Drowsiness Detection By Analysis Of Eyelid Movements

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ABSTRACT
“Drowsiness is a physiological condition that can occur long before you fall asleep at the wheel. It has a negative impact on your reaction time, your ability to concentrate and your general understanding of the road and traffic around you.”

This proposed work is related with human eyelid movement typically characterize the level of alertness. Various visual causes that typically characterize the level of alertness of a person are extracted systematically combined to infer the fatigue level of the person.

A probabilistic model is developed to model human fatigue and to predict fatigue based on the visual causes obtained. The simultaneous use of multiple visual causes and their systematic combination yields a much more robust and accurate fatigue characterization than using a single visual cause. This system was validated under real-life fatigue conditions with human subjects of different ethnic backgrounds, genders, and ages; and under different illumination conditions. It was found to be reasonably robust, reliable, and accurate in fatigue characterization.

Keywords
Driver vigilance, Human Drowsiness, Face Recognitions, Skin Detection, Eye Detection, Hough Transform

INTRODUCTION
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I. Literature Review

A. Face detection:
Traditionally the face detection task can be implemented with two very distinct approaches. These approaches are feature - based and image-based. Image based approach makes use of any information that the actual image can provide, such as color ranges, intensities. Feature - based approach uses information obtained from particular set of features corresponding to a given image, such as edges, pixel-pixel relative positioning, points of interest. Most of the existing face detection algorithms work with gray images. Without taking into consideration the color information, face detection becomes basically a pattern recognition task. [1]

Human face perception is currently an active research area in the computer vision community. Human face localization and detection is often the first step in applications such
as video surveillance, human computer interface, face recognition and image database management. Locating and tracking human faces is a prerequisite for face recognition and/or facial expressions analysis, although it is often assumed that a normalized face image is available. In order to locate a human face, the system needs to capture an image using a camera and a frame grabber to process the image, search the image for important features and then use these features to determine the location of the face. For detecting face there are various algorithms including skin color based algorithms.[1][2]

Color is an important feature of human faces. Using skin-color as a feature for tracking a face has several advantages. Color processing is much faster than processing other facial features. Under certain lighting conditions, color is orientation invariant. This property makes motion estimation much easier because only a translation model is needed for motion estimation. [3]

However, color is not a physical phenomenon; it is a perceptual phenomenon that is related to the spectral characteristics of electromagnetic radiation in the visible wavelengths striking the retina. Tracking human faces using color as a feature has several problems like the color representation of a face obtained by a camera is influenced by many factors (ambient light, object movement, etc.), different cameras produce significantly different color values even for the same person under the same lighting conditions and skin color differs from person to person. In order to use color as a feature for face tracking, we have to solve these problems. It is also robust towards changes in orientation and scaling and can tolerate occlusion well. A disadvantage of the color cue is its sensitivity to illumination color changes and, especially in the case of RGB, sensitivity to illumination intensity.

One way to increase tolerance toward intensity changes in images is to transform the RGB image into a color space whose intensity and chromaticity are separate and use only chromaticity part for detection. A new algorithm based on skin color classification in RGB, YCbCr color models. The skin region facial features have been extracted to get the face from the skin region. [4][8]

II. Motivation

A. Skin Detection:

Skin color and textures are important cues that people use consciously or unconsciously to infer variety of culture-related aspects about each other. Skin color and texture can be an indication of race, health, age, wealth, beauty, etc. However, such interpretations vary across cultures and across the history. In images and videos, skin color is an indication of the existence of humans in such media. Therefore, in the last two decades extensive research have focused on skin detection in images. Skin detection means detecting image pixels and regions that contain skin-tone color. Most the research in this area has focused on detecting skin pixels and regions based on their color. [9]

Very few approaches attempt to also use texture information to classify skin pixels. As will be described shortly, detecting skin pixels are rather computationally easy task and can be done very efficiently, a feature that encourages the use of skin detection in many video analysis applications. For example, in one of the early applications, detecting skin-colored regions was
used to identify nude pictures on the internet for the sake of content filtering. In another early application, skin detection was used to detect anchors in TV news videos for the sake of video automatic annotation, archival, and retrieval.

