Implementation of a Marker Type Augmented Reality-based Free Music Trial Listening Application at Physical Music Stores

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Abstract

The way we listen to music has undergone major changes—from cassette tapes and records to compact disks (CDs) and digital music that includes subscription-based online streaming and download- able sound sources. However, despite the popularity of digital music, CDs continue to be used as a means of listening to music due to the following reasons: the sense of safety felt upon holding the actual product and the collection factor for people interested in building personal collections. However, since the COVID-19 pandemic occurred in 2019, amid growing anxiety and turmoil about contact with "people" and "things," users have become sensitive to the use of auditioning machines at CD shops. Therefore, we have developed a music trial listening application that uses augmented reality (AR) technology to enable people who visit CD shops to listen to the music of artists they are interested in without any physical contact with the auditioning machines. Users can feel the com- mitment of the artist by actually holding the CD jacket in their hands via AR; they can also view various types of information about the artist by recognizing the image on the CD jacket by using our AR technology-based developed application. Our proposed application consists of the "Listening Mode," which provides the music trial listening function, and "AR Mode," which provides the artist information presentation function. Further, we conducted an evaluation experiment with 30 sub- jects to evaluate the operability, readability, functionality, relevance, effectiveness, applicability, and safety of our developed application compared to the CD auditioning machine. The experiment results showed highly positive user evaluations regarding most of the abovementioned tested attributes. The user evaluations also showed that there is room for improvement regarding the operability of the AR objects generated via the application. In future studies, we aim to focus on the improvement of the application's operability and enrichment of its contents, for example, we plan to add the "background playback function" and "administrator content registration function" to the existing functions of the applications.

Keywords: Augmented Reality, Smartphone Application, Music Trial Listening, Image Recognition, Digital Content, Compact Disks.

1 Introduction

Music is enjoyed by people worldwide. According to the "Survey on Live Music and Listening to Music 2014 [15]" conducted by SKY Perfect JSAT Corporation in 2014 including 1,000 men and women aged 15–69, 88.0% of the respondents listened to music at least once a week. The way people listen to music has undergone significant transformation: in the 1980s, cassette tapes and records were

the mainstream; however, in the 1990s, compact disks (CDs) became popular and their use surpassed that of cassette tapes.

Subsequently, in the 2000s, more than 90% of people used CDs to listen to music, and the use of cassette tapes declined considerably. Additionally, in the 2010s, the way to access music started diversifying; since then, the number of people who listen to music via digital means, including subscription-based online streaming or downloadable sound sources, has increased rapidly [12]. However, CDs continue to be used as a means of listening to music. According to the Recording Industry Association of Japan's "Production of Recorded Music & Digital Music Sales [13]," sales in 2021 account for 32% of music distribution, while sales of audio records (CDs, records, etc.) account for 45% of the total sales. There are two reasons that motivate people to buy CDs instead of accessing the same music digitally: the sense of safety felt of upon holding the actual product and the collection factor for people interested in building personal collections. First, regarding the sense of safety felt upon holding the actual product, there is a possibility that online streaming and downloading of sound sources may cause problems in the Internet communication environment and communication volume, damage to data and terminals, and suspension of services. On the other hand, CDs rarely become unplayable except due to deterioration or physical damage. Additionally, CDs can be lent and borrowed among family and friends, or displayed; hence, there is a sense of safety felt by customers due to having a visible possession. Subsequently, regarding the collection factor, many people want to own the songs of their favorite artists. In fact, being able to enjoy jacket photos and lyric cards is one of the advantages of CDs that are not obtained when downloading sound sources. Hence, many people opt to purchase CDs at CD shops to build their personal collection. However, due to the impact of the COVID-19 pandemic that started in 2019, anxiety and turmoil about contact with "people" and "things" has increased. While social distancing, wearing a mask, wash- ing hands, and gargling are recommended as precautionary measures against infectious diseases, various measures have also been implemented at physical stores to maximize safety of customers. Especially in places such as restaurants, etc., acrylic boards are installed, antiseptic solutions are always available, and tables and chairs are thoroughly disinfected after customers use them. Both service providers and con- sumers have become highly sensitive to countermeasures and responses to such infectious diseases. CD shops are no exception. Before the pandemic, people freely enjoyed music with auditioning machines installed in shops; however, currently, many people feel uneasy about using headphones connected to auditioning machines as numerous people use these headphones.

The rest of the article is organized as following: Section 2 presents the literature review. Section 3 describes the objective of our study. Section 4 explains the system configuration of our proposed music trial listening application. Section 5 describes the proposed music trial listening application. Section 6 evaluates the music trial listening application; finally, the study findings are concluded in Section 7.

2 Literature Review

2.1 Information Presentation System

Gutie´rrez et al. [6] developed an augmented reality (AR)-based mobile assistant, "PHARA," that sup- ports food decision-making in grocery stores. This system superimposes information regarding the nu- trition level, calorie breakdown, calorie intake nutrition guide, similar products, healthy alternatives, and recommended products on the real space by using AR technology.

Pachoulakis et al. [11] developed a "Virtual Fitting Room" that enables users to try on clothes and

accessories by using AR technology. This system allows customers to assess the fit of clothes and accessories in real time. Additionally, the social networking function provided in this system allows users to receive prompt feedback by sending photos and videos of oneself wearing the product to other people in the network.

Xu et al. [18] developed a system for smart devices that superimposes online product information on the real space. With this system, consumers can select products that better meet their needs from multiple similar products. This system improves the stability and accuracy of product detection by employing marker detection and object detection.

