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Virtual Mapping Party: Co-Creation of Maps for Visually Impaired People

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Abstract

In this paper, we present a new approach for collecting accessible information for visually impaired people. In the past, accessible maps for people with disabilities have been created by holding events called "mapping parties." During these mapping parties, participants are gathered at target sites to collect information and create maps while physically walking around the site. Due to the labor-intensive nature of this approach, mapping parties alone are not a practical means of creating enough maps to fulfill demand. To increase the efficiency of creating maps, we propose the "virtual mapping party," which enables the participants to contribute to the mapping party from anywhere and at any time. This method uses virtually reconstructed target sites instead of requiring participants to physically visit the sites. Omnidirectional movies and multichannel sound are recorded at the target site and are then used in the virtual reconstruction. Virtual mapping parties have advantages regarding costs, and inclusiveness by allowing visually impaired people to contribute to the mapping activity.

Keywords

Virtual mapping party, assisting technology for visually impaired people, omnidirectional images, head-mounted display

Introduction

Virtual Mapping Party

We have been developing technologies for assisting visually impaired people to walk to their destination by themselves. Previously, we developed a walking navigation system for the visually impaired by combining various localization methods, including pedestrian dead reckoning (PDR) and global navigation satellite system (GNSS) (Okuno et al.). Within the contents of the navigation, the system provides both POI (Point of Interest) and POR (Point of Reference) information. POI is defined as the name of a landmark in a map. POR is defined as a specific point location, the existence of which is easily recognized for confirming routes, such as steps, stairs, sloops, doors, sound/noise, and scent/odor.

In this paper, we present a new approach for collecting POR/POI information for visually impaired people. In the past, accessible maps for people with disabilities have been created by holding events called “mapping parties.” During a mapping party, participants are gathered at target sites where they collect information and create maps while physically walking around the site. OpenStreetMap (OSM) is a project for making maps available to everyone around the world. Mapping parties have been held to create maps for OSM.

Due to the labor-intensive nature of this approach, mapping parties alone are not a practical means of creating enough maps to fulfill demand. To increase the efficiency of creating maps, we propose the “virtual mapping party,” which enables the participants to contribute to the mapping party from anywhere at any time. This method uses virtually reconstructed target sites instead of requiring participants to physically visit the sites, as shown in Fig. 1. Therefore, at least one contributor must go to the actual site to record the site environment. Other contributors, through the internet, can experience the target sites in the virtual environment and search for

POR/POIs. We design the virtual mapping party as an inclusive activity by ensuring that visually impaired people can also contribute to the mapping. In order to allow them to contribute, we adopt an interactive tool called "AR (augmented reality) tactile maps" (Ichikari et al.) to confirm dynamic contents on the map using non-visual senses. AR tactile maps enable visually impaired people to not only confirm the contents collected during the virtual mapping party but also to request and verify the contents.

