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EXPERT SYSTEMS IN CONSTRUCTION SEMINARS

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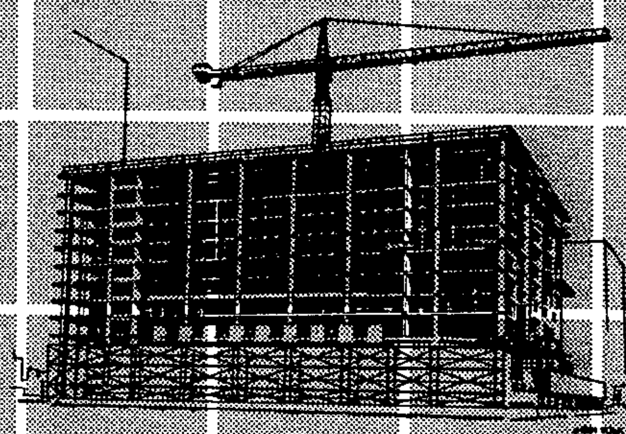

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1991

EXPERT SYSTEMS IN CONSTRUCTION SEMINARS

PROJECT NUMBER CE 89-2

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The principal investigator wants to thank the members of the Building Construction Industry Advisory Committee for their understanding of the problem of declining productivity in U.S. construction industry and its solution by use of advanced techniques, such as expert systems.

I am also thankful to Dr. Irtishad Ahmad and Dr. Ayman Morad, Assistant Professors in the Department of Construction Management for their contribution to the report and the workshop. Our secretaries Lourdes and Nicole have also provided assistance in organizing the workshop.

Last, but not least, Dr. Brisbane Brown and Patti Wood had been patient and understanding in recognizing the difficult task. Our sincere thanks to these fine individuals.

Bhaskar S. Chaudhari
Principal Investigator

Executive Summary

On December 14 1990, March 15, 1991, and April 26, 1991, one day workshops were presented to individuals in the construction industry by Dr. Bhaskar Chaudhari. Dr. Irtishad Ahmad, Dr. Ayman Morad, and Mr. Jose Mitrani. A workshop outline, slide set and video tapes were developed for future use. The tapes and expertise of the principal investigator, co-investigators, and faculty of the Construction Management Department are available for conducting future workshops.

Feedbacks from workshop participants indicated that the seminar was extremely beneficial in understanding expert systems and its applications to the construction industry.

Copies of this report can be obtained by contacting:

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Expert System Technology for the Construction Industry

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Introduction

The productivity of the construction industry in the U.S.A. has been declining at the rate of 1% to 2% per year, since 1960's. Florida's construction industry is one of the largest in the U.S.A. Poor coordination in this highly fragmented and specialized industry, utilizing planners, architects, and engineers in a single project, has resulted in higher costs and an inability to provide affordable housing to our citizens.

Comparison between construction and manufacturing productivity since 1969 shows that manufacturing productivity index has increased from 100.00 in 1969 to 155 in 1986. In the same period construction productivity drooped from 100 to 75 (See Fig. 1). While the manufacturing industry was utilizing modern techniques, the construction industry lagged in the use of new tools to increase its productivity.

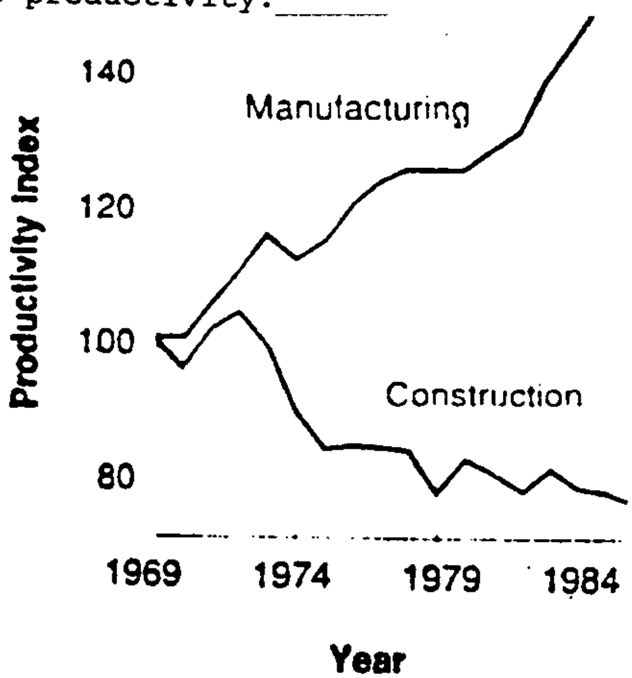


Figure 1. Productivity: Manufacturing vs Construction (Source: Construction Review, U.S. Department of Commerce)

