Virtual Reality 360 Content Preservation for Disaster Relief

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***Abstract*—In this project, we are interested in providing and customizing a distributable workflow of virtual reality 360 (VR360) suitable for compassion relief operation. Recruiting volunteers for disaster operation can face a number of obstacles and issues, these include physically and mentally challenges for volunteers. Disaster workers are usually volunteers from across the country and across the world. Most operations involves logistics in terms of financial support, transportation, emergency response vehicles and provide the victims and communities shelter, food, clothing, relief supplies and even comfort to those in need. In an ideal situation, we are looking at setting up a manageable workflow which can be operated by workers of compassion relief organization in terms of simplified method and apparatus for acquiring and generating 360 virtual content. The content should be operated and produced by multiple small teams of minimum-trained taskforces which have the capability to obtain and processing these 360 content in digital media.**

Keywords—virtual reality; augmented reality; digital humanities; disaster relief; user experience; data conservation

I. Introduction

Human resources for disaster operations are key for compassion relief management. Recruiting professionals and a great number of volunteers can be arranged based different requirements of disasters [3]. The types of disasters can include tornadoes, storms, floods, wildfires, earthquakes, and drought.

There are several modern approach such as virtual and augmented reality that can provide location-based 360 visualizations. For instance, the technical consideration and high fidelity workflow of digital preservation has been explored by Fisher et al. [1] and Okura et al. [2]. However, some of these sophisticated techniques are usually developed by and made available for professional industries and scientific communities. The lack of standardized information and open source references about 360 content creation and distribution becomes a difficulty for untrained relief workers which did not have multimedia technical background.

The main contribution of this on-going work is that we intend to provide a simplified virtual reality 360 (VR360) spherical panorama digital workflow which can be transferable and adaptable for disaster relief operators which value 360 content preservation. These preserved content shall be optimized on the 360 user experiences which enhances the awareness in terms of conservation and assessment [7]. During the initial stage of this project, the 360 content can be used for volunteer recruitment of compassion relief operations.

II. Background

In terms of training simulation and remote assessment for emergency relief operation, preparation is a key component of disaster relief operations in early stages [4]. Making virtual reality as a solution for disaster preparedness has becoming a practical interest [10][11]. Co-ordination and collaboration are usually the main requirements in preparation [12]. The 360 visual content either in static or video format can provide visual simulation available in mobile medium or head-mount-devices.

Inaccessibility is another issue for preparation [5], therefore it may be ideal for the multimedia taskforce that is capable of obtaining 360 data to be prepared for coping up with such issue which can be performed with sufficient equipment support. In an ideal situation, 360 visual content acquisition can be also used for site recovery and humanitarian activities monitoring. Hence, essential aspects of acquisition and handling of 360 data for disaster relief operations should emphasis on high level of convenience, transportable and ease-of-use.

Volunteer recruitment is a successful factor for human resources suitable for disaster relief supply chain [5]. Most multimedia data of the disaster sites are commonly being obtained by resourceful organizations and localized authorities. For instance, private non-profit organizations may have limited access to those data and it would be difficult for such organizations to coordinate sufficient preparation for relief

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operations [6]. To our interest, it will be worthy to explore 360 visualizations which can be experienced using panorama images and videos acquired at the disaster sites during the process of volunteer recruitment.

III. Approach

The proposed approach involves four simplified technical procedures, applicable for both 360 image or video. These ideal procedures to be adapted for disaster relief operations shall be made deployable instantly at the relief site should a disaster occur, this allows 360 content to be acquired first hand based on the real situation from the beginning to recovery stage. Figure 1 shows the intended digital workflow or procedure as it begins with identifying the nature of disaster whether there is a safe ground for a group operator to setup a small camera with monopod/tripod. To illustrate, the size of a Samsung manufactured dual-lens spherical panorama camera can be seen in Figure 2 [13].

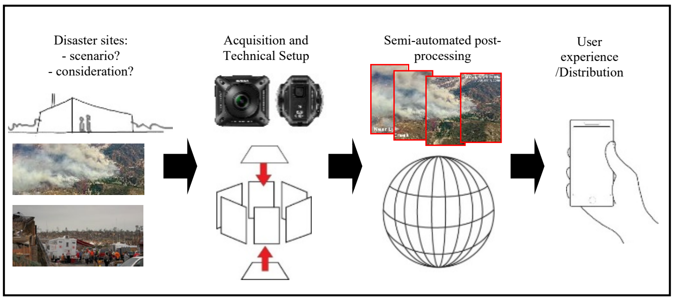

Fig. 1. Potential proposed workflow and training to be provided for relief workers /organizations.

