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

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Intelligence

Cognitive Science: “Interdisciplinary study of intelligence, or more generally, the mind.” (Pfeiffer and Scheier 1999)

- Capacity to Adapt: includes abilities such as language, consciousness, emotion, learning/memory, etc.
- Graduated Property: not a “have” or “have not” but “how much?”

Artificial Intelligence

Synthetic vs. Analytic Approach

- Synthesis became easier with rise of fast computational and mechanical technology
- Quickly uncovers assumptions made from analysis
- Easier to isolate/pull apart system for analysis

Embodied Artificial Intelligence

- Embodied system includes:
  - Body – morphology of system and movement capabilities
  - Control Architecture – nervous system, normally adaptive and plastic.
  - Environment – all things external to the system but can include system as well.
- All 3 dynamically coupled to each other

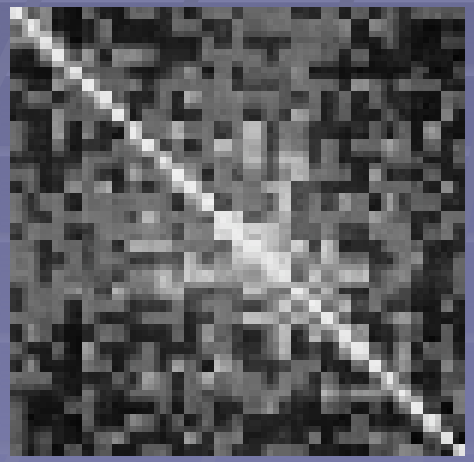
Information-Theoretical Aspects…

- Structure of input data is a fundamental principle of embodied AI.
  - The environment affects neural states but neural states also affect the environment
  - Embodied system is coupled to environment through sensorimotor interactions
- Information is recorded by neuron populations mainly through elevated firing rates and increased synchrony

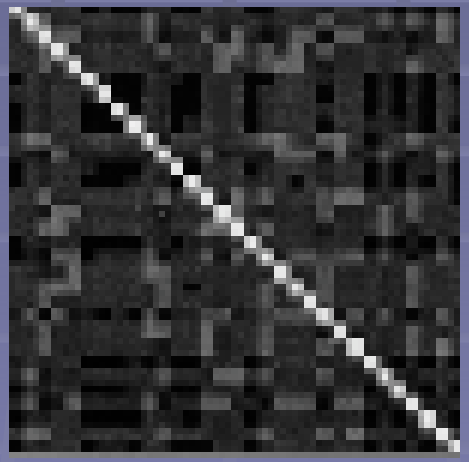
Integration/Specialization

[1] Information about stimuli in the environment needs to be efficiently extracted and mapped to *functionally specialized* neurons in the brain

[2] The information then needs to be *functionally integrated* to allow the emergence of coherent brain states that can guide behavior



RANDOM



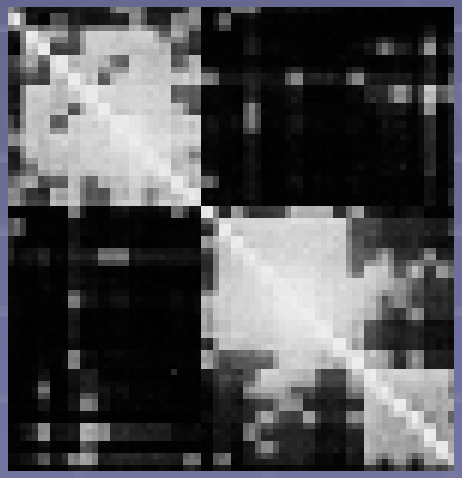
ENTROPY

INTEGRATION

Complexity

§ Networks optimized for complexity are very similar to those in real cortical connection matrices

§ Clusters, short path lengths
and short wiring lengths
§ Networks optimized for other measures have very different structures



Questions

- *Can we actually quantify sensory information in a sensorimotor system?*
- *Can we reproduce a system with high structural input through a fitness function of complexity?*
- *What is the effect of embodiment on the neuronal structure of the brain?*

References

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- Sporns, O., and Pegors, T.K. (2004) Information-theoretical aspects of embodied artificial intelligence. In: Embodied Artificial Intelligence, Iida, F., Pfeifer, R., Steels, L., and Kuniyoshi, Y. (eds.), pp. 74-85, Springer-Verlag, Berlin.
- Sporns, O., and Tononi, G. (2002) Classes of network connectivity and dynamics. Complexity 7, 28-38.