ADVANCES IN INTELLIGENT AND SOFT COMPUTING 166

David C. Wyld
Jan Zizka
Dhinaharan Nagamalai (Eds.)

Advances in Computer Science, Engineering and Applications

Proceedings of the Second International Conference on Computer Science, Engineering and Applications (ICCSEA 2012), May 25–27, 2012, New Delhi, India, Volume 1

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and Dhinaharan Nagamalai (Eds.)

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Preface

The Second International Conference on Computer Science, Engineering and Applications (ICCSEA-2012) was held in Delhi, India, during May 25–27, 2012. ICCSEA-2012 attracted many local and international delegates, presenting a balanced mixture of intellect from the East and from the West. The goal of this conference series is to bring together researchers and practitioners from academia and industry to focus on understanding computer science and information technology and to establish new collaborations in these areas. Authors are invited to contribute to the conference by submitting articles that illustrate research results, projects, survey work and industrial experiences describing significant advances in all areas of computer science and information technology.

The ICCSEA-2012 Committees rigorously invited submissions for many months from researchers, scientists, engineers, students and practitioners related to the relevant themes and tracks of the conference. This effort guaranteed submissions from an unparalleled number of internationally recognized top-level researchers. All the submissions underwent a strenuous peer-review process which comprised expert reviewers. These reviewers were selected from a talented pool of Technical Committee members and external reviewers on the basis of their expertise. The papers were then reviewed based on their contributions, technical content, originality and clarity. The entire process, which includes the submission, review and acceptance processes, was done electronically. All these efforts undertaken by the Organizing and Technical Committees led to an exciting, rich and a high quality technical conference program, which featured high-impact presentations for all attendees to enjoy, appreciate and expand their expertise in the latest developments in computer Science and Engineering research.

In closing, ICCSEA-2012 brought together researchers, scientists, engineers, students and practitioners to exchange and share their experiences, new ideas and research results in all aspects of the main workshop themes and tracks, and to discuss the practical challenges encountered and the solutions adopted. We would like to thank the General and Program Chairs, organization staff, the members of the Technical Program Committees and external reviewers for their excellent and tireless work. We sincerely wish that all attendees benefited scientifically from the conference and wish them every success in their research.

It is the humble wish of the conference organizers that the professional dialogue among the researchers, scientists, engineers, students and educators continues beyond the event and that the friendships and collaborations forged will linger and prosper for many years to come. We hope that you will benefit from the fine papers from the ICCSEA-2012 conference that are in this volume and will join us at the next ICCSEA conference.

David C. Wyld
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Automatic FAPs Determination and Expressions Synthesis

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Abstract. This paper presents a novel method that automatically generates facial animation parameters (FAPs) as per MPEG 4 standard using a frontal face image. The proposed method extracts facial features like eye, eyebrow, mouth, nose etc. and these 2D features are used to evaluate facial parameters, namely called facial definition parameters using generic 3D face model. We determine FAPs by finding the difference between displacement of FDPs in specific expression face model and neutral face model. These FAPs are used to generate six basic expressions for any person with neutral face image. Novelty of our algorithm is that when expressions are mapped to another person it also captures expression detail such as wrinkle and creases. These FAPs can be used for expression recognition. We have tested and evaluated our proposed algorithm using standard database, namely, BU-3DFE.

Keywords: a generic 3D model, expression, texture, FAPs, FDPs, MPEG-4.

1 Introduction

The MPEG-4 visual standard specifies a set of facial definition parameters (FDPs) and FAPs for facial animation [1, 2]. The FDP defines the three dimensional location of 84 points on a neutral face known as feature points (FPs). The FAPs specify FPs displacements which model actual facial features movements in order to generate various expressions. The FAPs are a set of parameters defined in the MPEG-4 visual standard for the animation of synthetic face models. The FAP set includes 68 FAPs, 66 of which are low level parameters related to the movements of lips, jaw, eyes, mouth, cheek, nose etc. and the rest two are high-level parameters, related to visemes and expressions. All FAPs involving translation movement are expressed in terms of facial animation parameters unit (FAPU). FAP determination methods [3] are classified in two categories (1) Feature based and (2) optical flow based.

