CHAPTER 7
CONCLUSION

As advances in information processing and optoelectronics make technology cheaper and more powerful, progress in biomedicine is growing at an exponential rate. This rapid development has opened up new fields suitable for biomedical applications. Till now, dangers from radiations and invasive procedures have been imposed on the patient. The need for noninvasive and reliable diagnostic tools has motivated this study. In this thesis, an investigation on the application of opto-electronics for improved medical diagnosis has been made. This work focuses on evolving new and better technologies for the future.

Optic tools for diagnostics under spectroscopy have been achieved. Surface reflectance to extract optical properties of tissue is first studied. To quantitatively assess the skin structure, in vivo measurement of diffuse reflectance spectra in the visible and near-infrared ranges of the electromagnetic spectrum has been carried out. This experiment helps to interpret the variations in reflectance with haemoglobin and melanin content of the test tissue as well as yields information about the scattering properties of the skin and the underlying tissue.
A compact prototype based on dual wavelength spectrometer to measure and quantify blood oxygen and blood volume changes has been developed. The proposed system differs from the conventional oximeters as it is reflectance based and also employs near-infrared spectroscopy, both the techniques being under research and development. Conventional oximeters being transmission based suffer from several disadvantages. Hence the development of this prototype is a step in the right direction. Tests carried out using the system show adequate detectivity and responsivity. Trials performed using this technique confirm the transferability of this potential diagnostic tool to a clinical setting.

In the medical imaging domain, an imaging modality using laser reflectance principles for detection and localization of skin cancer has been developed. With this, the surface back scattering profile can be constructed. The performance of this system to detect skin cancer was demonstrated by embedding abnormalities in tissue phantoms. From the reconstructed images, areas of different absorption could be identified. The system was also used to image the forearm of different complexioned subjects. Images taken from subjects of different skin tones show variations. These changes in the coloured images are caused due to differences in the tissue parameters. Observations from the reflectance imaging prototype indicate that this system shows variations in tissue composition and is a promising technique for detection of inhomogenities caused by skin cancer in biological tissue.
When imaging thin tissue samples (< 2 mm thick), it is possible to use photons that have not been scattered. These are called ballistic photons and they can be used to form high-resolution images. But through many centimetres of tissue when the ballistic-light signal is not detectable, imaging becomes a problem. The investigation next focuses on this aspect of imaging and proposes a novel medical imaging system using a white light source, filters, polarizer and a CCD camera.

The proposed system overrides the problem associated with scattering by employing image processing tools. A mathematical model is framed for the system in three phases. In the first phase, a technique called polarization filtering is proposed. Mathematical model based on Monte Carlo are simulated for a linearly polarized source at 632nm and a diffuse reflector object placed at various depths in the tissue phantom. Experimentation based on the simulation model was also demonstrated. Simulation and experimental results indicate that visibility is possible up to 1cm with a 632nm source.

To further improve on the depth of visibility, the use of longer wavelength is proposed in the second phase. Monte Carlo simulations were run by launching a linearly polarized beam of photon at two wavelengths, 632nm and 990nm and images of a diffuse reflector object placed at various depths were recorded. Experimentation was done to validate the simulation.
This investigation shows that the depth of visibility is enhanced to 1.5cm when a longer wavelength source is employed.

To still further improve the visibility depth, a technique integrating phases I and II is proposed. This imaging scheme takes the advantages of polarization filtering and wavelength effects. Simulation using Monte Carlo model is performed and the results are listed. It is found that the improvement in contrast at deep depth is more compared to the other existing techniques. This system, which integrates optics and electronics, offers much scope for a low cost, safe and accurate imaging system of the future.

In this work, a number of systems amalgamating optics in biomedicine have been portrayed. The imaging systems proposed in this work have been tested only on phantoms. The usefulness of the system on human subjects has yet to be tested. The model of the proposed thick tissue imaging system assumes single scattering. Further research can be done on improving the Monte Carlo model to include particle interactions. Also, this work has concentrated on imaging a diffuse reflector object using a linearly polarized source. The utilization of a circularly polarized source and imaging other types of object could be further areas of research.
In conclusion, this thesis makes several investigations on the use of optics for noninvasive and improved medical diagnosis. All the systems developed have been demonstrated to be effective. Development of optical diagnostic tools in spectroscopy and imaging has been accomplished. The research findings reported and the results presented in this work are certain to contribute to the development of novel optical based devices for improved medical diagnosis with little inconvenience to the patient.