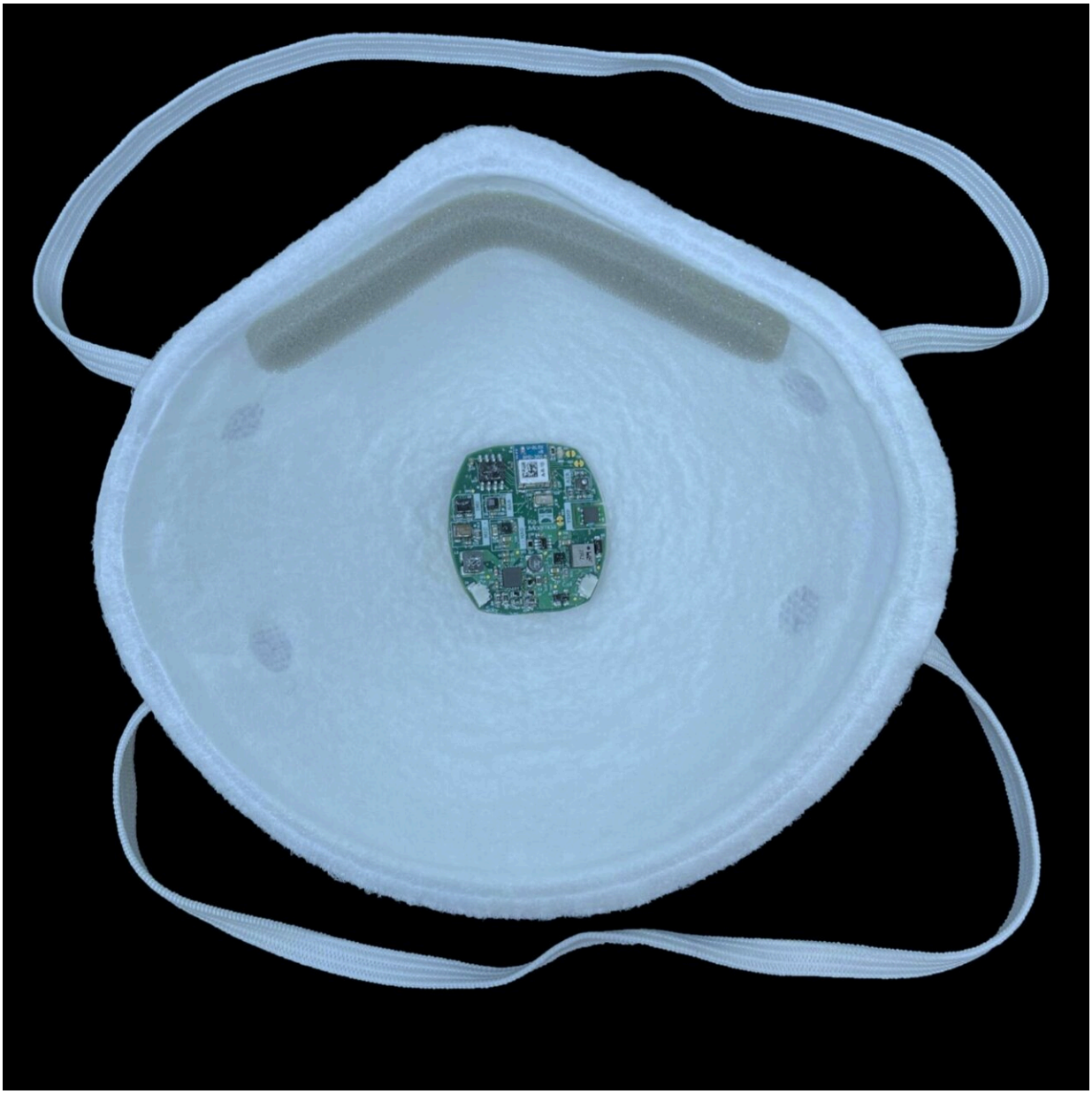
'Fitbit for the face' can turn any face mask into a smart monitoring device

January 12 2022, by Amanda Morris



About the size of a quarter, FaceBit clips onto any mask with a small magnet. Credit: Northwestern University

Northwestern University engineers have developed a new smart sensor platform for face masks that they are calling a "Fitbit for the face."

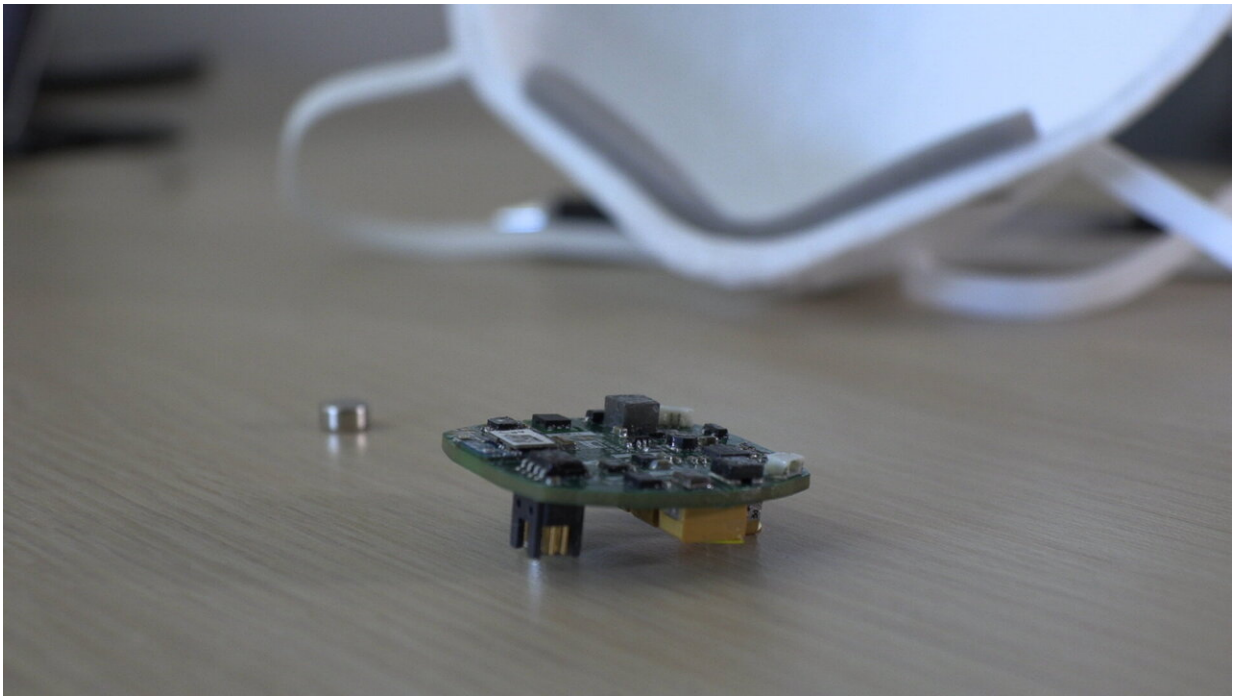
Dubbed "FaceBit," the lightweight, quarter-sized sensor uses a tiny magnet to attach to any N95, cloth or surgical face mask.

