Putting the IT in QuIT Smoking

Noah Klugman, Prabal Dutta - Department of Electrical Engineering and Computer Science - University of Michigan, United States

Introduction and Purpose

Cigarette smoking is responsible for millions of deaths, despite valiant individual efforts to quit. In response to these failed efforts, new programs have been proposed that would offer incentives for smokers to quit. Unfortunately, these programs suffer from dependence on unreliable, self-reported data to determine a participant's compliance. We claim that information technology can offer a better compliance mechanism.

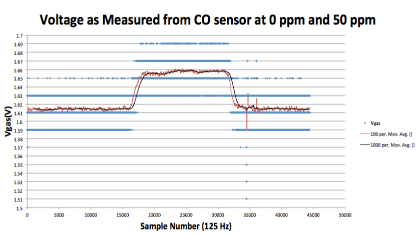
Because cigarette smoke contains carbon monoxide (CO), the absence of CO from a program participant's breath offers reliable evidence of compliance with an intervention program.

Results

We build a prototype small enough to carry in-pocket that is powered by a coin cell battery. We show that the average current consumption of the system is 1.8063 mA.

We test the accuracy of our system end-to-end by immersing the system into 50 ppm calibration CO gas.

We show that we can sense the expected value within the error bounds of the sensor (± 1 ppm) and gather this data back on a mobile phone over BLE. We demonstrate that we can process and store CO data on the phone both locally and in a central service.



Sensor Output: The KWJ Engineering CO sensor in our system outputs a voltage with a linear relationship to the amount of CO present. The BLE113 applies a transfer function that includes room temperature and a factory calibration offset before transmitting data to the smartphone. This graph shows the voltage as measured by the CO sensor at 0 ppm CO and 50 ppm CO. CO presence is observable as the higher reported voltage.

CO Monitor from Meredith et al. [1]: This system was developed and evaluated in [1]. The CO sensor physically tethers to a smartphone using the Hijack method over the audio jack [2]. Our system removes this physical tether. Photo taken from [1].

Prior Work

This effort directly follows work done by Meredith et al. [1]. In that work the authors show that a portable CO sensor, which communicates with a mobile phone over a physical teather, can be nearly as accurate as a larger commercial sensor and can reliably distinguish smokers from non-smokers.

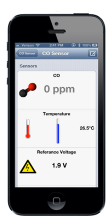
The authors ran trials using their system across 60 participants, each of whom self-reported their frequency of smoking. Smokers were identified by thresholding at 6 parts per million (ppm) CO present in exhaled breath.

Additionally, an acceptability survey revealed that smokers were interested in using this system as an aid during a quit attempt.

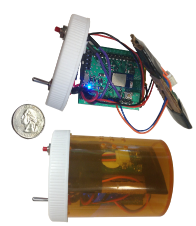
Conclusions

Encouraged by the results of [1], which show that a low-cost CO sensor can accurately distinguish a smoker from a non-smoker and that smokers would be interested in using such a sensor in a quit attempt, we implement a low-power, low-cost CO sensor that pairs wirelessly with a smartphone.

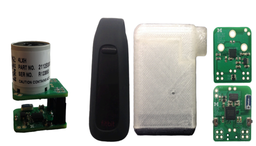
We demonstrate that our sensor can determine CO presence with a high degree of accuracy.



1



2



3

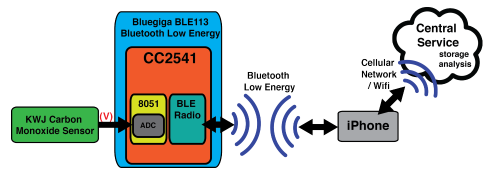
Implemented Sensor System At Scale: (1) iOS application that communicates with the system using BLE. This application displays data in real time, sends data to a central service and initiates the sensor calibration sequence. (2) BLE113 prototype outside of pill container and mounted inside pill container. (3) Next generation system stacked with CO sensor and flat. 3D printed enclosure and Fitbit wearable device for scale. The bottom PCB contains a Nordic nRF51822 system-on-a-chip. The top PCB contains a CO analog front end.

Design and Methods

Advances in MEMS gas sensing, along with the global adoption of smartphones capable of wirelessly communicating with external sensors using Bluetooth Low Energy (BLE), have made it possible to construct a low-cost, pocket-sized CO sensor that can run for long periods of time off a single, small coin cell battery and can pair with a smartphone.

We use an ultra-low power MEMS CO sensor from KWJ Engineering. A Bluegiga BLE113 BLE system-on-a-chip samples the sensor at 125 Hz.

An app running on the smoker's smartphone stores sensor data locally, displays CO concentration, puts the sensor into calibration mode and delivers data to a central service for analysis and compliance verification. We developed the first generation of our app for Apple iOS.



System Diagram: A KWJ Engineering CO sensor outputs a voltage with a linear relationship to the detected concentration of CO. The BLE113 samples and processes the voltage from the sensor and transmits the data to a smartphone app over 2.4Ghz BLE. This app then performs local processing and off-loads the data to a central service for storage and additional processing.

Future Work

Engineering: Transitioning chipset to Nordic nRF51822 to cut size, power and cost at scale. Completing mechanical designs. Implementing Android app. Continuing work on app GUI/usability. Incorporating privacy protections on data collection and store. Incorporating heuristics such as facial and fingerprint recognition to ensure honest measurements.

Impact: Forming strong North-South scientific partnerships. Developing incentive system to further aid smokers during quit attempts. Deploying system at scale.

Acknowledgements

We wish to thank the United States Agency for International Development for their support of this work.

References

1. Meredith, S.E., Robinson, A., Erb, P., Spieler C.A., **Klugman, N.**, **Dutta. P.**, and Dallery, J. 2014. A Mobile-Phone-Based Breath Carbon Monoxide Meter to Detect Cigarette Smoking. *Nicotine and Tobacco Research* (2014) 16 (6): 766-73.
2. Kuo Y., Verma, S., Schmid, T., and **Dutta, P.** Hijacking power and bandwidth from the mobile phone's audio interface. In *Proceedings of the First ACM Symposium on Computing for Development* (Dec. 17-18, London, UK) ACM/DEV, New York, 2010, Article 24, 10 pages.