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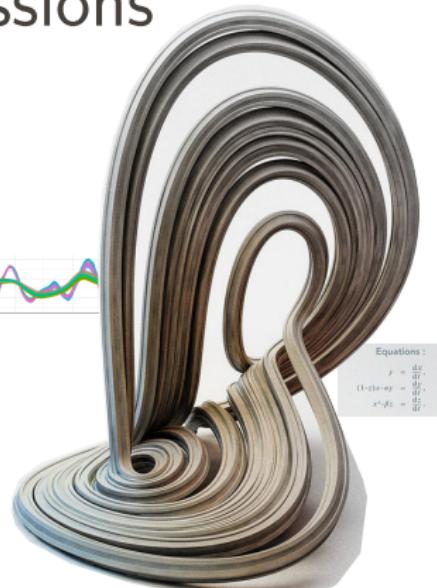
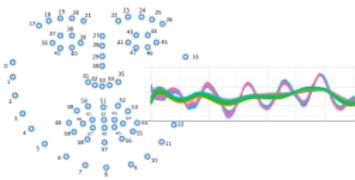
# Towards the Analysis of Movement Variability for Facial Expressions with Nonlinear Dynamics

@CERE\_Emotion #CERE2018

Glasgow, Scotland, 4-5 April 2018

Miguel P Xochicale and Chris Baber  
@\_mxochicale

School of Engineering  
University of Birmingham



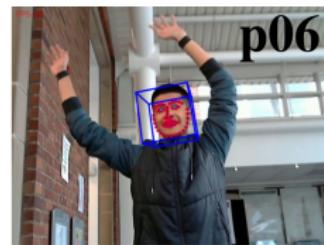
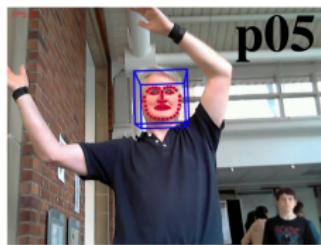
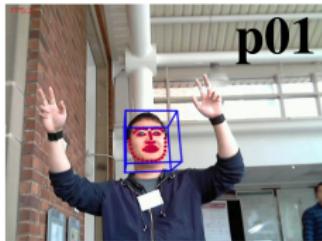
Equations :

$$\begin{aligned} \dot{x} &= dx/dt \\ &= a(y - x) \\ (1-a)x - ay &= dy/dt \\ x^2\beta_2 &= dz/dt \end{aligned}$$

# MOVEMENT VARIABILITY

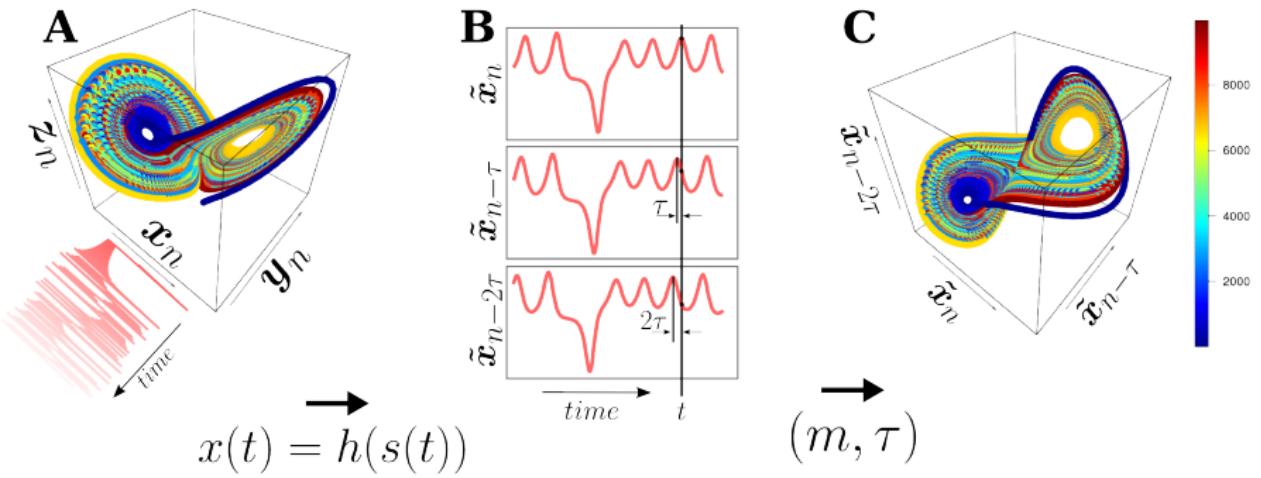
## WHAT IS MOVEMENT VARIABILITY?

