Fast Neonatal Jaundice Detection Using Colour Models and Machine Learning Classifiers

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Abstract: Neonatal jaundice is a usual condition in newborns caused by high levels of bilirubin in the body, which demands accurate detection to prevent severe complications. Using simple machine learning algorithm and image-processing techniques named Colour Space Models (RGB (Red, Green, Blue) , HSV (Hue, Saturation, Value) , YCbCr (Luminance, Chrominance), Lab (lightness (L), red/green (a), yellow/blue (b)) our research introduces a non-invasive method for precise jaundice diagnosis. Building upon a comprehensive dataset of diverse infant images, our approach utilizes machine learning algorithms—Decision Tree (DT), Random Forest (RF), and Gaussian Naive Bayes (GNB) —to enable real-time, non-invasive diagnosis within few seconds. Our work aims to empower neonatal healthcare specialists with AI-driven tools for efficient, non-invasive monitoring and timely diagnosis, thereby reducing potential risks associated with untreated neonatal jaundice.

Keywords: Neonatal Jaundice, Colour Models (RGB, YCbCr, HSV, Lab), Skin Detection, Region of Interest (ROI), Machine Learning Classifiers- Decision Tree (DT), Random Forest (RF), Gaussian Naive Bayes (GNB).

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1)Introduction

Jaundice is a common issue for newborns, making many of them go to the hospital during their first week of birth. About 60% of full-term and 80% of premature newborns get it and their skin and sclera turn into yellow because of a substance called bilirubin. Usually, it's not too serious. But if it's not treated, it can harm the baby's brain **[1-2]**. Jaundice must therefore be promptly treated to prevent dangerous complications. Invasive way of diagnosing high bilirubin levels usually needs a method that's uncomfortable for patients. **[3]** It involves taking blood samples, especially through tests like Total Serum Bilirubin (TSB) tests. The real time prediction of neonatal jaundice is important to help doctors make timely decisions for the appropriate treatment and diagnosis. **[4-5]** In recent years, the methods combining colour space models and machine learning algorithms have recorded as a highly reliable technique for the accurate diagnosis of neonatal jaundice.

[4] In a study by Hashim et al. (2021), employed colour models like RGB, HSV, and YCbCr for diagnosing neonatal jaundice and created a graphical user interface for diagnosis. But their study only used ten pictures of jaundiced and normal babies, so the findings were promising but limited. **[5]** In another study Hashim et al. also tried using image methods for diagnosing jaundice. But, they only had access to two manikins and 20 baby pictures, which made their study challenging due to the small number of images available for analysis.

In our research, we have used 760 images of newborns (560 jaundiced and 200 normal) of size 1000x1000 pixels **[6]**, which is very large dataset. We have considered different combination of colour models such as RGB, YCbCr, HSV, Lab and different combination of their components ([R,G,B,Y,Cb,Cr,H,S,V,L,a,b],[R,G,B,Y,Cb,Cr],[R,B,Y,Cb,Cr,H,b]). Also, we have used skin detection algorithm to get ROI (Region of Interest) and on ROI, we have found mean values of different colour components and used machine learning classifier algorithms like Decision Tree (DT), Random Forest (RF), Gaussian Naive Bayes (GNB) to classify the neonate images into 'Jaundice' and 'Normal'.

Next In section-2,3 of the paper we have explained the database and image processing steps and other methods, in section-4 the result of different models are evaluated and in last section-5 the conclusions and future works are discussed.

2) Database Description

The data set we have used, are collected and described by Abdulrazzak et al. **[6]**, which were taken in the NICU at Al-Elwiya Maternity Teaching Hospital in Al Rusafa, Baghdad, Iraq. This dataset contains normal and jaundiced newborn images from different angles and lighting environments. The collected data include 760 infant images (560 normal and 200 jaundiced) with 1000 × 1000 resolution, all in jpg format.

3) Image Processing and Other Used Methods

For image processing, training and testing tasks, python version-3.10 has been used. We have followed several steps to predict the newborns as 'jaundiced' and 'normal'. Here below diagram represents the following steps.

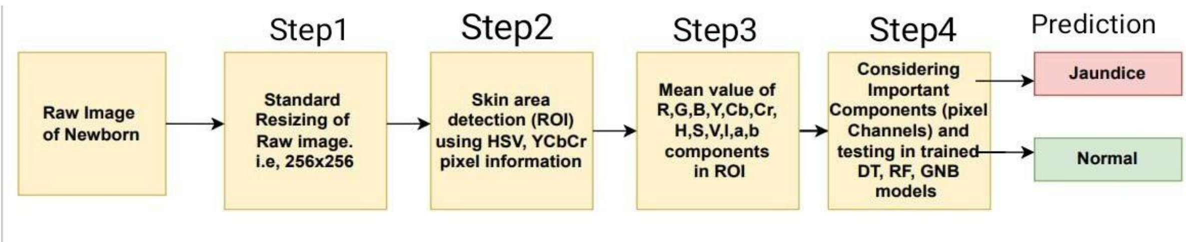

Figure 1: Steps for Predicting the Neonatal Images as 'Jaundiced' and 'Normal'

