Casa Paganini – InfoMus Lab
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EyesWeb Week 2010 – Track 2

Advanced use of EyesWeb for expressive gesture processing and social interaction analysis

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Social signals

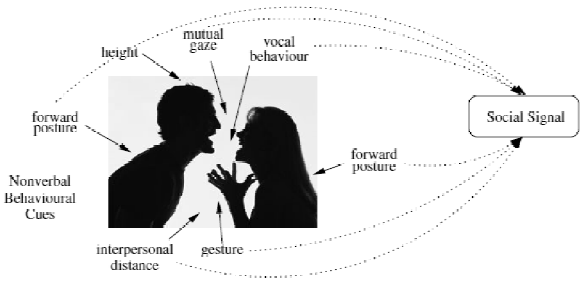
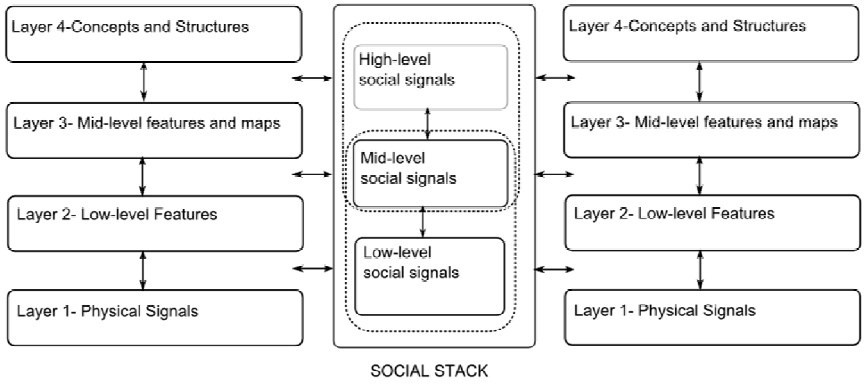


Figure 1: Behavioural cues and social signals. Combinations of multiple behavioural cues (vocal behaviour, posture, mutual gaze, interpersonal distance, etc.) produce social signals (in this case aggressivity or disagreement) that are evident even from static images showing only the silhouettes of the individuals involved in the interaction.

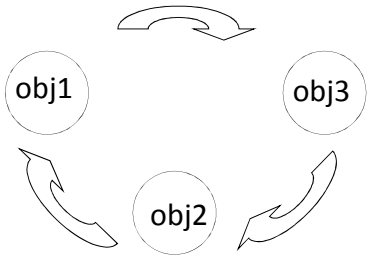
From: Vinciarelli, A., Pantic, M., Bourlard, H., and Pentland, A., (2008). Social Signals, their Function, and Automatic Analysis: a Survey. In Proc. ICMI'08, p. 61 – 68.

Conceptual Model



Synchronization

" *Adjustement* of *rhythms* of *oscillating* objects due to their *weak* interaction" [Pikovsky et al., 2001]



More general definition: appearence of some relations between functionals of two processes due to some from of interaction

BUT … no general universally accepted definition for synchronization!

Synchronization

- Complex dynamical process NOT state
- Oscillating objects
  self-sustained oscillators
  – identical
  – nonidentical
  – different




Research areas

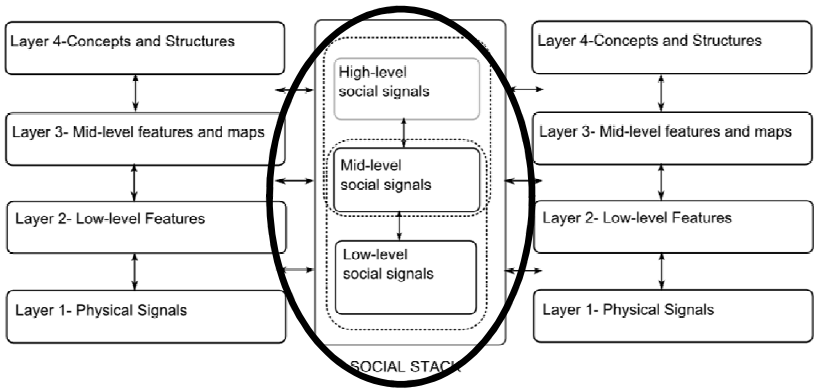
Natural Sciences, Medicine,
Neurosciences, Behavioural Sciences, Engineering

Synchronization at different levels

- At low level: synchronization of physical signals (e.g., motoric, auditory, biometric)
- At individual level: multimodal synchronization of features: communication of expressive intentions, display of emotional state.
- At social level: empathy, social behavior.

