Industrial Internship Report on

" Based Dual wavelength Non-Invasive Haemoglobin Sensor System"

Prepared by

T NANDHINI

Executive Summary
This report provides details of the Industrial Internship provided by Upskill Campus and The IoT Academy in collaboration with Industrial Partner UniConverge Technologies Pvt Ltd (UCT).

Abstract: Haemoglobin is the main constituent for characterizing the physiological conditions of a body. For pregnant ladies, haemoglobin is the main factor for the prevention of risk factors caused due to anaemia and polycythaemia vera. This will be used during pre-screening test for donating blood and to obtain complete blood count. Hb is calculated from invasive technique in which blood samples are taken using needle which causes pain and discomfort, delay is more in analyzing and receiving results, it doesn't allow real time monitoring. But an non-invasive test enables painlessly and obtain real time monitoring. Red and IR LED is passed through the finger, according to the amount of light absorbed by the tissue, remaining transmitted light detected by a photodiode, and the hemoglobin levels i.e. Hbo2and HHb can obtain by interpreting the ratio of red to IR. This method allows pain-free online patient monitoring with minimum risk of infection and facilitates real-time data monitoring allowing immediate clinical reaction to the measured data.

This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solutions for that. It was an overall great experience to have this internship.

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1   Preface

Summary of the whole 6 weeks' work.

Week-1:

Studied about Internship Project providing company "UniConverge Technologies Pvt Ltd" ,which domains does it work, what kind of products/solutions does it work.
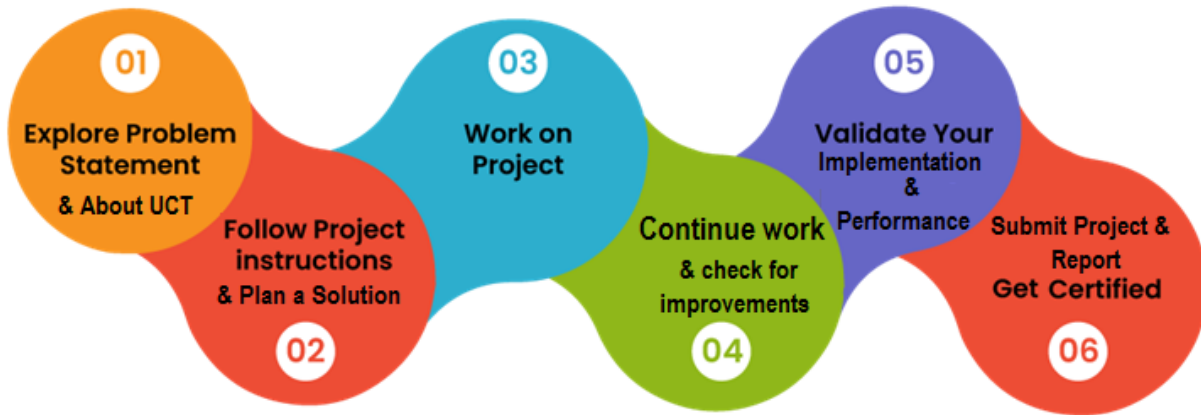
Week-2:

Do necessary study and Start working/designing the solution corresponding to your project.

- ➢ Embedded system & IoT
- ➢ Python
- ➢ Core Java
- ➢ Data Science & Machine Learning
- ➢ Digital Marketing
- ➢ 5G
- ➢ Drones
- ➢ Industry4.0
- ➢ Electrical Vehicles
- ➢ Cyber security

Week-3:Week-4:Week-5:Week-6

Project Implementation

Opportunity given by USC/UCT

Thank to all Upskills Team, who have helped me directly or indirectly.

2 Introduction

2.1 About UniConverge Technologies Pvt Ltd

A company established in 2013 and working in Digital Transformation domain and providing Industrial solutions with prime focus on sustainability and RoI.

For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

i. UCT IoT Platform (ucт Insight)

UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable "insight" for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- It enables device connectivity via industry standard IoT protocols - MQTT, CoAP, HTTP, Modbus TCP, OPC UA

- It supports both cloud and on-premises deployments.

