Abstract

Breast cancer and brain stroke are two critical and dangerous problems affecting people worldwide. Breast cancer is the most common and second leading cause of death in females after lung cancer, while brain strokes are among the common causes of permanent disability or death worldwide with more than 15 million people getting affected annually according to statistics.

Breast cancer in its early stages is not much harmful and can be treated with a high success rate if diagnosed accurately. Hence the critical factor is to have a system to detect it in the early stages reliably. During a brain stroke, abnormal blood flow inside the head of the patient starts, which can result in devastating changes in the brain or, at worst, lead to death. On-the-spot accurate detection and monitoring employing head imaging in the post-acute stage are of utmost importance for appropriate medication for ensuring the proper care and complete recovery of the patient. Currently available standard imaging tools such as X-Ray Mammography, which is considered as gold standard for breast cancer detection, while MRI and CT, the most common stroke monitoring techniques, are limited due to their cost, size, use of ionizing radiations and low reliability. These limitations encouraged us to design alternative imaging techniques, to overcome their limitations and to get reliable results.

The work done in this thesis is in the framework of designing highly efficient, low cost, low power, and reliable Microwave imaging (MI) systems to detect breast cancer and to monitor brain stroke. MI systems have the advantage of using low ionizing radiations, low cost, easy of use and are capable of producing reliable results.

The designed MI system for breast cancer detection is compact because it uses components off-the-shelf (COTS) to transmit and receive microwave signals, instead of heavy lab equipment like Vector Network Analyzers (VNA) which other MI systems usually use. I-MUSIC is the preferred imaging algorithm for the designed MI system over other common proposed approaches because it provides many processing and practical advantages over them. Measurements are performed on 2D, and 3D breast phantoms

having properties similar to normal breast tissues and tumor and the results obtained from the designed MI system are compared with the results obtained with the VNA based MI system. The results from the designed COTS-based MI systems are very similar to the results obtained with VNA and in some cases even better. Moreover, the acceleration of the computationally intensive parts of the algorithm due to the implementation of hardware acceleration in the FPGA of Zynq SoC (a development and evaluation board), increased the execution time of the algorithm 20 times faster than its execution in a high-performance server.

The designed MI subsystem in this thesis for stroke monitoring, is a low cost, low power and portable system. The imaging algorithm used for stroke monitoring is Truncated Singular Value Decomposition (TSVD), different from I-MUSIC. In this algorithm, signals are acquired at a single frequency, and the execution of the algorithm for image reconstruction is much faster. The algorithm detects the variation of the blood mass across two successive data, and then the reconstructed image shows this variation.

Moreover, the imaging algorithm is accelerated due to the implementation of hardware accelerator in the FPGA of the Zynq SoC and the obtained results are at least five times faster than the software execution of the algorithm.

Both the MI systems presented in the thesis successfully produced very reliable results, and at the same time they were low cost, compact, consumed very low power with fast execution times.