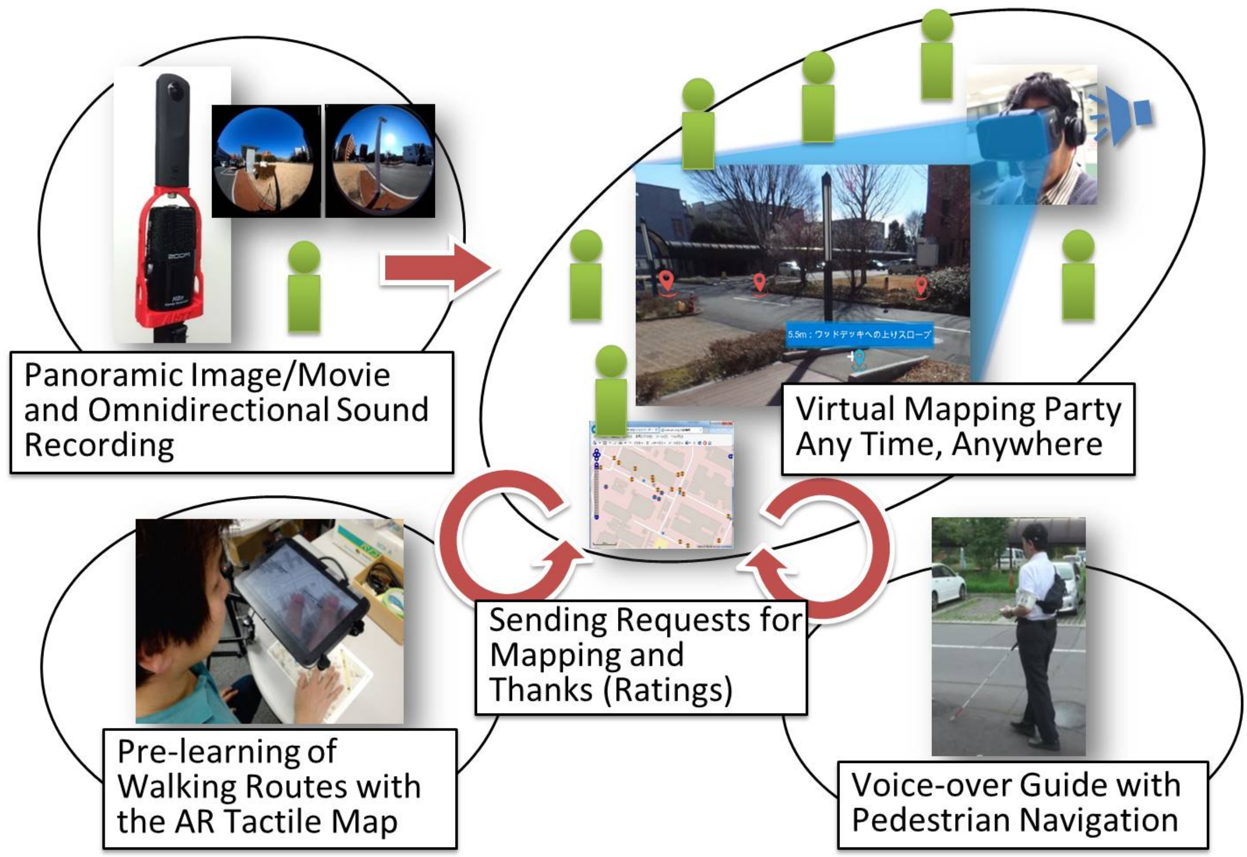

Fig. 1. Overview of Virtual Mapping Party.

In this paper, we introduce the system design of the visual mapping party as an inclusive activity for creating maps for visually impaired people. We implemented a prototype of the system and held a virtual mapping party workshop in order to obtain feedback about the system.

Related Works

There are existing activities designed to improve mobility assistance with the help of volunteer contributors. Miura et al. promoted an activity that collected accessible information with the help of volunteers by implementing smartphone applications (Miura et al.). Voigt et al. held mapping parties by utilizing ICT tools in many cities around Europe (Voigt et al). In one of them, they utilized Mapillary, which is a crowd-sourced service for sharing geo-tagged photos. They used Mapillary for collecting accessible information without going to actual sites. They called this a "Lab-based" approach. The Lab-based approach and our virtual mapping party are quite similar. However, distinctive characteristics of the virtual mapping party are as follows:

- The virtual mapping party focuses on collecting accessible information for visually impaired people.
- The virtual mapping party provides immersive virtual experiences of walking through environments by using pre-recorded omnidirectional movies and 3D sound.
- The virtual mapping party has compatibility for linking up with many applications, such as navigation systems and AR tactile maps (Ichikari et al.).
- The virtual mapping party aims to be an inclusive activity by allowing visually impaired people to join the activity with AR tactile maps.

In addition to the above comparison, we categorized the characteristics of various mapping activities and the differences between the activities, as shown in Table 1. In the next section, the system components used to create the virtual mapping party will be introduced.

Discussions

System Components

Capturing the Walking Environment

We adopt Ricoh's Theta S for capturing omnidirectional movies and Zoom's H2N for recording 4-channel sound. The Theta S and the H2N are vertically attached with a 3D printed mount for recording movies and sounds at the same location with alignment of frontal faces as shown in Fig. 2.

Fig. 2. Device for Capturing Walking Environments.

Table 1. Comparison of Various Mapping Activities.