It has features to
- Build Your own dashboard
- Analytics and Reporting
- Alert and Notification
- Integration with third party application(Power BI, SAP, ERP)
- Rule Engine
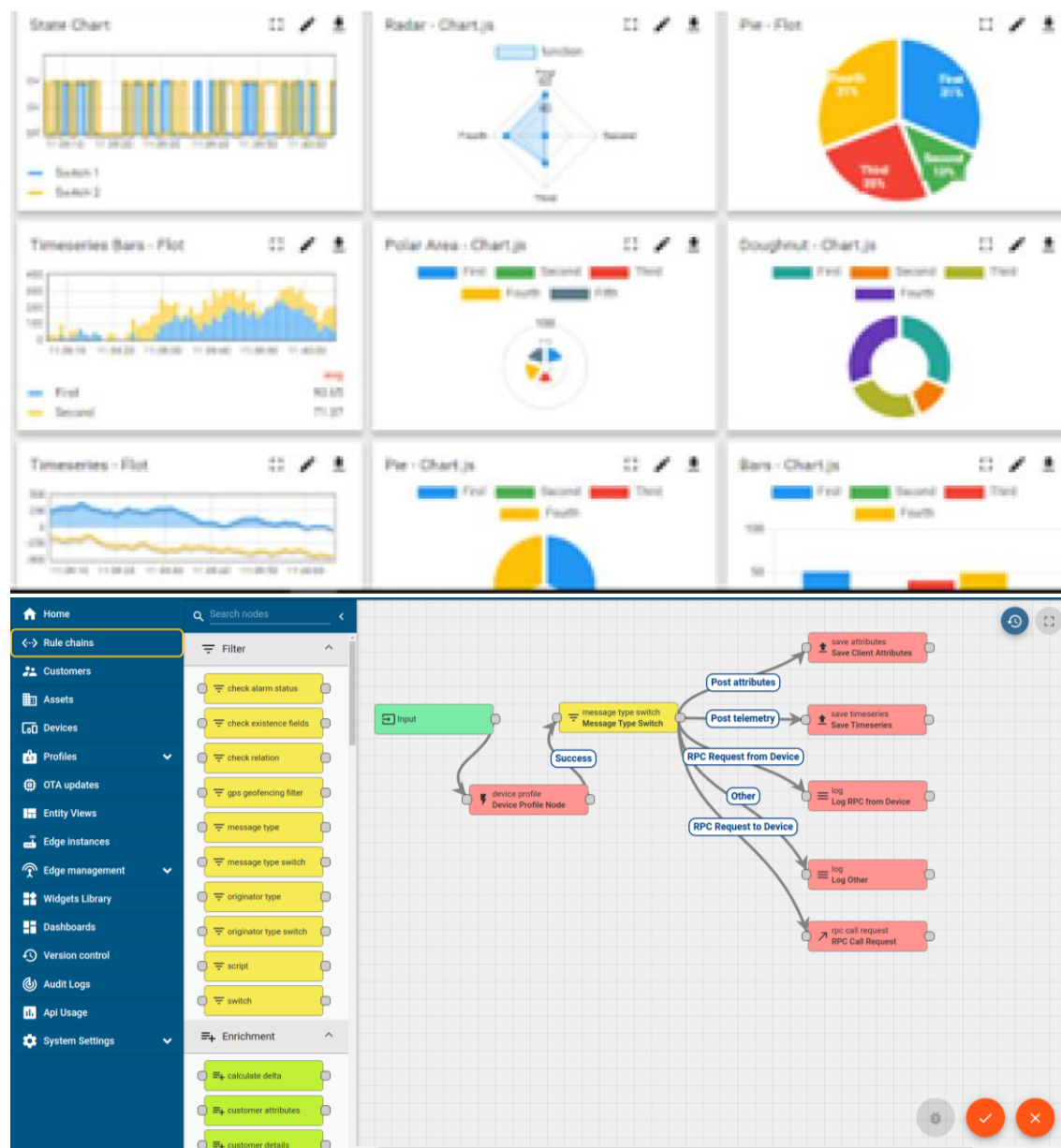
ii. Smart Factory Platform (**FACT⦿RY WATCH**)

Factory watch is a platform for smart factory needs.

