PAPER *Special Section on Data Engineering and Information Management*

Kiite World: A Web Service for Social-Aware Music Exploration on a Map Through Playlist Sharing and Synchronized Listening*

Kosetsu TSUKUDA[†a)], **Takumi TAKAHASHI**[†], **Keisuke ISHIDA**[†], **Masahiro HAMASAKI**[†b)], ***Nonmembers***, ***and*** **Masataka GOTO**[†c)], ***Fellow***

SUMMARY Numerous systems have been proposed for placing songs on a map to enable music exploration, but existing systems assume that users explore alone and thus lack social interactions, which has been identified as a significant issue for these systems. In this paper, we describe "Kiite World," a web service that enables social-aware music exploration. Kiite World has over 440,000 songs placed on a map and lets users perform the following social interactions while moving their avatars: (1) Users can publish "My Kiite World," where songs from their created playlists are displayed on the map, and they can visit each other's "My Kiite Worlds" to explore songs on the map. (2) The activities of all users exploring songs on Kiite World are visualized in real time, enabling users to synchronize with interested users and explore songs while listening to music together. (3) Any user can easily host music events where she listens to her favorite songs together with other users while they synchronize with her. Analysis of user behavior logs over seven months revealed several reusable insights on the usefulness of incorporating social aspects into map-based music exploration (*e.g.*, users often like songs that are farther from their original interests as a result of exploring songs in other users' "My Kiite Worlds.").

key words: *music exploration, map-based visualization, web service, user interaction, user behavior analysis*

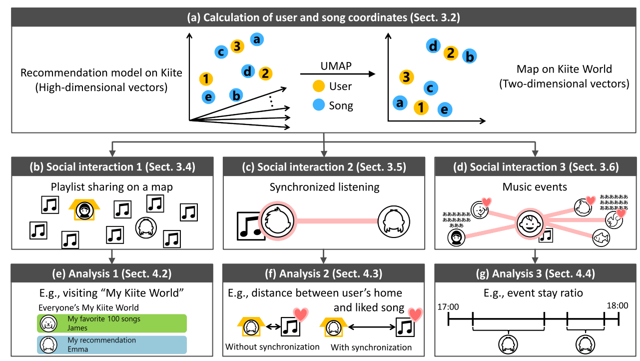

Fig. 1 Structure of this paper.

1. Introduction

In the field of music information retrieval, numerous systems have been proposed to visualize collections of songs in two- or three-dimensional spaces, called "maps," and thus enable users to explore songs on the map [2]–[21]. On these maps, songs are typically arranged according to certain criteria such as acoustic features or genres so that similar songs are placed closer together. Such visualization systems are known to be useful for enabling intuitive song exploration and providing users with enjoyment in their exploration [2]–[5]. However, existing systems have typically assumed that users navigate the map alone, without incorporating social interactions with other users, and this has been identified as a significant issue [22]. Examples of social activities in music include introducing one's favorite music to others [23], [24] and sharing playlists on music streaming services (MSSs) [25]–[27]. In addition, people can experience a sense of social connection with others by listening to music together at real-world music events or online [28]–[31]. These examples indicate that social activities are a crucial aspect of enjoying music in both face-to-face and online situations.

Motivated by this background, we propose a web service called "Kiite World"[†] that enables social-aware exploration of songs on a map containing over 440,000 songs. Kiite World uses a song recommendation model in which users and songs are represented as high-dimensional vectors. By nonlinearly transforming the high-dimensional vectors of users and songs into the coordinate values of two-dimensional (2D) vectors (Fig. 1-(a)), we can visualize both each user's position (treated as the user's "home") and each song's position on the map. As a result, songs that a user is likely to prefer are placed near the user's home, and the homes of users with similar music preferences are positioned close to each other. Users can freely move their avatars on the map and engage in various activities such as listening to songs on the map and visiting other users' homes.

Kiite World users can engage in the following social interactions: (1) Each user can specify a playlist she has created and publish her own map called "My Kiite World" to represent her preferences regarding music. In "My Kiite World," her home and the songs in the specified playlist are shown on the map. Users can visit each other's "My Kiite Worlds" to listen to playlist songs on the map (Fig. 1-(b)). (2) Kiite World provides real-time visualization of other users exploring the map and listening to songs. It allows users to synchronize with the playback of a song when a user of interest is listening to it, thus enabling users to explore

Manuscript received May 27, 2025.
Manuscript revised October 21, 2025.
Manuscript publicized January 14, 2026.
[†]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba-shi, 305–8568 Japan.
[*]An earlier version of this paper was published at a conference [1].
a) E-mail: k.tsukuda@aist.go.jp
b) E-mail: masahiro.hamasaki@aist.go.jp
c) E-mail: m.goto@aist.go.jp
DOI: 10.1587/transinf.2025DAP0004

[†]https://world.kiite.jp ("Kiite" means "listen" in Japanese.)

favorite songs together (Fig. 1-(c)). (3) As with experiencing music together at music events, users can easily host events on Kiite World where people can synchronize and enjoy listening to the same songs simultaneously in the host user's "My Kiite World" (Fig. 1-(d)).

We launched Kiite World as a free-to-use web service on July 19, 2023. We also analyze how users performed the aforementioned social interactions by analyzing usage logs from Kiite World over seven months (Fig. 1-(e), (f), and (g)). In studies that proposed map-based music exploration systems, it was often the case that no user evaluation experiment was conducted [6]–[9], [14]–[20]. Even when the usefulness of the system was examined through user evaluations, the main approach in existing studies was to recruit around ten participants specifically for evaluation experiments and/or to conduct the experiments over a short period ranging from about fifteen minutes to several days [2]–[5], [10]–[12]. In contrast, we analyze the usefulness of map-based music exploration systems using real usage logs collected from a larger number of users and over a longer period than in previous studies, and examine the effects of social interactions on a map on users. From the analysis results, we obtained insights that can be reused by researchers and companies that develop music exploration systems with social interactions in the future.

The contributions of this study can be summarized as follows:

- In map-based music exploration, we proposed three types of social interactions: playlist sharing on a map, synchronized music playback with other users, and hosting and participating in music events.
- We developed a web service called Kiite World, which implements the above three types of social interactions and is publicly available for free use by anyone.
- Using over seven months of usage logs from 2,493 users of Kiite World, we examined the effects of the introduced social interactions.

As a state of the art study that proposed a map-based music exploration system, we refer to EmoMTB by Melchiorre et al. [3]. In EmoMTB, no social interactions among users were introduced, and users explored music on the map individually. Moreover, EmoMTB was not released as a publicly accessible system. Instead, it was exhibited at a media art event held over five days, and the system was evaluated based on feedback from eight participants who used it during the exhibition. Therefore, the three contributions listed above represent the advanced aspects of our work: introducing social interactions, making the proposed system publicly available, and conducting analyses based on large-scale and long-term feedback.

