FUTURE COMPUTERS: NEW PERSPECTIVES FOR NUTRIENT DATA BANKS

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ABSTRACT

With the advent of widespread usage of microcomputers and continued rapid advances in computer technology, the future for nutrient data banks is at a turning point pointing towards new directions. This article will characterize this turning point and discuss the implied possible futures opening new perspectives for nutrient data banks.

For example, a breakthrough has occurred in the study of Artificial intelligence which has led to expert systems. As a result, it now becomes possible to design an "Expert Machine"--as an amplifier for giving access to the known and electronically stored knowledge of a field (in the future) to apply in the real-time of one's decisioning, management and control processes. Besides discussing this developing future, a number of other future computer directions and trends will be discussed.

A topical outline of some of the computer futures shaping new perspectives for nutrient banks includes;

- The information age for the 1980's and 90's--a changing environment for society
- Some alternative future information systems--new characteristics, functions and directions
- Artificial intelligence and expert information systems
- Expert systems for amplifying nutrient professionals and users of nutrient data banks
- Imbedded intelligence for automated machines
- Implied nutrient data bank profession turning points, expectations, impacts and consequences for the future in the 1980's, 90's and beyond.

INTRODUCTION

This paper is about the information age and the many trend paths we are on taking us through the decade of the 1980's and toward first quarter 21st Century futures. It discusses both short-term and long-term futures of interest to users of computers--especially for future nutrient data bank users.

In the last decade many breakthroughs were made in our understanding of how the brain works and in the design implementation of artificially-intelligent (AI) systems--especially in the areas of inference leading to expert knowledge-based systems. As a result, we are poised at the brink of a major technology transfer into computer systems of machine intelligence with AI characteristics, algorithms, heuristics and primitives. This paper characterizes possible future computer systems, now in R&D, which implement a number of these AI functions and extrapolates them for the future now being grown for the 21st Century. Included are discussions of computer architectures for the future such as smart machines, future expert systems, knowledge-based architectures and functions, current awareness functions, bio-computers, component systems for decision support, learning, inference discovery, deductive reasoning and problem-solving--and intelligent data bases/banks.

Outlined will be a number of future history maps delineating precursor past trends and alternative possible data processing system futures. Since the sum total of these new directions for the computer field represents a significant breakthrough in what future computer systems will be like and used for in society for assisting humans, this paper also extrapolates these trends and suggests some future impacts to expect.

INFORMATION AGE FUTURES

Massive forces are building for drastically altering which set of alternative futures will become most likely for the remainder of this century--and beyond. Rapid and accelerating advances are occurring in science and technology--especially in computers, communications, artificial intelligence, genetics, agriculture, microbiology, space and chemistry--for altering our future way of life. Economic, political and social forces are also building to cause step function changes.

The emergence of a new information age societal framework, based upon the expanded use of and need for information, supplied by electronic computers and communications, is altering the way in which social, business, economic, educational and political exchanges are conducted. Information age technology is rapidly thundering-in on most jobs and into many homes. Further, since information age technology affects, impacts and alters the way knowledge is created, stored, retrieved and applied, the character and type of jobs we work at, the networks in the way people are linked, the infrastructure of society is changed. These will in turn impact and change the tools we use in the information age, how we use them and for what purposes they will be employed. This is a revolution for society--and in the architecture, organization, processing and dissemination of information/knowledge--for which future computers will perform a central role (but in decentralized embodiments), and will speed the societal transformation underway.

To get a handle on what futures are being grown and what they will be about, one first needs to understand the information age environment being spawned. It has many characteristics and dimensions including an:

Information Ecology, Environment & Sociology
Information Economy and Capitalism
Information Technology, Tools & Systems
Information Resources
Information Conferencing and Dialoguing
Information Politics

Information Ecology includes a new age sociology of many dimensions--a few of which are: information interactions, real-time knowledge access and amplification, information/knowledge engineering, information management, and politics, new job creation and old job displacements, and new individual freedoms and protection options and impacts. In an information age, an information economy transforms capitalism in many forms. Information becomes a basic need and the major social capital as well as societal power source. In an information economy, information further substitutes knowledge for capital, energy, jobs, materials and travel. It de-industrializes jobs by substituting information flows to automations and robotic tools for performing work. An information age thus radically alters societal roles, values, jobs and needs by redesigning the infrastructure of the economy and society.

