Information-Theoretical Aspects of Embodied Artificial Intelligence (part 2)

Teresa Pegors

Background

- Statistical regularities of environment are highly important for predictions / efficient coding = survival (Barlow 1961)
- Embodied agents are able to shape their sensory input (Lungarella and Pfeifer 2001)
- Statistical measures have been applied to static images and some video clips (Dong and Atick 1995)
- Little work applying measures to sensory streams from living organisms/robots

Measures

- Entropy – measures the average uncertainty of a system
- Mutual Information – measures the deviance from statistical independence
- Complexity – High if small subsets are independent (locally segregated) but integration high at global level.

Simulation

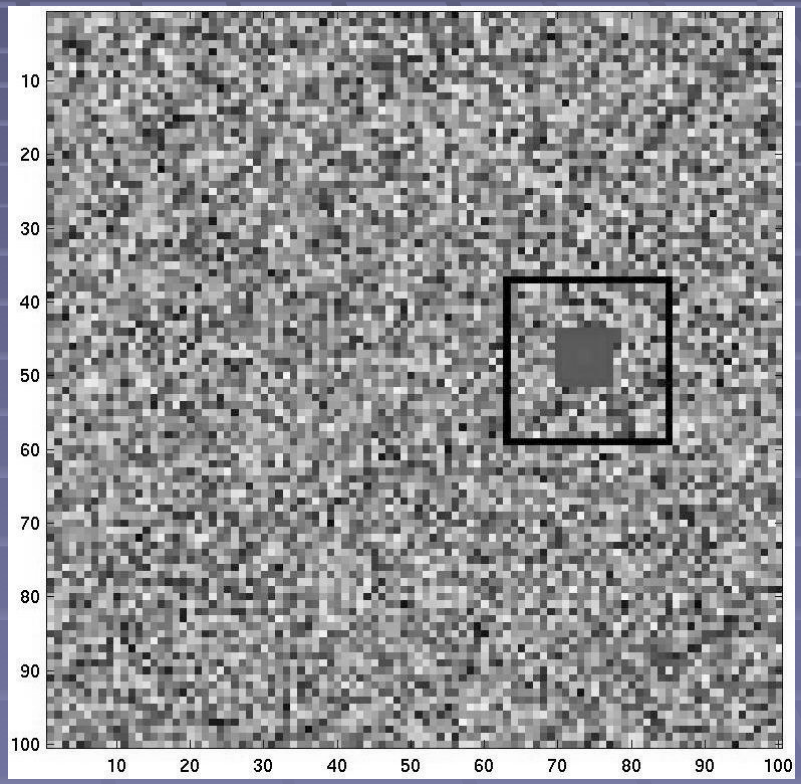
Simple Matlab environment

1 – random pixel environment – changed every time step

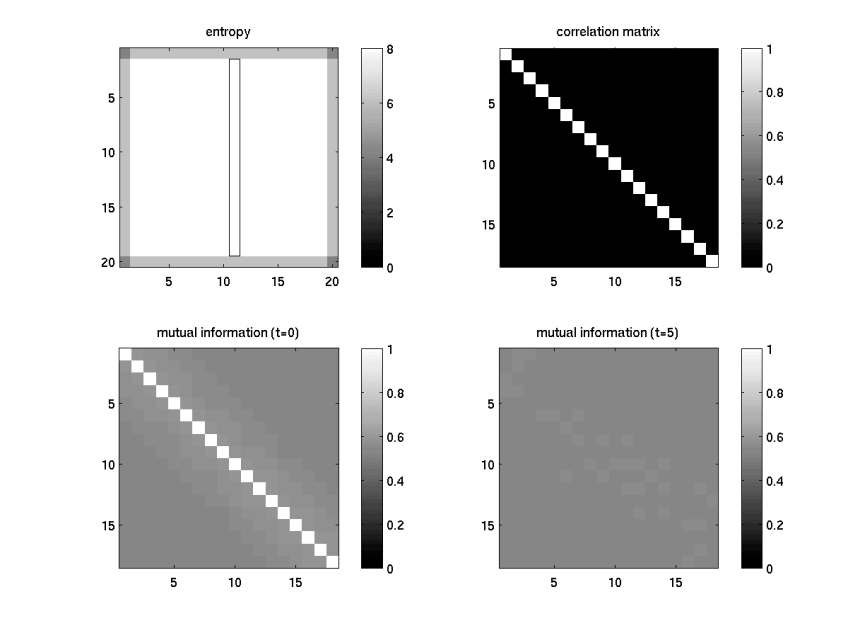
2 – view window. What the organism “sees”. Information inside this window stored.

