Big Fat Wand: A Laser Projection System for Information Sharing in a Workspace

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Abstract. This paper proposes the method to solve a problem of a triad relation thorough an augmented reality system in cooperative works. It enables us to explain shortly, because it utilize spatial information without translation it to verbal ones. This paper realizes it with the laser projection AR system, Big Fat Wand (BFW). It meets requirement for a real workspace. From experimental results, the AR method with BFW is effective to decrease the explanation time.

Keywords: Augmented Reality, Cooperative Work, Laser Projection System.

1 Introduction

This paper proposes a new cooperative work support method through augmented reality (AR) technology. When we cooperatively work together in a work field, if there exists a “triad relation”: a relation among a far target object, an explainer, and an explainee, they tend to have misunderstandings and/or difficulties in their communication. It is because the explainer and the explainee have difficulty to share common points and/or concepts about the target object. Figure 1 depicts the triad relation in such a communication task.

To cope with the difficulty, we utilize AR in the shorter explanation about the target object in order to support visual communication. For the purpose, in this paper, we report the experiments using Big Fat Wand (BFW) system: a portable laser projection system, which equips a handy version of a conventional laser show device.

The triad relation often raises such difficulties that they must translate the special information of the target object into verbal ones with the longer explanation. Such communication would cause some accidents, when there exist the triad relation in a manufacturing factory or a construction field, which are usually noisy, dirty, dangerous, and hard to approach.

To support such communication tasks with the triad relation, the shorter and simpler explanations are desirable in order to reach a common understanding about the target space. Therefore, they require the following three points:

1. Accurate and simple display of the target information: This will decrease misunderstandings about the triad relation;
2. Ease of use around the target object: This means the use of the AR to support ad-hoc communication;
3. Flexibility of the use both in the darker and lighter environment. This means we do not assume any experiment rooms on the triad relation.

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To meet the above requirements, we propose the use of AR by simultaneously displaying the visual information of the explainer to the explainee onto the target object directly. This enables us to decrease the difficulty of the explanation task, because it is not necessary to translate the spatial information into the verbal ones. Figure 2 shows the situation.

The objective of the paper is to experimentally demonstrate the effectiveness of the communication scheme shown in Figure 2 through our laser projection system BFW. The rest of the paper is organized as follows: In section 2, we briefly survey the related work in the literature; Section 3 explains the features of BFW; Section 3 describes experiments to cope with the triad relation problem; and concluding remarks follows in Section 5.

