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Grand Challenges in Modeling and Simulation: What M&S can do and what we should do for M&S?

http://www.site.uottawa.ca/~oren/pres/2020-CCCI.ppsx
- Most early challenges became past features, after some time lags.

- Some very early challenges are part of the folklore of M&S; despite strong initial opposition. (An example to follow)

- Some challenges are still not met. (I will refer to some of them)
Some very early challenges are part of the folklore of M&S; despite strong initial opposition. (An example to follow)

1980 June 25-27, Interlaken, Switzerland
International Symposium on Simulation - SIMULATION '80
Keynote paper: Computer-Aided Modelling Systems*


*At the conference, a simulationist strongly criticized the idea!
No progress is ever possible by keeping the status quo!

Emulate nature; keep blooming!
He that would perfect his work must **first sharpen his tools**.

Confucius, 551 – 479 BC

Hence, we may hope to find solutions to more complex problems by advancing M&S concepts, methodologies, technologies, and **using them ethically and wisely**.
Our activities should serve a worthwhile goal.

However, even (and especially) our goals need to be scrutinized.

Peter Drucker (1909 – 2005):

“Efficiency is doing things right; effectiveness is doing the right things.”

We may aim:

to be efficient while being effective.
Why we need to see the Big Picture of the M&S:
- For practitioners
- For methodologists and other professionals

• We also need to consider & contrast short- and long-term needs:
  • Example: in an operating room
    - Short term (immediate) need
    - Long term developments
      (the need & importance to start ahead of time)

From:
Invited talk at SIREN: M&S & Interoperability (on September 27, 2010)
DIPTEM, University of Genoa, Savona, Italy.
"Simulation: The Big Picture - A Comprehensive and Integrative View"
A recap: **Aspects** of M&S (Modeling and Simulation)

1. **Experimentation**
2. **Experience**
   - to gain / enhance 3 types of **skills**
     - motor skills
     - decision making skills
     - operational skills
   - for **entertainment**

**Imitation**

**From:**

A recap: **Aspects** of M&S (Modeling and Simulation)

**Imitation:**

**Etymology – Simulation:**
Since mid 14\textsuperscript{th} century
From: Latin: “simulare” (**imitate**); “similis” (**like, resembling**)

(On-line Etymology Dictionary)

**Imitation (purpose):**

(-): → fake
(+): → simulated leather, simulated pearl
The concept “similitude” provides a very rich paradigm:


Appendix 1.1 – Terms related with similitude
Under 14 categories:
### Appendix 1.1 – Terms related with similitude (Under 14 categories)

1. Simulation concept
2. Model
3. Analogy
4. Imitation
5. Behavioral similarity
6. Functional similarity
7. Similarity in mathematics
8. Similarity in linguistics
9. Similarity in literature
10. Similarity in art
11. To be similar
12. Indistinguishableness
13. Disguise similitude under a false appearance
14. Non-similarity
A recap: Aspects of M&S (Modeling and Simulation)

1. Experimentation
2. Experience
   - to gain / enhance 3 types of skills
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   - for entertainment


"Simulation is performing goal directed experiments with models of dynamic systems."


“Simulation is used for:
- behavior prediction and performance analysis;
- analysis of alternatives;
- sensitivity analysis;
- engineering design;
- virtual prototyping;
- planning;
- acquisition; and
- proof of concept.”

"Simulation is providing experience under controlled conditions for training, i.e., for gaining/enhancing competence in one of the three types of skills:

(1) motor skills (virtual simulation),
(2) decision and/or communication skills (constructive simulation; serious game), and
(3) operational skills (live simulation)."

From:
Entertainment
- gaming simulation

"Simulation is providing experience for entertainment purpose (gaming simulation).
Some aspects of gaming simulation make it a source of inspiration for serious games used for training purposes. These include advanced visualization techniques and specification of environments and scenarios."

1. Previous grand challenges
   1.1 By colleagues
   1.2 By Tuncer Ören

2. Can we enhance M&S to make it:
   2.1 more powerful?
   2.2 more reliable?

3. What M&S can do?
   3.1 Existing possibilities
   3.2 Are there application areas which could benefit from M&S?
1. Previous grand challenges

1.1 By colleagues

1.2 By Tuncer Ören


1. Previous grand challenges

1.1 By colleagues

1.2 By Tuncer Ören
(Normative views, future, directions to explore)


Simulation programming languages → Model specification languages (and generation of simulation programs by program generators)


Grand Challenges in Modeling and Simulation:

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Some useful possibilities may be synergy of simulation with:
- **computational awareness**

As part of synergy of **machine intelligence and simulation**. Along with:
- intelligent agents and simulation
- machine learning
- machine understanding
  - emotion understanding
Some useful possibilities may be synergy of simulation with:
- nature inspired modelling and nature-inspired computation.

