pARnorama: 360 Degree Interactive Video for Augmented Reality Prototyping

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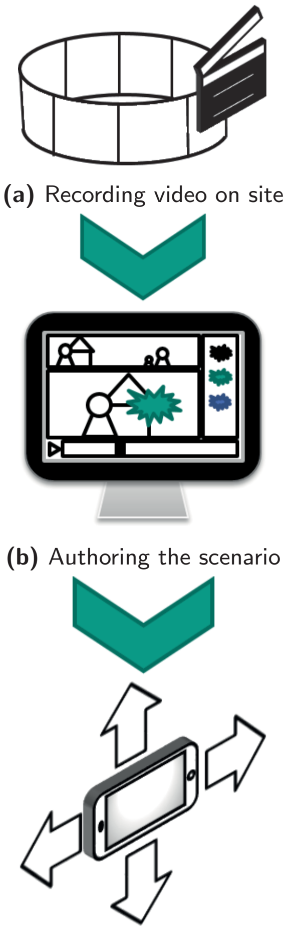
Abstract
Designing novel and meaningful interactions in the domain of Augmented Reality (AR) requires an efficient and appropriate methodology. A user centered design process requires the construction and evaluation of several prototypes with increasing technical fidelity. Although the main content of the application can already be conveyed with prerendered video, one of the main interactions in AR - the user-selected viewpoint - is only available in a very late stage. We propose the use of panoramic $360°$ video for scenario based user evaluation, where the user can select his point of view during playback. Initial users report a high degree of immersion in the constructed scenario, even for handheld AR.

Author Keywords
Augmented Reality, Mobile, Prototyping

ACM Classification Keywords
H.5.1 [Information interfaces and presentation (e.g., HCI)]: Multimedia Information Systems—Artificial, augmented, and virtual realities; H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces—Prototyping.

General Terms
Design, Experimentation, Human Factors



(a) Recording video on site

(b) Authoring the scenario

(c) Playback on the device

Figure 1: Simple three-step workflow for video prototyping.

Introduction

Modern mobile and wearable computing devices with steadily increasing capabilities, provide the basis for Augmented Reality (AR) applications that can support the user in a wide range of daily activities.

There are several SDKs available, which provide complete platforms including user and object tracking algorithms, as well as integration of the virtual content. Still, the design of new and meaningful interactions for mobile applications stays a very challenging task. The small number of documented experiences and also lack of clearly formulated design guidelines complicate the problem for AR systems. A common approach in this case is to test one or more aspects of the design in user evaluations by creating several prototypes [3][1].

In this work we focus on a user centered design methodology for the development of AR applications. This approach creates interactions in multiple iterative cycles using prototypes of increasing complexity. As a new prototyping method we propose the use of panoramic $360°$ video to easily create evaluation scenarios that can provide the full range of interaction modalities. The implemented tools and procedures as well as initial findings are described in this paper.

User centered design for AR

As AR applications rely heavily on user interaction, user centered design is considered a suitable approach for these systems [5]. There have been some adaptations to accommodate for the special nature of mixed reality systems [1], but the basic principle is preserved. Starting from initial formative user studies and prior experiences, prototypes are developed in an iterative process. Each iteration builds on the usability evaluation of the previous prototype and therefore the technical fidelity is increasing in each step. Small steps are favored to reduce the impact of repeating an iteration. For this to be efficient, prototypes need to be created fast and easy, often using only creative tools like pen and paper or digital equivalents in the early stages, avoiding the need for programming.

Previous work proposed recording and editing video as basis for AR application prototypes [4]. The simple workflow is shown in figure 1 and consists of three steps. First a video is recorded in the intended target environment. This is then augmented offline using video editing software to show the planned features. It is then played back on the AR display in the target environment for user evaluation. Although these prototypes can already convey the intent of the application, they provide no or only little interactivity. What is especially lacking is the users ability to choose its own point of view.

pARnorama

We propose the construction of a scenario in a virtual environment which the user can explore on its own. Our implementation of this idea is the use of panoramic $360°$ video as base material, which is augmented offline using standard tools. An example of such a recording in an unreeled and undistorted format is given in figure 2. During playback, the user is then able to select his own section of the full recording using the orientation sensors of the mobile device. With this novel approach it is easy to create detailed scenarios very early in the design process, which already provide one of the core interactions of AR systems.

Implementation

Our current implementation offers tools and procedures for all three steps of the video prototyping workflow