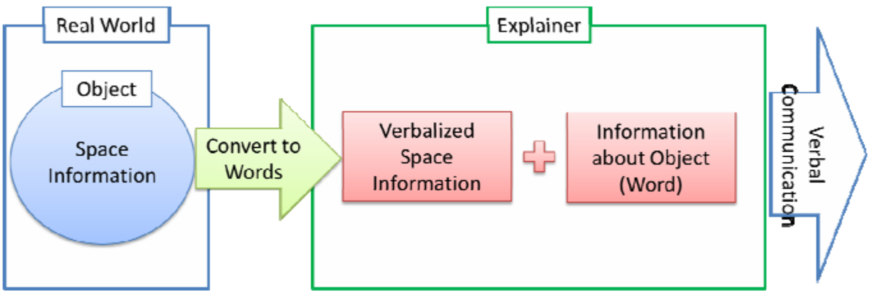

Fig.1. Triad Relation in a Communication Task

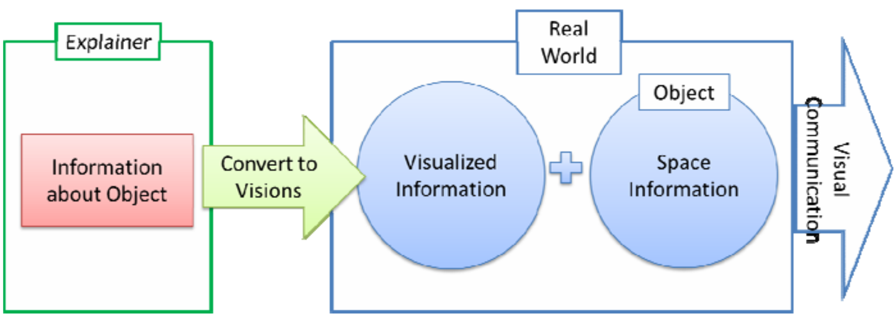

Fig. 2. Desirable Communication Scheme for the Triad Relation

2 Related Work

So far, there has been various works in the literature to support field works using AR systems [1]. The researches have usually focused on a very specific task in a restricted space. For example, in [2], they reported experimental work for the maintenance task of a laser printer. Also, in [3], a system has been developed for a medical education task.

Many of such AR systems require special purpose tracking techniques both to identify the place of a target object and to display the necessary information on it. Such typical systems include ARToolkit [4] and PTAM [5]. PTAM is characterized by its markerlessness. Of course, they are useful, however, to use such systems, there are the following defects: they must prepare a specific environment beforehand, or they are inflexible against the environmental changes.

3 Big Fat Wand: A Handy Laser Projection System

The objective of BFW is to enhance human-computer interaction activities [6, 7]. BFW is a handy smaller version of a conventional laser show device. Compared with a conventional laser show device [8, 9], the size is as small enough as we use it in hand. Also, compared with a conventional laser pointer, it is connected with a laptop PC and programmable to allow the user to specify the pattern displayed via any characters and/or symbolic patterns on the targeted object [6, 7, 9]. BFW stands for the very big magic wand. The system displays various information onto any kinds of target objects, even if they are in a bright place.

Therefore, BFW satisfies the AR system requirements described in the previous section. That is:

1) BFW can display accurate information onto the desired place by setting the handy part against the target object;
2) BFW can easily change the contents using contents editing toolkits on a PC, thus. We are able to show even hand-written information and animations at hand; and
3) The laser light is enough clear even in a very brilliant and /or fully dark place.

Big Fat Wand system has the following components: i) A laptop PC with line drawing image generation, image display, and editing software, ii) A one-board micro-computer to convert the digital information of the drawings to the analog ones to control the device, and iii) Laser show device with laser light generator, small dynamic mirror devices to control displays of the drawings, and power supplies. The system is also equipped with special purpose authoring tools for naïve users to prepare the explanation materials.

Very unique points of BFW are summarized as follows: i) A one-board 16 bit micro-computer manages DA conversion of explanation and controlling the images, ii) The portable cylinder part is carefully designed to avoid heat damages of the laser devices, and iii) the components of the devices are packaged in separated two parts to easily use the system.

Figure 3 shows the architecture and Figure 4 depicts the photos of integrated device of BFW. A user uses the cylinder part to show the desired information. The box behind the cylinder contains devices such as one-board micro-computer, power supply, laser light generator, and so on. The information is prepared beforehand and/or on-site using special purpose authoring tools equipped on a laptop PC.

The configuration of the authoring tools is shown in Figure 5. Using the tools, we are able i) to process static bitmap images (both characters and symbols), which are converted to line drawings, and ii) to generate simple animations combined with the bitmap images, and also processes line drawings written with the postscript language. This means that the user is able to both design and generate the necessary information with bitmaps beforehand and draw pictures and character in real time.

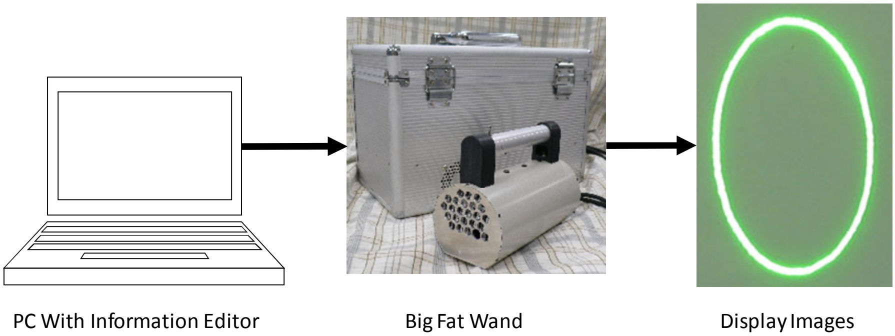

Fig. 3. Architecture of BFW

Fig. 4. Outlook of the Integrated Device

4 Effectiveness Validation

To validate the effectiveness of the proposed method with BFW, we have conducted a series of route explanation experiments, whether they would have smoothly communicated in a triad relation or not. The route explanation experiments are designed to simulate tasks of material picking work in a manufacturing factory.