The remainder of this paper is organized as follows. Section 2 reviews related work from two perspectives: music exploration systems on maps and social aspects in music listening. Section 3 describes the method for calculating the coordinates of users and songs on the map, which constitutes the methodological novelty, and then presents the system design contributions introducing social interactions into map-based music exploration. Section 4 reports the evaluation experiments and discusses the analytical insights. Section 5 concludes this paper and outlines future work.

2. Related Work

2.1 Music Exploration Systems on Maps

Although systems aimed at assisting music exploration have been proposed extensively [32], here, we discuss music exploration systems based on visualization using maps, which are closely related to Kiite World. In previously proposed systems, the main objects displayed on the map are songs and artists. In most systems, multidimensional vectors are created from the objects' features (*e.g.*, acoustic features of songs and artist tags); then, the vectors are transformed to low-dimensional coordinates on the map through methods like SOM [33], t-SNE [34], or PCA [35]. In the early stages of research, systems commonly displayed tens to hundreds of objects, such as personal collections [6]–[12]. With the advancement of computer processing capabilities and easier access to large music datasets, systems that can display hundreds of thousands of objects have emerged recently [2], [3], [13], [14]. Some of these systems allow users to explore songs while moving avatars on the map [2], [3], and it has been reported that users' interactions with the songs are enhanced by displaying avatars [2]. Kiite World displays over 440,000 songs on the map, and users can explore songs while moving avatars.

Additionally, Kiite World stands out in that it uses vectors from a song recommendation model to determine not only the coordinates of songs but also those representing a user's interests, which are then displayed as the user's "home" on the map. By determining coordinates so that songs matching a user's preferences are located around the user's home, users can efficiently explore songs by starting from their home. Moreover, unlike existing systems, Kiite World features daily coordinate updates for songs and user homes, thereby providing a map that reflects the latest information on users' music preferences.

2.2 Social Aspects in Music Listening

In addition to the features mentioned above, one of Kiite World's key features is the incorporation of social aspects into song exploration on the map, which has been an important research challenge [22]. In this section, we introduce insights revealed by previous research on how social activities relate to music listening and discuss these insights' relationship with the functionalities of Kiite World.

Music preferences are known to often reflect one's personality more clearly than preferences for movies or books [36]. In fact, individuals often share their favorite songs and playlists on MSSs or social networking services (SNSs) as a means of self-expression [25], [26], [37]. People seek to share their music preferences not only with acquaintances but also with strangers [23], [24], [38]. Given these insights, Kiite World allows users to visualize a playlist's songs on a map as "My Kiite World" to express themselves and share with other users. Conversely, people listening to songs that were shared or recommended by others often expect to encounter new songs that are unfamiliar or that reflect tastes they do not typically have [26], [39], [40]. We thus provide multiple methods for users to visit other users' "My Kiite Worlds" to increase the opportunities for such experiences.

People have long enjoyed listening to the same music together in both face-to-face and online situations [29], [30], [41], [42]. Accordingly, Kiite World provides a feature that enables users to listen to music together on the map through synchronization among users. Moreover, by leveraging this feature, any user can easily organize events where multiple users listen to music together, akin to concerts.

3. Kiite World

Kiite World is a feature offered within the music discovery service Kiite†. In this section, we first introduce the functionalities related to Kiite World within the Kiite. Then, we describe the method of visualizing songs and users on a 2D map. Finally, we describe the social interactions that are available to Kiite World users.

3.1 Kiite

Song data on Kiite are routinely collected from Nico Nico Douga††, which is one of Japan's most popular video sharing services. On Nico Nico Douga, it is quite popular for both amateur and professional musicians to upload songs created with singing voice synthesizer software called VOCALOID [43]. Because all songs on Nico Nico Douga are uploaded as music videos, when a Kiite user listens to a song, its video clip is played by an embedded video player. A registered user can set her own icon image, add songs to her favorites list, create playlists, listen to other users' playlists, and so on.

3.2 Calculation of User and Song Coordinates (Fig. 1-(a))

Kiite also provides a feature that recommends songs to each user. The recommendation model represents each user and each item (*i.e.*, song) as a multidimensional vector, similar to typical recommendation models [44]–[47]. The recommendation score for a song with respect to a user is calculated using the dot product of the two vectors, and songs with higher scores are displayed in the user's recommendation list. The recommendation model optimizes the values of user and song vectors by considering three conditions: songs preferred by users, songs with similar acoustic features, and songs having creators in common.

More specifically, the recommendation model adopted in Kiite is based on a Graph Convolutional Network (GCN) [48], and the graph is constructed according to the three conditions described above. In Kiite's recommendation feature, users can provide feedback for each recommended song. If a song matches a user's preference, the user gives a thumbs up, and if it does not, the user gives a thumbs down. During training, in addition to the songs that a user u has given a thumbs up to, the songs that u has added to u's favorites or playlists in Kiite or Kiite World are also used as positive samples, while the songs that u has given a thumbs down to are used as negative samples. Based on these training data, the model parameters are learned using the Bayesian Personalized Ranking (BPR) loss [49] and the mini-batch Adam optimizer [50].

In Kiite World, these calculated vectors are transformed to 2D vectors by using UMAP [51] to determine the coordinates of users and songs on the map. However, since UMAP typically uses the Euclidean distance function, it does not guarantee that vectors with large dot products in the recommendation model will be close to each other on the map. Therefore, we modified it to use the dot product as the distance function. This enables the placement of songs preferred by a user near the user's coordinates on the map. Additionally, because Kiite's recommendation model is updated daily to reflect users' latest preferences, the coordinates of users and songs in Kiite World need to be updated accordingly. Because of the random initialization of coordinates in UMAP, however, repeated application of UMAP may yield significantly different final coordinate values for the same user or song, which could confuse users. Therefore, we apply a technique of gradually changing coordinate values by using the previous coordinates as the initial values for UMAP.

Note that the essence of calculating coordinates in Kiite World lies in the two techniques described above, and the recommendation model's details are not essential. That is, other researchers or companies aiming to achieve visualization similar to Kiite World can use any recommendation model that represents users and songs as vectors.