3 – object – “interesting” salient part of environment

Random vs. Tracking strategy



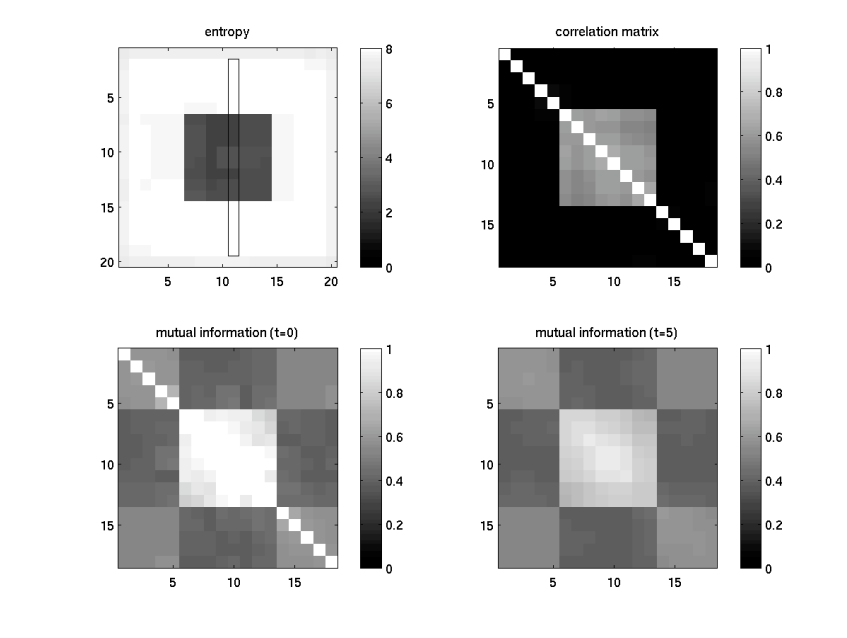
Results



Uniformly high entropy

Uniformly low Mutual information

C(x) = 0.0011



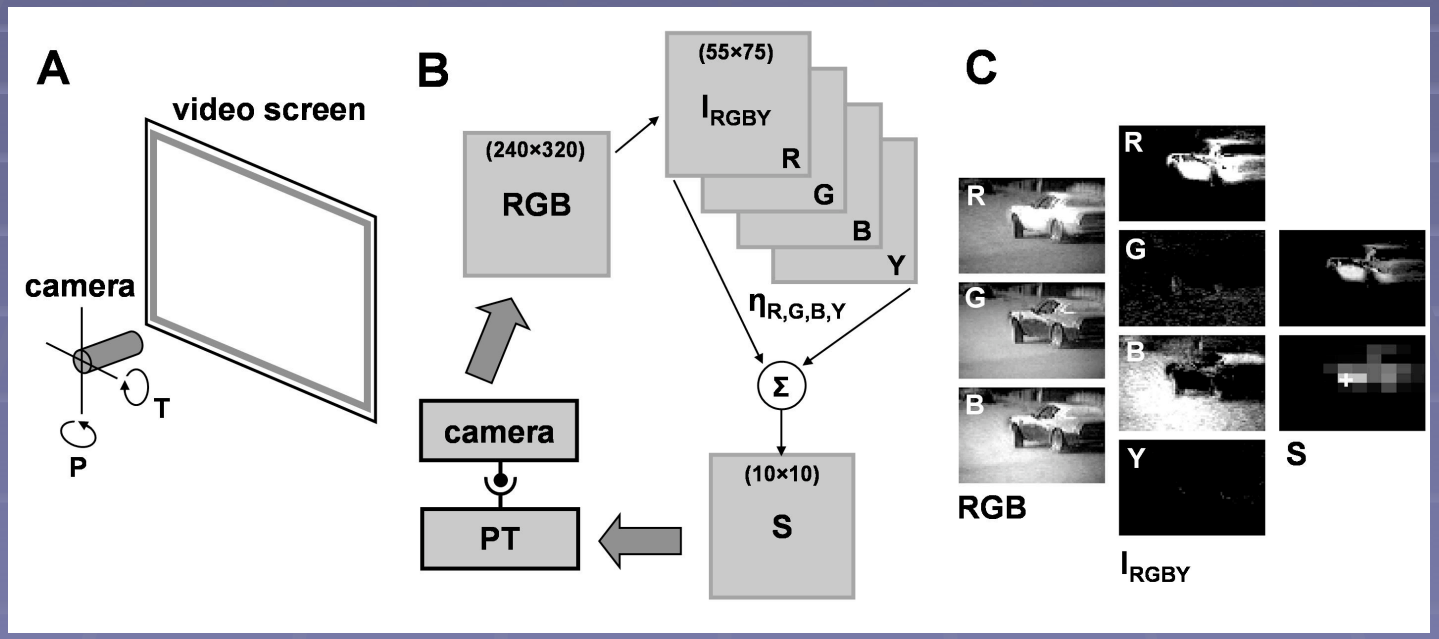
Reduced entropy around area of foveation

