Supporting Object-level Exploration of Artworks by Touch for People with Visual Impairments

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ABSTRACT
One of the reasons that people with visual impairments have difficulties in enjoying artworks is the limited number of accessible artworks. To enable people with visual impairments to explore and understand various artworks independently, we built a touchscreen-based mobile application as a prototype focusing on 2D paintings which plays object-level verbal descriptions upon users' touch. To confirm the needs and to collect initial feedback from potential users of such a system, we conducted an exploratory study with 8 participants with visual impairments using the prototype as a design probe. Overall, participants appreciated the prototype as they can learn artworks with less physical and time constraints while listening for details of contents as they explore each painting by touch.

Author Keywords
Art paintings; visual impairment; explore-by-touch; image understanding

ACM Classification Keywords
Human-centered computing → Interactive systems and tools; Accessibility

INTRODUCTION AND RELATED WORK
While people with visual impairments (PVI) are interested in enjoying art as much as sighted people, a number of artworks are not accessible for them [6, 10, 11].

To improve artwork accessibility for PVI, prior studies provided either or both audio descriptions and tactile cues [4, 7, 9, 12, 14, 15]. For instance, museums offer audio guides for visitors [1–4]. Eyes-Free Art [14] also plays different types of audio feedback depending on the distance between the painting and the user. Iranzo Bartolome *et al*. [12] and Reichinger *et al*. [15], on the other hand, provide both audio and tactile feedback with a 2.5D tactile representation of an artwork.

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Figure 1: An original painting example (left) and its visualization of segmented objects in different colors (right). Our touchscreen-based application plays verbal descriptions of each object upon touch (*e.g.*, "A cypress tree, painted black, located on the left side of the painting).

While promising, these require PVI to visit the exhibition sites in person, which can be additional barriers in terms of transportation and costs [6] or have a custom device per painting. Thus, the number of accessible artworks is still limited.

To improve painting accessibility for PVI on a large scale, we have designed and implemented a prototype that enables users to explore specific objects within each painting by touch on their personal devices while listening to verbal descriptions about their object of interests.

PROTOTYPE

User Interface
As shown in Figure 1, users can learn about each object segment expressed in a painting by touch and listen to object-level information in detail such as the name, color and position of the object similar to how Morris *et al.*[13] or Explore Photo feature on Microsoft's SeeingAI app [5] lets users understand visual contents. For instance, users can either use swipe gestures to go through a list of objects or freely explore objects in a painting by touch to better understand spatial information of objects within an image such as position, shape, and size, inspired by screen reader gestures (*e.g.*, Apple's VoiceOver).

Content Preparation
To provide an object-level description for this version of the prototype, the object segmentation and its text description were recorded manually. This process will be crowdsourced like LabelMe [16] or fully automated as in [13, 17] in the next version.

Implementation

Our prototype was first developed as a web application using HTML, JavaScript, CSS, and D3.js[1] and optimized to a VoiceOver compatible iOS application.

USER STUDY

To understand perceived benefits and potential design challenges of our approach, we recruited 8 participants with visual impairments through a national school for the blind and conducted a semi-structured interview study using our prototype. All of them were male and their age is 41.8 on average (*SD* = 10.7). One was totally blind since he was 2 years old, and others have either light perception or low vision. Participants were asked to freely explore 4 different genres of paintings[2] using the application, followed by a semi-structured interview about their experience with the prototype. All participants compensated for their time.

FINDINGS

We summarize participants' perceived potential and suggestions for improvements of our prototype below.

Exploring Objects in Paintings by Touch

Being able to explore paintings by touch while listening to verbal feedback was greatly appreciated by 4 participants (P2 & 5-8). Indeed, P8 complained that most museums have zero or few paintings available for touch. Participants mentioned that the proto-type enables them to understand the shapes of objects and where they are located. For instance, P7 said:

> *"It is hard to imagine what it (painting) looks like just by listening to descriptions. [But with this] I can grasp where things are by touching them with my finger."*

Painting Encyclopedia

Some participants also found our prototype to be valuable because they felt like they are gaining knowledge as if reading encyclopedia (P3 & 5). However, P5 suggests providing an experience similar to visiting a museum with a curator who can answer questions and provide details. Indeed, most of the participants preferred accompanying a curator when learning about paintings (*N* = 5) over audio guidance or friends or family (*N* = 1 each) as they can ask questions to someone with expertise.

Greater Access to Paintings

We asked participants what they like the most about the prototype, and most of them reported that they appreciated being able to imagine what each painting looks like without sighted person's help (P4-8). Some participants also valued that they can access paintings at any time they want and as much time as they need at their own pace (P3, 5 & 6). P5, for example, mentioned:

> *"Unlike art galleries, I can enjoy more paintings as quickly as I want and come back again anytime if I want to."*

Moreover, they liked being able to save time and money as visiting a museum is not necessary (*N* = 5 and 4, respectively).

Suggestions for Improvements

Participants provided insightful suggestions related to types of information they would like to know about paintings and a system interface. First of all, participants wished to know distinguishing features, painting styles and textures, overall mood and a link to relevant artworks (*N* = 2 each) and experts' opinion (*N* = 1) for the painting-level description. As for the object-level description, 5 participants requested for relative attributes of each object with respect to others such as position and size, as opposed to absolute descriptions we provided as well as verbal descriptions of color and shape more in detail.

CONCLUSION AND FUTURE WORK

To improve artwork accessibility for PVI, we developed a touchscreen-based mobile application as a prototype which allows them to explore objects that are expressed in paintings by touch with verbal descriptions. Findings from an exploratory study with 8 participants with visual impairments suggest that our prototype can help them freely explore various paintings by touch and learn about paintings more in detail with object-level descriptions as well as spatial information such as position and size.

The future version should support multimodal interactions as in [8, 13, 17] where users can specify an object by touch and verbally ask questions of their interests, providing similar experiences like curators at a museum which was favored the most. Moreover, while our current prototype could demonstrate 4 paintings, we plan to expand this work on a large scale supporting a greater number of paintings by collecting visual descriptions of each object in paintings from crowd workers or by opening a public platform which can be powered by collective intelligence following Wikipedia model[3]. Ultimately, we hope to automate the object segmentation and description generation process using machine learning once we collect sufficient data as in prior works on eyes-free photo exploration [5, 13, 17].

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[1] https://d3js.org/

[2] (1) Landscape - The Starry Night by Vincent van Gogh, (2) Portrait - Girl with a Pearl Earring by Johannes Vermeer, (3) Abstract - Composition II in Red, Blue and Yellow by Piet Mondrian and (4) Still life -The Basket of Apples by Paul Cézanne.

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