WEARABLE REAL-TIME ENVIRONMENT MONITORING SYSTEM

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***Abstract* - In this paper, we have presented a system which is capable of monitoring the environment quality by measuring the various factors affecting the environment using an array of sensors which transmit the dynamic data wirelessly. It is a wearable electronic device that consists of a Wireless Sensor Network (WSN) that can collect parameters of the environment such as humidity and temperature along with the major pollutants of environment such as oxides of carbon (COx), suspended particulate matter (SPM like PM2.5, PM10), etc. Along with these major parameters, UV radiation is also measured. These parameters are then transmitted through a Bluetooth module which uses Gaussian Frequency Shift Keying (GFSK) modulation scheme. It allows the updation of measured values as soon as it is measured. The existing models of the environment monitoring system are fixed or portable. This paper is useful in indicating the level of environmental parameters and the effect of change in composition of medicines, to be consumed by human beings, due to exposure to these pollutants.**

Keywords – Wireless Sensor network, Wearable, Bluetooth module, Environmental parameters.

INTRODUCTION

Air pollution causes major health issues in human beings. Breathing polluted air leads to high risk of asthma and other respiratory diseases. The air pollutants are generally carcinogenic and causes cancer. Coughing and wheezing are commonly seen in people residing in polluted areas. Higher level of suspended particulate matter leads to heart problems. The air pollutants cause around seven million deaths world-wide. UV rays affects the environment in several ways. The total light from the sun consists of 10% of UV rays. It is an electromagnetic radiation having wavelength in between x-rays and visible light. It causes irritation, rashes and even skin cancer in humans.

The major pollutants in air are oxides of carbon (CO_x), oxides of nitrogen (NO_x), ozone (O_3), Suspended Particulate Matter (SPM – PM2.5, PM10) and various hydrocarbons. These affect the well-being of all humans, plants and animals. These pollutants cause acid rain which in turn weakens leaves, reduces nutrients in soil and poisons them by releasing toxic substances into the soil. It also reduces the ability of the plants to perform photosynthesis. It threatens the animal's habitats and pushes them to the extent of extension. It also affects the quality of food supply.

The exposure to UV rays causes adverse effects in people consuming photo sensitive drugs. The variations in temperature and humidity changes the physical and chemical composition of the drugs or medicines. Exposure to high levels of carbon dioxide causes sleep disorders and breathing disorders. Inhalation of SPM at higher concentration causes breathing disorder and dust allergy in people.

The wearable device serves the purpose of indicating the levels of the environmental parameters and generating alerts if the parameters reach the harmful levels. The concentration of pollutants in the environment is measured by the sensors and compared with the standards specified by the Central Pollution Control Board. The alerts are displayed in the form of LEDs in the wearable device or pop-up messages in the mobile phone.

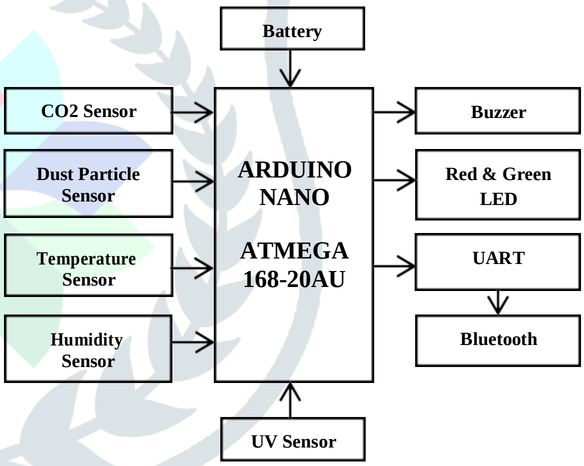
BACKGROUND AND RATIONALE OF THIS WORK

Environment pollution has been a major concern in the past years. The method for measuring the pollutants has improved over the years – from large fixed stations to small portable units. The initial fixed stations were set up near industrial areas to measure the extent of pollution the industries caused to the environment. Since these fixed stations were large, they can't be set up at every location and the equipment in the fixed stations were costly and required accurate calibration to produce accurate outputs. Though fixed stations provided higher accuracy than smaller portable units, the portable units provided mobility and the ability to be set up at multiple places without much expense. The portable units had the ability to connect with other devices or internet using GSM or Bluetooth. This was helpful in setting up a full network to monitor the pollutants. Even then the portable units were very costly to be used domestically or personally. Therefore, we have proposed a wearable device which measures crucial parameters which is useful for domestic or personal uses.

