Multi-Sensor Arduino Integration for PoC Applications

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***Abstract*—Microcontrollers are programmable, integrated circuit chips. Their applications extend to industrial instruments, vehicles, and household appliances such that microcontrollers are now the number-one selling electronic chip of all kinds. Simultaneously, the field of lab-on-a-chip research and technology has seen significant technological leaps towards sample handling, sample preparation, and sensing for use in molecular diagnostic devices. Yet, the transformation from a laboratory-based lab-on-a-chip technology to an actual point-of-care device products have largely been limited to a fraction of the foreseen potential microcontrollers. Arduino or Raspberry Pi has the potential to solve and even bridge the gap between lab-on-a-chip technology and real-life point of care applications. The profuse availability and extraordinary capabilities of microcontrollers, namely within computation, communication, and networking, combined with easy-to-use development environments prove to be very useful.**

***Index Terms*—Arduino, Microcontroller, Sensor, Bluetooth, Point of Care Device**

I. Introduction

Devices that can operate multiple tasks, from sample preparation to analysis, to fully integrated, sample-to-answer applications, operating on-site, in the form of so-called Point of Care (PoC) applications. PoC devices are defined as instruments that can perform an analytical or diagnostic test near the site of interest. The test itself should not only be quick but preferably also easy to perform, without the necessity of expensive or complicated equipment and without requiring a specifically trained technician. Microcontroller-based platforms, specifically Arduino boards, can be used in the field of PoC. The advantage of the Arduino platform is that it comes with three elements, which offer a complete solution for prototyping: the Arduino board (hardware), the Arduino software, and the documentation and learning resources.

	Point of Care Devices	Open-Source Microcontrollers (Arduino Platform)
Low cost	√	√
Easily accessible	√	√
Easy to use	√	√

Fig. 1. Advantages

In this project, we integrate three sensors namely: **Heart rate sensor, Humidity sensor (DHT11)**, and **Pressure Sensor (BMP280)**, with an Arduino board and send the data received to a mobile device using a **HC-05 Bluetooth module**. This could potentially be applied to any sort of sensor compatible with Arduino. The app was built using **Flutter** and uses the package **flutter_bluetooth_serial**, to receive the data sent from the Arduino.

A short description of the components used is as follows:

(i) ARDUINO:

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

Fig. 2. Arduino

(ii) HC-05 Bluetooth Module:

HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration. Bluetooth serial modules allow all serial enabled devices to communicate with each other using Bluetooth.

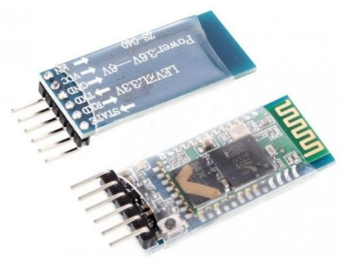

Fig. 3. HC-05 Bluetooth Module

(iii) Heart Rate Sensor:

This sensor module is provided with the transmitter and receiver leds. The light-absorbing property of Hemoglobin is used in the measurement of heart rate. Light from a green LED on the underside of the monitor is shone on blood vessels just under the skin. The light that is not absorbed but reflected back is captured by a Photodetector. Photodetector produces an electrical signal when light strikes it. This analog signal is converted into a digital signal, and slight changes of this signal are used to measure the heart rate.

Fig. 4. Heart Rate Sensor

(iv) Pressure Sensor (BMP280):

The BMP280 is an absolute barometric pressure sensor, which is especially feasible for mobile applications. Its small dimensions and its low power consumption allow for the implementation in battery-powered devices such as mobile phones, GPS modules or watches.

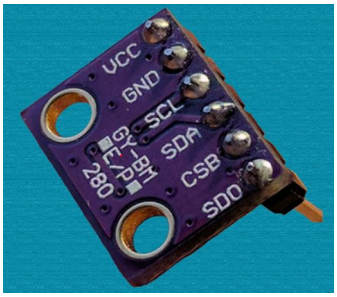

Fig. 5. Pressure Sensor

(v) Humidity Sensor (DHT11):

The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).

