MR-Based PreViz Systems for Filmmaking: On-set Camera-Work Authoring and Action Rehearsal

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Abstract

This paper describes pre-visualization systems using mixed reality (MR) for filmmaking. We have promoted and conducted the MR-PreViz project which includes this research and systems since Oct.2005. In the pre-production stage of today's filmmaking, PreViz, pre-visualizing a desired movie scene with CGI, is used for sharing final images of movies. MR-PreViz is an advanced approach that utilizes MR technology in PreViz.

MR-PreViz makes it possible to merge real backgrounds and the computer-generated humans and creatures in an open set at an outdoor location. We have successfully developed the first version of the MR-PreViz system including action editing tools for arrangement of action sequences and camera-work authoring tools for camera-work determination. Thus, the MR-PreViz system consists of many subsystems.

At the ISMAR 2007 main symposium, we demonstrate two MR based subsystems which are used on the set in MR-PreViz. The first one is a MR image capturing and compositing system which is the core hardware of MR-PreViz system. The second one is the MR based action rehearsal system. This system enables users to practice sword fighting actions while confirming enemies' actions through a head mounted display in front of them. These two demonstrations with the physical set attract users to our technology while feeling immersed in a movie.

Categories and Subject Descriptors

H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities

General Terms

Performance, Design

Keywords

mixed reality, filmmaking, pre-visualization, action rehearsal, camera-work authoring

1. Introduction

According to developing mixed reality (MR) technologies, many entertainment applications of MR technology are proposed [1, 2]. This indicates that MR technology has an ability to become a widely used method for creators of art and entertainment. As is well known, movies are the highest peak of entertainment. Therefore, the film industry has huge market and potential. Technologies which increase efficiency in filmmaking are required.

In the preproduction stage, storyboards have been traditionally used to illustrate the director's intention. However, it is not difficult to imagine the limitation of storyboards for smooth image interpretation. Recently, pre-visualization (PreViz) [3], which is sometimes called animatics, has been used to further develop the storyboard. PreViz is a technique based on computer generated images for visualizing action scenes, camera angles, camera blockings, lighting conditions, and other situations and conditions before the actual shoot.

To these ends, we have already started the MR-PreViz project that aims to develop technologies assisting filmmaking by utilizing MR technology [4]. MR-PreViz makes it possible to merge real backgrounds, and computer-generated humans and creatures in an open set at an outdoor location. At the ISMAR 2007 symposium, we demonstrate two subsystems for disclosure and evaluation of the progress of the project. This paper primarily introduces the progress mainly of these demonstrations. An overview of the MR-PreViz project is introduced in section 2.

2. MR-PreViz project

2.1 Basic concept of MR-PreViz

The typical filmmaking process has the following three stages:

- Preproduction stage: Planning, scripting, casting, location hunting, writing storyboards, and constructing props
- Production stage: Rehearsals, actual shooting, and special effects
- Postproduction stage: Film editing, sound mixing, and visual effects (VFX)

MR-PreViz consists of many subsystems to provide PreViz movies by superimposing pre-produced CGIs onto the actual shooting scene in the preproduction stage. It is the same as "2001: An MR-Space Odyssey" [5] in that CGIs are superimposed onto actual scenes. However, our MR-PreViz is mainly targeted to be used outdoor and not only in a motion picture studio. Thus, the MR-PreViz movies are made at the location site by trying various camera positions and angles and by changing footage and/or camera blocking. At the same time the camera-works are marked up and stored as digital data to be used in the actual shooting.

