Everyday Objects for Volumetric 3D Sketching in Virtual Reality

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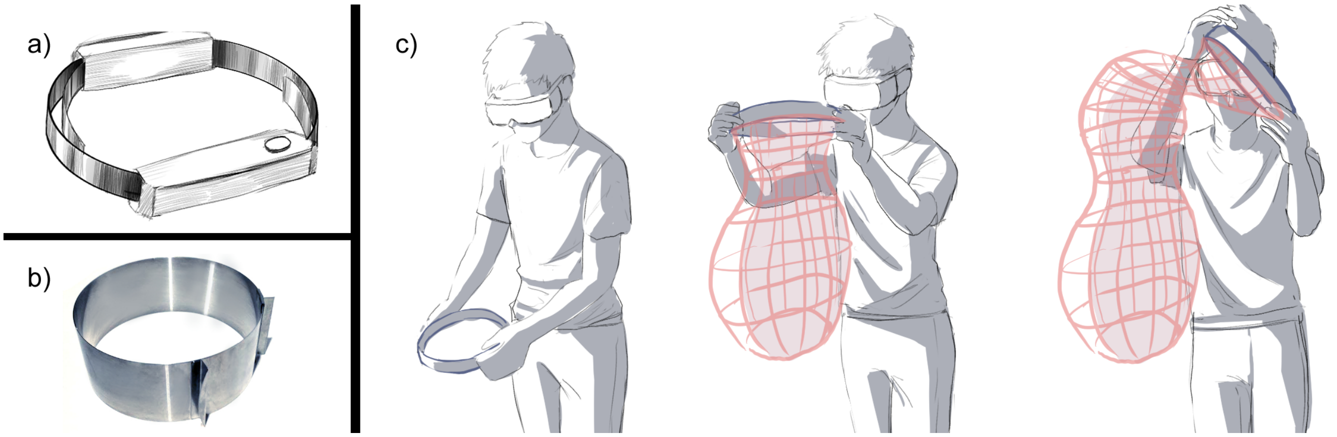

Figure 1: a) Our controller inspired by a cake-ring b) Real-life everyday object c) Volumetric 3D sketching process using an everyday object like a cake-ring

ABSTRACT

In the area of 3D sketching, modelling volumetric shapes has required some form of abstract operations, inhibiting intuitive free-form creation of organic 3D volumes. We propose a new interaction methodology which aims to achieve this goal. Inspired by everyday-objects, we envision an approach which exploits manipulable proxies, in order to generate volumetric shapes. We believe this idea will bring a new dimension to 3D sketching in Virtual Reality.

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**.

KEYWORDS

Virtual Reality, Tangible, Proxy objects, 3D modelling

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1 MOTIVATION

In the past, 3D modelling was almost exclusively performed through 2D input and 2D output, i.e. keyboard and mouse in front of a computer screen. With the recent advent in popularity and accessibility of Virtual Reality systems a new way of interacting with 3D content has become widely available. As such, manipulating 3D objects through stereoscopic HMD and 6-DOF hand controllers has enjoyed particular interest. While the concept was explored early on [2], only recently have commercial products become available, allowing for free-form 3D sketching [12]. However, as far as 3D volumes are concerned, they still offer few options for organic and immediate shape creation. Many users will opt to use countless small planar strokes in order to suggest volume [1], or will need to use some form of high-level abstraction, thus impeding the free-form aspect, arguably a large part of the appeal of modelling in virtual environments. Moreover, another area in which current commercial systems remain limited is haptics. While active haptics have been utilised to ease 3D sculpting [8], these devices often remain bulky and expensive preventing a wider audience from using them. Therefore, we aim to explore possible solutions to incorporate Passive Haptic Feedback into 3D sketching approaches. Everyday objects being inexpensive and widely accessible, we believe that utilising everyday objects as controllers for volumetric 3D sketching can act as one such solution. In particular, we are interested the way that everyday objects can be exploited to achieve unique and organic 3D volumes, without the need of any secondary abstraction steps.

In the following, we will first go over past research regarding everyday objects and 3D sketching, then present our concept and lastly, we will talk about the future of everyday objects and their role in 3D sketching.

2 RELATED WORK

In passive haptics the physical properties of an object are exploited in order to produce meaningful fore-feedback relevant to the task at hand. This is most commonly applied through a form of real-world proxies for virtual objects and has been shown to increase immersion, presence as well as task performance [3, 5, 9, 10]. In 3D modelling tasks this can be useful in order to inform the user about the properties of their built object during the creation process.

Lau et al. [6] presented an approach called *Situated Modelling*, in which 3D models were built through primitives in Augmented Reality. Several proxy primitives were provided to be used, and with a combination of two-handed-interactions and the use of a foot-pedal, the volumes of these proxies were reproduced virtually. The authors call this process *shape-stamping*, as the volumetric shape is copied to scale of the actual proxy. They described different interactions of this approach, such as utilising one hand for stamping while the other hand held a different proxy, which functioned as a spatial reference for the new object, thus allowing for accurate design decisions while preserving the advantages of 3D modelling in Augmented Reality. Additionally, they described a methodology of sketching with these primitives called *sweep-stamping*. With these features they were able to combine 3D modelling techniques with passive proxies.

