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Serious Game for Fire Safety Evacuation Plan

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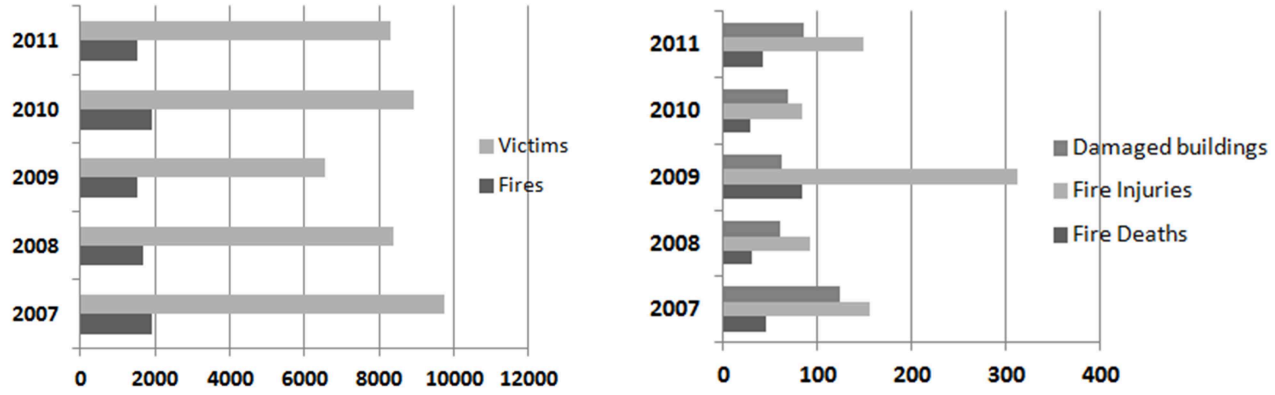
Abstract. Virtual worlds are successfully used for training a personal skill in an emergency situation. In this paper, we present a serious game for fire evacuation training in any public places like office buildings, conventional centers, hotels, and universities. The goal of fire safety evacuation plan is to minimize the damage, i.e. the number of injured people and casualties. In this paper, we built a virtual environment where imitates a classroom building in Bangkok University. We described a design process and development approach for achieving the objectives of evacuation training. The user evaluation was also conducted, showing that the prototype can be used effectively for training a fire drill at other public places.

Introduction

The daily news on disaster and accidents raise the awareness of disaster management planning. Generally, this is a mission of an organization like CTIF, where CTIF was founded in 1900 in Paris for encouraging and promoting cooperation among fire fighters and other experts in fire and rescue throughout the world. According to the report of center of fire statistics of CTIF [1], there are up to 7-8 Million fires with 70-80 thousand fire deaths and 500-800 thousand injuries among the population of the Earth, which was 6,300 million at the beginning of the 21th century.



(a) Number of victims and incidents caused by fires (b) Number of fire deaths and fire injuries

Fig. 1: Statisical records of fires in Thailand DDPM during 2006-2010 (DDPM)

In Thailand, one of the biggest tragedy in 2003 was, on February 20, a nightclub fire caused a multiple casualty disaster, with 215 victims requiring treatment at area hospitals. In the official report of the Department of Disaster Prevention and Mitigation (DDPM) of Thailand as shown in Fig. 1, the total number of fire victims in 2010-2011 was over 8,000; the number of injuries and deaths in 2011 were increasing from those in 2010. This is a considerable number to be ready for the fire disaster. For a fire drill regulation, the fire drills are mandatory to be conducted at least one a year in elementary, middle, and high schools as well as most colleges and universities.

In this paper, we will present how to design and develop a serious game for a fire drill. The objective of this game is to increase the personal fire safety skills in a building. The game is designed and implemented in a virtual world, named Second Life [2], and the virtual environment is in a

university building. The challenge of this game is that players will be pressured by the evacuation time and must make a correct decision among a number of actions on a given situation.

