Songrium: A Music Browsing Assistance Service Based on Visualization of Massive Open Collaboration Within Music Content Creation Community

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ABSTRACT

This paper describes a music browsing assistance service, *Songrium* (http://songrium.jp), that helps a user enjoy songs while seeing visualization of open collaboration. Songrium focuses on open collaboration for music content creation on the most popular Japanese video-sharing service. Since this open collaboration generates more than half a million video clips with a rich variety of music content, we call it *massive open collaboration.* To develop a shared understanding of this collaboration we have analyzed, we developed Songrium that visualizes relations among both original songs and derivative works generated from the collaboration. Songrium also features a social annotation framework to verbalize and share various relations among songs, and a flexible ranking mechanism to find interesting songs. After we launched Songrium in August 2012, more than 7,000 users have used our service in which over 98,000 songs and 520,000 derivative works have automatically been registered. We hope Songrium will not only encourage creators to create more derivative works, but also attract consumers to participate in the collaboration as creators.

Categories and Subject Descriptors

H.3.5 [**Online Information Services**]: Web-based services; H.5.5 [**Sound and Music Computing**]: Signal analysis, synthesis, and processing

General Terms

Design

Keywords

Massive open collaboration, Music interface, Visualization, Web service, User-generated content, Social tagging

1. INTRODUCTION

The goal of this research is to encourage consumers and creators to enjoy massive open collaboration for music content. Users of the most popular Japanese video-sharing service *Nico Nico Douga* (http://www.nicovideo.jp) spontaneously started collaboration on creating derivative works of original songs in the form of video clips on the service and uploading them. Such a collaboration can enable the creation of "derivative works of derivative works". This collaboration is open because anyone can join without explicit coordination or contract, though creators of derivative works often naturally express their appreciation for the use of their original work.

The open collaboration in this paper is similar to well-known open collaboration [24][7] in Wikipedia or open source software (OSS) because both collaborations are based on spontaneous motivations and self-organizing growth. Such existing open collaboration usually needs to merge and organize contributions from collaborators. Given the nature of music content, however, our open collaboration is different. The aggregation of personal contributions (video clips) itself is valuable and generates a rich variety of music content. This unorganized variety further generates diverse derivative works.

The most intensive open collaboration on the Nico Nico Douga service emerges from music content related to the singing synthesis technology *VOCALOID* [16]. It forms an interesting music content creation community that has already generated more than half a million video clips according to our analysis. We therefore call it *massive open collaboration.* A reuse network of this large number of derivative works in the VOCALOID community on Nico Nico Douga forms a huge directed graph where each node denotes a different video clip and each edge has a direction from an original work to a derivative work [5]. Figure 1 shows a small excerpt of the huge reuse network in the VOCALOID community. In our previous work [11, 10], we analyzed this network and realized that it was too huge for both consumers and creators to understand the whole picture.

We therefore developed a web service called *Songrium* (http://songrium.jp) that helps a user browse original songs and their derivative works by visualizing their relations (Figure 2). Original songs are visualized as if they are stars in a planetarium. Their positions are automatically arranged so that songs with similar moods can be closely located and
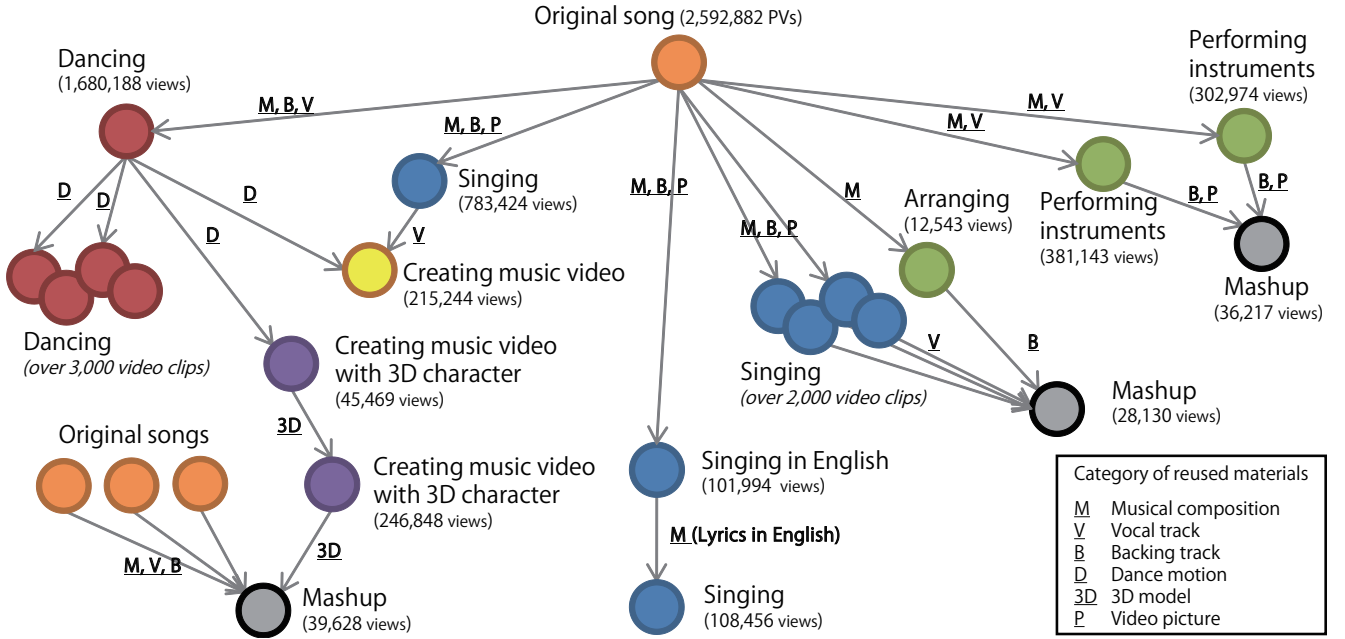
Figure 1: Excerpt of the huge reuse network in the VOCALOID community on the Nico Nico Douga service. Each video clip is denoted as a node (circle) with the name of its category and page views. The color of a node corresponds to its category. Each directed edge represents derivation and is accompanied by labels that explain which parts of the original work are reused in its derivative work. Edges from an original song to further derivative works of derivative works are omitted for simplicity. The root node of this excerpt is an original song having the video ID "sm12825985" on Nico Nico Douga and has generated a wide variety of derivative works.

