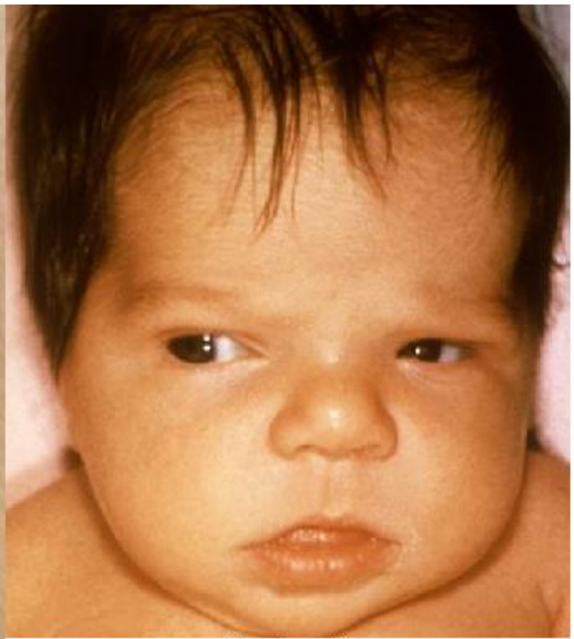
Neonatal Jaundice Detection

Project Report

Jaundice



Non-Jaundice

Ashish Sardana

14BEE0099

under the guidance of

Prof. Mathew M. Noel

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Introduction

In India, 5.1%[1] of infants of the total population are diagnosed with severe neonatal jaundice. Neonatal Jaundice is a "silent" cause of significant neonatal morbidity and mortality. Over 60%[1] of term new-borns develop jaundice by 24-72 hours of age. Neonatal Jaundice contributes to 4.55% of deaths in India. Around 1.1 million babies develop severe hyperbilirubinemia worldwide every year. It is also observed that almost half (45%) of the nurseries do not provide verbal or written instructions to the parent for diagnosing jaundice. In addition to that, 49.7% of mothers did not know any danger sign/symptom of neonatal jaundice.

If this disease is not treated on time, the extreme levels of bilirubin can lead to irreversible brain damage or Kernicterus.

Hospitals and nurseries of metropolitan cities are mandating the test of jaundice in newborn's but no care is being taken for the rural areas. Diagnosing jaundice require tests on blood samples, an invasive method which generally parents are afraid of for their baby. The limited number of testing equipment in rural areas also bars the detection of jaundice for many.

Our aim is to develop a portable jaundice detector that will be cheap (<₹5000) and accurate in detecting neonatal jaundice with image processing and machine learning technique (non-invasive).

[1] - Facts provided by Janitri Innovations Pvt. Ltd.

Background

Hyperbilirubinemia:

Hyperbilirubinemia is a condition in which there is too much bilirubin in the blood. When red blood cells break down, a substance called bilirubin is formed. Babies are not easily able to get rid of the bilirubin and it can build up in the blood, fluids and other tissues of the baby's body. This is called hyperbilirubinemia. Since bilirubin has a pigment or coloring, it causes a yellowing of the baby's skin, eyes, and other tissues. This is called jaundice.

Depending on the cause of the hyperbilirubinemia, jaundice may appear at birth or at any time afterward.

Diagnosis of Hyperbilirubinemia:

The timing of the appearance of jaundice helps with the diagnosis. Jaundice appearing in the first 24 hours is quite serious and usually requires immediate treatment. When jaundice appears on the second or third day, it is usually "physiologic." However, it can be a more serious type of jaundice. When jaundice appears toward the end of the first week, it may be due to an infection. The later appearance of jaundice, in the second week, is often related to breast milk feedings but may have other causes.