Our work does not aim at replacing the 'real' fire drill procedure with a serious game, but the game might be a training tool for increasing a personal fire safety skill. The advantages of a serious game are as follows: 1) the game can be played anytime and anywhere (asynchronous training) with no additional cost for players, 2) the players can be any person who are willing to be trained, and 3) the game will be suitable for public building where the occupants are mostly unaware of the topology of the building or the location of the emergency exits.

Fire drill policy. Following the law and regulations, the university must conduct at least annual fire drills for all individuals in educational facilities. All occupants of these buildings, at the time of the drill, must participate in the fire drill, vacate the building in an orderly fashion when the fire alarm signal is given, and not return until the ALL CLEAR signal is given by the staff. The object of the drill is to prepare building occupants for exiting a building during a fire. The drills are conducted by the university where no prior notification is given to any specific building as to a specific date or time.

Fire evacuation instruction. We develop our serious game based on the basic instruction of the fire evacuation training; there are things to do and do not do as follows:

MUST DO	DON'T DO
1) Activate the fire alarm sound at the nearest place. 2) Evacuate immediately and use the closest exit. 3) Touch a door before opening it. 4) Close the door behind you to confine the fire.	1) Do not use elevators. 2) Do not break windows because oxygen feeds a fire. 3) Do not open any door when seeing smoke or being hot. 4) Do not return to the emergency area.

Virtual Worlds and Serious Games

Virtual Worlds. We focus on the virtual worlds defined as a permanent virtual physical space where allows the user to experience the virtual reality environment. The virtual worlds are an alternative platform for corporate training in various ways, including direct instruction, training simulations, language immersion, diversity training, procedural practice, and visualization of a complex situation as in-depth explained in [3].

Table 1. Comparison of Active World (AW), Second Life (SL), and Croquet; by using the criterion scores in a range of 0 to 100 as explained in [4] where 0=none through 100=very good.

Criteria	AW	SL	Croquet
Realism of world	72.22	97.22	63.89
User interface	83.33	83.33	75.00
Communication	100.00	100.00	100.00
Avatar	85.00	100.00	75.00
Scalability	62.50	87.50	45.83
Security	50.00	91.67	33.33
Pedagogy	87.50	87.50	12.50

Among a number of virtual worlds, there are three widely used platforms: Active world, Croquet, and Second Life. They are different on the characteristics of the design used to build the world. The comparison conducted by Reis et al. [4] will illustrate the common and different features among Active World (AW), Croquet, and Second Life (SL). According to Table 1, SL contains most of the features better than others. We will then develop our serious game in SL.

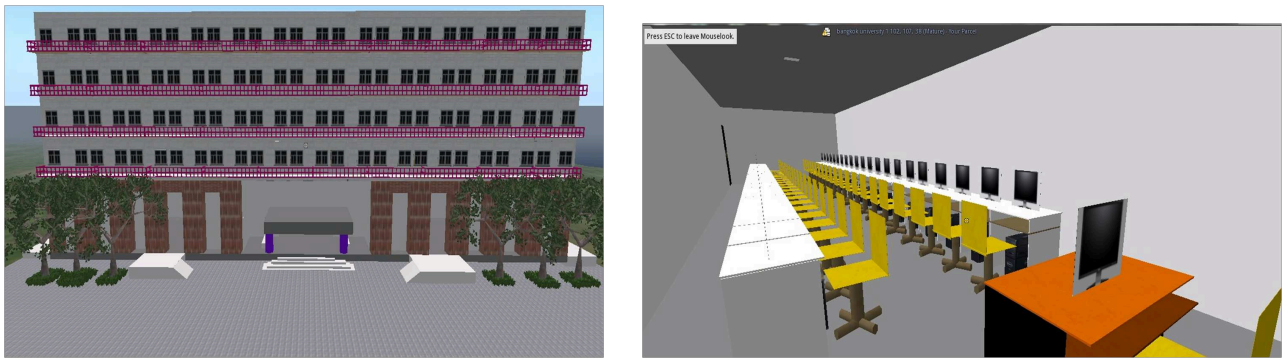
Serious Games. Several studies as reported in [5-8] show that playing computer games can be linked with motivational, behavioral, perceptual, cognitive, behavioral, affective and motivational outcomes. Their survey research was conducted with users aged 14 years or above for the potential

positive impacts especially with respect to learning, skill enhancement and engagement. For example, Mac Namee et al. [9] describe the development of Serious Gordon, a virtual environment to teach food safety. The game was carefully designed so that the story of the game can provide an interesting scenario, i.e., realistic and covering the necessary learning outcomes.