It provides Users/ Factory

- with a scalable solution for their Production and asset monitoring

- OEE and predictive maintenance solution scaling up to digital twin for your assets.

- to unleased the true potential of the data that their machines are generating and helps to identify the KPIs and also improve them.

- A modular architecture that allows users to choose the service that they what to start and then can scale to more complex solutions as per their demands.

Its unique SaaS model helps users to save time, cost and money.

| Machine	Operator	Work Order ID	Job ID	Job Performance	Job Progress		Output		Rejection	Time (mins)				Job Status	End Customer
					Start Time	End Time	Planned	Actual		Setup	Pred	Downtime	Idle		
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i

iii.   LoRaWAN™   based Solution

UCT is one of the early adopters of LoRAWAN teschnology and providing solution in Agritech, Smart cities, Industrial Monitoring, Smart Street Light, Smart Water/ Gas/ Electricity metering solutions etc.

iv.   Predictive Maintenance

UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.
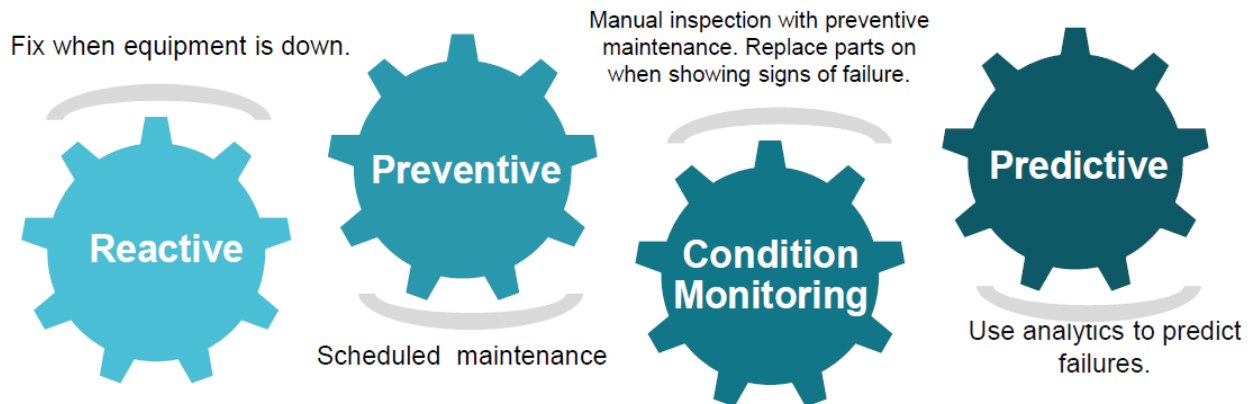
2.2   About upskill Campus (USC)

