These slides were for my presentation on Flow Selection for AVI 2006.

Flow Selection

A Time-Based Selection and Operation Technique for Sketching Tools

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My name is Gabe Johnson, and I am presenting work on a technique for selecting and operating on portions of hand-made sketches. This work was done with my advisors Mark Gross and Ellen Do.

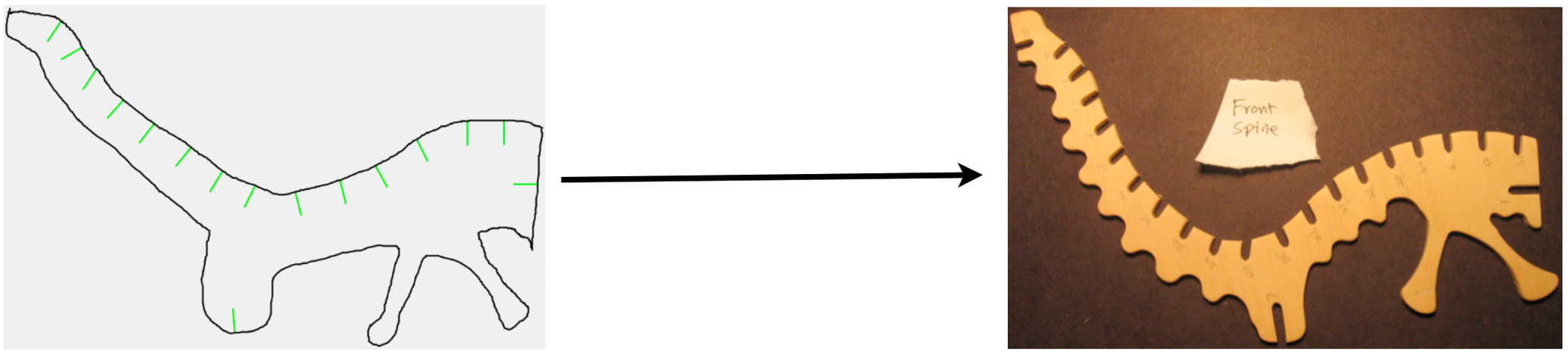
Flow Selection: Low-Level Pen Interaction Technique

- Precision of mouse vs. pen
- Mouse Interaction ≠ Pen Interaction
- Low-level techniques for pen interaction?
  - Flow Selection is one example

You probably know that a mouse lacks the precision of a pen. But for various reasons, developers of pen- and sketch-based interactive tools tend to rely on interaction techniques that were designed and optimized for mouse interaction. But there are lots of opportunities for exploring the space of interaction techniques that are appropriate for pen input. Today I will present one low-level technique called Flow Selection.

Flow Selection & Designosaur

- Designosaur "sketch-to-fabrication" prototype
- Hand-sketched 'bones' laser-cut from material
- How to quickly correct errors? Erase? Try again?



We did not sit down one day with the intention of developing a novel pen-based interaction method. Instead, we were hard at work developing an otherwise unrelated system, and Flow Selection was developed more or less by accident.

The unrelated system is called the Designosaur, which allowed users to sketch dinosaur bones that would later be laser-cut from flat sheets of wood. Here you can see the user's sketch on the left, including notches where this bone will join others. This is the dinosaur's spine.