Initially we had the images of size 1000 x 1000. It takes too much time to process those original images. So, the images are resized into standard size of 256 x 256 (step1 in **Figure 1**) which takes very few seconds to process. Then for resized image's all pixels YCbCr, HSV channel values (Y, Cb, Cr, H, S, V) are computed to detect the ROI area of image. Initially for skin detection we took the Y, Cb, Cr, H, S, V components range as Djamila Dahmani et al. suggested **[8]**. But it did not give the desired ROI for all images, so, we have changed the range of H, Y and Cr components to 0 ≤ H ≤ 13, 0 ≤ Y ≤ 200, 145 ≤ Cr ≤ 180 and kept other values (S, V, Cb) as suggested **[8]** . After all, we got desired ROI (step2 in **Figure 1**). Here Below is an example

Figure 2: Raw image (1000x1000) to ROI image of size 256 x 256

After finding ROI image, the average value of R, G, B (from RGB image), Y,Cb,Cr (from YCBCr image), H, S, V (from HSV image), L, a, b (from Lab) components are computed by considering only non-black part of the ROI images (Step3 in **Figure 1**). This task is done for all 760 images and all values followed by their image ID number are saved in a excel (csv) file.

For training the models we have used different combination of colour components of RGB, YCbCr, HSV, Lab images as features and feed them to simple machine learning classifier algorithms such as Decision Tree (DT), Random Forest (RF), Gaussian Naïve Bayes (GNB). For training 600 images and for testing rest 160 images are taken. Normal (non-jaundice) neonatal images were labelled '0' and Jaundiced neonatal images were labelled as '1'.

4) Results and Discussion

For binary classification (jaundiced and normal) of neonatal images we have considered 3 different feature combinations of channel values from RGB (Red (R), Green (G), Blue (B)); YCbCr (Y (Luminance), B-Y (Cb), R-Y (Cr)), HSV (Hue (H), Saturation (S), Value (V)) and from Lab model (lightness (L), green–red colours (a), and blue–yellow colours (b)). Three features combinations employed in our study are –

(1) Features Combination-1: [R, G, B, Y, Cb, Cr, H, S, V, L, a, b],

(2) Features Combination-2: [R, G, B, Y, Cb, Cr],

(3) Features Combination-3: [R, B, Y, Cb, Cr, H, b].

Different features combinations model performance using ML classifiers DT, RF, GNB are discussed below based on accuracy (prediction percentage for both normal and jaundiced neonatal images), specificity (prediction percentage for normal neonatal images) and sensitivity (prediction percentage of jaundiced neonatal images).

Table 1: Features Combination -1 Performance

ML Classifiers	Accuracy	Specificity	Sensitivity
DT	71.25 %	80.16 %	43.59 %
RF	77.50 %	87.60 %	46.15 %
GNB	74.37 %	75.20 %	71.80%

Table 2: Features Combination -2 Performance

ML Classifiers	Accuracy	Specificity	Sensitivity
DT	71.87 %	79.33 %	48.71 %
RF	76.87 %	86.77 %	46.15 %
GNB	73.75 %	76.03 %	66.67 %

Table 3: Features Combination -3 Performance

ML Classifiers	Accuracy	Specificity	Sensitivity
DT	74.37 %	81.81 %	51.28 %
RF	75.00 %	85.95 %	41.02 %
GNB	75.00 %	76.86 %	69.23 %

In our study specificity and sensitivity are most important parameter than all over accuracy of the model. Because, if one model give very good accuracy along with good specificity (or sensitivity) value but sensitivity (or specificity) value is very low , that means the model classifies only 'normal' (or 'jaundiced') subjects better, which is unwanted for riskless diagnosis.

In terms of accuracy and specificity, feature combination-1 (R, G, B, Y, Cb, Cr, H, S, V, L, a, b) with RF model gave best result (accuracy: 77.50 %, specificity: 87.60 %). But in case of sensitivity, features combinations-1 gave only 46.15 % correct prediction using RF. But using same feature combination (1), GNB gave better sensitivity (71.80 %). Also, with feature combination-1, DT did not give good sensitivity value. Similarly, using feature combinations-2,3 DT, RF did not give good sensitivity value. Whereas, GNB using all feature combinations (1,2,3) gave better result in terms of accuracy, sensitivity and specificity. Among of all 3 GNB model, GNB with feature combination-1 gave best sensitivity value (71.80%) and GNB with feature combination-3 gave best specificity value (76.86%).

All these above methods for training (for 600 images), testing (for 160 untrained images) of data take less than 1 seconds in each model. Also, we observed that image processing steps (from step1 to 3 in fig1), our methods totally take only around 2 seconds for each images. Therefore, in terms of fast and real time prediction and diagnosis of neonatal jaundice, the proposed models would be good choices to use. For more information see **Table 1**, **Table 2**, **Table 3**.

5) Conclusions and Future Works

Neonatal jaundice is a very common condition that affects newborns in their first week of life. Quick diagnosis and treatment of jaundice are essential to prevent newborn brain damage and its complications. In this paper we have explored the non-invasive method to diagnosis neonatal jaundice using skin detection algorithm (using HSV, YCbCr channel values) to obtain ROI, different colour model's channel values as features and ML classifiers such as DT, RF, GNB. We have obtained a good amount of accuracy (75.00 %) over a large newborn image dataset using GNB model over the features combination R, B, Y, Cb, Cr, H, b. Also, our proposed models and image preprocessing steps together take only few seconds to classify the neonates as 'jaundiced' and 'normal'. So, the proposed models have advantages over fast, real time, non-invasive way of diagnosing neonatal jaundice by just simply taking a photo of infant. But our study did not include several other ML algorithms like XGboost. Also in our future study, we would like to explore some new models using new colour models along with used colour models and other ML algorithms to achieve better accuracy, specificity, sensitivity.

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