ABSTRACT

Various Blood Chemical tests conducted in the Clinical Laboratories not only aid the diagnosis of various ailments and illnesses but also in determining the progress of treatment and compiling prognosis. Hence error in the measurement of concentration of Blood Chemical would misguide the Physicians and that would result in the wrong treatment of patients. In the case of diabetic patients, error and deviations in the measurement of Blood Glucose (Often called Blood sugar) might result in the perennial complications such as Heart attack, Brain attack, Strokes, Blindness, Kidney failure, etc.

Blood Chemical tests are done in the Clinical laboratories with the help of instruments such as Spectrophotometer or Colorimeter to measure the concentration of the Blood substances like Glucose, non protein nitrogen substances such as Amino acids, Peptides, Urea waste and Uric acid, Lipids such as Cholesterol and Triglycerides, Proteins, Enzymes and Steroids, etc. These complex substances appearing in Blood plasma would develop corresponding color, following their reaction with a reagent. Colorimeter measures the concentration of the Blood substance based on the amount of absorption of a monochromatic light in that solution.

Errors of 5 – 20% in analysis are not uncommon because those measurements require a stringent monochromatic source. The exacting
requirements for narrow bandwidth filters and the dynamic range of photo
detectors compound the problems of deviations in the analysis. Colorimeter
exhibits measurement complexity especially in the non-linear region of the
reagent solution. For example, only up to the Blood Glucose concentration of
400 mg/dl, the Glucose Oxidase reagent used for Blood Glucose
measurement offers linearity. Whereas, measurement of sugar level in this
non-linear region is very crucial as far as the diabetic patients are concerned.

This thesis attempts to bring about a marked improvement and
refinement over the existing metrics in clinical Blood Glucose analysis and
validates the betterment of results through a meticulous analysis and
stratagem. Two methods have been attempted to achieve this objective. As
the Blood chemical tests are premised on Color measurement, a Computer
with a CCD Digital Camera has been tried to replace the Colorimeters with a
great deal of accuracy. On the other hand, by allowing the White light to pass
through the Colored assay and detecting the output color light with the help
of RGB Color Sensor, color of the assay’s RGB equivalent can be obtained.
In both the cases, the RGB equivalent data of the colored assay has been used
as the parameter to measure the unknown concentration of the Blood
chemical in the assay. CIE 1931 Chromaticity Diagram and conversion of
RGB data to its equivalent dominant wavelength and purity of the color are
paving the way to measure the concentration of the unknown blood chemical
in the assay through the saturation of the color.

In the Digital Camera based image processing technique, the color
image of the image was captured and from the image’s pixels, RGB data of
the color has been deduced. From this RGB data, *Color measurement* principle has been adopted to find out the concentration of the Blood chemical in the assay. Though this method is a feasible alternative to the existing Absorbance Colorimeters, the RGB value of the adjacent pixels are changing significantly as light incident over the image is not uniform and is not very ideal. Keeping homogeneous surface and uniform glossy characteristic to capture images are also too difficult. Hence, performance of such a system was found to be far from satisfactory.

Hence the second alternative has been resorted to address this impediment. A new Colorimeter with RGB Color sensor has been devised by replacing photo detector with RGB color sensor which obviates the need of filter in the Colorimeter. As the output of the RGB Color sensor is directly an RGB data, *Color measurement* principle of CIE 1931 Chromaticity Diagram can be indigenously applied for the measurement of unknown concentration of Blood chemical in the assay.

This Colorimeter is superior to the existing Colorimeter in many ways. First of all, it does not require a monochromatic source and a simple White LED is sufficient to function as the light source. As there is no need for the monochromator, the filter assembly is totally removed from the Colorimeter. Also the RGB color sensor replaces the ordinary photo detector that converts colored light to proportional RGB analog voltage outputs. By converting RGB voltages into their equivalent digital output using ADC, RGB data can be obtained. This RGB data can be used to measure the concentration of the blood chemical using the *Color measurement* principle of
CIE 1931 Chromaticity Diagram. Unlike the Tristimulus Colorimeters, the Euclidean Distance between the color spaces of reference and unknown assay is not used for the measurement of concentration of blood chemical in the assay. Instead, *purity or saturation* of the color of the assay obtained from the CIE 1931 Chromaticity Diagram has been used as the parameter to measure the unknown blood chemical in the assay.

Experiments have been conducted in the Laboratory with both existing Absorbance Colorimeter and Colorimeter with RGB Color Sensor with known concentrated glucose solutions. The results have proved that the accuracy of the newly designed Colorimeter with RGB Color Sensor has been consistent throughout the linear region of the assay and it extends even into the non-linear region where errors crop up in the conventional Colorimeters.

Experiments conducted in the Clinical Laboratory with the blood samples of patients have also proved that this proposed Colorimeter can outperform the existing Absorbance Colorimeter. The analysis performed by compiling numerous blood samples has meticulously measured the content of Blood Glucose in a novel method, hitherto unimplemented, untested and unexplored. The painstaking analysis and metrics in this thesis have been evolved over a well defined strategy, personal experience and application of basic bio-chemistry in the proper perspective. Outcome of the newly developed Colorimeter with RGB Color sensor satisfies all requirements and standards prescribed by the various World standards including the ISO.