I-Draw: Towards a Freehand Drawing Assistant

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ABSTRACT

In this paper we present I-Draw, a drawing tool to assist free hand drawings on physical surfaces. We explore the interaction design space that combines the digital capabilities with the traditional drawing process. I-Draw device has been conceptualised in terms of its interactive philosophy, features and affordances. We developed a proof-of-concept prototype of I-Draw and discuss the future directions. We believe I-Draw would open new drawing possibilities between physical and digital spaces.

ACM Classification Keywords

H.5.2 Information interfaces and presentation: User Interfaces

Author Keywords

Freehand drawing, Smart Tools, Computer-aided Design

INTRODUCTION

Drawing is one of the earliest modes of human visual interpretation which has grown into a professional skill as well as a hobby over generations. Even though drawing is a common activity among humans, most people face problems when it comes to drawing with precision and accuracy. For example, drawing a precise straight line or a basic shape such as a circle is not an easy task for an untrained person. Maintaining desired proportions throughout a particular drawing is another challenge faced even by trained artists. Despite having a set of traditional tools such as rulers and compasses to support the artists with precision and accuracy, some tasks like scaling and rotating take more time and effort in physical space.

With the emergence of digital technologies, computer aided design (CAD) tools were created to support the drawing process. These opened new pathways for drawing techniques in digital space. Such digital techniques were capable of solving most of the physical world drawing challenges. However, digitally created artwork has the limitation that its final output only comes out as digital content or as printed media. Furthermore, traditional artwork done on physical surfaces such as papers, canvases, walls etc. are still highly appreciated due to the sense of originality attached and the personal narratives they carry.

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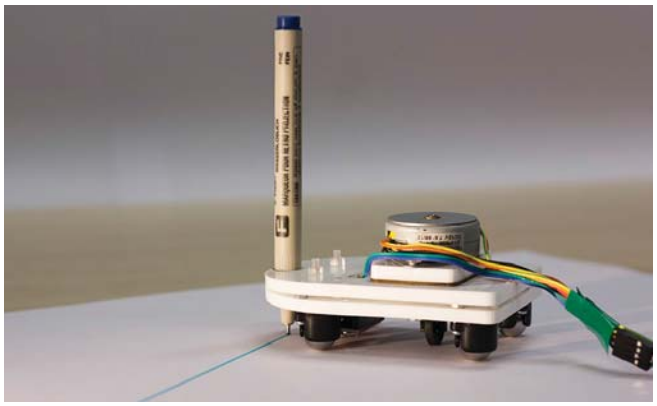

Figure 1. I-Draw freehand drawing assistant

With I-Draw (Figure 1), we explore a novel approach to combine digital capabilities with physical drawing while keeping the sense of originality and personal touch. I-Draw enables interplay between digital guidance and natural freehand drawing allowing users to switch seamlessly between them. In this paper, we describe a new drawing guidance mechanism based on the mechanical properties of a wheel to control and guide the natural freehand drawing process. The physical design and operational mechanism ensure compatibility of this interface with a wide range of traditional drawing media and usability over number of physical drawing surfaces.

Contributions of this paper are as follows.

- Exploration of the interaction design space, concept and potential interaction scenarios of I-Draw
- Design and implementation of a bidirectional (between freehand and guided drawing) drawing guidance interface

RELATED WORK

There are numerous works conducted on implementing drawing guidance systems in the field of human computer interaction. QuickDraw [1] was designed to support geometric diagram drawing by post correcting the diagrams drawn on a touch sensitive panel. Iarussi et al. worked on an assistive tool to provide automated guidance over digital photographs to practice traditional

drawing-by-observation techniques [2]. Such systems enabled users to draw easily and accurately in digital space.

Some systems attempt to integrate advantages of the digital capabilities with traditional pen and paper based drawing process. dePENd [4] is such a system which uses the ferromagnetism of the ballpoint pen to guide it using a movable magnet placed underneath the drawing table. It needs a special setup to operate and it only limits to the pen based drawings. Comp*Pass [3] is a similar interface which is used to draw computer drawn images on non digital surfaces functioning based on the mechanism of a traditional compass, but it lacks the intuitiveness and the gestural freedom of the traditional drawing process. In addition, most such systems are based on digital to physical mapping that limits the freedom of the user to follow the digital guide. Drawing inspiration from Zoran, et al [5], I-Draw explores the seamless switching between guided and freehand modes to add more personal touch and creativity to the artwork. In addition, I-Draw can be used with a wide range of traditional drawing media and drawing surfaces without needing a special setup.