3.3 Map Visualization

In Kiite World, as shown in Fig. 2 (i), all songs in Kiite are displayed as thumbnails of their music videos at the coordinates obtained in Sect. 3.2. Additionally, an icon representing each user's "home" is displayed at the user's coordinates (Ⓐ). In Kiite World, the map showing all songs is called "All Songs Kiite World" (ASKW for short), which is shared among all users. When a user accesses ASKW, her avatar (Ⓑ) is displayed at her home's position. She can move the avatar with a joystick control on the screen and click on a song's thumbnail to listen to it, and the music video will be played by an embedded player (Ⓒ). When the user likes a played song, she can click the favorite button (Ⓓ) to add it to her Kiite favorites list or click the playlist button (Ⓔ)

†https://kiite.jp (available on smartphones, tablets, and PCs)
††https://www.nicovideo.jp

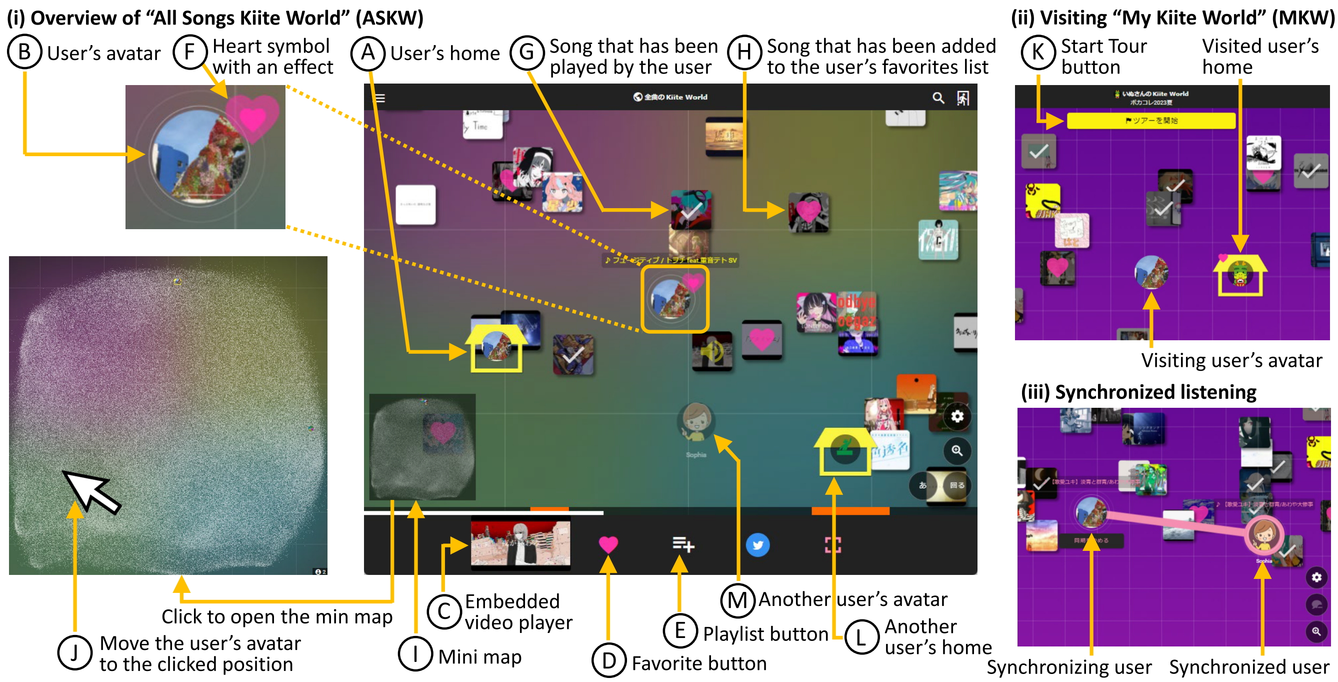

Fig. 2 Interface of Kiite World.

to add it to a playlist that she has created on Kiite. When the favorite button is clicked, a heart symbol with an effect is displayed on the user's avatar during the song's playback (Ⓕ).

Because of the coordinate calculation in Sect. 3.2, songs that a user is likely to enjoy (*i.e.*, songs with high recommendation scores) are placed near the user's home coordinates. This enables users to efficiently explore songs that they would prefer by starting from their home. Moreover, songs that were previously played or added to the favorites list are indicated with symbols on their thumbnails (Ⓖ and Ⓗ), which allows users to efficiently explore only songs they have not yet listened to. If a user becomes interested in songs located far from her current position, then she can open a mini-map (Ⓘ) to instantly move her avatar to the desired location by clicking any position in the mini-map, where each dot represents a song (Ⓙ). To allow users to explore on the map without preconceived ideas, as in previous studies [7], [8], [10], [13], [18], the meaning of the x- and y-axes and the distribution of music genres on the map are not presented to the users.

3.4 Social Interaction 1: Playlist Sharing on a Map (Fig. 1-(b))

In Kiite World, a user can specify one of her playlists created on Kiite and publish "My Kiite World" (MKW for short) based on it. The published MKW is then listed on the Kiite World top page under the section titled "Everyone's Kiite World," along with the publisher's username and playlist name. For instance, if user u selects user v's MKW listed there and visits it, then the songs included in v's MKW and v's home are visualized on the map as shown in Fig. 2 (ii) (visiting method 1). The coordinates of the songs and v's home in v's MKW are identical to those in ASKW. Initially, user u's avatar is displayed at the coordinates of v's home, thus allowing u to explore the songs displayed in v's MKW by starting from v's home†.

MKW also provides a "Start Tour" button (Ⓚ) to access the "Tour Function." This function automatically plays songs in the playlist specified for MKW in their assigned order. While a song s_1 is playing, user u's avatar is displayed at the coordinates of s_1. Then, when the playback reaches the end of s_1 and transitions to the next song s_2, u's avatar automatically moves to the coordinates of s_2. Because the order of songs in a playlist generally reflects the intentions of the user who created the playlist [25], [52], this method has the advantage of enabling other users to listen to songs with a sense of such intentions. Additionally, because the "Tour Function" can be stopped at any time, users can freely choose exploration methods. For example, a user can stop the "Tour Function" when she finds a song she likes and explore the surrounding songs by manually moving her avatar. This way of listening is possible because songs with similar user preferences are located close to each other on the map, and it is a major difference from Spotify's social playlist sharing, which shares playlists in list form.

While a user can create numerous playlists on Kiite, she can only specify one playlist for MKW. This limitation enables MKW to represent a user's world of music preferences and values. However, a user can change the playlist specified

†When a user publishes MKW, she can choose its background color from among 11 colors. For example, user v selects purple in Fig. 2 (ii).

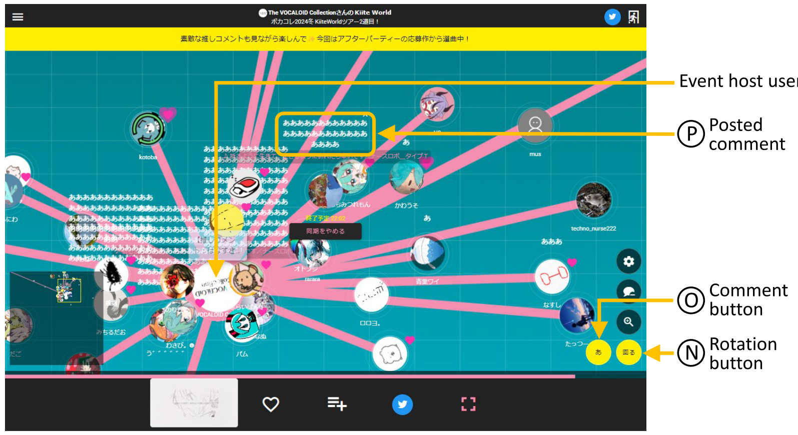

Fig. 3 A music event where many participants are synchronizing with the event host user.

for MKW as many times as she wants, thus letting her express her world according to her daily feelings and changes in music preferences. Furthermore, each user's MKW is assigned a unique URL so that users can share their music preferences with others on SNSs like X by sharing the URL. Other users can also visit a user's MKW via the shared URL (visiting method 2).

