Edward P. Katz, Ph.D.

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RESEARCH INTERESTS

- Intelligent Robotics (focus: *task-level middleware*)
- Smart Environments, Autonomous Mobile Robotics, and Automation Software Systems
- Computational Intelligence-Soft Computing (focus: *Fuzzy Logic*)
- Software Engineering for Robotics and Automation
- Intelligent Agents and Distributed Agent Systems
- Rule-based and Expert Systems

QUALIFICATIONS SUMMARY

Proven ability to research, design, prototype, and implement software solutions for intelligent automation in the areas of smart environments, intelligent/cognitive robotics, and automation systems. Experienced with industrial robotics, traditional artificial intelligence, rule-based expert systems, fuzzy logic, soft computing, computational intelligence, and intelligent agents. Deep background as senior software engineer, CMU Silicon Valley Senior System Scientist and Associate Professor with focus on Smart Environments, automation, and robotics Research.

EDUCATION

Visiting Scholar, Robotics Laboratory, Computer Science Department, Stanford University 1995-2002
Sponsored by Prof. Nils J. Nilsson

Key accomplishment

- *Invented the fuzzy logic extension to Nilsson's Teleo-Reactive paradigm.*

Ph.D. Computer Science, University of Louisiana – Lafayette

Dissertation title: *A Realization of Relational Semantics in an Automatic Programming System*

M.S. Computer Science, University of Missouri – Columbia

B.S. Mathematics, Purdue University

ACADEMIC EXPERIENCE

Loyola Marymount University, Los Angeles, CA — 2016 to May 2017

Visiting Associate Professor, Computer Science

Carnegie Mellon University Silicon Valley, Moffett Field, CA — 2004 to 2015

Entrepreneurial Teams Mentor — 2015
Mentoring teams for Entrepreneurial and Innovation courses

(dual titles)
Associate Professor of the Practice, Software Engineering — 2008 to 2014
Technical Track Master's Program.
Senior System Scientist --
Smart Environments Research

Key accomplishments

- *Mentored/guided 50+ Master's student teams in team-based courses* (click for video)
- *Co-initiated SmartSpaces smart environment research project*
  - SmartSpaces: Context-aware Agent-mediated Assisted Living; (click here)
- *Co-investigator remote table-top robotic telepresence*
- *Primary investigator ClearPath Robotic Guide Project for the Blind* (click here for video)

Consulting Professor of the Practice *2004 to Dec 2007*

Software Engineering Technical Track Masters Program.

Key accomplishments

- *Consulting Scientist for Smart Environments Research.*
- *Development team member of mobile robot platform for NASA robot software testing.*

Earlier teaching positions:

Santa Clara University, Santa Clara, CA .

Adjunct Lecturer, Department of Electrical Engineering and Computer Science.

West Valley and De Anza Colleges, Saratoga and Cupertino, CA

Computer Science Instructor (part-time).

University of Wisconsin-Oshkosh, Oshkosh, WI

Computer Science Instructor. Department of Computer Science (full-time)

PROFESSIONAL EXPERIENCE

SoftComputing Consulting October 2002 – present

Independent software consulting for applications of soft computing technologies and rule-based systems in specific service deployment.

Hewlett Packard Company, Palo Alto, CA

Senior Software Research Engineer, Software Agents for Mobility Dept., HP Laboratories

Part of a team performing research, architecture, design, and prototype implementation for a distributed system of Personal Assistants. Initial design and architecture major responsibility of the Personal Assistant agent program/concept.

Key accomplishments

- Member of design and development team created Personal Assistants-based distributed system.
- Spearheaded development framework for rule-based software agents.
- Awarded 2 patents:
  - Patent #7222113: METHOD AND SYSTEM FOR A SOFTWARE AGENT CONTROL ARCHITECTURE
  - Patent #7607136: METHOD AND APPARATUS FOR INTERFACING WITH A DISTRIBUTED COMPUTING SERVICE
- Authored 3 refereed papers accepted at international conferences *(Please see publications list below)*
- Authored 4 un-refereed HP Laboratories Technical Reports *(Please see publications list below)*

Senior Software Development Engineer, HP Corporate Division

As part of a cross-functional team, developed and enhanced an internal CAM system used throughout HP's worldwide manufacturing including the existing production robotic CAM system for HP's worldwide SMT manufacturing divisions.

Key accomplishments

- Authored 2 refereed papers accepted at conferences (Please see publications list below)

Software Research Engineer, HP Laboratories

Engaged in programming language design and implementation, robotics and factory automation, computer-integrated manufacturing (CIM) and other related technology programs. Prototyped and delivered CAM recipe systems, generative process-planning, expert system user interface design, batch manufacturing software control, process flow simulation, robotics programming, and automation systems software control.

