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Real World Edutainment Based on Flexible Game Story

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Abstract: Real World Edutainment (RWE) is story- game-based learning in the real world, which aims at increasing learning motivation. In RWE, learners can learn through interacting with real objects and human based on a game (learning) story, referring to digital learning materials presented on a handheld computer. In this study, in order to improve flexibility of the game story, we extended the RWE system by implementing the functions of branched game story interpreter, etc. Then, we designed a flexible game story for learning disaster prevention and considered its advantages.

Keywords: Edutainment, game story, sensor device, disaster prevention, real world

Introduction

The learning effect of video games has attracted increasing attention [1]. A current focus is on Edutainment (often called "Serious Game" in these days), which is software that unites learning and fun derived from video game and aims mainly at increasing children's learning motivation. There have been many Edutainment systems, which mainly work on personal computers. In other words, learning (game) is done in the virtual world. This means that learners cannot learn through seeing and touching real objects. In addition, Edutainment is not necessarily flexible. This is because it often focuses on visual and auditory effects and does not give proper information (e.g., hint, feedback, and instructions) to each learner. These points can be regarded as the weaknesses in Edutainment.

To remove the above weakness we proposed Real World Edutainment (RWE for short) and developed the RWE system [2]. RWE is realized as the fusion of the virtual world and the real world, and the RWE system works on a PDA (Personal Digital Assistant) that can be used everywhere. Therefore, learners can learn from real objects (e.g., creatures, artifacts, and human) and virtual objects (e.g., digital learning materials) with diverse interaction.

The RWE system, which uses RFID (Radio Frequency Identification) and GPS (Global Positioning System), may be categorized as not only an Edutainment system but also a ubiquitous/mobile learning system. A project called "AMULETS" bridges outdoors and indoors educational activities by using smartphones, PDAs and GPS devices [3]. In language learning systems RFID tags or visual markers are attached to real objects (including places) and the learning materials (e.g., quizzes) about the corresponding objects are presented to learners [4][5]. In museum learning not only route guide but also the learning materials to help visitors (learners) understand exhibits are presented in location-aware and game-based manners [6][7]. The use of ubiquitous/mobile devices may help make learning fun as learners can learn in different settings.

RWE attaches great importance to a game (learning) story and Human-Human Interaction (HHI) to increase learning motivation. We adopt story-based learning in the real world; that is, apply a role-playing game in the real world. Klopfer & Squire developed an augmented reality game that had a game story revolved in the real world and furnished students with scientific augmentation skills [8]. In this game a learner role-plays an 'environmental detective' and identifies the source of the pollutant, receiving location-based fictitious environmental data and advisory messages from virtual characters. Another idea involves human actors as active characters in the game story. Human actors can provide flexible instruction in various ways considering student's characteristics (e.g., understanding level and preference) and the environmental conditions (e.g., place and time). Schwabe & Göth have developed a mobile game for university orientation (for learning university life) adopting the same idea of HHI [9]. In this game, learners have to find not only places but also people to get important information by interviewing them.

We practiced RWE at educational events for elementary school students and confirmed that many student participants had fun, learning motivation, and learning efficacy through RWE. At the same time, however, we felt that RWE was still far from flexible because the RWE system could not work based on flexible game stories such as a branched story. For example, it cannot guide a learner who answered a quiz incorrectly to the next learning (game) scene proper for his/her understanding level. Although human actors can be competent instructors, they are not allowed to change the game story itself.

From this background, we are extending the RWE system so that it can work based on a flexible game story.

1. Real World Edutainment System

1.1 System Overview

The RWE system has standalone architecture and works on a PDA. The system recognizes learning scenes by RFID and/or GPS then presents learning materials corresponding to the scenes.

To play the game―to learn referring to the learning materials in the real world―, learners have to find specific real objects and/or visit specific locations.