In their study, the virtual counterpart of the proxy primitives were built before-hand. However, overlaying a virtual model onto a generic everyday object has been proposed before. Hettiarachchi et al. [4] presented an approach of utilising everyday objects as proxies in Augmented Reality, by approximating the 3D volume of each entity out of a collection of everyday objects, and then finding the best match between virtual object and proxy. Similarly, Simeone et al. [11] presented *Substitutional Reality*, in which the real world environment was scanned and then a virtual representation was generated accordingly. This way, obstacles in the real world could be visualised virtually without breaking the immersion of Virtual Reality. Additionally, by providing passive haptics, this further enhancing the virtual environment.

In a study by Feick et al. [3] participants were asked to perform several manipulation tasks, i.e. stretching, bending and rotating, comparing time efficiency between free-hand, controller and manipulable proxy. The study found the manipulable proxy to outperform over other input methods, suggesting that manipulable proxies might outperform conventional controllers in general, as far as manipulation tasks are concerned. Participants also reported that the direct connection between proxy and object manipulation helped with applying previously learned movements, also citing a lower degree of abstraction as a benefit. Generalising 3D modelling in VR as a set of manipulation tasks could thus also benefit from employing manipulable proxies. In this work, we want to explore how manipulable everyday objects may be used for less abstract 3D modelling tasks, specifically volumetric 3D sketching.

3 PROXIES FOR 3D VOLUMETRIC SKETCHING

Many approaches concerning passive haptics explore ways of representing a virtual object haptically via proxies. However, haptics can also be used to enhance the process of 3D sketching [13]. We present two manipulation tasks, which, when performed through various everyday objects, can be exploited to build 3D volumes by outfitting them with sensor and tracking units.

3.1 Expanding

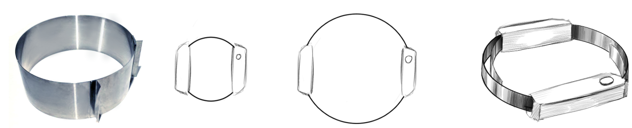

Figure 2: A cake-ring can easily be adjusted in diameter, making it an ideal target as a device for volumetric 3D sketching

Volumetric 3D sketching requires the controller to be able to expand and contract in order to outline a volume of variable size. For this purpose, we aim to employ a mechanism similar to a common cake-ring, which is a metal cylinder with an open top and bottom, which can change its diameter when squished or pulled on. By equipping such a proxy with appropriate sensors we can track its position and diameter through virtual space. With such a setup, we envision a controller with which we can trace its outline to produce a 3D volume. Through this, the interaction for creating 3D volumes with varying diameter can be directly associated with the already learned behaviour of using an everyday utensil. This is enhanced through the passive haptics provided by the controller, while meaningfully restricting movement, aiding with preventing involuntary hand-motions. We hope to find that this approach can reduce the layers of abstraction needed for 3D volume creation in currently available 3D sketching tools.

3.2 Deformation

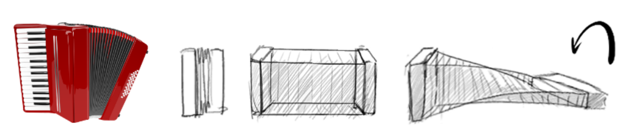

Figure 3: The device would be able to change its form similar to an accordion, by bending, twisting and expanding it.

Similarly, we can apply this idea to other examples in the sphere of everyday objects. For instance, we could observe the way an accordion expands and contracts while remaining relatively flexible. If equipped properly, such an object could provide haptic feedback to a twisting or bending manipulation, in addition to changing its size via expansion. This way, one could create bent and twisted volumes with varying diameter in one haptically supported motion.

Even users with no prior experience with neither the object nor Virtual Reality would be able to quickly achieve 3D shapes which in today's approaches require a fairly large number of iterations and high amount of abstraction.

3.3 Semantic Content Generation

As there are many ways of manipulating 3D objects, many different kinds of everyday objects could be used semantically to achieve unique interactions. We will present a short list of interactions between everyday objects and virtual 3D objects which could be useful in a 3D modelling task. A pair of scissors may be utilised to "cut" out parts of a virtual 3D volume. Similarly, we could use a cup to scoop out parts of the volume, or a large piece of cardboard to flatten surfaces. Li et al. [7] have previously built proxies like scissors, syringes, or wrenches, which semantically interacted with their virtual environment.

4 VISION

The advantages of passive haptics are well documented in the literature. Providing tools for volumetric 3D sketching should enable a novel and more intuitive way of generating 3D content. While current technology doesn't allow for manipulations on everyday-objects to be tracked, we envision a future in which any user can pick up an object in their immediate environment, and, without any prior knowledge, can start modelling in 3D, simply by interacting with the object as they do in everyday life.

This could be achieved in the near future, by developing algorithms which, after getting an object prior to and after an manipulation as input, could interpolate and estimate any in-between state of an object's manipulation, utilising concepts of Computer Vision and Machine Learning.

Going beyond this, we also imagine everyday objects to be much *smarter* in the future. Embedded IoT devices might find their way into, what we currently consider as everyday objects, allowing designers to easily use every physical object in their environment as a functional proxy.

5 OUTLOOK

We plan to design and build a prototype addressing the shortcomings of traditional 2D interfaces used for 3D content generation. Further, we plan to perform a series of user-studies, in order to evaluate possible benefits and drawbacks. In the future, we envision that every physical object in a user's natural environment can be utilised as a functional proxy – adding new dimensions to the creative process. Therefore, providing inside-out tracking for manipulable objects without the need for specialised hardware could be topic for future research.

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