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IoT Based Theft Detection System Using Machine Learning Algorithm

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Abstract. In the last few years, security plays a predominant role in human life. At this time, the cost is the greatest common factor. The traditional security systems trigger alarms when a security breach is detected. The breach is continuously monitored and recorded by the security personnel. In these methods, the camera is which occupies more storage space. The project aims to develop an IoT-based theft detection system using machine learning which detects the presence of humans only. The PIR Motion detection sensor detects the moment of the object and identifies it as a human using a Machine Learning algorithm. After the presence of the person is detected, the captured image or video is sent along with the alert message/voice call. The data is stored in the cloud for future reference.

Keywords: Machine learning, security breach, PIR Motion detection sensor.

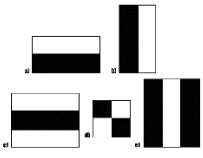
1. Introduction

In this modern era, there has been a revolutionary change in the standards of living of the people and their lifestyle maintaining expensive gadgets and goods, vehicles, and other appliances making lives easier. This is paving a way for intruders to keep an eye on us. Alongside the improvements in technology, there has been an alarming rise in thefts/ robberies creating concerns for security at houses, offices, and other public places. This has initiated a great demand for security/ surveillance systems and has become an integral part (or must-have feature) of almost all new high-rise ventures being developed by popular companies.

Internet of Things (IoT) technology aims to propose the plug and play feature thereby enabling the end-user to relish ease in its operation, access control, and configurability in a remote location. It is exhibiting its ubiquitous presence in numerous popular use-cases like AR (augmented reality), HD video streaming, autonomous vehicles, smart cities, health care, etc demanding higher data rates and bandwidth, increased capacity, and minimal latency with high throughput. In the ocean of imminent concepts, IoT has revolutionized the world with its seamless connectivity among heterogeneous networks (HetNets). Similarly, it has been playing a key role in the development of advanced and connected security systems enabling a wide group of people to live jitter-free even if they are away from their property for way long period.

1.1. HaarCascade

Haar Cascading is a deep learning method that involves building a classifier from a huge set of labeled pictures. Paul Viola and Michael Jones are the ones who forwarded the algorithm. The decision trees used for object detection are Haar feature-based cascade classifiers. This classifier employs a classification algorithm in which a cascade operation is infused from the existing pictures to discover items in new pictures. The detection of faces and facial expressions in pictures is also successful. The exercise is accomplished by supplying the classifier with positive and negative images. The properties would then be extracted from the picture. Every feature is an independent value, which is obtained by subtracting the total number of pixels in a chosen white rectangle from that of the black rectangle. It can detect the faces of various individuals in diverse environments. This variable size Haar-like feature can be calculated in constant time because of elemental pictures.



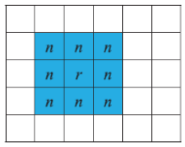


Fig. 1. Haar Cascade Classifier. Fig. 2. Representation of 3X3 macro-block in a given picture.

1.2.Local Binary Pattern Histogram [LBPH]

LBPH is an outstanding feature for the classification of a set of textures like faces. It demands four specific parameters to process a picture, known as the radius (r), neighbors (n), and X & Y-axis. The highlighted region in figure 2 represents a 3X3 macroblock. The algorithm to implement LBPH is as follows:

Binary values obtained from the comparison of each pixel with its 8 neighboring pixels are achieved by following the mathematical expression given in equation 1.

$$LBP = \sum_{P=0}^{N-1} K(I_P - I_C)2^P \qquad (1)$$

Matched images find by comparing two histograms and return the image with the closest histogram. We can use a different path to compare the histograms (calculate the distance between two histograms), for example Euclidean distance, chi-square, absolute value, etc.

