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New newborn jaundice monitoring scheme based on combination of pre-processing and color detection method

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ABSTRACT

Newborn jaundice is an apparent yellowing of the sclera or yellowish skin in newborn infants. This symptom is caused by a yellow pigment known as bilirubin. A high level of bilirubin in the infant is referred to as hyperbilirubinemia. Significant complications can occur if significantly increased bilirubin levels are not treated promptly. Severe hyperbilirubinemia can be caused by dehydration, lack of adequate nutritional intake, extravasation of blood, cephalohematoma, contusions and asphyxia, and may potentially cause kernicterus. Because many of these problems affect newborns, they may require critical care from specialty medical disciplines. Thus, in this paper we proudly proposed a Combination of pre-processing and the skin color detection method to detect jaundiced infants. Few statistical features are derived from the texture images and used as features to quantify infant image textures. Finally, a k-NN is employed as classifier for discriminating infant image textures. The experimental results reveal that the proposed method can act as a supplement to support earlier detection and more effective treatment due to improved jaundice recognition.

1. Introduction

In Malaysia, when newborns present with jaundice, the following clinical assessment need to be carried out such as taking a history, physical examination and assessment of severity of jaundice, including if any of the following signs and symptoms: jaundice below umbilicus jaundice up to soles of feet, rapid rise of serum bilirubin >8.5 mmol/L/h, prolonged jaundice >14 days, and family history of hemolytic disease/kernicterus. If the newborn has severe hyperbilirubinemia, he/she needs to be referred to for hospital management in a timely manner [5–7].

Malaysian babies have been known to have higher levels of significant jaundice and consequently are at higher risk of developing kernicterus [2]. Kernicterus can cause death; however, survivors suffer sequelae, such as athetoid cerebral palsy, high frequency hearing loss, paralysis of upward gaze and dental dysplasia [1]. With the elevated level of anxiety among local pediatricians, many studies have been taken into account to minimize the morbidity and mortality. However, there is no specific level of total serum bilirubin above which kernicterus can be predicted to occur [2].

However, some studies have been done on recognition of neonatal jaundice, or hyperbilirubinemia, such as transcutaneous bilirubinometer, that is placed on the baby's forehead or chest and gives a reading, or by taking a blood sample, usually from the baby's heel [3]. However, blood examination is invasive and transcutaneous bilirubinometry is less accurate for babies with dark skin tones [3,4]. Thus, the goals of this paper are to promote a new method of newborn jaundice monitoring based on a combination of a preprocessing method with a simple color detection algorithm to detect jaundice in infants that can act as a supplemental support for earlier and more effective jaundice recognition.

2. Methodology

The long-term goal of this research is the development of a stand-alone automated system that could be used as a supplement in the NICU to provide 24-hour per day noninvasive assessment for jaundice. The development of a jaundice-detection system involves the following three tasks: (a) the skin detection, (b) preprocessing stage and feature extraction. Finally (c), validations test to distinguish between jaundice and the normal newborn infant skin tone based on k-NN classifier. The complete block diagram is shown in Fig. 1.

2.1. Infant jaundice monitoring

Images were selected from a random database developed by the website infant monitoring.com [11]. All the acquired images differ from the illumination level, distance and the angle of the picture taken. The infant jaundice database contains a total of 120

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color photographs, ranging in age from 18 h of life to 3 days of life. The sample population was multi-ethnic: 70% of babies were white, 28% black, and 5% Asian. The rest were other varied ethnicities. We divide the facial expressions into two main categories: jaundice (80 images) and normal (40 images). This variety of images gives the further experiment more validity in order to find a robust portion to monitor infant jaundice. The data collection computer was configured with MATLAB R2009a and the Image Acquisition Toolbox.

