
Verification and Validation of Simulation Models – The Roles of Theory, Experimentation and Observation

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SIMULATION

Simulation – Broader View

- *Denn was ist Denken anderes als Simulation?*
Thomas Junker, *Die Evolution des Menschen*, Verlag C.H. Beck, München, 2006, pp 53-54.
- *... probeweises Handeln mit kleinen Energiemengen, ähnlich wie die Verschiebung kleiner Figuren auf der Landkarte, ehe der Feldherr seine Truppenmassen in Bewegung setzt*
Sigmund Freud, GW 15 (1933), p96

Simulation – Technical View

- *Produce a computer model of a process*
The Concise Oxford Dictionary, 8th Ed., 1990
- *Analisi di un fenomeno, di un processo, o di un sistema effettuata attraverso la costruzione di un modello matematico che lo simuli*
Dizionari Garzanti – Italiano, Prima edizione, 1994

Simulation – My View

- **What is our purpose?**
*We would like to understand a **natural/technical process** in order to **predict** the behavior of **a system** AND to take measures to **optimize** the result of such a process.*
- **What do we mean by prediction?**
The intention is not to exactly predict the future but to get a better understanding of the behavior both quantitatively and qualitatively.
- **What do we mean by system?**
A system is some structure that is too complex to be easily understood.
- **What do we mean by optimizing?**
Optimization is the process of minimizing or maximizing a given set of qualities under certain boundary conditions.
- **What do we mean by simulation?**
Simulation ***describes** natural/technical processes in a computer program and **computes** the results.*

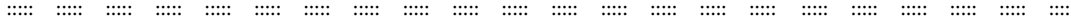
Can Simulation Fail

- “Social” Simulation
 - Financial markets 2008?
 - Love Parade 2010?

Was unter Menschen geschehen wird, die, wie man sagt, ihre Taten nicht nach den Naturgesetzen einrichten, ist nicht berechenbar.

Peter Handke, Die Hornissen, Suhrkamp, 1965, p230

- Technical Simulation
 - A380: Engines?
 - Boeing 737: Fuselage parts?



