Extended Abstract: Interaction Techniques for Spatial Augmented Reality Setups

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Abstract - Spatial augmented reality is an emerging technology, which has the potential to change the way humans perceive objects in their real environment. For a perfect blend of three-dimensional virtual and real features, the features' depth information has to be taken into account. However, projecting stereoscopic content on non-planar surfaces poses some challenges both in terms of potential perceptual effects and appropriate interaction techniques. The aim of the presented research project is to meet these challenges and to establish guidelines for future spatial augmented reality setups.

Index Terms - 3D projection mapping, Natural user interfaces, Spatial augmented reality

INTRODUCTION

Over the last decades, augmented reality (AR) has become a central part of human-computer interaction. Traditional AR setups use a separate display to superimpose computer-generated graphics on a user's view of the real world. Although AR devices bring advantages to many fields of application, they still suffer from optical, technical and human-factor limitations [1]. By projecting virtual contents directly onto the object's surface, these limitations can be overcome while benefits of traditional augmented reality setups are preserved. This method is the key principle of a special form of AR called spatial augmented reality (SAR). The potential of this approach is revealed in the increasing number of projects that appeared in a variety of application domains in the recent past [2].

From a technological point of view, the realization of such SAR setups involves several basic modules, including an internal and external calibration of cameras and projectors, the registration of virtual and real objects or the rendering setup. Several research projects cover these technical aspects [1,3,4]. In contrast, little research on interaction techniques that benefit from the special characteristics of SAR setups has been done so far. Furthermore, most existing projects are focused either on the projection of monoscopic content or on stereoscopic projection on planar surfaces.

Contributing to these two aspects of SAR, namely natural interaction techniques and stereoscopic projections onto non-planar surfaces, is the aim of my thesis, which I want to discuss in more detail in the following sections.

RESEARCH QUESTIONS

The projection of three-dimensional (3D) stereoscopic features onto real objects' surfaces is expected to be applicable in a variety of scenarios. Raw tangible objects can be individualized dynamically in form, surface characteristics and level of detail. In combination with 3D printing this could speed up and simplify various processes, for example in the field of rapid prototyping.

For exploiting these potential applications of stereoscopic SAR, several considerations regarding human factors have to be made first.

Former VR and AR studies revealed essential differences in the human's perception of virtual and real objects, e.g., a systematic depth underestimation in virtual environments. Some of these effects can be tied to the accommodation-convergence conflict, which can be reduced in a SAR setup since no additional display is located between the augmented object and the user's eyes. Therefore, one goal of this thesis is to verify former study results by transferring the experiments into a SAR environment. In addition, the perceptual effects of SAR specific problems should be investigated, e.g., when projecting onto an object's edge.

After deepening the understanding on how humans perceive a SAR environment, the next step is to develop appropriate techniques that allow a user to interact with this environment. For this purpose, the natural characteristics of the augmented object should be taken into account, in particular, the haptic feedback, which can be provided to the user. The main research goal will be to learn, what kind of interaction users perceive as the most natural one.

CURRENT STATE

In the following section, I would like to present the advances I have made in the first year of my Ph.D. studies.

I. SAR Framework

To allow a rapid implementation of future research ideas and user studies, I built a custom modular toolset. For this purpose, I utilized the results of existing projects and technological case studies, including Microsoft's *Room Alive* [3] and the *Point Cloud Library* [5], and adapted them to fit our needs. In the same scope, we developed a mobile interactive mapping application [6], which supports users in setting up a SAR environment in an intuitive and easy-to-use manner (see Fig. 1).

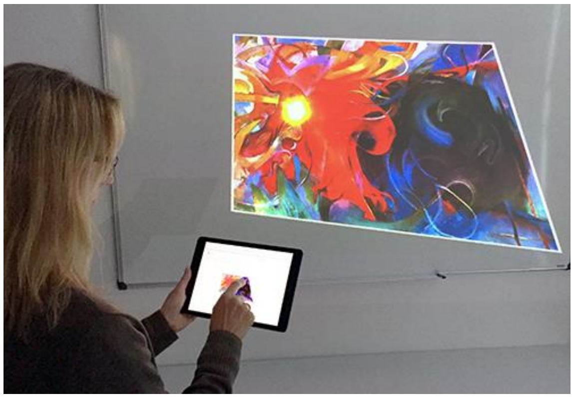

FIGURE 1. MOBILE INTERACTIVE MAPPING APPLICATION.

II. Perceptual User Studies

In a first perceptual user study we considered the question of whether it is possible to modify the human depth perception of an object by projecting different effects onto its surface. The experimental setup can be found in Figure 2. In the study, we applied four different illusions with 5 gains each, including modifications of the color temperature, luminance, blur and parallax. A first glance at the results suggests the assumption that the parallax condition affected the perceived depth the most, although further analyses have to be made.

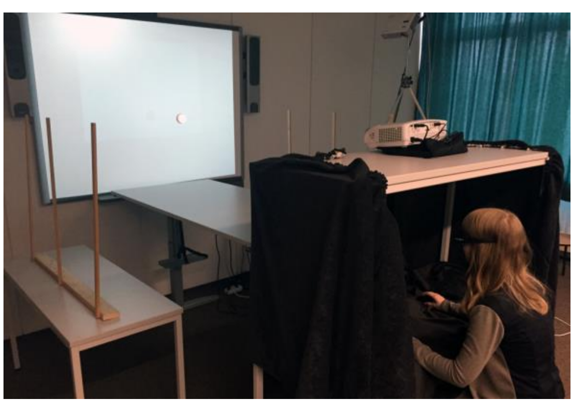

FIGURE 2. EXPERIMENTAL SETUP FOR STUDYING DEPTH ILLUSIONS IN A SAR ENVIRONMENT.

III. Interaction Techniques

To get a first impression on how users interact with augmented objects in SAR environments, we have done some informal experiments with different input techniques and observed the users' reactions. So far, we have investigated mid-air gestures, traditional mouse and keyboard input as well as interactions based on touching the augmented object itself or an external device. In general, the results were strongly dependent on both the scenario and the subjects. This impression was also confirmed in a formal user study conducted in the context of an architectural project [7], which involved a real magnifier lens for all zooming operations. While most users perceived the proposed interaction system as very intuitive, others felt it was too unnatural. Hence, a lot more investigations are necessary to derive verifiable statements on how to interact with SAR environments.

FUTURE WORK

In the near future my research will focus on studying the perceptual effects of stereoscopic projections on non-planar surfaces and the resulting implications on the development of interaction techniques. In particular, I am interested in the simulation of different surface characteristics with SAR and the associated question, whether it is possible to create virtual features that are indiscernible from real ones.

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