In the previous section, the virtual worlds are used for corporate training as classified as serious games [10]. In SL, the constructions like those of the real world can be reproduced, and then a series of situations will be fed to the trainee. The merit of using games is making fun and immersive as well as it can be both synchronize and synchronize. It allows the trainee can play when ready.

Our Serious Game for Fire Safety Evacuation Plan

Virtual Environment. Without loss of generalization, we develop a virtual environment of the Rangsit campus of Bangkok University. A six-story building of Engineering faculty is as an incident happening in a computer laboratory. The virtual environment is designed to mimic the real campus and the detail inside the six-story building is decorated as the real place including computer laboratory rooms, lecture rooms, and faculty offices as shown in Fig. 2. We use the blueprint of the university buildings for this development. The furniture is also created in each room as the same appearance in the real rooms. This is because our target trainees are students in the campus either who have been there before or never. For whom have been there, they will feel like being in a real place.



(a) Virtual building in a university campus. (b) Virtual computer laboratory room

Fig. 2: Virtual Environment

Required modules. To train successfully in the personal skill for the fire building evacuation, we designed and developed the main module as follows.

1 Incident happening simulation such as a place to be fire.
  1.1 Fire alarm's controller.
2 Tracking avatar route during evacuation.
  2.1 Timer
  2.2 Fire alarm pressing detection
  2.3 Elevator usage detection
  2.4 Assessment report

Game strategy. This game strategy is based on the fact that the incident can happen anywhere in the building, whereas the building occupants have to learn the fire evacuation. The in-game incidents are randomly categorized into two types: 1) A player is who a fire first is discovered. 2) Players are the building occupants who hear a fire alarm sounding.

The above categories are different on an assessment report whether the players must follow the fire evacuation plan. Each player will repeat the game until he/she can pass the baseline score where, for every time, the simulated situations are changed randomly. The most important measure for this training game is the evacuation time and the evacuation path of players.

Avatar controller. For in-game conditions, the trainees can control their avatar via a keyboard and a mouse, where the keyboard commands actions, the mouse control the direction of an avatar. The avatars are only allowed to walk, run, sit, crawl, and lie down. For some common controller like flying in the virtual world, the in-game environment has a script not to allow any avatars flying there. Note that, our game aims at training people to be more aware about the fire evacuation, but not the personal physical ability, i.e, a person feeling exhausted, in-game running faster than the real-life.

Experiments and Results

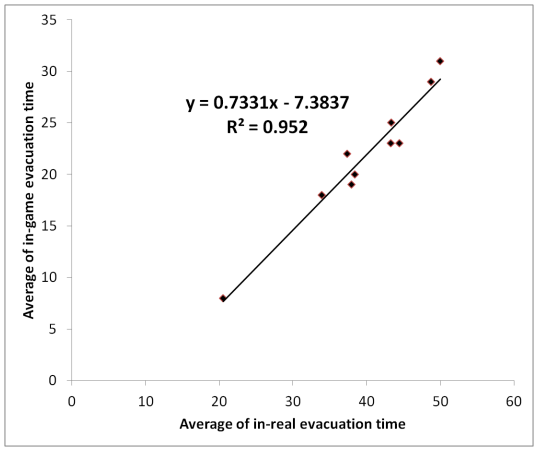
Experiment procedures. We conducted four experiments as follows:

1) Comparison between people who are familiar with an incident place and those who are not.
2) Investigation of people improving the cognitive skill from the game.
3) Discovery of the relationship among the in-game evacuation time and the in-real evacuation time.

