Trends in Software Simulation and Testing

Panelists

Prof. Dr. Marko Jäntti, University of Eastern Finland, Finland
Prof. Dr. Radek Kočí, Brno University of Technology, Czech Republic
Jos van Rooijen, Huis voor Software Kwaliteit, the Nederlands
Prof Dr. Sibylle Fröschle, TU Hamburg, Germany
Prof. Roy Oberhauser, Aalen University, Germany (Moderator)

Software Simulation

Process of creating a virtual model of a system or process that imitates the behavior of some other (real) system; usually a simplified model focusing on certain characteristics of interest

Software Testing

Systematic process that evaluates and verifies
that the software functions correctly
and meets requirements and expectations
while exposing defects and discrepancies
Broad categories include (non-)functional testing

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Panelist Position

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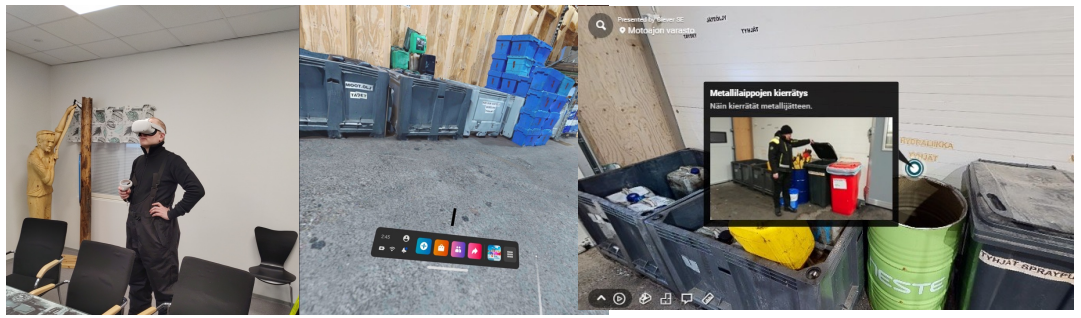
- Testing & development of digital twins is challenging
- Challenging areas
  1. **Integration** between different systems (a digital twin requires real-time data transfer from various sources)
  2. **Accuracy:** The model must accurately reflect the physical object to ensure testing produces reliable results.
  3. **Usability** of digital twins
- What did we test?
  - Usability testing for XR-based virtual storages, integration testing (Lapentor API), system testing including information security



LoraWAN
Tank Level Sensor

Figure: Motoajo's storage in Lapentor platform

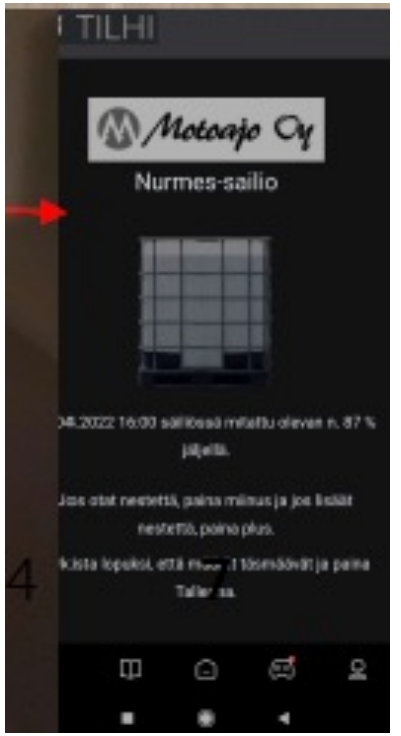


Figure: TILHI mobile app

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Radek Kočí
Brno University of Technology

We can expect deeper involvement of AI in software simulation and testing. Are we ready for this?

Assuptions and Expectations

- Automated code analysis for generating test cases.
- Autonomous testing, error prediction, and process optimization.
- More precise modeling and simulation for more relevant test data.

Changes

- The tester's role will change; they will no longer primarily create test scenarios but instead correct AI proposals.
- The importance of models in the design process and model-based design techniques will increase.

Challenges

- It will be necessary to prepare (and teach software engineers) for changes in development processes.
- The developer/tester must be a skilled professional and, at the same time, must be able to communicate/query AI tools correctly in order to properly check the outputs.
- Shouldn't we focus on formal approaches to software modeling with proper code generation and move testing/verification/validation to earlier stages of development?

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Panelist Position

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- **The tester:**
  - One-sided development. People are able to use tools. But they are not able to create a proper test design
  - Tester must re-invent himself (skills)

- **AI & Machine Learning in Testing**
  - Automated test case generation from user behavior, historical data, and defect patterns (see also my presentation)
  - Predictive testing: AI predicts where bugs are most likely to occur
  - Autonomous testing: AI-driven execution and analysis with minimal human intervention patterns (see also my presentation)
  - Who is owner of the software; business or IT?