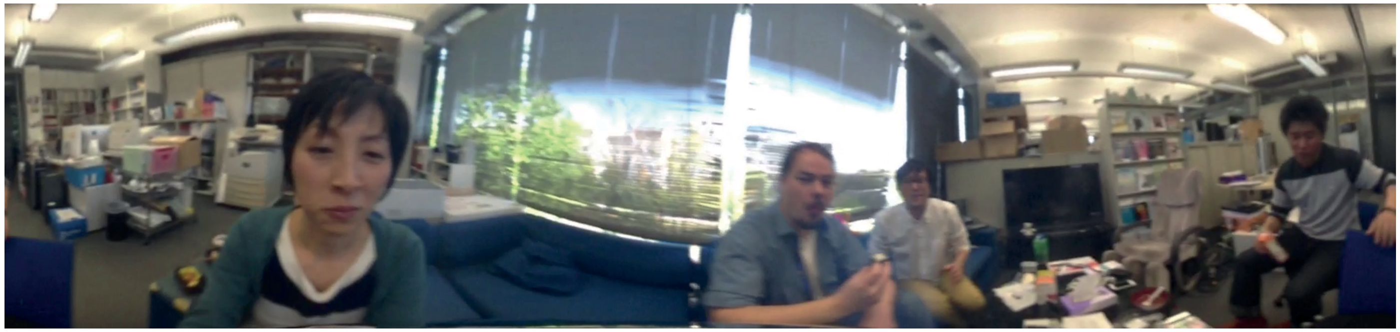


Figure 2: Example still picture from a flattened 360° video file.

described above. It consists of a recoding setup for 360° video, an authoring tool to transform the recordings into AR scenarios and a framework on the target device to playback the scenario and compute the camera orientation.

Recording Procedure
There are several approaches available to record omnidirectional video which are already used in different applications as e.g. robotics or mapping projects. Since additional hardware investments should be kept to a minimum for a software design process we focused on low cost solutions which adapt conventional cameras via lenses and mirrors. We selected the GoPano micro [2] which fits to a smartphone camera because of the large vertical field of view of $\pm 45^\circ$. For our experiments, the scenes were recorded using a tripod and fixed orientation as image movement should only result from device movement during playback. One special challenge was keeping the person operating the device out of the view. We found the results to be more convincing if we avoided any objects closer than 1m from the camera.

Editing and authoring tool
Although the flattened video can be trimmed and augmented with most standard editors we created an application to support the preparation of the material for our use case. The editor window is shown in figure 3. The desktop tool shows the full view of the source material as well as a preview of the section that will be displayed on the screen in the viewer application. In addition there is a timeline slider on the bottom to play/pause and jump to a specific frame, as well as a toolbar on the side.

The current version allows augmentation with small keyframe-animated 2d graphics called sprites. They are overlayed onto the video feed and can be transformed in position, size and opacity. All actions wrap around correctly at the border of the video. The complete scenario is saved in an XML file which can be transferred to the viewer application on the target device. Copying all information for the sprites, enables the viewer to compute if certain objects are in the field of view or if one of them is selected by the user. This makes the tools also useful for videos that were authored in other applications.

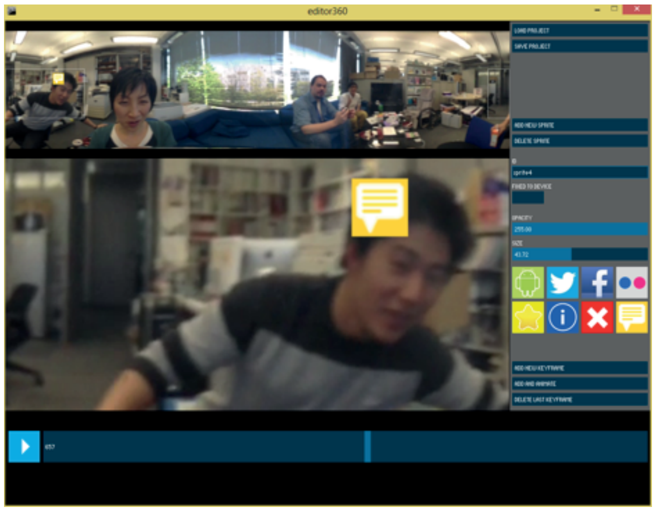


Figure 3: The video preview and editing application.

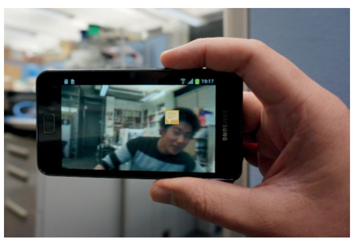


Figure 4: Viewer application running on a smartphone.

Viewer application
The third step in the process is the viewer application running on the target device. In our case this was a mobile phone running the Android operating system for handheld AR (s. figure 4), but the concept is also applicable to other devices. It takes the video and XML files as an input and renders the appropriate viewpoint for the user.

We implemented this in a small framework which provides a view on a virtual 3D environment, where the camera is situated in the middle of a tube that displays the video as its texture. Augmentation objects are added to this scene accordingly. The orientation of the virtual camera is rotated based on the orientation of the device. A simple approach using only compass and gravity sensors already provided good results for this calculation. The component can also be used as part of another AR application to be evaluated. It supports additional callbacks when objects become visible or are selected by the user.

Discussion and Future Work

During initial evaluation we found that our processes and tools can be handled very easily, also by novice users. The creation of simple and advanced scenarios was achieved in less than an hour. A surprising result was the level of immersion reported by the users of the viewer application in an office setting. This indicated that it might not be necessary to play back scenarios in their original environment, simplifying study designs.

Given the promising first results we plan to conduct an extensive evaluation on the effectiveness of the design process, especially focusing on the user experience of the viewer application. We are currently surveying the field of AR systems to collect requirements for the extension of our tools, which would result in a wider applicability.

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