A Method to Collect Multi-view Images of High Importance Using Disaster Map and Crowdsourcing

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***Abstract*—In recent years, research efforts have enabled using the internet in disaster areas, and information technology (IT) is expected to improve our comprehension and evaluation of disasters. In disaster areas, crowdsourcing can be employed to secure human resources and controlled-task distribution. In crowdsourcing, many workers with publicly defined tasks (also called microtasks) are used. A simplified and more efficient microtask framework is required for disaster areas due to the lack of human resources and facilities. In this paper, we describe a method that incorporates information collection from a disaster area into microtasks with machine processing support.**

Keywords—crowdsourcing, 3D reconstruction, multi-view images, grasping damage states, microtask generation

I. INTRODUCTION

Understanding the degree of damage in a disaster area can be used for both future disaster prevention and the reconstruction of buildings and infrastructure. Understanding the situation in disaster areas requires such human tasks as collecting information and judging the damage. However, since quickly grasping the damage situations of affected areas is difficult, we utilize crowdsourcing and allocate suitable tasks to such workers. For example, Inoguchi et al. estimated damage information using crowdsourcing [2][3]. Their participants were shown divided images from aerial photographs for collision-detection judgments. Since the photos captured from airplanes or satellites are used for the observations, seeing the side of a building is impossible (Fig. 1). Grasping its shape is also difficult.

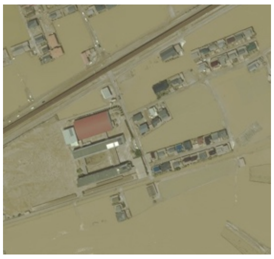

Fig. 1. Aerial photograph used for Inoguchi's microtask

In this research, we do not cover disasters whose topography changes from tsunamis or landslides. Large-scale disaster areas can be processed by satellite and aerial photographs. In this method, we target disaster areas where some buildings remain. We previously proposed a crowdsourcing platform that comprehends and judges damage situations using 3D photometry technology, which consists of two types of crowdsourcing: collective and judgment (Fig. 2) [1].

First, multi-view images are collected by crowdsourcing crowdworkers and integrated into a 3D model by applying structure from motion (SfM). Research has actively been using SfM for estimating the 3D shape data of imaging space from corresponding point information detected in multi-viewpoint images. Agarwal et al. [6] achieved city-wide 3D reconstruction using images of large groups from internet photo-sharing sites. They are reconstructing cities using 3D technology and cluster computers.

To effectively improve the evaluations of the crowdsourcing function, the judgment work must be divided into smaller tasks called microtasks, which can be distributed to large numbers of crowdworkers by the internet for quick processing. We divided our generated 3D model into specific areas around noteworthy points for disaster observation. As an example of an observation, Seth et al. used crowdsourcing for protein structural modeling [5] and created a puzzle-game that manipulates a 3D model of proteins. This game is published online and allows the participation of many workers. However, since the method needs a 3D model viewer and an interface, recruiting an unspecified number of crowdworkers is difficult. Thus, in our system, we generated a free-viewpoint video at each focusing point, allowing the crowdsourcing crowdworkers to easily judge disaster site situations by watching video sequences (i.e., shape can be grasped without manipulating the 3D model).

Our platform continues to suffer from a lack of resources. Since collective crowdsourcing needs to be carried out in the same areas affected by disasters, recruiting those people is very difficult. This paper introduces our trial that automated such processing. With an unmanned aerial vehicle (UAV) drone, information can be gathered for a long time with few human resources. By support from image processing, comprehensive and detailed data can be collected that increase the accuracy of a disaster's judgment, even by workers who lack expertise. Although information collection by machines simplifies the scaling of resources, ingenuity is required to gather critical information. We solve this problem by incorporating mechanized shooting and microtasks that can be easily processed by everyone (i.e., crowdworkers).