Dinic et al. [3] developed an application called "EatAR Tango" that evaluates nutrition by using a mobile device equipped with a depth sensor. This application calculates the volume of the meal from the captured image of the meal and the input label information, and calculates the nutritional value based on the food density. This application superimposes the calculation results on the real space by means of AR technology.

Fritz et al. [4] developed augmented binoculars that combine tourist binoculars and AR technology. This system aims to enhance the user's sightseeing experience by augmenting the real scenery with virtual information. Different types of information such as text, maps, old photos, videos, and 3D models of tourist attractions, are provided through the augmented binoculars.

Ando et al. [1] developed an AR-based relevant information system by employing image recogni- tion AR technology. This system not only provides information about recommended books, but also superimposes the position of the book in the real space through AR. However, this study only evaluates the image recognition rate and recognition time in the system, and the operability of the system is not evaluated.

Suzuki et al. [17] developed a system that displays product information by using a show window in a clothing store as a screen. This system uses AR technology to display product advertisements according to the movements of store clerks and shoppers. However, this system has the following shortcomings: it cannot deal with products with complicated patterns and it is unable to distinguish between store clerks and shoppers.

Soejima et al. [16] [14] developed an application that uses AR technology to virtually place large home appliances and furniture of the size desired by the purchaser, and can search for products based on their size. This application aims to propose a new product search method and promote sales. However, only rectangular parallelepiped-shaped objects can be placed virtually through this application, and it does not support searching for furniture with complicated shapes.

Fukada et al. [5] developed a tourist information system by using image recognition AR technology. This system automatically superimposes video content related to the tourist map photo captured by a smartphone on the real space. Consequently, seamless presentation of the tourist information is realized. However, the image recognition accuracy in this system is dependent upon the surrounding environment; therefore, the user may have to capture the photo of the tourist map multiple times depending on the environment.

Koyano et al. [9] developed a system that enables users to assess the texture and touching comfort of clothes in mail-order shopping by using image recognition AR technology and fabric samples. This sys- tem aims to reduce users' anxiety and unmet expectations when using mail-order shopping by enabling them to confirm the texture and touching comfort through AR, making them feel as if they are touching the real clothes. However, since this system uses real samples, it is necessary to prepare a

new sample when adding content, and it takes time and effort to prepare a new sample each time.

2.2 Music CD Audition System

Kirimura et al. [8] developed a music CD listening system by using streaming technology. This system aims to enable users to easily listen to music by holding a mobile phone over a music CD. However, as this system requires a non-contact IC with information attached to each music CD, the introduction cost of this system is high.

Hiraragi et al. [7] developed a system that helps users to create and listen to music playlists by intuitively judging their preferences of CD jackets. Th purpose of this system is as follows: "The discovery of the tune of the music genre which makes users want to listen to music again, even if they are not familiar with it." However, CD jackets are not limited to plastic cases; CDs are encased in cardboard packaging or Japanese paper depending on the artist's preference. Therefore, it is difficult for users to perceive the artist's commitment to the texture and material of the CD jacket from this system, which judges uses preferences only from the jacket image.

3 Research Objective

In this study, we develop a music trial listening application by using AR technology. This application comprises the following two functions:

3.1 Music Trial Listening Function

This function provides an audition of the music recorded on the CD to the user by recognizing the image of any CD jacket and playing the corresponding music. In the study by Kirimura et al. [8], it is necessary to attach a non-contact IC with information to each music CD. However, our proposed application makes it possible for users to listen to music by recognizing the image of the CD jacket. With this function, users can easily listen to music CDs of their choice from the selection in a shop on their smartphones. Additionally, by listening to music on their own smartphones instead of the auditioning machines in CD shops, users can ensure their safety from contagious diseases due to assured non-contact.

3.2 Artist Information Presentation Function

By setting the CD jacket as an AR marker and recognizing the image of the CD jacket by using AR technology, through this function, various types of information about the artist are superimposed on the real space. Hence, users can feel the commitment of the artist by actually holding the CD jacket in their hands, as well as view various types of information about the artist.

By realizing these two functions, it is possible to alleviate customers' the anxiety about using headphones connected to the auditioning machine due to the aftereffects of the COVID-19 pandemic. Addi- tionally, the user can feel the artist's commitment and audition the music without any contact.

4 Music Trial Listening Application Configuration

Figure 1 presents the configuration of the music trial listening application. This application comprises two functions: the music trial listening function and the artist information presentation function. Users can listen to music after the CD jacket image captured by their smartphone camera is recognized by

the application, and browse information related to the CD and artist in AR Mode. This configuration consists of a mobile agent, an application server group, and a database server group.

4.1 Mobile Agent

We assume that the mobile agent is a visitor of a CD shop. The mobile agent can use the system by installing our proposed application on their smartphone. By recognizing images on the music CD jacket via a smartphone, mobile agents are provided with both music trial listening and artist information presentation functions via the application interface. When the CD jacket is recognized, it sends an inquiry about the CD jacket information to the CD jacket imaging marker management server.

4.2 Application Server Group

The application server group consists of two servers: the sample sound source/artists' information man- agement server that manages sound sources and artist information recorded on CDs, and the CD jacket imaging marker management server that manages CD jacket images.

