Location Based Environment Sensing and Information Report using Cognitive Radio for Smart Grid Security

Mukul A. Khairatkar, Tulin E. Mangir

mkhairat@csulb.edu, temangir@csulb.edu

Department of Electrical Engineering, California State University Long Beach.

Abstract— **In this paper we present an approach to security through location based environment sensing and information report using cognitive radio. The term environment sensing is used to sense physical quantities in the surrounding area and not for RF spectrum sensing. The environment sensing system is an essential monitoring system which senses ongoing activity in the vicinity and reports using wireless interface. Since the system is connected to a network, it is possible to modify and monitor required parameter from a remote location. Normally this would be implemented using a security camera installation that provides images to remote monitoring system. However, with recent advancement in signal processing technology it is possible to recognize ongoing activity with a microphone and identify speech. If the system is provided with basic functionality of operation, location awareness and surrounding temperature understanding, rest of the sensing can be developed by process of speech recognition. In this paper we propose a system model to develop environment sensing system using speech recognition and potential application for smart grid security.**

***Index Terms*—environment sensing, cognitive radio, smart grid security, security and location awareness**

I. INTRODUCTION

The location monitoring systems are gaining importance in our day to day life. We often need to sense and monitor specific location in the environment and based on that we take definite action. For example, monitoring a vehicle parking lot, a freeway, a security gate, a walkway etc. if we look at indoor activities includes, monitoring a house, a bank hallway, public library, etc. We also have outdoor mobile applications such as public transport vehicle, security vehicle, airport shuttle etc. Most of the examples given above use a security camera placed in the surrounding and connected to internet for monitor and control. The security camera has a specific requirement as well as network of security cameras. The resolution of the camera decides the image size which could vary and number of cameras decides the required connection bandwidth. On the other hand, the camera receives an image which provides a fixed set of information which is repetitive in nature. Most of the time, security cameras does not provide audio interface and if we observe audio closely, the sound produced at any give location is also repetitive at regular interval. The monitoring location itself provides a specific audio pattern, which system understands and further takes corrective action [1]. With the speech recognition engine connected to source of sound, system detects most of the common sounds and its meaning in day to day life [2]. The entire system is accessible thorough wireless network which has cognitive communication capabilities. In case of an emergency all the possibilities should be considered such as power supply failure, network failure, access point unreachable etc. Cognitive communication is essential especially at an emergency where it is important to send vital information across the network. The cognitive communication capabilities will allow system to be connected to any available wireless access point for vital transfer of information [3]. The basic setup of the system is as shown in figure 1.

Figure.1 Basic Security system setup

II. PROBLEM WITH SURVEILLANCE SECURITY CAMERAS

Most of the security surveillance system uses Closed Circuit Television (CCTV) camera system for monitoring a specific location. Closed Circuit Television is an increasingly familiar element of the urban and suburban environment. The overwhelming majority of local councils have introduced CCTV in an effort to deter crime from the streets of their towns and cities. Systems can be as large as 200 cameras, though most systems are smaller, with an average of 20 to 50 cameras and a car park requiring 10. Most of the wireless cameras work on 2.4 GHz wireless transceiver in conjunction with home or office networking device. This gives flexibility

of monitoring on Internet through remote location. In addition recording of images becomes a simple task. The problem with existing security camera is the camera itself is visible. The view from visible camera could be blocked without efforts and the entire network security operation could be a big failure. In addition, U.S. government experts on security technology, noting that "monitoring video screens is both boring and mesmerizing," have found in experiments that after only 20 minutes of watching and evaluating monitor screens, the attention of most individuals has degenerated to well below acceptable levels. The system records the video on a data tape or in the form of digital video file which needs to be stored and preserved for specific amount of duration for security investigation if required.

III. REQUIREMENTS OF SPEECH RECOGNITION SECURITY SYSTEM

The speech recognition security system consists of following components. These are essential componants and more can be added as per the user requirement.

A. Reconfigurable Hardware

Reconfigurable hardware devices are hardware devices in which the functionality of the logic gates is customizable at run-time. The connections between the logic gates are also configurable. This reconfigurable hardware will allow system administrator to modify and install required system software such as sensor interface, memory allocation, algorithm for speech recognition etc. reconfigurable hardware is essential in order to add location specific details and location specific corrections to the main algorithm.

B. Environmental sensors

Environmental sensors are playing key role in operation of the system. The sensors are responsible for converting physical quantities into electrical signals. The complexity of the software and the system depends on number of sensors attached to it. The more the number of sensors, more is the information about location could be gathered. With more data from sensors, more likely the system will understand the environmental situation. Typical system will have at least three sensors such as microphone for sensing speech, a temperature sensor to record environmental temperature, and location identifier such as GPS. The additional sensors could be motion sensors, humidity sensor for outdoor systems and a gyroscope for outdoor mobile systems as per the requirement.