Fig. 2. The size of compact 360 spherical panorama camera.

Such 360 camera (omni-camera spherical panorama configuration) being selected into the proposed digital workflow is ideal to be a palm-size configuration and should have a "one-button recording" feature which can be operated quickly and easily even with untrained operator in the field. As shown in the Figure 1, the post-processing can be managed after an operator as successfully captured 360 raw footage stored in the memory of the 360 camera and has returned to his disaster location resource base. Post-processing method chosen essentially can be performed semi-automatically so that VR360 final content can be made ready for online distribution using a URL. In such a scenario Figure 3 shows a preset digital program provided by "KRpano" processing ten 360 samples for image-based virtual reality environment in a few minutes. Figure 4 shows more than ten spherical panoramas in 360 display being processed. These samples could be immediately viewable in platforms such as a personal computer, mobile devices and head-mount-devices (HMD).

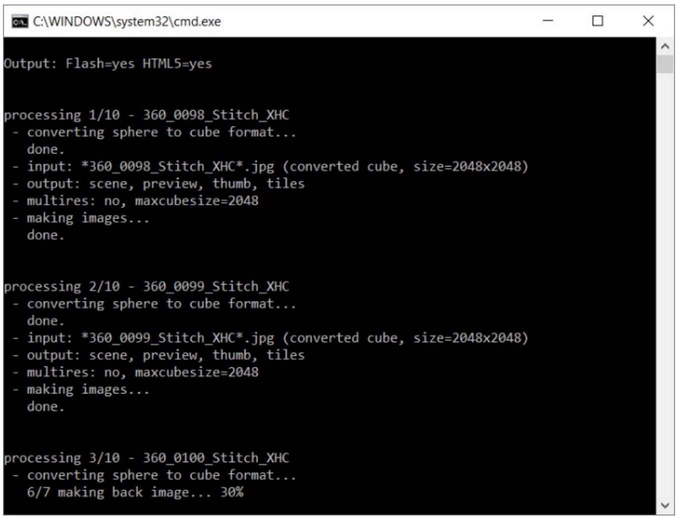

Fig. 3. Back-end automation using "KRpano" without needing complicated post-processing training.

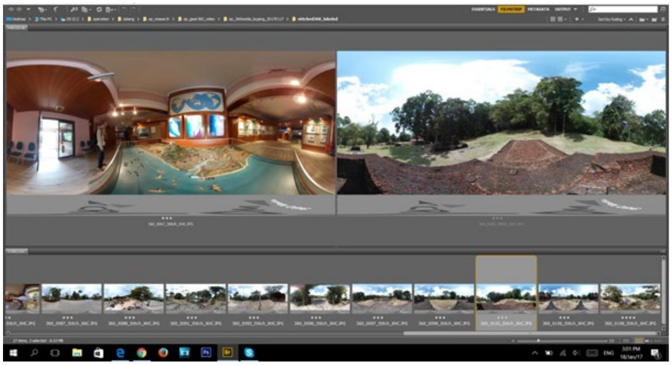

Fig. 4. A large number of spherical panorama fast and batch post-processing.

PC, mobile and tablet users can take advantage of WebVR which is widely compatible with most default web browsers of devices. WebVR approach allows target users to have flexibility to choose their preferred viewing platforms either in mobile or personal computers. The example shown in Figure 5 demonstrated VR360 content being view in stereo mode which is compatible to a head-mount-device (HMD) operated on a palm-sized mobile phone.

An example of 8k resolution panorama images which can be produced using the proposed simplified workflow can be seen in Figure 6, this was a 360 sample being obtained from the Bujang Valley historical site, Kedah in Malaysia [8]. The acquisition process requires less than 10 seconds from placing the camera on a stabilized monopod on the site to capture surround imagery.

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Fig. 5. Stereo viewing mode adaptable for mobile-based HMD.

Fig. 6. 360 sample being obtained from the Bujang Valley historical site.

However, some drawbacks in terms of imagery quality and visual abnormalities can be observed. Figure 7 shows parallax error during stitching of imageries from the dual-lens compact 360 camera and insufficient dynamic range in terms of luminance shadow and highlight.

Fig. 7. Visual abnormalities observed in 8k resolution content reproduced with simplified workflow.