In feature based approach [3] areas containing the eyes, nose and mouth are identified and tracked from frame to frame. Approaches that are based on optical flow information [3, 5] utilize the entire image information for the parameter estimation leading to large number of point correspondences.

In order to precisely extract facial features, various approaches aimed at different sets of facial features have been proposed in a diversity of modalities.

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The mainstream approaches can be categorized into brightness-based and edge-based algorithms. Brightness-base algorithms exploit the brightness characteristics of the images to extract facial features. A typical approach of this class of algorithms is to employ the knowledge of the geometrical topology and the brightness characteristics of facial features, such as the eyebrows, eyes and mouth [6]. Edge-based algorithms target contours of the features, such as those of the mouth, eyes and chin, usually based on the gradient images. Hough transform, active contour model, i.e. snakes, and deformable templates are the edge based approaches used to detect facial features [7].

In this paper we have proposed a feature based approach for FAPs determination. We detect features like eye, eyebrow, nose and mouth from neutral face or expression specific frontal face using edge and brightness information. These features are used to adapt generic 3D face model into face specific 3D model. The displacement of FDPs in neutral 3D face model is determined as per MPEG 4 standard. Same way displacement of FDPs in different expressions specific 3D face model is determined. FAPs are determined by finding the difference between the displacement of FDPs in neutral 3D face model and specific expression 3D face model. Using these FAPS we have generated six basic expressions like anger, surprised, fear, sad, disgust and happy for any person whose neutral frontal face is available. The paper is organized as follows: Section 2 describes feature extraction. It is followed by FDP/FAP estimation and expressions generation in section 3 and 4 respectively. Section 5 describes expression mapping. The simulation results and conclusions are discussed in section 6 and 7 respectively.

2 Feature Extraction

Facial feature extraction comprises two phases: face detection and facial feature extraction. Face is detected by segmenting skin and non skin pixels. It is reported that YC_bC_r color model is more suitable for face detection than any other color model [8]. It is also reported that the chrominance component C_b and C_r of the skin tone always have values between $77<=C_b<=127$ and $133<= C_r <=173$ respectively [9]. After detection of face the features like eyes, mouth and eyebrows are detected.

2.1 Eye and Eyebrow Detection

After detection of face, the features like eyes, mouth and eyebrows are detected. We first build two separate eye maps, one from the chrominance components and the other from the luminance component [10].We have used upper half of the face region for preparation of eye maps to detect eyes. The eye map from the chroma is based on the observation that high C_b and low C_r values are found around the yes. It is constructed by

$$Ec = \frac{1}{3}\left((C_b^2) + (\bar{C}_r)^2 + \frac{C_b}{C_r} \right) \tag{1}$$

Where C_b^2, $(\bar{C}_r)^2$ and C_b / C_r all are normalized to the range [0 255] and $(\bar{C}_r)$ is the negative of C_r (i.e. $255-C_r$).

The eyes usually contain both dark and bright pixels in the luma component so grayscale morphological operators dilation (⊕) and erosion (Θ) is used to emphasis brighter and darker pixels in the luma component around eye regions. It is constructed using equation (2).

$$E_l = \frac{Y(x,y) \oplus G(x,y)}{Y(x,y) \Theta G(x,y)} \tag{2}$$

Where Y(x, y) is luma component of face region and g(x, y) is structuring element.

The eye map from the chroma is combined with the eye map from the luma by an AND (multiplication) operation. The resulting eye map is dilated with same structuring element to brighten eyes and suppress other facial areas. The locations of the eyes are estimated from the eye map. We have determined mean and standard deviation of eye map which is used to find location of eyes. After the large number of experiments we have set the value of threshold (T) =mean +0.3*variance. Eye feature points, the left and right corners and the upper and lower middle points of the eyelids are extracted from the edge map of the eye using sobel gradient operator. After two eye corners and two middle points on the eyelids have been located two parabolas are applied on the detected eyes. The location and feature points of the eyebrows are found from the edge map of the region of the face above the eye.