upskill Campus along with The IoT Academy and in association with Uniconverge technologies has facilitated the smooth execution of the complete internship process.
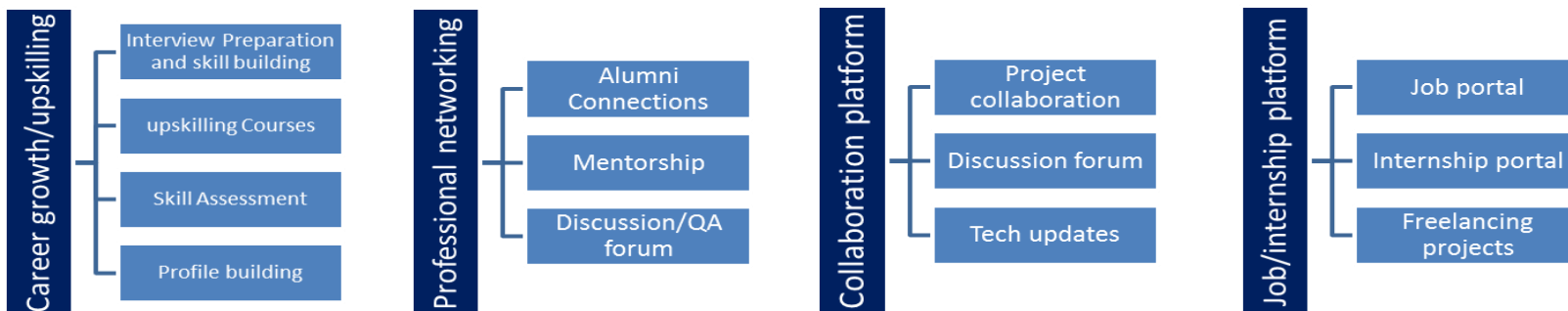
USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.
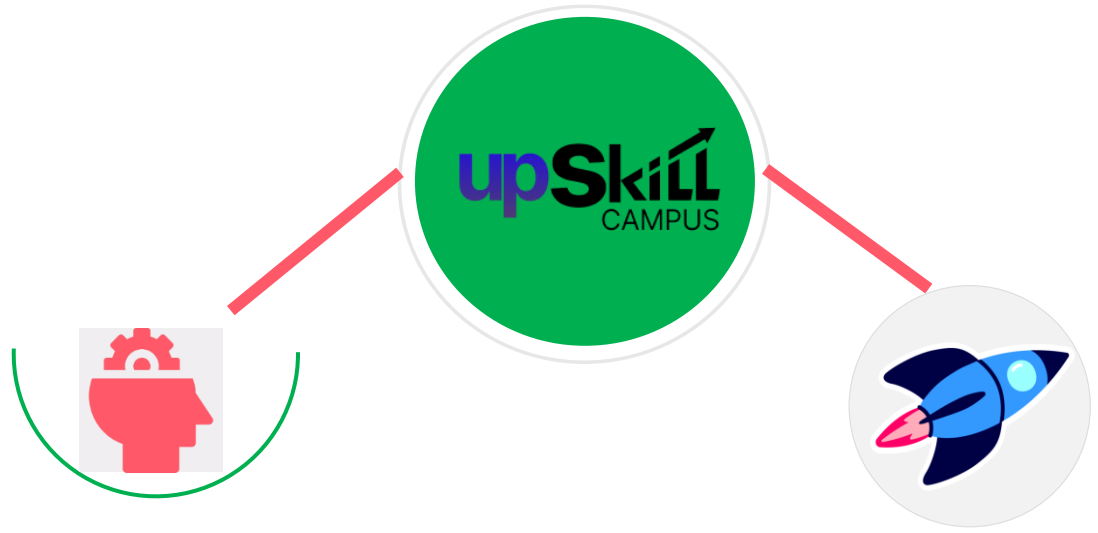
Seeing need of upskilling in self paced manner along-with additional support services e.g. Internship, projects, interaction with Industry experts, Career growth Services

upSkill Campus aiming to upskill 1 million learners in next 5 year

https://www.upskillcampus.com/

Career growth/upskilling
- Interview Preparation and skill building
- upskilling Courses
- Skill Assessment
- Profile building

Professional networking
- Alumni Connections
- Mentorship
- Discussion/QA forum

Collaboration platform
- Project collaboration
- Discussion forum
- Tech updates

Job/internship platform
- Job portal
- Internship portal
- Freelancing projects

2.3 The IoT Academy

The IoT academy is EdTech Division of UCT that is running long executive certification programs in collaboration with EICT Academy, IITK, IITR and IITG in multiple domains.

2.4 Objectives of this Internship program

The objective for this internship program was to

☛ get practical experience of working in the industry.

☛ to solve real world problems.

☛ to have improved job prospects.

☛ to have Improved understanding of our field and its applications.

☛ to have Personal growth like better communication and problem solving.

2.5 Reference

1.Rajashree Doshi, Anagha Panditrao, "Non-Invasive Optical Sensor for Haemoglobin Determination", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 2, March -April 2013, pp.559-562.

2.Kumar. R, Ranganathan.H, "embedded system based non invasive device development for haemoglobin estimation", International Journal of Industrial Electronics and Electrical Engineering, ISSN: 2347-6982 Volume-3, Issue-8, Aug.-2015.

