Supporting Concurrent Design Teams with Adjustably Autonomous Agents

Robin Barker, Anthony Meehan
Sheffield Hallam University, Pond Street, Sheffield S1 1WB, UK.
{R.Barker, A.Meehan}@shu.ac.uk

Extended Abstract

Successful deployment of knowledge-based systems in design is very limited. It has been suggested that one reason for this is that models of design have focused upon what machines can do and not on how designers actually design. [1]. The Cognitive Engineering Research Programme launched by the UK's Economic and Social Research Council in 1995 is seeking to achieve this goal by developing a better understanding of how we should design interactive systems through studying people and organisations. Oxman [2] offers an approach to this through the development of an integrated understanding of design theory, cognitive science and computing. This paper describes work which attempts to address some of the issues above by studying concurrent engineering designers to identify (some of) the dynamics of the concurrent design process and examine ways in which these might be captured in computational approaches to support design activity.

Design can be considered as consisting of two distinct tasks: the *analysis* task generates a formal design specification from an informal problem description; the *synthesis* task entails the generation of a design solution from the formal specification [3]. Concurrent design seeks to incorporate a number of different product life-cycle perspectives at the product design stage; commonly, these include design for market, cost, manufacture, assembly, maintenance, material recylclability, energy efficiency, and other perspectives [4]. Concurrent design is characterised by an iterative process of 'propose-critique-negotiate' both at the stage where a (revised) conceptual design is arrived during analysis and in the detailing of that conceptual design during synthesis [5].

In earlier work with concurrent designers we have developed a knowledge model to guide knowledge engineers in the development of design support systems [5]. Those studies revealed the need to examine computational techniques which allowed ways of implementing support systems which capture some of the dynamics which characterise concurrent design. To achieve this we propose an agent-based approach which features human/agent interaction, and specifically, human control of adjustable agent autonomy as an essential property of a system which seeks to support concurrent design. In examining support for implementationthis paper will focus on the sub task of negotiation.

We have examined existing approaches to supporting agent-based negotiation. The spectrum of computational approaches to negotiation includes systems which focus

on providing support for human negotiation through to systems which seek to implement autonomous agent-based negotiation. We have been able to exclude many negotiation systems which, whilst valuable in other contexts, do not capture negotiation as witnessed in concurrent design e.g. by depending upon central arbitrators or mediators. For other systems [6,7,8] we identify ways in which it is possible for humans to adjust the autonomy of an agent capable of negotiation.

Negotiation systems are characterisable by their fundamental assumptions. For example, negotiating agents may be assumed to be co-operative. But, in concurrent design, the degree of cooperativity/hostility can be creatively varied. In other negotiation systems agents are debarred from altering their beliefs/goals. Such systems leave human users to determine agent goals and change them in the event of unresolved conflict. Thus, in addition to being able to vary agent autonomy within any one approach to negotiation, it is also possible to determine agent autonomy by selecting/swapping one approach to negotiation over another.

We identify the extent to which current computational models of agent-based negotiation fall short of capturing concurrent negotiation behaviour and point to areas in which research is need.

References

1. T. Smithers, "On knowledge level theories of design process." in Artificial intelligence in design, Gero, J.S., Sudweeks, F. (eds.) Kluwer Academic Publishers pp 561-579, 1996
2. R. Oxman, Cognition and Design, Design Studies, vol 17, pp. 337-340, 1995
3. A. Bernaras, W. Van de Velde, "Design," in: Breuker, J., Van de Velde, W. (eds.) CommonKADS library for expertise modelling: reusable problem solving components. IOS Press, Chapter 8, 1995
4. H. Shiva Kumar, S. Suresh, C.S. Krishnamoorthy, S.J. Fenves, S. Rajeev, "GENCRIT : A tool for knowldege based critiquing in engineering design," Artificial Intelligence for engineering design, analysis and manufacturing, vol 8, Cambridge University Press, pp. 239-259, 1994
5. R. Barker, I. Tranter, A. Meehan, "Towards a knowledge-level model of concurrentdesign", 11th International Conference on Engineering Applications of AI and Expert Sysytems, Benicassim, Castellon, Spain, 1-4 June 1998 (Proc. IEA-98-AIE) Vol 1 Methodology and Tools in Knowledge-based Systems, Jose Mira, Angel Pasqual del Pobil, Moonis Ali (eds); Lecture Notes in Artificial Intelligence 1415; Springer-Verlag, ISBN 3-540-64582-9 pp57-67
6. S.T.C.Wong, "Preference-based decision making for cooperative knowledge-based systems." ACM Trans on Information Systems, 12:4, pp. 407-435, 1994
7. K. Sycara, "Multiagent compromise via negotiation," in Distributed Artificial Intelligence, L. Gasser and M. Huns (Eds) Vol 2 Pitman 119-137 1989
8. G. Zlotkin, J.S. Rosenschein, "Mechanism design for automated negotiation and its application to task oriented domains." Artificial Intelligence 86, pp.195-244, 1996