표면 텍스쳐와 햅틱 모델을 이용한 실제 3D 객체에서 햅틱 텍스쳐 매핑

Haptic Texture Mapping on Real World 3D Object using Surface Texture and Haptic Model

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Abstract

Haptic interfaces allow users to feel and explore real-world 3D objects in an intuitive way with realistic haptic feedback. In this work, we propose a novel framework for the haptic texture mapping on real world 3d object. At first, we capture the real world object using Kinect Xbox and afterward we employ texture mapping technique to assign the haptic texture model and surface texture on the triangular surface object. Finally, to validate the performance of the proposed approach we perform experimental analysis on four real-world 3d objects.

1. Introduction

Haptics has been investigated as a method of presenting users with natural and immersive feelings of digital content in the disciplines of entertainment, education, medical and so on. Haptic interfaces permit us to feel, examine, and manipulate real-world 3D objects in an intuitive way with realistic haptic feedback. Despite the significant benefits, however, haptics is yet mostly unfamiliar to many persons. Modern haptic texture modeling and rendering approaches produce a considerably realistic vibrotactile response [1][2][4]. In virtual reality, these approaches permit users to interact with a virtual object and feel surface textures.

In this work, we propose a novel framework for the haptic texture mapping on real world 3d object. We employ the texture mapping strategy to map the surface texture and haptic model to the 3d object. Finally, experimental analysis is performed on four real world objects in order to validate the performance of the proposed solution.

The remaining paper is organized as follows. In Sections 2, we present the related works while Section 3 describes the proposed method. The user study is explained in Section 4. Lastly, conclusions are drawn in Section 5.

2. Related Works

Several works have been proposed for haptic texture modeling and rendering. In this section, we describe the existing works that are closely related to our approaches.

In [1], the authors proposed a new approach to model textures and felt by a tool. Culbertson et al. [2] introduced a Haptic Texture Toolkit of haptic texture models. Furthermore, they presented methods for modeling and rendering haptic virtual textures. Later on, Waseem et al. [3] proposed a universal haptic texture library, which includes 84 surface texture along with image spatial features. In [4], the authors presented a data-driven method for modeling haptic responses of surface texture. Jiao et al. [5] also introduced a data-driven approach for the fabric textures on the electrostatic tactile display.

3. Proposed Method

The haptic texture mapping means assigning a haptic texture model [3] to the 3D objects, which can help us to feel the realistic vibrotactile response (realistic texture) of that particular object. In contrast, traditional texture mapping [6] allows us to map the texture of a 2D image into the 3D object. However, we cannot feel the texture of the object in the conventional texture mapping. In this work, we perform

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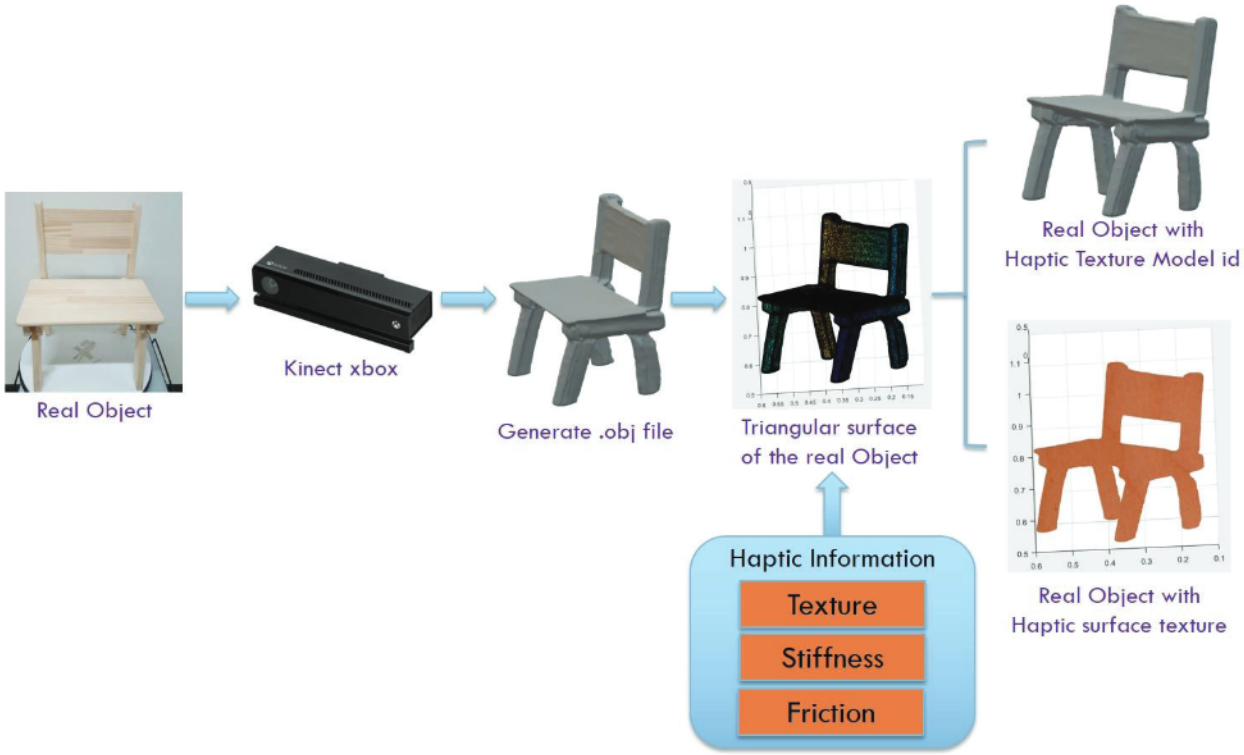

