Design of ESN(Educational Sensor Network) for interpretation of the data

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Abstracts: - This paper has focused on the development of an educational sensor network (ESN) based on wireless sensor networks(WSN) and pervasive monitoring systems for students'activity during scientific experiments. A number of WSN systems have been proposed with integrated wireless transmission, mounted sensor boards and local processing. However, there is no trail to employ WSN on the educational field. In this paper, to facilitate research and development using wireless sensor network and multi-sensor data fusion, the educational sensor network (ESN) hardware development platform is presented. The ESN project is conducted over one semester time period (Spring Semesters). It involves approximately twenty middle school students who enrolled a gifted program in Kongju National University. Though under prepared, these students are in general highly motivated to learning specially when presented with the ESN project. An ESN project such as this is expected to provide an excellent means for teaching and learning scientific and mathematical principles.

key words : Wireless sensor networks (WSN), Educational Sensor Network (ESN)

1. Introduction

This paper aims to describe an educational sensor network (ESN) hardware development platform whose objective is to motivate students into scientific education. The program is sponsored by Remote MBL(Microprocess or Based Lab) Star-project Program and Leading Edge Teacher Program (LETP) at the Kongju National University, South Korea. This paper has focused on the development of an educational sensor network (ESN) based on wireless sensor networks(WSN) and pervasive monitoring systems for students'activity during scientific experiments. A number of WSN systems have been proposed with integrated wireless transmission, mounted sensor boards and local processing [1].

Commercial WSN systems are also becoming available. This far, most of the WSN hardware platforms are designed for network research, environment monitoring, medical data acquisition (such as ECG or EMG) or tracking applications, such as Berkeley's Mica2 and Telos, ETH's BTnodes, Intel's iMote and UCC's DSYS25 [2-5]. Although there are a number of context aware sensing platforms such as the SmartITs and the MITes [6] due to the integrated sensor design, the incorporation of physiological sensor will require major redesign on the hardware platform. However, there is no trail to employ WSN on the educational field. In this paper, to facilitate research and development using wireless sensor network and multi-sensor data fusion, the educational sensor network (ESN) ha rdware development platform is presented.

The ESN project is conducted over one semester time period (Spring Semesters). It involves approximately twenty middle school students who enrolled a gifted program in Kongju National University. Though under prepared, these students are in general highly motivated to learning specially when presented with the ESN project. An ESN project such as this is expected to provide an excellent means for teaching and learning scientific and mathematical principles [7-10]. The ESN project also contributes to the preparation of teachers who receive supports from the Kongju Nation University LETP project.

2. EDUCATIONAL OBJECTIVES

The educational objectives of the programs are:

.To motivate students into scientific learning through the utilization of an ESN (Educational Sensor Network) that can be carried by themselves in acceleration measurement experiments during human normal walking.

.To make the students familiar with the various wireless sensor network platforms and components (temperature and light sensors, acceleration sensors etc.) that comprise the ESN.

.To enhance the laboratory skills of students such as reading and understanding ubiquitous system, remote access and wireless sensor network systems. Also develop understanding of electronic IC components featured on an ESN board.

.To demonstrate the students methods of recording and interpretation of empirical data through WSN.

.To increase the likelihood of student participants pursuing degrees and building careers in engineering and scientific research. Formal and integrated evaluation surveys are being designed and implemented concerning students' attitudes and interest towards scientific research.

3. PROJECT DESCRIPTION

To make the ESN project successful, it must be well defined and planned properly. The first thing a student has to learn during the project every scientific activity has a goal and he has to react accordingly during the course of his research. They are also taught the importance of developing instruments and electronic modules to support a specific scientific investigation. During this project to make students familiar with real time data acquisition and analysis ific investisensor nodes,vewo accelerometers mc nted on estiaccompane dasensor boards with each node (call damote) are gation dato gather estihoronontal and vertical acceleration data during eters meleromc nted oe tudents acquisitionvtl nteered for this js . The project is designed so that data collected during walking will enable them to scientific inquiry regarding these concepts. The project consists of a series of stages similar to those encountered in an actual mission. The stages are:

- ESN Setup
- Walking Movement
- Real time data Monitoring and Recording
- Post-Walking movement Analysis

Teams consisting of 4 or 5 students completed each of the project stages. Each stage is described below.

ESN Setup

The project utilizes an integrated electronic platform that includes a number of sensors that provide information related to the forces acting on the mote itself during walking. The platform for the project was based upon a design provided by the Maxfor.[11] Throughout the project, the acceleration measurement of walking has been performed. The acceleration data tracked by each remote ESN mote are gathered through one or more motes connected with one or more personal computers, called the base stations. Each hardware platform consists of the following three components

1) MSP430 microcontroller
2) Chipcon CC2420 Radio communication protocol
3) The sensor board

