On the mental background of computer simulations

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Outline

How does my scientific background relate to simulations?

- **Logic-based** formalism for the real-time processing of goal-directed (natural language) interaction between humans and robots
- Rework the standard procedure of **model-theoretic semantics** to a **simulation-based** pragmatics
- Extend the classical, set-theory based semantics (Tarski) to a dynamic (time-variant, context-dependent, reality-grounded) notion of pragmatics.
- Employ methods from linguistics, robotics, philosophy, psychology, computer science

Starting Point

- What distinguishes computer simulations from a philosophical point of view?
- With respect to which conceptions of simulation and computation are computer simulations distinctive?

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Motivation

- “A simulation *imitates* a (usually real) process by another process” [Frigg and Hartmann, Spring 2008]
- ’Simulation’ does not only refer to computer simulations
- Simulations are a fundamental means of **human commerce** with reality
- Investigation of such ’mental’ simulations provides a **background** for the philosophical analysis of computer simulations (Cp. Artifical Intelligence)

Mental models and simulation

- [Craik, 1943]: The mind uses small-scale models of reality to **anticipate and explain events**

$\Rightarrow$ Rational control over interactions with reality

- "Thought models, or parallels reality", it has "a similar relation-structure to that of the process it *imitates*."
- Characteristics of such mental models:
  - Incomplete
  - Constantly evolving
  - Possibly contain errors and uncertainty measures
  - Simple representation of a complex phenomenon

Two types of mental models

structural	data-driven	know-that	context-free
functional	process-driven	know-how	context-sensitive

Neuronal foundations of simulations

- **Predict and understand other people's behaviour** via simulation: "putting oneself in the other's place"
- Discovery of mirror neurons [Rizzolatti and Fogassi, 1996].

$\Rightarrow$ The simulational aspect does not distinguish computer simulations.

The computational nature of mental models

Mental models are **computational**: they are assumed to be based on symbolic reasoning (cf. [Craik, 1943, p. 50]).

1. *Construction*: 'Translation' of external processes into words, numbers and other symbols
2. *Simulation*: Arrival at other symbols by a process of 'reasoning', deduction, inference, etc.
3. *Interpretation*: 'Retranslation' of these symbols into external processes (. . .) or at least to the correspondence between these symbols and external events.

$\Rightarrow$ The computational aspect does not distinguish computer simulations.

JP-Duties: Exclusive problems of computer simulations?

Are the research duties of the proposed professorship on the philosophy of simulation exclusively related to computer simulations?
E.g.:

- “Philosophical questions related to a simulation-based world”
- “Strategies of experimentation”,
- “Architecture of modelling”,
- “Dealing with uncertainties”

