Abstract

Bringing together academia and industry, the research activities herein presented are characterized by a multidisciplinary nature and a translational approach. Taking advantage of the precious collaboration between Politecnico di Torino, the Molecular Biotechnology Center (MBC), and Eltek S.p.A., and with the aim of bridging the gap between electronics and biotechnology through impedance measurements, the projects of the present Ph.D. thesis were conducted.

The undoubted importance of healthcare research relies on its potential to improve life quality, leading to a positive impact on people's lives. Specifically, personalized medicine is seen as the medical upgrade of this biotechnology and data-rich era. Within the biomedical engineering field and willing to explore the synergy between electronics and biotechnology, the potential of impedance measurements was explored through four main applications: cell cultures, tissues, blood, and bacteria quantification. This kind of measurement presents several strengths: label-free, non-invasive, non-destructive, quantitative, real-time, and relatively low-cost.

The thesis is structured into seven chapters. Each one of the first six chapters corresponds to an individual application carried within the general frame of impedance-based devices development, as illustrated in the graphical abstract of Figure 1, and the last chapter is dedicated to the conclusions and future perspectives. The chapters start with an introduction to the research scenario, followed by the implemented methodology and development, and ultimately, the obtained results are presented and discussed. The most extensive studies were performed on cell cultures that are presented in Chapters 2 and 3, and in which drug-response assays provided the most promising results. Afterward, in Chapter 4, a 3D application for tissue biopsies measurement is covered, following the trend of 3D biological systems that better replicate the in-vivo settings. The encountered limitations of the three-dimensional analysis in clinical applications led to the concept of liquid biopsy directing the attention to blood as the target of analysis. Thus, a clinical application in the form of an innovative Point-of-care (POC) device prototype for blood analysis is proposed in Chapter 5. Moreover, keeping the idea of a direct clinical application, reconsidering the promising results obtained with drug-response assays in cell cultures, and scaling down to take advantage of systems at the microscale, Chapter 6 explores bacteria quantification in microchannels for antibiotic susceptibility testing.

The theoretical advantages of impedance measurements were confirmed through the development and validation of dedicated systems for each one of the presented applications. The potential of each one, in real life and clinical employment, was explained in each chapter, showing how it might positively impact healthcare. Overall, the present work confirms the potential of impedance measurement in the biotechnological field and is proof that through interdisciplinary work, novel alternatives, in response to the current healthcare challenges, might emerge.

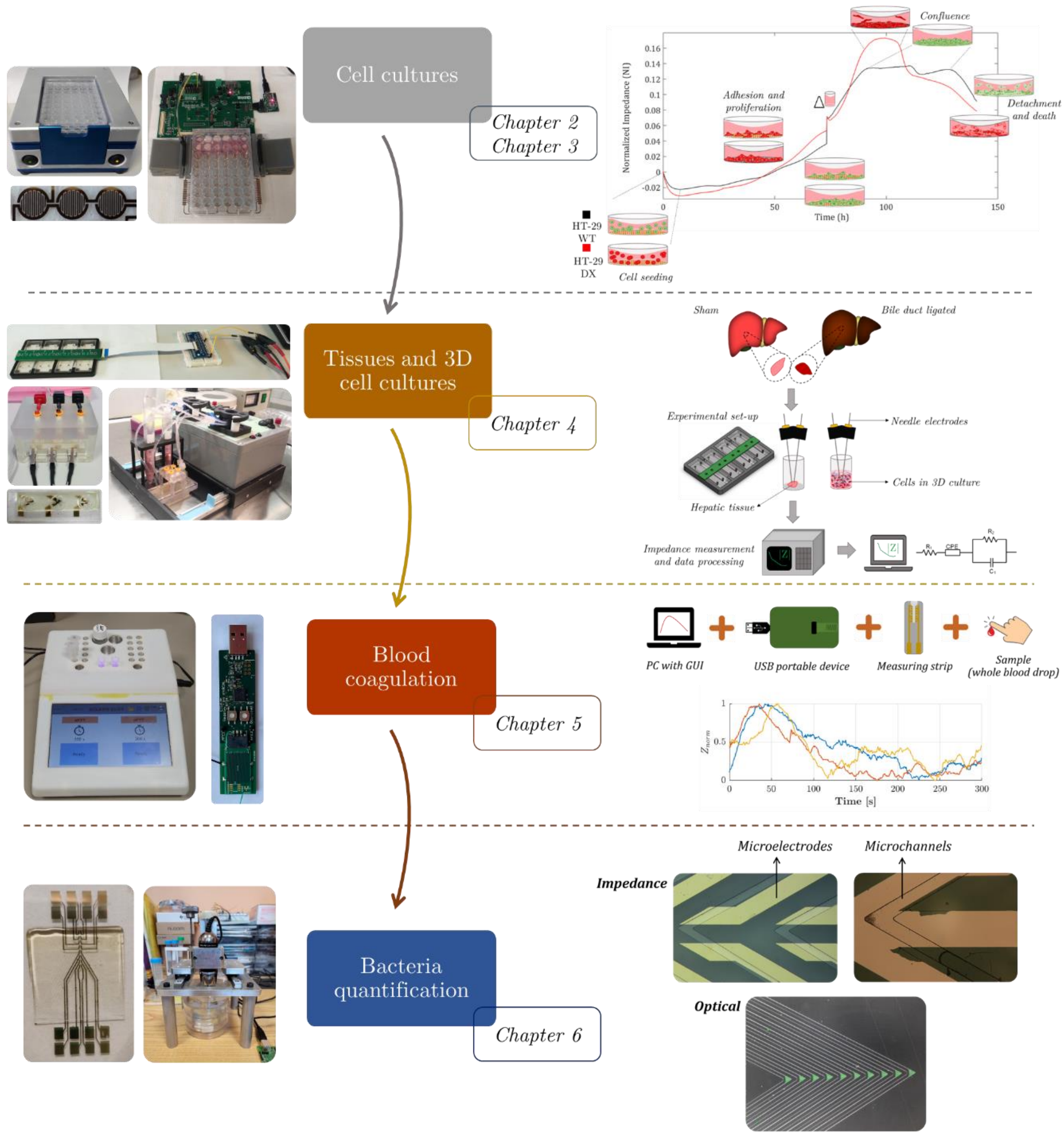

Figure 1. Graphical abstract of the thesis projects and their correspondent chapters. On the left side of the figure, pictures of the developed devices and experimental set-up are shown. On the right side, a schematic summary of the main results is presented.