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Research on Biometric Synthetic Faces

*Mihailescu Marius Iulian

* RESEARCH SCHOLAR CMJ UNIVERSITY,SHILLONG

ABSTRACT

The article discusses the behavioural information of facial expressions. One of the most important goals on which we will focus in this article is the analysis and the synthesis of facial expressions. The words "face synthesis" refers to a class of problems of which the task is to synthesizing a model of a static face. The words "facial synthesis" refers to the process of modelling the facial appearance. The second goal of the article is to establish a facial topology and demonstrate that facial topology represent a behavioural characteristic named facial expression, which represents the visible result of the emotions indicated by the face.

Keywords :synthetic face, biometrics, inverse problems, directproblems, face recognition

Introduction

When talking about analysis and synthesis of facial expressions, one must keep in mind that human face is primarily characterized by complexity, mobility and uniqueness (with certain exceptions). The topology of the face is called facial expression and the modelling of the facial appearance is called facial synthesis.

The direct and inverse problems of facial biometry are based on topological model, which leads to the conclusion that we can use transformations, representation, measures of manipulation, all from a topological point of view. Having this in mind, we can define face as the area between the line where hair starts and the chin, and between the two ears. This is basically the zone of facial expressions.

Some of the purposes and applications of facial modelling involve the system testing, rapid identification in large scaled databases, and recognition of fake (deceiving) figures, human-machine interfaces, the training of the security personnel and for other applications in medical and psychological field.

Direct and inverse problems of facial topology

Just like any other biometric feature, facial processing involves direct problems – topological structure of the face is analysed –, and inverse problems – faces are synthesized. Similarly to signature analysis by synthesis paradigm, synthetic faces are post-processed to obtain an image that resembles reality.

Psychologists are the ones that give classifications of facial expressions, such as fear, happiness, surprise, sadness etc., or, according to other sets of criteria, expressions can be divided according to their pleasantness (or unpleasantness), their activity or passivity, or their capacity for control. The relation between facial topology and an emotional expression is defined by an extension. To exemplify, the extension of a smile usually involves a series of facial topologies involving the movement of the mouth, eyes and eyebrows.

Modelling of facial expressions

When characterizing facial expressions, we must keep in mind that they contain long lasting features (also called static) – that change very slowly, due to the factors like age or state of health, and short-term features (dynamic) – which depend on emotional state of the person and possess a behavioural character, like changes in a person's state of mind, which translate into topological variation of the face. Also, in most of the cases, face cannot be covered in order to be hidden (as it can happen, for instance, in case of fingerprints). Another important characteristic of the face is that it carries receivers of information (eyes for the vision, nose for the smell or ears for the hearing), as well as transmitters of information (mouth for the speaking). Along with that, the static and dynamic features of the face generate information, known as non-verbal communication, which complete the speech.

During the performing of complex processes like analyse and synthesis of facial expressions, we must bear in mind that they represent topological configurations, with the capability of being measures and they contain distortion effects. Such observations are particularly important in case of human-machine interface design. Elements of face to face communication are present here, like the transmitter (the face generates topological configurations), the receiver (the eye receives and analyses the topological configurations mentioned earlier) and the channel, which may consist of certain distortion. Light, for instance, can modify the perception of a facial expression and transform it into another. Moreover, there can be other information as well, to support the communication act, for instance body movement or even the speech.

Components of a face model

Face model can be considered as a whole, but also as a sum of sub-parts of the model, which include models of the eye, the mouth, the nose, the eyebrow and the ear. When building a face model, first we generate a common, neutral face, to which we add specific attributes. Depending on the sub-model, the attributes can be: shape, size, texture, dynamic, quality of being open or closed etc.

As facial expressions represent the dynamic of muscles and skin, facial modelling involves the modelling of muscle activity and of the deformation of skin, combined together. During the process, we must take into account the attributes enounced earlier, for example the aging factor, which changes the features of the skin, mainly its elasticity. But the most important role in recognition and generation is played by the skin.

Facial behaviour models

As in the case of signatures, facial models can be divided in two main categories: static (focused on topology) and dynamic (models which intend to represent the behavioural charac-

teristics as well). In the second case, parameters of the model depend on the nature of the changes: long-term (features that change slowly during the course of a lifetime), or short-term (changes that occur instantaneously, as a result of an emotion). Short-term changes are revealed mostly during speeches and they can express many things, from the affective state, cognitive activity, temperament and personality features, and sincerity to psychopathology (Yuan, 2007).

