Intelligent and Biosensors

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Preface

The term intelligent sensor (or smart sensor) has been used in the sensor industry to describe sensors that provide not only measurements, but also functionality to specific measurements. There are three characteristics that define an intelligent sensor: i) firstly, it contains a sensing element that measures one or more physical parameter; ii) secondly, it has a computational element that analyses the measurements made by the sensing element; iii) thirdly, it contains a communication interface enabling interaction with the outside world in order to exchange information with other components in a larger system. Furthermore, intelligent sensors allow networks of sensors to connect to each other, locally or around the globe in order to accomplish specific tasks. The use of intelligent sensors have revolutionised the way in which we gather data from the world around us, also how we extract useful information from that data, and the manner in which we use the newly obtained information for various operations and decision making.

The field of Electrochemical sensors have shown that various methods can be employed in transducer modification in order to produce analytical probes that can be applied for the analysis of clinical, industrial, food and environmental samples. One specific type of electrochemical sensor that has received serious research attention over several decades is the Biosensor. A Biosensor can be defined as a compact analytical device containing biological material that is closely associated with a physico-chemical transducer, to produce either discrete or continuous digital electronic signals that are proportional to a single analyte or a related group of analytes. In this book the particular emphasis is on biosensors for the detection of organophosphorous and carbamate pesticide compounds. These pesticide compounds are known for their toxic effects due to their ability to irreversibly modify the catalytic serine residue in acetylcholinesterases (AChE) and subsequent inhibition of the AChE effectively prevents nerve transmission by blocking the breakdown of the transmitter choline.

This book is an attempt to highlight the current research in the field of Intelligent and Biosensors, thereby describing state-of-the-art techniques in the field and emerging new technologies, also showcasing some examples and applications.

The focus of the first eight chapters is on Intelligent Sensors. In Chapter 1 we are introduced to the work of Chen and co-workers on the design of a smart jacket and a power supply for neonatal monitoring with wearable sensors. This work has shown how it is possible to improve the comfort and quality of life for the child by elimination of the adhesive electrodes and by the elimination of wires. In Chapter 2, we are introduced to a comprehensive survey of signal processing, feature extraction/selection and classification methods used to provide the readers with guidelines on design *brain-computer interfaces* (*BCIs*). This work by Al-Ani and Trad have shown that the exploration of new methods in BCI design would be strongly driven by new properties that will have to be taken into

consideration in the real future applications of *BCIs*. In Chapter 3, Sashima and Kurumatani proposes some views of what a mobile sensor fusion platform can contribute to the field and two types of fusion architecture, e.g. "mobile sensing architecture" and "stable sensing architecture" are described with a prototype platform of the mobile sensing architecture introduced. In Chapter 4, the focus is on the assessment of the biomineralization capacity of polyamidoamine (PAMAM) dendrimers amino- and carboxylic-terminated immobilized on solid supports. This work by Stancu is aimed as the first attempt of investigation of biomaterials-induced biomineralization through the label-free Surface Plasmon Resonance Imaging (SPRi). In Chapter 5, the work of Rangelova and co-workers discusses the use of soft computing techniques for modelling the inputoutput dependency of a dopamine biosensor that takes into account the simultaneous influence of pH and temperature over the output current. In Chapter 6, Gargiulo and co-workers describes a long term, wearable personal monitoring system that is wireless, low power and uses convenient dry electrodes. The use of this system for electrocardiogram (ECG) and athlete monitoring has also been demonstrated. In Chapter 7, the work by De Silva and co-workers presents a framework to transfer the natural gestural behaviours of a human agent to a robot through a robust imitation algorithm. The novelty of their proposed algorithm is the use of symbolic postures to generate the gestural behaviours of a robot without using any training data or trained model. The idea behind using symbolic postures is that a robot is flexibly able to generate its own motion. In Chapter 8, the author Bae focuses our attention on a newly designed sensor or structure of an *in-vitro* giant magnetoresistance (GMR) biosensor with a specially designed magnetic shield layer (MSL). The physical sensing characteristics of the in-vitro GMR biosensor with an immobilized single FNSA are also discussed to explore its feasibility to a single molecular based disease diagnostic biosensor system.