Contributed to the design and implementation of early object-oriented programming language and system.

- Authored 5 un-refereed HP Laboratories Technical Reports (Please see publications list below)

Key accomplishments

- Contributed to batch manufacturing optimization software development for manufacturing sites.
- Designed a tri-level manufacturing recipe guideline adopted by many internal manufacturing sites.
- Major architect for robotic manufacturing prototype system for workcell contain 4+ robotics devices.

PROFESSIONAL SOCIETIES

- Association for the Advancement of Artificial Intelligence (AAAI) – Senior Member (2012)
- Association for Computing Machinery (ACM) – Senior Member (2008)
- Institute of Electrical and Electronics Engineers (IEEE) – Senior Member (2008)

Key accomplishments in IEEE:

- *Spearheaded creation of IEEE Robotics and Automation Society Joint Chapter for Santa Clara Valley, Oakland-East Bay, and San Francisco Sections (entire San Francisco Bay Area) 2007*
- *Chapter Chair, IEEE Robotics and Automation Society Joint Chapter for Santa Clara Valley, Oakland-East Bay, and San Francisco Sections, 2007-2010 and 2016.*
- *Program Chair, IEEE Robotics and Automation Society Joint Chapter for Santa Clara Valley, Oakland-East Bay, and San Francisco Sections, 2011-2015.*
- *Chapter Secretary, IEEE Computational Intelligence Society, Santa Clara Valley section, 2007-2010.*

PATENTS

- Patent #7222113: METHOD AND SYSTEM FOR A SOFTWARE AGENT CONTROL ARCHITECTURE -- issued May 22, 2007
- Patent #7607136: METHOD AND APPARATUS FOR INTERFACING WITH A DISTRIBUTED COMPUTING SERVICE -- issued October 20, 2009

Editorial Reviewer

- Journal of Instrumentation, Automation, and Systems (JoIAS) 2013-present
- Journal on Reliability of Intelligent Environments (JoRIE) 2012-present
- Journal of Software Engineering for Robotics (JoSER) 2014-present
- Journal of Software: Evolution and Process (JoSEP) 2014-present
- Journal of Aerospace Information Systems (JoAIS) 2015-present

PUBLICATIONS

Refereed

- Langley, P., Barley, M., Meadows, B., Choi, D., & Katz, E. P. (2016). Goals, utilities, and mental simulation in continuous planning. *Proceedings of the Fourth Annual Conference on Cognitive Systems*. Evanston, IL.
- Athreya, A., Chan-Maestas, H., Katz, E, Tague, P., Iannucci, R, *Energy-Governed Resilient Networked Systems*, Proceedings of the 11th IEEE Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, January 2014. ***Conference Award for Best Student Paper***.
- Bareiss, R, Sedano, T, and Katz, E, *Changes in Transferrable Knowledge Resulting from Study in a Graduate Software Engineering Curriculum*, Proceedings of the IEEE-CS 25th Conference on Software Engineering and Training (CSEET 2012), April 2012.
- Bareiss, R and Katz, E, *An Exploration of Knowledge and Skills Transfer from a Formal Software Engineering Curriculum to a Capstone Practicum Project*, Proceedings of the IEEE-CS 24th Conference on Software Engineering and Training (CSEET 2011), Honolulu, HI, May 2011.
- Acer, M. Chennhuru, A., Hu, X., Reed, E., Nefian, A., Katz, E., *Content-Based Planetary Data Mining*, Conference on Intelligent Data Understanding, 2010.
- Katz, Edward P., *Software Engineering Practicum Course Experience*, IEEE-CS 23rd Conference on Software Engineering and Training (CSEET 2010), Pittsburgh, PA, March 2010.
- Katz, Edward P., *A Multiple Rule Engine-Based Agent Control Architectur*e, IEEE 6th International Conference on Intelligent Engineering Systems (INES '02), Opatija, Croatia, May 2002.
- Katz, Edward P., *A Teleo-Reactive Paradigm Extension using Zadehan (Fuzzy) Logic,* CACS Centennial Symposium, Center for Advanced Computer Studies, University of Louisiana-Lafayette, Lafayette, Louisiana, November 1999. ***Invited paper*.**
- Katz, Edward P., *A Simplifying Diagrammatic Representation Of Crisp And Fuzzy Teleo-Reactive Semantic Circuitry For Application In Robotic Agent Task Contro*l, 1998 IEEE International Conference on Systems, Man, and Cybernetics (SMC '98), San Diego, California, October 1998. (extended version)
- Katz, Edward P., *Extending the Teleo-Reactive Paradigm for Robotic Agent Task Control Using Zadehan (Fuzzy) Logic,* 1997 IEEE International Symposium on Computational Intelligence in Robotics and Automation (CIRA '97), Monterey, California, July 1997. (extended version)
- Cline, Terry, Frayman, Felix, Fong, Wendy, and Katz, Ed, *The Board Construction Advisor: A Tool for Design for Manufacturability of Printed Circuit Board*s, Proceedings of the 1990 Design Technology Conference, San Jose, pp. 453-459, May 1990. ***Conference Award for Best Paper.***

