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Innovative Applications of AI (IAAI-06)

A Summary of Award-winning Deployed Applications &
Emerging Applications

Since 1989, each year the American Association for Artificial Intelligence has recognized true innovation in the application of AI to real world problems through the Innovative Applications awards. Each of these applications must be fully deployed and have demonstrated, measurable return on investment.

To date, some 362 applications have been recognized through the IAAI conference. Together, they show the breadth and depth with which AI has penetrated the fabric of modern life. They are running operations, and assisting engineers and managers under the ground, on the ground, in the ocean, in the air and in space. They can be found assisting insurance underwriters and financial traders, F-18 pilots and engineers, genomic and NASA scientists.

While these 362 applications, including this year's six winners, represent the myriad ways AI is in use today, together they are but the tip of the iceberg in terms of actual deployed applications. Many of the applications in use today are embedded in consumer electronics, in corporations' "secret sauce" where they are held close to the vest, or in classified government operations.

In addition to deployed applications, AAAI recognizes highly innovative new applications which are still under development but which hold great promise and are intriguing uses of various AI techniques. This year AAAI recognizes 15 emerging innovative applications.

2006 Innovative Applications of AI Award Winners

- **Constraint-based Random Stimuli Generation for Hardware Verification**
  IMB Haifa Research Lab (Israel)

  This award-winning application from IBM verifies hardware design prior to their casting in silicon. The application uses AI technology for the verification of its processors and systems, generating tests or stimuli, for simulating hardware designs. It ensures that the hardware implementation conforms to the specification before starting the expensive fabrication of silicon. IBM estimates that this system has saved IBM more than $100 million during the last decade in direct development costs and reduced time-to-market by using AI.

  An early version of this technology was an IAAI award winner in 1994. AI techniques were only rudimentarily implemented then. The ensuing decade-plus of experience has resulted in much more sophisticated AI (e.g., the ontology, a totally new and dramatically stronger constraint satisfaction solver), and great success in deployment. The current system has become the standard in processor verification within IBM. It has been used in the development of numerous IBM Power processors, i/p-series servers, Cell and Microsoft's Xbox ^{TM} core processors and systems, and various processors of Apple computers. The system has become a repository of extensive processor verification knowledge across multiple IBM labs and many processor architecture and implementations. It allows comprehensive reuse of knowledge, rapid reaction to changes, and gradual reduction in the need for human experts.

- **Case-Based Reasoning for General Electric Appliance Customer Support**
  General Electric Global Research

  This case-based reasoning system was created to support customers who purchased appliances from General Electric. When a customer calls GE for help, a call-taker uses the system to diagnose the problem, and step the customer through its solution. The system has been in use by 300 call-takers since 1999, resulting in a 20% increase in the probability that the customer's problem can be solved over the phone. This has greatly improved customer satisfaction and saved GE $44.5 million between 2000-2005 due to reduced cost of visits of field service technicians to customers' homes.

- **Expressive Commerce and Its Application to Sourcing**
  CombineNet, Inc.

  Sourcing professionals buy several trillion dollars worth of goods and services yearly. This award-winning paper introduces a new paradigm, called expressive commerce for sourcing. It combines highly expressive human negotiation with electronic reverse auction so that supply and demand are expressed in far greater detail than traditional electronic auctions, and are algorithmically cleared. The system has a fast tree search algorithm. CombineNet has hosted $16 billion of sourcing using the technology, and created $1.8 billion of hard-dollar savings in lowered procurement costs. The savings were measured compared to the prices that the buyer paid for the same items the previous time the buyer sourced them (usually 12 months earlier.) This does not normalize the savings by taking into account that during the same period, the prices in the largest segment, transportation, generally increased by 6-to-9%. Further, the savings does not

include those obtained by suppliers, nor those stemming from reduced effort and compression of event timelines from months to weeks or even days. There are also the more intangible benefits, such as better supplier relationships, and redesign of the supply chain.

- **Machine Translation for Manufacturing: A Case Study at Ford Motor Company**
  Global Manufacturing Engineering Systems, Ford Motor Company

  This award-winning system translates Ford's vehicle assembly build instructions from English to German, Spanish, Dutch and Portuguese to support assembly plants in Europe, Mexico and South America. Now deployed for 7 years, it makes vast amounts of dynamic information available within 24 hours of the process sheet being written and completed. To date, over 5 million Ford records have been translated from English into the target languages. While the translations are not as good as human translators, the system is highly accurate (the English/German is over 90% correct).

