DEVELOPMENT OF AN INTEGRATED AI SYSTEM FOR CONCEPTUAL DESIGN SUPPORT

M X Tang
1 INTRODUCTION

Design problems are typically ill-structured: they start with a design requirement which does not contain, or imply all the criteria by which acceptable solution can be completely identified. Such a design requirement may be incomplete, inconsistent, imprecise or ambiguous. An important characteristic of design therefore involves developing a complete and consistent design requirement at the same time as developing a solution that satisfies it. This requires an integrated design environment in which domain concepts, design objects, design heuristics and design materials, are classified and structured so that their functional, structural and causal relationships can be identified and effectively reasoned about, allowing high level design tasks, such as design synthesis, design analysis, design evaluation, and design modification to be carried out whenever the design requirements are specified or changed.

Supporting design tasks at the early stage of the design process is difficult because at this stage little is known about the inconsistency of the design requirement and the structure of the design problem. The concept of the design is not formed until a designer has identified a basic knowledge structure in which information about structural, functional and causal relations of design objects becomes available and organised. The central role of an AI system supporting conceptual design is to provide solutions, through proper representations and reasoning mechanisms, for a class of design problems where the design requirement is incomplete and inconsistent, and the design problem is largely under-constrained.

Although it is possible to develop tools that automatically perform design tasks that require intensive numerical calculation, it is more useful to build design support systems that combine human and machine intelligence. Automatic design tools can only support some well defined and isolated design tasks which rely on procedural knowledge and fixed design strategies. Theses tools contribute little to decision making in the early stage of the design process which requires intensive use of both heuristic and procedural knowledge.

This paper presents an integrated AI system for conceptual design support. In this system, functional reasoning methods are used to transform an initial design requirement, using knowledge transformation rules, to an initial design solution concept structure consisting of a set of connected design elements which satisfy the initial design requirement. This knowledge transformation process is supported by a representation and reasoning scheme developed by Chakrabarti [2]. The results of functional synthesis provide a basis for embodiment design during which the physical components realising the proposed initial design solution concept structure are identified and their geometric relationships established. In this stage the values of all design variables are specified and