DESIGNING CREATIVITY

FRANCES M. T. BRAZIER AND NIEK J. E. WIJNGAARDS
Intelligent Interactive Distributed Systems Group,
Faculty of Sciences, Vrije Universiteit Amsterdam,
de Boelelaan 1081a, 1081 HV Amsterdam, The Netherlands
Email: {frances,niek}@cs.vu.nl
URL: http://www.iids.org

Abstract. Is it possible to design for creativity? This is one of the most important research questions in AI and Design. This paper raises the question whether automated software agent design can be creative. Not only is the artefact dynamic in the sense that it adapts to its environment, it is also autonomous: an agent decides on its own when to be modified and by whom. An agent's functionality may evolve beyond the expectations of its designers and/or users resulting in very new, unique artefacts. Is this type of design creative? Is the process creative? The result?

1. Introduction

Creativity is almost a holy grail for the AI and Design research community. Researchers, in pursuit of the essence of creativity, have formulated different definitions of creativity and have built automated systems to explore the elements involved in creativity. The main question, whether it is possible to design (or engineer for) creativity, remains unanswered.

This paper raises the discussion whether automated software design can be creative. Adaptive agents are dynamic artefacts; they are designed to be re-designed. As agents are autonomous, agents can autonomously decide to be modified to adapt to their environment. In this sense software agents can be designed to be autonomous dynamic artefacts. Their functionality evolves during their lifetime, and can not be defined in advance: it may evolve beyond the expectations of their designers and/or users resulting in very new, unique artefacts.

In section 2, agents and adaptation are briefly discussed. Section 3 goes into a number of aspects of creativity. Section 4 discusses the feasibility of automated creative design.

2. Agents and Adaptation

The (multi-) agent paradigm provides a means to characterise interactions between autonomous pro-active agents and their environment. Pro-activeness and autonomy are related to an agent's ability to reason about its own processes, goals and plans. Agents (either human or automated) are responsible for these processes, where each agent has its own environment, consisting of other agents and a material world. Agents are able to communicate with each other, can co-operate to jointly perform tasks, interact with the world (observe and/or act), and perform specific tasks.

The agent metaphor provides a means to model situations with distributive activity (e.g., Jennings, 2000). Multi-agent systems have been proposed to model collaborative tasks such as design (Edmonds, Candy, Jones and Soufi, 1994; Vanwelkenhuysen and Mizoguchi, 1995; Dunskus, Grecu, Brown and Berker, 1995; Berker and Brown, 1996).

A distinction can be made between adaptive agents and the process of adapting agents. Research on *adaptive* agents is described in Section 2.1. Research on *adapting* agents is described in Section 2.2.

2.1 RESEARCH ON ADAPTIVE AGENTS

Agents can be designed to adapt to their environment. One application of adaptive agents entails personification, for example an information gathering agent may maintain a profile of another agent or human user (e.g., see Wells and Wolfers, 2000; Soltysiak and Crabtree, 1998). Learning techniques are often used for adaptive agents, e.g. as described by (Reffat and Gero, 2000; Grefenstette, 1992). Another perspective on adaptive agents is changes in the population of agents over time; an adaptive agent architecture (Maturana, Shen and Norrie, 1999). Examples include genetic programming and parametric design approaches in which individuals are modified (e.g., see Spector and Robinson, 2002).

An adaptive agent is a dynamic artefact, i.e. it exhibits changes in its behaviour, based on changes in its environment. Examples of other dynamic artefacts include houses that adjust lighting and temperature on the basis of occupation of rooms (Mozer, 1999); elevators which try to second-guess the behaviour of their clientèle; autopilots of aeroplanes, that take and give control to human pilots; and self-configuration of autonomous (spacecraft) systems (Williams and Nayak, 1996).

A more extreme form of adaptation is for an agent to modify its internal data and processes: a self-modifying agent (Brazier and Wijngaards, 2001b). This enables an agent to change the way it reasons and solves problems. It reflects on the manner in which it solves a specific problem, and adjusts its approach; an ability subscribed to reflective practitioners, as discussed by Schön (1983). The re-design process may be part of a self-modifying agent, or may be an agent factory. A self-modifying agent may, for example, employ an agent factory to modify its self-modification capabilities.

2.2 AUTOMATED REVISION OF AGENTS

The agent factory (Brazier and Wijngaards, 2001a; 2002) is a continuation of almost a decade of research in AI and Design, applied to multi-agent systems. The generic model of design (Brazier, Langen, Ruttkay and Treur, 1994) has been extended for the re-design of agents (Brazier, Jonker, Treur and Wijngaards, 2000). This work included the specification and implementation of a design agent, capable of re-designing agents (Brazier, Jonker, Treur and Wijngaards, 2001).

