Full-Scale Visualization of a Person on a Movable Transparent Screen

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ABSTRACT

We propose to visualize pre-recorded activity of a person on a movable transparent screen for *in-situ* reviewing of his/her activity in augmented reality fashion. Activity of the target person was taken as a video by a surveillance camera. Viewers can watch the activity in the scene as if it happened there because segmented image of the target person was projected onto a human-size transparent screen and other static objects around the target person can be visible throughout the transparent screen. Our final goal is to move the transparent screen by mounting it on a small robot and moves the robot to follow the target person in the video. On the way to the final goal, we currently assume that the viewers move the screen manually so as to pose the screen at the same location of the target person in the video. A tracking method of the transparent screen in the scene is devised by utilizing projector-camera calibration and simple infrared marker tracking.

Keywords: Spatial augmented reality, projector camera calibration, infrared marker, surveillance camera

Index Terms: H.5.1 [Information Interfaces and Presentation]: Artificial, augmented, and virtual realities; H.5.2 [Information Interfaces and Presentation]: Interaction Styles

1 INTRODUCTION

On watching pre-recorded behavior of people in a scene take by a surveillance camera, it is important to align the virtual image of the people to the real scene surrounding them. Our research focuses to invent a new AR system by which viewers in the same scene can watch the prerecorded activities of a target person in a full-size and recognize its spatial relationship to the scene.

Spatial Augmented Reality[1][2] is a promising methodology to review the target person's motion that was taken by a surveillance camera so that a number of viewers can join *in-situ* reviewing in the scene where the original motion was made. Since our visualization method is expected to be applied to any scene where surveillance cameras are installed, it implies single prerecorded video stream is usually taken by only a single camera, and it results in the fact that full 3D property of the motion cannot be obtained.

We propose to visualize pre-recorded motion of the target person on a movable transparent screen for *in-situ* reviewing of his/her activity where the pre-recorded motion is obtained from one single video stream taken by a surveillance camera in the scene. The target person is segmented from the recorded video and the segmented region is projected onto the transparent screen. Since the transparent screen is moved by reviewers, the segmented region is warped on the screen so that the warped region becomes a cut surface of the set of the lays from the target object to the focus of the surveillance camera.

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The idea of presenting a virtual person in a real scene has been realized by telepresence robots such as Doubles from Double robotics, Beam from Suitable Technologies, etc. However, it does not aim to present whole body motion because it needs human size display.

As for the large objects in a workspace, active projection-mapping could be made on texture-less movable object to present dynamic texture change on the object[3]. The human shaped white mannequin may work as a screen of projection mapping, but pose change could be the problem.

Since only one recorded video is taken at a fixed camera in our research setup, planner presentation of the image of the target person's motion is adopted. By setting the projector in a scene so that it can cover the recordable area of the camera, the transparent screen can be set anywhere in the area. The recommended place of the transparent screen is the target person's position in the scene. When he/she moves in the recorded video, the screen should be moved accordingly. The screen should be oriented to face the camera optical axis squarely. But it could be changed to have a better view of the image on the transparent screen as the spatial relationship between the projector, the screen, and the viewer may affect its visibility.

Our transparent screen is made by a very thin vinyl sheet spanned over a plastic frame. It is light enough to carry by a viewer and it could be mounted on a small robot in the future.

2 SCREEN TRACKING

Since the location and orientation of the transparent screen change, precise pose estimation is needed for later projection mapping process. We call this process screen tracking. We use infrared marker and infrared camera for that purpose because ordinary visible markers and/or object tracking may be affected by the strong light from the projector.

The infrared marker is just a set of tape which forms a marker square at the lower part of the transparent screen (Figure 1). By detecting the marker square in the infrared camera image, the 2D position of the four corners of the marker square is estimated. The four corners of the transparent screen is calculated based on the relationship between the infrared marker square and the corners of the screen.

Since the image warping was made under planner constraint, no explicit 3D pose estimation is needed.

3 PROJECTING MOTION ON THE SCREEN

A projector is placed when a viewer wants to review the motion of the target person in the scene. The projector should be placed so that it covers the recordable area by a surveillance camera (Figure 1).

