Aachen Summer Simulation Seminar 2014

Lecture 08

Model Testing (Verification and Validation)
Experimentation Preparation

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Motivation

- Model Testing (Verification and Validation)
  - Understanding the importance of model testing
  - Linking model testing to the process of performing a simulation study
  - Raise awareness for pitfalls and difficulties in model testing

Introductory Remark

- In this lecture we focus on DES verification & validation
  - Robinson (2004) Chapter 10 and 12
- More about SD verification & validation
  - Barlas (1996)
- More about ABS verification & validation
  - Midgley et al (2007)

Verification and Validation

- Model testing (verification and validation)
  - Required to place confidence in a study's results

Model testing is not a process of trying to demonstrate that the model is correct but a process of trying to prove that the model is incorrect!

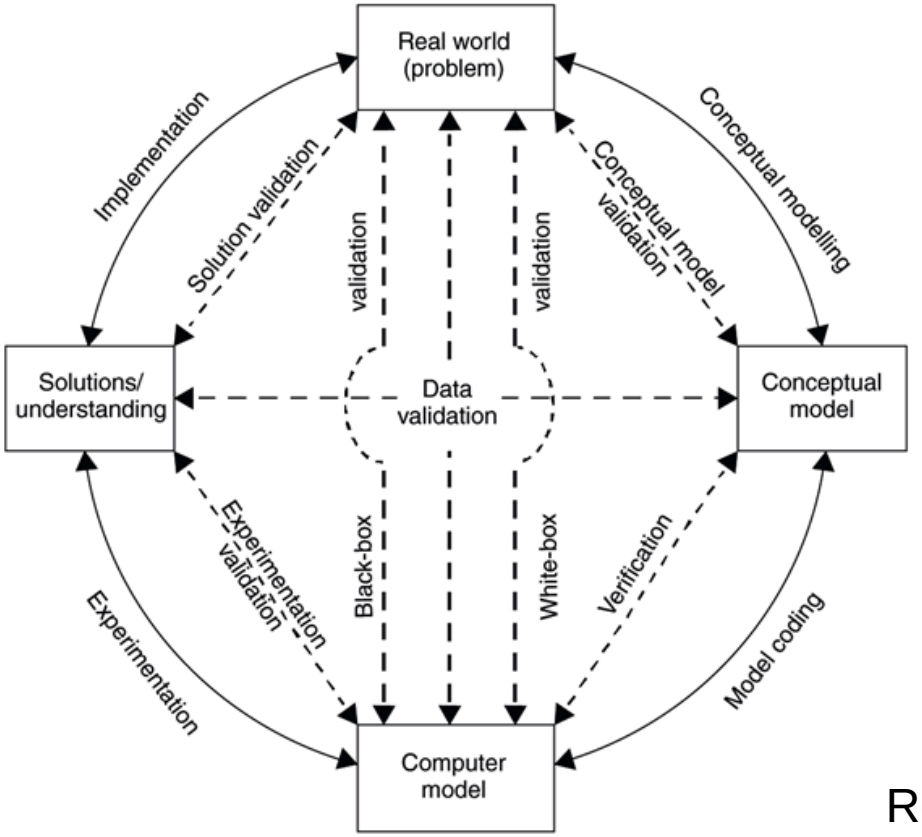
Verification and Validation

- Model verification and validation
  - **Model verification:** The process of ensuring that the model design has been transformed into a computer model with sufficient accuracy
  - **Model validation:** The process of ensuring that the model is sufficiently accurate for the purpose at hand
    - Models are not meant to be completely accurate
    - Models are supposed to be build for a specific purpose

- What is the difference between validity and accuracy?
  - Validity is a binary decision (conclusion: yes or no)
  - Accuracy is measured on a scale of 0 to 100%

Verification and Validation

- Linking V&V to the process of performing a simulation study



Robinson (2004)

Verification and Validation

- Conceptual Model Validation:
  - Determining that the content, assumptions and simplifications of the proposed model are sufficiently accurate for the purpose at hand.

- How can we do this?
  - Modeller should circulate model specification
  - Modeller and client should assess the assumptions and simplifications jointly

Verification and Validation

- Data Validation:
  - Determining that the contextual data and the data required for model realisation and validation are sufficiently accurate for the purpose at hand.