Un-refereed and Technical Reports

- Sameshima, Harry S., Katz, Edward P., *Experiences with Cricket/Ultrasound Technology for 3-Dimensional Locationing within an Indoor Smart Environment*, Carnegie Mellon Silicon Valley, CyLab Mobility Research Center technical report MRC-TR-2009-02, Feb. 2009.
- Correa, Joshua, Katz, Ed, Collins, Patricia, Griss, Martin, *Room-Level Wi-Fi Location Tracking*, Carnegie Mellon Silicon Valley, CyLab Mobility Research Center technical report MRC-TR-2008-02, Nov. 2008.
- Darrow, Alex, Jin, Jing, Katz Ed, Bareiss, Ray, and Griss, Martin, *Design Guidelines for Technology-Mediated Social Interaction in a Presence Sensing Physical Space,*Carnegie Mellon University - Human Computer Interaction Institute and Carnegie Mellon Silicon Valley, CyLab Mobility Research Center technical report MRC-TR-2007-01, Sep. 2006, revised 2007.

- Katz, Edward P., *A Multiple Rule Engine-Based Agent Control Architecture*. (revised), Technical Report HPL-2001-283R1, HP Laboratories, Hewlett-Packard Company, Palo Alto, California, November 2001.
- Katz, Ed, *Software Agent Use of Fuzzy Logic in Representation of Individual and Group Preferences* , Technical Note, Software Technology Laboratory, HP Laboratories, Hewlett Packard Company, Palo Alto, California, January 2001.
- Katz, Ed, Yip, Cindy, *Supporting Fuji's F4G Controller in MAN-LINK*, Electronic Assembly and Manufacturing Conference, Hewlett Packard Company internal conference, San Diego, CA., March 1997.
- Katz, Ed, Palm, Rick, and Safai, Fereydoon, *Setup Generation For A Build List*, Electronic Assembly and Manufacturing Conference, Hewlett Packard Company, internal conference, Colorado Springs, Colorado, pp. 593-600, September 1995.
- Katz, Ed, *Fuzzification of the Merlin Knowledgebase,* Technical Note, Manufacturing Technology Laboratory, HP Laboratories, Hewlett Packard Company, Palo Alto, December, 1992.
- Katz, Ed and Gunawarden, Shanti, ***Smart Tote**: Distributed Intelligence Applied to Batch Material Handling*, Internal Technical Note, Manufacturing Technology Lab, HP Laboratories, Hewlett Packard Company, Palo Alto.
- Katz, Ed, *Dynamic Generation of SMT Robot Recipes Directly From CAD*, Technical Note, Manufacturing Research Laboratory, HP Laboratories, Hewlett Packard Company, Palo Alto.
- Katz, Ed, *An Object-oriented Robot Programming Library for Programming Multiple Heterogeneous Robotic Devices*, Technical Note, Manufacturing Research Lab, HP Laboratories, Hewlett Packard Company, Palo Alto.

Carnegie Mellon University Silicon Valley [March 2004 *to present*]

Dual title:

Associate Professor *of the Practice* in the Software Engineering

Software Engineering Technical Track Master's Program.
- Taught 50+ teams of Master's students Extreme Programming team development
- Guided 30+ Master's student teams in capstone Software Engineering Practicum team-based course:
  - Student teams directly engaged actual external clients with real client's problems
  - External clients engaging teams include (multiple teams reflects additional client requests):
    Google (click for video), Paypal (4 teams), Lockheed Martin (3 teams), Stanford University Library Information Systems (2 teams), Nokia (4 teams), Intel, NASA Johnson, NASA Ames (5 teams), City of Palo Alto (3 teams), various start ups (many teams)
- Published 3 refereed papers at IEEE Software Education Conferences
- Authored 2 refereed papers at international conferences
- *Co*-authored 2 refereed papers at international conferences
- Co-authored 3 un-refereed CMU Silicon Valley Technical Reports

Senior System Scientist for Smart Environments Research.

SmartSpaces smart environment research project initiator, co-architect, and co-technical director supervising graduate student teams developing robotic and smart environments software systems. Conceptual originator of current smart environments research project.

