Preface

Diagnosis of diabetes mellitus is a significant topic worldwide. Diabetes mellitus indicates the physiological changes in person with deficiency in insulin hormone or incapability to recognize the insulin by the glucose sensing cells. It may lead to coma or even death when the glucose level rises in uncontrolled manner. Monitoring the glucose levels numerous times per day is essential for perfect regulation of blood glucose levels. The routine protocol for invasive blood glucose analysis is to puncture the fingertip to obtain the blood samples. It then reacted with enzymatic chemicals to obtain the desired results. Invasive techniques for obtaining blood glucose predictions, the person usually suffers from many painful procedures, skin injuries and from high risk of infections. In the continuation of developing noninvasive techniques, for pain free attitude, the need of non-invasive blood glucose measurement arises. In perspective of approaching the necessity for this need, this present thesis work aims to perform different *in-vitro* experimental study on different dextrose or human blood sample mixed Intralipid^{TM} phantom medium, by our indigenously developed technique based prototype for developing noninvasive glucose monitoring system. The present thesis contains seven subsequent chapters as follows: (i) Introduction; (ii) Literature review; (iii) Prototype design, calibration, methodology and performance analysis; (iv) Glucose induced optical transmission effect on Intralipid^{TM} based phantom; (v) *In-vitro* experimental study based results; (vi) Discussion; (vii) Conclusion and future work.

Chapter 1: Introduction

This chapter contains an overview of the thesis and briefly describes the problem and motivation towards the diabetes management. In framework of approaching to the prerequisites for this need, this chapter depicts the aim and objectives, research contributions and outcome of the present thesis work. The thesis organization part briefly highlights of all the chapters presented in this present thesis.

Chapter 2: Literature review

This chapter briefly describes the diabetes mellitus, its major types and three main types of blood glucose monitoring techniques. This part briefly describes tissue optical phantom and its properties, tissue optical phantom basic requirements, phantom utilization as a tissue-simulating process for medical purpose, optical phantom structural orientations and physical properties, selection of tissue optical phantom

constituents, tissue optical phantom purposes and their assessment criteria, spectrum of the Intralipid^{TM} scattering coefficients, lipid-based scatterers assessable commercially, biomedical application of Intralipid^{TM} suspension and utilization of Intralipid^{TM} based tissue phantom for developing various non-invasive optical technique in glucose concentration monitoring.

Chapter 3: Prototype design, calibration, methodology and performance analysis

This chapter describes the role of Intralipid^{TM} based tissue phantom, preparation of Intralipid^{TM} based tissue phantom, the significant descriptions regarding the principle applied, fabrication and designing aspects of modulated ultrasound and infrared light-based prototype for *in-vitro* blood glucose measurement. Further, this chapter contains the *in-vitro* examination for calibration aspects along with the brief description of the error grid analysis (Clarke and Parkes) and different statistical parameter used in this present thesis work for estimating the performance based accuracy of our prototype unit in measuring predicted blood glucose levels in *in-vitro* samples.

Chapter 4: Glucose induced optical transmission effect on Intralipid^{TM} based phantom

This chapter describes the results of experimentation, carried out on Intralipid^{TM} phantom to study the optical clearing properties of glucose. Glucose minimizes the refractive index dissimilarity between scatterers and their surrounding media, leading to a smaller scattering coefficient, consequently, a shorter optical path.

Chapter 5: *In-vitro* experimental study based results

This chapter describes the *in-vitro* experimental study performed by various investigational techniques such as standard Oral Glucose Tolerance tests (OGTT), Fasting blood glucose analysis, Postprandial blood glucose analysis and Random blood glucose analysis for measurement of blood glucose by our prototype. During the experimental procedures, our *in-vitro* analysis includes both the normal and diabetic human blood samples such as (a) blood plasma, (b) blood serum and (c) whole blood samples.

Another, significant investigation have been executed by adding different concentration of glucose in different phantom mediums such as water medium, commercialized milk medium, chicken breast tissue medium and human whole blood medium for monitoring the efficiency of our prototype in measuring glucose levels in *in-vitro* samples.

Chapter 6: Discussion

This chapter includes the statistical analysis of our whole *in-vitro* experimental results as provided in chapter 5 of this present thesis. Various statistical parameters applied here includes (a) Deming Regression analysis, (b) CUSUM test for linearity, (c) Paired sample t test based analysis, (d) Mountain Plot analysis, (e) Bland Altman Plot analysis, (f) Rank Correlation analysis, (g) Pearson Correlation analysis, (h) Clarke Error Grid analysis, (i) Parkes Error Grid analysis and (j) Accuracy Measure analysis. Further, the present chapter also includes the comparison between our total *in-vitro* experimental results with various published data, to establish the efficacy of the proposed technique.

Chapter 7: Conclusion and Future work

This chapter represents the conclusion part of the present thesis work and future direction of the research work.

After this, the reference section enlists total research papers referred to pursue this present work.