2.2 Lip Detection

Lip region is extracted using the observation that the lip pixels have stronger red component but green and blue components are almost same [11]. Skin pixels also have stronger red component but green component has higher value compared to blue component. Difference between red and green component is greater for lip pixels than skin pixels. Hulbert and poggio [12] proposed a pseudo hue definition that calculates pseudo hue as:

$$H(x,y) = \frac{R(x,y)}{R(x,y)+G(x,y)} \tag{3}$$

Where R(x, y) and G(x, y) are the red and green components of the pixel (x, y) respectively. However a person with reddish skin, pseudo hue may not give correct result. So we have combined pseudo hue H(x, y) with H1(x, y).

$$H1(x,y) = Log\left(\frac{G(x,y)}{B(x,y)}\right) \tag{4}$$

Where G(x, y) and B(x, y) are the green and blue components of the pixel (x, y) respectively. Lip pixels have lower value of Green and Blue color components so log function is used to enhance contrast. Lip pixels have higher value of H (x, y) and lower values of H1(x, y). The location of the mouth is detected by finding the region having higher value of H(x, y) and lower value of H1(x,y). We have found that pseudo hue (H) value varies from 0.55 to 0.65 and value of H1 is to be less than 0.73 for lip pixels. It is found that lip corners are in shadow and they have lower value of intensity. Lip corner points are found using intensity component of lip region having lower value.

The pseudo hue component H(x, y) of the lip region is shown in Figure 1. It is observed that the hue value (H) for the middle part of the lip pixels are higher when mouth is closed .But when moth is open the hue value is lower for teeth part but higher for cavity. This observation is used to check whether mouth is closed or open.

We have applied canny edge detector on intensity component of lip region and determined edge points corresponding to upper outer and lower outer lip contour for middle column. When mouth is closed, inner upper and inner lower boundary edge points are same. They are the points with maximum pseudo hue value for middle column as shown in Figure 1.

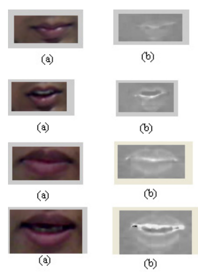

Fig. 1. (a) Lip region (b) Pseudo hue (H)

We have found P2, P3 and P4 points on the upper boundary of lip as shown in Figure 2. To find P2 we have traversed left edge of upper lip boundary from P4 till position is decreasing. P2 is an edge point with lowest position. Similarly we have traversed right edge of upper lip boundary to find point P3. When mouth is open feature points on inner upper lip boundary (P8) and inner lower lip boundary (P9) are determined. Teeth and tongue cause problems in determination of P8 and P9 from edge map.

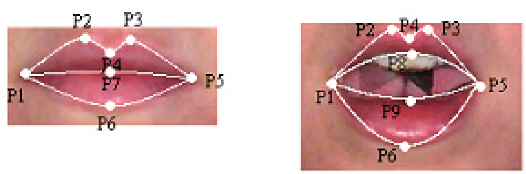

Fig. 2. Lip model

So after determination of P4 we have searched for first point in down direction up to P1 which has maximum gradient of pseudo hue (H) for middle column, which is P8. Same way after determination of P6 we have searched for first point in up direction up to P1 which has maximum gradient of pseudo hue (H) for middle column which is P9. After detecting feature points the upper lip boundary is modeled using cubic curve (cardinal spline) [13]. Experimentally it is found that upper inner boundary, lower inner boundary and lower outer boundary of lip can be modeled more accurately using parabola than cubic curve which is shown in Figure 2. The location and feature point of nose is found using vertical component of gradient of the face image between eye and mouth.