Moreover, as shown in Fig. 2 (Ⓛ), a user can visit other users' MKWs by clicking on their homes displayed in ASKW (visiting method 3). Thus, it is easy to discover users with similar music interests (*i.e.*, users whose homes are close to one's own) and visit their MKWs. Kiite World also provides real-time visualization of how other users are listening to music in ASKW or MKW. Specifically, a user can see which music world[†] each user is in and which songs they are listening to. When users' positions approach each other, their avatars become visible to each other, at which point the avatars of users in different music worlds are displayed transparently (Ⓜ). If a user becomes interested in another user's exploration activity, she can visit the music world in which that user is staying by clicking on the user's avatar (visiting method 4). This real-time visualization enables users to explore various songs and users while observing how others are exploring music, which was difficult in existing map-based systems.

3.5 Social Interaction 2: Synchronized Listening (Fig. 1-(c))

If one user is interested in another user's song playback, she can press the "Synchronize" button, which appears by clicking the user's avatar, to synchronize with that user's playback and listen to the same song together in the same music world at the same time. Then, a pink line connects the avatars in synchronization and surrounds the avatar of the synchronized user, as shown in Fig. 2 (iii). Thus, the synchronized user can visually see that she is being synchronized with another user. Even when user u is listening to a song while synchronizing with user v, the positions of u's and v's avatars are not synchronized. User u can thus stay in the same position without moving her avatar, or she can manually move her avatar as v moves to enjoy the synchronization with a stronger sense of listening together[††]. Other users can further synchronize with a user who is already synchronized, enabling multiple users to experience listening to music together. Synchronization can be stopped by either the synchronizing user or the synchronized user. Until the synchronization is stopped, even if the synchronized user moves on to the next song on the map, the synchronized playback will continue, so that users can listen to songs together one after another.

3.6 Social Interaction 3: Music Events (Fig. 1-(d))

The synchronization feature enables a large group of users to listen to a series of songs together while synchronizing with the music playback on a certain user's MKW map. That is, as shown in Fig. 3, a user who is synchronized can easily host a music event on Kiite World, in which she can showcase the music from her MKW to other users, like a DJ. During an event, the host user can play music while moving her avatar manually, or she can use the "Tour Function" (see Sect. 3.4) to automatically play songs in the playlist order. The latter playback method is particularly useful when hosting an event that involves setting a playlist with a meaningful song order, like a live setlist. A user who wants to host an event can announce it in advance by sharing the URL of the MKW where the event will be held, along with the date and time, on SNSs like X.

Event participants generally enter the target MKW before the event begins, synchronize with the host user, and wait for the event to begin. Participants are free to enter and leave the MKW during an event. If a participant adds the currently playing song to her favorites list, then a heart symbol with an effect is displayed as described in Sect. 3.4, which is visible to both the host and other participants. As a result, through the appearance of heart symbols on avatars one after

[†]Kiite World collectively refers to "All Songs Kiite World" and any "My Kiite World" as "music worlds."

[††]No matter how far apart the avatars of u and v are, the synchronization between them never breaks.

another, the host can see the moments when participants also like her favorite songs.

Moreover, participants can rotate their avatars by pressing the “Rotation” button, shown in Fig. 3 (Ⓝ). The button causes the avatar to rotate clockwise at a uniform rate until the played song ends. This can be used to show one’s fondness for a song in a more casual manner than adding it to the favorites list. Additionally, participants can display comments above their avatars by pressing the “Comment” button (Ⓞ). Here, we take advantage of the fact that in Japanese, the more the specific character “あ (a)” is repeated, such as in “ああああああ (aaaaaa)”, the more heightened the emotions can be. So, to reduce the psychological burden on users to enter comments, we provide a simple, unique comment function whereby each time the “Comment” button is pressed, that specific character is displayed while increasing by one (Ⓟ). Avatar rotations and comments are also visible to other users. Thus, participants can enjoy an event with a stronger sense of unity by using these features, and the host can also observe how participants are enjoying the event[†].

4. Evaluations

The Kiite World service was officially launched on July 19, 2023. In this section, we analyze the impacts of the aforementioned social interactions on users’ behaviors in exploring music and listening to music on the map. To this end, we analyzed the user behavior logs for the period between July 19, 2023 and February 29, 2024[††].

4.1 Basic Analysis

During the analysis period, 2,493 users used Kiite World. The number of songs initially displayed on the map at Kiite World’s launch was approximately 447,000. In addition to updating the coordinates of users and songs daily, new songs made available on Kiite after the launch were also added to the map daily. Therefore, as of February 29, 2024, the number of songs displayed on the map had increased to approximately 491,000.

Before analyzing social interactions, we first analyzed the behavior of users in exploring songs alone in ASKW (“All Songs Kiite World”). A total of 370 users added one or more songs (avarage, or AVG: 9.35 songs; standard deviation, or SD: 27.3) to their favorites lists (henceforth, we simply refer to “adding a song to a favorites list” as “liking a song” for short) while exploring songs alone in ASKW. To analyze the relationship between the coordinates of a user’s home and the coordinates of a song she liked (added to her favorites list), we calculated the distribution of distances between them. As described in Sect. 3.2, because the coordinates of users and songs are updated daily, we used the coordinates at the time when a user liked a song. As the map coordinates are normalized to values between 0 and 1 for both the x- and y-axes, the distance between a user’s home and a song can take values between 0 and $\sqrt{2}$.

The results are shown in Fig. 4 (i). From the graph with distance increments of 0.1, we can see that as the distance increases, the number of liked songs decreases sharply (there were no cases where the distance was 1.0 or more). Furthermore, for cases with distances of less than 0.3, even in the graph with increments of 0.01, there was a tendency for the number of liked songs to be higher when the distance from the user’s home was smaller. These results indicate that places closer to a user’s home have more songs that the user prefers. The results also validate the user and song coordinates obtained with UMAP.