**MOVEMENT VARIABILITY** is defined as the variations that occur in motor performance across multiple repetitions of a task and such behaviour is an inherent feature within and between each person's movement.



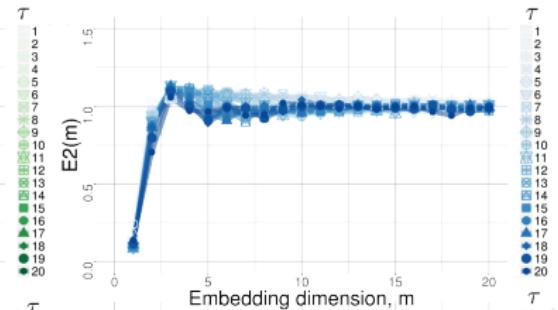
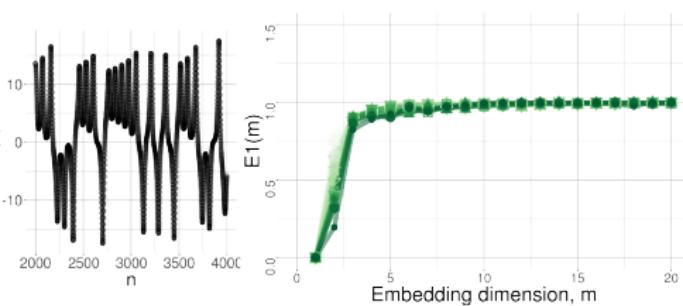
Variability in Body Movement and Facial Expressions

# STATE SPACE RECONSTRUCTION

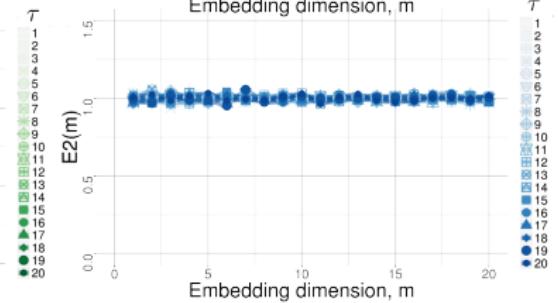
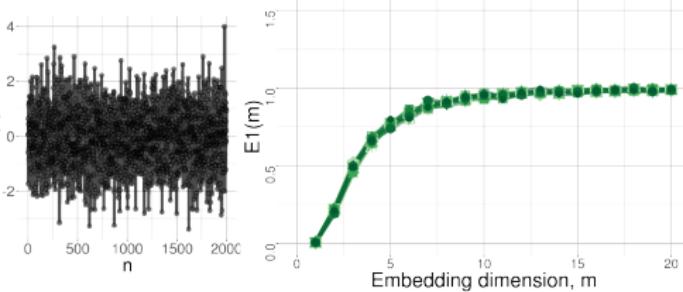


