

OTOTONARI: A Pervasive Game of Sound Composition based on Users' Collaboration

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ABSTRACT

Pervasive Games, also known as Pergames are games based on real space and holds the features of both the traditional real space games before computers and computer games that use computer graphics and sound. In this thesis, we propose a Pergame content ototonari to accelerate communication among the users participating in the games through sound composition by users' collaboration. Ototonari creates sound based on position, proximity and density of users in real space using mobile ad hoc network as the direct collaboration among users sharing the same time and the same place. Also, ototonari saves the sound data created by the user and enables other users who play afterwards to refer to it as an indirect collaboration among users sharing the same place and at a different time. Ototonari aims to accelerate communication among the users participating in the game through these 2 methods of collaboration. We carry out an evaluation experiment at the site of Expo Aichi 2005 and studied its result.

Categories and Subject Descriptors

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems - *Artificial, augmented, and virtual realities*

J.4 [Social and Behavioral Sciences]: Sociology

K.8 [Personal Computing]: Games

General Terms

Design, Experimentation, Human Factors, Verification

Keywords

Pervasive Game, Mobile ad-hoc network, Collaboration, Communication, Experience, Design, Sound

1. INTRODUCTION

Presently, a new entertainment category, which is called Pervasive Game, is highlighted. Pervasive Games, also known as "Pergames", are games based on real space and holds the feature of both the traditional real space games before computers and computer games that use computer graphics and sound [1]. Interactions of games played on real space before computers consists of two elements. One is the interaction of "human to physical space / environment" and the other is the interaction of "human

to human". These elements are fading as games started to introduce computers. Actually, computer games are more immersive and attract user's interest in terms of graphics and sound as virtual space. But, computer games forced the user to gaze the monitor and to use the controller or mouse, so the actual action of human and the interaction of human to human are restricted. Regarding this state, the entertainment category, called Pervasive Game, is the game based on real space incorporated with the more physical human action and the communication of human to human in order to retrieve two interactions of traditional games on real space while making use of the merits of computers – graphics processing and more. The opportunity of presentation is increasing as ACM Computer in Entertainment had a special topic [2] and Pervasive Workshop [3] was held as a sub-group on International Conference Pervasive. Not only are many projects about contents in themselves presented, but also are some projects that argue Pergames from more inclusive viewpoints [1] [4] [5].

Existing Pervasive Games achieve the interaction of human with physical space, of the two elements of traditional games in real space, in various ways – RFID [6], wi-fi [7], GPS [8] and wi-fi + GPS [9] [10] [11] [12] [13]. On the other hand, many projects have presented various methods to accelerate the communication among participants for the interaction of human to human. But, these methods have problems that they are only to present the communication through network like on-line computer games and they don't consider the direct face-to-face interaction and collaboration emerged by sharing the atmosphere of a place. And some projects only add computer technology to games based on real space before computers, so computations have no involvement in their entity as games. "Ototonari" proposed in this thesis aims to solve these problems and accelerates communication among participants.

Against the prior researches, we propose a Pergame content ototonari based on sound composition with user's collaboration. Ototonari has the features below.

1. Create a sound through users' collaboration using mobile ad hoc network based on the position, proximity and density.
 2. Saves the sound created by the user as data and enables other users who play afterwards to refer to it using mobile ad hoc network.
- Firstly, ototonari adopts the real space-centered interaction unlike the existing Pergame contents as described in feature 1. We attempt the direct collaboration among users sharing the same time and the same place by changing the generated sounds depending on the users' way of moving and gathering in real space. Next, ototonari adopts storage for user's experience in real space, which any existing Pergame content has not implemented as described in the feature 2. We attempt the indirect collaboration among users in the same place and at a different time by enabling other users, who play afterwards, to refer to the sound created by users. Ototonari aims to accelerate communication among users participating in the games with these two methods of collaboration based computation.

In the next chapter, we state the related works about our project. In the third chapter, we introduce the game design and the system of ototonari,

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Conference '04, Month 1-2, 2004, City, State, Country.