2.2 General workflow

In filmmaking, the first step is to establish a plan and to make a plot based on that plan. A screenplay is written next where you can find actors words and actions. Traditional storyboards and full CG PreViz are used at this stage to visualize ideas of an author or director. MR-PreViz is not a replacement for these traditional

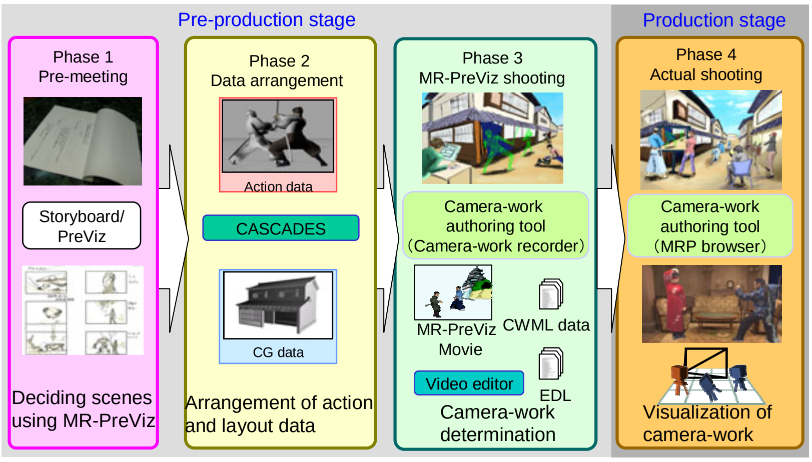

Figure 1 Workflow of the MR-PreViz

PreViz techniques but actually a powerful assistant to effectively visualize scenes that are not easily expressed.

The Workflow of filmmaking using our subsystems is as follows shown in Figure 1.

(1) Selecting scenes suitable for MR-PreViz

Selects scenes that should be checked using MR-PreViz, after making rough PreViz of full CG.

(2) Preparing data materials required

Collects CG character data, animation setting data, and action data before making MR-PreViz movies. Action data of different kinds have to be edited using CASCADES at this stage. CASCEDES is a subsystem of MR-PreViz introduced in latter chapter of this paper.

(3) Placing CG objects

Designs MR space by placing CG objects and action data collected and edited in step (2) above in the coordinates of the real world using CASCADES on a PC. This is a preparation before going to the shooting site.

(4) Making MR-PreViz movies at the shooting site

Contextualizes the layout made by CASCADES to the MR space at the actual shooting site and performs MR-PreViz using Camera-Work Authoring Tools. By repeated trial and error at this stage, you can significantly reduce the cost of actual film shooting.

(5) Application to actual shooting

Applies movies and data taken in the step (4) to the actual shooting. Actors and staffs can share ideas and images by seeing MR-PreViz movies shown on the MRP browser [4].

2.3 On-set MR-based systems in MR-PreViz

On-set visualizing subsystems are core of MR-PreViz project. Moreover, this is the most appropriate example to utilize the expressive power of MR technology in MR-PreViz. For on-set systems, we propose following the subsystems, detailed below, in MR-PreViz:

- **MR-PreViz image capturing and compositing system** renders MR-PreViz composite images for indoor and outdoor environments using a digital HD camera and rotary encoders. This is the core hardware system of the camera-work authoring tool. This system aims to support camera-work intuitively by using an actual shooting camera. This system is assumed to be used in phase 3 of the workflow mentioned in 2.2.
- **MR-based action rehearsal system** visualizes MR composite images from the first-person perspective for action rehearsal. The users of the system practice action while confirming another person's action viewed in front of them through a head mounted display (HMD). This system is assumed to be used after phase 4 and before phase 5 of the workflow.

The supporting system for filmmaking utilizing MR technologies has already been proposed in [5]. This system implemented in the on-set VFX system enables the visualization of VFX in real-time from a first-person perspective and an objective view simultaneously.

Compared to this system, our systems have the following differences.

- The goal of the MR-PreViz project is pre-visualizing final images of the movie at the pre-production stage in filmmaking
- Compared to the image quality of the MR composite image in [5], MR-PreViz enables rendering in high definition (HD) level MR composite imaging by using offline rendering
- Synthesized CG character's action scene is priory recorded and designed by using our design tool. 3D Videos [6] are newly adopted as action data for recording the appearance of action with clothes

At the ISMAR 2007 main symposium, we demonstrate these MR based systems which are used on the set.

In the remainder of this paper, we introduce the technical details of these demonstrations and related technologies.

