UNIVERSITY OF CALIFORNIA,
IRVINE

Cognitive Support Features for Software Development Tools

DISSERTATION

submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in Information and Computer Science

by

Jason Elliot Robbins

Dissertation Committee:
Professor David F. Redmiles, Chair
Professor Debra J. Richardson
Professor David S. Rosenblum

1999

The dissertation of Jason Elliot Robbins is approved
and is acceptable in quality and form
for publication on microfilm:

_____

_____

_____
Committee Chair

University of California, Irvine
1999

DEDICATION

To

my loving wife Sua-Yu

and my family

for their love and support

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation under Grant No. CCR-9624846 and Grant No. CCR-9701973. Effort also sponsored by the Defense Advanced Research Projects Agency, Air Force Research Laboratory, Air Force Materiel Command, USAF under agreement numbers F30602-97-2-0021 and F30602-94-C-0218, and Air Force Office of Scientific Research under grant number F49620-98-1-0061. Additional support is provided by Rockwell International. The U.S. Government is authorized to reproduce and distribute reprints for Governmental purposes notwithstanding any copyright annotation thereon. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the Defense Advanced Research Projects Agency, Air Force Research Laboratory or the U.S. Government.

CURRICULUM VITAE

Jason Elliot Robbins

1988-91, 1994-97	Summer Student, and Flex-Force Engineer Rockwell International Science Center, Thousand Oaks, CA
1992	B.S. in Computer Science, Cum Laude University of California, Los Angeles Major GPA: 3.9
1993	Senior Coder, CoBase Reseach Group University of California, Los Angeles Computer Science Dept.
1994 - 95	Teaching Assistant ICS 52 - Systematic Software Construction ICS 125 - Project in System Design ICS 141 - Compilers and Interpreters University of California, Irvine Dept. Information and Computer Science
1995	M.S. in Information and Computer Science University of California, Irvine Major Emphasis: Software Cumulative GPA: 4.00
1995 - present	Graduate Student Researcher, Software Research Group University of California, Irvine Dept. Information and Computer Science
1999	Ph.D. in Information and Computer Science University of California, Irvine Software Research Group Dissertation: “Cognitive Support Features for Software Development Tools” Advisor: Dr. David F. Redmiles

PUBLICATIONS

Journal Publications

A Component- and Message-Based Architectural Style for GUI Software. Richard N. Taylor, Nenad Medvidovic, Kenneth M. Anderson, E. James Whitehead, Jr., Jason E. Robbins, Kari A. Nies, Peyman Oreizy, and Deborah L. Dubrow. *IEEE Transactions on Software Engineering*. vol. 22. no. 6. June 1996. pp. 390-406. A significant revision and extension of the ICSE'95 paper.

Extending Design Environments to Software Architecture Design. Jason E. Robbins, David M. Hilbert, David F. Redmiles. *International Journal of Automated Software Engineering*. Special issue: The Best of KBSE'96. vol. 5. 1998. pp. 261-290. A significant revision and extension of the KBSE'96 paper.

Software Architecture Critics in the Argo Design Environment. Jason E. Robbins, David F. Redmiles. *Knowledge-Based Systems*. Special issue: The Best of IUI'98. In press. A significant revision and extension of the IUI'98 paper.

Refereed Conference Publications

Reusable Objects. David Morley, Stephen Chiu, Jason Robbins, Tim Maddux, Geoffrey Voelker. *Technology of Object-Oriented Languages and Systems (TOOLS'92*). Paris, France. March, 1992.

A Component and Message-Based Architectural Style for GUI Software. Richard N. Taylor, Nenad Medvidovic, Ken M. Anderson, E. James Whitehead, Jr., and Jason E. Robbins. *International Conference on Software Engineering 1995 (ICSE'95)*. Seattle WA. April 23-30, 1995. pp. 295-304. This paper was named one of the best papers of the conference.

