VOL. 10, NO 20, NOVEMBER, 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

OPTICAL TECHNIQUE FOR JAUNDICE DETECTION

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ABSTRACT

Optical technique is one of non-contact biopotential method which can detect jaundice babies without using blood testing. Jaundice is the most common problems occurred among newborn that need special medical attention. Jaundice can cause another effect to the newborn such as Kernictures. Kernictures or brain damage will cause death to the babies. Therefore, in this research, a new technique that can easily detect the jaundice problem will be introduced using non-invasive technique that surely could reduce the painful compared using the old technique. By using specific wavelength of electromagnetic spectrum, bilirubin will absorb the light intensity and photodiode will capture the reflection from bilirubin. This reflection will produce a voltage value to be processed by Arduino Uno. After being processed, the system will go to the online system through Dreamweaver to make it as online system. The doctor can monitor the babies' condition all the time. All the data that are collected using this system can be divided into three condition level of bilirubin concentration. The level of bilirubin concentration reflects to the level of jaundice and this data are very important for further investigation.

Keywords: non-invasive technique, jaundice, bilirubin, wavelength, reflection.

INTRODUCTION

Jaundice or hyperbilirubinaemia in newborns cause by the yellowness of the skin and eyes. The yellowness came from unconjugated bilirubin that could not excrete through the intestines.

The data from Hospital Perubatan Pantai, indicate that 60% to 70% newborn will have jaundice. Jaundice happen when liver could not excreted all excessive breakdown of red blood cell in one time (Sahib 2012). The increases of bilirubin will cause kernicterus or brain damage and worse can cause death (Mansor, Hariharan *et al*. 2013).

Early detection of jaundice can be determined by using Kramer's rule, invasive technique and non-invasive technique. Kramer's rule or visual inscpection assessment based on yellowness of skin. Meanwhile for invasive technique, some blood sample will be needed to be anaylized for the bilirubin concentration. On the other hand, non-invasive technique is less painful and reduce the traumatise to the babies.

TECHNIQUE OF JAUNDICE DETECTION

Kramer's rule: visual inspection

Visual inspection by Kramer's rule has been shown in Figure-1. Each of the body part has been divided into five zone, head and neck, upper trunk, lower trunk and thighs, arms and lower legs and last is plams and soles. The value of bilirubin concentration assessment will base on yellowness of skin(Mohammed, Matti *et al*. 2012). The yellowness of skin came from bilirubin itself. This bilirubin can be identifying as unconjugated bilirubin that bound with albumin that flow around the blood system.

Table-1 states that each prediction value of total serum bilirubin (TSB) concentration for each yellowness zone. The first yellowness will be from the head and end at soles shows the increasing TSB by 50 µmol/L per zone. Each zone will represent the jaundice level condition by normal, medium and critical stated.

The Kramer's rule has been used by pediatric department to identify prediction of TSB concentration value base on physical color of skin (Randev and Grover 2010) as shown in Figure-1. As an example, if the yellowness of skin reach to upper trunk of babies, TSB (refered to Table-1) is 150µmol/dL and need to be monitored under phototherapy light.

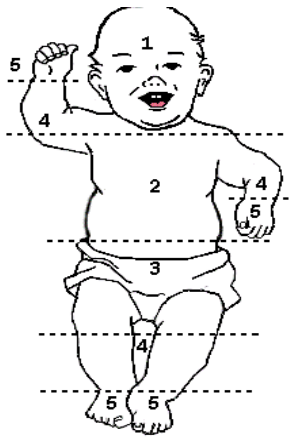

Figure-1. Zones of Kramer's rule.

Table-1. Serum bilirubin (SBR).

Zone	Definition	Total serum bilirubin (µmol/L)
1	Head and neck	100
2	Upper trunk	150
3	Lower trunk and thighs	200
4	Arms and lower legs	250
5	Palms and soles	>250

Invasive technique: blood test

The clinical estimation of Kramer's rule to identify the concentration value of bilirubin on dark skin babies still has error. Therefore, blood taken or invasive technique has to be used to verify the concentration value of bilirubin. Figure-2, shows the blood taken from baby's heel onto spot card to be sent by pathologies to doctors for jaundice result(Zakaria, Jalil *et al.* 2015). In this procedure, time taken between pathologies and doctors to analyze the result can cause serious problem if the concentration value of bilirubin is high that might cause death within the time.

