[POSTER] Design Guidelines for Generating Augmented Reality Instructions

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ABSTRACT

Most work about instructions in Augmented Reality (AR) does not follow established patterns or design rules – each approach defines its own method on how to convey instructions. This work describes our initial results and experiences towards defining design guidelines for AR instructions. The guidelines were derived from a survey of the most common visualization techniques and instruction types applied in AR. We studied about how 2D and 3D instructions can be applied in the AR context.

Keywords: Visualization, Mixed Reality, Instructions.

Index Terms: H.5.1. [Information interfaces and presentation]: Multimedia Information Systems - Artificial, augmented, and virtual realities.

1 INTRODUCTION

The effectiveness of AR for conveying instructions has already been proved in user studies [1, 2]. Effective visualization is paramount in AR applications, because it directly impacts in the usability of the systems, particularly education and training.

In our work, we define instructions as a way to convey procedural information and give feedback to the user. Hitherto, each AR system has managed instructions in its own way, since no guidelines existed. There is no agreement in the literature about the best way to present information and provide instructions for users via AR. Providing such design guidelines is challenging, because AR necessarily deals with open-ended real environments – perception issues in unpredictable circumstances, such as occlusion and depth relationships among virtual and real objects must be dealt with [3]. Besides, each scenario may introduce very different semantic or contextual rules.

In spite of the lack of instructions related to body movements compared to works related on object instructions, our approach can be applied in both cases. So, our main contributions are:

- an AR instructions system with a set of instructions that can be used in different AR contexts;
- the definition of a set of visualization techniques that can be applied in body and object instructions; and
- a set of guidelines to help in the development of AR instructions.

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2 BACKGROUND

Perceptual problems can arise while observing and interpreting information in AR [3]. In this work, we followed the perceptual issues presented by Kruijff et al. [3]. They classified perceptual problems in three areas: s*cene distortions and abstraction, depth distortions and object ordering, visibility*. We searched for guidelines or principles to AR instructions, but few concepts and directions are directly relevant for our work. For example, Furmanski et al. [4] define a set of guidelines to manage the depth perception and visual complexity for x-ray vision in AR. Neumann and Majoros [5] define rules for creating instructions in an augmentation. The authors present cognitive issues in the design of virtual content for manufacturing and maintenance tasks. They define that we must have specific designs to focus user attention (warnings or cautions), design objects to be adjustable, make objects dependent of operating conditions (e.g., higher contrast callouts in bright viewing conditions). A limitation of their work is that they do not consider any perceptual issues and neglect movement. Kalkofen et al. [6] work only on the visualization techniques, not on the instructions. Gimeno et al. [7] work on object instructions applied to industrial procedures, in contrast, we also work with body instructions. Tang et al. [8] focus only on physiotherapy movements, the users needs to wear specific sensors to track the movements, they do not define guidelines for instructions and the visualization of the depth movement is still not managed correctly.

In this work, we define our design guidelines for AR using a three stage-approach proposed by Agrawala et al. [9]. While they applied their design principles to 3D assembly instructions based on the best drawings examples, we defined our guidelines based on the analysis of visualization and instructions techniques in AR; so the content of each stage is different.

3 IDENTIFICATION STAGE

We derived our proposal from the analysis of visualization and instructions techniques applied to AR.

3.1 Visualization Techniques in AR

For visualization, we paid specific attention to perceptual issues prevalent in AR and, consequently organized the visualization techniques in three areas, they are presented next.

3.1.1 Visual attention category

In this category fall techniques that try to capture the user's attention to parts of the scene to guide the user. Only few AR works address visual attention models. One of the main reasons for this is the processing time required by the attention models. Attention models have been extensively studied and tested in the Computer Vision area, but they usually do not run in real-time. Commonly, the techniques are changed to be feasible in real-time.

Related approaches that fits here is ghosting [10] and edge emphasis [11]. Ghosting techniques keep the scene context and control the level of user attention in agreement with a level of transparency. Edge emphasis is a way to change the visual salience of the edges from the virtual or real objects.

3.1.2 Visual photometric consistency

This category includes the techniques that work with photometric issues such as shadowing and chromatic adaptation. Illumination usually is applied in photorealistic rendering. However, it is a typical issue that can affect the perception of any scene. Illumination is an important issue for depth perception and understanding of the relation between real and virtual objects.

3.1.3 Visual geometric consistency

This category contains techniques that deal with the correct placement and identification of virtual objects, by relying on size, occlusion and texture. Sometimes it is interesting to remove real objects and replace them with an improved virtual version. Besides, there may be undesired objects that could cause difficulty to the user during a task. In this case, Diminished Reality (DR) can be applied to remove real objects [12]. Image completion or inpainting techniques often do not run in real-time and must be redesigned for use in DR.

Table 1 summarizes the AR approaches analyzed. We group them in agreement with the visualization category and the perceptual problem. We could observe that there are no rules or pattern to apply them. Ghosting techniques are usually applied to manage occlusion. Edge emphasis, color and animation are common features applied to focus the user's attention. In spite of having a high potential, DR is still not popular to help with instructions in AR.