C. Speech Recognition Software

The speech recognition software analyses digital data sampled from microphone on the system. The speech software needs to identify and distinguish between spoken words and language, high frequency sound, continuous noise etc. One of the fundamental issues in spoken language recognition is to explore the discriminative cues for spoken languages. These cues, such as acoustic features and phonotactic representations, reflect different aspects of spoken language characteristics. Another issue is how to effectively organize and exploit the language cues in the classifier design for the best performance [3] [4]. Daily home life involves various sounds which indicate different environmental situations or events. Examples of such sounds include ringing telephones, knocks on doors, babies crying, windows breaking, and so on. Therefore, identifying sound classes provides significant help in environmental monitoring [2].

D. Programmable RF front end

Once the system analyzes different sound inputs, the result needs to be sent over the network for corrective action. The programmable RF front end is responsible for providing required connectivity to the network. It is highly essential that the RF front end must be programmable in order to acquire connection from any available wireless access point. This operation is extremely effective in case of an emergency where possible failure of dedicated access point cannot be avoided.

E. Battery operated power supply

The entire system is operated on battery backed-up power supply which provides required energy to the circuits inside the system. In general, all the security systems have battery operated power back up.

IV. SYSTEM MODEL AND OPERATION

Considering the requirements in previous section, we developed a system as shown in figure 2. The entire system is divided in three different sections, environment sensing, signal processing and information report.

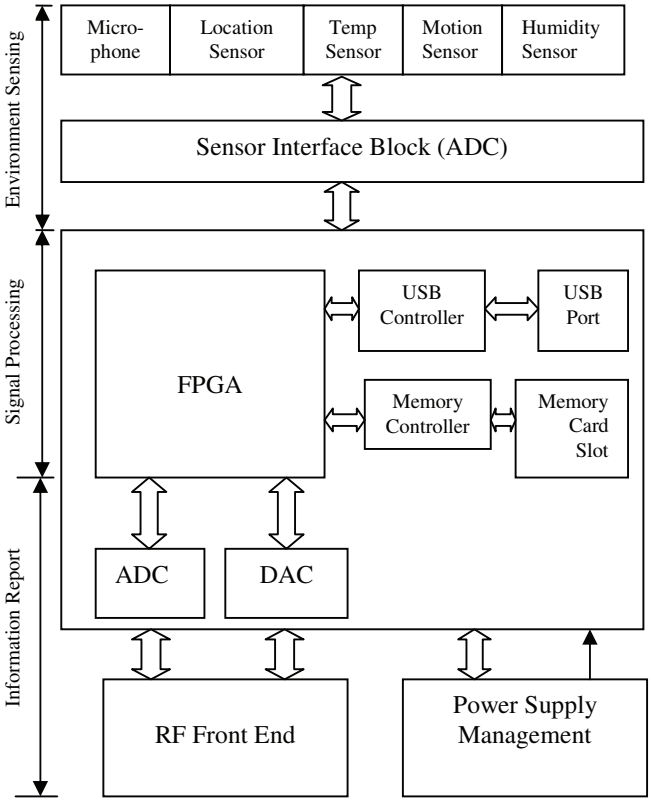

Figure 2. Speech Recognition Security System Model

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The environment sensing operation is performed by sesnsors connected to sensor interface block which is peripheral interface and performes analog-to-digital conversion operation. The digitized data is stored in the memory elements of FPGA for signal processing. The USB controller and Memory controller are interfaced with USB port and memory card slot respectively. The USB port is required to download firmware in the system. The memory card is used to stored location profile. The ADC,DAC and RF front end together forms software radio which is a key section in information report.

As stated earlier, the system could be fixed security system or a mobile security system. The number of sensors and the placement is location specific and should be tuned according to conditions of the location of the environment. For example, a fixed system need not have a location sensor as its location is pre-defined and is identified based on hardware address.The microphone placement is extremly cruicial as it is going to receive sound waves based on which enviornment will be sensed. The speech recognition system achieves high recognition accuracy in controlled laboratory environments. However, the performance of these systems drops off severely in real life, outdoor environments. The main causes of performance degradation are signal corruption and the open-set problem. Unlike in laboratory environments, the sound signals in real life environments are corrupted by background noises and room reverberations. The recognition system should be able to handle both signal corruption and the open-set problem. Therefore, rather than the relying only on use of conventional speech recognition systems which are targeted toward human voices and a closed set of vocabulary, we choose to use algorithm that utilizes the characteristic of the target sounds such as vehicle horn, whistle, typical calling bell etc.[2]. Figure 2 and 3 shows difference between a silence which is idle state of the environment and ringing of the bell.

