Deformation Gesture-based Non-visual Drawing Tool

Pranjal Protim Borah
Embedded Interaction Lab,
Department of Design,
IIT Guwahati, India.
pranjalborah777@gmail.com

Keyur Sorathia
Embedded Interaction Lab,
Department of Design,
IIT Guwahati, India.
keyur@iitg.ac.in

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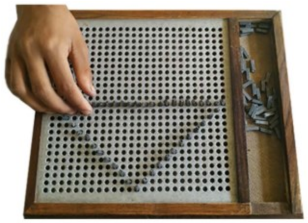
Abstract
Deformable user interfaces are increasing in HCI (Human-computer Interaction) research. Users can manipulate the physical form factor of a deformable user interface to interact with it. Deformation-based gestures provide innate tactile and kinesthetic feedback, essential for non-visual interaction. In this position paper, we reported a deformation gesture-based non-visual drawing tool for users with blindness or low vision.

Author Keywords
Non-visual drawing, Deformable device, Visually impaired, Accessibility.

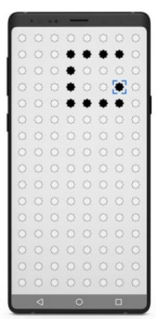
CSS Concepts
• **Human-centered computing ~ Human-computer interaction (HCI)**

Introduction
Smartphones are becoming ubiquitous and are also the most commonly used and carried digital devices by people with blindness [1]. However, for users with blindness or low vision, interacting with this more visually demanding interface through direct touch is difficult to learn without sighted assistance and challenging to use without tactile buttons. Although screen readers are available, the lack of tactile buttons minimizes the spatial visualization, and that leads to



(a) Tactile drawing on pegborad

(b) Deformation gesture-based interaction on a smartphone-sized flexible device



(c) Visual representation of primitive geometric shape drawing

Figure 1: Drawing tools and visual representation of drawing.

weak direct interaction with an intended target. To interact with the touchscreen devices through screen readers [2] and vibrotactile feedback [3] requires the user to perform non-visual touch gestures [4]. These interactions also demand the users' continuous attention to the feedback. Interacting with the screen reader itself by performing accurate touch gestures is a challenge for new users of touchscreen devices [5]. Moreover, frequently performing gestures on the screen during sequential access leads to occlusion in collaborative work with sighted users.

Another major challenge faced by blind or low vision (BLV) users is to access increasingly used graphical information in digital documents. The commonly encountered graphical information in educational, commercial, financial websites and mobile applications includes graphical data representation (bar graph, line graph, pie chart, Venn diagram), node-link diagrams (Flow diagrams, relational models, block diagrams, molecular structures), maps (static or dynamic), and pictures. Better accessibility to the reading and creating this graphical information is extremely important. Understanding these diagrams requires a better understanding of the primitive geometric shapes and their spatial relationships [6] among the elements of the shape and multiple shapes.

One potential opportunity to address the challenge of non-visual drawing is to use deformable user interfaces. Here the deformation of the device itself acts as a source of input. Users can provide a large set of distinct inputs depending on the location, direction, size, angle, speed, and duration of deformation [7]. Unlike touch-based interaction, deformation-based gestures can provide inherent tactile and kinesthetic feedback [8]. This tactile and kinesthetic feedback allows users to perform eyes-free interaction through deformation-based gestures [9]. The user group with blindness or low vision can take advantage of these features for interaction with digital devices [10]. This research investigates the use of deformation-based gestures for non-visual primitive geometric shape drawing to simulate the process of tactile pegboard-based (Figure 1a) drawing process.

Findings

To investigate the use of deformation-based gestures, we developed a silicone-cast deformable prototype (Figure 1b) that can detect bend gestures at 6 locations and two directions along with activation of 32 touch points on the surface. The drawing process was accompanied by verbal audio feedback (produced through Google Talkback), non-verbal audio feedback, and vibrotactile feedback. The progress in the drawing is displayed on a computer screen (Figure 1c) for collaborative work with sighted users.

Considering bend gesture-based interaction with two magnitude levels of size and angle-based gestures by BLV and sighted users, we found that both participant groups preferred two magnitude levels of size and angle of bend at all the four corners and two magnitude levels of only size at the top and bottom sides of the flexible device in portrait orientation. However, only BLV participants preferred both upward and downward directions of bend gestures. We also found that size differentiation is easier than angle differentiation, needs less continuous attention, and offers higher confidence.

Considering tactile drawing by BLV users, we found that drawing through bend gestures offers higher confidence regarding the direction of movement as compared to tactile pegboard-based drawing. In terms of task completion and ease of drawing through deformation-based gestures was found to be similar to that of the pegboard-based drawing tool. However, including advanced features proposed during participatory design process (such as prediction of mistakes, autocompletion of lines and shapes etc) can further enhance the effectiveness and efficiency of the drawing process.

Conclusion

In this work, we found that both BLV and sighted users can easily perform deformation gestures. With the advantage of innate tactile and kinesthetic feedback of deformation-based gestures, this interaction technique can complement the touch-based interaction to make interaction with digital devices more inclusive. We also found that deformation gesture-based digital non-visual drawing tools can enhance the experience, effectiveness, and efficiency of drawing by users with blindness or low vision. This also offers the opportunity for further exploration of deformable user interfaces for non-visual digital drawing.

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