A Demo of Talkit++: Interacting with 3D Printed Models Using an iOS Device

Lei Shi
Information Science
Cornell Tech
New York, NY U.S.A.
ls776@cornell.edu

Zhuohao Zhang
Computer Science
Zhejiang University
Hangzhou, China
zhuohaozhang@zju.edu.cn

Shiri Azenkot
Jacobs Technion-Cornell
Institute, Cornell Tech
New York, NY U.S.A.
shiri.azenkot@cornell.edu

ABSTRACT

Tactile models are important learning materials for visually impaired students. With the adoption of 3D printing technologies, visually impaired students and teachers will have more access to 3D printed tactile models. We designed Talkit++, an iOS application that plays audio and visual content as a user touches parts of a 3D print. With Talkit++, a visually impaired student can explore a printed model tactilely, and use finger gestures and speech commands to get more information about certain elements in the model. Talkit++ detects the model and finger gestures using computer vision algorithms, simple accessories like paper stickers and printable trackers, and the built-in RGB camera on an iOS device. Based on the model's position and the user's input, Talkit++ speaks textual information, plays audio recordings, and displays visual animations.

Author Keywords

Computer vision; 3D printing; visual impairments

INTRODUCTION

Teachers for the visually impaired (TVIs) often use tactile materials when teaching students with visual impairments. Nowadays, TVIs can acquire these tactile materials from 3D printers. For example, a TVI can print a 3D molecule model to teach organic chemistry to her students. As 3D printers become more popular, our goal is to enable TVIs to create custom interactive tactile materials with which they can teach their students more effectively.

In prior work, we presented Markit and Talkit [6, 7]. Markit is a design tool that allows a user (e.g., a TVI) to associate the elements of a 3D model with text labels [7]. A user (e.g., a blind student) can then access these labels while tactilely exploring the model with Talkit. Talkit is a desktop application that speaks the text labels when the user touches their associated areas. Both Talkit and Markit were evaluated in lab studies.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the Owner/Author.

ASSETS '18, October 22–24, 2018, Galway, Ireland

© 2018 Copyright is held by the owner/author(s).

ACM ISBN 978-1-4503-5650-3/18/10.

<https://doi.org/10.1145/3234695.3241004>

Figure 1. A visually impaired student is using Talkit++ on an iPad to learn the Plane model. Talkit++ speaks audio information when the student explores the model. The iPad is in a stand so that the camera can capture the student's interactions with the model.

In this demo, we present the next generation of Talkit, Talkit++, an iOS application that provides multimedia labels to 3D printed models. As shown in Figure 1, a TVI runs the Talkit++ application in her iPad. The TVI is teaching a session about the structure of a plane, and has added interactive multimedia elements to an existing plane model. As in Talkit, when the student touches different parts of the map, the application speaks their labels (e.g., “engine”). The student can also ask the application to provide a more detailed description by saying “more.” Beyond these functions that were present in Talkit, Talkit++ can play audio recordings (e.g., the sound of an engine), and display visual animations (e.g., the internal movement of an engine) for low-vision students. While this demo focuses on Talkit++, we also updated Markit, the model design tool, to support the new features in Talkit++.

NEW FEATURES IN TALKIT++

Compared to Talkit, Talkit++ has three new features: iOS compatibility, multimedia output, and a new model tracking method. We worked with TVIs through workshops and individual meetings to design these new features.

While Talkit is only a desktop application, Talkit++ can run on any iOS device. When working with students, TVIs commonly use mobile devices (e.g., iPads) as teaching tools. When running Talkit++, TVIs and their students can position their iOS devices in different ways, and the devices can capture users' activities from different angles.

Figure 2. We designed three interactive models: (a) the Map model, (b) the Volcano model, and (c) the Plane model.

In addition to text labels that were available in Talkit, Talkit++ also supports audio and visual animations. After trying out the Talkit prototype that plays audio labels (e.g., the name of a bird), some TVIs thought audio recordings (e.g., the sound of a bird) and visual animations (e.g., the animation of a flying bird) could be useful as well.