In this context agents are *designed to be re-designed*. Everything inside an agent may be replaced, deleted or modified, including its internal process structure, knowledge structure, data, ontologies, etc. To this end, a compositional structure is assumed, and re-usable agent components are identified in advance. A language (i.e. ontology) is needed to describe agents' functionality and behaviour. The design of an agent within the agent factory is based on specifications of building block configurations: *blueprints*. Building blocks include cases and partial (agent) designs (cf. generic models / design patterns), knowledge bases, and instantiated models. Building blocks are either components with open slots, fully specified components, or a combination of both.

In addition to the design centre an agent factory includes components for account management (which client requires which quality of service), agent packaging and handling (how to prepare an agent for transfer to an agent platform), etc. The design centre is based on a model for (re-)design of compositional systems (Brazier, Jonker, Treur and Wijngaards, 2001).

3. Creative Agents

Automated design of adaptive, self-modifying, software agents may be creative in two ways: the self-modification process itself may be creative (self modification is namely a re-design task), or self-modification may result in a more creative agent with respect to an agent's specific task. Creativity within the process of self-modification is directly related to creativity in design processes (e.g., Schön, 1983; Finke, Ward and Smith, 1992; Edmonds and Candy, 1997; Gero, 1996; Lawson, 1997; Gero, 2000). The application of the self-modification process to influence creativity within other processes within an agent, e.g. an agent's specific task, may yield creative results.

The self-modification process described in this paper includes four of the five stages distinguished in the five-stage model introduced by Kneller and described by Lawson (1997), shown in Figure 3: stage 3 is the exception. Unconscious effort is not easily defined for an automated agent.

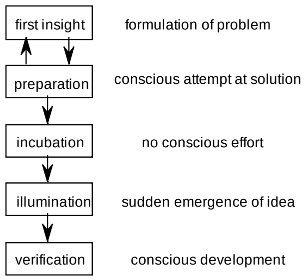

Figure 3. Five-stage model of the creative process (taken from Lawson, 1997).

Gero’s model for creative design (1996) is based on the view that creativity results from a discrepancy between expectations and unexpected results. If the unexpected results can be understood, then they are considered to be a creative solution. When, however, the unexpected results cannot be understood, these results are rejected as faulty. A self-modification process may have side effects that had not been anticipated. Influences on the creativity of an agent with respect to its own specific task may be purposefully sought by re-design, without knowing the results. In both cases, how well the results are understood will depend on the situation, e.g., who is responsible for monitoring an agent’s behaviour – a human being or another automated agent.

The environment of the designers plays an important role in determining creativity. Different kinds of creativity are described by Gero (2000): historical creativity, personal (or psychological) creativity and situated creativity. The agent factory can yield situated creativity for agents: the owner (or initial developer) of an agent cannot predict changes of its agent.

4. Discussion

The main question raised in this paper is whether automated design of dynamic self-modifying autonomous artefacts can be creative. This depends to a large extend on the definition of creatvity used. The design of dynamic artefacts, artefacts designed to be redesigned, is relatively new. The design of dynamic autonomous artefacts pushes current theory even further. Is the process with which an agent evolves creative? If not, are there aspects which can be considered to be creative? Who determines in this case whether a design is creative: the designer, the owner, the outside world? Other agents (Saunders and Gero, 2002) may be involved in ascertaining creativity, and a question that rises is whether creativity is required to recognise creativity.

The answers to above discussion issues are not simple; more research is clearly required to further explore the nature of the phenomena involved.

Acknowledgements

This work was supported by NLnet Foundation, http://www.nlnet.nl. The authors are grateful to the participants of the Computational and Cognitive Models of Creative Design V workshop in December 2001 for the discussions on creativity. The authors are grateful to Hidde Boonstra, David Mobach, Oscar van Scholten, and Sander van Splunter for their contribution to the work on the agent factory and the prototypes.

References

Berker, I. and Brown, D. C.: 1996, Conflicts and Negotiation in Single Function Agent Based Design Systems, *in* D. C. Brown, S. E. Landes and C. J. PETRIE (eds), *Concurrent Engineering: Research and Applications, Journal*, Special Issue: Multi Agent Systems in Concurrent Engineering, Technomic Publishing Inc., **4**(1), 17-33.

Brazier, F. M. T. and Wijngaards, N. J. E.: 2001a, Automated Servicing of Agents, *AISB Journal*, Special Issue on Agent Technology, **1**(1), 5-20.

Brazier, F. M. T. and Wijngaards, N. J. E.: 2001b, Designing Self-Modifying Agents, in J. S. Gero and M. L. Maher (eds), *Proceedings of Computational and Cognitive Models of Creative Design V, the fifth international roundtable conference*, Sydney: Key Centre of Design Computing and Cognition, University of Sydney, December 2001, pp. 93-112.