INTERACTION DESIGN SPACE

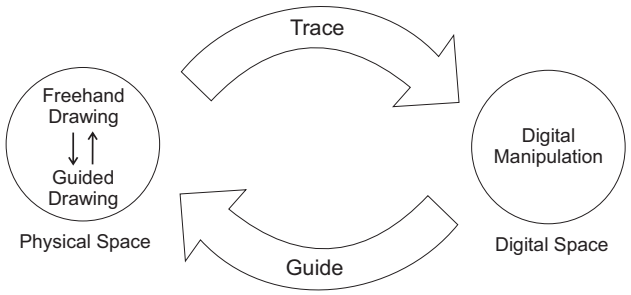

Figure 2. I-Draw

We explore the interaction space of I-Draw to find novel approaches to combine the digital and physical domains in the context of drawing (Figure 2). We identified, three interaction primitives of I-Draw.

- ***Guided drawing***: Drawing in the physical space is guided by I-Draw based on the command information received from a digital controller. The controller adapts and supports operations such as scaling and rotation.

- ***Freehand drawing***: Drawing in the physical space freehand without the assistance of the system. These freehand drawings are traced into a computer in real-time. User can switch between guided and freehand modes as needed.

- ***Digital manipulation***: Physical content traced into digital space can be manipulated digitally with digital tools. The digital content could be a trace of an image downloaded from a digital source (camera, internet, etc.) or traced content by I-Draw. This enables the traditional drawing process to leverage the advantage of digital tools.

We further explore potential composite interaction scenarios by combining the aforementioned interaction primitives.

Assisted Physical Drawings: I-Draw can be viewed as a tool to transfer an image available as digital content to a physical surface. This enables the traditional artists to benefit from digitally available content in their creative work using *Guided* and *Freehand* primitives. In addition, digital artists can work with digital tools (*Digital manipulation*) and then transfer the digitally created content into the physical domain (*Guided* and *Freehand*).

Physical to Digital Tracing: I-Draw can act as a tool to digitise a physical drawing. We call this as *Tracing*. When a user draws with the freehand primitive, content drawn are traced in the digital space. As such, contour of a drawing existing in physical space can be transferred into the digital space by *Freehand drawing* on the outline of the image. This process mimics the traditional way of tracing an image using a tracing paper.

Physical Copy-Paste: I-Draw can be used to copy-paste an image on a physical surface to another physical surface. Users could trace an outline of an image by *Freehand drawing* and replicate that on another surface by *Guided drawing*. This adds duplicability and rapidity to the traditional drawing process in physical space.

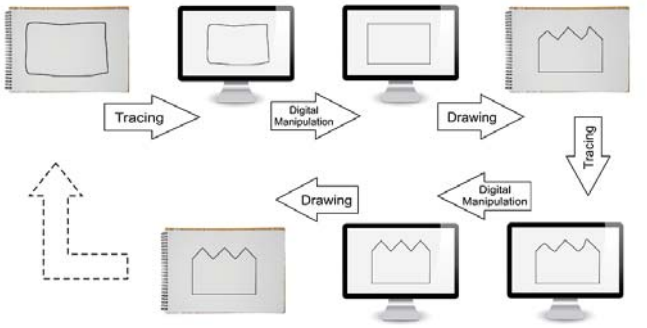

Figure 3. Steps of a physical to digital cyclic collaborative work

Physical-Digital Cyclic Collaborations: I-Draw can provide a collaborative, iterative drawing platform between traditional artists and digital artists. Traditional drawings on a physical surface could be traced (with *Freehand drawing*) into a digital environment, and the digital artist could manipulate it digitally. The resultant contents could be represented in a physical drawing with *Guided drawing* and *Freehand drawing*. Modifications done during the physical representation will again be traced in the digital environment. This process can be repeated to create multiple drawing iterations (Figure 3).

