ADVANCES IN FOREST FIRE RESEARCH

2022

Edited by

DOMINGOS XAVIER VIEGAS
LUÍS MÁRIO RIBEIRO

A study on the standard scenario and training evaluation system for the development of virtual forest firefighters training system

Donghyun Kim

Jeonju University, Jeonju-si Jeonbuk-do, Rep. of Korea, {72donghyunkim@jj.ac.kr}
IIASA(International Institute for Applied Systems Analysis). Laxenburg, Austria, {dhkim@iiasa.ac.at}

Abstract

This study relates to the establishment of a virtual reality training system that can reproduce various forest fire situations in a limited indoor space and evaluate the training results quantitatively for fire suppression and evacuation situations of forest fire extinguishers. For individual and team training of firefighters in a virtual space, it is necessary to create SOP-based various forest fire scenario scenarios and training evaluation tools for the development of virtual training contents S/W. In this study, first, a method for creating a standard scenario for virtual reality forest fire extinguishing training was presented and a standard scenario was presented. Scenarios were standardized to be prepared according to 4 types of forest fire environmental data, 4 types of firefighting environmental data, and training difficulty level. Forest fire environmental data was defined as 4 types of forest fire site spatial environment, forest fuel environment, meteorological environment, and fire environment. It was made possible to set the difficulty level of fire drills using 8 types of scenario configuration data. In the survey on the suitability of firefighters for the standard scenario content, it was found to be 95.8±2.5%. In the second scenario-based training competency evaluation tool, forest fire extinguisher CTA (Cognitive Task Analysis) job analysis was conducted to systemize the evaluation items for task performance, mutual cooperation and reporting system for each scenario staged event. Using the CTA model, job structure analysis was conducted on the professional characteristics, procedural skills, best mission performance, and cognitive process for maximizing the training effect of the firefighters. Based on this, a virtual training evaluation item and evaluation score table for each firefighter according to the scenario-based mission performance stage were prepared. In the evaluation of the suitability of the firefighters for each item's evaluation content and points, it was found to be 93.5±2.5% and 97.5±2.5%, respectively.

1. Introduction

In Korea, training of forest firefighters is generally conducted through theory and experiential learning. Theory learning is representative of the principles of forest fire, fire theory, forest fire spread, forestry and meteorology, command system and role, and case study. The experiential learning includes a program to strengthen individual field response capabilities such as how to use hand tools, how to read a map, and evacuation learning, and group training according to the division of roles for each team. Here, experiential learning has a disadvantage in that it is impossible to conduct firefighting training by actually generating a fire in a forest or outdoors. This study intends to establish a virtual reality experience forest fire extinguishing training system that can reproduce various forest fire situations in virtual reality in a limited physical indoor space and quantitatively evaluate the training results. It has been studied that the learning effect using virtual reality is 10 times higher than that of the theoretical lecture in general, and it is known that the training safety and economic feasibility are high. Therefore, this study intends to provide a basis for the production of virtual reality forest fire extinguishing training contents using the virtual reality standard scenario and training evaluation tool proposed through this study. First, an optimal standard scenario was developed by collecting the opinions of firefighters by creating a scenario necessary for virtual reality training by examining and analyzing past forest fire cases. Next, a tool was developed to evaluate the training process of each firefighter based on a scenario through job analysis of each member of the forest fire fighting team.

2. Methods

2.1. Standard scenario development

The virtual reality training system requires an SOPs-based standard training scenario that can be trained by experiencing rescue and evacuation along with the evolution in various forest fire situations in a virtual space.

In this study, in order to create a standard scenario for virtual reality fire training, events for each forest fire situation were defined in a total of four stages through past forest fire cases. Stage 1 (introduction stage: occurrence and growth of wildfires), stage 2 (deployment stage: establishment and implementation of an extinguishing strategy after arrival at the site), stage 3 (growth stage: types of damage caused by spread and accidents, evacuation and rescue request), the fourth stage (end stage: remained fire monitoring and suppression completed), and the worst-case wildfire scenario for the unpredictable dangerous event was written in the third stage.

The details of the standard scenario created by the entire four-step process were prepared by analyzing the time series work of the evolution firefighters. For the standard scenario prepared, more than 90% conformity was verified by surveying 300 forest fire firefighters.