In such an application, it is typical that the face and the hands of the anchor person are the largest skin-tone colored region in a given frame since, typically, news programs are shot in indoor controlled environments with man-made background materials that hardly contain skin-colored objects. In many similar applications, where the background is controlled or unlikely to contain skin-colored regions, detecting skin-colored pixels can be a very efficient cue to find human faces and hands in images. An example in the context of biometric is detecting faces for face recognition in a controlled environment. Detecting skin-colored pixels, although seems a straightforward easy task, has proven quite challenging for many reasons. The appearance of skin in an image depends on the illumination conditions (illumination geometry and color) where the image was captured. We humans are very good at identifying object colors in a wide range of illuminations, this is called color constancy. Color constancy is a mystery of perception.

Therefore, an important challenge in skin detection is to represent the color in a way that is invariant or at least insensitive to changes in illumination. As will be discussed shortly, the choice of the color space affects greatly the performance of any skin detector and its sensitivity to change in illumination conditions. Another challenge comes from the fact that many objects in the real world might have skin-tone colors. For example, wood, leather, skin-colored clothing, hair, sand, etc. This causes any skin detector to have much false detection in the background if the environment is not controlled.

B. Color Models for Skin Color Classification

The study on skin color classification has gained increasing attention in recent years due to the active research in content-based image representation. For instance, the ability to locate image object as a face can be exploited for image coding, editing, indexing or other user interactivity purposes. Moreover, face localization also provides a good stepping stone in facial expression studies.

It would be fair to say that the most popular algorithm to face localization is the use of color information, whereby estimating areas with skin color is often the first vital step of such strategy. Hence, skin color classification has become an important task. Much of the research in skin color based face localization and detection is based on RGB, YCbCr color spaces. [3]

C. Skin Detection and Color Spaces:

As was highlighted by Forsyth and Fleck the human skin color has a restricted range of hues and hues and is not deeply saturated, since the appearance of skin is formed by a combination of blood (red) and melanin (brown, yellow). Therefore, the human skin color does not fall randomly in a given color space, but clustered at a small area in the color space. But it is not the same for all the color spaces. Variety of color spaces has been used in skin detection literature with the aim of finding a color space where the skin color is invariant to illumination conditions. The choice of the color spaces affects the shape of the skin class, which affects the detection process. Here, some color spaces, which are typically used in skin detection [10]

Color spaces used for skin modelling Colorimetry, computer graphics and video signal transmission standards have given birth to many colorspace with different properties. A wide variety of them have been applied to the problem of skin color modeling. We will briefly review the most popular color spaces and their properties.
D. RGB:
RGB is a colorspace originated from CRT (or similar) display applications, when it
was convenient to describe color as a combination of three colored rays (red, green and blue). It is
one of the most widely used colorspaces for processing and storing of digital image data.
The RGB color model is an additive color model in which red, green, and blue light are
added together in various ways to reproduce a broad array of colors. The name of the model comes
from the initials of the three additive primary colors, red, green, and blue. [11]
Typical RGB input devices are color TV and video cameras, image scanners, and digital
cameras. Typical RGB output devices are TV sets of various technologies (CRT, LCD, plasma,
etc.), computer and mobile phone displays, video projectors, multicolor LED displays, and large
screens as JumboTron, etc. Color printers, on the other hand, are not RGB devices, but subtractive
color devices (typically CMYK color model).

![Fig: Rgb color model](image)

The main purpose of the RGB color model is for the sensing, representation and display
of images in electronic systems, such as televisions and computers, though it has also been used in
conventional photography. Before the electronic age, the RGB color model already had a solid
theory behind it, based in human perception of colors.[12]

E. YCrCb:
YCrCb is an encoded nonlinear RGB Signal, commonly used by European television studios
and for image compression work. Color is represented by luma (which is luminance, computed
from nonlinear RGB), constructed as a weighted sum of the RGB values, and two color difference
values Cr and Cb that are formed by Subtracting luma from RGB red and blue components.

\[
Y = 0.299R + 0.587G + 0.114B \\
Cr = R - Y \\
Cb = B - Y
\]

YCbCr is not an absolute color space; it is a way of encoding RGB information. The actual color
displayed depends on actual RGB colorants used to display signals. Therefore the value expressed as
YCbCr is only predictable if standard RGB colorants or an ICC profile are used. [13][14]
Fig: A color image and the Y, Cb and Cr elements of it. (Note that the Y image is essentially a grayscale copy of the main image.)