I-DRAW

Device Concept

We outline the key elements of I-Draw concept in terms of its interactive philosophy, affordances and features. The Interactive philosophy of I-Draw is completely based on the natural freehand drawing process.

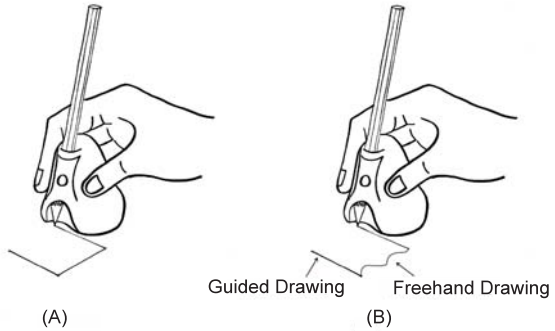

Figure 4. (A) Drawing a square shape (B) Switching between guided and freehand drawing

In this design, we tried to provide drawing assistance while performing freehand-like drawing without having to switch to another mode.

For example, when drawing a square consisting of straight lines using a ruler, the user needs to switch to a different gesture - holding the ruler in one hand and drawing from the other. However, with I-Draw the drawing pattern and the gestures will remain the same like freehand drawing (Figure 4 (A)). The design of I-Draw enables a seamless interplay between freehand and guided modes giving the opportunity to create one of a kind artwork enriched with unique personal features. User is provided with the control over the drawing and can switch to the freehand drawing mode when guidance is not necessary. (Figure 4 (B))

Figure 5. I-Draw compatibility

Drawing in the physical space is not limited to pen, pencil or paint brush based techniques, but feature a vast range of drawing media such as pastels, charcoal sticks, chalks etc. The operation principle of I-Draw doesn't depend on the qualities of drawing media. Therefore we propose the physical design of I-Draw to be compatible with a wide range of them (Figure 5).

I-Draw features adaptive scaling and rotating functions to enable the user to perform image transformations with

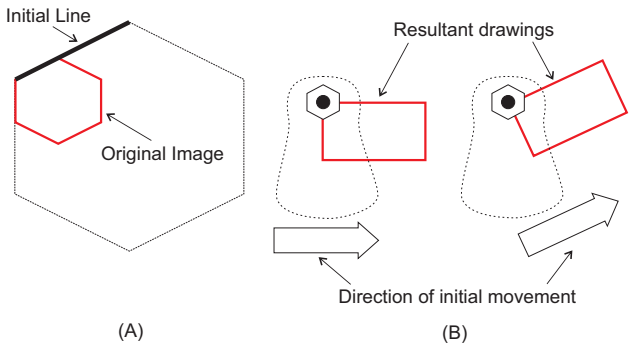

Figure 6. Drawing with (A) Scaling (B) Rotating

much ease. Size and rotating angle of the image are determined by magnitude and direction of the users' initial drawing movement vector. In adaptive scaling, the user can draw the initial line at any length, and remaining parts of the image will be rescaled according to the length of the initial line (Figure 6 (A)). In adaptive rotating, the initial direction of the wheel is set to the direction of the users' initial movement. All angles will then be drawn with respect to the initial direction of the wheel. Since these features need the user's involvement only at the start of the drawing, users can continue drawing without worrying about magnitudes and angles at each step (Figure 6 (B)).

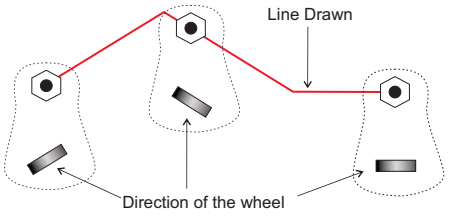

Figure 8. I-Draw Working Mechanism

Prototype Implementation

The design of I-Draw is based on a wheel which constrains the drawing movement of the users' hand. In other words user can only draw in the direction of the wheel. Therefore, lines of drawings can be controlled by controlling the direction of the wheel.The direction of the wheel is dynamically controlled by a stepper motor attached to it depending on the image to be drawn(Figure 8). Relative location of the device and the path it followed are traced by a trackball. The constraint wheel can be lifted, so that it will no longer be in contact with the surface, to facilitate unguided freehand drawing. We have implemented an initial prototype of this system with limited functions (Figure 9), to test the basic operation principle and the usefulness of the guided drawing mode. In this prototype we have used a commercially available 12V stepper motor and a trackball circuit. Arduino MEGA 2560 development board

