Model validation and use

Dr. ir. Igor Nikolic

21-10-13

Lecture goals

- Understand the issues surrounding ABM validation
- Understand the SWOT of ABM use

Validation

- What is validation?
  - Means many things to many people
  - To us :
  - Did we design and built what we needed to answer the questions of the problem owner?

- *Did we built the right thing?*
  - *i.e. do the model outcomes correspond to reality?*
  - *In classical scientific discourse this means, does a theoretical model make correct predictions*

Validating models of LSSTS

- With our ABM we attempt to make a prediction about the future state of the world (after some change has been implemented)
- the validating experiment would consist of making such a change in the real world, and observing the effects
- Performing such an experiment at the scale of a large socio-technical system is impossible and unethical
  - Of course, we perform them each and every time we make policy/laws...

No traditional validation possible

- we cannot form a hypothesis, perform a real world experiment and see if the theoretical model outcomes correspond with reality.

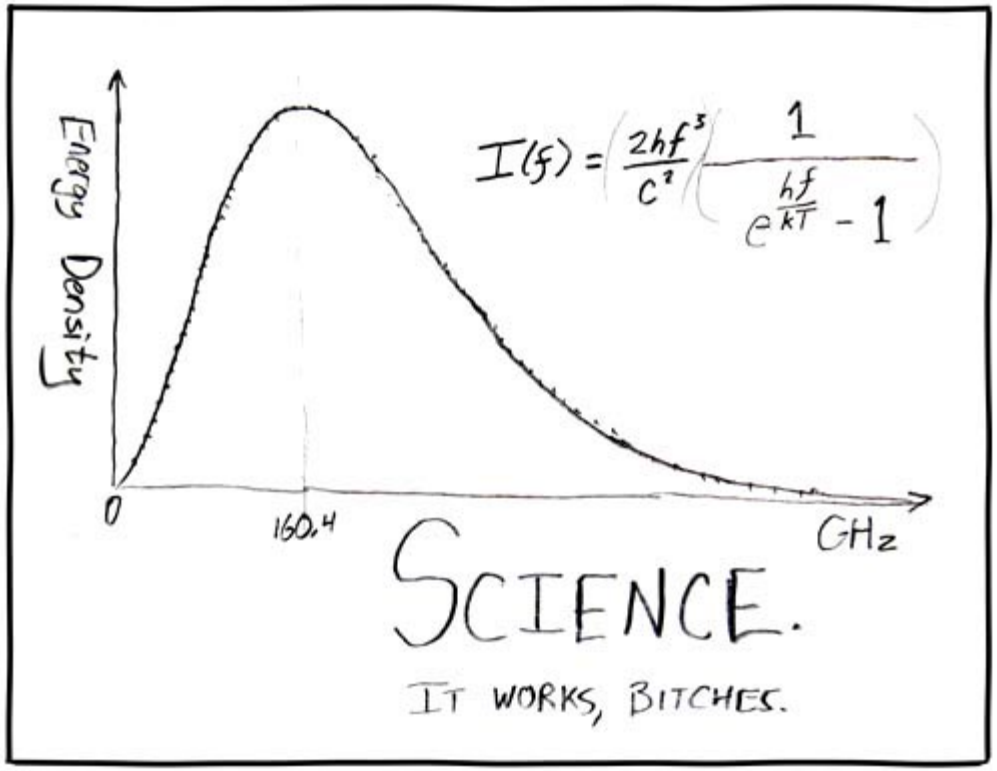
- Instead, Validation is a continuous process
  - modellers and domain experts continually evaluate if the model is useful and convincing.
  - What is useful is socially determined, and can not be objectively set (think post-normal science)

- So, is this even science ???

Epstein argues it is science !

- "... from an epistemological standpoint, generative social science, while empirical, is not inductive, at least as that term is typically used in the social sciences (e.g. as where one assembles macroeconomic data and estimates aggregate relations econometrically).
- The relation of generative social science to deduction is more subtle. The connection is of particular interest because there is an intellectual tradition in which we account an observation as explained precisely when we can deduce the proposition expressing that observation from other, more general, propositions.... In the present connection, we seek to explain macroscopic social phenomena. And we are requiring that they be generated in an agent-based computational model. Surprisingly, in that event, we can legitimately claim that they are strictly deducible.''

Example of classical validation



http://imgs.xkcd.com/comics/science.jpg

- cosmic microwave background (CMB) radiation , theoretical prediction and actual measurement, one of the best examples of a match between of theory and reality

So what do we have then?

- Historic replay
- Face validation through expert consultation
- Literature validation
- Model replication

Historic replay

- Past agents, states, behaviors, rules, environment etc are parameterized
- The model is set to start in the past
- We observe emergent phenomena what correspond to the past and current situation.
- If the patterns correspond, we have a “validated” model.

- However...

