

Network Analysis of an Emergent Massively Collaborative Creation Community

-How can people create videos collaboratively without collaboration? -

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Abstract

The Web technology enables numerous people to collaborate in creation. We designate it as *massively collaborative creation via the Web*. It is becoming an important activity such as Wikipedia and Yahoo! QA. As an example of massively collaborative creation, we particularly examine video development on *Nico Nico Douga*, which is a video sharing website that is popular in Japan. We specifically examine videos on *Hatsune Miku*, a version of a singing synthesizer application software that has inspired not only song creation but also songwriting, illustration, and video editing. As described herein, creators of interact to create new contents through their social network. We analyzed the process of developing thousands of videos based on creators' social networks. The social network reveals interesting features. Different categories of creators serve different roles in evolving the network. We also extracted communities from the network and observed different community structures and investigated the evolving nature of the network using motif analysis.

Introduction

The Web was created as a publishing platform, but now it is becoming a two-way communication platform for people. Thanks to the flexibility of the Web, communications of various types have emerged. As a platform for communications, the Web presents various advantages over older systems. For example, it erases the sense of distance because people at any place can mutually communicate. It supports massive interactive collaboration through large-scale BBS and social tagging, which is impossible in real-world communication channels. It also enables large-scale information sharing not only of texts but also of various multimedia content such as videos. This activity already produces valuable digital contents such as Wikipedia and Yahoo! QA which would never have been born without the Web. We designate this type of activity as *massively collaborative creation* where a huge number of people mutually collaborate to create contents on the Web.

Massively collaborative creation on the Web has features that augment traditional collaborative creation; one is the style of participation. Vastly numerous people are involved.

For that reason, they often do not know each other. Numerous evolved or inspired versions of a video can be created if a video explores a new idea or catches on. Another difference is the digital re-use of contents. Some components of a work are re-used in evolved or inspired versions, e.g., an image or sound in a video can be re-used in a new version of the video. Consequently, digital work can be developed among people via the Web.

We are interested in the development of such digital works, particularly in the process as it unfolds in a video sharing website. We selected a video sharing website called Nico Nico Douga¹, in which intense collaborative video creation is occurring. We specifically address Hatsune Miku², which is a version of singing synthesizer application software that has inspired many people to produce various music, picture, and video compositions. The Hatsune Miku phenomenon is interesting because different creators interact in projects: song creators, illustrators, and CG creators.

We adopted a method of social networking analysis as a basic method to investigate the phenomenon. Applying social network analysis method to web contents has yielded important results for explicating the structure of interaction among people. In our case, we investigate how creators of different types interact to create new contents through their social network.

This paper is an extended version of a preliminary report (Hamasaki, Takeda, and Nishimura 2008). We herein describe results of the analysis in greater detail, in addition to new results obtained using different analyses.

Targets

Nico Nico Douga

Nico Nico Douga is the most popular video sharing website in Japan. Started in December 2006, it now has more than 10 million users (Dec, 2008); it has published more than 2.2 million videos. The basic service closely resembles that of YouTube, but it has some unique functions and has gathered many users rapidly. The most interesting and unique function is the direct overlaying of comments on videos. A user can add comments about a specific playback time at a specific position in the video, which gives people a sense of

¹<http://www.nicovideo.jp/>

²<http://www.crypton.co.jp/mp/pages/prod/vocaloid/cv01.jsp>

sharing the viewing experience virtually. Furthermore, the creator can instantly know which specific moment or specific scene is appreciated by a viewer. That feedback inspires the original creator or other creators to produce new videos to match such effects.

In Nico Nico Douga, a popular category of video is a so-called MAD movie. The key feature of a MAD movie is that the used extracts are often taken from commercial anime programs. That feature has merit for people because it is fun to view different versions of popular programs but it is problematic because it often engenders copyright violations. The birth and development of Hatsune Miku suggests a new direction to MAD movies. In Hatsune Miku videos, extracts are not taken from commercial programs; instead, the community creates videos.

Hatsune Miku and Its Boom

Hatsune Miku is a version of singing synthesizer application software. The singing synthesizer program developed by Yamaha Corp. enables users to synthesize songs that include singing by inputting lyrics and melody on computers just like computer music. Hatsune Miku is a version of singing synthesizer applications called Vocaloid2; its uniqueness is that it adopted recorded vocals of a famous anime actress. Amateur songwriters can publish their songs with Hatsune Miku. However Hatsune Miku affected them more. They regard Hatsune Miku as a pop singer so that they write and publish songs that are suitable for her.

