Auryn: adaptor for general-purpose digital microfluidic Biochips

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ABSTRACT

Digital microfluidics programs biology by transporting droplets on an electrode array. Droplets can carry a variety of fluids (e.g., biological samples, nutrient media, buffers, reagents), and their transportation is entirely programmable. Biology is becoming digital through digital microfluidics.

We have developed a cyberphysical system that offers hardware support for digital biology. The main piece of our system is a digital microfluidic biochip (Auryn) developed for general-purpose use. We designed Auryn to be mounted on top of lab-on-a chip device (OpenDrop). The droplets are transported on an electrode array shielded by an ITO glass cover. Our Auryn is easy to reproduce with available personal fabrication machines, and we supplement the design files open source. As future work, we will further fabricate specialized microfluidic biochips using inkjet printed electronics.

Keywords: digital microfluidics, biochip, hardware design

INTRODUCTION

Nowadays the overall cost for lab equipment and maintenance is prohibitively high for starting and running any kind of biological activity outside an institutional environment. The goal of our work is to build a cheap, user-friendly and programmable platform that allows to run molecular biology experiments *without a need of a laboratory*.

The main applications of our platform are in the area of point-of-care diagnostics (e.g., during on-site visits of veterinarians) and agriculture (e.g., on-field test and control of crops). However, we believe important applications will be found in human medicine, as our platform will enable detection of toxins or pathogens in an early disease phase allowing for an early stage treatment.
The immediate benefits are: *cost reduction* (better health care coverage) and *decentralization* (i.e., veterinarians and farmers can have their personal labs).

CYBERPHYSICAL SYSTEM DESIGN

Digital microfluidics programs biology by transporting droplets on an electrode array. In Figure 1a, we depict OpenDrop (Gaudenz, Alistar, & Trojok, 2016), the digital microfluidic platform developed in GaudiLabs (www.gaudi.ch). OpenDrop transports droplets by using electrowetting on dielectric: the droplet moves towards the electrode that is activated by voltage (Hong, Fair, & Shaughnessy, 2002).

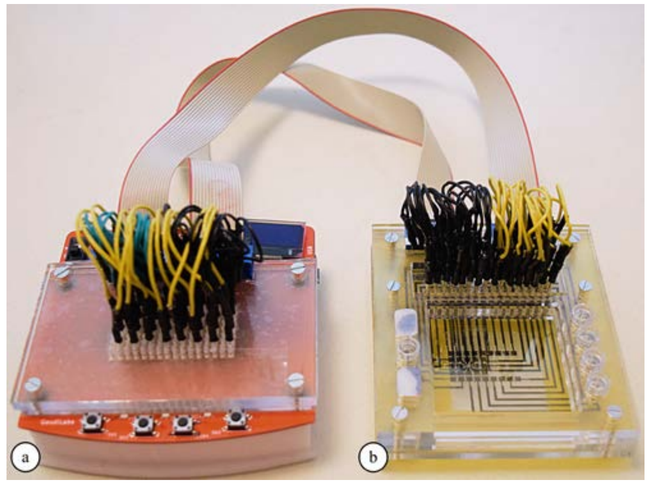

Figure 1 Our system consists of (a) OpenDrop and (b) Auryn

Droplets can merge, mix and split. Droplets consist of a variety of fluids (e.g., biological samples, nutrient media, buffers, reagents), and their transportation is entirely programmable by computer software. We name "*fluxels*" (fluid pixels) the electrodes used to transport fluids.

AURYN CARTRIDGE

Auryn is assembled by screwing together 4 acrylic layers as depicted in Figure 2. Layer (1) is the bottom plate, giving physical strength and support to the other layers and to the objects between them. Layer (2) contains the inlets (reservoirs) for the fluids and the holes for the wire connectors.

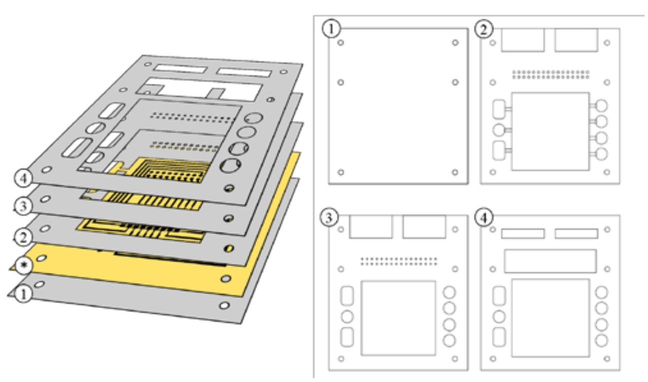

Figure 2 Assembling Auryn using 4 layers of acrylic. On left side we show the order of assembly (layer 1 – 4). The yellow layer (*) contains the fluxel array.

