Leaning Origami Using 3D Mixed Reality Technique

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Abstract. 3D Mixed Reality Technique is a kind of the AR (Augmented Reality). Using AR, we can reduce mistakes and can lead effective works. Especially, utilizing 3DCG will enhance the potential of AR. In the research of 3DCG, Non Photo Real rendering is proposed as a manner to understand structure of 3DCG easily. No researches have been done so far to verify whether the Non Photo Real technique works well in AR. This paper inspects whether the Non Photo Real technique is effective in utilizing AR to learning Origami (Japanese paper craft). We approach a way to rendering 3DCG animations in AR system and compare of works using each 3DCG animations. We got results accomplishment rate and easier to watch. As a result, we show that learning works using Non Photo Real in AR was improved understanding works.

Keywords: Leaning Origami, Mixed Reality.

1 Introduction

3D Mixed Reality Technique is a kind of AR (Augmented Reality) and, in 3D Mixed Reality Technique, 3DCG animation displays on the real world together. AR can display digital information in real world [1]. As, using AR, we can understand information more intuitively than watching a manual or a monitor separately from the targets, we can reduce mistakes and can work effectively. AR is increasingly being paid much attention in many fields such as the medical works and the maintenances of machines. Though 3DCG should be enhance the potential of AR because it cam represent more complexity information, no researches have been done so far to verify what kinds of rendering methods suit to AR.

3DCG can be classified into two types, Photo Real and Non Photo Real. Photo Real is a way to render objects in the manner to reflect the reality faithfully. On the other hand, Non Photo Real is a way of rendering objects for the purpose of easily understanding structure of 3DCG. Enhancing the outlines of objects is the most popular technique in Non Photo Real because it makes complex shapes clearer. In addition, it is also one of the effective techniques to give some simple shadows to represent the depth.

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Though, in this way, Non Photo Real renderings are be useful in 3DCG, the perspectives obtained in the researches in 3DCG may not be adopted in utilizing them in AR. For example, the enhanced shapes of objects may provide unnatural feelings in overlapping physical objects because some features of physical objects are deformed and some gaps may be appeared between physical objects and their 3DCG.

This paper aims to find some rendering manners suitable for the 3DCG mixed reality, and especially we focus on the Non Photo Real rendering. We investigate, in this paper, whether Non Photo Real rendering technique are suitable for the 3DCG mixed reality in making Origami.

Origami is one of the traditional plays in Japan and we transform one piece of paper into a complex shape such as animals and flowers by holding paper. Though there are many books with the illustrations, movies, and 3DCG to explain how to make Origami, it is difficult for the beginner to how to make origami correctly.

2 Related Works

Kitamura proposed a system which explains how to make Origami using AR [2]. The reason why Kitamura utilize the AR technique is that it is difficult for the beginners to comprehend the guidance because they should watch the paper and the instructions alternately and not to be able to understand where they hold the physical paper only watching the instructions. This system consist of a web camera and HMD (head mount display). When a web camera catches the AR markers on the paper, this system superimposes the line to fold on the paper through the HMD. Though the Kitamura's system could solve some problems of origami instructions, the users sometimes complicated the lines on the paper.

Mitanni and Suzuki proposed a rendering manner of 3DCG for Origami 3DCG [2]. In general, it is difficult to understand how much paper is overlapped with 3DCG and even if the quality is improved. So, they proposed the Non Photo Real approach. Their approach represents a shape of origami in 3DCG as Non Photo Real like the illustrations used for the instructions in many books. In this approach, "Gap of Faces" and "Misaligned Overlap" were presented. Gap of Faces is the technique, to make easy to express which folded parts of the paper are overlapped, to render the paper of the top layer in thicker. In Misaligned Overlap, the overlapped parts of the paper are rendered in staggering positions even if they are overlapped precisely.

3 Using Origami 3DCG Animation

To investigate the Non Photo Real rendering animation is effective in 3DCG MR, we created two types of origami 3DCG animations. One is called "Normal Model", which is the animation of one of the traditional origami 3DCG renderings. The other is the one whose each frame are rendered by the Non Photo Real technique, called "Approach Model". To make these models to be superimposed on the physical paper, we utilize the ARToolKit [4].

