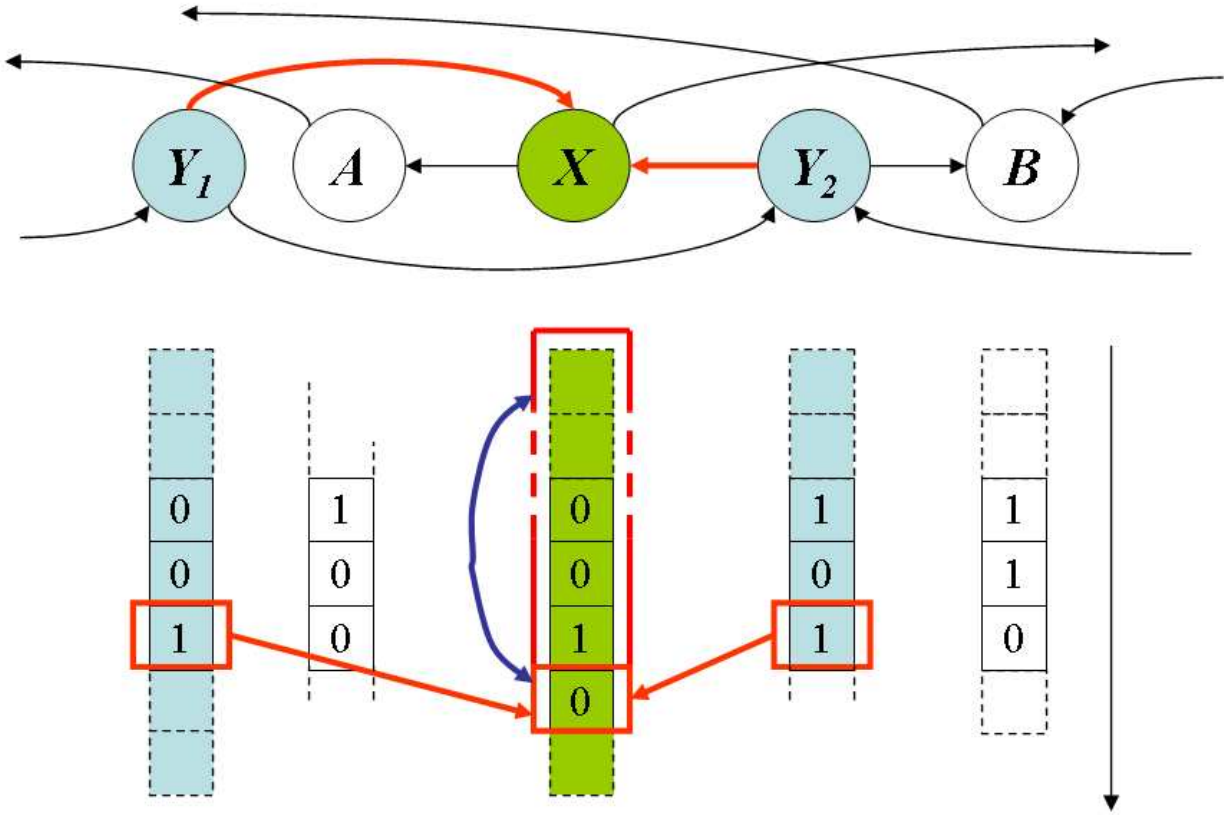


www.csiro.au

The local information dynamics of distributed computation in complex systems

Joseph T. Lizier[1,2]

Supervisors: Mikhail Prokopenko[1], Albert Y. Zomaya[2]

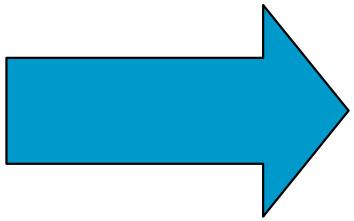
1. CSIRO ICT Centre; 2. School of IT, The University of Sydney

USyd Engineering Postgraduate conference, Sept 29 2009

CSIRO

Computation: memory, signalling, processing

- We talk about computation as:
  - Memory
  - Signalling/Comms
  - Processing



- **Goal**: quantify computation via:
  - Information storage
  - Information transfer
  - Information modification
- Distributed computation is any process that involves these features, e.g.:
  - Time evolution of cellular automata
  - Information processing in the brain
  - Gene regulatory networks computing cell behaviours
  - Flocks computing their collective heading
  - Ant colonies computing the most efficient routes to food sources
  - The universe is computing it's own future!

