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EVACUATION TRAINING USING SCENARIO-BASED AUGMENTED REALITY GAME

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ABSTRACT

Evacuation training is important as disaster education that covers how to survive disasters. However, traditional evacuation training does not provide realistic simulated evacuation experience (SEE). To provide the such, we developed game-based evacuation training (GBET), where trainees are required to reach a shelter in the real world within a time limit while making decisions against virtual disaster situations presented as digital contents (e.g. video and single-choice question) on GPS-enabled smartphones or tablets. However, the GBET was insufficient in the audiovisual reality. To provide a more realistic SEE, we created an evacuation training using scenario-based augmented reality (AR) game that integrates marker-based AR and scenario-based game. Although only applicable in indoor activities, the evacuation training (the extended GBET system) presents AR that expresses disaster situations (e.g. flood and fire) by superimposing three-dimensional computer graphics onto the real-time view through a handheld head-mounted display.

Keywords: evacuation training, reality, AR game, branched scenario

1. INTRODUCTION

Natural and man-made disasters are threats to our lives and properties. Thus, substantial energy has to be invested in disaster management (disaster risk reduction) to counter these threats. There are two types of disaster management: structural (e.g. shelters and coastal levees) and non-structural (e.g. education and information systems). It is indisputably important to combine these for steady disaster management, but it would depend eventually on our decision-making on whether we can survive disasters. Emphasising on the importance of non-structural disaster management, this study focuses on disaster education that covers how to evacuate, that is, how we should make decisions against disaster situations.

A typical example of disaster education is evacuation training, which provides simulated evacuation experience (SEE). For example, in an earthquake evacuation training, trainees (participants) take actions of 'drop, cover and hold on' and simply evacuate to a fixed shelter via a recommended route. This simplicity is necessary for a wide range of trainees (i.e. from children to the elderly) but can sacrifice the reality. In actual evacuations, we can encounter disaster situations where it is difficult to make decisions (e.g. which to detour instead of a closed route). Traditional evacuation training frequently excludes such difficult disaster situations and makes SEE unrealistic. However, the unrealistic SEE, which excludes decision-making, cannot encourage trainees to have a sense of tension and earnestly learn how to evacuate. Hence, we need to create novel and effective evacuation training that involves realistic SEE.

In recent years, virtual reality (VR) and augmented reality (AR) have been actively applied to disaster education. There have been many examples of VR-based training for emergency responders, commanders and crane operators (see, e.g. Cha and Han, 2012; Bacon et al., 2013; Molka-Danielsen et al., 2018; Xu et al., 2018; Longo et al., 2019). In addition, VR-based evacuation training has attracted much attention especially in terms of the integration with gaming elements (Feng et al., 2018). For example, Smith and Ericson (2009) developed a VR game using cave automatic virtual environment that encourages children to take proper body actions during evacuation. Chittaro and Sioni (2015) developed a desktop VR serious game where players can learn how to evacuate from terrorist attacks while receiving instructions about proper decisions. Lovreglio et al. (2018) developed a VR serious game using a head-mounted display (HMD) that requires players to evacuate from an earthquake-damaged hospital while interacting with environments and agents (non-player characters). To define better emergency protocols and procedures, Nicoletti and Padovano (2019) examined the relationships among emergency managers' workload, stress and outcomes in a virtual reality (VR)-based serious game where the managers can experience responses to a conflagration in an industrial plant.

Compared with VR-based evacuation training, AR-based evacuation training has not been popularised yet and can be regarded as a new field (Lovreglio, 2018). Traditional evacuation training requires trainees to move in the real world, and the trainers must be concerned about avoiding the trainees' injury. In VR-based evacuation training, an evacuating world (virtual disaster world) is modelled as three-dimensional computer graphics (3DCG), and the trainees can safely move around the world with gamepads or body actions. Thus, VR-based evacuation training can provide not only realistic but also immersive safe SEE. Meanwhile, AR must adopt the real world as the evacuating world and express disaster situations by superimposing 2D/3DCG onto the real-time view captured via a mobile device (e.g. smartphone). In other words, for realistic SEE, AR-based evacuation training must ensure safety as a prerequisite and geometric consistency (i.e. the accuracy of the superimposition in position, size and angle).