Stanford University [1995-2002]

Visiting Scholar in the Computer Science Department's Robotics Laboratory, sponsored by and collaborated with Prof. Nils J. Nilsson to work on Prof. Nilsson's Teleo-Reactive paradigm. This is a reactive middleware paradigm for robotic agent, goal-directed control. During this collaboration, invented the Fuzzy Teleo-Reactive extended paradigm which generalizes the original version.

- Katz, Edward P., *A Teleo-Reactive Paradigm Extension using Zadehan (Fuzzy) Logic,* CACS Centennial Symposium, Center for Advanced Computer Studies, University of Louisiana-Lafayette, Lafayette, Louisiana, November 1999. ***Invited paper*.**
- Katz, Edward P., *A Simplifying Diagrammatic Representation Of Crisp And Fuzzy Teleo-Reactive Semantic Circuitry For Application In Robotic Agent Task Contro*l, 1998 IEEE International Conference on Systems, Man, and Cybernetics (SMC '98), San Diego, California, October 1998. (extended version)
- Katz, Edward P., *Extending the Teleo-Reactive Paradigm for Robotic Agent Task Control Using Zadehan (Fuzzy) Logic,* 1997 IEEE International Symposium on Computational Intelligence in Robotics and Automation (CIRA '97), Monterey, California, July 1997. (extended version)

HP Laboratories, Hewlett Packard Company, Palo Alto, CA

Senior Research Engineer and Member of the Technical Staff. Making contributions in a wide range of real-world applications. These include the use of AI in problem solving, e.g. rule-based manufacturing generative process planning, intelligent robotics workcell software design and interfacing, factory product forecasting using a fuzzy logic expert system shell, data and information management for product manufacturing setup optimization, 3D robotic graphic simulation of manufacturing applications, object-oriented language design and implementation, generating and enhancing CAD/CAM software products for our internal customers, and contributions in distributed software agent control. *Awarded two US Patents (see above).*

University of Wisconsin-Oshkosh, Oshkosh, WI

Computer Science Instructor. Department of Computer Science (full-time). Developed and taught the first Introduction to Artificial Intelligence course in addition to other undergraduate computer science courses.

Record of Distinction *(part of the* **AAAI Senior Member** *application submission)*

(approximate chronological order)

Ph.D. Dissertation Title:

A Realization of Relational Semantics in an Automatic Programming System.

This proposes a methodology based upon a data-driven approach for relation constraint validation and deductive satisfaction of relational, graph-based models. Consider an elemental relation, b+c=a. Given values for all the variables, it can be determined if the constraint is valid. If one value is missing, or a new value arrives invalidating the constraint for the remaining previous values, the model describes how deduced values can be calculated to (re-)satisfy the relational constraint. The data-driven model used dynamically directed arcs in the model graph to realize these semantics over time striving to maintain consistency and propagate changes throughout the system. Complex systems whose components can be expressed relationally can be modeled over time while maintaining consistency as computational elements change values. This can provide a useful infrastructure whose underlying semantics could apply to higher-level, automatic programming systems.

Today, if this sounds a bit like Prolog-style logical programming, it is rather close. Prolog was being developed around the same time and in parallel to my dissertation research without my knowledge. Someone once said that if the Prolog people had known about my paradigm model, that it might have eased some of their original semantics problems.

Related publications

- Katz, Edward P. and Towster, Edwin, *A Relational Approach to a Nonprocedural Language,* Proceedings of the Southeast Regional ACM Conference, Biloxi, Mississippi.
- Edwards, William R. and Katz, Edward P., *An Abstract Model of Relational Algorithms,* Proceedings of the Tenth Southeastern Conference on Combinatorics, Graph Theory, and Computing, Florida Atlantic University, Boca Raton, Florida Vol 1., pp. 423-449.

HP Laboratories, Palo Alto (Robotics and Artificial Intelligence-related activities.)

- Object-oriented, multi-robot package

At the time, Hewlett Packard was engaged in the design and manufacturing not only of computing equipment but also of the manufacturing of various electronic and medical testing products. Some of the latter required specialized manufacturing techniques using various automation equipment. Our group's mission was to explore various robotic and automation methodologies for future in-house manufacturing.

One example of R&D development environment for future, in-house, electronic manufacturing consisted of a prototype robotic work cell with several different robot types (from different manufacturers) all capable of different movements. The goal was to explore and demonstrate enhancements for "*odd component*" electronic assembly. An SDK (the term "*SDK"* had yet to be invented) was developed allowing the application developer to control each robot regardless of robot type despite differences in structure and movement. At the time, it was radical to use software object-oriented principles to model and control a robot. Object-oriented encapsulation proved to be extremely useful by shielding the application developer from most of the details for the particular robot encapsulated inside. This approach later proved useful for plan generation involving multiple robotic devices and task coordination within the same work cell.

