SYSTEMIC COMPUTATION
Modelling and Analysis of Processes with Natural Characteristics

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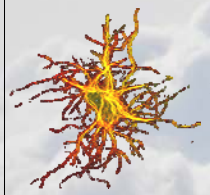
Context

Everything computes…



But:

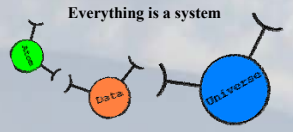
Nature computation properties	Computers computation properties
Stochastic	Deterministic
Asynchronous	Synchronous
Parallel	Serial
Homeostatic	Heterostatic
Continuous	Batch
Robust	Brittle
Fault tolerant	Fault intolerant
Autonomous	Human-reliant
Open-ended	Limited
Distributed	Centralised
Approximate	Precise
Embodied	Isolated
Circular Causality	Linear Causality
Complex	Simple



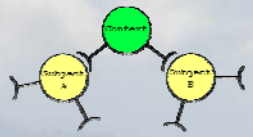

1. Systemic Computation

"A new model of Computation with Natural Characteristics based on the Systemics view"

Everything is a system

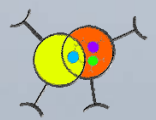


Systems interact within a context system

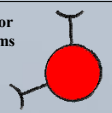


Interaction is Computation

Systems may comprise or share other nested systems



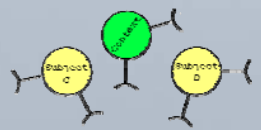
Blue, violet and green belong to Orange, blue also belongs to yellow



Interactions are constrained by the scope of systems

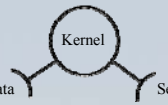
Red could only interact with yellow and orange

Systems can be transformed Never destroyed



2. Systems Management

A system has three parts (encoded in binary)



Two kinds of Systems

Non-Context systems

Contain only Data

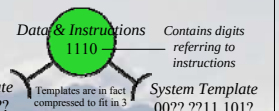
Ex:

Context systems

Contain Data, Computation Instructions and Templates of the Interacting systems

Ex:

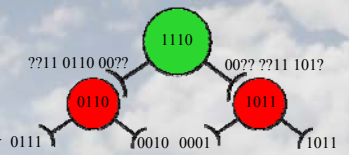
Def: '?' is a wildcard



Example of interaction:

In green the context of this computation.

In red the two interacting subjects (they can be context or not as long as they match the context's respective schematas).

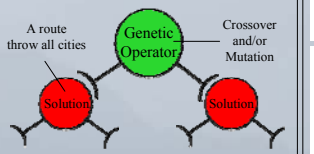


3.1 Travelling Salesman Problem

"Given a number of cities and the distance from one city to another, find the shortest round-trip route that visits each city exactly once and then returns to the city of origin."

Aim: **Developing a simple and efficient solution to the TSP using the native features of SC.**

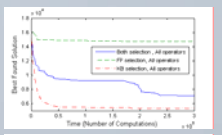
Approach: Genetic Algorithm



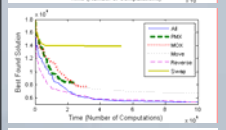
Population : N solution systems
Crossovers : PMX, OX
Mutations : Move, Reverse, Swap

Evolution two by two → No generation
Selection : Keep best, Fitness proportional

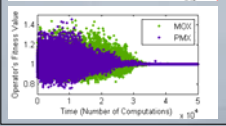
Results



Only KB selection alone enables solutions to converge in a normal manner



All operators together perform better than any used individually



Premature convergence when using crossover only

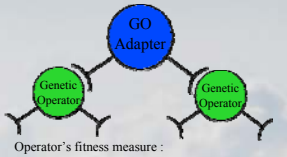
3.2 Self-Adaptive Evolutionary Ops

"When solutions interact in the right context at the right times, the speed of evolution can be increased, or the ability of evolution to continue making progress can be improved."

State: **The first experiment allows us to tune the configurations by try and error. This cannot be satisfying.**

Idea: **Evolving the genetic operators over time to better fit the evolution needs ≡ Evolving the evolvability**

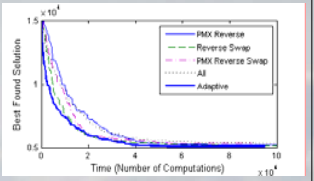
Adding a Genetic Operator Adapter



Operator's fitness measure :
parent's fitness / child's fitness

Evaluation of an operator's fitness averages it on the last W operations:
$W = A.(1-exp(-k.n))$
with n the number of computations, A and k are constants set to 1000 and 0.0001 respectively.

Results



Comparison of the adaptive method with the best tuned methods found in the previous experiment.

The adaptive version outperforms the other approaches in convergence speed all along the experiments.

4. Conclusion

"Biological computation has many significant characteristics that help give it desirable properties. Systemic computation is a model of computation that incorporates those characteristics and suggests a non-von Neumann architecture compatible with conventional hardware and able to support biological characteristics natively."

"Systemic computation is an alternative approach to computation. It may also be viewed as a method of analysis for biological systems."

This poster introduced systemic computation, its major rules and a first concrete application. This work underlies the realisation of a systemic computer as a first achievement in this project. The TSP was then chosen as a concrete complex system to analyse and study using systemic computation.

References

• Bentley, P. J. (2007) Systemic Computation: A Model of Interacting Systems with Natural Characteristics. In Adamatzky, A., Tueuscher, C. and Asai, T. (Eds) Special issue on Emergent Computation in *Int. J. Parallel, Emergent and Distributed Systems* (IJPEDS), Taylor & Francis pub., Oxon, UK. Vol 22:2. April 2007. pp. 103-121. [BE04]

• Le Martelot, E., Bentley, P. J., Lotto, R. B. (2007) A Systemic Computation Platform for the Modelling and Analysis of Processes with Natural Characteristics. In Proc of Genetic and Evolutionary Computation Conference (GECCO 2007) Workshop: Evolution of Natural and Artificial Systems - Metaphors and Analogies in Single and Multi-Objective Problems. [LEBLLOC1]