It is obvious that new technology such as artificial, intelligence (Expert Systems and Robotics) must be understood, developed, and used by the A/E/C (Architecture/Engineering/Construction) industry. The purpose of this study is to provide the basics and applications of the expert systems and robotics to the construction industry. It is expected that the understanding and appreciation of these new tools will result in their use. Reduction in planning and design time due to fewer delays, reduced errors, fewer drawings, and use of construction automation, efficient scheduling, and improved coordination during construction phases of the project, will increase productivity and reduce costs.

At the present, the A/E/C industry started using computers for CAD/CAE in design, drafting, administration, management, accounting, estimating, and procurement. Since A/E/C is a fragmented industry, rapid flow of information using new tools is important. One can and should now proceed to the next step of utilizing expert systems and robotics in the construction industry. Bidding process, project control, field practice, facility management, and other functions can be efficiently accomplished using these advanced tools.

These thoughts are well presented by the Center for Integrated Facility Engineering (CIFE) at Stanford University.

FUTURE VISION

In the integrated design and construction environment that we envision, a beam shown on a structural steel layout drawing might have the geometry for its analysis and fabrication represented graphically. Attached to the graphic objects visible on the computer screen, though not necessarily displayed with them, might be: the type of steel required for the beam with the design code and section on which the design was based; stress-and-strain data generated by an analysis program; the fabricator's name and telephone number; a planned installation date, synchronized with a scheduling program; the installation contractor's labor estimate; payment status information; and recommended maintenance intervals for painting. Any participant on the project could easily access this data by simple selecting the graphic object and requesting the information. All participants would have access to all of the information, but would update just the data for which they were responsible.

There has been some effort made already to utilize 3D CAD systems for a variety of design and engineering tasks. However, these efforts have generally been isolated attempts by individual companies. There are currently no unifying standards of guidelines in place. The design of such graphic attribute data bases must be assembled through collaboration between all participants in the process. We envision common conventions that will allow the participants to communicate quickly and more clearly. We also envision a series of knowledge-based systems with reasoning capabilities, systems that can detect conflicts and present possible solutions. We expect that such knowledge-based systems will integrated with CAD-data base systems, and that they will act as "critics" or "consultants" for human designers, contractors, and facility managers.

The success of such an endeavor will require extensive knowledge about the emerging theories and technologies, collaboration among researchers with a broad range of industrial input, generous amounts of fortitude, and considerable time and money. As the following section illustrates, however, the benefits of such research are substantial.

BENEFITS OF EXPERT SYSTEMS TO CONSTRUCTION INDUSTRY

Reduced planning and design time, due to fewer delays and improved communication among participants on a project.

Elimination of errors that arise from the manual re-entry of other participants' data.

Reduced rework due to fewer obsolete design drawings.

Reduced construction methods, evaluate their feasibility, and gauge their impact on cost and time estimates.

Improved facility designs that accommodate construction and operating constraints.

Enhanced opportunities for construction automation.

Improved definition of the knowledge required in all aspects of planning, design, construction, and facility management.

Improved coordination during all aspects of facility development, from the initial planning phase through facility maintenance.

The development of improved product and process technology to meet the challenges of complex projects, allowing participants in all segments of the A/E/C industry to gain a better competitive advantage.

FUTURE TASKS TO BE PERFORMED

The problem plaguing the A/E/C industry are firmly rooted in tradition. We do not expect that dislodging them will be an easy task. But we have begun by developing five primary thrust areas that bear directly on these problems. They are:

1 - Three dimensional computer-aided design systems (3D CAD) with object-oriented attributes for analysis, design, construction automation, and facility management.