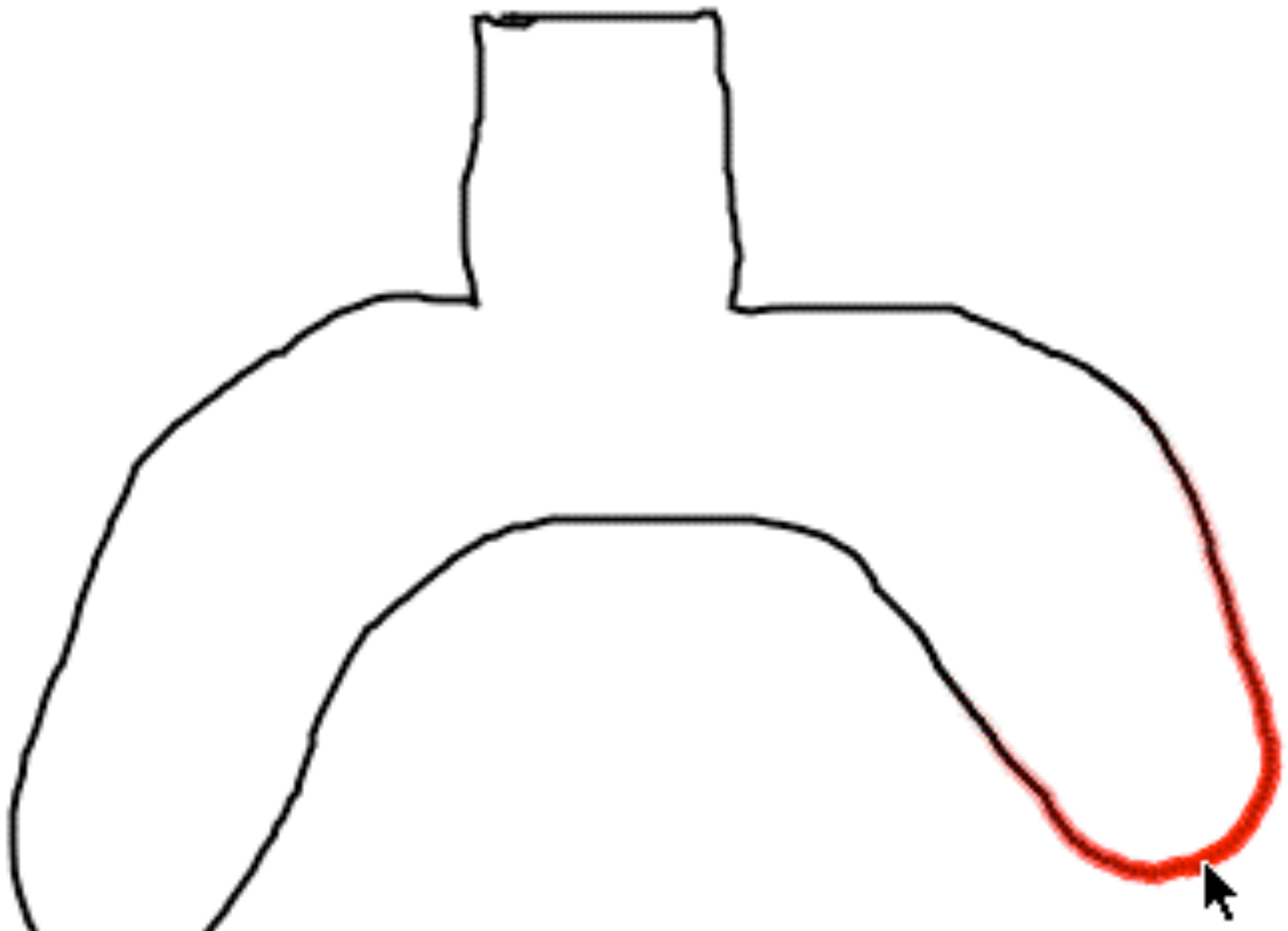
Flow Selection & Designosaur

- Designosaur "sketch-to-fabrication" prototype
- Hand-sketched 'bones' laser-cut from material
- How to quickly correct errors? Erase? Try again?

Here you can see a complete model developed with the Designosaur.

As we developed the Designosaur it became apparent that it was difficult to correct minor errors. Say you have just drawn a long stroke, and most of it is good, but there's one little spot that you'd like to correct. You could erase the whole thing and try again. But it occurred to us that the system might let you select just a small part and operate on it without damaging the rest of the sketch.

Flow Selection & Designosaur



Here is a video of Flow Selection at work. The user draws the outline of a rib bone. Unfortunately the two sides are uneven. To correct this problem the user will select part of the right side and move it downwards to be even with the left. This is done by pressing the pen down near the center of the area to change, and holding it while the selection grows over time. When the desired area is selected, the user then begins moving the pen without lifting up. Now that the rib is more symmetric, the user may lift the stylus.

Live Demo

What is different about flow selection from other selection and editing strategies?