In this study, we aim to create an evacuation training that integrates marker-based AR and scenario-based game while believing that AR leads to providing more realistic SEE than VR.

2. GAME-BASED EVACUATION TRAINING

A typical cycle of disaster management starts from the occurrence of a disaster and consists of four phases: response, recovery, mitigation and preparation (NGA, 1979). To survive disasters, we should primarily focus on the response phase (i.e. a short time immediately after a disaster occurs) and learn how to evacuate. However, trainees in traditional evacuation training do not necessarily have high motivation. This is because disasters infrequently occur and they do not necessarily receive benefits from the training. Such trainees may fail in evacuation in actual disasters. In other words, there is little effect of the training.

Evacuation training should have a motivational impact as a prerequisite for improving the effect. To create such training, we focused on geo-fencing (location-based) game using global positioning system (GPS). This is because geo-fencing games (e.g. Pokémon GO) have been popularised due to their motivational impact and share similarity with evacuation training in terms of moving into the real world.

2.1. Design

Focusing not only on the motivational impact but also the training effect, we proposed game-based evacuation training (GBET) that adopted a geo-fencing game mechanism. In the GBET, trainees are required to reach a shelter in the real world within a time limit while making decisions against virtual disaster situations at designated locations or times (Mitsuhara et al., 2015). The GBET aimed to provide realistic SEE by expressing the virtual disaster situations with a branched scenario and digital contents and encouraging the trainees to effectively learn how to evacuate. An ideal model of the GBET is based on Kolb's experiential theory that consists of four stages (Kolb, 1984):

- Concrete experience (CE): A trainee is provided with the first SEE. Here, the trainee evacuates (moves) in the real world while making decisions against virtual disaster situations.

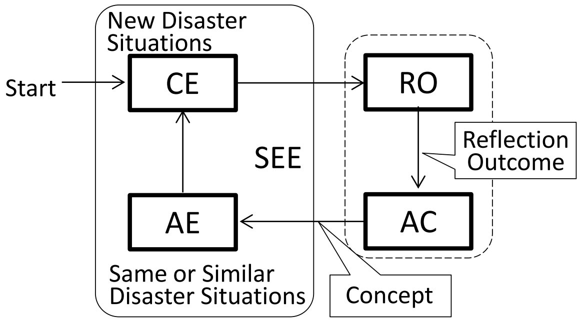


Figure 1: An Ideal Model of GBET

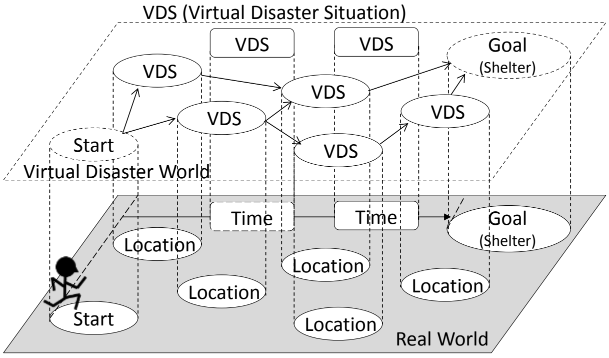


Figure 2: Relation between Virtual Disaster World and the Real World

- Reflective observation (RO): The trainee reflects on his/her first SEE.
- Abstract conceptualisation (AC): The trainee conceptualises better evacuation from his/her reflection outcomes.
- Active experimentation (AE): The trainee attempts his/her concept in the second SEE with similar or the same disaster situations.

In this model, the trainee follows the cyclic stages and eventually learns how to evacuate in various disaster situations, that is, to survive disasters. Figure 1 shows the ideal model of the GBET. Figure 2 shows the relation between the virtual disaster world and the real world.

The GBET uses the strength of being conducted in the real world to provide more realistic SEE in terms of physical experience. For example, trainees who decide to rescue an injured person in a virtual disaster situation are made to evacuate while conveying a heavy doll in the real world; they may fail in evacuation due to fatigue and decrease of their moving speed. This kind of real-world burden can promote the trainees to reflect on their decision (e.g. whether they should have rescued the injured person during speedy evacuation).