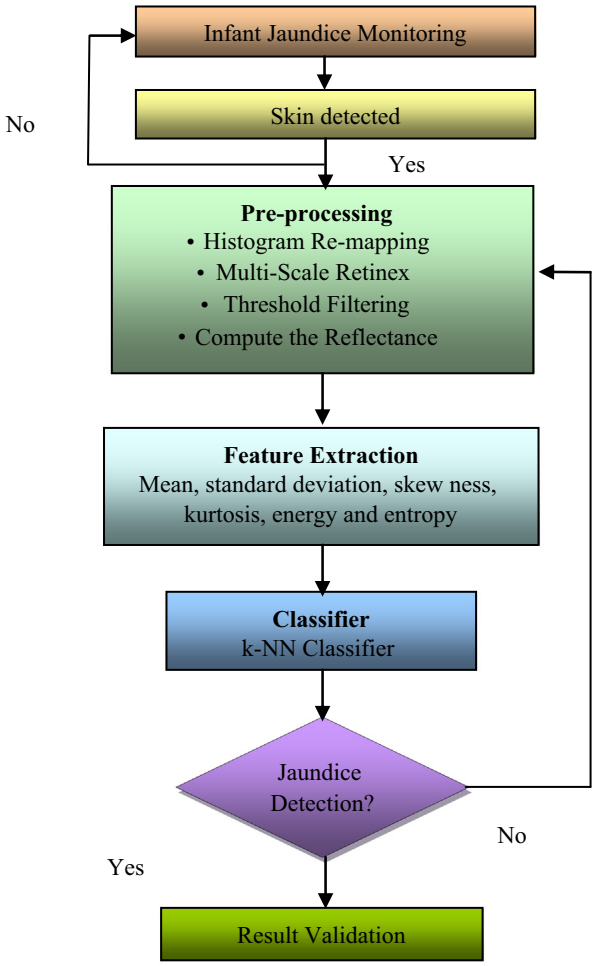

Fig. 1. System block diagram.

2.2. Skin detection

It seems that lighting information could easily lead to false detections [8], hence the luminance component in YCbCr need to be discarded, [9,10]. The result of Face Detection is first processed by a decision function based on the chroma components CrCb from YCrCb and Hue from HSV by [10]. If all following conditions are true for a pixel, it is marked as skin area, shown in Fig. 2.

2.3. Pre-processing

The proposed combination algorithm is composed of four steps. First we used a concept of histogram remapping based on Ref. [12]. Secondly, an illumination level estimation based on a combination of several weighting (*wn*) Gaussian filters with different scales (*N*) of image using Mutli Scale Retinex by Ref. [13] was employed. Thirdly, threshold filtering was employed followed by reflectance estimation and histtruncate respectively by Refs. [14,15]. The proposed pre-processing method is shown in Fig. 3

2.4. Feature extraction

Images of texture measures were then generated. Texture measures used in this study were mean, standard deviation, skewness, kurtosis, entropy and energy, suggested by Ref. [16]. The formulas of statistical features used in his study are given in Eqs. (1)–(6) (Fig. 4).

$$P_K = \frac{h_K}{\sum_{K=1}^{K} h_K} \tag{1}$$

$$\text{mean} = \mu = \sum_{k=1}^{K} kP_K \tag{2}$$

$$\text{Variance} = \sigma^2 = \sum_{k=1}^{K} (k-\mu)^2 P_K \tag{3}$$

$$\text{Skewness} = \tau_3 = \frac{1}{\sigma^3} \sum_{k=1}^{K} (k-\mu)^3 P_K \tag{4}$$

$$\text{Kurtosis} = \tau_4 = \frac{1}{\sigma^4} \sum_{k=1}^{K} (k-\mu)^4 P_K - 3 \tag{5}$$

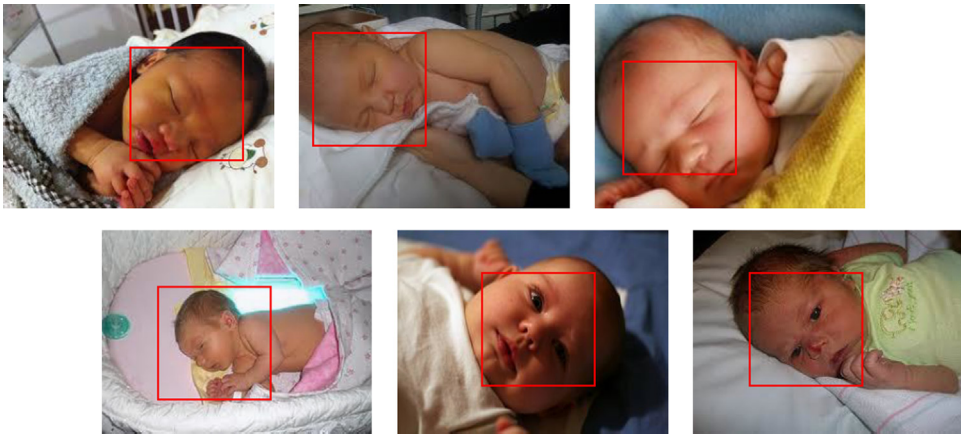

Fig. 2. Example of face detection based on YCrCb color space.