F. Skin Color Based Face Detection in RGB:
Crowley and Coutaz said one of the simplest algorithms for detecting skin pixels is to use skin color algorithm. The perceived human color varies as a function of the relative direction to the illumination. The pixels for skin region can be detected using a normalized color histogram, and can be further normalized for changes in intensity on dividing by luminance. And thus converted an [R, G, B] vector is converted into an [r, g] vector of normalized color which provides a fast means of skin detection. This gives the skin color region which localizes face. As in, the output is a face detected image which is from the skin region. [1]

G. Skin Color Based Face Detection in YCbCr:
We have implemented a skin color classification algorithm with color statistics gathered from YCbCr color space. Studies have found that pixels belonging to skin region exhibit similar Cb and Cr values. Furthermore, it has been shown that skin color model based on the Cb and Cr values can provide good coverage of different human races. The thresholds be chosen as [Cr1, Cr2] and [Cb1, Cb2], a pixel is classified to have skin tone if the values [Cr, Cb] fall within the thresholds. The skin color distribution gives the face portion in the color image. This algorithm is also having the constraint that the image should be having only face as the skin region. [2]

IV. Objectives and Scope

A. EYE DETECTION AND TRACKING:
Fatigue monitoring starts with extracting visual parameters that typically characterize a person’s level of vigilance. This is accomplished via a computer vision system. The computer vision system we developed to achieve this goal. The system consists of a camera focusing on the face and eyelid movement. The system starts with eye detection and tracking. The goal of eye detection and tracking is for subsequent eyelid - movement monitoring and analysis. A robust, accurate eye tracker is therefore crucial. We proposed robust methods for eye tracking under
variable lighting conditions based on combining the appearance-based methods and the active infrared (IR) illumination approach. Combining the respective strengths of different complementary techniques and overcoming their shortcomings, the proposed method uses active IR illumination to brighten subject’s faces to produce the bright pupil effect. The bright pupil effect and appearance of eyes (statistic distribution based on eye patterns) are utilized simultaneously for eyes detection and tracking. The latest technologies in pattern-classification recognition and in object tracking are employed for eye detection and tracking based on eye appearance.

To eliminate the background and reduce external light illumination, the odd image is subtracted from the even image, producing the difference image, as shown in Fig. With most of the background and external illumination effects removed.

The difference image is subsequently threshold. A connected component analysis is then applied to the threshold difference image to identify binary blobs that satisfy certain size and shape constraints, as shown in Fig. , we can see that there still are several nonpupil blobs left, because they are so similar in shape and size that we cannot distinguish them from the real pupil blobs, so we have to use other features.

From the dark pupil image, as shown in Fig., we observed that each pupil is surrounded by the eye region, which has a unique intensity distribution and appears different from other parts of the face. The appearance of an eye can therefore be utilized to separate it from noneyes. [15][16]

**Fig.** (a) Threshold difference image marked with possible pupil candidates, (b) image marked with possible eye candidates according to the positions of pupil candidates, and (c) image marked with identified eyes.

**Fig.** Bright and dark pupil images with glints
V. Proposed System Implementation:

Proposed Data Flow Diagram:

1. Input Image
2. Face Detection
3. Label the Face
4. Find Parameters of Labelled Image
5. Find Maximum Boundary Box
6. Make a mask
7. Obtained the filtered Image
8. Slice eye area
9. Apply eye detection algorithm
10. Is Eye Detected?
   - YES
   - NO
      - Detected Eye Coordinates
   - Increment the Counter
   - Alter and Reset Counter
     - YES
8. Is Counter > Threshold
    - YES
   - Go to 1
   - NO
     - Detected Eye Coordinates

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A. Requirements and Input Output Specification

- **Background and Ambient Light:**
  Because the eye tracking system is based on intensity changes on the face, it is crucial that the background does not contain any object with strong intensity changes. Highly reflective object behind the person’s, can be included a black background and low ambient light.

