Quantifying Complexity of Facial Expressions Variability with Nonlinear Dynamics in Human-Humanoid Interaction

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Abstract

This research proposal aims to investigate the use of a method from nonlinear dynamics (RQAEnt) to quantify the complexity of face expressions variability and its relationship with mental states (e.g. anxiety, disinterest, relief) in the context of human-humanoid interaction. The proposal contains two research questions, an introduction to RQAEnt, and a pilot experiment with preliminary results.

1 Introduction and Research Questions

Movement variability is an inherent feature within and between persons. Research on measurement and understanding of movement variability has been well established in the last three decades in areas such as biomechanics, sport science, psychology, cognitive science, neuroscience and recently in human-robot interaction [XB18a]. Hence, considering methodologies for movement variability to quantify complexity of facial expressions variability and one preliminary experiment of this problem [XB18b], I am therefore interested in quantifying the complexity of facial expression for a person and in researching the subtle variations of facial expressions that can be related to different mental states (e.g. anxiety, disinterest, relief, etc.) [BJ14] in the context of human-humanoid interaction. Such statements have then led me to ask two research questions for this proposal:

(i) does the quantification of the complexity of facial expressions variability can tell us something about the state of mind of a person?,

(ii) how the quantification of facial expressions can be related with the complexity of facial expressions?.

2 Methods

With the work of my Ph.D. thesis, where I investigated nonlinear dynamics to quantify movement variability in human-humanoid interaction [Xoc18b], I am therefore proposing to apply Recurrence Quantification Analysis (RQA) to give insights into the raised questions. RQA computes measurements based on the recurrence points density of diagonal or vertical line structures in Recurrence Plots [MRTK07]. Such

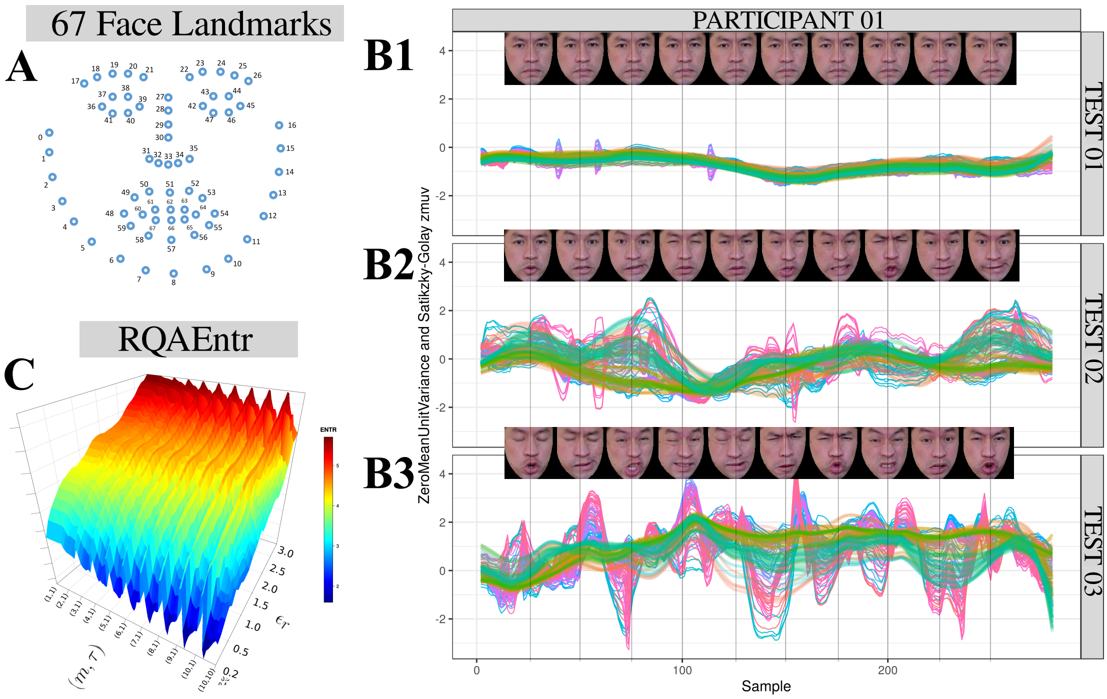

Figure 1: **Dynamics of face landmarks variations.** **(A)** 67 2D face landmarks (FL) with OpenFace [BZLM18]. Time series and faces for one person (myself) with vertical lines for: **(B1)** neutral face expressions, **(B2)** slowly variation of face expressions, and **(B3)** faster variation of face expressions. **(C)** 3D surface of RQAEntr for x 2D landmark position over time. Code and data to reproduce the figure is available from [Xoc18a].

measurements can provide understanding of the dynamics of a system i.e. the determinism (predictability) or Shannon entropy (complexity). Hence, I hypotheses that the complexity of face expressions variations can be quantified applying Shannon Entropy with RQA (also known as RQAEntr).

3 Preliminary results

Figs 1 illustrate the proposed methodology for the dynamics of face landmarks variations where one participant (myself) were asked to perform three levels of face expressions: (i) neutral variation, (ii) slow variation and (iii) faster variations. Figs 1(B) shows the time series from the $x - axis$ 2D landmarks for normalised and smoothed time series. It can be noted from the time series an increase of amplitude and complexity as the face expressions varies. Fig 1(C) shows a 3D surface of the RQAEnt in $z - axis$ with embedding values in $x - axis$ and recurrence thresholds in $y - axis$ that quantify the complexity of face expressions (see [XB18a] for RQAEnt). Hence, I can state that such changes can be related to subtle variation of face expressions and therefore ,I hypothesise, these can be related with the state of mind of a person.

References

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