Complex systems

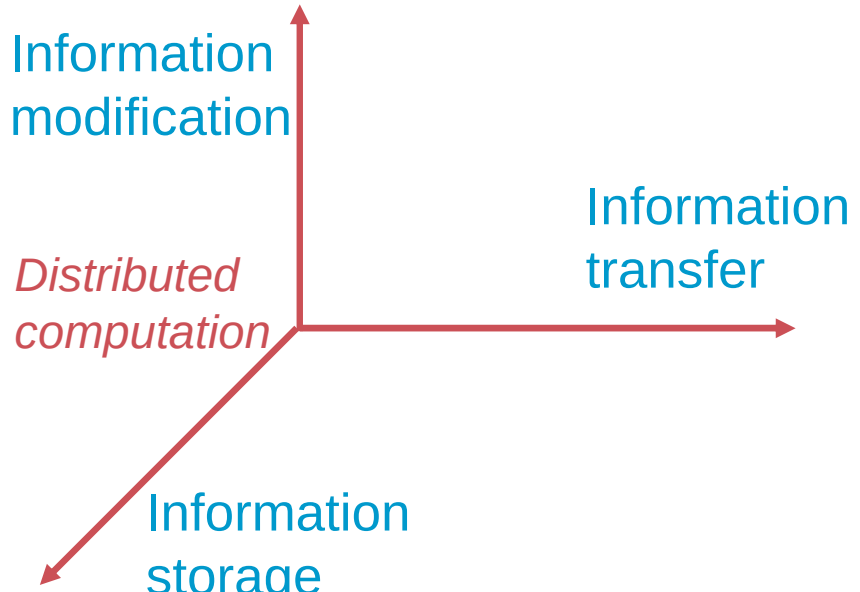
- General idea: by quantifying intrinsic computation in the language it is normally described in, we can understand how nature computes and why it is complex.

Computation: memory, signalling, processing

- We talk about computation as:
  - Memory
  - Signalling/Comms
  - Processing
- **Goal**: quantify computation via:
  - Information storage
  - Information transfer
  - Information modification
- Research aims:
  1. Quantify computation via information dynamics
  2. Understand computation in complex systems
  3. Use knowledge to design distributed computing systems

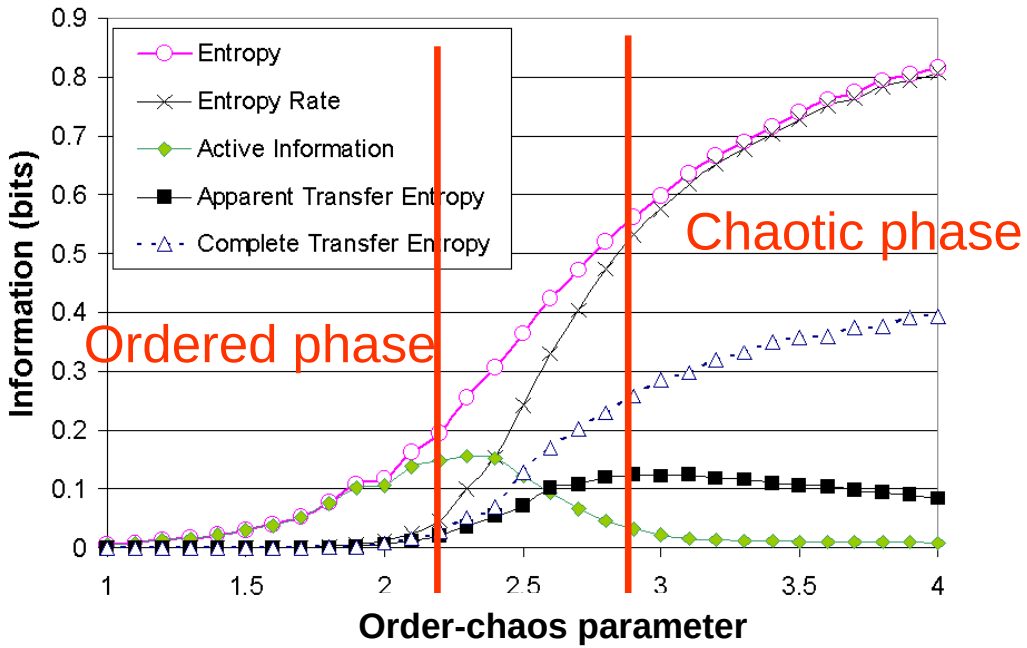
Science

Engineering



Theoretical outcomes

1. Framework for distributed computation.
2. Quantified role of emergent structure in distributed computation.
3. Compared to related concepts
4. Are computational properties are maximised in order-chaos phase transitions?