=> Different research challenges
Different techniques

Social low/mid - level features



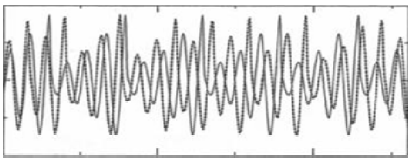
- Phase synchronization
- Leadership
- Rarity / saliency

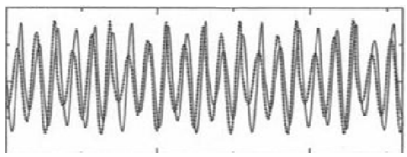
Phase Synchronization (PS)

- Locking of phase/frequencies

$$\varphi_{n,m}(t) = |n\phi_x(t) - m\phi_y(t)| \leq \text{constant}$$

- Unlocking of amplitude





Recurrence and Recurrence Plots

- Recurrence [Poincarè, 1890]
  fundamental characteristics of many dynamical systems
- Recurrence Plots [Eckmann, 1987]
  time-time visualisation of recurrences
- Recurrence matrix:

$$R_{i,j} = \Theta\left(\varepsilon_i \quad \| \vec{x}_i \quad \vec{x}_j \|\right) \qquad \mathrm{i}, j = 1...N$$

Rij = { 0 : xi ≈ xj ⟶ □
      { 1 : xi ≈ xj ⟶ □

Recurrence and Recurrence Plots

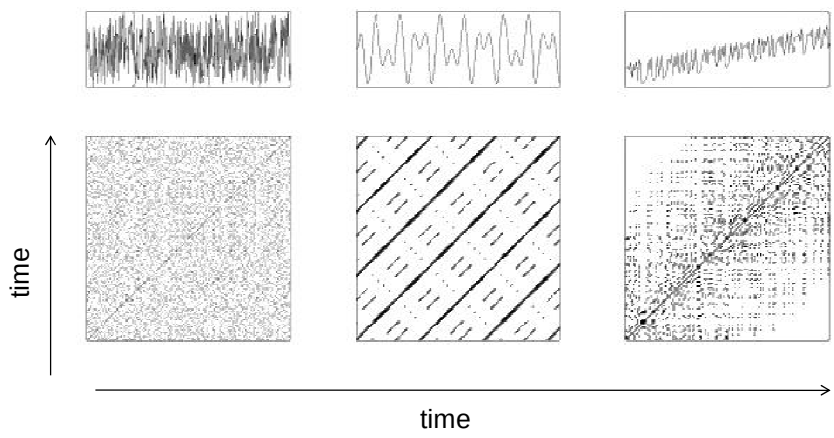


Figure from " Recurrence plots for the analysis of complex systems".
Physics Reports, 438:237-329, 2007 . Marwan et al.

Recurrence Quantification Analysis (RQA)

- Small-scale patterns:
  - single dots
  - vertical lines
  - diagonal lines

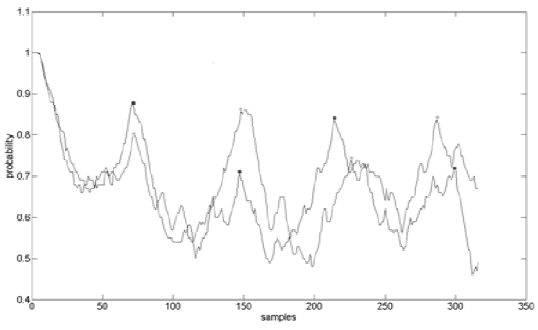
- RQA: quantification of small-scale patterns

E.g.., Recurrence Rate (RR) : $RR(\varepsilon) = \frac{1}{N^2} \sum_{i,j=0}^{N} R_{i,j}(\varepsilon)$

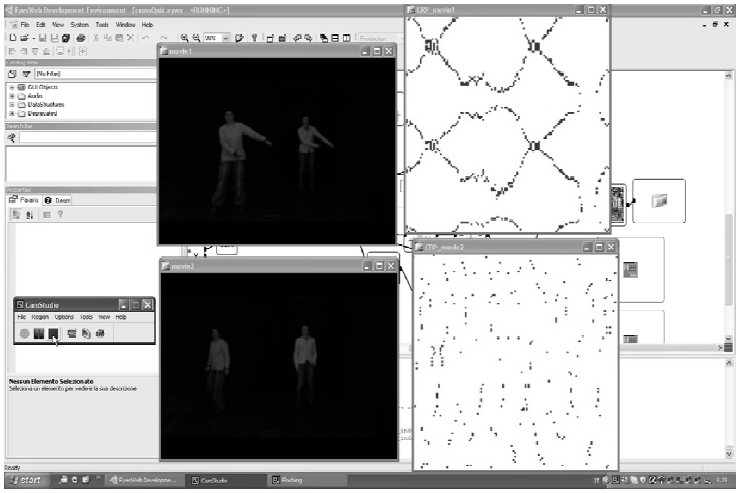
RPs-RQA and PS

- Quantification of probability of recurrence
- Phase synchronization occurring when a high cross-correlation index between the probabilities of recurrence of two signals is high (CPR index) [Romano et al., 2005]

