An Integrated Environmental Monitor

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Abstract: More and more pollutions have been made since the Industrial Revolution occurred in the late 18th century, and these environmental problems are not confronted seriously until the previous century. In recent years, people face these problems and start to pay attention on monitoring our living environment by self. Simple and practical instruments are required in measuring environmental parameters and pollutions. In this purpose, we developed an integrated environmental monitor (IEM), based on Arduino platform. This monitor is composed by several sensors, includes measurement of temperature, humidity, atmospheric pressure, air quality, sound strength, solar ultraviolet (UV) radiation, etc. All sensors are modular, which means these sensors could be added/removed depending on different requirements. A GPS receiver is also build-in to get real time and position, and all the observed data are recorded on a SD card. The advantages of this monitor are low-cost, low-power consumption, high accuracy, and multi-function. It's suitable for education and can be a good household environmental monitor in the future.

Keywords: environmental monitor, air quality, automatic weather station, Arduino.

1. Introduction

In the last century, scientific and industrial advancement changed human life dramatically. Accompanies with the progression of technology, a huge amount of natural resources, fossil fuels, and energy are consumed, environmental pollution and toxic chemicals become a major issue in the world at this situation. Therefore, people turn to attend to their living environments and try to protect the health and living quality. However, observing temperature and humidity is effortless by using a dry- and wet-bulb thermometer, but measuring other environmental parameters, such like noise and air quality, is much more difficult. Unattended and automatic recording is also required to help people monitor their living environment whole day.

In recent years, light, low-cost, and high-performance electronic devices have been developed, people can use these portable and beneficial devices to improve their living quality. The revolution in electronic device also provides a good opportunity for people to measure environmental parameters. Nowadays, it's possible to attend and try to protect our environment by using consumer electronics products.

In this paper, we present an environmental monitoring system with several advantages, include low-cost, low-power consumption, high accuracy, etc. This monitor is a modular system, it's able to customize for any purpose and also suitable for environmental education.

2. System Configuration and Operation

The present integrated environmental monitor (IEM) is based on Arduino electronics platform, which is an open-source micro-controller with high performance and low-power consumption. Environmental sensors, data storage, and display units could be integrated into Arduino platform. All sensors and units are self-governing and modular, customized designs are available by adding or removing sensors/units depending on different requirements. The programmable micro-controller provides customized sampling and data rate, and some calculations and unit conversions could be done immediately.

Most of sensors which follow one of the protocols, such like 1-wire, I^2C (Inter-Integrated Circuit), SPI (Serial Peripheral Interface), are compatible with Arduino and could be stacked/attached to the present IEM. This system uses a 5 volts DC power via USB port, in other word the power can supply from the USB port of a computer or an AC/DC adapter. External battery or power bank are also acceptable to power this system.

The dimension of the present IEM is quite small and can be contained in a 20 * 10 *10 cm^3 box, and the total weight does not exceed 500 grams (includes battery which could power this IEM more than 1 day). This portable size fits for hand-held box, handbag, backpack, etc., and could be transported to any place to observe environmental parameters. An illustration of this system is shown in Figure 1.

Figure 1. The present IEM could be stored in a hand-held box. Two fans are installed to maintain airy condition.

In the following sections, we show two applications of the present IEM. These two applications have different configurations both in hardware and firmware, i.e., the sensors and program codes used in these two are different. Three sets of the present IEM have been tested. The IEM (#1) in the first application is constructed by a universal air quality sensor to measure air quality, and we set a sampling rate of 1 sample per minute. In the second application, some meteorological sensors are attached to the IEMs (#1, #2, and #3) to observe meteorological parameters during a rainy day and the influence of a typhoon, sampling rate is set to 1 sample per 10 seconds to record both short- and long-period variations. GPS receiver has also been build-in to get real time and position information. All the observed data were recorded on SD cards.

The present IEM is an easy-to-use system, two university students who have no experience in electronics and micro-controllers participated in the test of this system. Two IEMs (#1 and #2) were placed in students' dormitory rooms at National Central University (NCU), and the other one (#3) was placed at Changhua, about 150 km away from NCU. All the instruments were installed indoor with airy condition, and kept powered on 24 hours.