1) Music Star Map 2) Planet View

3) Arrow Tag 4) Filter

Figure 2: Screenshots of Songrium.

be easily listened to by the user. When the user clicks an original song, its derivative works appear and rotate around it as if they are planets orbiting a star (i.e., the original song). The user can thus find open collaboration related to the song.

Songrium also enables users to annotate, share, and enjoy relations between original songs. In this paper, we propose a new social annotation framework where a user voluntarily puts a directed tag, called an *Arrow Tag*, on a relation from one song to another. Each Arrow Tag represents an implicit

or explicit relation between songs and is immediately shared with other users after being annotated by anyone or being automatically generated from web information. A user can click Arrow Tags to follow and enjoy various relations to encounter unknown songs. Furthermore, Songrium supports a customizable ranking mechanism where a user can change criteria to generate a personal ranking of original and derivative works to find interesting songs.

Although we launched Songrium in August 2012 and over 7,000 users have used our service, this paper is the first academic report of this service. Since more than 98,000 original songs and 520,000 derivative works have already been registered and new songs are also automatically registered every day, Songrium is the only large-scale web service that can provide a comprehensive overview of massive open collaboration within the music content creation community for VOCALOID.

This paper is organized as follows. Section 2 explains massive open collaboration within the VOCALOID community on Nico Nico Douga. Section 3 introduces functions provided by Songrium and Section 4 describes how they are implemented. Section 5 presents our experiences with Songrium and Section 6 discusses related research and future potential of Arrow Tags. Section 7 summarizes this paper's contributions.

2. OPEN COLLABORATION WITHIN THE VOCALOID COMMUNITY ON NICO NICO DOUGA

This section first describes the Nico Nico Douga service as a platform of the open collaboration and the VOCALOID community in which massive open collaboration emerges. It then reveals key factors that contribute to the collaboration and discusses its open issues.

2.1 Nico Nico Douga

Nico Nico Douga is a popular video communication web service started in December 2006 and had more than 30 million users (including more than 1.8 million paying users) in Japan in December 2012. It was developed by Dwango Co. Ltd. and managed by Niwango Co. Ltd. As with other video sharing services (e.g., YouTube [27, 31]), users can upload, share, and view video clips.

In addition, the Nico Nico Douga service supports a novel networked text communication that enables users to post, share, and watch time-synchronous text comments (semantic information) related to video clips. Recent text comments by anonymous users are overlaid on the video screen in synchronization with the video playback. Each comment typed in at a specific playback time within a video clip flows from the right to the left over the video screen at that time. Comments can therefore be related to various events in a video clip and can be shared with users who watch the clip currently or in the future. Although relevant web-based video annotation systems in which comments can be associated with events in a video clip exist [30, 15], these systems do not support the comment overlay functionality.

Because the overlaid comments can create a sense of shared watching/listening experience, called *Pseudo Synchronized Communication* by Satoshi Hamano, users can feel as though they are enjoying the experience together with a crowd of anonymous users. Users usually post impressions, interpretations, and feelings about the video/music content. Such time-synchronous comments are helpful for creators to get feedback from consumers (listeners) and often motivate creators to upload original video clips much more.

2.2 Open Collaboration with VOCALOID

VOCALOID is a singing synthesis technology that enables a creator to synthesize the vocal track of a song by inputting the melody line with lyrics. In particular, Hatsune Miku [2] is the name of the most popular software package based on VOCALOID and has a cute synthesized voice with an illustration of a cartoon girl. Most creators regard Hatsune Miku as not only a musical instrument but also a pop star for whom they create songs with lyrics to match her character.

Although only a few illustrations of Hatsune Miku were officially provided, enormous numbers of illustrations have already been drawn and shared by anonymous creators. Creators also started creating video clips of original songs featuring Hatsune Miku. Furthermore, some creators built three-dimensional (3D) character models of Hatsune Miku and created video clips containing 3D character animation. The chain of such creation has been officially granted and encouraged by a unique license framework called *Piapro Character License (PCL)* that allows creators to use the Hatsune Miku character for their own creations.

Creation of derivative works has also been supported by a reusable content-sharing web service called *Piapro*. Video clips of derivative works on Nico Nico Douga were often created in a manner similar to the remix culture in music [5]. Already published video clips are reused as materials to create new video clips. Creators usually welcome the reuse of their works because they are pleased to contribute to other works. The open collaboration of creating derivative works has thus grown at a rapid rate.

After the success of Hatsune Miku, more than 30 software packages based on VOCALOID, each having a different voice and character, have been released. Video clips of not only Hatsune Miku but also other VOCALOID characters are also uploaded in large numbers on Nico Nico Douga and reused in the open collaboration.

2.3 Key Factors

By analyzing the massive open collaboration that emerges in the VOCALOID community on Nico Nico Douga, we found that the following factors are essential.

