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Formal Framework to improve the reliability of concurrent and collaborative learning games

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Abstract

Multi-player learning games are complex software applications resulting from a costly and complex engineering process, and involving multiple stakeholders (domain experts, teachers, game designers, programmers, testers, etc.). Moreover, they are dynamic systems that evolve over time and implement complex interactions between objects and players.

Usually, once a learning game is developed, testing activities are conducted by humans who explore the possible executions of the game's scenario to detect bugs. The complexity and the dynamic nature of multi-player learning games enforces the complexity of testing activities. Indeed, it is impracticable to explore manually all possible executions due to their huge number. Moreover, the test cannot verify some properties on multi-player and collaborative scenarios, such as paths leading to deadlock between learners or prevent learners to meet all objectives and win the game. This type of properties should be verified at the design stage.

We propose a framework enabling a formal modeling of game scenarios and an associated automatic verification of learning game's scenario at the design stage of the development process. We use Symmetric Petri nets as a modeling language and choose to verify properties by means of model checkers. This paper discusses the possibilities offered by this framework to verify learning game's properties before the programming stage.

Keywords: Concurrent and Collaborative learning Game; Scenario Modeling; Scenario Verification; Model Checking; Symmetric Petri Nets

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1. Introduction

Context. Learning games can be defined as "(digital) games used for purposes other than mere entertainment" [1]. They are a way to help people to acquire domain knowledge and develop skills. Fabricatore [2] defines a learning game as : "[...] a virtual environment and a gaming experience in which the contents that we want to teach can be naturally embedded with some contextual relevance in terms of the game-playing [...]".

Learning games are complex software applications resulting from a costly and complex engineering process, involving multiple stakeholders (domain experts, game designers, designers, programmers, testers, etc.). In addition, the learning games implying multiple players are dynamic systems that evolve over time and implement complex interactions between objects and players. Once a learning game is developed, testing activities are conducted by humans who explore the possibles executions of the game to detects bugs.

Problem. The complexity and dynamic nature of multi-player learning games enforce the complexity of testing activities. Indeed, exploring all possible execution paths manually is impossible due to their large number. Also, multi-player learning games belong to the class of systems for which it is well known that testing activities are not sufficient to ensure reliability.

Moreover, testing activities do not allow to verify specification properties and are intrinsically performed too late because they require the game to be implemented first; thus, detected problems are costly to correct.

Contribution. To avoid costly testing procedures and improve the learning game reliability, we propose to perform automatic formal verification of scenarios of learning games at the design stage. Our objective is to ensure that a learning game satisfies properties which are extremely difficult to assess by means of

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modeled through initial marking of some places. The second example illustrated this need. Before the game can be played, it is necessary to define, for each group, an activities order that must satisfy some conditions. We have verified that a given pre-defined order is relevant, it would be interesting to study how scheduling and control theory results allow us to compute, among all the possible orders, the "good ones" [18, 19].

Another trend is to define transformation rules in order to construct semi-automatically Petri nets from some more user friendly models of scenarios such as eAdventure [20], LEGADEE [21].

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