Extending the ASSIST Sketch Recognition System

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The Problem: ASSIST is an environment for developing mechanical systems that understands freenhand sketches. Its current vocabulary of objects includes bodies of various shapes, forces, joints, springs, dampers, and anchors. The goal of this project is to expend this device vocabulary in order to allow the user more freedom and complexity in his designs.

Motivation: Most design tools focus on later stages of design. A designer often will make a freehand drawing of his design, but this original sketch, along with evidence of the motivating factors in the design, is often discarded once the final design is transferred to the computer. Sketch recognition allows the engineer to enter designs naturally into the computer from the start, and allows them to be simulated at all stages of the design process. We hope that this in turn will facilitate recording design rational, so that others can understand not only how the design works, but also why it works that way.

Expanding the device vocabulary of the system moves it one step closer to being a useable tool, as well as forcing the issue of recognizing more complex objects using both recognition of the shapes and the context in which they appear.

Previous Work: The original ASSIST system was developed in the master's work of Christine Alvarado [1]. It interprets the user's srokes as they are drawn, choosing the best interpretation based on such factors as temporal and spatial locality (i.e, the strokes that make up one object are usually drawn in sequence, near each other), and a preference for simple interpretations over those that are more complex. At any point while sketching in ASSIST, the user can press the "run" button to see his drawing simulated.

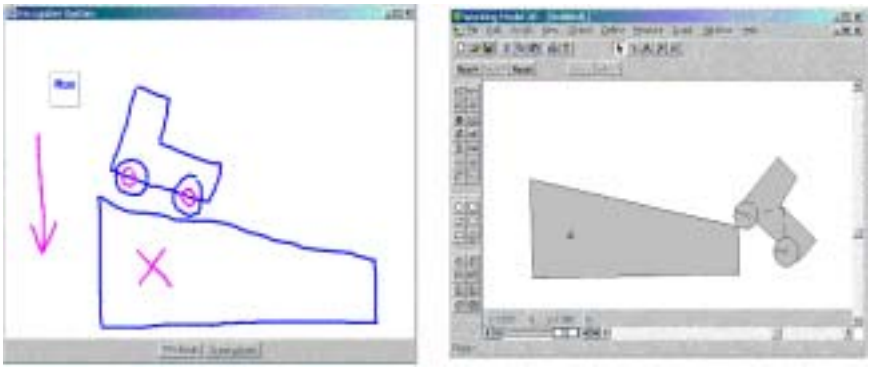

Figure 1: The original sketch in ASSIST and a simulation of it in Working Model 2D [2]

The low-level sketch interpretation that serves as input to the extended ASSIST system was designed by Sezgin [3]. It performs vertex detection and curve fitting using speed and curvature data and returns basic primitives such as ovals, circles, arcs, lines, and rectangles.

Approach: A variety of new objects are being added to the system. As one of the main goals is to make this system a practical tool, the devices to be added were chosen by investigating what devices are most commonly used in mechanical engineering drawings and existing design tools. The devices currently in development are: motor, spring damper, rotational spring, rotational damper, and torque.

For each new object that is added, the first step is to determine the most natural representation for the object. Although this may be obvious in some cases, others require more investigation. Sources for this research include noticing the symbols used by other software programs, examining drawings in mechanical engineering and physics texts, and speaking to experts in the field.

Once the representation is chosen, the recognition procedure for each device must be determined. As discussed above, ASSIST uses real time sketch recognition. Each recognizer takes as input the new stroke and attempts to determine if it could be a part of the complex object in question. Next, reasoning is applied to determine which of the possible interpretations is most likely. This reasoning uses the factors discussed above and an understanding of the context in which various devices are most frequently drawn.

Work is also underway on enhancing objects that are already a part of the system. Examples of these improvements are work that allows arbitrarily extendable mechanical objects (e.g., a user can draw additional pulley wheels to extend an already existing pulley system) and deducing additional information from features of the drawing (a larger force arrow may imply a stronger force).

Impact: This work moves towards making sketch recognition a useable tool for mechanical engineers in the field. The tool has a natural sketch interface and also will include the important constructs used by mechanical engineers. This will allow these designers to use and develop their early design sketches and to receive feedback at all stages of the design.

We are also exploring use of the tool in the classroom. We believe that there will be considerable benefit to students in a variety of disciplines arising from the ability to sketch a design and see it "behave" right in front of them. This will, we suspect, help students develop an intuitive understanding for the systems they are studying.

Future Work: Future work includes finishing design and implementation of the recognizers for the remaining objects and integrating them into the system. The long-term goal for this project is to incorporate these new constructs into the new blackboard based recognition system currently in development by other members of the Design Rational group.

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References:

[1] Christine Alvarado. A natural sketching environment: Bringing the computer into the early stages of mechanical design. Master's thesis, Massachusetts Institute of Technology, May 2000.

[2] Christine Alvarado and Randall Davis. Resolving ambiguities to create a natural computer-based sketching environment. *Proceedings of IJCAI-2001*, pages 1365–1371, August 2001.

[3] Tevfik Metin Sezgin. Early processing for sketch understanding. *Proceedings of PUI-2001*, November 1990.