Comparison of Statistical Methods for Analysis of Affective Haptic Expressions

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Abstract

Several studies showed the relevance of haptics for conveying emotions to users. These studies usually cover recognition rate of emotions from haptic expressions. Surprisingly, the analysis of features of these haptic expressions is in counterpart often limited to a classical analysis of variance. However, this method suffers of several limitations for the analysis of such data. This paper investigates the complementarity of three different statistical methods for the processing of haptic expressions of emotions.

Keywords: Emotion, Haptics, Statistics

1 Introduction

Emotions play an important role in human-human communication. The capabilities of facial expressions and speech to express emotions during human-computer interactions are addressed in multiple studies [Picard 1997]. The use of haptic expressions for effective and intuitive communication of emotions to users remains little exploited [Hertenstein et al. 2006]. Existing studies mainly focus on the recognition rate of emotions. They exploit the analysis of variance (ANOVA) [Bailenson et al. 2007] to exhibit discriminative features of the affective haptic expressions.

However, this approach commonly used is limited since it can neither highlight multiple possible expressions of a given emotion nor compare several emotions or features simultaneously. We propose here an approach to deal with these limitations by comparing three independent analysis methods (analysis of variance, principal component analysis and clustering) and highlight the benefits and drawbacks of each one.

To achieve the analysis, we asked forty participants to record 3D haptic expressions of eight different emotions using a PHANToM Desktop haptic arm. For each collected haptic signal, we computed twenty-seven measures that were used in previous studies and observed to be relevant for finding out the discriminative features of haptic and gestures expressions of emotions [Bailenson et al. 2007], as the travelled distance, mean speed or the amplitude of movement.

2 Comparison of approaches

Analysis of Variance The ANOVA approach commonly used enables the identification of differences between two emotions, according to a given measure. For instance, haptic expressions of studied emotions of "Joy", "Elation" and "Rage" present all significant differences with others emotions, for numerous measures. At the opposite, the same emotions present at most eight significant differences compared with each other.

This approach suffers of three main limitations. First, it compares only two emotions at a time. For example, it would be irrelevant to compare the mean speed of mixed expressions of "Irritation" and "Rage" to the mean speed of "Joy" since there is a huge difference in the mean speed of expressions of "Irritation" and "Rage". Second, a simple ANOVA cannot deal with eventual correlations between measures, contrary to advanced methods as analysis of covariance or multivariate ANOVA. Finally, this method is not suitable when applied if emotions studied could be expressed with multiple ways, as observed in other modalities.

Principal Components Analysis The PCA enables the simultaneous processing of expressions from all emotions and measures. The results obtained corroborate those of ANOVA, except it highlights far distances between expressions of "Joy", "Elation" and "Rage", showing the influence of correlations between measures for the analysis. The simplification of data by reduction of dimensionality using correlations also suggests the existence of multiple expressions for some emotions.

Despite PCA highlights subpopulations in a specific emotion, it cannot process them. It is important to be able to distinguish subpopulations as some kind of expressions of the same emotion could be more useful than others to differentiate close emotions. Moreover, this method must deal with at least two measures at a time. For example, contrary to ANOVA, a PCA is useless if one considers only the measure of mean speed.

EM-Cluster Analysis Clustering methods regroup haptic expressions which are close to each other, regardless of the emotion labels. The EM algorithm estimates the optimal number of clusters from the data. This approach is useful to identify subsets of haptic expressions for the same emotion. For instance, this algorithm classified emotions of "Joy", "Elation" and "Rage" each inside a different cluster, proving these emotions are expressed differently. However, some expressions of the first two emotions are also mixed together in another cluster, explaining why these emotions are difficult to discriminate with the ANOVA.

But this result also highlights a limitation of this analysis. As some clusters mix several emotions, they display similarities in the haptic expressions they contain. Thus, it is difficult to exhibit specific features for emotions which are not dominant in any cluster.

3 Perspectives

The information extracted enable the identification of relevant haptic expressions for different investigated emotions. Future works consist in carrying out a perceptive evaluation using the most representative haptic expressions according to the three previous analyzes, and collecting more spontaneous and interactive haptic expressions of emotions to compare them with the acted data described here.

References

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