

Speaker: Matthias Van Hove

Types of uncertainty in simulation models: Categorisation for better identification, accounting and assessment

A1 Matthias Van Hove

Department of Architecture and Urban Planning, Ghent University, Belgium, matthias.vanhove@ugent.be

A2 Marc Delghust (PhD)

Department of Architecture and Urban Planning, Ghent University, Belgium, marc.delghust@ugent.be

A3 Jelle Laverge (PhD)

Department of Architecture and Urban Planning, Ghent University, Belgium, jelle.laverge@ugent.be

A simulation model is a rich and complex structure that maps between the input(s) and the output(s) [1]. It aims to replicate the workings and logic of a real system by using physical and/or statistical descriptions of the activities involved [3]. Consequently, no simulation model can be a perfect representation of the system it aims to emulate [25]. All simulation models inevitably contain uncertainty, which should be addressed and quantified as part of the quality assurance process of the model and as part of inferences.

Uncertainty in modelling can be defined as “any departure from the unachievable ideal of complete deterministic knowledge of the system” (Walker *et al.*, 2003). As the systems, being modelled, increase in scale and complexity, it is expected that the uncertainty in the model also increases (Langevin J., 2020). Though, a fair amount of simulation model outputs are expressed as a single value (Cerezo, 2017), which may yield misleading impressions about the certainty of model insights when used for inferences and/or policy making (Langevin J., 2020).

In the literature, several different authors have addressed sources of uncertainty in simulation models in wording and/or schemes (Booth *et al.*, 2012 [6]; Walker *et al.*, 2003 [8]; Coakley *et al.*, 2014 [9]; Oberkamp *et al.*, 2002 [23]), however a general consensus in terms of uncertainty classification and related terminology does not appear to exist (Refsgaard *et al.*, 2007 [28]). A review of 25 existing uncertainty classification schemes ([5]-[29]) highlighted a broad pattern with types of uncertainty being grouped according to where it occurs in the modelling chain: in the model inputs, the simulation model itself or the model outputs.

In *Figure 1*, the different types of uncertainty in simulation modelling are categorised. In *Table 1*, a concise definition is given.

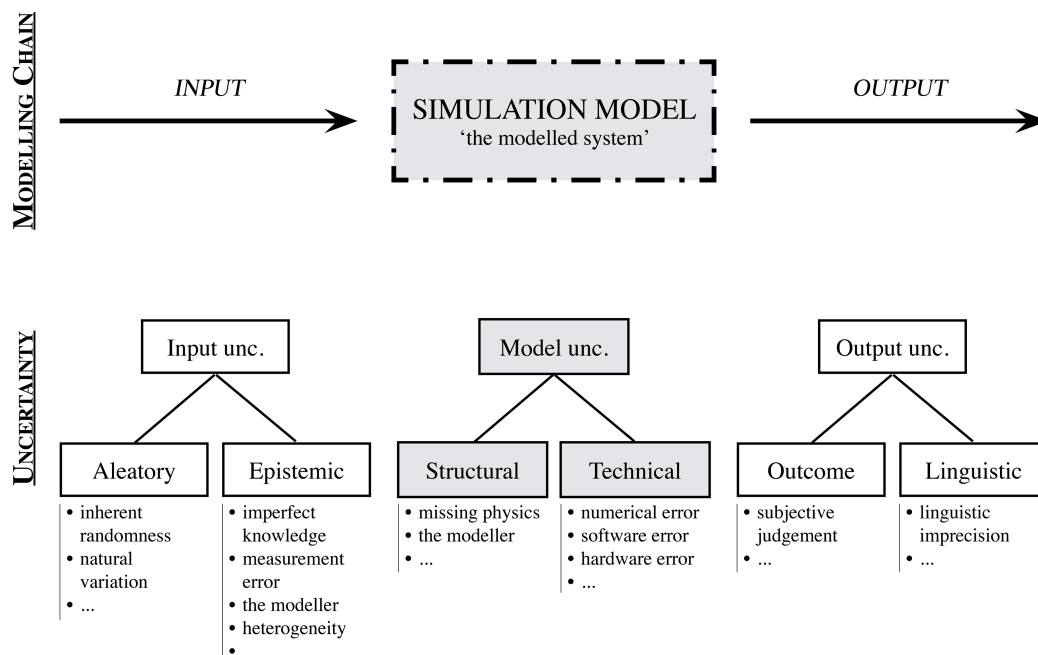


Figure 1 - Types of uncertainty identified in existing uncertainty classification schemes. Types of uncertainty may be grouped by whether they relate to model inputs, the model itself, or model outputs.

Definitions

Aleatory uncertainty: Uncertainty due to inherent or natural variation of the system under investigation.