Facial topology transformation and manipulation
When analysing emotional state of a person, the most accurate result is obtained when combining all indicators during the testing procedure: face, voice, hand movements, speech and relation between facial expressions and body posture. But when analysing facial expression is very important to keep in mind the fact that they can be untruthful. Nevertheless, it is possible to read facial expressions as they can give information voluntarily or involuntarily (Faundez-Zanuy, 2004).

Given the fact that facial appearance can be considered as a topological structure, a primary technique for facial expression synthesis involves topological transformations. Among the dimensions of the face which can be measured is the area, the perimeter, the roundness, the curves, the holes, the symmetry and, of course, the various distances between two essential points of a face. There are a series of labelled feature points which help identification.

Various techniques for synthesizing facial expressions
Face analysis and synthesis require a series of measurements to be performed. Among them there is the position and orientation in space of the head, the movements of the eye and direction of the gaze, the movements of the mouth and lips and the actions of the facial muscles (Nazar, 2008).

Morphing is another technique for synthesizing facial expressions, age, gender, race or other static or dynamic features. In addition to that, facial analysis and synthesis uses two kinds of facial transformations: local and global. First involves the changing of a local zone, if given the topological division into parts (ex. eye zone, mouth zone) in order to be modelled individually. Their combination leads to various facial transformations (relative to age, emotional state etc.). Second, global transformation possesses a higher degree of complexity, given the correlation between parts. In conclusion, first option is preferable as it has a higher optimization and effectiveness rate (Shen, 2010).

Local facial models
We can obtain two types of information from the face regions (eye, mouth, eyebrows, lips): visual information and electrophysiological signals. With the aid of processing algorithms, the visual information is processed in order to perform identification and facial recognition, generation. Electrophysiological signals represent the activity of the facial muscles, like blinks and movements of the eye. Between the two types of information exists a connection given by the correspondence between the topology of a local region of the face and the electric activity of the corresponding muscles (Deane, 1995).

Eye synthesis
The eyes are one of the richest sources of information about a person's emotional state and much more, as they are a regulator of the conversation through non-verbal communication and signals they transmit, which says whether the person reacts positively or negatively to one's speech, if he/she understands and many other details that complete the act of communication between people. Biometric features of the eye and static and dynamic transformations can be studied with respect to the iris, the retina or the whole image of the eye. First two have many applications in biometric identification systems and in the field of medicine, as they represent markers of a person's state of health.

Mouth and lips synthesis
The richest source of information, besides the eyes, is the mouth and the lips, because of their mobility. In coordination with mouth movements can be analysed the deformation around the mouth, but the most complex analysis is given by the combination of lip movements and other elements, like, for instance, eyebrows, as it is known that the two often work together in creating facial expressions. Besides the simple movements of the lips and mouth, the other signal which offers insight into one person's emotional and psychological state are the speech signals, which reinforce the sounds to complete the communication, de**s**pite the fact that not all sounds can be visually illustrated as well.

Some of the features that can be analysed are the width, the height, and the dimensions of the mouth. In vowel recognition, for instance, the area around the mouth is very important. These observations are meaningful for the lip readers. Movement of the lips, mouth and surrounding muscles constitute real challenges in the inverse problems. Synthesizing human speech so that the three elements mentioned above to coordinate with the sounds can pose problems.

Facial caricatures
A manner of face synthesizing is caricature: a particular art of drawing which emphasises certain features of a person's face in order to suggest the idea of ridiculous. In biometrics it can be used to test the capacity of the system in face identification area. Most used technique for drawing the face caricature-like is by changing certain distances between the control points (make them bigger or smaller) to emphasize certain very specific and individual features, so that the face of the person, although modified, be recognisable. The understanding of these techniques by automated systems is a step forward in the face recognition techniques improvement (Webb, 2006).

Conclusions
One of the riches sources of information about a person's age, gender, health, state of mind, emotional state is the human face, information which can be classified according to a number of criteria, and its analysis is useful in many areas, both socio-psychological and in the field of biometrics. We must keep in mind that face can be modelled both from a topological and a physical point of view; given the two known approaches – that facial expressions are considered topological structures or that the relation between skin and facial muscles is characterized by mathematical equations. Also, we can consider the geometry of the face from two points of view: global (face) geometry, involving the relation between the elements of the face and local geometry, which includes the geometry of specific regions of the face, like mouth, eyes, nose etc. Face modelling can be used in a series of applications that we have mentioned earlier, which help systems identify truths expressed by certain signs (specific to face movements and reactions), although automated systems require still the assistance of an expert. Actually, the role of automated systems is more to assist the expert in its evaluation process, by putting at its disposal a database to be analysed. Such systems can be useful in areas like immigration, the conceiving of non-contact lie-detectors or in algorithms for the prediction of human behaviour in a series of cases.

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