New biometric watches use light to non-invasively monitor glucose, dehydration, pulse

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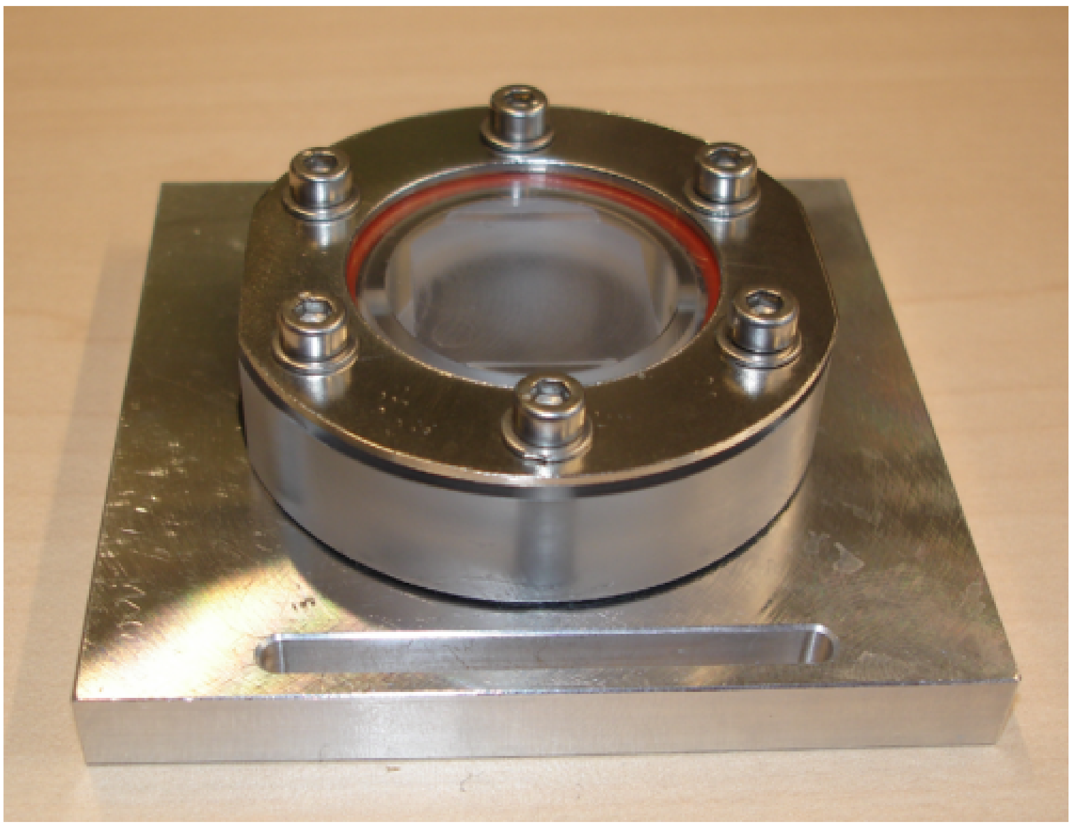


To test their pulse monitoring technique, researchers built a device that mimics blood pulsing through a person's veins under their skin. Milk was pumped through the device to mimic the blood flow, and a type of plastic called Delrin was used to mimic skin's light-scattering properties. Pitured is the blood vessel mimic ("flow cell"). Credit: Mahsa Nemati.

Monitoring a patient's vital signs and other physiological parameters is a standard part of medical care, but, increasingly, health and fitness-minded individuals are looking for ways to easily keep their own tabs on these measurements. Enter the biometric watch.

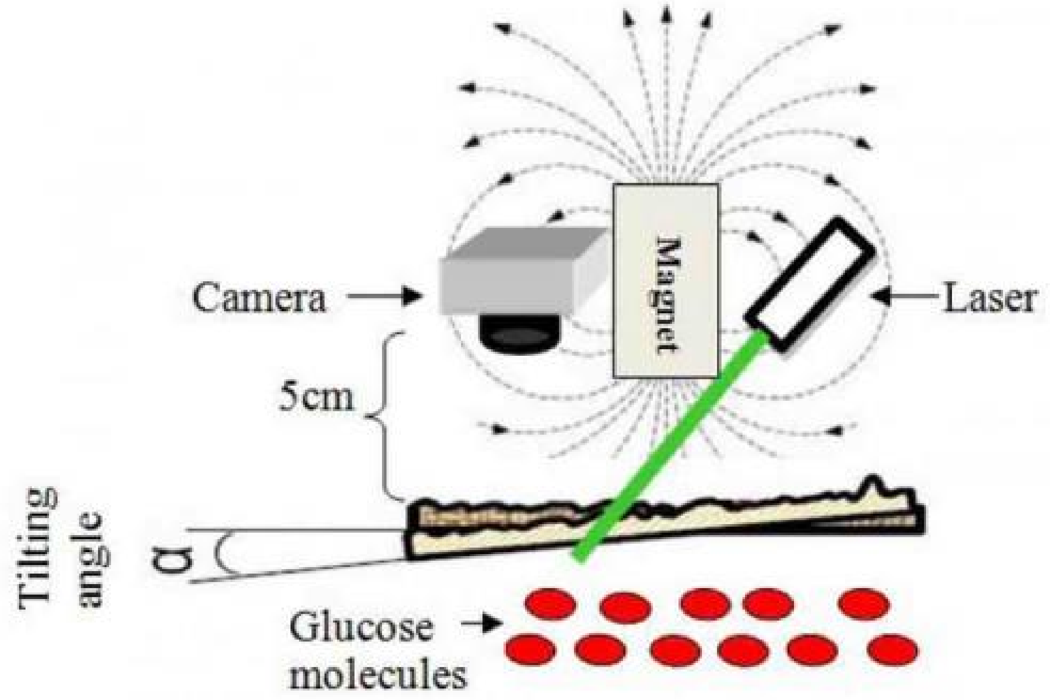
In a pair of papers published in The Optical Society's (OSA) open-access journal *Biomedical Optics Express*, groups of researchers from the Netherlands and Israel describe two new wearable devices that use changing patterns of scattered light to monitor biometrics: one tracks glucose concentration and dehydration levels, and the other monitors pulse.