3 FDP and FAP Generation

This is a process in which the generic 3D face model is deformed to fit a specific face [14]. Our proposed generic model [13] is shown in Figure 3 and Figure 4 which is polygon-based (triangle mesh) and consists of 350 triangles and 215 vertices. Model is adapted to given frontal face with the help of two geometrical transformations scaling and translation. Assuming orthographic projection, the translation vector can be derived by calculating the distance between the 3D face model centres to the 2D face centre. Let C_l indicate centre of left eye, C_r indicate centre of right eye, C_c indicate middle point between two eyes and C_m indicate centre of mouth in given face. Similarly C_l’, C_r’, C_c’ and C_m’ are corresponding points in the 2D projection of the 3D face model. Model is scaled by an amount S_x, S_y and S_z using equation (5)

$$S_x = \frac{|C_l - C_r|}{|C_l^{'} - C_r^{'}|} \qquad S_y = \left|\frac{C_c - C_m}{C_c^{'} - C_m^{'}}\right| \qquad S_z = \frac{S_x + S_y}{2} \tag{5}$$

After global adaptation of model we perform local refinement of model eyes, eyebrows, mouth and contour with that of face features. Appropriate translation factor does local refinement of the model. Constructed 3D models are shown in Figure 5.

Fig. 3. Generic face model

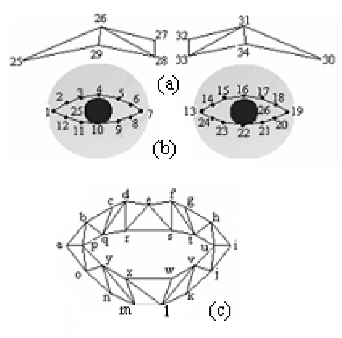

Fig. 4. Models of (a) Eyebrow (b) Eyes (c) Mouth

After we have modified generic face model, we can extract 3D coordinates of the FDP feature points from the model. We have determined position of FDPs corresponding to eye, eyebrow, and lip for neutral face image. We have also determined position of FDPs corresponding to eye, eyebrow, and lip for different facial expression models. We have determined FAP by finding difference between displacement of FDPs in specific expression face model and neutral face model. Measured FAPs for different expressions are shown in Table 1. They are measured by

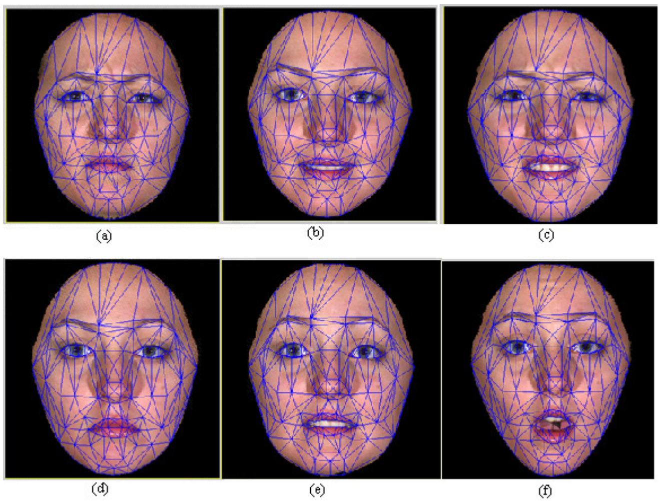

Fig. 5. constructed 3D models (a) angry (b) happy (c) disgust (d) sad (e) far (f) surprise

Table 1. Automatic determination of FAPs for different expressions

FAP	Happy	Sad	Disgust	Surprise	Anger	Fear
raise_l_i_eyebrow	1	-1	-5	29	-13	20
raise_l_o_eyebrow	0	-2	-17	8	-28	4
raise_l_m_eyebrow	0	-1	-14	18	-29	7
close_t_l_eyelid	1	3	8	-1	8	-3
lower_t_midlip_o	8	0	24	17	8	4
lower_t_midlip	10	-1	25	17	7	7
raise_b_midlip	-1	-1	7	-19	7	9
raise_b-midlip_o	-1	-1	13	-19	10	9
raise_l_cornerlip	17	-3	17	4	6	0
stretch_l_cornerlip	14	2	9	-13	2	1
squeeze_l_eyebrow	1	2	-4	0	-2	6

facial animation parameter units (FAPUs) that permit us to place FAPs on any facial model in a consistent way [15]. The FAPUs are defined with respect to the distances between key facial features in their neutral state such as eyes (ES0), eyelids (IRDS0), eye-nose (ENS0), mouth-nose (MNS0) and lip corners (MW0) as shown in Figure 6.