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a Pervasive Game proposed in this thesis. In the fourth chapter, we take up the experiment we did at EXPO aichi 2005, and evaluate and consider it in the fifth chapter. Lastly, we finalize this thesis.

2. RELATED WORKS

As related works of this proposal, we state some problems of the existing Pergame contents' method to accelerate communication among the participants. The existing methods can be categorized into 3 categories as below.

- Direction type [6] [9] [14] : this method proposes the interaction between the players participating in games and the helper on network
- Match-up type [15] [16] : this method proposes the face-to-face interaction among the players in real space.
- Hybrid type [7] [10] : this method proposes the face-to-face interaction among the players in real space and the between each player participating in games and with each helper on network

In addition, Direction type has no division between friend and foe but Match-up type and Hybrid type have a division between friend and foe. Examples of each method and its points of issue are stated below.

As an example of Direction type, we state the Space Race [14]. In Space Race, the users are divided into the player(s) moving over real space and the navigator(s) on network. The Player(s) have to move in real space following the directions from the navigator(s) and search the crystal hidden in the virtual space linked to the real space. As the cooperation of the player(s) and the navigator(s) is compelled in the game design, consequently they can not help each other by communicating. Thus, Direction type has a problem that the participants can't get the effect of communication based on the direct face-to-face interaction.

As an example of Match-up type, we state AR2 Hockey [15]. AR2 Hockey aims to play Air Hockey on AR (Augmented Reality) environments and the players in real space plays the game with a puck on a virtual space. Here, the players can play the game face-to-face with each other, so they can communicate directly. But, many cases of Match-up types actually establish the game in only the physical space and have a problem that the essential amusingness of the game doesn't come from computation. In addition, Mach-up type has cases that the game goes on by parting the player into real space and on network, for example Can You See Me Now (CYSMN) [11] and Uncle Roy All Around You (URAAAY) [12]. In this case, a problem occurs that the direct face-to-face interaction can't consist like Direction type.

As an example of Hybrid type, we state Human Packman [10]. In Human Packman, the players, wearing HMD (Head Mount display) , are separated into a team of Packman and Ghost. The aim of Packman is

to collect the biscuits in the virtual space by looking through the HMD. And the aim of Ghost is to touch Packman. The helpers on the network indicate the position of each player as one team in real space can't detect the other team in real space. Also, Hybrid type has a problem that the users can't get the effect of communication based on the direct face-to-face interaction. To solve this problem, Human packman adopts the element of Ghost's touching Packman. It was remarkable that in evaluation of Human Packman, 95% of the users answered that this tangible interaction increased the fun of the game and the users wanted to have more interactions like this adopted. On the other hand, 35% of the users answered that the collaboration between the players and the helpers made it less enjoyable. Thus, we think the users want direct face-to-face communication.

Otononari adopts the real space-centered game design to realize direct face-to-face communication, for the limit of communication emerged by transmitting atmosphere of the place which arises in the case of direct communication on network like Direct type and Hybrid type (feature 1). At the same time, ototonari adopts the game design that computation is indispensable for the entity of the game (feature 1, 2).

3. OTOTONARI

Otononari creates a sound based on the position, proximity and density of the user in real space using mobile ad hoc network. Then, it saves the created sound to the location as data through a particular terminal using mobile ad hoc network. This enables not only the current users that exist at that location, but also the users that appear afterwards at that location to share the sound. In addition, ototonari has a specification which the game can only be done with mobile ad hoc network, considering the simplicity in its introduction in terms of being able to play wherever you want if a player and a place are ready without the condition of a specific network infrastructure.

Otononari forms of multiple sub areas as the game area and the user plays a unique instrument at each sub area, then as the users get closer to each other, the number of instruments increase. The sound created by each user is merged and saved at each sub area. Users who play the game afterwards can listen to the sound that is saved at that location.