Moreover, a mascot image of Hatsune Miku has caught on. There is only a single illustration of Hatsune Miku: it is printed on the software package. People draw and post different illustrations of Hatsune Miku. Then people started to create videos, such as promotion videos for musicians, with such original songs and drawings.

Then videos are created in the manner of MAD movies. Already published videos are used as materials to create new videos. Fundamentally, creators welcome it because it indicates that their works are valuable to others. Consequently, many videos are created and published as collaborative works.

The mixture of different creation types is very interesting. Hatsune Miku gathered creators of different types: songwriters from the computer music field, illustrators who come from self-published manga culture ('doujinshi') and even CG creators. Most are amateurs, but some are professionals. They are stimulated by the work of others.

We found the following types of creative activity related to Hatsune Miku.

- (a) **Songwriting:** Amateur songwriters are eager to promote their songs, but it takes time and money to produce promotional tapes with professional singers. Using Vocaloid, they can produce sound with vocalizations as computer music.
- (b) **Song creation:** It is not easy to make Hatsune Miku sing songs naturally. Certain techniques are necessary to tune Hatsune Miku, but it is fun to tune the software to create nice songs for singing. Contributors mutually compete to create them.
- (c) **Illustration:** The Hatsune Miku image is that of a typical anime character which attracts anime fans. They are used to drawing their favorite characters by themselves. They produce

many different scenes and facial expressions. They even produce different versions of the character such as Hachune Miku (an infantile version of Hatsune Miku) and Yowane Haku (a pun or a fainthearted version).

- (d) **Editing:** There are so many Hatsune Miku videos that some people collect them and produce summary videos, with ranking programs of Hatsune Miku videos.

We will analyze the creative activity on Hatsune Miku using the creation categories described above.

Results of Analyses

Data Collection

In all, 36,709 videos had the tag 'Hatsune Miku' on Nico Nico Douga (31 May 2008). From among them, we selected 7,138 videos that had been viewed more than 3,000 times as data for this study. We crawled their metadata during 1–5 June 2008. These 7,138 videos were uploaded by 2,911 unique contributors³.

Reference Network

Each video has a title and a description written by the creator. The description often includes hyperlinks to other videos that can reflect details of the video's creation. A customary practice on Nico Nico Douga is that a creator cites other videos if a sound, image, or any part of another video is used. By tracing these hyperlinks, we generated a reference network of videos. Among the collected videos, 4,585 videos include hyperlinks in the description; we obtained 12,507 links among videos.

We infer a relation between the creators of videos A and B when video A has links to video B . Consequently, we generated a network among the creators. This network has 2,920 nodes (creators) and 2,757 links (relations among the creators). As described in this paper, we regard this network as a social network of creators.

Category of Creation Activity

We presented four categories for activity related to Hatsune Miku movie creation: Songwriting, Song creation, Illustration, and Editing. In this section, we present analyses of data based on these categories. Because the editing activity here is excerpting and combining multiple videos, it does not commit the contents of videos. For that reason, we used the former three categories. Therefore, we manually excluded 179 Editing videos of 7,281 videos.

We classified videos and creators into creation categories automatically using tags for videos. Tags on Nico Nico Douga include not only review or content categories, but also those indicating the kind of creation. We provide a set of tags that are important for specific creation categories. The video is classified into these categories simultaneously if a video has tags of different categories. We also determine the creator's category by aggregating that person's works.

³On Nico Nico Douga, only the uploader is named. That person is not necessarily the creator of the video. However, for this study, we regard an uploader as the video creator.

Table 1: Categories of creation for creators: *W* signifies *Songwriting*, *C* means *Songcreation*, and *I* represents *Illustration*. *N* and *E_{in}* respectively denote the number of creators and in-links.

Category	<i>N</i>	<i>E_{in}</i>	Category	<i>N</i>	<i>E_{in}</i>
W	284	590	W&I	24	21
I	529	487	C&I	44	176
C	642	267	C&W&I	17	36
W&C	75	351	unknown	1,296	349

A single creator is classified into multiple categories if the videos are classified into more than a single category⁴.