Figure-2. Invasive technique (blood test).

Non-invasive technique: optical method

Non-invasive technique is less painful, reduce traumatize and give fast result. By using the concept of optical reflection and absorption, bilirubin concentration can be monitored in early stage.

In Figure-3, the bilirubin concentration will absorb wavelength of light between 457nm until 473nm. Meanwhile, hemoglobin will absorb 527nm until 532nm(Mostafa Hamza, Ahmad Mohammad Hamza *et al.* 2001).

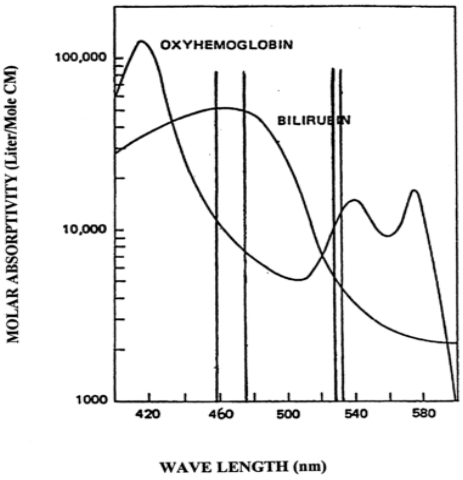

Figure-3. Absorption of spectral light for bilirubin and hemoglobin concentration.

Based on magnetic spectrum in Figure-4, the visible light wavelength is between 390nm until 700nm which is near to ultra violet and high frequency (Ryer 1998). Referring to this chart, as the absorption of wavelength by bilirubin concentration is between 450nm to 500nm, the blue light can be absorbed perfectly (Bruno and Svoronos 2005). Therefore, in this research the blue light will be used as the source to determine the bilirubin concentration with wavelength on 465nm to 470nm.

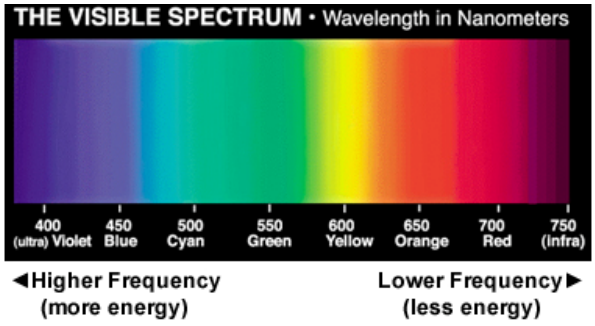

Figure-4. Visible spectrum.

RESEARCH PROTOTYPE

A. Mock skin (sprague-dawley rat,SD)

The mock skin of Sprague - dawley (SD) rat has been used as artificial skin in this research because of its similarity to human skin (Osman, Ahmad *et al.* 2014). The rat skin has been shaved and soaking into fix calibrated

bilirubin concentration value as shown in Figure-5. These samples will be used to identify value of its voltage reflection and also the voltage reflection prediction for the other calibrated bilirubin concentration value that cannot be supplied from the market. Each SD skin has been mark to six different bilirubin concentration with three level jaundice condition shown in Table-2.

Figure-5. Soaking SD skin.

Table-2. Level jaundice condition for bilirubin concentration (mg/dL)

Bilirubin concentration (mg/dL)	Condition level of jaundice
1.0 & 4.0	Normal
7.0 & 10.1	Medium
15.2 & 20.2	Critical

As shown in Table-2, the bilirubin samples are fix into 6 values only (1, 4,7,10.1,15.2 and 20.2 mg/dL) where the other values need to be predicted using a graph that will be discussed in the next section.

B. Prototype design system

Based on Figure 6, there are two parts involved which are hardware and software. The hardwares used in this system include the blue led as light source, the photodiode to receive the amount of reflected light after go through to the mock sample and the arduino uno for signal processing from the photodiode. The result of bilirubin concentration will be displayed on liquid crystal display (LCD). Meanwhile, to make this system online, the softwares such as Visual Basic, SQLyog Database and DreamWeaver are needed therefore user can enter the value of bilirubin concentration after each measurement on the website.