Uniform Time-Delay Embedding

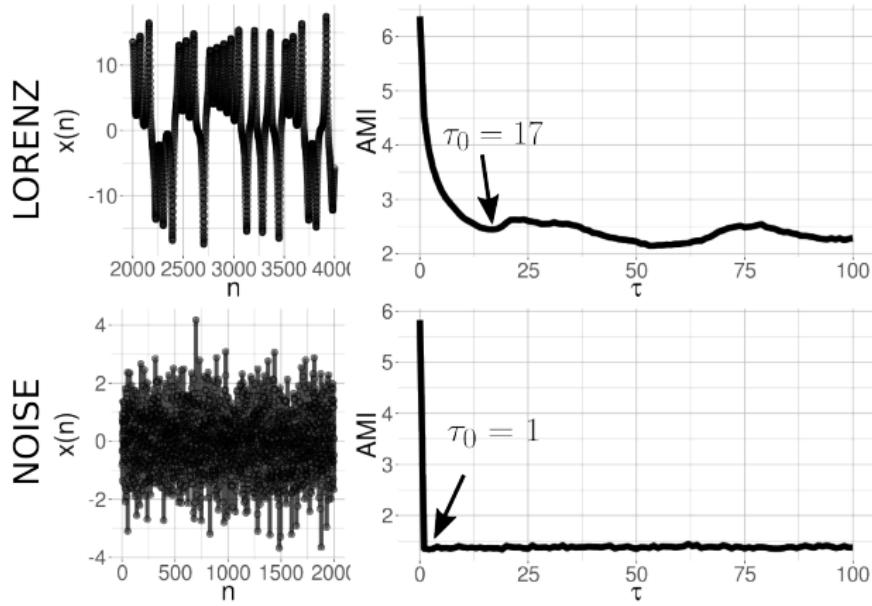
## LORENZ



## NOISE

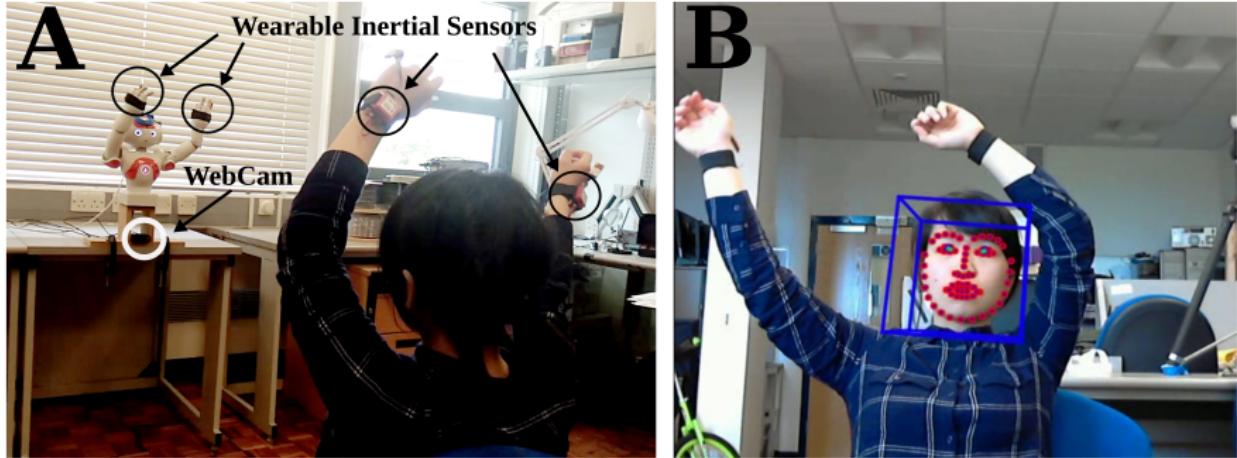


Minimum Embedding Dimension ( $m$ )

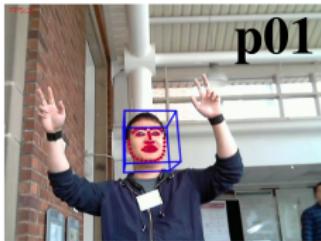


Minimum Embedding Delay ( $\tau$ )