- *Availability of reuse*: VOCALOID characters are officially allowed to be reused for creation. This directly helps creators to create derivative works. It can also contribute to an increase of active creators since reuse of content is often easier than creation of content from scratch.

- *Variety of expression*: When music is reused, it can be combined with various types of performances or expressions, such as singing, dancing, animation, and movies. This wide variety of derivative works makes it easier for users to join the open collaboration, using their own skills or talents. Furthermore, the more diverse the content of video clips is, the wider the audience video clips can attract.

- *Community-based encouragement*: Time-synchronous text comments on the Nico Nico Douga service fosters communication among listeners and creators. Such communication often encourages creators. Since Nico Nico Douga has already hosted many derivative works, there are many users who have already preferred derivative works from the beginning and can join the massive open collaboration.

2.4 Open Issues

Open collaboration within the VOCALOID community on Nico Nico Douga is on the rise both in terms of quantity and variety. Figure 3 shows the number of monthly published original songs and their derivative works from September 2007 to August 2012. According to this figure, the number of uploaded original songs and derivative works has been increasing in general.

This wide variety of a huge amount of video clips makes it more difficult for users to grasp the whole picture. For example, when a user listens to an original song, it is often difficult for the user to notice the existence of its derivative works and play them back. If the user could easily access derivative works, the user can have a better understanding of the massive open collaboration because derivative works are good examples of the collaboration. The assistance of browsing derivative works is thus important for the user to not only find interesting video clips but also understand and respect the collaboration in a deeper way. We believe that such enhanced understanding of the open collaboration encourages both creators and consumers to participate in the open collaboration.
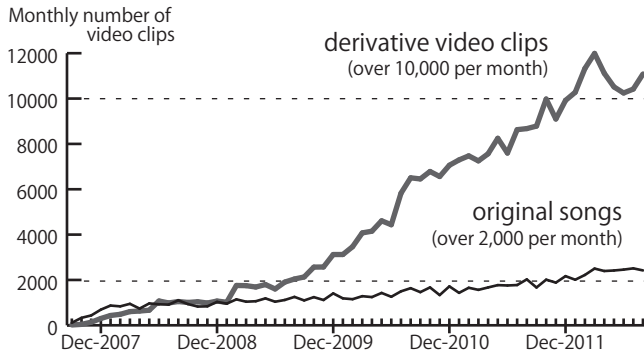
Figure 3: The monthly number of published original songs and their derivative works during September 2007 − August 2012.

3. SONGRIUM

Songrium is a music browsing assistance service that facilitates the understanding of the massive open collaboration within the VOCALOID community on the Nico Nico Douga service. It automatically gathers information about original songs and their derivative works that grow day after day. It then estimates relations between original songs and derivative works and visualizes them. Furthermore, Songrium has a social annotation framework using the *Arrow Tag* to help users encounter unfamiliar but interesting songs.

Songrium supports four functions: browsing original songs (*Music Star Map*), visualizing derivative works (*Planet View*), annotating songs (*Arrow Tag*), and filtering content (*Filter*). The browsing and filtering functions facilitate discovery and understanding of songs. The annotation (Arrow Tag) function allows users to reveal relations between original songs. The visualized relations and derivative works provide a better user experience of retrieving and browsing songs.

3.1 Original Songs and Derivative Works

Songrium continues to collect relevant information from the Nico Nico Douga service since we launched an alpha version of Songrium in August, 2012. More than 97,000 VOCALOID original songs and 520,000 derivative works have automatically been registered in Songrium.

In previous work [11], we analyzed and defined four categories of creative activity related to VOCALOID: *Creating* an original song; *Covering* an existing song by using VOCALOID to synthesize the main vocal; *Drawing* pictures or creating graphics for a music video clip, and *Editing* different VOCALOID video clips for compilation albums and rankings.

In this paper, we propose the following six categories of creative activity, which have emerged since the previous work. Now there are many derivative works in which humans are singing, dancing, and performing. In addition, VOCALOID songs have often been covered using other VOCALOID voices different from the original and VOCALOID characters have appeared in non-music video clips. This suggests that the personality of VOCALOID characters has become established.

(a) *Singing*: This is currently the most popular category

of derivative works where a human singer covers a VOCALOID song whose original main vocal was a synthesized singing voice. Some creators of an original song share the karaoke version without the main vocal to encourage such derivative works.

(b) *Dancing*: A human dancer dances along with a VOCALOID song. After a dancer choreographs dance moves for a VOCALOID song, other dancers can reuse them.

(c) *Arranging and Performing*: Human musicians arrange and perform a VOCALOID song on musical instruments such as guitar, piano, and violin. Or, they cover a VOCALOID song by using other VOCALOID voices.

(d) *Featuring 3D characters in music video*: By using a tool for creating three-dimensional (3D) computer graphic animation, such as *MikuMikuDance (MMD)*[1], some creators first design 3D character models, and other creators then reuse those models to create music video clips. There are more than 10 different models for the Hatsune Miku character alone.

(e) *Creating music video*: Music video clips are often created by reusing other existing video clips or some materials such as 3D character models and singing voices.

(f) *Others*: Other derivative works include the karaoke version of an original song, a medley of some original songs, and mashup video clips in which not only original songs but also derivative works are reused.

