Multimodal Augmentation of Surfaces Using Conductive 3D Printing

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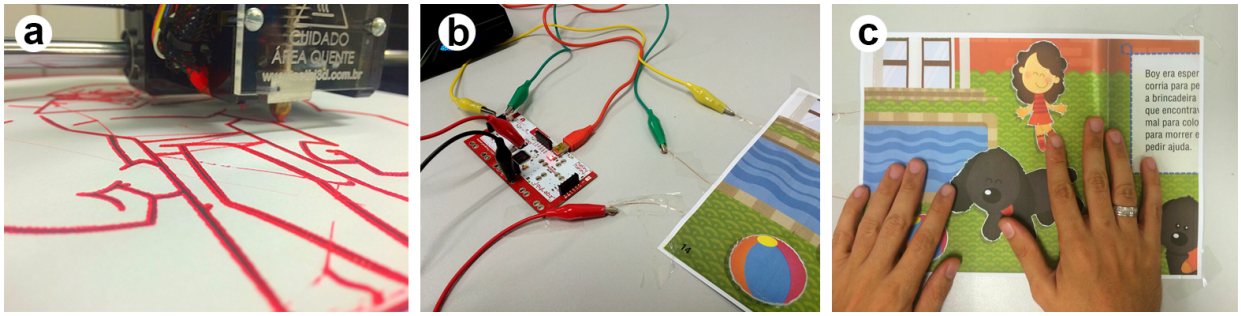

Figure 1: *(a) Registered 3D printing over the drawing placed on printer's bed. (b) Connections between printed content using conductive filaments and Makey Makey board for audio feedback. (c) User sensing the assistive content and triggering the audio associated to the elements being touched.*

1 Introduction

Accessible tactile pictures (ATPs) consist of tactile representations that convey different kinds of messages and present information through the sense of touch. Traditional approaches use contours and patterns, which create a distinct and recognizable shape and enables separate objects to be identified. The success rate for recognizing pictures by touch is much lower than it would be for vision. Besides that, some pictures are more frequently recognized than others. Finally, there is also some variation from individual to individual: while some blind people recognize many images, others recognize few. Auditory support can improve the points listed before, even eliminating the need for sighted assistance.

[Fusco and Morash 2015] propose a tactile graphics helper mobile system based on visual finger tracking. QR-codes are used as trigger to the content to be read. When users approximate the finger to one of the markers, they can hear a description regarding the visual element. They also revealed that tactile graphics usually take too much time to be produced, due the lack of assistive content processes available.

In this work, we propose a pipeline using computer vision techniques for augmenting existing surfaces through touch and sound [Teixeira et al. 2016]. Computer vision is adopted in the content preparation phase, speeding up the assistive content elaboration. Conductive material is deposited over the image and sound feedback is given by mapping printed elements and keyboard letters. We show that infant books can be easily transformed into assistive content for visually impaired children using the proposed technology.

2 Our Approach

The proposed pipeline makes use of four distinct components: a computer, a FFF (Fused Filament Fabrication) 3D printer (using conductive filament), a webcam attached to it and a Makey Makey board. The later is used to provide audio response based on what user touches. The fabrication process starts with the webcam capturing an existing image placed over the 3D printer's bed. The tool was developed with the OpenCV Library (using C++ language) and receives as input the captured image. Since the camera-printer system was already calibrated, the tool establishes a correspondence between both coordinate systems. The image is then rectified, segmented and it has its contours detected. Each contour defines an interaction zone and maps the touch to a specific sound. In order to optimize the g-code generation, countours are simplified using a polygonal approximation algorithm. Both image segmentation and polygonal approximation can be manually adjusted using the sliders present on the tool developed. The generated g-code solely uses G0 and G1 instructions which corresponds to extruder movement and extruder movement with material deposition, respectively. After sent to the 3D printer, the instructions alow the printing process to be registered with the drawing still placed on the printer (Figure 1.a). After printed, each contour is connected to an end point in the Makey Makey board using copper wires and associated to a given sound (Figures 1.b and 1.c).

We are currently testing the system with visually impaired users in order to verify its potential. By printing on both sides of the surface, we will also be able to automatically construct the conductive channel from the contour to the Makey Makey board connector on the backside of the paper. A deep analysis regarding the conductive filament adherence is also being performed. We plan to test different base materials including Paper, Nonwoven, Acetate, Nylon and PVC so we can know which existing content can be adapted by the proposed pipeline.

References

FUSCO, G., AND MORASH, V. S. 2015. The tactile graphics helper: Providing audio clarification for tactile graphics using machine vision. In *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility*, ACM, 97–106.

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