Brazier, F. M. T. and Wijngaards, N. J. E.: 2002, Automated (Re-)Design of Software Agents, *in Proceedings of the Artificial Intelligence in Design Conference 2002*, to appear.

Brazier, F. M. T., Jonker, C. M., Treur, J. and Wijngaards, N. J. E.: 2000, Deliberate Evolution in Multi-Agent Systems, *in* J. Gero (ed.), *Proceedings of the Sixth International Conference on AI in Design, AID'2000*. Kluwer Academic Publishers, 2000, pp 633-650.

Brazier, F. M. T., Jonker, C. M., Treur, J. and Wijngaards, N. J. E.: 2001, Compositional Design of a Generic Design Agent, *Design Studies journal*, **22**(5), 439-471..

Brazier, F. M. T., Langen, P. H. G. van, Ruttkay, Zs. and Treur J: 1994, On formal specification of design tasks, *in* J. S. Gero and F. Sudweeks (eds), *Proceedings Artificial Intelligence in Design (AID'94),* Dordrecht: Kluwer Academic Publishers, pp. 535-552.

Dunskus, B. V., Grecu, D. L., Brown, D. C. and Berker, I.: 1995, Using Single Function Agents to Investigate Conflict, *Artificial Intelligence in Engineering Design and Manufacturing (AIEDAM)*, Special Issue: Conflict Management in Design, **9**(4), 299-312.

Edmonds, E. A. and Candy, L.: 1997, Supporting the Creative User: A Criteria-based Approach to Interactive Design, *Design Studies*, **18**(2), 185-194.

Edmonds, E. A., Candy, L., Jones, R. and Soufi, B.: 1994, Support for Collaborative Design: Agents and Emergence, *Communications of the ACM*, **37**(7), 41-47.

Finke, R. A., Ward, T. B. and Smith, S. M.: 1992, *Creative Cognition, theory, research, and applications*, MIT press, Cambridge, MA.

Gero, J. S.: 1996. Creativity, emergence and evolution in design: concepts and framework, *Knowledge-Based Systems*, **9**(7), 435-448.

Gero, J. S.: 2000, Computational models of innovative and creative design processes, *Technological Forecasting and Social Change*, **64**(2-3), 183-196.

Grefenstette, J.: 1992, The evolution of strategies for multiagent environments, *Adaptive Behavior*, **1**(1), 65-90.

Jennings, N. R.: 2000, On agent-based software engineering, *Artificial Intelligence*, **117**(2), 277-296.

Lawson, B.: 1997, *How designers think: the design process demystified*, 3rd edition, Architectural press.

Maturana F., Shen, W. and Norrie, D. H.: 1999, MetaMorph: An Adaptive Agent-Based Architecture for Intelligent Manufacturing, *International Journal of Production Research*, **37**(10), 2159-2174.

Mozer, M. C.: 1999, An intelligent environment must be adaptive, *IEEE Intelligent Systems and their Applications*, **14**(2), 11-13.

Reffat, R. M. and Gero, J. S.: 2000, Computational Situated Learning in Design, in: J. S. Gero (ed), *Artificial Intelligence in Design '00*, Kluwer Academic Publishers, Dordrecht, pp. 589-610.

Saunders, R and Gero, J. S.: 2001, Artificial creativity: A synthetic approach to the study of creative behaviour, *in* J. S. Gero and M. L. Maher (eds), *Computational and Cognitive Models of Creative Design V*, Key Centre of Design Computing and Cognition, University of Sydney, Sydney, pp. 113-139.

Schön, D. A.: 1983, *The Reflective Practitioner: how professionals think in action*, Basic Books Inc.

Soltysiak, S. and Crabtree, B.: 1998, Knowing Me, Knowing You: Practical Issues in the Personalisation of Agent Technology, *in Proceedings of the third international conference on the practical applications of intelligent agents and multi-agent technology* (PAAM98), London, pp. 467-484.

Spector, L. and Robinson, A.: 2002, Multi-type, Self-adaptive Genetic Programming as an Agent Creation Tool, *in Proceedings of the Workshop on Evolutionary Computation for Multi-Agent Systems, ECOMAS-2002*, International Society for Genetic and Evolutionary Computation, to appear.

Vanwelkenhuysen, J. and Mizoguchi, R.: 1995, Workplace-Adapted Behaviors: Lessons Learned for Knowledge Reuse, *in* N. Mars (ed), *Proceedings of Second International Conference on Building and Sharing Very Large-Scale Knowledge Bases*, Enschede, Netherlands. IOS Press, pp. 270-280.

Wells, N. and Wolfers, J.: 2000, Finance with a Personalized Touch, *Communications of the ACM*, Special Issue on Personalization, **43**(8), 31-34.

Williams, B. C. and Nayak, P. P.: 1996, A Model-Based Approach to Reactive Self-Configuring Systems, *in Proceedings of the AAAI-96*, **2**, pp. 971-978.