Electronic Supplementary Material (ESI) for Lab on a Chip.

A low-cost smartphone-based device for point-of-care ovulation testing

Authors

Vaishnavi Potluri[1]†, Preethi Sangeetha Kathiresan[1]†, Hemanth Kandula[1], Prudhvi Thirumalaraju[1], Manoj Kumar Kanakasabapathy[1], Sandeep Kota Sai Pavan[1], Divyank Yarravarapu[1], Anand Soundarrajan[1], Karthik Baskar[1], Raghav Gupta[1], Neeraj Gudipati[1], John C. Petrozza[2], Hadi Shafiee[1,3]*

Affiliations

[1]Division of Engineering in Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA.

[2]Division of Reproductive Endocrinology and Infertility, Department of Obstetrics and Gynecology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

[3]Department of Medicine, Harvard Medical School, Boston, MA, USA

†These authors contributed equally to this work.

* Corresponding author. E-mail: hshafiee@bwh.harvard.edu

Supplementary Information

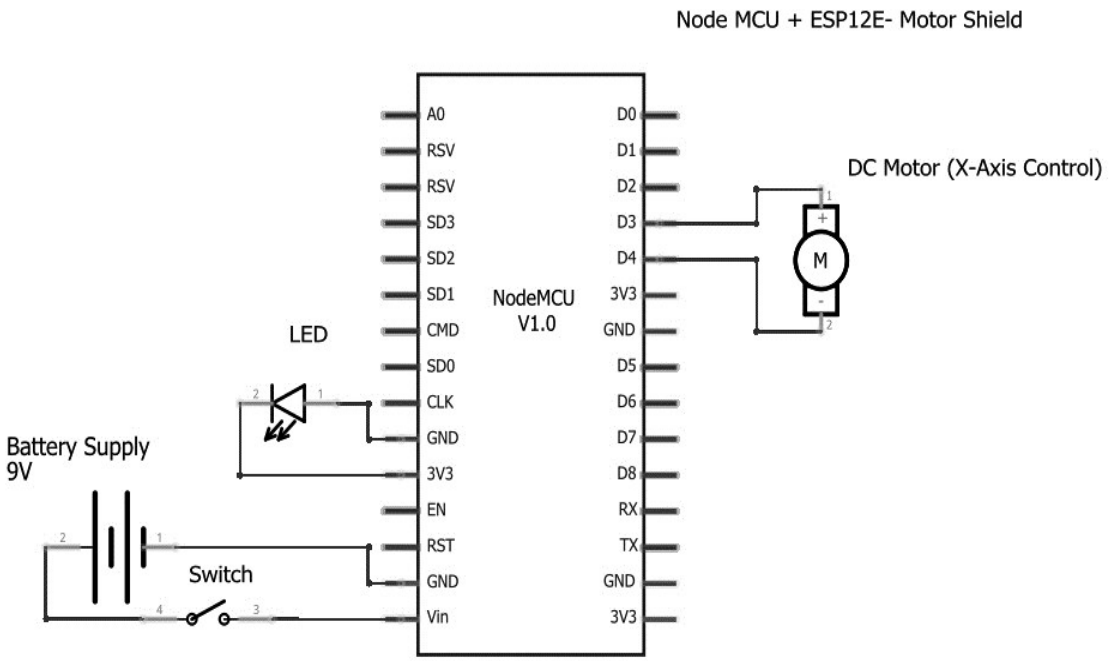

Figure S1. Circuit diagram of the electrical enclosure of the optical system. Wireless communication between the smartphone and the optical attachment was achieved by configuring the Single-board microcontroller (NodeMCU) as an http web server. The system includes a DC motor for automation, a LED for illumination, a 9 V battery for power source, and a switch for control purposes. All components are connected to the NodeMCU.

