

A video game-based training mode for decision making in construction project control and management

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Abstract

This paper presents a computer game for training decision making on project management based on the role-playing game mode. The development of this game integrates various commercial software including Virtools, MS projects, Autodesk 3ds Max, and MATLAB to provide features, such as accident event handling, resource allocation, selection of subcontractor, adjustment of project scheduling, performance evaluations, and so on, that allow the user to practice while managing a virtual project. A virtual project is presented to the user as a dynamic 3D scene of a developing construction site, which varies by following the progress of the game. Various events are presented as video clips when set off. By playing the proposed game, the user can gain virtual experience in practicing management and control tasks of a construction project, which generally is difficult to provide in conventional training modes. While playing this game, the user can play the role a project manager to make various decisions on accident handling and resource allocation during the progress of a virtual construction project. Results of the decisions made are obtained by real-time simulation based on project data, and they visually and interactively respond to the user for understanding the consequent effects. In this training mode, decision simulation can provide realistic and reliable consequences. Therefore, the virtual experience of playing this game can be an economical and valid substitute for real experience.

Keywords: decision simulation, training, computer game, project management

1 Introduction

Recently, various computer game modes have become a kind of assisted mode for the professional training by combining them with all kinds of professional knowledge. The application of computer game mode in training is divided into operational mode and role-playing mode. The operational mode is used by trainees to practice operations, such as driving an excavator or operating the large-scale machine, in a virtual environment. It focuses on training the adaptability of trainees for those operations (Javier and Abraham, 2005; Lu et al. 2009; etc.). The role-playing mode is used by trainees to manage a virtual company or shop from the manager's point of view and to make a series of responding strategies according to the information supplied by the computer game. Therefore, the trainee can accumulate the management experience (Nassar, 2002; Wang et al., 2007; etc.). However, most applications currently available are for providing virtual experience on operating a machinery or equipment, while applications for role-playing game mode for training decision making on engineering problems are relatively few.

The conventional training modes for the managerial staff of construction engineering are classroom instruction, business practice, site visit, and so on, among which the classroom instruction is used as the main teaching method. It is assumed that students have some practical experience in the design of existing construction management courses, when in fact they lack real opportunities for exercise. Some training classes or schools provide students with opportunities to practice in enterprises, but learning is limited because students can only be assigned to low-level work without the opportunity to play a part in the management core. Therefore, the students tend to struggle after entering the industry, and they learn the correct practical approaches after trial and error and after gaining experience through time. If the training mode of a computer game, in which the trainee acts as an engineering managerial staff who operates engineering projects, is offered with the combination of a computer game mode and construction engineering, then it can improve the presence, simulation, security, and playfulness while training. This provides the trainee with supplementary training aside from class studying. At present, this computer game mode can offer a simulative scene to trainees, allowing them to feel by themselves and to visualize site situation using pictures and words, which will no longer be subject to individual imagination. In the simulation, the proposed solution from existing classroom case studies can be included in the game for analogous calculation and for comparison with the original estimated situation for the purpose of further study. With regard to security, it can eliminate the risk in a real training site and present the process of accident through an animated film, giving the trainees the feeling like they were on site but without the fear of being hurt.

Therefore, this study proposes a computer game mode for training a project manager in simulation game style. It aims to develop assistant training software based on the principle of decision-making management by combining the simulation game with engineering managerial knowledge. In this game, the user acts as a project manager of a construction site who has to make a series of decisions presented through 3D visualization and a game event, such as the arrangement of labor, number of material and equipment required by each project, control of cash flow and construction period, selection of contractor, safety in the management of construction site, field inspection and control, and weather factors, to achieve desired goal in construction control.

This virtual construction game is expected to provide the trainees the chance to practice managing a virtual construction site. By applying what they have learned to the virtual construction, trainees would be able to appreciate the experience and have the chance to inspect and verify. Thus, it can help them clarify the cases from books and strengthen their perceptions. In addition, it is relevant for the trainees to observe the extent of damage caused by using improper management modes without worrying about actually losing of money and compromising the security. Trainees can repeat the practice according to their training results.

