HOW VALID IS YOUR SIMULATION? LEARN TO APPLY METAMORPHIC TESTING TO INCREASE CONFIDENCE ON YOUR SIMULATION

Mohammad Raunak
Loyola University Maryland
Baltimore, MD, USA
raunak@loyola.edu

Megan Olsen
Loyola University Maryland
Baltimore, MD, USA
mmolsen@loyola.edu

ABSTRACT

A simulation model must be validated for its results to be reliable. However, simulation validation, i.e. demonstrating that it accurately represents the system it studies, is a challenging task. One of the primary sources of this challenge is the absence of an *oracle* to test its validity. Without an oracle, one cannot determine if the result of a program is correct. This oracle problem has long been studied in software engineering, and *Metamorphic Testing* has been found to be an effective technique to test software without an oracle by creating pairs of test cases that act as pseudo-oracles. In our work, we provide guidelines on applying a modified version of metamorphic testing to increase confidence in the validity of simulation models. In this technique, pseudo-oracles are developed based on *metamorphic relations* between parameters and behaviors within an executable simulation model. These relations represent an understood property of the system being studied, which can be used to check the validity of the simulation without knowing the correct answer. In this tutorial, we will explain metamorphic testing and how it applies to simulation model validation. We will introduce the participants to the process of identifying metamorphic relations in underlying systems that the simulation models represent. We will also discuss the guidelines for applying metamorphic testing in two prevalent simulation approaches: agent-based, and discrete-event simulation modeling. In addition to demonstrating the application of metamorphic testing towards validating example simulation models, we will walk the participants through a guided, hands-on application of these ideas. Participants will be invited to either use their own model for this hands-on aspect, or a provided example model.

REFERENCES

Chen, T. Y., Cheung, S. C. and Yiu, S. "Metamorphic testing: a new approach for generating next test cases," Dept. of Computer Science, Hong Kong Univ. of Science and Technology, Tech. Rep. HKUST1300 CS98-01, 1998.

Murphy, C. Raunak, M., King, A., Chen, S., Imbriano, C., and Kaiser, G. "On effective testing of healthcare simulation software," in Software Engineering in Health Care (SEHC '11), 2011.

Olsen, M. and Raunak, M. "Metamorphic Validation for Agent-based Simulation Models." Summer Simulation Multi-Conference. July 2016. Nominated for Best Paper Award.

Raunak, M. and Olsen, M. “Simulation Validation Using Metamorphic Testing (WIP).” Summer Simulation Multi-Conference. July 2015.

Segura, S. Fraser, G., Sanchez, A. B. and Ruiz-Cortés, A. “A survey on metamorphic testing.” *IEEE Transactions on software engineering”*, *42*(9), 805-824 2016.

AUTHOR BIOGRAPHIES

MEGAN OLSEN is an Associate Professor of Computer Science at Loyola University Maryland. She earned her M.S. (2009) and Ph.D. (2011) in computer science from University of Massachusetts Amherst, and her B.S. in computer science from Virginia Tech (2005). Dr. Olsen’s research currently focuses on improving simulation approaches and validation. Recent work includes quantifying the level of validation achieved on a simulation model, guidelines for using metamorphic testing for simulation validation, and utilizing reinforcement learning within agent-based predator-prey models. Recent work has been published in SummerSim, WinterSim, SpringSim, and the International Conference on Computational Science.

MOHAMMAD RAUNAK is an Associate Professor of computer science at Loyola University Maryland, Baltimore, MD. He earned his M.S. and Ph.D. in computer science from University of Massachusetts Amherst, where he worked in the Laboratory for Advanced Software Engineering Research (LASER). Dr. Raunak's research interests include simulation model validation, and developing and measuring test approaches for `difficult-to-test' programs such as cryptographic algorithms. Along with Dr. Olsen, he has developed quantification approaches for measuring validity of simulation models. Dr. Raunak regularly publishes in simulation as well as software engineering conferences.