Open Bike Initiative: Air Quality Sensor Hub Proposal

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Overview
The Open Bike Initiative (OBI) is a bike sharing model project based on open source software and hardware. The design implements a locking mechanism unit with GPS and cellular modules capable of attaching to any bicycle. The units communicate through client and server side software in order to manage the OBI system.

Our goal is to design a small, low cost, and self-contained board with sensors used to measure a bicycle riders' exposure to air pollution. It will collect and send real time air quality information over an RS232 interface as requested by the OBI system.

Additionally, through the use of a dynamo, we aim to provide a method to use rider effort to generate and provide power to the OBI unit.

Deliverables

- Functional air quality sensor prototype consisting of the fabricated PCB and sensors mounted in an enclosure will be delivered. The unit will be demonstrated to communicate using the RS232 protocol with an Arduino Uno which will stand in for the host system.
- A bottle dynamo will be attached to a bicycle and demonstrated to provide a ~6V signal consistent with the required input of the OBI unit
- Final report describing our design, functionality, testing and sample data.

Research: Air quality sensors
Primary urban air pollutants as defined by the EPA (http://www.epa.gov/air/emissions/index.htm) are ozone, nitrous oxides, sulfur dioxide, lead, particulate matter and carbon monoxide. Every day, bicycle riders are exposed to these pollutants with no reliable method of evaluating their level of intake. We aim to provide this information to riders in order to help evaluate ideal paths of travel, best times to ride, as well as any other factors that can be used to minimize their exposure to pollutants.

Sensors to detect the ozone, nitrous oxides, sulfur dioxide, and lead are expensive, in the hundreds of dollars. Our design will focus on detecting particulate matter and carbon monoxide with the possibility of adding benzene/hydrocarbon. In order to accomplish this, low cost metal oxide gas sensors for CO and possibly benzene and hydrocarbons, as well as environmental sensors for particulate matter will be implemented into the system.

Metal oxide gas sensors are sensitive to other environmental factors such as temperature and humidity. These factors can also directly affect pollutant concentration in the air at any given time. Thus, implementing temperature and humidity sensors will provide context for the data as patterns start to emerge. In order to further evaluate the riders' exposure an external heart rate sensor will be implemented with the goal of correlating heart rate to respiration. Fluctuations in the riders' heart rate will directly affect their breathing patterns and can result in a deeper uptake of pollutants. These sensors will be chosen based on reliability, durability, cost, and accuracy.

Sensor Unit Details

The system will be housed in an enclosure with openings to allow for copious airflow as required by the sensors. The box will have an RJ45 jack to connect to the main OBI unit, as well as two 2-pin headers to pass AC power from the dynamo to the host system.

The box will communicate with the OBI system through the RS232 interface. In accordance with sponsor specification the designed system will implement the following features:

1. Data collection will begin when the 3.3V power supply is turned on.

2. Up to ~1000 data records will be stored internally. The data will be delivered to the host system in response to a “read record” request. After records have been delivered it will be purged from the storage. There will be a procedure for reporting the current number of stored records, as well as a command to clear all records.
3. The system will implement a power-supply independent real time clock so that each record has a timestamp. The OBI host will be able to set the real-time clock.
4. The OBI host will be able to set the data collection rate from once per second (1 Hz) to once every 300 seconds (3.33 mHz). Some of the sensors cannot take readings every second. In this case the most recent record will be duplicated.
5. Arduino code for the host will be developed. This will include setting the real time clock, reading and purging records, reporting the number of stored records and setting the sensor rate. The sponsor will be responsible for the code that turns on the 3.3V power supply.
6. After a record has been read the host system will send the data to cloud storage. The data will have a GPS coordinates added. The sponsor is responsible for implementing the GPS data and cloud interface.
7. The data can be downloaded from cloud storage in a format suitable for presentation using a spreadsheet.

Research: Power generation

The development of a usable rim dynamo for providing power to the OBI system was evaluated. Preliminary prototyping with rim mounted magnets and a “U” shaped coil did not produce usable amounts of power. The distance between the magnets and the wire and the non-ideal spatial configuration of the wire produced very small amounts of EMF which was not enough to provide the necessary 5V to the USB charger. Better results could be achieved using stronger magnets and more wire. However, this means higher cost and complex implementation. A better solution was determined to be a bottle dynamo which can be mounted to virtually any bicycle without modification and produce relatively large amounts of power at low cost. While we recommend the use of a bottle or possibly even a hub dynamo as the power source, further optimization of the rim dynamo design can be researched if requested.

Parts

Please see an itemized list of parts below. Please note that this list is subject to change as development progresses. Overall cost of the project, including prototyping and testing, is estimated to be approximately $200-$400.

- Arduino Uno
- Optical Dust Sensor: COM-09689
- Dust Sensor: SEN12291P
- Carbon Monoxide Sensor: SEN-09403
- Humidity Temperature Sensor: SEN-10167
- Pulse Sensor: SEN-11574
- Material for enclosure
- PCB board fabrication
- Microcontroller IC (Atmega328)
- Real Time Clock: DS1307
- Boost Converter: LT1302
- 32kHz Crystal
- 16MHz Crystal
- SRAM Memory: 23K256
- Logic Level Shifter
- Capacitors, Resistors, Inductors
- Bottle Dynamo