- How can we do this?
  - Modeller should investigate the source of data to determine their reliability

Verification and Validation

- White-Box Validation:
  - Determining that the constituent parts of the computer model represent the corresponding real world elements with sufficient accuracy for the purpose at hand (micro check)

- How can we do this?
  - Checking the code
  - Visual checks; the following aspects should be checked:
    - Timings
    - Control of elements
    - Control of flows
  - Inspecting output reports

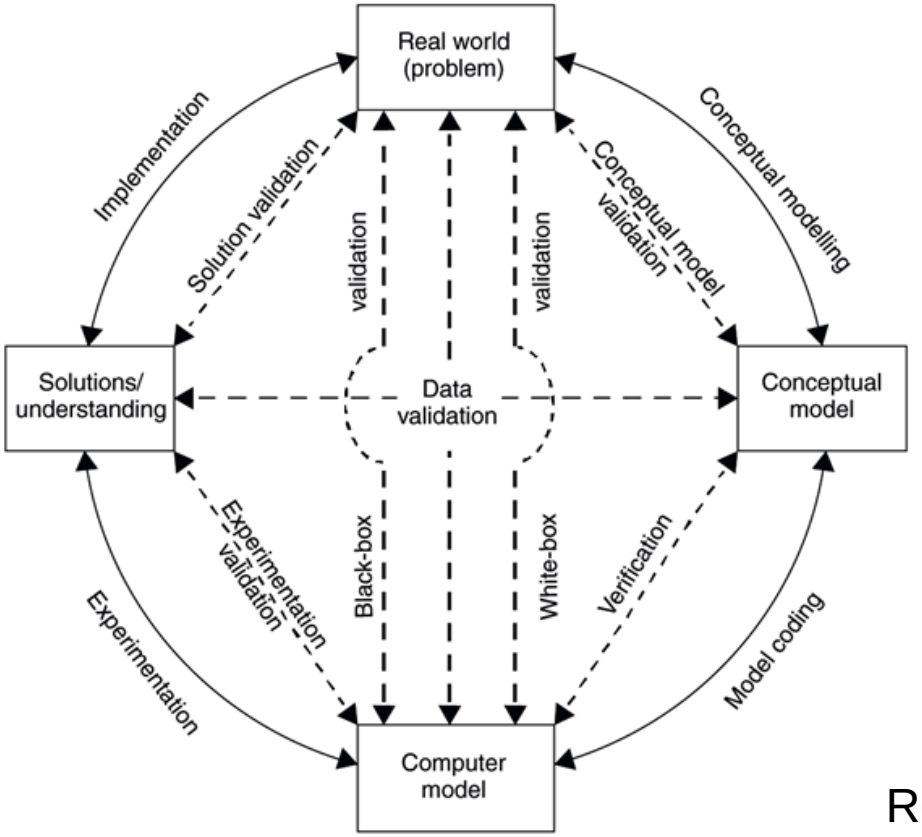
Verification and Validation

- Black-Box Validation:
  - Determining that the overall model represents the real world with sufficient accuracy for the purpose at hand (macro check)

- How can we do this?
  - Comparison with the real system
  - Comparison with other (usually simpler) models

Verification and Validation

- Linking V&V to the process of performing a simulation study



Robinson (2004)

Verification and Validation

- Experimentation Validation:
  - Determining that the experimental procedures adopted are providing results that are sufficiently accurate for the purpose at hand.

- How can we do this?
  - Graphical or statistical methods for determining warm-up period, run length and replications (to obtain accurate results)
  - Sensitivity analysis (to improve the understanding of the model)

Verification and Validation

- Solution Validation:
  - Determining that the results obtained from the model of the proposed solution are sufficiently accurate for the purpose at hand
    - Solution validation compares the model of the proposed solution to the implemented solution while black-box validation compares the base model to the real world

- How can we do this?
  - Once implemented it should be possible to validate the implemented solution against the model results

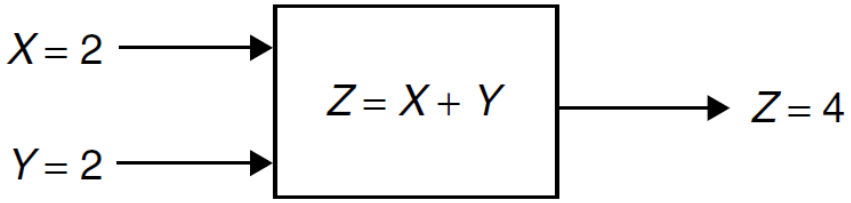
Verification and Validation

- Verification:
  - Testing the fidelity with which the conceptual model is converted into the computer model. Verification is done to ensure that the model is programmed correctly, the algorithms have been implemented properly, and the model does not contain errors, oversights, or bugs.