$$D = [\sum_{i=1}^{n}(hist1i - hist2i)^2]^{\frac{1}{2}} \qquad (2)$$

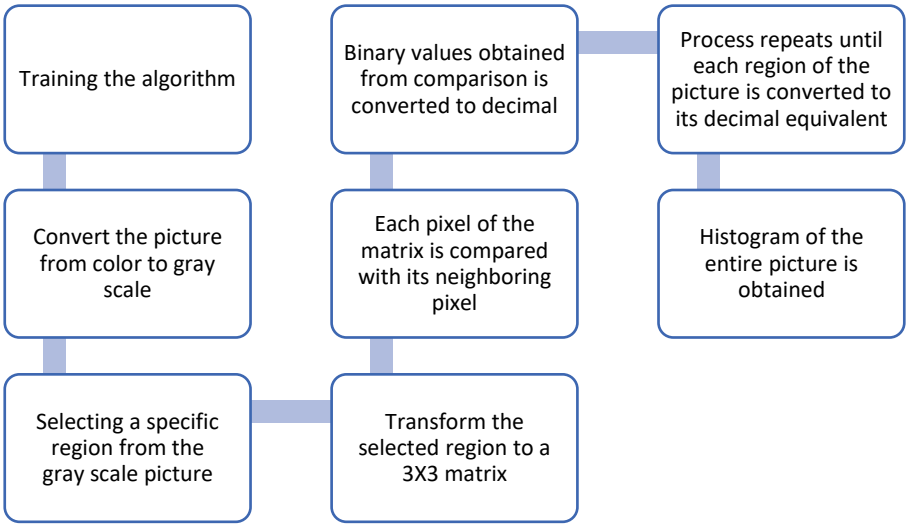


Fig. 3. Block diagram representing the functionality of LBPH.

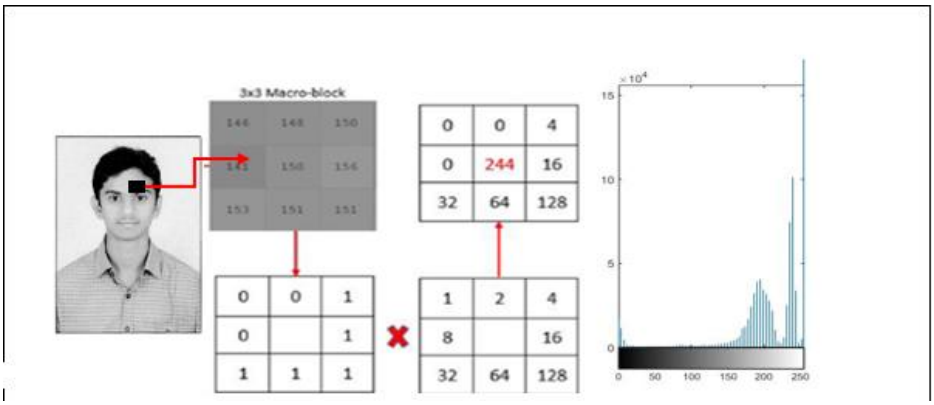


Fig. 4. Conversion from binary values obtained by comparison to their decimal equivalents and Histogram of the patch.

1.3.PRINCIPLE COMPONENT ANALYSIS [PCA]

PCA is a typical method for identifying statistical designs, reducing dimensionality, and feature extraction. It is used to save the pattern's critical information while discarding irrelevant details. Given a database with a large number of pictures, a face recognition system must exemplify that the image being examined belongs to an

individual in the database. Principal components, often known as Eigen's faces, are a set of distinctive features that make up a face. The principal component analysis is used to extract such features from the original image. A 1-d vector is used to represent the aesthetic of a face image of size.

The simplicity, speed, and insensitivity to small or gradual changes on the face make the distinction from other face recognition systems. The issue is restricted to archives that can be used to recognize the face of the person. The pictures must, in particular, be lateral frontal viewpoints of human faces. PCA flowchart for the feature extraction process can be seen in Figure 5.

1.3. LINEAR DISCRIMINANT ANALYSIS [LDA]

LDA is similar to PCA other than that it can also find the axes that improvise distinguishing multiple classes. The main goal of LDA is to project a feature space i.e., N-dimensional data onto a smaller subspace k where $k \leq n - 1$ while retaining the class discrimination information as shown in fig.7. The algorithm is as follows:

Step 1: Compute within-class scatter matrix (S_W) where $S_W = S_1 + S_2$, where S_1 and S_2 are the co-variant matrices of class 1 and class 2 respectively.