Historic replay - issues

- Pattern “corresponds” is problematic
  - Exact quantitative replication of some pattern ?
  - Qualitative similarity ?
  - No way to objectively determine ?
- Past data are also problematic
  - History is written by winners
  - Data is unknown/uncollected
  - Unknown external factors
  - System is chaotic, small (unknown) details matter

Face validation by experts

- Most commonly used approach
  - Domain experts and problem owners discuss the behaviour of agents, the patterns of behaviour of system and also the application of model for its designed purposes
- Structured interviews
- Workshops with larger groups of experts
  - systematically dicussing/validating model assumptions, mechanisms and outcomes
- However....

Face validation by experts - issues

- Experts may
  - understand what has happened and not what may happen
  - rely on their own internal models of system behaviour to estimate possible futures
  - subjective, biased and flawed in various degrees.
- Expert selection bias
  - looking for experts to validate the model who already agree with the type of outcomes created, while ignoring experts with dissenting views
- Experts make assumptions
  - about how the model works instead of really understanding it.

Literature validation

- Similar conclusions
  - theoretical research
  - non agent-based
- When recommending a action
  - If compatible with an available theory or published case studies, we can claim an increase in model validity.
- other, non agent-based models
  - Of the same or similar systems problems
  - even if they ave been used to answer a different question
- However...

Literature validation - issues

- Theories in literature may have fundamentally different assumptions
- Literature may be unclear about those assumptions
- Generalizing is very dangerous!

Model replication

- Make another model of the same thing, with different people
- If outcomes same/similar, strong validation

- However...

Model replication - issues

- Expensive !
  - Both in money and time
- Different stakeholders will have different ideas about how the system works → different model

ABM use

- Main model use is answering the lack of insight identified in step 1

- Some aspects:
  - Outcome presentation
  - Raising new questions
  - ABM and stakeholders
  - Computer vs mental models

What ABM can do

- Explore
  - Help us explore system emergence
  - Provide a sense of the range of possible system futures.

- Reasoning support - Bicycles for the mind
  - Humans are
    - weak at systematic reasoning across many agents/interactions
    - excelent at pattern recognition.
  - Computers
    - excellent at systematically exercising the relations between system elements, creating complex behavioral patterns.
    - Weak at pattern recognition

What ABM cannot do

- Models are developed with a particular purpose in mind and are limited to it
  - A strategic model can not answer operational questions

- Exact prediction is impossible
  - Because of intractable properties of system evolution

ABM advantages

- ABM offers a straightforward representation of the system
  - World is distributed and bottom up
- Intuitive understanding by stakeholders
  - Easy to understand entites that want/need/do something
- ABM is new and exciting
  - Modelers and users like ``shiny new toys''
- Relatively easy collective modeling
  - Easy logical split of modeling tasks

ABM disadvantages - Technical

- ABM as a bottom up simulation has a large data requirement
  - the number and detail of individual entities that need to be described is large

- Implementation of a ABM is not straightforward.
  - behavioral algorithms requires computer programming skills

ABM disadvantages - Social

- Modeling has been oversold to policy makers.
  - SD, OR, etc. promoted by modelers to policy makers with the promise of a rational prediction of future system states.
  - These predictions have turned out to be erroneous, raising doubts about the usefulness of modeling in general.
  - Need to educate users and be modelers need to be careful about their claims of prediction.
- When policy makers have accepted a model they will over/mis use it

ABM disadvantages - Social

- Prevalence of the traditional top-down, command and control paradigm
  - Users seem uncomfortable with bottom-up, distributed approach to modeling
  - tend to be distrustful of notions of emergence and self-organization

Outcome presentation

- Stakeholders are (generally) clueless about computers/models
- Modelers task is to aid them in understanding.

- Things to worry about :
  - They want a clear answer to their question
  - Dont care and wont/cant follow the model intricacies/subtleties
  - Pretty pictures cloud the mind !
  - Stakeholder believes “good” results more than “bad” ones

Raising new questions

- When modeling a complex system, you have to start simple and evolve it to be complex.
  - Modeling is iterative
  - So expectation management before hand is key !
- Each answer/insight leads to new questions.
- New questions may need a new or strongly adapted model
  - Is the new work interesting to us?
  - Is the client ready to spend more money/time on this?

Stakeholders and ABM

- Humans tend to think about entities having goals and “wanting” things
  - narrative of agent actions and choices is generally intuitive,
- While the agents may be intuitive, the emergence and self-organisation that arises from such a bottom-up, distributed approach is not.
- Stakeholders not used to modelling, or more familiar with a traditional top-down, command and control paradigm, may be distrustful of conclusions drawn from agent based modelling results.

Stakeholders and ABM

- Modeling has been oversold in some cases to policy makers
  - Distrustful of models in general
- In some cases they are very excited by the models, and trust them too much

Mental vs computer models

- Humans operate mental models all the time
  - Expectations about reality
- We are good at predicting simple things over short periods of time
  - Flight of a ball, reaction of a person to something
  - These models are reenforced by experience

- In CAS / LSSTS this fails
  - Mental shortcuts dont work
  - Intuition fails

Mental vs computer models

- Trusting simulations to overcome these shortcomings is difficult
- Building simulations that are better than intuition is difficult, as the modeler also has alimited set of metnal models
- When a stakeholder gives you the trust, you must make sure you are worth it as a modeler!