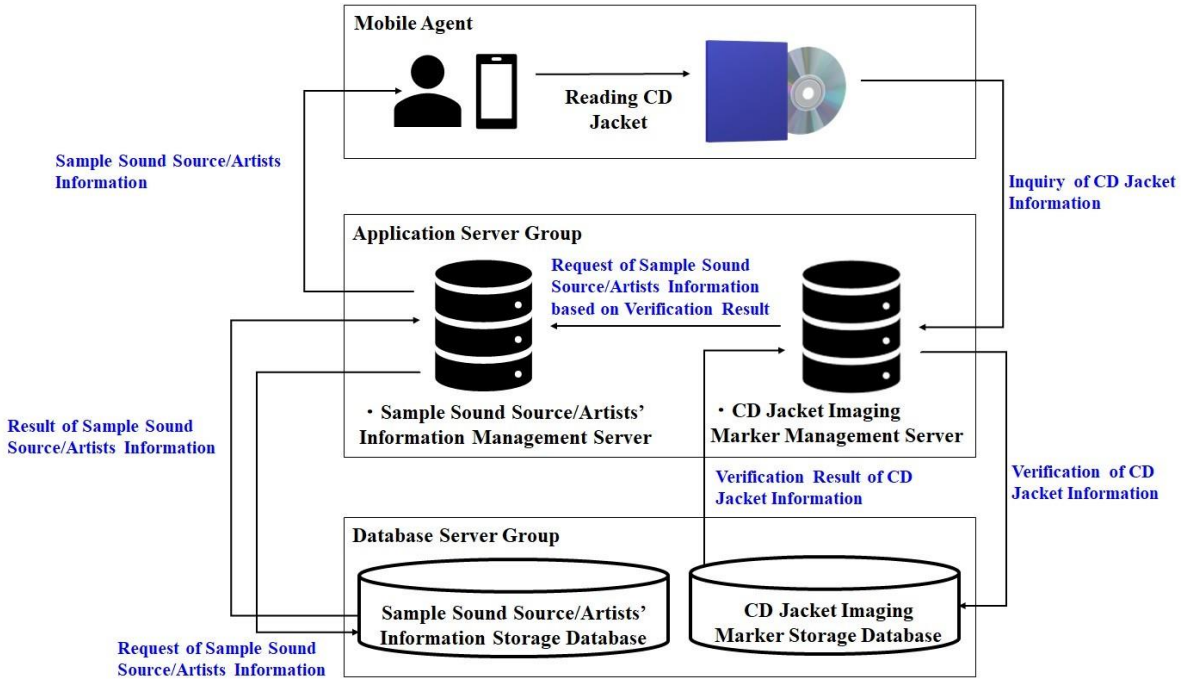

Figure 1. Music trial listening application configuration

4.2.1 CD Jacket Imaging Marker Management Server

In response to a CD jacket information query request from the mobile agent, the CD jacket imaging marker management server checks the CD jacket information from the CD jacket imaging marker stor- age database and receives the matching result. Subsequently, this server requests the sample sound source/artists' information based on the verification result from the sample sound source/artists' infor- mation management server.

4.2.2 Sample Sound Source/Artists' Information Management Server

The sample sound source/artists' information management server manages music information, sound

source information, and artists' information. In response to a request for sample sound source/artists' information from the CD jacket imaging marker management server, this server requests sample sound source/artists' information from the sample sound source/artists' information storage database. Subsequently, this server receives sound source/artists' information results from the sample source/artists' information storage database and provides the sound source/artists' information to the mobile agent.

4.3 Database Server Group

The database server group consists of two databases: the CD jacket imaging marker storage database and the sample sound source/artists' information storage database.

4.3.1 CD Jacket Imaging Marker Storage Database

The CD jacket imaging marker storage database stores CD jacket images as AR markers. In response to the CD jacket information matching request from the CD jacket imaging marker management server, the

matching result of the CD jacket information is returned to the CD jacket imaging marker management server.

4.3.2 Sample Sound Source/Artists' Information Storage Database

The sample sound source/artists' information storage database stores the songs on the CD, their informa- tion, artists' information, and so on. In response to a request for sample source/artists' information from the sample source/artists' information management server, the results of sample source/artists' informa- tion are returned to the sample source/artists' information management server.

5 Music Trial Listening Application

Figure 2 presents the application startup screen. A menu screen is displayed when the application is launched; from this menu, the user can select the "Listening Mode," thus activating the music trial listening function, or the "AR Mode," thus activating the artist information presentation function. When the user selects the "Listening Mode" button, the screen transitions to the music trial listening screen through which the user can listen to music. Further, when the user selects the "AR Mode" button, the screen transitions to the artist information presentation screen through which the user can browse information about CDs and artists by using AR technology.

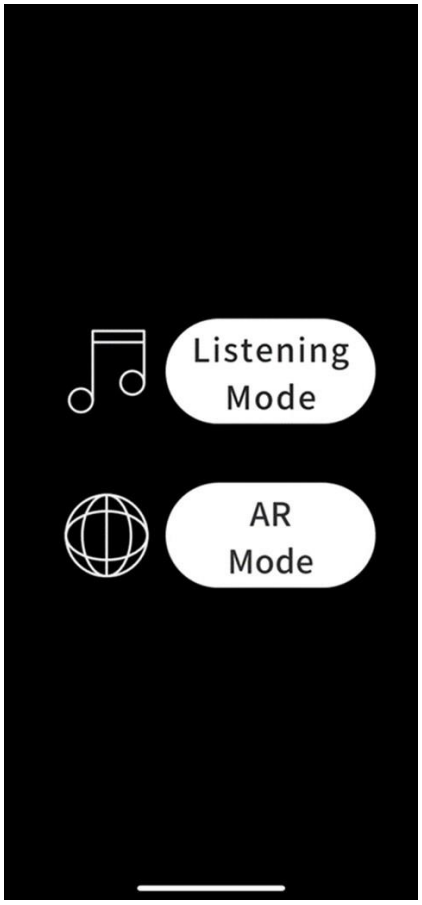

Figure 2. Music trial listening application startup screen

Figure 3 shows the music trial listening screen. Through the options available on this screen, users can play and audition the music. The six buttons available on the music trial listening screen are described below:

A) Music Selection Button : By using the music selection button, the user selects a song to audition from the dropdown button as shown in Figure 4.