1.2 Fundamental Functions

(1) Learning scene recognizer

This function recognizes learning scenes according to a game story loaded and interpreted on a PDA. The game story is described in XML and has linear structure. Location data (latitude and longitude) is gathered from GPS at a regular interval. A learner reads an RFID tag using the PDA and immediately the object ID data recorded in the tag is gathered. When the gathered data matches the data (location and object ID) specified in the game story, the corresponding scene ID is given.

(2) Learning material presenter

The system presents two kinds of learning materials: expository text (with one image) and a single selection quiz (with one image). This function presents the learning material corresponding to the scene ID on the PDA.

1.3 Learning Flow

Initially a learner (or a learner group) is given one PDA with an RFID tag reader and/or GPS receiver, and subsequently starts game (learning). A typical learning flow is as follows.

i. The learner is briefed on the game story by a human actor(s).
ii. He/she looks for an RFID tag attached to a real object or move to a specific location.

iii. He/she finds the RFID tag and read it using the PDA or visits the location. Then, the quiz corresponding to the scene ID is presented.
iv. He/she deduces the correct answer to the quiz while observing real objects and surrounding situations.
v. If having difficulty in determining the correct answer, he/she is given hints for the quiz by and has discussions with the human actor(s) — this is HHI.
vi. When the correct answer is input, expository text including information about the next learning scene (e.g., the location of the next learning scene) is presented.
vii. When he/she correctly answers all of the prepared quizzes, the learning game is completed.

1.4 Weaknesses

The RWE system has the following weaknesses that decrease flexibility and learning effect.

(1) A branched game story is not supported.

The system supports only the linear structure story and cannot switch the next learning scene according to a learner's characteristics (e.g., understanding level) and behaviors in a game story. For example, a learner is forced to move to the same next learning scene whether he/she answers correctly or incorrectly. This weakness, which can be true of most ubiquitous/mobile learning systems, means that the next learning scene cannot be tailored to each learner, and learners cannot learn flexibly and effectively.

(2) Learning scene recognition is limited.

The system recognizes learning scenes only by RFID and GPS. For more effective learning, the system should recognize more various learning scenes. In some cases, it is important to observe real objects or surrounding situations in terms of not only a learner's current location but also his/her direction of eyes and point of gaze.

Moreover, the learning scene recognition by RFID is limited in range of use because an RFID tag must be attached to real objects being within arm's reach so that learners can read the tags.

(3) Low expressiveness of learning materials.

The learning materials composed of text and image are not enough in expressiveness. For more effective learning, the system should present learning materials composed of not only text and image but also animation, sound and video.

2. Extended Real World Edutainment System

In this study, we extend the RWE system to work based on a flexible game story in order to remove the weaknesses described in Section 1.4. First of all, we adopted not a PDA but a UMPC (Ultra Mobile PC) as the platform to obtain high extendibility, processing speed and capacity of memory and disk. Figure 1 illustrates the composition of the extended system and a snapshot in experimental use of the extended system.