3.2 Music Star Map Function

Music Star Map is a function that visualizes original songs in a two-dimensional space where songs are automatically mapped based on audio feature similarity. The position of a song on the map is determined so that it can be located close to songs having similar moods (i.e., audio features). Figure 4 shows a screenshot of this function.
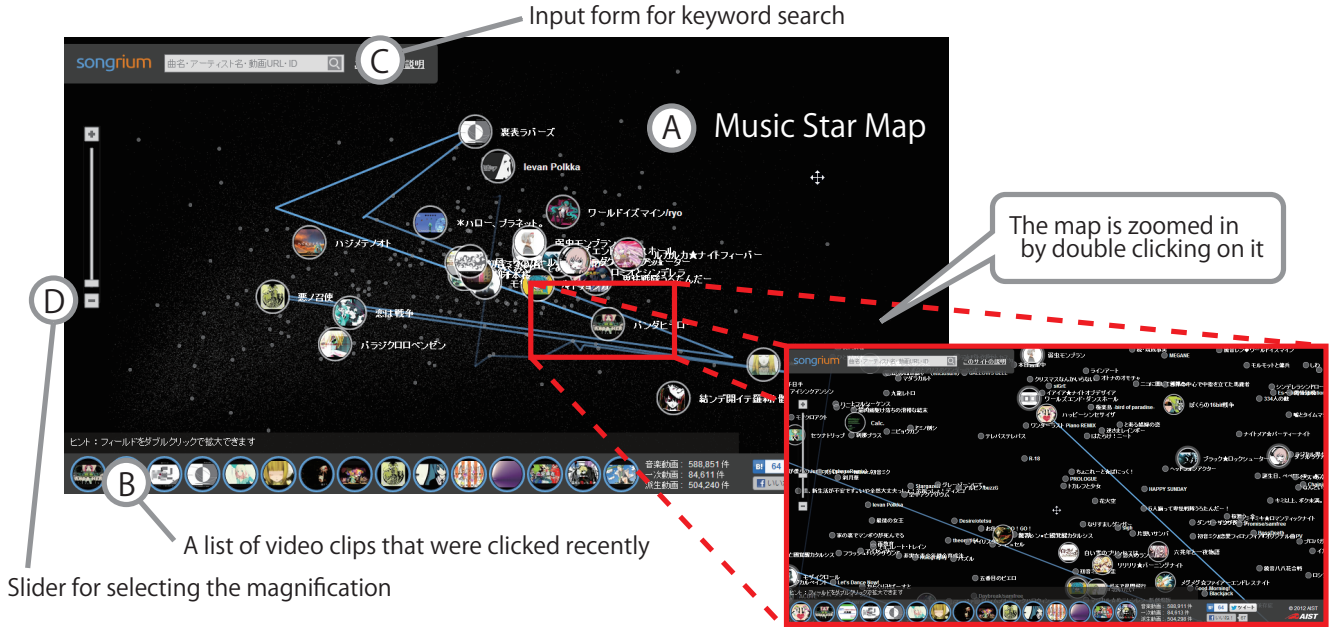
Well-known songs having many page views are displayed with larger icons. Other songs are displayed with smaller icons according to their number of page views. When a user zooms into any area by double clicking, small icons become larger icons with thumbnail images from Nico Nico Douga. The user can see other areas by dragging the mouse.

3.3 Planet View Function

When a user clicks one of the original songs on Music Star Map, the selected song moves to the center. Its derivative works then appear as colorful icons and rotate around the selected original song. We called this view *Planet View*. Figure 5 shows a screenshot of the Planet View.

The official embedded video player of the Nico Nico Douga service is shown at the upper-right corner to play back a video clip of the selected original song. Our music-listening interface with a chorus-search function for trial listening, *SmartMusicKIOSK* [8], is shown below the embedded player. This SmartMusicKIOSK interface enables a user to jump to the chorus section and other key parts of a song. It also visualizes the song structure consisting of chorus and repeated sections. These functions make it easier for a listener to find the desired parts of a song, thereby facilitating an enhanced listening experience.

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[1]http://www.geocities.jp/higuchuu4/index_e.htm

Input form for keyword search

Music Star Map

The map is zoomed in by double clicking on it

A list of video clips that were clicked recently

Slider for selecting the magnification

Figure 4: Screenshot of the "Music Star Map" interface for browsing original songs. (A) All original songs are arranged in a two-dimensional space so that similar songs can be located close together. Any area can be zoomed in by double clicking and then scrolled to by dragging. Light blue lines indicate the personal record of video clips that a user clicks on Songrium recently. (B) This personal record is also shown as thumbnail icons at the bottom. (C) Songs can be searched by keywords. (D) The magnification ratio of the map can be changed by a slider.

A list of Arrow Tags that represent relations of this song with other songs is shown at the lower-right corner. The user clicks one of the Arrow Tags in the list to jump to a different original song. Or, the user can directly click one of the Arrow Tags that are connected to the original song in the center. Songrium then smoothly animates the transition from the current song to the connected song by following the line of the clicked Arrow Tag. In contrast to the Music Star Map that is useful for finding songs with similar moods, Arrow Tags allow the user to find and encounter *other types* of related songs that might have different moods.

Once an original song has been selected, its derivative works appear as circle icons around it. Each circle icon denotes a derivative work whose attributes are represented by the orbit, size, color, and velocity of the icon. The radius of the rotation represents the length of time between the publishing date of the original song and its derivative work. The size of each icon represents its popularity (page views), and its velocity represents the degree of attention (a proportion of "favorites" to page views). The color indicates the category of each derivative work. When most icons have the same color (i.e., most derivative works are in the same category), the user can easily notice that this category dominates. In Figure 5, for example, there are many blue icons (Singing). In Figure 6 on the other hand, there are many red icons (Dancing). The Planet View thus shows the power of the original song to generate derivative works.

A user can also see a complete listed view of derivative works. The user can play back one of them or sort them by page views, categories, and publishing date.

