EUROSIM 2001: Shaping Future with Simulation

Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulation

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Aims:

To elaborate on

- the types and importance of
  - data
  - simulation
- the impact of data on simulation

Plan:

- Impact of Data: A Milestone Example
- Basic Concepts: Belief, fact, **data**, information, and knowledge
- **Where Data Matters in Simulation**
- 3 Perceptions of simulation
- Simulation and Real System: Concurrency
- Possibilities for Augmented Reality
- Levels of Perception of Simulation
- Some Advanced Types of Simulation
- Unity in Diversity

Impact of Data: A Milestone Example

From earth-centric universe to sun-centric solar system

C. Ptolemy	(100-175)	***earth-centric*** view
N. Copernicus	(1473-1543)	formulation of the ***sun-centric*** view
Tycho Brahe	(1548-1601)	relentless **observations** (**i.e., data**) of the planetary system
J. Kepler	(1571-1630)	abstraction & formulation
G. Galilei	(1564-1642)	own **observations** (**i.e., data**) and support of and fight for Copernican view

Basic Concepts: Belief, fact, data, information, and knowledge (1/4)

Belief is a hypothesis about some unobservable situation.

Beliefs do not need to be true!

Fact (1539) is what makes a belief true or false.

(from *factum* – a thing done)

Basic Concepts: Belief, fact, data, information, and knowledge (2/4)

Data (1646) plural of datum;

Data means factual information given or admitted, as measurement or statistics, to be used as a basis for reasoning, inferencing, discussion, or calculation.

Basic Concepts: Belief, fact, data, information, and knowledge (3/4)

Knowledge

- **(Russell)**: a sub-class of true beliefs.
- **(Minsky):** *justifiably true beliefs*.
- **(Hayes-Roth):** facts, beliefs, and heuristic rules.

Contradistictions: Belief, fact, data, information, and knowledge (4/4)

(Wildberger)

Data are facts.

Information is data organized for some human purpose.

Knowledge is information and how to use it.

Deciding is acting on information.

(about 150) Types of data:

- abnormal data
- abstract data
- actual data
- affected data
- alphabetic data
- alphanumeric data
- altered data
- ambiguous data
- analog data
- analog input data
- available data
- background data
- biased data
- certain data
- certified data
- complementary data
- conditional data
- confidential data
- contradictory data
- conventional data
- corrupted data
- customizable data
- discrete data ...

(about 150) Types of data:

- divided data
- domain-dependent data
- domain-independent data
- dynamic data
- dynamical data
- dynamically-changing data
- electronic data
- empirical data
- emulated data
- encripted data
- endogenous data
- evidential data
- exogenous data
- external data
- externally defined data
- externally described data
- externally generated data
- factual data
- formatted data
- global data
- heterogenously stored data
- hidden data
- hierarchical data ...

Where Data Matters in Simulation:

To have meaningful and credible results from a simulation study, one must have relevant and correct data.

datasets need to be reliable, validatable, auditable, and replaceable.

Data may be needed in *several phases* of a simulation study:

- to formulate a model (parameter fitting and calibration);
- to formulate an environment (static or dynamic)
- to validate/verify model and experimental conditions
- to generate *model behavior* (*initial conditions*, *parameters*)

3 Perceptions of simulation: (1/11)

"Simulation" is derived from Latin "***simulacre***".

"Simulation" has 3 images:

- **non-scientific view**
- **scientific view**
- **military perception**

3 Perceptions of simulation: (2/11)

- non-scientific view

"Simulation" means fake, a sham object, counterfeit, or imitation. (used since 14th century)

Examples: simulated leather, simulated pearl

There is a *confusion of the terms* simulation and emulation.

Emulation means: "ambition or endevour to equal or excel others (as in achievement).

Example: a child may emulate her parents; and by doing so she does not simulate them. (However, her behaviour, not being the innate one, may be considered imitation or fake.)

3 Perceptions of simulation: (3/11)

- scientific view

"Simulation" is goal-directed experimentation with dynamic models.

When the experimentation cannot or should not be done on the real system, one can perform it using a dynamic model and hence ***use simulation***.