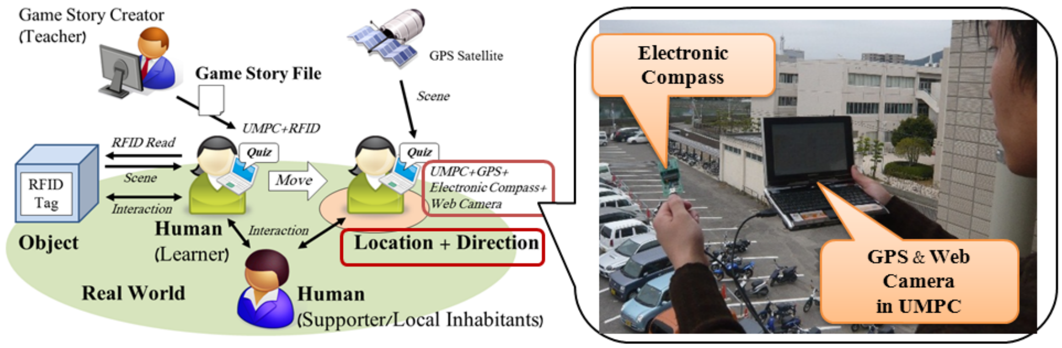

Figure 1: Extended system

2.1 Implemented Functions for Extension

2.1.1 Branched Game Story Interpreter

This function can switch the next learning scene tailored to each learner based on a branched game story. The branched game story deals with the two kinds of branches (river-current branch and reversible branch) as shown in the examples in Figure 2 and consists of some acts (learning themes). Each act consists of some learning scenes. Two learning scenes are connected with a directed link (one or two directions).

Chang et.al. have also stressed the importance of flexibility in game-based learning and proposed a method of personalizing a learning path (sequenced learning spots and learning objects) based on individual learner's characteristics [10]. The personalized learning path can be regarded as a flexible game story focusing on the learner side. On the other hand, the branched game story of the extended RWE system can be regarded as personalization fairly organized from the teacher side and will often be more suitable for child learners.

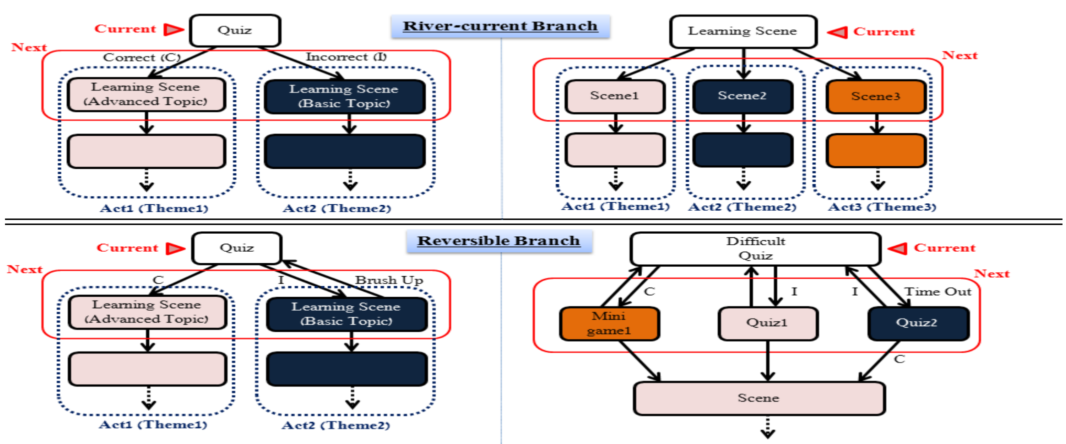

Figure 2 : River-current branch and reversible branch

(1) River-current branch

The river-current branch does not have backtracking and loop in the story. Two and more learning scenes can be included in the next learning scene. Learners are not allowed to move to the previous learning scene or to alternate learning scenes (to move to the other next learning scenes that they did not move to).

In a typical branch the next learning scene corresponds to a learner's answer to a quiz. For example, if the answer is correct, he/she is directed to move to the advanced topic. If the

answer is incorrect, he/she is directed to move to the basic topic. The learner is expected to understand learning topics steadily. Moreover, the river-current branch allows a learner to choose the next learning scene from some candidates. In other words, the game story changes depending on the learner's choice and provides self-directed learning and multi-ending. These characteristics of the river-current branch can increase learning motivation because learners often hope to experience all cases of learning (ending).
To achieve maximum effect of the river-current branch, a game story creator (e.g., teacher) has to forecast a variety of learners' characteristics and behaviors for story design.

(2) Reversible branch
The reversible branch has backtracking and loop in the story and allows learners to alternate learning scenes. For example, a learner with wrong answer can move back to the previous learning scene to brush up his/her understanding. If being given some locations (detected by GPS) as the next learning scene, a learner can move to every location.
The reversible branch can provide supplementary or secondary learning scenes such as a special learning scene (e.g., mini game) for learners who answered a difficult quiz correctly so that high flexibility of learning can be offered.

