TOWARDS OBJECTIFYING INFORMATION HIDING

Abbas Cheddad, Joan Condell, Kevin Curran, Paul Mc Kevitt

Intelligent Systems Research Centre, University of Ulster, Derry, Northern Ireland

I. Introduction

- Detecting human skin tone is of utmost importance in numerous applications such as, video surveillance, face and gesture recognition, human computer interaction, human pose modelling, image and video indexing and retrieval and steganography.
- Modelling skin colour implies the identification of a suitable colour space and the careful setting of rules for cropping clusters associated with skin colour.
- Unfortunately, most approaches to date tend to put the illumination channel in the "non useful" zone and therefore act instead on colour transformation spaces that de-correlate luminance and chrominance components from an *RGB* image.

II. Solution: Skin Tone Detection

Illumination is evenly smeared along *RGB* colours in any given colour image. Hence, its effect is scarcely distinguished here. There are different approaches to segregate such illumination. The utilized transformation matrix is defined in Eq.1.

$$\vec{\alpha} = [0.298936021293775390,\ 0.587043074451121360,\ 0.140209042551032500]^T \quad (1)$$

where the superscript *T* denotes the transpose operator to allow for matrix multiplication. Let denote the 3D matrix containing the *RGB* vectors of the host image and let . Note that this method acts here on the *RGB* colours stored in double precision, i.e., linearly scaled to the interval [0 1].

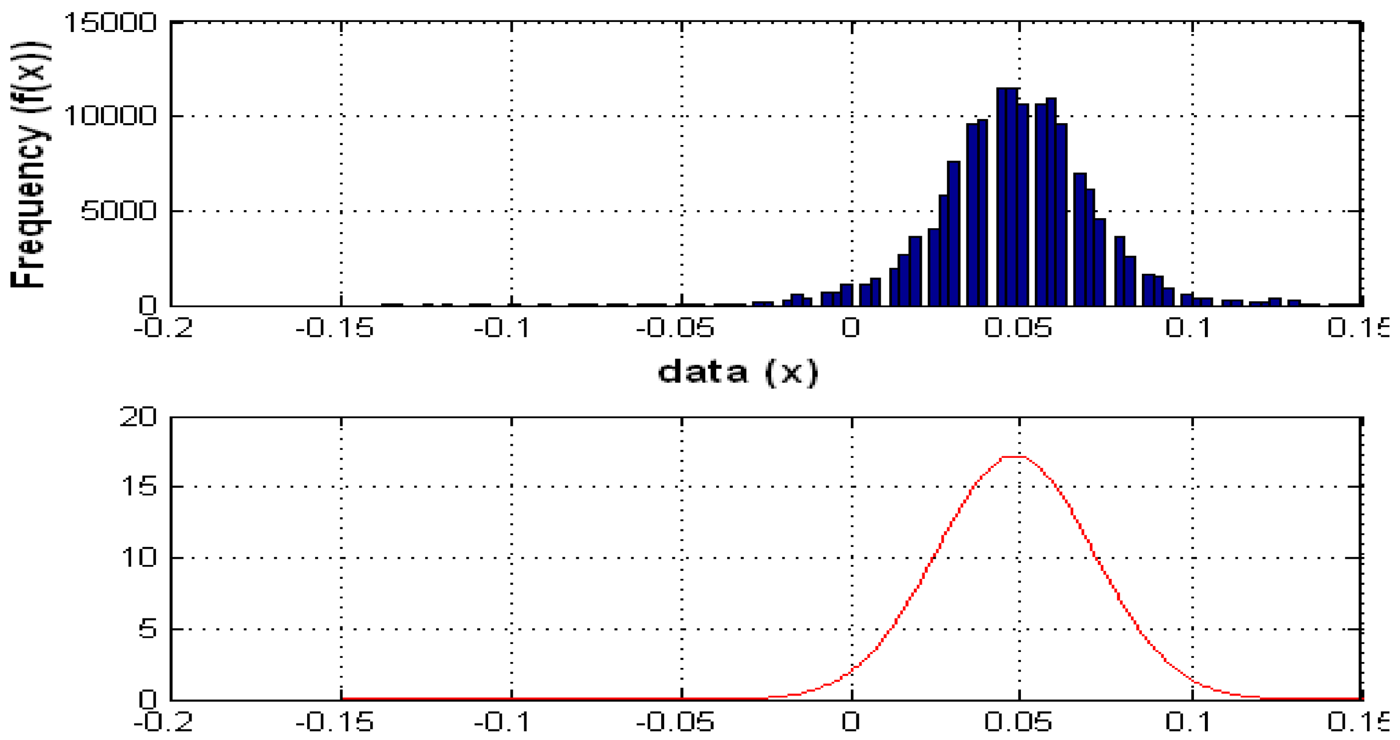

Figure 1: Frequency distribution of the data (top) and its Gaussian curve fit (bottom).