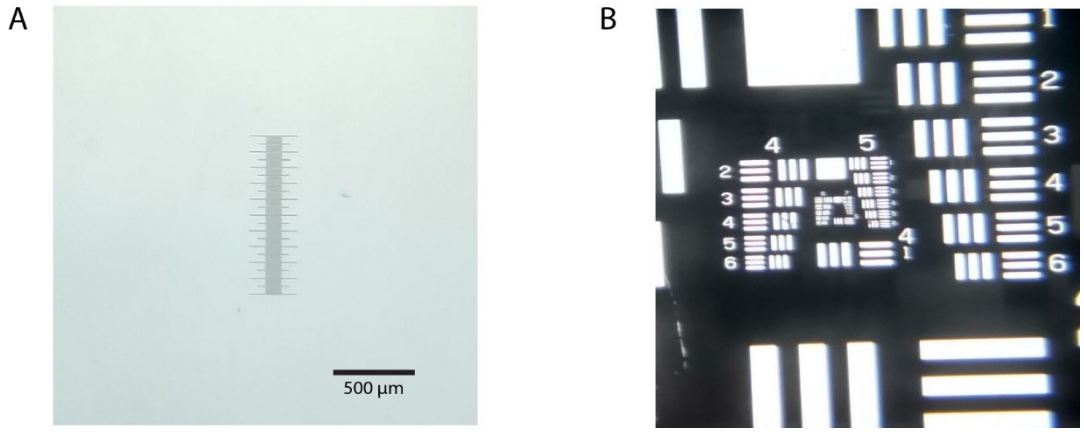

Figure S2. Image of micrometer scale and 1951 US Air Force (USAF) resolution test chart recorded with the smartphone system. (A) The spacing between the divisions of the stage micrometer (Omax, B00FG89F0M) is 10 µm. The dimensions of the image shown here are 642 × 642 pixels. One micron is represented by 0.226 pixels. (B) Resolution of the reported smartphone-based optical imaging system was 7µm.

