Poster: Puppetooner: a puppet-based system to interconnect real and virtual spaces for 3D animations

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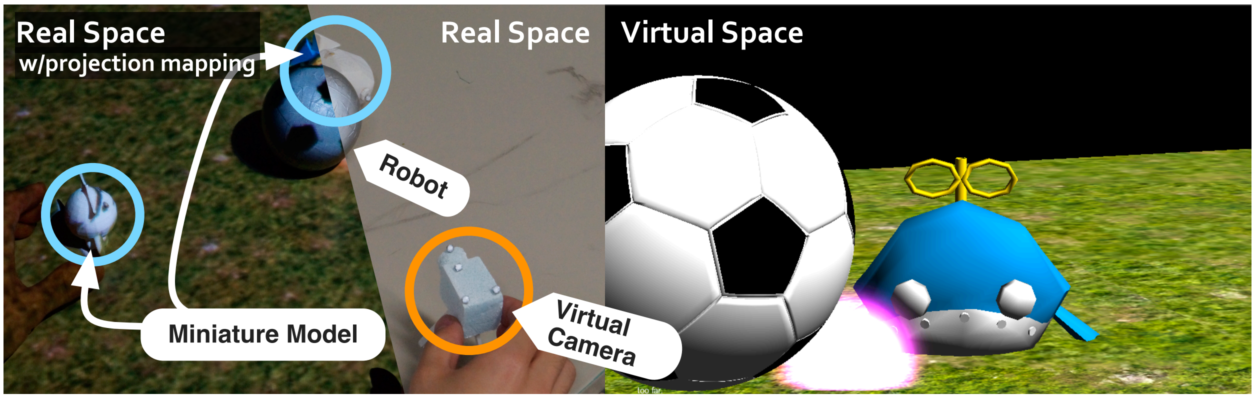

Figure 1: Left: Miniature models including a camera and a robot enhanced by AR technique. Right: A view from the virtual camera.

Abstract

We propose a system for producing 3D animations using miniature models. Our system enables users to interact with 3D objects and/or camera by direct manipulation of miniature models and enhances miniature models power of expression using projection-mapping technology. That is, users can control all 3D objects including camera in six dimension during the recording process. Using robots to reflect user-determined movements, the system also supports the production of repetitive step-by-step animation in which several objects move simultaneously. We developed a prototype on the basis of our approach and identified several flaws in the prototype.

Index Terms: H.5.2 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: User Interfaces—Interaction styles; I.3.7 [COMPUTER GRAPHICS]: Three-Dimensional Graphics and Realism—Animation

1 Introduction

The layout/animation process in 3D animation creation defines the spatial relationships among models (3D objects) and a camera in a scene. The animator lays out models in a scene during this process. The most common way to lay out models is to use a 3D animation software. Such softwares provide GUI based control tools and programming interfaces for the position, motion, and size of each object in the scene. However, this can be a complicated task for inexperienced users because they are forced to use high-threshold and high-ceiling interfaces. In addition, incorporating physics calculations into 3D animation softwares is becoming popular in order to increase the realism of the scene. The realism of the scene can be increased by adding a gravity force to the models or attaching an event happened in a collision. However, such calculations require high-computational power, and this leads to increase in processing time in rendering process.

We propose a miniature puppetry-based 3D animation recording system, *Puppetooner*, to solve the above-mentioned problems. It brings tangibility to the 3D animation creation process and allows users to easily create 3D animations by directly manipulating miniature models as puppets (shown in Figure 1, left). Puppetooner also enables interaction between the real and virtual spaces (3DCG space) using two key technologies: projection-mapping and motion-capturing technologies. These technologies make it possible to interconnect the real and virtual spaces. That is, the locations and rotations of each miniature model in the real space are assigned to the locations and rotations of corresponding 3D models in the virtual space. Using projection-mapping technology, the texture, events, and animations of each 3D model are projected onto the corresponding miniature models. This feature adds characteristics of an interactive media to the 3D animation creation process and provides an enjoyable user experience, especially for children. In addition, by using robots, Puppetooner makes it possible to physically reflect an event occurring in the virtual space within the real space. Using robots allows the creation of repetitive step-by-step 3D animation.

2 Related Work

A tangible interface is one way to interact with a virtual space using physical objects [2]. Kojima et al. proposed tabletop AR game environment [3]. Held et al. proposed a video-puppetry system to create animations by performing character motions [1]. Their system is similar to our approach in which creating 3D animations is accomplished by handling and moving physical objects. The most significant difference between the method presented by Held et al. and our approach is the interaction between the real and virtual spaces. Held et al. did not consider such interactions; their goal was simply to capture and use puppets as input devices for creating 3D animation. However, in our approach, there is interaction between the real and virtual spaces, where textures and events (e.g., collisions or characters expressions) are reflected on 3D objects by

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projection-mapping technology. Puppetooner also allows us to create a repetitive step-by-step animation scene.