3.U. Timm, D. McGrath and E. Lewis, J. Kraitl and H. Ewald, "Sensor System for Non-Invasive Optical Haemoglobin Determination", IEEE SENSORS 2009 Conference 978-1-4244-5335-1/09/$26.00 ©2009.

4. Ravi.T "10-Nanometer carbon nano tube field effect transistor based high celerity transposed polyphase decimation filter" Materials Today: Proceedings, Volume 3, Issue 6, 2016, pp: 1799–1807

Problem Statement

Introduction:

Haemoglobin is the iron–containing protein molecule in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs .There are mainly two different types of haemoglobin present in the blood i.e. Oxygenated haemoglobin and de-oxygenated haemoglobin ,Hbo2 is nothing but when oxygen binds to the heme component of the protein haemoglobin in red blood cells molecule whereas for HHb it is not attached. Measuring of Hb is essential for all individuals, especially in pregnant ladies, because the low levels leads to anaemia and high levels of haemoglobin leads to polycythemia. The normal haemoglobin range for men is 13.5 to 17.5 and for women 12.0 to 15.5 gm/dl. There are two different ways to measure Hb, one way is invasive and the other is Non-invasive methods. Invasive techniques are Hemocue, Cynameth, copper sulphate gravimetric method .In Cynameth method, blood is mixed with potassium cyanide, potassium ferri cyanide and drabkin solution then haemoglobin converts to cynameth haemoglobin, when a light is passed through that solution some amount of light is absorbed[4,5] , that absorbance is compared with that of the standard haemoglobin cyanide solution by using a formula to obtain the amount of haemoglobin. ,but for this ejection of blood is required. Another way to calculate is Non invasive e.g. spectro photometry, opto-acoustic and transmission spectroscopy. These methods are based on spectrophotometry and beer lambert's law. Spectrophotometry is a method to measure how much a chemical substance absorbs light by measuring the intensity of light as a beam of light passes through sample solution. The principle of Beer-Lambert's law which states that absorption is directly proportional to absorbent and density of the absorbent of an object. Different types of spectrophotometry includes single Wavelength and dual wavelength spectro photometry, multiple spectro photometry. The design uses dual wavelength spectro photometry[6,8].

Existing and Proposed solution

II. EXISTING INVASIVE METHOD

In invasive techniques hematology analyzers are used to predict haemoglobin in which cells are passed in single stream they are struck by laser which gets scattered. The light scatter at different angles i.e. between 10 and 70 deg is used by VCS instruments. The scattered light gives information about cell surface and granularity. Based on the degree of light scatter, the analyzer obtain a measure of the average haemoglobin content but these analyzers are very costly and patient feel discomfort during ejection of blood.
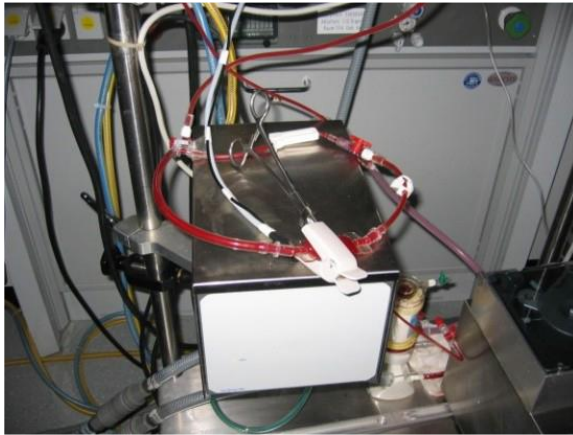

Fig a :Hb measurement taken on a blood flow model

III. EXISTING NON INVASIVE METHOD

The recent studies by Ranganathan proposed a Single wavelength spectrophotometry to calculate the HB. It is found that Hbo2 and Hb have different absorption characteristics .The absorption transmission and scattering of light by Hb products are wavelength dependent the light absorption is minimum at wavelength 603 nm for Hbo2 , HB and Hbo2 absorbs equal amount of light at 805nm which is isosbestic point[10] .These optical features are used in the estimation of Hb using Light sources .By using beer-Lambert's[4] law principle

