



About iv4XR

iv4XR - Intelligent Verification/Validation for Extended Reality Based Systems - is an H2020 European project focusing on the automated testing verification of extended reality (XR) systems through the use of autonomous and intelligent test agents. The project is in its first year and has so far made important progress in formalizing the problems and contextualizing them along the challenges faced by industrial partners. For more information consult the project [website](#).

Kick-off & subsequent meetings

iv4XR officially kicked-off with a meeting in Lisbon, Portugal on 17 & 18 of October, 2019.

[Watch vlog of kick-off meeting](#)

Subsequent to kick-off, iv4XR has carried out two project meetings in which fruitful discussions were carried out among the consortium members. The second project meeting was held in Utrecht, Netherlands on 21 & 22 January, 2019.

The third project meeting, however, was held virtually due to the lockdown imposed to combat the pandemic on 6 & 7 July, 2020.

Checkout our media gallery for photos: <https://iv4xr-project.eu/media-gallery/>

Github repository

iv4XR has developed an autonomous agent library with basic intelligent test agents implemented in Java. The agent library offers basic agents with built-in capabilities for autonomous navigation in a given virtual world. Furthermore, a domain specific language (DSL) is defined to enable the passing of tactics to the test agents.

On the other hand, while the integration of the pilots from industrial partners is underway, the project has also developed a game called LabRecruits which would serve for the purpose of developing and testing the test agents.

These and other prototypical implementations are available in the project Github repository:

iv4XR on GitHub: <https://github.com/iv4xr-project>

Publications

Agent-based Testing of Extended Reality Systems

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Abstract—Testing for quality assurance (QA) is a crucial step in the development of Extended Reality (XR) systems that typically follow iterative design and development cycles. Bringing automation to these testing procedures will increase the productivity of XR developers. However, given the complexity of the XR environments and the User Experience (UX) demands, achieving this is highly challenging. We propose to address this issue through the creation of autonomous cognitive test agents that will have the ability to cope with the complexity of the interaction space by intelligently explore the most prominent interactions given a test goal and support the assessment of affective properties of the UX by playing the role of users.

Index Terms—agent-based testing, AI-based testing, testing computer game, testing virtual reality, user experience testing



Fig. 1. A game called Space Engineers as an example of an XR system, featuring advanced 3D worlds and an elaborate system to construct sophisticated custom objects, from simple solar panels to a complete space station.

We have so far managed to formulate the initial ideas and proposal of iv4XR and present them in various venues to get early feedback from the community.

Here are some of these articles published:

- iv4XR - Intelligent Verification/Validation for Extended Reality Based System @ RCIS'2020
- Tactical Agents for Testing Computer Games @ EMAS'2020
- Adoption Dynamics and Societal Impact of AI Systems in Complex Networks @ AIES'2020
- Agent-based Testing of Extended Reality Systems @ ICST'2020

For details, check out our:

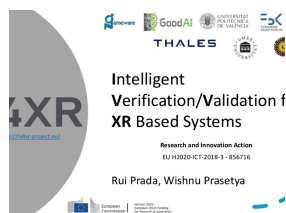
website: <https://iv4xr-project.eu/publications/>

Zenodo: <https://zenodo.org/communities/iv4xr-project/>

Events and presentations



Rui Prada (project coordinator) presented the iv4XR project at a Research Seminar at the Helmut Prendinger Lab National Institute of Informatics, Tokyo, December 2019.



Rui Prada and Wishnu Prasetya gave a project pitch at the Workshop on Interactive Technologies, EC DG CONNECT.G2, June 26, 2020, WebEx.

[Slides are available on SlideShare](#)



Wishnu Prasetya presented an extended abstract at AAMAS and a short paper at EMAS, on May 2020, introducing the solution proposed by iv4XR and the APLib agent programming library, videos of the presentations can be found on the links below:

[AAMAS extended abstract](#)

[EMAS full paper](#)



Fernando Pastor presented the iv4XR project at the Research Projects workshop held at RCIS2020 conference, September 2020. The workshop program is available at:

<http://www.rcis-conf.com/rcis2020/program.php>

Ongoing work

TESTAR at iv4XR

TESTAR is a tool that implements a scriptless approach for completely automated test generation for event-based Systems Under Test (SUT). Once the tool has sufficient information about the characteristics of the states of the SUT and what actions or events the SUT expects in a specific state, it can test the SUT fully automatically, without the use of programmed scripts. This is due to the agents that implement various action selection mechanisms and test oracles. The underlying principles are very simple: generate test sequences of (state,action)-pairs by starting up the SUT in its initial state and continuously selecting an action to bring the SUT into another state. The action selection characterizes the most basic problem of intelligent systems: what to do next. The difficult part is optimizing the action selection to find faults and recognizing a faulty state when it is found. Faulty states are not restricted to errors in functionality, also violations of other quality characteristics, like accessibility or security, could be detected by inspecting the state. This totally shifts the paradigm of event-based testing: from developing scripts to developing intelligent AI-enabled agents. At the moment, in iv4XR, TESTAR's testing capabilities are being researched on LabRecruits and Space Engineers.

Model-based testing

One of the lines being pursued in iv4XR is the use of models to capture the desired behavior of the system under test (e.g., a game) in order to apply testing techniques based on the model. We are currently exploring the use of extended finite state machines (EFSMs) in combination with search based as well as model-checking based automated test generation algorithms. The game developer defines a model in EFSM for the specific scenario of the system (as modeling the whole system will be complex and error prone) that is currently under development/test. Such a model is then used to generate test cases automatically in order to achieve desired adequacy criteria. Prototypical implementation using our LabRecruits game is underway and will be shortly made available via our GitHub repository.

Reinforcement learning

For different aspects of the project we are exploring the application of reinforcement learning (RL). In particular, we are exploring RL for:

- Testing the system under test to achieve the exploration of different aspects of the behaviour of the system under test (WorkPackage 3). One of the tools we will try this out with is TESTAR. The action selection mechanism fits quite well with the RL action systems.
- Exploring different behavioral aspects and dimensions of the affective perspective related to XR based systems. This includes, but not limited to, exploring collaborative behaviors among test agents (WorkPackage 4)

Automated UX testing

The project is exploring the use of agents endowed with affective/cognitive models with the intent of automatically assessing User eXperience (UX). The objective is to create agents that are able to interact with XR environments and modify their internal affective or cognitive models accordingly. This would allow developers and testers to automatically predict how certain changes would impact UX. We are currently exploring how we could use agents endowed with a core affect model to test different maps of our LabRecruits game.

Integration of use cases

The integration of project use cases with the agent-based iv4xR testing framework is underway. In particular, prototypical integration of the Space Engineers use case has been started with support for basic access of iv4XR agents to the Space Engineers world. In particular, there is support for observing the world as well as making basic movements. Current implementation is in our GitHub repository.

