Computer-Based Advisors for Environmentally Coscious, "Green" Product Design

A. Dlaz-Calderon, S. Fenves, M. Hon, J. Garrett, C. Hendrickson

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Computer-Based Advisors for Environmentally Conscious, "Green" Product Design[1]

by Antonio Diaz-Caldcron,[2] Steven Fcnvcs,[3] Hon. M., James Ganrett,[4] A.M.; and Chris Hendrickson,[5] M.

Abstract

Many corporations have explicit goals to produce environmentally conscious, "green" products to reduce harmful emissions, energy use and material waste. Numerous regulations on allowable materials and product disposal exist, and additional regulations can be expbeted. Howcver, while a significant (and growing) literature on "green design" exists, there are few computer-based aids to give direct guidance to designers cortcerning the environmental implications of their designs. In this paper, we repdrt cttiseveral experimental systems intended to provide such assistance. One sjrstem intencted to provide direct design advice is described in more detail. It was developed by including additional analysis algorithms aftd adding rules to an existing knowledge based expert system design advisor intended to provide critiques of the design of plastic pans to be produced from injection molding.

1. Introduction

In recent years, environmental policy and regulation has experienced a major change in concept and focus[OTA 92, Lave 94]. In the past, environmental legislation emphasized allbwablc emissions and required waste treatment systems. More recent environmental policy and legislation has emphasized pollution prevention and waste minimization [(JEQ 92]. As a result, cnvirompental constraints and objectives have become Uitegral portions bf product and process design decisions. Extending the traditional profcsaoiial responsibilities of environmental engineering and solid waste nrartagdfirient, civil engineers can play a new role in product and process design decisions to insure environmental consciousness, both for constructed facilities airtirother industrial products or processes.

Corporate policies for life cycle "product stewardship" or "environmentally

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Graduate Research Assistant. Engineering Design Research Center, Carnegie Mellon University, Pteborgh, PA 15213.

[3]Sun Company University Professor. Dept. of Civil Engineering, Carnegie Mellon University, Pittsburgh, PA 15213.

[4]Assoc. Prof., Dept of Civil Engineering, Carnegie Mellon University, Pittsburgh, PA 15213.

[5]Assoc. Dean, Carnegie Institute of Technology and Prof., Dept 'Of Civil Engineering, Carnegie Mellon University, Pittsburgh, PA 15213. Phone: 412-268-2948, Internet: cth^cmu.edu

conscious design" as well as new regulatory restrictions on material choices represent substantial new challenges and opportunities to design professionals and corporate managers [Fischer 93]. Products are intended to be easier to recycle so as to minimize waste. Processes and product operations are intended to have fewer environmental burdens in the form of energy needs or undesirable waste streams. However, there is a lack of detailed knowledge and design aids to achieve these goals. In addition, the existing environmental regulations and standards are difficult to assimilate and are changing significantly over time, so that simply achieving compliance with existing requirements is a challenging undertaking even without setting proactive environmental innovation as a goal.

There is an emerging body of knowledge and methods to achieve more environmentally conscious product design [EDRC 92]. For example, [Burall 91] and [Henstock 88] describe changes in component joints and material selection choices that could make recycling more effective. A variety of detailed standards for environmentally conscious products exist, such as the Green Seal standard for air conditioners [Green Seal 93]. Methods for environmental life cycle assessment [Keoleian 93, Curran 93] and full cost accounting [Popoff 93] have been devised. However, existing knowledge may not be adequate nor available in a form readily usable by designers.

Researchers at Carnegie Mellon University have had a formal program of research and development in the area of product design for the environment (PDE) since 1992. This PDE effort emerged from activity in the Engineering Design Research Center (an NSF sponsored Engineering Research Center), the campus-wide Environmental Institute and the Center for Intelligent Manufacturing and Decision Support (CIMDS) in the Robotics Institute. Work is underway on the discovery of new technologies (such as benign chemistry or shredder fluff separation methods), aids for designers (as described below), appropriate approaches for environmental education, and general issues of organization, public policy and market behavior (such as the appropriate definition of "recycling" [Lave 94] or the best methods for diffusing innovation). Figure 1 shows the (current) strategic plan for this activity, with the focus barriers on the left, the various research thrusts in the center, and the research goals on the far right Application targets include chemicals, electronics (including personal computers), automobiles and constructed facilities.

In the remainder of this paper, we describe a suite of PDE advisors under development at Carnegie Mellon University and focus more closely on a material and joint selection advisor.