Diagnostic procedures for hyperbilirubinemia may include:

- Direct and indirect bilirubin levels - These reflect whether the bilirubin is bound with other substances by the liver so that it can be excreted (direct), or is circulating in the blood circulation (indirect).
- Red blood cell counts
- Blood type and testing for Rh incompatibility (Coomb's test)

Prevention of hyperbilirubinemia:

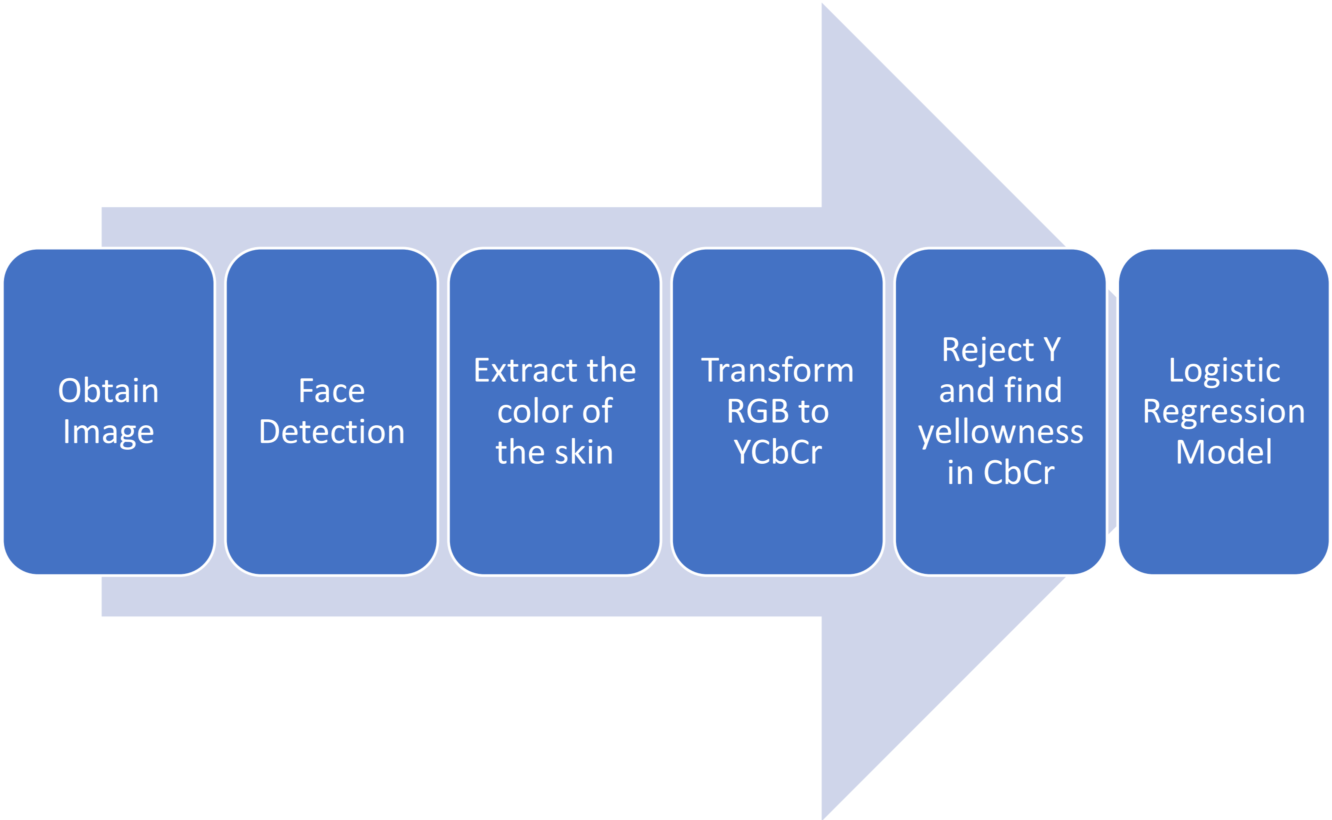
While hyperbilirubinemia cannot be totally prevented, early recognition and treatment are important in preventing bilirubin levels from rising to dangerous levels.

Methodology

As the change in color (yellowing) of skin, eyes and urine are symptoms for jaundice, we will use them for the detection of neonatal jaundice.

We've developed an algorithm which uses the color of baby's face to predict whether the baby has jaundice or not.

We've used Raspberry Pi for prototyping our concept, with the pi-cam for capturing images.



Part I. Obtaining the image:

The complete process of detection depends on the image captured thus it's important to capture the image in a consistent manner, such that the algorithm gives reproducible results.