Figure 1: Flowchart of our proposed framework for Haptic Texture Mapping.

the haptic texture mapping on the real world 3d objects. Figure 1 demonstrates the proposed framework for the haptic texture mapping using surface texture and haptic model.

Figure 2: Qualitative results of the proposed framework.

In our work, at first, we capture the real world object using Kinect Xbox, which helps us to scan the 3d objects. These scanned objects are represented as the .obj files. Afterward, we employ texture mapping [6] concepts on the scanned object, which converts the object to the triangular surface object. Texture mapping simply wrapped and mapped pixels from a surface texture to a 3D surface or object. Later on, we apply the haptic texture model and surface texture on the triangular surface object, which produces the 3d objects with the haptic texture model and haptic surface texture respectively. This work helps us to feel the surface texture in the virtual environment.

4. User Study

In this part, we evaluate the performance of the proposed approach. In order to prove the effectiveness of our method, we perform an experiment on four real-world 3D objects which includes chair, cushion, bag, and wallpaper. Figure 2 demonstrates the qualitative results of the proposed framework. From this experiment, we can validate the performance of the proposed framework.

5. Conclusion

In our work, we introduced a new framework that enables the user to perform haptic texture mapping on the real-world 3d object. This work assigns the haptic texture model and surface texture on the triangular surface object. Lastly, experiments are performed to prove the effectiveness of the proposed approach. In future, we will integrate our work with the real-time virtual reality environment in order to obtain kinesthetic and tactile feedback through hand exoskeleton glove. Afterward, we will do extensive experimental analysis to validate our work through a quantitative measure.

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References

[1] Heather Culbertson, Joseph M. Romano, Pablo Castillo, Max Mintz and Katherine J. Kuchenbecker, "Refined methods for creating realistic haptic virtual textures from tool-mediated contact acceleration data", In Proceeding of the IEEE Haptics Symposium (HAPTICS), 2012.

[2] Heather Culbertson, Juan José López Delgado and Katherine J. Kuchenbecker, "One Hundred Data-Driven Haptic Texture Models and Open-Source Methods for Rendering on 3D Objects", In Proceeding of the IEEE Haptics Symposium (HAPTICS), 2014.

[3] Waseem Hassan, Arsen Abdulali, Muhammad Abdullah, Sang Chul Ahn, and Seokhee Jeon, “Towards universal haptic library- Library-Based Haptic Texture Assignment Using Image Texture and Perceptual Space” IEEE Transaction on Haptics, vol. 11, No. 2, 2018.

[4] Arsen Abdulali and Seokhee Jeon, "Data-Driven Modeling of Anisotropic Haptic Textures: Data Segmentation and Interpolation", In Proceeding of the EuroHaptics, pp. 228-239, 2016.

[5] Jian Jiao, Yuru Zhang, Dangxiao Wang, Yon Visell, Dekun Cao, Xingwei Guo and Xiaoying Sun, "Data-driven rendering of fabric textures on electrostatic tactile displays", In Proceeding of the IEEE Haptics Symposium (HAPTICS), 2018.

[6] Huamin Wang, "Texture Mapping" (PDF). Department of Computer Science and Engineering. Ohio State University. Access date: 2019-03-15. [Online] Available: http://web.cse.ohio-state.edu/~wang.3602/courses/cse5542-2013-spring/15-texture.pdf