- Time-based selection
- Continuous selection
  - Each point is selected on continuum 0-100%
  - Operations depend on selection strength
- Easy to transition between ink, selection, and operations

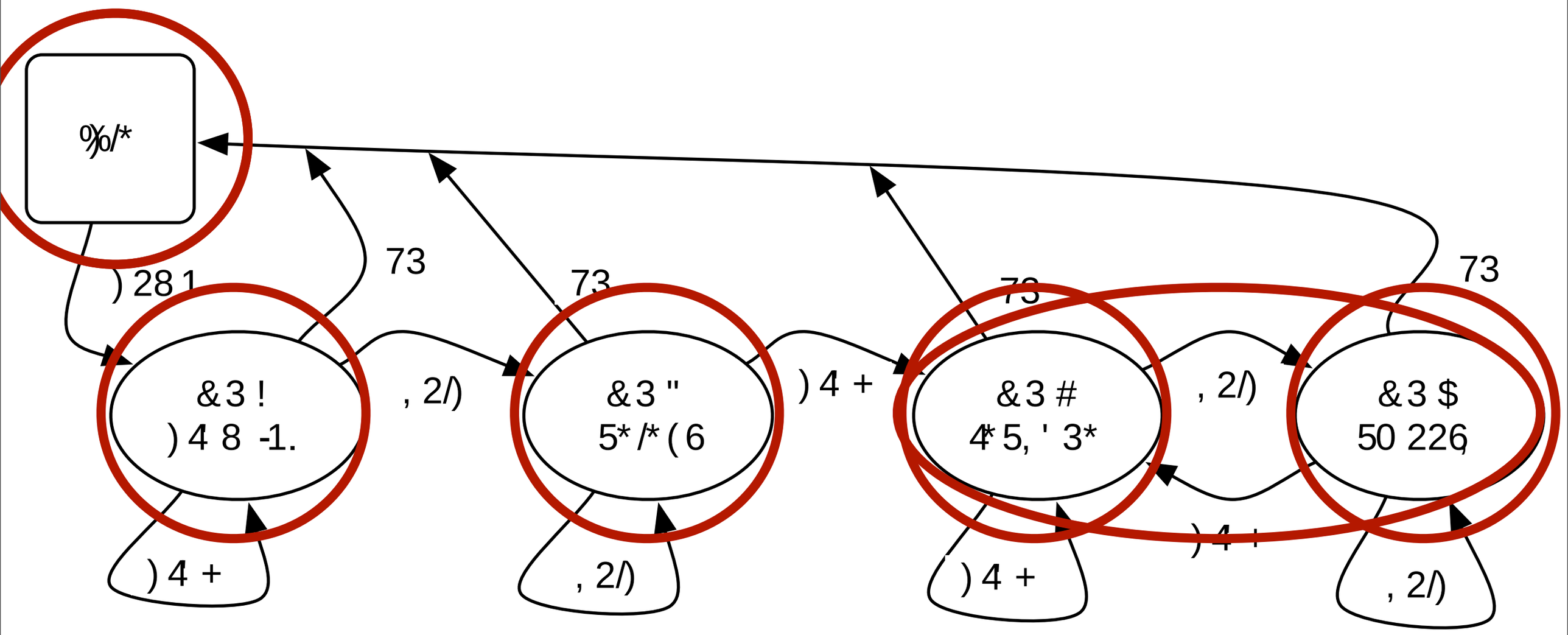
Now for a live demo.

As you can see, Flow Selection has a substantially different ‘feel’ than traditional selection and editing techniques. What are those differences?

First, Flow Selection is time-based. The longer you hold the pen still, the greater the area of effect, and the stronger the selection will be.

Second, the selection is continuous: the points closest to the pen will be more strongly selected while those farther away are weakly selected. This way when we operate on the selection, points far away will be effected less.

And last, because it is easy to transition between applying ink, selecting, and operating on selected areas, it feels modeless--everything you need is right there at the tip of your pen.



