Euclidean distance digital image processing for jaundice detect

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**Abstract.** Jaundice is a serious health issue. Late treatment of jaundice cases in babies may result in neurodevelopmental disorder and irreversible brain damage. Diagnosis inaccuracy is usually caused by the fact that health professionals and health service providers often rely on visual observation instead of laboratory examination. Lack of expertise in detecting jaundice is a serious matter. This research proposes a method of web-based digital image processing as an alternative for early detection of jaundice based on babies’ complexion. Images of babies’ complexion and color calibration cards are taken to obtain images for online analysis. Determination of bilirubin levels is carried out using the method of Euclidean approximate distance of RGB values from babies’ complexion and those of color calibration cards. Results show correlation of Euclidean distance to bilirubin level of babies of 0.93596 and web-based digital image processing accuracy of 90%. These mean that the information system developed here is capable of detecting jaundice cases. This research was performed observationally in high-risk prenatal ward involving 30 infants as samples.

1. Introduction

Lack of accuracy in detecting newborn jaundice is one of the reasons why newly born babies need special care [1,2]. Digital image processing requires the use of some image elements. Image elements of pel and pixel are some parts used to show the elements of digital images [3]. Stages of digital image processing includes color-based balancing, feature extraction, regression machine learning, and bilirubin level estimation [4].

Colored images are known as RGB image with red, green, and blue components for each pixel [5]. Digital image processing is carried out on photo therapy results including non-invasive system treatment performed by health professionals or family members used to periodically find out bilirubin levels before a patient needs doctor’s attention [2,4]. Increased bilirubin level is experienced by babies due to heme degradation resulting from damages in erythrocyte that disrupts albumin transport to the liver [6,7]. Babies suffering from hyperbilirubin or jaundice are prone to hemolytic diseases, metabolic and endocrine disorder, liver anatomic disorder, infection, and asphyxia.

Digital image processing helps to monitor jaundice in babies. Earlier researches suggests that a mobile phone feature called BiliCam can be used to monitor jaundice in babies. However, BiliCam is only used for offline application [2]. Therefore, there is the need to develop an online application system.
that can be easily used anytime and anywhere [8]. Development of health monitoring system should result in an application that is easy to access, light, cheap, and comfortable to use. This is meant to allow monitoring from home [9]. Web-based digital image processing is capable of detecting jaundice cases.

2. Methods
Colored images are known as RGB image with red, this research employed observational method by detecting jaundice from babies’ complexion. It was carried out in high-risk prenatal ward involving 30 babies that meet certain qualifications. There are four stages of jaundice detection: (a) image collection and complexion detection, (b) RGB digital image processing and Euclidean distance measurement, (c) web-based information system utilization, and (d) system accuracy validation. Euclidean distance is used to determine similarities in color between babies’ complexion and color calibration cards. A diagram of the information system realized is shown in Figure 1.

2.1. Babies’ image collection
Babies’ images are taken using a 16 mega pixel camera with flash. Babies’ are lied down with a calibration card put on their body. Complexion detection is performed using visual observation that later serves as comparison to that gained from web-based complexion detection using digital image processing.

2.2. Digital image processing
Euclidean distance is calculation of the distance between 2 points in the Euclidean space [4,10-12]. Value of Euclidean distance is gained from calculation between RGB (Red, Green, Blue) value of babies’ complexion and color calibration cards. The color calibration cards have eight colors of black, grey, white, cyan, magenta, yellow, and two skin colors [2]. An example of a baby’s image is shown in Figure 2.

![Figure 1. Diagram of realized information system.](image-url)
2.3. Information system for jaundice case monitoring

The web-based information system is used to help detect jaundice cases effectively and as early as possible to prevent them from becoming pathological issues. A scheme of the information system is given in Table 1.

3. Results and discussion

3.1. Correlation of baby’s complexion and bilirubin level

Theoretically, skin complexion has Euclidean distance value that approximates the calibration card. Therefore, this research presents results of correlation between Euclidean distance of baby’s skin complexion and calibration card, with that of bilirubin level from laboratory examination for cases of newborn jaundice, as given in Table 2.

![Figure 2. Example of a baby’s image with a color calibration card.](image)

Table 1. Information system scheme.

| Input                  | Process                                      | Output                          |
|------------------------|----------------------------------------------|---------------------------------|
| a. Mother and baby identities |
| b. Baby’s clinical data |
| c. Image of baby’s body | Digital image analysis                      | a. Jaundice diagnosis test result |
|                        | Data matching                                | b. Table of baby’s clinical data |
|                        | Notification                                 | c. Geographical information of jaundice case |

Table 2. Correlation of baby’s complexion and bilirubin level.

| Euclidean Distance | U1    | U2    | U3    | U4    | U5    | R     |
|--------------------|-------|-------|-------|-------|-------|-------|
| Bilirubin levels   |       |       |       |       |       |       |
| (mg/dL)            | 9.31  | 9.74  | 10    | 11.45 | 13.42 | 0.93596 |
|                    | 12.764| 14.602| 15.652| 19.755| 20.745|       |
It can be seen in Table 2 that baby’s complexion is significantly related to bilirubin level with $R = 0.93596$, which results from calculation of correlation between Euclidean distance and bilirubin level (from laboratory examination). The Euclidean value itself is taken from calculation of RGB value of baby’s complexion and that of color calibration card attached to the baby’s abdomen. Relationship equation of Euclidean distance and bilirubin level is shown in Figure 3.