Type of activities	Location	Time	Remarks
Conventional mapping party	On-site	Sync.	Face to face communication Deep understanding of real conditions Mandatory skill for organizing events Up to weather
Mapping party utilizing smartphones app.	On-site	Any time (Async.)	Mapping while commuting Easy to contribute Deep understanding of real conditions Position of contents depending on localization methods
Mapping party utilizing crowdsourcing image sharing service	Anywhere (Off-site)	Any time (Async.)	Crowdsourcing Remote mapping Easy to contribute anytime and anywhere Depend on shared data Limited understanding of real conditions
Virtual mapping party	Anywhere (Off-site)	Any time (Async.)	Crowdsourcing Remote mapping Easy to contribute anytime and anywhere Easy to measure contents' position Easy to verify registered contents Mandatory pre-recording

The length of captured data at each location should be more than a certain length since we would like to capture time-sequential data such as movies and sound. Therefore, movies and 3D sounds are captured by iteratively stopping and recording for about 30 sec. at 10 to 50 meter intervals. The Theta S can record 360-degree spherical movies at full HD resolution (1920x1080 pixels). We record both omnidirectional movies and 3D sound in synchronization.

Reconstructing the Walking Environments into a VR (virtual reality) Experience

To enable the contributors to join the mapping party without visiting the actual sites, the sites are reconstructed in virtual reality space. We use the Unity 3D game engine for the reconstruction. The recorded omnidirectional movie can be displayed in the VR space using texture mapping on spheres. To walk through the VR space, users can change the location by switching to different omnidirectional movies and 3D sounds. Unity 3D can generate naturally cropped images to fit an appropriate viewing angle for humans, depending on the viewing direction. Because of this, as shown in Fig. 3, the system can offer a 360-degree view of the site at each position.

Fig. 3. Reconstructed walking environment through omnidirectional movies.

One of the most important operations for reconstructing the walking environments is registering correct positions and orientations for each piece of recorded data, since the positional accuracy of the registered POR/POI depends on the positional and rotational accuracy of the arrangement of the omnidirectional images. The Theta S has functionality that provides auto horizon correction for the recorded omnidirectional images using gyroscopes. We can also measure the height of the Theta S camera position. Additionally, an initial estimate of the position can be obtained by a smartphone’s GPS if the Theta is controlled by a smartphone remote controlling application. The parameters we need to calibrate are longitude, latitude, and yawing angle for each recorded data point. These positions and angles can be semi-automatically corrected at the same time if correct longitude and latitude information of the same objects in the omnidirectional images are known.

The four recorded channels of 3D sounds can be recreated by arranging four virtual sound sources around the user's location. We adopt Oculus Audio SDK for 3D sound.

As devices for experiencing the VR scene, we adopt various types of HMDs (head-mounted displays), such as Samsung's Gear VR, Oculus Rift DK2, and Google Cardboard-type instant HMDs. Through the HMDs, the contributors of the mapping activities can visually experience the reconstructed walking environment with a wide-range field of view, creating a sense of immersion. In addition, HMDs have head tracking sensors, which enable the users to look around the panoramic view by naturally changing their viewing direction. The Gear VR and the instant HMDs can utilize the user's smartphone to create the VR experience. For an option that does not require HMDs, we build the VR scene on the WebGL platform to reproduce the VR experience using only a web-browser. In this option, users can use a computer keyboard for text input. We also adopt headphones for hearing 3D sound and a Bluetooth game pad for inputting triggers into the system.

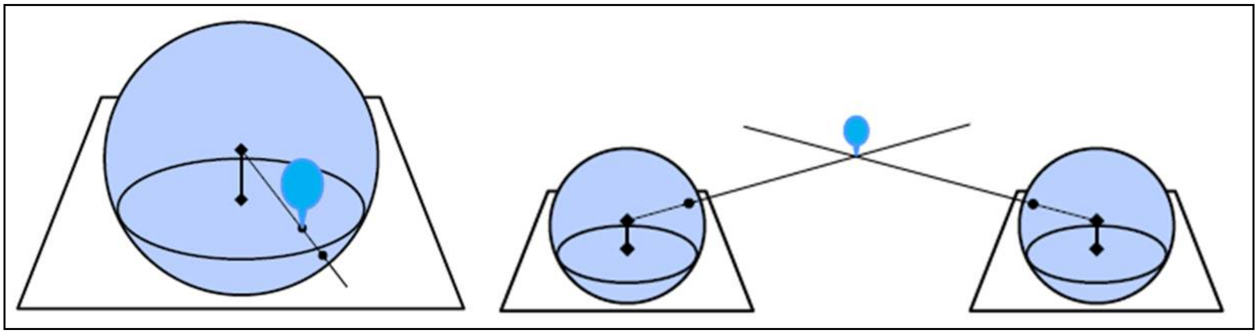

Fig. 4. Pointing Methods for POR/POI

(Left: For pointing to a nearby POR/POI, Right: For pointing to a far POR/POI)

Searching for and Collecting POR/POIs in the VR Space.