Later, a refined version of this OO approach was eventually deployed by a manufacturing applications group for production work cells in two of HP's internal manufacturing sites.

References

- Katz, Ed, *An Object-oriented Robot Programming Library for Programming Multiple Heterogeneous Robotic Devices*, Technical Note, Manufacturing Research Lab, HP Laboratories, Hewlett Packard Company, Palo Alto.

- Multi-level control paradigm for use in an automated, electronic manufacturing line.

A batch-oriented manufacturing line might be reconfigured several times a week (and possibly within a 24-hour day) for product switch over in low-volume product manufacturing. Products sometimes had unexpected minor design changes. In such a reconfigurable environment, changing the assembly machine set up and also including production changes can be challenging for automated work cells.

To address this problem, a multi-level control paradigm (the first two-levels were later used inside most of HP's electronic manufacturing) was developed for hierarchical control and dynamic replanning (reprogramming). The two levels used essentially comprised a strategic plan level and a tactical plan level. The strategic plans described how a product in the batch environment was intended to be built given the current assembly line resources (work cell availabilities). From this strategic plan and the available work cell resources, tactical plans (actual robot/assembly machine programs) were automatically generated. This dynamic tactical plan generation was necessary for two reasons:

First, potentially each assembly machine (or work cell) might be quite different (e.g. different manufacturer) yet capable of performing the same set of assembly functions. As an example, suppose the factory floor contains two assembly machines, one manufactured by Fuji and the other by Panasonic. Both are capable of assembling a particular class of parts. Because of the Fuji-Panasonic machine differences (and computer controller differences), a dynamic tactical plan might have to be generated depending on which machine was available at a particular time in the manufacturing process.

Second, a product's tactical plan for the particular machine could be pre-compiled if all necessary parts for the manufacturing step were always available. Unfortunately, this is not the case for a batch manufacturing environment with overlapping concurrent product assemblies (manufacturing small batches of two or more products concurrently in the same production area). The finite parts capacity of each assembly machine might contain a mixture of parts for none, one, or all of the products currently being assembled. Thus a product manufactured on one day might use a set of machines with a particular parts set up and the next day the same product manufacturing would find the same machines with different parts set up due to parts change over for assembling other products since the day before. The third day may find that a different set of machines might have to be used due to resource availability, and these might be different machine types (e.g. Fuji vs. Panasonic) with the same capabilities. The dynamic nature of batch manufacturing with ever changing machine part configurations required an on-the-fly tactical plan generation using a specific parts configuration for use-once-only execution (throw-away).

Thus, as the strategic plan was executed together with the available (and changing) manufacturing resources, the use-once-only tactical plans were dynamically generated on the fly and executed on an available assembly machine for the particular parts configuration already set up on that machine.

References

- Katz, Ed, *Dynamic Generation of SMT Robot Recipes Directly From CAD*, Technical Note, Manufacturing Research Laboratory, HP Laboratories, Hewlett Packard Company, Palo Alto.

- Prototype CAM system for rapid hardware prototyping.

When surface-mount technology for electronic assembly was being introduced, there were very few hardware and software tools for automated assembly. Especially for this technology, an early CAM program was developed to extract product design out of an existing CAD systems and to generate robot programs (component part placement plans) for a specialized, surface-mount robot. The robot motion constraints planning together with surface-mount parts availability were modeled to generate product assembly plans. Classic AI-planning techniques were employed.

- Rule-oriented manufacturing generative process planner.

This was similar to the earlier robotics strategic plan generation. Instead of product orientation, this was a case whereby the factory floor scheduling system drove the production line requirements. This generative process planner could generate a strategic plan in response to the dynamic needs of manufacturing (e.g. part unavailability, part depletion, assembly work cell availability, etc.).

This was not a production rule-based system that would be found in an expert system shell. Rather, it was rule-oriented representation of the configuration and production constraint rules that needed to be satisfied. AI searching strategies were used and the plan generation system was prototyped in LISP.

References

- Katz, Ed and Gunawarden, Shanti, ***Smart Tote****: Distributed Intelligence Applied to Batch Material Handling*, Internal Technical Note, Manufacturing Technology Lab, HP Laboratories, Hewlett Packard Company, Palo Alto.

- Constraint-propagation printed circuit board design advisor.

A printed circuit board designer (just the raw board without parts) for surface-mount technology electronic products has to make many decisions among the large number of materials and board characteristics choices. As the designer proceeds, each decision constrains and reduces the available selections for remaining decisions yet to be made.