Step 2: Compute between-class scatter matrix S_B where $S_B = (\mu_1 - \mu_2)(\mu_1 - \mu_2)^T$

Step 3: Find the best LDA projection vector $S_W^{-1} * S_B V = \lambda V$

Step 4: Perform Dimension reduction with the given equation, $Y = W^T . X$, where W^T is the projection vector and X is the number of input data samples.

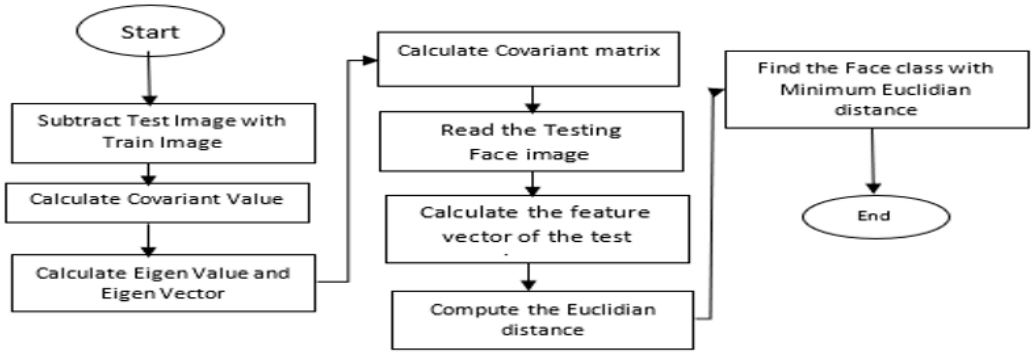


Fig. 5. Flow chart of PCA.

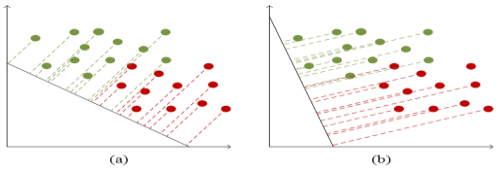


Fig. 6. Histogram obtained using Grid in LBP: (Color online) Comparison between PCA and LDA. (a) PCA, (b) LDA.

2. Literature Review

This paper explains how the smart home mechanism is implemented. Here it is described what physical components it needs, the communication between them, the architecture of the application, and details of implementing the mentioned functionalities. [1]

This paper presents the IoT technology from a bird's eye view covering its statistical/architectural trends, use cases, challenges, and future prospects. The paper also presents a detailed and extensive overview of the emerging 5G-IoT scenario. Fifth Generation (5G) cellular networks provide key enabling technologies for ubiquitous deployment of the IoT technology. [2]

The paper discusses a novel Proof-Of-Concept based on the Frugal Lab IoT Platform (FLIP) for smart home applications. It comprises a WebApp, SDK, cloud integration, a gateway, and peripheral devices along with communication modules like onboard WIFI and Bluetooth. As a processed result, this system can control windows and doors.[3]

A switch sensor-based person detection implemented in Raspberry Pi with Python & Open CV is proposed [4]. Unlike other motion detection sensors like IR and PIR which may fail due to extremely high or low temperatures that may affect the functionality, the switch sensors are highly efficient in terms of functionality.

A new human face detection algorithm by primitive Haar cascade algorithm combined with three additional weak classifiers is proposed. The three weak classifiers are based on skin hue histogram matching, eyes detection, and mouth detection.[5]

3. Methodology

3.1 Conventional Method

Traditional security systems that monitor the property with video cameras lack the capacity to alert the security administrator in the event of trespassing. When utilized in conjunction with a digital video recorder (DVR), a security camera is only useful as a source of evidence if the video feed is constantly watched by dedicated staff.

