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Real-Time Ambience Sensing and Image Authentication using Internet of Things (IOT) in a Fleet Tracking System

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Abstract

Background/Objectives: To create a comprehensive fleet tracking system using Internet Of Things (IOT). A fleet tracking system generally provides information on the route that is being used by the vehicle. Other general information like source, destination and driver information can be fed into the system beforehand. **Methods/Statistical Analysis**: For Intelligent Transportation System (ITS) applications, it becomes necessary to provide several real-time data such as temperature, pressure and humidity to ensure that the transported perishable goods are in good condition. In this paper, the parameters are monitored using a Raspberry-pi and a Sense Hat. **Findings:** This paper also aims to provide a security feature that can identify authorised personnel who can get access to the transported goods, using Raspberry pi and a Raspberry pi Camera with night vision to provide the real-time information and security alerts using image processing technology. These data are then fed to a server to provide access to drivers, administrators, vendors and management teams for efficient handling of the services. **Applications/Improvements:** With the boom in online shopping sector and an increase in demand in the freight transportation services, a security feature that can identify authorised personnel can go a long way in improving security.

Keywords: IoT, ITS, Raspberry pi, Sense Hat

1. Introduction

In a country like India where agriculture has a significant role in the socio-economic fabric, it is essential that the perishable goods transported over long distances in vehicles are taken care of during its journey. Also, commercially, security in transportation systems is not highly sought after in India and as a result several mishaps occur. With the boom in online shopping sector and an increase in demand in the freight transportation services, a security feature that can identify authorised personnel can go a long way in improving security. In a normal fleet tracking system the information on route of a vehicle is provided. The basic mechanism of this work draws inspiration partly from the work found in Mini-UAV[1] based Sensory System for Measuring Environmental Variables in Greenhouses which describes how two aerial and ground vehicles make use of sensors and actuators using a Raspberry pi based IoT system to control and monitor the greenhouse gases. Our paper is based on providing additional features in a fleet tracking system which would especially be meant for transportation of perishable goods, providing an efficient mean to monitor the ambience conditions and also ensure that the goods transported is accessed by the intended recipient at the destination point through an image-based authentication process which would involve face detection followed by face recognition. The proposed system makes use of the Embedded Linux board namely Raspberry Pi and its advanced feature of storing database in real-time. If the ambience conditions do not match the pre-determined criteria set in the server or if there is any mismatch during the image authentication process, then alarms can be set in the form of a message or a tweet which would guide the

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client to take necessary steps or corrective measures. The paper "Ubiquitous GPS vehicle tracking and management system"[2] discusses the needs and applications of an intelligent fleet tracking system and our paper adds to this, an intelligent security system. Also the paper "Challenges in safety, security and privacy in the development of vehicle tracking systems"[3] sheds some light on the challenges in safety and security in an Intelligent Transport System which are overcome in our paper. An efficient vehicle tracking system is designed and implemented in[4] for tracking the movement of any equipped vehicle from any location at any time. The proposed system made good use of a popular technology that combines a smartphone application with a microcontroller. In[5], the development of the vehicle tracking system's hardware that utilizes GPS to obtain a vehicle's coordinate and transmit it using GSM modem to the user's phone through the mobile network is presented. The developed vehicle tracking system demonstrates the feasibility of near real-time tracking of vehicles and improved customizability, global operability and cost when compared to existing solutions. An Efficient Authentication Model (EAM) for protecting the web applications from various security attacks is discussed[6]. A novel algorithm based on Zero Knowledge Protocol and Accumulated Hashing to provide secure authentication to sensor enabled mobile devices in IoT is introduced[7].

The following features make our Fleet tracking system more comprehensive than the above mentioned models available in literature:

- It monitors the parameters such as pressure, temperature and humidity in vehicles carrying perishable goods.
- In case of deteriorating conditions during the journey, the administrator can make a decision to direct his/her vehicle to a nearby cold storage unit.
- It makes sure that the owner is able to keep track on all the vehicles from any remote place and make sure that the goods are received by the authorised person at the destination point.
- It facilitates the administrator to exert total control over his/her fleet and benefit the manufacturer as well as the consumer of perishable goods being transported for long distances.

This paper is organised as follows: Section 2 gives a description of the major hardware components involved in the module. Section 3 illustrates how real-time ambience sensing is employed in the system. Section 4 sheds light on Image-based authentication for security purposes. Section 5 provides the conclusion and the future scope of the work.

2. The Hardware System

2.1 Raspberry Pi

The Raspberry pi-B, a small-sized computer with 40 GPIO pins and the Sense Hat are interfaced. Interfacing is simple because the Sense Hat is merely an add-on for the Raspberry pi-B model. It has a port Camera Serial Interface (CSI) port located behind the Ethernet port to which the Raspberry pi camera is connected. Here, the Raspberry pi is used as a computer that senses the environment.