3.4 Arrow Tag Function

Arrow Tag is a directional named link from one song to another song. It describes a relation between original songs in natural language. Arrow Tag A from $song1$ to $song2$ means "Song1 has an 'A' relation to Song2". Songrium enables a user to annotate various relations among original songs using Arrow Tags. It can encompass non-directional relations between songs (e.g., same genre, same theme) in the same way as traditional tagging methods, but it also has the specific advantage of making a Songrium user aware of directional relations between two songs (e.g., a new arrangement or a response to another song).

Some relations are directional (e.g., same genre, same theme), and others are non-directional (e.g., answer song, arrange). Since some of non-directional relations can be described by existing representation methods, the Arrow tag includes information of its direction.

The data structure of each Arrow Tag is a triple of the form ("Song as the starting point", "Name of relation", "Song as the end point"). Songs annotated by Arrow Tags construct a directed graph where each node is a song and each edge is an Arrow Tag. More than two Arrow Tags can be put between songs. The same Arrow Tag can also be put between songs bidirectionally, for example.

In the following, we present examples of Arrow Tags that have been added by Songrium users. We can find that various Arrow Tags are generated. The Arrow Tag does not restrict the type of represented relations. In general, social tagging can represent both a subjective and objective phenomenon [26]. Our Arrow Tag can also be used for implicit,
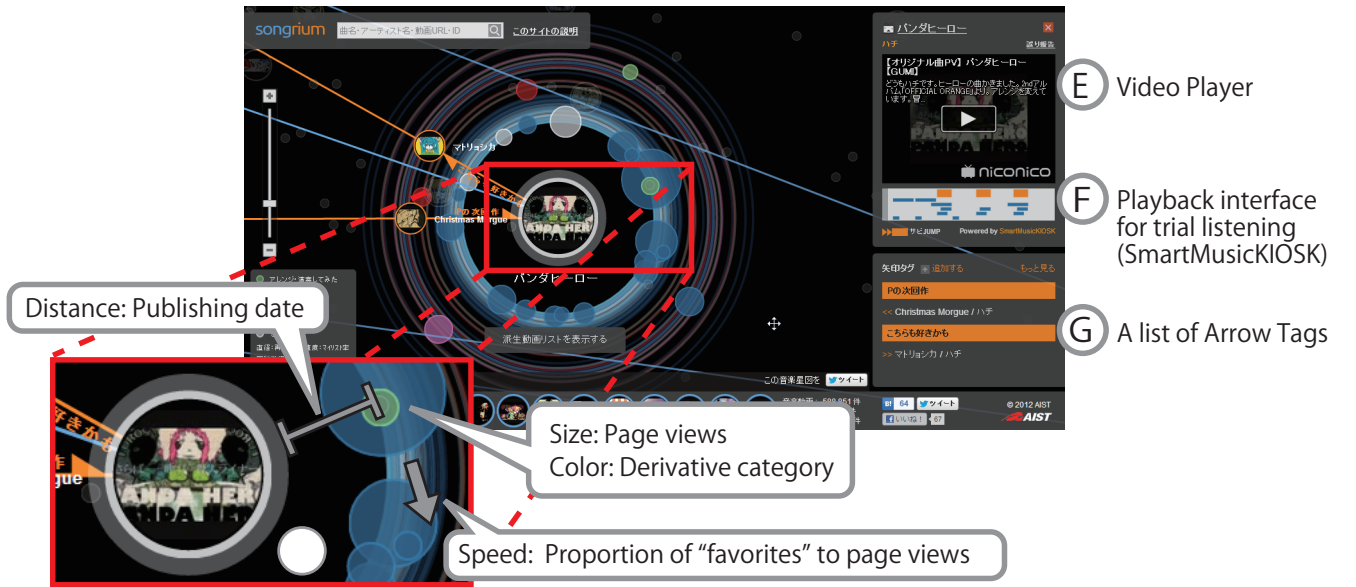
Figure 5: Screenshot of the "Planet View" interface. After selecting an original song on Music Star Map, a user can see its derivative works rotating around the selected song in the center. (E) The embedded video player of Nico Nico Douga for video playback. (F) Playback interface for trial listening (called SmartMusicKIOSK). (G) Arrow tags from and to this song are shown. (H) An explanation of the icon for each derivative work. The distance from the center represents the publishing date. The latest work is in the outermost orbital. The size of each icon reflects the number of its page views. The color indicates one of the following categories (see Section 3.1): Blue (Singing), Red (Dancing), Green (Arranging and Performing), Purple (Featuring 3D characters in music video), Yellow (Creating music video), and White (Others).

explicit, subjective, and objective relations. In fact, it is important that they can be mixed. Users can thus freely tag and share an Arrow Tag. If somebody invents a new useful label for Arrow Tag, other users will start reusing it.

- *"Creator's next song"*: This represents a relation from the current song to the next released song by the same creator.

- *"Want to listen after this"*: When a user finds a song that is suitable to listen to after the currently playing song, the user can put this Arrow Tag as a music recommendation.

- *"Similar themes in the lyrics"*: When the lyrics of two songs have similar themes, this Arrow Tag can be put. This is useful for listening to only songs having similar lyrics.

- *"Respect this song"*: If a creator of the current song respects another song, this Arrow Tag can be put from the current song as the starting point to the respected song as the end point.

Figure 6 shows how to input a new Arrow Tag. When a user adds an Arrow Tag between two original songs, Songrium shows excerpts of popular existing Arrow Tags as suggestions or a complete list of all Arrow Tags.

In our current implementation, Songrium only allows users to put Arrow Tags only between original songs. A derivative relation between an original song and a derivative work is automatically estimated and registered in Songrium,

so far. However, the Arrow Tag has the potential to represent various relations not only among original songs but also among derivative works. We will discuss the future use of Arrow Tags in Section 6.2.