2.2. System

We developed a GBET system that works on GPS-enabled Android smartphones or tablets and is available for outdoor evacuation training (CE and AE). By always checking a trainee's current location and the current time from a branched scenario, the system recognises designated locations and times and then presents corresponding digital contents (e.g. video, slideshow and single-choice question). The trainee stops to look a virtual disaster situation (e.g. whether to rescue an injured person) presented as a digital content and then chooses his/her decision from options presented as digital content. Figure 3 shows an overview of the system components together with examples of digital contents.

2.2.1. Branched Scenario

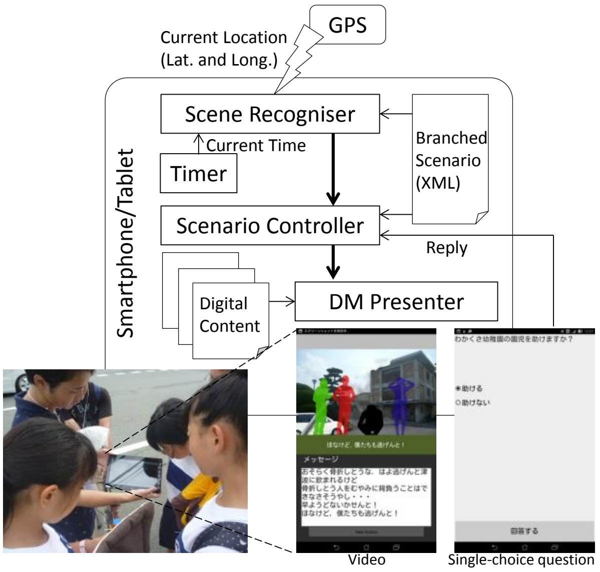
The GBET introduces a branched scenario and digital contents to express virtual disaster situations. The scenario begins and ends at designated locations or times—successful and failed evacuations will end at a shelter and a time limit, respectively. In the scenario, the designated locations and times are referred to as scenes shown as follows:

- Stay scene (SS): Each SS corresponds to a location (a rectangular area designated by latitude and longitude) and is used to express a disaster situation that may arise at the location.
- Interrupt scene (IS): Each IS, independent of locations, corresponds to an elapsed time or a designated time and is used to express a time-dependent disaster situation.
- Move scene (MS): Each MS, conceptually assigned between SSs, is prepared for trainees to reach the next SS.

Each scene has at least one cut, which corresponds to presenting digital content. A single-choice question is included in the digital content and frequently used to branch the scenario. The scenario is branched according to the following conditions:

- Option selected: The next cut depends on which option a trainee chooses.
- Already visited: The next cut/scene depends on which cut/scene the trainee has visited in/till the current scene.
- Visited: This condition is valid only for an MS linked with multiple SSs as the next scene. The trainee visits one of the SSs from the MS.
- Elapsed time: Since visiting a scene exceeds a threshold, when time elapses, the trainee compulsorily visits (enters) an IS.
- Designated time: When a designated time comes, the trainee compulsorily visits an IS.

The branched scenario, written in extensible markup language (XML), controls the storyline of disaster situations (CE and AE) and realises interactive SEE based on decision-making. This interactivity can be regarded as a gaming element—e.g. multiple endings can be provided. Figure 4 shows an overview of the branched scenario.



ほなけど，僕たちも逃げんと！

メッセージ

おそらく骨折しとうな．はよ逃げんと津波に飲まれるけど
骨折しとう人をむやみに背負うことはできなさそうやし・・・
早ようどないかせんと！
ほなけど，僕たちも逃げんと！

わかくさ幼稚園の園児を助けますか？

● 助ける
○ 助けない

回答する

Figure 3: System Components and Digital Contents

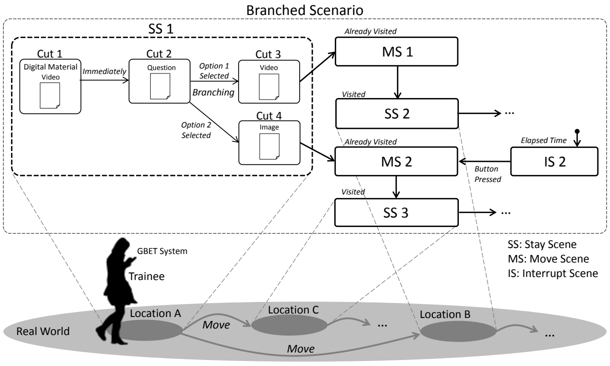


Figure 4: Branched Scenario

2.2.2. Reality

In the GBET, the reality can be regarded as actual expressions of possible disaster situations which depend on how the virtual disaster world is fused with the real world. The reality can be divided into two:

- Situational reality: This reality is related to the branched scenario and depends on whether trainees perceive that virtual disaster situations are possible. For example, in actual disasters, worsening disaster situations (i.e. the extent of damage) will be influenced by not only time and location but also psychological factors. This reality focuses on how these factors are reflected in the scenario.
- Audiovisual reality: This reality is related to digital contents and depends on whether trainees perceive virtual disaster situations as if the situations occur in front of them. This reality focuses on how audiovisual effects are reflected in the digital content.

If both the realities are at high levels, then the trainees can be immersed in virtual disaster situations, and they urgently make decisions against the situations.

3. EXTENSION TO SCENARIO-BASED AR GAME

In the GBET, the digital contents are created reflecting possible disaster situations in actual locations (SSs) and times (ISs) but insufficient in the audiovisual reality. In particular, the digital contents with a low level of visual reality can prevent trainees from perceiving virtual disaster situations as real. Ideally, the digital contents should express disaster situations more realistically so that the trainees can feel as if they encountered disaster situations.

To present the ideal digital contents, we extended the system to a scenario-based AR game that is available for a handheld HMD (Mitsuhara et al., 2018). The handheld HMD, which consists of a smartphone and a lightweight frame, realises more immersive AR. In the GBET, the handheld HMD is easy for trainees to wear (hold to their eyes) when looking digital contents in SSs or ISs and take off when moving in MSs.

3.1. Why not VR but AR

With the recent advancement of VR technologies, VR-based evacuation training has been realistic, immersive, safe and thus, popularised. Meanwhile, due to difficulties in ensuring safety and geometric consistency, augmented reality (AR)-based evacuation training has not been popularised, though mobile AR technologies are becoming increasingly common in various fields (e.g. navigation and geo-fencing game). Currently, AR-based evacuation training may be a challenging issue.

Thus, AR-based evacuation training can be advantageous for promoting trainees to look more squarely at reality (i.e. risks). In particular, possible disaster situations superimposed onto the real-time view (i.e. daily scenery in their local communities) can promote the trainees to think and take practical measures for the situations. In this study, we deal with not VR- but AR-based evacuation training, expecting a higher training effect.

3.2. Extended System

By attaching importance to easier implementation and broader utility, the extended system adopts marker-based AR. Currently, we suppose that the extended system is available only for indoor GBET (e.g. fire evacuation from a building) because printed fiducial markers are difficult to use outside based on loss, break or defacement due to the wind, rain, etc.

3.2.1. Mechanism

The extended system recognises SSs from captured fiducial markers and presents AR corresponding to the recognised SSs; a fiducial marker is prepared for each SS. The AR is implemented using a game engine (Unity 3D) and a marker-based AR software development kit (Vuforia).

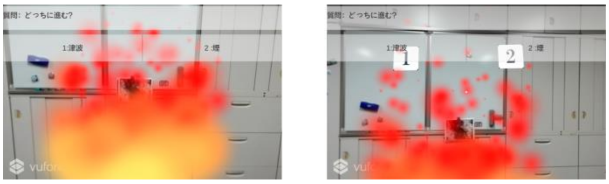


Figure 5: Single-choice Question

In an MS, a trainee finds and gazes at a marker through the extended system (a handheld HMD) and then, the corresponding AR is presented via the following steps:

1. The extended system recognises the next SS by checking the captured marker based on the scenario. If the captured marker matches one of the SS candidates, the matched SS is recognised as the next SS.
2. It presents the AR corresponding to the recognised SS by superimposing the corresponding 3DCG onto the real-time view.
3. It adjusts the superimposition of 3DCG synchronously based on the direction in which the trainee is looking (i.e. the direction in which the smartphone's rear camera is pointing).

It is difficult to touch the smartphone's screen in the handheld HMD. Hence, the extended system does not adopt finger-touch operations in a single-choice question and for pressing a 'next' button; instead it enables the trainee to choose his/her reply (decision) by gazing at one of the presented options and move to the next cut or scene. Figure 5 shows a screenshot of a single-choice question.