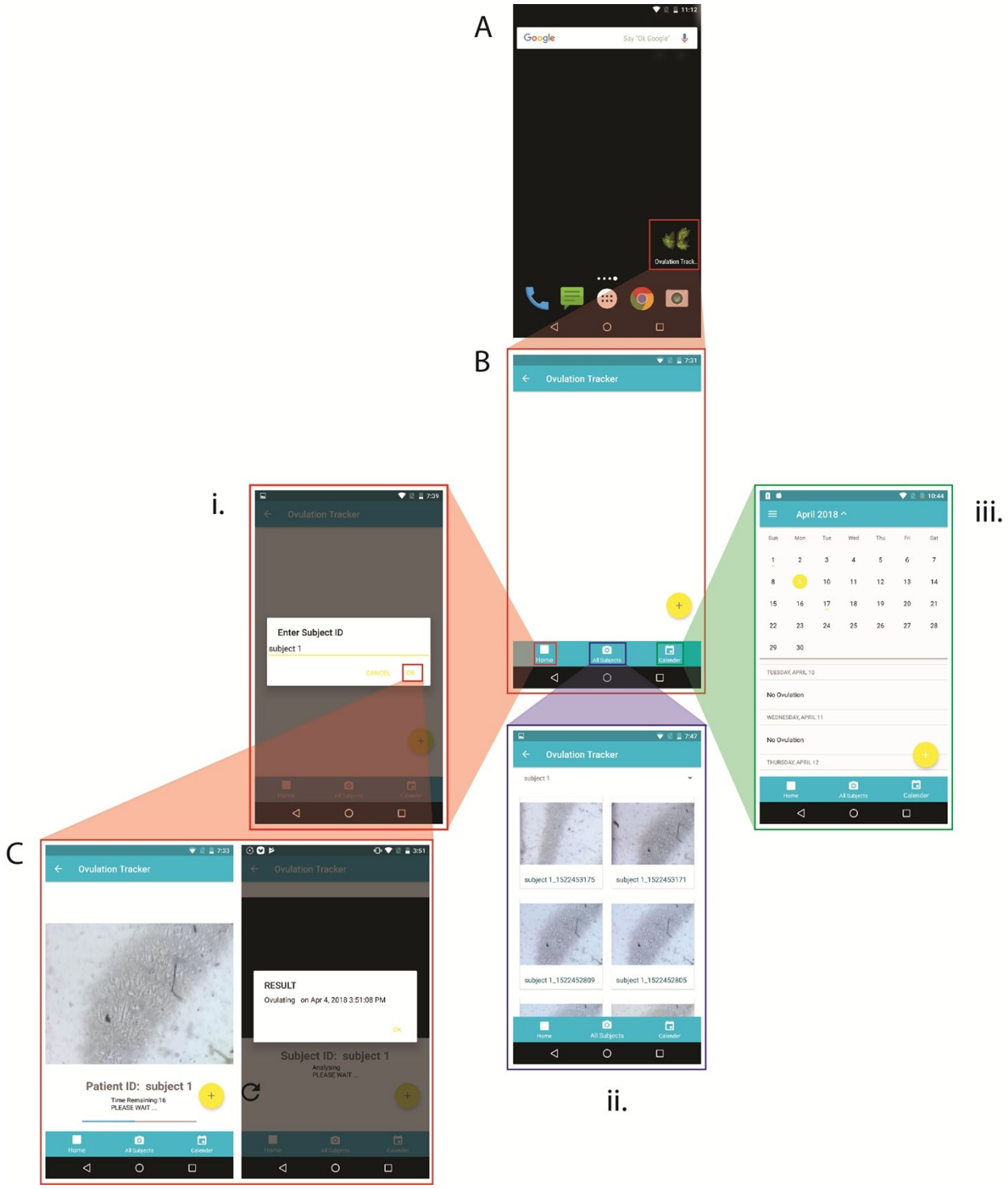

Figure S3. Smartphone application user interface. These figures show the process flow of the android application developed for image processing and ovulation detection. (A) The smartphone

application can be selected on the home screen of the smartphone. The smartphone application icon is shown within the red box in this figure. (B) The home screen of the application shows different options that can be accessed. The schematic has been color-coded to show the different possibilities. (i) Red color option leads to initialization of sample testing; (ii) blue color option leads to test result history; and (iii) green color option leads to a calendar to track ovulation cycle. (C) Time remaining for completion of the test is first displayed followed by the result.

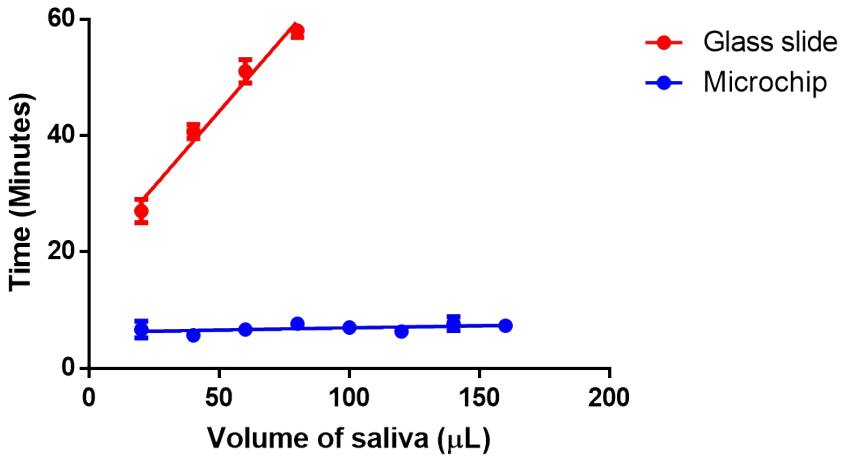

Figure S4. Drying time for human saliva samples. Different volumes of saliva samples were used on the developed microfluidic device and on a simple glass slide to test the drying time at room temperature. The slopes of the regression lines for the microfluidic device and the glass slide groups were 0.01 and 0.52 with R^2 values of 0.94 and 0.06, respectively. Each data point represents the mean value (n=3) while the error bars represent the standard error of mean.