3.1 Game Design

Here we state the game design for ototonari that is proposed in this thesis. There are 2 types of games in ototonari and each is expressed as "term 1" and "term 2". The game flow of each term is stated in Table 1. In term 1, the sound data created is saved to the game area. Then another user gets the data left in that game area and listens to the reconstructed sound based on that data in term 2 "2. Listening time". The process of reconstructing

Table 1. Game Flow

Term 1		Term 2	
Phase	Time line	Phase	Time line
1. Moving Time (1 min.)	00 : 00~01 : 00	1. Moving Time (1 min.)	00 : 00~01 : 00
2. Creating Time (3 min.)	01 : 00~04 : 00	2. Listening Time (3 min.)*	01 : 00~04 : 00
3. Mixing Time (1 min.)	04 : 00~05 : 00	3. Creating Time (3 min.)	04 : 00~07 : 00
4. Mini Game Time (3 min.)	05 : 00~08 : 00	4. Mixing Time (1 min.)	07 : 00~08 : 00
5. Mixing Time (1 min.)	08 : 00~09 : 00	5. Mini Game Time (3 min.)	08 : 00~11 : 00
6. Listening Time (3 min.)	09 : 00~12 : 00	6. Mixing Time (1 min.)	11 : 00~12 : 00
		7. Listening Time (3 min.)	13 : 00~16 : 00

*phase"2. Listening Time" exists only in term 2. The sound data created and saved in term 1 can be listened to.

the sound in the application based on the data left in that game area is called “remain”. Term 1 and term 2 can be rephrased as remaining term and non-remaining term. However, there is no need for term 1 and 2 to be done continuously, and can be done at particular.

Below, we state summarize each phase.

Moving Time: Users spread to a particular place in the game area.

Creating Time: A sound is created based on the users’ position, proximity and density. The created sound is output in real time. In this creating time, communication is made easier by making it unable to create sound unless a user approaches another user. Also, the instrument differs for each sub area, so the users can enjoy the sound by moving from one sub area to another with other users. In ototonari, we adopted the style where the user does not create the sound from scratch, but by mixing the sound samples created based on the users’ position, proximity and density. This specification was made considering the perfection of the music and entertainment as a game. Of course, there is a method of putting the users’ position data in a virtual instrument parameter. But there are some problems such as the recognition of the change in sound being unclear and the dissonance when sounds are created. Therefore, we adopted the method where a sound sample, that is already a musical piece, is dismantled and is reconstructed due to the users’ movement in real space.

Mixing Time: The sound data created by each user is changed to a sound data for the particular area.

Mini Game Time: A mission is sent to the user from the agent in the application. There is a change in sound by clearing the mission. The aim of this mini game time is for the users to communicate with each other and clear the mission together.

Listening Time: The created sound can be listened to. Also, the sound saved in the area can be listened to in term 2. The aim of this is for the sound to have influence on the users’ action in the game by listening to the saved sound.

In each phase above, not only the sound but also a graphic is presented. To be concrete, (1) each user visualizes the instrument (refer 3.2.2) and (2) supports the progress of the game. The latter can be subdivided into presenting the left time in each phase, directing the user’s action in each phase and supporting the progress of the mini game time (refer 3.2.4).

3.2 System

3.2.1 System Structure

The system structure for ototonari is shown in Figure 1. The application of ototonari is operated in a PDA. The PDA used is the ai-MATE terminal developed by KDDI CORPORATION [17]. ai-MATE has Windows Mobile 2003 Second Edition for Pocket PC and enables communication functions such as wireless LAN (802.11b) and CDMA

1X WIN. Ototonari uses this ai-MATE as the mobile terminal that the user carries and also for the fixed terminal that is set in the game area.

Macromedia Flash is used for the interface of ototonari, and the game flow is shown graphically by this (Figure 3, Figure 4). The ototo player is described by .NET C# and is taken a picture with a camera. Then the created sound is output within the hardware, the data is input and output, and then the communication log is output. Cast Service and JPEG Lib Wrapper are described in Native C++. Cast Service is a dll (dynamic link library) module using CCS (Contents Crusing System) developed by Murai Laboratory, Keio University [18]. In this proposal, as we use only the mobile ad hoc network, we omitted the corresponding module and use dll for the distributing function of the mobile node (=One Hop Neighbors), although the CCS as a communication architecture modules the communicative part with GPS.