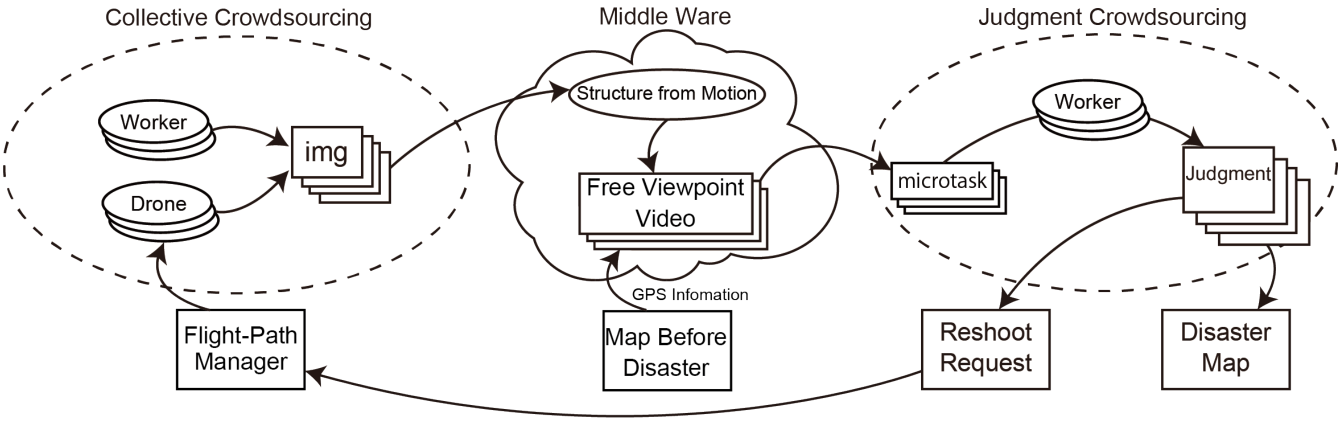

Fig. 2. Flow of microtask generation to collect multi-view images for collective crowdsourcing based on 3D disaster map

II. Collecting Critical Multi-view Images Using Disaster Maps and Crowdsourcing

As shown in Fig. 2, our proposed method consists of two types of crowdsourcing combined with image processing middleware.

We created microtasks for collecting critical images with the positional information (e.g., longitude and latitude) of the object to be captured and important observations. We estimated the information from 3D maps before and after the disaster and performed 3D reconstruction with the captured images. The 3D model is linked with the GPS information given by the drone. Before the disaster, we piloted a drone above the site and captured images to generate 3D maps. The positional information of the buildings is estimated from the captured images and added to the 3D map.

When a disaster occurs, we fly drones to comprehensively capture the entire region and generate new 3D maps. In the middleware, these 3D maps are divided based on the positional information of buildings that were previously estimated. Free-viewpoint video of each building is generated from these divided 3D maps. We created a microtask to estimate the damage to buildings from the free-viewpoint video. Microtasks (in a simple questionnaire form) were given to the judgment crowdsourcing crowdworkers and each worker was asked about the building's state. We set the re-shooting priority to high when the building's condition was "unknown" (i.e., re-shooting is required for more detailed observations). The drone re-shoots such high priority buildings by crowdsourcing on a flight path that provides more detailed information than the previous shots. The captured multi-view images are sent to the middleware, and free-viewpoint videos are generated again with images obtained by the re-shooting process and provided to judgment crowdsourcing. This routine helps grasp the situation of afflicted areas for constructing a disaster situation map.

III. Generation of Free Viewpoint Video Using 3D Map

Before the disaster occurs, aerial photographs of the area are taken by the drone. By using the Drone' 's GPS, it is possible to link aviation photos with the world geodetic system (WGS). The building area of an aerial photograph which is good for image processing is determined. The selected area is registered as map information. Kaiming et al. created an image segmentation method that employs a neural network technique (Mask R-CNN) [4]. We created a model by enhancing the knowledge of the appearance of the target objects. As an application, a model segments the building regions from satellite photos. Fig. 3 shows an example of the segmentation process of a region. In the event of a disaster, collective crowdsourcing gathers multi-view images from drones, which automatically fly and take photos based on the pre-defined settings to comprehensively and quickly shoot the entire region. We then send a captured group of images to the middleware to generate a 3D model. Fig. 4 shows an example of a reconstructed 3D model. The residential area's 3D model is divided with the positional information of the segmented buildings. We generated a free-viewpoint video from the divided 3D model to create microtasks of judgment crowdsourcing to prioritize the re-shooting.

