Diabetes is a potentially devastating disease with no known cure. The pancreas of a person who has type 1 diabetes does not produce insulin. The failure to strike the right balance between food and insulin intake can lead to extreme physiological reactions—from crying jags to loss of consciousness. The long-term effects of uncontrolled blood glucose imbalances can be even more devastating.

NON-INVASIVE BLOOD GLUCOSE MONITORING
Today, people with type 1 diabetes use needles to prick their fingers multiple times throughout the day, every day, including meal times, for blood samples that allow them to monitor and maintain healthy glucose levels, which is critical to reducing the impact diabetes has on the patient’s health. The never-ending, daily blood draws are not only unpleasant for the person with diabetes, but they also provide limited information.

Researchers from the University of Washington (UW) and Microsoft Research Connections are working together to develop a non-invasive, technological solution that promises to improve both the health and overall quality of life for people with diabetes: a contact lens that monitors blood glucose levels. This innovative solution represents a trend in technology, the natural user interface (NUI).

NUI technology can benefit the user without being obvious or intrusive. This has tremendous potential in the healthcare industry, where technology is a necessary, but not always pleasant, part of a patient’s diagnosis and/or care.

The contact lens NUI would replace the blood tests and provide real-time feedback regarding fluctuations in glucose and insulin levels to the wearer, allowing the user to react quickly—for example, by increasing insulin intake or eating a piece of candy to raise their blood sugar level. If such fluctuations are not detected by a blood draw, the diabetic may experience physical symptoms including blurry vision, nausea, emotional instability, and loss of consciousness.

Babak Parviz, a researcher at UW, and Desney Tan, a senior researcher at Microsoft Research, are developing the “functional lens,” a contact lens that would address all of these issues and more. As envisioned, the lens would be worn daily, just like regular contact lenses. But in addition to (or instead of) correcting vision, the lens would monitor the wearer’s glucose level through their tears.

“What is inside the blood, to a degree, appears on the surface of the eye,” Parviz explained. “So there is a reflection of the body chemistry directly on the surface of the eye. If you...
have a contact lens that can sample that surface, analyze it, and maybe send out the information through a radio, this contact lens, in principle, can give us information about what’s happening inside the body without actually going into the body or collecting a blood sample.

The lens has the potential to help people like Kevin McFeely, who has lived with type 1 diabetes for three decades, and his two younger children, ages 10 and 7, who were diagnosed with type 1 diabetes three years ago.

“When we first wake up, the first thing we do is test our blood sugar to see where we’re at,” McFeely said. “All three of us wear insulin pumps, so once we test our blood sugar, it automatically beams the results into the pump. When we eat, we count carbohydrates. We put the carbohydrate count [into the insulin pump], and the pump calculates how much insulin is needed. And that’s how we go throughout the day.”

“I’m really proud of our potential to impact real people like Kevin,” Tan said. “And Kevin’s just one in a slate of millions who have this particular condition.”

DEVELOPMENT OF THE FUNCTIONAL LENS

Parviz’s lab has built a variety of contact lenses with small radios and antennas built in, enabling them to send and receive information through radio frequency radiation. The team also has been able to place a glucose sensor on the contact lens and demonstrate that it can detect glucose at levels that are found in the tear film. The goal is to pull these elements together to develop a contact lens that constantly monitors the blood glucose level and records information that can be accessed by the patient’s doctor.

The lens is the result of a large collaboration involving many disciplines. “There are quite a few people who work on building these contact lenses,” Parviz said. “We have a number of electrical engineers that build miniaturized devices, design and build sensors, and build radios or interface circuitry. We work with material scientists who think about issues related with the contact lens material. And we directly work with ophthalmologists to make sure that these devices are safe and medically relevant.”

In addition, the UW research team has worked closely with Microsoft Research Connections in recent years. The UW/Microsoft Research Connections collaboration dates back to a conference in Boston several years ago, where Babak Parviz and Desney Tan met.

“At the time I met Babak, he was starting to work on the functional contact lens, putting displays, or LEDs, into the contact itself, to create displays that sat on the surface of the eye,” recalls Tan. “He was having a slightly hard time selling the idea, both in terms of feasibility, but also in terms of vision. What we added to the equation was basically a set of needs in all computing environments or in our projections of future computing environments that gelled very well with a particular technology.”

INSTANT FEEDBACK WITHIN THE WEARER’S VIEW

The team envisions a way to automatically display important information—including abnormal glucose or insulin alerts—in the lens wearer’s view. It could alert the wearer when their glucose levels indicate that they should stop eating, or remind them when it’s time to eat a snack. This real-time feedback would empower the user to react quickly, before their health or safety is compromised. The visuals would be dormant the rest of the time, adhering to the NUI ideal of unobtrusive technology.

“The functional contact lens provides us with the ability to have displays that we don’t have to pull out and look at, and that require we take our attention away from the real world,” Tan notes. “They aren’t socially quite as intrusive as wearing the goggles that are sort of the state of the art in the field right now.”

Working on the functional lens has inspired Tan to dream beyond just healthcare applications. “The project allows us to remove some of the barriers to the imagination,” he said. “It allows us to imagine a world in which the virtual and the real are truly fused, without some of the technology barriers that exist in the way. Imagine being able to overlay digital images in the real world seamlessly at any given time. It’s a pretty amazing set of capabilities we could provide to the user.”

For example, “I’m walking through the hallways of this building—you could overlay directions; an arrow on the floor that guides me around the building,” Tan said. “Walking through the grocery store, personalized health information could appear on the items I select. I might see recipes that are useful in managing my health or I may be directed towards alternative options. The possibilities are endless if you are open to them,” he noted.

Tan and Microsoft Research Connections have been great supporters of the project, Parviz said. Their willingness to explore and invest in the project was critical to advancing research and development of the functional lens.

“A lot of people considered it science fiction,” Parviz says. “Desney and Microsoft Research were actually, very early on, convinced that this is perhaps a worthy cause. And they were willing to work with us, and support us. And I’m very grateful they did.”