Software Architecture Design from the Perspective of Human Cognitive Needs. Jason E. Robbins and David F. Redmiles. *Proceedings of the California Software Symposium 1996*. Los Angeles, California. April 17, 1997. pp. 16-27.

Visual Language Features Supporting Human-Human and Human-Computer Communication. Jason E. Robbins, David J. Morley, David F. Redmiles, Vadim Filatov, Dima Kononov. *IEEE Symposium on Visual Languages 1996 (VL'96)*. Boulder, CO. Sept. 3-6, 1996. pp. 247-254.

Extending Design Environments to Software Architecture Design. Jason E. Robbins, David M. Hilbert, and David F. Redmiles. *Knowledge-Based Software Engineering 1996 (KBSE'96)*. Syracuse, NY. Sept. 25-28, 1996. pp. 63-72. This paper was selected as best of conference.

Using Object-Oriented Typing to Support Architectural Design in the C2 Style. Nenad Medvidovic, Peyman Oreizy, Jason E. Robbins, and Richard N. Taylor.

Proceedings of SIGSOFT'96: The Fourth Symposium on the Foundations of Software Engineering (FSE-4). San Francisco, CA. October 16-18, 1996. pp. 24-32.

Argo: A Design Environment for Evolving Software Architectures. Jason E. Robbins, David M. Hilbert, David F. Redmiles. *Proceedings of the 19th International Conference on Software Engineering (ICSE'97)*. Boston, MA. May 17-23, 1997. pp. 600-601.

Software Architecture Critics in Argo. Jason E. Robbins, David M. Hilbert, David F. Redmiles. *Proceedings of the 1998 International Conference on Intelligent User Interfaces (IUI'98)*. San Francisco, CA. Jan. 6-9, 1998. pp. 141-144. This paper was named one of best papers of the conference.

EDEM: Intelligent Agents for Collecting Usage Data and Increasing User Involvement in Development. David M Hilbert, Jason E. Robbins, and David F. Redmiles. *Proceedings of the 1998 International Conference on Intelligent User Interfaces (IUI'98)*. San Francisco, CA. Jan. 6-9, 1998. pp. 73-76.

Modeling C2 in the Unified Modeling Language. Jason E. Robbins, David F. Redmiles, David S. Rosenblum. *Proceedings of the California Software Symposium 1997*. Irvine, CA. Nov. 7, 1997. pp. 11-18.

Integrating Architecture Description Languages with a Standard Design Method. Jason E. Robbins, Nenad Medvidovic, David F. Redmiles, David S. Rosenblum. *Proceedings of the 1998 International Conference on Software Engineering (ICSE'98)*. Kyoto, Japan. April 19-25, 1998. pp. 209-218.

Workshop Publications

Software Architecture: Foundations of a Software Component Marketplace. E. James Whitehead, Jr., Jason E. Robbins, Nenad Medvidovic, and Richard N. Taylor. *ICSE 1995 Workshop on Software Architecture*. Seattle, WA.

Using Critics to Analyze Evolving Architectures. Jason E. Robbins, David M. Hilbert, and David F. Redmiles. *Second International Software Architecture Workshop (ISAW-2)*. Held in conjunction with FSE'96. San Francisco, CA. October 16-18, 1996. pp. 90-93.

Technical Reports

A Software Architecture Design Environment for Chiron-2 Style Architectures. Jason E. Robbins, E. James Whitehead, Jr., Nenad Medvidovic, and Richard N. Taylor. January 1995. Tech Report Arcadia-UCI-95-01.

Using Critics to Support Software Architects. Jason E. Robbins, David M. Hilbert, David F. Redmiles. April 1997. Technical Report UCI-ICS-97-18.

Supporting Ongoing User Involvement in Development via Expectation Driven Event Monitoring. David M. Hilbert, Jason E. Robbins, David F. Redmiles. April 1997. Technical Report UCI-ICS-97-19.