3. MR-PreViz image capturing and compositing system

3.1 Overview of the system

In the MR-PreViz system, pre-visualizations are generated for sharing images of the final movie and for considering camera-work and camera blocking. The targets of our MR-PreViz system are scenes where computer-generated creatures or vehicles play

Figure 2 Aspect of MR-PreViz image capturing and compositing system
(Left: Appearance, Right: Screenshot of composite images)

some role and also live action scenes where actors play her/his roles.

To composite real backgrounds and CGIs, MR-PreViz image capturing and compositing system, which is a core hardware system in MR-PreViz shooting, is introduced in this demonstration. This system aims to be a supporting tool for determining camera-work, camera blocking, and framing while adhering fundamentally to traditional style of filmmaking. Therefore, the dedicated equipment for filmmaking such as a digital HD camera (Sony HDW - F900R), a zoom lens (Canon HJ22ex7.6B IASE), a tripod, and a camera head are adopted for this system. Rotations of camera, panning and tilting angles, are detected by the rotary encoder built on the tripod for superimposing CGIs into camera images. Lens-related parameters such as zoom value and focal length are also detected by the lens encoder built in the zoom lens and are utilized for composition. By using this information, MR-PreViz image capturing and compositing system renders and visualizes MR-PreViz movie in real-time at the shooting site. Figure 2 shows aspect of the system in the set and composite image rendered by the system.

3.2 Camera-work authoring

In MR-PreViz, we define "camera-work authoring" as the collective term that indicates the process for determining framing, action scenes, position of the camera, camera angle, camera transition, and camera blocking by the director with collaboration from the cinematographer. To increase efficiency of these creative works, we are developing camera-work authoring tools [4].

With the increasing number of participators in today's epic movies, it is difficult for the director to communicate with his staff without them misunderstanding his ideas. In this research, we aim to propose supporting tools which enable a director to communicate with a staff by visualizing his/her ideas.

In particular, the following three functions are proposed for the authoring tools:

(a) Determining camera-work by visualizing composed images while manipulating a real camera

(b) Recording the result of the determining camera-work in CWML

(c) Visualizing and interpreting recorded data

The function of (a) and (c) are utilized in Phase3 and Phase4 of Figure 1 respectively. The function of (b) is aimed to be an intermediate between them. MR-PreViz image capturing and compositing system are used for (a).

3.3 Demonstration of the system

As mentioned before, we demonstrate the MR-PreViz image capturing and compositing system at the ISMAR2007 symposium as an introduction of the core hardware of the MR-PreViz project. The features of the demonstration are as follows.

Methods for composition of real backgrounds and CGIs using chroma-key or rotary encoder are already available in shooting studios. However, they are limited to indoor use. Meanwhile, methods of composition for mixed reality with HMD (head mounted display) are also proposed. This system aims to realize indoor-outdoor systems to pre-visualize the movie scene with the dedicated camera for filmmaking.

Compared with conventional PreViz, our system has an advantage that users can determine camera-work intuitively by confirming composite images which utilized real backgrounds in