## EXPERIMENT AND RESULTS



Human-Robot Imitation Activity



p01



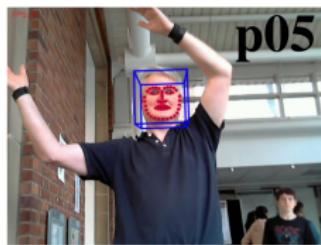
p02



p03



p04



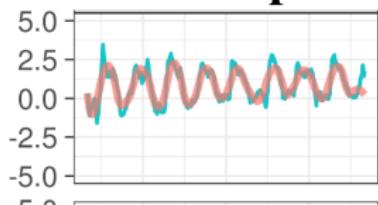
p05



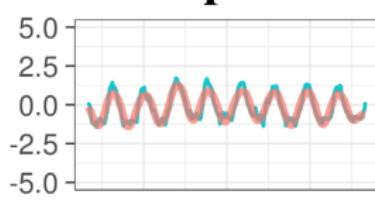
p06

Participants

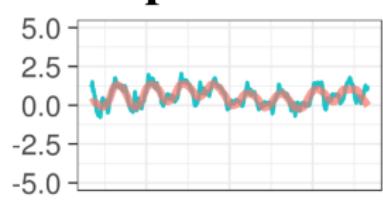
**p01**



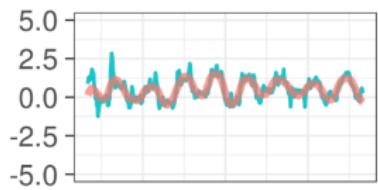
**p02**



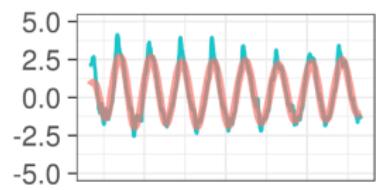
**p03**



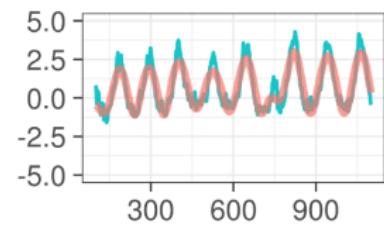
**p04**



**p05**

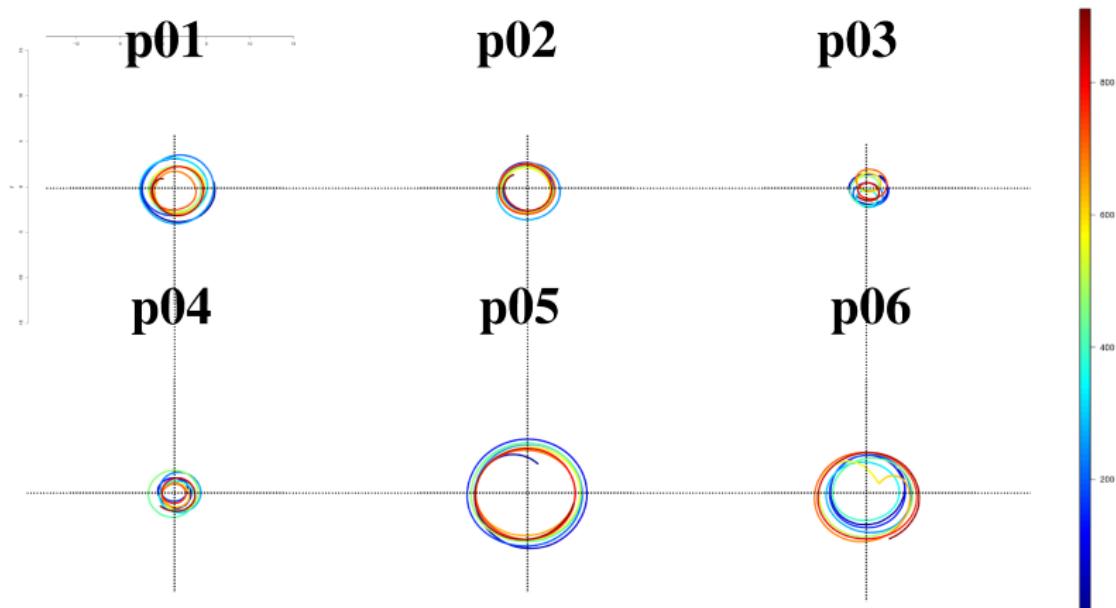


**p06**

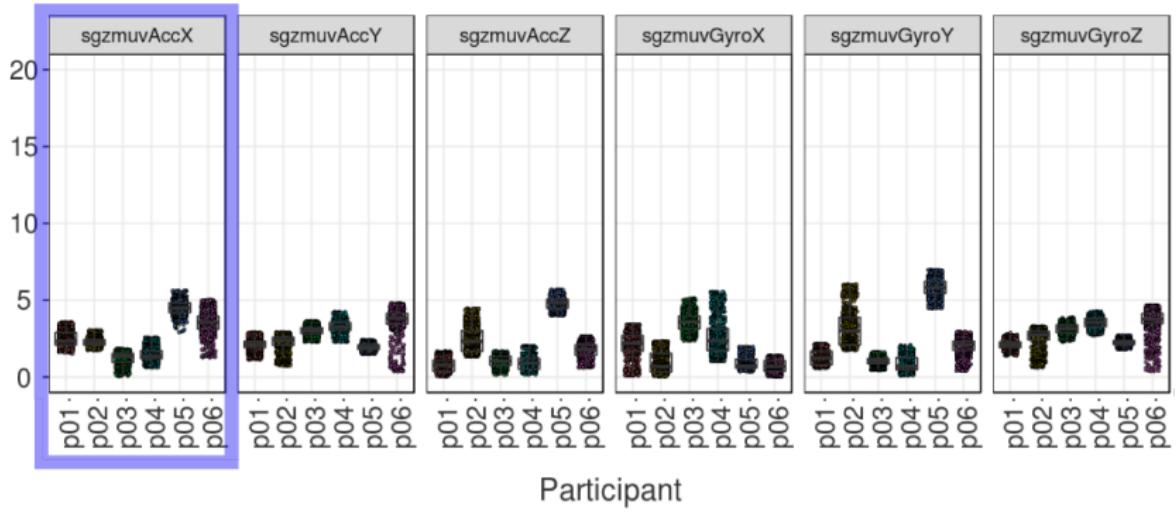


Feature  
— sgzmuvAccX  
— zmuvAccX