VERIFICATION & VALIDATION

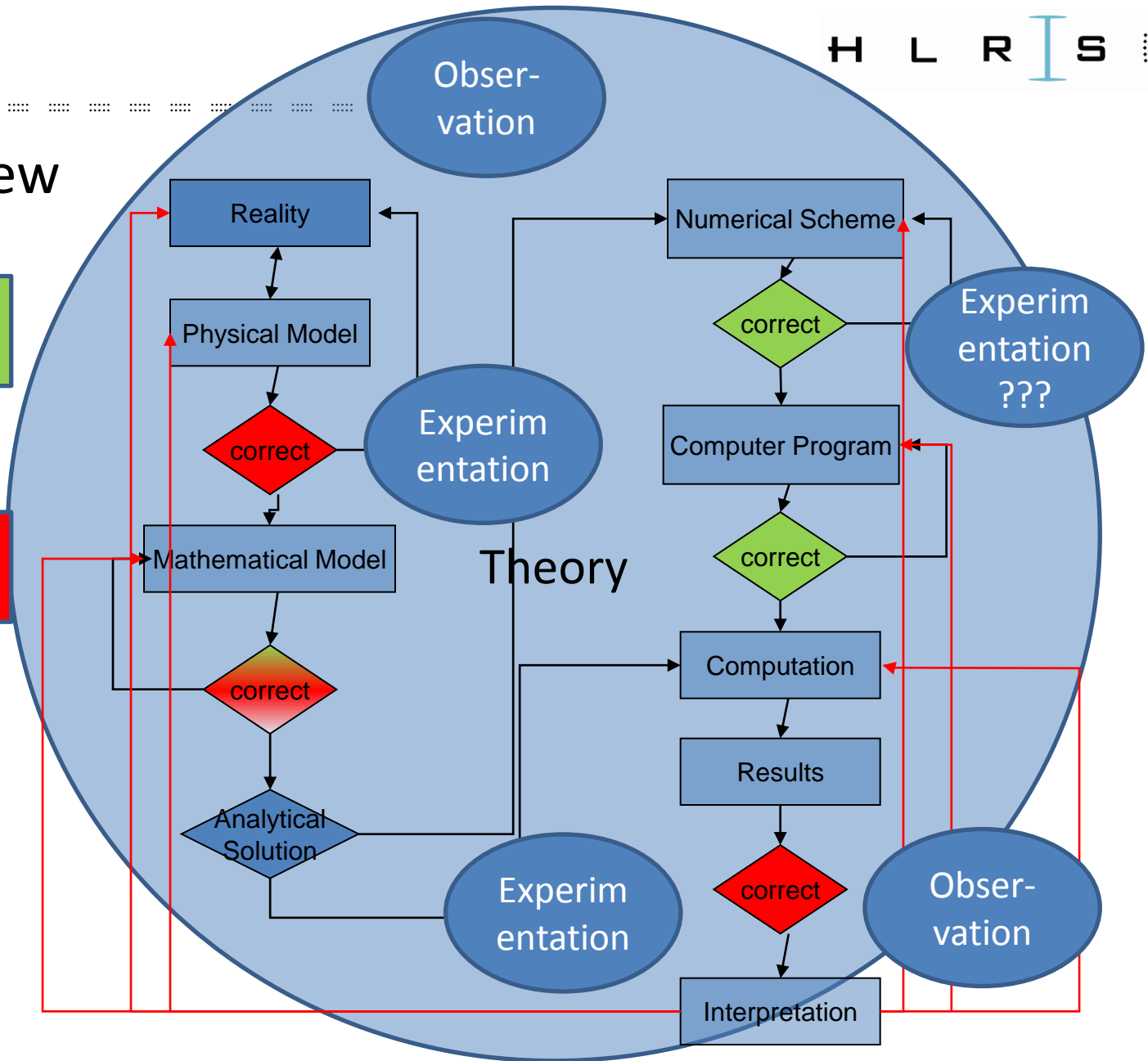
Definitions

- **Verification:** ... *on this conception, is the process of determining whether or not the output of the simulation approximates the true solutions to the differential equations of the original model.*
- **Validation:** ... *on the other hand, is the process of determining whether or not the chosen model is a good enough representation of the real-world system for the purpose of the simulation. (all emphasis M.R.)*
- Eric Winsberg, *Science in the age of computer simulation*, The University of Chicago Press, 2010, pp 19-20

Process View

Verification

Validation



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RESULTS & INTERPRETATION VS. VERIFICATION & VALIDATION

Ways of Interpretation

- Which questions did we ask?
- Which answers do we expect?

... a good enough representation of the real-world system for the purpose of the simulation.

- What shape/form does the answer take?
 - Numbers
 - Diagrams
 - Pictures (gathered data / geraffte Zahlen)
 - Movies
 - Virtual Reality

Various Considerations

- Thomas Theorem: *If men define situations as real, they are real in their consequences* (W. I. Thomas & D.S. Thomas, *The Child in America*, 1928, p 572)
- Felicitous Falsehoods: *Understanding is often couched in and conveyed by symbols that are not, and do not purport to be, true. Where such symbols are sentential, I call them felicitous falsehoods.* (Catherine Z. Elgin, *True Enough*, *Philosophical Issues*, 14, *Epistemology*, 2004, p 116)

... and furthermore most simulated worlds ...

- ... are too small to be validated by experiments (e.g. nanotechnology)
- ... are too big to be validated by experiments (e.g. world climate)
- ... last too long to be validated by experiments (e.g. black hole collision)
- ... last too short to be validated by experiments (particle collision)
- ... are too dangerous to be validated by experiments (e.g. Tschernobyl)
- ... are too expensive to be validated by experiments (e.g. plane crash)

- **Generally speaking:** The space of systems for which we can do simulations and can validate them doing experiments is much smaller than the space of systems for which we can not do any experiments

Questions

- What do we (human beings) do when we simulate?
 - How do we go through a modeling chain?
 - What are the consequences of such a modeling chain?
 - Does it make sense to simulate what can never be validated?
 - Does it make sense to talk about “numerical experiments”?
- What happens when we interpret simulation results?
 - What is the physiological reaction?
 - What is the framework in which we interpret?
- What happens when technical simulation becomes “public”?
 - What happens when simulation moves from the „expert“ to the „lay person“?
 - What is the “truth” in a simulation?
 - What if we disagree?

Issues

- Technical
 - The scientific and technical understanding of global systems is rudimentary
 - Models are usually not developed for global but for local systems
- Societal
 - We need to find ways to transfer output of simulations to the society
 - We need to find ways to transfer output of simulation into the political decision process keeping the uncertainties in mind and not overextending the meaning of our results

Questions?

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