Vibration & Noise Analysis System in Wireless Environment

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Abstract—In this research, we developed a ubiquitous computing platform that can analyze the vibration and noise in wireless environment by wireless LAN and sensors. In order to utilize the COTS(Commercial Off The Shelf) concept, we used a PDA that supports wireless LAN and serial communication as a main board. Following platform is used to measure the noise level of heavy construction equipments in a remote area.

Index Terms—wireless LAN, sensors, COTS, vibration and noise

1. INTRODUCTION

Wireless Communication System triggered the development of an ubiquitous system that receives lot of attention recently. The concepts of ubiquitous computing are now adjusted (cleared) by many researchers. However, it is still a long way to bring out the killer application that can expand the applications of the ubiquitous computing. The development of a ubiquitous application is still challenging and difficult task since the knowledge of ubiquitous environments is very limited. Therefore, it is important to increase the understanding of ubiquitous environment by developing a lot of ubiquitous applications. By this reason, the utilization of COTS (Commercial Off The Shelf) components can help and catalyze in building more ubiquitous applicable system in various application area. In this research, we developed a PDA-based ubiquitous applicable system that uses wireless LAN and the serial communication and applied the developed platform into measuring the level of noise of heavy construction equipments in ubiquitous environment.

2. THE STRUCTURE OF UBIQUITOUS COTS PLATFORM

This platform works by first, measuring the data at sensor module, then using the serial interface; the host PC will receive the data. Then using wireless LAN, data will transfer from the PDA to the server. Fig. 1 illustrates the system's entire structure. The data, which received from the sensor module, is sent to a PDA through RS-232C interface. This data is again forwarded to AP (Access Point) by using socket communication from a PDA that is connected by wireless LAN, and through the network which is connected by AP, the data will be sent to the host PC.

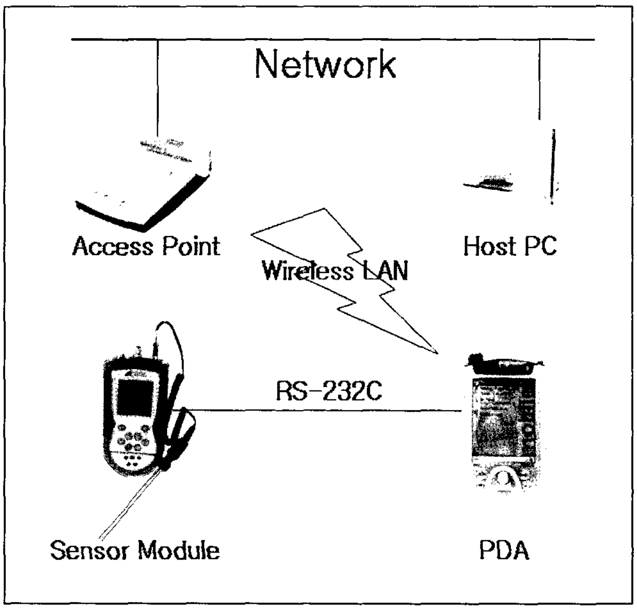

Fig.1 A block diagram of the proposed measurement system

In order to develop the platform, we used the digital multi-meter which can provide serial interface. PDA is able to support various measurement instruments that support serial interface. The data that has been read can be transferred between PDA and wireless LAN and connect to the socket communication, then PDA will transfer its data to the host PC. PDA and the host PC also installed an applicable program which is able to receive, send and generate data.

2.1 PDA Software

The PDA software receives the physical measurement through the sensor module and sends them to the host PC. In addition, it indicates the condition of current status of S/W. This program has four functions: connect, transfer, stop, and complete. First, in order for communication to work through the sensor module, the program connects and initializes the serial communication. The socket is created for the communication between the host PC and

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the PDA. Second, with the data that is received from the sensor module, it transfers to the host PC. One thing we need to be cautious is that it operates only after the connection is completed. Third, the stop function works when the program is trying to stop transferring the data from the sensor module transfers to a PDA and a PDA to the host PC. Here, it maintains the connection but it will only stop transferring the data. Fourth, this program safely disconnects the connection and turns off the program. Fig. 2 is the picture of a PDA's screen when the transfer button is pressed while program is still operating.