B) “Return” button : The return button returns the playback position of the song to the beginning.

C) Play” button : The play button plays the selected song.

D) “Pause” button : The pause button stops the song that is currently playing.

E) Volume Control Button : The volume control button adjusts the volume of the song. The volume increases from left to right.

F) X button : The X button returns the user to the startup screen.

Figure 3. Music trial listening screen

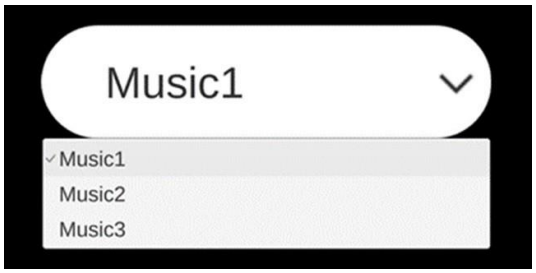

Figure 4. Music selection screen

Sample sound source data can be played by downloading it from the server. In this study, uwr instance is generated based on the URL of the sound source file on the server in order to acquire the sample music. We used three free sound sources in our proposed application.

Through the artist information presentation screen, users can view lyrics and artists' information via AR technology. Users can browse various types of information by flipping the CD jacket virtually in the real space through AR technology. When the user selects the "AR Mode" button from the startup screen, the screen switches to the artist information presentation screen shown in Figure 5, and the camera image is displayed.

Figure 5. Artist information presentation screen

The X button at the bottom of the artist information presentation screen shown in Figure 6 returns the user to the startup screen; thus, it is identical in function to the X button in the music trial listening screen. Subsequently, when the user captures the actual CD with a smartphone camera, the same AR image as the jacket image is superimposed on the CD jacket as shown in Figure 6.

The user can view the information by swiping the superimposed AR object from the bottom corners like flipping through a book. Additionally, by setting the cover image of the AR object to the same image as that on the CD jacket, we realized the operation of actually flipping over the CD jacket and browsing the contents. Figure 7 shows the action of flipping the jacket from the right, and Figure 8 shows the action of flipping from the left.

Subsequently, we describe the information content presented on the artist information presentation screen. The CD taken as an example case in this study contains three free sound sources as a prototype. Figures 9–11 show the AR display screens that include the lyrics of the 1st–3rd songs, and Figure 12 shows the AR display screen for browsing the general information regarding the CD.

Figure 6. AR information superimposed on the actual CD jacket

Figure 7. Action to flip AR object from the right

Figure 8. Action to flip AR object from the left

Figure 9. AR display screen for the first song

Figure 10. AR display screen for the second song

Figure 11. AR display screen for the third song

Figure 12. General information browsing AR display screen

On the AR display screen for 1st–3rd songs, a popup including lyrics and recommended points is displayed. Additionally, the AR display screen on which the user can view general information comprises the following: a button to transition to the artist's homepage, a button to transition to the artist's ticket information and sales page, and a button to transition to the artist's SNS (Social Networking Service). Additionally, on the right side of this screen, the video associated with the title song of the album is played endlessly; thus, it is possible to watch the music video of the title song of the selected album.

The information accessible through the artist information presentation screen is described below:

A) Lyrics: Upon selecting this option, the lyrics of the songs recorded on the CD are displayed one by one. This AR content is supposed to be a lyric card.

B) Pop: Upon selecting this option, introductions and recommended points about the songs recorded on the CD are displayed. This AR content is supposed to pop up and in a format that resembles something written by a CD shop clerk.

C) Web Content: Upon selecting this option, the screen transitions to showing web content where information about the artist can be viewed. This AR content provides users with the artist's homepage, ticket site, and SNS account.

D) Music Video (MV): Upon selecting this option, the music video of the title track on the CD is played.

The music video playback method was realized by pasting the video onto the Plane object displayed when the AR marker was recognized. "Book - Page Curl Pro [2]" used in this system cannot insert animation into the page. Therefore, by inserting the video between the book object and the CD jacket, the virtual image viewed was set as if the video were being played on the book object page. A Video Player was attached to the Plane object displayed on the CD jacket, and the music video was specified as the source.

Figure 13 shows the input/output sequence of this application. The screen transitions as the user operates the application. Accordingly, the necessary information is accessed from the server and acquired by going through the database. The application and the server exchange data via HTTP communication. The audition sound source sent from the server to the application is in .wav format.