3.5 Filter Function

Filter is a function that enables a user to make a personal short list of video clips selected by criteria or rules using categories and indicators such as genre, popularity, and publishing date. Traditional tag search or bibliographic sort has already been useful in general, but the user has to input queries every time. Complex rules are not usually used in a query because it is too difficult for some users to design them.

This Filter function can easily produce a short list of video clips based on page views, the number of users who put "favorite", tags, publishing dates, and so on. The user can simply choose a preset or saved "filter" to narrow down the list of video clips. One filter could consist of multiple rules such as "page views higher than 1,000" and "publishing date was less than 1 week ago". Since general useful filters have already been pre-defined, the user can simply customize them or generate a new filter by designing rules. Furthermore, if the user likes the results, the user can name and save the personalized filter for future reuse.

4. IMPLEMENTATION

Songrium consists of three components: a web crawler, a web server, and a user interface. The web crawler automatically checks updated music video clips related to

Selection of a target song for Arrow Tag

Input form of Arrow Tag
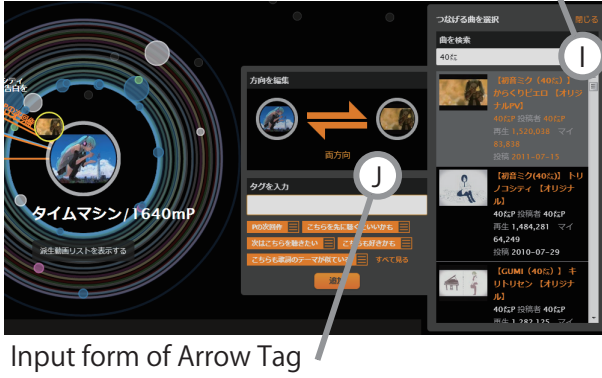
Figure 6: Screenshot of the input form to generate a new Arrow Tag. (I) A user searches video clips by keywords and selects one of them as the end point of a new Arrow Tag. (J) The user then types in a label and chooses the direction of an Arrow Tag. Existing Arrow Tags are suggested as input aids below the input form.

VOCALOID on Nico Nico Douga every day. It classifies them using the technique described in Section 4.1, and estimates their chorus and repeated sections using the method described in Section 4.2. The web server generates the Music Star Map as described in Section 4.3, maintains a database for video clip metadata and Arrow Tags, and works as a website that provides the Songrium user interface. The user interface is implemented using HTML5, SVG, JavaScript, the JavaScript library D3.js, and the embedded video player of the Nico Nico Douga service. Songrium can be used on the latest web browsers including Chrome, Safari, and Internet Explorer.

4.1 Classification of Video Clips

Every music video clip on Songrium is automatically classified into original song or derivative work. Because Nico Nico Douga supports social tags for each clip and the "Original Song" tag is usually put on original songs on Nico Nico Douga, we can rely on this tag. However, even if some original songs do not have this tag, Songrium correctly classifies them by crawling a set of related web sites to automatically generate the "white list" of VOCALOID original songs. In order to check accuracy of our method, we randomly selected 100 videos that were classified as VOCALOID original songs and reviewed them manually. Of these, 89 videos were correct, 6 videos were alternative versions of original songs, and 5 videos were derivative works or not songs.

In the case of derivative works, these can be readily identified when the description text of the video clip includes a hyperlink to the original video clip from which it was derived. These hyperlinks almost always exist on Nico Nico Douga since users like to acknowledge the original video clip.

When a new original VOCALOID song is added to Nico Nico and incorporated into Songrium, its relations to other original songs are analyzed and some Arrow Tags can be automatically assigned. In the current implementation, Songrium can only put the Arrow Tag *"Creator's next song"* to link two songs from the same creator. This connection

Table 1: Classification results of 522,875 derivative works. Since some derivative works have multiple categories, the sum of classifications is greater than the total number of derivative works.

category	# of works
(a) Singing	384,726
(b) Dancing	22,764
(c) Arranging and Performing	22,995
(d) Featuring 3D characters	18,991
(e) Creating Music video	7,826
(f) Others	70,874

is made using the "white list" and the video clips with a creator's unique ID number.

Likewise, when a derivative work is incorporated, its relation to the original song is automatically estimated. The derivative works are classified into one of the six predefined categories described in Section 3.1. With the exception of category (f) *Others* all the remaining categories are extremely popular and have their own unique social tags on Nico Nico Douga. Using these tags Songrium can make a reliable classification of derivative works. Table 1 shows the result of the classification of 522,875 derivative works.

Moreover, Songrium enables users to easily report an error in any of the above classifications to improve the user experience.

4.2 Estimation of Chorus Sections

Chorus sections and repeated sections are estimated by using the audio-based chorus-section detection method *RefraiD* [8], which was also used as the back-end for the original SmartMusicKIOSK interface. By analyzing relationships between various repeated sections, the RefraiD method can detect all the chorus sections in a song and estimate both the start and ends points of each section. It can also detect modulated chorus sections, which are especially common in pop music.

4.3 Generation of Music Star Map

The position of each original song is mapped to a two-dimensional space of the Music Star Map based on analysis of audio features. Although any feature vector designed for computing music similarity could be used, in our current implementation, we use a 35-dimensional feature vector, which is obtained using the MARSYAS software framework [28] that automatically analyzes the mood of each song. The effectiveness of this feature vector has already been confirmed in the context of music genre classification. The feature vector consists of the mean and variance of local spectral features (centroid, rolloff, flux, and zero-crossings) calculated across the entire song (8 dimensions); the mean and variance of average values of mel-frequency cepstral coefficients (MFCC) across the entire song (26 dimensions); and the tempo in the chorus section (1 dimension).