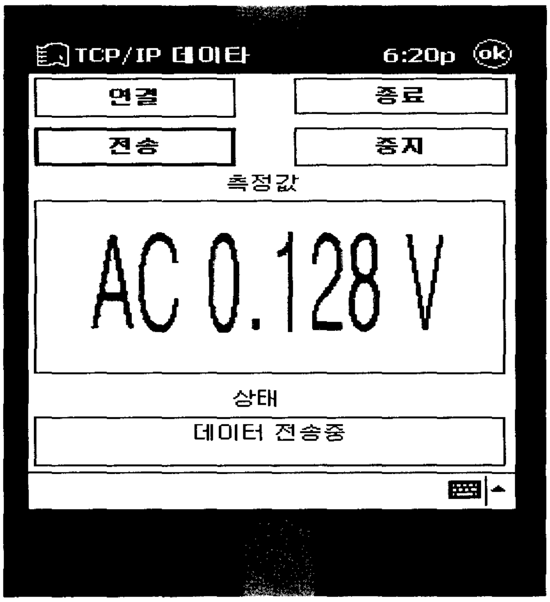

Fig. 2 The GUI of the PDA software

2.2 PDA Software Block Map

The Block diagram, as it shows on Figure 3, represents the relationship between inside movement and other peripheral equipments. In order to connect the sensor module, a PDA initializes the serial communication. Next, socket is created for the communication between the host PC and the PDA. And then it begins three threads; 1) a thread that receives the data from the sensor module, 2) a thread that sends the data to the host PC, and 3) a thread that receives the command from the host PC. When a PDA is turned off or the host PC commands the program to stop, above three threads end their works. Also, by removing the socket, it stops the communication from the host PC and by removing the serial communication, it disconnects the communication between the serial communication.

2.3 The Operation of the Host PC's Program

Initializing the serial communication and designating the port is the first step. DCB (Device Control Block) is the structure that contains the information about the serial communication that is from WIN32 API. DCB is created and initialized as 0. By the agreement of the sensor module's serial communication, DCB is set up. For instance, DCB sets up the transfer speed, start, stop bit, availability of parity check according to its equipment. Next, socket communication is initialized. With the host PC's IP address and its PORT number, it connects through the C/S process. After handling process is completed, the connection between different equipments is created. Next, two threads start to operate, receive and send the data. The rest will receive the command from the host PC and perform the Operations. If the command is from its own PDA or the host PC is end, then it will end the program.

2.4 The Operation of the Thread

First, the program will command the sensor module to transfer the measured data. A PDA sends the data by 1 byte and saves into buffer. It will receive the data by 1 byte each. Once receiving process is completed, a designated thread that is responsible for sending the data to the host PC will be commanded to copy the data and it will appear on the screen. Unless a thread receives the stop command, it will continually send the data to the sensor module. Fig. 3 shows the operation of the thread.