$CPR = \langle p_{\vec{x}}(\tau) p_{\vec{y}}(\tau) \rangle$

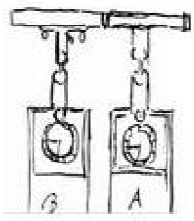


Example: phase synchronization in body movement



Experiment: phase synchronization in music performance

- Players as a two component complex system
- From Huygens observations on pendulum clocks

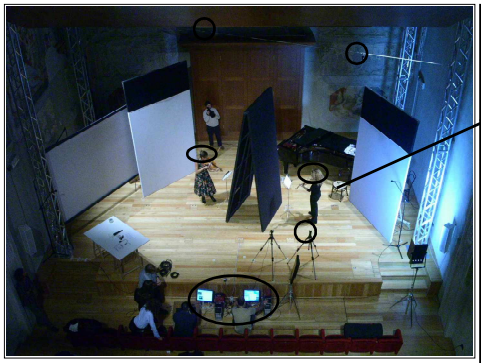


Players as interacting self-sustained inverted oscillators

Synchronisation can emerge as property of the whole system

Experiment: phase synchronization in music performance

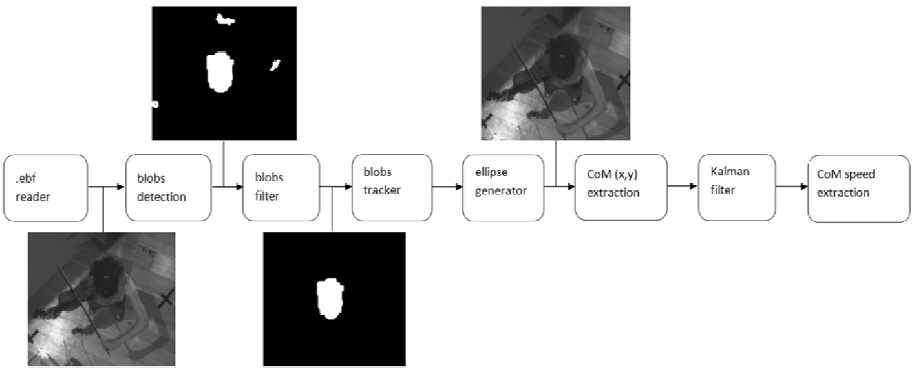
Motions & Gestures	*Audio*	*Physiological Data* ECG – EMG



- 4 professional players
- *J.S. Bach score:* Canon at unison from "Musical Offering"
- *Conditions:*
  Audio feedback only
  Audio and visual feedback
- *4 emotional states:*
  anger, joy, sadness, serenity

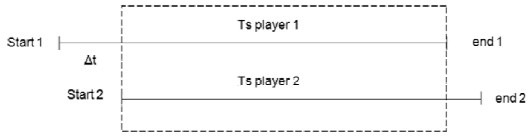
Head motion tracking and signal processing

- 2 b/w video-cameras : 720 x 576, 25 Hz
- Height: 5-meters
- EyesWeb XMI application



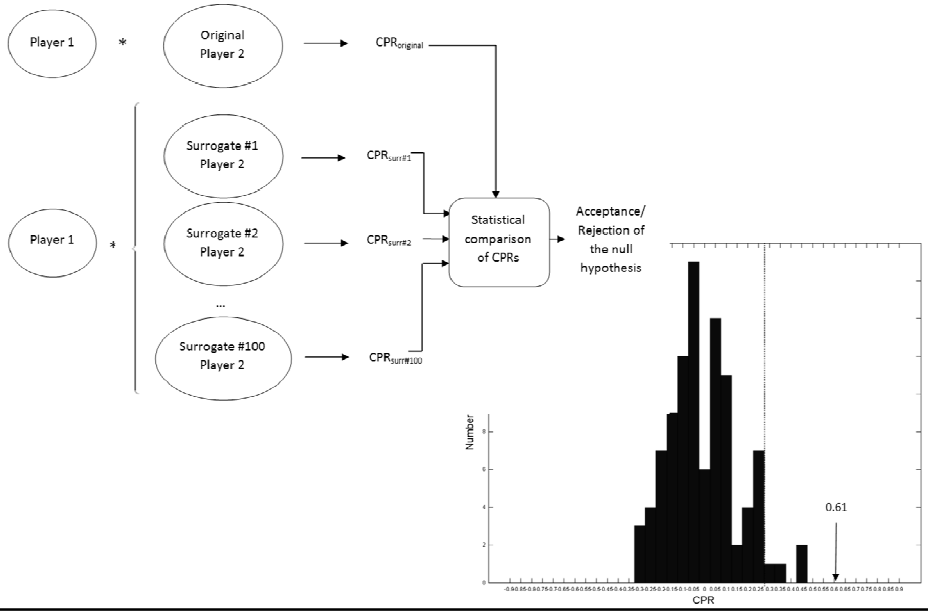
Analysis

- 60 video signals
- state vector: (x,y,v_x,v_y) of CoM
- no time alignment



- ε: sensitivity study! [Zbilut and Webber jr.]
- Statistical significance checked with the twin surrogate method.

