Development of wireless sensor network (WSN) for remote monitoring of illegal cutting trees in forest

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Abstract
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Wireless sensor networks (WSNs) have been emerging as one of the most promising research areas in recent years and are widely recognized as powerful means for in situ observations of events and environments over long period of time. The wide spectrum of WSNs can offer application such as environment and habitat monitoring, healthcare applications, home or industrial automation and control, product quality monitoring and security purpose. Our necessary requirement to protect and maintain forest and environment application manually is very difficult. So, camera will be mounted above the tree level & capture the images and compare with previous image data base with full trees available. So, by using image processing pattern matching technique mismatching can be detected. The present pattern of trees will be matched with data base & if any changes detected then the illegal cutting of trees can be identified. The application works under low power requirements, establishing a wireless sensor network and routing protocol that connects the battery-powered sensors to a central server. From there, alerts are sent to control room if the application recognizes the sound of a chain saw cutting down a tree.

In order to achieve the large area coverage, wireless sensor network has to be used. The sound analysis and recognition is performed in this network. The sensor network "listens" to environment, records the sound by microphone and changes time domain to frequency domain by Fourier transform. Data provided by Fourier transform are still too large for being transferred to other parts of the network data about trees avaibility, recognizes the sound of a chain saw cutting down a trees.

I. INTRODUCTION

The scale of illegal cutting trees in forest is difficult to be accurately estimated, but more than half of all logging activity in the most vulnerable forest regions is believed to be conducted illegally. According to the estimates for the year 2006 it costs world governments at least 15 billion USD annually in lost revenue [1]. Despite the work of ecological movements, non-governmental organizations and existence of systems to track export timber products, there is currently no system employed that would provide *effective solution* to the problem of illegal cutting trees detection. As a result of analysis and comparison with existing systems to monitor logging activities (e.g. system based on reconnaissance satellites [2]) we have determined several imperfections of currently used systems. Main improvements of the system we have proposed are: fast reaction when logging occurs and permanent monitoring of critical areas in a forest. We have designed the system, using wireless sensor network for remote monitoring of illegal cutting trees in forest by that recognises and localizes the sound of illegal cutting activity. Wireless sensor networks to cover critical forest areas.

This paper is divided into six sections. Section **II** introduces several projects and systems related to segments of our project. Sections **III** and **IV** are dealing with sound analysis and wireless sensor networks with regard to the purposes of our project. Section 5 presents the presents the conceptual design and architecture of

Forest Monitoring. Section **VI** concludes the paper and presents possible benefits of Forest Guardian deployment.

II. RELATED WORK

Although the idea of monitoring the forest from illegal logging by the sound recognition is unique, we have recently encountered with a project called "*Forest Watcher," a monitoring system for preventing forest devastation* [3] which is closely related to our work. This project utilizes a sensor network of *Bluetooth* technology and its sensors consist not only of microphones. This network of up to 200 wireless sensors covers a forest area up to 200 hectares. We didn't find any employment of this system in commercial use yet.

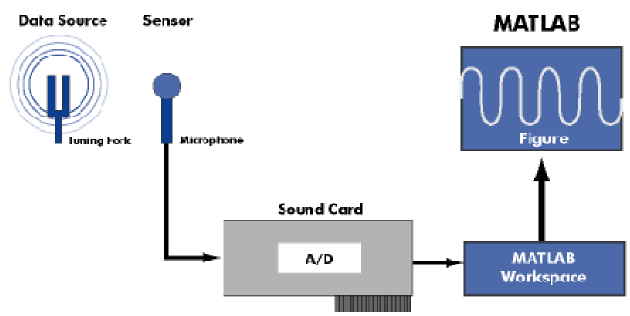
Automatic Sound Recognition for the Hearing Impaired [4] is one of many projects on scene using sound recognition as means for processing audio inputs. The authors design a system which helps hearing impaired persons by recognition of simple mechanical sounds such as doorbells,phones, teapots etc. All of these sounds have clear distinct spectral peaks. The authors develop a new method of recognition – normalized peak domination ratio (NPDR). This system can be integrated into as small device as a watch.

Another project – *Non-speech sound recognition with microphone array* [5] from Mitsubishi Research Institute – can identify seven types of sounds such as a bell ringing and hand clapping with an accuracy of 80% or higher. System uses a microphone array and conventional PC to

process audio input, perform sound recognition and even compute relative position of its source. Wireless sensor networks are widely used in various areas. Kay Romer and Friedman Mattern in [6] describe different custom made sensor network applications which are being used for research purposes in natural sciences like biology, meteorology, geology, medicine and monitoring purposes in everyday life, especially when time is an essential factor.

