Understanding Naturally Conveyed Explanations of Device Behavior

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The Problem:

One of the goals of human computer interaction research is to make interacting with a computer as natural as interacting with a person. Current mechanical design tools do not meet this goal. They require formal specifications of relationships and parameters, rather than understanding informal descriptions conveyed with sketches and verbal utterances, of the sort people use when talking with one another. When using a traditional mechanical CAD program, for example, the designer must explicitly specify a spring connected to a block and must set parameters such as the length of the spring and its rest length. This stands in sharp contrast to the way a designer might describe the system to a colleague, sketching the block and spring and saying "the spring pushes the block." Designers should not be forced to encode the behavior of the device in its parameters if the parameters are not the primary concern. The system that we have developed is based on a sketch understanding system named ASSIST (A Shrewd Sketch Interpretation and Simulation Tool). The system that understands informal and naturally conveyed explanations is called ASSISTANCE (ASSIST Augmented with Naturally Conveyed Explanations).

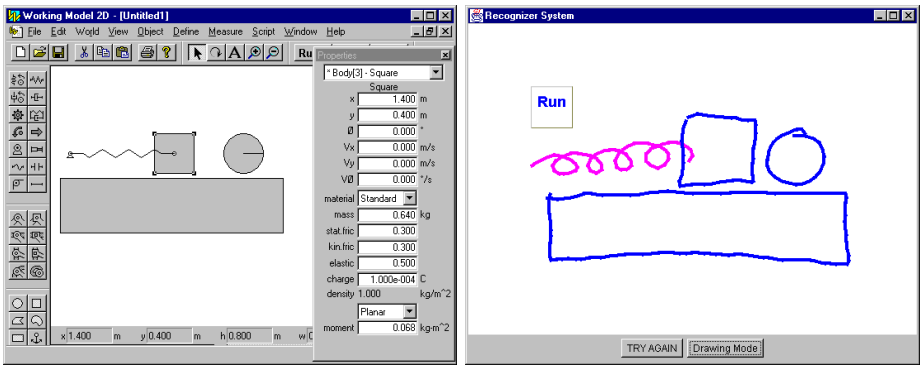

Figure 1: **A block and spring constructed in CAD and in Assistance**. In the CAD tool, the designer selects components from templates and specifies parameters. In ASSISTANCE the designer sketches the block and spring and says "the block pushes the ball." From this description the system generates a simple causal model in which the spring causes the block to move and that in turn causes the ball to move.

Tool:	Type of description:
Mechanical CAD	spring length = 2.3cm spring rest length = 3.0cm
Qualitative Reasoner	(< (length spring) (rest-length spring))
ASSISTANCE	"The spring pushes the block"

Table 1: **Three ways to specify the behavior of a spring and block.** Only ASSISTANCE allows the designer to explicitly mention the behavior of a block attached to a spring (pictured in Figure 1)

Motivation:

Despite the potential utility of a behavioral model 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 convey the behavioral model to the computer with hand drawn sketches and verbal explanations. This reduces the differences between interactions between designers and interactions between a designer and a computer.

Previous Work:

Borchardt has done work on understanding explanations of devices from textual descriptions and reconstructing the causal relationships involved in the devices behavior [5]. The central insight of Borchardt's

work is that focusing on the changes in a devices state, rather than the states themselves, makes it easier to construct a causal model of a device. While our system does not explicitly use the representations proposed by Borchardt, it makes use of this insight in its emphasis on behavior and causal structure and expands on the description understanding task by incorporating sketched input.

Our system is also intended as a first step in a design rationale capture system that assists a computer design environment in capturing and understanding the rationale behind design choices. To this end we have drawn on ideas developed by Myers, Zumel, and Garcia [2] about reducing the impact of rationale capture on the design process. The goal of their work is to make the capture of design less trouble than it is worth. While our goals are the same they focus on the detailed phases of the design process, whereas we are focusing on the earlier, less formal phases of design.

The system we have built is based on the sketch recognition system developed by Luke Weisman, Manoj Muzumdar, and Christine Alvarado [3, 4, 1], which enables sketch recognition and manipulation of mechanical parts.

Approach:

The cues provided by the verbal explanation often describe causal relations and complex events. For example the phrase "the block pushes the ball" combined with basic knowledge about the motion of mechanical devices implies that the motion of the block causes the motion of the ball. This type of inference is complimented by sketched gestures, such as arrows. An arrow provides the geometric information about the path taken by an object and augments the representation of the motion that was inferred from the verbal utterances. Combining these cues makes it possible for the computer to generate causal models of devices without forcing the user to formally specify them.

Impact:

The informality of the interface and its adoption of input media 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. Involving the computer in early design may also make it possible to provide the designer with tools later in the process that use information collected early in the design process.

Future Work:

We intend to create design tools capable of inferring design details that provide the desired behavior. For example, given a rough sketch of the system and the desired behavior model, it will 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 a record of the designers actions is a good start but the ability to infer the designers intentions and goals are necessary for the information to be useful as a design rationale capture tool.

Research Support:

This project is supported by the Ford/MIT Collaboration.

References:

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