

NUMERICAL MODELS IN REPRESENTATION DESIGN: COMPUTING SEAWATER PROPERTIES IN AN ECOLOGICAL INTERFACE

Nathan Lau

Greg A. Jamieson

Cognitive Engineering Laboratory, University of Toronto
Toronto, Ontario, Canada

The contribution of cognitive engineering in complex systems is often limited by the availability of information to populate advanced representational forms, such as those characterized by the Ecological Interface Design framework. We suggest the application of numerical models to derive required information, supplementing the analytical methods that are commonly used in computational aiding. We demonstrate the approach by presenting a solution combining numerical and analytical methods to the problem of determining seawater properties in a nuclear power plant. The example demonstrates that numerical approaches can expand the range of possible applications of representation aiding in complex systems.

INTRODUCTION

The nature of work in complex systems is becoming increasingly knowledge-based as well-defined and frequently occurring tasks are automated, leaving ill-defined problems and unanticipated events for the operators to manage. As a result, today's operators face challenges associated primarily with monitoring and problem solving. This aspect of work can be supported by human-machine interfaces that provide effective representations of domain constraints that enhance monitoring and diagnostic performance (Woods, 1991; Vicente & Rasmussen, 1992).

The development of interfaces usually involves two generic stages – analysis and design (Figure 1). The analysis generates requirements while design translates the requirements into perceivable representations. However, some requirements specify parameters that cannot be measured due to limitations in either instrumentation availability or capabilities (see, e.g., Reising & Sanderson, 2004; Maddox, 1996). Reising and Sanderson (2004) investigated the impact of instrumentation availability in a simulator study. They find a main effect of instrumentation and an interaction effect between interface design type and instrumentation availability. The study showed that an ecological interface for a pasteurizer simulator was superior with maximum instrumentation but inferior with minimal instrumentation compared to a mimic representation. These empirical results caution designers to be cognizant of the fact that the effectiveness of representational forms is dependent on the connection between instrumentation availability and design frameworks (i.e. combinations of specific analysis and design concepts).

The other limitation is the inability of instrumentation to measure higher-order information. In some such cases, the parameter in question can be derived from sensed data. For example, energy transfer in a heat exchanger cannot be measured directly, but it can be derived from measures of temperature and flow rate given values for the densities and specific heats of the fluids and the first law of

thermodynamics. This is an example of computational aiding using an analytical method - the approach that underlies much of the literature on configural displays. However, as the complexity of the modeled domain increases (e.g., when fluid properties vary with environmental conditions), it becomes increasingly difficult, if not impossible, to obtain analytical solutions. In such cases, the representation designer might conclude that some requirements simply cannot be satisfied in practice even if there is an effective representation. Thus, the ability to obtain information on physical processes limits the potential contribution of both analyses and representation aids to complex systems.

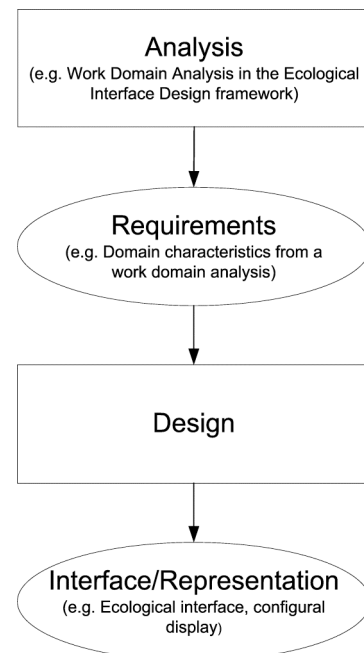


Figure 1: Generic stages and products of interface development.