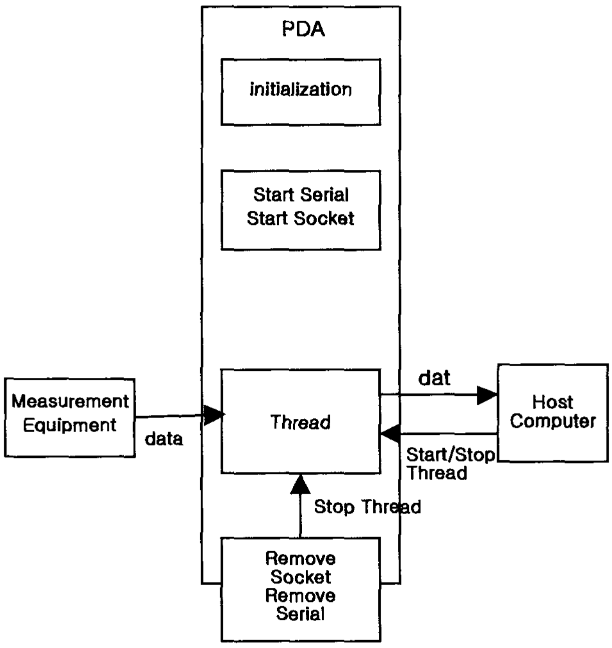

Fig. 3 Structure of PDA S/W

2.5 The Host PC Program

This program operates a PDA by providing the start and stop transfer. Start transfer will command a PDA to start sending the data and stop transfer will command a PDA to stop sending the data. When a PDA receives the start transfer command, then it will receive the data through the sensor module and send it to the host PC.

3. SOUND METER APPLICABLE SYSTEM

For sound measuring sensor, we used the Sound Level Meter (SLM). Figure 4 and 5 represent a PDA and the host PC when the sound measuring process is in completion. According to the figure, Int. Noise indicates the internal sound measurement, and Ext. Noise indicates the external sound measurement. 'Status: Finished' signal, which is right below these two noise indicator, represents that the measuring process is completed. The data that is received to the host PC will either be saved into the database, or it will constantly allow us to analyze the measurement with tools such as Shot Time Fourier Transform (Fig. 6).

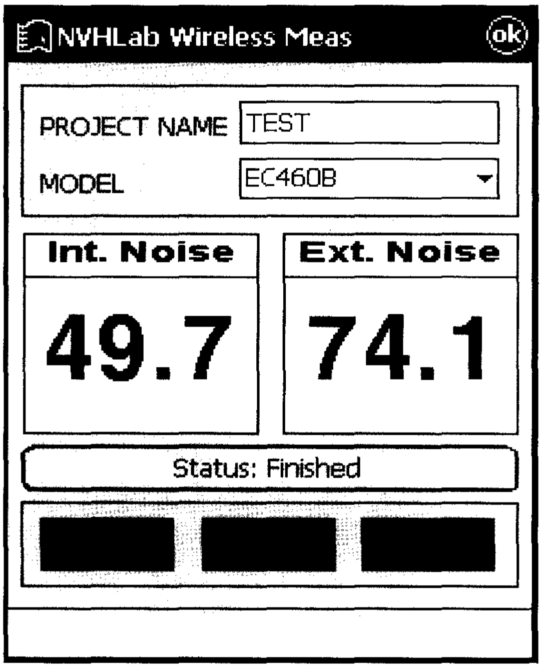

Fig. 4 The Noise Measure System on a PDA Screen

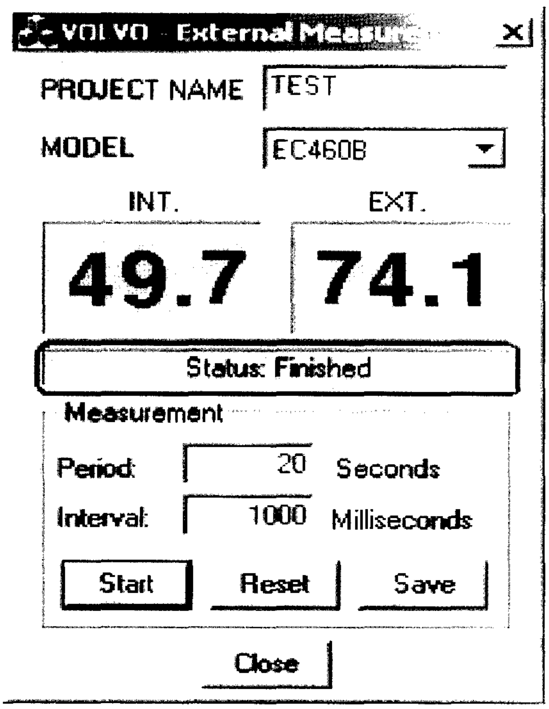

Fig. 5 The GUI of the host computer .