2.1.2 Extended Scene Recognizer

To recognize more various learning scenes, we extended the learning scene recognizer by introducing an electronic compass and a Web camera.

(1) Electronic compass
An electronic compass plugged into a UMPC can sense the direction so that the extended recognizer can recognize a learning scene in terms of a learner's direction of eyes at the current location. For example, the next learning scene is recognized when a learner visits a specific location and furthermore looks at a direction with a real object of a learning topic. The compass helps make the learning scene recognition more exact and increase learning effect. Learners will point the compass to various directions to find the next learning scene.

(2) Web camera
A UMPC built-in Web camera can capture pictures and video. The extended recognizer processes the captured data and recognizes a learning scene. To be more precise, it executes feature-point matching for a picture (including one frame in video) that a learner is now shooting with the Web camera and pictures of real objects that were shot beforehand by a game story creator. Even if a real object is without arm's reach, the extended recognizer can recognize a learning scene from the real object shot by the Web camera.

2.1.3 Extended Learning Material Presenter

To enhance expressiveness of learning materials, we extended the learning material presenter so that it can handle multimedia learning materials and increase answering (inputting) methods for a quiz. The extended presenter helps make learning more various and effective. For example, a learner deduces the correct answer to a quiz watching a video given as the hint. In another example, a learner answers a quiz by pointing the compass to a direction (e.g., "Point the direction of the oldest temple in this park.")

2.2 User interface

Figure 3 shows the user interface of the extended system and a snapshot in its experimental use. In this figure, when a learner visits a temple, the extended system recognizes the next learning scene by GPS and the electronic compass and presents a quiz about the temple. The learner being in front of the temple is answering the quiz while observing the temple. The user interface aims at simple design so that even children can easily use it.

Figure 3: User interface of the extended system and a snapshot

3. Experimental Design of Flexible Game Story

Undoubtedly nothing is better than the real world in terms of reality and natural surroundings can increase learning effect through authentic learning. In RWE, therefore, a game story should focus on reality and provide learners with educational experience. Especially, a branched game story can encourage learners to think and learn autonomously. We think that RWE is well suited for learning "disaster prevention" because a disaster is immediate threat that can happen in the real world at any time. Learners should know thorough experience in the real world how they should act in a disaster to survive and help others.

3.1 Learning Flow

We designed a game story for learning proper evacuation activities in a large earthquake. The game story, which takes place at a school, is composed of six learning scenes. Figure 4 shows the learning flow of the game story.

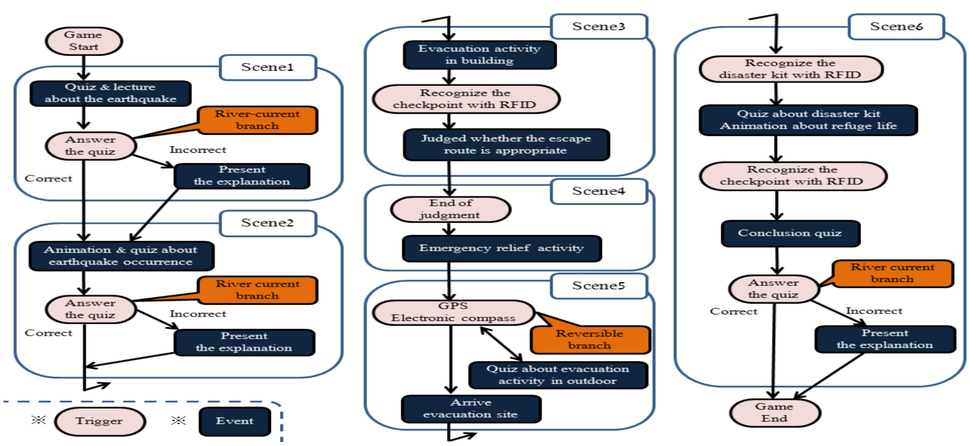

Figure 4: Learning flow of "disaster prevention" game story

i. Attending a class (Scene 1)

