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Event-based Portable Pen for Monitoring Anaesthetics Delivery

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The anaesthesia is a critical surgery medical procedure that requires the administration of a cocktail of drugs: hypnotic, analgesic, and muscle relaxant. The usage of prediction models to estimate the right dosage presents today high errors due to the patient's diversity. Differently, the Therapeutic Drug Monitoring (TDM) aims to measure the actual drug concentration in the patient's body to meet the personal requirements with a dynamic adjustment of the anaesthetic infusion [1]. Electrochemical investigation can be adopted to measure the therapeutic compounds (Propofol, Midazolam, and Paracetamol), techniques like Cyclic Voltammetry (CV) and Differential Pulse Voltammetry (DPV) are highly attractive due to fast measurements, multi sensing, and high sensitivity [2]. We propose a portable-pen able to measure at the point-of-care the delivery-rate of therapeutic compounds during surgery, as presented in Figure 1, to overcome the lack of commercially-available systems to monitor on real-time the anaesthetics. In this scenario, the electronic interface requires to be portable, low power, low cost, and suitable to fit the barrel of a pen. Considered those requirements, the design of the system is based on a bio-inspired event-based approach to guarantee low complexity and low power consumption [3], [4]. Fig. 2 presents the developed prototype of the portable-pen: an 18 mm diameter plastic tube contains a custom Printed Circuit Board (PCB) implemented with Commercial Off-The-She1lf (COTS) components, while a commercial Screen-Printed Electrode (SPE) acts as an electrochemical sensor for testing. Our bio-sensor electronic-interface relies on quasi-digital to analog conversion, and vice-versa. Fig. 3 shows the design of our board which contains a voltage driver (Pulse Width Modulation to Voltage - PWMtoV) and a current read-out (Current to Quasi-Digital Events - ItoQDE): the driving voltage comes to the system in form of a PWM signal with variable Duty Cycle, while the output produced by the system is a QD stream of events, coding the information in timing in a series of pulses. The system is validated through an exhaustive comparison, between the proposed system and a lab instrument, considering as benchmark drug the paracetamol (APAP). Table 1 proves that the presented approach obtains comparable performances in terms of sensitivity and resolution with the ones obtained by expensive commercial instrumentation. Moreover, the results show a 95% power consumption reduction and a 92% area decrease w.r.t. previously presented implementation, highlighting that the proposed approach is the best suitable for the required portable smart system.

References

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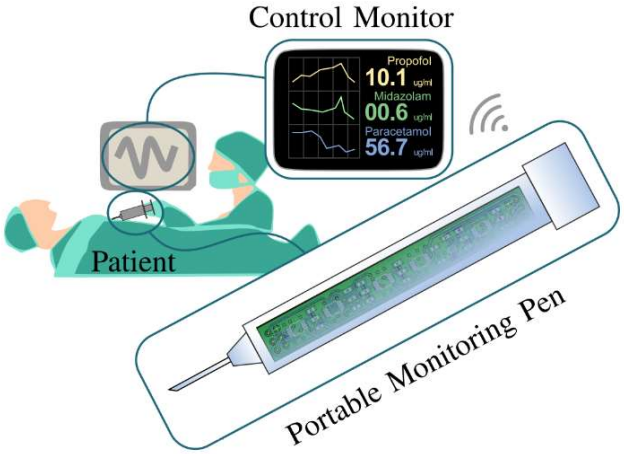

Figure 1: The portable pen continuously provides the concentration of anaesthetics infused in the patient.

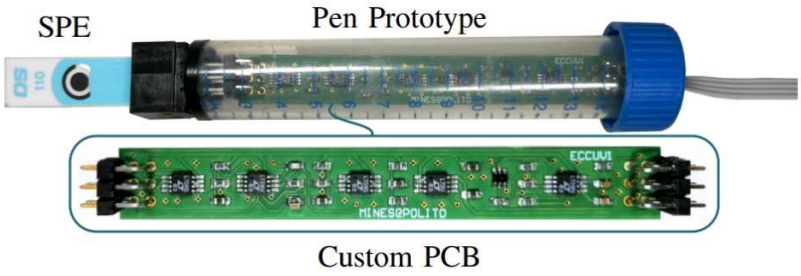

Figure 2: Portable pen, the custom PCB implements the proposed biosensor-interface and the SPE acts as electrochemical sensor.

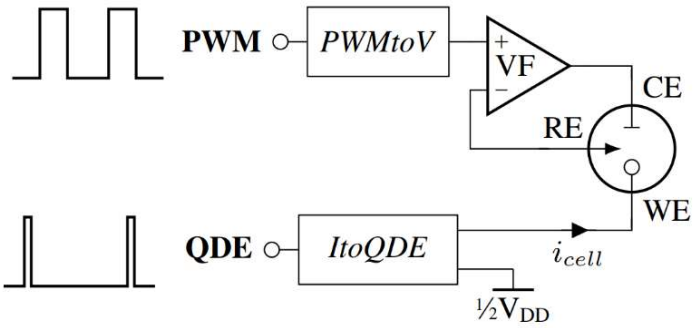

Figure 3: The voltage driver (PWMtoV) and the current read-out (ItoQDE) are both event-based modules.

	Autolab	**Our System**
Sensitivity (nA/µM)	54.1 ± 7.1	47.5 ± 5.0
Limit of Detection LOD (µM)	1.43 ± 0.18	5.43 ± 0.57

Table 1: Performance comparison between the lab instrument and our system