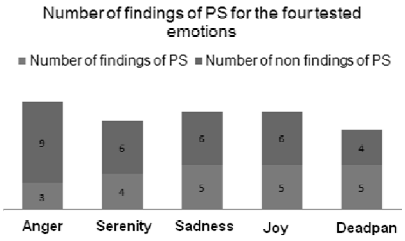
Twin surrogates



Results

Acoustic AND visual channels: 10 findings of PS
Acoustic channel only: 14 findings of PS

On average: |CPRa |= 0.57 |CPRav|= 0.38



Not significant difference among emotions
BUT
Indication of a significant role of positive emotions:

findings of synch at least in one trial for each couple of players

G. Varni, A. Camurri, P. Coletta, G. Volpe. 2009. Toward Real-time Automated Measure of Empathy and Dominance. In Proceedings of the 2009 IEEE International Conference on Social Computing (SocialCom-09), Vancouver, Canada, August 2009.

Current work

Quartetto di Cremona, Casa Paganini, May 2009.
Collaboration with Queen's University, Belfast (Prof. B. Knapp)

Measuring dominance

- Causal (driver-response) relationship: leader in the interaction!

- Mutual relationship:

no leader in the interaction

Figure from *"Synchronisation: a Universal Concept in Nonlinear Sciences"*, 2001. Pikovsky et al.

Measuring dominance

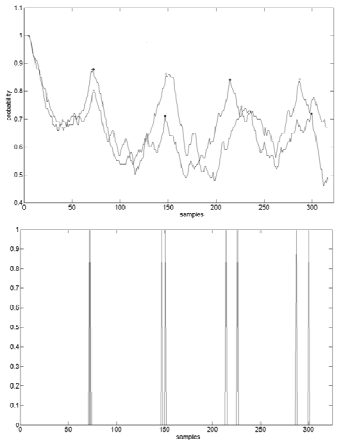
Combining Recurrence with Event Synchronization:

$$Q_\tau = \frac{c^\tau(y|x) + c^\tau(x|y)}{\sqrt{m_x m_y}} \qquad q_\tau = \frac{c^\tau(y|x) - c^\tau(x|y)}{\sqrt{m_x m_y}} \qquad 0 \le Q_\tau \le 1 \text{ and } -1 \le q_\tau \le 1.$$

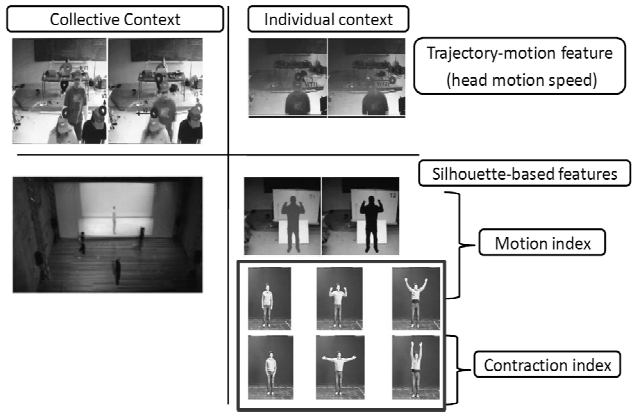
$$c^\tau(y|x) \sum_{j=1}^{m_y}\sum_{i=1}^{m_x} J_{ji}^\tau \qquad c^\tau(x|y) \sum_{i=1}^{m_x}\sum_{j=1}^{m_y} J_{ij}^\tau$$

$$J_{ij}^\tau = \begin{cases} 1 & \text{if } 0 < t_i^x - t_j^y < \tau \\ 1/2 & \text{if } t_i^x = t_j^y \\ 0 & \text{else} \end{cases}$$

[Quian Quiroga et al., 2002]



Analysis of rarity and saliency for context-aware analysis



M. Mancas, D. Glowinski, P. Bretéché, G. Volpe, J. Demeyer, T. Ravet, A. Camurri, P. Coletta. Real-Time Motion Attention and Expressive Gesture Interfaces. *J. of Multimodal User Interfaces*, Springer Verlag, in press.

For more info…

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