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DEPARTMENT OF COMPUTER SCIENCE

AGENT-BASED MODELLING

Introduction

- Agent-based modeling and simulation (ABMS) is an approach to modeling systems comprised of autonomous, interacting agents.
- Applications range from modeling agent behavior in the stock market, supply chains, and consumer markets, to predicting the spread of epidemics, mitigating the threat of bio-warfare, and understanding the factors that may be responsible for the fall of ancient civilizations.
- **Useful:** Why ABMS is an appropriate modeling approach for a large class of problems and has advantages over
- conventional modeling approaches in many cases,
- **Usable:** How ABMS is advancing to the point of producing portable, extensible, and transferable software, with bet-ter integrated development environments and more examples of good applications, and
- **Used:** How ABMS is being used to solve practical problems.

Why is agent-based modeling becoming widespread?

1. The systems that we need to analyze and model are becoming more complex in terms of their interdependencies.
2. Some systems have always been too complex for us to adequately model. Modeling economic markets has traditionally relied on the notions of perfect markets, homogeneous agents, and long-run equilibrium because these assumptions made the problems analytically and computationally tractable
3. data are being col-lected and organized into databases at finer levels of granularity. Micro-data can now support individual-based simulations.
4. computational power is advancing rapidly. We can now compute large-scale micro-simulation models that would not have been plausible just a few years ago

Complexity of Systems

- A complex system is a system composed of numerous elements that interact strongly with each other and with their environment.
- These interactions are often non-linear and typically involve feedback loops.
- These systems are characterized by the emergence of phenomena that are not observable at the level of their constituent elements: an external observer will perceive and understand the system differently from an observer internal to the system. Therefore, it is characterized by the emergence, at the global level, of new properties and a global operational dynamic that is difficult to predict based solely on the observation and analysis of elementary interactions.

Agent-based Modeling and Simulation

- the term "simulation." Agent-based simulation refers to a model in which the dy-namic processes of agent interaction are simulated repeatedly over time, as in systems dynamics, time-stepped, discrete-event, and other types of simulation.
- An agent-based model, more generally, is a model in which agents repeatedly interact.
- For example, when agents optimize their collective behavior through simple exchanges of information as is done in ant colo-ny optimization or in particle swarm optimization, the purpose is to achieve a desired end-state, i.e., the optimized system,rather than to simulate a dynamic process for its own sake.
- ABMS has connections to many other fields including complexity science, systems science, systems dynamics, computerscience, management science, several branches of the social sciences, and conventional modeling and simulation.
- ABMS is related to the fields of multi-agent systems (MAS) and robotics from the field of artificial intelligence (AI), as well as Artificial Life (ALife).
- ABMS is not only tied to understanding and designing "artificial" agents. Its most common use is in modeling human social and organizational behavior and individual decision-making

AGENT-BASED MODELLING USAGE

- ENT-BASED MODELLING USAGE
- There are four separated fields of real applications
- where agent-based modelling has been introduced to
- practice:
  - flow simulation;
  - organizational simulation;
  - market simulation;
  - diffusion simulation.

MODELLING PROCESS

- The beginning of modelling is initiated with assumptions about agents and their interactions.
- Dynamic consequences of these assumptions are generated by simulation.
- Each objective of agent-based modelling can be characterized by one of four successive forms:

– **empirical aim**: should be explained by repeated activities and interactions of agents. The observed result is evidenced by agents' actions that are repetitive.

– **normative aim**:ooks after exhaustive usage of well-known rules in agent-based system. This means the simulated system is seen essentially steady during its whole runtime and behaves expectable according to basic normative guidelines.

– **heuristic aim**: reveals possible hidden phenomenon in the system. Usually this spectacle outgrows basic interaction between two agents and hence influences the whole network.

– **methodological aim**:s elementary objective that can be reachable by rudimentary principles.

ADVANTAGES OF AGENT-BASED MODELLING

- Three elementary statements about agent-based modelling say that such modelling method:

1. **captures emergent phenomena:** emergent phenomenom results from mutual interactions of individual entities.
2. **provides natural system description:** makes created model more similar to reality.
3. **abounds flexibility:** They are manageable in any way user wants. Every one aspect of agents' life is controllable by attributes assigned to them.

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- **There is a lot of software aimed to simulate various systems.**

1. **Adaptive Modeler**

- Adaptive Modeler is multiple window software aimed for agent-based financial market simulation models to forecast prices.
- Real market data serves as input for the technical trading rules that are developed by adaptive form of genetic programming.
- Output can be visualized in real-time manner using two-dimensional graphics - diagrams and charts. It is distributed in free evaluation version with some restrictions against full proprietary version for research

1. **AgentBuilder**

- AgentBuilder is the integrated software tool aimed at creation of general purpose multi-agent systems.
- There are more versions to download - pro, lite and also evaluation version that is restricted to run only chosen sample agent simulations.

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- AgentBuilder consists of two major components :

1. **the AgentBuilder Toolkit** :includes tools to manage the agent-based software development process, to analyze the agent operations, to design and to develop agent communication networks, to define behaviour of individual agents and to debug and to test agent system.
2. **The Run-Time System**: provides engine to execute agent software in generated environment.

- Agents communicate using the Knowledge Query and Manipulation Language.
- According to this AgentBuilder allows the developer to define new interagent communication commands that suit his particular need.

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- **AnyLogic**
- AnyLogic describes itself as the only multiple-method simulation software that supports discrete event, agent-based and system dynamics simulation.
- Probably the biggest advantages lie in option to choose three-dimensional graphics and in use of Real Time Unified Modelling Language, what is very familiar to Unified Modelling Language standards.
- Some parts of source code can be written directly in Java and then imported into the application.
- This tool is compliant with geographic information systems too.