- How can we do this?
  - Same methods as for white-box validation (checking the code, visual checks, inspecting output reports) but …
    - Verification compares the content of the model to the conceptual model while white-box validation compares the content of the model to the real world

Verification and Validation

- Pitfalls:
  - Black-box validation: Is this a valid model?
    - Data has been obtained for two inputs (2,2) and one output (4)
    - A simple model is proposed: Z = X + Y



  - Relying on black-box validity alone can lead to the temptation to calibrate the model; in isolation it can lead to a simulation that is unrepresentative of the system it is trying to model

    It is important to test both, white box and black box validity!

For more details see Robinson (2004)

Verification and Validation

- Difficulties of verification and validation
  - There is no such thing as general validity
    - A model is only valid with respect to its purpose
  - There may be no real world to compare against
  - Which real world?
    - Different people have different interpretations of the real world
  - Often real world data are inaccurate:
    - If the data are not accurate it is difficult to determine if the model's results are correct
    - Even if the data is accurate, the real world data are only a sample, which in itself creates inaccuracy
  - There is not enough time to verify and validate every aspect of a model

Verification and Validation

- Some final remarks:
  - V&V is a continuous and iterative process that is performed throughout the life cycle of a simulation study.
    - Example: If the conceptual model is revised as the project progresses it needs to be re-validated
  - V&V work together by removing barriers and objections to model use and hence establishing credibility.

- Conclusion:
  - Although, in theory, a model is either valid or not, proving this in practice is a very different matter. It is better to think in terms of confidence that can be placed in a model!

Further Reading

DES related resources

- Sargent (2000). Verification, validation, and accreditation of simulation models. In: Proceedings of the 2000 Winter Simulation Conference, Orlando, FL.

SD related resources

- Roy and Mohapatra (2000). Causality and validation of System Dynamics models incorporating soft variables: Establishing an interface with structural equation modelling. In: Proceedings of the 18th International Conference of The System Dynamics Society, Bergen, Norway.

ABS related resources

- Xiang et al. (2005). Verification and validation of agent-based scientific simulation models. In: Proceedings of the 2005 Agent-Directed Simulation Symposium (ADS 2005), San Diego, CA.
- Macal and North (2005) Validation of an agent-based model of deregulated electric power markets. In: Proceedings of the North American Computational Social and Organization Science (NAACSOS) 2005 Conference, South Bend, IN

Comparison of validation process between different simulation methods:

- Kennedy et al. (2006). Verification and validation of agent based and equation based simulations: A comparison. In: Proceedings of the 2006 Spring Simulation Multiconference, Huntsville, AL.
- Skvortsov et al. (2007). Epidemic Modelling: Validation of agent-based simulation by using simple mathematical models. In: Proceedings of the 2007 International Congress on Modelling and Simulation (MODSIM2007), Christchurch, New Zealand .
- Qudrat-Ullah (2005). Structural validation of system dynamics and agent-based simulation models. In: Proceedings of the 19th European Conference on Modelling and Simulation (ECMS2005), Riga, Latvia.

Summary and Outlook

- Summary
  - Verification and validation
  - Experimentation preparation
    - Obtaining accurate results

- Outlook
  - Experimentation Preparation (Part 2)
    - Improving the understanding of the model (Sensitivity Analysis)
    - Improving the efficiency of the experimentation process
  - Output Analysis

Questions / Comments

References

- Barlas (1996). Formal aspects of model validity and validation in system dynamics. System Dynamics Review 12(3), 183-210
- Midgley et al (2007). Building and assurance of agent-based models: An example and challenge to the field. Journal of Business Research 60(8), 884–893
- Robinson (2004). Simulation: The practice of model development and use. John Wiley & Sons: Chichester, UK