# FUTURE EXPERT COMPUTER SYSTEMS FOR ACTUARIAL PROFESSIONALS

by

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## INTRODUCTION TO AI

In this paper the future state-of-the-art in computers and Artificial Intelligence (AI) are highlighted together with some implications for the actuarial profession.

There have been many breakthroughs in our understanding of how the brain works and in the design and implementation of Artificially Intelligent (AI) computer programs, especially in the areas of inference reasoning, leading to expert knowledge-based systems. As a result, we are poised at the beginning of a major technology transfer into future computer programs and computer architecture using artificially intelligent characteristics, algorithms, heuristics, and primitives that, heretofore, were only performable by human minds.

"Smart machines", which are already impacting office systems, usually have imbedded microcomputers, sensors and actuators, which give the machines adaptability to their environment and functionality well-in-advance of their "dumb" forerunners. But now, we are at the brink of the era of using artificially intelligent "expert" systems.

Currently, we are in the midst of the information age. In some parts of the world, and in the U.S.A., for example, over half of the population work in information related jobs. Information technology is flourishing - and, as would be expected, new tools and appliances for assisting us in this new age are appearing. When we were in the agricultural age, multiple gangplows, reapers, combines, manure spreaders and irrigation machines (etc.) amplified farm workers and their output. In the industrial age (although a recent age, to some parts of the world it belongs to the past), machines for raising the productivity of people were introduced, like lathes, welding machines, riveters, punch presses, milling machines, etc. , that altered the infrastructure of society by molding the industrial age from the agricultural age. Now in this new information age, new tools and new appliances are coming into use for amplifying what society does with information, usually in offices, and for opening the door to greater information access. These new tools are for raising both the productivity of people in offices and the use (and access) of information everywhere - including the home, education and defense.

Information-age tools and appliances include computers - a tool which emerged from the industrial age - that speeded its demise and at the same time helped create the new age of information dimensions. Computers, word processors, calculators, and the like, as they are forecasted to evolve into future information technology, portend to provide future business, professionals, educators, governments, offices, farmers, industry, managers, politicians and institutions with information access techniques and methods to help measure, acquire, store, process, manipulate, associate, retrieve, disseminate, communicate, and apply information - and to assist in turning information into real-time applicable knowledge.

This information age will be impacted by this relatively new Artificial Intelligence (AI) technology which is rapidly advancing beyond the research stage into practical use. Thus, actuaries, scientists and management, as well as most other areas of business and society, will soon rapidly begin to reap the benefits of almost 30 years of AI research. In recent years, AI has been moving toward the development of expert systems.

What is an expert system? Today, it is a computer system consisting of a set of AI programs that use a stored knowledge base and inference procedures to solve problems. Artificial Intelligence research is a subfield of computer science that investigates the imitation of human processes (within computer systems). These AI processes are called heuristics. Heuristics include learning, symbolic reasoning, logic, inductive discovery and reasoning, deductive analysis, problem solving, and other intelligence processes including machine representation of knowledge for use in inference tasks. AI assumes that such heuristic knowledge is of equal or greater importance than factual knowledge - in fact, for AI purposes, heuristics is assumed to be the process defined as "expertise" - i.e., what "experts" do.

Heuristics goes beyond the use of just logical procedural-oriented strings of instructions operating on streams of data, or on data bases - like programs that occur in standard computer systems. Simply, AI heuristics imitates the human brain, especially including heuristic processes for discovering how to solve a problem, or to diagnose.

AI expert systems are also known as knowledge information processing systems. Their growth is spawning "knowledge engineering" as a new profession for computer scientists and programmers.

Conventional information processing computer systems execute a string of instructions (the program) as they stream from memory, processing and transforming data in its memory.

In knowledge processing computer systems, overlayered upon the conventional information processing system, tree strings of knowledge inference procedures working on data, heuristic rules and question/answers are executed from and on information in memory. Expert systems thread through their knowledge bases via "IF-THEN-AND" heuristic rules - that is, the contents of knowledge bases in expert systems is the recodification of knowledge into IF-THEN-AND logic. Generation of knowledge bases using IF-THEN-AND rules is akin to programming but without procedure-oriented statements and instructions.