Among 2,911 creators, we obtained eight categories: three basic four by variously combining the basic categories, and an unknown category. Table 1 presents the number of creators and the number of in-links per creator by these categories. It might be readily apparent that the Songwriting and Song Creation category attract many links, although Illustration does not. That fact indicates that Songwriting and Song Creation triggers creative activities. On the other hand, Illustration acquires many creators. Illustration activity is good at attracting collaborators.

Community on Creators Network

In this section, we analyze the creators' community. The term "creators' community" means a tight group of nodes within a social network of creators. We adopt Newman clustering to detect such communities from the social network of creators.

Newman clustering generated 83 clusters (communities) from the social network of creators. We especially investigated 10 clusters of which the size is greater than 50. Table 2 presents the parameters of these 10 clusters.

In Table 2, *Size* means the number of creators in the cluster. *Centralization* shows an index of the centrality of a network in terms of degree (Freeman 1978). χ^2 shows a degree of bias of tags in the clusters. When creator *A* has a video tagged *B*, we regard that creator *A* is tagged *B*. Then we can find the distribution of creator's tags in the cluster.

A category of the key person (K-Cat) means the creative category of the key person. We set a node that has the most links as a key person of a cluster. However, we do not set a node as a key person if the number of links of the node is less than 10 percent of the whole links of the cluster. In this case, there is no key person exists in the cluster. A category of majority (M-Cat) is the most popular creative category of creators in the cluster.

We observed that there are two types of community from the viewpoint of network structure: a centralized community and non-centralize community. The former includes clusters 1, 3, 5, and 6 in which there is only a single key person with an extremely high number of in-links. The latter includes clusters 2 and 4 which do not clearly have key persons.

The key person in a community is often of the Songwriting category, which indicates that Songwriting triggers cre-

⁴Some videos cannot be categorized correctly using this method. We checked some top-ranking videos and creators and corrected them manually.

Table 2: Parameters of the biggest clusters. Columns of K-Cat and M-Cat respectively show categories of key persons and the majority.

#	Size	Centralization ($\times 10^{-3}$)	χ^2	K-Cat	M-Cat
1	161	4.293	2130.5	W	I
2	144	0.080	1747.3	-	I
3	118	5.257	1921.0	I&C	I, C
4	95	1.868	1857.7	-	I
5	91	5.897	2799.9	I	I
6	90	7.055	2333.7	W&C	C
7	79	5.164	1942.8	W	C
8	56	3.012	1797.1	-	C, C&I
9	55	6.923	2079.6	W&C	C
10	51	4.000	1761.1	-	I

ative activity. We also find that some communities have key persons with the Illustration category. In such communities, new ideas are developed intensively such as a new characterizations of Hatsune Miku and a 3D modeling tool. Such communities contribute to widening the world of Hatsune Miku and stimulate additional creative activities.

The results of the community-based analyses strengthen and refine the conclusion from the category-based analysis described in the previous subsection. Two types of collaboration are identifiable. One type originates with Songwriting creators which involves Song Creation and Illustration creators. It is the birth of a creative idea and diffusion of a new topic. The other is collaboration among Illustration creators, where creators are mutually dependent. It is the next phase in which the diffusion takes place among Illustration creators.

Apart from the diffusion process, we found that centralization of the network and localization of the tag are mutually correlated. The correlation coefficient among centralization and χ^2 is 0.63. It represents a strong positive correlation, meaning that a strongly centralized community tends to have community-specific tags that are used in many creators in the community and vice versa. It indicates that tag analysis may be used to identify communities. In fact, that is good news because identifying links has high costs and is often impossible.

The Analysis Network Motif

Motif analysis is a method to investigate particular social dynamics using small local patterns of a network (Milo et al. 2002). In motif analysis, the hypothesis that networks display certain patterns, termed "network motifs," at much higher frequency than expected in randomized networks is used. We applied motif analysis to our creators' social network (Fig. 1). We also present the motifs of the two social networks for comparison. One is the social network of prison inmates (MacRae 1960) as analyzed by Milo. The other is the social network of a QA site as analyzed by Adamic (Adamic et al. 2008).