To determine the (x-y) position of a song on the Music Star Map, its 35-dimensional feature vector is projected onto two dimensions using principal component analysis (PCA), where only the first two components are retained.

4.4 Optional Web Browser Extension

Although Songrium is a web service that can immediately be used on a web browser without installing any additional components, we have also developed an optional browser extension designed for heavy users of both Songrium and Nico Nico Douga. After installing the extension, users have access to some Songirum functions directly on Nico Nico Douga. For example, when the user watches the video clip of an original VOCALOID song on Nico Nico Douga, our extension inserts the SmartMusicKiosk interface below the video clip so that the user can jump to the chorus section. The user can also see the Planet View and use Arrow Tags on the Nico Nico Douga service, thereby facilitating a seamless experience of both services.

5. EXPERIENCES WITH SONGRIUM

The alpha version of the Songrium service was released to the public at http://songrium.jp on August 7th, 2012. In addition to the web service, the Songrium extension for Google's Chrome browser was then released on February 28th, 2013. As of June 2013, over 97,000 original songs and 520,000 derivative works have been registered in Songrium. Over 7,000 users have visited our web site and over 1,700 users have installed the browser extension. Many users have made favorable comments about Songrium on social media, and have indicated their excitement in obtaining a new means to find music content with open collaboration. One user wrote that "Songrium affects my style of watching and listening to VOCALOID video clips".

6. DISCUSSION

While research dealing with a public web service for music browsing assistance based on visualization of massive open collaboration has not been pursued in the past, there have been various approaches related to open collaboration and music browsing. In the following, we introduce related work and then discuss how Arrow Tags of Songrium could open up new possibilities of music content in the future.

6.1 Related Work

6.1.1 Encouraging Open Collaboration

Antin *et al.* [1] highlight the importance of conducting research into open collaboration across diverse platforms and domains and building knowledge through analysis. In fact, not only well-known platforms such as Wikipedia and open source software (OSS), but also other platforms and domains were analyzed from the viewpoint of open collaboration [4, 5, 18, 22]. Our research also contributes to this diversity by analyzing a new style of music content creation.

Most previous research into such open collaboration, however, has mainly focused on the analysis of collaboration, not on the direct assistance of users on the basis of the analyzed results. For example, the collaboration in social networks was analysed in [13, 14, 5], and the collaboration outside of social networks was analyzed in [19, 5, 6]. Even if those previous approaches visualized some relations within open collaboration, they did not help users collaborate or enjoy the results of collaboration on the basis of the analysis and visualization.

A key aspect of our research is not just to analyze and visualize open collaboration but to provide a means for users of Songrium to engage in a deeper and more meaningful collaboration with music content and other users. In this way, we believe this research to be the first of its kind. Furthermore, the open collaboration we analyze and visualize addresses reuse of content into multiple forms as described in section 3.1. This is unique since reuse of content in a single form was analyzed in most previous approaches dealing with reuse network of content creation [5, 6].

6.1.2 Assisted Music Browsing

Most previous research into interactive music browsing has effectively used visualizations to explore musical collections [3, 20, 29, 21, 9, 25]. For example, as we showed in the Music Star Map (see Section 4.3), visualization of a music collection in a two-dimensional plane is often attempted [3, 20, 29, 25]. Interactive interfaces are also important for user experiences; the Musicream interface [9] assists a user in discovering songs and the MusicRainbow interface [21] assists a user in finding artists. Songrium offers users additional functionality, where they can interact with, and contribute to, the Music Start Map through the use of Arrow Tags. This collaborative aspect of Songrium as well as the visualization of derivative works is essential for music browsing of massive open collaboration, and is beyond the scope of previous approaches.
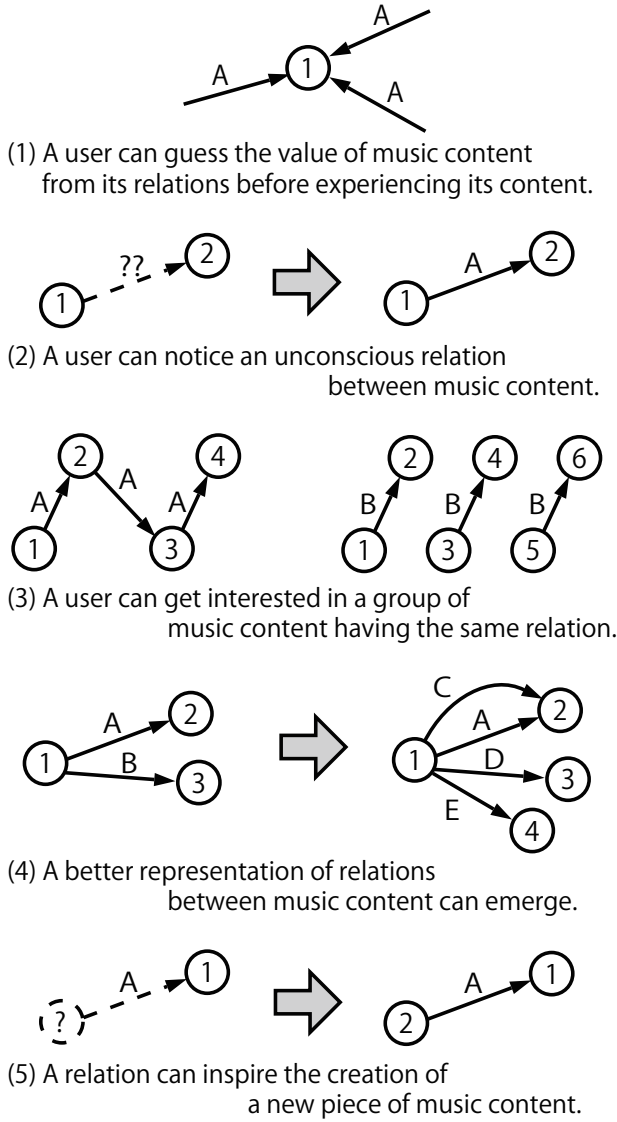
The Arrow Tags we proposed are also related to previous studies that dealt with music relations in the context of the Semantic Web [23, 17]. Since the Semantic Web focuses on the construction of structured data, the consistency of semantics of relations is important [12]. However, within Songrium we choose to allow the Arrow Tags to be inconsistent because we believe it is more important that non-expert users feel free to add any Arrow Tag to any music relation of interest to them. This leads to the interesting prospect of a wide variety of semantics of relations. The purpose of the Arrow Tags is thus original.