This state transition diagram summarizes how a person might use Flow Selection. The initial state is idle when the pen is not doing anything. Users may draw ink freely by setting the pen down and dragging. They may lift the pen up at any time—in this case the system is simply a drawing program. But if the user instead presses the pen down and holds it steady, the system begins to select. The longer the user holds the stylus still, the larger the selected region becomes. If the user lifts up the selection is lost and we may start over again. Alternately if the user has a selected area and begins dragging their stylus, it begins an editing operation. In my implementation the behavior is to reshape, or move, selected points. When the user is finished operating, they may lift the pen up. At this point the user could instead hold the pen still and begin another operation—in my implementation this is a smoothing operation. The user may transition between reshaping and smoothing quite easily by simply holding the pen stationary or dragging it.

How Does Flow Selection Work?

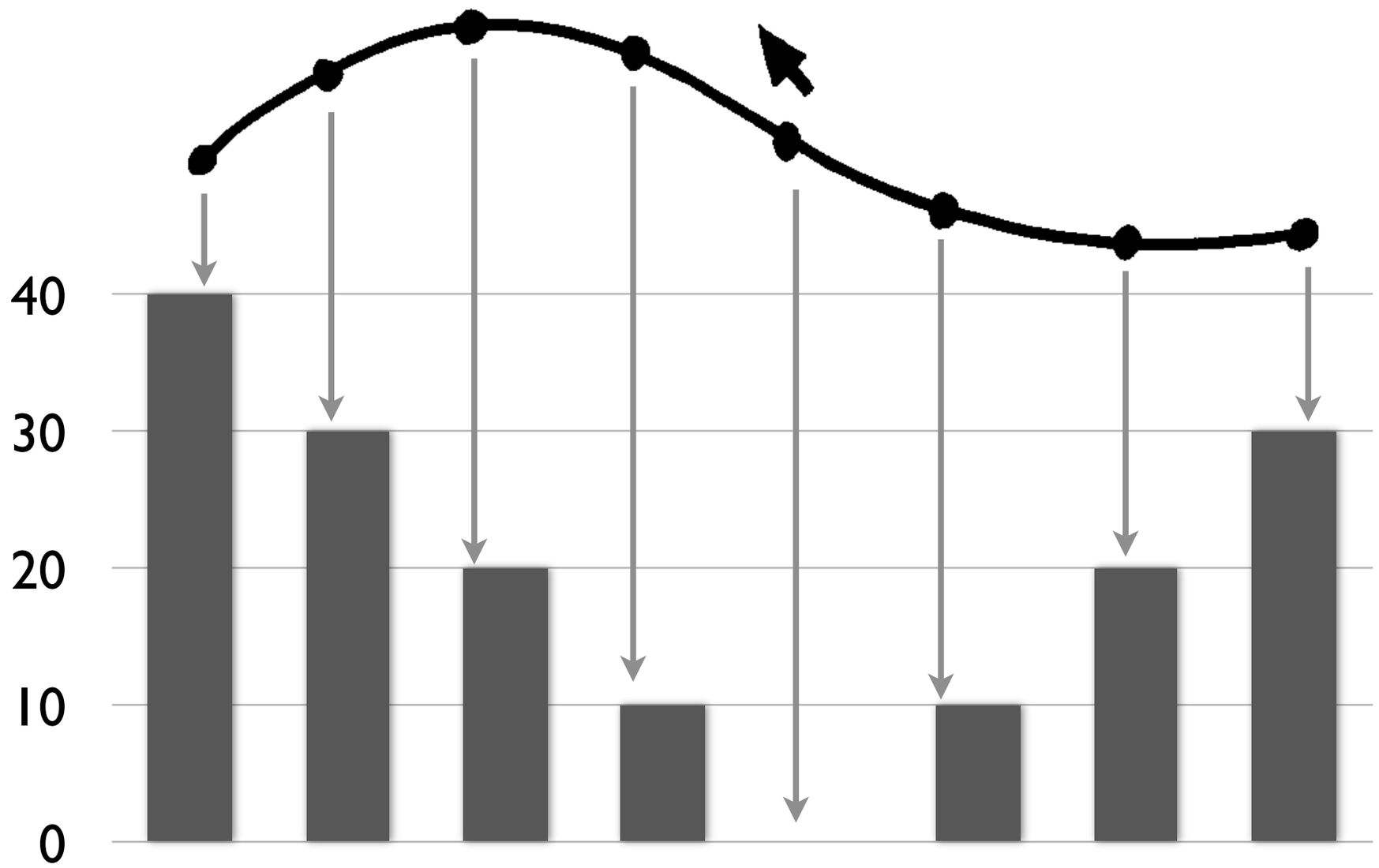
- Raw ink lines are ‘normalized’
- Pen down and stationary triggers selection
- Operations triggered by alternately moving the pen and holding it still
- Effort and strength functions

So how does Flow Selection work? User input consists of a sequence of raw digital ink points. Flow Selection begins by ‘normalizing’ these sequences so that each point is equidistant from the next. This helps make subsequent calculations much easier.