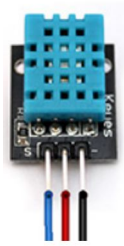

Fig. 6. Humidity Sensor

While the aim of the project sounds simple, it has many far-reaching applications and will be explored in future projects.

II. Implementation

The project mainly consists of two components:

First is a mobile application that can be downloaded on any device. The **Blueserial App**, named after the plugin used to make it work, provides the user interface to send and receive data from the Arduino.

Fig. 7. Application Interface

Second is the Arduino board, IDE, and the sensors involved, which collect and provide the data in real-time and can be used for monitoring different situations, from external uses to those closely related to medical applications. The circuit diagram and connections made in the project are as follows:

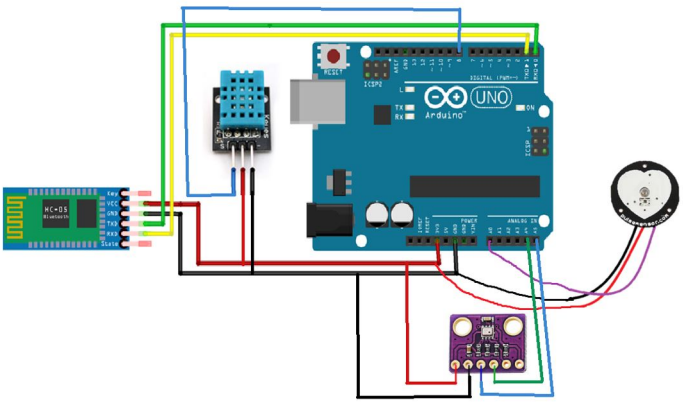

Fig. 8. Circuit Diagram

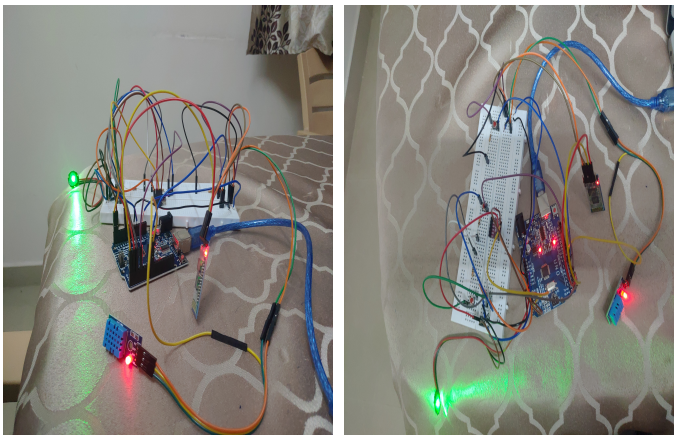

Fig. 9. Connections and Components

After making the required circuit connections, the Arduino code is uploaded to the Arduino board. Subsequently, the app is made ready to receive the information by creating a successful connection to the HC-05 Bluetooth Module. Once both the components are ready, a reading can be taken, and the output is shown in both the **serial monitor** of the Arduino IDE and the **Blueserial App**.

Do note that the circuit diagram shown does not include the pushbuttons and 10K Ω resistors. The pushbuttons allow for seamless switching between the three sensors which were used simultaneously, and the resistors ensure that excessive current does not flow into the sensors, causing them to malfunction.

III. Results and Future Work

The output from the sensors was successfully received on the app and matched with the output from the serial monitor of Arduino IDE. The result can be observed in the following set of images:

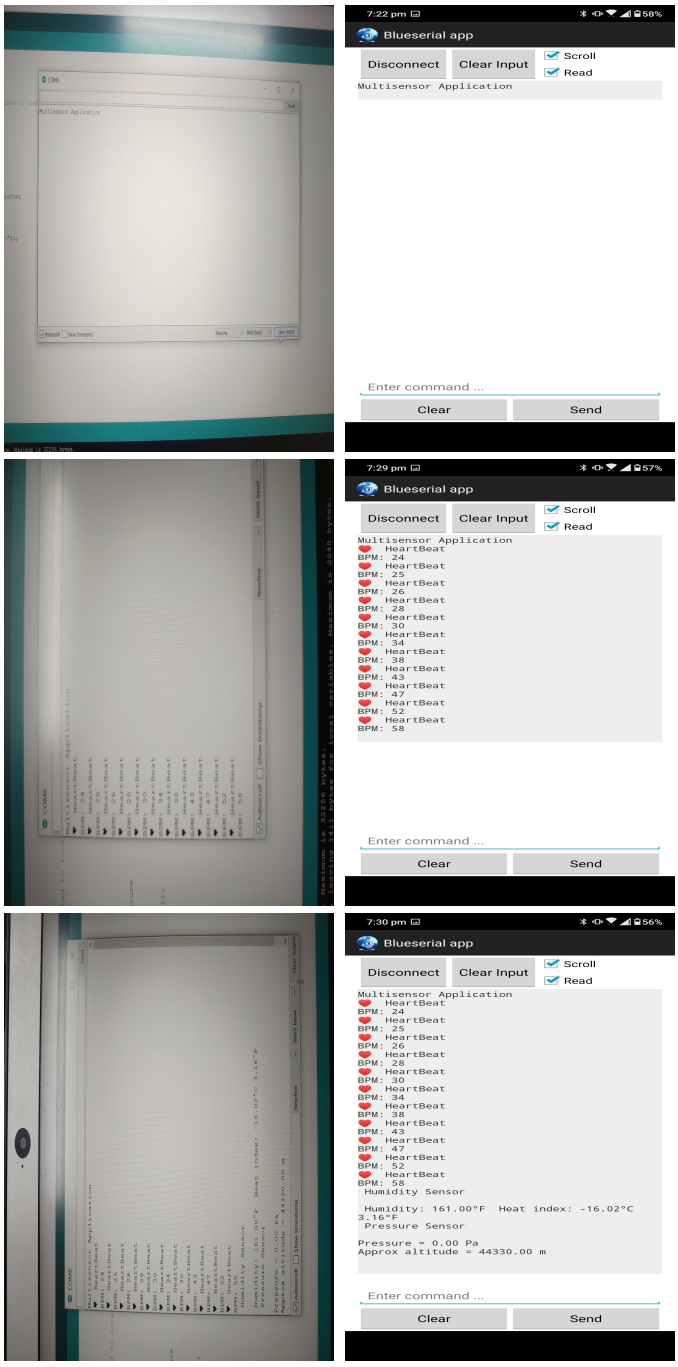

Fig. 10. Output of Sensors

Having obtained the desired results, we can extend the project for a much broader application. Using many more and a different variety of sensors, storing the output and observing the data for any trends, etc. The project may also be combined with different others to build a fully functional system that can be used in different fields.

IV. Errors

There may be errors in readings due to many factors:

1) Loose connections.
2) Faulty equipment.
3) Arduino code not taking into account environmental factors.

While the presence of these errors could potentially be harmful, the aim of this project is not to get accurate readings but rather to enable data from the sensors to be sent to an application via Bluetooth. However, suppose the setup is used for some industrial, medical, or other applications where such errors could be fatal. In that case, it is recommended to fix the errors and ensure the output is in a permissible range before applying them on-field.

V. Conclusions

The Arduino boards and accompanying software are one of the most successful and well-recognized open hardware platforms. Together with all reasons aforementioned in the previous sections, microcontroller-based development boards (Arduino, Raspberry Pi, etc.) will aid in closing the gap between LoC technologies and real-life PoC devices.
Furthermore, as smartphones are now becoming increasingly inexpensive, easy to use, and globally available, microcontroller-based hardware can easily be made to connect to smartphones via Bluetooth or Wi-Fi. Ultimately, this could lead to the possibility of online monitoring and online detection applications. Furthermore, together with the rapid development of 3D printing and other additive manufacturing techniques, combined with increasingly cheap prototyping of electronics, for example, light-emitting diodes (LEDs), phototransistors, potentiostats, and so on, we can speed up the prototyping process and create more opportunities for low-cost and sensitive instrumentation and for realizing PoC devices.

The application APK can be downloaded from this LINK.

References

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