Altered Reality: Augmenting and Diminishing Reality in Real Time

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Abstract

Augmented Reality applications overlap virtual objects over a real scene, taking into account the context, in order to add information to the end user. Nowadays, more advanced applications also make use of Diminished Reality that removes real objects from a scene. This paper describes an approach that combines Augmented Reality and Diminished Reality techniques to modify real objects present in applications. The proposed approach removes an object and replaces it with its purposely-modified replica. The solution uses dynamic texture techniques and Inpaint to enhance the visual response of the modification performed. The results are promising considering both realism of the modified real object and performance of the application.

Keywords: augmented reality, diminished reality, physically-based simulation.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; I.4.4 [Image Processing and Computer Vision]: Restoration

1 Introduction

Augmented Reality (AR) applications insert virtual objects into a real scene, while Diminished Reality (DR) applications remove real objects to show information covered by them [1].

According to [2], to obtain good results in realistic AR applications, three aspects must be enforced: shape, appearance and behavior. Shape can be respected by keeping the object's proportions according to the scene proportions where it is inserted. The objects appearance is realistic if it reproduces the real scene illumination conditions. And, finally, the object's behavior is realistic if its interaction with the scene is coherent, in relation to occlusion, shadows, and some other ways of interaction between real and virtual objects.

The focus of this work is on the realistic behavior aspect of AR applications. A system has been developed that is capable of performing modifications on real objects, in real time, aiming at providing realistic means of interaction among real and virtual objects. A virtual replica of the real object is superimposed onto it, with an acceptable level of realism, so that the user cannot detect it is a replica. A possible application that can take advantage of the proposed approach would be a game, where the introduced virtual objects could interact with modifiable real objects, by deforming them.

The most common way of interaction between real and virtual objects in AR consists in modifying only the virtual ones. An example of such interaction can be seen in [3], where a real castle occludes virtual elements, as well as virtual objects collide with it (Figure 1).

A recent work with a good and fast Diminished Reality technique was developed by Herling and Broll[4], but the solution performance still is a problem (40ms with a small area of Inpaint, in a powerfull machine).

Figure 1. A virtual car colliding with a real castle ruin (left) and being occluded by a real castle (right) [3].

Other work related with real and virtual objects interaction may be found at [5], with use of projectors. However, authors don't take into consideration the usage of DR techniques.

In contrast to these related works, the solution presented in the current paper handles with the modification of real objects, caused by the interaction with virtual elements, and consider the usage of DR techniques.

2 Proposed Technique

As previously mentioned, the developed technique simulates the geometric modification of real objects in AR applications, by overlapping them with a realistic purposely-altered replica of it.

To achieve realism, it was chosen a simple approach, which consists of mapping a texture onto a 3D model that represents the object to be modified. This texture is obtained from the image of the object itself in real time. After we have a 3D model, with a texture correctly mapped onto it, we can modify the 3D position of some of the model's vertices, and render this modified model over the original one, overlapping it. This approach was chosen mainly for simplicity, and also because, depending on the modification performed on the model to be projected, the realism in the lighting of the projected object is acceptable.

The geometric modification on the objects consists in changing only the spatial location of its vertices, not changing its faces, nor vertices order on a face. Note that the modification performed on the object may cause portions of the projected object to cover areas that were in the background, and likewise, uncover areas of the original object.

Parts of the original object, while visible, may compromise the coherence of the scene, so an Inpaint technique is used, as in [6], to fill those portions that would possibly be visible. Therefore, the area on the image where the object appears is demarcated, and an Inpaint is applied to the entire area, completely removing it from the scene.

After performing these steps, one can project the modified object with the dynamic texture appropriately applied over it in the position the object was initially tracked.

The technique proposed has four basic steps: tracking, texture mapping, Inpaint and reprojection. Figure 2 shows these steps.

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A crucial step in the system is tracking. At this phase, the goal is to get the camera position in the world, for proper insertion of virtual objects. To track the object to be modified, any tracking technique that can distinguish between different objects could be used with markers or markerless. In this work, the technique used was based on markers using the ARToolKit library.