The glucose sensor is the first wearable device that can measure glucose concentration directly but noninvasively, the authors say.

And while other wearable devices have been made to monitor pulse, the authors claim their new design would be less sensitive to errors when the wearer is in motion, for example while walking or playing sports

Both of the watches described in the two papers make use of the so-called "speckle" effect, the grainy interference patterns that are produced on images when laser light reflects from an uneven surface or scatters from an opaque material. When the material that is scattering the light is moving—say, in the case of blood flowing through the circulatory system—"the speckle pattern changes with changes in the flow," explained biomedical engineer Mahsa Nemati, a graduate student in the Optics Research Group at the Delft University of Technology in the Netherlands and the lead author of the *Biomedical Optics Express* paper on monitoring pulse. Those light variations are a valuable source of information, she says.

The 'Holy Grail' of Diagnostics



This schematic diagram shows how the new system can be used to measure a person's glucose levels non-invasively. Credit: *Biomedical Optics Express*.

In the first paper, bioengineer Zeev Zalevsky of Israel's Bar-Ilan University and his colleagues describe a new wearable biometric system that uses the speckle effect to directly monitor the glucose concentration in the bloodstream, as well as the wearer's relative hydration level.

"Glucose is the holy grail of the world of biomedical diagnostics, and dehydration is a very useful parameter in the field of wellness, which is one of our main commercial aims," Zalevsky said.

The watch-like device consists of a laser to generate a wavefront of light that illuminates a patch of skin on the wrist near an artery, and a camera that measures changes over time in the light that is backscattered off the skin. Unlike other chemicals present in the blood, glucose exhibits a so-called Faraday effect. This means that in the presence of an external magnetic field (generated by a magnet attached to the device) the glucose molecule alters the polarization of the wavefront and thus influences the resulting speckle patterns. Analyzing these changing patterns provides a direct measurement of the glucose concentration. Because one of the main signs of mild to moderate dehydration is muscle weakness, which will alter the strength of the signals, the same device can also be used to indicate the relative dehydration level of the user as it changes over time.

Zalevsky and his colleagues are now working to reduce the margin of error in the device's readings. "Around 96 percent of our in vivo measurements were within a range of 15 percent deviation from the readout of a medical reference glucometer device," Zalevsky noted. "The main factor for errors now is the stability of our device on the wrist of the user. We are currently investing efforts in deriving proper calibration and motion cancellation procedures that will allow us to reduce this sensitivity."

Zalevsky says this is the first step toward non-invasive, continuous in vivo measurement of glucose that is based on sensing an effect that is directly related to glucose concentration. The team expects a commercial version of the device to reach the market within two to three years.

Pulse Tracker

This shows the new glucose- and dehydration-monitoring "watch," strapped to a subject's wrist and connected to a computer for readout. Credit: *Biomedical Optics Express*.

In the second *Biomedical Optics Express* paper, published today, Nemati and her colleagues at Delft and at Phillips Research developed a method that could be used to monitor pulse non-invasively with a sensor that isn't thrown off by the wearer's movement.

Using simulated heart beats generated in milk and measurements performed on the finger of a volunteer, they found that speckle changes can be used to accurately measure flow pulsations—that is, the heart rate—even when the light source used to create the speckle pattern is also moving, as would be the case with a wearable biometric sensor. The researchers found that just a couple of pixels from the image were sufficient to extract the pulse rate.

"This paper shows for the first time that a speckle pattern generated from a flowing liquid can give us the pulsation properties of the flow in spite of motion-induced artifacts," Nemati said. "Sophisticated optics is not necessary to implement this, so the costs for devices can be kept low. Another advantage is that the devices can be non-contact or far from the sample," she added.

The team is currently working with companies to integrate their motion-friendly pulse-monitoring technique into existing sensors, for potential use clinically as well as in sports, Nemati said.

More information: "Improved noncontact optical sensor for detection of glucose concentration and indication of dehydration level," N. Ozana et al., *Biomedical Optics Express*, Vol. 5, Issue 6, pp. 1926-1940 (2014). www.opticsinfobase.org/boe/abs … cfm?uri=boe-5-6-1926

"Dynamic light scattering from pulsatile flow in the presence of induced motion artifacts," M. Nemati et al., *Biomedical Optics Express*, vol. 5, Issue 7, pp. 2145-2156 (2014). www.opticsinfobase.org/boe/abs … cfm?uri=boe-5-7-2145

Provided by Optical Society of America

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