3. Applied Example 1 – Air Quality

In this case, an air quality sensor is attached to IEM to measure pernicious gases. The output of this sensor is a numerical air quality index (AQI), indicates how polluted the air is. Higher/lower index indicates worse/better air quality.

Figure 2 shows an example of air quality measurement, which the IEM was sited in a university dormitory influenced by biogas from neighbor drains. Biogas is a mixture of different gases, such like methane (CH_4), carbon dioxide (CO_2), Nitrogen N_2, and toxic gas as hydrogen sulfide (H_2S). Hydrogen sulfide is very poisonous and corrosive (World Health Organization, 2003), which may harm health and safety.

In Figure 2, the AQI remains higher values during nighttime, and trends to lower values during daytime. After sunrise, the atmosphere becomes unstable as solar heating increase, strong and gusty winds are more likely to occur (Ahrens and Henson, 2015). The hydrogen sulfide produced from drains will be blown away from its source region while the weather is windy. Therefore, the AQI lowers as the concentration of hydrogen sulfide decreases during daytime, and then heightens during nighttime.

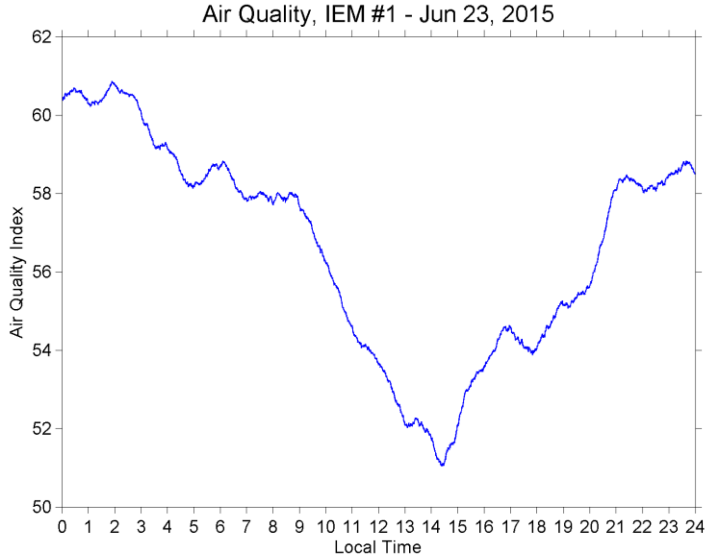

Figure 2. The measurement of air quality.

4. Applied Example 2 – Automatic Weather Station (AWS)

The present IEM is also sufficient for weather observations. In this section, we show two examinations of meteorological behavior. The attached sensors are thermometer, hygrometer, barometer, etc.

4.1 Humidity

People feels most comfortable while the relative humidity (RH) is in the range of 50% – 60% ("Relative humidity," n.d.). In this section, we try to find a quite uncomfortable room which was reported by residents in a university dormitory, and the IEM (#2) was prepared as an AWS and installed during rainy days.

Figure 3 shows the observed temperature, RH, and corresponding mixing ratio (which means the mass ratio of water vapor in day air) on May 24, when the weather was influenced by Mei-yu front whole day. Since the indoor temperature is nearly the same as outdoor temperature (figure is not shown here), and the air was moist because of raining, the indoor RH maintained very high values, exceed 90%. The residents in the dormitory reported that it was a humid day, consistent with the high humidity observed by the IEM.