If the users find POR/POIs while experiencing the VR space, they can register them into the POR/POI database. The POR/POIs are shared with other contributors and superimposed onto their view as annotations in the VR environment. As a result, the activity of searching for POR/POIs can be split up while avoiding overlaps. It is impossible to know the distance between the viewpoint and the annotations, so the distance is displayed with the annotations.

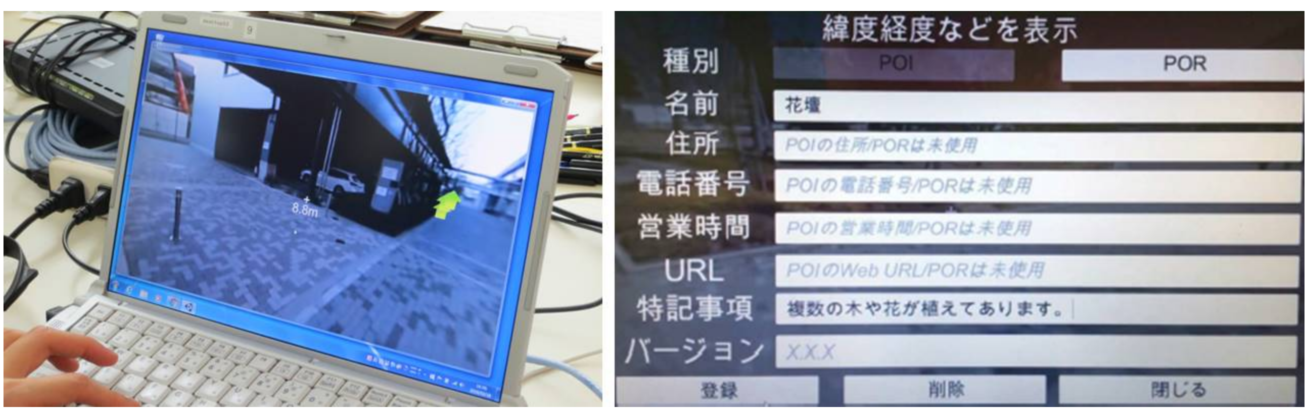

Fig. 5. Interface for Registering POR/POI for Web-GL Users.

The process for registering POR and POI into the database can be separated into pointing at the POR/POI location and registering attribute information. Fig. 4 shows the conceptual illustration of the methodologies for pointing at POR/POIs. First, the pointing vector in 3D is defined by finding the indicated pixel in the omnidirectional images. Then the indicated location in the world coordinates can be calculated by finding the intersection between the vector and a ground plane, if the intersection exists. If POR/POIs are far from the viewpoint, positions can be calculated by finding intersections between the multiple pointing vectors from different locations. Attribute information is inputted by normal text input. For Web-GL version users, text can be entered into GUI text forms by computer keyboard, as shown in Fig. 5. For HMD users, we implemented voice memo functionality since they cannot use keyboards while wearing a HMD. The voice memo can be heard afterward to make an accurate copy. A screenshot of the application for making an accurate copy is shown in Fig. 6.

Fig. 6. Interface for Registering POR/POI for Instant HMD Users.

We constructed a database server for sharing POR/POI information, request logs, and other auxiliary information for the virtual mapping party, such as links to the captured data in the file repository. As a database management system, we adopted PostgreSQL.

