Developing an Untethered Network of Low-Power Air Quality Sensors

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Recent years have seen the proliferation of affordable air quality sensors, yet they still only map a small subset of areas in Utah. Differences in elevation, proximity to roads or green spaces, and canyon winds create unique microclimates that affect air quality. Tools such as PurpleAir [1] and AQ and U [2] have demonstrated the value of mapping air quality data at a more granular level than the relatively sparse EPA stations. While the growing number of air quality sensors is useful, the fact that they must currently be tethered to continuous power and WiFi does not allow for more granular maps.

Our team at Brigham Young University is currently exploring several strategies to create a network of untethered, low-power sensors that can report accurate data in realtime. This would allow us to place sensors in a much wider range of locations including more remote locations (e.g., canyons that play a critical role in airflow patterns), bus stops, schools, and other high-priority locations such as parks. Such a network would support the public in making more informed decisions about activity (e.g., canceling soccer games at the park), as well as help them realize their impact on the hyper-local air quality (e.g., idling in front of a school). The increase in air quality resolution and strategic placement of monitors can also support researchers trying to model airflow patterns, measure the impacts of policy or development interventions (e.g., public transit), and changes caused by new development or compliance with new air quality standards by industry.

Several challenges must be overcome to realize our vision. To reduce the power of the circuit itself, we plan to use Field-Programable Gate Arrays (FPGAs). FPGAs allow computer logic to be programmed to a reprogrammable circuit an alternative to a traditional computer processor, but at much lower energy [3]. Standard wireless communication protocols can unnecessarily drain power, prompting us to explore low power wide-area network (LPWAN) protocols, such as LoRa [4]. These class of protocols provide long-range communication while using little power. Another strategy to reduce power is the ability to strategically turn air quality sensors on and off. Once a full network is deployed, we imagine developing optimization algorithms that can intelligently determine which sensors to turn on and off at key points. For example, nearby monitors may take turns monitoring the data unless an unexpected rise or drop in air quality measurement occurs, in which case the nearby monitors would turn on. While we imagine these sensors will run on batteries that are recharged via solar power, it is clear that human involvement will be necessary to maintain them. A key component of our long-term vision is to develop a community of citizen science volunteers who will host wireless gateways at their homes, help with maintenance and replacement of monitors, and serve as air quality advocates to their neighbors.

References

[1]: https://www.purpleair.com
[2]: http://www.aqandu.org
[3]: “Energy-efficient signal processing using FPGAs”, https://dl.acm.org/citation.cfm?id=611850
[4]: https://www.semtech.com/lora