2.6 Code submission (Github link):

There is no code for this Project

2.7 Report submission (Github link) :

3 Proposed Design/ Model

Design system uses dual wavelength spectrophotometry and beer-lambert's law principle. The developed haemoglobin sensor system consist of a number of hardware modules, which include appropriate light sources, constant light intensity circuit, power amplifier, NODEMCU, and PC. The sensor consist of emitter as LEDs, with centre wavelengths of = 660nm, = 940nm. These two wavelengths are selected because at 660 nm wavelength absorbance of de-oxy haemoglobin greatly exceeds the absorbance of oxy-haemoglobin where as at 960nm wavelength absorbance of oxy-haemoglobin greatly exceeds the absorbance of de-oxy haemoglobin (figure 1). These LEDs are installed in the upper shell of a finger clip. And single receiver photodiode is installed in the lower shell of the finger clip. The probe is placed to the patient's body usually on the finger. Red and infrared light is then emitted sequentially through the body tissue. Some light is absorbed by the tissue and remaining light is transmitted which is sensed by photodiode. Output voltage of photodiode increases linearly with light intensity and vice versa.[2]

$$OD = ecl = \frac{OUTPUT\ VOLTAGE}{TRANSMITTED\ VOLTAGE}$$

  OD-optical density,

  I_0-light intensity of incident light,

  I-intensity if transmitted light,

  e- extinction coefficient of haemoglobin

  c- concentration

  L-length of light path.

Haemoglobin concentration is calculated. By comparing the readings for both 700nm and 805nm light sources, the output of 700nm shows more linearity than the other one. Also it is observed that thickness of the finger plays a role on the amount of light transmitted through finger. In design part,SD-7BA photodiode range of 320-1150nm is used which has peak sensitivity at 805nm,microcontroller Mcp3551 that uses low power, has single channel, 22-bit delta sigma ADC which is used for conversion from analog ppg signal to the value of Hb[1].

To operate Lid's sequentially a H-bridge circuit is used which consists of two p-n-p and two n-p-n transistors .The output waves that are obtained from the Led's are to be filtered to remove the DC component signal due to bones, tissues, skin. The two AC signals are to be ratio

  Ratio= $\frac{ac\ voltage(red\ LED)}{ac\ voltage(IR\ LED)}$.

the received ratio is to be calibrated for the resulted Haemoglobin value. To digitalise this analog signal 40 pin Arduino NODEMCU is used which is having inbuilt ten bit analog to digital converter. The software for NODEMCU is used to timely operate the LED's and also for calibration. The nodemcu has inbuilt wifi module which makes it most suitable because the results of Hb are shown directly in a website so, that in an emergency ,doctor can know the patient condition from far distant place.[3]

3.1 High Level Diagram (if applicable)

Fig 1 depicts the absorption spectra of oxy haemoglobin and deoxy haemoglobin, at different wavelengths both LED's absorb different levels.
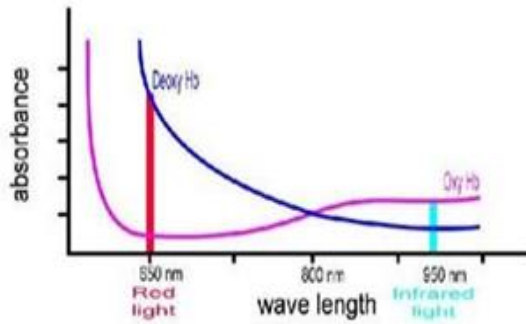

Fig.1: Absorption spectra of de- oxy and oxy-haemoglobin[5,8]

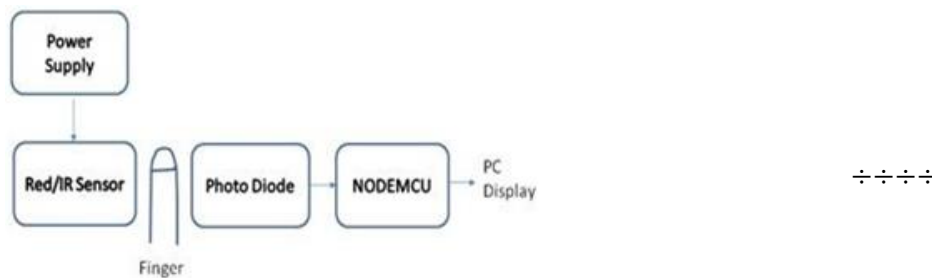Fig2 tells the overall block diagram of the proposed non invasive haemoglobin sensor system.