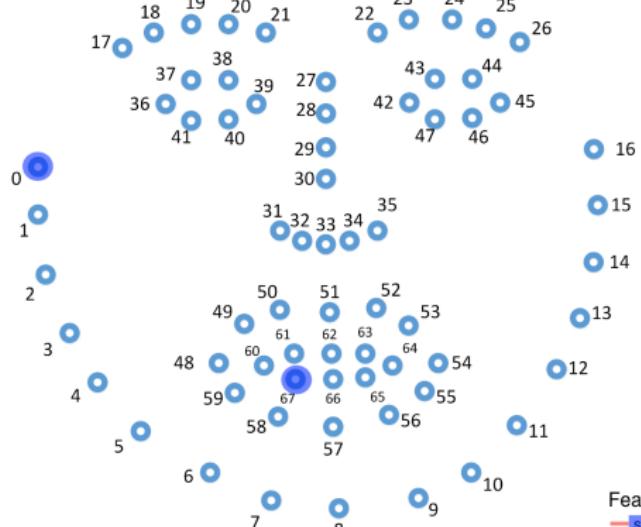
Time Series for IMU

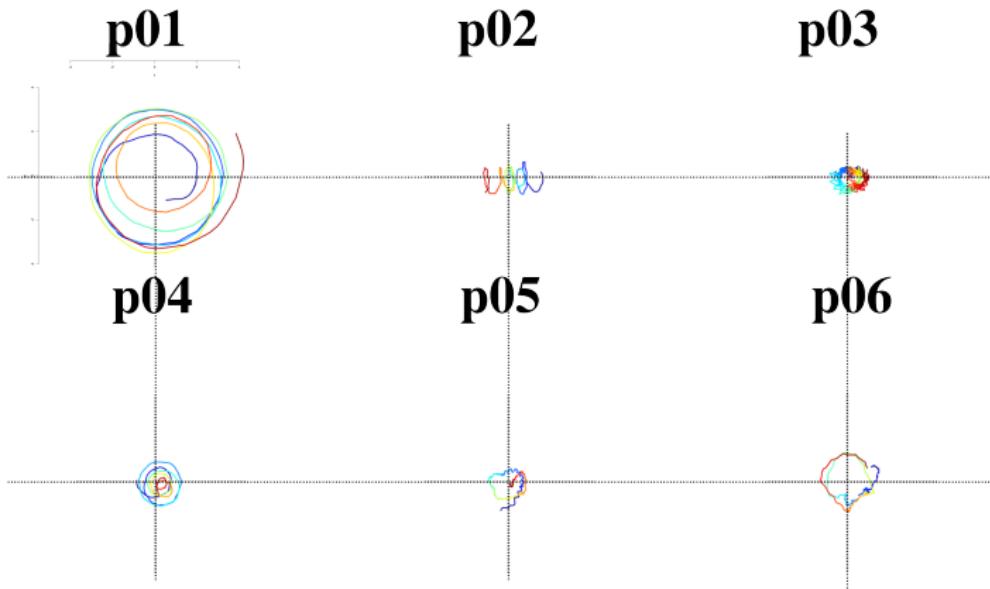


RSS ( $m10 \tau 10$ ) for sgzmuvAx

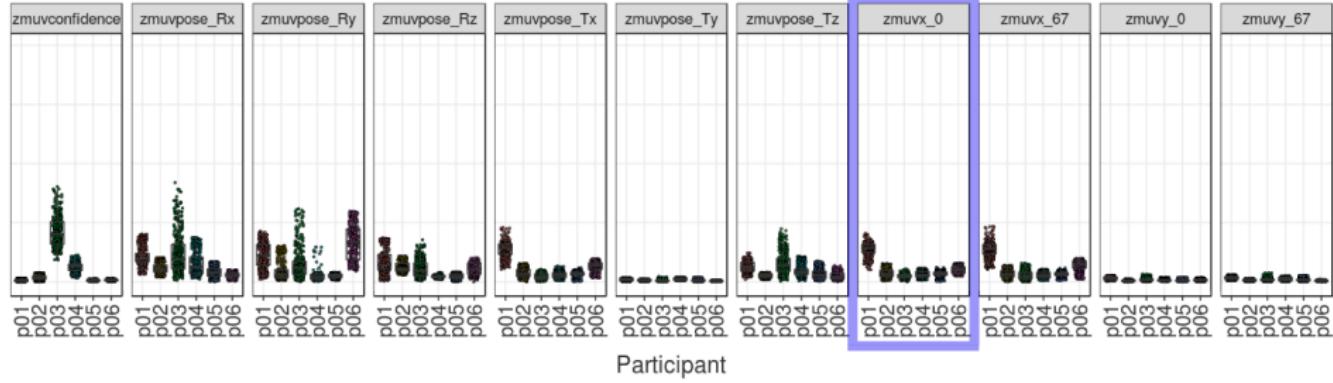


Euclidean Distances ( $m10 \tau10$ ) for IMU



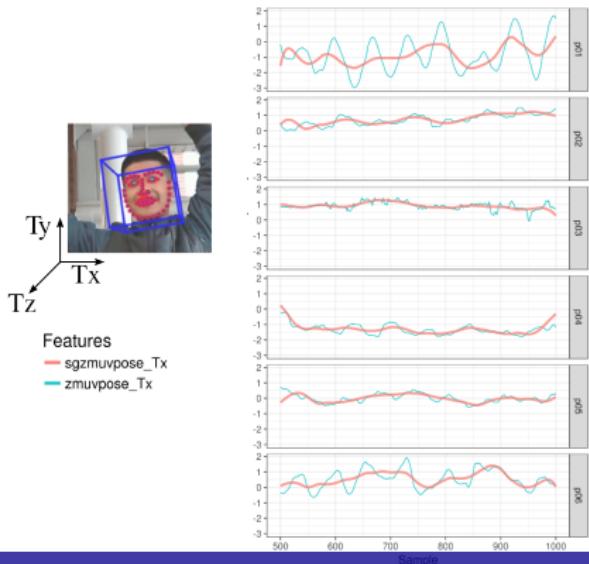


RSS ( $m10 \tau10$ ) for zmuvx\_0

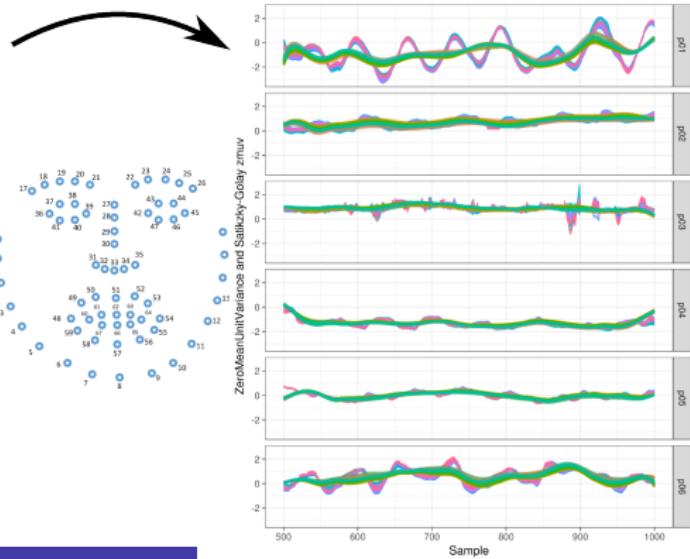


Euclidean Distances ( $m10 \tau 10$ ) for Openface

## Head Pose Estimation



## Face Landmark



Timer series for head pose estimation are mounted on face landmarks

