Active segmentation for immersive live avatar

S.-Y. Lee, I.-J. Kim, S.C. Ahn and H.-G. Kim

An improved segmentation method of the human body with optical IR-keying and image-based active illumination is presented. This approach provides effective generation of photo-realistic live avatars in an immersive display environment for tele-interaction.

Introduction: Recently, spatially immersive display environments such as CAVE^{TM} have become increasingly significant and collaborative high fidelity virtual worlds have been researched extensively where live avatars represent human beings of remote participant [1, 2]. Nevertheless, there still remain limitations of object segmentation from the dynamic background of display screens owing to the low lighting condition of the immersive environments, making it difficult to acquire realistic texture data for the live avatar. In [2], a synchronised stroboscopic light and shutter glasses are used to capture a vivid human image in immersive environments, but the system requires expensive hardware equipment and users must wear shutter glasses. Image-based illumination of physical objects has also been reported [3]. However this algorithm needs exact 3D information of the physical objects.

In this Letter we present a real-time robust method that provides a realistic avatar image using active segmentation in immersive environments. The suggested active segmentation method consists of optical IR-keying segmentation and active illumination. The texture of the segmented image is enhanced by illuminating only the moving objects with image-based active projectors, providing high-quality realistic texture acquisition for the live avatar while preserving the user's immersive display environment. This enables one to communicate and interact with the live avatar in immersive display environments for tele-presence or a distributed collaborative environment.

Real-time segmentation with optical IR-keying: The optical IR-keying system consists of an IR-keying camera and retro-reflective IR screen as shown in Fig. 1. The IR-keying camera consists of an IR illuminator, a colour video camera and an IR camera to capture the texture of the physical object and the IR segmented silhouette images, respectively. These image sequences are fed to the PC through an IEEE-1394 for further processing of image enhancement to provide image-based active illumination, as shown in Fig. 3. The same camera model of fire-i 400 from UNIBRAIN with a 3.5 mm lens is used and aligned to provide coincident nodal points using a cold mirror that reflects short wavelengths of visible light and transmits long wavelengths of infrared.

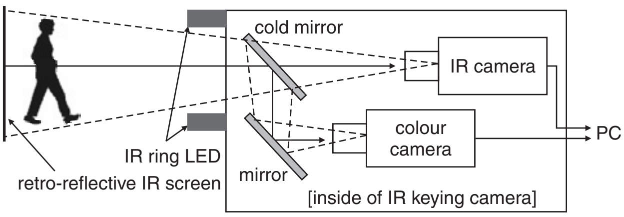

Fig. 1 *Optical IR-keying for real-time object segmentation*

An important property of the proposed optical IR-keying system is that the intensity of IR reflected from the object is much lower than that reflected from the retro-reflective IR screen material. The retro-reflective IR screen is made by coating retro-reflective IR film on the rear-projection screen material from DALITE such that it reflects IR signals illuminated from the IR-keying camera while displaying images on the screen projected by rear projectors. The reflected matt image is processed with binary operation to generate correct silhouette images for 2D live avatar composition.

Active Illumination of dynamic objects: The output of the real-time IR segmentation is also used as an input of the image-based active illumination projector, as shown in Fig. 2. The active projector illuminates only the moving physical objects in the immersive display environment to provide a realistic texture for the live avatar to the colour video camera in the optical IR-keying system. The operation of the image-based active illumination projector can be modelled using the duality of the standard pinhole camera model. In the proposed system, the duality of the camera and projector is achieved by aligning the optical axis of the projector and the optical axis of the IR-keying camera using a beam splitter. This provides exact silhouette illumination on the object without accurate 3D information of projectors, cameras, physical objects and display surfaces. This active illumination of projector and the IR-keying camera configuration provides well aligned relationship between the input image of the projector and the silhouette shape of the moving object observed by the projector's view.

