Designs for the Future

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The Problem: Computer aided design tools built to date have typically shared three important characteristics: *(i)*, they are intended for use relatively late in the design process, *(ii)* they typically employ a style of interaction familiar to programmers but not necessarily intuitive to designers, and *(iii)* they capture the final product alone, recording almost none of the thinking, exploration, or rationale that motivated the endproduct. We are working to change this by designing and building a set of programs that are focused on the early, conceptual stage of design, that use as their input language familiar and natural kinds of interaction, namely sketching, gesturing, and talking, and that are capable of capturing the design process as well as the final product.

Motivation: We see particular value in creating tools that aid at the earliest design stages and that provide for the capture and subsequent dissemination of design rationale information. Such tools would assist those faced with redesign avoid the traditional task of intellectual archeology, i.e., attempting to determine why the design is as it is, typically tripping over the very same problems encountered and solved, but not recorded, by the orginal designers. While the focus of our current work is physical artifacts, we believe the issues explored here are considerably broader, and are equally relevant to nearly everything we design, including software, plans, policies, organizations, etc.

Previous Work: Our early work produced a program that began with a sketch and produced a model that we call a *behavior-ensuring parametric model*, a parametric model augmented with constraints, derived from the sketch itself, which ensure that any solution to the parametric model will in fact produce the desired behavior described for the device (see [6], [7]). Our techniques focused on the geometry of devices with time varying engagements (i.e., variable kinematic topology), and are thus complementary to the well known design techniques for fixed topology mechanisms, such as the gear train and linkage design techniques in [2]

Previous work by others has produced an extensive literature on design rationale capture and rationale construction; [4] offers a good overview of work relevant here. Our approach can be seen as similar in spirit to efforts in [3] in that it reasons about causality, but out approach is unique, in its ability to determine which dimensions are relevant, and in its ability to generate a wide variety of design alternatives via reverse engineering.

Our more recent work has focused on natural interaction, and has resulted in systems that permit sketches of simple mechanical devices to be understood and then animated (by an off-the-shelf numerical simulator), see [1]. We have also constructed a system capable of understanding a multi-modal (sketching, gesturing, and voice) description of intended device behavior, see [5].

Approach: We are building a system and environment that is in many ways completely familiar to a working engineer: it will allow the engineer to sketch, gesture and verbally describe a design, much as he does in the presence of other designers, with one important difference: the "audience" viewing the sketch and listening to the description will be a computer. The system will act as an assistant in much the same way as human assistants, making notes about the design and its rationale, asking sensible questions about the alternatives chosen and eventually suggesting variations on the design.

The tools we are developing will be able to deal with these multi-modal descriptions: We want engineers to be able to communicate with their design tools by sketching out their conceptual designs with the same *imprecision* they are used to, using rough sketches that indicate relationship among dimensions rather than the precise values of the dimensions (see research abstracts by Alvarado and Sezgin, this volume). We also want them to be able to describe the behavior of their devices in ways that feel natural, i.e., with voice and gestures.

We believe that design rationale capture can be facilitated by tools that make describing a design as simple as

having a conversation with an intelligent assistant.

Impact: Tools of the sort we are developing will, we believe, make rationale capture *less* trouble than it is worth. This has the ability to change the practice of re-design substantially. Designs will carry a sizable body of machine-interpretable information in addition to the design itself; that information will be used to check design modifications to ensure that the new design does not defeat some goal accomplished by the original design.

Future Work: Creating recognizers for shapes and gestures is currently a labor-intensive process that requires considerable coding skill. We are developing languages for describing shape, drawing sequence, and gestures, in order to make it possible to generate recognizers from these descriptions, rather than hand-crafting each one. We are also designing and implementing a new, multi-level architecture for our system, to enable far easier addition and testing of new knowledge to the system.

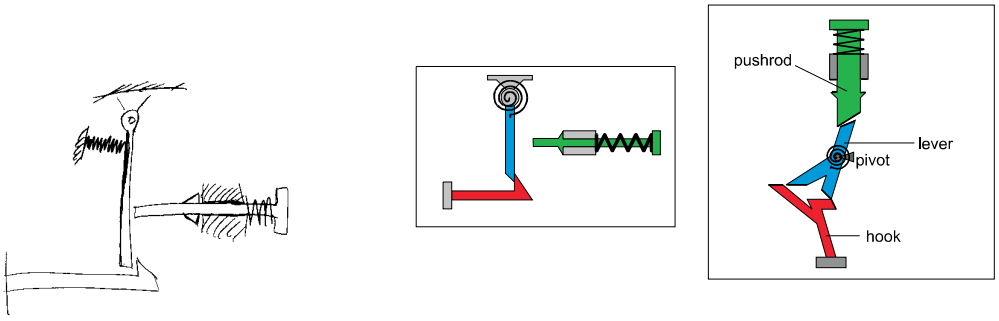

Figure 1: A sketch and some of the designs that result.

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References:

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