Integrating Architecture Description Languages with a Standard Design Method. Jason E. Robbins, Nenad Medvidovic, David F. Redmiles, David S. Rosenblum. August 1997. Technical Report UCI-ICS-97-35.

FORMAL PRESENTATIONS

Software Architecture Design from the Perspective of Human Cognitive Needs. California Software Symposium 1996. Los Angeles, CA. April 17, 1997.

Visual Language Features Supporting Human-Human and Human-Computer Communication. IEEE Symposium on Visual Languages 1996 (VL'96). Boulder, CO. Sept. 3-6, 1996.

Extending Design Environments to Software Architecture Design. Knowledge-Based Software Engineering 1996 (KBSE'96). Syracuse, NY. Sept. 25-28, 1996.

Argo: A Tool for Evolving Software Architectures. Nineteenth International Conference on Software Engineering (ICSE'97). Boston, MA. May 17-23, 1997.

Software Architecture Critics in Argo. 1998 International Conference on Intelligent User Interfaces (IUI'98). San Francisco, CA. Jan. 6-9, 1998.

Extending Design Environments to Software Architecture Design. Presented at Jet propulsion Laboratories. Pasadena, CA. June 1997.

Modeling C2 in the Unified Modeling Language. California Software Symposium 1997. Irvine, CA. Nov. 7, 1997.

Using Critics to Analyze Evolving Architectures. Second International Software Architecture Workshop (ISAW-2). Held in conjunction with FSE'96. San Francisco, CA. October 16-18, 1996.

Integrating Architecture Description Languages with a Standard Design Method. EDCS Cross Cluster Workshop. Austin, TX. Nov. 10-12. 1997.

RESEARCH PROPOSALS

Applying Design Critics to Software Requirements Engineering. (PI: D. F. Redmiles). Submitted to the Microelectronics Innovation and Computer Research Opportunities (MICRO) program. Funded with a one-year budget of $33,152 (includes $20,000 in matching funds from Rockwell). August, 1997.

Open Technology for Software Evolution: Hyperware, Architecture, and Process. (PI's: R. N. Taylor and D. F. Redmiles). Submitted to the Defense Advanced Research Projects Agency (DARPA). Funded with a three-year budget of $2,606,666. October, 1996.

PROFESSIONAL ASSOCIATIONS

Association for Computing Machinery (ACM)
IEEE Computer Society
ACM Special Interest Group on Software Engineering (SIGSOFT)
ACM Special Interest Group on Computer Human Interaction (SIGCHI)

HONORS, AWARDS, FELLOWSHIPS

Thomas J. Watson Memorial Scholar
National Merit Society Finalist
Twice elected President of UCLA's Computer Science Undergraduate Association (UCLA's student chapter of the Association for Computing Machinery)
Tau Beta Pi (the national engineering honor society)
UCLA School of Engineering Dean's Honor List
UCLA School of Engineering Dean's Circle
MICRO Fellowship

ABSTRACT OF THE DISSERTATION

Cognitive Support Features for Software Development Tools

By

Jason Elliot Robbins

Doctor of Philosophy in Infomation and Computer Science

University of California, Irvine, 1999

Professor David F. Redmiles, Chair

Software design is a cognitively challenging task. Most software design tools provide support for editing, viewing, storing, sharing, and transforming designs, but lack support for the essential and difficult cognitive tasks facing designers. These cognitive tasks include decision making, decision ordering, and task-specific design understanding. To date, software design tools have not included features that specifically address key cognitive needs of designers, in part, because there has been no practical method for developing and evaluating these features.

This dissertation contributes a practical description of several cognitive theories relevant to software design, a method for devising cognitive support features based on these theories, a basket of cognitive support features that are demonstrated in the context of a usable software design tool called Argo/UML, and a reusable infrastructure for building similar features into other design tools. Argo/UML is an object-oriented design tool that includes several novel features that address the identified cognitive needs of software designers. Each feature is explained with respect to the cognitive theories that inspired it and the set of features is evaluated with a combination of heuristic and empirical techniques.