Holonic simulations may be helpful to appreciate how cooperation can be useful to solve problems.

“Cooperation is becoming an important paradigm for both civilian and military applications. 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 achieve a goal. A **holonic agent** is a multi-agent system where each agent (called a holon) acts with deliberately reduced autonomy to assure harmony in its cooperation in order to collectively achieve a common goal.”

Integrated use of simulation to support real systems:

- For predictive displays
- For on-line diagnosis abilities

From: Ören, T. (2004). Invited Presentation: **Growing Importance of Modelling and Simulation**: Professional and Ethical Implications, at: EPUM (Ecole polytechnique Universitaire de Marseille), Departement du Genie Industriel et Informatique, Universite de Provence-Aix-Marseille I, September 15, Marseille, France. ([presentation](#))
Predictive displays

During the operation of a real system, a simulator of the system,

- gets the time-varying information about the environment of the system, directly through sensors and A/D convertors,
- gets the values of the control variables, from the system through transducers, and
- displays the predicted state (trajectory) of the system.
By using a predictive display,

Decision maker/operator can base his/her decision(s) on:
- **system characteristics**
  (as represented in the model) and
- **facts** as generated by the simulator;

Instead of using an undocumented mental model.
On-line diagnosis abilities can be provided by comparing the outputs of the real system and the simulator working under same conditions.

A discrepancy may indicate a misfunction of the system.
3. Can we enhance M&S to make it:
   3.1 more powerful?
   3.2 more reliable?

In modeling and simulation studies:
- Validation & Verification
- Quality Assurance (QA)
- Failure Avoidance (FA)*

Some Sources of Failures in M&S

Common mistakes in
- modeling
- experimentation
- computerization
- project management
- expectations of users

Multi-paradigm approach for successful M&S projects

V&V Paradigm
QA Paradigm
Failure Avoidance Paradigm for
- M&S
- agent-based modeling
- rule-based systems
- autonomous systems
- agents with personality, emotions, and cultural background
- input (externally generated, internally generated)
- systems engineering
A coalition of M&S companies committed to **ethical conduct** would be useful.

MSII (Modeling and Simulation Industry Initiative)

**Defense Industry Initiative**
On Business Ethics and Conduct (DII) (USA)

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3. What M&S can do?
   3.1 Existing possibilities
   3.2 Are there application areas which could benefit from M&S?
3. What M&S can do?

3.1 Existing possibilities

3.2 Are there application areas which could benefit from M&S?

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<tr>
<th>Simulation Types</th>
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<td>peer-to-peer simulation</td>
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<td>perceptual simulation</td>
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<td>petascale simulation</td>
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<td>Petri net simulation</td>
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<td>physical simulation</td>
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<td>process-based discrete event simulation</td>
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Upgrading from model-based activities to simulation-based activities has all the advantages that simulation can provide.

3. What M&S can do?
   3.1 Existing possibilities
   3.2 Are there application areas which could benefit from M&S?

“Would you tell me, please, which way I ought to go from here?”

“That depends a good deal on where you want to get to,” said the Cat.

“I don’t much care where —” said Alice.

“Then it doesn’t matter which way you go,” said the Cat.

"— so long as I get somewhere,“ Alice added as an explanation.

"Oh, you're sure to do that," said the Cat, "if you only walk long enough."

Alice’s Adventures in Wonderland (1865)
Lewis Caroll (Pen name of Charles Lutwidge Dodgson (1832-1898)
English author, mathematician, logician, Anglican deacon and photographer.)
(from Wikipedia)

From: Ören, T. (2010). (Keynote speech at the awards banquet), Old Dominion University, VMASC
M&S can be useful for **fact-based rational decision making**!

**Experience** is very valuable in fact-based rational decision making.
- on-the job
- using simulation / simulators

Pilots get their experience
- using simulators (a vital type of experience)
- on-the-job (and become seasoned pilots)

**Social systems** are much more complex than aircrafts!
Hope one day, similar to training of pilots on simulators, education/training of public decision makers (including those at the highest levels) will include experience with predictive displays based on simulation and multisimulation.

Thank you for your attention!