Poster: Bimanual Design of Deformable Objects Thanks to the Multi-tool Visual Metaphor

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Figure 1: Illustration with a mock-up edited figure of the bimanual design of deformable objects as proposed by our novel Multi-tool approach. The right hand manipulates the Multi-tool through a generic handle. The left hand allows to change the tip of the Multi-tool thanks to a panel selection on the left, as well as the selection of the virtual deformable objects.

Abstract

In this paper, we introduce a novel visual interaction paradigm called the "Multi-tool" dedicated to the design of virtual deformable objects. Our approach proposes an interaction multi-tool metaphor that enables various types of interaction with deformable objects using a tool with a generic real handle and interchangeable virtual tips. Our bimanual control scheme allows a large amount of interaction possibilities as for real object design applications. Preliminary subjective evaluation by users shows that our approach can reproduce natural real hand gestures and the manipulation of many different tools in an intuitive way. The multi-tool interaction paradigm could thus be used in a wide range of applications involving the design or the shape modification of deformable objects such as for virtual prototyping, medical simulators or artistic projects.

Index Terms: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Interaction Styles; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques;

1 Introduction

The virtual design of deformable objects represents a key feature of virtual reality applications as it enables the user to freely build and modify any shape without high constraints on the feasibility or the material properties of the resulting objects. When designing the object, the manipulation remains one of the most fundamental task in the user interactions [1].

In applications such as sculpture or virtual prototyping, the use of various tools is particularly of interest for carving or molding the material as in the real world. The use of a large amount of tools remains however rarely implemented in virtual reality applications since the switch between the tools can rapidly become cumbersome and exhausting. The use of both hands for a unique task and not independent subtasks remains also rarely proposed although the gestures could become more natural, as we are generally using our two hands in a collaborative way in the real world.

In this paper, we aim at proposing a novel visual interaction paradigm, called the "Multi-tool", to design deformable virtual objects. The paradigm is based on a bimanual control scheme: a first hand is dedicated to the manipulation of the tool with interchangeable tips while the second hand manages the target object motion as well as the tip selection. The interchangeable tool tip allows the design of various deformable shapes in a more natural way thanks to the use of both hands as in real world applications. Our approach is only based on a visual feedback and could thus be used without any haptic device for manipulating deformable objects in virtual environments.

2 The Multi-tool Interaction Paradigm

The two main components of our novel visual interaction paradigm dedicated to the design of deformable objects and called the "Multi-tool" are: (1) a bimanual control scheme to select and manipulate the deformable virtual objects, (2) a visual metaphor based on a tool with interchangeable tips to render the use of various real tools while using an unique generic real handle.

2.1 A bimanual control scheme

The control scheme of our interaction paradigm uses the two hands for the selection and manipulation of the deformable objects. One hand holds the Multi-tool while the other one allows the selection and the size control of the tool tip as well as the motion of the virtual objects. The hand with the Multi-tool is called the manipulation hand in our approach while the other hand is called the selection hand.

2.1.1 Description of the global framework

In our framework, the two hands are tracked in real-time, either with a classical tracking system or with a low-cost setup. Our approach works whatever the choice of the tracking system. The two hands of the user are collocated with the virtual hands, with colored

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spheres representing the finger tips in the virtual environment. It allows a direct interaction with the deformable objects of the virtual environment, without any need for virtual hand simulation. Furthermore, it enables the use of interchangeable tips for the Multi-tool while the user is holding an unique handle. The Figure 2 represents the collocated setup of the bimanual interaction. In order to handle potential self-occlusion on 3D display, visual and auditory feedbacks were added to warn the user when a contact with an object is established. Thus, the grey spheres representing the finger tips become green when a contact occurs, together with a sound representing the interaction between the hand holding the tool and the deformable object.

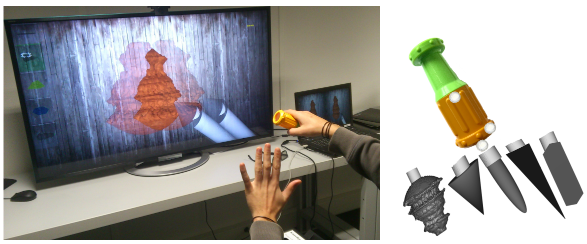

Figure 2: (Left) Collocated setup with the two hands: the left hand can select the tip using a panel while the right hand manipulates the Multi-tool through a generic real handle. (Right) Examples of interchangeable tips of our Multi-tool approach.