2 - Data base management techniques for multiple data base integration and distribution among participants.

3 - Artificial Intelligence (AI) and logic-based computer science techniques for knowledge representation and reasoning about a project.

4 - The development of new methods to define the knowledge environment and control mechanisms needed to support increased automation of construction tasks.

5 - Analysis of the management issues that affect advanced technology for design and construction, including the institutional, legal, and organizational barriers to integration and technology.

Barriers for use of computers in the A/E/C industry has been well documents in CIFE reports.

FUTURE TRENDS IN CONSTRUCTION
P. Teichnolz, Stanford University

Bidding Process

The database created during the detail process will be used to prepare the cost estimate. The material quantities can be extracted and combined with the construction productivity knowledge of the contractor. This knowledge can be captured in a company database and used with an expert system that will apply this data to a specific project. Estimators will review and estimate rather than starting from scratch. This should speed the generation of a bid and allow more time for thought about alternative work methods.

Procurement

The project database will be used to extract the bill of materials (quantities, descriptions, sizes, etc.) The date material is needed will be defined by relating work packages to schedule activities (also defined in the database). Thus, as changes are made to the design, the corresponding changes can be made to the bill of material and required delivery data. The process of issuing requisitions and purchase orders will become electronic contractors, owners, and vendors will use an "electronic market place" to issue and respond to requisitions, issue POs. arrange transportation and perhaps even financing. Standard material codes will be used in the design database to allow easy specification of material and tracking (via bar codes) after the material arrives at the site. Warehouses will use bar code scanners to receive and issue material. Computers will develop picking lists to pick the material for a given work package (perhaps using automated picking systems on large projects). Contractors will expedite material using electronic messages generated by the material system (in addition to the manually generated messages). Vendors will increasingly use project to allow "just in time" delivery, thereby reducing lay Project Control.

The project design database and knowledge base become the starting point for the cost, schedule, material control, change order and other control systems. These systems all have a common starting point, and all require a work breakdown structure (WBS) that is ties to the design (though they may not use the same WBD). Thus, changes to the 3D model and associated data will have their corresponding impact on these control systems. Graphic output will be used to relate the feedback from a control system, Eg. to show the activities on the critical path, to show which work packages have the required material on hand, to show the work performed by a given foreman which is over budget, etc. Graphic output will tend to replace printouts as the preferred mode of communication. Expert systems will be used to develop and critique project schedules (networks).

Field Practice (work methods)

