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Worldwide Perspectives and Trends in Expert Systems

An Analysis Based on the Three World Congresses on Expert Systems

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Some people believe that the expert system field is dead, yet others believe it is alive and well. To gain a better insight into these possible views, the first three world congresses on expert systems (which typically attract representatives from some 45–50 countries) are used to determine the health of the global expert system field in terms of applied technologies, applications, and management. This article highlights some of these findings.

Over the past six years, there have been some interesting trends in expert system activity worldwide (Lee, Liebowitz, and Chae 1996; Liebowitz 1996, 1994a, 1994b, 1991; Liebowitz et al. 1996; Cantu-Ortiz 1991; Lee et al. 1991; Suen 1991; Zarri 1991). An excellent way to gain a global perspective on expert system technology, applications, and management is to examine the world congresses on expert systems (sponsored by the International Society for Intelligent Systems in Rockville, Maryland).

The World Congress on Expert Systems was established to bridge the gap between the academician and the practitioner and concentrate on expert system work being performed throughout the world. It provides an international representation of both scholarly and practical issues on expert system technologies and applications. The congress tries to connect expert system theory and practice and promote the sharing of worldwide ideas in the expert system field that would lead to the standardization of expert system methodologies, techniques, and tools. Also, an important part of the world congress is the awarding of the Feigenbaum Medal to an individual who has contributed worldwide to expert system research and technology transfer. The recipients have been Professor Edward Feigenbaum (who also serves as the congress's honorary chair), Peter Friedland (formerly with NASA Ames in charge of Al research and applications for the National Aeronautics and Space Administration), and Donald Michie of the University of Edinburgh and the Turing Institute.

The congress typically has three major components: (1) expert system technology, (2) expert system applications, and (3) management of expert system programs and projects. The congress attracts representatives from some 45 countries; about 60 percent of the attendees are from universities, 30 percent from industry, and 10 percent from government. The World Congress on Expert Systems is held every two years; the first congress was held in Orlando, Florida, in 1991; the second in Lisbon in 1994; and the third in Seoul in 1996. The Fourth World Congress on Expert Systems will be held in Mexico City on 16–20 March 1998 (Francisco Cantu-Ortiz, ITESM, conference chair). The past three congresses have included close to 800 papers from about 50 countries.

To gain an appreciation for worldwide expert system activities over the past six years, the World Congress on Expert Systems serves as an excellent sampling of applied (mostly) papers in expert system technology

and applications. This article highlights some of the major global expert system trends and activities based on an analysis of the first three world congresses on expert systems.

Worldwide Expert System Applications

The First World Congress on Expert Systems showcased some of the leading expert system work being used worldwide. The quality of the operational expert systems was outstanding. Applications ranged from blast-furnace control at Fukuyama Works in Japan to elevator design at Japan's Mitsubishi Electric Corporation to strategic management support in Germany. The variety of expert system work being conducted was evident at the congress. Applications ranged from the scheduling of crews in Portuguese railways to sheep-reproduction management in Australia to hurricane damage assessment in the Caribbean to the modeling of a black teenager on subjects of teenage pregnancy, drug, and alcohol abuse.

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The congress also had sessions on representative expert systems in various geographic regions throughout the world. In the Far East, expert systems were highlighted in the steel, electromechanical, power, automobile, oil, paper, airline, construction, and investment industries. In Europe, expert system work in Germany, Spain, France, and the United Kingdom was described. The following trends were noted: Expert systems are being used chiefly for the heavy industries in Germany, and a wave of interest in fuzzy logic is rapidly growing in Germany. The United Kingdom remains conservative in its development and deployment of expert systems, and foreign investment, particularly Japanese, is evident in the expert system companies in the United Kingdom. In France, a trend of mergers and acquisitions within the expert system field continues, and in Spain, a great need exists to provide the transfer of expert system technology from the university labs to industry. Other sessions on representative expert systems in Mexico, the Caribbean, Eastern Europe, Scandinavia, Canada, Australia, South America, and Africa were held. It was apparent that there is growing interest in expert system technology and applications in these regions.

At the second congress in Lisbon, a worldwide outlook on expert system activities and trends was gained. In the Pacific Rim, notably Japan, Korea, Hong Kong, and Singapore, expert system activity was steadily growing in 1994. Even though Japan was in the midst of a recession then, high-technology projects (including expert systems) were still being funded. The typical funding for a corporate expert system project at the time was $100,000 to $500,000. Korea, Hong Kong, and Singapore were rapidly growing countries for expert system development. In Korea, expert systems are being used in ship building, telecommunications, finance, and engineering. Singapore, through the National University of Singapore, is active in Al and expert system development, including projects in interactive multimedia and Al development, case-based reasoning, and intelligent information retrieval.