- **TPBOSCourier: A Transportation Procurement System (for the Procurement of Courier Services)**
  Hong Kong University of Science and Technology, South China University of Technology, Red Jasper Limited (Hong Kong), Philips Electronics (Hong Kong)

  This Transportation Procurement and Bid Optimization System (TPBOX) for Philips Electronics automates and optimizes procurement of courier services. Philips typically procures courier services for more than 2500 shipping lanes annually. Deployed in 2005, this intelligent software with its optimization engine has resulted in significant cost and time savings in analyzing and optimizing procurement decisions.

- **Predicting Electricity Distribution Feeder Failures Using Machine Learning Susceptibility Analysis**
  Columbia University, Consolidated Edison Company of New York

  This award winning application uses machine learning techniques as the foundation of ROAMS (Ranker for Open-Auto Maintenance Scheduling) to identify weak links in the almost one thousand 13.8kV-27kV energy distribution feeder cables that supply electricity to the boroughs of New York City. In Manhattan, rankings are updated every 20 minutes and displayed on distribution systems operators' screens. A separate system makes season predictions of failure susceptibility. The feeder failures, known as "Open Autos" are a significant maintenance problem. A year's development effort has resulted in a system that demonstrates high accuracy: 75% of the feeders that actually failed over the summer of 2005 were in the 25% of feeders the system ranked most at-risk. By the end of the summer, the 100 most susceptible feeders as ranked by the ML system were accounting for up to 40% of all feeder failures that occurred each day. The system also identifies the factors underlying failures, providing insights into the feeder system.

2006 Emerging Innovative Applications of AI

- **MedEthEx: A Prototype Medical Ethics Advisor**
University of Hartford, University of Connecticut, Amherst College

  As part of a larger Machine Ethics Project, researchers are developing an ethical advisor that provides guidance to health care workers faced with ethical dilemmas. This work explores machine ethics, which is concerned with the behavior of machines towards human users and other machines. This work may also function as a model for creating machines that can follow more general ethical principles in any domain.

- **Building Explainable Artificial Intelligence Systems**
The Institute for Creative Technologies, University of Southern California

  This system is a modular and generic architecture for explaining the behavior of simulated entities. As AI systems and behavior models in military simulations become increasingly complex, it has been difficult for users to understand the activities of computer-controlled entities. Such simulations are used for training and as predictive tools. This paper focuses on a case study using the domain independent, modular software to develop explanation facilities for Virtual Humans, a Department of Defense project designed to teach soft skills such as leadership, teamwork, negotiation, and cultural awareness.

- **Monitoring Food Safety by Detecting Patterns in Consumer Complaints**
The Robotics Institute, Carnegie Mellon University; Food Safety Inspection Service, U.S. Department of Agriculture

  Emerging Patterns in Food Complaints is a statistical data mining component of the Consumer Complaint Monitoring System, designed to help the food safety officials efficiently and effectively monitor incoming reports of adverse effects of food on consumers. The reports are collected in a passive surveillance mode from various sources such as consumer phone calls to federal, state, or local health departments, as well as the Food and Drug Administration. Each year in the U.S., there are 76 million recorded cases of food-borne illness, and about 5,000 of them are terminal. The attacks of September 11th, 2001 brought special attention to the vulnerability of the U.S. food supply system. This system is being envisioned as one of the key components of the nationwide bio-security protection infrastructure. It has been accepted for use and is currently going through the final stages of deployment to monitor meat, poultry and egg products. There are a number of plans to extend the system, e.g., incorporate new sources of consumer complaint data, engineer interoperability with other databases and surveillance systems run independently by other federal and state agencies, as well as with the National Bio-surveillance Integration System.

  This application is an instance of the generic Tip Monitor. It illustrates the applicability of this approach and suggests it could be useful in other domains, e.g., analyzing hospital records for signals of disease outbreaks, analyzing maintenance records for early evidence of systematic patterns of equipment failures, analyzing law enforcement reports, etc.