Security is the most crucial aspect of human existence. At this point, the most key consideration is cost. A system is presented that will equip for handling photos very fast in order to reduce the expense of monitoring movement from the outside. A Biometric system is the authentication system to measure different physical characteristics. The physical characteristics are retina recognition, palm, pupil, fingerprint, face, and voice. In recent years, out of these authentication systems, face recognition has a lot of attention in the research field. Face recognition system is the most challenging task in recent years. Face recognition is the most accurate method of identifying a person for authentication purposes. Faces can be seen with a variety of expressions, including laughter, melancholy, smiling, and happiness. The authentication mechanism can also recognize the other face duplications. Face recognition is a useful tool for distinguishing between thousands of people's faces. Face recognition, in this case, provides realistic proof that there is no problem without a solution. It compares and distinguishes tens of thousands of faces. Variation in vision is the fundamental issue with facial recognition systems. It can be deduced that image variation is always less than the lighting and viewing direction of two separate subjects. When there are a lot of variances in a person, the main issue arises.

The facial recognition system has a wide range of applications. It could be employed in the main entrance system of the building Face recognition technologies are receiving a lot of attention in today's networking world. Face recognition software will be used on web servers as well. Face recognition technologies are used on many identic cards, such as voter cards and PAN cards.

3.2 Proposed Method

The main objective of this project is to “Protect the Home, by Recognizing People or Face”. Towards this purpose, a Raspberry-pi integrated with a camera is chosen to perform necessary processing/computations to capture the image and detect faces and recognize them. Face recognition algorithms are used to identify people. Finally, if the image is of an unidentified person or an intruder then a notification is sent via Gmail, WhatsApp, and Voice calling to the security personnel and or the owner or authority concerned.

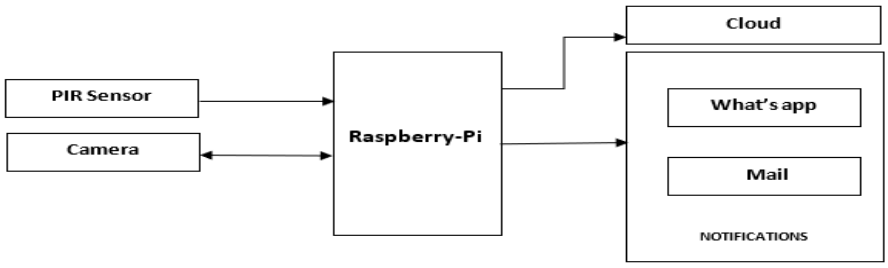


Fig. 7. Block Diagram of IoT Based Theft Detection System.

The above block diagram explains the operation of IoT based Theft Detection System

before initialization, make sure that the camera module and PIR sensor are Connected to the Raspberry Pi. Connect the ethernet cable to the Raspberry Pi and switch on the power supply.The PIR sensor detects based and adjusted range and sensitivity, the digital value is given to the controller.The controller initializes the camera and captures the video and extracts images from the footage to check whether the detected object by the PIR sensor is a human or any other creature by using the Haar-cascade classifier.If the detected object is not human, loop again system starts with the initialization process.But the object is a Human, then the Processing unit starts computations using one of the 8 best Algorithms .After performing necessary steps i.e.,

feature extraction and classification, etc, returns the output i.e., matched face with an existing database.And sends the alert Captured Images sent via using WhatsApp Captured Images sent via using Email is Stored in the Cloud Platform for future reference. System Initialization displays information about configuration parameters that affect the system when it is first powered on, through system boot. Initialization includes boot parameters, start-up scripts, and kernel parameters. Sensor Interfaced to device detects the motion of the object and if any object is detected, sends the signal to the controller. Haar-Cascade Classifier is used to detect the person by using the XML library.The main task of the system is to extract the features,

- Hardware.
- Algorithms Used.

