

Crowdsourcing Weather Using Smartphone Batteries

American Geophysical Union



A group of smartphone app developers and weather experts have discovered a way to use the temperature sensors built into smartphone batteries to crowdsource weather information. These tiny thermometers usually prevent smartphones from dangerously overheating, but the researchers discovered the battery temperatures tell a story about the environment around them.

Crowdsourcing hundreds of thousands of smartphone temperature readings from phones running the popular OpenSignal Android app, the team estimated daily average temperatures for eight major cities around the world. After calibration, the team calculated air temperatures within an average of 1.5 degrees Celsius (2.7 degrees Fahrenheit) of the actual value, which should improve as more users join the system.

While each of the cities already has established weather stations, according to the new method's creators it could one day make predictions possible at a much finer scale of time and space than is currently feasible. Whereas today, weather reports typically provide one temperature for an entire city and a handful of readings expected throughout a day, the technique could lead to continuously updated weather predictions at a city block resolution.

"The ultimate end is to be able to do things we've never been able to do before in meteorology and give those really short-term and localized predictions," said James Robinson, co-founder of London-based app developer OpenSignal that discovered the method. "In London you can go from bright and sunny to cloudy in just a matter of minutes. We'd hope someone would be able to decide when to leave their office

to get the best weather for their lunch break."

The work was published in *Geophysical Research Letters*, a journal of the American Geophysical Union.

Smartphone sensors

Robinson's OpenSignal app collects information voluntarily sent from users' phones to build accurate maps of cellphone coverage and Wi-Fi access points. The app boasts about 700,000 active users according to Robinson, about 90 percent of which opt in to providing statistics collected by their phones.

Robinson originally wondered whether smartphones running on newer, 4G networks ran hotter than those running on older networks. When no difference showed up, he looked for other potential uses of the temperature information available on Android-powered devices.

"Just sort of for fun we started looking to see if there was a correlation with anything else," said Robinson. "We got some London weather data for comparison and found the two sets of temperatures were offset, but they had the same sort of shape."

While OpenSignal is available to iPhone and iPad users, the temperature readings on those devices are not accessible like on their Android counterparts.

Cellphone thermometers

After finding the correlation between smartphone and air temperatures in London, Robinson and his fellow developers assembled temperature data from other major cities where they had a large number of users. Comparing data from Los Angeles, Paris, Mexico City, Moscow, Rome, San Paulo and Buenos Aires, Argentina, they saw the same link between the two sets of temperatures they saw in London.

"It was amazing how easily the correlation sort of popped out," said Robinson. "We didn't do any handpicking of data—it sort of just emerged."

A smartphone's environment affects its temperature, according to Robinson. On a sweltering day, a cell phone tucked in a pocket will be hotter than the same cell phone on an icy day. Weather experts helped Robinson develop a way to calculate outdoor temperatures from smartphone battery temperatures, the latter of which are typically hotter.

However, other factors unrelated to the outdoor weather can play a role. A phone outdoors running the latest 3-D game could run at 46 degrees Celsius (115 degrees Fahrenheit) while the same phone idling in an air-conditioned building nearby could be only running at 27 degrees Celsius (80 degrees Fahrenheit).

To avoid fluctuations in temperature unrelated to the real outdoor temperature, Robinson needed large amounts of data. While an individual phone might not provide an accurate representation of the weather, combining the readings from

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hundreds or thousands of phones together gives a more truthful overall picture. Currently Robinson collects over half a million temperature readings each day from users of his OpenWeather app. He said he plans to make the data freely available to academic researchers.

"There's the wider promise when logging all this information that there will be something really interesting you can understand," said Robinson. "The most obvious application is climate and weather tracking."

Personal weather predictions

Currently weather tracking primarily takes place at weather stations, such as those at airports. However, weather stations provide only one point of reference and are rare outside of densely populated areas, forcing weather forecasters to fill in the gaps when making their predictions, reducing both accuracy and how specific an area they can make predictions for.

While Robinson says his multitude of mobile phones can provide large amounts of data, individual areas still need to be fine-tuned using existing weather stations before the incoming information can be usable for weather prediction.

"The challenge is whether we can take this technique and use it in places where we don't already have reliable weather information to retune the model," said Robinson. "That's something we're still working on."

Robinson says some recent smartphones come with built-in sensors specifically built to measure the environment around them such as air temperature, humidity and pressure. To take advantage of these features, Robinson and his fellow developers released WeatherSignal, an app built around mobile weather watching.

As these features become commonplace in the smartphone market, Robinson foresees smartphones becoming an important tool in weather monitoring.

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