Blood Analysis for Patients with Chronic Liver Disease at Home

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Originated from clinical needs and driven by key targeted scenarios, the European project d-LIVER plans to develop prototype systems with the aim of porting monitoring instrumentation from a laboratory platform to portable devices localized at home. CSEM is in charge of leading the development of three prototypes based on multiple optical and electrochemical sensors for fully automatic discrete measurement of a defined set of biochemical species.

The liver is a complex organ with various vital functions in synthesis, detoxification, and regulation; its failure is life-threatening and the only curative treatment is transplantation. Transplantation is unfortunately limited by the insufficient number of donors available. Whilst awaiting transplantation, or after liver resection, patients need to be supported with detoxification systems which are currently mainly based on filtration and consequently do not support metabolic liver functions (this can only be provided by living cells).

The d-LIVER[1] integrated project targets sensor-based monitoring of patient health status at home, concentrating on continuous monitoring of physiological parameters and discrete measurement of a defined set of biochemical species. d-LIVER also targets remote monitoring and control of a bio-artificial liver and communication with patient sensor networks and hospital information systems. Systems will be capable of remote and secure communication of the status of both the patient and the bio-artificial liver to central clinical services so that they can schedule swift and beneficial treatment and remedial actions. The overall goal of the project is to provide systems to enhance the quality of medical treatment and to improve the quality of life for patients by reducing the incidence and duration of hospitalization and consequently the healthcare economic burden of liver disease.

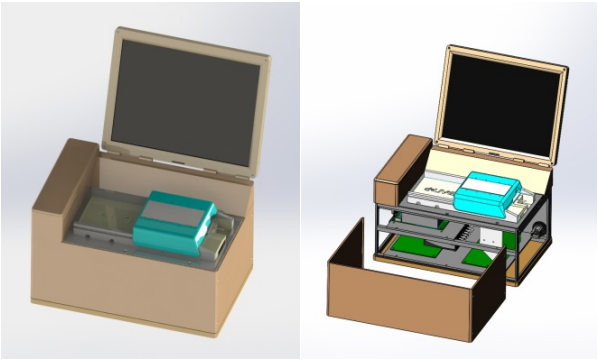

Figure 1: Blood biochemistry instrument.

In the context of this project, several project partners collaborate to develop the home blood analysis technology, and CSEM is in charge of the development of a blood biochemistry instrument (BBI) which allows patients with liver disease to monitor levels of biomolecules (albumin, bilirubin, and creatinine) and electrolytes (sodium and potassium) as well as blood clotting time at home. Human serum albumin is detected by impedance measurements using a three-electrode system. Bilirubin is measured by amperometry also using a three-electrode system. Creatinine is measured by indirect potentiometry by using an enzyme to catalyze the production of ammonia at the sensor surface. Potassium and sodium ions are detected by potentiometry. Clotting time is measured optically by detecting the speckle pattern due to the movement cessation of red blood cells during coagulation.

The BBI itself (Figure 1) is a desktop device with an embedded computer. A pneumatic system made out of a micro pump and electro-valves allows driving of the fluids within the cartridge while a bunch of optical barriers follows its progression. A turning valve, integrated within the cartridge, is also used for the fluidic routing. This valve is driven by a stepper motor. Moreover, a heating system and temperature sensors are used to control the temperature of the cartridge at 37°C. The BBI desktop device also contains all the electronics required to drive those actuators as well as the readout devices used to measure data from the electrochemical sensors are hosted on custom PCBs.

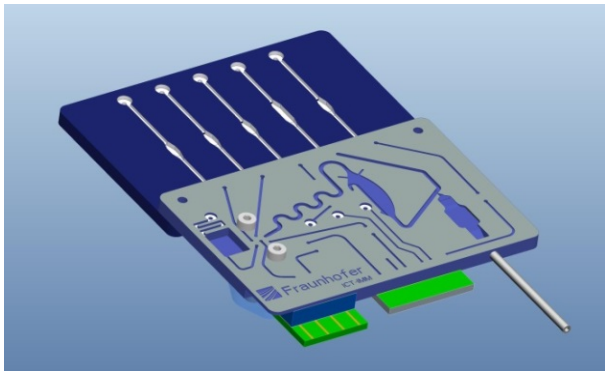

Figure 2: Biochemistry cartridge.

Patients will use a lancet to prick their finger and obtain a small quantity of blood, insert the blood sample into a microfluidic biochemistry cartridge (Figure 2), and plug the cartridge into a specially designed support of the BBI. A graphical user interface, designed to remain as simple as possible for everyday users, will allow the end user to initiate a new blood analysis. Once a new measurement is run, the BBI software will execute the complete measurement protocol in a fully automatic way and will communicate the results to the hospital information systems.

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[1] www.d-liver.eu