Next, the system uses the finite state machine shown earlier to transition between inking, selecting, and operation modes based on whether or not the pen is moving or is stationary.

In order to determine how to select points and what their selection strengths are, we use two functions: effort and strength. These are discussed in the next few slides.

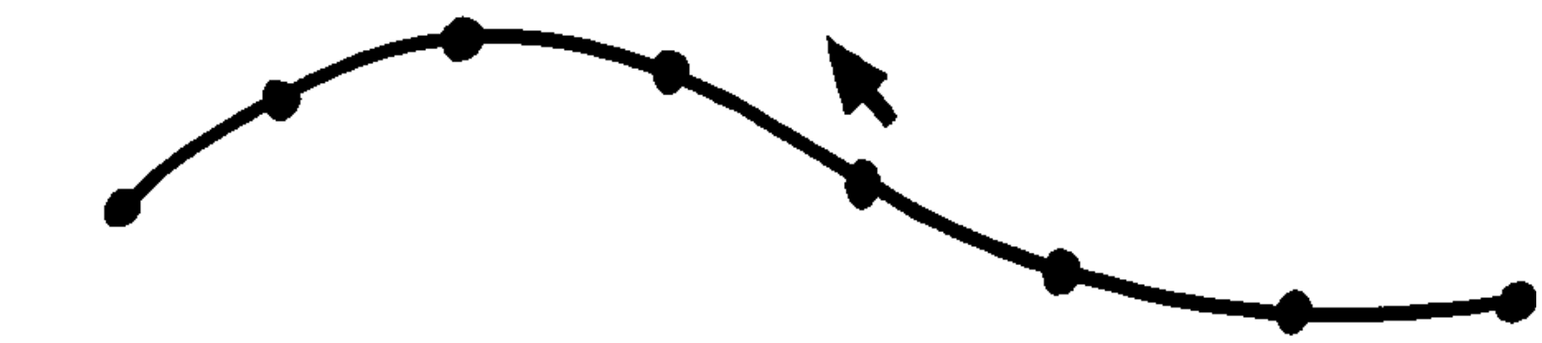
Example Effort Values

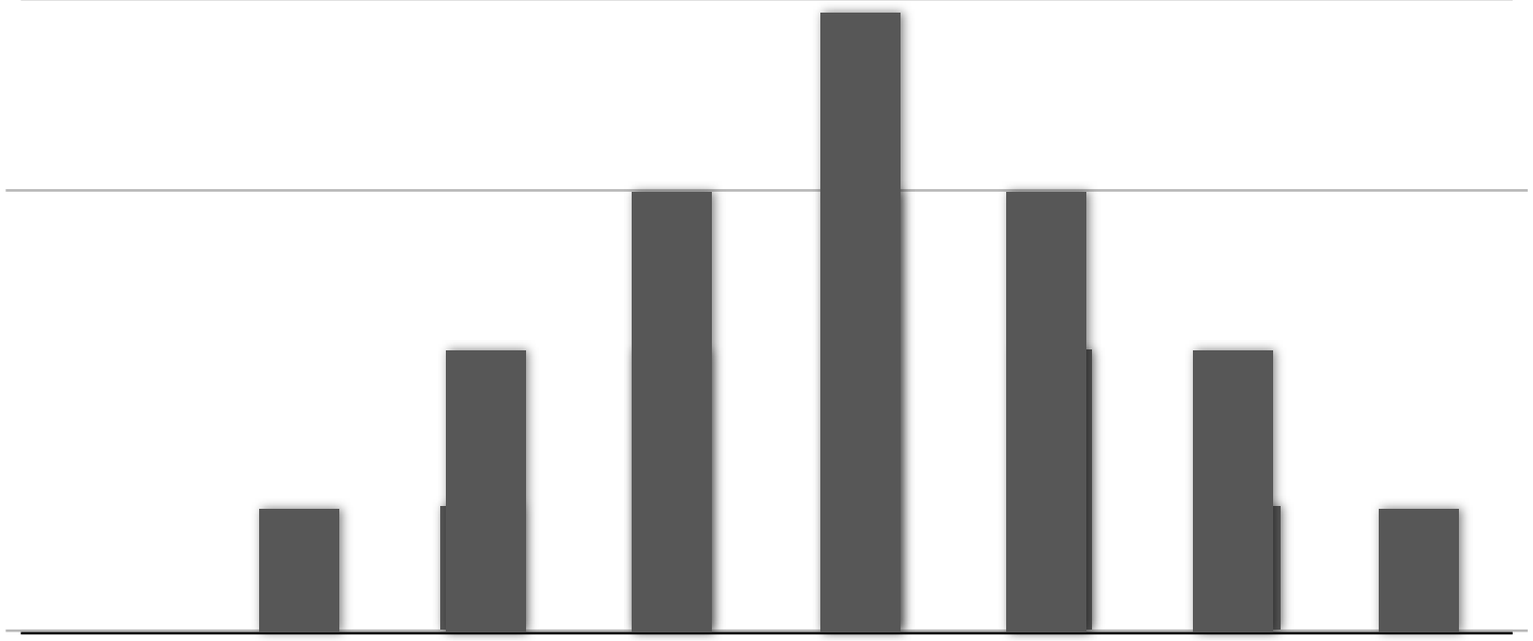


Linear Effort Function

Effort describes how difficult it is to select a point. Here you can see a normalized sketch stroke—all the points are the same distance from one another. Say the user begins to Flow Select by holding the pen still near the middle point, which we call the epicenter. At the beginning of a Flow Selection procedure, the system calculates the effort required to incrementally select each point by using an effort function. In this example, the epicenter takes zero effort to select, the points to each side take ten effort units, the points next to them take twenty, and so on.

