David Sengeh, MIT (Cambridge, MA)
$15,000 Lemelson-MIT “Cure it!” Graduate Winner
Next-generation wearable mechanical interfaces for amputees

The Challenge: There are an estimated two million amputees in the United States\(^1\) with an estimated global amputee population of ten million\(^2\); many of these people have comfort and mobility issues with their prostheses. Advances in prosthetics abound, however the prosthetic socket or interface often dictates usability. The current state-of-the-art socket solutions are often uncomfortable, leading to pressure sores, deep tissue injury, and other secondary challenges.

The Solution: David Sengeh is designing and building next-generation prosthetic interfaces using quantitative patient-specific data in a reliable, cost effective and repeatable way. His process uses advances in magnetic resonance imaging, computer-aided design and manufacturing to create 3D printed, customized prosthetic interfaces that better match the contours of the human body, reducing pressure on the body and improving comfort and mobility. The anatomy of the remaining limb is used to design a socket interface with structural integrity based on human data. The recent addition of carbon fiber made Sengeh’s 3D printed sockets more structural, while allowing for the intended prothetic to conform to bony structures in the residual limb. Sengeh has also worked with low-level laser therapy practitioners to design a custom product to treat patients who have pressure sores on their residual limbs.

Application and Commercialization: Sengeh’s hope is that the tools and processes he creates will bring low-cost and highly functional prosthetic sockets to patients all over the world. His invention has been tested by veterans and other amputee patients. This invention could also lead to industry advances, from streamlining production, to reducing costs, and most importantly enabling prosthetics to fit more patients. His design has implications beyond prosthetics to all mechanical interfaces including braces and orthotics. There is a patent-pending application for this technology, and Sengeh is focused on launching a prosthetic socket and interface design company within the next few years.

The Challenge: Diabetes is an incurable disease that affects nearly 350 million people worldwide. Eighty percent of diabetes deaths occur in lower income countries. The monitoring supplies necessary for patients to manage their disease are not readily available in these resource-poor settings or are too expensive for patients to afford. Clinics receive donations of glucose monitoring devices, but they are often incompatible with the brand of test strips donated, rendering both essentially useless.

The Solution: Tyler Ovington and team members, Alex Devon and Kayla Gainey believe that the use of inkjet printing will drastically lower the cost of test strips (1/100th of the cost of standard strips), making it possible for diabetics in resource-poor settings to properly manage their disease. The team’s system has two parts: The InkJet Printed Glucose Test Strips and the Glucometer.

The Clemson Bioengineering team’s glucose test strips are created using coffee filter paper, contact paper and standard ink-jet printers. The printer cartridge is filled with enzymes instead of ink, and the printer settings are controlled to deposit the appropriate volume of enzymes on the paper. Once the paper is printed, it is cut into strips to be read by the glucometer.

The glucometer uses standard photodiodes and LEDs to measure changes in strip color. A tray receives the strip and is then pushed to an inside locked position, where it aligns the test strip with the LED and photodiode to take the reading and display the patients’ blood sugar on. The output of the photodiodes is read and processed to produce an amplified absorbance reading. The equation relating absorbance readings and glucose levels is obtained from a standard calibration curve. The output of the amplifier is read and assessed by a microcontroller and displayed on the LCD screen.

Application and Commercialization: The simplicity of the test strip manufacturing process and usability of the glucometer allow for local manufacturing and reduced costs. A reduction in logistical problems associated with purchasing and distributing diabetic test materials from other countries is also anticipated. The team, with the support of the Clemson Creative Inquiry Program, is currently focusing efforts and testing on quality control measures using glucose standard solutions to advance their work further. Under the mentorship of advisors Dr. Delphine Dean and Dr. John DesJardins, the team is also piloting the technology at Muhimbili Hospital in Tanzania with plans to partner with local technicians, hospitals, clinics, and the Tanzanian Diabetes Association to produce and distribute the technology.