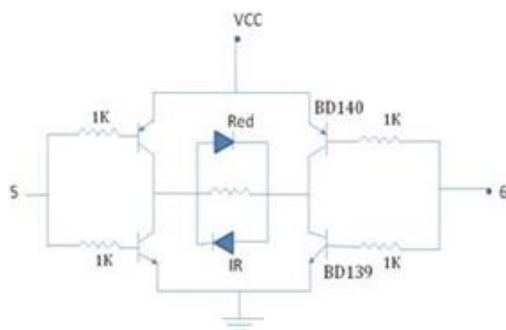**Fig. 2.Block diagram of the proposed system**

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Fig. 3: H-bridge circuit to operate LED's

3.2 Low Level Diagram(if Applicable)

Fig. 4:Circuit design of proposed system

Fig. 5. Proposed prototype overview

3.3 Interfaces (if applicable)

Update with Block Diagrams, Data flow, protocols, FLOW Charts, State Machines, Memory Buffer Management.

4 Performance Test

This is very important part and defines why this work is meant of Real industries, instead of being just academic project.

Here we need to first find the constraints.

How those constraints were taken care in your design?

What were test results around those constraints?

Constraints can be e.g. memory, MIPS (speed, operations per second), accuracy, durability, power consumption etc.

In case you could not test them, but still you should mention how identified constraints can impact your design, and what are recommendations to handle them.

3.4 Test Procedure

The design uses spo2 probe which consists 670 nm and 940 nm is tested on various subjects and output ratio is measured using software the ratios are converted to the haemoglobin values and various subjects involves both men and women of age 18-21. The laboratory readings and calculated non-invasive readings are tabulated below. By calibration and analysis developed system readings are close to the laboratory readings.
The prototype output is displayed on the local website that can be checked by the doctor from anywhere in the world, which helps in taking precautions during emergency conditions.
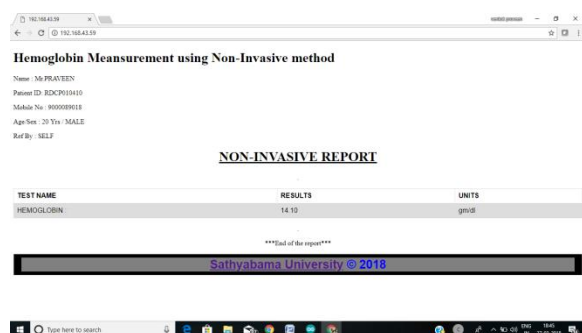
Fig 6. Output on mobile using IoT

Fig .7: Haemoglobin value output on webpage

Tab.1:**Observed haemoglobin vales from both methods**

s.no	Description	age	sex	Invasive values	NonInvasive values
1	Patient 1	20	M	14.3	14.11
2	Patient 2	21	M	16.7	16.3
3	Patient 3	20	F	11.7	11.3
4	Patient 4	35	F	11.8	11.45
5	Patient 5	42	M	16.5	16.2
6	Patient 6	17	M	14.7	14.53
7	Patient 7	20	M	15.6	15.87
8	Patient 8	20	M	13.9	13.45

4.2   Performance Outcome

The prototype model of a Non invasive sensor unit for haemoglobin measurement   is   designed and developed. This paper clearly tells that invasive techniques causes discomfort to patients and delay in measuring haemoglobin, whereas Non invasive methods are real time and comfort. This paper describes about the measurement of haemoglobin using non invasive method in order to estimate Hb using a portable homemade device, which is user friendly and used for real time applications.

4 My learnings

The Work Experiences I Encountered During The Internship Allowed Me To Develop Iot Embedded System. I Think I Still Require To Work On My IoT Real Time project. But, The Overall Experience Was Positive, And Everything I Learned Would Be Useful In My Future Career In This Field.