2.2 Sense Hat

Sense Hat is an add-on board for Raspberry Pi-B Model. It has several integrated circuit based sensors to track temperature, pressure, humidity, and the orientation. The **8x8 LED Matrix** enables the data from the various sensors to be displayed on it

2.3 Raspberry Pi Camera

The raspberry pi camera module is used to take high definition video, as well as still photographs. It is capable of taking a full HD 1080p photo or video. Once the camera module is connected to the CSI port of the Raspberry pi, the camera software is enabled for its functioning.

3. Real-Time Ambience Sensing

The block diagram for real-time ambience sensing is shown in Figure 1. It indicates in simple steps how environmental parameters such as temperature, humidity and pressure can be obtained in real-time by interfacing the Raspberry pi and the Sense hat and making the real-time values obtained, accessible to the administrator. Once the Sense Hat is connected to the Raspberry pi, it is powered up. For obtaining the ambience conditions, programming is done in PYTHON. The PYTHON programs are written in IDLE 3.2 version. The programs framed are then run on LX Terminal (a standard terminal emulator of LXDE). The instantaneous values obtained have variations or fluctuations which arise generally due to the Drift error and Bias error which are very common in any sensor devices. In order to eliminate these errors and minimise the standard variation, optimisation is done.

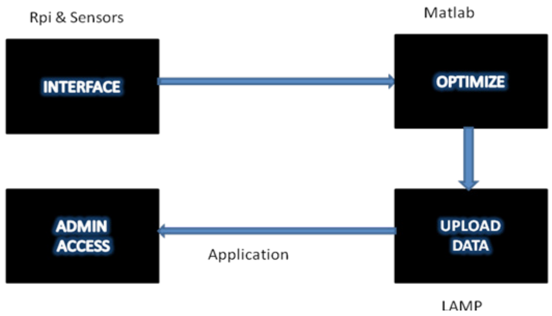


Figure 1. Block diagram for real-time ambience sensing.

However, the most important part is not the sensing itself. For the clients and other stakeholders to be made aware of the real time sensor values, the sensor data needs to be uploaded into a server to provide access. This is achieved by means of using a multi-purpose 'ThingSpeak' server. First, an account is created for the server at ThingSpeak.com. The server website provides the account holder with an API key that is used to log into the page. Correspondingly a Python script, containing the Application Program Interface (API) key, is written to input sensor data into the server. The most interesting feature of Thing Speak is that it enables the administrator to send out tweets to notify the stakeholders about the ambient conditions.

Another important part of this set-up is to enable the administrator to have total control over the raspberry pi from a remote location. To do the x-RDP software is installed on the pi and it is rebooted. Then the port 3389 is forwarded on the router to the IPv4 address of the pi. Finally, the remote desktop app is used to log on to the pi from a remote location. Figure 2, and Figure 3 represents the plot of Time with Temperature, Pressure and Humidity respectively obtained in ThingSpeak. These graphs enable the administrator to make a decision if any filters are required in case of large fluctuations in the real-time values obtained.

4. Image-based Authentication

The major steps involved in the process of Image-based authentication are shown in Figure 6. This authentication process will make sure that the goods are handed over to the intended person at the destination point. This process involves two major steps. They are face detection and face recognition. The image-based authentication model requires two main components in its structural design. They are Raspberry pi and a Raspberry pi camera module with IR modules. The camera module is enabled and programmed using PYTHON (version 2.7.3 or version 3.2).

The following sub-headings would give an insight to the concepts involved and used in face detection and face recognition.

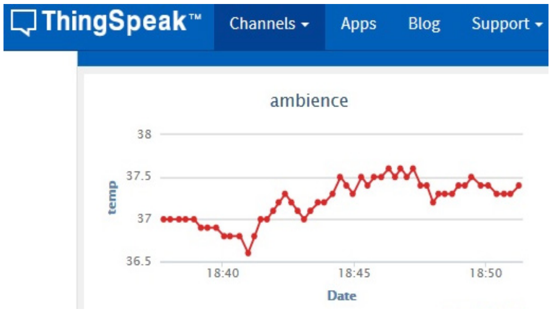


Figure 2. Plot of time vs. temperature.

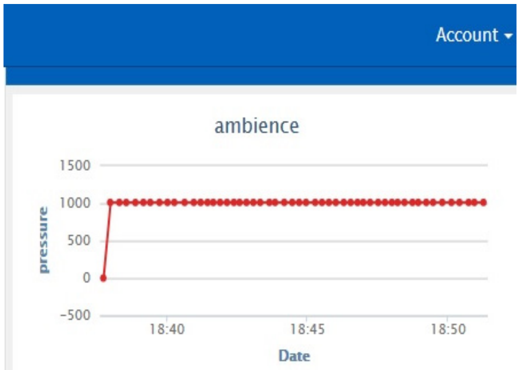


Figure 3. Plot of time vs. pressure.

