Portable Diagnostic Platform At A Point-Of-Care Setting

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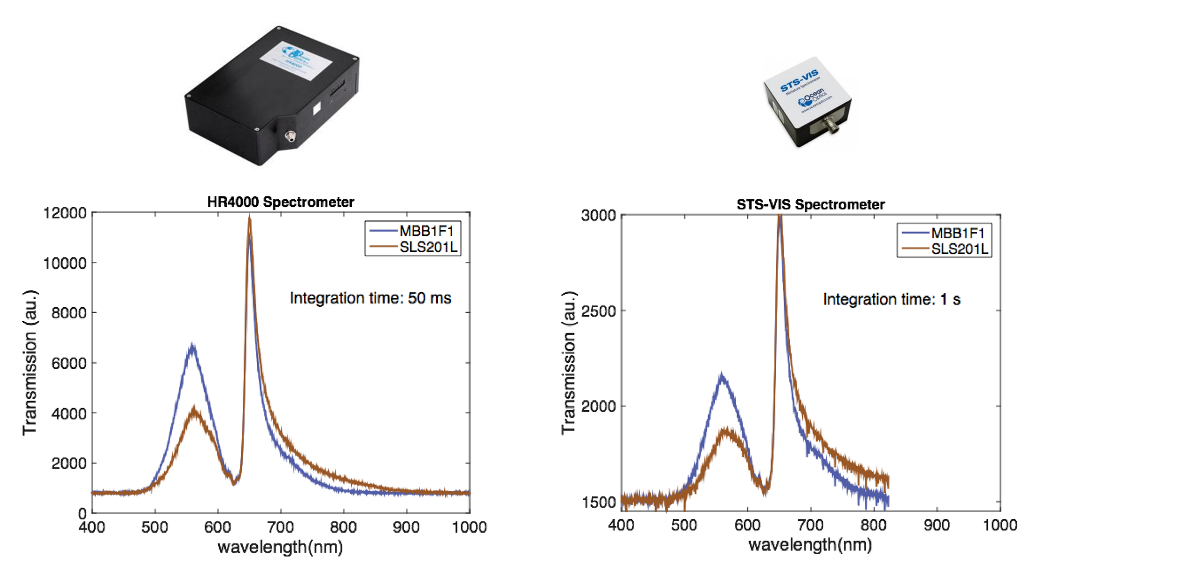
Abstract

With this project we aim to deliver a light weight, cost-effective, and portable diagnostic system for use at a point-of-care setting. The spectrometer-based system provides a means of pathogen detection by spectral analysis of a sample. The system in intended to be simple to use, in order that medical or research personnel can utilize it without worrying about size or complicated interfaces. Existing equipment utilizing this method is cumbersome and highly expensive; we are attempting to reduce these factors by delivering a device approximately the size of a textbook, which can be manufactured for a much lower cost than the full-sized equipment.