2.1.2 The manipulation hand

The manipulation hand holds the Multi-tool and can interact with the 3D deformable object. Each finger tip is represented within the virtual environment with a grey sphere. Thus, the user can directly alter the virtual shape with his hand if desired. The collocated setup allows the use of a unique handle, thus facilitating the user hand motion and preventing him from complex tool switch during the design of the virtual object.

2.1.3 The selection hand

The selection hand allows the switch of the tool tips as well as the control of the virtual object behaviour. Thanks to the selection hand, the user can choose the desired tip for the tool among a panel of various tips. The hand controls also the behaviour of the virtual objects. The user can modify the position, the orientation as well as the scale of the virtual objects. The scale of the tip can also be modified. Two control modes can be implemented: a continuous mode and a discrete mode. In the continuous mode, the hand position and orientation are directly used for selecting the tips or the objects. In the discrete mode, the hand is controlled thanks to defined states. States are defined by finger positions or hand opening and closing.

2.2 The Multi-tool visual metaphor

In our approach, we propose the use of novel metaphor called the "Multi-tool". The main objective of the metaphor is to facilitate the interaction with the objects with smooth switchs between the different potential tools used during the design of a deformable shape. The metaphor is inspired from real interchangeable tool used in our daily life, for sculpture project for example. A representation of our multi-tool is given in Figure 2. Our Multi-tool is composed of two main components: a generic real handle controlled by the manipulation hand and a set of interchangeable virtual tips controlled by the selection hand.

2.2.1 The generic real handle

The generic handle is held by the user. The collocated setup allows to manipulate a real handle while the tips remain virtual. With this device, the user can perceive inter-penetration of the tool into the 3D shape, without any haptic feedback. The grasping of a real device allows the user to reproduce natural gestures as with real multi-tool.

2.2.2 The interchangeable virtual tip

Our interchangeable tips mimic real multi-tools. The user can switch the tip with his selection hand. The position and the orientation of the tip are defined by the manipulation hand while the selection hand controls the scale. An infinite number of tip shapes can be modeled. The unique handle allows also fast modifications of the tips and then prevent from breaking immersion when designing a virtual object.

3 Implementation

Our setup is composed of a 3D display system and a tracking system. The virtual environment is displayed on a 3D 55 inches screen. The user has to wear stereo glasses to collocate his hands with the virtual tools. Concerning the tracking system, we illustrate our metaphor with two systems: a classical virtual reality system and a low-cost Desktop setup. In the classical tracking system, the optical tracking system is composed of 10 infrared Vicon Bonita cameras. The user wears gloves with markers. The low-cost Desktop tracking system tracks the hands with a Leap Motion and the head with a depth camera (Microsoft Kinect). The tracking and the 3D display are real-time in both setups.

Our virtual environment is composed of deformable objects. We used a voxel-based volumetric modelling coupled with a physical simulation as proposed by Dewaele et al. [2]. The material allows the simulation of plastic deformations with constant volume, thus mimicking the behaviour of real clay.

We implemented different use cases to illustrate our approach. Figures 1 and 2 illustrate the use of the Multi-tool metaphor sculpting in a piece of clay with different tips.

4 Discussion and Conclusion

In this paper, we proposed a novel visual interaction paradigm called the "Multi-tool" dedicated to the bimanual design of deformable virtual objects. Our Multi-tool metaphor enables interactions with deformable objects using a tool with a generic real handle and interchangeable virtual tips. We introduced also a bimanual control scheme allowing the use of one hand to accurately contribute to the modelling while the other hand is used to control the tool and the environment. Our collocated experimental setup enables the user to deform the shape of the virtual object with the Multi-tool or the fingers directly.

With the Multi-tool approach, we provide the user with a natural and intuitive way to interact with deformable material. Thanks to the bimanual control scheme, we exploit the natural dexterity of the users two hands according to the dominant and non-dominant motor abilities of the hands. We also increase the interaction bandwidth as defined by the ratio between the deformation numbers applied to the deformable object and the duration of the interaction session.

As future work, our interaction paradigm should be evaluated, both in terms of accuracy and gestures performances. This evaluation could then confirm our attempt to mimic the natural bimanual ability of the human for the design task of deformable object. The virtual environment could also be improved, especially with the use of more realistic material model. Our approach could thus be used in a wide range of potential applications such as virtual prototyping or artistic projects.

References

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