# Analysing Complexity of Movement Variability for Facial Expressions with Nonlinear Dynamics

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**Abstract**

This proposal will investigate the use of nonlinear dynamics tools to quantify the variability of face expressions and its relationship with mental states (e.g. anxiety, disinterest, relief) in the context of human-robot interaction. This proposal contains two research questions, RQAEnt to quantify variablity of facial expressions, pilot experiment and preliminary results.

## 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 and Baber, 2018a]. Also, considering methodologies for movement variability to quantify variability in facial expressions and my preliminary experiments of variations for facial expressions using nonlinear dynamics [Xochicale and Baber, 2018b]. Hence, I am interested in quantifying the complexity of facial expression that one person or multiple persons can present in scenarios of human-robot interaction and in researching the subtle variations of facial expressions that can be related to different mental states (e.g. anxiety, disinterest, relief) [Back and Jordan, 2014]. Such statements have led me to ask two research questions where, to the best of my knowledge, little has been done in the context of human-robot interaction:

(i) does the quantification of the variation for facial expressions using nonlinear dynamics 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

Considering the work of my Ph.D. thesis where I investigated nonlinear dynamics to quantify movement variability [Xochicale, 2018b], I am proposing to apply Recurrence Quantification Analysis (RQA) for this work. 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 dynamics of a system, e.g. the determinism (predictability) or Shannon entropy (complexity)

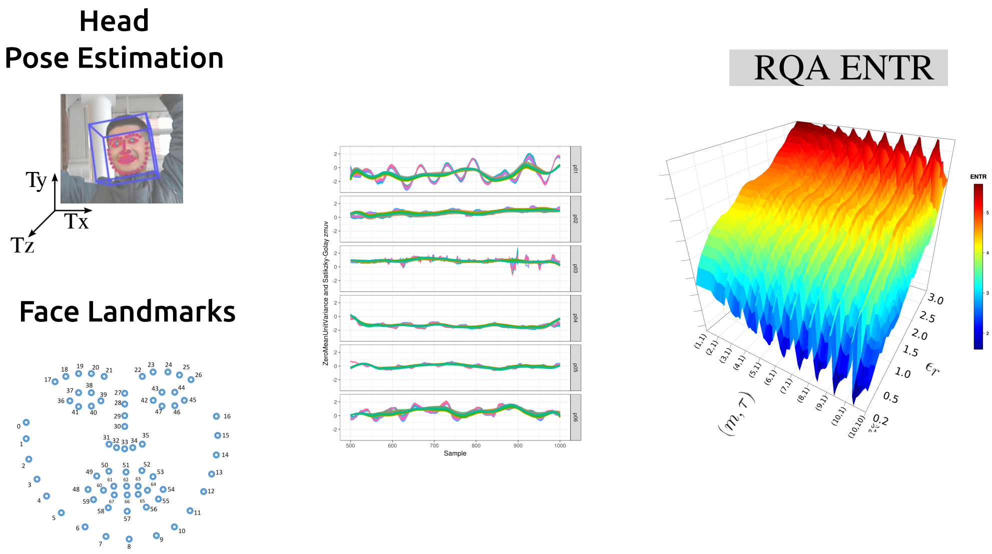


Figure 1: **Quantifying variations of face variations using nonlinear dynamics.** (A) Head pose estimation and face landmarks with OpenFace [Baltrusaitis et al., 2018], (B) time series from landmarks, and (C) 3D surface of RQAEntr for one time series. R code to reproduce the figure is available from [Xochicale, 2018a].

[Marwan et al., 2007]. Hence, the use Shannon Entropy with RQA (also known as RQAEntr) can be applied to quantify the complexity of face expressions.

# 3 Preliminary results

Fig 1 shows the proposed methodology with some preliminary results for one participant (myself) performing three levels of face expressions.

# References

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