- **Hand Grip Pattern Recognition for Mobile User Interfaces**

Interaction Lab, Samsung Advanced Institute of Technology (Korea)

This experimental system is exploring a novel user interface for handheld mobile devices that recognizes hand grip patterns and launches the appropriate applications. The working prototype is provided with an array of capacitive touch sensors and a 3-axis accelerometer underneath the exterior cover. The goal is to provide users with an intuitive and natural user interface that adapts to the personalized hand grip patterns of the user. The prototype uses pattern recognition techniques for identifying the users' hand grips from the touch sensors.

- **Trip Router with Individualized Preferences (TRIP): Incorporating Personalization into Route Planning**
  University of Washington, Microsoft Research

  Current popular route planning systems (Windows Live Local, Yahoo! Maps, Google Maps, etc.) generate driving directions using a static library of roads and road attributes. They ignore both the time at which a route is to be traveled and the preferences of the driver. This working prototype, named TRIP, includes a set of methods for including driver preferences and time-variant traffic condition estimates in route planning. It uses a large database of GPS traces logged by drivers, and learns time-variant traffic speeds for every road in a widespread metropolitan area. TRIP also leverages a driver's past GPS logs when responding to future route queries to produce routes that are more suited to the driver's individual driving preferences. Using experiments with real driving data, the authors demonstrate that the routes produced by TRIP are measurably closer to those actually chosen by drivers than are the routes produced by routers that use static heuristics.

- **Local Negotiation in Cellular Networks: From Theory to Practice**
  Bar-Ilan University (Israel), Harvard University

  This experimental system includes a novel negotiation protocol for cellular networks which intelligently improves the performance of the network. The proposed reactive mechanism enables the dynamic adaptation of the base stations to continuous changes in service demands, thereby improving the overall network performance. It uses a distributed agent-oriented local negotiation mechanism for cellular network simulations which can affect the real-time adaptation of deployed cellular networks. It includes clusters and intro-cluster negotiation, as well as an investigation of the nature of the committed offers. Experimental results show the applicability of the proposed method in two distinct scenarios. The negotiation protocol initiated a change in the pilot power between two base stations; and it appears that better performance was achieved when the sum of differences between the pilot power before and after the change was positive. Future work may include extending the algorithm to multi-attribute negotiations, and heuristics can be employed to take more than one parameter into account.

- **AM-Extractor: An Application for Automating Medical Quality Measures Abstraction in a Hospital Setting**
  A-Life Medical, Inc, Partners HealthCare Systems Inc.

  This prototype product supports health care providers in meeting requirements to report evidence-based quality measures to various governmental and independent regulatory

agencies. This computerized system automates the process of abstracting appropriate facts from a patient's medical record to provide the data for these measures. It uses natural language processing and a rule-based approach. An evaluation of a deployed system used for hospital inpatient cases is discussed. The results show the NLP performed with high accuracy across multiple types of medical documents, and user productivity improved significantly. Challenges remain in the areas of availability of electronic patient data and a model for large-scale deployment and support.

- **Visual Explanation of Evidence in Additive Classifiers**
  University of Alberta (Canada)

  General-purpose framework for making various machine-learned classifiers used in data mining and knowledge discovery systems more transparent. It provides explanation of a classifier's reasoning. This can facilitate end-user acceptance and confidence in the system. So far, the developers have demonstrated using ExplainD on example applications that use several different classifiers (i.e., naive Bayes, linear support vector machines, and logistic regression classifiers.) The system generates a simply graphical explanation of the classification process to provide visualizations of the classifier decisions, and evidence for the decisions. It also offers the capability to speculate on the effect of changes to the data, and to drill down and audit the sources of the evidence. The paper describes using ExplainD for a deployed web-based system (Proteome Analyst, a working bioinformatics application that has been used by hundreds of biologists), and a Python-based implementation.

- **A Sequential Covering Evolutionary Algorithm for Expressive Music Performance**
  Music Technology Group, Barcelona, Spain

  This emerging application uses an evolutionary approach to model the knowledge applied by a musician when performing a piece in order to produce an expressive performance. The system extracts a set of acoustic features from standard Jazz recordings and provides a symbolic representation of the musician's expressive performance. It then applies a sequential covering evolutionary algorithm to the symbolic representation, generating an expressive performance computational model capable of endowing a computer-generated music performance with the timing and energy expressiveness that characterizes human generated music.