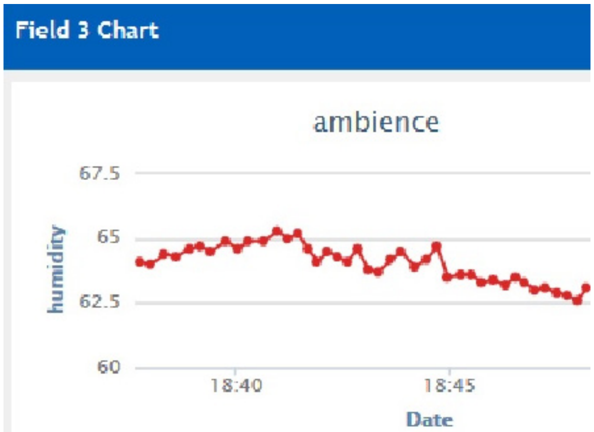


Figure 4. Plot of time vs. humidity.

Figure 5. Issue of a warning via a Tweet.

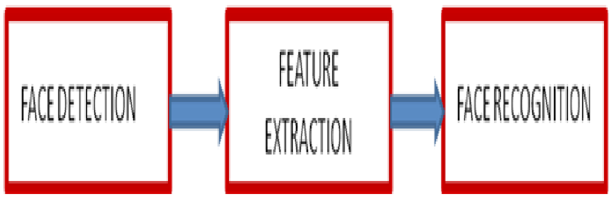


Figure 6. Image authentication process.

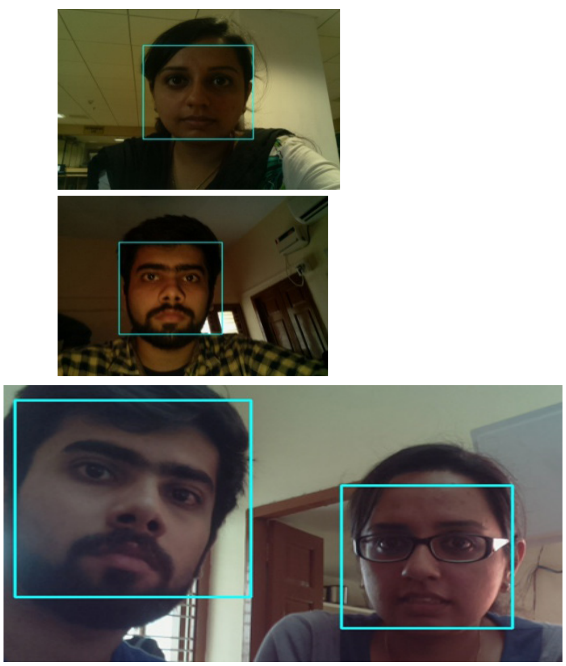


Figure 7. Face detection using viola jones algorithm.

4.1 Face Detection using Viola-Jones Algorithm

It is the algorithm used for face detection which is very efficient in not just detecting an entire face but also facial features like eyes, nose, mouth etc. individually. Viola–Jones requires full view frontal upright faces. Thus in order to be detected, the entire face must point towards the camera and should not be tilted to either side. The Viola-Jones algorithm performs face detection based on the following four stages:

- Haar Feature Selection
- Creating an Integral Image
- Adaboost Training
- Cascading Classifiers

4.2 Face Recognition

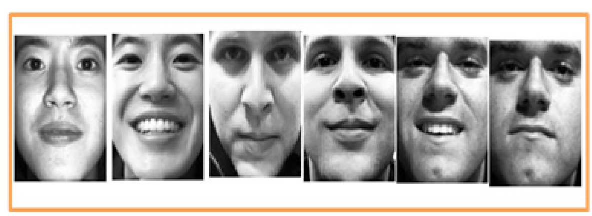
Before performing face recognition, a database is created into which the pictures that are snapped by the Raspberry pi camera can be stored. A separate folder is created into which the photos of authorised personnel are stored. The image that is captured at the destination point is now compared with the images stored into the database. This recognition process is achieved by using PCA (Principle Component Analysis) algorithm along with the eigenface approach.

4.3 Principle Component Analysis (PCA) Algorithm

For efficient validation of images we use PCA algorithm along with Eigen Face Approach. According to PCA, face is a complex multidimensional structure and hence PCA treats face recognition as a two-dimensional recognition problem. The system performs by projecting pre extracted face image onto a set of face space that represents significant variations among known face images. Face will be categorized as known or unknown face after matching with the present database.