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- **Java Agent Development Framework**
- Java Agent Development Framework, known also under acronym JADE, is the software framework aimed at making straightforward the implementation of autonomous entities into distributed peer-to-peer applications of multi-agent

systems.

- Involvement set of graphical tools supports the debugging and deployment phases.
- This framework meets the Foundation for Intelligent Physical Agents standards.
- The configuration of agent system can e changed even during runtime.
- The whole framework is implemented in Java programming language.
- It is distributed as freeware under Lesser General Public License 2.

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- **NETLOGO**
- NetLogo is the multi-agent modelling environment originally aimed at teaching and educational purposes
- It is suitable for modelling complex system.
- NetLogo is as easy as appropriate to play for students for educational purposes or to show interesting fields of life through modelling and simulation
- One of the main advantages of NetLogo is capability of visualization. There is no need to write own source codes for visual display of agent-based system. Simulation itself is demonstrated in separate window
- NetLogo is able to demonstrate simulation in three-dimensional way. This visualization can be rotated in two axes to get better angle of view during observing.
- There is network tool to add more computers to participate on one project called HubNet. It provides management of modelling and simulation of shared project.

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- **NetLogoWindow**
- The NetLogo window consists of three tabs:
  - the Interface Tab;
  - the Info Tab;
  - the Code Tab.

The Interface Tab represents basic view of model. There are displayed all the applied components included in the opened model. There is area where the simulation itself is visualized too.

- The tab itself can be divided into three parts:
  - the ribbon;
  - the desktop;
  - the command centre.
- The upper ribbon is strip with three sections where
- following buttons:
  - the edit button;

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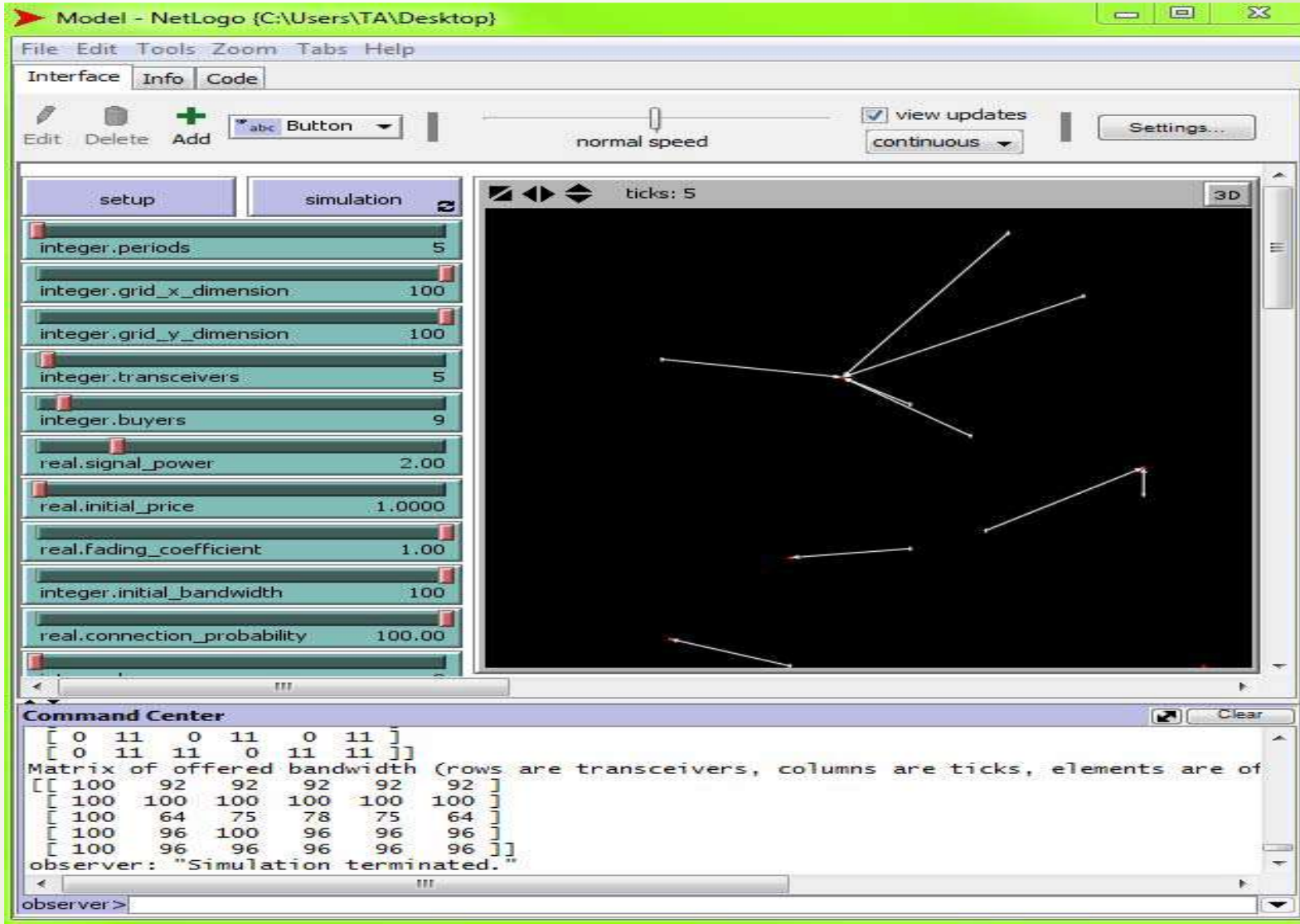
– the delete button;
– the add button;
– the component chooser button;
– the speed slider;
– the update checkbox;
– the update chooser;



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- **NetLogo Output**
- There are two options to make output from opened model in NetLogo:
  - nlogo file;
  - Java applet.

System Simulation