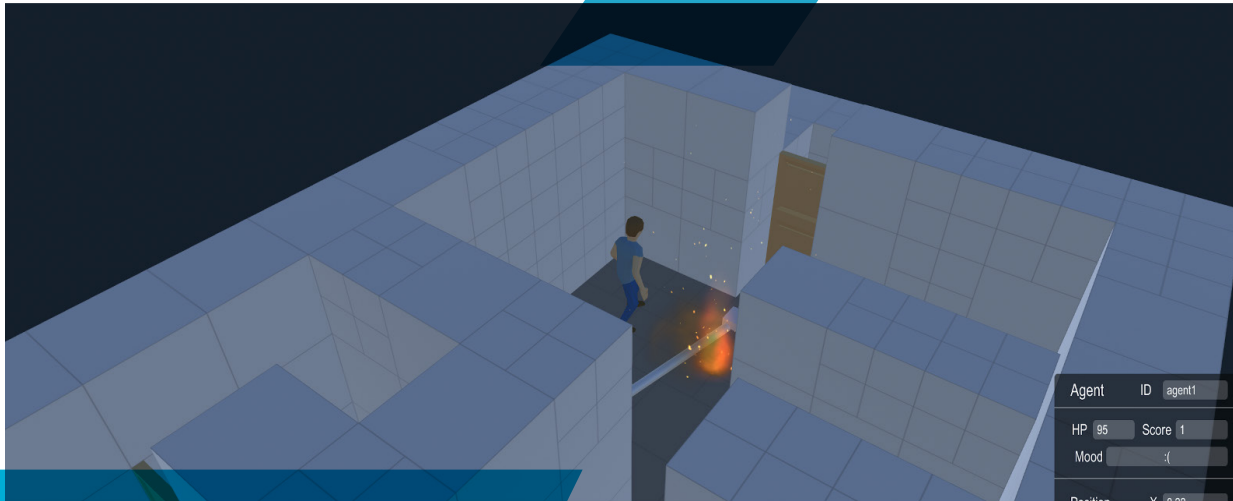


# iv4XR

Intelligent Verification / Validation  
for Extended Reality Based Systems

#2

Project Newsletter  
February 2021

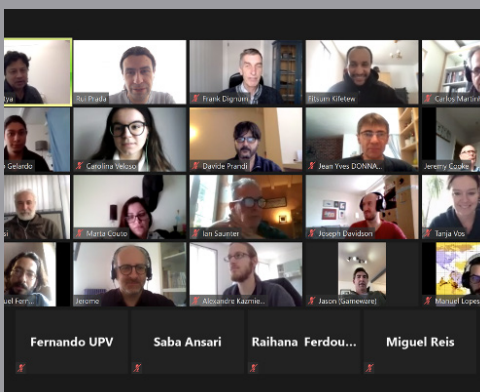


## / About iv4XR

**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 second year and has so far made important progress in formalizing the problems and contextualizing them along the challenges faced by industrial partners. Solutions are being prototyped and applied gradually to the use cases.

For more information consult the [project website](#)

## / Project meetings



The fourth project meeting was held on 1-2 February, 2021. This time as well, the meeting was held virtually, but was rather successful. During the meeting, the achievements of the project so far in reaching the target milestone and obtaining a basic iv4XR framework is reported. The next steps are discussed including WP plans, intermediate integration of the pilots, and upcoming review meeting.

## / 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.

Integration of the pilots from the industrial partners is progressing well. We have a new prototype of the iv4XR plugin for the Space Engineers game as well as an improved demo project that integrates the iv4XR agent environment with the Space Engineers game. The projects can be found in the project Github repository:

**Space Engineers Demo:**

<https://github.com/iv4xr-project/iv4xrDemo-space-engineers>

**Space Engineers plugin:**

<https://github.com/iv4xr-project/iv4xr-se-plugin>

The LabRecruits application, developed in the project as a home grown case study, has a new release (version 2.0) with improved functionality, including scoring mechanisms showing the agent's state when interacting with the various elements in the application (e.g., fire). **The project can be found in the project Github repository:**

<https://github.com/iv4xr-project/iv4xrDemo>

We have also an early prototype of a model-based test generation tool for functional testing. The tool is based on a model of the system under test, in the form of an extended finite state machine (EFSM), and it is able to generate test suites that achieve predefined coverage requirements, such as covering all states and transitions in the model. The prototype contains example scenarios from LabRecruits. **It can be found in the project Github repository:**

<https://github.com/iv4xr-project/iv4xr-mbt>

**The integration of TESTAR with the iv4XR platform has also been improved:**

[https://github.com/iv4xr-project/TESTAR\\_iv4xr](https://github.com/iv4xr-project/TESTAR_iv4xr)

## / iv4XR as case study for RE Course @UniTN

FBK, one of the iv4XR consortium members, offers courses at the University of Trento (UniTN) on Requirements Engineering. Professor Anna Perini, who is also a researcher at FBK, used two of the pilots in iv4XR as case studies for student projects on requirements elicitation. Representatives of the pilots in iv4XR participated in the process as interviewees. Here's what Professor Perini has to say about it:

*What automatic testing tools would XR applications developers like to have? —This is the question the ten Master students, who were attending the Requirements Engineering (RE) course at University of Trento in the first semester of the academic year 2020/21 were asked to answer.*

The students were informed about the iv4XR project's objectives and use cases by Fitsum Kifetew during the class on October 7. They organized themselves in four teams and decided to focus on two use cases, namely Space Engineers and LabRecruits.