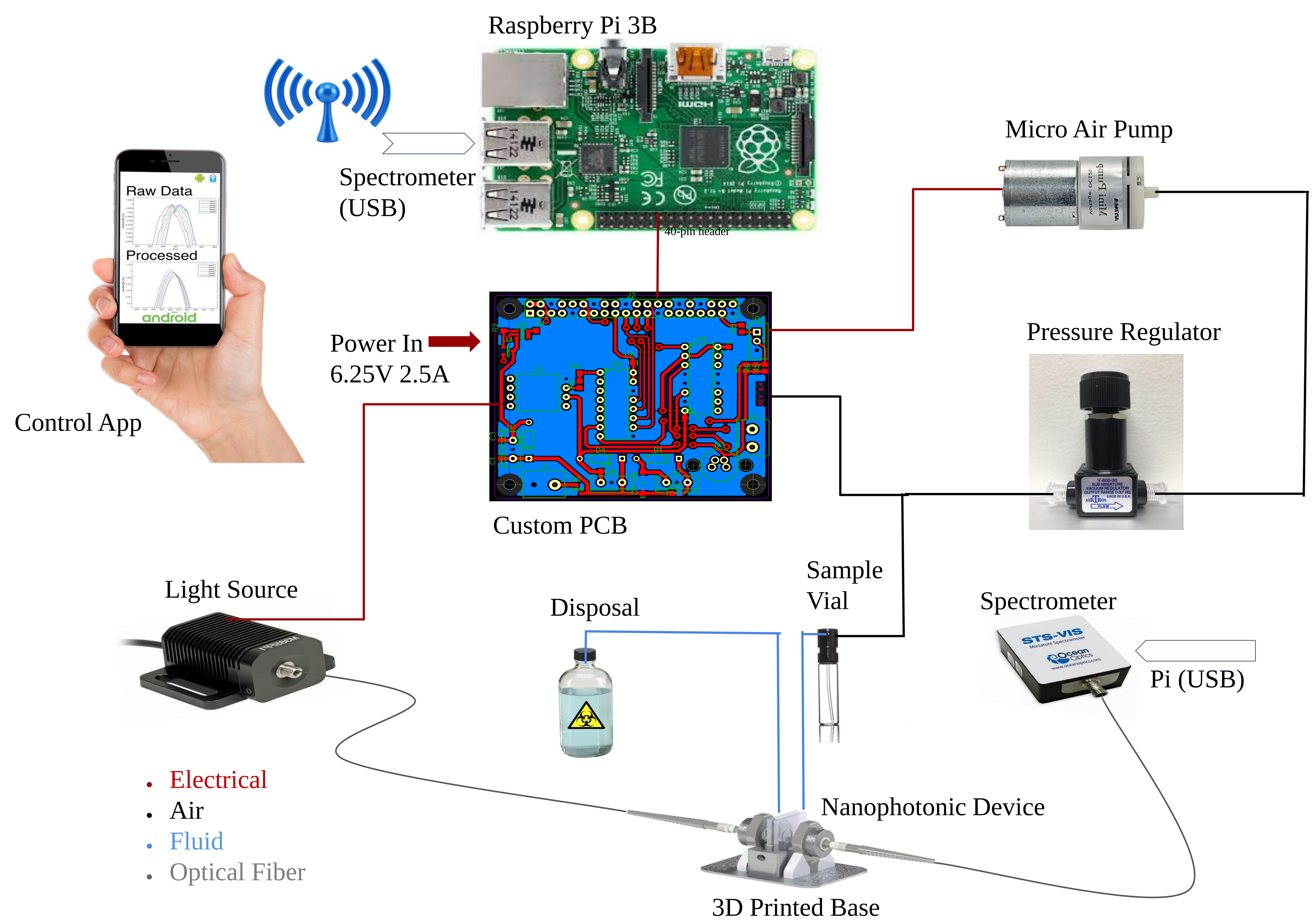
Motivation

Full-sized spectrometer setups require a large amount of space and come with steep price tags up to $30,000+, making it difficult to perform tests in remote areas. Additionally, their operation generally requires trained personnel. Miniaturizing and automating the system will provide researchers with a better method for performing diagnostics and analyzing samples with a portable device costing less than $3,000-.



Comparable results between both spectrometers with a 95% size reduction

Overview



The system incorporates off –the-shelf and purpose-built components in order to fit the size constraint:

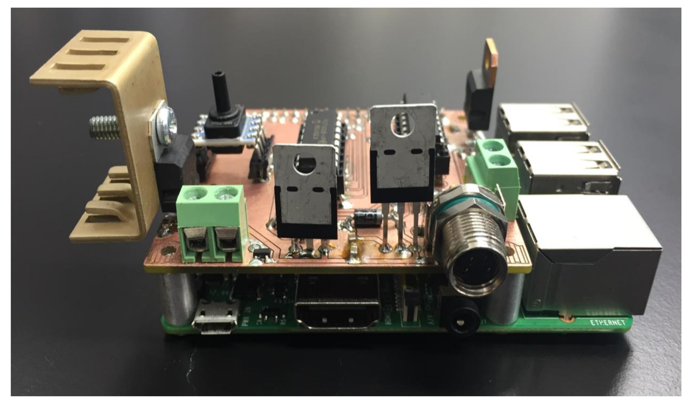
- A carefully calibrated optical system illuminates the nanophotonic device, the output of which is sensed by the spectrometer.
- A cutsom 3D-printed base holds the device in a translational stage and precisely aligns the optical elements.
- An air pump, pressure regulator, and sample/disposal vials form a microfluidic pump for low flowrate pumping.
- A Raspberry Pi interacts with the control application to actuate each hardware component and deliver data.
- A custom PCB sits atop the Pi, routing power to the pump, LED, and Pi with dedicated driver circuits.

Results

The iterative process took us through several designs, with improvements each time.