Information technology marries computers and communications into many other things, and in the process makes "things" smart and intelligent, as well as into our daily lives. Part of this information technology tool kit consists of: people amplifier appliances (computers, calculators, expert systems, etc.), micro-technology/computers/communicators, information appliances (e.g., word processors, "paperless book" systems, computer mail systems, etc.), information systems, information networks, information utilities, information software (DBM/MIS/DSS/OA/CAD/CAM/MRP/KIP/...), data bases and information services. Information technology is part of the information resource environment which additionally includes a rapidly expanding information industry, laws, controls, standards, knowledge bases, media, telecommunication and data communication systems, and computer-aided-systems (e.g., CAD, CAI, CAM, etc.).

In this new information age, people increasingly "discourse" and "dialogue" directly with information via computer terminals, tele- and computer-conferencing and the like, instead of just with people. Information conferencing allows us to conquer distance via electronic computer/communication networks with information appliances backed-up with information services, data bases, knowledge bases and information retrieval and information management software systems. Thus, in such an information environment, policy making, management decision making, people-to-people, people-to-machine, and machine-to-machine interactions, and machine operation increasingly are performed remotely via computer networks using screens, voice channels, keyboards and data bases--instead of face-to-face in conference rooms, back-rooms, offices or in factories.

Information politics included individual privacy and freedom considerations relative to "data-basing people", jobs and employment, societal structuring changes, transborder data flows, information taxing, and the like.

In the process, the information economy now growing increasingly moves a major portion of the GNP from being supplied by the sale of products to sales of information services, i.e., sales of information, information data bases (e.g., nutrient data bases), information systems, information networking, and information assistance.

Taken in total, such a future information environment, now birthing, points to a long list of new computer applications--many of which have their precursors in the primitive (current) data base management system, management information systems, decision support systems and computer-aided-design/instruction systems now in place.

Thus, for the computer word, the movement into this neo-modern information age, which we are leaping into, evolutionary advance is the name of the game rather than revolution--even though for society it is a revolution relative to the magnitude of change occurring and the impacts expected and forecastable.

For example, the current computer revolution differs from the early 1950's, when computers and automation were introduced, in several critical aspect domains. First, the computer application arena is changing from

1) large centralized and costly computer hardware, memory and software to distributed, personal and low-cost systems,
2) use of computers by a few large firms, the military and Federal Government to use by individuals at work and at home, as well as being embedded in a wide variety of machines,
3) displacing "low-level" jobs to displacing "high-level" jobs,
4) creating more jobs than displaced toward the real possibility of displacing jobs faster than society can create new ones,
5) automating industrial age systems to automating post-industrial information age systems and jobs, and
6) computer systems that required considerable education and software development in order to apply them to easy to use systems with a vast array of ready to use package software and data bases.

But the major change occurring is that total computer system and usage costs (hardware, software, terminals, memory, communications, etc.) are at the turning point wherein they are diving ever lower in cost at a faster clip than the inflation rate--and at the same time their functionality and applicability are increasing and widening. Thus, computers, software and data bases have passed the threshold of affordability and are entering an era for being involved in our daily lives, almost world-wide, with billions of people already entering such a computer age.

COMPUTER FUTURES

Both technological knowledge and knowledge about the direction we're traveling into the future, and therefore knowledge about most probable futures, often can have a catalytic impact. That is, a small increase in one's knowledge about either can have an amplifying payoff. Therefore, it's cogent to ask what new computer system developments should we expect for the remainder of this decade and on into the 1990's. Are there new breakthroughs or turning points forecastable? Or, will the decade see only continued but rapid evolutionary developments? What are the dynamics of change to anticipate? In answering these questions, this article maps some of the new territory of future computers for amplifying society in the information age--and for amplifying knowledge workers. Its further purpose is for outlining some likely trends and alternatives for computers: the new powerful information age technological driving force of change, that everyone must become literate of in order to capitalize on its opportunities.

In general, each new future generation of computers will continue to have more memory, be of higher speed, have more functions, be complemented with more application software (programs) and data bases, and be of lower cost, as each succeeding future generation hits the marketplace, than earlier systems as in the past, but at a speeded-up rate.

Computers come in various sizes and with widely different capabilities. The latest and newest type is also the smallest--the microcomputers, or Personal Computers (PCs). Microcomputers today cost as little as 100 dollars and can cost more than 5,000 dollars. Ten years from now, when they are more like components rather than like the boxes today, they could cost one-tenth as much. Microcomputers are screen and keyboard, desktop type devices and were introduced in the late 1970 decade.

The next size computer is called a mini-computer. Today, minis cost up to a hundred times as much as micros and are considerably more capable (at least 10 times) in both their speed of computation and data processing power. Minis also have a much higher memory capacity for storing data and programs than their smaller micro cousins. However, micros and PCs are growing in capability with each new wave of hardware technology advance and are forecasted to take over the mini-computer world as it is known today. Mini-computers are typically file cabinet sized devices and were first introduced in the later half of the 1960 decade.

