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Project Proposal

Quick AQI

This Quick AQI project will focus on creating a Rust application for rapid measurement of the local air quality index (AQI). It will be an embedded application targeting a STM32 microcontroller unit (MCU) and an external AQI sensor. The goal will be to provide on-demand AQI measurements, displayed to the user in a human-readable format. The application will make use of existing Rust crates providing a hardware abstraction layer (HAL) for the target MCU.

Hardware

For initial development, the project will use a STM32 F3 Discovery board, which has a STM32F303VCT6 MCU. The reasoning behind choosing this board for initial prototyping is that it is the target board in the Embedded Rust Book, so there are existing examples of working configuration, step-by-step guides for setting up the toolchain, and a number of basic, runnable programs. STM32 MCUs are also well-supported by existing Rust HAL crates, including those found in the Embassy project, which also provides small example programs. This specific board includes a built-in user hardware button and several LEDs, which may be used for some aspects of an early user interface.

The sensor for the first iteration of the project will be the PMSA003I, specifically through the Adafruit PMSA003I air quality breakout board. Communication between the STM32 and the sensor breakout board will take place over I2C.

For human-readable output, initial development will focus on streaming data to a connected host computer through a debug mechanism. Once a basic implementation exists with correct data displayed on a connected machine, the next stage will be adding a dedicated display. This will either be a seven segment display or a small OLED display.

Software

This project plans to use the embassy-stm32 HAL crate. To begin, the project will attempt to use the minimal number of related crates necessary to implement basic functionality. For example, this project will initially use blocking code rather than async, in an effort to maintain simplicity. Starting with Embassy, however, provides room to expand the project and add complexity without needing to leave the Embassy platform. For example, there is an Embassy timer crate which may be necessary for aspects of the user interface and display. Besides the broader functionality available, the embassy-stm32 crate seems to be in a much more active development state than other stm32 HAL crates, based on a review on crates.io.

Development Stages

As discussed above, the initial stages of work will be focused on communicating with the AQI sensor over I2C, and the processing and display of returned data through a debugging display. Next will be to add some user control through the hardware button, allowing a user to possibly cycle through display of different particulate matter concentrations, or simply toggle data collection on or off. The "definition of done" for this stage is that it should be possible for a user to plug in the STM32 F3 discovery board with the connected AQI sensor to a host machine via USB, flash the program, and view human-readable output showing current AQI readings, with some control through the hardware button.

The next stage of development will focus on outputting the data to a dedicated display. This could either be a seven segment display or a small OLED display. A seven segment display will likely be simpler, but reduces the flexibility and density of content displayed. An OLED display will enable more detailed data to be output, but possibly at the cost of a more complex implementation. Prior to beginning this stage of development, a review should be done of support for OLED within existing Rust crates. A comparable review could be performed for seven segment display support, though it's much more likely that this data could be written directly through GPIO pins, or multiplexing a single pin.

With additional I/O work to a dedicated display, it would make sense to work towards using Rust's async features. This would be the logical next phase in development.

Logistics and Next Steps

Some proof-of-concept work has been performed, creating a small project using the embassy-stm32 crate to blink an LED on the STM32 F3 board. This has been flashed on the board, validating the toolchain and configuration. This exists at the project repo: https://github.com/nkanderson/quick_aqi

Next steps for the first phase of development include the following:

1. Review the sensor datasheet and determine I2C details, such as device address and any necessary power or configuration requirements (e.g. pull-up resistors on the I2C bus)
2. Review the STM32 F3 board documentation related to I2C details, such as pins for SCL and SDA
3. Review embassy-stm32 examples and documentation related to I2C
4. Test basic communication
5. Review the sensor datasheet to understand the output and what processing may be necessary
6. Implement processing of data in Rust
7. Expand on basic communication to retrieve all necessary data for a basic AQI display