Microwave Imaging Algorithms Based on Genetic Algorithm

In this thesis, the GA-based reconstruction algorithms were optimized by various techniques, the choice of the best setting, acceleration by custom hardware, and by taking advantages of the problem nature (i.e., if a high contrast exists). Those techniques are applied for 1D and 2D only. We showed that the choice of the appropriate settings for the GA parameters for 1D inverse scattering problem is of a critical impact on performance measures. Also, with the communication overheads are avoided – by implementing GA algorithm itself in the FPGA – the overall performance of our hardware accelerator for 1D problem can reach 240x speeding up when compared to PC(S/W only) version. Finally, our novel intelligent-decision GA-based technique reduces the time of computation by a factor of 50 while achieving a more accurate reconstructed image.

In Chapter 2, a number of important issues have been discussed. First, GA concept and operators were introduced including standard and Micro-GA (mGA). 1D reconstruction algorithms using GA were proposed for normal and oblique incidence. The performance of these algorithms investigated under different setting. Choosing the appropriate measures such as convergence behavior and run time. Meanwhile, some other settings (such as, the state of polarization) has a minor effect. The results are obtained from this study showed that:

a) mGA showed better performance than conventional GA, as; the mGA-based algorithm does not fail to find the global minimum, in contrary to the conventional GA-based case. That is why we didn’t study the effect of setting on the rate of success in the case of mGA.
b) We can reduce the computation time, and hence, improve the performance, by using only K no. of frequencies in the reconstruction process.
c) And the recommended settings for 1D inverse scattering problem that yield the best performance are based on mGA.

In Chapter 3, the proposed engine shows 2x speeding up compared to the software version. This performance enhancement can be highly increased by using a more powerful FPGA chip. For example, performance gain can reach 80x (compared to 2c in case of using XC3S500E) in case of using XC5VLX155T chip. That 40x gain is a result of the ability to implement 20x more H/W computational engines, since each is just consuming 4% of the available FPGA chip area, combined with the ability of running twice as fast. Further performance 3x gain can be achieved by avoiding the communication overhead. The communication overheads can be avoided by implementing GA algorithm itself in the FPGA. In such a case the overall performance can reach 3x80=240x speeding up when compared to the PC (S/W only) version.

In Chapter 4, the novel intelligent-decision GA-based technique reduces the time of computation by a factor of 50 while achieving a more accurate reconstructed image, thus, making the GA-based reconstruction algorithms implementable. With the aid of hardware acceleration investigation in

Chapter 3 for 1D problem, we can reduce the time of computation by factor of 50x80= 4000. In Chapter 5, the conclusion and future work were outlined.