- The device footprint steadily decreased as components were improved or replaced. Form factor constraints were met.
- User can interact wirelessly with the hardware; initially required a screen and command line interface
- The initial flowrate of the custom microfluidic pump was experimentally determined to be 108 mL/minute and was improved several orders of magnitude to reach a final flowrate of 100 μL/minute

Full system integration with cell phone control

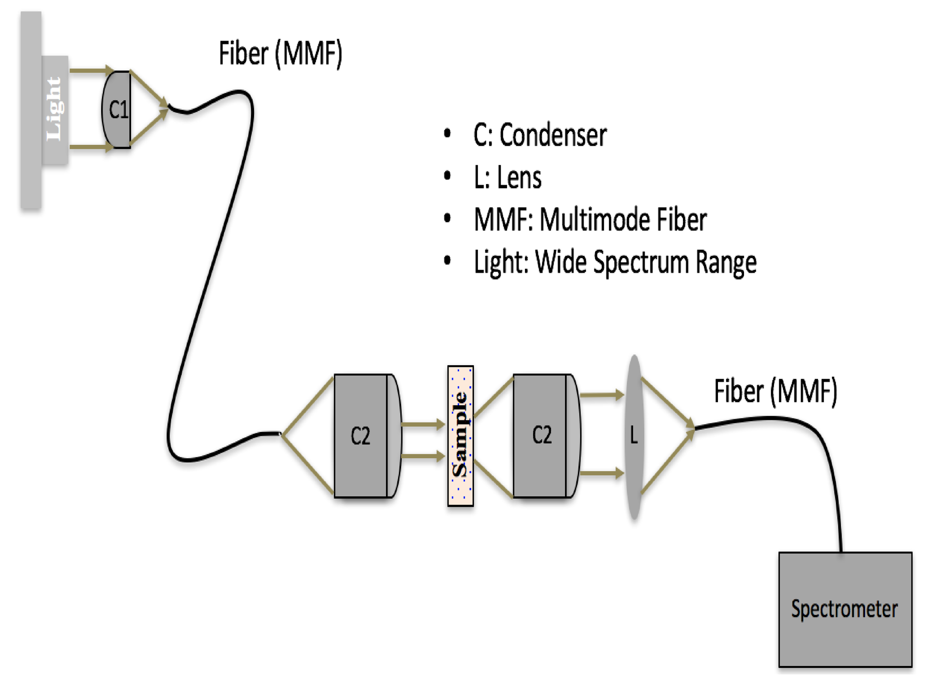


Custom daughterboard with Raspberry Pi

Next Steps

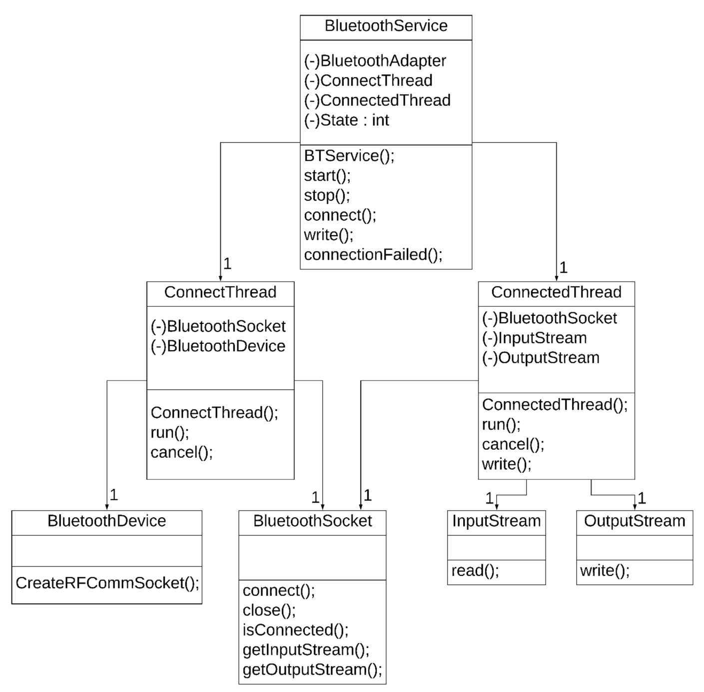
- Further improvements will be made to the pumping system to reach lower flow rates; the goal is 30 μL/minute.
- The application will be updated to facilitate easier device pairing.
- The PCB will be further refined and sent out for professional manufacturing
- An updated enclosure will be 3D printed; currently laser-cut acrylic.