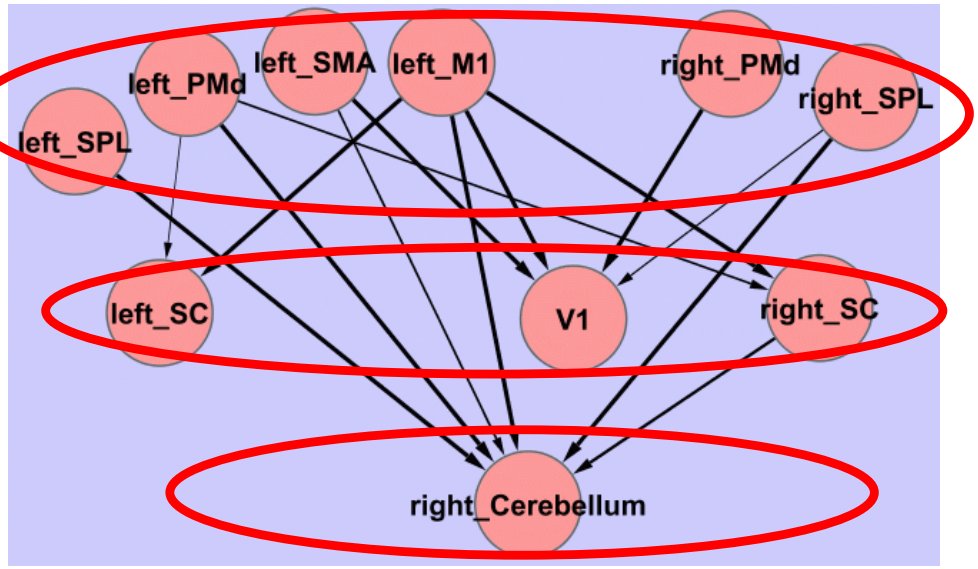
Application-oriented outcomes

1. Determining information structure in cortical activity

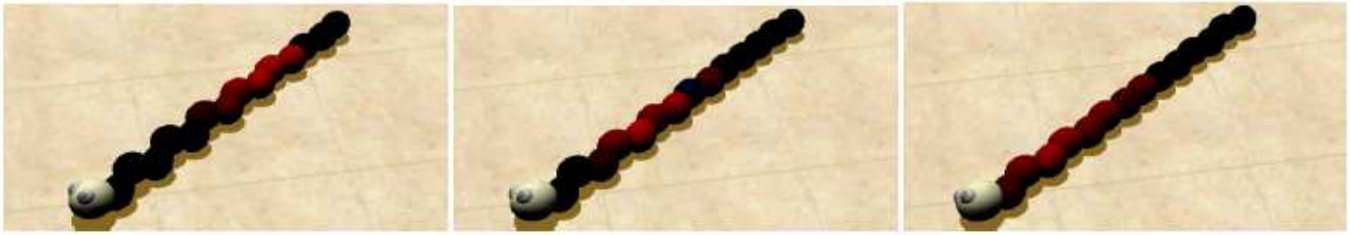
planning

perception & control

execution



2. Information structure in evolved artificial agents



3. Analysis of computation in cascading failures in power distributed networks

Conclusion

- Produced a framework for information dynamics of distributed computation.
- Framework has both theoretical and practical importance.

- Later/Future work:
  - Further application to biological systems
  - Investigate relationship between network structure and dynamics
  - Guiding design of self-organised systems

