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GUEST EDITORIAL

Special Issue: Research Methodology

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Studies on the application of AI techniques to engineering design, analysis, and manufacturing (AI EDAM) problems have been expanding steadily over the past decade. These studies have led to the founding of many new journals and the initiation of series of conferences. If all these research efforts were successful, some of us might have been unemployed but living happily off the royalties from our successful research products that were deployed in practice.

This, however, is not the case. Usually, research projects advance marginally toward their stated goal. Many research paths are fruitless and waste resources, but the stories of these lessons remain untold. Undoubtedly, those who encounter an impasse in their research learn from it. Even in published reports, rarely are the assumptions underlying studies, the methods used to conduct them, the interpretation of the results, and their relation to intermediate failures or the partial attainment of research objectives elucidated or reflected upon.

What we wish to investigate in this special issue is whether we, as a research community, can do better.

The answer is both simple, hard, and uneasy. It is simple because it simply involves having researchers share research activities including failures with the research community. It is hard because it challenges existing beliefs and institutions. For example, which journal would publish research failures, or which university would grant tenure to a researcher who continually publishes excellent research failures with their illuminating lessons? The answer is also uneasy because, as research becomes more competitive, researchers are unwilling to unveil their research heuristics to their peers. Moreover, the particular research style of AI exacerbates the latter issue by allowing researchers to be vague even when writing research reports.

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To briefly illustrate the benefits from reflecting on research activities, consider the development project of an AI-based control system aboard a U.S. Navy aircraft carrier (Sloane, 1991). The development was designed as a participatory approach that included the future users of the system. Unfortunately, the system was designed to impose a centralized, hierarchical control that would devalue the role of its future users and, as they perceived, would reduce their ability to function effectively. Needless to say, the project failed. A study of research methodology would have immediately uncovered this contradiction. What is the upshot of all this? While it is clear that reflection is beneficial to practice, it is hard to acknowledge and practice publicly. The goal of this special issue on research methodology is to initiate such reflections on our research activities and their meaning.

To introduce the issue, Reich elaborates on the motivation for studying research methodology and outlines a framework that can help improve the understanding and the organization of research methodology studies. He also discusses many of the issues related to such studies. Following this introduction are the remaining papers roughly ordered in their treatment of methodological issues from general to more specific topics.

Dym and Levitt discuss the failure of CAE to flourish as an engineering discipline. After a brief historical analysis of CAE, informed by a long involvement in classical engineering and CAE research, they locate the reasons for the present status of CAE in various factors such as the structure of the industry and the perceived lack of domain expertise of CAE researchers. They discuss the nature of CAE that is different from traditional engineering, thus requiring different evaluation criteria and, subsequently, elucidate several such criteria based on which CAE research could be evaluated. Dym and Levitt propose that an improvement of the situation can arise from revising the university educational system, in particular, by substantially improving the practical training and involvement of researchers.

Steinberg discusses the development of a science of design consisting of principles that apply to a broad range of tasks and artifacts. Informed by analysis of several research projects, Steinberg argues that, in order to achieve these goals, design methods need to be applied to multiple tasks and domains, and research must be pursued in close collaboration with domain experts to challenge the design methods with real problems. Design science will culminate in a set of methods and a mapping that can assist in the selection of appropriate methods for solving particular tasks.

Adelman, Gualtieri, and Riedel discuss many of the critical issues concerning the evaluation of expert systems. They describe a multifaceted approach consisting of: (1) a technical facet—evaluating the inside of a system; (2) empirical facet—assessing the system's contribution to task performance; and (3) subjective facet—evaluating usability. After discussing the overall development cycle of expert systems, they turn to elaborate on a diversity of methods for conducting the multifaceted evaluation. The issues that Adelman, Gualtieri, and Riedel discuss apply well to the assessment of programs developed in AIEDAM research projects as well as to those expected to move from research to practice.

Lowe analyzes a project that applies the formal method of proof planning to the configuration of computers. She casts the project in a Popperian framework and argues that this framework is useful for guiding research. The nature of developing applications with proof planning supports this hypothetico-deductive approach. Lowe discusses the details of the project, including the formalization of the domain and the development, testing, and experimentation of the resulting program in this framework, as well as the methodological issues that are relevant to each of these activities. Lowe's paper provides a good example of a method that is compatible with its development methodology.

Tomiyama analyzes a long research program for developing intelligent CAD tools that originated from a formal theory of design. He reviews the theory, including its assumptions, predictions, and limitations. He then describes how a study of design augmented ideas from the theory to arrive at a new model of design processes and the implementation of these ideas in a CAD system. These ideas have also led to the development of a new type of machine that were subsequently patented. Tomiyama's paper exemplifies a work that has several highly sought properties: it has a formal foundation, it is informed by cognitive science experiments, and it has improved engineering practice.

Garcia, Howard, and Stefik discuss a particular research project of building computer aids for design documentation. In the discussion they elaborate on the execution of field studies aimed at eliciting requirements for their design and discuss methodological issues relevant to such studies. Subsequently they discuss the computer system developed based on their field studies and its preliminary evaluation. Garcia, Howard, and Stefik's paper provides an example of one complete research iteration, including some of the methodological issues that govern such research.

Completing this issue is an annotated bibliography on research methodology. The goal of this bibliography is to complement the introductory paper by providing additional references to studies on research methodology in disciplines that influence the research methodology of AIEDAM. The bibliography is not comprehensive but, rather, representative.

While editing this issue it became apparent to me through discussions with various authors and potential contributors that writing papers on research methodology is very hard. Therefore, I wish to thank the authors and the anonymous reviewers for their contributions to this special issue, and Clive Dym for acknowledging the need for this issue and for his support during the period of its production.

REFERENCES

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