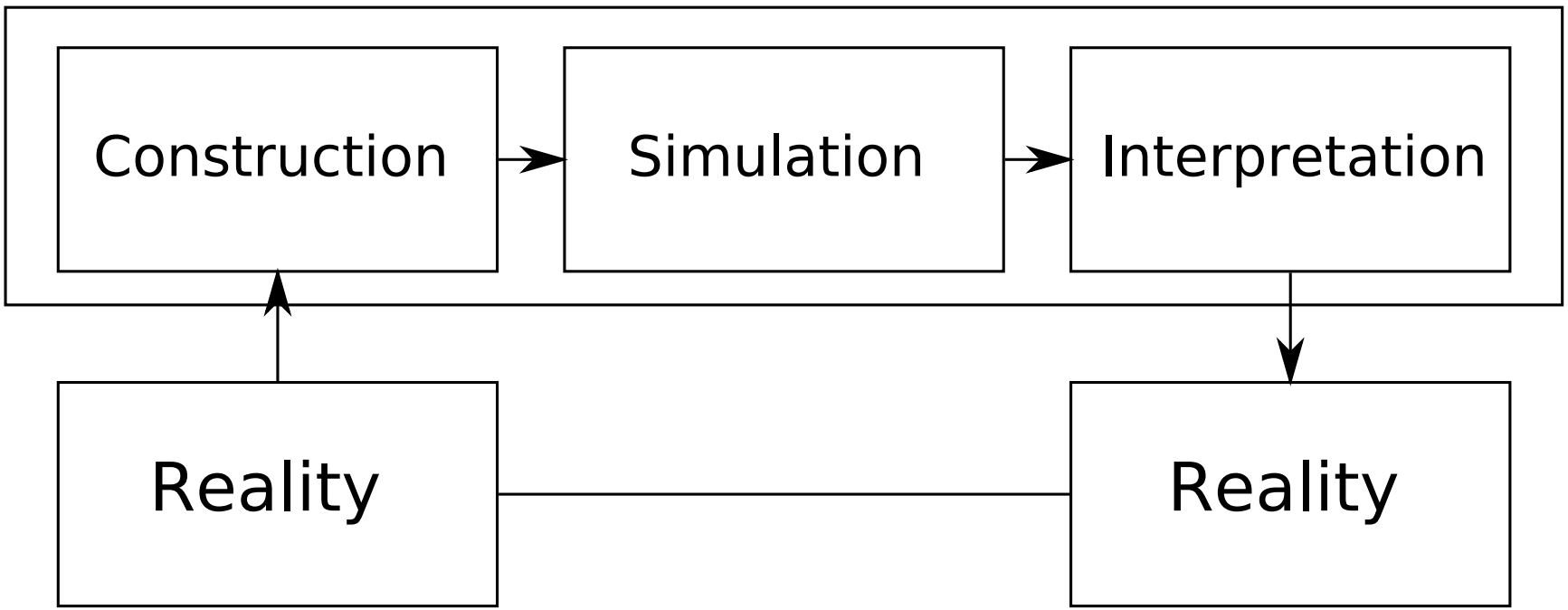
These problems do not only occur in the context of computer simulations, but also for mental simulations.
$\Rightarrow$ So **why is there a specific need** for philosophical reflection and evaluation of computer simulations?

The distinctive quality of computer simulations

What is the distinctive quality of computer simulations with respect to mental simulations?

Recap: the process of mental simulation

Recall the process of mental simulation:

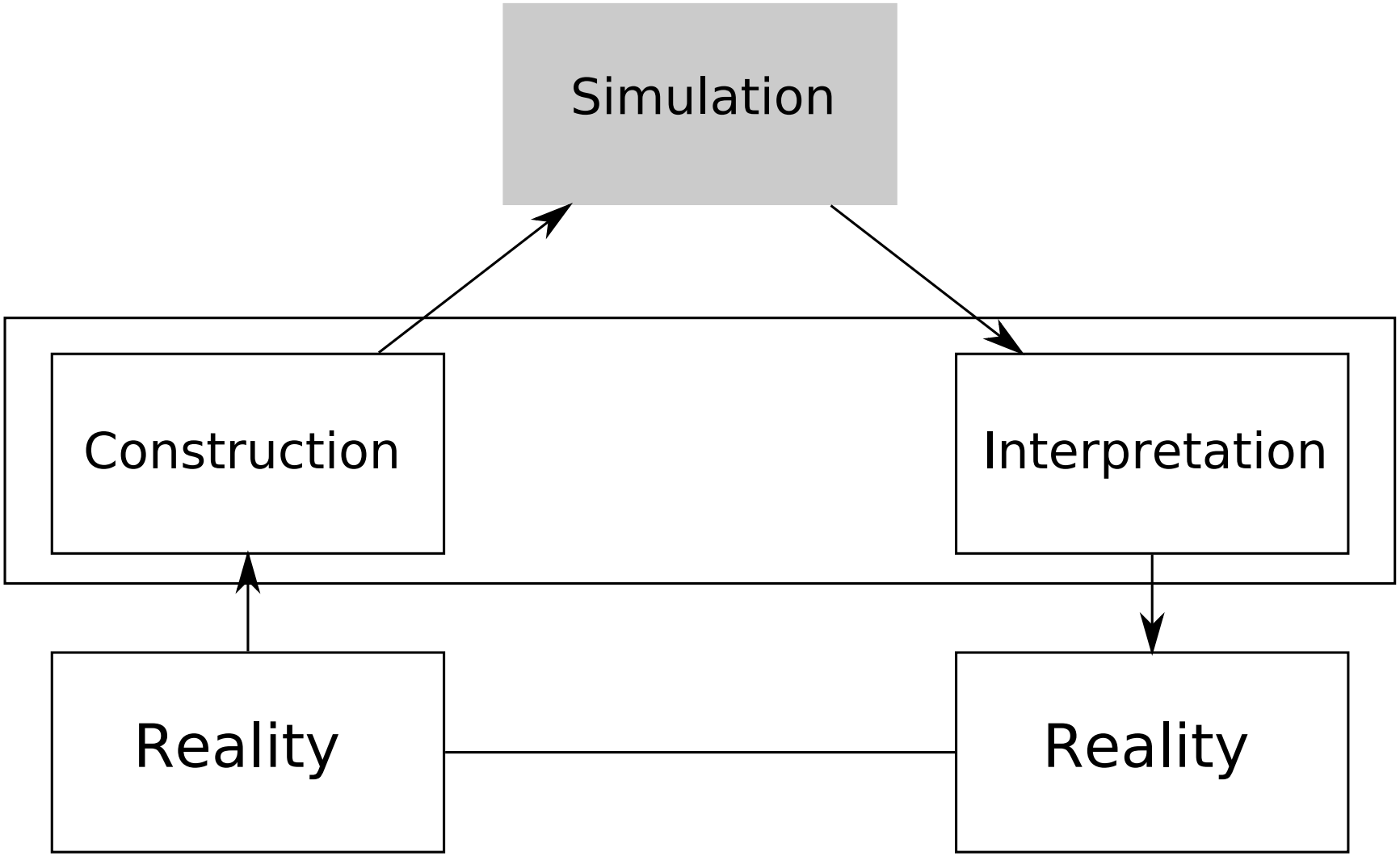


Externalisation and extension

What is the distinctive quality of computer simulations with respect to mental simulations?
Computer simulations externalise and extend the simulation step:

- **Externalisation**: Transfer of computational work
- **Extension**: of memory and processing power

Externalisation of mental simulation



A first hint on the distinctive nature of computer simulations

- But: human ability to cope with information **remains the same** with respect to the construction and interpretation of a simulation.
- Basically, this “mismatch” is a first hint on the distinctive quality of computer simulations.
- Note: Both designers (i.e. scientists) and users of the computer simulation have to face this problem.

Consequences of extension

Extension of memory and processing power entails an increase of structural and functional constrictions:

- **Structural:** selection, simplification and aggregation of information,. . . ($\Rightarrow$ creation of a virtual reality)
- **Functional:** stereotyping and preformation of procedural possibilities,. . . ($\Rightarrow$ creation of a virtual actuality)

Combining extension and externalisation I

The **virtuality** of computer simulations results from the combination of externalisation and extension:

- Externalisation 'hides' the limitations, modifications and preformations of the simulation as well as the simulation 'itself' inside the simulation code and corresponding system states
- The computer simulation is only accessible via its **effects** (e.g. a visualisation) which can (normally) not be created "by hand"
- Virtual: "being in effect, but not in appearance" (Oxford Dictionary); "a hypothetical particle whose existence is inferred from indirect evidence" (Merriam-Webster)

$\Rightarrow$ This implementation of virtuality distinguishes computer simulations from mental simulations

Combining extension and externalisation II

- The effects of selections, aggregations, preformations and stereotypes inherently build into a computer simulation **influence** or even **determine** the interpretation of and interaction with the effects of the simulation

$\Rightarrow$ There is a need for philosophical reflection about the implications of “growing virtualisation”