AI heuristics include logical inference procedures which allow semantic access of knowledge bases which use AI processes for making "expert" judgements. AI expert systems capture and store the known expertise of a field, and translate such knowledge, via AI programs and hardware that offer intelligent assistance, to a practitioner in that field - (i.e., for amplifying a person, with its stored knowledge, and AI heuristics for interpreting such expert knowledge). That is, expert systems assist humans (actuaries) in becoming more expert.

Thus, an expert system uses AI inference coupled with a knowledge base for assisting in solving problems, making decisions and judgments or for creating, discovering, or inventing opportunities. Expert systems allow the tackling of problems that are difficult enough to require solutions which go beyond simple arithmetic or logic, and that require heuristics of significant power for approaching what heretofore required human "experts" for their solution. The knowledge and AI heuristic processes necessary to perform at such an expert level, plus the AI inference algorithms used, can be viewed in the AI expert system as a model of the collective expertise of the best human expert practitioners in that field. Knowledge, once captured in such a fashion in an AI expert system, would also allow a non-expert to apply such expert knowledge and the heuristics to nearly match and often exceed the average unaided human expert in that field. Further, AI expert systems and their knowledge bases can be constantly updated as society gains new knowledge - e.g., the "education" of expert systems continues via the updating of their knowledge base.

What is a knowledge base? The process of building a knowledge base for use with an AI expert system requires the compilation of an extremely "factual" taxonomy of the (each) specialized field - and the heuristics for its application. Such knowledge-based taxonomies turn out to be far more understandable and accurate, and therefore, more useful, than today's manuals and textbooks. "Knowledge engineering", requiring knowledge engineers, since AI systems recently became practical, is a rapidly growing new profession. Part of the task is the creation of "knowledge bases" for use in "expert systems", codifying a knowledge base is a task, as stated earlier, closely related to programming. Today, there are few knowledge engineers and perhaps not many that are employed full time. In the future, most computer professionals could become, in one form or another, knowledge professionals. Today, expert systems are computer programs employing artificial intelligence operations using knowledge bases for advising people (in an expert fashion) in the "real-time" of the process of doing something - like assisting and amplifying actuary professionals.

## FUTURE AI/EXPERT ACTUARY MACHINE ALTERNATIVES

In forecasting the future of AI expert systems, there are a number of obvious and expanding application areas. Perhaps at the top of the list for the course of future events for the 1980s are AI advice-giving systems. Already expert system programs exist, or are on the CAD screens, for medical diagnosis, architectural design, design of very large-scale integrated silicon circuits, molecular generic design, programming, office management decisioning, factory management, home advice (e.g., financial, garden, lawn, repairs) and much more, including many applications in accounting, actuarial and auditing. Being designed are expert management systems, expert programmer systems, expert accounting/auditing machines, and the like. For example, envision how your profession would be enhanced and changed with an expert actuarial acquisition management system or machine.

Besides consulting, AI expert systems also can assist in the creative, management, design and other invention arts, as well as to give diagnostic and prescriptive advice, and to dialogue, giving recommendations for the real-time tasks at hand. Such dialogues involve the AI expert system threading itself through its knowledge base via "IF-THEN-AND" heuristic rules together with the human that it is advising. Some additional near-term uses and markets involve: configuration management, robotics, assessment and planning, forecasting, intelligent agent functions, office automation, image, signal and voice interpretation, and education and training. Thus, each of these areas, in the future, will undergo drastic changes as AI is implemented in these areas - not only in how they will be enhanced, but also in what will be acquired and how they will be acquisition managed.

Future expert systems, in the form of "people amplifiers" (future remote screen and keyboard computers or terminals or hand-held computers), present factual data or information and advice or give opinions, based upon the "AI knowledge" contained in their knowledge bases.

Further, and importantly, an expert system can backtrack to tell the logical process that it went through to arrive at its "expert" advice or opinion.

