A 3D Learning Game for Representing Artificial Intelligence Problems

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Abstract. In recent years, there has been growing interest in 3D educational games. This is due to the confidence that 3D environment can offer several learning benefits to learners. Specially, 3D educational games focusing on Artificial Intelligence (AI) are needed today. In particular, problem representation by state-space approach is seen as an important part of problems solving for learners. So, developing 3D educational games which enhance learners' motivation for the AI subject is the main issue of this work. In this context, this paper presents a 3D educational game for higher education. This new game is called Bridge Crossing Game and it allows learners to benefit from the 3D environment to solve Bridge Crossing Problem in an amusing story.

Keywords: Educational Game, 3D Environment, Problem Representation

1 Introduction

Learning AI faces the problem of low motivation of students. This is due to the complexity of this subject and the diversity of students' backgrounds [1]. In fact, most students study AI course at the end of curricular [2]. In fact, before this course, they need to have some basic skills of programming. However, many students have a difficulty in understanding problems solving, even students who previously had little trouble with the basic data structures.

On the other hand, many researchers have stressed the importance of problem representation in problem solving process. Some of them considered the problem representation as a cardinal point [3]. Some others considered it as a key to problem solving among novice learners and experts [4]. Thus, to solve a problem the learner needs to understand that problem and then represents it as a state space. The students find the process of solving AI problems so difficult and so incredibly boring because it requires a lot of effort from them. . For instance, Bridge Crossing Problem (BCP) is one of famous AI problems that have been around in many incarnations and with various anecdotes attached to it, and her history has explored

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by Torsten Sillke that assembled on his web page [5]. So, the teaching process of BCP needs today a learning environment that is interesting and stimulating for learners [6] to increase learner's motivation and engagement during problem solving process.

Among learning environments, 3D environments offer new opportunities for learners to learn through exploring environments in relatively open-ended ways [7]. Therefore, 3D environment facilitates the learning of the individual steps of a problem solving representation. In addition, the use of computer games is an interesting alternative to reinforce learning experience since it can render education more motivating and engaging and can keep learners more interested in learning [8]. In particular, a new generation of learners, called Game Generation [9], spends a significant amount of time playing computer games. In view of these, *do 3D games help learners in AI problem representation?*

To answer this research question, we develop a serious game called Bridge Crossing Game (BCG) to help learners' in AI problem representation. Also, our educational game is designed to render the difficult process of learning AI problems engaging, motivating and more amusing. BCG allows learners to have the opportunity to play a 3D game, which enables them to learn while playing.

This paper is structured as follows: Section 2 contextualizes the contribution by analyzing related works. Section 3 presents the move from Bridge Crossing Problem to Bridge Crossing Game including elements of effective educational game design. Finally, section 4 concludes the paper with a summary of the work.

2 Related Works

Researchers have demonstrated the effectiveness of educational games in many domains such as Language Learning, and Math. Table 1 presents examples of 3D educational games and their pedagogical objective.

Table 1. The Effectiveness of 3D Learning Games in Different Domains

Pedagogical Objective	3D Educational Game
Language Learning	Tactical Language training System [10]
Math	Ring [11]
Ecology	CMPRPG [12]
Geography	VR-ENGAGE [13]

As it is shown in table 1, many 3D educational games are used in different domains (e.g. education and security) such as:

Language Acquisition teaching, the Tactical Language training System [10] is designed to help people rapidly acquire basic spoken conversation skills, particularly in languages that few foreigners learn because they are considered to be very difficult. Each language training package is designed to give people enough knowledge of language and culture to carry out specific tasks in a foreign country such as introducing yourself, obtaining directions and arranging meetings with local officials.

In Ring [11] game, students are presented with a set of rings in the water and are challenged to try to swim through as many as possible with one mathematical function.

CMPRPG [12] is used for teaching notions of dynamic ecosystem equilibria. Notions of dynamic ecosystem equilibria are applied to given situations: prey and predator. Notions of rupture of the ecosystem equilibria by natural factors are applied to given situations. In each situation, players have to collaborate in groups to find a solution for the situation.

VR-ENGAGE [13] is used for teaching geography. In VR-ENGAGE, The ultimate goal of a player is to navigate through a virtual world and find the missing pages of the book of wisdom, which is hidden. To achieve the ultimate goal, the player has to be able to go through all the passages of the virtual world that are guarded by dragons and obtain a score of points, which is higher than a predefined threshold. The total score is the sum of the points.

3 From Bridge Crossing Problem to Bridge Crossing Game

3.1 Elements of Effective Educational Game Design

Many researchers found that narrative context is an important element of effective educational game design. According to Dickey [14], narrative contexts offer learners, "a cognitive framework for problem-solving because the narrative storyline in games provides an environment in which players can identify and construct causal patterns which integrates what is known (backstory, environment, rules, etc.) with that which is conjectural yet plausible within the context of the story". Another significant element of effective educational game design is concerning the goals and rules of playing [15, 16]. Although they are integrated within a narrative context, goals and rules are not subordinate to context; they are equally important elements of it.