The experiment consists of the following steps: first, the route of the material moves is shown to a subject: explainer; second, the subject is required to place specified materials at specified places and directions; third, the explainer is required to let another subject: explainee executes the material movement task. Through the experiments, we let them carry out the task with/without BFW and in noisy/silent environments.

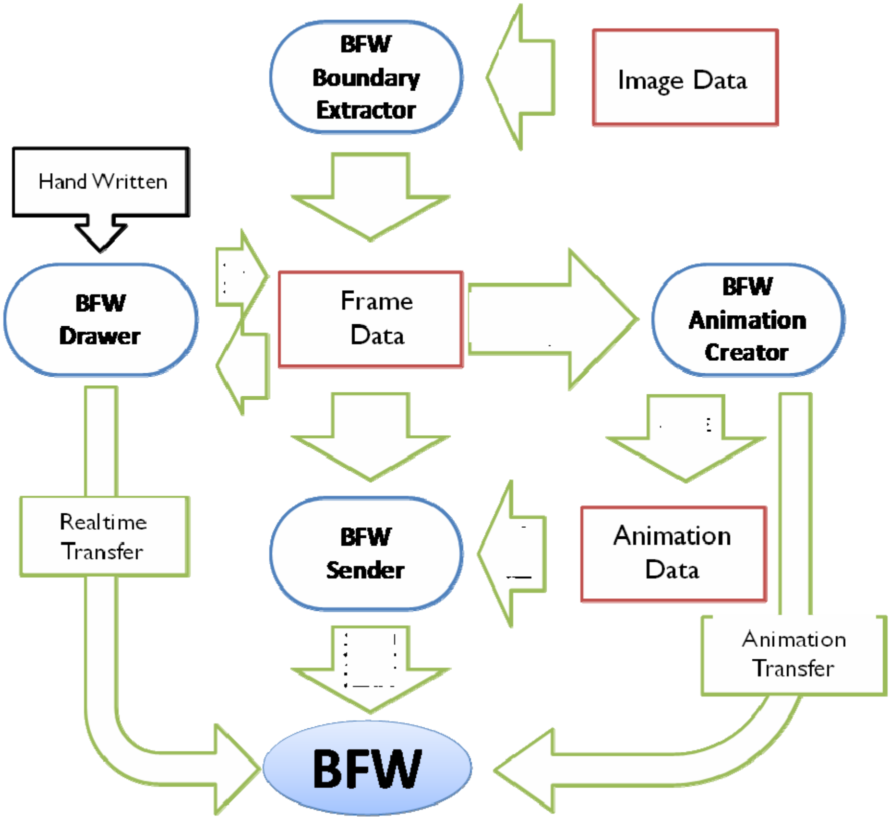

Fig. 5. Software Configuration of BFW

4.1 Subjects and Experimental Set-Ups

We have prepared three set of subjects: explainer and explainee. They have changed their roles in turn in the triad relation. These subjects are graduate students in our engineering department. They usually communicate each other in their daily life.

An explainer explains the movement instructions to an explainee with a paper or BFW (Figure 6). To set the environment noisy or silent, they are required to wear or not to wear a headphone with white noises in order to prevent them from verbal communication.

Fig. 6. Scene of Experiment

We have evaluated the effectiveness by measuring the time for explanation, the accuracy of the competing the tasks, and a questionnaire survey after the experimental tasks. The explanation time is said to be 5 minutes, however, we allow them for 15 minutes. The questionnaire survey contains the following items:

Q1. Is BFW easy to use to transfer the information to the other from the accuracy and easiness viewpoints?

