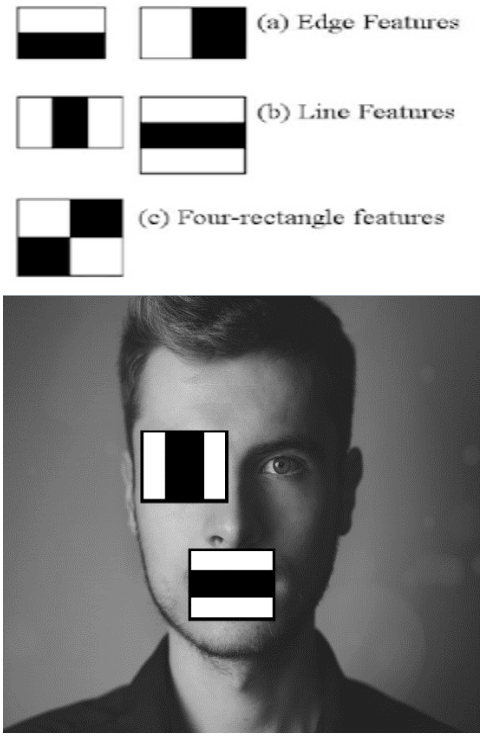

Fig -2: Haar Cascade Features

The haar cascade algorithm is primarily used for face-detection. It fundamentally makes use of image subtraction of each pixels. For this the algorithm takes two parts of an

image; one being the positive part which includes the features of a face and negative part, that is the non-facial features. Each of these features are subtracted to obtain a unique value that is by subtracting the sum of white rectangle to the sum of black rectangles. Sometimes there are flaws while doing this. For example, one image may have region of eyes darker in comparison to the region surrounding nose and cheeks; while on the other hand, another image might have section of eyes darker in comparison to the bridge of nose [7]. To determine which would be the best feature, a feature called as AdaBoost is used [7,9] . As a machine learning algorithm, AdaBoost has obtained significant success in classifying the data and detecting objects [8,9] .Often while finding out the values of each pixels, there could be minor errors or misclassification. The adaboost is used to determine which of these features have minimum error rate. The adaboost repeatedly calculates the weight of each pixel by subtraction of pixels until the one with best fit is obtained. Finally, Cascade classifier is implemented. The role of classifier is to find the images and classify it as found or not. In case of found, it classifies as positive, and negative for not found[9].

3.2 VGG Network Architecture

Visual Geometry Group (VGG) is a CNN architecture which has a wide variety of applications. Before inception of VGG, AlexNet was used to identify certain facial features. However, it provided lower accuracy and thus it did not help in identifying the emotions, because AlexNet has 8 weights which includes 5 convolutional layers and 3fully-connected layers. Whereas VGG is much deeper in comparison and has 21 layers (13 convolutional layers,5 max pooling layers and 3 dense layers) with 16 weighted layers [10]. This gives us an accuracy of 92.7%. To use this model a dataset is created with a user's image [11]. Additionally CNN relies on multiple convolutional and sub sampling layers so that dimension reduction is easier [11]. There are around thousand images collected and each of them are segregated based on the emotions. It has 7.5% error on validation set and 7.4% on test set [12].

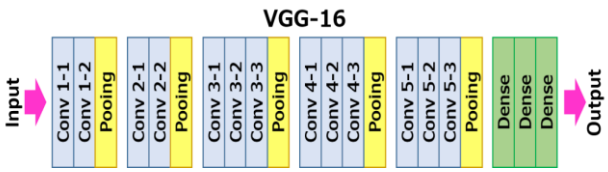

Fig -3: VGG Layer Definition

To achieve this, Keras is used . It is a high-level neural networking API, written in Python and is having a potential to run on TensorFlow, CNTK, or Theano [13]. This is used in different deep learning models like Convolutional Neural Networks (CNN), Deep Neural Networks (DNN) to name a few [14]. This makes the implementation of images faster and easier. Then the images are segregated based on emotions, and further, into training and testing datasets. To find out what are the emotions a list is created. Further, the video recorder captures the image and then finds out the emotion based on live feed. To obtain the result playsound module is used. The facial features are also recognized using the width and height of the face.

3.3 Local Binary Pattern Histogram

The LBP is used for finding texture of an image. It is a simple operator which labels the pixels of an image by segmentation of neighboring pixels and gives the result in the form of binary number [15]. It is popular because of the computational simplicity it offers. This algorithm is basically used for feature extraction[16]. It basically forms labels for the image pixels by segmentation of 3x3 neighborhood of each pixel with its center value and finally considers the result in form of binary number. The histogram of this can be used for obtaining the features of a face. It is done by following these steps - 1.For every pixel (a, b) of an image, we first find *P* neighbouring pixels at radius *R* [17]. 2. Then the intensity difference of the current pixel (a,b) with the *P* neighbouring pixels is calculated and then kept [17].3.Then the image is segmented by taking intensity difference, such that the negative values are assigned as 0 and the positive values are assigned as 1, after which we get a bit vector [17].4. Then the *P*-bit vectors is converted to a decimal value and the intensity value at (a,b) is replaced with the decimal value [17]. Here P denotes the number of pixels and r is the radius surrounding the pixels.

3.4 Support Vector Machines (SVM)

It is a supervised machine learning algorithm that is used to classify two group [18]. In the case of face detection we classify the faces of family members present in the house. The SVM is used to explicitly capture the dissimilarities between two facial images [19].It is also used to find dissimilarities between the dissimilarities between two people. It ideally gets the data and then plot it on a graph and then it finds the best fit by setting up a hyperplane[20].