As a member of the development team prototyping this design advisor, my contributions to various components of this system's constraint propagation capabilities allowed for a spreadsheet-like environment. The designer could incrementally try out various designs by incrementally selecting available choices (which constrained availability of remaining selections), observe the resulting characteristics, and with a controlled retraction system, incrementally backing up to explore other alternatives selections and their resulting configuration characteristics.

References

- Cline, Terry, Frayman, Felix, Fong, Wendy, and Katz, Ed, *The Board Construction Advisor: A Tool for Design for Manufacturability of Printed Circuit Board*s, Proceedings of the 1990 Design Technology Conference, San Jose, pp. 453-459, May 1990. [refereed] ***Conference Award for Best Paper.***

- UI prototyped for a rule-based inventory prediction system.

A product division inside Hewlett Packard was using a commercially available, rule-based (not LISP-based) system for predicting inventory levels that had a terrible interface and was difficult to integrate with HP parts databases. A colleague and I designed a specification for a UI and subsystem interfacing that rule-based, commercial system to the HP databases.

To demonstrate the viability of our specification, we prototyped a quick database interface and UI in LISP to demonstrate feasibility. LISP was chosen because of the desire to quickly demonstrate a running system in order to show specification viability and the ease with interfacing to the existing rule-based system.

- Fuzzy logic rule-based inventory prediction system.

The previous inventory-level prediction system in part consisted of a very large knowledgebase rule set. With that knowledgebase size, further development and maintenance scaling issues developed. Using Fuzzy Logic to address rule-base size and growth, my own Fuzzy Logic version of this prediction system was developed.

Because a Fuzzy Logic rule-based system can address a more general situation, the construction of a functionally equivalent FL rule-based inventory level prediction system performed slightly better with an **order of magnitude smaller rule base**. This combination of equivalent performance together with a significantly smaller Fuzzy Logic rule-base was important for addressing the inventory system's scaling issues.

References

- Katz, Ed, *A Demonstration of Applying Fuzzy Logic to Scaling Issues of the Merlin Knowledge Base,* Technical Note, Manufacturing Technology Laboratory, HP Laboratories, Hewlett Packard Company, Palo Alto, December, 1993.

- Agent-based research for group preferences

Immediately after joining HP Lab's Distributed Software Agents group, I was assigned to investigate group preference systems and was challenged to develop a restaurant recommender tool as a demonstration. To illustrate this, suppose a group of co-workers wants to go for lunch and needs a tool to help consider all the group's constraints and desires for the selections. The recommender's essential component was to model the group's preferences for the food type and eating place selection.

To produce the result, the recommender considered for a particular group each individual's food preferences, non-preferences, and allergies, together with information sets representing the group suggestions for distance to travel, ambiance, and eatery category (fast food, sit down, cafeteria, etc.). Each person needed to have previously established their food category preferences (both positive and negative) together with the food preference's degree strength. Inputs to the recommender were the participating people, a set of possible ideas for food types, a set for possible eatery categories, a set for ambiance, and finally a set of preference distances chosen from a predefined distance category list (e.g. {walk, short-drive, not-far} or {any-distance-within-20-minutes}).

Using Fuzzy Logic was useful in several ways for this application. The group's food preference was constructed via fuzzy conjunction of all the participant's preferences to produce a fuzzy group preference. Fuzzy conjunction could then be applied to this fuzzy preference and the fuzzy representations for distance, ambiance, and eatery category creating a filter. The resulting filter was then applied to a Zagat restaurant database producing a ranked list of possible eating places. This Fuzzy Logic approach provided a rather straight forward solution robust enough to handle dislikes and allergies dynamically based entirely on the particular group population as well as vague and imprecise descriptions for distance, eatery category, etc.

References

- Katz, Ed, *Software Agent Use of Fuzzy Logic to Representation of Individual and Group Preferences* , Technical Note, Software Technology Laboratory, HP Laboratories, Hewlett Packard Company, Palo Alto, California, January 2001.

- Personality-based, multiple-rule engine agent control paradigm

Not content with programming software agents in Java in our distributed agents research group, a programming paradigm for rule-based agents was developed. Each agent contained at least one embedded rule-engine and was programmed via rules. The paradigm allowed for capability "personalities" to be constructed from rule groups. For example, an agent playing blackjack would be configured with the blackjack-player personality rule set. Likewise, another agent would become the blackjack-dealer by configuring it with the blackjack-dealer personality. However, the dealer personality is a composite personality consisting of the base blackjack-player together with the added dealer rules. The latter personality thus has rules that supersede (replaces) the base personality in those cases when the dealer behavior is different from the regular player.