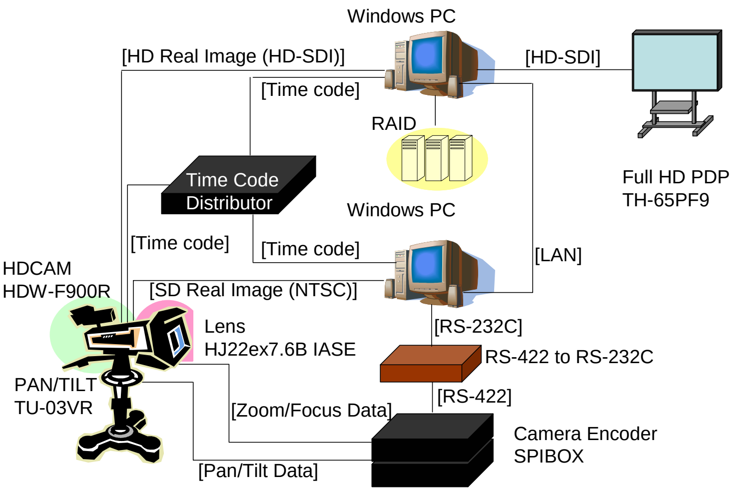

Figure 3 System configuration

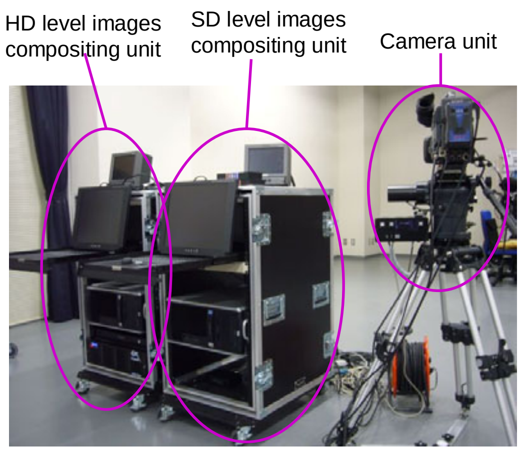

Figure 4 Aspect of MR-PreViz image capturing and compositing system

real time at the shooting site.

In addition, our system has an advantage of higher image quality. The system visualizes not only SD level MR-PreViz images, but also HD MR-PreViz images by offline rendering using stored images in a RAID system and recorded camera motion information. Our system suggests confirming SD level MR composite images in real-time and rendering HD level MR composite images which contain the same objects with the earlier, non-real-time one.

3.4 System configuration

Here we introduce the system configuration of the MR-PreViz image capturing and compositing. The system configuration is shown in Figure 3, and the appearance of the system is shown in Figure 4.

3.5 Scenario of the demonstration at ISMAR

To increase the reality of the demonstration related to filmmaking, we assumed the demonstration place as the shooting site of kung-fu movies, and decided to construct the studio set base off of a street in Asia such as in Hong Kong. Computer-generated kung-fu actions are superimposed onto a real background.

With this scenario, the flow of the demonstration actually experienced by users is as follows:

1. Arrangement of the camera in the demonstration space where the look is similar to that of a shooting site
2. Measuring the interior and exterior parameters of the camera
3. Superimposing animation of CG characters whose actions are recorded and designed earlier as shown in the right image of Figure 2 onto a real background within the system
4. Determining camera-work while confirming composite images in real-time
5. When camera-work is decided, offline rendering of HD composite images (HD MR-PreViz movies) is started
6. After above offline rendering, the user can review the HD MR-PreViz movie

In this demonstration, we will let the audience experience 4. and 6. to understand our system.

4. MR-based action rehearsal system

4.1 Background

In the MR-PreViz project, actions are recorded and collected beforehand by using motion capture (MoCap) and 3D Video technology. This action data is edited and placed in 3D-CG space using CASCADES (Computer Aided SCene & Action DEsign System). CASCADES is a subsystem of the MR-PreViz that enables the reconstruction of action scenes performed by many actors by combining solo action. Edited Action data is superimposed onto the real scene at MR-PreViz shooting.

To realize these concepts, we require several visualizing techniques to design the action scene as follows:

- Visualizing from an arbitrary viewpoint in 3D-CG space
- Visualizing composite images in which action data is superimposed onto the real background from an objected point of view by a camera
- Visualizing the composite images from a first-person perspective

In this research, we aim to visualize action scenes from a first-person perspective to confirm real-size action and action rehearsal. To this end, we propose the MR-based action rehearsal system as a subsystem of MR-PreViz.

4.2 Overview of MR based action rehearsal system

This system is the MR-based action rehearsal system for actors who are inexperienced in fighting action. The users of the system can practice with real-size CG enemies in front of them viewed through a video see-through head mounted display. We propose a novel rehearsal method that enables one-person to act correctly while confirming the other person's action. Therefore, users can confirm timing and position of their action. As a first step, we apply this method to sword fighting action. We adopt a sword device as an interactive device. The device enables collision detection and evaluation of user's action simultaneously.