Not only can it sense the user's real-time respiration rate, heart rate and mask wear time, it also may be able to replace cumbersome tests by measuring mask fit. All this information is then wirelessly transmitted to a smartphone app, which contains a dashboard for real-time health monitoring. The app can immediately alert the user when issues—such as elevated heart rate or a leak in the mask—unexpectedly arise. The physiological data also could be used to predict fatigue, physical health status and emotional state.

Although a tiny battery powers the device, FaceBit is designed to harvest energy from any variety of ambient sources—including the force of the user's breathing, motion and heat from a user's breath as well as from the sun. This extends the sensor's battery life, lengthening time between charges.

"We wanted to design an intelligent face mask for health care professionals that does not need to be inconveniently plugged in during the middle of a shift," said Northwestern's Josiah Hester, who led the device development. "We augmented the battery's energy with energy harvesting from various sources, which means that you can wear the mask for a week or two without having to charge or replace the battery."

The research was published last week in the Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies. In the study, researchers found FaceBit's accuracy was similar to clinical-grade devices, and the battery lasted longer than 11 days between charges.



FaceBit outside of a mask, next to its small battery. Credit: Northwestern University

Approximating the fit test

Before designing FaceBit, Hester and his collaborators first interviewed doctors, nurses and medical assistants to better understand their needs for smart face masks. In a series of surveys, all clinicians indicated that quality of mask fit was most important—especially when working directly with patients with viral infections.

To ensure their N95 masks are properly sealed to their faces, health care workers periodically undergo a 20-minute "fit test." During this process, health care workers first put on an N95 respirator followed by a clear hood over their entire head. Another worker then pumps either sweet or bitter aerosol mists into the hood. The concentration of the aerosol is gradually increased inside the hood until it can be detected by the person wearing the respirator. If the wearer tastes bitter or sweet before a certain number of aerosol pumps, then the mask is not properly sealed.

Although Hester's FaceBit cannot yet replace this cumbersome process—which is a long-standing challenge in the medical industry—it can ensure the mask retains proper fit between testing events. If the mask becomes loose throughout the day or if the user bumps the mask during an activity, for example, FaceBit can alert the wearer.

"If you wear a mask for 12 hours or longer, sometimes your face can become numb," Hester said. "You might not even realize that your mask is loose because you cannot feel it or you are too burnt out to notice. We can approximate the fit-testing process by measuring mask resistance. If we see a sudden dip in resistance, that indicates a leak has formed, and we can alert the wearer."

Face-centric bio-sensing

But the FaceBit can assess more than mask fit—it also can monitor the person wearing the mask in real time. By gathering various physiological signals—such as heart and respiratory rates—FaceBit can help wearers better understand their own bodies in order to make beneficial health decisions. All health information, including mask fit and wear time, are displayed on the accompanying smartphone app.

According to Hester, every time a person's heart beats, their head moves an imperceptibly tiny amount. FaceBit can sense that subtle

motion—and differentiate it from other motions—in order to calculate heart rate.

"Your heart is pushing a lot of blood through the body, and the ballistic force is quite strong," Hester said. "We were able to sense that force as the blood travels up a major artery to the face."

Because stressful events can elicit physiological responses, including rapid breathing, FaceBit can use that information to alert the user to take a break, go for a walk or take some deep breaths to calm down. Hospital systems also could use this data to optimize shift and break schedules for its workers. And because heart rate and respiration rate are so tightly entangled with each other, having the ability to effortlessly monitor both could open new research possibilities.

Battery-free future

An expert in sustainable, battery-free technology, Hester hopes his team or others eventually will be able to make FaceBit completely battery free. Now, the wearer's breathing and movements or the sun can extend the battery's life. But, in the future, harvested thermal and kinetic energy could solely power the device.

Although his team evaluated the device on volunteers in real-world scenarios, Hester said FaceBit still needs to undergo clinical trials and validation. The team released the project as open source and open hardware so others can build and validate the device.

"FaceBit provides a first step toward practical on-face sensing and inference and provides a sustainable, convenient, comfortable option for general health monitoring for COVID-19 frontline workers and beyond," Hester said. "I'm really excited to hand this off to the research community to see what they can do with it."

Medical Xpress

More information: Alexander Curtiss et al, FaceBit, *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* (2021). DOI: 10.1145/3494991

Provided by Northwestern University

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