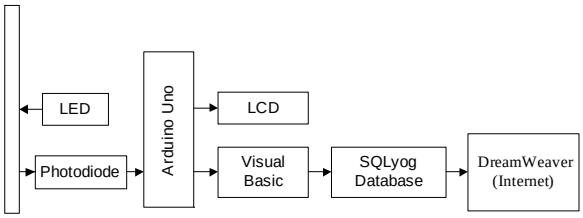

Figure-6. Block diagram of the system.

a. Hardware design system

The optical sensor, photodiode will measure the reflection light of blue led and send the data to the arduino. This reflection of light values is then converted by arduino to voltage to be further processed. The distance between the optical sensor to mock skin is 0.5cm as shown in Figure-7. The measurement of this reflected blue light has to be done inside the black box to reduce the error of ambient light during collecting data.

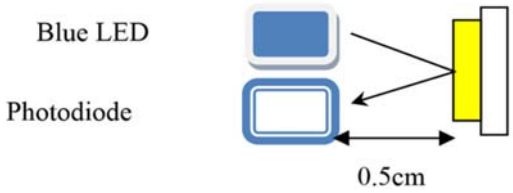

Figure-7. Optical sensor with mock skin.

One of the function of the arduino in this system is to map the voltage value of the reflected blue light to the concentration of the bilirubin. The mapping value which is supposed to be the bilirubin concentration will then be displayed through liquid crystal display (LCD). Other than that, the Arduino will also communicate with Visual Basic software for results storage in website.

b. System design online

In this system, Microsoft Visual Basic has been used in order to communicate between Arduino Uno and the website system. The website system has been designed by using Dreamweaver for user interface and it can be seen in Figure-8. This website is designed for hospital staff usage to monitor bilirubin concentration of the baby. A SQLyog database has been set up to store the bilirubin concentration reading in this system.

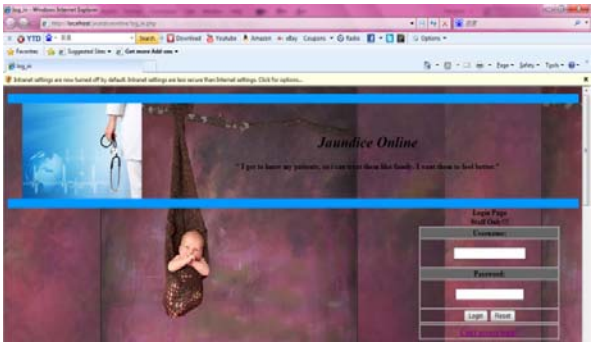

Figure-8. Website design.

This website only allows for hospital staff access, especially doctors and nurses. Figure 9 shows the flow of

website system. Three stages in the system which are login, patient's registration and patient's data.

Figure-9. Flow of website system.

Figure-10 shows the first page of website design which is login section. The hospital staff are provided with username and password to access this website in order to key in the data of the baby.

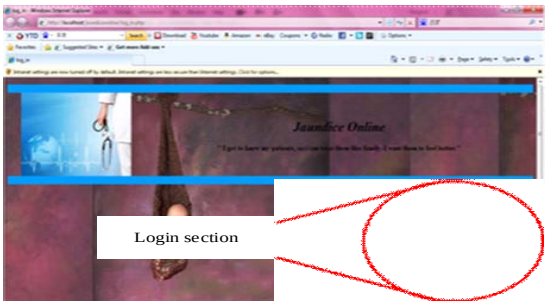

Figure-10. Login section.

Figure-11 shows the second page of designed website system after user have successfully login into the system. The details of patients such as baby's id, name and date of birth will be registered by hospital staff. Then, the list name of jaundice babies is updated after it has been saved. In this system, the data which are no longer needed can be deleted by the user. The information about jaundice disease are also displayed on this page for user references.

Figure-11. Second page of website.

The information about the baby is displayed on the last page of the website where it is related to their personal detail and also bilirubin concentration reading. The bilirubin concentration reading about the baby is stored in the SQLyog database for reference of hospital staff. It can be seen in Figure-12.