3.1 Normal Model

Normal Model renders physical objects with the traditional manner to be realistic. Here, the outlines of the paper are rendered by the depth buffer rendering method (Figure 1), and, to clarify which part we should fold at the operation, green mesh lines are drawn on the surface we should fold the surface which no operations are done at that step are painted in blue.

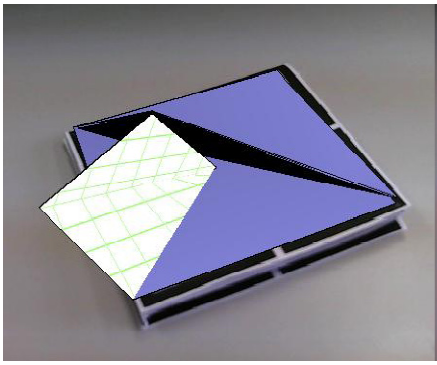

Fig. 1. Normal Model

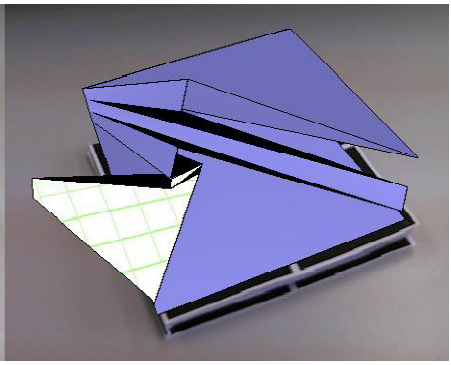

Fig. 2. Approach Model

3.2 Approach Model

Non Photo Real rendering were developed to create a still CG. As the Approach Model requires their animation, we create the first frame and the last frame by Non Photo Rendering, and do the frames between them by tweening. The thickness of the paper in each frame is also tweened using the first and last frames to apply the “Gap of Faces” technique.

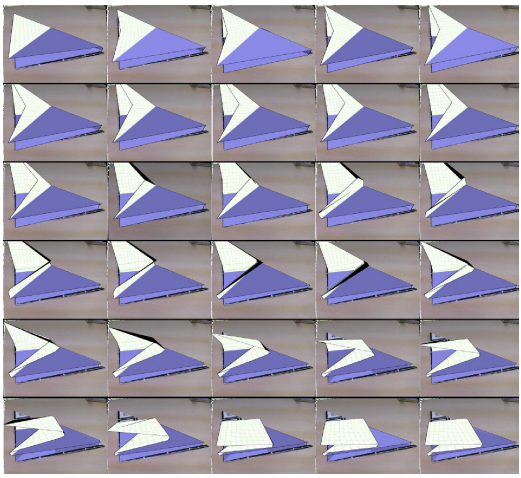

Fig. 3. Frame-by-frame playback of Approach Model

4 Experiment

In this system, we use the HMD for single eye to superimpose the 3DCG animations on the physical paper, and the WEB Camera to detect the special position of the paper (Figure 4). Several AR markers are printed on the paper. The subjects are 20 students who are not the expert of origami though they have a few experiments. 10 subjects were under the "Normal Model" condition and the other ten subjects are under the "Approach Model." After making Origami under their assigned condition, all subjects show the Origami CG animation of the other condition and filled out the questionnaires. Figure 5 is the steps of the task to be done in this experiment.

Fig. 4. Device NWEBcamera: Logicool 2-MP Portable Webcam C905m, HMD: SCALAR Teleglass-3 T3FCEMA

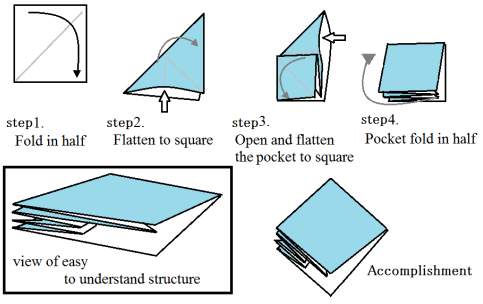

Fig. 5. Origami work illustration

5 Result

Figure 6 shows the rates the subjects accomplished each step. Though all subjects could accomplish the step1 and step2 with both of the Approach Model and the Normal Model because of too easy tasks, in the step 3 and step 4, the rate with the Approach Model is higher than the one with the Normal Model. By this result, it can be said that the Non Photo Real rendering also make special understanding easy even

in animation and in overlapping physical objects. The subjective evaluation supports this result (Figure 7) Figure 7 shows the result of the question that the subjects felt easy to understand how to fold paper. Majority of the subjects answered that "the Approach Model is more understandable than Normal Model" and, interestingly, they also answered that "I feel real in the Approach Model than in the Normal Model", despite the Normal Model represents physical objects more realistically.