4.3 Prior action consideration using recorded actions

CASCADES has the following functions to support designing an action scene intuitively and interactively.

(1) Coexistence of various types of action data

CASCADES can handle various types of action data including MoCap, 3D Video, and hand animated action data. MoCap and hand animated action are imported with CG character model as FBX format file by using Autodesk MotionBuilder. "3D Video" is a technology that allows one to reconstruct an image seen from any viewpoint in real time from video images taken by multiple cameras [6]. It is a kind of video-based rendering and is sometimes called "Virtualized Reality" [7]. We adopted the method developed by the Kyoto University [8]. 3D Video data is inputted as polygon data and color information of every point as .x file format. Because these data types are polygon data types, the data can be drawn using OpenGL or DirectX graphics libraries. However, to handle different file types of action data, we face another problem of the differing sampling rates. The sampling

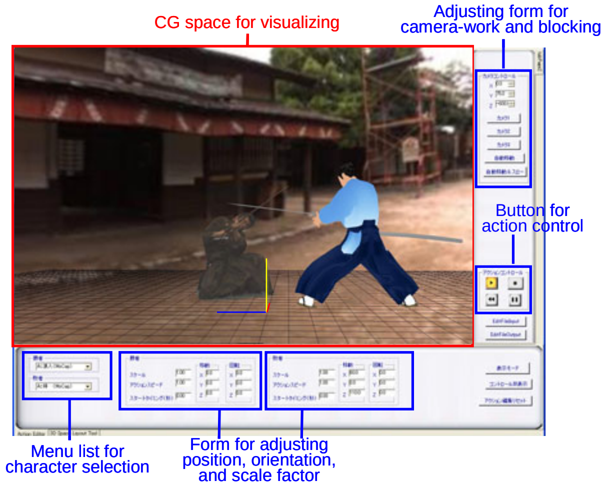

Figure 5 Screenshot of CASCADES

rate of current 3D Video data is lower than that of other types of motion data. We solved this problem by the nearest-neighbor approximation on the time axis.
(2)Adjustment of action data

CASCADES can arrange action data at arbitrary positions with arbitrary orientations and scale factors. These functions are manipulated by using the GUI shown in Figure 5. The user can design action scenes interactively with arbitrary camera-work and camera blocking. CASCADES also has a function of semi-automatic adjustment for action speed and initial position of action.

4.4 Elemental technologies of the MR-based action rehearsal system

4.4.1 Semi-automatic adjustment for timing of action and initial position of action

To construct a sequence of action which is composed of individually recorded action data, semi-automatic adjustments are performed. Reference points which correspond appropriately with position and timing are specified spatiotemporally for optimization of initial position and timing of actions. Nowadays, head to head sword fighting is assumed as an action scene. The adjusting of the actor alters the timing and position to correspond with those of the reference actor. Timing is altered before adjusting initial position.

4.4.2 Key Frame and Timing Controllable Frame

Key Frames (KF), a frame in which two character's actions are intersected, is assigned to adjust timing. Timing Controllable Frames (TCF), frames which don't affect feeling sensitively when playing speed of action are changed, are also assigned. Finally, playing speeds in TCFs are adjusted to correspond each actor's timing of KFs. The conceptual diagram of the adjustment of timing is shown in Figure 6.

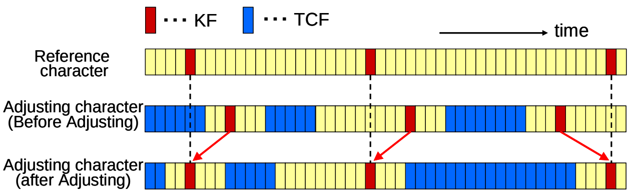

Figure 6 Adjustment of timing

4.4.3 Contact Point

Contact Point (CP), a position in the two characters' actions intersected in KF, is assigned to adjust initial position of actor. In the case of sword fighting action, CPs are the intersected points of the swords of each actor. CPs are assigned with respect to each KF. Initial positions of actions are determined so that the sum of the distinction between corresponding CPs is minimized.

