Color Facial Image Representation with New Quaternion Gradients

Artyom Grigoryan and Sos Agaian*, Department of Electrical and Computer Engineering, The University of Texas at San Antonio, USA, Computer Science Department, College of Staten Island and the Graduate Center, Staten Island, NY, USA

Abstract

This paper proposes a new color image representation and multiple feature fusion based method for improving color face recognition performance under different lighting conditions. First, a new image color image representation has been derived. Second, a quaternion gradient has been given to enhance and extract the faces/object’s edges, contours, and texture. Also, we propose a novel feature representation based on Quaternion Gradient-based LBP tool for color face recognition. Finally, we present a concept of combining the color facial recognition system, which is based on the local quaternion gradients based binary patterns LBP Image Representation, and a new color-to-gray new mapping. The presented concept can be used for surveillance, security systems, computer animation, face tagging, human–computer interface, biometric identification, behavioral analysis, content-based image and video indexing applications.

Introduction

Identification in recent years [42], several LBP’s variations) changes; c) it is sensitive to blurred/noisy images; and d) it is computationally not us. The algorithm of facial image processing can be described by the following composition of the 8 grayscale new gray new new gradients (used to extract the faces/objects’ edges, contours, and texture). In this paper, we propose a novel image representation scheme, or description, which is based on the local binary patterns (LBP) representation, or description, which is based on the local binary patterns (LBP) theory. We describe this representation in terms of simple gradient operators with following composition of the 8

\[ f_{n,m} \rightarrow V(f)_{n,m} \quad n = 0:(N - 1), m = 0:(M - 1) \]

\[ V(f)_{n,m} \rightarrow V(f)_{n,m} \otimes h_{n,m} \]

\[ E(f) \]

Figure 1. The block-diagram of the facial image representation.
The kernel of the Gaussian function is of size $3 \times 3$. Stage 3. A complex gradient image composition is calculated. In the $3 \times 3$ square window $W$, we consider the following simple set of eight gradient operators:

$$A_1 = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad A_2 = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad A_3 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$A_4 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & -1 \\ 0 & 0 & 0 \end{bmatrix}, \quad A_5 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}, \quad A_6 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

$$A_7 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ -1 & 1 & 0 \end{bmatrix}, \quad A_8 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ -1 & 0 & 0 \end{bmatrix}$$

The center of the masks is in the origin $(0,0)$ and it is underlined. The order of these gradient operators is shown in Fig. 2.

Figure 2. The coordinates and the order of 8 neighbor sampling points.

$$SP = \{(-1,-1),(0,-1),(1,-1),(0,1),(-1,1),(1,0)\}$$

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$$B_k(f)_{n,m} = u[A_k(f)_{n,m}], \quad k = 1:8.$$  \hspace{1cm} (2)

$$b_{n,m} = B_1(f)_{n,m} + 2^1B_2(f)_{n,m} + 2^2B_3(f)_{n,m} + \cdots + 2^8B_8(f)_{n,m}.$$ \hspace{1cm} (3)

$$b_{n,m} = \sum_{k=1}^{n} 2^{k-1}[f_{n,m} - f_{n+s(k),m+p(k)}].$$ \hspace{1cm} (4)

$$(s(k),p(k))$$ is the position of the $(k)$th sampling point in $SP$. The LBP image can be written in the standard form

(g_{1})_{n,m} = T[(g_{1})_{n,m}],
(g_{k})_{n,m} = T[(g_{k-1})_{n,m} + B_{k}(f)_{n,m}],
\quad k = 2:8. \quad (5')

\begin{align*}
E(g)_{n,m} &= \ln \frac{\max_{w_{k}}(g_{n,m})}{\min_{w_{k}}(g_{n,m})}, \\
E(c)_{n,m} &= \ln \frac{c_{n,m} - \text{mean}_{w}(c_{n,m})}{c_{n,m} + c_{0}}. \quad (10)
\end{align*}

Figure 5. (a) The color “flowers” image, (b) the MEVCI, and (c) grayscale image of the MEVCI.

\begin{align*}
E(c)_{n,m} &= k \frac{\max_{w}(c_{n,m}) - \min_{w}(c_{n,m})}{\max_{w}(c_{n,m}) + \min_{w}(c_{n,m})}. \quad (11)
\end{align*}

