UCLA engineer's telemedicine invention poised to begin trials in Africa

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Cell phones are accumulating a Swiss Army Knife-esqe assortment of capabilities; substituting as cameras, providing internet access, and soon operating as medical labs if Aydogan Ozcan's plans come to fruition. This month's cover article of the journal *Lab on a Chip* features the latest creation by the Ozcan group, a functioning prototype of a cell phone microscope. The lensless imaging platform behind the cell phone microscope is nearing readiness for real world trials, after receiving prestigious awards in the past month from the Bill & Melinda Gates Foundation, National Geographic, and the National Science Foundation (NSF).

"Cell phones present a tremendous opportunity in Global healthcare," remarked Ozcan, an assistant professor of electrical engineering at the UCLA Henry Samueli School of Engineering and Applied Science and a researcher at UCLA's California NanoSystems Institute. "We can leverage the fact that eighty percent of the world's population lives in areas covered by cell phone networks to bridge the gaps left by a lack of health care infrastructure in developing countries."

That lack of health care infrastructure includes not only buildings, but also trained personnel. For telemedicine tools to effectively fill in for hospitals, the devices have to meet several criteria. They must be cheap enough for widespread use in poor areas, be simple enough for a minimally trained person to correctly operate, and be able to easily transmit information over existing cellular networks. Optical microscopes, a key diagnostic tool in hospitals, are too bulky for

telemedicine applications.

In optical microscopes, one of the elements which limits the miniaturization possibilities and drives up the cost is the lens. Ozcan's telemedicine microscope avoids both these constraints by capturing an image with a lensless system. This innovative engineering means that the microscope can be miniaturized (it only weighs ~1.5 ounces) to the point where it fits on most cell phones, while remaining inexpensive enough for widespread use in developing countries, costing only about ten dollars each.

Images are captured through a process called diffraction, or shadow-based, imaging. An ordinary light-emitting diode (LED) from the top illuminates the sample, and the detector array already installed in cell phone cameras captures the image, recording the patterns created by the shadows resulting from the LED light scattering off of the cells in the sample. Because cells are semi-transparent, enough information is obtained from this type of imaging to detect sub-cellular elements, and to produce holographic images. By using an inexpensive LED light instead of a laser as typically required for holographic imaging, the size and cost are further reduced.

The cell phone microscope is also easy to use, and versatile. Samples (blood smears or saliva) are loaded into single-use chips that easily slide into the side of the microscope. Because the microscope uses the entire detector array to capture an image and has a relatively large aperture, it has a wide imaging field-of-view. Samples do not need to be precisely aligned for images to be captured, and the chance of debris clogging the light source is lessened. Alternate uses of the technology include testing water quality in the field following a disaster like a hurricane or earthquake.

The lensless imaging platform is an ideal telemedicine tool because it is

so easily integrated with cell phones, which are becoming cheaper to produce while gaining sophistication. Even base models in developing countries often have cameras. Ozcan's group developed an algorithm that instantly identifies and counts red and white blood cells and microparticles in samples, a time consuming process typically done by trained technicians. The image results are then sent by the cell phone to centralized hospitals for analysis by doctors. As an alternative for people whose cell phones don't have built-in cameras, Ozcan's group also created a standalone lensless microscope that only requires a USB connection for power and to upload the captured shadow images to either a laptop or cell phone for transmission.

Field tests of the cell phone microscope will begin in Africa this summer using funds received from the three major awards. In early May a proposal of Ozcan's was selected by the Bill & Melinda Gates Foundation for a $100,000 Grand Challenges Exploration Grant; in mid May he was selected as a National Geographic Emerging Explorer, for which he will receive $10,000; and in late May he received $400,000 for a CAREER award from the NSF.

More information: For more information on Ozcan's research group, visit innovate.ee.ucla.edu/

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