ICT Centre
Joseph Lizier
PhD Student

Phone: +61 2 9325 3167
Email: joseph.lizier at csiro.au
Web: www.ict.csiro.au

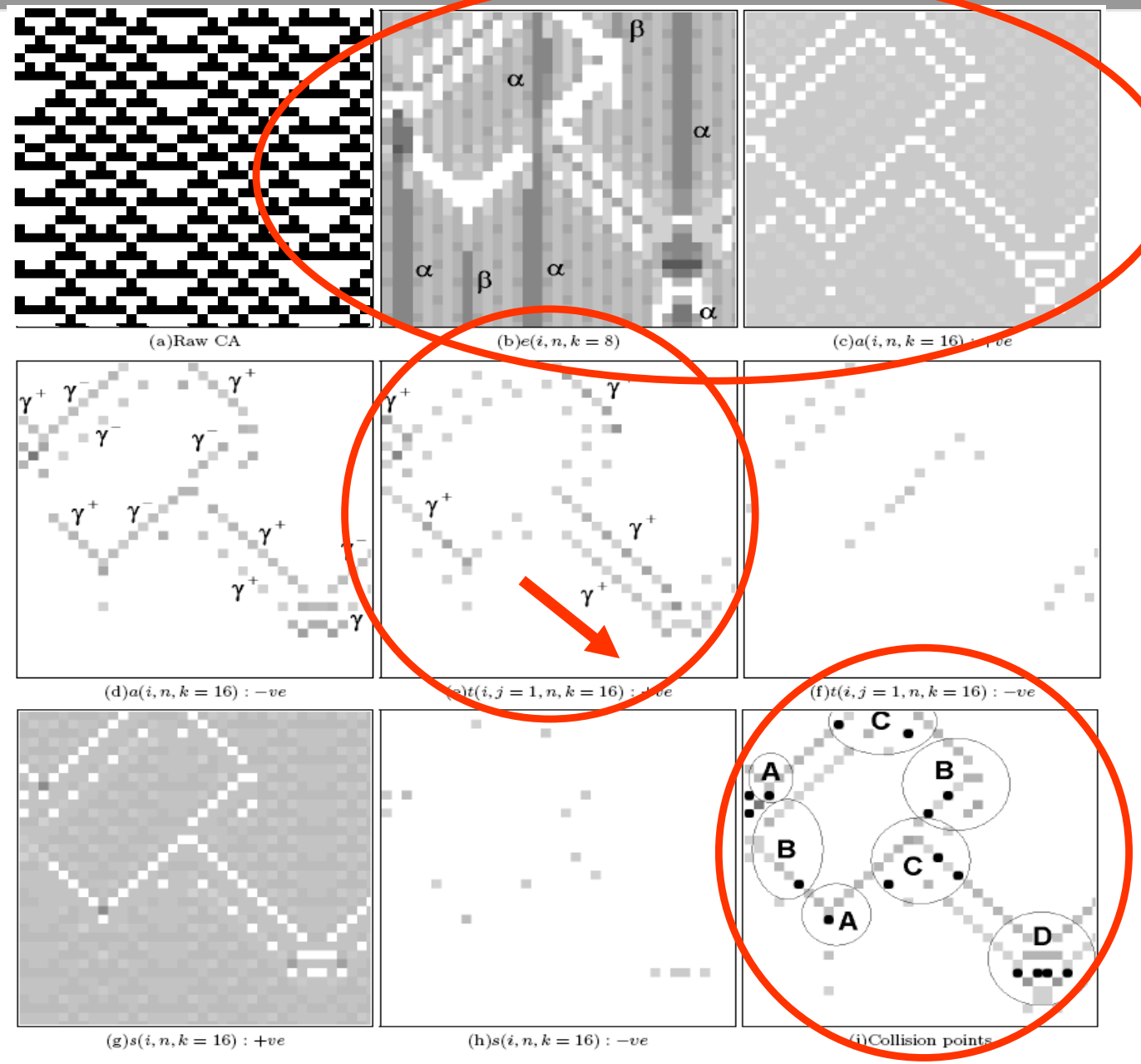
www.csiro.au

Thank you

Contact Us
Phone: 1300 363 400 or +61 3 9545 2176
Email: enquiries@csiro.au Web: www.csiro.au

CSIRO

Emergent structures in cellular automata



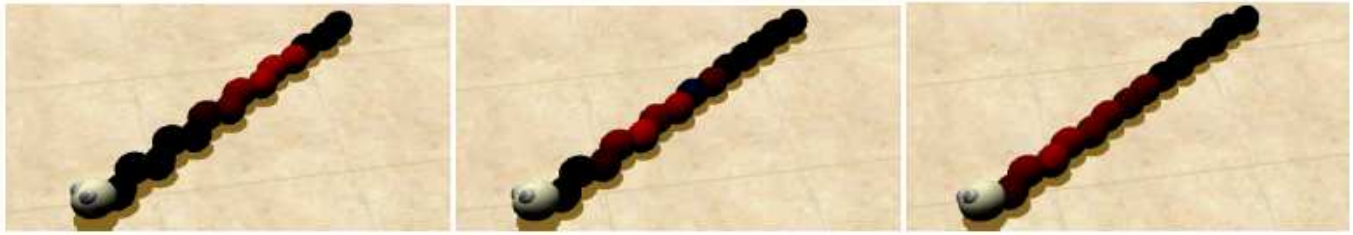
← Information storage

← Information transfer

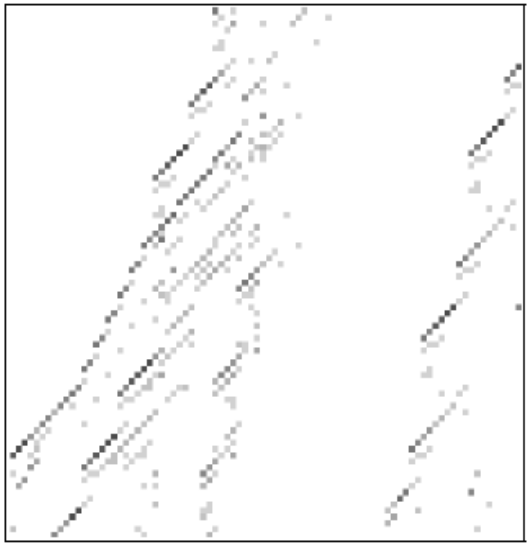
← Information modification

Results: gliders in the snakebot

Snakebot



Cellular Automata



- Coherent travelling info structures are analogous to gliders in CAs.
- **Significant** because gliders play a vital role in distributed computation in CAs.