The knowledge base of an expert system consists of "facts" and heuristics. The "facts" constitute a body, or taxonomy of knowledge (information), that is similar to the information that a human expert would use for whatever expert task such an expert would be performing - codified in "IF-THEN-AND" rules. But herein lies the stumbling block - what does an expert (human) do? Thus, it is no easy task to create a knowledge base which contains expert information and knowledge which is generally agreed upon by experts in a field. Further, not all expert knowledge is a set of "black and white" logic facts - much expert knowledge is codifiable only as alternatives, possibles, guesses and opinions (i.e., as fuzzy heuristics). Heuristics, thus, consist of rules of good judgment, fuzzy knowledge, rules of plausible reasoning, as well as hard and fast logical reasoning, rules of good guessing, and the like, that are characteristic of expert-level decision making. Therefore, the performance level of an AI expert system is primarily a function of the size and capacity of the knowledge base, the quality of its contained expert information, the completeness of its taxonomy, and the number and characteristics of its stored or programmed artificial intelligent heuristics (inference rules and procedures). Today, we are just at the ground floor of creating a variety of knowledge bases. The future will see this variety grow and the knowledge base contents evolve with considerable recodified knowledge.

Thus, there should be little doubt for the future, that as AI expert systems evolve to become "experts", humans will possess very powerful people-amplifying tools to assist the actuary profession in almost any task they tackle - including, to reiterate, actuarial acquisition management. In fact, because a knowledge base arranges knowledge in a somewhat procedural fashion, like a computer program, it must be more complete, correct and comprehensible than the typical text book or manual. Therefore, experience with current expert systems shows that, when compared with traditional sources of knowledge (books, tapes, classrooms, etc.), present and future knowledge-based systems are (or can become) 10 to 1,000 times more complete, precise, correct and comprehensible.

But perhaps more importantly, as was stated earlier, AI expert systems allow knowledge application in the real-time of human decision making and actions - to amplify the management process. The expanded use of expert systems can thus be forecasted to impact distributed computer system development in the following directions: 1) more conviviality - more ease-of-use, friendly and helpful interface functions, 2) more portability for real-time use by managers and professionals, and 3) more inference and knowledge processing engine architectures.

**Is there an AI expert system in your future? We can now forecast a positive "yes", even for actuaries.**

Two expert systems have recently reached the "champion" level - they are DENDRAL and MACSYMA. DENDRAL is a knowledge-based expert AI system for solving a class of symbolic chemistry problems. It is the culmination of 16 years of AI research and experimentation at Stanford University. It has reached the level wherein there exists no other better means (human or machine) for doing symbolic chemistry. MACSYMA is a knowledge-based expert AI system for solving symbolic general math equations and systems of equations. MACSYMA solves symbolic algebraic equations and performs differential and integral calculus. It also has reached the champion level at which no other better means (tool) exists (human or machine) for performing general mathematics and statistics.

In development are numerous AI knowledge-based expert systems that soon could reach "champion" level status. Included in this growing list are AI knowledge-based expert systems for such applications as: Air Traffic Control, Computer Configuration, VLSI Design, Crisis Management, Computer-Aided Design, and Computer Maintenance.

Because of these recent AI breakthroughs, funding for AI should be expected to be significantly expanded.

However, the biggest recently announced development in AI comes from the Japanese. In October, 1981, the Japanese announced their 5th Generation Computer for the 1990s. It is to be a knowledge information processing system. Briefly, this Japanese AI Computer System, that they have recently committed to development, includes: a Knowledge Base Management System, an Intelligent Interface System, a Problem-Solving and Inference System, a large Knowledge Base, a Relational Algebra Machine, an Intelligent Programming System, an Intelligent VLSI CAD Development System, and a collection of Innovative non-von Neuman mechanisms/processors.

Further, the expected speed ranges up to 1,000 Mega LIPS (Lips stands for Logic Inference Processing steps and 1 LIP equals approximately 1,000 information processing steps). That is, its upper computational speed range is close to executing the equivalent of a trillion instructions per second! However, future defense systems will need many different types of AI machines, most with lesser capability.

The Japanese goal is to elevate knowledge and information to the level of a basic human need (like food), and, in so doing, realize that they must create a new industry. Their current plan is to leap far ahead of the rest of the world and to lead the world in AI machines. They have initiated this effort. Thus again, the Japanese have set an advanced technology target for us to shoot at and perhaps to go beyond.

The future of AI includes: widening application, rapid growth in usage, growth in AI application programs for assisting most scientific, engineering and management disciplines including the development of new inference engine-type computers and their acquisition, development, growth, evolution, and acquisition of knowledge bases.

