Sensor Board for Wireless Sensor Networks

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August, 2011
Goal

Present a Open-Source Hardware platform which is used in Wireless Sensor Networks applications. Furthermore, present a research project for the Politecnico di Torino, where it was developed a software interface to drive the OSHW in order to monitor and correct the movements of an athlete.
Outline

1. Introduction
   - Open-Source Hardware
   - Wireless Sensor Networks

2. Sensor Board
   - Arduino
   - Waspmote Libelium
   - Applications

3. Politecnico Thesis Project
   - Objectives
   - Description
   - Results

4. Conclusions
Open source hardware, also known as OSHW, consists of physical platforms and designs which are treated and offered in the same way as free/open-source software (FOSS). Where generally:

- The logical design is shared.
- The hardware description language (HDL) is shared.
- The software that drives the hardware is shared.

Some examples of OSHW platforms are:

- *The Arduino*.
- The Aurora 224: a 2 channel open source DJ mixer.
- The Milkymist One interactive VJ station.
A WSN consists of low power autonomous sensors nodes, generally randomly deployed to monitor, measure and gather environmental information.

Nodes are equipped with a radio interface to transmit the sensed data to a more powerful node.

Nodes critical constraint is its battery power supply, therefore solutions to reduce power consumption has become an important research goal.

WSNs self-organizing capabilities has required collaboration and coordination among sensors by means of multi-hop routing algorithms.
“Arduino is an open-source single-board microcontroller, designed to make the process of using electronics in multidisciplinary projects more accessible.”

- In 2005 the first idea of Arduino was developed in Ivrea, Italy.
- The Arduino project started as a master’s thesis at the Interaction Design Institute Ivrea, with the support and supervision of founders Massimo Banzi and David Cuartielles.
- Today, more that 120,000 boards have been shipped.

* Arduino, Wikipedia.
Description

**Hardware**
- 8-bit Atmel AVR microcontroller.
- Programmed over an RS-232 serial connection or USB.
- On-board I/O support.

**Software**
- The Arduino IDE is a cross-platform application written in Java.
- The IDE is written in C/C++.
Libelium company goal: "Libelium designs and manufactures hardware technology for the implementation of wireless sensor networks and mesh networks so that system integrators, engineering and consultancy companies can implement reliable solutions to end users within the minimum time to market." The main lines of development and research are:

- **Waspmote**: low consumption sensor device for the creation of wireless sensor networks that integrates more than 50 different sensors.

- **Meshlium**: the only multi-tech router integrating Wifi mesh (2.4GHz - 5GHz), ZigBee, GPRS, GPS and Bluetooth technologies in a single unit.

Based on the hardware and software of the *Arduino* board.

Developed as a modular architecture, to integrate the modules needed in each device.

Communication module based on 802.15.4 protocol.

GSM/GPRS and GPS modules.

Sensor modules.
Libelium presents three different types of open hardware sensor modules:

- Gases board
- Event detection board
- Prototyping board

Also it includes a receiver gateway, which acts as a data bridge or access point. This device collects the data that flows in the sensor network into a computer.
Applications

**Smart Agriculture**

- Monitor cultivations combining sensors such as temperature, humidity, soil moisture and atmospheric pressure, among others.
- Control environmental conditions and prevent possible plant diseases or watering requirements.
- Wireless system to collect information and send data to a higher analysis.
Contamination Control

- Respiratory problems are growing as the pollution grows; degrading the quality of life.
- Waspmote sensors monitors atmospheric contamination levels and gathers climate-related data.
- Monitoring air pollution with Waspmote is simple and cost effective.
**eHealth: 24 hour care**

- Real time control and monitor of patients.
- Waspmote can include sensors for measuring biometric parameters, capable of detecting heartbeats, breathing rates and movements, among others.
- Furthermore can control environmental patients surroundings.

Other applications include: production control, logistics services, non-invasive marketing and meter reading.
Body Sensor Networks (BSNs) for health monitoring has garnered lots of attention in the scientific community and the industry during the last years.

The design and development of wearable biosensor systems to measure athletes performance is still an open research issue.
Body Sensor Network project (2)

- The objective of the master’s thesis “Analisi e Progetto di una Body Sensor Network per applicazioni sportive”, is to develop a system to monitor and analyze the technical movements of an athlete in the volleyball ambit.
- The thesis was designed using the sensor board Waspmote, an open-source hardware and software from the Libelium company.
The project use of the board Waspmote, acquiring data from the accelerometer sensor.

- Wireless communication using the standard protocol 802.15.4.
- Developing and including an API in the open-source software of the Waspmote interfaces.
- The device is attached to the back of the athlete by means of an elastic belt.
- The data from all the sensor nodes is sent to the computer for further analysis.
Identification of the fundamental phases of the block volleyball movement for the three axes: vertical, lateral and frontal.

Phases: Starting position, countermovement, push/detach and landing.
L'obiettivo più importante dell'atterraggio è prendere contatto con il suolo in maniera morbida, con il minor contraccolpo possibile a carico delle articolazioni. Per questo motivo gli avampiedi dovrebbero arrivare sul terreno per primi, seguite dalle ginocchia piegate in modo da assorbire il peso del corpo. L'indicazione ideale è quella di un atterraggio su due gambe.

Forza di impatto = peso atleta × altezza di caduta − altezza di ammortizzamento

Con ciò si vuole affermare che esiste una correlazione diretta fra l'altezza di ammortizzamento e la violenza dell'impatto sul suolo.

![Figura 4.7: Accelerazione Medio-Laterale per un muro con salto da fermo ideale.](image.png)

Analizzando le curve di accelerazione si può dedurre che:

- l'accelerazione verticale presenta inizialmente un picco molto alto (con possibilità di saturazione dell'accelerometro) dovuto all'improvvisa inizialità.
Conclusions

- New applications and advances have been proposed to improve patient care, promote wellbeing and study sport training. The objective of the master thesis is to provide feedback based on multidimensional physiological data collected from a body sensor network.

- The collection of the athlete data is done using a open-source hardware and software platform; which allows developers to have certain freedom in the design of the prototype.

- Nowadays developers and designers are preferring open-source. The Libelium company has based their designs in the Arduino board and has developed a high number of applications for Wireless Sensor Networks.
Thank you