4.4 Implementation of PCA

1. Training set of images are taken (M).



Dimension of each is $N \times N$

2. Converting the image of training set into image vector (T_i) i.e. [$1 \times N$] matrix form which is represented by [$r_1, r_2, \ldots\ldots\ldots\ldots r_k$].

3.Normalizing the face vector requires:

(a) Calculating the average face vectors (U) i.e. $m_1, m_2, \ldots\ldots\ldots m_k$

(b) Normalized vector $A = T_i - U$

4. Project the normalized face onto the Eigen space.
    - Calculating the Eigen vector requires:

Calculating the covariance vector C

$$C = A \bullet A^T$$

where $A = [\Phi_1, \Phi_2, ...\Phi_M]$

A is of dimension: $A = N^2 \times M$ so $C = N^2 \times N^2$

matrix in this the co variance matrix is being of a very large size

- Calculate Eigen vectors from reduced covariance matrix by "Dimensonality Reduction Method"

New $C = A^T \bullet A$

$A = N^2 \times M$ AND $A^T = M \times N^2$

Hence $C = M \times M$ matrix.

- Selected K eigenfaces MUST be in the ORIGINAL dimensionality of the face Vector Space.

$$u_i = A \times v_i$$

$u_i = i^{th}$ eigenvector in the higher dimensional space

$v_i = i^{th}$ eigenvector in the lower dimensional space

5. Represent each face image as a linear combination of all 'K' vectors. Here,

w_i = weight of each face.

$$w_i = A \times u_i$$

The whole process can be summed up into the diagram represented below in Figure 10(a) and 10(b). Figure 10(b) shows the working of face recognition code in MATLAB using GNU octave in raspberry-pi. This fig tells that after image is being captured and face detection has taken place the image is being matched from loaded image of database and once the image is being found. The admin will send alert message stating that the user is authorised.

5. Conclusion and Future Scope

In today's day and age, the technology at our disposal facilitates effortless remote surveillance. Our paper offer industries that transport valuable goods a solution to do what they do in a safe and secure manner by keeping a check on the various parameters such as temperature, humidity and pressure that affect the shelf life of perishable goods, by making use of self operational gadgets. This helps the goods reach their destination not only safely but also has a real time alert system with time stamps that helps the administrator take necessary action immediately in case of emergency or unauthorised access. Therefore this system can benefit both the consumer and

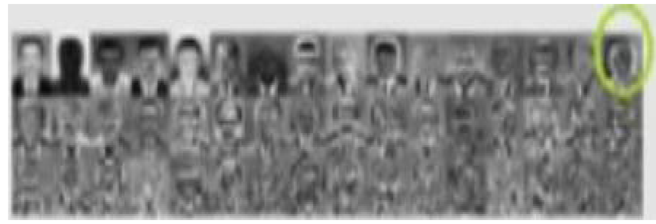


Figure 8. Image representing the selected eigen face.

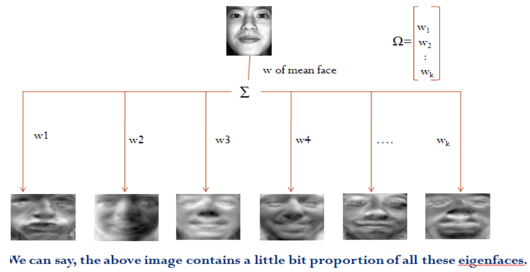


Figure 9. Representation of image containing small proportions of each eigen faces.

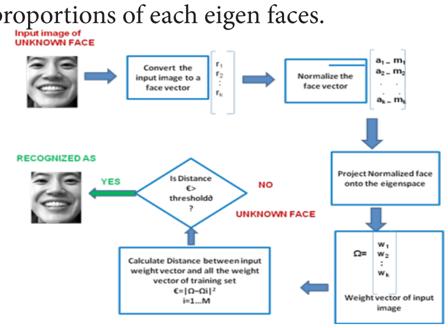


Figure 10a. Face recognition using PCA.

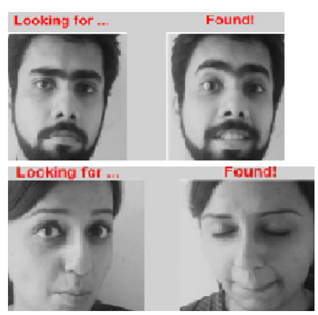


Figure 10b. Face recognition result using MATLAB.

manufacturer economically. We have employed the use of a Sense Hat which is which is typically a combination of sensors integrated onto a single board. Since it is an add-on to the Raspberry pi (B Model), it makes the circuitry much simpler. However, cost constrain should also be taken into account. Instead of making use of a Sense Hat, individual sensors can be made use of to measure the required parameters. This would make the module a bit complex since it would require individual sensors to be interfaced with the Raspberry pi and also individual programs to be written for each. But this approach would bring down the cost of the module effectively.

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