"**Simulation**" is the contemporary *sine qua non* technique of Francis Bacon's (1561-1626) scientific method which is based on experimentation. (as advocated in his *Novum Organum* published in 1620.)

3 Perceptions of simulation: (4/11)

- scientific view

"Until we attempt to simulate a system, we don't realize how little we know* about it"

Donald Knuth

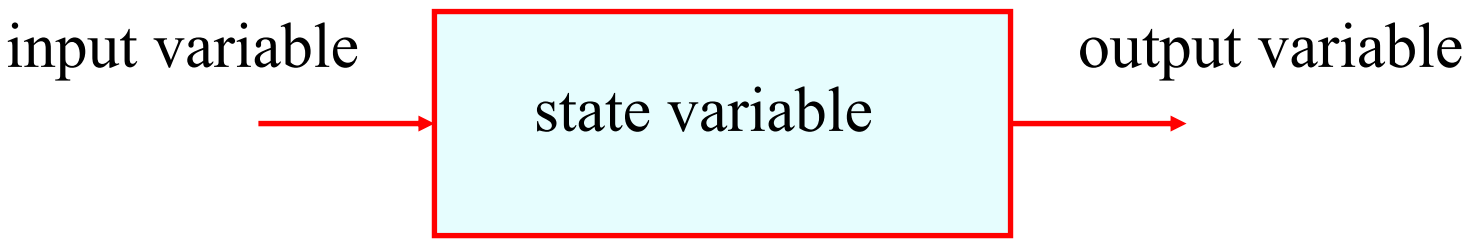
* both the **dynamics** and

the **relevant parameters** (i.e., data)

3 Perceptions of simulation: (5/11)

- scientific view

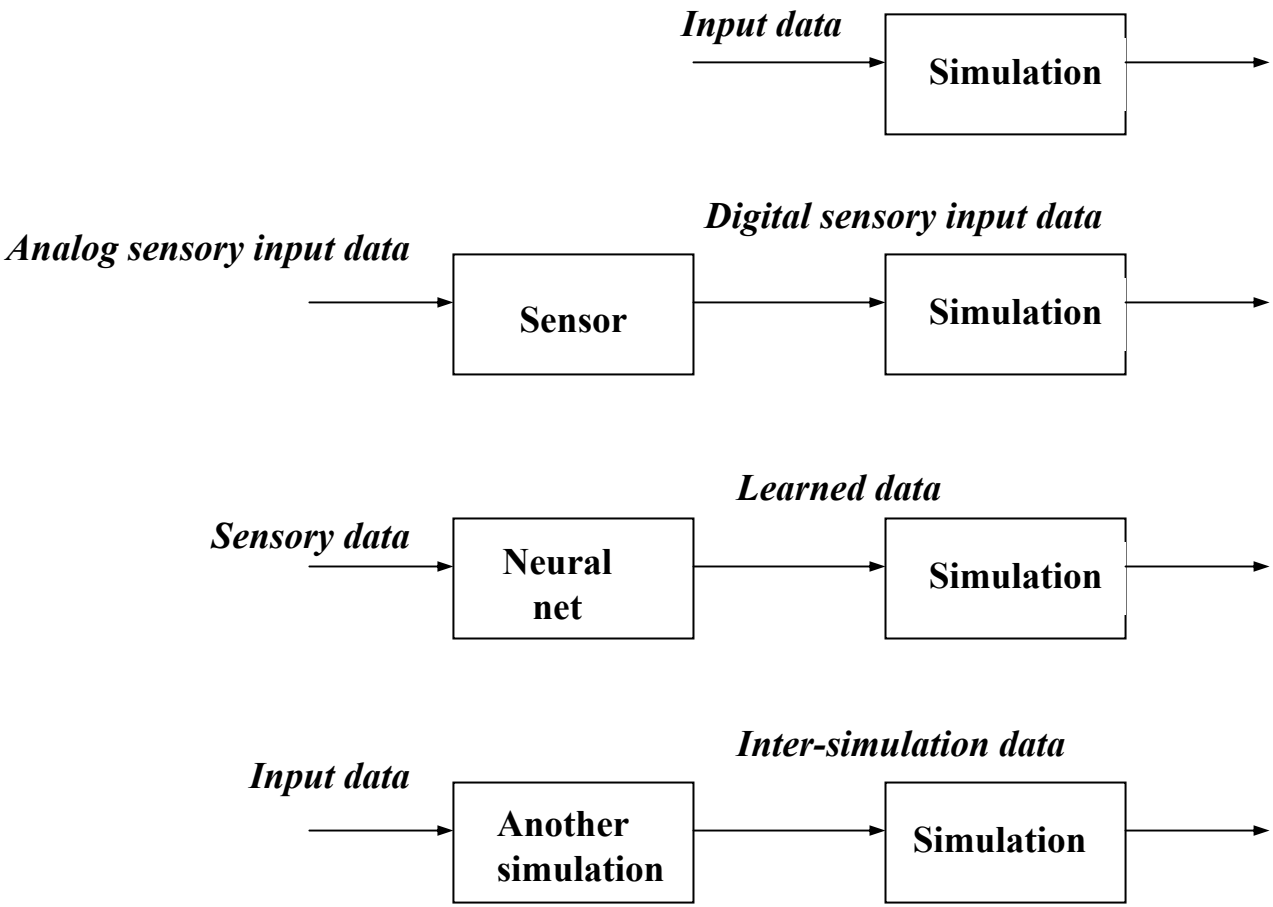
-(from a systemic point of view) simulation can be used to find the values of **output**, **input**, or **state variables** of a system; provided that the values of the two other types of variables are known. (W. Karplus, 1976).



