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NetBioDyn, a smart Agent-Based software to intuitively model and simulate complex biological systems

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Objectives

To facilitate the process of investigating, teaching and learning complex biological systems

- Creating realistic models and simulations of complex biological systems to investigate their dynamics and grasp complexity
- Reducing the gap between the actual programming skills of (future) biologists and most modelling software needs
- Stimulating students creativity by promoting abduction (observe, build and test hypothesis)

Proposal

To design an intuitive Agent-Based software aimed at biologists (students, teachers, researchers) to easily build and simulate complex biological mechanisms observed in multicellular and molecular systems

Modelling and teaching complex biological systems

Scientific approach

Using an Agent-Based (discrete) approach (vs. continuous)

- Focus on individuals (cells, molecules), their behaviour and their interactions, instead of population
  - Definition of local interactions leading to global emerging behaviours
  - Variability in cell population, cell differentiation
  - Easier to understand, do not require advanced mathematical skills
  - Model’s parameters are closer to the field of biology
- Design of an intuitive graphical user interface (GUI) guided by the Multi-Agent paradigm

Complex biological phenomenon

NetBioDyn

Intuitive Agent-Based GUI

Entities

Interactions & Behaviours

Environment

Self-adjusting mechanisms to calibrate the parameters of the model (test phase)

- Aiming at automatically find the proper values for all the parameters involved in a simulation
- Based on real results provided by users, obtained for example in vitro

Specific graphical user interface

- Guided by the Multi-Agent paradigm (entities, behaviours and environment)
- No need of any prerequisite or knowledge in computer programming
- Providing at any time a simplified and complete view of the system’s state (suitable external representation)

The environment is a 2D or 3D grid where entities interact according to their behaviours

- An entity occupies a whole grid cell
- Von Neumann neighbourhood: 4 neighbours in 2D and 6 in 3D
- Behaviours involving current entities are probabilistically performed at each time step

Examples of applications

Water-blood O2 exchanges in Zebra

- Investigating the efficiency of the Zebra Fish counter-current respiratory system by changing easily the flow direction

A predator-prey relationship involving two marine bacteria (Bdellovibrio and Photobacterium leiognathi)

- Emergence of interdependences and cycles between the two populations observed in real predator-prey systems

A simple autopoietic system

- 4 entities: A, B and mA and mB (produced by A and B)
- A and B entities use each other’s products (mA and mB) to multiply
- The system converges towards a balanced state

NetBioDyn, an intuitive and open-source software

http://virtulab.univ-brest.fr/

More examples of applications, tutorials and the software sources are available at http://virtulab.univ-brest.fr/