![Figure 3. Relationship equation of Euclidean distance and bilirubin level.](image)

It can be seen from Figure 3 that color matches indicated by Euclidean distance relates to bilirubin level gained from clinical observation. Correlation of Euclidean distance and bilirubin level is represented with $y=0.463$, which means that each 1 increase in distance equals an increase of 0.463 mg/dL in bilirubin level.

Digital image processing of baby’s image results in RGB values that is converted to the Euclidean distance, which in turn is matched with the color calibration card attached to the baby’s abdomen with the consent of a specialist in charge of the baby. Euclidean distance is the parameter of K Nearest Neighbor (KNN) classification that determines the match between objects being observed, hence, allowing the object to be used to measure its nearest neighbors [13]. Monitoring for jaundice cases can therefore use digital image processing by detecting baby’s complexion [14,15].

3.2. Web-based jaundice case monitoring

Details of observed jaundice cases using the web-based information system is shown in Figure 4, which shows data of hyperbilirubin / jaundice cases based on baby’s complexion. Diagnostic test for jaundice case uses the following categories: a) hyperbilirubin at bilirubin level of $<10$ mg/dL, b) hyperbilirubin at bilirubin level of 10-13 mg/dL, c) hyperbilirubin at bilirubin level of $>13$ mg/dL. The web-based information system with digital image processing is proven to be capable of effectively detect jaundice cases.
3.3. System accuracy validation

There were 20 cases belonging to the accurate category of the 30 samples in this study. Meanwhile the other 10 cases have approximate match (the least Euclidean distance value) and hence, have to be eliminated. So, there are 20 successful system users. Validation of system accuracy shows 90% case diagnosis accuracy. This means that the system developed here is capable of monitoring hyperbilirubin / jaundice cases. System accuracy validation is given in Table 3.

### Table 3. System accuracy validation.

| Name   | Age   | Address | Diagnosis     | Visual Information System |
|--------|-------|---------|---------------|----------------------------|
| Patient 1 | 6 days | Brangsong | Hyperbilirubin | Hyperbilirubin             |
| Patient 2 | 3 days | Kendal   | Hyperbilirubin | Hyperbilirubin             |
| Patient 3 | 3 days | Boja     | Hyperbilirubin | Hyperbilirubin             |
| Patient 4 | 5 days | Pageruyung | Hyperbilirubin | Hyperbilirubin             |
| Patient 5 | 4 days | Rowosari | Hyperbilirubin | Hyperbilirubin             |
| Patient 6 | 3 days | Cepiring | Hyperbilirubin | Hyperbilirubin             |
| Patient 7 | 4 days | Kendal   | Hyperbilirubin | Hyperbilirubin             |
| Patient 8 | 4 days | Pegandon | Hyperbilirubin | Hyperbilirubin             |
| Patient 9 | 7 days | Cepiring | Hyperbilirubin | Hyperbilirubin             |
| Patient 10 | 4 days | Gemuah  | Hyperbilirubin | Hyperbilirubin             |
| Patient 11 | 3 days | Kangkung | Hyperbilirubin | Hyperbilirubin             |
| Patient 12 | 7 days | Kangkung | Hyperbilirubin | Hyperbilirubin             |
| Patient 13 | 4 days | Petebon  | Hyperbilirubin | Hyperbilirubin             |
| Patient 14 | 3 days | Petebon  | Non-hyperbilirubin | Hyperbilirubin             |
| Patient 15 | 4 days | Pageruyung | Hyperbilirubin | Hyperbilirubin             |
| Patient 16 | 14 days | Singorejo | Hyperbilirubin | Hyperbilirubin             |
| Patient 17 | 11 days | Petebon  | Hyperbilirubin | Hyperbilirubin             |
| Patient 18 | 4 days | Weleri   | Hyperbilirubin | Non-hyperbilirubin         |
| Patient 19 | 3 days | Kangkung | Hyperbilirubin | Hyperbilirubin             |
| Patient 20 | 4 days | Weleri   | Hyperbilirubin | Hyperbilirubin             |
| **Total** | 20    | 18      |               | 90%                        |

4. Conclusion

Web-based digital image processing with matches measurement of Euclidean distance results in approximate values that can be used to detect jaundice cases based on bilirubin levels in babies. Digital image processing using Euclidean distance on bilirubin level results in correlation value of 0.93596, and correlation value of bilirubin level with Euclidean distance of $y=0.463$, which means that each 1 increase in distance relates to 0.463 mg/dL increase in bilirubin level. The web-based digital image processing method employed in this research has a validated accuracy of 90% in detecting jaundice cases.
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