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# FingerDraw: More than a Digital Paintbrush

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Figure 1: Children can capture sketches of real scenes, and pick colors/textures from objects in their surroundings

## ABSTRACT

Research in cognitive science shows that engaging in visual arts has great benefits for children particularly when it allows them to bond with nature [7]. In this paper, we introduce FingerDraw, a novel drawing interface that aims to keep children connected to the physical environment by letting them use their surroundings as templates and color palette. The FingerDraw system consists of (1) a finger-worn input device [13] which allows children to upload visual contents such as shapes, colors and textures that exist in the real world; (2) a tablet with touch interface that serves as a digital canvas for drawing. In addition to real-time drawing activities, children can also collect a palette of colors and textures in the input device and later feed them into the drawing interface. Initial reactions from a case study indicated that the system could keep a child engaged with their surroundings for hours to draw using the wide range of shapes, colors and patterns found in the natural environment.

## Categories and Subject Descriptors

H.5.2. [User Interfaces]; Interaction styles, Input devices and strategies

## General Terms

Design, Human Factors

## Keywords

Children, Drawing, Finger-worn Devices, Interactive Visual Arts

## 1. INTRODUCTION

Visual arts play an important role in the early development of children's cognitive skills. Research has proven the existence of strong links between arts and cognition, including thinking, problem solving, concept understanding, information processing and overall intelligence [7]. Students who engaged in visual arts do better in college admission exams (e.g. SAT) by learning

through persistence, expression, making clear connections between schoolwork and the real world, observing their environment and innovating through exploration [8]. Not only do visual arts support perceptual abilities such as awareness of colors, shapes, forms, lines and textures, they also assist children to gain fine muscle control and strengthen eye-hand motor coordination, which is necessary for later writing activities [19].

In 2003, according to the National Center for Education Statistics, USA, 67% of children in nursery schools were using a digital device such as a notebook computer [4]. This abundance in digital technology exposes children to many drawing applications on smartphones/tablets and other personal digital devices. While drawing applications do a decent job in engaging young children in the digital domain, they may disconnect these children from the physical world around them. Rivkin and Mary suggest that nature provides a rich multisensory stimulation, which is critical for brain development in early childhood [16]. Children have shown improved science test scores after short outdoor educational programs [15], validating the bond between education and exposure to nature. This motivated us to develop a visual art related tool for helping children to engage in drawing while bringing environmental attributes into the context.

We propose FingerDraw, a tangible and portable tool that enables children to draw on a digital touch screen while allowing them to remain actively connected with the physical world. FingerDraw augments the human finger, allowing children to easily bring environmental attributes such as sketches of their surroundings and colors and textures of real objects into their artwork. Children can then use those attributes as digital templates or ink for immediate drawing on a digital touch screen, or collect and save them virtually inside the augmented finger for later drawing activities.

## 2. RELATED WORK

ClayStation [21] and kidCAD [6] enable children to create virtual characters in a graphical interface while physically making clay models. Video Puppetry [2] and ZOOTOPIA [1] define a tangible toy set for children to make animations by placing each toy on a mat. Spelling Bee [5] combines several tangible blocks for a collective user experience. These attempts actively engage children with physical objects, but with a limited opportunity to bring the real-world environment into the activity. Instead we

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attempt to empower children with a tangible tool for interacting with the surroundings and their digital devices in a seamless way.

I/O Brush [18] is a tool for picking colors, textures and movements from everyday objects and using them as brush strokes on a digital drawing canvas. Seeing with Your Hand [3] proposes a glove with sensors for viewing surroundings including inaccessible environments, even though it is not designed for drawing purposes. FingerDraw extends these ideas by capturing not only colors and textures, but also entire objects and indoor/outdoor scenes into the digital domain. Unlike I/O Brush, Fingerdraw is a mobile tool, which enables more freedom in exploration of the environment as an inspiration for drawing material.

A number of software-only drawing applications for portable digital devices are commercially available. For example Coloring Book<sup>1</sup> and Kids Paintings Coloring Book<sup>1</sup> allow children to draw with a fixed set of templates and colors. Moving one-step further, Coloring Maker<sup>2</sup> lets children improvise on images captured from the surrounding with a fixed set of digital colors. FingerDraw provides a seamless way to bring scenes, colors and textures from the real world into digital drawings.

The fingers provide an interesting interaction design space for always-available input/output [11, 22]. Fingers have an incredibly rich and expressive repertoire [17, 20], which allows us to interact with touchscreens in a very natural way. FingerDraw aims to combine the above two characteristics to deliver a seamless drawing experience.