III. SOUND ANALYSIS

Every sound is composed of many frequencies, some of them with higher amplitudes than others. Footprint of amplitudes can be used to definitely identify source of sound, e.g. chainsaw or other logging machinery To achieve the effective sound recognition This document will describe some of the general usage of MATLAB's Data Ac-quisition Toolbox (DAT). The software in the toolbox allows MATLAB to acquire data from sensors and to send out electrical signals that can be used to control or drive external devices. We will be using this toolbox with two deferent pieces of hardware. One is the sound card built into your laptop, the microphone and speaker will serve as the data acquisition (and output) devices. The sound card provides convenience because it will allow you to test the DAT outside of the lab. We will also be using Measurement Computing data acquisition cards that will ¯t into your laptops PCMCIA slot, these devices will be in the class laboratory. The data acqui-sition (DAQ) cards allow your computer to acquire data from many different types of sensors. The documentation on the MATLAB web site provides a reasonable amount of information on the different commands in the toolkit. This tutorial will provide you an overview of some of the basics of data acquisition and show you how to use the toolkit. Much of the information used in this tutorial is translated from the MATLAB web-site, we have just distilled down some of the key points through a few simple examples. We are assuming that you are reading the MATLAB book and learning the basic operation of MATLAB. We will not explain the syntax of every MATLAB command. Also, you should read through the tutorial with your laptop next to you to test commands as you go. The focus of this tutorial is to provide examples that use your built in sound card: at the end we will show you how to use the PC DAQ cards as well.



To verify that the fundamental frequency for the hack saw is 440Hz, a tone is acquired and then analyzed in MATLAB. This is the setup for the example described below. For this example, we will verify that the fundamental (lowest) frequency of a hack saw is 440 Hz. To do this, we will use a microphone and a sound card to collect sound level data. Next, we will perform an FFT on the acquired data to find the frequency components of the hack saw. We begin by acquiring two seconds of sound level data on one sound card channel. Since the tuning fork vibrates at a nominal frequency of 440 Hz, the sound card sampling rate can be set to its lowest sampling rate of 8000 Hz. After we have set the tuning fork vibrating and placed it near the microphone, we will trigger the acquisition. The complete data acquisition session for the sound card is shown below.

Initialization

The first step is to create the analog input object (AI) for the sound card.

```
AI = analoginput('winsound');
```

Configuration

Next, we add a single channel to AI, and set the sample rate to 8000 Hz with an acquisition duration of 2 seconds:

```
addchannel(AI, 1);
Fs = 8000;            % Sample Rate is 8000 Hz
set (AI, 'SampleRate', Fs)
duration = 2;         % 2 second acquisition
set(AI, 'SamplesPerTrigger', duration*Fs);
```

Execution

Now, we are ready to start the acquisition. The default trigger behavior is to start collecting data as soon as the start command is issued. Before doing so, you should strike the tuning fork to begin supplying a tone to the microphone (whistling will work as well).

```
start(AI);
```

To retrieve all the data

```
data = getdata(AI);
```

Termination

The acquisition ends once all the data is acquired. To end the acquisition session, we can delete the AI object from the workspace:

```
delete(AI)
```

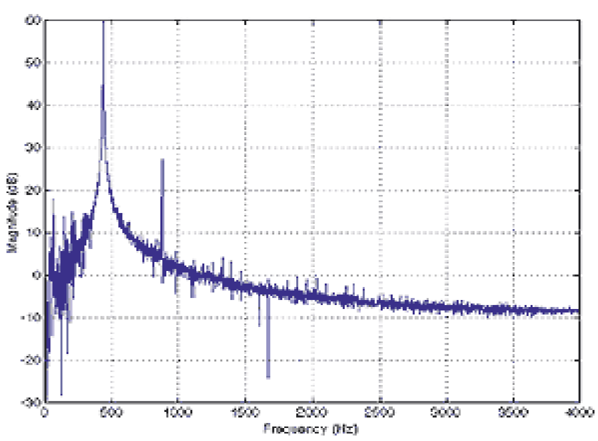
Results

Let's now determine the frequency components of the tuning fork and plot the results. First, we calculate the absolute value of the FFT of the data.

```
xfft = abs(fft(data));
```

Next we convert the absolute value into dB magnitude and extract the real frequency components:

```
mag = 20*log10(xfft);
```




```
mag = mag(1:end/2);
```

The results show the fundamental frequency to be around 440 Hz and the first overtone to be around 880 Hz. A simple way to find actual fundamental frequency is:

```
[ymax, maxindex]=max(mag);
```

The answer is 441 Hz.

Using Different Hardware

This example could also be repeated using different hardware by simply changing two lines of code. For example, if we were to use a National Instruments multifunction card then we could create the analog input object using:

```
AI=analoginput('nidaq','Dev1');
addchannel(AI,0)
```

Likewise, if we were to use a Measurement Computing board to acquire the data, the code would read:

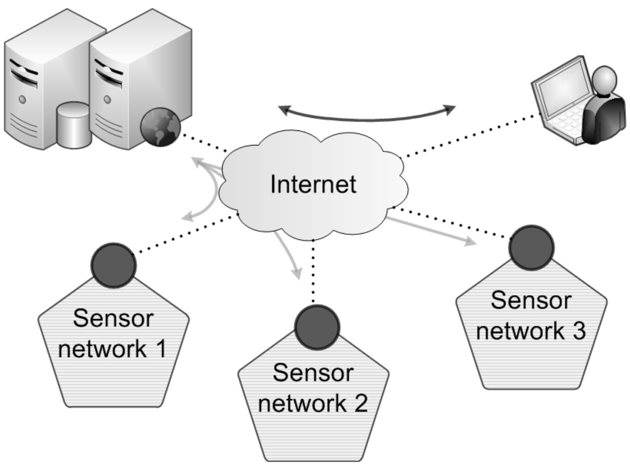
```
AI=analoginput('mcc',8);
addchannel(AI,1)
```