Creating a *skin probability map* (SPM) that uses an explicit threshold based skin cluster classifier which defines the lower and upper boundaries of the skin cluster is crucial to the success of the proposed technique.

A collection of 147852 pixel samples was gathered from different skin regions exhibiting a range of races with extreme variation of lighting effect.

After transformation using the proposed method, the projection of data admits a distribution that could be easily fit into a Gaussian curve using Expectation Maximization (EM) method which is an approximation of Gaussian Mixture Models (GMM) as shown in Figure 1. It is also clear that there are no other Gaussians hidden in the distribution.

The hypothesis that this work wants to support is that luminance inclusion does increase separability of skin and non-skin clusters. In order to provide evidence for this hypothesis, the proposed algorithm was tested on different *RGB* images with different background and foreground complexities. Some images were selected exposing uneven transition in illumination to demonstrate the robustness of the algorithm.

III. Results

The proposed algorithm outperforms both YC_bC_r and *NRGB* which have attracted many researchers to date. Figure 2 exemplifies how inherent properties of luminance can aid performance if handled intelligently. Notice how the proposed colour space is not affected by the colour distribution which enabled the system to detect skin tone with better efficiency.

Figure 2: Skin detection in an arbitrary image: (left to right) original input image (image 8 in Table 1), skin tone detected by (Hsu et al., 2002), by (Berens et al., 2000) and by our method (far right)

IV. Application to Steganography

Skin regions are extracted based on colour tone; therefore, are undisturbed by translation (Cheddad et al., 2008). To cope with rotation, it is sufficient to locate face features, i.e., eyes, based on the method described in (Zhao et al., 2008).

Let the distance between the two centres of the eyes be *D*, then the geometrical face model and its relative distances can be described as follows:

- Centre of the ellipse (x_0, y_0): is the centre of distance between the two eyes
- Minor axis length (*a*) : is the distance between the two eyes where both eye centres lie on each side of the ellipse
- Major axis length (*b*): is 2*D* where *D* denotes the distance between two eyes
- Angle (): the ellipse must have the same orientation as the detected face. A face orientation can be easily determined based on the angle made by the baseline (a line connecting both eyes) and the horizontal *x* axis

Salient features form reference points that dictate the orientation of embedding and thus aid recovery from rotational distortions (see Figure 3).