- **Camera**
  The system consists of a CCD camera that takes images of the person’s face. This type of Fatigue detection system is based on the use of image processing technology that will be able to

![](image.png)

**Figure: Photograph of Drowsy Person’s Detection System prototype**

picked up by the camera, and be consequently mistaken as the eyes. Since this design is a prototype, a controlled lighting area was set up for testing. Low surrounding light (ambient light) is also important, since the only significant light illuminating the face should come from the system. If there is a lot of ambient light, the effect of the light source diminishes. The testing area accommodates individual person’s differences. The camera is placed in front of the person’s, approximately 30 cm away from the face. The camera must be positioned such that the following criteria are met:
1. The person’s face takes up the majority of the image.
2. The person’s face is approximately in the centre of the image
Fig: Image taken by Camera

Fig: Image Converted to YCbCr

Fig: Detection of Skin
• MATLAB:

MATLAB, which stands for MATrix LABoratory, is a state-of-the-art mathematical software package, which is used extensively in both academia and industry. It is an interactive program for numerical computation and data visualization, which along with its programming capabilities provides a very useful tool for almost all areas of science and engineering. Unlike other mathematical packages, such as MAPLE or MATHEMATICA, MATLAB cannot perform symbolic manipulations without the use of additional Toolboxes. It remains however, one of the leading software packages for numerical computation.

Matlab is an interactive system for doing numerical computations. A numerical analyst called Cleve Moler wrote the 1st version of Matlab in the 1970s. It has since evolved into a successful commercial software package. Matlab relieves you of a lot of the mundane tasks associated with solving problems numerically. This allows you to spend more time thinking, and encourages you to experiment. Matlab makes use of highly respected algorithms and hence you can be condensing about your results. Powerful operations can be performed using just one or two commands. You can build up your own set of functions for a particular application. Excellent graphics facilities are available, and the pictures can be inserted into LATEX and Word documents. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

• Math and computation
• Algorithm development
• Data acquisition
• Modelling, simulation, and prototyping
• Data analysis, exploration, and visualization
• Scientific and engineering graphics
• Application development, including graphical user interface building

Specifically, MATLAB is a matrix programming system with many mathematical methods implemented. It also has many toolboxes such as statistics, image processing, signal processing, wavelet, and so on.

MATLAB is described by Mathworks [16], the software creator, as a “high-level computing language” with technical applications and “environment for algorithm development, data visualization, data analysis, and numeric computation”. By using MATLAB for these areas of programming the product as a whole, language and environment, can be used to great effect as extensive specialized libraries of usage definable functions are available to the user. These are implemental by simply naming and passing parameters to their function of choice. MATLAB can be used in a large spectrum of applications, including but not limited to signal and image processing, communications, control design, test and measurement, financial modelling and analysis, and computational biology.

The functions which allow users to control and build their algorithms with

Such ease is stored in “toolboxes”. These are collections of MATLAB functions which relate to a particular application of area. For example, the image processing toolbox is used in this project. The large range of toolboxes demonstrates the extent and range of situations to which the MATLAB
environment can be applied to solve particular problems in its application areas. MATLAB also provides a number of features for documenting and sharing work.

**Alarm Procedures:**

An auditory signal to alert the person’s was decided as the best medium to convey this message as the subject may have their eyes closed thus making any visual signals useless.

The alarm procedure should be active for the duration that the rules are broken. This would force the person’s to remedy the situation by opening their eyes or placing their hands back on the sensor. Also care must be taken so as not to startle the person’s as this could have a greater detrimental effect with the possibility of the person’s losing control of the car of forcing it off the road accidentally.

For the purpose of the project it was not necessary for an auditory alarm to be assembled. Instead a warning message appears to indicate the state of the system. These are generated from the conditions on which the system makes its decisions.

**VI. CONCLUSION**

Through research presented in this paper, we developed a nonintrusive prototype computer vision system for monitoring of a person’s vigilance. First, the necessary hardware and imaging algorithms are developed to simultaneously extract multiple visual cues that typically characterize a person’s level of fatigue. Then, a probabilistic framework is built to model fatigue, which systematically combines different visual cues and the relevant contextual information to produce a robust and consistent fatigue index. These visual cues characterize eyelid movement.

The main components of the system consist of a hardware system for the acquisition of images of the person and various computer vision algorithms and their software implementations for eye tracking, eyelid - movement-parameters computation, and eye -gaze estimation analysis. To effectively monitor fatigue, a BN model for fatigue is constructed to integrate these visual cues and relevant contextual information into one representative format. Experiment studies in a real-life environment with subjects of different ethnic backgrounds, genders, and ages were scientifically conducted to validate the fatigue-monitoring system. The validation consists of two parts.

The first involves the validation of the measurement accuracy of our computer vision techniques and the second studies the validity of the fatigue parameter that we compute in characterizing fatigue. Experiment results show that our fatigue monitor system is reasonably robust, reliable, and accurate in characterizing human fatigue.

**Title and Authors**

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