This game story begins from the scene where learners attend a class in a school building and a quiz about basic knowledge of earthquake is presented. If answering the quiz incorrectly, a learner must move to the next learning scene after reading the expository text. If answering the quiz correctly, the learner can move to the next learning scene immediately— this is the river-current branch.

ii. Earthquake occurrence (Scene 2)
As a matter of course, real earthquake never happens in the game story. In this scene, video of earthquake is presented to let the learner know terror of earthquake. After that, a quiz and animation about danger avoidance in a classroom are presented.
iii. Evacuating from the building (Scene 3)
The learner is directed to evacuate from the building through the proper evacuation route. RFID tags are attached to some spots on the route as checkpoints, and he/she reads the tags while evacuating. When he/she goes out of the building, his/her evacuation route is judged based on the checkpoints he/she passed.
iv. Emergency treatment activity (Scene 4)
An injured person (human actor) is calling for help near the building exit and the learner has to give emergency treatment to the injured person, referring to learning materials presented. At this time, real objects used for emergency treatment are put near the injured person.
v. Moving to a specified evacuation site (Scene 5)
The learner moves freely to a specified evacuation site. His/her current location is gathered from GPS and two learning scenes (location A and B) are recognized. At the location A on a narrow path between buildings, potential danger caused by building collapse is presented with composite pictures. At the location B near a river, potential danger caused by Tsunami is presented with composite video. The learner can move to either location of A or B, or move quickly to the evacuation site without visiting A or B— this is the reversible branch.
vi. Learning refuge life (Scene 6)
On the evacuation site, finally, the learner learns refuge life. RFID tags are attached to tools available as a disaster kit and he/she learns how to use the tools by referring to learning materials. Finally, he/she answers a conclusion quiz and the game (learning) finishes.

3.2 Advantages of the "Disaster Prevention" Game Story

A promising approach for learning disaster prevention is to introduce ICT, especially GIS (Geographic Information System) and simulation systems [11][12]. In some cases, however, ICT is used as just a media for one-sidedly showing evacuation plans to local residents. Therefore, ICT should be used to encourage learners (especially, local child residents) to think of disaster prevention autonomously and seriously. We think that RWE and the designed game story have the following advantages in learning disaster prevention.

- Learners who had no interest in disaster prevention will learn autonomously with fun because they can learn through playing the game.
- Learner will learn seriously because the game story can take place in their living place and the branched game story allows them to choose their own behaviors.
- Learners can learn effectively thorough experiences of evacuating, helping the injured person, observing surrounding situations, etc.
- Learners can know fear of the disaster by multimedia learning materials.

4. Conclusion

This paper described the extended RWE system that can handle flexible game stories and showed a game story example for learning "disaster prevention". The river-current branch and the reversible branch will improve the flexibility of a game story (learning) and contribute especially to making learning more fun. The scene recognition by an electronic compass and a Web camera and also the multimedia learning materials will diversify learning scenes and increase learning effect.

A current weakness of the extended RWE system is that the branching conditions are not diverse. A learner's answer to a quiz is the fundamental easy-to-use branching condition but does not cover authentic learning sufficiently. For example, there is need to branch a game story based on passing of time, a learner's surroundings (e.g., temperature and luminance), and other learners' current situations (e.g., location and learning scene). Another weakness is that the multimedia learning materials are not well integrated with the real world and do not make learning more real. As a challenge to increasing the reality, for example, the learning materials should be superimposed on real-time camera images using markerless AR (Augmented Reality) technology.

We are conducting an experimental practice of the "disaster prevention" game story to evaluate its learning effect and the system's usability. Through the experimental practice, moreover, we would like to investigate whether disaster prevention to be seriously learnt should involve game (entertainment) aspects.

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