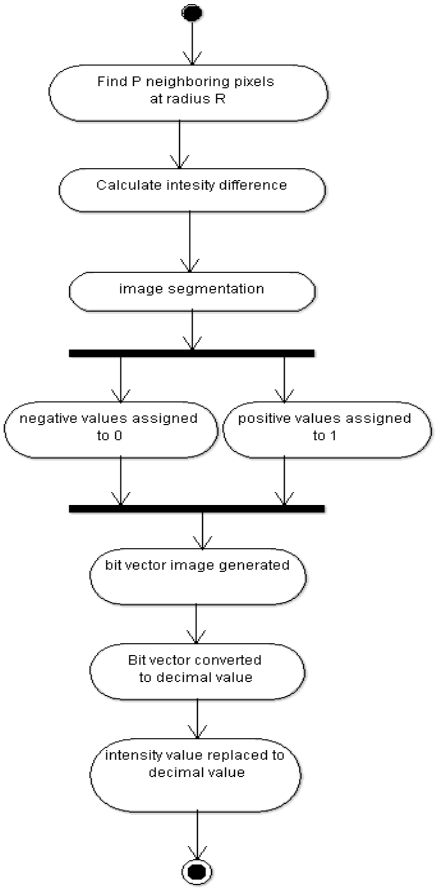

Fig -4 : Flowchart of Local Binary Pattern Histogram

Following are the ways by which the algorithm works: First it collects the datasets of the family members. Then it is sorted into testing and training dataset. Then the SVM machine learning model is applied along with local binary pattern histogram to train them. For emotion detection we use a predefined dataset which has various emotions and is implemented using VGG network architecture. Now the working takes place in this manner: When a person tries to enter into the house, the emotion is first checked. If the person shows signs of happiness or neutral, then the face recognition algorithm starts running. If the machine is able to recognize the person then the relay turns to 1 and the door unlocks. If not then the relay turns to 0 and the door gets locked and a multimedia message is sent to the user; after which the user takes particular action.

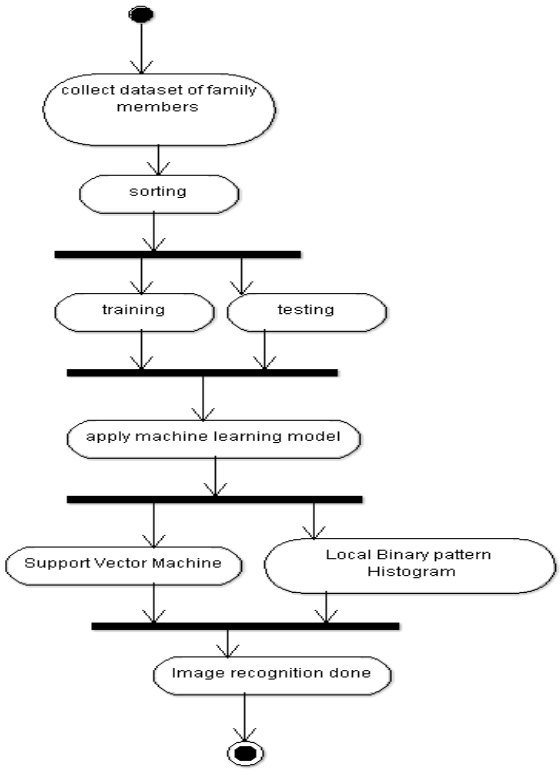

Fig -5: Working of image recognition

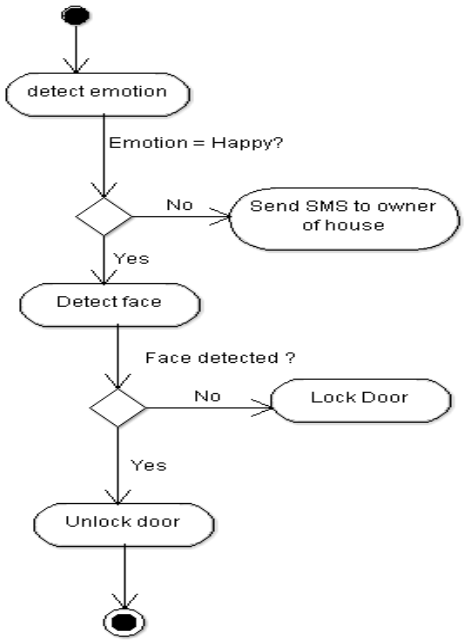

Fig -6: Mechanism of door locking system

4. OUTPUT AND RESULT

Fig -7: (a) and (b). Working of Behavioral Model

Whenever a person stands in front of behavioral camera, it recognizes the emotion and based on that the next stage i.e. face recognition takes place. Before the face recognition starts working, first the dataset is created. The machine starts capturing images; the moment when the box, which is surrounding the face, turns red. After collecting the dataset it is trained, then it shows the desired output.

Fig 8: Output of the face recognition

Finally the facial recognition is done and the person is granted access. In case of an unknown person a multimedia message(MMS) is sent to the owner of the house.

6. CONCLUSION

In this paper, we were able to address the flaws that were presenting the existing system. The accuracy that were obtained were of 95%. In addition to the experimental results, this paper can provide support on how behavior can further be used in other fields of security. Moreover this can also help in reducing the burglary not just in houses but also in various other places where robbery takes place.

7. FUTURE SCOPE

From this small implementation one can apply this to various places where biometric systems are used such as, places where legal documents are kept i.e. archives[21], where the secretary, or the client of an organization could be granted access based on behavior, or a new faculty of an institution who wishes to enter into the Head of Department's room, also protecting the safe from unauthorized access and many more.

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