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Sloppy selection: Providing an accurate interpretation of imprecise selection gestures

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Abstract

This paper describes on-going work in the analysis of motion dynamics in pen-based interaction. The overall goal is the creation of a model of user motion in pen gestures where constraint and curvature vary over the length of the path. In particular, speed/curvature models of motion are used to analyze pen trajectories and infer target constraints obeyed by a user performing selection gestures. We aim to use this information to calculate an effective local spatial selection tolerance associated with each gesture. This can be used to perform selection according to user intent instead of their literal stroke. Here, we describe our early analysis of constrained user selection gestures, and outline a prototype application that infers a tolerance for one type of selection gesture. The application selectively splits pen strokes based on an analysis of user motion.

Keywords: Intelligent scissors; Inferred mode; Steering law; Minimum jerk; Stylus; Motion; Pen interface

1. Introduction

This paper describes on-going work in the analysis of motion dynamics of pen-based interaction. The particular problem at hand is the analysis of selection gestures in pen computing. Pen-based selection strategies include two common selection options, tap-to-select and encircling. We focus on the latter, that is, selection by drawing a freehand closed shape around a target object.

Different applications treat selection by encircling according to domain-specific or application-specific criteria. Most paint programs, for example, view selection gestures as definitive and cut image material precisely on the gesture's path. Advanced selection techniques can adjust a selection stroke to fit the borders of salient visual objects.

In pen-based note taking applications, selection gestures are typically interpreted in light of underlying pen strokes. Digital ink strokes themselves, and sometimes groups of ink strokes forming words, are viewed as immutable objects, and the selection gesture selects among strokes or words. A problem faced by these programs is, which objects should become selected when the selection gesture in fact intersects immutable objects?

In our work, we seek to interpret selection strokes based on inference of user intention. We hypothesize that significant and useful aspects of intent can be estimated from measurable characteristics of the gesture.

This work is currently in its early stages. The purpose of this paper is to present initial work in selection gesture analysis under varying curvature and target constraints. In addition, we outline a prototype proof-of-concept application which uses this analysis to make

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an intelligent judgment when executing one type of selection gesture.

2. Problem formulation

Reliable assertions about user intention with respect to their actions would allow designers of pen-based interfaces to take into account users' likely goals when choosing among program responses. Consider, for example, the user gesture in Fig. 1. Here, the user has drawn a circle around a line of text. Note that at the extreme endpoints of the line the user has clipped a number of letters from the gesture.

Given the spatial and semantic coherence of the sentence itself, a reasonable assumption can be made that the user intended to select the whole. Under some circumstances, however, a user may in fact wish to lop off one or more characters, or otherwise select a less salient set of markings. We suggest that in these cases users will gesture more carefully and deliberately, and hence generally speaking, more slowly than they otherwise would.

Our goal is therefore analysis of the deliberateness, or carefulness, of user gesture. More accurately, we formulate our problem as follows. Given a user gesture, such as shown in Fig. 2, can we infer at any point on that gesture the intended carefulness of the user at that point? Inferring this accuracy allows us to create a "tunnel" around the gesture. Objects located inside this tunnel may be excluded or included in the selection region based on their attachment to objects within or outside the selection region. Based on this attachment and the tolerance in the gesture, we can develop an interpretation of the selection gesture that allows a certain degree of inaccuracy, or sloppiness, in a user's expression of his or her intention.

Speed alone is not an indicator of carefulness because any gesture normally varies in speed along its path as a function of its starting and ending points, and shape. Our analysis must effectively factor apart baseline properties of trajectories executed under casual, or default, conditions (for example, the natural variation in speed due to variation in curvature of the path) from properties governed by intentional constraints due to task-specific targets.

3. Related work

The most successful analysis of human motion is undoubtedly Fitts' law [1], relating the time taken to acquire a target with the distance from and size of the target. However, work exists on the analysis of trajectories, both in HCI and in Neuroscience. In this section, we first detail related work in trajectory analysis, before going on to detail specific work in intelligent selection gestures.

3.1. Trajectory analysis

Trajectories have been analyzed in Neuroscience and in HCI. In Neuroscience, Flash and Hogan [2], and Viviani and Flash [3] have analyzed the characteristics of trajectories of motion by analyzing pen gestures. This research led to the development of the $\frac{2}{3}$ power law and the minimum jerk law, two laws of human motion that describe the instantaneous velocity of human movement during trajectories. In HCI, work has focused on the analysis of straight line motion under constraint, and resulted in the development of the Steering law, describing the movement characteristics of users when traversing nested menu structures.

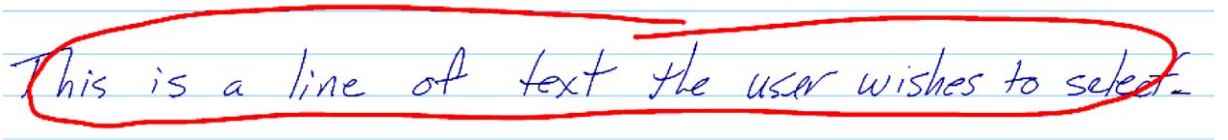

Fig. 1. A user selection gesture with inaccuracies.

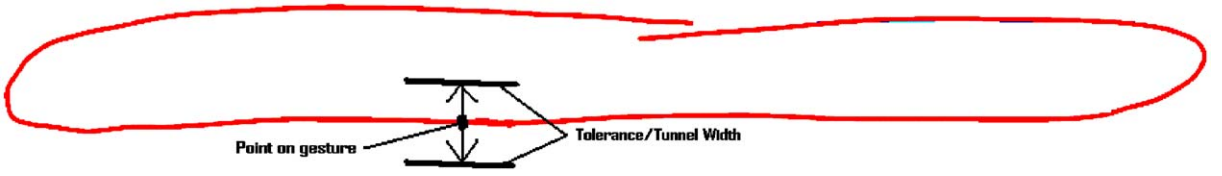

Fig. 2. Inferring tolerance at a point on the gesture.