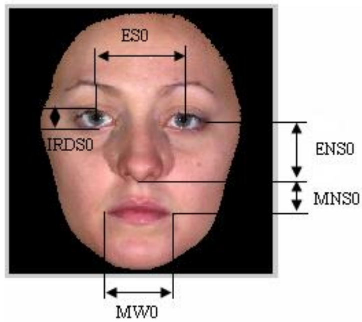

Fig. 6. Neutral face and FAPUs

4 Expressions Generation

Expressions are represented with the help of FAPs, a set of parameters defined in the MPEG-4 visual standard for the animation of synthetic face models. We have generated six basic expressions with the help of low level FAPS as discussed in [16]. The FAPS are computed through tracking a set of facial features and they are measured by facial animation parameter units (FAPUs) that permit us to place FAPs on any facial model in a consistent way [15]. The FAPUs are defined with respect to the distances between key facial features in their neutral state such as eyes (ES0), eyelids (IRDS0), eye-nose (ENS0), mouth-nose (MNS0) and lip corners (MW0) as shown in Fig. 6 and values are shown in Table 2.

Table 2. FAPUs

FAPUS	Value
ES	ES0/1024=0.1737
ENS	ENS0/1024=0.0902
MNS	MNS0/1024=0.0838
MW	MW0/1024=0.1133
IRISD	IRISD0/1024=0.0293

Table 3 gives the relation between expressions and involved FAPs. Expressions are generated by moving and deforming various control vertices of face model according to FAPs. If V_m indicates the neutral coordinate of the m^{th} vertex in a certain dimension of the 3D space, its animated position V_m' in the same dimension can be expressed as

$$V_m' = V_m + w_n * FAPU_n * FAP_n \tag{6}$$

Where ω_n is the weight of the n^{th} FAP, $FAPU_n$ is the FAPU to n^{th} FAP and FAP_n is the amplitude of FAP. In fact, the term, ωn * FAPU*n* *FAPn defines the maximum displacement of m^{th} vertices. We have developed scan line algorithm [16] which establish correspondence between each triangle of neutral model and expression model for each scan line for each pixel to generate expression specific texture.

Table 3. Facial expressions and FAPs

Expressions	FAPs no
Happiness	Raise corner lip, stretch corner lip, mouth open 59,60,6,7,4,5,51,52
Sadness	Lower corner lip, lower inner eyebrow, close eyelid 59,60,31,32,19,20
Disgust	Close eyelid , mouth open , raise corner lip 19,20, 4,5,51,52,59,60
Surprise	Raise eyebrow , mouth open, open eyelid 31,32,33,34,35,36, 4,5,51,52,19,20
Anger	Open eyelid, lower eyebrow, squeeze eyebrow , mouth open 19,20 ,31,32,37,38, 4,5,51,52
Fear	eyebrow, mouth open 19,20 ,31,32,33,34,35,36,37,38, 4,5,51,52

5 Expression Mapping

Our proposed algorithm determines FAP from the given expressions database. It constructs 3D model from the frontal neutral face of any person and using these FAPs it also successfully map expressions of one person onto another person. To take care of the expression details such as wrinkle we have to also consider illumination changes along with geometry deformation. Let A and A' are the images of person A's neutral and expression face respectively. Let B denotes person B's neutral face. Our algorithm first determines FAPS from the A's expression image. Then the method discussed in section 4 is used to generate expression image of B denoted as B'. Now make it more realistic we also consider illumination changes in calculating intensity at every pixel.

According to phong illumination model intensity at a given point is given as

$$I_{a=}K_{d*I_p}(L_a \cdot N_a) \tag{7}$$

Where L is light source direction and N is a normal to surface and Kd is diffuse reflection coefficient and Ip is light source intensity. Intensity of deformed expression model is determined as

$$I_a^{'} = K_d * I_p(L_a^{'} \cdot N_a^{'}) \tag{8}$$

Where Ia and Ia' are intensity at every pixel of neutral face A and expression face A' respectively. With the help of expression synthesis algorithm we have already found out expression image of B denoted as B'.