On the other hand, Figure 8 shows a near-perfect captured 360 content using different experimental system [9], 16k resolution high fidelity content can be reproduced but it requires an extremely complicated process. This example was a 360 spherical panorama image of a reconstructed disaster site (Great Hanshin earthquake in 1995) of the main street of Kobe, Japan. Such sophisticated system [9] produces minimum visual abnormalities and extended dynamic range, however it requires qualified personnel to provide technical support which may be unavailable on-site while managing disaster relief work.

Fig. 8. 16k screen resolution high fidelity content preservation.

There are vast amount of difficulties which required to be solved for improving the practicality of VR360 content creation. Solving these difficulties shall provide improved immersion in terms of user experience in virtual reality applications. Our observation of such obstacles for spherical panorama reproduction that may result in poor VR360 user experience are illustrated in figure 9.

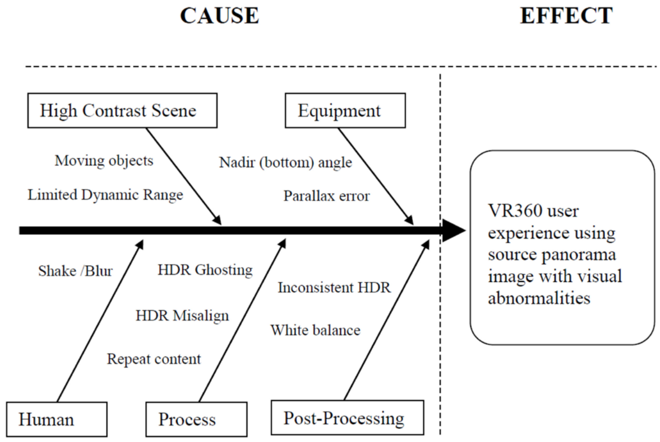

Fig. 9. Obstacles of panorama reproduction which affect VR360 experience.

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Consideration of minimizing these obstacles during acquisition and post-production stage may result in improved and usable 360 content reproduction. Some of these recommendations that produces optimum image results are based on our on-site experiment.

A. Parrallax Error to be avoided or corrected

There are several approaches that can be used for having 360 content that has reduced parallax error. Parallax error is one of the major issues that would result in inaccurate photographic reproduction [14][15]. This is one of the earlier known issue in omni-camera panorama (multiple cameras) and multi-row (single camera in a camera rig that permits viewpoint rotations and multiple shoots) computational photographic techniques. Parallax error occurs when two image angles that are to be stitched together as they were photographically acquired from dissimilar sources of viewpoint (also known as the nodal point). This can result in both the images cannot be visually merged correctly. It is vital to understand that parallax error technically cannot be entirely avoided in omni-camera configuration, but minimizing the such error is possible with some preparations. In the context of omni-camera shooting scenario, one of the most effective approaches is to avoid parallax error which only can be done by having a clear and careful consideration of having correct placement of the 360 camera in the shooting scene. In this case we assume the dual lenses of 360 camera have been optimized during the manufacturing process with near-perfect alignment. Parallax error can be optically exaggerated when the 360 camera placement is positioned too close to some physical objects in the scene environment shown in figure 10.

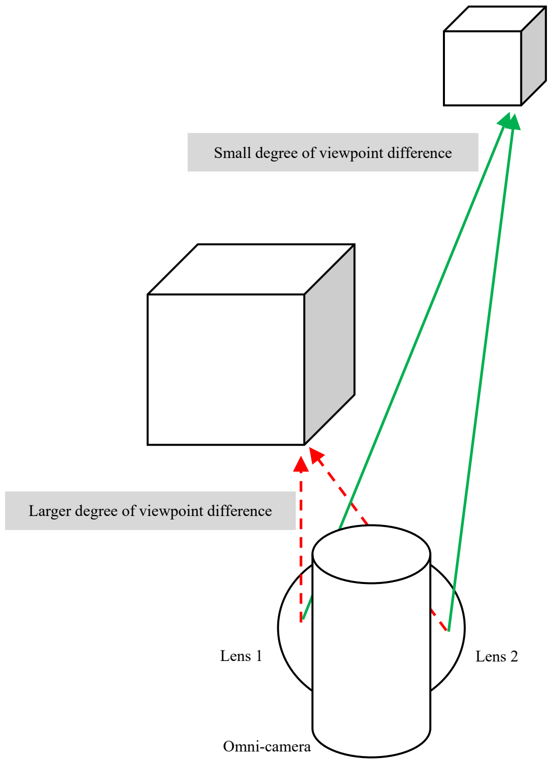

Fig. 10. Omni Camera configuration suffers from parallax error.