3.2 Bridge Crossing Game (BCG)

Our new game BCG is designed with 3D technology for educational purpose. It provides a 3D environment for learners to solve the bridge crossing problem and to build a state-space associated to that problem.

Game Story. The transmission of learning content in the form of a narrative game story is very important for learner [14, 17]. In this way, the bridge crossing problem statement is transmitted in the form of a narrative game story where learners have the chance to explore it in real context and learn by playing the BCG.

The story of BCG incorporates four persons on a plane which its fuel ends near an island. The main goal of the game is to help the 4 persons navigate through the island and to find a solution to leave. To do that and based on a wise old man advice (non player character), these 4 persons have to find and cross an old bridge (bridge problem). The game design (3D environment) and the story aim to make the learners more immersive while solving the problem. Besides, it aims to make learners live this learning experience.

Goals and Rules of Play. When they find it, the game interface will be divided in two parts; the first part concerning the game space and the second one concerning the problem representation (Fig. 1).

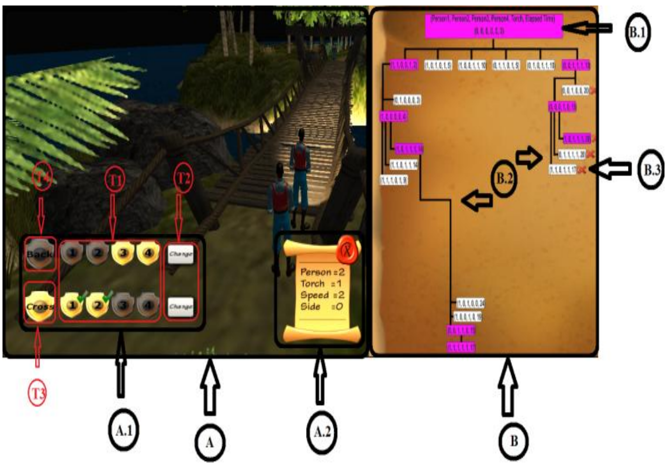

Fig. 1. The bridge crossing game (BCG)

Fig. 1 presents the interface of the BCG. This interface contains two principle parts (A and B), the part A includes two sub-parts (A.1 and A.2) and the B includes three sub-parts (B.1, B.2 and B.3).

Part A. This part holds the elements of game such as the four people, the bridge, the torch and an island design in which the learner should move people from the left side to the right side of the bridge. The sub-part "A.1" contains four types of button (T1, T2, T3, and T4) that help learners to play easily.

In T1: The "1", "2","3"and"4" buttons means that the chosen persons are respectively number 1, 2, 3 and 4. And, when the learner clicks on one button from T1, some information must be displayed in the sub-part "A.2":

- The person's number (1, 2, 3, 4),
- Person's maximum speed (1min , 2min , 5min , 10min),
- Person's side ("=0" if in the left side and "=1" if in the right side),
- Person's torch ("=0" if the torch is not with it "=1" if the torch is with it).

T2 contains the "change" button in witch learner can change people chosen in T1. In order to move them to the right side of the bridge, learner clicks on the 'Cross' button (T3) and click on the 'Back' button (T4) to move people from the right side to the left side of the bridge. After each crossing, all possibilities of the next step in the game are displayed in the part B in which learner solves the problem by playing and in the same time learns how to represent the problem by the state-space approach.

Part B. This part holds the representation of the BCP by state-space approach. The state space is the set of all states reachable from the initial state, it forms a graph (or map) in which the nodes are states and the arcs between nodes are actions.

All states hold 6 ordered variables (person1, person2, person3, person4, torch, elapsed time), the 5 first variables are binary ("=0" if person/torch is in the left side of the bridge and "=1" in the reverse), the last variable is an integer conserved the elapsed time that helps the learner by guiding him/her to the solution. Each state visited by the learner is colored by the roze color to help him/her to know the path towards the solution.

The sub-part "B.1" presents the initial state (0,0,0,0,0,0) linked by all possible next states {(1, 1, 0, 0, 1, 2), (1, 0, 1, 0, 1, 5), (1, 0, 0, 1, 1, 10), (0, 1, 1, 0, 1, 5), (0, 1, 0, 1, 1, 10), (0, 0, 1, 1, 1, 10)}.

The sub-part "B.2" presents the link between states. If the elapsed time in next states in any step in the game is over than 17 or equal to 17 and one or more of the rest variables equal to 0, the game displays a failure icon next the state like in "B.3". If the learner does not solve the problem, the game can give you the hand to try again the game and conserve in the part B all the state visited by him/her.

The harmony between the two parts A and B helps the learners to learn how to represent AI problems with state-space approach in an amazing game environment.

4 Conclusions

We have described a bridge crossing game for assisting learners to learn artificial intelligence problem solving. Common difficulties experienced by learners in studying problem solving were identified and the BCG was designed to assist with these difficulties. The BCG operates in 3D environment. 3D environment facilitate the learning of the individual steps of a problem solving representation while BCG facilitates learning of the representation of problem solving by state-space approach.

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