Between mid of October and mid of December 2020, the students were struggling to figure out first the actual approach to development and testing of such XR applications (called "as-is"), and then to elicit and understand developers' needs about automatic testing (called "to-be"), by applying RE methods they were learning in class.

The iStar 2.0 goal-oriented modelling language was applied to build "as-is", and "to-be" models where key stakeholders (e.g. end-users of XR applications, developers, and testers) are represented with their goals and mutual dependencies for goal achievements.

To understand stakeholders' needs, the students designed and ran a Design Thinking session within their own team, thus empathising with Personas corresponding to end-users, developers and testers. Results helped them to design an interview that they had the possibility to conduct with "real" stakeholders. On November 25, in a long zoom-class, two students, Devis and Matteo conducted the interview with Wishnu Prasetya (Utrecht University) for Labrecruits. Andrea and Giuliano interviewed Joseph Davidson and Premysl Paska from GOODAI, for the Space Engineers use case. All the ten students were excited indeed (thank you again Wishnu, Joseph and Premysl!!)

**... so what's the happy ending of this story?**

Among high level requirements for a "to-be" with automatic testing at support of XR applications developers, students found the following:

- having an autonomous agent playing the role of tester, who can be assigned by a developer the goal of exercising a new aspect of the XR application/game, and then being able to autonomously define and execute plans to achieve the assigned testing goal. In addition the tester agent should be able to compile a suitable testing report for human developers;

- building a tool that automatically analyses end-users' feedback and links it to existing test cases to be (re)run, or generates an alert to developers if related test cases do not exist.

But most importantly, students passed the RE exam, which means that while applying RE methods to answer the above question, they learned what's the purpose of RE and how to use RE methods presented in the course. Moreover, ten prospective XR application engineers now know about novel contributions by iv4XR project to automated testing for XR applications.

Further details from this initiative will eventually be available on the project website: <https://iv4xr-project.eu/news>

## / Events and presentations



The project had a media appearance in an interview for the Portuguese national radio station Antena 1 in the program "90 seconds of science".

[Rui Prada talks about the project](#) (in Portuguese)

ICST 2020. videos of the presentations can be found on the links below: [Slides are available on SlideShare](#)

### **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.

At the moment, an integration has been developed with the first version of the iv4xr Framework and LabRecruits game, which allows the TESTAR tool to extract information and create a state that contains the properties of existing virtual entities, and execute actions that send instructions back to the Framework and the XR system.

Currently, the development is being updated with the second version of the iv4xr Framework and LabRecruits game, it is intended to start the first integration with the Space Engineers pilot, and different Reinforcement Learning strategies are being investigated and implemented in the TESTAR tool, to improve the action selection and the exploration of the iv4xr systems.

[https://github.com/iv4xr-project/TESTAR\\_iv4xr](https://github.com/iv4xr-project/TESTAR_iv4xr)

### **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 of the tool is now available in the project Github repository, The prototype also includes EFSM models of scenarios from LabRecruits.

<https://github.com/iv4xr-project/iv4xr-mbt>

### **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 where the agent is intended to test the functionality of the XR system

through exploration. Different Reinforcement Learning strategies are being investigated and implemented in the TESTAR tool, to improve action selection and exploration.

> One of the use cases of iv4XR framework is the verification of the defense strategy of a critical infrastructure against an infiltration. In such scenario, Deep RL approaches are being investigated to aid the adversarial testing where the testing agents try to defeat the defense strategy of a nuclear plant infrastructure.

- 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 and cognitive models to automatically assess User eXperience (UX). The objective is to create agents that can interact with XR environments and modify their internal affective or cognitive models accordingly. This would allow developers and testers to predict how certain changes would impact UX automatically. We are currently exploring how we could use agents endowed with a core-affect model to test different maps of our LabRecruits game. In its current version, the software uses a rule-based approach to model pleasure and arousal of an agent that traverses a level/scenario. The next step will be to include bio-sensors to measure physiological parameters during an interaction. We are also testing a cognitive load model to create a toolset that will provide designers with a measure of the working memory resources being engaged when a user is interacting with a system. To test our cognitive load model, we created a game called WayOut.

<https://github.com/iv4xr-project/userexperienceeval>

<https://github.com/albertoramos1997/WayOut>

### **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. The integration also allows performing basic actions in the game such as placing objects as well as some basic construction.

<https://github.com/iv4xr-project/iv4xrDemo-space-engineers>

Similarly, the pilot from Thales on intrusion detection has been integrated into the iv4XR platform. The prototype implementation of the integration allows some basic commands to be exchanged between iv4XR and the pilot application. It is available in the project Github repository.

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

## / Collaboration with other projects

We have established collaborative efforts with a number of other projects. One of these projects with which we have established a synergy is the H2020 ARETE project. The ARETE H2020 project (<https://www.areteproject.eu>) aims to support the pan-European interactive technologies effort both in industry and academia, through the multi-user interactions within Augmented Reality technologies evaluated in educational settings in both professional and private contexts. The authoring tool used within ARETE is based on the Mirage. XR Community Edition, Open Source for authoring and re-enactment of AR learning content to scale down mobile platforms. Within the three pilots of the ARETE project, highly usable, useful and desirable AR technologies and contents will be delivered, leading to a wider uptake and further stimulate their creative usage.

We will report on other collaborative efforts in upcoming editions of our newsletter.

## / Check out our channels

We have set up various channels where we regularly disseminate updates and progress on our project. Follow us on your preferred channel:

Twitter: <https://twitter.com/iv4xr>

Facebook: <https://www.facebook.com/iv4xr>

LinkedIn: <https://www.linkedin.com/company/iv4xr-project>

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

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



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