However, all rendering ways of Non Photo Real do not have such effects. Figure.8 and Figure 9 show whether the subjects noticed each Non Photo Real techniques. Though most of subjects noticed the effect of the "Gap of Faces", only few subjects do not notice the effects of "Misaligned Overlap".

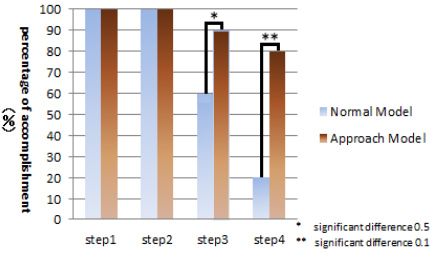

Fig. 6. Accomplishment rate

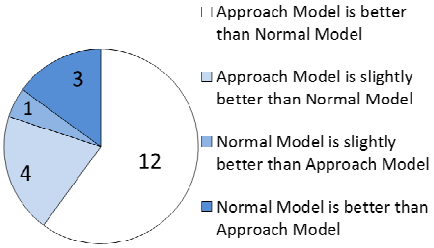

Fig. 7. Easier to watch

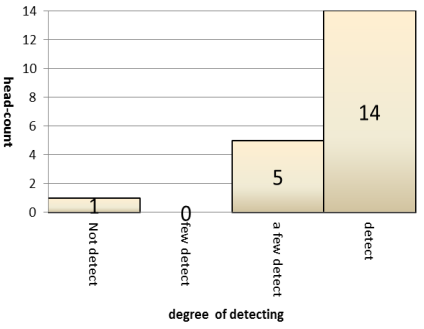

Fig. 8. Detected "Gap of Faces"

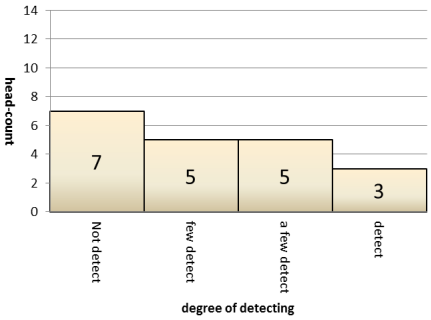

Fig. 9. Detected "Misaligned Overlap"

6 Discussions

The analysis showed Non Photo Real rendering is more understandable and human feel more realistic than the Photo Real rendering approach, even though the Photo Real technique reproduces physical situations. This may be caused by the nature of humans' internal image representation. It has been known that we do not represent external world in mind in just the way they are, but also in the manner of emphasizing their features. If the emphasis in rendering the feature coincide the human internal representation, we may feel realistic even if overlapped images have different external appearances from the physical objects.

All rendering techniques, however, do not allow human to be understandable. They feel "Gap of Faces" is realistic, while they do "Misaligned Overlap" is unrealistic. "Gap of Faces" is a technique to convey how to fold paper and to represents the internal structure. On the other hand, "Misaligned Overlap" is the one to depict how many layers of papers there are at one point and to represent the internal structure. It can be considered, therefore, the CG which represent the internal structure do not provide some sort of mismatch for human, even if it is unrealistic, while some sort of deformed CG such as depicting the external appearance provide it when they are overlapped on the physical object.

7 Conclusion

This paper investigated the effectiveness and the human feelings in overlapping the non-realistic 3DCG animation on the physical objects in Origami. The results show that human feels some non-realistic rendering more realistic than the realistic rendering and they allow human to understand the structure better, in spite of the gap between the CG and physical objects. We also showed that the rendering techniques to represent internal structure work well but the ones to emphasize the feature appearance do not well in overlapping physical object.

References

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