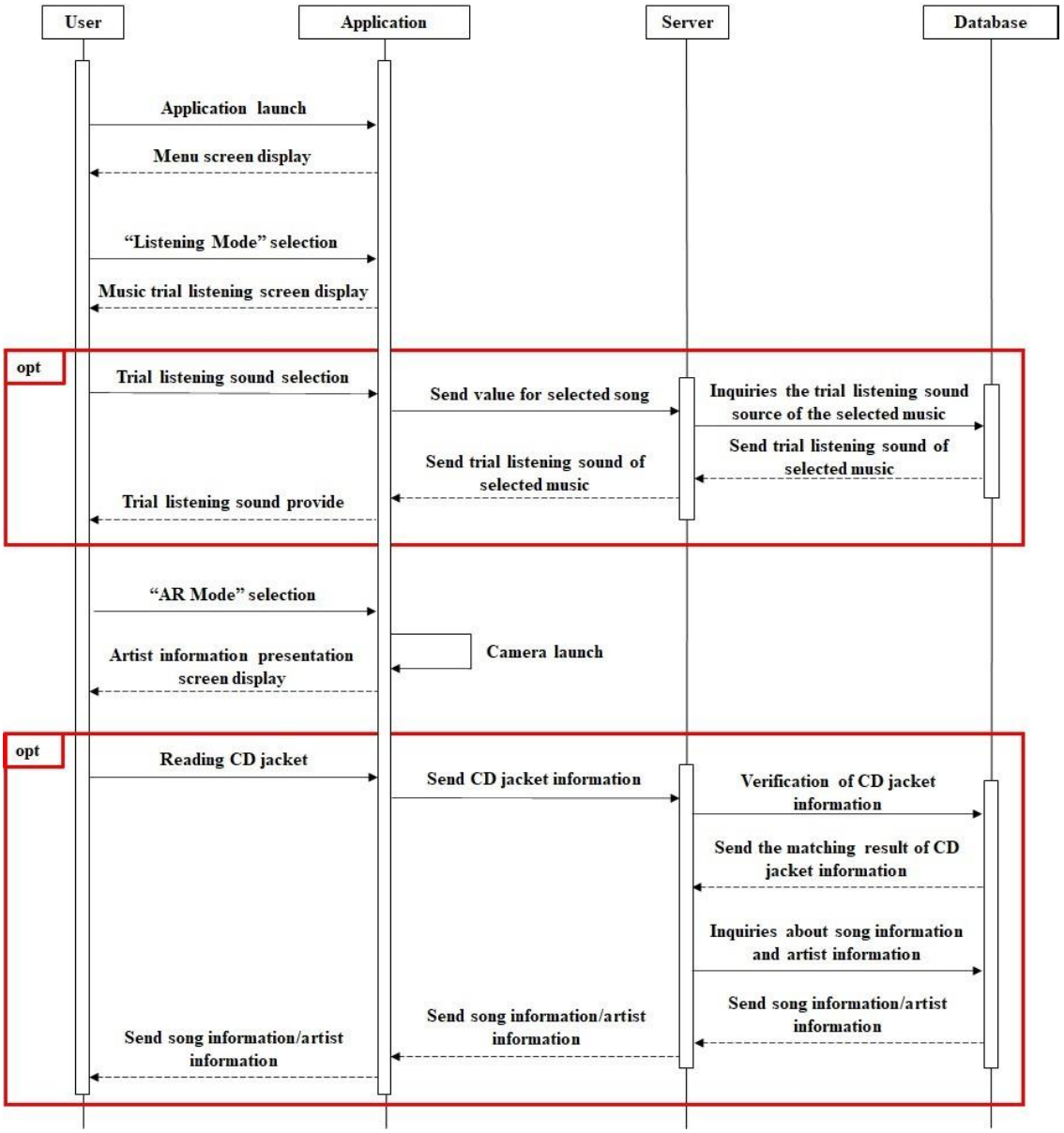

Figure 13. Music trial listening application input/output sequence diagram

6 Music Trial Listening Application Evaluation

In this study, we conducted an evaluation experiment with 30 subjects to evaluate the operability, read- ability, functionality, relevance, effectiveness, applicability, and safety of this application as compared to that of the CD auditioning machine. In this evaluation experiment, the subjects used the music trial listening application, evaluated both the music trial listening function and artist information presentation function.

Figure 14 shows the evaluation results of the operability of the music trial listening application. Approximately 70% of the subjects answered "easy [to use]," and more than 90% of the subjects answered positively when including the number of respondents who answered "somewhat easy." Based on this, we confirmed that the music trial listening application is easy to operate for most users. Additionally, in the free description field, we received comments such as "It's a little difficult to flip the AR content" and "It's hard to keep grasping the AR marker, so it would be nice to be able to fix the AR content." Therefore, it is necessary to consider an operation method in future studies that can fix the AR content after reading the AR marker and flip the page in a stable state.

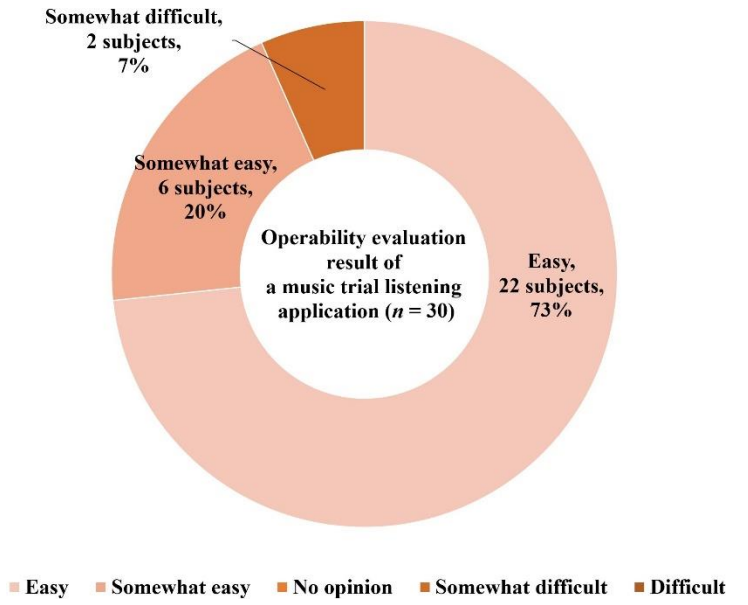

Figure 14. Result of the operability evaluation of the music trial listening application (n = 30)

Figure 15 shows the evaluation results of the readability of the music trial listening application. Of the total number of experiments, 90% of the subjects answered "easy to understand," and 100% of the subjects answered positively when including the number of respondents who answered "somewhat easy to understand." Based on this, we confirmed that the music trial listening application screen has fonts and layouts that are easy for all subjects to understand.