The file list used in ototonari is shown in Table 2. And the flow of the file movement between mobile terminals and fixed terminals are shown in Figure 2. In the following sections after 3.2.2, only the file name is described.

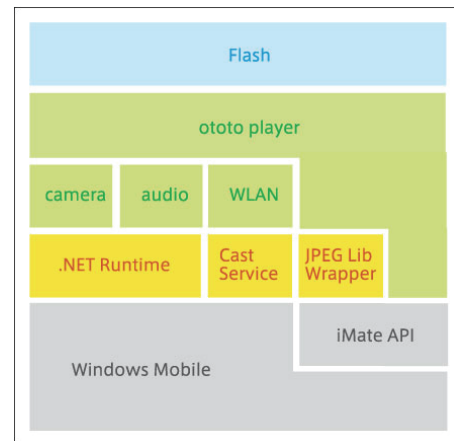


Figure 1: System Structure

3.2.2 Creating Time

We implemented 2 modules in ototo player to create sound in a mixing style.

First module, the base rhythm module, decides the type of music based on the sub area. Ototonari consists of a maximum of 4 sub areas (abcd) in a game area. Each sub area has a fixed terminal and casts an area message for each 5000 milliseconds to its coverage area. The mobile terminals that receive this area message play the basic rhythm formed of bass and drums. Each sub area has a unique type of basic rhythms, Disco,

Table 2: Tasks and types of files in ototonari

File name	File structure	Sender	Function
Area message	Terminal MAC address –A- area ID (abcd)	Fixed terminal	Notify the area
Created message	Terminal MAC address –G- area ID (abcd) –terminal ID (0-9)	Mobile terminal	Notify the area and the instrument used for creating the sound.
Mix file	Terminal MAC address –M- area ID (abcd) –terminal ID (0-9)	Mobile terminal	Record data of the sound created by each player or recorded sound mixed at each area.
Remain file	Terminal MAC address –R- area ID (abcd)	Fixed terminal	Merges the mix file in term 1 and saves it for each area. Used in phase 2 of term 2.

* Record data in the file is recorded as high (=1) and low (=0)