In the new information age, what seems to be emerging is an exponential growth in new knowledge and information - that requires new tools like AI systems to assist humans in their application. For the AI system to be a useful assistant, efforts are required to reduce this vast growth of detained information into something digestible, and to add intelligence. Thus the trend is to squeeze partitionable discipline areas into specific frames or models. Such reductionalisms are marked by their integrative nature through the universal language of modeling, which is fast taking over the role heretofore played by mathematics. The computer enters the picture as the tool allowing such real-world models to be simulated. Through computer simulation, scientific experimentation occurs and becomes possible without attendant cumbersome laboratory equipment and procedures. Now by coupling AI knowledge base expertise to assist in the discovery and decisioning processes, future actuarial use of knowledge should be greatly enhanced.

That is, through modeling and simulation with AI, it is now possible for scientists to "play" serious experimental and mathematical "games" with the object of their research or in tactical situations via the use of inference engines. This is accomplished without first needing to learn sophisticated heuristics, management sciences, laboratory techniques or mathematics. In other words, the detailed discipline-oriented experimental skills and procedures are imbedded within the computerized AI model. Such "robot-simulators" allow decision makers and scientists to concentrate with the system (knowledge) being investigated, rather than being buried within the mathematics and discipline "crafts" to perform the desired experiment or to test a decision. Today, however, we must first learn our field, plus the computer simulation/modeling language - however, with AI expert systems, one need only know (and concentrate on) one's field of expertise. That is, expert AI systems are convivial. Thus, robot AI simulator assistants increasingly will do for the scientist and decision maker what the calculator does for the average person in applying arithmetic. That is, calculators remove the need to perform bulky, precise and rote skill math functions, allowing the researcher to get more quickly and easily to the core matters at hand - i.e., the search and acquisition of new knowledge or for making strategic or tactical decisions.

With future AI robot-simulators amplifying what we do, we could ask questions of computer modeling and have simulated AI experiments performed that otherwise would be nearly impossible or too time-consuming and costly.

Next, envision future robot-simulators, in the form of advanced hand-held calculators, with voice dialoguing and with AI capabilities. Further, envision them in the form of a simulator for general decision making rather than for calculating. The utility of such future smart robot-simulators for actuaries, managers, generals, admirals, programmers, doctors, politicians, voters, and so forth, becomes obvious when we think of them as people-amplifiers or as "electronic assistants".

Thus, computerized AI expert systems, in the not so distant future, could become everyday necessary adjuncts to be worn or carried as part of our dress. They could assist us in many ways to amplify our minds, as well as our bodies, including our interactions and communication with others and with our systems.

## CONCLUSION

For centuries, advances in many different science and technological areas have altered many times over the context of life and the structure of society. Now we are at the threshold of placing society's accumulated knowledge into Artificial Intelligence-type expert systems for amplifying what we do with knowledge. Human capabilities are extremely limited when unaided via technics. In the past, mechanistic technological advances amplified human abilities for pounding, locomotion, lifting, toting, cutting, seeing, digging, hearing, resisting diseases, coping with weather, arithmetic operations, and much more.

We are now at a new technological threshold, entering a new era for amplifying human powers for perceptual reasoning, decision making, inventing, creating, thinking and other mental activities - and what an actuary does. This new era results from our recent acquisition of knowledge for constructing artificially-intelligent expert machines for amplifying our mind's activities. Such amplification for raising the productivity of the mind is achieved by imitating artificially the brain's reasoning and other mental powers with computer technology in the form of expert systems.

The result of recent advances in AI expert systems is about to put the actuary profession at the brink of massive application of Artificial Intelligence. As a result, a new era is opening that should totally change the character of what an actuary does.

Even though AI has been a subject of study and research within computer science for decades, few are versed in what it is and its new developments. Now, with its recent breakthrough into practicality, the actuary profession is ill-prepared for reaping early on its full potential and the opportunities it affords. Nor are we prepared for the changes that it must force in education, the office and in society, as it goes into massive use.

From the foregoing, there should be little doubt that this AI breakthrough should explosively grow in usage by actuaries, and relatively soon.