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Research paper

IoT based Smart Passenger Surveillance System for Airport

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Abstract

Airport security system is mandatory in all developing and developed countries. The major threat to any country's economy, health and development is targeted and transported via airports which are evident from the past historical examples. The developments in Science and Technology have improved the methods of surveillance but failed to address few key health issues including privacy. The main objective of this paper is to develop a smart IOT based surveillance systems that is implemented in airport in smart screening without causing any unpleasant disturbances to the passengers. This paper makes use of the recently developed smart sensors, Tiva processor from Texas instruments connected via IOT and cloud and a remote station to effectively secure the airport area and overcoming all the real time challenges.

Keywords: *Airport, Surveillance, Internet of things, smart sensors*

1. Introduction

Smart surveillance technology has become an important element in security infrastructures. This system involves smart cameras besides metal detectors and baggage x-ray machines at the security point in the departure lounge. The system generally scans the entire body for concealed weapons, explosive materials hidden underneath the clothes. These scanning and screening systems are regularized by the act of TSA. Even though the current systems are smart, effective and fast in surveillance, the promise on privacy and health factors are still under with great fuzzy. The existing systems report with various threatening factors including the exposure to the ionizing radiations, revealing of private body parts and shape, etc. A novel method has to be adopted to overcome these challenges without compromising the quality and accuracy of body screening systems at present. This paper is based on developing a smart IOT based surveillance system that can be used in airports without causing inconvenience and health hazards. This proposed model involves the usage of smart sensors namely, proximity sensor, electronic nose and a terahertz camera in order to detect the metallic devices, smell the unwanted explosive materials and scan the total body respectively. These sensors are connected to the WiFi based IOT module which communicates to the Tiva™ TM4C1294NCPDT Microcontroller connected to remote TSA Agent machine via the cloud. In case of ant anomalies an alarm is set in the remote station to identify and isolate the unusual activity. This proposed system overcomes the challenges in the existing systems and the results are found promising without compromising the TSA regulations.

The aviation security is an enduring challenge in detecting the explosive materials hidden under cloths. The Aviation and Transportation Security Act of 2001 (ATSA; P.L. 107-71) made the screening of baggage for explosive detection as compulsory but could not address the challenges in possession of such explosions in aircraft cabins. Many notable unpleasant attacks and attempts have been taking place across the globe and hence in 2004, the 9/11 Commission recommended that the Transportation Security Administration (TSA) and Congress to improve the priority for explosive detection on passengers. It is also recommended that for all individuals to undergo explosives screening.1 Mirroring the 9/11 Commission recommendation, the Intelligence Reform and Terrorism Prevention Act of 2004 (IRTPA; P.L. 108-458) directed TSA to give high priority to developing, testing, improving, and deploying airport checkpoint screening technologies to detect non-metallic, chemical, biological, and radiological weapons, as well as explosives on passengers and in carry-on items. TSA alternatively adopted the evaluation and eventual system of whole body imaging (WBI) by incorporating Advanced Imaging Technology (AIT) [1]. At present TSA uses this advanced imaging techniques for primary screening and all the passengers are further subjected for a mandatory secondary screening like walk through metal detector screening and pat down by an expert TSA screener of same gender.

Hence a smart surveillance system that overcomes the existing challenges is the need of the hour. Considering all the above risks and standards, this paper aims at developing a novel smart system to effectively identify and sense any sort of anomalies like metallic objects namely knife, gun or explosives easily at the same time without trouping passengers with multi-stage screening phases.

2. Existing Methods

Currently there are many surveillance systems used for body scanning and identification of metal, explosive and hidden objects. The following are some of the most commonly used systems-

2.1 Back Scattering X ray

The backscatter X-ray is widely used in number of countries for aviation security purposes.
Among which Rapiscan technology holds good for major surveillance process. This device uses a low level of X-ray dosage that can penetrate through clothing to produce a grey scale equivalent image of the person under surveillance. The operator at the other end can identify any sort of abnormalities in different shades of grey that differs from the normal body shape. The backscatter system operates by implementing a narrow x-ray beam that scans a person at high speed from top to bottom and left to right. Meanwhile, a detector array collects the backscattered radiation from the person. Finally, an image is formed on a computer screen within ten seconds. It is observed that most of the radiation detected is scattered from the surface of the skin, hence the backscatter is effective at imaging objects hidden under clothing only [2].
But the main drawback of this system is that general features namely, hair, other facial features are not revealed with clarity and very difficult to identify an individual when required. The person is either made to stand in different poses in single scanner mode and in double scanner mode the person is scanned front and back simultaneously. Usually in airport security set up the person responsible for viewing the image may be located far away such that to ensure that no one else can oversee the images and also to clarify that the image viewer cannot have a clue about the passenger. The image obtained from the backscatter is normally considered to be sharper and clearer than images created by other scanners.