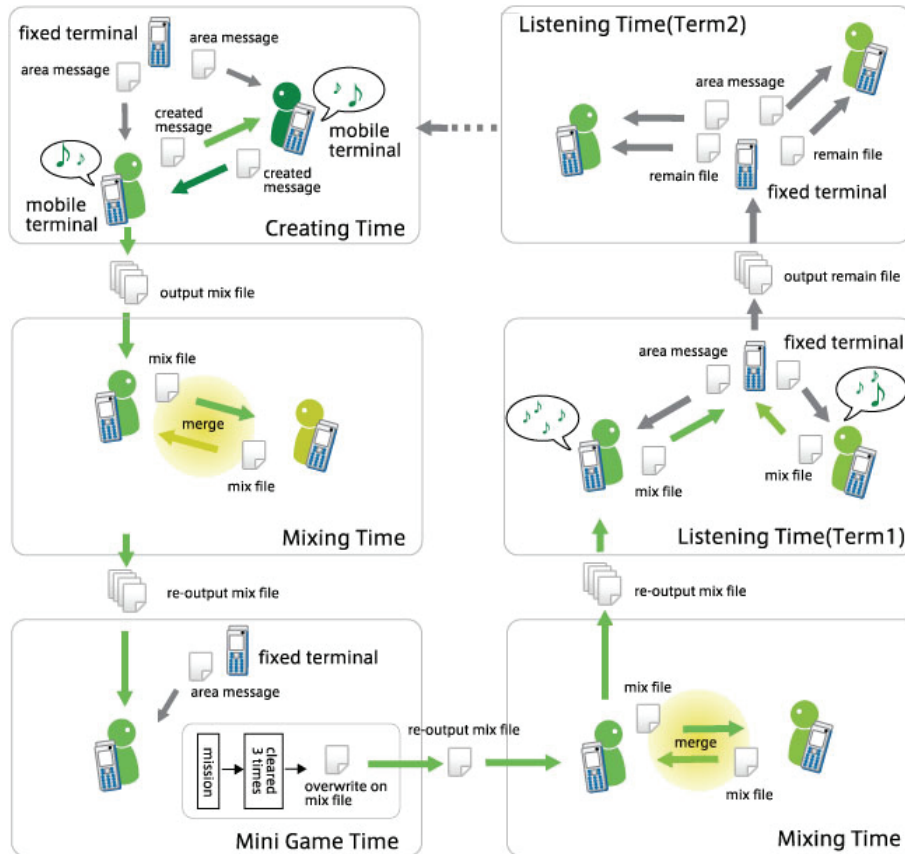


Figure 2: File movement flow

Funk, Samba and Electro. In addition, these basic rhythms should be set to each sub area before the game starts.

The second module, instrument module, plays the instrument assigned to each sub area. Mobile terminals have an assigned instrumental set for each terminal ID corresponding to each sub area. For example, the user with ID {1} has an instrumental set of a-1, b-1, c-1 and d-1 in area abc. Mobile terminals play an instrument corresponding to the ID in that area at the same time they receive an area message. Furthermore, in the present version, there are 10 types of instrumental sets for each sub area. These instruments sets should be set to each sub area before the game starts.

In creating time, the sound is created using these modules. The sound based on the position information is created by using the base rhythm module and the instrument module. The sound based on the proximity and density is created by the collaboration of the instrument module and the message casted by each mobile terminal. The mobile terminal {1} with ID {1} casts a created message to terminals in its coverage area. If mobile terminal {1} exists in area A, it casts a created message with the file name G-a-1, and all mobile terminals in mobile terminal {1}'s coverage area and also in area A play instrument 1 for type "a" for 5000 milliseconds. Here, the display on the terminal graphically shows the played instrument so that the user can distinguish which instrument is being played (Figure 3). To be concrete, in creating time, a trapezoid corresponding to the instrumental set assigned to each user repeats expanding and reducing along with the played instrument (Figure 3a). If a user receives a created message from another user, the trapezoid for that ID repeats expanding and reducing (Figure 3b).

Also, if mobile terminal {2} exists in a different area from mobile

terminal {1}, and receives a created message from mobile terminal {1}, errors are avoided by comparing the area ID of the final received area message and the area ID of the received created message in mobile terminal {2}. In connection with this, referring to the error processing of the overlapping of coverage areas of fixed terminals in each sub area, the space between each fixed terminal should be decided considering the reception status of the fixed terminals before the game starts. If a mobile terminal exists in a blank area which is not covered by any fixed terminals area, the sound is created by processing uncertainty based on the last area message received [11].



Figure 3: Image of the display for Creating time
 (a) State when instrument of only the user with ID8 is played
 (b) State when instruments of users with ID1, ID8 are played