Layer (2) is designed to hold the ITO glass right over the droplets.Layer (3) is a supporting layer, with tighter holes for better fixation of the spring loaded connectors (pogo pins). In the last layer (4) we carved all the holes to stabilize the shields and the wire connector from above.

The 4 layers form a tight structure that holds the fluxel array (the yellow layer in Figure 2). In our setup, the fluxel array is coated with an ultra-fine foil that provides the hydrophobicity needed for droplet transportation.

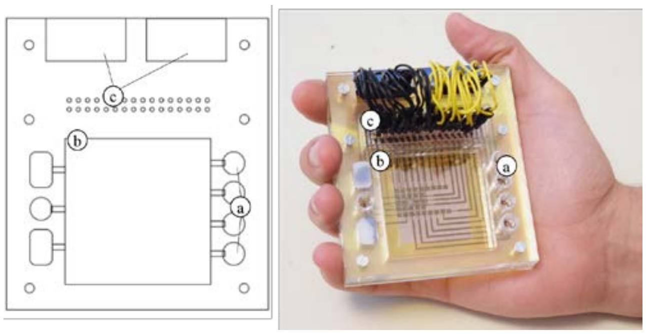

Figure 3 Auryn components: (a) inlet reservoirs for fluids, (b) ITO glass as top cover and (c) connector array for cables and spring loaded connectors.

The droplets are dispensed from the inlets, located at the sides of Auryn (Figure 3a). The droplets are covered with ITO glass, fitted in the top acrylic layer (Figure 3b). The connector array, located at the top of Auryn, is designed to fit 32 cables that connect to the OpenDrop. All the design files are available as Electronic Supplementary Information, under the Open Hardware License. This work focuses on the design of the Auryn adaptor (layers 1—4 in Figure 2). Designing the application-specific biochip containing the fluxel array (yellow layer in Figure 2) will be covered in our next publication.

MATERIALS AND METHODS

The purpose of Auryn is to adapt the use of OpenDrop for inkjet printed biochips (Figure 1) using conductive ink such as the technique developed in Lab311, Sogang University (Shin, et al., 2013). With inkjet printed biochips contained in the Auryn cartridge the user can easily adapt and reuse OpenDrop, by simply disposing and replacing the affordable Auryn cartride (yellow layer in Figure 2).

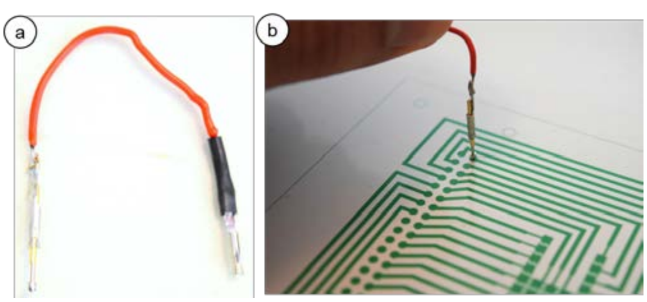

Figure 4 By using a spring loaded connector (a), each fluxel on the inkjet printed biochip (b) is connected to a fluxel on Opendrop

Auryn connects each fluxel of the OpenDrop with each fluxel on the inkjet printed biochip (Figure 4). Our solution uses spring loaded connectors in order to connect the adaptor and the printed biochip. Figure 5 presents all the materials used for the construction of Auryn. All materials are available over the counter in the local hardware and electronic shops.

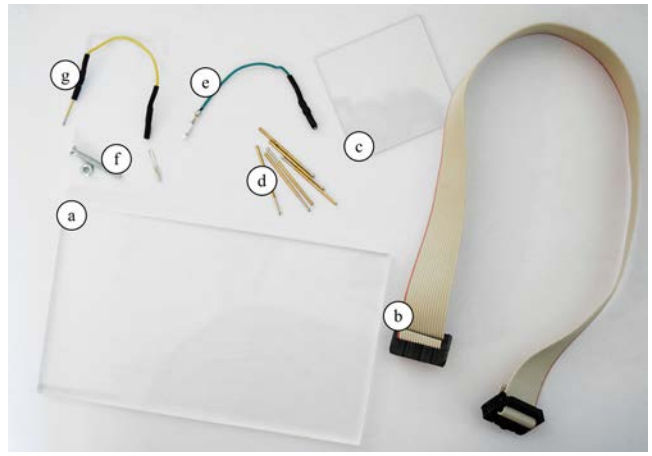

Figure 5 Materials: (a) acrylic sheet (b) cable (c) ITO glass (d) pogo pins (e) wire (f) wire with a spring loaded connector (g) screws

CONCLUSIONS AND FURTHER WORK

As future work, we will develop microfluidic biochips using inkjet printed electronics. Our biochips will be customized for specific applications. We aim at providing a design methodology for application-specific biochips, as well as the software for automated design.

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