2.2 Millimetre Wave Technology

This technique is comparatively among other body scanner techniques is considered to be compatible as it is not based on ionizing radiation. Waves between the frequencies of radio frequency and infrared frequency (approximately 30 GHz) is used to scan the body because of the translucent property of this frequency waves to detect any unusual objects hidden under clothes. The technological developments in imaging have increased the resolution and also it is sensitive to density differences. But care should be taken that the imaging software and other procedures shall not expose the body structure instead blurring the body parts and not storing the data. Moreover, as this technique make use of low energy and low-density waves that does not penetrate the human tissue. Also, the RF energy used in this procedure is lower than the RF exposure of cellular phone usage. The effect of these waves on human skin is still under study.
So comparatively this system can be implemented for detecting any anomalies considering the detection sensitivity and health effects. But it involves well trained operators or high performance automated systems in terms of communication between the scanning officer and security officer. The number of faulty detections reported is also high in this method due to false detection of other usual objects. It is also mandatory to obtain license with respect to the usage of radio frequency waves even though the range is limited. Major drawback of the system is that it can only detect objects on the body of a person: it is not capable of detecting items within the body.

2.3 Thermal Infra-Red Imaging

The thermal infra-red imaging techniques was initially implemented in detecting the Influenza A(H5N1) and the pandemic of Influenza A (H1N1) 2009 in the national and international borders for mass screening of travelers infected with influenza. It measures the body surface temperature non-invasively even without contact of the person hence minimizing the risk of contagion. Therefore, it complies with the International Health Regulations. But in case of security surveillance the complexity arises in the usage of the camera itself. The physics behind the operating principle has to be understood better in interpreting he images especially the thermal colors [2, 10]. Also, another important fact is that there is no regulation act regarding the thermal imaging.

2.4 Terahertz Imaging System

The THz radiation has unique properties in imaging and analysis hence grabbed the attention recently. For instance, the non-conductive material transparency in the THz range is widely useful for systems inspection. The diffraction limit of this THz is the major drawback of this imaging system due to the long wavelengths (0.15-1.5 mm). But it is extremely impressive in resolution that can even sense the Nano particles. But the practical implementation difficulties are extensive because of the tedious procedures in imaging as well as analysis that involves various circuits like focusing elements, laser source and modulator, beam splitter and detector [3]. The analysis part is still complex because of various calibration procedures required.

3. Methodology

The proposed IOT based smart surveillance system includes three different sensors which can sense real time data of metallic objects, explosive substances and hidden objects. The proximity sensor to detect metallic object, electronic nose to sense odour pattern of explosive substances, camera is used to scan hidden object behind the clothes and sends to WiFi based IOT module. The WiFi based IOT module with pattern recognition features identifies pattern as per trained data and sends classified information to TSA remote machine through cloud as shown in figure 1.

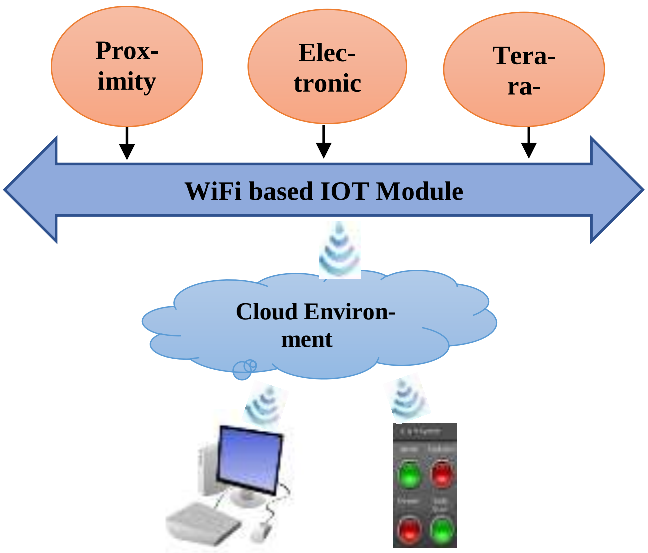


Fig 1: IOT based architecture for Smart Surveillance system

3.1 To Detect Explosive Materials

As detection of explosives has become very important process in a public place like airport. The electronic nose or odour sensors which can sense like a human nose mimicking olfactory system. It uses pattern recognition, neural networks to sense even a small quantity of explosives. It consists of multi-sensor array system for chemical sensing, sampling system, pattern recognition system and WiFi-enabled IOT module. It can detect complex odours using array sensors. There is composited detector which can sense the difference in the odoured and sampling system will convert it into signals. The pattern recognition system uses a database with known pattern of odors are used to train the system. Depending on the number of patterns used to train the system, it can identify most of the chemical substances. WiFi enabled IOT module will obtain the pattern of chemical substance sensed and classify it into explosive and non-explosive. It sends the information about chemical substance classified as explosive to remote machine used by TSA authority [4].