2.2. Training evaluation tool

The evaluation tool for each individual team for virtual reality training based on standard scenario was performed through field work CTA job analysis of forest firefighters. As shown in Figure 1, for the job analysis procedure, procedural technical analysis according to the professional characteristics and firefighting work of the firefighters and the cognitive process structural analysis to maximize the best performance and efficiency are performed. For evaluation items and score distribution table, more than 90% conformity was verified by surveying 300 forest fire firefighters. The training evaluation table was divided into personal equipment, rescue/evacuation equipment, firefighting activity, and rescue/evacuation activity items according to the task of each team member, and detailed evaluation criteria and evaluation methods and weights were applied.
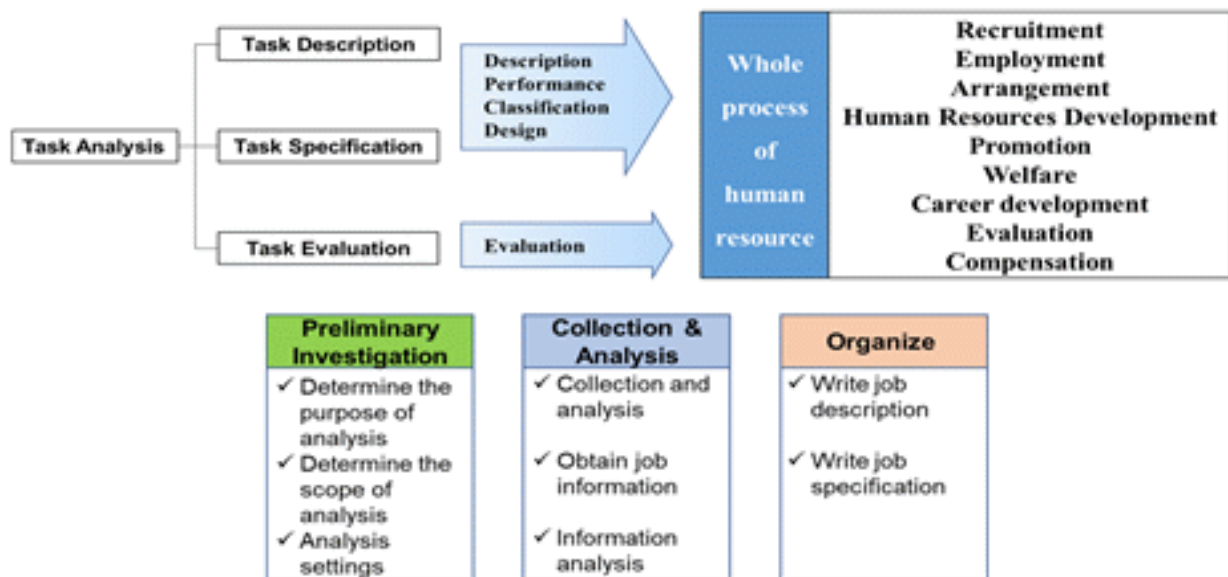

Figure 1- CTA job analysis flow chart and contents

3. Study Results

3.1. Standard scenario

Scenario composition is divided into 4 stages: introduction stage, development stage, growth stage, and termination stage according to the forest fire spread according to the time series. The details are shown in Figure 2.

■ Fire Scenario Composition

S#.	Event	Sub_S#	Contents	Pages
#1	Fire detection and reporting	1	Fire detection and reporting	3~4
#2	Report reception and response	1	Confirmation and Response Preparation	5~6
#3	Arrival at the fire site	1	On-site dispatch	7
#4	Check forest fire situation	5	Fire line, Head fire, Terrain, Weather, Fuels	8
#5	Establish strategy for fire fighting	5	Strategy depends on each fire situation	8
#6	Start of firefighting work	5	Fire fighting work	9~10
#7	Fire spread growth	3	Crown fire, Spotting Fire, Rapidly fire spread	11~13
#8	Unexpected situation(Spotting, Rolling stone and wood etc.)	5	Observation and congnition, Decision making to work	13~15
#9	Use of fire extinguishing equipments		Proficiency in using the equipment	15~17
#10	Evacuation		Planning, Safety	18~19
#11	Build a fire break line	-	Proficiency in working	20~21
#12	Protected object protection activities		Check for success	22~23
#13	Report to the commander center		Compliance with communication procedures	24
#14	Remaining Embers Management and the end		Check the embers management process	25
	Forest Fire Hazard Level 4/5 : Large scale fire spread and damage			

Figure 2- VR training scenario composition for forest firefighters

The scenario details were standardized to be prepared according to 4 types of forest fire environment data, 4 types of firefighting environment data, and training difficulty level. Forest fire environment data is defined as four types of forest fire site spatial environment, forest fuel environment, meteorological environment, and fire environment. It is possible to set the difficulty level of fire drills using a total of 8 types of scenario configuration data. In the survey of firefighters on the training evaluation tool, the suitability evaluation was found to be $95.8\pm2.5\%$.

3.2. Training evaluation tool

In this study, evaluation items were classified according to the tasks of each crew member for a team of 10 firefighters in each scenario stage, and the evaluation score was designed to be evaluated as a total score of 100 points through the majority evaluation. The format of the evaluation tool is shown in Figure 3.

Figure 3- Individual virtual reality forest firefighter training evaluation table

A total of 14 evaluation items for each scenario are as follows.

①Whether or not information on forest fire situation is collected and confirmed, ②Establishment and feasibility of firefighting strategy, ③Selection of location for firefighting work, ④Construction of fire line, ⑤Effect of ground firefighting work, ⑥Preparation and use of ground firefighting equipment, ⑦Sudden situation (Spotting fires, Fire Storm, Rolling Stone or wood etc) check and response, ⑧ Use of evacuation equipment, ⑨Secure an evacuation route and a safe place, ⑩Feasibility of evacuation judgment and method, ⑪Arrangement of remaining balance, ⑫Communication by team, ⑬ Report the situation to the command center and make an emergency request, ⑭Protection object protection.

In the survey of firefighters on the training evaluation tool, the suitability evaluation was found to be 97.5±2.5%.

4. Conclusions

The following conclusions were drawn as a result of the study on the scenario writing and training evaluation system, which are the main technologies for the development of the forest fire training system using virtual reality technology.

First, the scenario writing stage through forest fire case analysis was divided into 4 stages, and detailed contents were standardized to be prepared according to 4 types of forest fire environment data, 4 types of firefighting environment data, and training difficulty level.

Second, the evaluation of the suitability of the firefighters for the prepared standard scenario for the virtual forest fire training was found to be effective at 95.8±2.5%.

Third, the evaluation items for each scenario stage through CTA were defined as a total of 14 evaluation items, and a virtual training evaluation system was created with a total of 100 points by assigning different points for each evaluation item.

Fourth, the evaluation of the suitability of the distributed evolution team for the virtual training evaluation tool was found to be effective at 95.8±2.5%.

By using the results of this study on virtual reality scenarios and evaluation tools, virtual reality 3D content work is performed to contribute to the construction of an overall system for individual and team virtual training.