Raskar et al. aimed to improve the power of expression of miniature models by projection-mapping technology [4]. They projected the color and/or texture of architectural structures onto miniature prototypes using a projector. Our approach also uses projection-mapping technology. However, in addition to improve a miniature models power of expression, we also aim to interconnect the real and virtual spaces. Zhou et al. argued the possibility of using AR as a connector between a real world and virtual world [5].

3 Prototype

3.1 Setup

We developed a prototype on the basis of our concept. For the real space environment, we made miniature models using a 3D printer (Stratasys, uPrint) and used Sphero, a ball-shaped robot. To track model motions, we used an optical motion-capturing system (Optitrack FLEX V100R2) and attached optical markers to the models. For the virtual space, we used a Unity 3D game engine and a projector for projection-mapping technology. The positions of each miniature model were tracked and transferred to the Unity engine via TCP/IP. The Unity engine renders textures and visual effects, and its results are projected onto the miniature models. The prototype consists of a projector, eight motion-tracking cameras, miniature models, a virtual camera, and a robot. The table was 1.5m $\times$ 0.9 m. The angle of the projector was fixed at 60°. Figure 2 shows the physical setup of the prototype.

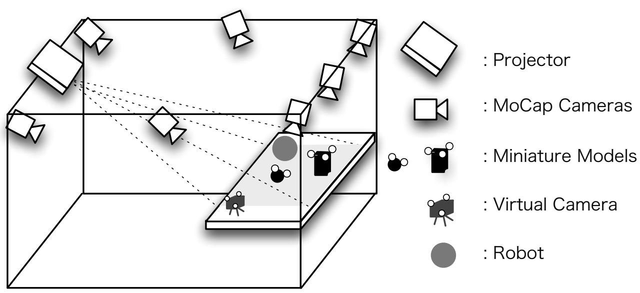

Figure 2: The physical configuration of the prototype. The prototype consists of a projector, 8 motion tracking cameras, miniature models, a virtual camera and a robot. The size of the table is 1.5m $\times$ 0.9 m.

3.2 Demonstration

We performed a feasibility study using our prototype. In the study, we attempted to record a scene in which two characters toss a ball back and forth, as shown in Figure 1. We set events as follows. 1) Each character can toss the ball when the ball is placed near the character and a user rotates the character. 2) When the character catches the ball, a visual effect (shown in Figure 1) is added to the scene. The feasibility study consisted of two main phases: event implementation and puppetry. In the event implementation phase, events were implemented using the Unity environment and a C# based programming language. Coding the event implementation required approximately 1 hour. In the puppetry phase, two men with no 3D animation experience successfully created and recorded a scene in which two characters performed the ball-tossing game.

From the study, we found that our concept helps inexperienced users to create 3D animations. However, the study highlighted several flaws in the prototype. We discuss these flaws in the next section.

4 Concluding Remarks

In this paper, we presented a new concept for creating 3D animation using puppetry in a miniature space. The concept consists of two spaces: the real and virtual spaces. These two spaces are interconnected by two key technologies: motion-capturing and projection-mapping technologies. These technologies realize mutual enhancement between the real and virtual spaces. Specifically, our concept realizes the following:

- It allows users to puppeteer 3D characters by directly manipulating the miniature models.
- It brings physical constraints of the real space to the virtual space to improve the representation of physical expressions.
- It reflects virtual space events in the real space using robots.
- It enables users to create repetitive step-by-step 3D animations.

We developed a prototype on the basis of our concept and performed a feasibility study. The study showed that our concept assists inexperienced people to create 3D animations and revealed several flaws of the prototype. Certain challenges are as follows.

Repetitive scene creation Since we used only one ball-shaped robot in the prototype, we could not evaluate repetitive scene creation. To evaluate this feature, we must create robot chassis for miniature models and implement certain functions to realize this feature within the virtual space. In future, we aim to incorporate and evaluate this feature using a new prototype.

Movement prediction Our prototype requires three steps, capturing, rendering and projecting, to project a texture onto a miniature model. Since each step can be a lag element, the projection often separates from its correct position when the miniature model is in rapid motion. Movement prediction may prove to be an effective method in solving this problem. We expect to use robots because their motions are initially predictable. This enables effective projection of images onto the robots.

Movement prediction technology is applicable when a user interacts with a miniature model. In this situation, the movement prediction of a miniature model corresponds to the movement prediction of a user movement. We aim to apply such prediction models in our future study.

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