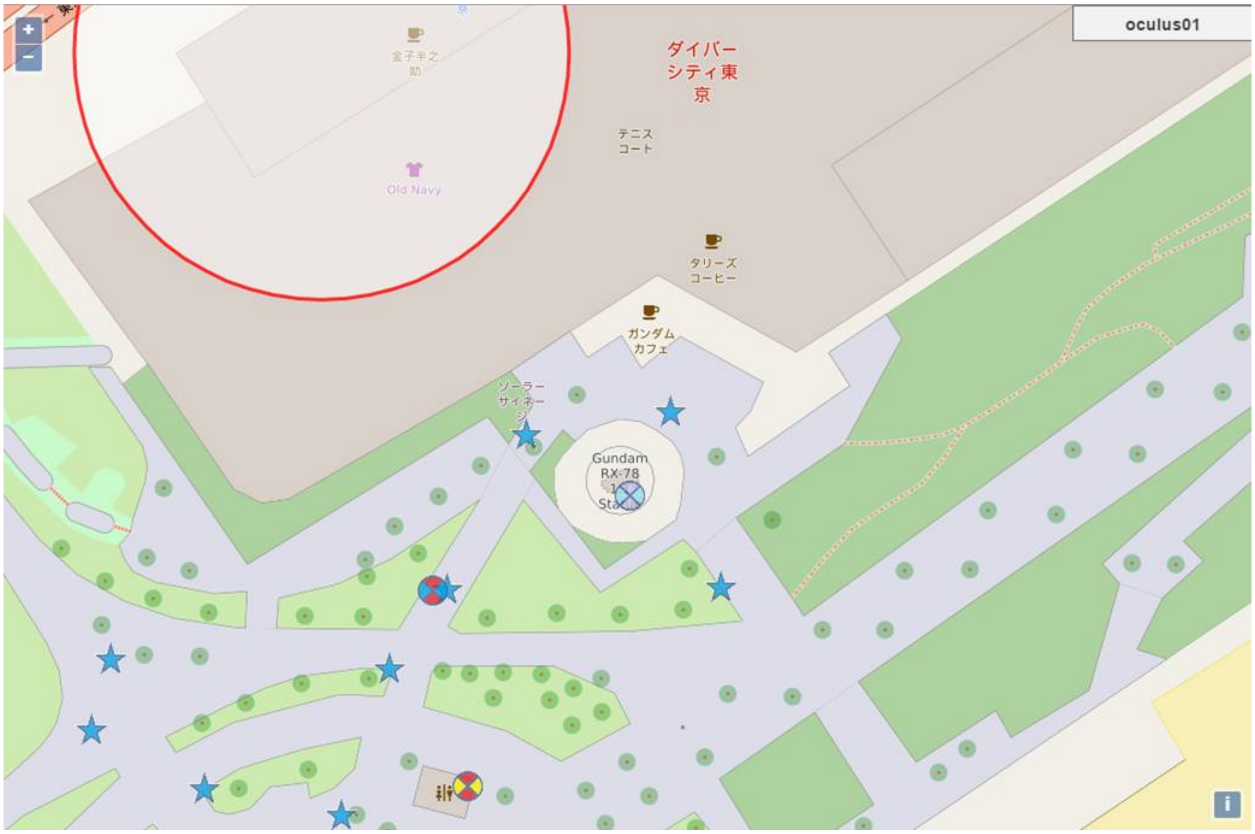

Fig. 7. Confirming POR/POIs with Maps.

Confirming and Checking POR/POIs on the Map Coordinates.

The registered POR/POIs can also be visualized with maps as shown in Figure 7. We implemented a web-based map application with OpenLayers for confirming POR/POIs on the maps. Confirming the position of the registered POR/POI at the map coordinates is a very important process because most of the applications of the collected data are based on the mapping coordinates, such as printing a map (including AR tactile maps) and navigation. The users can input and also edit POR/POI information with this application. This map application can be utilized for visualizing enlarged or enhanced representations of maps for low-vision users. The contents on the map are dynamically updated by reflecting the current data in the database.

Integration with AR Tactile Maps.

To enable visually impaired people to join the virtual mapping party, the system has the ability to utilize AR tactile maps. To integrate AR tactile maps with the virtual mapping party, the AR tactile map is connected to the same database as the virtual mapping party to share POR/POI data. AR tactile maps have functionality for detecting a position where the user touches the map, as well as gesture commands by utilizing RGB-D camera input. Gesture commands can be assigned to specific functions in the applications.

In the application of the virtual mapping party, we assigned gesture commands as follows. The tapping gesture is assigned to the act of confirming the POR/POIs through sound augmentation onto the tactile map and voice over. The detailed contents of POR/POIs can be read out when the user taps. The flat-hand gesture is assigned to the act of searching the existence of the contents around the location where the user touches the map. When the user touches the tactile map, they can find locations of POR/POIs around the touched area by sound feedback. The double tapping gesture can be used to transmit requests asking other contributors to add POR/POI around the specific area.