Jos van Rooijen
Huis voor Software Kwaliteit

- **Shift-Left & Shift-Right Testing (“Testing Everywhere”)**
  - **Shift-Left**: testing as early as possible in requirements, design, and development
  - **Shift-Right**: testing in production, A/B testing, canary releases, and real-user monitoring
  - Stronger focus on observability and telemetry to detect hidden issues in live systems because we don’t know the system anymore

Panelist Position

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Jos van Rooijen
Huis voor Software Kwaliteit

- **Hyperautomation**
  - Automating the full QA lifecycle: test data generation, environment setup, CI/CD integration, reporting
  - Test impact analysis: only running the tests relevant to recent code changes, reducing regression overhead
  - Less human effort required

- **Test Impact Analysis & Risk-Based Prioritization**
  - Identifying which tests are relevant per code change instead of rerunning entire suites
  - Focusing test efforts on high-risk or frequently changing areas
  - But; do we know still the entire system (see my presentation)

Panelist Position

Jos van Rooijen
Huis voor Software Kwaliteit

Some challenges:

- **Reliability**: potential for false positives/negatives and unstable results
- **Test maintenance**
- **Security & compliance**: privacy and regulation (GDPR and beyond) require stronger testing focus.
- **Skill requirements**: testers must step forward
- **Knowledge**; how become a junior a senior?
- **Transparancy** of algorithm's

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Panelist Position

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- **General Position: Great techniques are available to us. By all means use them.**
  At the same time make sure not to get carried away.
  Remember that "precise-looking result" does not equal "sound result"!
  - **Model-based Testing/Digital Twins.** Example security of (systems of) cyber-physical systems: digital twins can play an important role throughout development and operation. During operation they can be crucial for situational awareness and help to decide on and prioritize mitigation measures.
  - Challenges: the name "digital twin" has the unfortunate connotation that the simulation model is an exact version of the system under investigation. Need to be aware of the limitations wrt both: which aspects are modelled and what can be efficiently computed. Provide simulation models at the right level of abstraction and put more focus on how they can be composed in a meaningful way (beyond standards for co-simulation).
  - **Automated Verification.** Example cryptographic protocols and APIs: (semi-)automated protocol provers such as Tamarian and ProVerif have been successfully employed for the verification of real protocols, e.g., during the standardization of TLS 1.3.
  - Challenges (as usual): how to fully automate the verification problems and beyond (e.g., cryptographic architectures)? How to ensure that the implementations of protocols and APIs are secure? How to make sure the models fit the specifications? AI may help to tackle some of these well-known challenges.
  - **Uncertainty Quantification.** There are sophisticated statistical methods for uncertainty quantification and prediction. Attention has to be paid on their sound use: that the mathematical assumptions are in line with the use case, and that the data employed is suitable. More methods or (even just categories) are needed to coin the quality/suitability of data.
  - **Uncertainty in TARA (Threat Analysis and Risk Assessment).** Restrict the use of probabilities to parts of the system that can be controlled by the defender. Otherwise need very precise assumptions on the type and means of the attacker, which we usually don't have.

Sibylle Fröschle
Technische Universität Hamburg

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Panelist Position

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The Age of Ongoing Disruption

- Automation Trends affecting Software Testing
  - DevOps Pipelines
  - MLOps Pipelines
  - Agility and Continuous Development
    - Agentic AI and Human-In-The-Loop (HITL)
- AI-supported SE Trends
  - Code generation and test generation
- Expanding software functionality
  - Increased size and complexity
  - Increased dependencies
  - Large software supply chains
  - Shared access to (tested?) open source software
    - Foundational functionality (frameworks, libraries, platforms)
    - Rapid feedback (crowd testing)
  - Faster and greater dynamicity (versioning)

Challenges

- Consistency/synchronization & impact analysis
- Resiliency, error-handling
- Knowledge (modeling)
  - Who knows what?
- AI slop, awareness of contextual/implicit requirements, debugging (assumptions), parallelization, specialization, conceptual integrity issues, hallucination detection.
  - AI tests AI? Who tests AIGen (test the test?)?
- Transparency, integrating updates/fixes
- Security and trust
- Resources (for testing/fixing)
- Human and AI limitations
  - Comprehension, team conceptual integrity and mixed mode communication
- (Inherited) Technical Debt

Roy Oberhauser,
Aalen University

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