Table 1. AR and MR approaches organized by visualization technique and perceptual issue

Visualization Category	Perceptual Pipeline Problem	AR approaches
Visual attention	Depth distortions and object ordering	[8][13] [14][15][16]
	Visibility	[17][18][19][22][23] [24][
Visual photometric consistency	Scene distortions and abstraction	[25][26][27][28][29] [30][31][32][33][34]
	Depth distortions and object ordering	[35][36]
Visual geometric consistency	Visibility	[37][38] [39][15]
	Depth distortions and object ordering	[40][41][42][43][44] [45][46]

3.2 Instructions in AR

There are two basic methods to give instructions: classical mode and perceptual mode.

- *Classic mode*: the instruction is only superimposed on the screen, or image processing techniques are applied to emphasize or guide the user. The most basic and traditional way to present instructions is by text - it is simple and easy to understand by the user. Other kinds of traditional instructions are images, virtual objects and animations. The third person explanation is simple and often applied in AR applications; it can be seen as a union of virtual objects plus animation instruction. In this case, a virtual person tries to explain the steps.
- *Perceptual mode*: perception issues are considering in presenting the instructions to users. The instructions are basically the same as the classical ones, but some processing is done to deal with depth and occlusion, for example.

Table 2 presents a summary about the AR approaches related to classical mode.

Table 2. AR approaches related to classical mode

Types of Instructions	Instructions presentation	AR approaches
Text/Animation	Superimposed	[47]
Text/Animation/2D arrows	Superimposed	[48]
Text/3D arrows	Superimposed	[49]
Text/2D and 3D arrows/3D models	Superimposed	[50]
Virtual agent	Superimposed	[51][52]
Text/3D models/ Images/Video	Superimposed and image processing	[53][54][55]
Text/Images	Superimposed	[56]
Video	Image processing	[57]
Text/Animation/3D objects	Superimposed	[78]
Text/2D objects/Video	Superimposed	[79]

All the examples of perceptual mode managed the depth distortion and object ordering. They are presented in Table 3.

Table 3. AR approaches related to perceptual mode

Types of Instructions	Way to manage the perception problem	AR approaches
Text/Images/3D models/3D arrows	Depth map of the scene	[7]
Video/3D objects	Z-buffer approach	[60]
Animation/3D objects	Depth map of the scene	[61][62]
Images/3D objects	Probability map and penalties scores	[63]
Text/Images	Monocular depth cues	[64]
Text/2D and 3D objects	Filters/layout algorithm	[65]
Text/Images	Energy function	[66]
Text/2D and 3D objects	Depth map and texture	[67]

Text is commonly used in AR applications, but for tasks that deal with movements, it is usually not enough. Few approaches manage perception problems before presenting the information; besides, most of them are developed for a specific task - the possibility to apply the same AR application in a different task is limited. It can be observed that most approaches used in the literature are basically the same: information is presented using text, images, videos, 2D and 3D objects; each work defines its own set of instructions according to the task at hand. The use of instructions related to body movements still needs to be explored.

3.3 Design Guidelines for AR

In order to give instructions in AR, we propose that the AR applications need to:

- *Indicate movement*: an instruction must indicate the correct path, the correctness of the movement and, in some cases, the velocity or acceleration. The path sets the trajectory of the movement, whereas the correctness indicates the right way to achieve the goal.
- *Emphasize parts of an object or a body to be moved or changed*: this is important for body instructions to inform the user about which part of the body must be moved. In object instructions, when there are many small objects or parts, it is important to identify which one must be moved.
- *Allow different kinds of visual appearance attributes*: visual appearance of the AR instructions should agree with the environment conditions. The user should remain in control over the appearance, because some tasks could have specific patterns to follow.
- *Give feedback*: the process of giving an instruction must deal with feedback for users to convey if the user is proceeding

correctly, what must be changed, or if there are alternatives. It is essential that such suggestions be presented in real-time.

- *Manage occlusion and depth*: instructions conveying three-dimensional information, such as in a disassembly task, must incorporate visual cues to let the user understand occlusion, depth relationships and distances in general.

4 Instantiation Stage

In this phase, we started the implementation of an AR instruction system for generating instructions, but with few results. First, we analyzed how to apply AR visualization in an instructions process. For each visualization category presented in section 3, we found a representative approach:

- In visual attention, ghosting technique is applied, because it can be used to keep the context available to the user during an execution task.
- In visual photometric consistency a technique called color harmony [30] is applied to remove the user attention from virtual objects. So when the task demands that the user change the focus of attention from a virtual object, this technique could be applied.
- In visual geometric consistency, DR could be applied to remove undesirable areas and keep the user attention in important ones.

5 Evaluation Stage

This stage deals with feedback from the users and how useful the instruction was. Possible evaluation methods include subjective user feedback (interviews and surveys) and user studies comparing the user performance with paper-based instructions.

6 Conclusion and Future Works

It was shown that there are a wide variety of visualization techniques in AR in general, but a lack of variety of applying them to instructions. We followed a three-stage approach to define our guidelines. In particular approaches related to visualization of body instructions in AR are very limited. We are working on a system to present the instructions in agreement with these guidelines, and after to do the evaluation with the users.

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