### 3. FINGERDRAW

FingerDraw is inspired by the way in which early artists obtained colors from nature. It extracts colors, textures, as well as traces of entire scenes and objects from everyday life, and converts them into digital ink. Through finger augmentation, it allows children to use the same finger for both capturing these environmental attributes as well as drawing with them. As a result, children are encouraged to think of digital ink adhering to their finger just as is the case with using real paint for finger-painting (Figure 2)<sup>3</sup>. By building upon this familiar activity, we intend to draw the attention of children back to interacting with the real physical world.

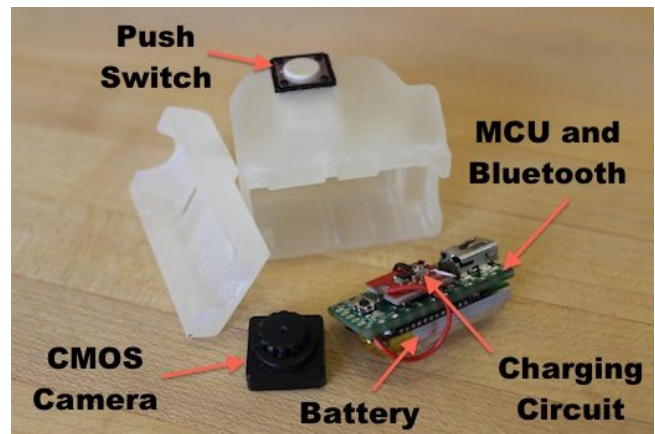


**Figure 2: Traditional finger-painting: the child touches the real paint and applies it to the canvas. Paint adheres to the fingertips.**

<sup>1</sup> <https://play.google.com/store/apps>

<sup>2</sup> <https://itunes.apple.com>

<sup>3</sup> Image courtesy goddessinprogress' photostream, flickr.com



**Figure 3: Components of EyeRing**

### 3.1 Implementation

The FingerDraw system consists of two components. A finger-worn camera device to extract visual attributes from the surroundings and a digital canvas for drawing.

#### *Finger-worn Device*

The FingerDraw hardware is based on EyeRing [13]. It consists of a ring-shaped, finger-worn device with an embedded camera, micro controller, wireless connectivity and a trigger button (Figure 3). Images are captured and wirelessly transferred over to a connected device upon a single or double click of the trigger button.

#### *Digital Canvas*

The Digital Canvas has been implemented on a tablet running Android operating system 4.0.4. The Digital canvas application has an option for a user to connect the finger-worn input device through bluetooth. Once connected, image data received from the finger-worn input device can be used for extracting sketches, solid colors and textures. The canvas allows the user to make use of these visual attributes in his or her drawings, along with options for changing brush size, saving drawings and saving palettes. It also allows the user to upload a color/texture palette that he or she had earlier saved inside the finger-worn device to the digital canvas.

#### *Generating pencil-sketch, solid color and texture*

The FingerDraw application continuously listens for image data that is being sent from the finger-worn input device via Bluetooth. A software variable flag along with a prefix (preceding image data) is being used to distinguish among generating a sketch (edge map), extracting solid color and extracting texture from the received snapshot. According to the flag and prefix, the system delivers corresponding messages to the image processor to generate a sketch, solid color or texture. A single button click on the finger-worn input device corresponds to extracting the most common solid color inside the middle 80x80 sub-image, while a double click corresponds to extracting the image itself as a texture. We utilize color conversion and smoothing followed by Canny's edge detection algorithm for generating a digital sketch of a scene. This was implemented using OpenCV improc library.

#### *Storing color palette inside the finger-worn input device*

The user can store a palette of colors inside the finger-worn device for later use even if it is not connected to the digital canvas. In the current implementation, this was done by wirelessly transferring images from the finger-worn device to the tablet and



storing it in a unique folder. The user may perform a long-press on the color palette in the digital canvas to retrieve the stored colors. We are working on either having an internal storage inside the finger-worn device or implementing a cloud-based storage for colors.

### 3.2 FingerDraw Enabled Interactions

The following is a real life usage scenario of FingerDraw:

*FingerDraw generates sketches of real world scenes:* Sarah, a five-year-old girl shops with her mom every weekend. One Saturday, a toy car catches her attention while she is passing by a toy store. She points the finger-worn input device at it and presses on the trigger button to capture a picture and generate a digital pencil-sketch of the toy car (Figure 4). This interaction offers children like Sarah a limitless space of templates without restricting them to a set of predefined sketches as in regular coloring books.