Epistemic uncertainty: Uncertainty resulting from imperfect knowledge; can be quantified and reduced.

Model structural uncertainty: Uncertainty that arises from a lack of sufficient understanding of the system (past, present or future), that is the subject of the policy analysis, including the behaviour of the system and the interrelationships among its elements.

Model technical uncertainty: The uncertainty generated by software or hardware errors.

Model outcome uncertainty: Total uncertainty on the model simulation (so endogenous rather than exogenous as the other categories).

Linguistic uncertainty: Uncertainty arising from language issues; can be quantified and reduced.

Table 1 - Definition of the types of uncertainty categorised in Figure 1.

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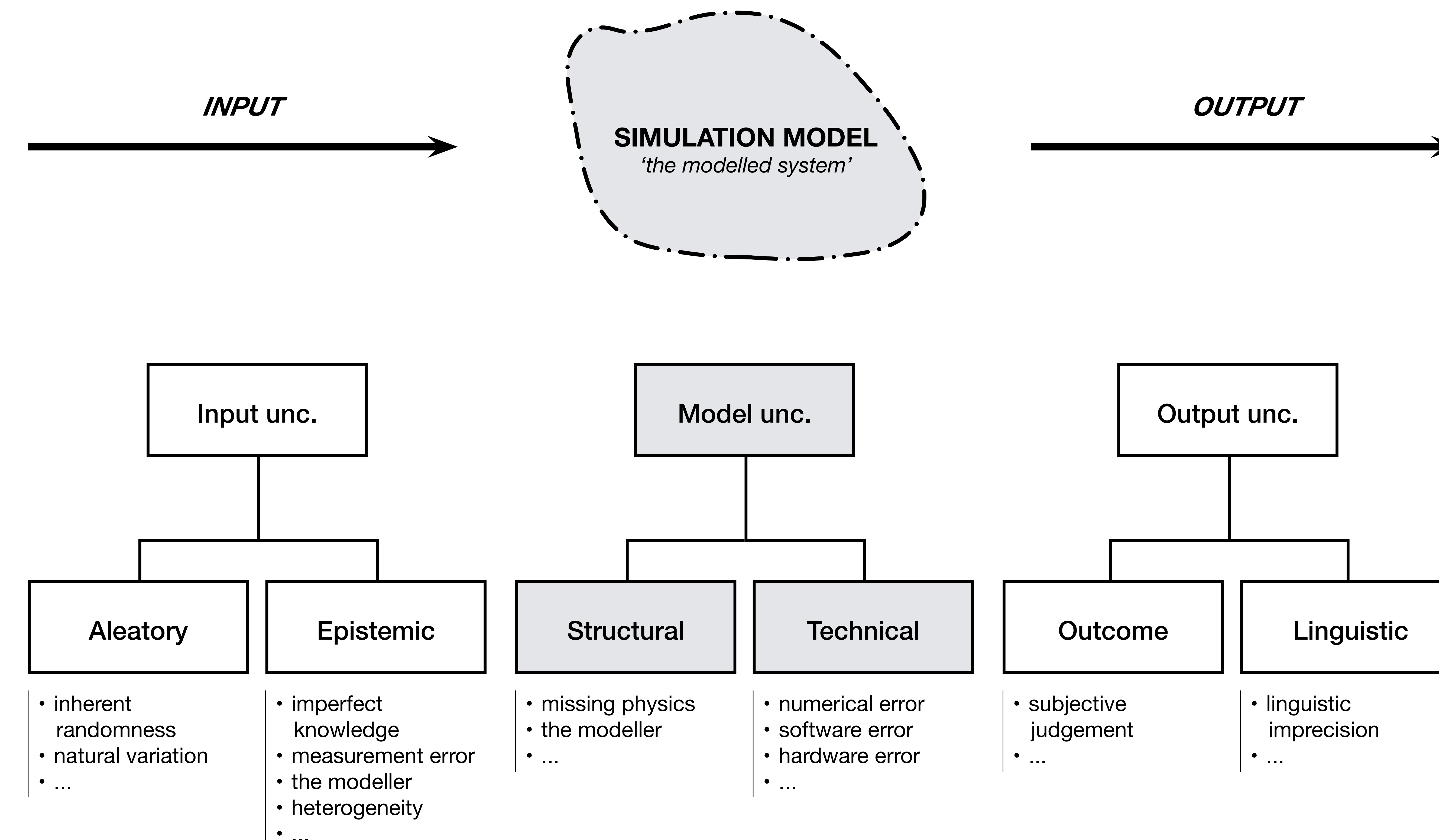
SUMMARY

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UNCERTAINTY CATEGORISATION ACCORDING TO OCCURRENCE IN MODELLING CHAIN



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