Figure 16 shows the evaluation results of the functionality of the music trial listening application. Approximately 70% of the subjects answered "satisfied," and when including the number of respondents who answered "somewhat satisfied," 100% of the subjects answered positively regarding the function- ality of the music trial listening application. Based on this, we confirmed that the music trial listening application provided satisfactory functions for all subjects. Additionally, in the free description field, we received comments such as "It would be nice if there was a zoom function when displaying information" and "It would be nice if there was background playback because I want to see information while listening to music." In response to these comments, we plan to implement the zoom function as a mandatory function in future studies. We also plan to investigate incorporating a background playback function to enhance the level of comfort and ease while using the application.

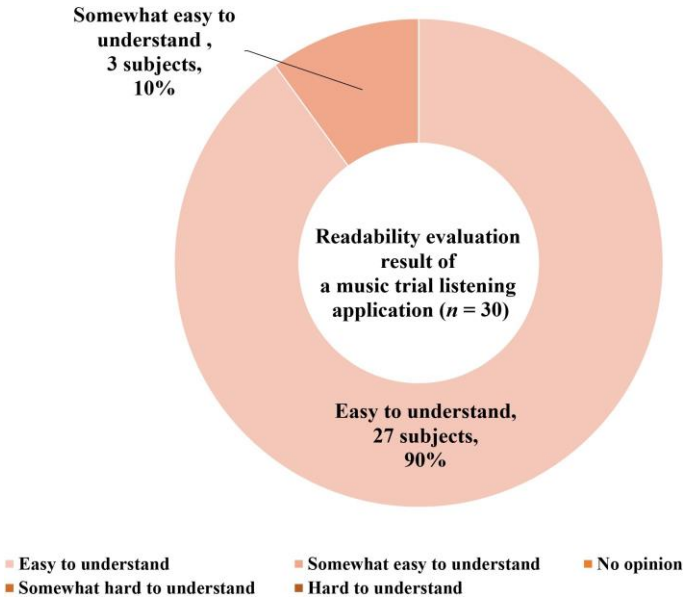

Figure 15. Result of the readability evaluation of the music trial listening application (n = 30)

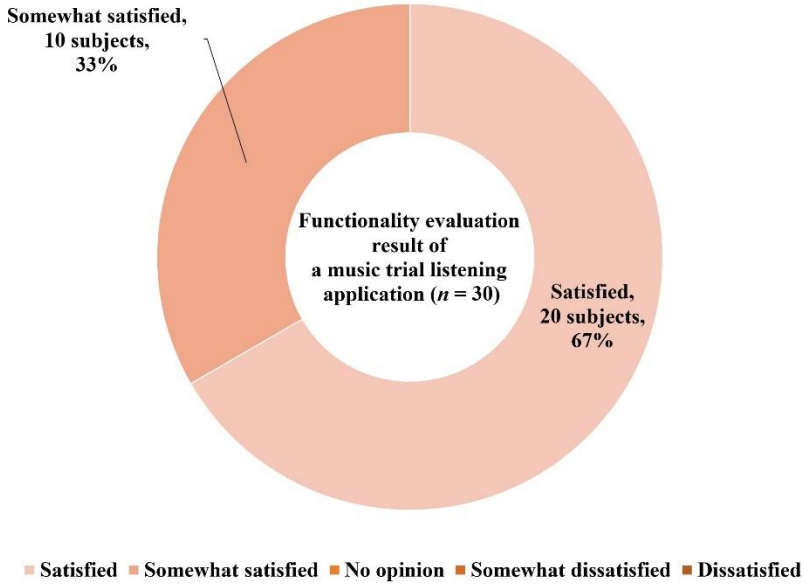

Figure 16. Result of the functionality evaluation of the music trial listening application (n = 30)

Figure 17 shows the evaluation results of the relevance of the music trial listening application. Approximately 80% of the subjects answered "relevant," and when including the number of respondents who answered "somewhat relevant," 100% of the subjects answered positively in this regard. Based on this, we confirmed the high level of relevance of our music trial listening application.

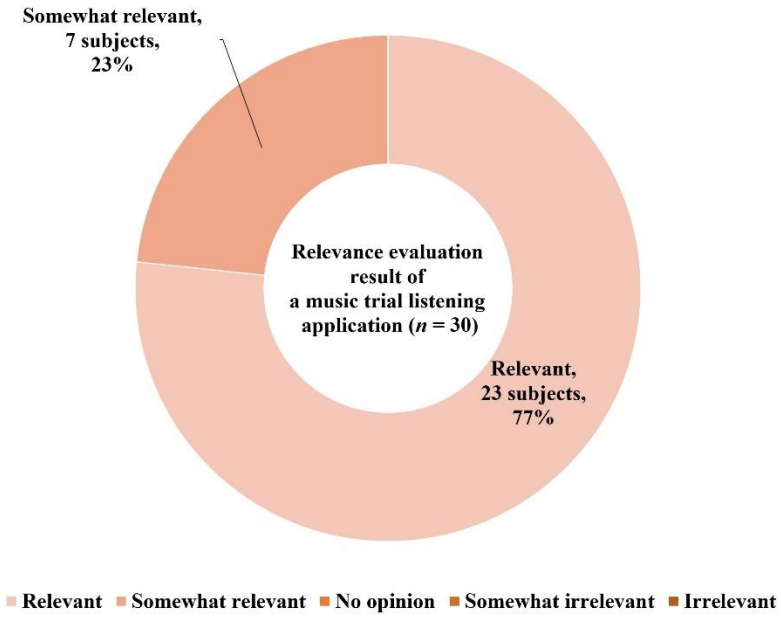

Figure 17. Result of the relevance evaluation of the music trial listening application (n = 30)