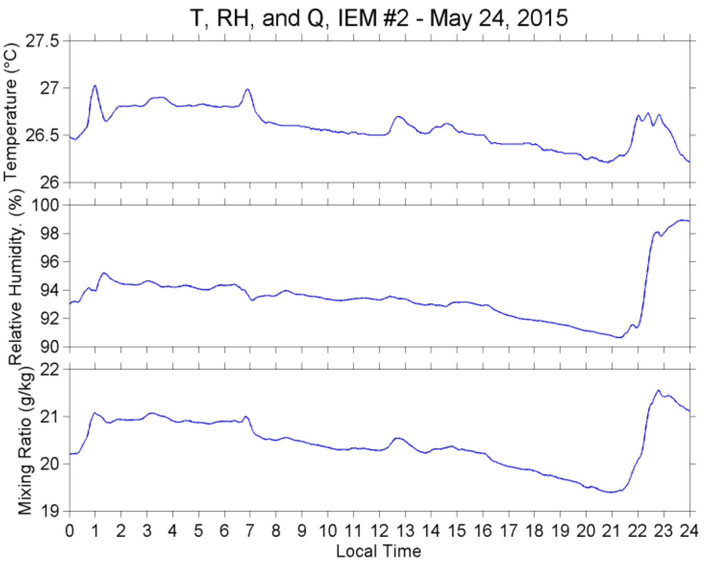

Figure 3. The observed temperature (top), relative humidity (middle), and corresponding mixing ratio (bottom), respectively.

4.2 Atmospheric Pressure

Figure 4 shows the examples of barometric pressure measurement. The Typhoon SOUDELOR influenced Taiwan from August 6 – 9. Two IEMs were set at different positions to observe the barometric variations during the passage of this typhoon.

IEM #3 was sited at Changhua during typhoon. The observed lowest mean sea level pressure (MSLP) is about 959 hPa while the center of typhoon is located 20 km away from this site in the morning of Aug 8 (blue line in Figure 4a). The surface observations at Taichung Weather Station operated by Central Weather Bureau, Taiwan are used to validate the data observed by the IEM (red line in Figure 4a). Although Taichung Weather Station is 20 km farther from the center of Typhoon than Changhua is, the barometric trends of these two are similar within 4 hPa difference in values.

Another comparison is shown in Figure 4b. The second set of the IEMs (#1) was sited at NCU, and the observed data at Sinwu Weather Station, Taoyuan are used to validate the IEM data. These two locations are neighbor and much farther away from the center of typhoon, and the MSLP measurements are almost the same.

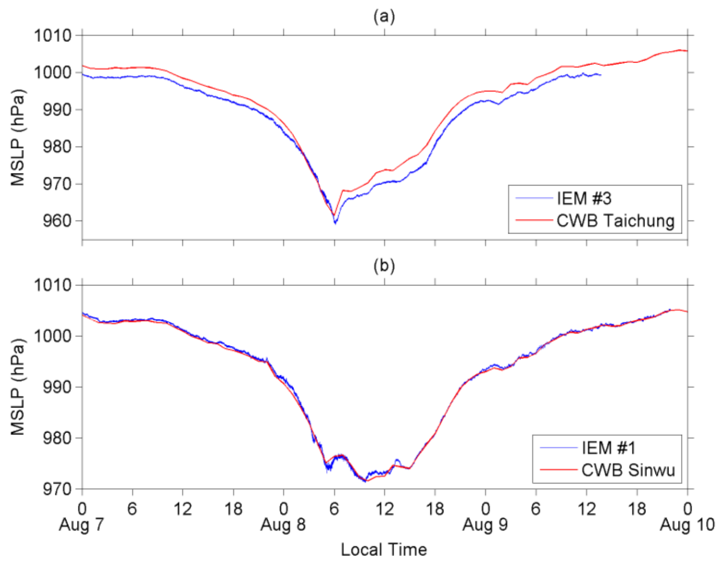

Figure 4. (a) The barometric pressure observed by the IEM at Changhua (blue) and the comparison observed by neighbor weather station at Taichung (red). (b) Similar to (a) but the IEM placed at NCU and compared with weather station at Sinwu.

5. Summary

In this paper, we present an integrated environmental monitor (IEM) used to measure environmental parameters, include temperature, humidity, atmospheric pressure, and some factors of pollution, such like air quality. The present IEM is quite stable for continuous observation, and the performance and observational results are satisfied, as discussed in Sections 3 and 4. This system is suitable for people who have no experience in electronics and could be used in environmental education.

Acknowledgement

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Reference

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