Firstly, the experiment has 10 participants who are students divided into two groups: familiar, not familiar with the place as shown in Fig. 3 (a). After the game, they received a personal report that only one participant is judged not to pass the game because that one stand still for a long before starting the evacuation. The second experiment used the same group of participants. All of them have to play the game three more times which of them are designed in different situations. The last experiment has different three participants who must do the evacuation at the real place, i.e., evacuation from different floors and rooms in a total of 10 trials.

Results and discussion. Firstly, we did the statistical analysis (Kruskal–Wallis one-way analysis of variance) and found that there is no significant difference between two groups who are familiar, and not familiar (p=0.07). Secondly, we investigated whether all participants did the evacuation instruction correctly. We found that all of them can do correctly after the first play such as they will not use the elevator after the first report. For the evacuation time, the faster they can find the correct evacuation route, the more times, they play the game. Lastly, the result of the relationship of the in-game and in-real evacuation time is shown in Fig. 3 (b).

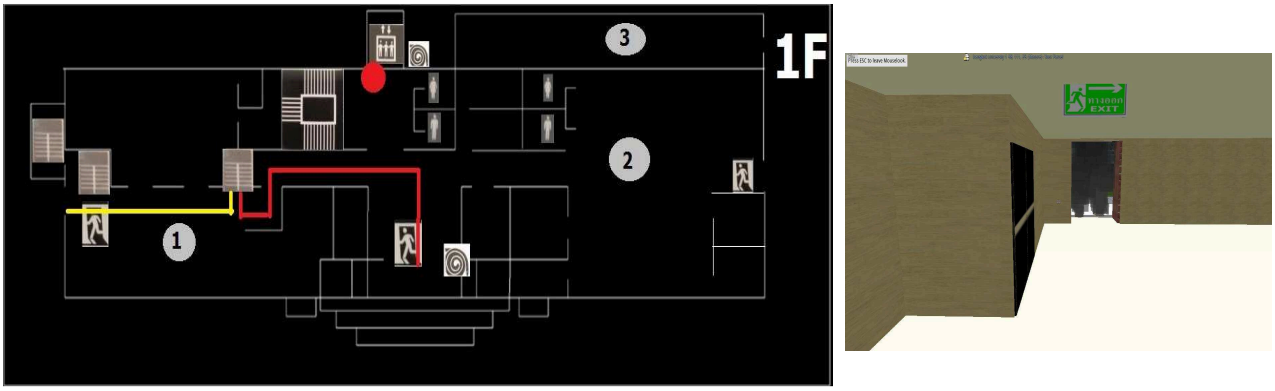
(a) In-game training users



(b) Relationship between in-game evacuation time and in-real evacuation time.

Fig. 3: Experimental results

We also tracked the player's evacuation route to determine whether the players took the shortest route or not. The results show that, in some cases, players did not take the shortest path. Fig 4 (a). shows the path that all the subjects have taken in red, and the path in yellow is the shortest path. This may be because 1) the players tended to take the same path they were most familiar with and 2) no exit sign was visible which the players could notice clearly when they were evacuating.



(a) Players' evacuation path (red line) VS the shortest evacuation path (yellow line) (b) Insert the virtual exit sign

Fig. 4: Discovery of the design defect of the building

Conclusion and Future Work

The occupants of a building have to be able to survive when an incident happens by following the correct evacuation plan. Our game can serve that purpose especially the public places like a campus university. We developed a serious game for training people the fire evacuation plan in a building. We decided to mimic the virtual environment like the Rangsit campus of Bangkok University. In our experiment, the simulated incident will take place at a six-story building having lecture rooms and computer laboratory rooms. The experimental results can show an interesting finding that there is no significant difference between two groups who are familiar, and not familiar with the place. There is very high correlation coefficient between the in-game evacuation time and the in-real evacuation time. Considerably, in the game, we are able to insert the virtual exit sign (Fig. 4 (a)) in order to do the experiment whether people will use the shortest evacuation path (yellow line).

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