Summary

Embedded systems are being widely used in health care related applications. They are used in imaging systems, regenerative medicine and tissue engineering, rehabilitation medicine, continuous monitoring and delivery of drugs, personalized medicine, detection of diseases and early stage diagnostics, and so on.
During the design of an embedded system for a specific application, there can be several constraints or requirements. The system might be required to carry out certain complex tasks; it might need to operate in real-time to meet timing deadlines; the system might need to consume very low power; the system might have restrictions on the dimension and weights. So, designing an embedded system can be very challenging and complicated depending on the actual applications and it is necessary to follow certain design procedures or design methodologies in order to guarantee that the designed system would meet all the functional or non-functional requirements of the application. The thesis focuses on designing embedded systems for five biomedical applications and each design follows a proper embedded system design methodology. The design of these embedded systems goes from ready-to-use to custom, then from custom to standard.
The first project is in Chapter Two and it is about designing an electrical and mechanical signal generation system for cell stimulation and monitoring application. The designed embedded system is based on a ready-to-use Raspberry Pi (RPi) board and only an external custom circuit board is designed for the project. So, the design of the system is very easy and not much extra effort is needed in terms of hardware design. However, the RPi contains many hardware resources that are not required for the project and they contribute to an excessive amount of power consumption. The board is also not flexible as its hardware design is fixed. So, in the following applications presented in Chapter Three, Four and Five, embedded systems are custom designed in order to achieve flexibility and optimization in hardware, reduction in area, optimization in performance, reduction in cost and also in power consumption.
In the Chapter Three, a custom designed wearable, wireless, low-power surface EMG system is presented. The main objective of the system is to acquire surface EMG signals from muscles of the patient for a long time of up to several days. The commercially available surface EMG devices could carry out maximum 12-hour

continuous EMG signal acquisition and are not suitable for long-term monitoring. So, a power efficient, wearable, wireless embedded system is designed for this purpose. The design of the system has followed the successive refinement model and three prototypes are designed. The measurement results show that the designed system could carry out continuous signal acquisition for 32 to 61 hours with a coin battery of 450 mAh capacity.
In the Chapter Four, a custom designed electrochemical biosensing platform for anesthesia monitoring and delivery is presented. The continuous monitoring and correct delivery of anesthesia is important as the anesthesia is a very powerful and dangerous drug that could result in serious safety problems if not monitored or delivered correctly to the patient. So, an embedded biosensing platform is presented in this chapter. The design of the system has strictly followed the hardware and software design methodology and relevant experiments are carried out on Paracetamol and Propofol using different electrochemical techniques.
In Chapter Five, a custom designed memristive biosensing platform for early stage cancer diagnostics is presented. Memristive biosensors are ideal candidates for the cancer detection due to their ultra-high sensitivity. However, commercially available electronic platforms for memristive biosensors are probe stations and parameter analyzers. These devices are very bulky and the test would take very long time. Therefore, a portable, easy-to-use embedded biosensing platform is required for the measurement and also for automatic data processing. So, by following hardware and software design methodology, an embedded system is designed and relevant tests are carried out for the Prostate Specific Antigen (PSA) detection. The test results confirm the functionality of the system and the correct design process.
After the design of the custom electrochemical and memristive biosensing platforms, the two hardware architectures are compared with each other and several similarities are found. For example, in both platforms, the voltage signals coming from the biosensor analog front end are processed by the Analog to Digital Conversion blocks, then analyzed by the data post processing blocks. Both platforms are controlled by similar Graphical User Interfaces (GUI). So, these hardware architectures can be standardized and in the final application in Chapter Six, the design target has switched from custom to standard and a general purpose embedded platform that supports various types of biosensors is presented. The system is validated with three types of electronic biosensors such as electrochemical, memristive and ion-sensitive biosensors and its generality, the design concept and the design approach are confirmed through experimental results.