2. A Suite of Design Advisors

The development of design aids as part of the product design for the environment effort is intended to explore the usefulness of specific tools for design teams. Designers are employing more and more widely dispersed design tools, and we believe that computer-based environmental design advisors offer a good application opportunity. At Carnegie Mellon, four prototype design aids have been developed or are in the process of development

- **ReStar.** The ReStar system is intended to identify the optimal recovery path for the material and components in a given product [Navinchandra 93]. A discarded product, such as a computer or automobile, is typically partially

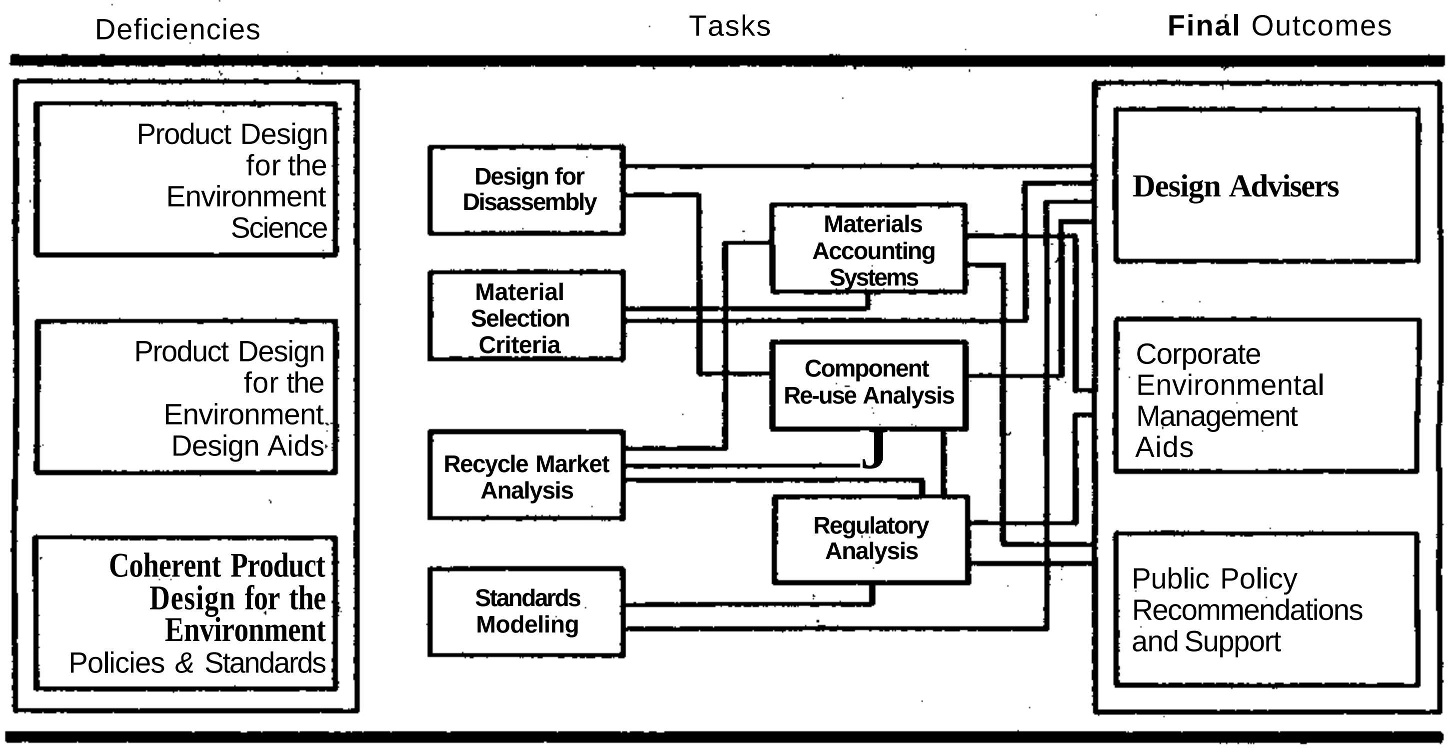

Figure 1: Strategic Plan for Product Design for the Environment Research at Carnegie Mellon University

disassembled to recover valuable components for re-manufacture and re-sale, shredded to allow recovery of constituent materials such as metals, and some portion of the product is discarded into a landfill. In some cases, no component recovery is economical (or required) and direct disposal into a landfill occurs. The computer system ReStar assesses a variety of levels and extents of disassembly for re-use to determine more economical disposal opportunities based on the original product design,

- **Environmental Standards Processor.** Design teams designing today's products are multi-disciplinary, geographically dispersed, and multi-national. These product design teams are now expected to take more and more issues and objectives into consideration. For example, design teams are now striving to make their products more environmentally friendly or "green" [Burall 91]. As these new design initiatives emerge, they are accompanied by a large number of applicable publications, guidelines, specifications, and standards. It is unrealistic to assume that a designer is able to identify easily that a specific standard is applicable to his or her problem.

