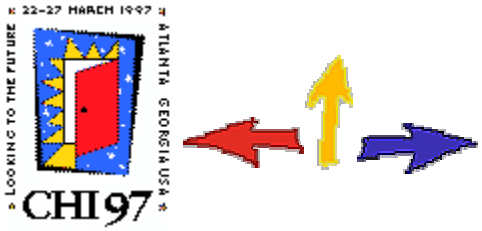
CHI 97 Electronic Publications: Doctoral Consortium



Computer aided creativity and multicriteria optimization in design

Denis Lalanne
+41 21 693 3824
lalanne@imt.dmt.epfl.ch
Ecole Polytechnique Feédérale de Lausanne
Institut de Microtechnique
MT-Ecublens
1015 Lausanne
Switzerland

ABSTRACT

Establishing that machines cannot automate creative design and that it is a difficult task for humans, I propose a computational model based on the human and machine complementarity and collaboration.

Keywords

Human-machine asynchronous collaboration, interactive intelligence, creative design.

INTRODUCTION

By not considering human factors of artificial intelligent systems, we risk building large software systems which can solve complex problems, but unable to communicate to users. Our goal is to put interfaces to the AI systems and to create an "interactive intelligence," a type of human and machine synergy. Few systems treat human computer interaction at the reasoning level. In the user modelling domain , researchers aim at building adaptative interfaces that fit with the users' task models in order to make the use of computers more intuitive. Our approach is different. We do not try to make systems able to understand the user, but build systems capable of complementing user's skills [2]. Humans live in a stimulating and dynamic environment which allows them to be creative and productive. But there are limitations of human cognitive faculties. We thus want to augment human intelligence in terms of their computational, perceptual and attentional power in order to increase their reasoning abilities. For this reason, we assume an asymmetric mode of interaction; that is the machine serves as a computational slave while humans concentrate on creative tasks.

Problem solving is a task where such a synergy between two different intelligences is useful. We are thus interested in supporting problem resolution. Design is such a problem solving task which involves creative skills, artistic intuitions, as well as a rich repertory of knowledge. Further, design is not description of what is, it is exploration of what might be. However, most existing CAD tools do not allow designers to express their creative skills. Rather, they impose a predefined algorithmic structure on designers when these software packages are used.

ARCHITECTURE

COMIND[1] is a system that I have developed which allows humans and computers to collaborate and cooperate, sharing their cognitive and computational resources. We have done some studies and identified a set of design activities that are suitable for humans and those that are suitable for machines [3]. There is no task structure in our system because we do not believe in a specific sequence of use. Tasks are distributed, rather than organized in a hierarchy. The user is thus free to choose his own way of interaction. An open architecture contradicts the traditional algorithmic nature of software and organizes its functionalities at the cognitive level of task distribution instead of the control of task performance. This human-centered design environment offers many software modules as servicing agents. Agents appear as iconized caricatures in the working area and they consist mainly of two types: computational and reflective agents. Computational agents process inconsistencies in design space, generate partial and complete solutions, help designers visualize a set of competing solutions, and propose tradeoffs. Reflective agents are fully autonomous and their main goal is to serve as a cognitive map of the user.

COMPUTATIONAL ASSISTANTS

In order to define a problem, the designer can use the BRAINSTORMING assistant. In this step, the designer can type freely his ideas about the problem in an editor.

The BRAINSTORMING assistant proposes analogies with older sessions. The goal is to produce as many ideas as possible. Other helps are provided in order to support the structuring of the problem. The aim of the Brainstorming assistant is both to keep a trace of initial ideas and goals, and to support the formalization of the problem.

After the production of a good number of ideas, the designer can use the PARAM-DEF assistant in order to define the problem in a more formal way and to be able to solve it. The definition follows the structure of a Constraint Satisfaction Problem. However, the constraints can be defined by either logic rules or matrices. Writing rules can be a difficult task for a designer. The PARAM-DEF assistant supports this process by providing to the user a menu containing all the possible types of rules and their intuitive translations. It also provides a visualization of the graph created by parameters and constraints. It is a good visual feedback for the user because it gives an overview of the problem as a constraint network.

