Characterizing The Natural Pen Stroke

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Abstract

We present initial results of a study on the effects of biomechanical influences in the human hand on the natural pen stroke. A geometric model suggests that a user interface, curved to match the natural motion of the hand, would be more appropriate than a user interface aligned with the horizontal and vertical boundaries of the display device. While our results confirm the presence of a curve in the natural pen stroke, the curve does not appear to be of sufficient magnitude to justify modifying user interfaces.

Key words: User interface, biomechanics, pen

1 Introduction

Current user interfaces are rectangular or radial - aligned in some manner with the horizontal and vertical boundaries of the display device. While this alignment is *reasonable* or *natural* from a graphic arts perspective, it is unclear whether this alignment is still appropriate when biomechanical factors are considered, particularly for pen-based interface devices.

We report here on the results of our study of the natural pen stroke. The study is motivated by the question: "*Are biomechanical influences in the human hand sufficient to motivate changes to traditional user interface layouts?*"

Kinesiologists have observed [3] that people tend to minimize the amount of energy used to perform an action. If we ask a user to draw a *straight* line, the line tends to be *curved* in some way – the reach of the hand itself controls how the action is performed. This observation leads us to question the presumed validity of horizontal and vertical alignment of user-interface elements: perhaps user interfaces should be *curved*.

2 Background and Related Work

The influence of biomechanics was noted by Fitzmaurice *et al* [1] in their paper exploring artwork orientation in user interfaces. Observing that artists need to be able to move their page around as they draw in order to make themselves more comfortable or to facilitate certain kinds of strokes, they show that equivalent functionality on computer based tools is advantageous. Inspired by the animator's turntable (a desk on which part of the desktop swivels to allow the artist to turn their page freely), the placement and orientation of user interface elements is modified to match the current orientation of the input device.

Biomechanics is also important to radial interfaces like those proposed by McGuffin *et al* [2]. These interfaces present options in each of the eight cardinal directions, but the underlying coordinate system was aligned to the edges of the display device and not to the natural motion of the hand.

Our experiments tested a model (Figure 1(a)) that assumes that the biomechanics of the human hand influence the natural pen stroke to exhibit curved rather than straight-line results.

3 Experimental Method

Figure 1(b) depicts the experimental apparatus. An alignment constraint apparatus was used to constrain the position of each participant's forearm. The position and pen-tip pressure on the tablet were sampled at 100 Hz throughout each test run.

Under verbal direction of a researcher, the participant performed a series of stroke gestures on the graphics tablet. The participant did not receive visual feedback as they performed the gestures - the study is investigating *natural* stroke mechanics and we did not want the participant to adjust their movements based on visual feedback.

Each participant was asked to complete 2 sets of gesture sequences. The first gesture sequence required straight-line pen strokes in each of the 8 cardinal compass directions (N, NE, E, SE, S, SW, W, and NW). The second gesture sequence required the participant to perform an arbitrary series of gestures as directed by the researcher. Each participant was asked to perform a 3-stroke sequence of each gesture, where the sequence was defined as short, medium, and long versions of the requested gesture. 3-STROKE SEQUENCE FOR BOTH SETS?

4 Initial Results

Thirty-three participants were recruited from upper-year and graduate students in Computer Science.

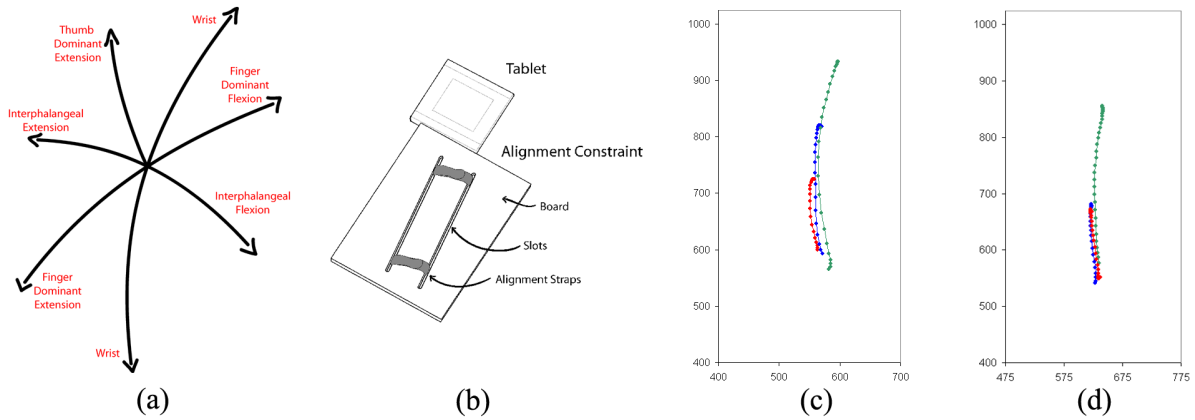

Figure 1: (a) Biomechanical Model, (b) Apparatus (c,d) Typical Results

Analysis of the first sequence of pen strokes reveals that there is a consistent curve to the natural pen stroke (Figure 1(c)). However, it may not be significant enough to matter in any practical interface design (Figure 1(d)). Some participants had a tendency to *hook* the ends of their lines (Figure 2(a)) which could cause difficulties with marking menus or gesture interfaces that might interpret these hooks as commands.

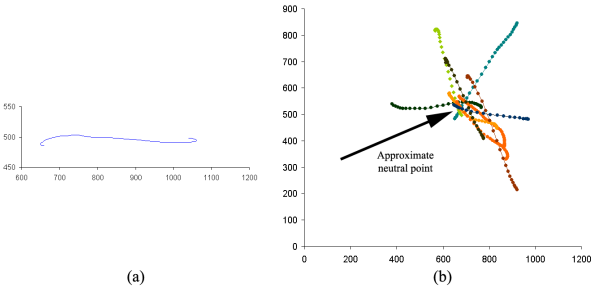

Figure 2: Stroke Results

Our initial analysis of the second stroke sequence seems to indicate that designing input devices based on geometric models may be unrealistic. During the experiments, the researchers observed such variety in the way the pen was held that it is difficult to identify similarities let alone identifying a dominant style. We observed that simply holding one finger at a slightly different angle in relation to the pen had a significant effect on the shape of the lines drawn on the tablet.

For some participants, motions from their recorded neutral position toward their gripping hand were difficult, if not impossible. Some compensated by starting the pen stroke on the far side of the neutral position then drew through the neutral position in order to complete the three strokes, particularly the medium and long lines (Figure 2(b)).

5 Conclusions and Future Work

This was an exploratory study, designed to help us decide whether to pursue a full scale investigation. Our initial analysis of the data supports our hypothesis that the biomechanics of the hand and the placement of the wrist do have an effect on the natural pen stroke. However, it does not appear that the effect is as pronounced as expected. Further analysis is warranted.

Observing the participants indicated that the participant's grip on the pen had noticeable effects, sometimes impeding the participant from completing a task. Given that the way an individual grips the pen mimics a more traditional physical disability, we feel that further investigation is warranted.

Analysis of the roles of the neutral position and of pressure is underway.

References

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