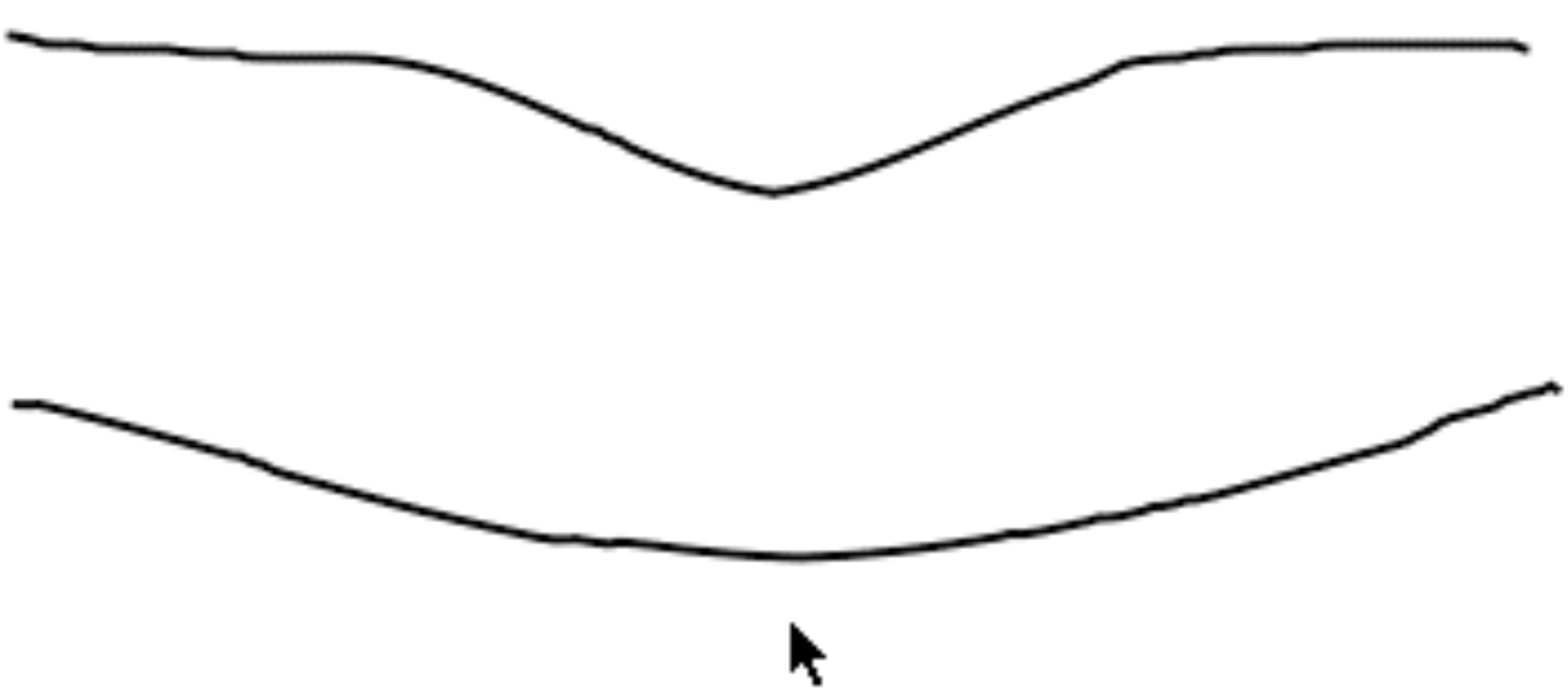
Example Strength Values





While the effort function is applied only one time at the beginning of a flow selection operation, the selection strength function is applied many times on a times, repeating schedule. Selection strength is a value between zero and one, where zero means unselected, and one means completely selected. Here is a simple strength function that assigns higher strength to points closer to the epicenter. Over time these values would all get larger and converge to one, meaning the entire line is fully selected.

Strength Function Depends on Effort and Time



The selection strength function depends on both effort and time. In this video example, these two strokes begin as nearly identical lines. The stroke on the top is selected for about a second, then moved a centimeter down. The stroke on the bottom is selected for longer, about three seconds, and also moved a centimeter down. So by using the same effort and strength functions the user can achieve different results by simply varying the timing of selection and operation.

Strength Function Depends on Effort and Time

Alternative Implementations:

- Linear
- Square Root
- Squared
- Trigonometric (shown in demo)

There are many possible implementations of both the strength and effort functions. Earlier in this presentation I gave examples using linear functions because they are perhaps the easiest to understand. But you could experiment with other types of functions such as a square root, or parabola. In my implementation I use trigonometric functions because I like the results they give.

Potential Applications of Flow Selection

- Cartooning
- Diagrammatic Sketch
- Photograph touch-up
- 3D Modeling of organic shapes