The target person in the video was manually indicated by the viewer and the corresponding image region is segmented from the video by conventional computer vision approach.

In order to warp input video that includes the segmented region, the spatial relationship among the infrared camera, the transparent screen, the projector, and the surveillance camera should be obtained. We decompose this into three relations:

(1) Infrared camera - screen

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(2) Infrared camera - surveillance camera
(3) Infrared camera – projector

Note that the two cameras and the projector does not move on reviewing. The process (1) is explained in the previous section.

The calibration (2) between two cameras can be done by applying Zhang's method[4][5] because the infrared camera can capture the image in ordinary visible light too. It is done when the infrared camera is set to the scene. It is better to place the infrared camera close to the surveillance camera so that it can cover the same recordable area.

The calibration (3) between the infrared camera and the projector is done by a projector-camera calibration process. We adopt Moreno's method[6] because it only needs a chessboard and it does not care the layout of objects in the scene.

By obtaining these three pair of calibration, the segmented region of the target person in the recorded video captured by the surveillance camera can be warped for projection from the projector. It could be formulated as a series of homography projection. The projected region on the transparent screen corresponds to the cut surface of the set of lays from the target object to the focus of the surveillance camera at a given position and orientation of the transparent screen.

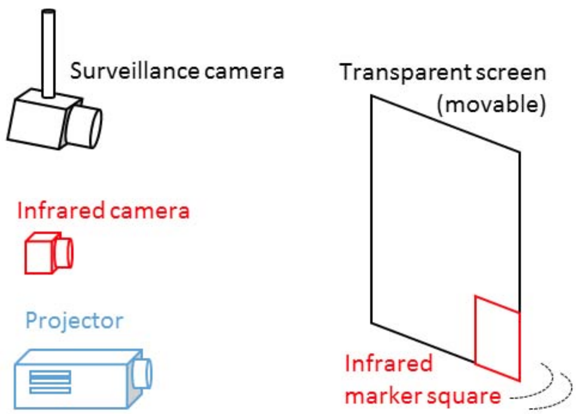

Figure 1: Cameras, projector, and the transparent screen.

4 DISCUSSION

We have implemented a preliminary system of reviewing the recorded motion of the target person in a scene. A snapshot of the review is shown in Figure 2. The surveillance camera and the infrared camera were both set at about 1 meter behind from the place where this snapshot was taken. The transparent screen is the size of 1×2 meter and the infrared marker square of which size is 25 cm by 25cm could be found at the lower right part of the screen. The resolution of the surveillance camera was 640×480 pixels. .Motion of the target person was visualized on the transparent screen and surrounding objects in the scene were visible through the clear part of the screen as shown in Figure 2.

When the target person moves in the video, the transparent screen should be moved by a reviewer accordingly so that the screen keeps the standing position of the target person. The new pose of the screen is estimated by the calibration step (1).

There are some limitations on our current implementation.

Planner and one side representation: Since the video was taken by one camera, back side of the person cannot be seen. Therefore, reverse side of the transparent screen should not show the texture of the person. One solution may be that the segmented region is represented by only a silhouette when a reviewer comes to see the reverse side of the screen. But this solution needs reviewer tracking. In addition, it is not available for multiple reviewers.

Misplacement of the screen: So far as the calibration (1) is accurate, the visualized region on the screen is always optically correct, but it does not mean the textured region on the screen indicates the real size and the real position of the target person if the screen is misplaced.

Light leak: Since the current projector cannot shut light for black color completely, a certain amount of light is projected to the surrounding environment through the clear part of the screen. Moreover, some amount of light of the segmented region goes through the screen and it lights up the objects behind the screen. In Figure 2, a part of the ceiling is strongly lit because the projector was set on the ground. It could relieve if appropriate luminous transmittance is chosen for the vinyl screen material and control of brightness of the projector, but it may cause darker visualization and/or worse view of the objects through the transparent screen.

Figure 2: A snapshot of visualization on a full-scale transparent screen.

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