Interacting with a virtual tool on a real object

Bayart Benjamin ∗ Didier Jean-Yves ∗ Kheddar Abderrahmane ∗∗

∗ IBISC Laboratory, Evry, France (e-mail: bayart,didier@iup.univ-evry.fr).
∗∗ Centre National de la Recherche Scientifique (CNRS), Paris, France (e-mail: kheddar@ieee.org)

Abstract: This paper presents an application enabling the interaction on a real object with a virtual tool. In order to interact within the real world, a real haptic probe is used to interact with the real object so that the user feel the interaction. Furthermore, through the use of a visual diminished reality process and a camera placed on the real scene, the real tool is visually replaced by the virtual one. Since, the real and virtual probes do not match necessarily, a model of the virtual tool is used to modify the haptic feedback, while visually, the virtual tool is modified relatively to the real forces measured. Eventually, proposing a mixed painting application, the painting, applied on the real object, i.e. when the user comes in contact with this latter, is visually displayed such that its form is computed from the virtual tool geometry while its size and intensity from the the real measured forces.

Keywords: Haptics Augmented Reality, Visual Diminished Reality, Interaction, Mixed Painting simulation.

1. INTRODUCTION

To interact within a mix world is not as straightforward as to interact either only in the real world or in the virtual world. The Augmented Reality (AR) domain includes a lot of applications where real and virtual environments are visually merged whereas few works address the haptic merging issue. Bayart et al. propose in [1] to interact with a composite object made of real and virtual parts. Our idea is to interact on a real object with a virtual tool. We illustrate our proposal with an application where virtual paint is applied on real objects. In this paper, we address the problem of keeping multi-modal coherence, between visual and haptic feedbacks.

2. A MIXED INTERACTION SYSTEM

We propose to interact in real time on a real object with a virtual tool. Using a tele-operated system, the user has the possibility to interact in real time with an object. At the same time, a camera being at the interplay site, he can visualize the result of the interaction with the chosen virtual tool. For instance, if manipulating a brush, some paint is added onto the object. The main issue is that since the virtual and the real tools do not necessarily correspond (in size, geometry or orientation), the force feedback does not consequently match to the visual one. The user can perceive an inconsistency between the visualization and the haptic feedback. For instance, there is difference if the real probe is rigid while the virtual model is deformable. The proposed solution is to add a coupling, taking into account a model of the virtual tool, in order to modify the visual and haptic information in accordance. Furthermore, a visual Diminished Reality (DR) process is added such that the real haptic probe is visually replaced with the virtual interaction tool.

The figure 1 presents the system, the first possibility (slashed lines), which is to send back directly the force of interaction to the user, and our solution, which adds a coupling, modifying the visual and haptic information.

In order to ensure the correlation between the haptic and the visual feedback, we propose to add a virtual coupling. This virtual coupling considers a model of the virtual tool and enables:

1. to modify the visual model of the virtual tool taking in account the real measured forces,
2. to modify these forces accordingly to the model limitations, i.e. the forces sent back to the user are the result of the real measured forces and the deformation limitations of the visual virtual tool,
3. to modify the visual result of the interaction accordingly to the model of the virtual tool and the real forces.
3. THE VISUAL DIMINISHED REALITY PROCESS

The term of Diminished Reality (DR) is dedicated to AR applications where real parts appearing in captured video or image sequences are removed or replaced.

![Fig. 2. The DR Process: the real haptic probe is visually replaced by the virtual tool, while the marker is used to find the initial position.](image)

The goal of our DR process aims at removing the real haptic probe and replacing it with the chosen virtual tool. Similarly to [2], we chose to use only one camera and to take a maximum of background information at the start of the process, in order to replace the removed parts. To improve the robustness and the speed of our technique, we add a chroma keying method as in [3], which enables a fast detection of the parts to be removed. Figure 2 illustrates the process, which works in four steps:

1. at startup, an image of the background is registered as a reference (A)
2. the haptic probe is placed on the scene (B)
3. the marker is used to place the virtual probe, before being removed (C)
4. the DR process is launch and the real haptic probe is detected (through the search of a specified color on the live image) and removed (i.e. the detected zone is replaced by the similar counterpart from the image of reference - D).

4. A MIXED PAINTING APPLICATION

We present an application of mixed painting such that the user can choose different brushes and apply strokes of paint on any kind of object. Three types of brushes are proposed, namely a rigid pencil, a deformable sponge brush and a deformable calligraphic brush. The models taken into account within the coupling are then respectively a rigid and a deformable unilaterial beams.

Accordingly to the coupling, the brushes representations are visually modified as the beam model deforms due to the real measured forces. The boundary of deformation are then used to modify the real forces sent back to the user. The forces sent back to the user correspond to the real ones modified accordingly to a virtual model. Hence, the forces sent back to the user are always equals to a fixed value for the pencil (rigid interaction) while for the two other deformable tools, the maximum forces are sent when the boundary (i.e. limit of deformation of the virtual tool) is reached.

Finally, for the strokes, which are the results of the interaction, their size is proportional to the real forces intensity while their orientation and their form are computed from the virtual tool geometry, as illustrated on figure 3.A. Figures 3.B,C,D show the final result, i.e. some virtual paint added on a real object.

![Fig. 3. A: The strokes of paint are computed accordingly to the model of the chosen tool and the intensity of the interaction forces. B,C,D: Applying some paint on a real object with different virtual brushes.](image)

5. CONCLUSION

We present in this paper an application enabling interaction on a real object with different virtual tools. Through the use of a coupling, taking into account a model of the chosen virtual tool, the visual and haptic information are modified in order to ensure a consistency between the two. Furthermore, this solution offers the benefit that since no virtual model of the object is used, the collisions detection process is not required. An application of mixed painting is proposed as a result.

REFERENCES