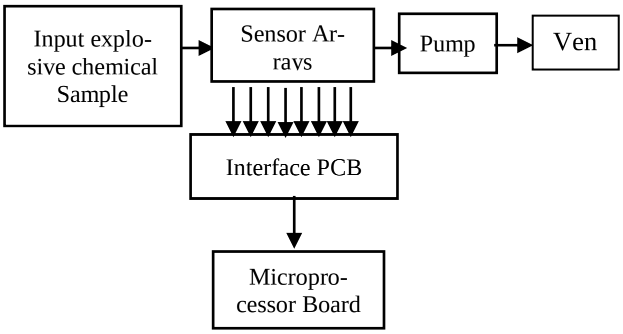


Fig 2: Working of Electronic Nose System

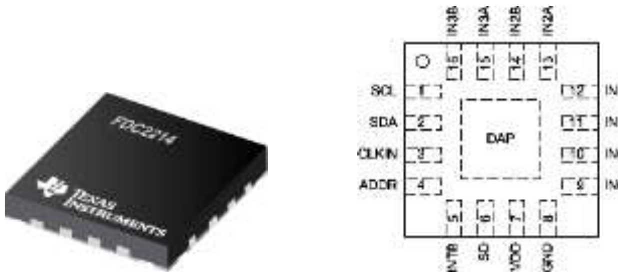
The figure 2 depicts the working of electronic nose which consists of different sensors like Metal oxide semiconductor, conducting polymers, quartz crystal microbalance, piezo electric sensors, metal oxide sensors. Metal oxide semiconductor is used for switching and amplifying electronic signals, it charges molecules entering into sensor areas as positive or negative. Conducting polymer senses gas absorption in terms of change in electrical resistance. Metal oxide sensor whose conductivity changes based on the gas molecules absorbed. Piezoelectric sensors absorb gas to a surface of polymer which changes its mass and in turn changes resonant frequency. Quartz crystal microbalance measures mass per unit area by measuring the change in frequency of crystal resonator. The sensor arrays include different types of sensors connected to microprocessor board via PCB as shown in the Figure 2, respective sensor identify the chemical substance and convert into electrical signals which is sent to processor board. There are three different types of sensor data analysis supported by E-Nose, graphical analysis, multivariate data analysis and network analysis. The proposed method used trained neural network multivariate data analysis technique for known explosive chemical pattern and untrained principal component analysis for unknown sample [7].

3.2. To Detect Metallic Objects

The proximity sensor is a device used to find objects nearby without physical contact. The detection of object is based on the electric field in front of its electrodes. When object is nearing the active zone of the sensor, capacitance increases and influences the amplitude of oscillator. There is a signal evaluator which detects this change in amplitude. Sensitivity of the sensor can be adjusted via potentiometer. The capacitance can be evaluated using the equation 1 [5].

$$\text{Capacitance} = \frac{\text{dielectric constant * area of active zone or electrode}}{\text{distance between electrodes}} \quad (1)$$

As shown in eq (1), greater the dielectric constant and electrode area but smaller electrode distance can cause greater change in the capacitance. Factor1 proximity sensor can detect most of the metals like aluminum, stainless steel, mild steel, copper, lead, brass and other metals placed at the same distance. They can accommodate wider range of applications and environmental conditions. It auto adjusts the sensor's position and can be mounted in small areas [6]. The proposed method implements WiFi based IOT module which automatically evaluates the value of capacitance and detects the change in the capacitance. These capacitance values are sent to remote TSA machine via cloud and also generates alarm when there is change in the capacitance. The proposed method used Texas FDC221x EMI-Resistant 28-Bit, 12-Bit Capacitance-to-Digital Converter for Proximity and Level Sensing Applications as proximity sensor which employs L-C resonator known as L-C tank. A change in the capacitance of L-C tank can be used as a shift in the resonant frequency. The FDC2214 sensor and its pin diagram is as shown in figure 3 (a) and (b) [5,8].