The next scales of computers can be considerably more capable than mini-computers; they are the mainframe macro-computers (in increasing size):

Small scale computers
Medium scale computers
Large scale computers

These computers were first introduced early in the 1950 decade. The large scale computers are typically room-sized and have an average cost of a million dollars or more.

Forecasters predict that future mini-computers will grow in capability, to become super-minis and thus squeeze out of the running the small and medium scale computers, and that later the micros will take over in this range of computing power also. Further, most future nutrient data banks can be forecasted to migrate toward the microcomputers. They further forecast that large scale computers (today's million dollar class computers) will get bigger and smaller and thus also put the squeeze on the small and medium scale computers, as well as future mini-computers.

The largest scale computers are the supercomputers costing a few million dollars each to more than 20 million dollars--depending on their features, capabilities, functions and capacity. For the future, supercomputers are forecasted to grow in capability by about a factor of ten or more per decade--with a possible step-function increase in capability as we move toward knowledge inference processing systems by the 1990's.

What seems to be happening is that computers are in transition from: 1) a collection of boxes as room-full devices (large scale and super scale computers), to 2) a computer in a single box (e.g., like today's mini-computers in a rack or as the desktop PC microcomputers), to 3) computer on a circuit board and to 4) a computer integrated onto a single chip component. Further, they are being distributed in communication and control networks. A similar trend is occurring with computer <u>systems</u> (collections of computers). The transition that computer systems are undergoing is again along multiple paths, including:

1) centralized and distributed networks of de-centralized collections of boxes;

2) computer systems integrated within a box for centralized applications;

3) distributed/embedded board and chip-level computers integrated as a computer system based in a communications network and later,

4) computer systems (collections of computers) integrated on single wafers and/or on single large chips.

Why are there so many different scales of computers? Simply, to supply varying degrees of capability (like horsepower of motors and cars).

Near-term future trends, in the classical larger computers for large-scale business and scientific applications, and for nutrient data banks, are tending also toward multiple directions; i.e., data base-managed architectures, advanced distributed data processor systems, higher levels of circuit integration, multi-microprocessor architectures, network configurations, considerably smarter and easier-to-use data processing systems, more fault-tolerance architectures (later we may even see self-repairable computers and systems, friendlier computers, knowledge-based systems, integrated smart memory systems, more artificial intelligence, and component computers. Later on, microcomputers will take on these characteristics, and in some cases start the trend with such revolutionary new characteristics--in fact, this process has already started.

Additionally, the need for more data communications (bussing) to link the little ones with other little ones and with the big ones will grow--requiring more high-speed communications (e.g., optical fiber) data links--and an increase in computer networks supplying information like a utility service. "Information utilities" should emerge very soon delivering information (including nutrient data bank information) into homes, offices, schools, labs and factories much like water and electricity are today--thus further widening the usage of computers and PCs.

There are some straightforward reasons why computers and data processing systems are so important today and will continue to be so in the future. First of all, our society is moving into the information age. Computer systems and networks increase the productivity of information activities--it's as simple as that. And, the more capability, the smarter and more intelligent computers become through technology advances, the more that productivity is raised--feeding back to allow growth in our societal quality-of-life.

Software (programs) are on a trend path into the future toward easier-to-use types, more software cast in hardware, growing diversity of applications and lower cost.

Artificial intelligence (AI) type computers, as "inference engines" and "knowledge inference processing" systems are now being researched.

A relatively new technology, Artificial Intelligence (AI) is rapidly advancing beyond the research stage into practical use which soon could be used in nutrient data bank systems. Even though AI has been investigated for about 30 years, it has only been in recent years that AI has been moving toward the development of practical expert systems.

In the last decade we have earned more about the way the human mind works than in all of previous history.

This growth in new knowledge about the human mind and its functioning has lead to recent breakthroughs in the design and implementation of artificially intelligent computer programs. The primary direction of research is especially in the areas of inference reasoning leading to the creation of "expert" knowledge-based systems for amplifying human application of knowledge. As a result, we are poised at the beginning of a major technology transfer into future computer programs and computer systems using artificially intelligent characteristics, algorithms, heuristics, and primitives that, heretofore, were only performable by human minds--via the creation of "expert systems"--for assisting all professions.

But 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 limitation of human processes (within computer systems). These AI processes are called heuristics. Heuristics include earning, intuition, symbolic reasoning, logic rules, inductive discovery and reasoning, deductive analysis, problem solving, and other human intelligence processes including machine representation of knowledge for use in inference tasks. AI assumes 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 heuristics processes for discovering how to solve a problem, or to diagnose.