Fig. 3. Determine building area from aerial photograph

Fig. 4. Example of reconstructed 3D model

IV. Determination of Importance of Re-shooting of a Building

We created microtasks of buildings using free-viewpoint video provided by middleware (Fig. 5). Crowdworkers determine the severity of the damage by observing the free-viewpoint video in microtasks and report them by web browser. Fig. 6 shows an example of a microtask presented to a worker. It is linked to WGS. A resulting disaster situation map is created using damage and location information.

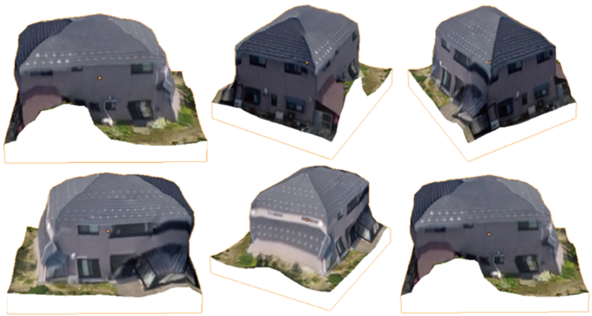

Fig. 5. Example of free viewpoint video

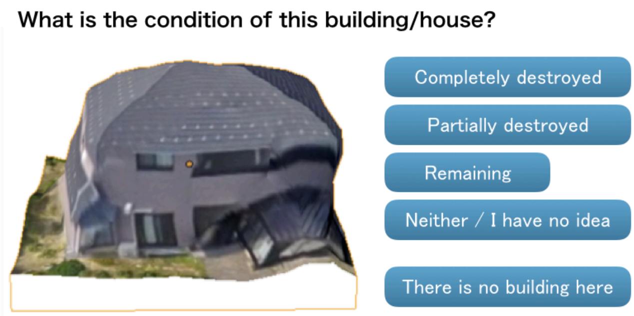

Fig. 6. Examples of microtasks executed on the web browser

V. Re-shooting of Regions for Damage Estimation

We focus on quickly generating a 3D model based on data obtained during a drone's first flight and providing it for crowdsourcing. Therefore, the 3D model's quality is low, and many crowdworkers have difficulty estimating the extent of the damage. It is assumed that the re-shooting priority is high for buildings with a large degree of "unknown" judgment crowdsourcing determinations. The flight-path manager pilots drones over these high priority buildings. In the drone, a flight route is set that can shoot the buildings and capture their details to generate more detailed 3D models than with the first flight using re-shot images. The free-viewpoint video created from the 3D model is returned for a crowdsourcing decision for more accurate damage estimation.

VI. Conclusions

This paper described a method that collected multi-view images of high importtance using disaster 3D maps and crowdsourcing just after a disaster. Future work will experimentally demonstrate whether our proposed method works well in actual environments. As a field trial, we are planning crowdsourcing drills in disaster prevention.

Acknowledgment

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References

[1] Koyo Kobayashi, Hidehiko Shishido, Yoshinari Kameda, Itaru Kitahara, "Method to generate disaster-damage map using 3D photometry and crowd sourcing", 2017 IEEE International Conference on Big Data, 11-14 Dec. 2017, 17504996

[2] Atsuyuki Morishima, Norihide Shinagawa, Tomomi Mitsuishi, Hideto Aoki and Shun Fukusumi, "CyLog/Crowd4U: A Declarative Platform for Complex Data-centric Crowdsourcing", Proceedings of the VLDB Endowment, Volume 5, Issue 12, pp. 1918-1921, August 2012.

[3] Munenari Inoguchi et al., "MIND: Micro-volunteering for Help in Natural Disasters", "http://crowd4u.org/en/projects".

[4] K. He, G. Gkioxari, P. Dollar, and R. Girshick. Mask r-cnn. ´ arXiv:1703.06870, 2017.

[5] S. Cooper, F. Khatib, A. Treuille, J. Barbero, J. Lee, M. Beenen, A. Leaver-Fay, D. Baker, Z. Popovic, and Foldit players, "Predicting protein structures with a multiplayer online game," Nature, vol.466, no.7307, pp. 756–760, Aug.2010.

[6] Sameer Agarwal, Noah Snavely, Ian Simon, Steven M. Seitz and Richard Szeliski, "Reconstructing Rome", IEEE Computer, pp. 40-47, June, 2010.