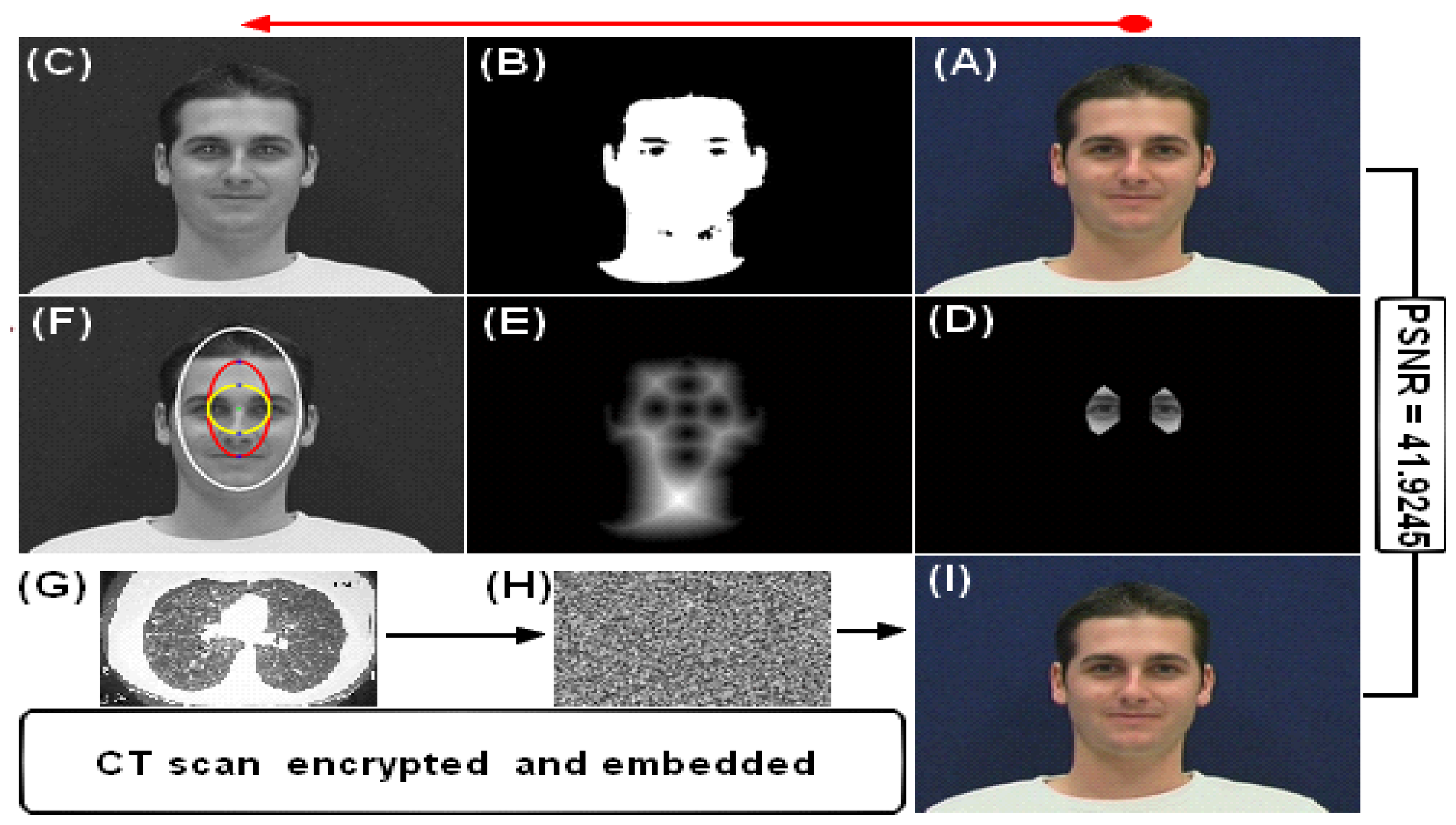

Figure 3: Our skin based steganography system concealing medical data in a face image: original image (A), skin blob of the segmented skin area (B), eyes' centroid detection (C), eye regions (D), distance transformation based on face features (E), construction of ellipses [41] (F), CT scan image (G), CT scan encrypted (H) and stego-image carrying the embedded CT image (I). Shown on the right is the PSNR (Peak Signal to Noise Ratio)- measurement for image distortion.

- The introduced colour space reduces the *RGB* composite from 3D space to purely 1D space reducing the number of image colours which is salient for segmentation and lossy compression of colour visual information. It would also play a vital role in content based video coding and content-based image retrieval (CBIR).

V. References

- Berens, J. and Finlayson, G. (2000) Log-opponent chromaticity coding of colour space, in: Proceedings of IEEE International Conference on Pattern Recognition, Barcelona, 2000, vol.1, pp. 206-211.
- Cheddad, A., Condell, J., Curran, K. and Mc Kevitt, P. (2008) Skin tone based steganography in video files exploiting the YC_bC_r colour space, in: Proceedings of IEEE International Conference on Multimedia and Expo, June 23-26 2008, Hannover, Germany, pp.905-909.
- Hsu, R., Abdel-Mottaleb, M. and Jain, A. (2002) Face detection in color images, IEEE Trans. Pattern Analysis and Machine Intelligence, 24(5)(2002) 696-702.
- Zhao, Y., Dai, S. and Xi, X. (2008) A Mumford-Shah level-set approach for skin segmentation using a new color space system, in: Proceedings of International Conference on Simulation and Scientific Computing, China, 10-12 October 2008, pp. 307-310.