6.2 Future Use of Arrow Tags

This section discusses a vision of the potential usage of the Arrow Tag in the future by showing how Arrow Tags could be used to augment the user experience within a massive open collaboration. If users find Arrow Tags connected to one of their favorite songs, they can, of course, follow the Arrow Tags to listen to and discover other original songs. This gives users the opportunity to encounter unfamiliar but potentially interesting songs and can cultivate a deeper understanding of songs and their musical relations. In addition, we describe five use cases, shown in Figure 7, which could be achieved through widespread usage of Arrow Tags.

1. Before taking the time to experience (e.g., listen to or watch) a particular piece of music content, a user could understand its relations to other music content from the Arrow Tags and see whether the user would be interested in it. In Figure 7-(1), for example, the music content 1 is tagged with Arrow Tag 'A' from three other pieces of music content. If a user has already been interested in Arrow Tag 'A', the presence of Arrow Tag 'A' pointing to music content 1 could be sufficient by itself to attract the interest of the user towards this content 1."

2. Once a user becomes familiar with a certain relation thanks to the use of Arrow Tags, the user could easily notice this relation between pieces of music content.

(1) A user can guess the value of music content
   from its relations before experiencing its content.

(2) A user can notice an unconscious relation
                  between music content.

(3) A user can get interested in a group of
             music content having the same relation.

(4) A better representation of relations
             between music content can emerge.

(5) A relation can inspire the creation of
                  a new piece of music content.

Figure 7: Five use cases that could be brought through widespread usage of Arrow Tags.

In Figure 7-(2), for example, a user could notice an unlabeled hidden relation (i.e., 'A') between music content 1 and 2 and put Arrow Tag 'A' to mark this relation.

3. A user could be interested in a group of music content having the same relation and experience this group together. At the left of Figure 7-(3), music content 1–4 are associated by the Arrow Tag 'A', which could help the user become aware of this group of music content. The Arrow Tag could thus be used as a method for grouping content. At the right of Figure 7-(3), on the other hand, a user could notice that three pairs of music content have the same Arrow Tag 'B' and become interested in exploring these pairs.

4. If various users are encouraged to freely invent and share new Arrow Tags and delete inappropriate ones,

a huge variety of Arrow Tags could emerge and go through a form of "natural selection". Arrow Tags could thus evolve towards creating a better representation of relations between music content as in Figure 7-(4).

5. The widespread usage of a certain Arrow Tag could inspire the creation of a new piece of music content. In Figure 7-(5), a creator who becomes familiar with the usage of Arrow Tag 'A' could create music content 2 so that it could potentially have the relation 'A' with music content 1 and the user could put the Arrow Tag 'A' later. The Arrow Tags could thus contribute to content creation.

Beyond these five use cases we fully expect and hope to see other uses of Arrow Tags, which naturally emerge from the open collaboration in Songrium.

7. CONCLUSIONS

We have described Songrium, a music browsing assistance service in which the Music Star Map and Arrow Tag functions enable the interactive visualization and annotation of relations among original songs. The Planet View function also enables the interactive browsing of relations among derivative works and their original song, which are results of "massive" open collaboration. Moreover, the Filter function facilitates the creation of a personalized list of music content. Songrium makes a social contribution by providing the public web service that helps both creators and consumers understand the huge reuse network within the VOCALOID community. We hope that such enhanced understanding of the open collaboration further facilitates more massive open collaboration in the future.

The academic contribution of this study is to show how the results of analyzing the open collaboration can be used for the assistance of the further open collaboration. While the majority of existing work on open collaborations merely analyze the open collaboration, we believe that the topic of assistance within the open collaboration is of particular importance and should also be addressed much more in the future. Interactive visualization is one of the most effective ways to assist users, and we propose Songrium as a useful example.

Open collaboration creates a lot of user-generated data and organizing this data is an important issue. Within Songrium our proposed solution is the "Arrow Tag" which is not used to name and mark music content directly, but rather to mark a relation between different pieces of music content. We consider the Arrow Tag to be a simple, yet powerful way to organize relations of any type of content. Since Arrow Tags can be created and deleted by users and content creators, they can evolve to provide a rich environment for understanding music relations.

We will continue to run the Songrium service and improve it based on user feedback. Although Songrium has already supported typical categories of derivative works, we plan to analyze other emerging categories of derivative works arising from open collaboration as it is a significant and unique characteristic of the VOCALOID community on Nico Nico Douga. Furthermore, we hope that the widespread use of user-generated Arrow Tags will give us new insight for understanding the whole picture of the huge reuse network in the VOCALOID community.

8. ACKNOWLEDGMENTS

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