3 Perceptions of simulation: (6/11)

- scientific view

Type of problem:	Find	Given		
Analysis	Output	input	state	
Design	State	input		output
Control	Input		state	output



Types of Simulation Input Data

3 Perceptions of simulation: (8/11)

- military perception

Military perception of simulation can be summarized as "***All but war is simulation.***"

3 types of military simulation:

- Live simulation
- Constructive simulation
- Virtual simulation

3 Perceptions of simulation: (9/11)

- military perception: Live simulation

In **live simulation**, experimentation is performed with simulated (fake) ammunition and real system acting in real environment.

In *live simulation,* real people and real equipment are both augmented with special sensors to act as target designators.

Live simulation can best be conceived as a special case of augmented reality simulation.

3 Perceptions of simulation: (10/11)

- military perception: Constructive simulation

Constructive simulation is war gaming.

Forces, equipment, and environment are represented by models.

At decision points, decision makers inject their decisions to the simulation system.

Constructive simulation fits to the scientific definition of simulation with war gaming connotation.

3 Perceptions of simulation: (11/11)

- military perception: Virtual simulation

***Virtual* simulation** is military simulation where *virtual* equipment –namely, a physical model of the system– is used for training purposes.

In non-military applications the term **simulator** is used when a physical model of the system is used.

When the physical model has a man-in-the-loop, simulators are used for training purposes.

Virtual simulation fits to the scientific definition of simulation with simulator connotation.

Simulation and Real System: Concurrency (1/9)

2 possibilities:

- Stand-alone simulation

- On-line simulation

Simulation and Real System: Concurrency (2/9)

Stand-alone simulation

Stand-alone simulation is use of simulation independent of the real system.

There are 3 **purposes**:

- Pure experimentation
- Training to develop skill in the use of hardware
- Training to enhance decision making skill

Simulation and Real System: Concurrency (3/9)

Stand-alone simulation:

Pure experimentation

Most common purpose in the use of simulation for both civilian and military applications.

This type of usage supports design, analysis, control, planning, logistic operations, simulation-based acquision, and simulation-based evaluations of products and processes.

Simulation and Real System: Concurrency (4/9)

Stand-alone simulation

Training to develop skill in the use of hardware

A human operator uses a virtual equipment (a simulator) to develop skills to use the equipment.

This usage corresponds

- to **simulators** (in civilian applications) and
- to **virtual simulation** (in military applications).

Simulation and Real System: Concurrency (5/9)

Stand-alone simulation

Training to enhance decision making skill

This type of usage is done by ***gaming simulation***.