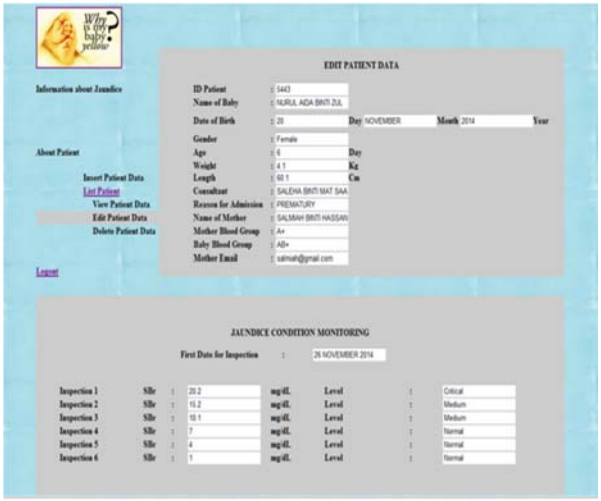

Figure-12. The actual data display.

MOCK SKIN JAUNDICE MODEL

The bilirubin concentration has linear relation with voltage reflection absorption as shown in Figure-13. Although the sample only prepared for six fix values as mentioned in previous section, we can predict the voltage value for another bilirubin concentration by using a graph as shown in Figure-13. The concept of Beer-Lambert law has been proven where, the increasing of bilirubin concentration will reduce the intensity of light (Hplc.chem.shu.edu 2014). This happen because the higher the value of bilirubin, the lower the light can be reflected back to the photodiode as the bilirubin absorb more light. This shows that bilirubin concentration is inversely proportional to voltage reflection absorption.

By using plot fitting toolbox of MATLAB software, the graph of the bilirubin concentration versus voltage reflection absorption can be drawn. Figure-13 shows this graph drawn using MATLAB and the prediction equation of the graph is:

$$y = -13.874 *x +33.414 \quad (1)$$

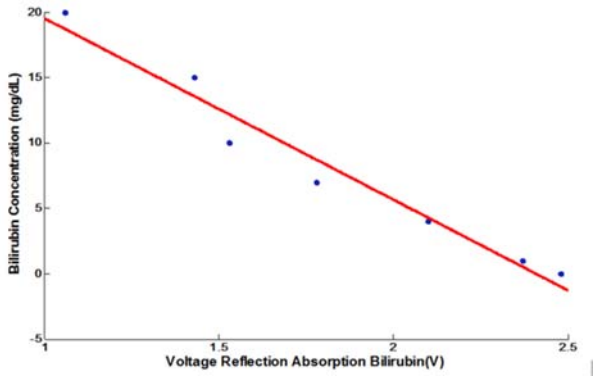

Figure-13. Graph concentration bilirubin versus voltage reflection Absorption.

Based on equation (1), the prediction of bilirubin concentration is divided into three condition level of jaundice. For normal jaundice, the bilirubin concentration value is between 1 to 4 mg/dL. Meanwhile, medium value is between 7 to 19mg/dL and the cirtical level of the bilirubin concentration is between 15 to 20 mg/dL.

Medium condition level will be monitored under phototherapy exposed to reduce jaundice level. In critical condition, an operation need to be done to the babies to make transfusion exchange (Simkiss, Edmond *et al*.). This will cause painful and scar to the babies.

Table-3. Voltage averange reflection absorption of mock skin bilirubin concentration.

Concentration bilirubin calibrator (mg/dL)	Jaundice condition level	Voltage averange reflection absorption (V)
1-4	Normal	2.37 – 2.1
7-10	Medium	1.78-1.53
15-20	Critical	1.43-1.06

CONCLUSIONS

Based on the experimental result, optical technique for jaundice detection system has been successfully implemented using Arduino. In order to implement this system on website, the Arduino have been interfaced with visual basic software which to assists the doctors and nurses monitor the babies jaundice level through online system.

ACKNOWLEDGEMENT

This research was supported by FRGS with Vot 1209. We thank our Universiti Tun Hussein Onn Malaysia who provided insight and expertise that greatly assisted the research.

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