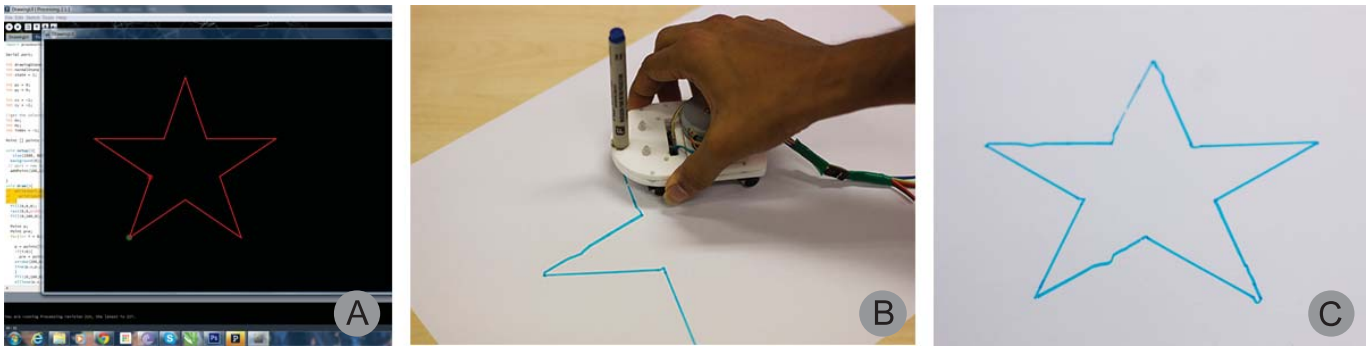

Figure 7. Usage of the I-Draw system (A) Software interface to connect with I-Draw (B) Guided drawing on a physical surface (C) Completed drawing

has been used as the controller and the serial communication interface. A wheel with a rubber grip, diameter of 12mm has been used as the constraint wheel and four free running small ball casters were attached to the four corners of the device to maintain balance and smoothness of movement. Device was powered up using an external power supply. Processing based software application was implemented to send digital inputs to the device using serial communication interface. The usage of the I-Draw system is shown in Figure 7.

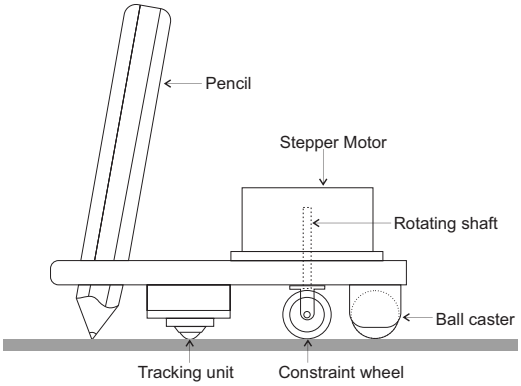

Figure 9. I-Draw Prototype Implementation

LIMITATIONS AND FUTURE WORK

Traditional drawing media (e.g. pencil, brush etc.), when used freehand, gives freedom to manipulate the media itself and create diverse stroke patterns, line weights and textures. As such, the physical design of I-Draw has been designed to be compatible with multiple traditional drawing media. However, the current form factor, partially restricts gestural freedom which may cause the artist to divert from such wide range of manipulation techniques. We are currently working on miniaturised hardware components with improved ergonomics of I-Draw to provide maximum gestural freedom.

The current tracking system of I-Draw tracks the location relative to the starting drawing position. As such, it loses the track if the user lifts the device and starts drawing from a new position. We wish to explore implementing an absolute tracking mechanism to address this. Low resolution of the stepper motor used in the current prototype limits I-Draw to draw shapes only consisting of straight lines. In future versions, we plan to use a high resolution stepper motor or a DC motor with high resolution encoder to support drawing curves. Furthermore, the grip of the wheel used is not sufficient to draw on smooth surfaces. The device began to slip and move in other directions when used on a slippery surface such as a white-board. This could be overcome by using a wheel with better grip. Finally, we wish to study this system with both traditional and digital artists and explore more potential collaborative application scenarios.

ACKNOWLEDGMENTS

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