Figure 18 shows the evaluation results of the effectiveness of the "Listening Mode." Of the total number of respondents, 90% of the answered "effective," and when including the number of respondents who answered "somewhat effective," 100% of the subjects answered positively. Based on this, we confirmed the high level of effectiveness of the Listening Mode of our application.

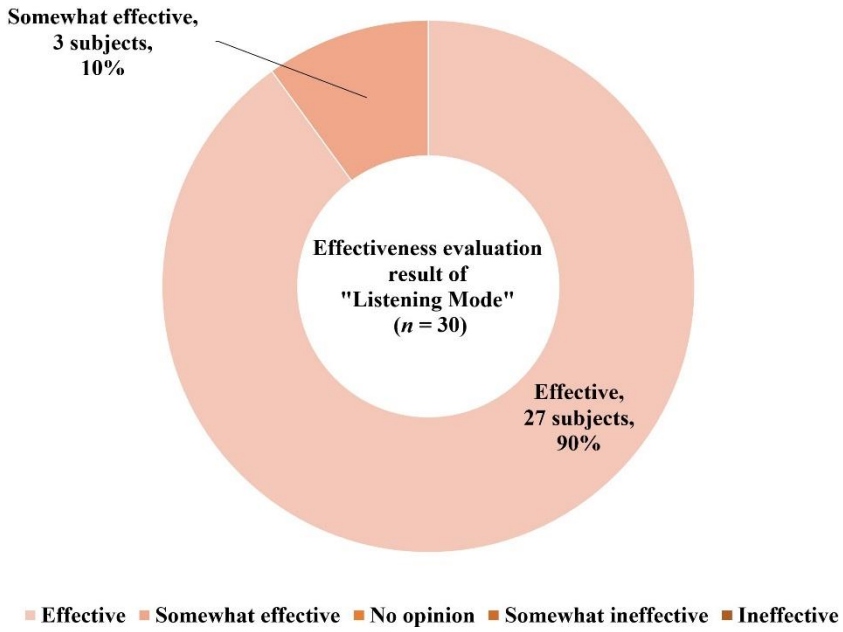

Figure 18. Result of the effectiveness evaluation of the "Listening Mode" (n = 30)

Figure 19 shows the evaluation results of the effectiveness of the "AR Mode." Of the total number of respondents, 80% of the subjects answered "effective," and when including the number of respondents who answered "somewhat effective," 100% of the subjects answered positively in this regard. Based on this, we confirmed the high level of effectiveness of the AR Mode.

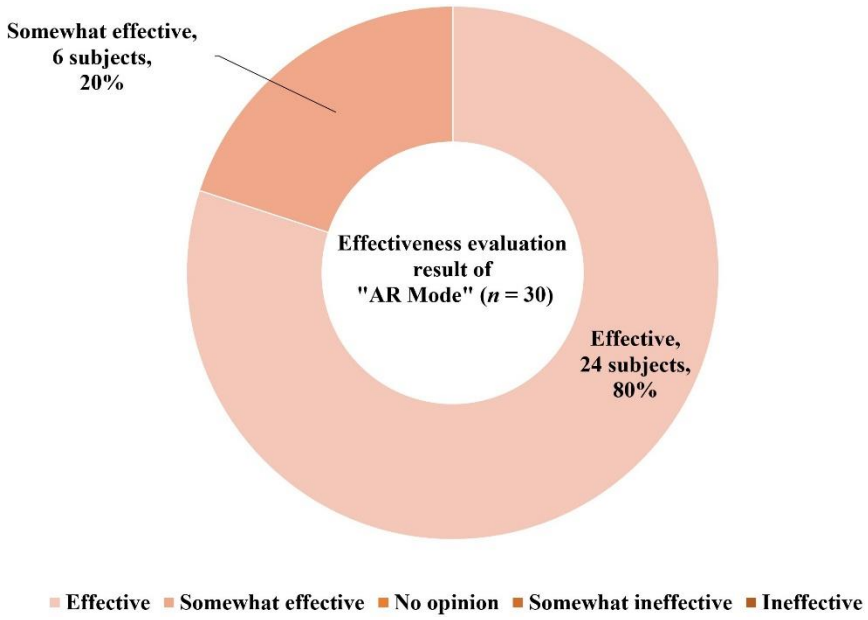

Figure 19. Result of the effectiveness evaluation of the “AR Mode” (n = 30)

Figure 20 shows the evaluation results of the applicability of the music trial listening application. Of the total number of respondents, 70% of the subjects answered “possible,” and when including the number of respondents who answered “somewhat possible,” more than 90% of the subjects answered positively. Based on this, we confirmed the high applicability of our music trial listening application. Additionally, in the free description field, we received comments such as “It seems to be applicable to watching previews on DVD” and “It seems to be useful for trial reading of comics.” Therefore, we think that this application can be applied to the trial viewing of DVDs and the trial reading of books.

