Live Demonstration: A Mobile Diagnostic System for Rapid Detection and Tracking of Infectious Diseases

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***Abstract*—A mobile diagnostic system is demonstrated for the early detection of infectious disease outbreaks in remote areas. The system comprises an ISFET-based platform, an AndroidOS application running on a smartphone, and a cloud server. Incorporation of microfluidics on the 78x56 ISFET array permits on-board isothermal DNA amplification and detection. Each die is mounted on single-use cartridges. The platform is controlled by the app, which collects relevant data via Bluetooth to process through algorithms stored on the smartphone. Upon a positive result, a data package containing disease type, geographical location, and timestamp is sent to the cloud. Real-time monitoring of outbreaks to pandemics can be visualized accordingly.**

I. Introduction

The status quo for diagnostic pathways involves lengthy and complicated processes carried out in professional laboratory environments. The time spent determining whether a pathogen is present may consequentially lead to further unconstrained spread of the disease. To streamline diagnoses and make detection of outbreaks more accessible for developing countries, especially in remote areas, this system is conceived to integrate Lab-on-Chip technology [1] with a cloud network. An opportunity is recognized in using scalable CMOS ISFET sensors [2], combined with the ubiquitous adoption of mobile devices. The aim is to bring diagnostic capability equivalent to a laboratory directly to such areas and report results worldwide in real-time, permitting efficient response concurrently from medical professionals on-site and worldwide.

The Lab-on-Chip platform is portable and uses ISFET arrays on ICs [3]. The sensors perform ion imaging of the reaction at the surface of the chip, thus enabling DNA amplification to be monitored in real time by detecting the release of H^+ ions in the solution. The chip is paired with a temperature regulator to guarantee a steady operation environment at a constant temperature for amplification to occur. An on-board microcontroller handles data acquisition and transaction through Bluetooth to a smartphone app for platform interfacing.

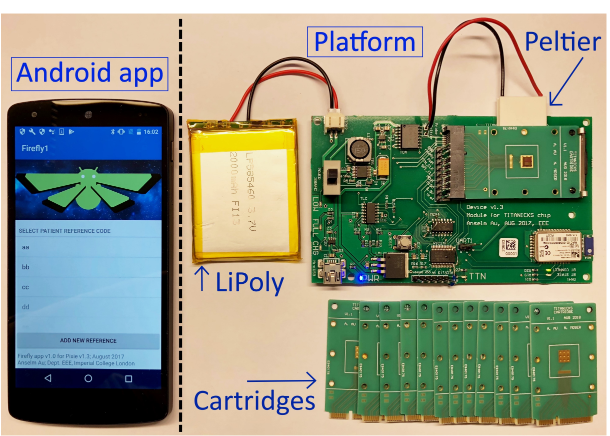

Fig. 1. Android app (*left*); Platform (*top right*); Cartridges (*bottom right*)

II. Demonstration Description

A single unit of each component in the diagnostic network is shown in *Figure 1*. The 71mm x 120mm portable platform has all chip-interfacing functionalities embedded onto a single SMD PCB. It is driven by a PIC microcontroller, supplemented by DACs, a temperature controller, Bluetooth radio, cartridge edge connectors, power regulator and protection circuits, an external peltier and a rechargeable lithium-ion polymer battery. The smartphone app provides clear guidance on proper usage of this technology, designed around an icon-based pictorial user interface. An Android smartphone is used to run the app. One platform-app 'paired unit' is managed per demonstrator, and one cartridge used per experiment/trial where liquid samples will be supplied via pipettes to microfluidics mounted on the cartridge. The cloud itself can communicate with multiple units concurrently, effectively parallelizing the 'diagnoses' in the 'suspected infection area'. A laptop is used to access a website that displays data (disease reports) stored on the cloud.

III. Visitor Experience

The demonstration aims to simulate the event of a suspected epidemic and a possible crisis response strategy designed around this Network. Visitors can select from various known pH buffer solutions to be tested, each mimicking the DNA amplification pattern of selected widespread infectious diseases, and a control solution referring to the healthy case.

For the purpose of the demonstration, 'patient' engagement during the diagnosis process will be increased, with the demonstrator guiding each visitor through the platform processes: from initialization, calibration, temperature regulation, DNA amplification, data readout and transmission to the app. Following the experiment, the visitor can observe in real-time the detection algorithm running on the app, visualized in both temporal and spatial domains. Next, 'disease detection reports' will be sent to the cloud if the result returns positive, where the current location,or one chosen by the visitor, will be tagged immediately with relevant data and displayed on the website loaded on the laptop. Finally, the visitor can verify whether the report matches the solution initially selected, present date and time, and chosen location.

References

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