Figure 6. (a) The color “pepper” image, (b) the MVCI, and (c) grayscale image of the MVCI.

\begin{align*}
E(g)_{n,m} &= \ln \frac{\max_{w}(f_{n,m})}{\min_{w}(f_{n,m})}(f_{n,m})^\beta, \\
E(c)_{n,m} &= \ln \frac{\max_{w}(c_{n,m})}{\min_{w}(c_{n,m})}(c_{n,m})^\beta. \quad (9)
\end{align*}

Quaternion Image Gradients

\begin{align*}
f_{n,m} &\rightarrow E(f)_{n,m} = E(g_{n,m})E(c_{n,m}). \quad (8)
\end{align*}

\begin{align*}
q_{n,m} &= a_{n,m} + (r_{n,m} + kg_{n,m} + kb_{n,m}). \quad (12)
\end{align*}

\begin{align*}
a_{n,m} &= (r_{n,m} + g_{n,m} + b_{n,m}).
\end{align*}

Color Visibility Images

\begin{align*}
E(g)_{n,m} &= \frac{1}{k_{1}k_{2}} \sum_{k=1}^{k_{1}} \sum_{l=1}^{k_{2}} 20 \ln \frac{\max_{w_{k}}(g_{n,m})}{\min_{w_{k}}(g_{n,m})}. \quad (6)
\end{align*}

\begin{align*}
\text{Figure 5. (a) The image (g_{1})_{n,m} before the mapping, (b) the uniform LBP image, and (c) the histogram of the image.}
\end{align*}

\begin{align*}
\text{Color Visibility Images}
\end{align*}

\begin{align*}
\text{Figure 5. (a) The color "flowers" image, (b) the MEVCI, and (c) grayscale image of the MEVCI.}
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\end{align*}
The magnitude of the real and imaginary parts of the edge shows the imaginary part of the quaternion Sobel gradient, and all edges can be found by representing as a full, when processing the color image is shown in part (a). The histogram of the color facial image, to obtain a set of features that can be used in face classification, when the color image is transformed into the quaternion space. The color image can be presented as a pure quaternion image, and then can be processed by the quaternion gradient operators defined with different components. The quaternion gradient operators defined with such components are size of the mask.

Thus, let the convolution mask is windowed Sobel compass quaternion gradients with masks are called the 5 × 3 D Gaussian function with the standard deviation of 0.5 in part (c).

As an example, Fig. 7 shows the色 facial image of size 66 × 66 after each gradient image calculation to obtain the uniform LBP table by applying the eight gradient operators that are given in Eq. 13.

The histogram of the facial image processing can be described by the following steps.

\[
H_{n,m} = (1 + (i + j + k)) H_n(m')
\]

\[
Y_{n,m} = \sum_{n_1}^{L_1} \sum_{n_2}^{L_2} q_{n-n_1,m-n_2} H_{n_1,m_1}
\]

\[
G_x = \frac{1}{4}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \quad G_y = \frac{1}{4}\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}
\]

\[
H_{X} = (1 + (i + j + k)) G_{x} \quad H_{Y} = (1 + (i + j + k)) G_{y}
\]

\[
|H(q)| = |H_{x}(q)| + |H_{y}(q)|
\]

\[
H_{i} \neq H_{j} \neq H_{k} \neq H_{l}
\]

Figure 7. (a) The imaginary part and (b) the real part of the quaternion H_{x} - Sobel gradient image.

Figure 8. (a) The imaginary part and (b) the real part of the quaternion H_{y} - Sobel gradient image. (c) The magnitude of the quaternion Sobel gradient image.

Figure 9. The block-diagram of color facial image processing.

Figure 10. (a) The original image and the quaternion gradient image (b) before and (c) after filtering by the 2-D Gaussian function.
A novel face recognition approach is proposed, by using multiple feature fusion across color, spatial and frequency domains. The proposed approach is useful and applicable not only for face recognition, but also for object recognition. We are planning to evaluate the presented face recognition concept, by using the color FERET database: http://www.face-rec.org/databases/.

References