Conventional information processing computer systems execute a string of instructions (the program), as it streams 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, heurstic and logic rules, and question answers are executed from and on information in its knowledge base (memory). Expert systems thread through their knowledge bases via "IF-THEN-AND-ELSE" heuristic rules--that is, the contents of knowledge bases in expert systems is the recodification of knowledge into a form of heuristic logic. Generation of knowledge bases using such logic 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 (as interpreted from a number of human experts); and translates such knowledge, via AI Programs and hardware that offer intelligent assistance to a practitioner in that field, (i.e., for amplifying a nutrient professional, with its stored knowledge, and AI heuristics for interpreting and applying such expert knowledge). That is, expert systems are people amplifying machines assisting humans in becoming more expert.

Thus, an expert system uses AI inference coupled with a knowledge base for assisting in solving problems, making decisions and judgements, for creating, discovering, planning, designing, or inventing things and 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, could 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., education" of expert systems continues via the updating of their knowledge base.

But 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 (including data as now contained in data banks) of the (each) specialized field and the heuristics for its application. Such knowledge-based laxonomies turn out to be far more understandable and accurate, and therefore more useful, than today's manuals and textbooks and data banks. 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.

In forecasting the future of AI expert systems for nutrient data bank usage, 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 1980's is AI advice-giving systems. Already expert system programs exist, or are on the design drawing screens, for medical diagnosis, consulting, architectural design, nutrient expertise, design of very large-scale integrated silicone circuits, molecular generic design, programming, office management decisioning, factory management, home advice (e.g., financial, garden, lawn, repairs), and much more, including applications in the arts. Also being designed are expert management systems, expert programmer systems, and the like. For example, envision how your profession would be enhanced and changed with an expert system or (later) a general purpose mind amplifier.

Future expert systems, in the form of "people amplifiers" (future remote screen and keyboard computers or terminals or hand-held calculator-like devices) 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, heuristics, information and logic, what it went through (used) to arrive at its expert advice or opinion.

The knowledge base of an expert system consists of "facts" and heurstics. The "facts" constitute a body or taxonomy of knowledge (and information) that is similar to the information that a human expert would use for whatever expert task such an expert would be performing. But herein lies the stumbling block--what does an expert (human) do?

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 judgement, fuzzy knowledge, rules of plausible reasoning, as we as hard and fast logical reasoning, rues of good guessing, and the like, that are characteristics of expert-level decision making. Therefore, the performance level of an AI expert system is primarily a function of the speed, size and capacity of its 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 intelligence heuristics (inference rules and procedures).

Today, we are just at the ground floor of creating a variety of knowledge bases. When will/can a variety of knowledge bases be codified for nutrient applications? Only when the nutrient data bank profession gets involved with AI.

The future will see the variety grow and the knowledge base contents evolve with considerable re-codified knowledge. 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 textbook or manual. Therefore, experience with current expert system shows that when compared with traditional sources of knowledge (books, tapes, classrooms, data banks, etc.) present and future knowhow 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 humans in real-time decision process.

Is there an AI Expert System in your future? We can now forecast a positive yes.

CONCLUSION

Taken as a whole, these trends allow for both the long and short-term future reality of going beyond science fiction--allowing "Star Trek" like computers and communications systems--and next steps toward (artificial intelligence) "inference engine"-type computers.

Rapid, technological change always has been the norm in the computer field and, recently, in the bio-genetic and communications fields. In the past, technology-driven change has forced an increasing diversity; and from the foregoing, we now see that the same technological-advance trends are forcing the merger of some of this diversity. However; most computer future watchers see this merger as a way for making way for a new form of diversity. The most likely form that such future spintering, now forecastable, will take is among "smart"/"intelligent" vs. "dumb" computer lines, and along application areas.

In summary, this article outlined digital computer and communication trends relative to expectations for: smart computers, convivial systems, current-awareness systems, communicating and discoursing machines, smart computer machines and systems, and artificially intelligent computers of interest to nutrient data bank users and designers.

PC microcomputers are thus evolving into the future along a number of basic paths. One direction of this evolution is its expansion of capabilities--as it chases up the scales of larger computers and displaces some in the process. Another direction, and future for microcomputers, comes about from hardware developments allowing them to be made physically smaller and smaller. This allows them to be embedded into all manner of machines for making the machines they become an integrate part of ever more smarter and (later) more intelligent. When microcomputers are made artificially intelligent then we will call them either "inference engines" or "knowledge inference processing systems".

But, whichever multiple directions the computer and communication fields take into the future, there should be little doubt that these developments will allow computer systems to penetrate deeper into society, providing and making new opportunities and causing considerable change and impact--for providing opportunities for individuals; institutions and society--and most important for helping nutrient data bank users.