Quantification of Complexity for Facial Expressions with Shannon Entropy

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Research on understanding and quantifying movement variability with nonlinear analyses has been well established in the last three decades in areas such as biomechanics, sport science, psychology, cognitive science, and neuroscience [DGAB03]. This work is then hypothesising that nonlinear analyses can be used to quantify subtle variations of facial expressions that can be related to different mental states (i.e. anxiety, disinterest, relief, etc) [BJ14]. This hypothesis has then led the author to ask two research questions:

(i) how the quantification of facial expressions can be related to the complexity of facial expressions?, and

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

In order to give insights into the raised questions, this work is proposing the use of Recurrence Quantification Analysis (RQA) to quantify the complexity of facial expressions which is based on previous investigations of the author on nonlinear dynamics to quantify movement variability in human-humanoid interaction [Xoc18]. Hence, RQA computes measurements based on the density of recurrence points of diagonal line structures in the Recurrence Plots. For which, RQA provide understanding of the dynamics of a system i.e. the determinism (predictability of a system) or Shannon entropy (complexity of a system) [MRTK07]. With that in mind, a pilot experiment is designed to show the complexity of facial expressions variability. In the experiment one participant (the author) were asked to perform three levels of variability for face expressions: (i) neutral variations, (ii) slow variations, and (iii) faster variations. Then, using 67 face landmarks time-series data collected with OpenFace [BZLM18], 3D plots of RQA Entr (Shannon entropy) were computed in order to quantify the complexity of face expressions and therefore relate such metric to both (i) the subtle variations of facial expressions and (ii) the state of mind of a person. Additionally, this work presents applications in the context of human-humanoid interaction of the proposed approach.

References

[BJ14]   Elisa Back and Timothy R. Jordan. Revealing variations in perception of mental states from dynamic facial expressions: A cautionary note. *PLOS ONE*, 9(1):1–5, 01 2014.

[BZLM18]   T. Baltrusaitis, A. Zadeh, Y. C. Lim, and L. Morency. 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, May 2018.

[DGAB03]   Keith Davids, Paul Glazier, Duarte Araujo, and Roger Bartlett. Movement systems as dynamical systems. *Sports Medicine*, 33(4):245–260, Apr 2003.

[MRTK07]   Norbert Marwan, M. Carmen Romano, Marco Thiel, and Jrgen Kurths. Recurrence plots for the analysis of complex systems. *Physics Reports*, 438(5):237 − 329, 2007.

[Xoc18]   Miguel Xochicale. *Nonlinear Analyses to Quantify Movement Variability in Human-Humanoid Interaction*. PhD dissertation as submitted, University of Birmingham, United Kingdom, 10 2018.