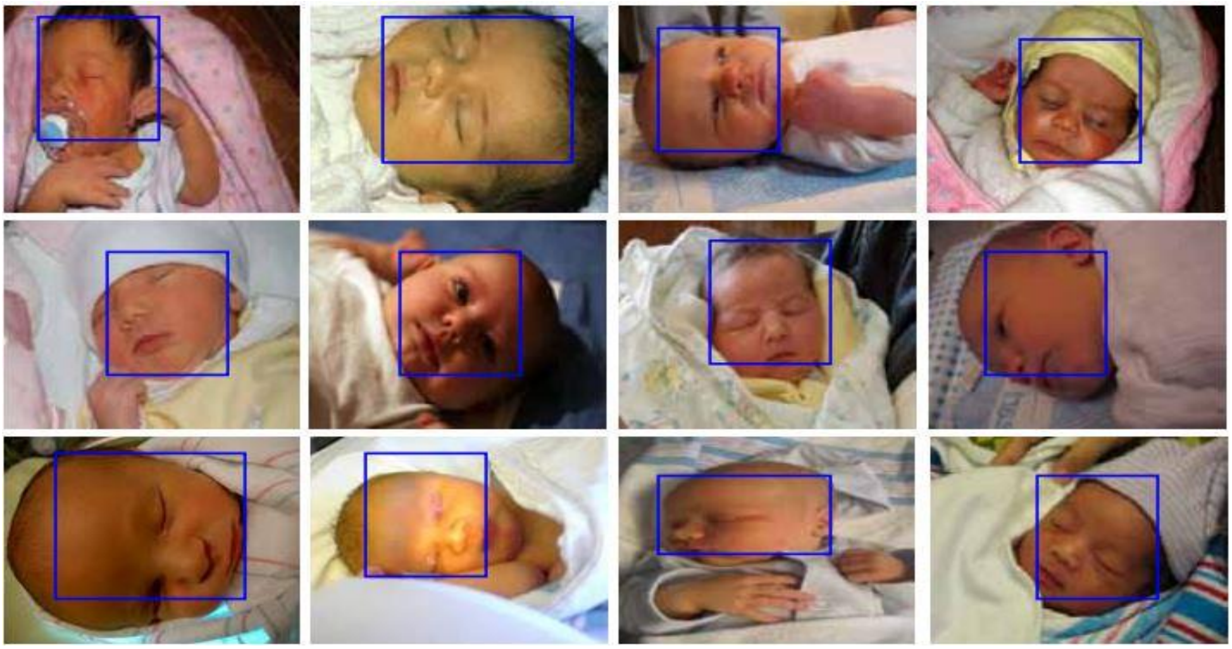
To be able to capture consistent images, we've fixed our development board on the outside of the box and the camera inside. The box is closed on all sides except one. The open side of the box is pointed towards the baby such that we are able to capture its face properly. A push button is used to click the picture.

Part II. Face Detection

The captured image may contain many objects which may be irrelevant for us. Since we need to extract the color of the face, we will use face detection algorithm to get the contour around the face.

The image is resized to 128x128px so as to standardize the process. Face detection is done using Haar Feature-based Cascade Classifier. This method was proposed by Paul Viola and Michael Jones in their paper, "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001. It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

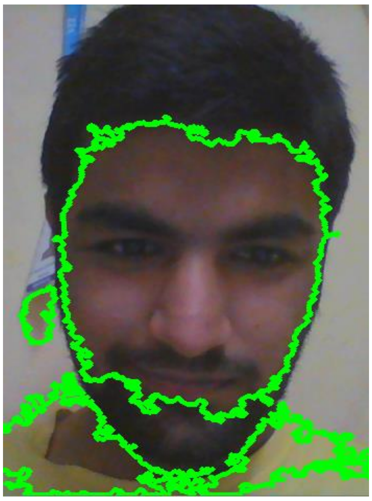
After successful face detection, we obtained the following results on a sample dataset:



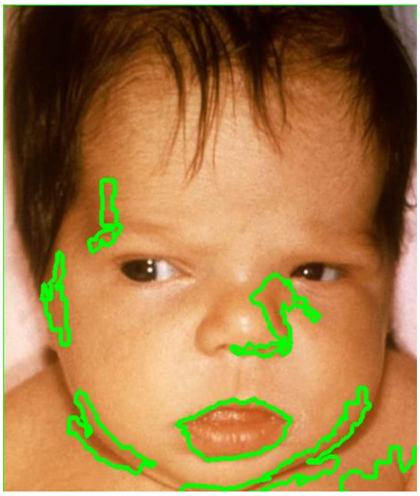
Part III. Extracting skin color

A human face has several distinct areas which have main features like – forehead, eyes, nose, mouth and eyelashes. To extract the color of the skin, we have to consider everything except the eyes, eyelashes and lips. Since these features have a distinct color, we first need to locate the region which has pure skin.

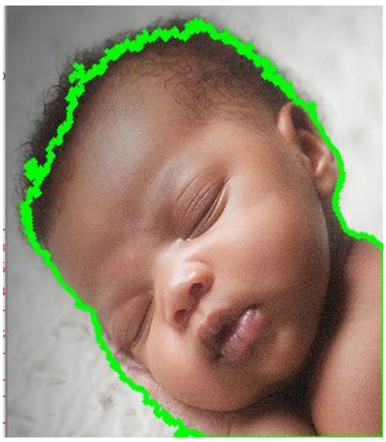
We developed an algorithm which identifies the skin region of the face irrespective of light/dark complexion of the baby. After identifying the skin region, we extract the specific color of that region.



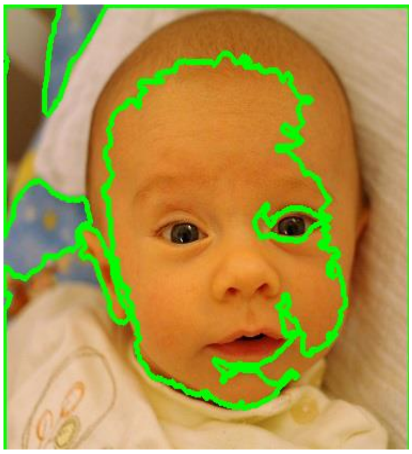
(1) RGB - (62, 56, 50)



(2) RGB - (207, 137, 83)



(3) RGB - (160, 127, 115)



(4) RGB - (189, 130, 68)

The algorithm is able to identify different skin tones on sample dataset. The result shows that it is able to identify skin color irrespective of the complexion of the baby.
We also tried the algorithm in real-time. We observed that it is decently accurate in identifying the skin region with additional noises due to the background.

Part IV. Transforming to YCbCr and Collecting

Medical research has proved that the human eye has different sensitivity to color and brightness. We've used this transform to extract the meaningful color out of the image while ignoring the Lumosity.

Y: Luminance; Cb: Chrominance-Blue; Cr: Chrominance-Red are the components of YCbCr.

Y is the luma component of the color i.e. the brightness of the color. Cb is strong in case of parts of the image containing the sky (blue), both Cb and Cr are weak in case of a color like green, and Cr is strong in places of occurrence of reddish colors.

We've transformed our extracted skin color from RGB to YCbCr and removed the "Y" component which signifies light intensity. Using the CbCr components, we found the yellowness (amount of yellow) in each image.

This yellowness is stored in a database against a label (manually labelled) which was further used to train and test our logistic regression model.

Results

The model was trained on 30 samples and we achieved an accuracy of 65% on the small test set. We observed that the number of false negatives were majorly contributing to the error.

Some identifiable issues which led to this performance are:

1. Less amount of data to learn from
2. Imbalanced class

Future Scope

There are a number of assumptions we've made, parameters we've neglected and have been working with a small dataset.

We have thought of some improvisations that'd make it commercially usable:

1. Build a better case for proper image capturing or move to building a smartphone application.
2. Bilirubin pigment (yellow) is significantly present in eyes as well as urine too. These data can also be collected to improve the classification.
3. Leverage deep learning techniques (CNNs) on pre-processed images to build a model on complex features (pixel).