Raised Mutual information around foveal area

C(x) = 2.4402

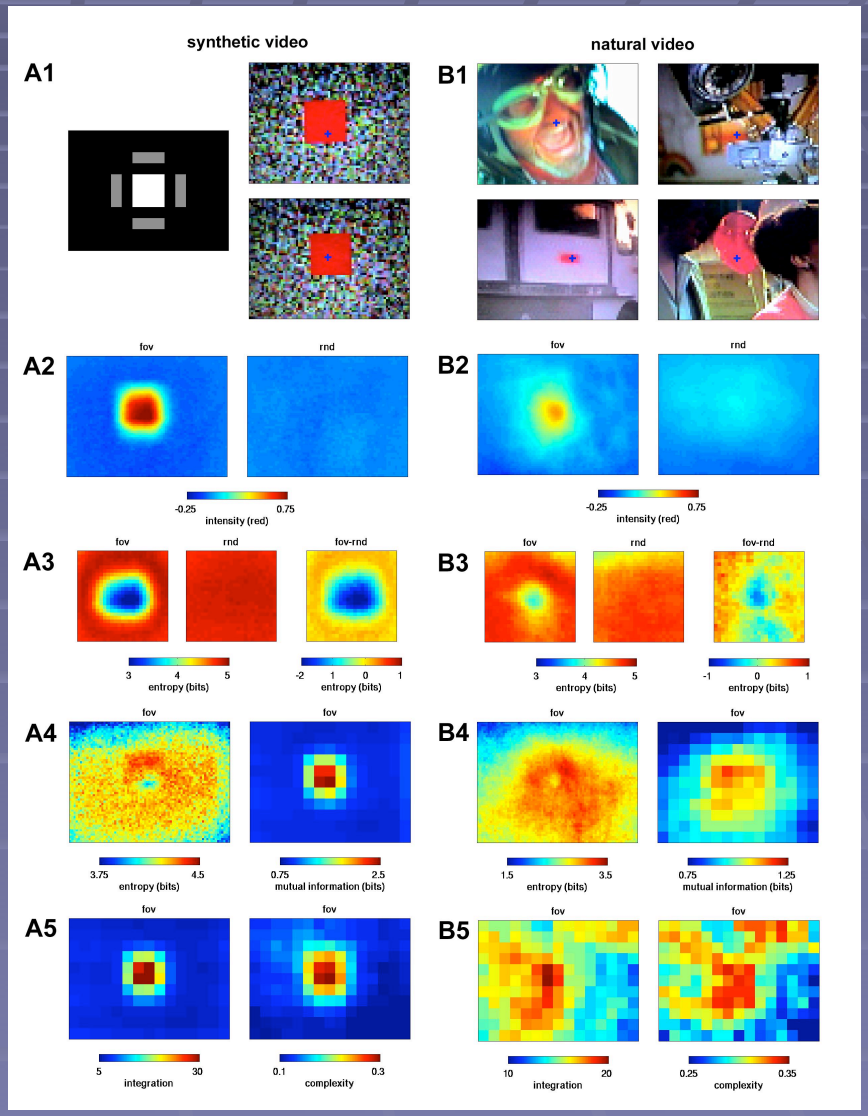
Robotic Application

- Pan-Tilt robotic system
- LCD screen displayed natural and synthetic video input
- Data downsampled etc. and Bulwinkle's saliency model used to direct foveation



Results

Same statistical pattern as synthetic though “messier”



Discussion

- Embodied agents can self-structure their information input by means of being coupled with environment
- Structure of environment can be quantitatively measured
- What about other sensory channels?
- Measures taken from living organisms

References

- Barlow, H.B. (1961). Possible principles underlying the transformation of sensory messages. In: W.A. Rosenblith (ed.) *Sensory Communication,* 217-234. Cambridge, MA: MIT Press.
- Lungeralla, M. and Pfeifer, R. (2001). Robots as cognitive tools: Information-theoretic analysis of sensory-motor data. *Proc. Of the 1st IEEE-RAS Intl. Conf. on Humanoid Robots,* 245-252.
- Dong, D.W. and Atick, J.J. (1995). Statistics of natural time-varying images. *Network: Computation in Neural Systems 6* (3), 345-358.
- Lungarella, M., Pegors, T., Bulwinkle, D., Sporns, O. (2005) Methods for Quantifying the Informational Structure of Sensory and Motor Data (in press).