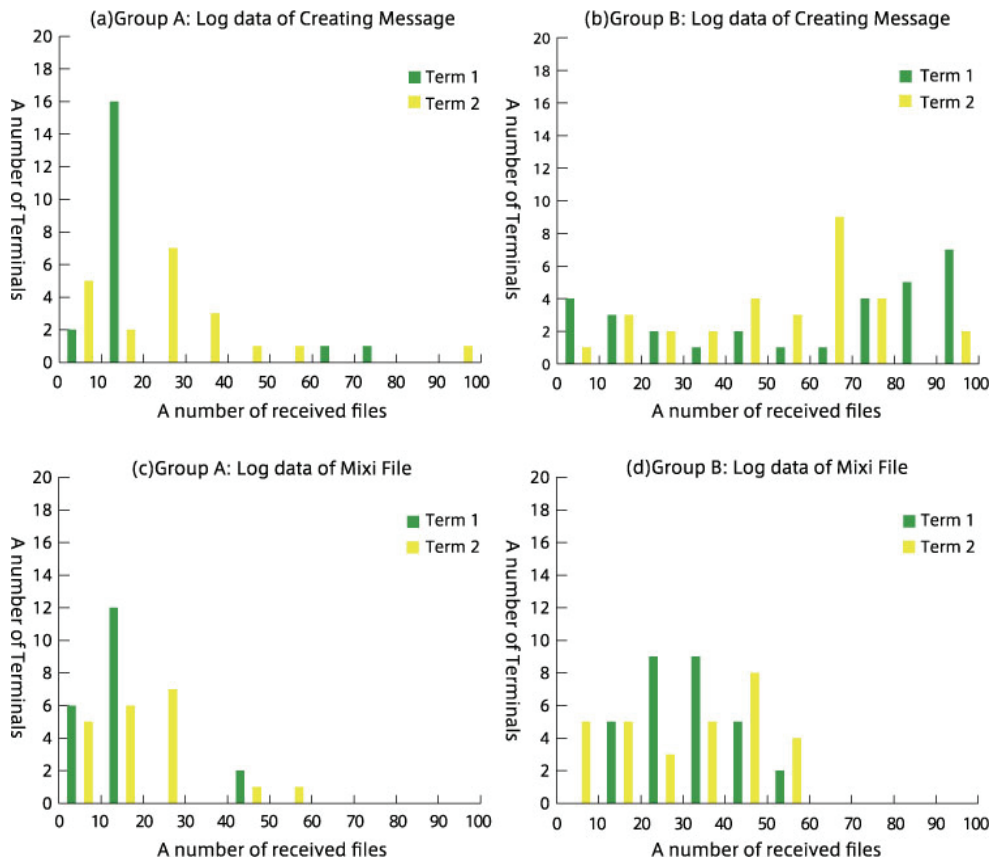


Figure 6: Data Log of created messages and mix files
(row: instrument ID, column: time transition per 5000msec)

of the direct collaboration among the users sharing the same time and the same place.

Figure 6a, 6b visualize the receiving status for created messages of each terminal for each term of group A and group B from the log data. The horizontal axis has a number of the received files per 10. The vertical axis has a number of terminals having received the created messages. In creating time, the maximum number is 95 files and the average number is 23.8 files per one mobile terminal for 3 minutes in the case of group A with 20 people. In the case of group B with 30 people, the maximum number is 101 files and the average number is 57.03 files per one mobile terminal for 3 minutes. Comparing these graphs in creating time, we surmise group A with 20 players had formed some small groups and group B with 30 people had formed some small, medium and large groups evenly.

Figure 6c, 6d visualize the receiving status for mix files of each terminal for each term of group A and group B from the log data. The horizontal axis has a number of the received files per 10. The vertical axis has a number of terminals having received the mix files. In mixing time, the maximum number is 58 files and the average number is 17.5 files per one mobile terminal for 2 minutes in the case of group A with 20 people. In the case of group B with 30 people, the maximum number is 60 files and the average number is 32.7 files per one mobile terminal for 2 minutes. Comparing these graphs in mixing time, we surmise group A with 20 players had formed some small groups and group B with 30 people had formed some groups from small to medium.

4.3 Questionnaire Result

The questions and the results of the questionnaire are shown in Figure 7. With these data, we verify the method of the indirect collaboration among users on the same place and on a different time. We assume that the indirect collaboration should consist, as term 2 user's action is based on the action of user in term 1, if the action of the user in term 2 who had listened the sound saved in the location particularly differed from the action of the user who hadn't listen it in term 1. Here we state the questions in the questionnaire results where there was a notable difference in whether there was the remain phase or not.

In question a, compared to the positive answers from 30% of the users in term 1, there were positive answers from 48% of the users in term 2. Therefore, we surmise that there was an effect on the user who creates the sound by listening to the saved sound in the location.

In question e, compared to the positive answers from 52% of the users in term 1, there were positive answers from 62% of the users in term 2. Therefore, we surmise that there was an increase in interest for not only the game experience of oneself but also for the game experience of other players by experiencing the remain phase.