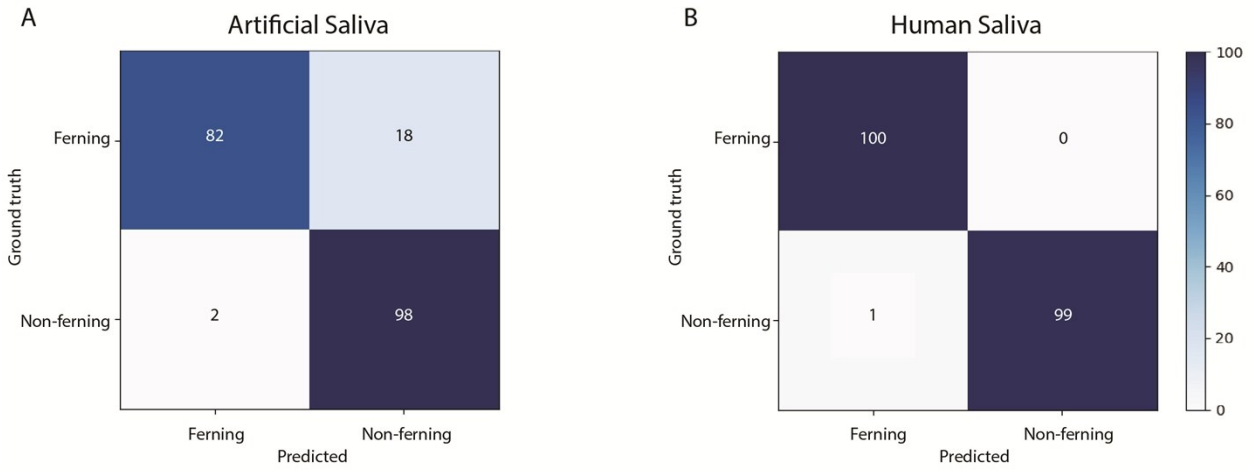

Figure S5. Confusion matrices for the test sets using artificial saliva and human saliva samples. (A) The system accuracy when artificial saliva samples (n=200) were tested was 90%. (B) The system accuracy when human saliva samples (n=200) were tested was 99.5%. Prior to testing, the samples were classified into ovulating and non-ovulating based on the urine test results.

Materials cost		
	Cost (USD)	**Total (USD)**
Hardware attachment		13.58
Lenses (both)	1.73	
PLA	1.52	
LED	0.1	
Battery	1.25	
Switches and wires	0.7	
Node MCU	3.47	
DC motor	3.22	
Linear rods	1.59	
Microchip		0.33
Glass slide	0.19	
PMMA	0.09	
DSA	0.006	
PLA	0.04	
Total		13.91

Table S1. Estimated material costs of the hardware. Material costs for all the elements used in the fabrication of the optical attachment and the microfluidic chip.

Artificial saliva samples	Samsung Galaxy 5	Xiaomi Redmi Note 4	OnePlus 5T	LG G6	Moto X
Sample 1	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 2	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 3	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 4	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 5	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 6	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 7	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 8	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 9	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 10	Ferning	Ferning	Ferning	Ferning	Ferning
Sample 11	No Ferning	No Ferning	No Ferning	No Ferning	No Ferning
Sample 12	No Ferning	No Ferning	No Ferning	No Ferning	No Ferning
Sample 13	No Ferning	No Ferning	No Ferning	No Ferning	No Ferning
Sample 14	No Ferning	No Ferning	No Ferning	No Ferning	No Ferning
Sample 15	No Ferning	No Ferning	No Ferning	No Ferning	No Ferning

Table S2. Software performance when different smartphones used. Artificial saliva samples were diluted to create samples with and without fern structures. All samples were imaged an analyzed by each smartphone individually.