  Active support for recognition and retrieval of relevant standards, codes, specifications and guidelines will not be a luxury in the near future, but rather it will be a necessity. Because of environments such as Internet, World-Wide Web [Berners-Lee 92], and Mosaic [Andreessen 93], it will not be long before many organizations make their codes, guidelines and standards accessible electronically. By doing so, all users will immediately have access to the most up to date versions of these documents. Users will need help in discovering, accessing and using such documents.

  Garrett, et al. [Garrett 94] are developing a standards processor to assist the designer in discovering, selecting, accessing, and using applicable environmental standards. This support includes: 1) locating and accessing applicable standards; 2) determining which provisions/sections of these standards are applicable; 3) displaying to the user a hypertext version of the applicable provisions; and 4) when applicable, evaluating provision logic given the specifics of the product being designed to automatically determine the conformance of the design to the applicable standard provisions.

- **Label Advisor.** A variety of corporate and standard environmental labelling systems exist [Schurman 94]. For example, the Society of Automotive Engineers recommends a particular type of label for the primary resin in plastic parts. The label advisor being developed is intended to recommend and to design an appropriate human and/or machine readable label for small parts.

- **Component Design Advisor.** This advisor assesses an existing component design for possible improvements based on published guidelines and "rules of thumb" developed for particular types of products. In effect, the advisor is an intelligent "look-up" agent based on the features of an evolving design. By providing textual advice on design problems and possible improvements, individual designers are freed from searching design manuals for appropriate provisions. An example application is described below.

These four tools are intended to serve as aids to individual designers and design teams. They are intended to interact with models of an evolving product design (thereby reducing the need to manually transfer design information), and to access substantial corporate or external databases on costs, product experience or applicable standards. Thus, they serve as "intelligent assistants" by identifying relevant information and banging it to U»c aijenfconctf,tJ^d««#iKf «.ai»Mj^te times.

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3. Prototype Advisor for Component Design

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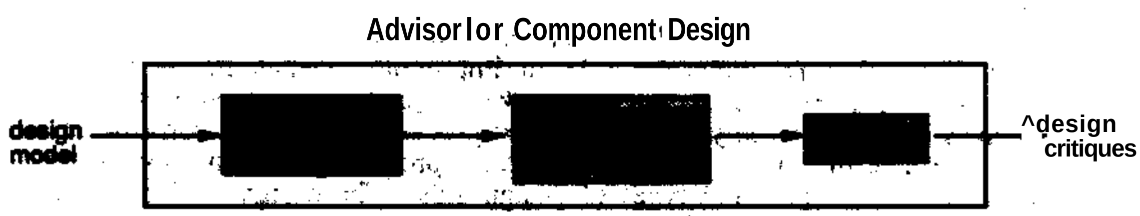

Figure 2: Architecture of the Design Advisor

Figure 3 shows an example of a component with two ribs, bosses and holes. In

Figure 4, some of the textual critique is shown, commenting that the bosses are a useful feature to reduce material use and noting that it may be preferable to limit the design to a single material type.