This can be augmented using multiple interacting/communicating rule engines within a single agent. In effect, an agent with multiple rule engines might be considered to be a holonic agent (a community of sub-agents) where the multiple rule engines worked and contributed to the same set of problems sharing knowledge bases.

In addition to a conference paper and technical report, this work was awarded a U.S. Patent.

References

- Katz, Edward P., *A Multiple Rule Engine-Based Agent Control Architectur*e, IEEE 6th International Conference on Intelligent Engineering Systems (INES '02), Opatija, Croatia, May 2002. [refereed]
- Katz, Edward P., *A Multiple Rule Engine-Based Agent Control Architectur*e. (revised), Technical Report HPL-2001-283R1, HP Laboratories, Hewlett-Packard Company, Palo Alto, California, November 2001.
- Patent #7222113: METHOD AND SYSTEM FOR A SOFTWARE AGENT CONTROL ARCHITECTURE -- issued May 22, 2007

- Dynamic interfacing for ontology-based distributed computing service

Using an ontology specification describing messages of the distributed computing service, a software agent or service can be dynamically configured at run-time, and autonomously acquires the behavior and interfaces (via a rule-based, expert system) needed to access other software agents/computing services. This US patent describes how this might be accomplished in general terms using a rule-based approach.

References

- Patent #7607136: METHOD AND APPARATUS FOR INTERFACING WITH A DISTRIBUTED COMPUTING SERVICE -- issued October 20, 2009

Visiting Scholar, Stanford University

- [1995-2002] Prof. Nils J. Nilsson, Robotics Laboratory, Computer Science Department

Prof. Nilsson at Stanford University had been developing his Teleo-Reactive paradigm which was a new formalism for computing and organizing actions for autonomous agents in dynamic environments. After reading several of the Teleo-Reactive technical reports, I contacted Prof. Nilsson suggesting to him that he might want to consider extending this T-R paradigm using fuzzy logic in order to produce a more general version. He immediately liked the idea and invited me to become a Visiting Scholar.

Using fuzzy logic principles to create a generalized T-R paradigm extension, both imprecision in agent task specification and imprecision in real-world sensor measurements were readily accommodated. The resulting extension provided more robust capabilities required for real-world robotic applications. Further, the new extension was proved to be a proper superset within which the original Teleo-Reactive paradigm was a special case.

References

- Katz, Edward P., *A Teleo-Reactive Paradigm Extension using Zadehan (Fuzzy) Logic,* CACS Centennial Symposium, Center for Advanced Computer Studies, University of Louisiana-Lafayette, Lafayette, Louisiana, November 1999. ***Invited paper*.**
- Katz, Edward P., *A Simplifying Diagrammatic Representation Of Crisp And Fuzzy Teleo-Reactive Semantic Circuitry For Application In Robotic Agent Task Contro*l, 1998 IEEE International Conference on Systems, Man, and Cybernetics (SMC '98), San Diego, California, October 1998. [referred] (extended version)
- Katz, Edward P., *Extending the Teleo-Reactive Paradigm for Robotic Agent Task Control Using Zadehan (Fuzzy) Logic,* 1997 IEEE International Symposium on Computational Intelligence in Robotics and Automation (CIRA '97), Monterey, California, July 1997. [referred] (extended version)

Carnegie Mellon University Silicon Valley

- [2004-2006] Robotics Research

Project lead, Mobile Robot Test Platform -- CMIL Lab

Accomplishments

- *Team developed CMIL Lab* mobile robot platform *for NASA mobile robot to be used as a test vehicle for mission-based software testing. This effort produced several mobile robotic platforms that NASA JPL, NASA Ames, and other NASA sites could use for real (Earth-based) testing saving considerable time and funding for realistic robotic software algorithm testing.*

- [2005-present] Software agents infrastructure for smart environments.

After arriving to teach at CMU SV, I conceived of a smart environment research topic (SmartSpaces) to augment people's working and living environments via a ubiquitous computing environment of distributed software agents. For example given a growing senior citizen population, consider an elderly individual living alone without the benefit of full-time living companionship. A smart home/apartment could monitor the daily routine and assist with food ordering, transportation scheduling, etc. as seniors often do not drive. In particular, the smart environment could detect unusual situations and contact a care giver (e.g. via SMS) when necessary. An unusual situation might be the person living alone and lying motionless on the kitchen floor. The smart house could also help schedule, direct, and control smart appliances (smart robot vacuum cleaners, etc.). This research employs a wide variety of sensing technologies together with advanced algorithms and AI technologies to support the environment that can behave and interact in an intelligent manner.