The fact that the coordinates updating process in Kiite World was continuously performed for more than seven months demonstrates the stability of the two techniques described in Sect. 3.2: using the dot product as the distance metric and applying UMAP with the previous coordinates as initialization values. Furthermore, to verify the usefulness of the technique that applies UMAP using the coordinate values of users and songs from the previous update as the initial values, we conducted an evaluation using data from November 8, 2023, which is the midpoint of the analysis period. Specifically, we first obtained two sets of coordinates for the map: (1) coordinates calculated using the proposed technique, and (2) coordinates calculated by applying UMAP to the high-dimensional vectors of the recommendation model on November 8, 2023, without using the proposed technique. We then compared each of these with the coordinates on November 7, 2023, and calculated the movement distance of each user and each song. As a result, in case (1), the mean and standard deviation of the users’ movement distances were 0.00236 and 0.00190, respectively, and those of the songs were 0.00320 and 0.00280, respectively. In case (2), the mean and standard deviation of the users’ movement distances were 0.253 and 0.159, respectively, and those of the songs were 0.335 and 0.190, respectively. These results demonstrate that by using the proposed technique, it is possible to update the coordinate values to reflect information from the latest high-dimensional vectors of the recommendation model while keeping the values close to those of the previous day, thereby confirming the usefulness of the technique.

4.2 Social Analysis 1: Playlist Sharing on a Map (Fig. 1-(e))

A total of 1,242 users published their MKWs (“My Kiite Worlds”), with a total of 2,331 playlists specified for MKW. 306 (24.6%) users changed the playlist specified for MKW to a different playlist at least once. This indicates that a considerable number of users adjusted their MKW representation according to their situation.

[†]The rotation and comment features can also be used when listening to music alone (Sect. 3.4), or when listening to music while synchronizing with other users outside of events (Sect. 3.5). These social features might seem surprisingly simple, but thanks to their simplicity, they are already highly favored by users.

[††]The Terms of Use state that user interaction logs will be used for research purposes.

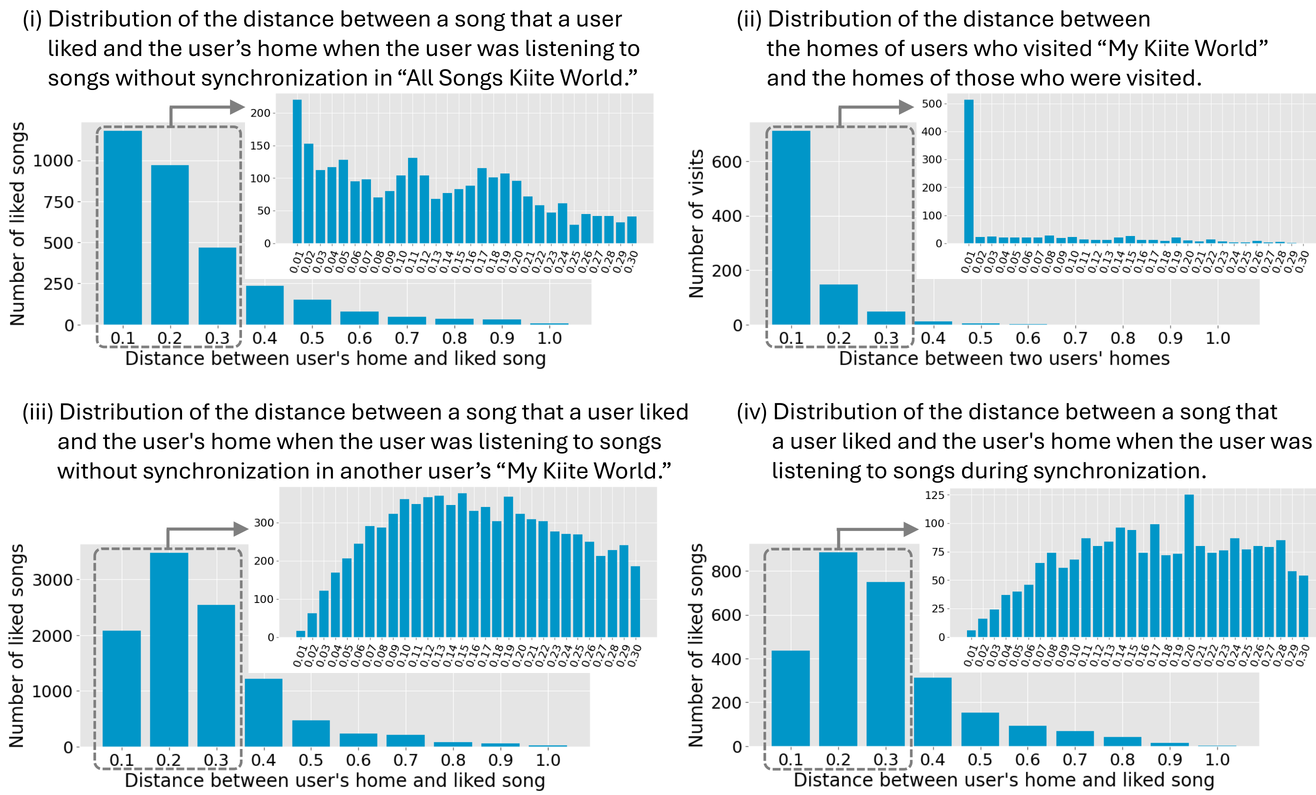

Fig. 4 (i), (iii), and (iv): Distribution of the distance between a song that a user liked and the user's home. (ii): Distribution of the distance between users' homes. On the x-axis, "0.2" indicates, for example, that the distance is between 0.1 and 0.2.

Table 1 Statistics of visiting "My Kiite World."

Visiting method	#total visits	#users	Avg
(1) Everyone's Kiite World	6,280	866	7.25
(2) Shared URLs	556	236	2.36
(3) Homes on "All Songs Kiite World"	998	310	3.22
(4) Users who are exploring songs	614	177	3.47

In Sect. 3.4, we introduced four methods for users to visit other users' MKWs. For each method, Table 1 lists the number of visits, the number of users who visited, and the average number of visits per user. Given the high number of users and average usage via method (1), we can infer that users primarily browsed the list of MKWs displayed in "Everyone's Kiite World" to visit the ones they were interested in. Methods (3) and (4) had similar average usage per user, but method (4) had fewer visits, likely because it required users to be on the map simultaneously; thus, method (3), which was always available, was used more frequently. Method (2) had the lowest usage, but of the 236 users who used it, 76 (32.2%) visited MKW only through method (2). Therefore, sharing the URL on SNSs provided a good visiting opportunity for users who did not habitually visit other users' MKWs through other methods. We also analyzed the distribution of the distance between a visiting user's home and the visited user's home when visiting MKW through method (3). The results are shown in Fig. 4 (ii) (there were no instances with distances above 0.7). The frequency of visits to the homes of users whose distance was less than 0.01 was by far the highest, which indicates a strong interest of users seeking tastes particularly similar to their own when they explore in ASKW.