Europe and Scandinavia are actively pursuing expert systems, intelligent systems, hybrid systems, and knowledge technology. The ESPRIT Program is probably the major source of funds for expert system projects in Europe. Most of the European countries are engaged in expert system projects, but some countries, such as Portugal, are lagging behind somewhat. In Scandinavia, expert systems are being applied to the fishing, shipping, oil, and engineering industries. In The Netherlands, knowledge technology is gaining in popularity and use.

In the United States in 1994, expert systems were being deployed under such labels as hybrid intelligent systems, integrated systems, business-process reengineering, business-process automation, and knowledge technology. The expert system field was fairly healthy in the United States in 1994, even though funding for expert system research had declined over recent years. Many corporations are using expert systems as a strategic advantage. Others are using expert systems as a value-added feature. As we continue to move toward knowledge technology and management, expert systems will play a major role.

Developing countries such as Mexico, Thailand, and Egypt are also becoming involved with expert system development and deployment. Agriculture, manufacturing, medicine, and engineering are popular domains for expert systems in these developing nations.

At the third congress, chaired by Jae Kyu Lee of the Korea Advanced Institute of Science and Technology (KAIST), a number of expert and intelligent system techniques echoed. These techniques included data mining, hybrid systems, machine learning, intelligent database systems, intelligent agents, fuzzy expert systems, model-based reasoning, neural networks, genetic algorithms, multimedia expert systems, and case-based reasoning. Business, financial, medical, engineering,

manufacturing, environmental, agricultural, energy, retailing, transportation, and other expert system applications were covered during the congress.

In reviewing the expert system application areas of papers accepted for the first three world congresses on expert systems, the following can be observed:

First, the leading expert system applications worldwide are engineering-manufacturing (35 percent), business (29 percent), medicine (11 percent), environment-energy (9 percent), agriculture (5 percent), telecommunications (4 percent), government (4 percent), law (3 percent), and transportation (1 percent).

Second, from papers accepted for the third congress, the leading business global expert system applications are, in order, finance, production management, general management, accounting-auditing, marketing-sales, electronic commerce, international business, and human resource management.

Third, from papers accepted for all three congresses, the following trends appear: Business showed a sizable increase in expert system applications (29–40 percent). Engineering manufacturing showed a steady increase in expert system applications. Agriculture decreased (7–4 percent). Medicine increased (7–21 percent). Environment-energy showed a sizable increase (2–13 percent); telecommunications remained stable (about 4–5 percent). Transportation remained stable (about 3–4 percent). Law decreased (about 3 percent). Government decreased (about 5 percent).

Expert System Technology

The first congress was full of sessions that dealt with the integration of expert systems with conventional and new technologies. It appeared that the "hot" technologies associated with expert systems were case-based reasoning, object-oriented programming, interactive multimedia, and neural networks. There were also several sessions on the use of fuzzy logic throughout the world. Interest in fuzzy logic seems to be increasing worldwide, but the United States lagged behind in sponsored research in fuzzy logic.

Several researchers stressed that expert systems in the future should possess increased power and decreased complexity. Increased power will be in the form of large knowledge bases, integration with other systems, and the use of packages of methods. Decreased complexity will be in the building and maintenance of expert systems (knowledge-acquisition tools, machine learning) and in the use of the expert systems (customizable systems, *invisible systems*, designed for specific problems or person-role, place). Others stressed the gap between the Al theorist and the expert system practitioner.

At the second congress, much focus was placed on knowledge sharing and the need for furthering research and applications in this area. The idea that expert systems are merely islands needs to be greatly expanded into developing the bridges and covering the water between the islands. Other selected trends emerged from this second congress:

First, expert-intelligent systems are becoming more widespread and are being developed and used for a myriad of tasks at varying levels of maturity.

Second, hybrid systems, knowledge technology, fuzzy logic, business-process automation, and interactive multimedia are the popular buzzwords.

Third, real-time expert systems, expert scheduling systems, and expert diagnostic systems are gaining in popularity and use.

Fourth, the management of expert system technology and the legal implications of using or misusing expert systems are still not as strongly considered by developers and managers as they should be.

Fifth, embedded expert systems (that is, the raisin in the bread phenomenon) are gaining momentum in use.

Sixth, the developing countries are becoming more interested in expert system–AI technology, using shells to develop expert systems.

At the third congress, it was felt that knowledge acquisition still looms as a major stumbling block in expert system development. Some interesting ways of improving the knowledge-acquisition process were using genetic algorithms (GAs) to weed out the bad rules, with simulated breeding (GA-based) and inductive learning used to develop decision rules from questionnaire survey data, and developing a framework to assess the impact of culture on knowledge-acquisition methods.