- **AWDRAT: A Cognitive Middleware System for Information Survivability**
  MIT CSAIL, Teknowledge

  Much of the infrastructure of modern society is controlled by Software systems that are vulnerable to attacks. This DARPA-funded project aims to protect systems and enable them to self-diagnose and recover after compromise. The emerging system is a middleware system, AWDRAT (Architectural-differencing, Wrappers, Diagnosis, Recover, Adaptive software, and Trust-modeling). It is designed to provide survivability to both new and legacy applications as an infrastructure to which an application may be tethered. It provides survivability properties such as error detection, fault diagnosis, backup and recovery. It uses cognitive techniques to provide the system with the self-awareness necessary to monitor and diagnose its own behavior. AWDRAT gains visibility into the execution of an application system and compares the application's

actual behavior to that which is expected. Discrepancies between intended and actual behavior are diagnosed using Model-based diagnosis techniques. Recovery is guided by decision theoretic methods. In the case of a deviation, AWDRAT conducts a diagnosis to figure out which computation resources are likely to have been compromised and then adds these assessments to its trust-model. The trust model in turn guides the recovery process. The system has been tested on an example application system, a graphical editor for constructing mission plans. It has been demonstrated effective in detecting, containing and recovering from compromises that might arise from a broad variety of attack types. It works from models of what the application should be doing rather than a library of specific attack types.

- **Multiagent Coalition Formation for Computer-supported Cooperative Learning**
University of Nebraska-Lincoln

  This emerging application implements a computer-supported cooperative learning system in education, I-MINDS. It consists of a set of teacher agents, group agents, and student agents. While the individual agents possess individual intelligent capabilities, what is novel is the multiagent intelligence and coalition (group) formation. I-MINDS supports student participation and collaboration, helping the instructor manage large, distance classrooms, forming student groups in a structured cooperative learning setting. I-MINDS has been deployed experimentally in an introductory computer science class in the spring and fall of 2005. It was compared against traditional, face-to-face collaboration. Results showed students using I-MINDS performed (and outperformed in some case) as well as students in traditional settings.

- **Ontology Base Semantic Modeling for Chinese Ancient Architectures**
Zhejiang University (China)

  This intelligent system models ancient Chinese complex architectures. It uses an ontology based approach to analyze the styles of different architectures. The system has been successfully applied in the digital heritage project for ancient architectures in southeast China. Most ancient Chinese buildings are wooden, so the original goal is to build geometric models of endangered architectures.

- **Heuristic Search and Information Visualization Methods for School Redistricting**
University of Maryland Baltimore County

  This application applies AI search and information visualization techniques to school redistricting. This is a multi-criteria optimization problem in which competing objectives must be considered, such as school capacity, busing costs, and socioeconomic distribution. Tools help end users generate, evaluate, and compare alternative school assignment plans that represent different tradeoffs in the decision space. It uses heuristic search methods. Preliminary testing has been done on the population data from the Howard County, Maryland school district. Plans are underway to work with the superintendent's office in an effort to release an alpha version of the system for use during the 2006-07 redistricting process.

- **Design and Implementation of the CALO Query Manager**
USC Information Sciences Institute; AI Center, SRI International, Knowledge Systems Group; AI Lab, Stanford University

This emerging work addresses the problem of integrating and querying information residing in heterogeneous knowledge sources with different query-answering capabilities. It employs a hybrid reasoning architecture, reusable ontology, and a query planner. This query manager is part of a larger multidisciplinary project, CALO (Cognitive Assistant that Learns and Organizes), funded by DARPA to create cognitive software systems that can reason, learn from experience, be told what to do, explain what they are doing, reflect on their experience, and respond robustly to surprises. The current project is targeted at developing personalized cognitive assistants in an office environment where knowledge about email, schedules, people, contact information, and so on is distributed among multiple knowledge sources. This emerging application has been tested and empirical results demonstrate its efficiency.

- **CPM: Context-Aware Power Management in WLANs**
  University of Arizona

This emerging application addresses some of the energy consumption and balancing issues inherent in mobile devices. It takes a unique approach to the problem since it tunes the power characteristics of the network interface based on high-level behavior – the user's interaction with running applications, instead of the more typical low-level monitoring of application behavior. The system uses simple machine learning techniques such as K-means coupled with correlation of clusters with observed device activity to distinguish different usage patterns. The developers suggest that this approach will improve accuracy and respond to new demands better due to the proactive nature of the resource allocation/configuration it enables.