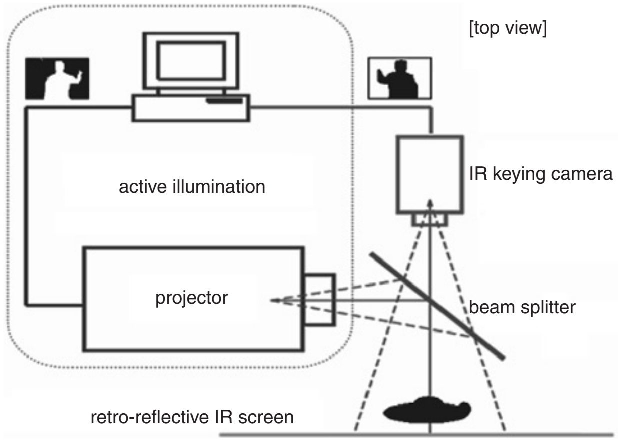

Fig. 2 *Active segmentation system configuration*

Fig. 3 shows the flow chart of processing to create live avatars based on the proposed active segmentation. The optical IR-keying system captures the shape of moving objects from the projector's view. This segmented silhouette image is used both for the avatar composition and image based active illumination. The warping operation in the process is performed using calibration parameters to correct the distorted images and also compensate for the misalignment of the geometry setup. The warped image is then used as an input image of the projector illuminating only the moving objects with white light by the projector.

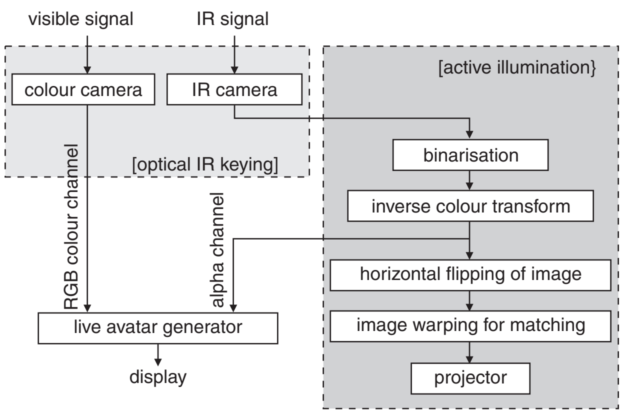

Fig. 3 *Flow chart of image-based active segmentation algorithm*

In the avatar generation process, the alpha channel generated by the processed IR image is added to combine the virtual world with the captured image using alpha-blending and multi-pass rendering.

Fig. 4 shows resulting images of the various stages of the processing; Fig. 4*c* is the result of the texture image with proposed active illumination and Fig. 4*d* is the segmented texture image of the human body using the active segmentation.

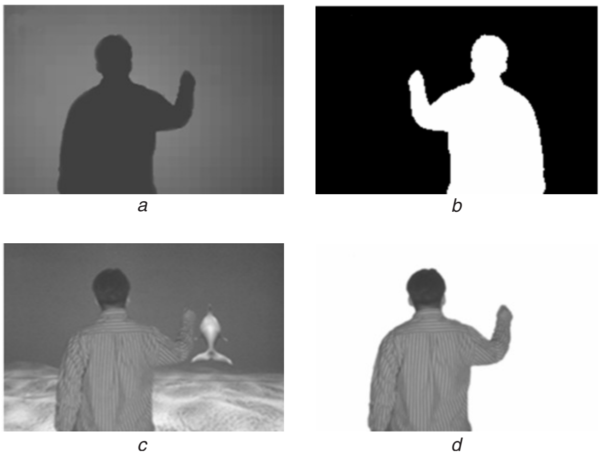

Fig. 4 *Resulting images*

a Captured image from IR camera in CAVE-like environment
b Input image of projector
c Captured image from colour camera with proposed active illumination
d Segmented image using active segmentation

Conclusions: To create effective live avatars for tele-presence or tele-interaction, it is desirable to obtain an exact and realistic image of the human body in the immersive display environment. A real-time robust method of active segmentation in immersive environments is presented based on IR segmentation and image-based active illumination. The proposed approach can segment human bodies with unconstrained background, and preserve original textures with completely spill-free segmentation of the objects. The resulting realistic texture image of dynamic human bodies can be combined with the images of the virtual environment. A future version of the proposed system will be used for real-time 3D reconstruction based on Shape from Silhouette (*SfS*) in a CAVE-like environment.

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