Beside knowledge acquisition, another important area that was stressed during the third congress dealt with intelligent scheduling and constraint-based programming. One project, called the generically used expert scheduling system (GUESS) (Liebowitz et al. 1996), was discussed. It uses an object-oriented, constraint-based, AI toolkit approach for performing scheduling. Other intelligent scheduling papers described the use of genetic algorithms for job-shop and project man-

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agement scheduling applications. A constraint-based approach, using CHIP, has also been developed (as a prototype) for airplane gate assignment for Korean Air. Other uses for constraint logic programming involved resource-allocation problems (such as for personnel, vehicles, slots, and timetables).

Another emerging topic that was emphasized at the third congress dealt with intelligent agents and their use on the web and for electronic commerce. A workshop entitled "AI on the Web" was held as well. It might turn out that the "killer application" for expert systems and AI is intelligent search engines and browsers for the web. For electronic commerce, a need exists to apply AI technology for intelligent customer and vendor agents, interagent communications methods as they relate to AI in electronic commerce, and the like. KAIST has established a research center that focuses on intelligent systems in electronic commerce.

From the data surveyed from the first three world congresses, it appears that the applied expert system market is healthy but growing slowly.

In reviewing the accepted papers related to expert system technologies and the percentages of the expert system-technology totals, the following trends can be noted:

There was a sharp increase in development methodologies (3–14 percent).

There was a steady increase in chaos theory (0–4 percent), genetic algorithms (1–5 percent), intelligent and multiple agents (1–5 percent), model-based reasoning (1–4 percent), and hybrid expert systems (around 6 percent).

The following areas were stable: distributed expert systems (about 4 percent), fuzzy expert systems (about 16 percent), knowledge acquisition (about 6 percent), knowledge sharing (about 2 percent), machine learning (about 3 percent), neural networks (about 4 percent), AI with quantitative techniques (about 3 percent), verification and validation (about 6 percent), expert system tools (about 3 percent), case-based reasoning (about 4 percent), knowledge base management (about 2 percent), multimedia expert systems (about 4 percent), and expert system interfaces (about 3 percent).

There was a steady decrease in uncertainty management (7–4 percent) and miscellaneous.

Management of Expert Systems

Several sessions at the first congress addressed the management of expert system programs and projects. It was evident that the technology might not be the stumbling block in expert system applications: The management of the expert system technology is just as, if not more, important. The need for proper institutionalization of the expert system technology was emphasized. Several sessions addressed the need for standards or guidelines in expert system development, integration, and use.

At the third congress, knowledge management was a topic of widespread discussion. Knowledge management looks at continual, incremental improvement, whereas business reengineering is more of a one-time "shock treatment" for the organization. Presenters at the congress emphasized the need to use knowledge management techniques and the need for companies to consider knowledge asset management. Most chief executive officers realize the strategic importance of knowledge in their organization but don't have the metrics to determine what the knowledge asset's size is and how to value knowledge.

Finally, sessions on the explanation of expert systems at the third congress suggested that explanations might not be as important as some believe. Several studies indicated that commercial users might not need it (which was pointed out by a medical expert system application from the United Kingdom). However, there are mixed views because others feel that explanation is necessary for maintaining the expert system.

Summary

The enthusiastic, positive feedback from the international assemblage of congress attendees indicates that there is a great need for the World Congress on Expert Systems. Most registrants have felt that the congress serves as an ideal platform to bridge the gap between the academician and the practitioner in the worldwide expert system market.

From the data surveyed from the first three world congresses, it appears that the applied expert system market is healthy but growing slowly. Figures from the March 1996 *Intelligent Software Strategies* report (from Cutter Information) indicate the 1995 North American knowledge-based system tool and consulting market is about $258 million (which accounts for about 71 percent of the Al market) and has grown since 1994. In his catalog of expert system applications, Jack Durkin (University of Akron) estimated the number of expert systems to be about 12,500 (which includes an estimate of company proprietary expert systems).

Growing interest in expert system technol-

ogy and applications is stable to steady, but the research dollars to support and advance the state of the art in expert systems seem to be declining. To further advance this field, and the intelligent systems field in general, more work needs to be done to address the research issues at hand. Recently, the General Accounting Office and one of the House congressional subcommittees showed interest in further exploring the use of expert systems in our government and the U.S. society as a whole by holding a one-day conference entitled "Exploring the Use of Expert Systems in Government." Perhaps, with reaching these strategic decision makers, the expert system field will get the recognition it so richly deserves.

For information on the Fourth World Congress on Expert Systems (16–20 March 1998 in Mexico City), send e-mail to wces98@cia.mty.itesm.mx or go to www-cia.mty.itesm.mx/wces98.

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