Q2. Is BFW explanation easy to understand by the explainer?

Q3. Is the paper explanation to use to transfer the information to the other from the accuracy and easiness viewpoints?

Q4. Is the paper explanation easy to understand by the explainer?

Q5. Which is better to understand in the explanations by BFW or paper?

Q6. Which is easier to make the explanations by BFW or paper?

Answers of Q1, Q2, Q3, Q4 are measured by 1(negative), 2, 3, and 4(positive). Answers Q5 and Q6 are paper or BFW.

4.2 Experimental Results

Figure 7 displays the explanation time. We have observed the statistical difference about the explanation time of BFW and the paper with/without noises. Figure 8 summarizes the questionnaire results. The results have suggested the superiority of BFW explanations. About the accuracy and ease of understandings, the explanation by BFW is usually better than the one by the paper. The ease of use of BFW is worse than the one of the paper explanation.

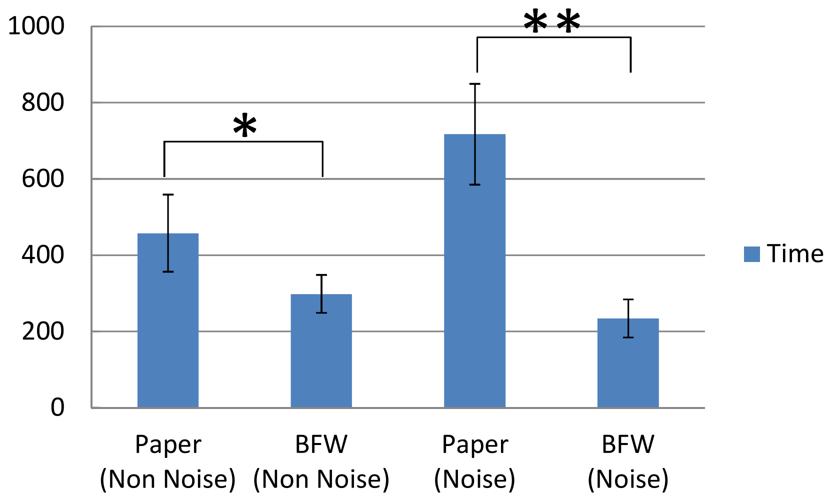

Fig. 7. Explanation Time

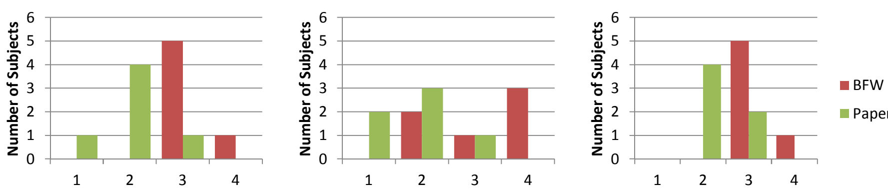

Fig. 8. Questionnaire sumarisation

4.3 Discussion

From the experiments, we have observed that the use of AR with BFW decreases the explanation time, especially it is effective in a noisy environment hard to orally communicate. This means the AR method can omit the special explanation on the tasks. Also, the direct projection of the explanations to the target object has decreased the ambiguity of the indication and increased the ease of understandings.

On the contrary, in a noisy environment, the paper communication have required so much time because they must write everything in detail. However, the operations of a PC toolkit have caused the difficulty of communications. The operation of the handy part of BFW might has caused the difficulty of detailed explanation because of the shaking of images made by the laser system.

5 Concluding Remarks

This paper has proposed a cooperative work support method in a triad relation environment through augmented reality (AR) technology. The communication in the triad relation environment is difficult because of the hard tasks to translate special information about the target object into verbal ones. To cope with the issue, we have utilized Big Fat Wand: a handy laser projection system. BFW enables us to directly project the necessary information onto the target object.

Our experimental results have suggested the AR method with BFW is effective to decrease the explanation time especially in a noisy environment, which is usually the case in a real manufacturing factory. Our future work includes further field investigations of the AR method with a very long range and the improvement of BFW both in a software system and a hardware device.

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