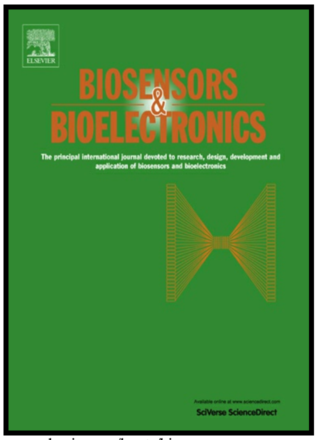

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The eLoaD platform endows centrifugal microfluidics with on-disc power and communication

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Abstract

In this paper we present a comprehensive description of the design, fabrication and operation of an electrified Lab-on-a-Disc (eLoaD) system. The smart platform is developed to extend conventional Lab-on-a-Disc applications with an electronic interface, providing additional flow control and sensing capabilities to centrifugal microfluidics platforms. Wireless power is transferred from a Qi-compliant transmitter to the eLoaD platform during rotation. An Arduino-based microcontroller, a Bluetooth communication module, and an on-board SD-card are integrated into the platform. This generalises the applicability of the eLoaD and its modules for performing a wide range of laboratory unit operations, procedures, or diagnostic assays, all controlled wirelessly during spinning. The lightweight platform is fully reusable and modular in design and construction. An interchangeable and non-disposable application disc is fitted with the necessary sensors and/or actuators for a specific assay or experiment to be performed. A particular advantage is the ability to continuously monitor and interact with LoaD experiments, overcoming the limitations of stroboscopy. We demonstrate the applicability of the platform for two sensing experiments involving optical, electrochemical, and temperature detection, and one actuation experiment involving controlled heating/cooling, and flow control with active valves. The complete electronic designs and example programming codes are extensively documented in the supplementary material for easy adaptation.

Keywords: Wireless, Lab-on-a-Disc, centrifugal platform, automation, on-disc

1. Introduction and motivation

Lab-on-a-chip (LOC) systems are portable devices designed and developed for complex diagnostic purposes. They integrate basic analytic steps such as sample and reagent injection, mixing, sedimentation, amplification, incubation, and detection. Lab-on-a-Disc systems form a sub-category in the form of a spinning microfluidic disc, typically of the same dimensions as a common optical disc such as a CD or DVD, in which the centrifugal force is used to pump liquids along radial microfluidic channels. The system is particularly advantageous for use in 'point-of-care' and 'point-of-use' applications, as its function requires only a common spindle motor rather than specialist microfluidic pumps. Laboratory unit operations (LUOs) such as valving, pumping, metering, mixing, and sample preparation on centrifugal microfluidic platforms have been widely studied (Ducrée et al., 2007; Strohmeier et al., 2015; Kong et al., 2016). Sample preparation might include a single or multiple steps such as particle sorting, purification/concentration, sedimentation/filtration, and cell lysis. The platform is particularly powerful due to the inherent ability to centrifuge samples, such as needed for blood processing (Kinahan et al., 2016b). The existing solutions to perform these LUOs have been mainly achieved using passive techniques.

However, while the LoaD technique has simplified basic operations, solutions to other arising needs, such as the integration of (active) operations, or the readout of a bioassay result, has proven more challenging to achieve when the platform is under continuous spinning motion. Without the possibility of a direct connection of sensors and/or actuators to a stationary power supply, stroboscopic observation and excitation has remained the most widely means of detection and actuation in LoaD systems (Burger et al., 2016). These include absorbance (colorimetric), fluorescence and chemiluminescence detection methods for many biological and chemical assays, as well as laser scanning microscope systems, imaging based detectors. Even resonance detection via vibration and deflection sensing techniques for mechanical (cantilever-based) sensors have been reported (Burger et al., 2016; Kong et al., 2016).

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