Figure 4: Generating a pencil-sketch of a real scene

*FingerDraw extracts colors and textures from everyday objects:* Sarah captures numerous colors and textures from various toys she finds in the store, and uses them to color the sketch of the car which she had taken previously (Figure 5). She ‘picks’ colors/textures by pointing at objects in her surroundings to generate brush strokes for her drawings.

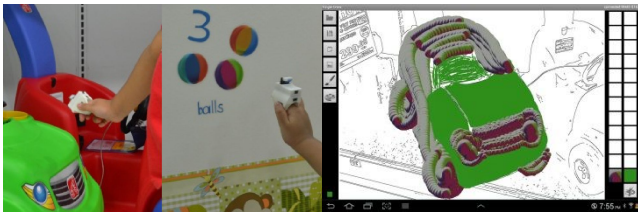


Figure 5: Extracting colors and textures from real world objects.

*FingerDraw stores a color palette inside the finger:* On the way back home, she encounters some colorful leaves and bark on various trees in the park, which she stores as a palette of favorite colors and textures inside her finger-worn device. Once at home,



Figure 6: Storing a palette of colors inside the finger-worn device

she feeds the stored palette into her tablet with a simple touch (Figure 6). This empowers children to explore the world freely and encourages them to be keen observers of shapes, patterns and colors in the natural environment.

### 4. USER REACTIONS

We conducted a case study of FingerDraw with a 5-year old girl at her home. After a brief demonstration, she was free to try the FingerDraw system on her own. The immediate reaction we noticed was that she was very excited and eager to search for a scene or object that would result in an interesting tracing. At first, she started drawing immediately and searched for colors/textures whenever she needed them. After a while, she started collecting colors/textures before making a drawing. We noticed that she sometimes had difficulties with connecting the finger-worn device to the tablet, as she wasn’t familiar with bluetooth pairing. Sometimes she found unanticipated ways to capture colors/textures. For instance, she captured colors from a cartoon in a television program and also tried to capture colors from a far away wall. We observed that the finger-worn device was slightly too big for her finger and had obstructed the view of the drawing she worked on. A smaller version of the finger-worn device would resolve this problem. Surprisingly, the girl did not try to replicate the exact same colors of the real object in her drawings. For example, she captured a sketch of her brother, painted him with a black color and said, “that’s my brother, but he is black now”. This was a single user case study, but it gave us some useful insights for future improvements.

### 5. DISCUSSION

The main purpose of FingerDraw is to provide a playful tool for children to get in touch with their surroundings. We believe that the portability of FingerDraw would encourage children to explore their surroundings more freely. Being able to store a color palette inside the ring for later use would release them from being always attached to digital devices and stimulated their curiosity to find attractive colors and textures in their surroundings. The ability to capture entire objects/scenes along with colors/textures would enable children to associate real world attributes to digital equivalents. Even some adults who tried FingerDraw found it to be an engaging tool. Figure 7 shows some of the drawings they made using the FingerDraw system.

The FingerDraw system could be used as a portable learning tool to serve students at different skill levels. From kindergarten to graduate school, drawing books are used for a wide variety of purposes. While assisting young children to learn boundaries [14], these books assist students to retain complex information by kinesthetic learning [9]. Moreover, visual arts assist children to relieve stress, emotional problems, trauma, etc. [12]. As such, FingerDraw could be used as a therapeutic tool to address some of the above conditions, providing soothing effects by bringing nature into drawings [10].

Motivated by the limitations of our current implementation that we identified through the case study, we expect to redesign the finger-worn device such that it fits different finger sizes and does not obstruct the view of the screen. We also intend to enhance the image processing software to provide even more clear sketches and to capture colors with higher accuracy. We also expect to simplify the procedure for connecting the finger-worn device with the touch-enabled screen.

### 6. CONCLUSION

FingerDraw aims to take children from a purely digital domain back to the physical world, letting them enjoy the benefits of



Figure 7: Some of the drawings made using FingerDraw.

being simultaneously in touch with nature and engaging in digital arts. It invites children to actively explore and study their environment as an inspiration for objects, scenes, colors and textures, which can then be used in their digital drawings. Because of its portability, children may explore the setting outside the house or playroom, and make drawings on the spot wherever they find exciting sceneries, colors and textures. Alternatively, they can save a palette of scenes, colors and textures inside the finger-worn device for later use in their drawings. A smaller form-factor and intuitive pairing with the drawing canvas would help in encouraging children to see FingerDraw as an extension of their finger. Despite the current limitations, we believe FingerDraw system would help children to be more engaged and aware of their surroundings.

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