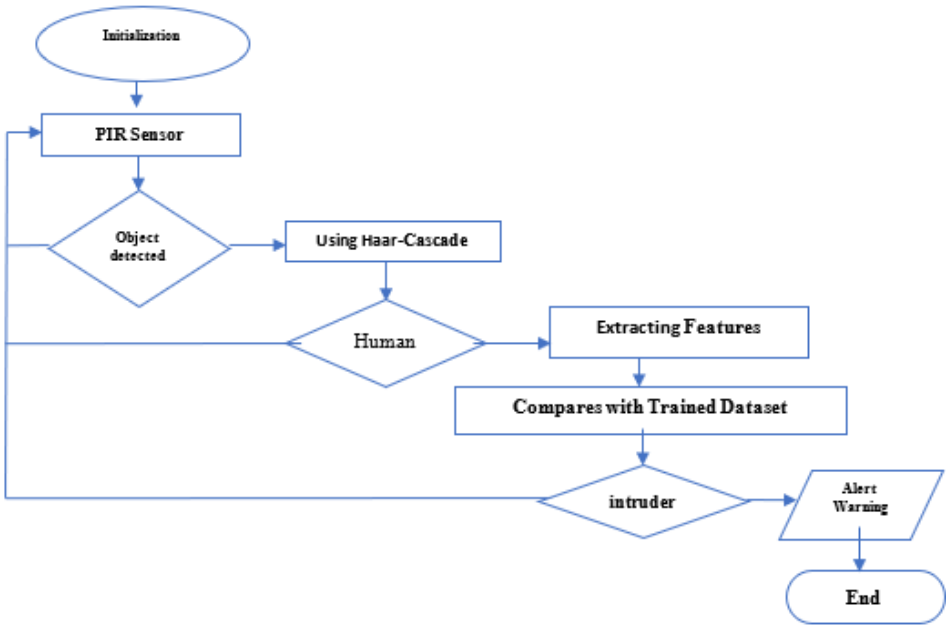


Fig. 8. Flowchart of the Theft detection system.

3.2.1. Hardware

The constructed device consists of a Raspberry-PI board of version-3 with 32GB of external storage. And the Pi-camera module is interfaced with it.

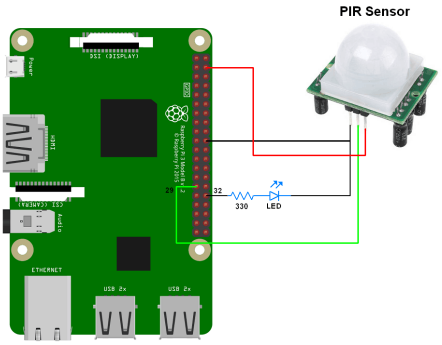


Fig. 9. Fritzing diagram of the circuit.

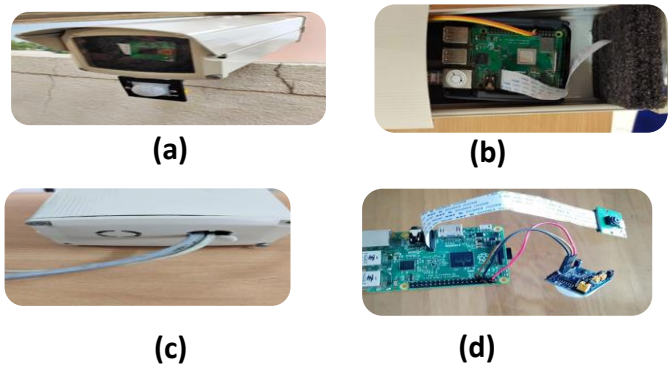


Fig. 10. (a)Represents Image of Constructed Device. (b) IoT Based Theft Detection System. (c) Ethernet cable and Power supply. (d) Raspberry-pi in the Implemented system.

3.2.2 Algorithms Used

Implemented System uses Eight Algorithms alternatively with "ORL IMAGES" as the input data Set.

- *LBP*
- *PCA*
- *LDA*
- *Combination of DWT and LBP*
- *Combination of DWT and PCA*
- *Combination of DWT and LDA*
- *Hybrid LBP and PCA*
- *Combination of Hybrid LBP and PCA*

4. Experimental Results

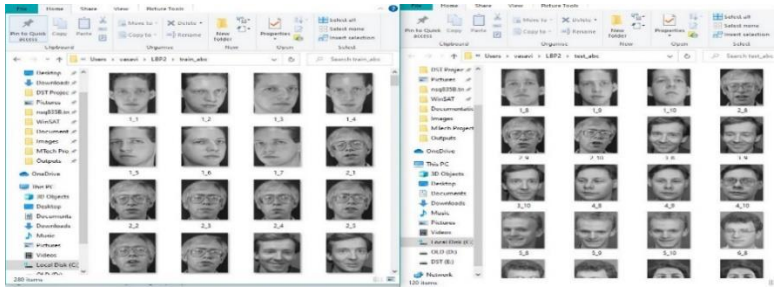


Fig. 11. Train and Test Images of ORL Dataset.