To provide realistic SEE, the extended system should ensure the geometric consistency. However, the extended system has not enabled trainers to set the initial geometric settings (position, size and angle) of superimposed 3DCG automatically or easily. The initial geometric settings depend on how large a fiducial marker is prepared and where it is placed on. This means that to ensure the geometric consistency, the trainers must adjust every marker in a trial-and-error method beforehand.

3.2.2. AR Examples

Presently, the extended system can present AR that expresses six disaster situations: flood, fire, smoke, a crack, debris and an injured person (Fig. 6). Animation and sound can be added to the AR. Text messages can be superimposed onto the upper area of the real-time view to supplement the expressed disaster situation.

As a scenario-based AR game, the extended system can provide realistic, immersive and interactive SEE including decision-making. By looking at the AR, trainees are expected to have a sense of tension and learn earnestly how to evacuate. For example:

- When encountering a fire, they will think which way to detour.
- When entering a smoke-filled room, they will think of how not to inhale smoke.

- When finding an injured person, they will think of whether or not to rescue the injured person.

3.2.3. Extended Scenario

To describe the settings for the AR, we extended a GBET scenario (XML) while adding the following property values in ‘content’ tag:

- ‘AR’ for ‘type’ property: This value means that AR is presented as digital content in the cut.
- ‘Flood,’ ‘Fire,’ ‘Smoke,’ ‘Crack,’ ‘Debris,’ and ‘Injured Person’ for ‘name’ property: These values mean which disaster situation the AR expresses.
- ‘Small’ and ‘large’ for ‘intensity’ property: These values mean how much the disaster situation has been worsened.

Figure 7 partially shows a GBET scenario that covers fire situations. Disaster situations can be worsened as time passes. Hence, a GBET scenario should express disaster situations that vary with time. The combination of the branching conditions (e.g. ‘Option selected’ and ‘Time elapsed’) can be used to express such time-variable disaster situations. However, it may be difficult for trainers to describe the settings for the expression (i.e. complex branching control). For the easier description, we added a new tag (timer) in the scenario. For example, the extended system presents the AR according to the following settings in the scenario shown in Fig. 7:

- It recognises SS-3 (line #1) by capturing the marker of fire (line #3).
- It reads Cut-1 for presenting a digital content that expresses a time-variant fire situation (line #6).
- It checks how many minutes have elapsed since a trainee first visited this scene. If 0 min (i.e. his/her first visit), it sets ‘1’ to the branching value (line #7). If more than 10 min, it sets ‘2’ to the value (line #8).
- When the value is ‘1,’ the next cut is Cut-2 (line #10). When the value is ‘2,’ the next cut is Cut-3 (line #11).
- In Cut-2, it superimposes 3DCG of small fire (line #16). In Cut-3, it superimposes 3DCG of larger fire to express a worsened situation (spread damage) (line #22).
- If gazing at a ‘next’ button on the screen for several seconds, the trainee moves to the next scene (line #25).

(a) Flood

炎が燃え広がっている！5階も危険だ！屋上に逃げよう！
（移動する前に白い丸を見てください）

(b) Fire

(c) Smoke

床が落ちてる！
（移動する前に白い丸を見てください）

(d) Crack (in the floor)

(e) Debris (collapsed wall)

(f) Injured person

Figure 6: AR Examples

```
<scene id=”3” type=”stay”>
  <name>Fire occurred!</name>
  <condition sensor=”marker”>Fire</condition>
  <cut id=”1”>
    <name>Fire Expansion</name>
    <content type=”time”>
      <timer id=”1” min=”0”>1</timer>
      <timer id=”2” min=”10”>2</timer>
    </content>
    <next condition=”immediately” value=”1”>2</next>
    <next condition=”immediately” value=”2”>3</next>
  </cut>
  <cut id=”2”>
    <name>Small Fire</name>
    <message>You Found Fire on Corridor!</message>
    <content type=”AR” name=”Fire” intensity=”small”/>
    <next condition=”end”>-1</next>
  </cut>
  <cut id=”3”>
    <name>Large Fire</name>
    <message>You Found Fire on Corridor!</message>
    <content type=”AR” name=”Fire” intensity=”large”/>
    <next condition=”end”>-1</next>
  </cut>
  <next condition=”button_pressed”>4</next>
</scene>
```