4. VIBRATION NOISE ANALYSIS SYSTEM

In this research, we embodied the Time-frequency analysis that is one way to represent the information of the signal according to its time and frequency. If we use the Time-frequency analysis, it will analyze FFT and CPB and then we will be able to look at the result instantly in 3D graph. Not only that, we can control the experimental condition in various ways by setting dialogue. The developed system provides four ways to analyze: 1) STFT (Short-Time Fourier Transform), 2) WVD (Wigner-Ville Distribution), 3) Gabor, 4) Scalogram. In setting dialogue, we can choose and analyze the time data, and its result can be saved through the project manager and it is also possible to analyze with other tools.

STFT is special format of a Fourier Transform where the time signal is multiplied with sliding window. The proposed system supports the sliding window such as Hanning, Hamming, Gauss, Blackman, Uniform, etc. and it also contains the special feature which the program analyzes the window's different noise bandwidth. The result of STFT represents a typical complex structure and in order to show this, this program uses RMS as a main function. In regards to the way of analyzing, the size of window determines the assumed result of resolution. The resolution of a given frequency is affected by the size of time data. Therefore, the resolution of a frequency of the small window size is not very good because the small window size can decrease the size of time data that is to be analyzed.

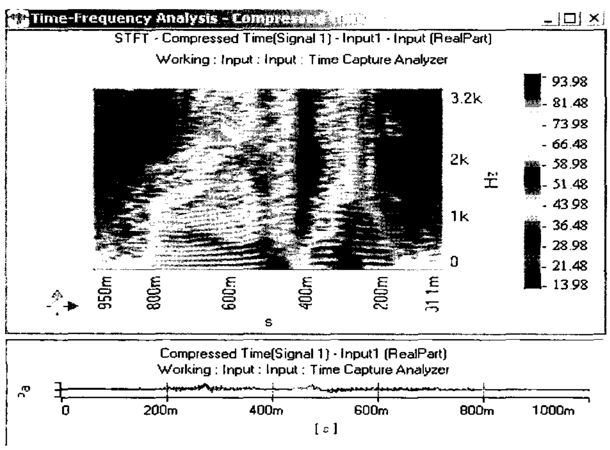

Fig. 6 The Measured Data's Shot Time Fourier Transform Result

As a fundamental analysis method, STFT is used in this research. The STFT is inputted the information such as the number of lines, the number of multi-buffer, and the types of the sliding buffer. Fig. 6 illustrates the experimental results of the STFT default analysis of the Compressed Time (signal1)-Input1 that is registered at the Compressed Time group among the time-frequency analysis project data. In the experiment, the size of the signal is 8192 and the number of liens is 200, and the number of multi-buffer is 100. The Hanning window was used as the sliding window, and the 8036 data was used in the actual experiment.

In order to decrease the redundancy in the STFT analysis, Gabor used the degree of over sampling. If the value of the degree of the over sampling is over 3, the smoothing value of the used sliding window increases and the redundancy reduces by using the windowing Fourier Transform.

Apart from the STFT and the Gabor representation, WVD distributes the energy of the signal at the time-frequency domain. WVD is a Fourier Transformation of the autocorrelation function of the signal related to the delay. In this method, the sliding window has the time-scaled, time-reserved value. Also, WVD is related to the frequency modulation, movement, group delay, and the smoothing characteristics of a given function. In general, the time-frequency analysis method uses the convolution of the WVD function and two-dimensional sliding function. The smoothing of the WVD implies the multiplication of the ambiguity function with the two-dimensional function called kernel. According to the intention of the analyst, we can have various types of kernel and distribution functions.

5. CONCLUSIONS AND FUTURE RESEARCH

In this research, we developed an ubiquitous computing platform that can analyze vibration and noise in wireless environment by wireless LAN and sensors which support the serial communication system. In order to utilize the COTS concept, we used a PDA that supports wireless LAN and serial communication as a main board. Following platform is used to measure the noise level of heavy construction equipments in a remote area. Currently, our laboratory is developing platforms that can adopt different sensors.

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