

Analysis of Movement Variability for Facial Expressions with Nonlinear Dynamics

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1 Introduction

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 robotics [Xochicale, 2018] With that in mind, I hypothesise that the subtle variations of facial expressions can be quantified in a similar fashion as with the methodologies of movement variability. Hence, I am interested in quantifying the complexity of facial expression that one person or multiple can present in scenarios of human-robot interaction, particularly I am interested in these two questions: (i) can the quantification of the variation of facial expressions tell us something about the state of health or the state of mind of a person?, (ii) how the quantification of facial expressions can be related with the complexity of the facial expressions?.

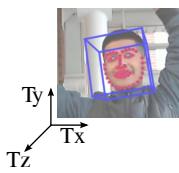
2 Methods

Considering my work of my PhD thesis for quantification of movement variability using nonlinear dynamics methods [Xochicale and Baber, 2018], I am proposing to work with Recurrence Quantification Analysis (RQA). RQA computes measurements based on the recurrence points density of diagonal or vertical line structures in Recurrence Plots. Such measurements of dynamics can determine the determinism (predictability) or Shannon entropy (complexity) of a nonlinear system [Marwan et al., 2007]. Hence, I am proposing to use Shannon Entropy measurement from the recurrent quantification analysis, also known as RQAEntr to quantify the complexity of face expressions. (Fig 1).

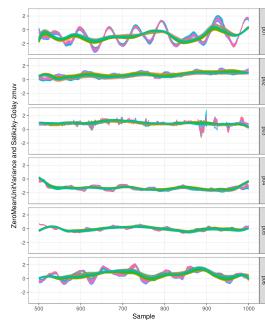
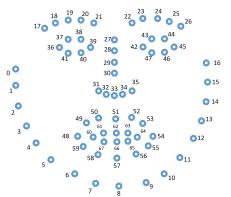
References

- [Baltrusaitis et al., 2018] Baltrusaitis, T., Zadeh, A., Lim, Y. C., and Morency, L. (2018). Openface 2.0: Facial behavior analysis toolkit. In *2018 13th IEEE International Conference on Automatic Face and Gesture Recognition (FG 2018)(FG)*, volume 00, pages 59–66.
- [Marwan et al., 2007] Marwan, N., Romano, M. C., Thiel, M., and Kurths, J. (2007). Recurrence plots for the analysis of complex systems. *Physics Reports*, 438(5):237 – 329.

Head Pose Estimation



Face Landmarks



RQA ENTR

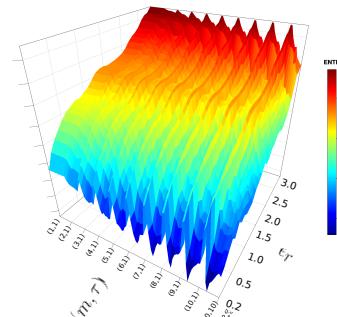


Figure 1: **Quantifying variations of face variations using nonlinear dynamics.** (A) Head pose estimation and face landmarks with OpenFace [Baltrušaitis et al., 2018], (B) time series from landmarks, and (C) 3D surface of RQAEentr for one time series.

[Xochicale, 2018] Xochicale, M. (2018). *Nonlinear Analyses to Quantify Movement Variability in Human-Humanoid Interaction*. PhD dissertation as submitted, University of Birmingham, Birmingham, United Kingdom. As submitted, awaiting viva and further revision.

[Xochicale and Baber, 2018] Xochicale, M. and Baber, C. (2018). Strengths and Weaknesses of Recurrent Quantification Analysis in the context of Human-Humanoid Interaction. *arXiv e-prints*, page arXiv:1810.09249.