2 Content and scope of the proposed virtual construction game

The proposed game mainly aims to provide the user with an overall understanding of the concept of decision making in construction engineering. Although the main training objects are the on-site managerial staff, game content covers the work of the project manager, owner, and contractor, and it is not limited to specific roles. As for the method of presentation, under the premise of allowing users to understand effectively the situations and based on the clear instruction provided by the animations and film, it is not expected to simulate the actual situation completely and accurately.

This system aims to simulate all kinds of work needed to make decisions and schedules in construction project management. It has a wide coverage, and thus this study chooses the contents of a course, named project planning and control, as the main references to system simulation. At first, this study sorts out the virtual construction scripts from related content in the course related to construction management and administrative operation. The contents of the simulative construction are divided into four parts. Their descriptions are given briefly as follows:

1. Construction contracts and management: This covers specifications based on construction contracts, bid package format, construction claims and disputes resulting from contracts, and provisions of changing orders after starting the project.
2. Subcontract: This covers the concept of construction bidding and the selection methods for owner to choose the cooperating company including quality control methods to manage subcontract after the construction has started.
3. Construction procedures: This covers the processes of confirming the contract before starting the construction, daily management after starting construction, and accepting provisions after finishing the construction.
4. Cost estimation and control: This covers quantity takeoffs in the training of construction operation, how to control costs and schedule, and how to make resource allocation.

The main content of the game script of the virtual construction proposed in this study includes drawing up a construction contract at the beginning, selecting cooperative companies, resource allocation after starting the construction, controlling costs and schedule, treatment of uncertain emergencies such as construction safety, and performance evaluation of construction quality after acceptance. Those all together become the basis for building a game-based training mode for decision making in construction management.

3 System requirement analysis

After establishing the game's script for virtual training, this study makes further analysis based on the above planning to prepare the details of system development. The required system functions of the training mode are as follows:

3.1 *Decision making*

One of the key responsibilities of a construction manager is to make decisions in construction management. Whether making the appropriate management decision or not is one of the determinant factors for the success or failure of project management, and it is one of the key competencies that need to be acquired first. Based on the script in this study, the management decision making given to trainees in the game includes two parts: decision making for emergencies and decision making for selecting the contractor. Emergencies are generally divided into two parts: those caused by climate and those caused by human factors. The disaster triggered randomly by the climate system of the game causes delays or a shut-down, and thus users must make a decision immediately. With regard to accidents caused by human factors, many accidents questioning construction safety caused by the incompetence of the cooperating company or by the improper habits of the construction workers are triggered in order for users to prepare solutions and select contractors carefully.

3.2 *Resource allocation and management*

During construction, the manager must arrange the resources including labor, money, and machinery, for reacting to various uncertain factors. These are very important as they can affect the schedule of the whole construction. Therefore, the virtual construction management presented in this study provides trainees with the function of adjusting resources used in construction.

The number and type of resources initially planned for each work item are the reference basis. After the scheduling is completed, the actual resource number is divided by the reference number. The ratio is divided into several blocks for different days, and the stepwise method is applied to reduce the days. The number of resources after adjustment is multiplied by unit price and days after changing. The obtained number will be the cost of the operation.

3.3 Schedule and progress control

Due to uncertainties in the simulation, the system allows users to adjust the operating resources according to the encountered situation. The original schedule and progress control are then changed with the occurrence of events and related arrangement. Moreover, based on the schedule and progress control, it is necessary to update the schedule and the cost. Therefore, the function of the dynamic treatment of schedule and progress control is required.

To attain the requirement of schedule and progress control, which is achieved by integrating MS Project, each game data in the main program is produced as a text files, and then it is converted to the specified format set by the MS Project. All the kinds of operations in virtual construction can be arranged using this software. After finishing the operation arrangement, the updated scheduling information is sent back to the main program for updating game status through reading text file.

