The TECO Envboard: a Mobile Sensor Platform for Accurate Urban Sensing – and More

Matthias Budde, Matthias Berning, Mathias Busse, Takashi Miyaki and Michael Beigl
Karlsruhe Institute of Technology
TECO / Pervasive Computing Systems
Karlsruhe, Germany
Email: {lastname}@teco.edu

I. Introduction

Participatory Urban Sensing scenarios have increasingly been studied in the past years. At the same time, society's concern about the effects of pollutants on people's personal health as well as on the environment grew. This, in conjunction with studies that helped to give a better understanding of those effects, lead to new and stricter regulations and standards set up by governments. Such standards define limits for concentrations which should or may not be exceeded. There are usually several of such maximum permissible values for different pollutants, and they may differ from country to country. As a result, we see the need for ways to take accurate, fine-grained and mobile measurements, e.g in order to identify hot spots or monitor people at risk. Standard fixed measuring methods are not suitable for such scenarios. This demo presents a generic platform for such measurements – the TECO Envboard.

The Envboard is an environmental sensing platform for research and development purposes. It carries a variety of COTS sensors, ranging from weather sensors like temperature and humidity to sensors for gas concentration and particulate matter. The Envboard is operated from an integrated battery or a standard USB-micro connector supplying 5V, which is also used for recharging. It can be used in a stand-alone fashion as well as in conjunction with a host device – e.g. an Android™ phone – to which it connects via bluetooth. Sampling of the built-in sensors can either be triggered via the command API, or the Envboard can be configured to sample periodically and send the values via bluetooth or store them on the integrated microSD card for later readout.

II. Related Work

Mobile phone based urban sensing is done in the UCLA project *peir* [1], [2], which is short for *personal environmental impact report*. This project aims at sharing "how you impact the environment and how the environment impacts you". However, the exposure is not directly measured, but calculated based on a variety of parameters such as the closeness to known hazardous conditions or sites, as for example freeways.

The project *inAir* [3] presented a tool to measure, visualize and share indoor air quality through a specifically developed device. While this aims at assessing the environmental conditions locally, the project *Common Sense* [4] featured a similar device was developed as a handheld air quality monitor, but with a focus on outdoor participatory urban sensing. There it was already stated that – while it would be desirable that the necessary sensors are eventually incorporated into cellphones – today there is still the need for dedicated measurement devices. This is especially true when using rather large sensors such as the GP2Y1010 dust sensor (see below). The incorporation of this particulate matter sensor is one of the key differences between the *Common Sense* handheld device and the TECO Envboard. Others include the addition of custom circuitry to sense noise pollution and the potential to use a multitude of vibration and orientation sensors to recognize activities or rate and possibly correct the sensed environmental data based on the sensing context.

III. System Design

At the heart of the Envboard is an *ATmega 2561* microcontroller, which was mainly chosen for two reasons: First, it offers a sufficient number of input pins for the variety of sensors the Envboard carries. Second, since the Envboard is intended as a research and development tool that should allow

Fig. 1. The TECO Envboard.

Fig. 2. Different modes of application.

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TABLE I
SENSORS AVAILABLE ON THE TECO ENVBOARD.

	sensor	phenomenon
digital	SHT-21	temperature
		humidity
	MPL115A	atmospheric pressure
	iAQ-Engine	VOC (indirect: CO_2)
	ADXL345	3D acceleration
analog	WM-61A	noise level (dBA)
	GP2Y1010	particulate matter
	TEPT5700b	ambient light
	AlGaN-TO18	UV light
	MICS 2614	O_3
	MICS 4514	CO
		NO_x
optional	HMC5883	3D gyroscope
	ITG-3200	3D magnetometer
	MVS0608.02	motion/microvibration
	TGS4161	CO_2
	NTC thermistor	temperature (for compensation)
	GPS module	global postion

for easy modification, a MCU that can be programmed using the Arduino language and IDE seemed to be a sensible choice.

On the communication side, the Envboard is outfitted with a *Bluegiga WT12* bluetooth transceiver for wireless transmission. Alternatively, the device can be configured to communicate in the same fashion through its serial USB interface. As an alternative to directly sending out the measured data, it can be stored on an inserted microSD card.

Table I shows the different sensors that are incorporated into the Envboard. These are all commercial off-the-shelf components (COTS). Some sensors are optional and can easily be added, because footprints or connectors are already in place. They just were not populated in the demonstrated revision because the research focus lying on environmental sensing.

The protocol that is used to interface with the TECO Envboard is based on the *Firmata* protocol [5]. It can be used to request the Envboard's status and configure its parameters. This can be anything from setting the desired mode of operation (stand-alone-measurement, periodical, queried or mixed) or parameters such as the system time or individual sampling intervals over (de)activating sensors to adjusting calibration data.

IV. APPLICATIONS

1) Urban/Participatory Sensing: Urban City Sensing approaches have been proposed in the past to create noise pollution maps of urban areas. [6], [7] The Envboard can serve as a platform for mobile measurements that supply the data for these kinds of maps as well as research platform for the development of new algorithms to create maps from sparse sampling. In addition to noise levels, the Envboard allows the measurement of various gases as well as particulate matter which could allow multimodal maps incorporating various pollutants in order to map hazardous areas and mark pollution hot spots. While it is expected that the accuracy using simple devices is lower than that which can be achieved using expensive stationary equipment, mobile measurements would allow for a much higher spatial and temporal resolution. Also, if the measurement equipment is cheap enough, such devices could e.g. allow developing countries to erect inexpensive air quality measurement grids.

2) Personal/Life Log: Both the individual exposure to potentially hazardous conditions as well as the susceptibility to negative health effects vary from person to person. [8] As a result, the need for fine-grained mobile measurements in order to monitor people at risk arises. Similar to the kind of devices which people carry in nuclear facilities in order to measure and record their occupational exposure to radioactivity, the Envboard could be applied in potentially hazardous environments such as factories, chemical plants, coal mines or woodworking shops. Also, people who know of their higher-than-usual susceptibility to certain environmental conditions could use a device like the Envboard as personal warning system or exposure log.

3) Activity/Situation Recognition: The Envboard could be used as research platform for activity/situation recognition, sensor fusion or pedestrian dead reckoning. Through the variety of sensors, potentially more aspects of a situation or activity can be captured. This could result in a finer distinction between classes or the ability to detect novel ones. In addition, the environmental sensors could be used to warn the user from continuing to carry out certain activities in case the environmental sensors indicate especially harmful conditions.

V. CONCLUSION AND FUTURE WORK

The TECO Envboard is a research and development platform suitable for various application scenarios, e.g. as an easy to use data source for the investigation of higher level algorithms. It is currently used to investigate different research questions. One of them is to examine the suitability of commodity dust sensors for particulate matter measurement. [9]

The Envboard will be further used as a research and development platform. Specifically, methods to increase the accuracy as well as different sensors for future generations are currently being studied.

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