MSP430 is a family of fairly cheap and feature-rich micro controllers from Texas Instruments (TI) Corporation. These microcontrollers are designed as Reduced Instruction Set Computers (RISC), which means they are small, cheap computers designed to perform simple specific tasks efficiently. The size and price of these controllers make them very suitable for this project, where the gait device should be small enough to be carried in your pocket or possible to attach to a leg without hampering normal walk in any way. For this project, the TIP710CM [11] has been used, which is an evaluation board equipped with a MSP430 micro controller (MSP430F16 11) and a whole series of other useful features, such as a 4Mbit data flash memory, a Real Time 32,768 Hz Clock oscillator, a Chipcon CC2420 ZigBee (IEEE801.15.4) communication IC, a boot-loader for programming port, and an acceleration sensor IC ADXL202. The ADXL202 is a low cost dual-axis accelerometer from Analog Devices capable of detecting acceleration up to ±2g (1g = 9.8 m/s^2), which should be sufficient for detecting normal walking. Theuse of accelerometers for walking is possible due to the re cent advances in this technology, which makes it more and more popular in technologies measuring tilt, shock and vibrations. The output from the ADXL202 is a digital signal whose duty cycles(another name for the signal’s pulse width) are proportional to the acceleration. The outputs from the accelerometers are converted into micro volts by the ADC of the evaluation board and are referred to as the “accelerationdata”. The ESN platform allows for sensor data to be sampled at regular intervals and converted to a digital form for storage. A major difference between this system and those used in actual practice is that data is stored in the platform's memory rather than being transmitted back to a base station via a ZigBee communication link. The platform design involves four sensors(x acceleration, y acceleration, ultra violet light, and temperature). Readings from the four sensors are recorded into the personal computers and stored during the walking movement of the ESN. These readings can then be downloaded into a spreadsheet on a personal computer to allow students to analyze them during the post walking movement analysis stage.

One accelerometer is mounted on the platform printed circuit boards to allow for the measurement of acceleration along two orthogonal axes as shown in Figure 1.

Two accelerometers are used to sense acceleration along the x and y axes, while an accelerometer measures acceleration along the z axis. The readings obtained from the x and y accelerometers are used primarily to yield a measure of how much vibration the ESN experiences during walking movement. Readings from the accelerometer are used primarily to help determine the height of the ESN during walking.

Figure 1 Coordinate System and Accelerometers

Walking Movement

Several teams of students having five members are formed and they carried out the walking experiment and recorded the data for post analysis.

Post-Walking Analysis

At the onset of the project, teachers provide students with sufficient instructions about the scientific principles of the project. In particular, students learn about the topics of force, gravity, drag, acceleration, velocity and position. Tutorial lessons are developed that discuss these terms and the principles before their use. After the acceleration data are recovered, the sensor platforms are removed from the ESN nodes. The platforms are then taken back to the high school for the initiation of the post-walking movement analysis. Data collected during the walking movement are transmitted into a personal computer connected with another ESN board that can receive the sensed acceleration data from the ESN board attached on the subject's foot. A java and tinyOS program is utilized to accomplish the transmitting and receiving of walking movement data. Once the data appear in the personal computer, mathematical analysis and scientific inquiry begins. The z-axis acceleration measurements are produced by an *ADXL202* accelerometer available from Analog Devices. Prior to walking movement the accelerometer is tested by measuring the acceleration produced by gravity alone. When this measurement is made, the students discover that the accelerometer produces a reading of 2.5 *volts* reflecting the presence of gravity. The students are provided an equation that allows them to relate the voltage produced by the accelerometer (V) and the acceleration of the ESN (A) measured in *g*unitsusing a constant *(K)* associated with the commercial accelerometer.

$$V = A * K + 2.5 \qquad (1)$$

For the ADXLl50 accelerometer, the value for the constant (K) is0.039 *volts/g.* By incorporating this value and manipulating the equation, students can derive the relationship. Using the equation along with the measurements produced by the z-axis accelerometer, students are able to produce an acceleration graph with data unit conversion similar to that shown in Figure 2, 3 and 4.

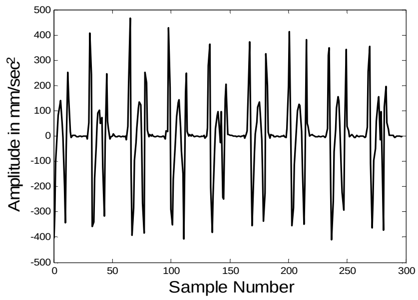

Figure 2 Plot of acceleration along x-Axis

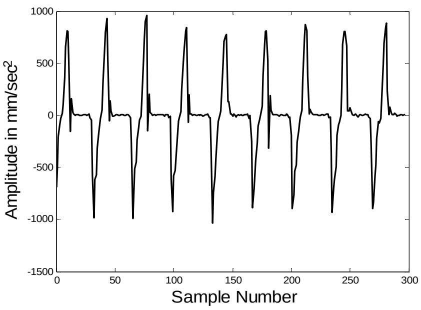

Figure 3 Plot of acceleration along y-Axis

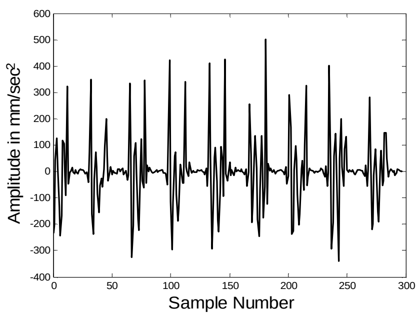

Figure 4 Plot of Acceleration along z-Axis

Students readily recognize the ascent and descent phases of the walking movement through qualitative interpretation of the plot knowing the amount of time between time marks. Thus students can calculate the relative timing of events. By examining the plots, students can estimate the period of rotation and consequently the roll rate. Students are introduced to the concept of statistical averaging to obtain improved estimates of the roll rate.

4. CONCLUSIONS

The planning and conduction of this project has involved faculties from the Colleges of Engineering and Education of Kongju National University. One pre-service and three in-service teachers are participating in the project. Students from the gifted education program have been selected for the project. Conducting the student ESN project with classes at different levels will give insight into the effectiveness of the project based on the level of educational background. Based upon the assessment results of the accelerations experiments, plans for the student ESN project are to be modified so that it can serve as an activity in the Star Project Program to be conducted at the Kongju National University during the Spring 2007 Semester.

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