IV . Wireless sensor networks

The suitability of certain type of wireless communication is related to the purpose of the system as well as to the coverage area in which the system will operate. The term purpose accounts for requirements such as: data throughput required by an application, operating radio range, power consumption limitations of the system components, reliability, security and modularity of the system. Communication standards potentially applicable for our project are IEEE 802.11 (Wireless Local Area Networks) and IEEE 802.15 (Wireless Personal Area Networks). The IEEE 802.11 with its intention of being an alternative to IEEE 802.3 (Ethernet) offers many surplus features and its implementations are energy demanding and bandwidth consuming. The IEEE 802.15 standard specifies Bluetooth and IEEE 802.15.4 (Low-Rate WPANs) [7]. Bluetooth offers relatively high. The most suitable communication protocols are protocols based on the IEEE 802.15.4 specification: ZigBee [8] and MiWi. ZigBee as an open standard is supported by many vendors of radio transceivers. Despite the purpose of IEEE 802.15.4 of being a short-range protocol, the market offers many ZigBee compliant devices with communication range measured in kilometers [9, 10]. throughput but is not applicable for networks with high number of nodes (5)

V. FOREST MONITORING

The concept of the proposed system Forest Monitoring is as follows (see Figure 1): the system *permanently monitors* a forest via sensors recording the sounds of surrounding environment. Then, acquired sound samples are compared to the general samples of the logging tools (e.g. logging
machinery or chainsaws) in order to detect any logging activity. In case of detection of logging in monitored area Forest Guardian *immediately notifies* responsible personnel (via email, SMS etc.) so he/she can take direct actions to stop illegal logging. Any detected logging activities are visualized on an interactive map that is accessible through a web application. Forest Guardian is divided into three logical layers (see Figure 2): sensor networks, local aggregating points (LAPs) and central information system (CIS).



Central information system

The purpose of central information system is to collect and save messages from the lower layers (LAPs) through the Internet and visually represent logging activities on an interactive map. Applications, running on general purpose computers (data and web servers), constitute central information system. CIS is composed of two main parts

– *web application* running on web server and *Central database server*. *Web application* retrieves information about logging activities and other data from *Central database* and displays them appropriately on an interactive map. It provides the user with interfaces by graphically representing following information.

− At least these information about monitored areas: networks total coverage (map), location of LAPs (map), logging history of selected area (caption)

− Essential information about the list of LAPs: location, responsible personnel, time of last update

− Detailed information about selected LAP's sensor network components: list of connected devices with their location, battery status, logging activity, time of last update (list)

Web application is being implemented using Bing Maps, Microsoft Silver light 3 and .NET Framework 4.0 on Microsoft Windows platform. The most important data in the *Central database* are: logging's GPS coordinates varying with time, start date and time and intensity which depends on how many sensors detect logging
activity. Given the danger of potential misuse of detailed information available to CIS it is desirable to restrict the access to the system. *Public users* should be allowed to see only general information about logging activity displayed on the map. Detailed information will be made available to *privileged users* in order to enable subsystem maintenance and law enforcement supervision.

VI. Conclusions and further work

In this project we have phrased a problem regarding illegal cutting trees activities and described a monitoring system that we believe is capable of solving the problem of early detection. We have performed a thorough analysis of problematic area and existing systems designed to facilitate surveillance of logging activities. The results of this analysis led to the design of original solution.

. The possible spread of Forest Monitoring applications throughout the world would lead to better environmental sustainability through protecting of existing forests. Modular design of the system permits extension of system functionalities by adding new modules. The proposed architecture is universal and thus has a potential for usage in other applications (e.g. monitoring of large factory halls). We have verified the design by prototyping several respective parts of the system. Future work includes building functional prototype of the whole system and commencing a test run.

REFERENCES

[1] Brack D.: "Briefing Paper: Illegal Logging", Chatham House, 2006.

[2] Romer, K., Mattern, F.: The Design of Wireless Sensor Networks, *IEEE Wireless Communications*, 2004.

[3] Miroslav Babis, Maros Duricek, Valéria Harvanova, Martin Vojtko; " Forest Guardian – Monitoring System for Detecting Logging Activities Based on Sound RecognitionWireless Sensor Network".

[4] Awang, A. Suhaimi, M.H.; "A forest monitoring system using wireless sensor networks" *IEEE Explorer, ICIAS 2007*.

[5] I.-C. Yoo and D. Yook: Automatic Sound Recognition for the Hearing Impaired. In: *IEEE Transactions on Consumer Electronics*, Vol. 54, No. 4, NOVEMBER 2008, pp. 2029-2036.

[6] Mitsubishi Research Institute: Non-speech sound recognition with microphone array.
[Online; accessed January 2nd, 2011]. Available at:
http://tosa.mri.co.jp/sounddb/nospeech/system/indexe.htm.