Workshop on Virtual Mapping Party

We held a workshop for the virtual mapping party in Tokyo, Japan, in March 2016. As the devices for the VR experience, we used HMDs including Oculus Rift DK2, Samsung's Gear VR, and the Google Cardboard-type HMDs. We also asked participants to try the AR tactile map for confirming and requesting POR/POIs. We held six one-hour-long workshops one weekend. The number of total participants was 44, and they collected 454 POR/POIs. The detailed statistics of the registered POR/POIs is shown in Table 2. Because of the limitation of the time for mapping and lack for instructions, we find many registered POR/POIs without attribute information. As shown in the Table 2, 97 percent of POR/POIs registered by Web-GL version users have attribute information. By contrast, only 27 percent of POR/POIs registered by Instant HMD users have attribute information. This table reveals the effectiveness of Web-GL version for inputting attribute information and necessity of the refinement of user interface to register attribute information for HMD users. At the end of the workshop, we asked the participants to answer a questionnaire, which consisted of open-ended questions related to several aspects of the virtual mapping party. Feedback from the participants is summarized in Table 3.

Table 2. Statistics of POR/POIs Registered at the Workshops.

	(a) Number of Total Registered POR/POIs	**(b) Number of Registered POR/POIs with Attribute Information**	**(b)/(a)**
PC(Web-GL)	203	197	0.97
Instant HMD	251	68	0.271
Total	454	265	0.584

Table 3. Feedback from the Participants who Attended the workshop on the virtual mapping party.

Categories of Feedback	Positive Feedback	Negative Feedback/Suggestions
About VR experience with omnidirectional images/movies and 3D sound	• I like the function for 3D sounds. • 3D sounds seem to be very useful, since visually impaired people can confirm amount of traffic on roads. • I could more realistically experience the VR scene by omnidirectional movies than still omnidirectional images.	• Estimating direction of sound sources was difficult. • The quality of the images/movies was not perfect.
About devices for VR experience	• I like instant HMD, since we can experience VR with what I have. • I like VR experience with Oculus VR HMD since I can realistically experience by movies. • I like Samsung's Gear VR HMD, because the image quality looked good and it was comfortable for wearing.	• It took a while to get used to HMD, and I got tired when I wore HMD. • Mapping with PC is better in terms of degree of fatigue. • An instant HMD was not so comfortable for wearing. • Wearing HMD on glass was difficult.
About user interfaces	• I like the function for pointing in first person’s view not map view.	• PC is the easiest platform for inputting POR/POI.
About AR Tactile map	• I like the function for sending request by visually impaired people.	• The accuracy of gesture recognition for AR tactile map needs to be improved.
About POR/POIs	• There are so many POR/POIs in the display. I think it becomes much clearer if the displayed contents are limited to nearby contents.	• I found empty POR/POIs without detailed information. I think filtering of the registered contents are required.

Categories of Feedback	Positive Feedback	Negative Feedback/Suggestions
Other suggestions	• It was the most beneficial application of VR I have ever experienced.	• I wondered if the system could support communication between participants. • I would like to regularly contribute virtual mapping parties from my home.

Conclusions

In this paper, we proposed the virtual mapping party, which enables the collection of POR/POIs in VR space for co-creating maps for visually impaired people. We introduced the components of the virtual mapping party and feedback from the first workshops. In the workshops, we only asked the participants to answer open-ended questions about certain aspects of the virtual mapping party. Overall feedback was very positive, especially about the immersive VR experience and the inclusive aspects of this activity with AR tactile maps.

For future work, we will keep improving the components of the virtual mapping party by reflecting the feedback and the statistics obtained at the workshops. We will also plan to conduct objective evaluations in future workshops. Currently, the virtual mapping party is open at a limited level at the workshops, because many components are under development. To make the virtual mapping party ready for release, the aspects of preparing data, such as the arrangement of omnidirectional images, should be refined or automated. We plan to implement user-friendly tools for the contributors who can capture walking environments and upload data to the server. Our final goal is the social implementation of the virtual mapping party activity. Therefore, we would like to release the whole software package for potential organizers to start conducting the virtual mapping party activity without our help.

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