Support System to Review Manufacturing Workshop through Multiple Videos

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ABSTRACT
With the increasing popularity of digital machine tools such as 3D printers, even common people are being involved in personal fabrication (Fab age). For example, manufacturing workshops using digital machine tools are often held by the Fab community (e.g., FabLab [1]). In such workshops, manufacturing processes are important experiences for users (both organizers and attendees). However, such processes are often difficult to record and review. This paper proposes a system for recording manufacturing workshops from multiple viewpoints, and helping users review manufacturing processes through multiple videos.

Author Keywords
personal fabrication; manufacturing workshops; digital machine tools; review; video edit.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces

1 INTRODUCTION
With the recent price reduction of digital machine tools such as 3D printers, the personal fabrication age (Fab age), where ordinary people can also engage in the manufacturing, has arrived. With this, several workshops are being organized by manufacturing communities, such as FabLab. In these workshops, not only the production but also the production process using a digital machine tool is an important experience. However, since both organizers and participants are themselves involved in the production, they cannot video record the workshop and edit it. This situation is a great opportunity loss for both participants and organizers. If the production process can be reviewed through the video, participants can use this experience for their own technological advancement, which will increase their motivation for production. This experience can also be widely used by organizers as follows: reviewing the program of the workshop, creating promotion video to share the workshop experience, and creating a workshop manual. This paper proposes a system that supports the summarization of workshop videos, in which the workshop process is automatically video-recorded and can be easily edited by the participants and the organizers.

[1] http://fablabjapan.org/

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2 RELATED WORK
In this section, we introduce previous research related to this study from the perspectives of "Manufacturing support" and "Reducing the burden of video editing."

Extensive research aimed at supporting manufacturing using digital machine tools has been pursued. FabNavi [1] is a system that supports assembly work for novices who do not have expert knowledge and skills, by projecting the assembly method on a desk. SketchChair [2] is a system that can interactively adjust the design of a chair to generate part data that can be output by a laser cutter. To edit videos, special knowledge and experience are necessary, so beginners need much labor and time to perform video editing. To solve this problem, there are many studies aimed at alleviating the burden of video editing. CinemaGazer [3] is a system through which the user can watch videos in a short time by changing the playback speed by guessing the high and low importance of the video based on the given subtitle information. DemoCut [4] is a system that supports video editing by analyzing frames specified by the user, performing processing such as high-speed playback and cutting of unnecessary places and emphasizing the display of important parts semi-automatically.

However, these related studies target short-term viewing of videos and creation of video manuals, and only a few studies have targeted the review of manufacturing workshops. Therefore, in this paper, we propose a system that allows the participants and organizers to edit videos while looking back at the workshop.

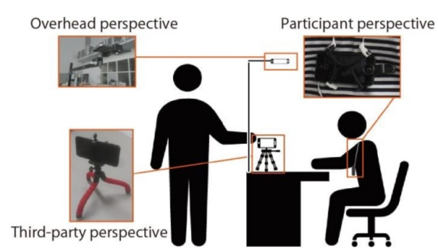

Figure 1. Position relationship of multiple cameras for recording manufacturing workshop

Figure 2. Example videos of each perspective Left: overhead perspective, Central: third-party perspective, Right: participant perspective

3 SUGGESTION
Here, we explain the three concepts of the proposed system: (1)Semi-Automatic recording, (2)Recording from multiple perspectives, (3)Easy video editing integrated with the review. First, video recording is performed almost automatically. One of the reasons for getting less opportunities to review the

manufacturing workshops is that both the organizers and participants concentrate on their own work, so it is difficult to keep recording the production process manually. Therefore, by (semi) automating the video recording during the production process, both the organizers and participants can continue concentrating on their work.

Second, the video is recorded from multiple perspectives. Considering the ease of camera installation and the effectiveness of the information obtained from the video, the cameras are arranged in positional relations shown in Fig. 1. In other words, the overhead perspective is fixed to the upper part of the work desk, the third-party perspective is fixed to the opposite side of the workshop participants, and the participant perspective is fixed to the participant's chest. Fig. 2 shows examples of images taken from each perspective. We assumed that using the video from multiple perspectives would make the review effective.

The third concept enables users to edit the video integrated while reviewing. The system user performs simplified tagging by selecting a part of high interest while viewing the video captured from the three perspectives on a device such as a tablet. By doing this, the participants can review their workshop and create a review video that gathers points of high interest. The interface created will be described in the next section.

4 IMPLEMENTATION

In this section, we describe a video recording system and a video creation system.

4.1 Video Recording System

We performed video recording by using a smartphone prepared by the workshop's organizer. As described above, smartphones were installed in multiple locations such as the overhead/third-party/participant perspectives. To record the video from the overhead perspective, we used our own frame to record from the top of the desk at a distance of about 1 m. To record the video from the third-party perspective, we prepared a small fixture, such as a tripod, for setting the smartphone on the opposite side of the participants. For the participant perspective, we mounted a wearable fixture with a 3D printer to place the smartphone around the neck.

Figure 3. Interface of video-edit system

4.2 Video Editing System

We describe the basic functions of the developed video-edit system. The system is based on a software that runs on a Windows tablet, and the user operates it through the touch panel. The interface of the system is mainly composed of a video display unit and a scene search unit (Fig. 3). First, the user presses the "select" button and selects the save folder of the workshop video, so that the videos from the three perspectives can be automatically read into the video display unit. Next, the user records the timing / perspective information by tapping the video frames through reviewing the workshop process. Furthermore, perspective information is recorded by arbitrarily switching the video of interest (large-size window). When the video review is completed, pressing the "create" button causes the system to cut out, combine, and fade the video captured from each perspective based on the timing/perspective information to create one review video.

4.3 Scene Search Functions

The scene search function visualizes various features of videos using image analysis techniques to help users review videos effectively. First, we recorded several manufacturing workshops and analyze videos of each perspective. In result, we found several detectable features as follows: (1) facial expressions (e.g., smiles) of attendees in the third-party view, (2) use of hands and a tool in the participant view, (3) overall tools and parts in the overhead view. Therefore, we developed three visualization functions: (1) smile detection (third-party view) using OpenCV, (2) hand detection (participant view) using color recognition, and (3) tool detection (overhead/participant view) using SURF. Figure 4 shows the example of visualization applied for the videos of a quick workshop to create a laser craft. The lengths of the videos are about 10 minutes. The attached images are example scenes searched by this function. Figure 4 shows the example of visualization applied for the videos of a quick workshop to create a laser craft. The lengths of the videos are about 10 minutes. The attached images are example scenes searched by this function.

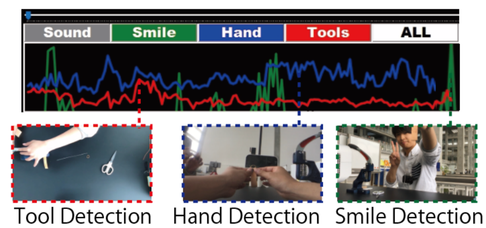

Figure 4. Examples of multiple scene search functions

5 CONCLUSION

This paper proposed a support system to review manufacturing workshop through multiple videos. First, we proposed three concepts: (1)Semi-Automatic recording, (2)Recording from multiple perspectives, (3)Easy video editing integrated with the review. Then, we developed a video recording system and a video editing system. Especially, we implemented scene search functions (e.g., smile detection, hand detection, and tool detection) to quickly access the scenes suited for the review process. We plan to perform evaluation of the system through actual manufacturing workshops held by fab community.

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