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TOWARDS THE VALIDATION OF A SIMULATION ENVIRONMENT

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ABSTRACT

While the topic of validating simulation models is rich in literature, validating the environments in which models run has been poorly researched. Despite the fact that such environments have high face validity, in most of the cases there are no formal methods developed for validating them. In this project, we first distinguish between the different forms of validity, such as data, model, and environment validity and then we propose an automated procedure for validating simulation environments, similar to what unit testing is for verification.

1 INTRODUCTION

Validation is a fundamental part of a simulation study. In literature, the term validation usually refers to model validation, which is defined as the substantiation that the model, within its domain of applicability, behaves with satisfactory accuracy consistent with the study objectives (Balci 1998). Regardless of its common usage, there are also other forms of validation; such as data validation.

Simulation data can be classified as input data, which are the data the simulation model requires as an input to run, output data, which are the data the simulation model produces as an output, and behavioral or operational data (Sargent 2004), which are data of the system under study. Data validation is concerned with confirming whether the data used throughout the simulation model development phases are accurate, complete, unbiased, appropriate in their original and transformed forms (Balci 1990), and adequate (Sargent 2000). Since input data are required to run a simulation model, their validation is the first step that should be taken towards validating a simulation model. During this first step, the behavioral data should also be validated, in order to confirm that they are consistent with the input data. In other words, an initial validation of the behavioral data ensures, to some extent, that the comparison between the simulation model and reality is fair.

Upon confirming that the input and behavioral data are valid, there are several validation methods for validating the actual model; both formal and informal. During the validation, several of these methods can be used. Choosing one method over another heavily depends on whether there are behavioral data available. If behavioral data are not available, for example when simulating an earthquake of a magnitude that has not happened before, emphasis is given to experts opinion. Whereas, if behavioral data are available, for example when simulating a train network, emphasis is given also in formal validation and statistical methods. Choosing and applying validation and statistical methods is just an intermediate step throughout the validation cycle.

If the model is not valid, then the results of the validation study should be checked for a *Type I Error*, meaning that the hypothesis that the model is valid is rejected when in fact it is sufficiently credible (Balci 1989). Once the possibility for a *Type I Error* is eliminated, then the system under study should not be considered adequately simulated.

If the model is valid, then the results should be checked for a *Type II Error*, meaning that the hypothesis that the model is valid is accepted when in fact it is not sufficiently credible (Balci 1989). Once the possibility for a *Type II Error* is eliminated, the model can be considered valid.

The reason that a system is not adequately simulated might have multiple causes. The model might have been poorly designed and built, then again, the model might be good but the simulation environment might have validation or verification issues, especially when it is custom-built to fit the specific needs of a company.

From the above analysis, several questions arise:

> **Q1:** If the model is validated, under which circumstances does a *Type II Error* occur?
> **Q2:** If the model appears not to be valid, how can we know whether the invalidity occurs due to the model or due to the simulation environment?

To answer Question 1, a *Type II Error* can occur due to a statistical error, which is a risk that can be mitigated by replicating the validation study multiple times with the same model but with a different dataset. A more serious reason for a *Type II Error* to occur is the tendency, from the modeller(s), to over-fit the model to the behavioral data.

The methodology for answering Question 2 depends on the complexity of decomposing in depth the simulation model and environment. Assuming that usually it is more simple to decompose the model than the environment, the validation study should start with the data, as mentioned earlier in this document, and then proceed with validating the model. If both the data and the model are valid, then by reductio ad absurdum, the initial conclusion should be that the simulation environment is invalid, unverified, or both.

The verification of a simulation environment is usually straightforward and can be done with traditional techniques, like debugging and/or unit testing. On the other hand, validating a simulation environment is considerably less straightforward. There are no procedures developed for validating such environments. Ergo, this paper aims at proposing an automated procedure for validating simulation environments, similar to what unit testing is for verification. Such a procedure will be particularly useful on occasions where the simulation environment is updated, and new versions become available, several times per year.

Our main research question is:

> **Main Research Question:** What steps need to be taken to develop an automated procedure for validating simulation environments, and what are the advantages and disadvantages of such an automated procedure compared to traditional methods?

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