Behavior Annotated Designs:
A multimodal approach to design rational capture and intelligent design environments

Michael Oltmans, Randall Davis

The Problem:

When building tools to aide design rationale capture and the mechanical engineering design process, it is often necessary to consider the desired behavior of the device being designed. Our goal is to allow a designer to use both sketched and spoken cues to add intended behavior to hand drawn mechanical engineering design sketches.

Motivation:

Despite the obvious utility of a model of the intended behavior of a device, there is currently no way to specify such a model that is both informal and powerful.

Our goal is to allow the designer to provide the behavior model to the design environment in the same way that it would be conveyed to a colleague, i.e., letting the designer use hand drawn sketches and verbal explanations at a relatively high level of abstraction.

Previous Work:

Our project draws on ideas developed by Myers, Zumel, and Garcia [2] about seamless design rationale capture. Their goal is to make rationale capture invisible to the users of CAD tools. Where their focus is on the detailed phases of the design process, we are focusing on the earlier, less formal phases of design. We are also building on ideas proposed by Baudin et al. [1], of using the structure of the model to aide the retrieval of design information that could not be retrieved from keywords or other simple search mechanisms.

We are building on the sketch recognition system developed by Luke Weisman, Manoj Muzumdar, and Christine Alvarado [3, 4], which enables sketch recognition and manipulation of mechanical parts.

Approach:

Our approach is based on two key observations. First, designers commonly employ sketches, gestures, and verbal descriptions to explain device behaviors to colleagues. By giving designers the same tools that they use in person to person interactions we make the knowledge transfer easier for the designer.

Second, designers refer to common design patterns in their explanations. For example, when one part prevents the motion of another it is commonly referred to as a *stop*. A designer may point to a part of a design and say "This piece acts as a stop." By collecting a library of these types of concepts the system will be able to represent and express the behavior information in a language and at a level of abstraction that are familiar and comfortable to the designer.

Difficulty:

To be a useful advance, the system must be able to reason about the behavior in ways that allow it to answer questions more complex than can be answered by replaying a transcript. This might include queries about actions that are not explicitly described by the designer but could be inferred from the actions that were described and a basic understanding of the design. By using high level concepts as the basis for our representation we hope to be able to handle a wide variety of queries and answer them in terms that are easily understood by the designer.

Current speech and sketch recognition tools are prone to errors. These errors can be compensated for by having the two systems bias one another appropriately. For example, the environment can indicate to the speech system which utterances it is likely to receive based on what the user is currently sketching and the current state of the design.

Impact:

The informality of the interface and its adoption of input modalities already familiar to designers will help designers involve computers in the earlier phases of design. This is important for automated design rationale capture since this is when many of the important decisions about a model are made.

Future Work:

We intend to integrate the behavior models more closely with design tools that will be able to participate in many of the low level details involved in designing a model that will fulfill the desired behavior. For example, with a rough sketch of the system and the desired behavior model, it could then determine numeric parameters and make other adjustments so that the device will exhibit the desired behavior.

We also want to develop progressively more complex design rationale capture tools. Having the record about what the designer did is a good start but the ability to infer the designers intentions and goals will improve the system further.

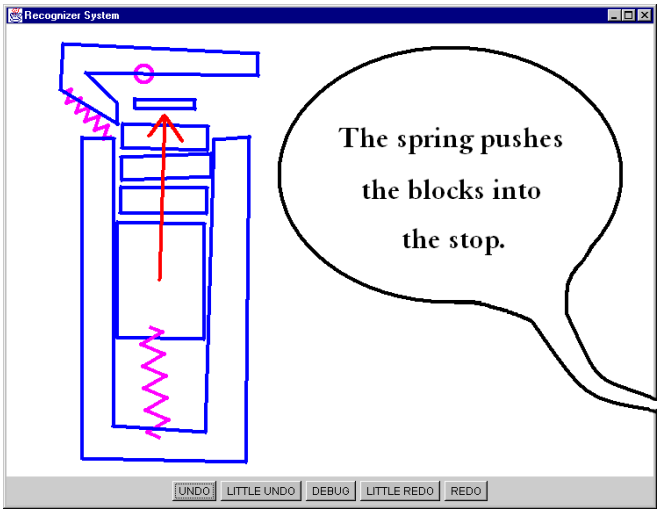

Figure 1: The user sketches the dispenser and the motion of the spacer while verbally describing the action.

Research Support:

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References:

[1] Catherine Baudin, Jody G. Underwood, and Vinod Baya Using Device Models to Facilitate the Retrieval of Multimedia Design Information *Proceedings of the Thirteenth International Joint Conference on Artificial Intelligence (IJCAI-93)*, Chambery, France, pp. 1237–1243.

[2] Karen L. Myers, Nina B. Zumel, and Pablo Garcia Automated Capture of Rationale for the Detailed Design Process. *Proceedings of the Eleventh National Conference on Innovative Applications of Artificial Intelligence (IAAI-99)* AAAI Press, Menlo Park, CA, 1999

[3] Manoj D. Muzumdar ICEMENDR: Intelligent Capture Environment for Mechanical Engineering Design. Master's Thesis, MIT, 1999.

[4] Luke Weisman A Foundation for Intelligent Multimodal Drawing and Sketching Programs. Master's Thesis, MIT, 1999.