As the number of constraints increases, the resolution of the problem becomes impossible for a human solver. However, artificial intelligence techniques for search and for finding solutions in a constraint network are well suited for these tasks. In particular, our SOLVE agent uses automatic search algorithms to automatically find design solutions. It also provides different visualizations of the search space. The use of both algorithms and visualization allows to interactively search for solutions.

In our opinion, creativity in design comes from two types of cognitive process: tradeoff and break-through process. Those two kinds of processes come from another distinction between two extreme types of problems: over and under-constrained problems.

For under-constrained problems, too many solutions are possible. People need to do tradeoffs to find the optimal solution. However, according to the large number of criteria, choices are difficult. The TRADEOFF assistant provides an editor for defining the criteria of the design. The calculation of those criteria is a post-processing evaluation. They are calculated for all the solutions found during the search process. Several visualizations are proposed at this step. The designer can thus evaluate the solutions according to the criteria s/he has set. S/he can also evaluate the quality (or the sharpness) of the criteria. If users are dissatisfied with the current solutions, they can abandon these neighborhoods and opt for others in the search space. Though it seems that we allow designer to "shoot in the dark" in the process of discovering creative designs, this kind of serendipity is part of discovery.

In over-constrained problem, there is no solution. People have to find conflicts and solve them. It requires two things: consistency checking and creativity to enlarge the space of solutions and thus to avoid the conflicts. The limitation of human memory is a problem. Dealing with on the order of a hundred constraints is difficult and finding the escape requires ingenuity; the designer has to break-through the current space of solutions. This

step is particularly important in the creative process because avoiding a conflict is often done by mutation; in order to escape from a conflict, the user has to reformulate the problem, or relax certain constraints. The CONFLICT RESOLUTION assistant is based on a visualization of the conflicting rules. The CONFLICT ELICITATION assistant indicates the conflicting parts of the constraint network. The designer can then select a conflicting area and see the values of the space forbidden by each participating rules. The main point in this step is to help the user play with constraints in order to solve conflicts that forbid the finding of solutions. Visual interactivity is also important because it allows, by interacting with some visualizations of solutions, a better view of constraints' influences on each other.

REFLECTIVE ASSISTANTS

An attention decrease in a decision making process can be catastrophic. The designer is going to miss good solutions or to miss alternatives in his reasoning. Cognitive maps [1] have been found useful in prompting humans in exploring unknown territories. Since it is critical that designers do not slip into their usual way of thinking, the cognitive maps can serve as a prosthesis of the attentional system of a human so that if they notice it, they may choose to change it. Furthermore reflecting the designer's search can give him a feeling of closure. That is the role of the HISTORY assistant.

CONCLUSION

Our main hypothesis is that the interaction between human and machine has an important role in computer-supported design, especially when creativity is required. By providing intelligent and reflecting tools that complement human skills, and by making software systems more transparent and interactive, users have more control over the decisions being made, and thus are able to explore their creativity more freely. However, many new and challenging issues remain to be solved: 1) what contributions human and machine can each provide to the creative design process, 2) what are the mirroring and processing roles of agents, and 3) what will be the collaborative technique which allows contributions from humans and machines to take place in the creative design process.

AKNOWLEDGMENT

COMIND is being sponsored by the Swiss National Science foundation (Fonds National Suisse de la recherche scientifique).

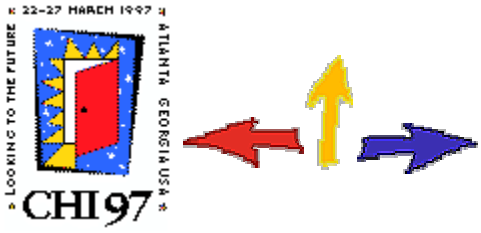
REFERENCES

1. Boden, M.: The creative Mind. Basic Book, 1990.
2. Fischer, G.: Creativity enhancing design environments, in Modeling Creativity and Knowledge-Based Creative Design, edited by J. S. Gero and M. L. Maher, Lawrence Erlbaum Associates, Inc., Publishers, 1993.

3. Pu, P. and Lalanne, D. Human and Machine Collaboration in Creative Design, in Proceedings of the Eurpean Conference on Artificial Intelligence, Budapest, 1996.

[1]for COmputer aided creativity and Multicriterai optimization IN Design

---



CHI 97 Electronic Publications: Doctoral Consortium