## CONCLUSIONS AND FUTURE WORK

## CONCLUSIONS FUTURE WORK

- (+) Quantification for Arm Movement and Head Pose Estimation Variability with Nonlinear Dynamics is possible. However,
- (-) the timeseries from the landmarks are mounted on the pose location of the head.
  
- Test other techniques of Nonlinear Dynamics, e.g. Lyapunov Exponents, Recurrent Quantification Analysis
- Use of Convolutional Neural Networks for automatic identification of Movement Variability

# BIBLIOGRAPHY

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»Practical method for determining the minimum embedding dimension of a scalar time series.«  
Physica D, 110, 43-50, 1997.
-  Xochicale M P  
»Emotion and Movement Variability: a pilot study«  
GitHub repo (2018), <https://github.com/mxochicale/emmov-pilotstudy> [Q]

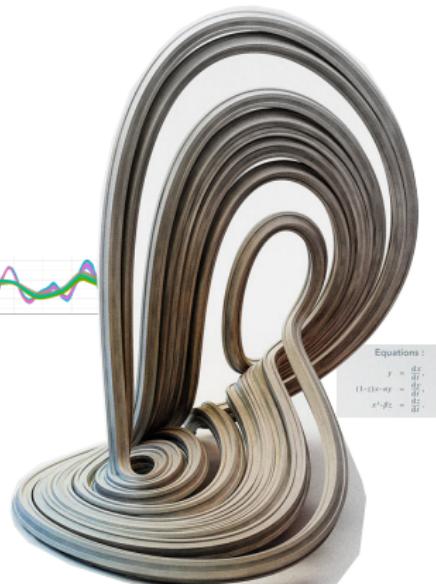
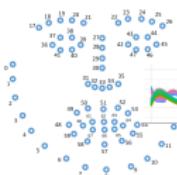
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Miguel P Xochicale and Chris Baber

 @\_mxochicale  @mxochicale

<http://mxochicale.github.io/>



Equations :

$$\begin{aligned} \dot{x}_1 &= \frac{dx_1}{dt} \\ (1-\alpha)x_1\alpha x_2 &= \frac{dx_2}{dt} \\ x_1^2\beta_2 &= \frac{dx_3}{dt} \end{aligned}$$



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