The earlier models of portable systems used a variety of sensors which could detect greenhouse gases, ultraviolet, etc. and transmit the values via Bluetooth or GSM. Initially, A metropolitan air pollution sensing system that describes a low-cost sensing system that uses a network of sensors which connects with a smartphone using Bluetooth and involves cloud computing, and mobile apps to measure, model, and personalize air pollution information for individuals [1] was developed. Later, Air Quality Monitoring System Based on ISO/IEC/IEEE 21451 Standards describes an Air Quality Monitoring System (AQMS) with the help of GSM wireless communication module which is capable of real-time measurement of greenhouse gases like CO2, CO, NO2, and SO2 [2] was developed. In addition to this, High-sensitivity ambient PM2.5 particle detector which measures the concentration of PM2.5 particles in the environment were adaptively applied to intelligent air quality monitoring devices [3]. The Ultraviolet light intensity monitor described in [4] can be used in personally wearable devices for measuring and monitoring UV light intensity. Environment Monitoring in smart cities involve collecting, processing and distributing geo-referenced information about the influence of pollution and micro-climatic on the quality of life [5]. We have proposed a system which integrates all these former models to form an effective wearable device which uses a Wireless Sensor Network (WSN) of sensors such as Particulate matter or dust particle sensor, UV light sensor, temperature sensor, humidity sensor and carbon dioxide sensor. These are connected to a microcontroller which collects and accumulates the values and analyses it, to check whether the values have crossed the limits set by the pollution control authorities. It, then, generates alerts with the help of LEDs, which are also connected to the microcontroller along with the sensors. In addition to this, the values are also transmitted to a mobile phone via Bluetooth to viewed in a mobile application.

SYSTEM ARCHITECTURE

The basic block diagram of the system is depicted in figure(a).



Figure(a) Block Diagram

The block diagram depicts a Wireless Sensor Network (WSN) connected to the microcontroller – ATMEGA168-20AU. From the data from the WSN the concentration of pollutants in the environment can be presented to the user. Our sensor network measures the following parameters – Carbon dioxide (CO_2), PM2.5, Temperature, Humidity and Ultraviolet light intensity. All the components are fitted inside a small box to make it wearable.

A. Sensors and Communication platform

We have used the following sensors for the detection of the above-mentioned environmental parameters.

- MQ9 (Gas Sensor)
- GP2Y1010AU0F (Compact Optical Dust Sensor)
- LM35 (Temperature Sensor)
- HR202 (Humidity Sensor)
- GUVA-S12SD (UV Sensor)
- HC-05 (Bluetooth)

The gas sensor is used to measure oxides of carbon, specifically carbon dioxide. The concentration of carbon dioxide can be determined by the output voltage from the sensor. The output voltage increases as concentration increases. The optical dust sensor senses the dust particles with the help of an infrared emitting diode and a photoresistor. These are arranged diagonally within a device. This arrangement allows the detection of light reflected by the dust particles. The sensor output is an analog voltage which is proportional to the concentration of dust particles. The LM35 is a simple temperature sensor consisting of a thermistor. The output voltage is proportional to the temperature with a scale factor of .01V/^{0}C. The HR202 is a resistive type humidity sensor whose resistance changes with change with humidity. It measures relative humidity in the environment. The UV sensor detects UV-B with the wavelength of 240 – 370 nm. The output voltage of the sensor id directly proportional to the UV light intensity. These sensors are dedicated for the detection and measurement of the environmental parameters. The environmental parameters are collected and organized by the onboard micro controller ATMEGA168-20AU. The Bluetooth module HC-05 which uses Gaussian Frequency Shift Keying and transmits data serially to the mobile phone. All the specifications and features of these sensors are available online.

HR202

LM-35

MQ-9

Figure(b) Sensors

B. Air Quality Standards and Limits

In India, Air Quality Standards are defined by the Central Pollution Control Board (CPCB). These standards are widely used to determine the level of pollution in different areas. Apart from this, Humans can only tolerate exposure to harmful pollutants up to certain limits. The limits for our model are based on the tolerance level of humans. The detection limits of the sensors are:

- 200ppm for CO_2
- 20 to 95% RH for Humidity
- -55^{0}C to 150^{0}C for Temperature
- 240 to 370 nm for UV
- 1um< for Dust Particles

The threshold levels that are fixed for our model are:

- 2000ppm < for CO_2
- Based on UV Index
  1. 3 – 4: Low
  2. 5 – 6: Moderate
  3. 7 – 9: High
- 100 ug/m^3 < for Dust particles (based on Air Quality Index)

The threshold limits define the state of the LED – “GREEN” or “RED”. If the measured values are below threshold, LED glows “GREEN”. If the measured values are above threshold, LED glows “RED”.

EXPERIMENTAL RESULTS

The construction of the wearable device is made as per the block diagram. As the wearable node is switched on, the environmental parameters are detected and measured. The parameter values are received by the microcontroller and processed to check whether they have crossed the limit or not. The LEDs turned "RED" if the limits are exceeded, else the LEDs remained "GREEN". The parameter values are simultaneously transmitted to the mobile device using Bluetooth. The transmitted data is viewed in a mobile application which showed the sensor name and its corresponding value.

CONCLUSION

A wearable environment monitoring system was proposed for personal and domestic uses. All the sensors were combined to form a Wireless Sensor Network (WSN) and connected to Arduino Nano. The sensor detection and measurements were made and transmitted via Bluetooth to a mobile phone. The alerts were generated for indicating the abnormal levels using LEDs. Since exposure to UV is harmful for people consuming light sensitive drugs than normal healthy human, the indication provided by this device about UV exposure level helps in alerting the individual. Similarly, variations in temperature and humidity has major effects on the composition of medicines, our device alerts the user in such cases. In addition to this, Alerts were generated for high concentration of CO_2 and dust particles using LEDs. This model can be further used, along with automated systems which provides domestic ventilation or air conditioning.

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