3.4 Evaluation of management performance

In current project management practice, the evaluation of management performance as a management tool has been introduced. According to the resources to invest and the schedule, the performance index is calculated theoretically to help the manager control and determine in real time the effectiveness of the management strategy in use. Using the evaluation index can analyze the reasons why the results are not effective. This is to discuss further the occurrence point of the reason and to consider and acquire the improved method and make adjustments.

The game should provide the function of evaluating management performance in a virtual construction. Based on performance evaluation function offered by the system, users can check, during the game training period or after, their management strategy for resource allocation, cost and time control, and decision making. The proper evaluation theories, including the score index and S Curve, are selected to calculate real-time indexes and control curves based on all kinds of status data in the process of game such as loss amount caused by construction safety, types of accidents, and expenses.

3.5 System interface

It is necessary to decide on the presentation methods of the proper game contents and the interactive modes with the user based on the contents of the game's script. To give the user more realistic scenes, the main interface from a third-person perspective commonly used in a general simulation game is applied as the system; thus, it will be convenient for the user to browse and control the process of each content in the scene and to make the related setting in menu. The construction scene is presented in 3D visualization model. It can increase the interaction with the user and have interesting visual effects comparable to a game with 2D scenes. Moreover, the system is equipped with operational interfaces such as message boxes and function columns to help the user operate the game. The user can send instruction by clicking the buttons in the menu. As the game progresses, all kinds of emergencies are presented by a 3D animated video. After the training is completed, the results are provided by means of a diagram with simple scoring.

4 System architecture and implementation

The system architecture of the proposed game-based training system is the integration of several commercial packages, which include: Autodesk 3ds MAX, which provides the function of creating 3D models and animations; a 3D game development software Virtools, which provides the function of setting up game scripts and the interaction function; the project management software MS Project, which provides the scheduling function; and the mathematical software MATLAB, which provides the function of calculation and chart drawing. The proposed game-based training system is developed

according to the above functions. There are five functional bars that allow users to control and summon all kinds of functions. The functions of each function menu are listed as follows:

1. Main function toolbar : Users can access the contract contents and select the cooperating company from the list of many contractors, adjust resource number in each construction, shorten or extend duration, rearrange the operating time to control construction operation, and make verifications and adjustments by accessing the performance score.
2. Time status bar : This menu indicates the date in the game world; operation is run based on it. Users can speed up or reduce game speed and stop the game.
3. Project status bar : The weather situation is represented by an icon. The condition of the worker, owner, finances, and duration are indicated by three lights: red, yellow, and green light to remind users to control them in real time.
4. Sub function toolbar for daily management : Users can teach the trainees, pray for better weather, and give other management instructions using various management functions offered in this function column.
5. Display area of virtual scene : The animations of construction operations and animations of triggered events is shown here. Users can switch scenes for a close view on-site by clicking the building under construction.

5 System demonstration

Before the start of the game, the initial setup process needs to be executed, as shown in Figure 1. First, users have to click a button to view the task list and the virtual construction project name recorded in the contract to determine the kind of contractor needed. After confirming the work content recorded in the contract, users have to choose the appropriate contractor by clicking the company button on the main menu to open contractor list. The project will start after choosing the appropriate company. The daily management process in the period of construction is shown Figure 2. In addition to viewing the project, the user can manage and control by using the status bar on the right screen and the sub menu. During the construction process, incidents due to mismanagement or natural disasters would be triggered by the system. In this case, the manager must make decision to choose a solution from the decision menu. If there is a delay resulting from an incident, the manager must rearrange the construction period by clicking the operation buttons to open the work item window to adjust resources and construction period. After arranging the resources, the updated operating data will be exported into MS Project for updating project schedule. The updated scheduling information will then be imported to the main program after the rearrangement of the construction period. The process of the performance evaluation in the course of the implementation of a virtual project is shown in Figure 3. The user can open the performance menu at any time by clicking the control button for various evaluation tools.

