Quantifying Dexterity in Dance

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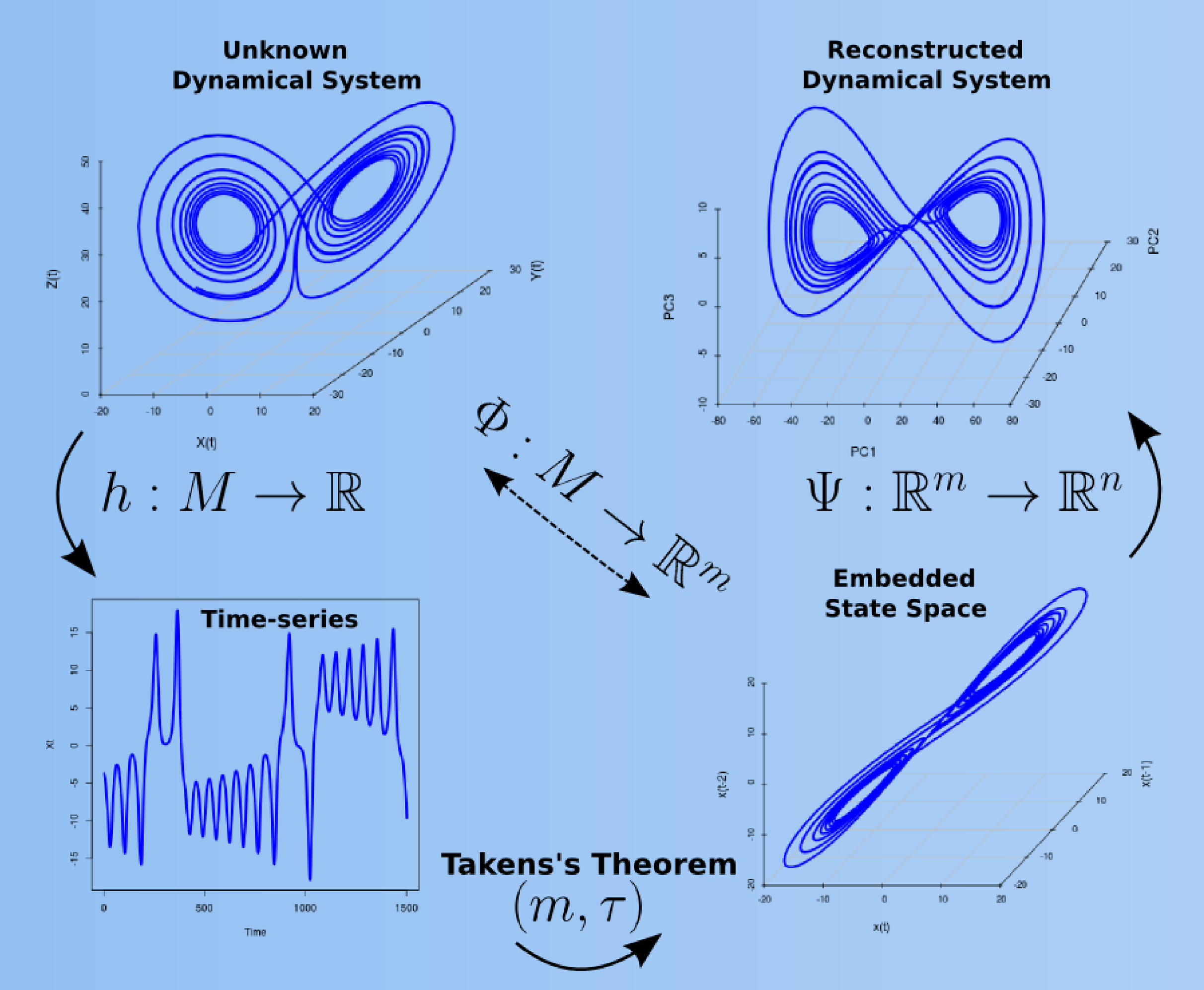
Introduction

The use of data from wearable sensors to analyse Human-Activity Recognition (e.g. walking, running, cycling, rowing, etc.) has incresed during the last 20 years. Nonetheless, when it comes to studying dextrous performance, recognition of event activities might not be sufficient.

Dexterity in human activity is seldom an exclusive matter of performing events faster or sequencing the events in a more consistent and defined manner, but could involve performing the actions in a very different way when compared to novices. Theferefore, identifying how *well* an action is performed is more challenging than simply identifying action type [1].

This research will extend the field of HAR by applying concepts from Chaos Theory [2] to create novel analysis and interpretation of the data which allows us to recognise dexterity.

Phase Space Representation



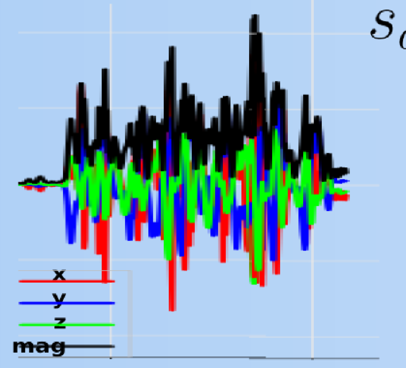
Research Questions

- How can phase space representation quantify dexterity in human activities?
- How can we apply Takens's Theorem and Principal Components Analysis to characterize Human Activities?
- How do concepts from nonlinear dynamics help us to characterize dexterity in human activities?