We asked question f, to users who answered "Yes" to question e, to compare with question d. Compared to the positive answers from 81% of the users in term 1, there were positive answers from 87% of the users in term 2. There is a slight increase in positive answers by experiencing the remain phase. Also, there were more people who had good impressions to the sound that other users made than to their own music in

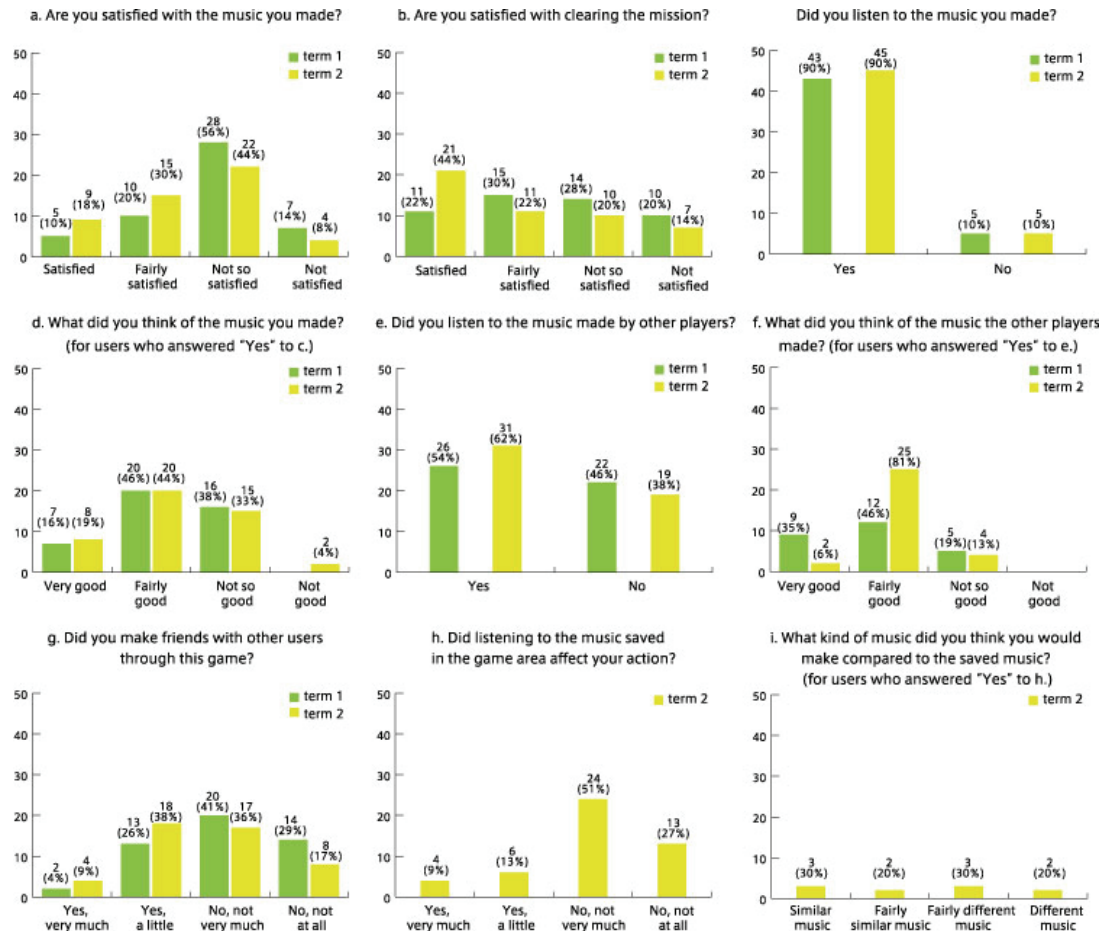


Figure 7: Questions and Results to the Questionnaire

both terms.

In question g “Did you make friends with other users through this game?”, compared to the positive answers from 30% of the users in term 1, there were positive answers from 47% of the users in term 2. Therefore, there was an increase in positive answers by experiencing the remain phase.