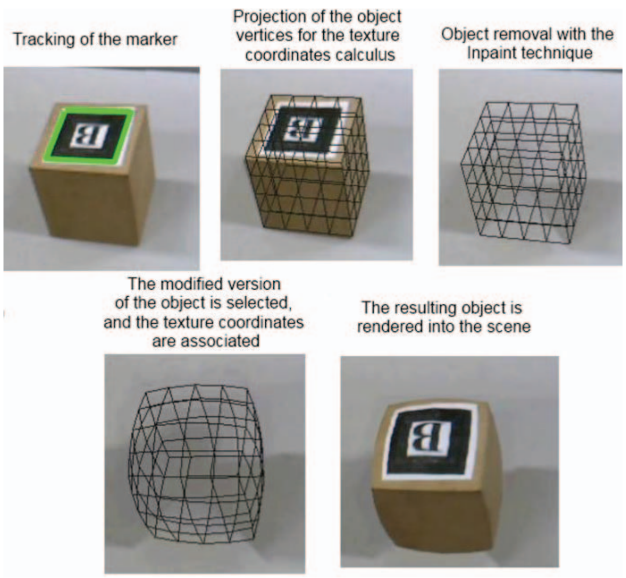

Figure 2. Overview of the steps of the technique.

After the object is tracked in the input image, the next step is to apply a texture on it. The dynamic texture approach, obtained in real time from the image itself, is adopted as a simple alternative to obtain a satisfactory level of realism.

As said, an Inpaint technique is required to deal with cases where the actual object is not completely hidden by the virtual one. The application of an Inpaint technique in the input image can be divided into two steps: first, it creates a mask, with the same size as the original image, monochrome, with non-zero pixels values where the Inpaint technique should be applied, and zero otherwise; next it applies Inpaint on the image, with reference to the mask created in the previous step.

The technique implemented here, as in [6], is simple; it moves a mask of size 3x3 over the area where the Inpaint must be applied in a downward spiral, calculating the value of a pixel as the average of its valid neighbors.

After the dynamic texture is loaded into memory, correctly associated with the vertices of the object, and the Inpaint is applied to the image, the object can be reprojected with its geometry modified in the scene, using the texture coordinates obtained and the texture image loaded. This step comes to render a textured model using OpenGL.

3 Results

The results were quite satisfactory on what concerns to the modification applied to the object. Figure 3 shows the results.

We have found some difficulties with the deformation applied because if it shows a face of the object that is not visible in the original image, a false will be mapped to it. If a piece of the cube is out of the camera range, it will not have a valid texture image to map in this part of the object too, so, if the modification brings this part to the screen, a invalid texture will be shown.

Regarding the runtime, there is only one bottleneck in the step of Inpaint. However, with the test machine (Pentium Dual Core 2.4 GHz, NVIDIA GeForce 8800 GTX), it was obtained an average rate of 15 fps with the Inpaint developed.

An application that integrates the developed technique to NVIDIA PhysX was also developed, so that the geometric deformations applied to the object are automatically generated, therefore increasing the coherence of the deformation. A video with demos of the technique and its integration with PhysX is available at https://www.gprt.ufpe.br/~crystian/MODGEO.wmv.

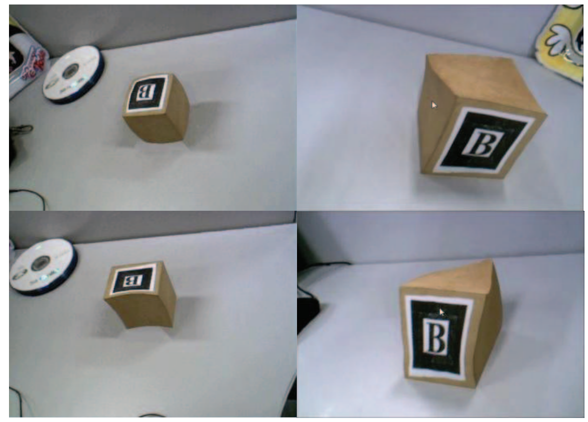

Figure 3. The four figures show changes applied to the object. The two in the right show the integration with PhysX.

4 Conclusions and future work

The work dealt with the interaction between real and virtual objects through an approach based on geometric modification, aiming to increase the realism of AR applications. The results are promising and may be considered good in respect to the realism of the modified object, and reasonable in relation to the application performance as a whole.

As future work, an alternative to dynamic texture for realism using a modification of the procedure as described in [2] could be implemented. Note that using RPR for lighting calculations means that we will be able to estimate the shadows generated by the virtual objects, increasing the scene realism. The Inpaint technique implemented here could be improved by finding a way to apply it only where it will be needed. Other types of Inpaint techniques also could be analyzed with the main goal to find some other that fits better with this work.

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