The work in the following chapters focus on Biosensors for the detection of various analytes. In Chapter 9, Somerset and co-workers describe the application of a mercaptobenzothiazole-on-gold biosensor system for the analysis of organosphosphorous and carbamate pesticide compounds. The aim of this work was to improve the detection limit of these insecticides with an AChE biosensor, applied to various water miscible organic solvents. In Chapter 10, the work of Cortina-Puig and co-workers focuses on AChE biosensors as a rapid and simple alternative method for the detection of organophosphorous insecticides. They indicate that such sensors should be small, cheap, simple to handle and able to provide reliable information in realtime with or without minimum sample preparation. In Chapter 11, the work of Stoytcheva highlights the fact that the analytical potential of electrochemical biosensors for the detection of organophosphorous insecticides is obvious, despite the fact that they still demonstrate limited application in the quantification of real samples. In Chapter 12, Srivastava and co-workers focus our attention on the first continuous, electrochemical biosensor for real-time, rapid measurement of Neuropathy Target Esterase (NEST (or NTE) esterase activity. The biosensor was fabricated by coimmobilizing NEST protein and tyrosinase enzyme on an electrode using the layer by layer assembly approach. In Chapter 13, the work of Nien and co-workers showcase two systems. In the first system, a poly(3,4-ethylenedioxythiophene) (PEDOT) modified electrode was used as a matrix to entrap glucose oxidase and was integrated in a flow system for sensing chip applications. In the second system, the proposed electrode fabricated by multilayer structures successfully works as a glucose biosensor in the oxygen-independence solution, and the anode of the biofuel cell operates not only on glucose

solution but also on real blood of human beings. In Chapter 14, Budai discuss the fabrication of single- and multibarrel carbon fiber (CF) microelectrodes, the covalent modifications of the carbon surface as well as the applications of CF microelectrodes in recording spikes from neurons, electrochemical or biosensor signals from various tissues. This chapter further discuss the novel use of CF microelectrodes as oxygen detectors usable *in vitro* and *in vivo* applications. In Chapter 15, the work of Reshetilov and co-workers focuses on microbial biosensors and showcase that the properties of microbial sensors are in many respects analogous to the properties of enzyme biosensors. In Chapter 16, the work of Mateo-Martí and Pradier focuses on DNA biosensors with specific attention on a new artificial nucleic acid, PNA, as a highly specific probe. They also provide an overview of some surface analysis techniques that have been successfully applied to the detection of PNA-DNA hybridisation. In Chapter 17, the work of Yakhno and co-workers demonstrate the unique use of an uncoated quartz resonator in the diagnostics of multi-component liquids without detection of their content. This is a new type of analytical instrument, based on non-linear non-equilibrium processes in drying drops, so called selforganization. The main feature of this approach is that phase transitions in drying drops were registered and used as the informative parameter. In Chapter 18, Konuk and co-workers introduce and ALAD (δ-Aminolevulinic Acid Dehydratase) biosensor and indicates that the expression of ALAD activity gives us a clear indication of the severity of the effect of Pb pollution along the pollution gradient. In Chapter 19, the work of Vidic focuses on a bioelectronic nose based on olfactory receptors indicating that the development of sensor technology incorporating natural olfactory receptors provides the basis for a bioelectronic nose mimicking the animal olfactory system. Such devices can be used for qualitative and quantitative identification and monitoring of a spectrum of odorants with much higher selectivity and sensibility than the present electronic devices.

It is envisaged that this book will provide valuable reference and learning material to other researchers, scientists and postgraduate students in the field. The references at the end of each chapter serve as valuable entry points to further reading on the various topics discussed and should provide guidance to those interested in moving forward in the field of Intelligent and Biosensors.

My sincere gratitude is expressed to the contributing authors for their hard work, time and effort in preparing the different chapters, because without their dedication this book would not have been possible.

Editor

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