Moreover, in question h, which meant to directly inquire the user whether or not it had influence, only 22% of the users answered that they were affected. We surmise that there is an unconscious effect on the user as the 4 questions examined above clearly show a difference in their action by figures. Furthermore, we asked these people who answered “yes” to question h, the next question i. There were about 50% of each similar music and different music. This is a very interesting result for behavioral sociology that it has the same range.

Furthermore, there were notable comments on the free sections of the questionnaire, such as “I felt like I was communicating using the power of music”, “It’s interesting for we can talk to each other and have communication” and “we created a interesting sound when we moved around together in a group These comments were concerned about communication among users.

5. DISCUSSION

We study the 2 features that we adopted in this proposed contents to accelerate communication among users.

Feature1: Direct collaboration among users sharing the same time and the same place

In the proposed content, we adopted the method of creating sound based on the users’ position, proximity and density to realize the direct collaboration among users participating in the games. To be concrete, the creation of sound was made possible under the 2 conditions; 1) the area information agrees with each other and 2) can receive created messages between users. In addition, we adopted the 2 methods as game design to accelerate the direct collaboration. One is the method that 10 instruments were allocated to each user per one area and a musical composition can be complete till all the users gathered. The other is the method that we adopted mini game and we set the situation to make it easy for users to communicate face-to-face through the mission. These methods were the methods which were achieved by using computer technologies in contrast to traditional games and which were unique for Pergames.

Through the analyzed log data of created message and mix files shown in 4.2, we confirmed that the users had formed groups in various scale and realized collaboration among users. In addition, we observed in the game that many users had cleared the mission with other users in the mini game time. Furthermore, we saw some comments on the free comment section of the questionnaire, such as “I was glad to make a chance to talk with other users through mini game”.

The limit of this method is the point that creating sound of the direct collaboration is based on the two conditions; 1) the area information agrees with each other and 2) can receive created messages between users. Users don't have to access each other if the user invades the other user's coverage area. It is necessary to adopt more motivation to the game design to approximate the users and to accelerate communication. To be concrete, it is achieved by controlling the coverage area of mobile terminals to change the created sound due to the radio intensity in controlling or by adjusting the set up so that an interaction is made only when there is a fixed radio intensity.

Feature2: Indirect collaboration among users on the same place and on a different time.

In the proposed content, we adopted the method of saving the sound created by the user as data and enabling other users who play afterwards to refer to it to realize the indirect collaboration among not only the current users that exist at that location but also the users that appear afterwards at that location.

In 4.3, we verified whether there is a difference in action between term 1 and term 2. By examining the results of the questions a,e,f and g in each term, we came to a conclusion that there is a difference in the action between term 1 and 2. Also, according to question h, it can be said that it is an unconscious difference. The users' action in term 2 is based on an influence of the user's experience in term 1 as a particular but there are unconscious difference exists between the users' action in term 2 who listened the sound saved in the location and the users' action in term 1 who didn't listen. As long as these data, the indirect collaboration is realized.

The limit of this method is that the effect of a user's experience to the other user's action is indirect from the perspective of the action based on listening sound. This method can be stated as uncontinuous inheriting model. On the other hand, there is a direct inheriting model. This inherits directly or continuously to one or all the attributes saved in the location as parameters to the sound created by other users. Namely, the created sound by other user oneself is directly influenced by the sound created and saved to the location by user. This accelerates collaboration between the current users and the users that had participated in the games beforehand.

6. CONCLUSION

In this thesis, we proposed a Pegame content ototonari to accelerate communication among the users participating in the games through sound composition by users' collaboration. We realized the direct collaboration among users sharing the same time and the same place by creating sound based on position, proximity and density of users in real space. Also, we realized the indirect collaboration among users on the same place and on a different time by saving the sound created by the user as data and enabling other users who play afterwards to refer to it. Ototonari will especially bring a big impact in the field of entertainment computing called Pergames, as ototonari not only brings face-to-face communication in direct lacking in the existing Pergames into the heart of the game design but also adopts the storage and inheritance of game experience not seen in any of existing Pergames.

7. ACKNOWLEDGEMENT

This project is granted by CREST and JST.

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