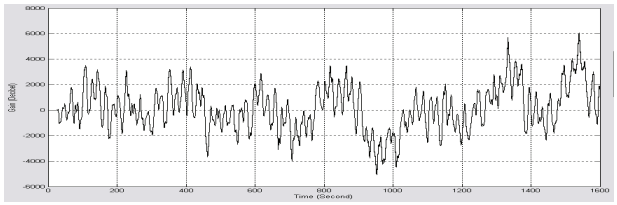

Figure.3 Microphone input of a silence (idle condition)

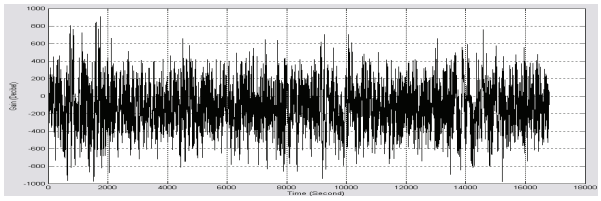

Figure.4 Microphone input of a ringing bell

In order to identify spoken language or sounds generated by humans, method of speech recognition model using ensemble classifiers is effective. The state-of-the-art systems rely on two types of features: the acoustic features and the phonotactic features. The acoustic features reflect low-level spectral characteristics, while the phonotactic features represent the phonological constraints that govern a spoken language. This method comprises of a feature extraction front-end, a vectorization backend, and a language recognition decision classifier. This method extracts spoken utterance features from the sound source and converts into a polynomial expansion and produces distributed output codes. These codes represent spoken languages which are results of test of hypothesis.

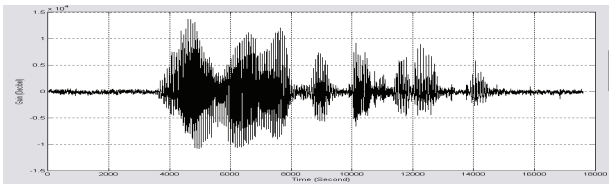

Figure.5 Speech activity

The real-time activity of the system is recorder and stored into system memory for wireless transmission via wireless access point. The RF front end is continuously scanning and recording available access point for communication [6] [8]. The system always has one dedicated access point with which it is associated and uses as a primary node of communication. In case of failure of primary communication node, security system must be equipped with secondary source of communication. The RF front end provides this vital information through the process of spectrum sensing.

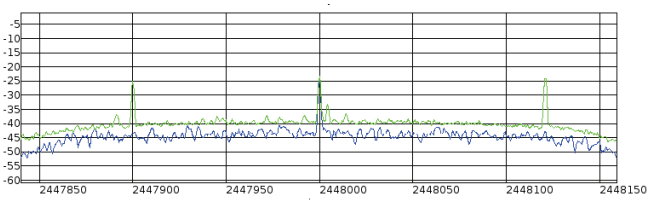

Figure.6 Spectrum sensing activity of cognitive radio

The process of spectrum sensing is categorized in three major sections as transmitter detection, cooperative detection and interference based detection. The transmitter detection method is most commonly used method which uses matched filter detection, energy detection from transmitter or cyclostationary feature detection as one of the process of spectrum sensing. The sensing interface of cognitive radio which can also provide antenna based positioning using radiosensor. Radiosensor is the antenna based signal processing method which estimates the location information from the received signal statistics such as time of arrival (TOA), received signal strength (RSS), and angle of arrival (AOA) etc [4]. This

advance form of cognitive radio is an alternative to the location sensor in system shown in figure.2.

V. APPLICATIONS

The location based environment sensing system has variety of applications such as hallway monitoring, parking structure surveillance, railway and bus station premise, monitoring community place etc. The most effective application is to monitor and record activates near smart grid meter and smart grid substations. The smart meters are vital components of smart grid and could be easily altered if a hacker gets full access to its operation. It is mere impossible to monitor all smart grid substations and smart meters with the help of video surveillance and keep a track of intruders. With location based environment system installed it will sense and record physical presence near electric meter and can report the same using wireless interface. The presence of temperature and humidity sensor will detect accidental circumstances such as fire or water near the system. The cognitive radio not only will assure the secure data transmission over the network but also interference from other wireless sources minimizing wireless attacks on the system. The collective result of this will be ensuring minimal meter attacks and data alteration.

The security system data which will be transferred over the wireless network comprises of respective values from temperature, motion and humidity sensor and polynomial factors of speech signal received from microphone. The security center receives this data and reconstructs the received signal indicating spoken language and other received parameters. These parameters can be further transferred to a wireless handheld system if required. More advanced form of this system could be transferring voice activity directly on the walkie-talkie system. The other sensor parameters can be displayed on the tiny LCD screen of the walkie-talkie system as shown in figure 7.

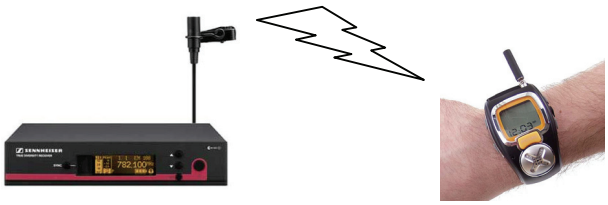

Figure.7 Peer to Peer communication using cognitive radio

VI. CONCLUSION

Location based security systems are essential to monitor ongoing activity in the environment. The CCTV camera systems are often used to monitor locations but are not completely reliable because of their visible presence. The advanced digital processing system provides speech and sound activity detection which could be a replacement for security cameras. In this paper, we proposed a security system model which shows functionality as a speech recognition security system. The use of different sensors on the system provides vital information about the environment. Using cognitive radio approach, the data is transferred over wireless network to centralized security monitoring system. The core application of this system is in smart grid security where security of smart meter and substations is of high importance. The advance form of the system can also invoke peer-to-peer communication with a walkie-talkie using cognitive radio approach.

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