Method

Phase space representation of the time-delay embedded series data [3].

Raw Data: $s_a(n)$



$$s_a(n) = \{s_a(1), \dots, s_a(L)\}$$

$s =$ sensor (acc,mag,gyr)

$a =$ axis (x,y,z)

$n =$ index

$L =$ window length

Takens's Theorem: $E^{\tau}_{m}\{s_a(n)\}$

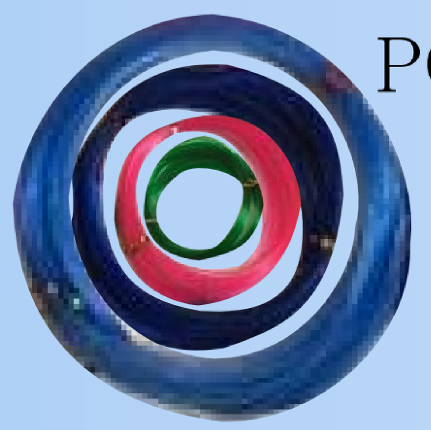
$$E^{\tau}_{m}\{s_a(n)\} = \{s_a(n), \dots, s_a(n-(m-1)\tau)\}$$

$E^{\tau}_{m} =$ Embedded Matrix

$\tau =$ Time-delay

$m =$ Dimension

Principal Component Analysis



$$\mathrm{PCA}[E^{\tau}_{m}\{s_a(n)\}] = (\lambda_i, v_i)$$

$\lambda_i =$ Eigenvalues

$v_i =$ Eigenvectors

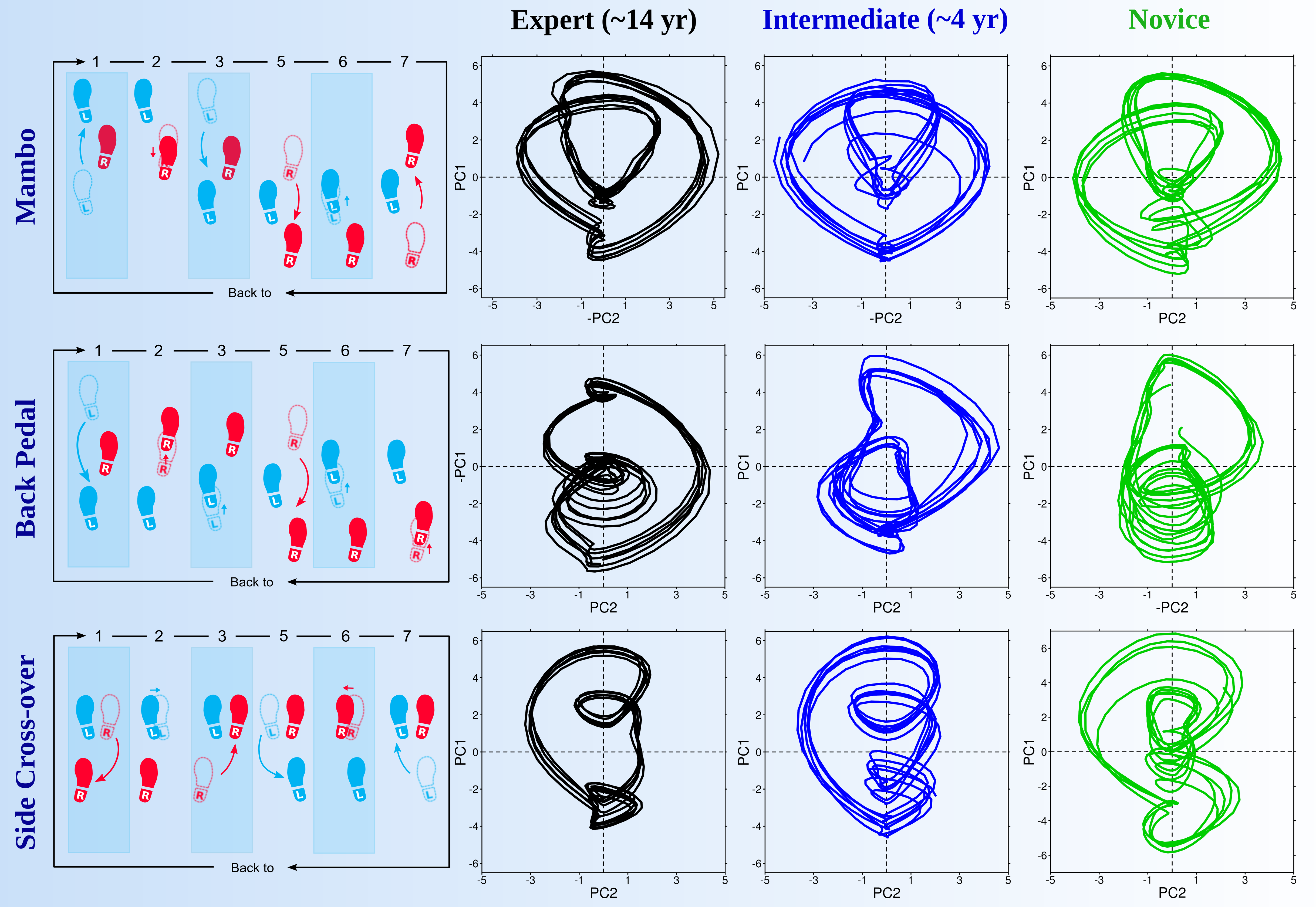
Data Collection

Thirteen male participants with different years of experiences in dancing salsa were recruited, one expert (14 yr of experience), one intermediate (4 yr of experience) and eleven novice dancers.

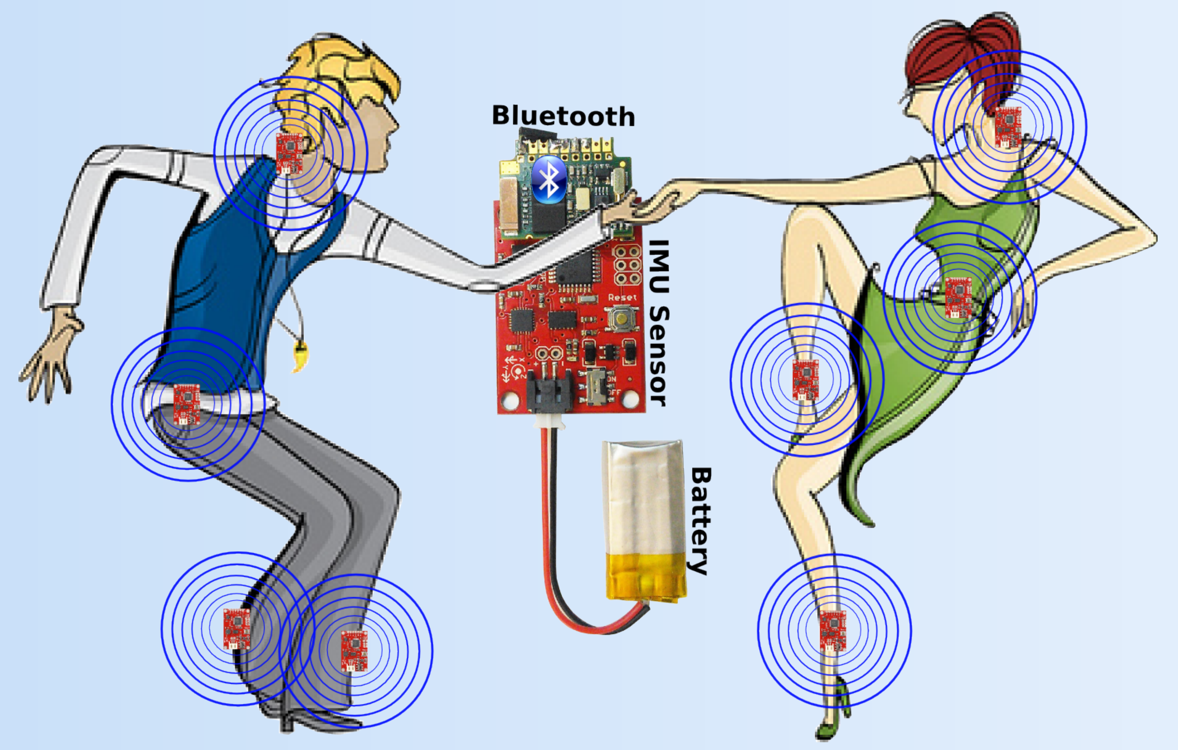
Each participant was shown a series of video clips (demonstrating salsa steps) and were then asked to copy the steps in time to music during 20 seconds.

Results: Phase Space Representation

The shape of the state space show a tighter and less variated pattern for the expert than for the other dexterity levels. The intermediate participant is showing a consistent action but this is different than the expert, and the novice is showing a pattern which appear disjointed and noisy.



Wearable Sensors



Areas Of Exploitation

Rehabilitation, pain therapy, sports, gaming and human-robot interaction.

Conclusion & Future Work

The phase space representation applies a model of consistency to the data for dexterity assessment. Investigate manifold learning methods for dimensionality reduction.

References

[1] N. Hammerla, T. Ploetz, P. Andras, P. Olivier Assessing Motor Performance with PCA In *International Workshop on Frontiers in Activity Recognition using Pervasive Sensing '11*

[2] A. Sama, F. J. Ruiz, N. Agell, C. Perez-Lopez, A. Catala, J. Cabestany Gait identification by means of box approximation geometry of reconstructed attractors in latent space In *Neurocomputing '13*

[3] M. Perez-Xochicale, C. Baber, N. Cooke. Dexterity Assessment for Salsa Dancers Through the Time-delay Embedded Phase Space Representation. Submitted to *ISWC '15*