Next, we analyzed the behavior of adding songs to the favorites list while listening to music alone in other users' MKWs. In this analysis, we focused on situations where users did not synchronize with other users. A total of 11,137 songs were added to favorites lists by 444 users (AVG: 25.1 songs; SD: 63.9). As in Sect. 4.1, we calculated the distribution of distances between users' homes and the songs they liked. Note that when a user u visits another user v's MKW and likes a song s, we compute the distance between u's home and s, not between v's home and s. This is because we want to analyze the positional relationship between u's inherent musical interests as represented by u's home coordinates and the liked song s on v's MKW. The results are shown in Fig. 4 (iii). As compared to the results in Fig. 4 (i), users tended to like songs that were farther from their homes. Brunner-Munzel test revealed that the average distance of 0.220 in Fig. 4 (iii) was significantly longer than the average distance of 0.184 in Fig. 4 (i) ($p < 0.001$, effect size $r = 0.147$)[†]. That is, through the incorporation of social interactions (*i.e.*, visiting other users' MKWs) into map-based music exploration, users gain the opportunity to like songs that are farther from their original interests.

Furthermore, we calculated the mean distances for the 126 users included in both the 370 users analyzed in Fig. 4 (i) and the 444 users analyzed in Fig. 4 (iii). The mean distance in the former was 0.204, while that in the latter was 0.223, and the latter was statistically significantly larger ($p < 0.001$, effect size $r = 0.098$). Therefore, it was confirmed that the larger mean distance in Fig. 4 (iii) was not due to an accidental inclusion of users who tend to like distant songs from their homes. Even for the same users, the social features of Kiite World provide opportunities to like songs that are farther from their original interests.

4.3 Social Analysis 2: Synchronized Listening (Fig. 1-(f))

We analyze the behavior of synchronizing with other users in ASKW or in other users' MKWs. Synchronization during events is not included here, as it will be analyzed in Sect. 4.4. A total of 233 users listened to music while synchronizing, and among them, 162 users (69.5%) synchronized two or more times, indicating that many users perceived value in listening to music while synchronizing. Of the 233 users, 165 liked one or more songs during synchronization (AVG: 12.3 songs; SD: 31.8). Figure 4 (iv) shows the distribution of distances between a song that a user liked during synchronization and the user's home. Once again, users tended to like songs that were farther from their homes as compared to those shown in Fig. 4 (i). The average distance in Fig. 4 (iv) was 0.241, and here as well, compared to Fig. 4 (i), users tended to like songs located significantly farther from their homes ($p < 0.001$, effect size $r = 0.252$). Therefore, synchronizing with other users' song playback also creates opportunities for users to like songs that are further from their original interests.

4.4 Social Analysis 3: Music Events (Fig. 1-(g))

In Sect. 3.6, we mentioned that event hosts can announce events in advance on SNSs by using the URLs of their MKWs. Indeed, among Kiite World users, it has become common practice to announce events on X. Additionally, users spontaneously create hashtags that are used for announcements on X, thus allowing Kiite World users to stay informed about event schedules without missing out. We manually collected event announcements by searching for X posts containing either the hashtag or "Kiite World." Based on the event schedule information, we extracted and analyzed the logs of event host users and participants who synchronized with event hosts during events.

[†]Because Sects. 4.3 and 4.4 also involved testing for differences in the mean distances, we applied Bonferroni correction for all tests.

A total of 231 events were held in Kiite World during the study period, with an average duration of 71.8 minutes per event (SD: 48.4). There were 92 event hosts, of whom 47 (51.1%) organized two or more events. The cumulative number of users participating in events was 2,951 (397 unique users), with an average of 12.8 participants per event (SD: 9.91). If an event host did not recognize any value in holding an event with low attendance, she could simply exit from the MKW shortly after starting the event and thus cancel it. However, our analysis of the logs revealed no significant correlation between the actual duration of events and the number of participants, with a Pearson correlation coefficient of 0.088 ($p = 0.183$). That is, many hosts continued their events even with few participants. In addition, if dissatisfaction with low attendance was common among hosts, they would organize events less frequently. However, since December 1, 2023, when active event hosting began on Kiite World, events were voluntarily held on 88 out of 91 days until February 29, 2024. From these results, we can say that the essence of Kiite World events lies not only in the number of participants but also in the provision of an environment where anyone can easily organize music events.

A total of 292 participating users liked one or more songs during events (AVG: 40.9 songs; SD: 84.3). The distribution of distances between a user's home and a song that the user liked was similar to the one in Fig. 4 (iii) and the average distance was 0.213, which was significantly longer than the average distance in Fig. 4 (i) ($p < 0.001$, effect size $r = 0.131$). Therefore, it was revealed that through the social interaction of participating in events, users have more opportunities to like songs that are further from their original interests compared to when they listen alone in ASKW.

Finally, we evaluated the event stay ratio. Specifically, for each participating user u in each event, we calculated the percentage of time that u stayed at Kiite World from the time of her initial event participation to the end; then, we calculated the average percentage across all users and all events. For example, suppose that an event is scheduled from 5:00 PM to 6:00 PM. If user u joins the event at 5:10 PM, temporarily leaves from 5:30 PM to 5:40 PM, rejoins at 5:40 PM, and leaves again at 5:55 PM without returning, then u's stay ratio is calculated as $\frac{20\text{min}+15\text{min}}{50\text{min}} \times 100 = 70\%$. We do not use the total event duration (in this case, 60 minutes) as the denominator to account for situations where users cannot participate from the beginning for some reasons and to capture user decisions about whether to stay after initially joining. The average stay ratio calculated in this manner was as high as 84.5%. Additionally, there was a negative correlation between the number of event participants and the stay ratio, with a correlation coefficient of -0.16 ($p < 0.001$). This indicates that participants did not seem to stop participating in events with low attendance. One possible reason is that they valued listening to music together with the host user in the MKW that they were interested in.

4.5 Discussion

Through the evaluations in this section, we obtained the following reusable insights:

- The visualization of users' homes and users who are exploring on a map and the capability for users to listen to songs by synchronizing with other users are useful for providing opportunities to listen to songs in other users' "My Kiite Worlds."
- The incorporation of such social elements into music exploration on a map increases opportunities for users to discover new favorite songs that are farther from their original interests.
- The continuity of events held in Kiite World and the high stay ratios of participants indicate that event hosts value having participants listen to the hosts' favorite songs, and that participants value listening to the songs with the hosts and other participants. Moreover, this value is not dependent on the number of participants.

Because the idea of incorporating social interactions into map-based music exploration is a general one, these insights are reusable. Furthermore, for companies and researchers developing map-based music exploration systems in the future, these insights are meaningful as they provide motivation to introduce social interactions.

5. Conclusion

In this paper, we proposed Kiite World, a web service that enables social-aware exploration of music on a map. Through analysis of over seven months of user logs, we revealed the three reusable insights as we discussed in Sect. 4.5. Although the comment function takes advantage of the characteristic specific to Japanese, since other functions of Kiite World are language-independent, the insights above are valuable for future research. Finally, since the recommendation model we use also represents song creators as vectors, creators have been displayed on the map since May 13, 2024. This allows users to explore songs by specific creators, discover new creators located near their favorite creators on the map, and so on. It is an interesting future work to analyze the impact on users' song exploration behavior when creators, along with songs and users, are all represented on the map.