References

- Sameshima, Harry S., Katz, Edward P., *Experiences with Cricket/Ultrasound Technology for 3-Dimensional Locationing within an Indoor Smart Environment*, Carnegie Mellon Silicon Valley, CyLab Mobility Research Center technical report MRC-TR-2009-02, Feb. 2009.
- Correa, Joshua, Katz, Ed, Collins, Patricia, Griss, Martin, *Room-Level Wi-Fi Location Tracking*, Carnegie Mellon Silicon Valley, CyLab Mobility Research Center technical report MRC-TR-2008-02, Nov. 2008.
- Darrow, Alex, Jin, Jing, Katz Ed, Bareiss, Ray, and Griss, Martin, *Design Guidelines for Technology-Mediated Social Interaction in a Presence Sensing Physical Space,*Carnegie Mellon University - Human Computer Interaction Institute and Carnegie Mellon Silicon Valley, CyLab Mobility Research Center technical report MRC-TR-2007-01, Sep. 2006, revised 2007.
- E. Katz, M. Griss, SmartSpaces: Context-aware Agent-mediated Assisted Living

- [2010-present] Telepresence robotics

In response to a remote department faculty member, my team created a telepresence robotic project to assist the remote faculty member with a better meeting experience beyond just being a voice on the telephone. The initial version allowed the remote person to control a table-top robot with webcam and display (initially a laptop onboard the robot). The remote person's face appears on the display and can "look" at a particular person in the meeting by rotating the robot to "face" the speaker using the webcam and display. As the current speaker in the room changes, the remote person can rotate the robot to face the new speaker.

The essential research thrust here is to develop the remote user's UI to make the telepresence robot control's very intuitive to use especially for the non-robotics user and hopefully improving the remote user's meeting experience. The developing remote UI model is based on several principles. This includes avoid clicking and typing as much as possible and instead follow more intuitive mouse movements (e.g. the robot rotates left as the mouse moves left), the use of face recognition for local meeting participants, the construction of a person map (where each local person is located in the room), and the dynamic update of this person map as people arrive and depart the meeting over time. Future work might include automatically rotating the robot to face the current person speaking in the room using directional microphones.

- [2011-present] Clearpath Project: Guide robotics for the vision challenged

Overview: A suggestion from a sight-challenged colleague prompted my investigation into developing a robotic guidance device for indoor environments when a guide dog is not appropriate. Two of the major goals are for a low-cost and a robust research and development robotic platform. (This may be the forerunner of a possible future product.) My team is using an available low-cost robotic platform with an IR distance measuring sensor and Kinect-like sensors to guide a vision-challenged person within an indoor environment. The system will be capable of two-way communication via a Bluetooth audio headset worn by the user and on-board speech generation and recognition. The communication needs to be bi-directional as the robot will need to communicate special circumstances it encounters while guiding the user as well as receiving verbal commands. This problem is proving to be more challenging than originally considered with the need for bi-directional communication over and beyond the standard need for path planning and collision avoidance. The system is leveraging the Teleo-Reactive paradigm used at Stanford together with open source ROS packages from the Open Robotics Software Foundation (a spin-off from Willow Garage) such as locationing, mapping, SLAM, and distributed processing. Later, more high-level task planning and decision control will be added via a Clojure-based environment.

- [2014] Clearpath Project: Interim achievements

I found a small bit of funding to pay for a research graduate assistant, Mia Manalastas, for 6 months. She and I proceeded to develop an initial version of the proof-of-concept indoor guide appliance. We used an unmodified, off-the-shelf Neato XV-11 with a guide harness attached to lead the user from one room down the hall to another room.

During the 6 months we only met 1-2 times per week, and Mia was only paid for 10 hours/week. I roughly put in the same amount of time per week having a full teaching load. We chose a client-server architecture. The C++ client that she built drove the robot and interpreted high-level commands from the server (e.g. *go through the doorway, follow wall on right keeping a fixed distance,* etc.). The server would receive high-level feedback from the robot client and issue commands back to the client for the robot to execute. Embedded in the server was the controlling middleware in the form of a rule inferencing engine (JESS). This allowed an expert system-like software environment to make high-level, intelligent command and control decisions. The client and server communicated via bidirectional messages sent over the socket connection.

Mia created a poster of our work for the August 2014 Tech Fair and also created a video of the robot actually leading a user from one room down the hall to another room. Our approach proved to be quite successful as we could start the robot in almost any location and orientation. This straight forward approach allowed us to develop the prototype in 6 months working 10 hours per week without significant issues, and I believe the elegance of the rule-based approach contributed greatly to our achievement.

The next step is to replicate this achievement (including the rule-based command and control) replacing the client/server architecture which we used with ROS's publish/subscribe architecture.

References

- Interim project abstract [link]
- Clearpath youtube [link]