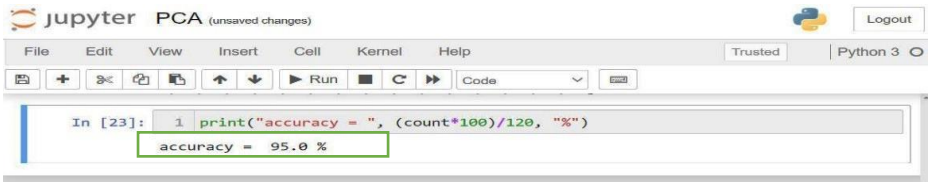


Fig. 12. The output of PCA-40subjects.

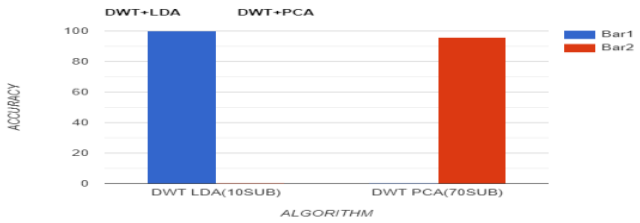


Fig. 13. Bar Graph of DWT_LDA vs DWT_PCA.

Table 1. Comparison of all algorithms.

Name of the algorithm	10-Sub (Train=70, Test=30) Accuracy	40-Sub (Train=280, Test=120) Accuracy
LBP	90	60.83
PCA	96.66	**95**
LDA	80	80
DWT+LBP	93.33	67.5
DWT+PCA	96.66	95.83
DWT+LDA	100	76
LBP+PCA	90	55.83
DWT+LBP+PCA	93.33	60.83

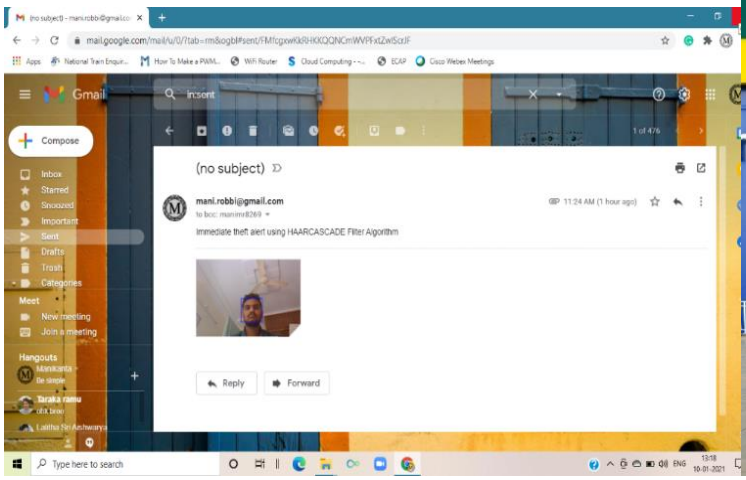


Fig.14. Image Notification Via Email.

Fig. 15. WhatsApp Notification.

The Proposed PCA methodology acquired 95% of accuracy in detection. And able to notify through Email and WhatsApp applications.

5. Conclusion

In this project, a Facial Recognition system was implemented using the Haar-cascade algorithm to detect the face of the intruder and send the alert using Email and WhatsApp. Towards theft detection i.e., the presence of humans the machine learning algorithms are used. The LDA, PCA, LBP, and LBP & PCA methods were tested using the ORL dataset. In this process the dataset of 400 images of 10 subjects, 280 images were used for training and 120 images for testing with a ratio of 7:3, it is found that the PCA method gave better results. As Embedded-system are used in security systems, which have low resources like memory and architecture a DWT-based approach is applied alongside the above learning algorithms. And it is found that DWT & PCA method gave better accuracy than the other algorithms.

As the result obtained from PCA, the scope of the work is to develop a Hybrid approach using PCA to produce better accuracy for the Facial Recognition system.

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