Acknowledgments

We thank Crypton Future Media, INC. for developing Kiite with us and Nico Nico Douga for initially tacitly (later explicitly) encouraging us to work on this research. We also would like to extend our appreciation to users of Kiite and Nico Nico Douga, creators of VOCALOID songs, and all people who have created, supported, and enjoyed the VOCALOID culture.

This work was supported in part by JST CREST Grant Number JPMJCR20D4, Japan.

References

[1] K. Tsukuda, T. Takahashi, K. Ishida, M. Hamasaki, and M. Goto, "Kiite World: Socializing map-based music exploration through playlist sharing and synchronized listening," Proc. 31st International Conference on Multimedia Modeling, MMM 2025, pp.197–211, 2025.
[2] I. Andjelkovic, D. Parra, and J. O'Donovan, "MoodPlay: Interactive music recommendation based on artists' mood similarity," Int. J. Hum.-Comput. Stud., vol.121, pp.142–159, 2019.
[3] A.B. Melchiorre, D. Penz, C. Ganhör, O. Lesota, V. Fragoso, F. Fritzl, E. Parada-Cabaleiro, F. Schubert, and M. Schedl, "Emotion-aware music tower blocks (EmoMTB): An intelligent audiovisual interface for music discovery and recommendation," Int. J. Multimed. Info. Retr., vol.12, pp.1–13, 2023.
[4] B. Vad, D. Boland, J. Williamson, R. Murray-Smith, and P.B. Steffensen, "Design and evaluation of a probabilistic music projection interface," Proc. 16th International Society for Music Information Retrieval Conference, ISMIR 2015, pp.134–140, 2015.
[5] J. Kunkel and J. Ziegler, "A comparative study of item space visualizations for recommender systems," Int. J. Hum.-Comput. Stud., vol.172, p.102987, 2023.
[6] G. Tzanetakis, "Automatic musical genre classification of audio signals," Proc. 2nd International Symposium on Music Information Retrieval, ISMIR 2001, pp.205–210, 2001.
[7] E. Pampalk, A. Rauber, and D. Merkl, "Content-based organization and visualization of music archives," Proc. 10th ACM International Conference on Multimedia, MM 2002, pp.570–579, 2002.
[8] E. Pampalk, S. Dixon, and G. Widmer, "Exploring music collections by browsing different views," Comput. Music J., vol.28, no.2, pp.49–62, 2004.
[9] F. Mörchen, A. Ultsch, M. Nöcker, and C. Stamm, "Databionic visualization of music collections according to perceptual distance," Proc. 6th International Conference on Music Information Retrieval, ISMIR 2005, pp.396–403, 2005.
[10] P. Knees, M. Schedl, T. Pohle, and G. Widmer, "An innovative three-dimensional user interface for exploring music collections enriched," Proc. 14th ACM International Conference on Multimedia, MM 2006, pp.17–24, 2006.
[11] S. Leitich and M. Topf, "Globe of Music - music library visualization using GeoSOM," Proc. 8th International Conference on Music Information Retrieval, ISMIR 2007, pp.167–170, 2007.
[12] D. Lübbers and M. Jarke, "Adaptive multimodal exploration of music collections," Proc. 10th International Society for Music Information Retrieval Conference, ISMIR 2009, pp.195–200, 2009.
[13] M. Hamasaki, M. Goto, and T. Nakano, "Songrium: Browsing and listening environment for music content creation community," Proc. 12th Sound and Music Computing Conference, SMC 2015, pp.23–30, 2015.
[14] M. Schedl, M. Mayr, and P. Knees, "Music Tower Blocks: Multi-faceted exploration interface for web-scale music access," Proc. 2020 International Conference on Multimedia Retrieval, ICMR 2020, pp.388–392, 2020.
[15] R. van Gulik and F. Vignoli, "Visual playlist generation on the artist map," Proc. 6th International Conference on Music Information Retrieval, ISMIR 2005, pp.520–523, 2005.
[16] R. Neumayer, M. Dittenbach, and A. Rauber, "PlaySOM and PocketSOMPlayer, alternative interfaces to large music collections," Proc. 6th International Conference on Music Information Retrieval, ISMIR 2005, pp.618–623, 2005.
[17] P. Lamere and D. Eck, "Using 3D visualizations to explore and discover music," Proc. 8th International Conference on Music Information Retrieval, ISMIR 2007, pp.173–174, 2007.
[18] S. Stober and A. Nürnberger, "MusicGalaxy - an adaptive user-interface for exploratory music retrieval," Proc. 7th Sound and Music Computing Conference, SMC 2010, pp.23–30, 2010.
[19] M. Schedl, C. Höglinger, and P. Knees, "Large-scale music explo-