In civilian applications: ***business games***

In military applications: **war games, conflict management simulation, and peace support simulation**

Simulation and Real System: Concurrency (6/9)

On-line simulation

On-line simulation is use of simulation concurrently with the real system.

There are 3 goals of usages:

- To support the operations of the real system
- To foster on-line diagnosis
- To augment reality

Simulation and Real System: Concurrency (7/9)

On-line simulation

To support the operations of the real system

Simulation can provide **predictive displays**.

Simulation and Real System: Concurrency (8/9)

On-line simulation

To foster on-line diagnosis

- Run real system and simulation concurrently and compare their behaviors.
- A **difference** may indicate **a mulfunction** of the real system.

Simulation and Real System: Concurrency (9/9)

On-line simulation

To augment reality

In **augmented (or mixed) reality simulation,** real and virtual entities (that can be people or equipment) and the environment can exist at the same time.

Hence, operations can take place in a richer *augmented reality environment*.

Reality is a special case of simulation!

Possibilities for Augmented Reality

	Real equipment	Virtual equipment
Real operator	**- Live simulation** (a human operator uses *virtual* guns)	**- Simulators** **- Virtual simulation**
Virtual operator	**- Automated vehicles** (auto pilot, aircraft wo pilot; vehicle wo driver)	e.g., **an AI aircraft**

Levels of Perception of Simulation: (1/4)

3 levels: simulation as

- a computational activity
- a model-based activity
- a knowledge generation activity

Levels of Perception of Simulation: (2/4)

Simulation as a computational activity

The emphasis is on the generation of model behavior.

(Conventional simulation)

All issues of **input data** and **initialization** are applicable.

Levels of Perception of Simulation: (3/4)

Simulation as a model-based activity

In addition to generation of model behavior, computer-aided modelling, model-base management, parameter-base management, and symbolic processing of models are considered.

The role of data in modelling and parameter-base management is primordial.

Levels of Perception of Simulation: (4/4)

Simulation as a knowledge generation activity

The definition of simulation can be interpreted as follows: Simulation is model-based experiential knowledge generation.

This abstraction facilitates the synergy of simulation with other knowledge generation techniques: Optimization, statistical inferencing, reasoning, hypothesis processing.

Some Advanced Types of Simulation: (1/4)

- Federated simulation
- Agent-directed simulation
- Holonic simulation
- Holonic agent simulation

Some Advanced Types of Simulation: (2/4)

Federated simulation

This is an example of interoperability of several simulation studies each called a federate.

Current realization relies on HLA (High Level Architecture).

A specific **example** of the role of data in federated simulation:

Reduction (minimization) of data exchange requirements between federates.

Some Advanced Types of Simulation: (3/4)

Agent-directed simulation

3 possibilities:

- *Agent simulation*

  (simulation of entites represented by agents)

  (challenges to quantify motivation and autonomy)

- *Agent-based simulation*

- *Agent-supported simulation*

Some Advanced Types of Simulation: (4/4)

Holonic simulation and **holonic agent-simulation**

Holonic systems are excellent candidates to conceive, model, control, and manage **dynamically organizing cooperative systems**.

A holonic system is composed of autonomous entities (called **holons**) that can deliberately reduce their autonomy, when need arise, to collectively achive a goal.

Unity in Diversity

A view of the topics of the invited presentations at the EUROSIM 2001 Congress

- Art of simulation, Emerging trends*

Methodologies/techniques:

Application areas:

Impact of data on simulation

*** We shall find a way or we shall make one!**

Unity in Diversity

A view of the topics of the invited presentations at the EUROSIM 2001 Congress

- Art of simulation, Emerging trends*

Methodologies/techniques:

- Validation
- Sim environments with adaptive behavior
- Visualization / animation

Application areas:

- Societal models
- Atmospheric modelling
- Integrated water management

Impact of data on simulation

*** We shall find a way or we shall make one!**

We Have Seen:

- Impact of Data: A Milestone Example
- Basic Concepts: Belief, fact, data, information, and knowledge
- **Where Data Matters in Simulation**
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