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Project Design Plan

Personalised Air Quality Monitor using Wearable Sensors

Research Question

An investigation into the accuracy of the use of wearable sensors to monitor air quality and the best methods to possibly improve the accuracy of the results.

Project Scope

- Microcontroller (MCU) SPI/I2C driver to interact with the peripheral devices.
  - Sensors for air quality and other peripheral sensors.
- Method of data retrieval from the MCU to be developed.
  - Possibility of data logging through a serial port or through a Bluetooth Low Energy (BLE) channel.
- Mitigation of inaccuracies of errors in data recording.
  - Does movement affect the measurement accuracy? How to detect and mitigate the effects.
  - Do the sensors have a temperature/humidity drift? Mitigation for this.
- Testing the accuracy of the sensors used against a 'gold' standard measurement.
  - Irish EPA base station, commercial product to be used as gold standard measurement.

Design Approach

Using a STMicroelectronics Sensor Tile device incorporating an accelerometer, magnetometer, barometer and gyroscope sensors. Figure 1 shows the block diagram of this device, this provides sensors necessary to detect movement to investigate any errors being induced from the movement of the sensors. Can use a serial debugger to log the data being recorded or alternatively develop the SPI interface to use the BlueNRG-MS chip to connect to an external device. This development is a major risk of the project and may not be completed, this is low in priority of tasks.

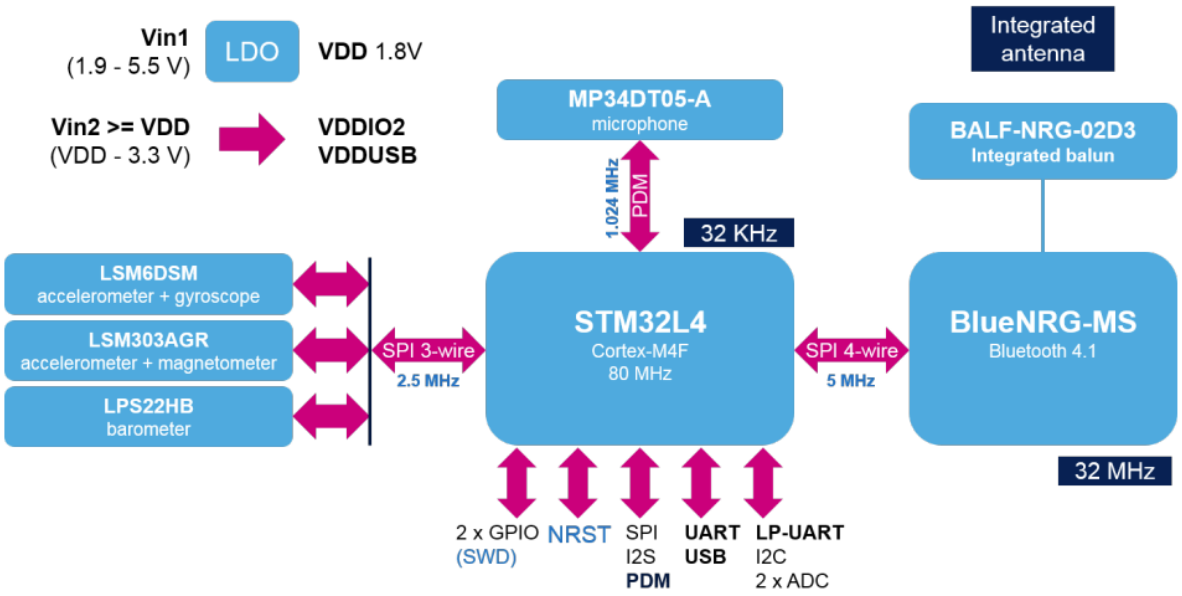

Figure 1: Functional Block Diagram of Sensor Tile from STMicroelectronics [1]

Using the LSM6DSM sensor to obtain the accelerometer and gyroscope data to determine if the device is being moved, can also use the barometer to detect if errors in reading are likely, a large change in pressure is most likely to occur in a faulty reading.

Using the external peripherals listed (SPI/I2C) to interface with the external sensors for reading of the environmental sensors to monitor the Air Quality. The current plan is to use an SPS30 PM detector to detect particles of different diameters to determine the Air Quality.

From the data gathered, can then begin to analyse the data to try to find correlations to any issues presented in the data to external factors, e.g. temperature drift or movement of the sensors.

Detailed Timeline

	May		June				July				August			
Masters Project Tasks	23/05/2023	30/05/2023	06/06/2023	13/06/2023	20/06/2023	27/06/2023	04/07/2023	11/07/2023	18/07/2023	25/07/2023	01/08/2023	08/08/2023	15/08/2023	22/08/2023
Firmware Programming:														
SPI Interface for on-board sensors														
On-board sensor data acquisition														
I2C interface for air quality sensors														
Air Quality Sensors data acquisition														
Data Logging:														
Serial Wire interface for data logging														
BLE interface for data logging														
Phone app development to log data														
Perform Experiment 1														
Perform Experiment 2														
Data Interpretation:														
Methodology for determining the air quality														
Investigation of the external influences on the data														
Detail the effects of the external factors														
Determine mitigation techniques														
Perform Experiment 3														
Final Report:														
Document the code development														
Document the hardware functionality														
Document the experiments														
Document the external influences on sensor readings														
Document the mitigation techniques														
Differing performance after mitigation techniques														

Figure 2: Project Schedule Plan

The BLE interface to a phone app is a major concern in this project development, this may be abandoned in favour of using a serial wire connection to a debugger to log data in the experiments being performed as outlined in below:

Experiment 1. Baseline performance of the sensors detecting air quality against known values (A good quality sensor or EPA Base Station).
Will show issues in spikes of measurements showing false readings and indicating false results.

Experiment 2. Perform the same measurements as Experiment 1 while moving the sensors to show the effects movement can have on the measurements performed.

Experiment 3. After the investigation of methods to mitigate false readings or less accurate readings than expected, implement the mitigation techniques and perform Experiment 1 and 2 again.

The investigation of external influences on the sensor data will include but not limited to:

- Examining the drift of temperature reading over temperature or humidity.
- Changes in weather, i.e. wind.
- Change in movement of the device.

Mitigating these factors will involve detecting such events to ensure recorded data is legitimate and not a consequence of external factors on the sensor.

Success Criteria

A successful project can be determined through the completion of the tasks listed in the Detailed Timeline section as well as milestones correlated to the Project Scope:

Milestone 1. Developing a prototype system to interact with the available sensors and successfully log the data.

Milestone 2. Determining a set of factors that can falsely influence the readings of the air quality sensors being used.

Milestone 3. Determining a set of methodologies to mitigate these factors, implementing the mitigation techniques and validating the sensor accuracy via results from Experiments 1, 2 and 3.

Reaching these 3 milestones along with writing the final report will encapsulate a successful project.

References

[1] STMicroelectronics, “SensorTile development kit,” [Online]. Available: https://www.st.com/resource/en/data_brief/steval-stlkt01v1.pdf.