(a) (b)

Fig 3: FDC2214 Sensor and its pin diagram

This frequency measurement can be converted into equivalent capacitance, Sensor capacitance C_s, using the following equation (2)-

$$C_s = \frac{1}{L*(2\pi * f_s)^2} - C \quad \textbf{(2)}$$

Where, C is parallel sensor capacitance, L is inductance, fs is sensor frequency.

$$f_s = \frac{CHx\_FIN\_SEL * f_r * d_x}{2^{28}} \quad \textbf{(3)}$$

Where, CHx_FIN_SEL *is* channel select, for channel 2, CH2_FIN_SEL [13:12] is used. fr is Frequency reference, valid range for multi-channel is fr ≤ 55 when internal clock is used and fr ≤ 40 when external clock is used. The key clocks are fIN, fr, and fCLK. fCLK is selected from either the internal clock source or external clock source (CLKIN Pin). The frequency measurement reference clock, fr, is derived from the fCLK source. It is recommended to use external master clock for high accuracy and stability. Dx is conversion result from DATA_CH2 register. This register holds 12 MSBs of 28-bit result and DATA_CH2 belongs to channel 2.

3.3 To Detect Objectionable Objects Hidden In the Human Body behind Clothes

There is a need for safe and secured imaging system full body scanning of the passenger considering privacy and medical requirements as per TSA and FDA standards. These systems should be able to scan human body to identify hidden objectionable objects with revealing the body structure and details. Also, this system should not cause adverse effects on the skin and organs as body is exposed to strong rays. This proposed method includes steps which captures body scanned image using MICROXCAM-384i-THz Terahertz Camera with raw data acquisition and data transfer over GigE [6] and sends scanned images to processor board which consists of module to identify hidden objects and reconstructs the body image to hide the outline structure and inside details. This helps to hide gender information, body structure, and inner organs details of passenger in the image. This sensed and post processed image along with information about objectionable object if any is sent to TSA remote machine via cloud.

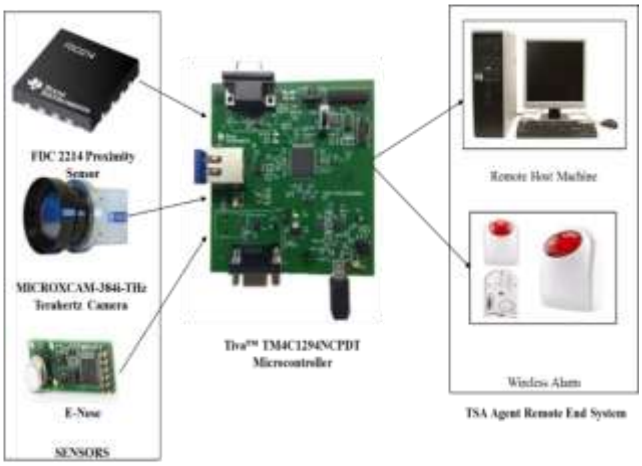


Fig 4: IOT based smart surveillance system with sensors and Tiva™ TM4C1294NCPDT Microcontroller connected to remote TSA Agent machine and wireless alarm.

The figure 4 depicts a circuit diagram for IOT based smart surveillance system, which shows how three sensors are connected to Tiva™ TM4C1294NCPDT Microcontroller and on which interfaced to remote TSA machine and alarm system via cloud.

4. Results and Discussion

As per TSA rules, it is mandatory for the passengers to undergo screening at public transportation service providers like Airport which is due to increased burglary, terrorism etc. In order to present these unpleasant incidents and to ensure safety of every passenger Airport need accurate and intelligent surveillance system which can scan objectionable materials faster and notify to concern TSA agent to take further immediate actions. Traditional surveillance system like explosive material detectors were responding only to energetic chemicals like nitrates, body scanner system requires human intervention for monitoring and interpretation which was offending some passengers as it was breach of their privacy. Also, body scanner system involved exposing passengers to powerful x-rays which could cause health issues. To overcome these drawbacks of body scanning system were built using advanced imaging system which includes less harmful rays but still TSA agent was involved in viewing the image captured and persisting privacy issues. The proposed method uses different sensor which can sense any metal object, explosive chemicals and hidden objects by using powerful sensors. The method connects different sensors detecting objectionable materials to remote machine, also it processes sensed data and stores it in a cloud for further analysis. The modified module for body scanning system identifies the hidden objects if any and then reconstructs the image into random shape thus hiding the actual body structure. This reconstructed image with information about identified hidden object is sent to the remote system used by TSA Agent. The module also sets alarm when hidden objectionable object is found for immediate action. Also, odour or electronic nose used in the proposed system are designed such a way that it can respond to all odoured chemical. As it uses library of odour signature and provides unambiguous interpretation of sensed input. This IOT based smart passenger surveillance system identifies metals, explosives, bombs, hidden objects in more efficient way and with less human intervention ensuring privacy of the passenger.

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