Consequences of Virtualisation I

Philosophical issues related to virtuality (to name some. . .)
E.g. Preformation of artificial environments (“acting in virtual environments”):

- Gap between ’everything is virtually possible’ and functional-structural constrictions
- Increase of possibilities in combination with functional-structural constriction entails a loss of possibilities to independently encounter the **resistance and boundaries of reality**
- “Customised virtual reality”: loss of referential anchoring in a **shared common ground**

$\Rightarrow$ Loss of possibilities to shape conceptions of reality and the self (cp. [Hubig, 2003])

Consequences of Virtualisation II

E.g. Interpretation of the effects of a simulation (“dealing with uncertainties”):

- How to **retranslate conducted computations** to a “correspondance between symbols and external events”?
- In particular with respect to
  - The epistemological status of computer simulations
  - The (intrapersonal) consistency of virtuality, actuality and reality (disappearance of “traces” in virtuality)
  - The impracticality to retrace the executed computations in detail (uncertainty of inferences)

Philosophy of simulation

How should a philosophy of simulation be shaped such that it matches the requirements of an “integrative platform of reflection and evaluation” given

- The **different jargon** in different branches of science and
- The **complexity** of the topic?

Outlook: Formal philosophy of simulation I

Develop a new “jargon", i.e. a formal metatheory of simulations.

- Formalisation makes implicit assumptions and decisions **explicit**, detects uncertainties
- “Controlled” abstractions and generalisations
- **Unambigous** definition of denotation and meaning
- E.g. describe, control and evaluate the behaviour of a simulation “along all futures versus some futures” (computer science: “model checking” with temporal logic [Emerson, 1990])

Outlook: Formal philosophy of simulation II

- Draw upon established methods from cognitive science to manage interpretation and interaction with simulations (e.g. planning theory)
- Integrate mechanisms of “Stuttgart model of parallel communication” (e.g. on-demand communication, self-explanation, exit/alternative options) into the framework of Human-Machine-Interaction (cp. my doctoral thesis)

Discussion

- Comments and Questions

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Abduction

- Examples of abductive inference:

  All balls in this bag are green
  All balls on the table are green
  $\Rightarrow$ All balls on the table are from this bag

- “Where there’s smoke, there’s fire.”
- In combination with virtuality:
- Virtual:“a hypothetical particle whose existence is inferred from indirect evidence” (Merriam-Webster)

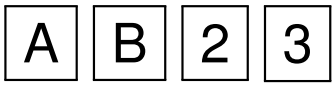
$\Rightarrow$ Multiple sources of inferential uncertainty

Mental Models and Visualisations

Types of mental models:

- Propositional representation (NL-like): Non-analog, non-iconic, digital/discrete, referentially arbitrary
- Mental model (structural analogy)
- Mental imaginery (perceptual correlates to a model): Analog, iconic, continous, referentially isomorphic

Wason Selection Task



- Each card has a number on one side and a letter on the other side.

Wason Selection Task

A	B	2	3

- Each card has a number on one side and a letter on the other side.
- Claim: If a card has a vowel on the one side, then it has an even number on the other side.

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- Cards “A" and “3”.

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- Which cards are to be turned over in order to determine whether the claim is false or true for these four cards?
- Cards “A" and “3”.
- “If a person is drinking beer, then she must be over the age of 18.”

Practical Syllogism

Let

- x be the actor,
- P be a subjective, (imagined as being possible to realise) means
- Q' be a subjective, (imagined as being possible to realise) goal
- Q'' be the actually realized goal
- M be an outer, real existing means

$$\frac{x \text{ intends that } Q' \text{ via } P \qquad P \text{ via } M}{x\text{'s doing } M \text{ brings about } Q''}$$

Methods: Logics vs. Statistics

- Example: Language
- Skinner vs. Chomsky
- Statistic learning vs. rule-based
- Computational Linguistics:
  - Climax of statistical methods reached?
  - Dialogue processing
  - Google vs. semantic search