Figure 7: Example of GBET Scenario for Presenting AR

3.3. Related Work

Lovreglio (2018) reviewed research on AR applications for building evacuation and presented five research projects that focused on training. For example, Mañas et al. (2010) developed a mobile phone application for fire evacuation training that detects a trainee’s current position and speed in a building by using WiFi positioning techniques and accelerometer sensors. Without fiducial markers, this application can superimpose 3DCG of fire onto the real-time view when the trainee comes to designated positions. Our research group has developed AR-based evacuation training applications using tablets (Mitsuhara, et al., 2013), smart glasses (Kawai et al, 2015), a binocular opaque HMD (Kawai et al., 2016) and a handheld HMD (Iguchi et al., 2016; Mitsuhara et al., 2017).

Recently, markerless AR has been attracting much attention, and there have been markerless AR applications available for evacuation training. Dong et al. (2016) developed a markerless AR-based training application in which first responders can attempt to adequately assess disaster situations and plan responses by using a smartphone’s GPS, electronic compass and disaster scenarios. Itamiya (2017) developed a markerless AR simulation application that visualises flood and smoke realistically using Google Tango and handheld HMDs.

AR can be used for evacuation support, that is, navigation to a safe place in actual disasters. AR-based navigation applications detect an evacuee’s current position using personalised pedometry (Ahn and Han, 2012) and radio-frequency identification (Atila et al., 2018) and superimpose a directional indicator (arrow) guiding to the safe place onto the real-time view. These applications or technologies can be used for evacuation training.

4. PRELIMINARY EXPERIMENT

In this section, we conduct a preliminary experiment focusing particularly on how the AR-based expression of a time-variant disaster situation (TVDS) influences SEE to examine the training effect and the reality of the extended system.

4.1. Settings

In this experiment, participants (trainees) used the extended system in a small-scale building evacuation training.

4.1.1. Participants and Procedure

The participants (twenty university students) were divided evenly into two groups on the basis of their replies to a question that is asked about their awareness of disaster management.

- Group A (*N = 10*): At the SEE (i.e. CE), the participants evacuated according to a no-branch sequential scenario with a TVDS.
- Group B (*N = 10*): The participants evacuated according to the same scenario without the TVDS.

We did not take into account of RO, AC and AE; the participants were not encouraged or forced to reflect on their first SEE, conceptualise their evacuation and attempt their concept in the second SEE.

Also, the participants who were given the extended system (a handheld head-mounted display (HMD)), were given brief instructions on how to use the system (e.g. gaze-based operation) and then shown the time-unconstraint condition of evacuation success (i.e. reaching a safer place) and the rule in the training (i.e. ‘if you find a fiducial marker, please gaze at it’). After the end of the training, the participants replied a questionnaire with the following 5-degree Likert scale questions (options: 1 = definitely no, 2 = no, 3 = neutral, 4 = yes, 5 = definitely yes):

- Question 1. Do you agree that you felt your awareness of disaster management improved through the training?
- Question 2. Do you agree that you felt a sense of fear through the training?
- Question 3. Do you agree that you felt a sense of tension through the training?

In making the questions, it was assumed that the training effect could be regarded as their improved awareness of disaster management. Almost all the participants had not evacuated in a real disaster and had difficulty in judging the reality. Thus, we regarded the reality as their senses of fear and tension in the training and asked about the reality by Questions 2 and 3.

4.1.2. Scenario

The scenario expressed three disaster situations caused by a big earthquake: fire, flood (huge water leak) and crack. The evacuation started from the fifth floor and thus, the participants were required to move downstairs from the fifth floor to escape from the building. The fire situation (the size of fire) changed by the TVDS. The scenario unfolded as follows (see Fig. 8):

1. A big earthquake occurs and a participant takes a proper action (e.g. hides under a table) against strong shake.
2. Immediately after the shake stops, the participant starts to move to the nearest stairs (the emergency exit).
3. However, the participant finds a small fire on a corridor to the stairs.
4. The participant moves toward the stairs on the opposite side.
5. On the corridor, the participant finds a crack on the floor and keeps moving carefully.
6. The participant moves downstairs through the opposite-side stairs but encounters a flood at the low level and cannot move downstairs any more.
7. The participant moves back to the emergency exit, expecting that the fire has disappeared. In the TVDS scenario (group A), the fire has enlarged. In the non-TVDS scenario (group B), the fire still remains.
8. The participant decides to move up to the roof to wait for rescue.
9. The participant reaches the roof; the training ends.