The scenario in figure 10 demonstrates a situation where an360 omni-camera (eg. two lenses configuration) were placed near to some objects which cannot be perfectly photographed from the exact same viewpoint by multiple lenses. Therefore, a usable solution for minimizing parallax error is to place the 360 omni-camera far from any physical objects, doing so reduces the degree of different viewpoint (also known as nodal point) which can enhance stitching results in post-processing. However, post processing correction performed manually or via post-processing digital software may be helpful when there is any minor parallax error in the stitched panoramic imagery, however major parallax error is almost unable to be tolerated.

B. Limited Dynamic Range

One of the ways of having enhanced luminance coverage of captured scene is to use multiple exposure high dynamic range (HDR) photography approach. However, this feature may be limited to some small-sized omni-camera configuration [13]. Sometime, the lighting condition of the scene environment is too contrast and it may be difficult of digital imaging sensors to cover adequate reproduction of shadow and highlight. Ghosting error is another issue when using multiple exposures HDR approach which caused by moving objects such as human or vehicles in bracketed images of the same angle. It may be possible to apply multiple exposures HDR technique in multi-row condition where the control of manual exposures is accessible, however this may not be practical in fast-pace omni-camera workflow.

Consideration of optimum lighting condition for LDR capture:

- Avoid indoor scene that contains half of the light source that comes from outdoor
- Avoid shooting in high contrast sunlight condition (such as late evening)
- Manage and control usable ISO of omni-camera

C. Nadir Angle Difficulty

Nadir (bottom) angle is a difficult viewpoint to be photographically acquired in multi-angle setup. The nadir angle is being blocked by the equipment setup which is placed on the ground whereas the acquisition process attempts to capture the photographic content facing down.

Since nadir angle is unlikely to be entirely fixed in omni-camera configuration based on the nature that taking away the camera tripod has not been easily being done. In our observation, a stable monopod may help to reduce the appearance of tripod legs in lower angle. It is also recommended to place the omni-camera at about 120-150cm from the ground for a VR360 visual result that simulates a sitting or standing position of a human.

D. Other Factors

We also noticed several obstacles or visual errors that is difficult to be predicted during capturing process:

- Inconsistent white balance (for multiple angles)
- Inconsistent lighting distribution (for multiple angles)

In the situation of having two or more lenses in omni-camera configuration, each camera attempts to capture the scene based of subjective lighting conditions. There were situations where the image captured by the first camera appeared to be darker than the second camera resulting a strange look of differently exposed images being stitched together in post-processing.

IV. Discussion

This work is to find ways of conserving scalable data from disaster relief events to mentor and coordinate from the transfer of data to the next event. At this conference, we expect to discuss further about issues of VR, smart technologies, and multimedia to interact and coach volunteer workers. Developing our digital and sustainable conservation methods could have worked on a range of environmental and cultural applications.

In an ideal situation, virtual reality 360 content perseveration should provide extended data visualization of those disaster relief sites without increasing major workload to existing human resources. Figure 11 shows 360 content being experienced in a generic head-mount-device (HMD) using a mobile device as a computing module. The level of use-of-use and usefulness using the proposed approach for preserving, processing, interpreting and distributing VR360 content should be considered as the key challenge of introducing and implementing such system.