The normalized *z*-scores of 13 network motifs are presented in Fig. 1, the motif of which normalized *z*-score is high, meaning that it is a characteristic pattern of the net-

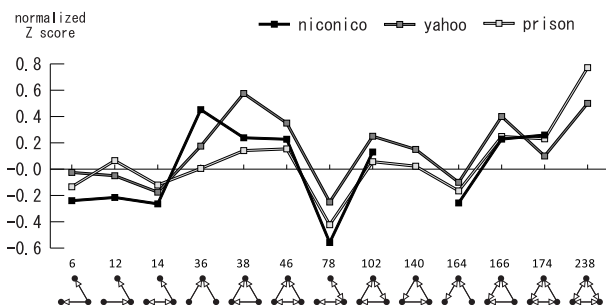


Figure 1: Results of motif analyses with three social networks. The networks are as follows (where N and E respectively denote the number of nodes and links): (i) creators' citation network on Nico Nico Douga (niconico $N = 1454$, $E = 2339$); (ii) a users' question and answer relationship network on the Wrestling community of YahooQA (yahoo $N = 9,959$, $E = 56,859$); (iii) a friendship network of prison inmates (prison $N = 67$, $E = 182$).

work. We used the motif analysis tool *FANMOD*⁵ to carry out our motif analysis. In Fig. 1, our social network shows no triad 140 and 238. The absence of triad 140 arises from the fact that our social network does not include such a local pattern. On the other hand, the absence of triad 238 arises from the fact that the random network has no such local pattern because the number of links to the number of nodes is too small.

Figure 1, shows that three results are fundamentally similar. It is clearly different from other networks such as WWW (Milo et al. 2002). However, each network has a different highest scored motif from the others. It is triad 36 in the case of our network, triad 238 in the case of the prison network, and triad 38 in the QA cite network.

The prison network is based on real world communication, although others are based on online interaction. It is probably easier than others to generate a complete graph (triad 238) in the network. Adamic interpreted the meaning of triad 38 in the QA site network as follows. In triad 38, one person was helped by two others, but one helper has helped the other helper.

A star graph (triad 36) in our network is important in comparison to the other social networks. In this motif, a user is cited by two others; no relation exists anymore, which indicates that a few popular creators attract many non-popular creators.

Results show that that creators' social network has characteristics resembling those of other social networks. Furthermore, its remarkable characteristic is the existence of popular nodes (trigger persons). How did such a network evolve? The next question is how this characteristic is formed. We investigated the evolutionary nature of the network to answer the question. To investigate this point, we generated networks in the specific periods and compared them. We split the whole period into three. We analyzed motifs of these networks (Fig. 2).

The characteristic triad (triad 36) is exaggerated as time

⁵<http://theinfl.informatik.uni-jena.de/~wernicke/motifs/>

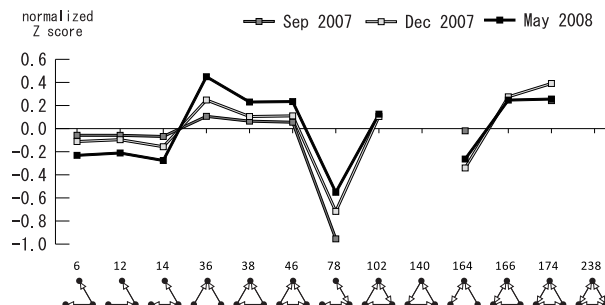


Figure 2: Results of motif analysis with three times of networks. The networks are as follows: (i) Sep. 2007 ($N = 240$, $E = 296$). (ii) Dec. 2007 ($N = 976$, $E = 1450$). (iii) May 2008 ($N = 1,454$, $E = 2339$).

goes by. The initial network is rather similar to the prison network. It indicates that the initial collaboration is as close as that in the real world. The participants tend to cite to each other's work. However, the late participants do not. They are less cited and merely cite the previous creators. It is interesting that the style of collaboration is shifted from a close one to a sparse one even in such a purely online environment. It might be a hint indicating when and why the network bursts in online environments.

Conclusion

We have investigated how different types of creators interacted in massively collaborative creation. We extracted and analyzed the social networks of creators, revealing some interesting facts. Social media are expected to be interactive, but interactivity is not simple. As described herein, the different types of creators form interactions of different types. Interaction also differs depending on the evolution. We should take that point into account when designing new social media, particularly those which support creative activity.

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