There are many possible applications of Flow Selection. For example you might have a cartooning or diagramming application and use Flow Selection to straighten up portions of lines or curves, or to mend errors. Flow Selection might be useful for selecting portions of photographs or parts of 3D models.

Summary of Flow Selection

- Correct errors quickly without losing focus
- Time-based selection
- Continuous selection strength:
  - Each point selected on continuum 0-100%
  - Operations depend on selection strength
- Easy to transition between ink, selection, and operations

To summarize my presentation, I have shown Flow Selection, a time-based, low level pen interaction technique for correcting errors quickly without losing focus of your work. Two key properties of Flow Selection are the continuous selection strength that allows points to be partially selected, and the ease by which users can transition between ink, selection, and operation modes.

New Low-Level Interaction Techniques for Pen-Based Computing

Flow Selection represents just one point in a potentially large but unexplored and undefined space of interaction techniques for pen- and sketch-based computing. My personal sense is that current interaction techniques are inadequate and are holding back a lot of progress in sketch-based modeling.

Future Work

- User Testing
- Determine appropriate strength and effort functions for different applications
- Investigate other low-level techniques for pen-based interaction

Flow Selection remains a proof-of-concept system, and user testing should be conducted in domain-centric applications that leverage it. In doing so we can experiment with other strength and effort functions.

To touch on the original context in which Flow Selection was made, we might discover additional pen interaction techniques if we choose to not rely on existing interaction techniques designed for mouse-and-keyboard interaction.

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Thanks.