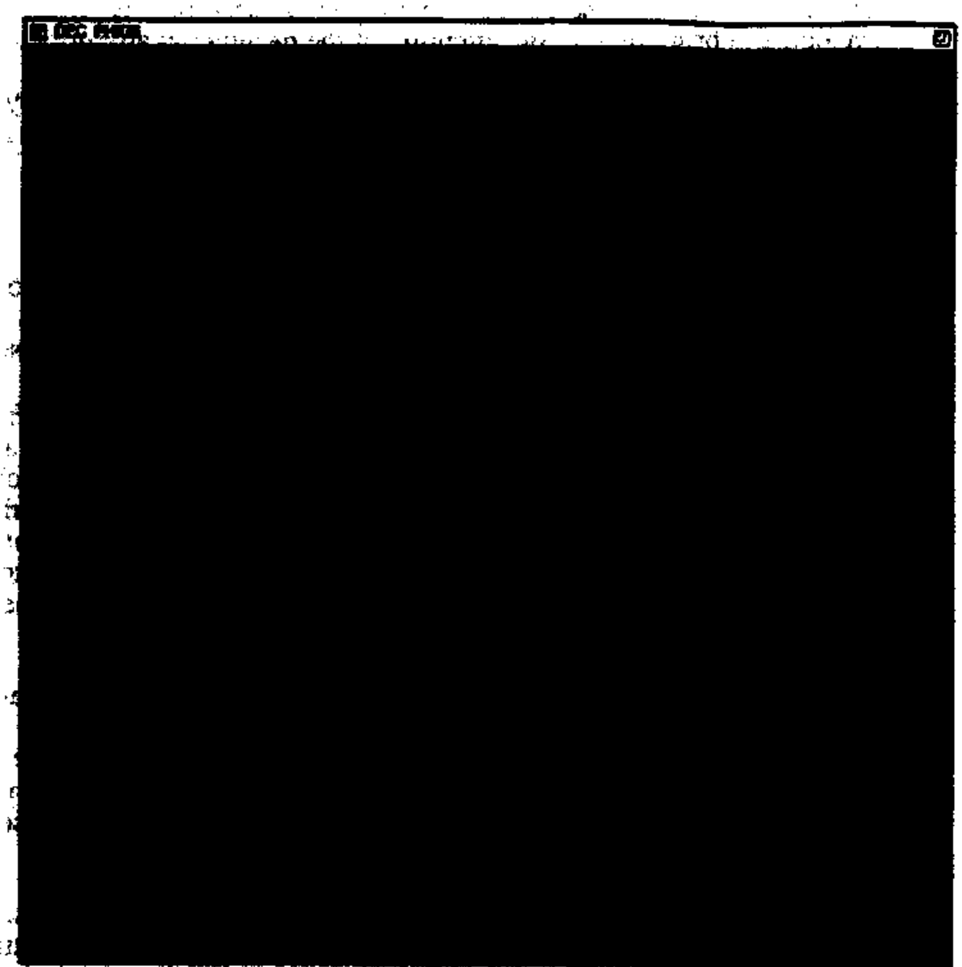

Figure 3: Example of a Plastic Part to be Assessed

4. Conclusions

This paper has argued that computer-based aids for environmentally conscious design can play an important role in improving designs in an environmentally conscious way. Both regulation and market forces provide incentives for such design changes in a wide variety of products and processes, including constructed facilities. With the lack of existing aids, this is a very promising axea for development This papa* noted four different types of design aids. The design advisor described also illustrates the extent to which existing expert systems can be modified to serve new applications.

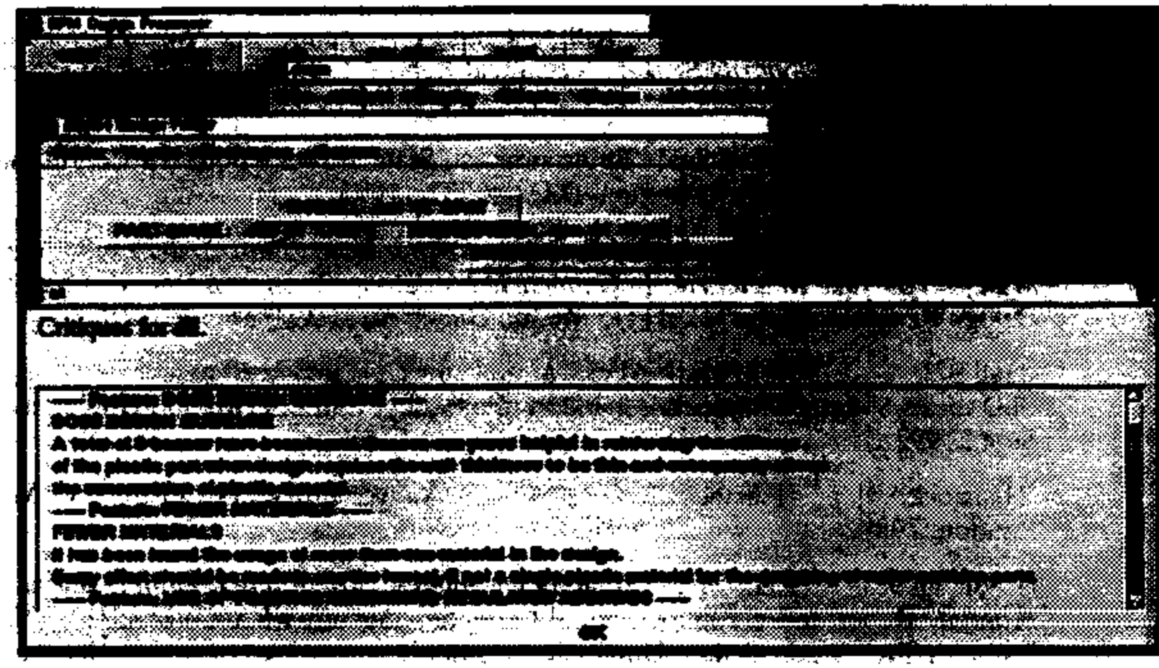

Figure 4: Results of Assessing a Plastic Part

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