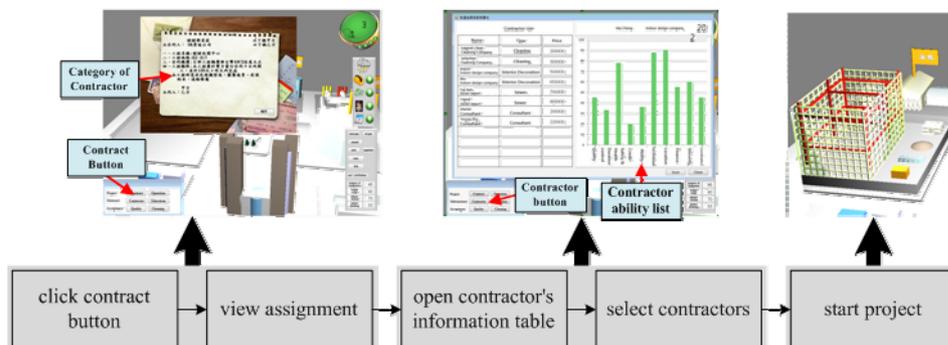


Figure 1. The initial setup process

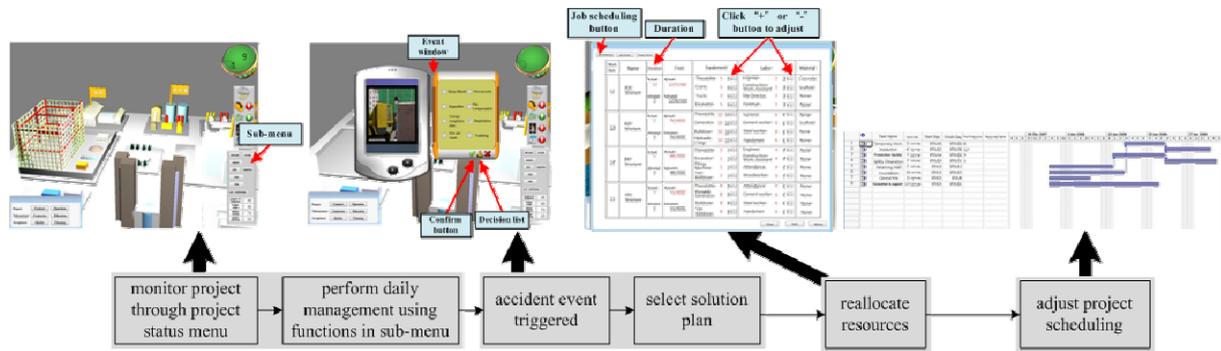


Figure 2. The daily management process

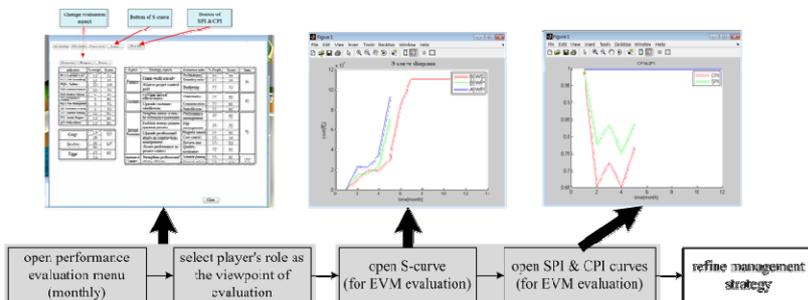


Figure 3. The performance evaluation process

6 Effectiveness evaluation

The proposed game has been test played by 50 students who are taking the Project Planning and Control course currently. The statistic of a user survey shows an agreement level of 4.32 out of 5 on that this game overall is beneficial to their learning and understanding about the course's contents. In comparison with other training modes, this game-based training is regarded to have better performance in simulation, interest, interactivity, learning efficiency, and immersion. The top five important features selected in order are management decision making, 3D display of virtual construction site, tutorial hints, project scheduling, and resource allocation and management.

7 Conclusion

In this study, role-playing and simulation games are applied to train students on decision making in project management. The training mode proposed in this study provides presence, as it allows users to observe the incident on site, and interaction in the decision-making process, unlike in using teaching methods in the classroom. Moreover, it allows the calculation of cost and safety in practical training to be better performed compared with practical training in enterprises, site visits, and other modes.

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