



7th International conference on Intelligent Human Computer Interaction, IHCI 2015

## Mathematical Representations of Blended Facial Expressions towards Facial Expression Modeling

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### Abstract

The paper mainly aims to create a mapping between facial expression and its corresponding facial muscle contractions along with their movement directions. This mapping is illustrated in terms of mathematical symbolic representations. The paper proposes a set of mathematical representations of basic as well as blended facial expressions. These symbolic representations of facial expressions are evaluated from different normalized facial features and 2D spatial coordinates of a face. They offer a simple generalization of 18 facial expressions and will be used as a background formulation for generating expressive face image from a given neutral face. The facial expression modeling and synthesis is a widely useful application for man-machine interaction.

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Peer-review under responsibility of the Organizing Committee of IHCI 2015

**Keywords:** Blended facial expressions; basic facial expressions; facial features; facial expression modeling; man-machine interaction;

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### 1. Introduction

Blended facial expressions of emotions can be defined as a phenomenon of instantaneous display of different facial expressions of emotions on the upper and lower face. The study of basic facial expressions has been started from more than 100 years ago. Charles Darwin introduced the facts of facial expressions and emotions in 1872<sup>1</sup>. It is commonly acknowledged that there are at least six basic facial expressions of emotions: happiness, surprise, fear, sadness, anger and disgust. All emotions rather than the basic ones are subcategories or mixtures of basic emotional expressions.

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The main objective of this study is to define how the association of facial features to a particular facial expression can be unveiled. This information will be applied in the process of regenerating expressive face image from the neutral one. The paper aims to generate a set of symbolic representations for basic as well as blended facial expressions. These offer a quantitative representation of facial expressions in compact way using a small set of facial feature point distances. It is expected that facial expressions can be reconstructed using these representations in 2D face images. In this paper, compound facial expressions of emotions database<sup>4</sup> has been used for blended facial expressions.

The rest of the paper is as follows. Section 2 discusses blended facial expressions. Section 3 demonstrates facial feature parameters. In section 4, symbolic representations have been illustrated for 18 facial expressions. Lastly conclusion and future work has been drawn in section 5.

## 2. Blended Facial Expressions

Facial expression can be termed as an indicator of human emotional state<sup>2</sup>. Blended expressions can be thought as a superposition of two expressions. Superposed expressions are mixed felt emotional expressions. Different methods like neural network<sup>3</sup>, KSDA<sup>4</sup>, direction intensity signature<sup>5</sup> have been used in blended expression recognition. In this paper, we have considered 12 blended expressions. These are happily surprised, happily disgusted, sadly fearful, sadly angry, sadly surprised, sadly disgusted, fearfully angry, fearfully surprised, fearfully disgusted, angrily surprised, angrily disgusted, and disgustedly surprised. The illustration of blended expression creation with facial action units has been given through the Fig. 1.

## 3. Overview on Facial Feature Parameters

Tian et al.<sup>6</sup> introduced upper and lower facial feature parameters and defined a face coordinate system. In the face coordinate system, the line connecting the inner corners of eyes is defined as x-axis and the line perpendicular to it is y-axis. They defined 15 parameters for upper facial features and nine parameters for lower facial features. Fig 2 (a) and (b) show the upper and lower facial feature representation. Facial feature parameters are normalized by the ratio of the current feature values (i.e. expressive one) to that of neutral one. The normalized parameters are inner brow motion ( $\bar{b}_{inner}$ ), outer brow motion ( $\bar{b}_{outer}$ ), eye height ( $\bar{e}_{height}$ ), eye top lid motion ( $\bar{e}_{top}$ ), eye bottom lid motion ( $\bar{e}_{btm}$ ), cheek motion ( $\bar{c}_{cheek}$ ), distance of brows ( $\bar{D}_{brow}$ ), lip height ( $\bar{l}_{height}$ ), right lip corner motion ( $\bar{r}_{right}$ ), left lip corner motion ( $\bar{l}_{left}$ ), lip width ( $\bar{w}_{width}$ ), top lip motion ( $\bar{t}_{top}$ ), bottom lip motion ( $\bar{b}_{btm}$ ), motion of chin ( $\bar{c}_{chin}$ ).

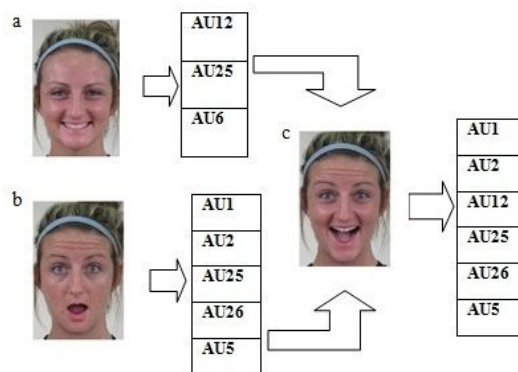


Fig. 1. Creation of Blended Facial Expression with their associated Action units (a) Happy expression; (b) Surprised Expression; (c) Happily Surprised Expression (Images are taken from<sup>4</sup>)

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