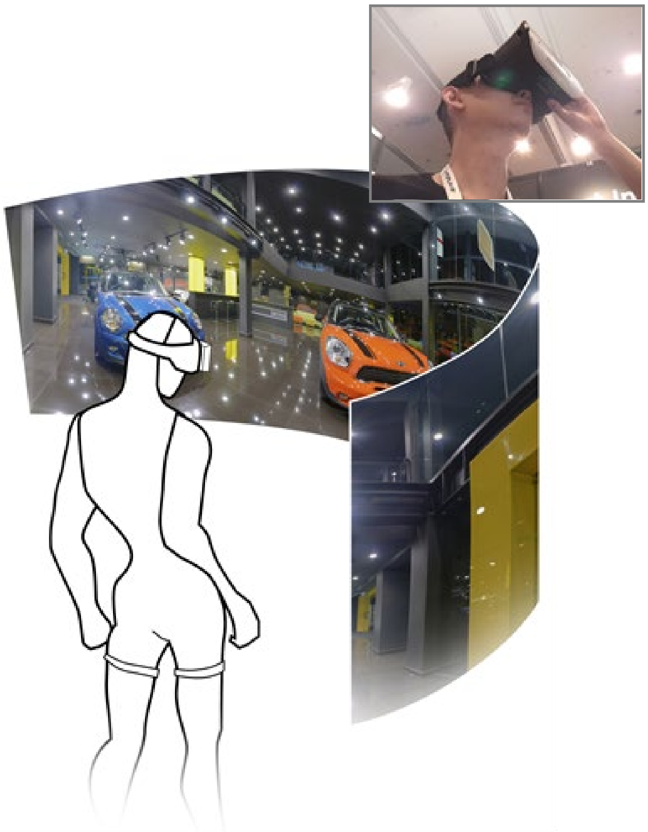

Fig. 11. VR360 user experience of actual location using mobile-based HMD.

Figure 12 demonstrate user experiences of viewing 360 content using mobile tablet. 360 content which can be made available in the form of still image and videos may provide different perceived user experience in terms of ease-of-use and usefulness.

Fig. 12. VR360 user experience using their personal mobile devices or tablets.

A series of pilot study was conducted to evaluate 360 content user experience comparing HMD and mobile devices. In one of the tests, we collected feedback from a set of 16 visitors, 8 female, and 7 male ranging in age between 18 to 62 years old. The experiment involved a demonstration of how 360 content is being operated in head-mount-device [16] powered by a mobile device and compare it the visual experience of viewing it on an android-based tablet. Participants experienced 360 content using a 10.1 inch Android tablets (Samsung Tab 2 GT-P5100), and the HMD configuration shown in figure 11 (using Samsung S7 Edge G935FD)

We asked if the participants may experience any physical discomfort (like nausea) when viewing the content. We found 0% of users experience any kind of reported discomfort when viewing 360 content on tablet. On the other hand, 43.75% of the participants experienced mild-to-moderate discomfort when using HMD for VR360

In addition to the survey, we asked participants for their comments on the system usability. Users said "I enjoy the 360 content where I can look around freely.. ", "..very interactive..". However users also felt that "..It will be important if we are able to have clearer image quality...".

Participants who suffered from discomfort described that "I feel dizzy when I view the content for too long (for HMD)", "To much turning while my sight is limited by the device" and "..the content looks too close to my sight".

When asked about their VR experience on a Likert scale of 1 to 7, where 1 = not very much, and 7 = very much, the average score was 3.25. Some participants were new to VR360 and were not sure how it works consistently. However, users who have any previous experience on how 360 content is operated, they seemed to pick up both HMD and mobile tablet experiences easily. Some participants even requested if they could experience or see more of the demonstrations. Although

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the simplified workflow and approach shown in this study works quick and promise a result which can be produced with minimum training, the fidelity of the 360 content is still the key factor of providing a successful user experience.

Future study involves various aspects of maximizing the usefulness of 360 capture in multiple scenarios including the event of disaster relief and site inspections. Figure 13 demonstrates a work-in-progress of an experimental configuration of Aerial 360. The similar 360 camera used in this study has been retrofitted into a DJI manufactured drone for obtaining 360 airborne content.

Fig. 13. 360 camera retro fitted on a drone.

Recent advances have allowed VR360 experiences to be possible on palm-sized or eye-wear personal mobile devices. This means that it is possible for end-users to experience VR360 content using their own mobile devices. Therefore, the ease of distribution for 360 content a practical aspect of making spherical panorama images or videos available via online platforms. For instance, 360 content can be hosted on an organization-owned website or public domains. To illustrate, youtube and facebook are some public accessible social media providers which have built-in 360 content hosting feature. This allows hosted content to be managed, distributed and accessible for selected audience based on the intention of the of content producers and owners. Additionally, providers such as SteamVR and Microsoft MR systems have introduced various tools and ways to store and view personalized 360 archives.

V. Conclusion

In summary, in the aspect of preserving 360 information for the future in the digital space, we hope that this innovative practice is easily and conveniently adaptable for disaster relief operators. The procedure can be conserved as data which can be used for future disaster relief and training. Therefore, each time, this can be used as a model of VR360 data and content creation for relief operators in scalable preservation subject to different size and nature of disasters.

In future we wish to examine usability mixing of VR360 and augmented reality systems and which can provide greater level of visual communication details for disaster relief operations. We will also explore ways to improve VR360 experience such as working with HDR spherical panorama which can be viewed on high resolution displays.

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