Talkit++ has new model tracking methods that require less modification to a 3D model. The previous Talkit application locates a model by locating an attached 3D tracker, which is a $2 \times 2 \times 2$ cm³ cube five bicolor tags, as shown in the Plane model in Figure 2. Some TVIs had concerns about the 3D tracker, explaining that it was too bulky. As such, we added support for 2D trackers in Talkit++. The size of these trackers can be changed to fit the model. These 2D trackers are printable bi-color tags that can be stuck onto a model, as shown in the Map model and Volcano model in Figure 2.

USING TALKIT++

To create an interactive model, a model designer uses the updated Markit application to add trackers and interactive multimedia elements. The designer can choose either type of trackers for a given model. For example, the designer may use a 3D tracker on a plane model, since a visually impaired student may rotate the plane model during exploration. For models that involve less spatial movement (e.g., the Map model in Figure 2), the designer can use several 2D trackers. In addition to the trackers, the designer needs to associate elements on the model with multimedia labels of their choice.

To use an interactive model, a visually impaired user sticks a red sticker on his fingernail, and runs Talkit++ on his iOS device (e.g., an iPhone or an iPad). The Talkit++ application tracks models through 2D or 3D trackers, and identifies the user's finger using the red sticker.

IMPLEMENTATION

Talkit++ has three main functionalities: (1) locating the model, (2) detecting the user's finger gestures, and (3) recognizing speech commands.

Talkit++ was developed in Swift and C++. To locate a model, Talkit++ uses the Chilitag trackers and library [3], which includes functions that provide the coordinates of 2D and 3D trackers. Based on these coordinates, the system calculates the real-world coordinates of the model, and

tracks a red sticker (placed on the user's fingernail) using OpenCV [4]. We cross compiled Chilitags and OpenCV and called them in Swift. After locating the model, Talkit++ plays a multimedia label based on the location of the sticker. For processing speech commands, Talkit++ uses Swift's built-in speech dictation functions.

SAMPLE MODELS

After developing Talkit++, we co-designed interactive models with three TVIs for use with their students. We held four weekly remote meetings with each TVI. During these meetings, the TVIs provided ideas and teaching plans, and the researchers helped them design the models. The entire design activity took one month, and produced three interactive models, as shown in Figure 2:

1. *Map*: A Washington State Regions map modified from a topographical map [8]. A TVI annotated the five regions on the map with text labels, and audio recordings. For example, she added the sound of an ocean for the "Coastal Range" region.
2. *Volcano*: A volcano model modified from Thing: 1316498 [1]. The model had five annotated elements. In addition to text labels, a TVI designed an animation of a volcano eruption for her low vision students.
3. *Plane*: A plane model modified from Thing: 182252 [5]. The model had six annotated elements, and a TVI added text labels for the cockpit, the body, and the jet engines of the plane model.

FUTURE WORK

In the future, we plan to make the application available to the public. In addition, we will create an online repository for interactive 3D printed models. The repository will collect practical samples of interactive models, and enables teachers and students to access these models freely.

ACKNOWLEDGEMENT

This research was supported in part by Oath and National Science Foundation (NSF) under grant #IIS-1746123. We thank Niti Parikh and Simone Stern for printing study materials. We also thank all the reviewers for their valuable comments.

REFERENCES

- [1] 3D Print a Volcano by mfritz - Thingiverse:
<https://www.thingiverse.com/thing:1316498>. Accessed: 2018-06-17.
- [2] AER – Association for Education and Rehabilitation of the Blind and Visually Impaired: <https://aerbvi.org/>. Accessed: 2018-06-17.
- [3] Bonnard, Q. et al. 2013. Chilitags 2: Robust Fiducial Markers for Augmented Reality and Robotics. CHILI, EPFL, Switzerland.
- [4] Bradski, G.R. and Kaehler, A. 2008. *Learning OpenCV: computer vision with the OpenCV library*. O'Reilly.
- [5] Plane by YahooJAPAN - Thingiverse:
<https://www.thingiverse.com/thing:182252>. Accessed: 2018-06-17.
- [6] Shi, L. et al. 2016. Magic Touch: Interacting with 3D Printed Graphics. *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '16)* (2016), 329–330.
- [7] Shi, L. et al. 2017. Markit and Talkit: A Low-Barrier Toolkit to Augment 3D Printed Models with Audio Annotations. *UIST '17* (2017).
- [8] Washington State Topographical Map | 3D CAD Model Library | GrabCAD:
<https://grabcad.com/library/washington-state-topographical-map>. Accessed: 2018-06-17.