In this evaluation item, we evaluated the users’ perception of the degree of safety of listening to music through this application as compared to listening to music by using the CD auditioning machine installed in the CD shop (Figure 21). Of the total number of respondents, 80% of the subjects answered “ [I] feel safe,” and when including the number of respondents who answered “[I] feel somewhat safe,” 100% of the subjects answered positively in this regard. Based on this, we confirmed that this application gives the user a sense of safety more than that given by the CD auditioning machine.

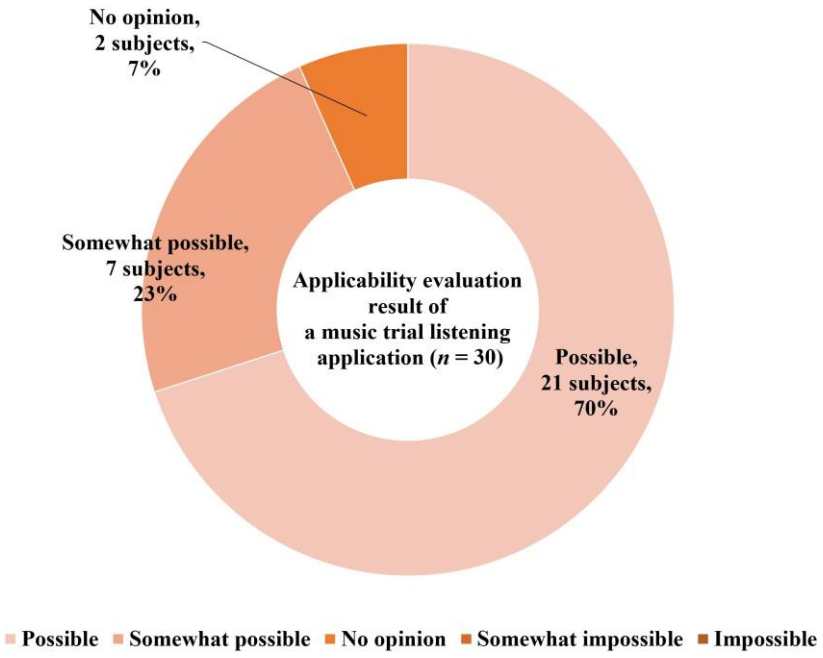

Figure 20. Result of the applicability evaluation of the music trial listening application (n = 30)

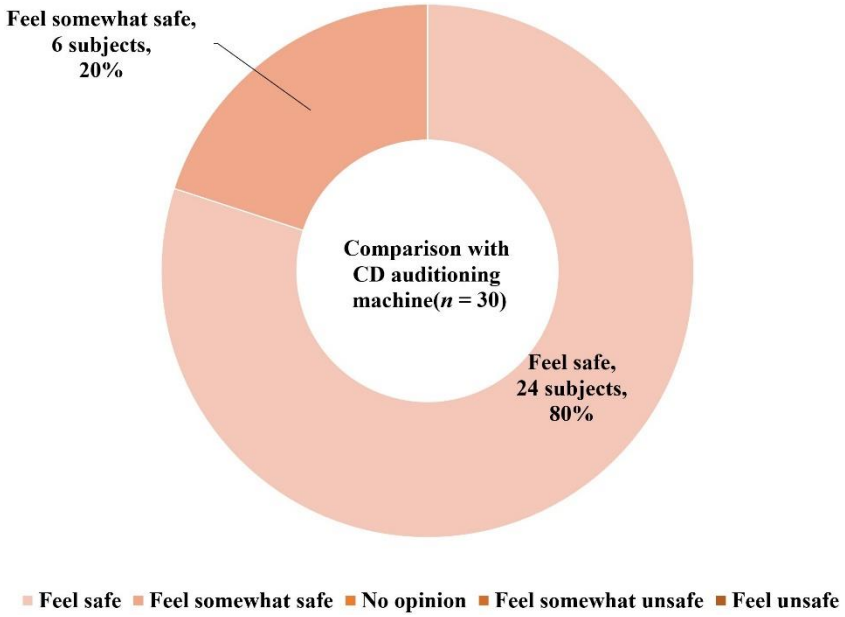

Figure 21. Comparison of safety felt by users of the music trial listening application as compared to that felt while using the CD auditioning machine (n = 30)

7 Conclusion and Future Works

In this study, we described the development and evaluation of a music trial listening application that uses CD jackets as an AR marker. Our proposed application superimposes a booklet-type AR on the real space by capturing the CD jacket registered as an AR marker via a smartphone camera by using AR technology. By developing the music trial listening application, people who visit a CD shop can listen to the music of the artists they are interested in without any physical contact through AR

content.

Further, we conducted an evaluation experiment with 30 subjects to evaluate the operability, readability, functionality, relevance, effectiveness, applicability, and safety of this application as compared to the CD auditioning machine. The evaluation experiment results showed highly positive evaluations regarding many of the abovementioned attributes. On the other hand, it became clear that there is room for improvement regarding the operability of the AR objects.

In the evaluation experiment, we received a comment from several subjects that "I want to see information while listening to music." Our proposed application has the "Listening Mode (music trial listening function)" and "AR Mode (artist information presentation function)"; however, both modes cannot be op- erated at the same time. Therefore, the experiments subjects demanded to see the lyrics in the booklet in AR Mode while listening to music, thus requesting a background playback function. In order to meet this request from the subjects, we plan to implement a background playback function in future studies that allows users to listen to music while displaying information by using AR technology. Furthermore, in our proposed application, information about CDs and sound sources are registered on the development screen. However, considering the burden of content registration on the administrator, in future studies, it is necessary to design a mechanism that allows the administrator to register information about CDs and sound sources easily.

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