Design



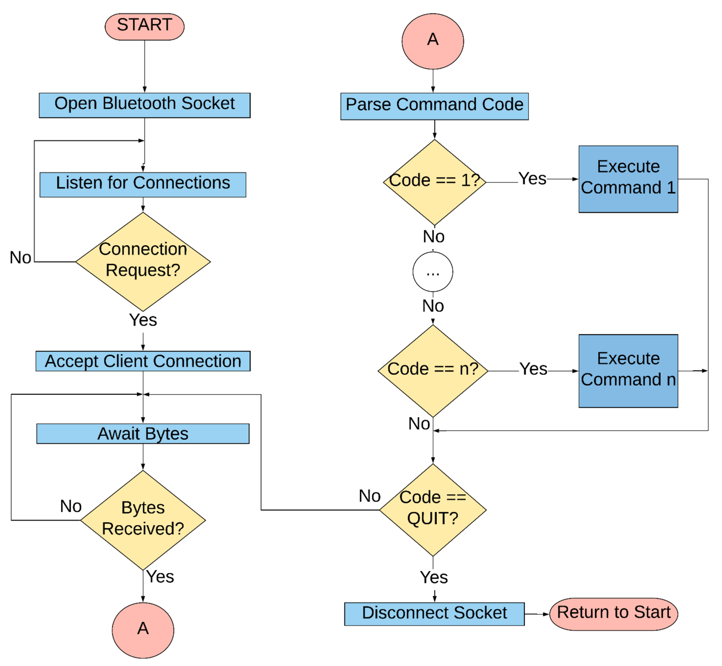
Optical schematic demonstrating signal path and alignment components

Client Side (Application)

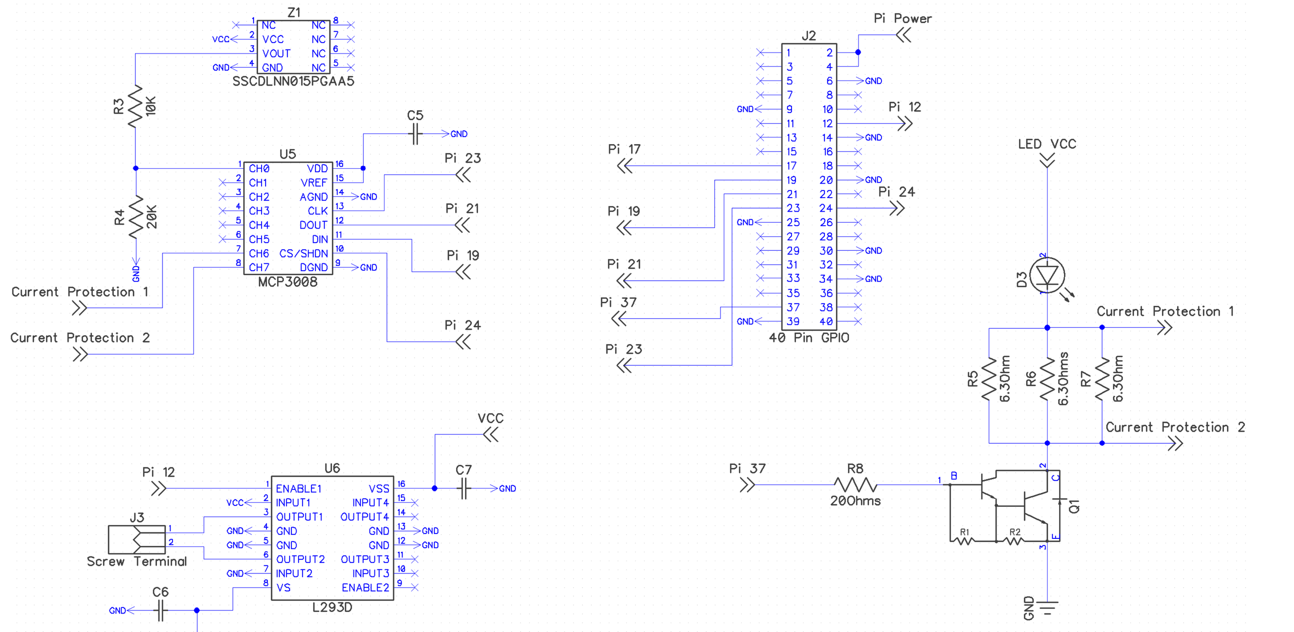


Simplified object diagram of the Bluetooth service Implemented in Java.

Server Side (Pi daemon)



Flowchart governing server activity, with arbitrary commands. Implemented in C.



Schematic capture of the PCB demonstrating IC interconnections and driver circuits

References : Pump design adapted from MiniDrops project: https://metafluidics.org/devices/minidrops/

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