IV4XR- Intelligent Verification/Validation for Extended Reality Based Systems

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1 Summary of the project

1.1 Challenges and Objectives

"Extended Reality" (XR) systems are advanced interactive systems such as Virtual Reality (VR) and Augmented Reality (AR) systems. They have emerged in various domains, ranging from entertainment, cultural heritage, to combat training and mission critical applications. As the complexity of these systems keeps increasing, testing is getting more complex too. Current toolsets do no propose XR testing technology beyond rudimentary record and replay tools that only work for simple test scenarios. The following challenges need to be addressed:

1. **Fine-grained interaction space**. XR systems more accurately reflect the real world, so they allow fine grained, almost continuous, interactions. Also, XR worlds are inhabited by independent and dynamic entities simulating the corresponding real world entities. They interact with the user as well as with each other, and often lead to emerging behavior. These result in an interaction space far larger than in traditional interactive digital products, and intractable by existing automated testing approaches.
2. **Assessing user experience (UX)**. High quality UX is very important for XR systems. If it is not smooth enough, is too boring, or too overwhelming, the users become unhappy, annoyed or can make mistakes. The latter is a serious concern for mission-critical XR applications. Since manually assessing the UX quality is very labour intensive, automation is needed. Unfortunately, existing tools are too simplistic and lack deeper models of human emotion and cognitive capabilities to be able to judge the different emotional states that an interaction event might evoke on users. Moreover, they are not able to deal with the diversity of users nor are they able to judge the progression of the UX that is built up over time as users engage in long term interactions.

The IV4XR project aims *to build a novel verification and validation technology for XR systems based on techniques from AI to provide learning and reasoning over a virtual world*. The developed technology enables XR developers to deploy powerful test agents to automatically explore and test the correct parameters of their virtual worlds as they iteratively develop and refine them. In addition, user experience is an equally important aspect for all XR systems. We will therefore also develop socio-emotional AI to enable test agents to conduct automated assessment of the quality of user experience and parameterization by different demographic and socio economic types, such as male, female, young, and elderly.

1.2 Expected tangible result

1. A multi-agent framework to automate XR testing tasks featuring: reasoning agents, search algorithms to generate test coverage, automated UX assessment through a computational model of emotion, and automated learning AI. This will be provided open source.
2. A set of guidelines on how to integrate IV4XR framework and target XR systems. This will be supported by examples from the pilots that will be run during the project.
3. Studies assessing the effectiveness of the IV4XR technology.

2 Summary of current project results

An initial version of the underlying multi-agent framework of IV4XR, called *Agent Programming Library* or aplib[10], has been released [1]. Aplib is inspired by the Belief-Desire-Intent(BDI) model of intelligent agents a la [2]. It features a novel layer of *tactical programming* that provides an abstract way for agent-programmers to exert imperative control on the underlying reasoning-based behavior of agents. as they search for solutions. So-called *tactics* can be defined to enable agents to strategically choose and prioritize their short term actions and plans, whereas longer term strategies are expressed as so-called *goal structure*, specifying how a goal can be realized by chosing, prioritizing, sequencing, or repeating a set of subgoals. A preliminary experiment on the viability of using this framework to automate testing tasks showed a promising result[11].

References

1. Prasetya, I.S.W.B., Dastani, M., Prada, R., Vos, T.E.J., Dignum, F., Kifetew, F.: Aplib: Tactical agents for testing computer games. In: to appear in the Proc. of the 8th International Workshop on Engineering Multi-Agent Systems (EMAS) (2020)
2. Rao, A.S.: Agentspeak (L): BDI agents speak out in a logical computable language. In: European workshop on modelling autonomous agents in a multi-agent world. Springer (1996)

[10] `https://iv4xr-project.github.io/aplib/`

[11] The experiment (using a configurable small 3D game) is available at `https://github.com/iv4xr-project/iv4xrDemo`.