ration in hierarchically organized landscapes using prototypicality information," Proc. 1st ACM International Conference on Multimedia Retrieval, ICMR 2011, pp.1–7, 2011.
[20] T. Takahashi, S. Fukayama, and M. Goto, "Instrudive: A music visualization system based on automatically recognized instrumentation," Proc. 19th International Society for Music Information Retrieval Conference, ISMIR 2018, pp.561–568, 2018.
[21] P. Gajdusek and L. Peska, "SpotifyGraph: Visualisation of user's preferences in music," Proc. 27th International Conference on Multimedia Modeling, MMM 2021, pp.379–384, 2021.
[22] M. Schedl, "Intelligent user interfaces for social music discovery and exploration of large-scale music repositories," Proc. 2017 ACM Workshop on Theory-Informed User Modeling for Tailoring and Personalizing Interfaces, HUMANIZE 2017, pp.7–11, 2017.
[23] A. Bassoli, J. Moore, S. Agamanolis, and H.C. Group, "tunA: Local music sharing with handheld Wi-Fi devices," Proc. 5th Wireless World Conference, WWC 2004, pp.1–23, 2004.
[24] M. Håkansson, M. Rost, and L.E. Holmquist, "Gifts from friends and strangers: A study of mobile music sharing," Proc. 10th European Conference on Computer-Supported Cooperative Work, ECSCW 2007, pp.311–330, 2007.
[25] A.N. Hagen, "The playlist experience: Personal playlists in music streaming services," Pop. Music Soc., vol.38, no.5, pp.625–645, 2015.
[26] A.N. Hagen and M. Lüders, "Social streaming? Navigating music as personal and social," Convergence, vol.23, no.6, pp.643–659, 2017.
[27] Y. Tan and Q. Min, "What motivates people make music playlists? A social value orientation perspective," Proc. 25th Pacific Asia Conference on Information Systems, PACIS 2021, pp.1–5, 2021.
[28] J.L. Crompton and S.L. McKay, "Motives of visitors attending festival events," Ann. Tour. Res., vol.24, no.2, pp.425–439, 1997.
[29] S.C. Brown and D. Knox, "Why go to pop concerts? The motivations behind live music attendance," Music Sci., vol.21, no.3, pp.233–249, 2017.
[30] K. Tsukuda, K. Ishida, M. Hamasaki, and M. Goto, "Kiite Cafe: A web service for getting together virtually to listen to music," Proc. 22nd International Society for Music Information Retrieval Conference, ISMIR 2021, pp.697–704, 2021.
[31] D. Swarbrick, B. Seibt, N. Grinspun, and J.K. Vuoskoski, "Corona concerts: The effect of virtual concert characteristics on social connection and *Kama Muta*," Front. Psychol., vol.12, p.648448, 2021.
[32] P. Knees, M. Schedl, and M. Goto, "Intelligent user interfaces for music discovery," Trans. Int. Soc. Music Inf. Retr., vol.3, no.1, pp.165–179, 2020.
[33] T. Kohonen, "Self-organized formation of topologically correct feature maps," Biol. Cybern., vol.43, pp.59–69, 1982.
[34] L. van der Maaten and G. Hinton, "Visualizing high-dimensional data using t-SNE," J. Mach. Learn. Res., vol.9, pp.2579–2605, 2008.
[35] I. Jolliffe, Principal Component Analysis, Springer Verlag, 1986.
[36] P.J. Rentfrow and S.D. Gosling, "The do re mi's of everyday life: The structure and personality correlates of music preferences," J. Pers. Soc. Psychol., vol.84, no.6, pp.1236–1254, 2003.
[37] S.Y. Park, K.Y. Lee, and J.H. Lee, "Cross-cultural exploration of music sharing," Proc. ACM on Human-Computer Interaction, vol.6, no.CSCW2, pp.1–28, 2022.
[38] I. Choi and D. Kim, "Toning: New experience of sharing music preference with interactive earphone in public space," Proc. 14th International Conference on Tangible, Embedded, and Embodied Interaction, TEI 2020, pp.533–538, 2020.
[39] L. Spinelli, J. Lau, L. Pritchard, and J.H. Lee, "Influences on the social practices surrounding commercial music services: A model for rich interactions," Proc. 19th International Society for Music Information Retrieval Conference, ISMIR 2018, pp.671–677, 2018.
[40] S.Y. Park, A. Laplante, J.H. Lee, and B. Kaneshiro, "Tunes together: Perception and experience of collaborative playlists," Proc. 20th International Society for Music Information Retrieval Conference, ISMIR 2019, pp.723–730, 2019.
[41] S.J. Cunningham, D.M. Nichols, D. Bainbridge, and H. Ali, "Social music in cars," Proc. 15th International Society for Music Information Retrieval Conference, ISMIR 2014, pp.457–462, 2014.
[42] A. Laplante, T.D. Bowman, and N. Aamar, ""I'm at #Osheaga!": Listening to the backchannel of a music festival on "Twitter"," Proc. 18th International Society for Music Information Retrieval Conference, ISMIR 2017, pp.585–591, 2017.
[43] H. Kenmochi and H. Ohshita, "VOCALOID - commercial singing synthesizer based on sample concatenation," Proc. 8th Annual Conference of the International Speech Communication Association, INTERSPEECH 2007, pp.4009–4010, 2007.
[44] P. Knees and M. Schedl, "A survey of music similarity and recommendation from music context data," ACM Trans. Multimedia Comput. Commun. Appl., vol.10, no.1, pp.1–21, 2013.
[45] F.O. Isinkaye, Y.O. Folajimi, and B.A. Ojokoh, "Recommendation systems: Principles, methods and evaluation," Egypt. Inform. J., vol.16, no.3, pp.261–273, 2015.
[46] M. Schedl, "Deep learning in music recommendation systems," Front. Appl. Math. Stat., vol.5, p.457883, 2019.
[47] S. Zhang, L. Yao, A. Sun, and Y. Tay, "Deep learning based recommender system: A survey and new perspectives," ACM Comput. Surv., vol.52, no.1, pp.1–38, 2019.
[48] S. Wu, F. Sun, W. Zhang, X. Xie, and B. Cui, "Graph neural networks in recommender systems: A survey," ACM Computing Surveys, vol.55, no.5, pp.1–37, 2022.
[49] S. Rendle, C. Freudenthaler, Z. Gantner, and L. Schmidt-Thieme, "BPR: Bayesian personalized ranking from implicit feedback," Proc. 25th Conference on Uncertainty in Artificial Intelligence, UAI '09, pp.452–461, 2009.
[50] D.P. Kingma and J. Ba, "Adam: A method for stochastic optimization," Proc. 3rd International Conference on Learning Representations, ICLR, 2015.
[51] L. McInnes, J. Healy, and J. Melville, "UMAP: Uniform manifold approximation and projection for dimension reduction," arXiv preprint arXiv:1802.03426, 2018.
[52] H.V. Schweiger, E. Parada-Cabaleiro, and M. Schedl, "Does track sequence in user-generated playlists matter?," Proc. 22nd International Society for Music Information Retrieval Conference, ISMIR 2021, pp.618–625, 2021.

Kosetsu Tsukuda received the Ph.D. degree in Informatics from Kyoto University, Japan in 2014. He is currently a Senior Researcher at the National Institute of Advanced Industrial Science and Technology (AIST), Japan. His research interests lie in the areas of recommender systems and user behavior analysis regarding user-generated content and music content.

Takumi Takahashi received the M.E. degree from the Graduate School of Systems and Information Engineering, University of Tsukuba, in 2019. After working as a Technical Staff (Creative Engineers) at the National Institute of Advanced Industrial Science and Technology (AIST), he is currently working as a musician.

Keisuke Ishida was the CEO of Ohma Inc. and managed an online social network mining system, SPYSEE, until 2011. Since 2012, he has been a Technical Staff (Creative Engineers) at the National Institute of Advanced Industrial Science and Technology (AIST), Japan. He has implemented web applications regarding musical information processing and information visualization.

Masahiro Hamasaki received the Ph.D. degree in informatics from the Graduate University for Advanced Studies (SOKENDAI), Japan in 2005. He is currently a Deputy Director of Artificial Intelligence Resarch Center (AIRC) at the National Institute of Advanced Industrial Science and Technology (AIST), Japan. His research interests include Web mining, semantic Web, and social media analysis. He is a member of the JSAI, the IPSJ, and ACM.

Masataka Goto received the Doctor of Engineering degree from Waseda University in 1998. He is currently a Senior Principal Researcher at the National Institute of Advanced Industrial Science and Technology (AIST), Japan. Over the past 33 years, he has published more than 350 papers in refereed journals and international conference proceedings and has received 76 awards, including several best paper awards, best presentation awards, the Tenth Japan Academy Medal, and the Tenth JSPS PRIZE. He has served as a committee member of over 140 scientific societies and conferences, including as the General Chair of ISMIR 2009 and 2014. As the research director, he began the OngaACCEL project in 2016 and the RecMus project in 2021, which are five-year JST-funded research projects (ACCEL and CREST) related to music technologies.