4.4.4 Result of semi-automatic adjustment

Result of the semi-automatic adjustment of timing and initial position of sword fighting action is shown in Figure 7. This shows the difference between the before and after application of the method. From these result, we can confirm that actions are successively adjusted for timing and initial position in KFs by our method.

Figure 7 Adjustment of initial position

Figure 8 Screenshot of the action rehearsal system

4.5 Demonstration of the MR-based action rehearsal system at ISMAR 2007

As mentioned before, we demonstrate the MR-based action rehearsal system at ISMAR2007 symposium as example demonstrations of visualizing action scenes from a first-person perspective. The scenario of the demonstration is as follows:

- The story of the demonstration is that the samurai, who is the hero, forces himself on the residence kept by the boss of the rascal to seek justice
- The system is demonstrated in an imitated set of an old samurai residence
- The users play the role of the hero while confirming the MR composite images from a first-person perspective through a HMD. A screenshot of the user's view is shown in Figure 8
- The users fight against the rascal, 2 close confidents of the boss, and the boss respectively in 3 stages
- The action of the enemies are fixed, so the users only have to is put their sword device on the proper point of the enemies' action
- If the user's sword and the enemy's sword hit each other, a sound is played and the device is vibrated
- The user's actions are evaluated by their precision of handling the sword
- Subjective view of the demonstration is shown by the audience

4.6 System configuration

The MR-based action rehearsal system consists of the Canon MR Platform System [9] with the Canon VH-2002 video see-thorough HMD, the sword device attached with a Polhemus magnetic sensor, and a vibration device. The sword device detects their position by a magnetic sensor and the vibrations are controlled by RBIO. In addition to the PC for the first-person perspective, the PC for subjective view is also composed into the system. The

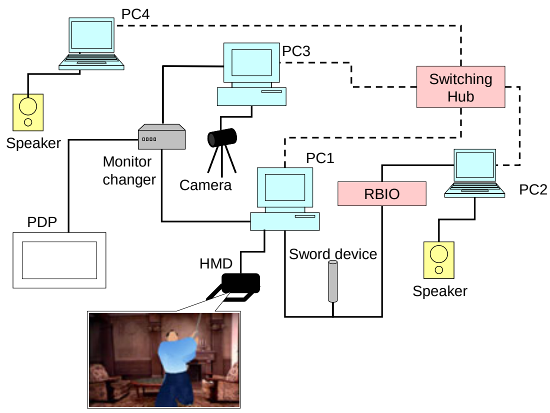

Figure 9 System configuration of MR-based action rehearsal system

Figure 10 Sword device

system configuration is shown in Figure 9. The sword device is shown in Figure 10.

5. Conclusions and future works

This paper introduces an on-set, MR-based systems used in the MR-PreViz project. We believe that demonstration at ISMAR 2007 will indicate the potential of the MR-PreViz while being an enjoyable experience.

For practical application, there are some limitations and problems which we have to work out.

The MR-PreViz image capturing and compositing system is limited in its movement to only panning and tilting. We already adopt the IS-900 ultrasonic sensor to detect camera movement as 6DOF for indoor space. It is not advisable to rely on mechanical sensors when increasing the degrees of freedom of the camera-work from two to three and four. The vision-based tracking method is considered promising while considering the degree of freedom in outdoor environment. If we can attain geometric correspondence by the vision based tracking method [10] or some other method, a method to achieve photometric correspondence between outdoor scenes and CGIs should be devised. Even if our MR-PreViz movies are successful, the weather conditions may differ from those of the actual shoot.

A MR-based action rehearsal system needs to consider how best to support the actors. We plan to research visualizing methods and support features such as changing action speed adaptively. The sword device also needs improvement with the method of force feedback.

The PreViz technology cultivated throughout this project has applications other than just films. In addition, theatrical performances or live events in outdoor environments can be effectively pre-visualized and successfully simulated.

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