4.2. Results and Considerations

By assuming a normal distribution and homoscedasticity, we analysed the questionnaire results with nonparametric statistics. Table 1 shows the medians and mean ranks of the participants' replies. For all questions, the medians were the same or similar between the two groups; Wilcoxon rank sum test revealed no significant differences.

Regarding their improved awareness of disaster management (Q1), the medians were the same. However, the mean rank of group A was higher than that of group B. With regards to their sense of fear (Q2), the median of group A was higher than that of group B. These results indicate that the TVDS improved their awareness and aroused their sense of fear. With regards to their sense of tension (Q3), the medians were the same and the mean ranks were almost the same. This result indicate that the TDVS did not arouse their sense of tension. Tension in evacuation can be influenced by various factors such as time pressure, distance to a shelter, etc.

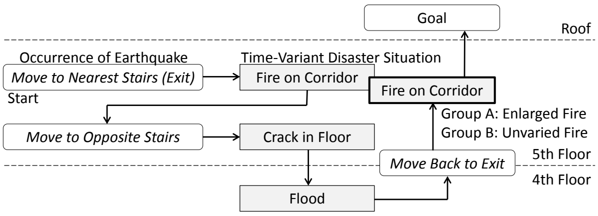


Figure 8: Scenario in Preliminary Experiment

Table 1: Questionnaire Results

Q1. Improved awareness of disaster management			
Group	Median	Mean rank	P
A	4	10.6	0.43 (n.s.)
B	4	8.3	
Q2. A sense of fear			
Group	Median	Mean rank	P
A	4	11.5	0.10 (n.s.)
B	3.5	7.4	
Q3. A sense of tension			
Group	Median	Mean rank	p
A	4	9.2	0.87 (n.s.)
B	4	9.7	

not significant (n.s.); probability (p); question (Q).

For both groups, the medians of all questions were favourable. These results indicate that the extended system (i.e. the scenario-based AR game) is effective as evacuation training regardless of whether the TDVS is used. A few participants expressed positive opinions about the audiovisual effects (e.g. 'It was easy to think how I should evacuate this building because I saw a fire and crack in front of my eyes'). The favourable medians may result from the high visual reality of the presented AR. However, there were the following complaints:

- The scenario was not realistic. I do not know why we have to visit the fire corridor again, encounter flood on the fourth floor, evacuate to the roof in a building fire, etc.
- I got motion sickness by viewing AR.
- I disliked holding the handheld HMD during the training.

Three participants complained about the scenario's reality (i.e. the situational reality). In this experiment, the scenario aimed at examining the TVDS and did not significantly take the validity of situational reality into account. From this complaint, we realised the significance of not only the audiovisual reality but the situational reality.

5. CONCLUSION

In this paper, an evacuation training using scenario-based AR game, which was implemented as the extended system of the GBET to provide realistic SEE, was described. In the evacuation training, disaster situations (e.g. flood and fire) corresponding to designated locations and times are expressed by marker-based AR based on a branched scenario; 3DCG-rendered disaster situations are superimposed onto the real-time view captured via a handheld HMD. Trainees who look at the disaster situations at high levels of visual reality and immersiveness are expected to have a sense of tension and earnestly learn how to evacuate. In this paper, the results of the preliminary experiment indicate that the scenario-based AR game is effective as evacuation training, but the TVDS did not significantly contribute to improving the training effect and reality. Furthermore, we need experiments that adopt scenarios with high situational reality.

VR-based evacuation training is becoming common due to the popularisation of VR devices (e.g. low-priced HMDs), whereas, AR-based evacuation training has not yet been acknowledged by the public although many of them may be interested in AR itself. We believe that the higher reality leads to the higher training effect, and AR involving the real world is superior to VR in reality. For the acknowledgement, we must overcome possible difficulties about the geometric consistency, safety and easiness in practice, etc. In addition, we must clarify the training effect through experimental practices and develop systems that totally support AR-based evacuation training, taking account of RO and AC in the ideal model of the GBET. If the training effect exceeds the difficulties, the public (trainers) may get motivated to conduct AR-based evacuation training.

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