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Opinion

Green Engineering AI Tools Benefit the Environment

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For over a decade now, AI techniques have been applied to some of the hardest problems faced by business today, often with stellar results and a tenfold-plus return on investment. One of the major problems faced by businesses in the 1990s is how to produce environmentally friendly products and stay profitable.

A pioneering consortium at Carnegie Mellon University (CMU) is using AI, combined with operations research, environmental science, public policy, and other disciplines, to build tools for green engineering. *Green engineering* is an approach to product development that balances environmental compatibility against economic profitability. It looks at the entire life cycle of the product, from design to disposal, and seeks to extend this life cycle through remanufacturing, reusing, and recycling products and components.

Proactive Engineering

Today, industrial solutions to environmental problems focus largely on recycling, figuring out how to dispose of products at the end of their useful lives. The Product Design for the Environment Consortium (PDEC) is taking a proactive approach to the problem, developing tools to help engineers arrive at optimal product design at the front end of the product life cycle. PDEC is helping consortium members plan at the outset for the entire life cycle of a product, designing for component recovery, or remanufacture, reuse, and recycling. This holistic approach to the product life cycle goes beyond *concurrent engineering*, which strives to design for assembly, diagnosis, and maintenance, to include a product's environmental impact.

The consortium is currently engaged in two major development activities: (1) *green indicators* that are measures of environmental compatibility and (2) tools that use the green indicators to help designers make design decisions. At the heart of these tools are AI techniques.

The Economics of Green Engineering

There is a common belief that addressing environmental concerns makes products more expensive. D. Navin Chandra, who spearheaded PDEC, takes a different view. "When you take a holistic view of the product life cycle, recycling and material compatibility can lead to simplification," he explains. For example, a manufacturer was using dozens of plastics to produce a product. However, after a closer look, only half a dozen different specifications were found, which meant the product could be designed with fewer types of material. Fewer materials translated into less vendors and material inventories, less varieties of glues and epoxies, and less assembly operations. When the manufacturer implemented these design changes, the net result was lower cost and increased recyclability.

Although the economic results of PDEC's green engineering techniques are only beginning to come in, they are nonetheless compelling. One office products company found that through remanufacturing and reusing leased equipment, it could save $120 million a year. In addition, as green engineering grows in practice, new jobs in remanufacturing and recycling will be created.

A Green Engineering Tool

RESTAR is an economic modeling tool for recovery-cost optimization. Designed as a computer-aided design (CAD) tool, it is implemented in Common Lisp. It plots a cost curve that represents the effort put into disassembly, testing, repair and remanufacturing, quality assurance, and product design changes that allow for recovery. It also plots a curve of the revenue from resale and reuse. RESTAR assists engineers in finding the optimal meeting point of these two curves.

"We attempt to shift the percentage of reuse," explains Chandra, "so the balance point is closer to 100-percent recovery." Chandra is quick to explain that striving for 100-percent recycling seldom makes economic sense. He likens the problem to a chess game: You have to be willing to sacrifice some pieces to achieve your goal.

Material-Selection Tool

PDEC has also developed a tool for material selection and substitution with an eye toward recycling. KONING assists engineers in comparing various materials, helping with material properties and environmental considerations such as energy requirements, recyclability, and a variety of

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emissions issues. The tool is based on Common Lisp fuzzy logic.

Experimenting with Robots

The robotics lab at CMU is working with PDEC to examine the potential role of robots in remanufacturing. The pilot project involves remanufacturing old personal computers (PCs) from around the campus. "We have literally converted PC doorstops to working 386 machines," reports Chandra.

Although much of the remanufacturing today is human powered, there have been experiments in automating the process. Experimental algorithms have been attempted that take computer-aided design models and develop assembly and disassembly sequences executed by three robots.

High-Impact Work

Although PDEC's work is still in its infancy, the preliminary results are encouraging. "We have to teach our engineers and designers how to be environmentally conscious while making design decisions," notes Chandra. Powerful tools such as RESTAR will certainly help. Getting more groups involved in applying AI and other advanced computing techniques to the problem will certainly accelerate the effort.

International Symposium on Integrating Knowledge and Neural Heuristics

Sponsored by University of Florida, and AAAI, in cooperation with IEEE Neural Network Council, INNS-SIG, and FLAIRS.

May 9-10 1994; Pensacola Beach, Florida, USA.

A large amount of research has been directed toward integrating neural and symbolic methods in recent years. Especially, the integration of knowledge-based principles and neural heuristics holds great promise in solving complicated real-world problems. This symposium will provide a forum for discussions and exchanges of ideas in this area. The objective of this symposium is to bring together researchers from a variety of fields who are interested in applying neural network techniques to augmenting existing knowledge or proceeding the other way around, and especially, who have demonstrated that this combined approach outperforms either approach alone. We welcome views of this problem from areas such as constraint- (knowledge-) based learning and reasoning, connectionist symbol processing, hybrid intelligent systems, fuzzy neural networks, multi-strategic learning, and cognitive science.

Examples of specific research include but are not limited to: 1) How do we build a neural network based on *a priori* knowledge (i.e., a knowledge-based neural network)? 2) How do neural heuristics improve the current model for a particular problem (e.g., classification, planning, signal processing, and control)? 3) How does knowledge in conjunction with neural heuristics contribute to machine learning? 4) What is the emergent behavior of a hybrid system? 5) What are the fundamental issues behind the combined approach?

Program activities include keynote speeches, paper presentation, panel discussions, and tutorials. Scholarships are offered to assist students in attending the symposium. Students who wish to apply for a scholarship should send their resumes and a statement of their research goals.

Extended paper summaries should be limited to four pages (single or double-spaced) and should include the title, names of the authors, the network and mailing addresses and telephone number of the corresponding author. Important research results should be attached. Send four copies of extended paper summaries to

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Students' applications for a scholarship should also be sent to the above address. Notice of Acceptance: February 1, 1994. Camera Ready Papers Due: March 1, 1994

General information and registration materials can be obtained by writing to Rob Francis, ISIKNH'94 DOCE/Conferences, 2209 NW 13th Street, STE E University of Florida, Gainesville, FL 32609-3476 USA (Telephone: 904-392-1701; fax: 904-392-6950).