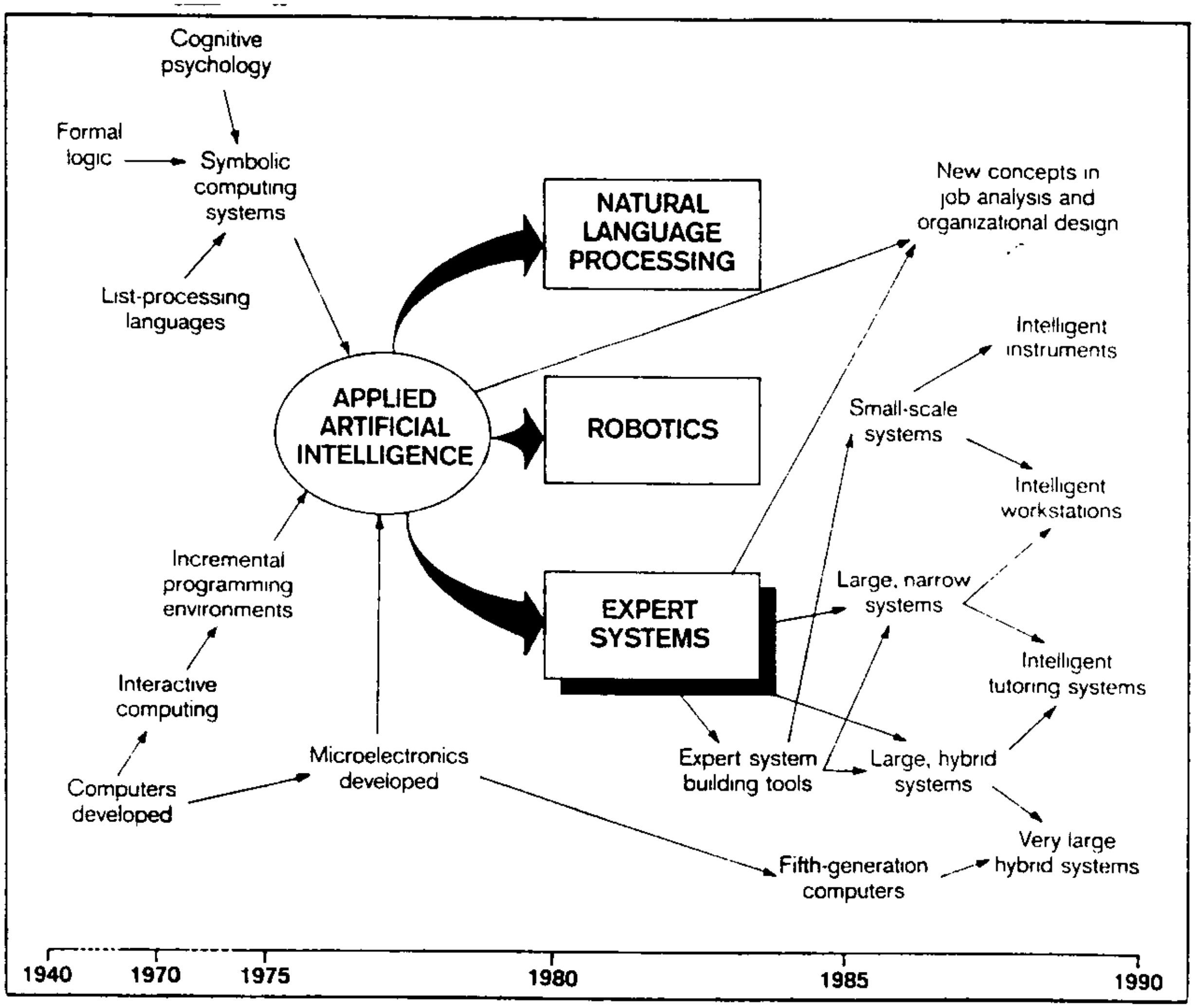
The use of a 3D model for walkthrough analysis will become standard practice for complex and/or fast moving projects. The same database will be used to control the movement of machines and robots that are used for material movement, pipe bending, fabrication, painting, etc. These tools will have digital controls that are fed from project specific data. Workers will be trained to control and repair these automated tools. There will be less need for unskilled workers and more for workers with robotics and computer user skills.

HISTORY

Since World War II, computer scientist are visualizing and working on tools and techniques which allow computers to act like humans. The field, called Artificial Intelligence (AI) conceived at that time, has been developing rapidly in the 80's. It is allowing people to analyze problems and make decisions. Complex planning and scheduling, diagnosing diseases, locating minerals, designing and building computer hardware, trouble-shooting problems and other applications of AI which are possible with development of "Expert Systems". Intelligent robots are performing complex tasks in the manufacturing industry.

Figure 2 illustrates the history and evolution of the expert systems.

Figure 2. Evolution of Expert Systems (Source: Harmaon and King 1985).



WHAT IS AN "EXPERT SYSTEM?"

Professor Edward Feigenbaum of Stanford University, one of the leading researchers in expert systems, has defined an expert system as:

> "...an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. Knowledge necessary to perform at such a level, plus the inference procedures used, can be thought of as a model of the expertise of the best practitioners of the field.
>
> The knowledge of an expert system consists of facts and heuristics. The "facts" constitute a body of information that is widely shared, publicly available, and generally agreed upon by experts in a field. The "heuristics" are mostly private, little discussed rules of good judgment (rules of plausible reasoning, rules of good guessing) that characterize expert-level decision making in the field. The performance level of an expert system is primarily a function of the size and qualify of a knowledge base it possesses".

Feigenbaum call those who build knowledge-based expert systems "knowledge engineers" and refer to their technology as "knowledge engineering." Early systems were usually called "expert systems", but most knowledge engineers now refer to their systems as "knowledge systems".

To understand artificial intelligence, it is essential to know the working of a human mind, as shown in Figure 3

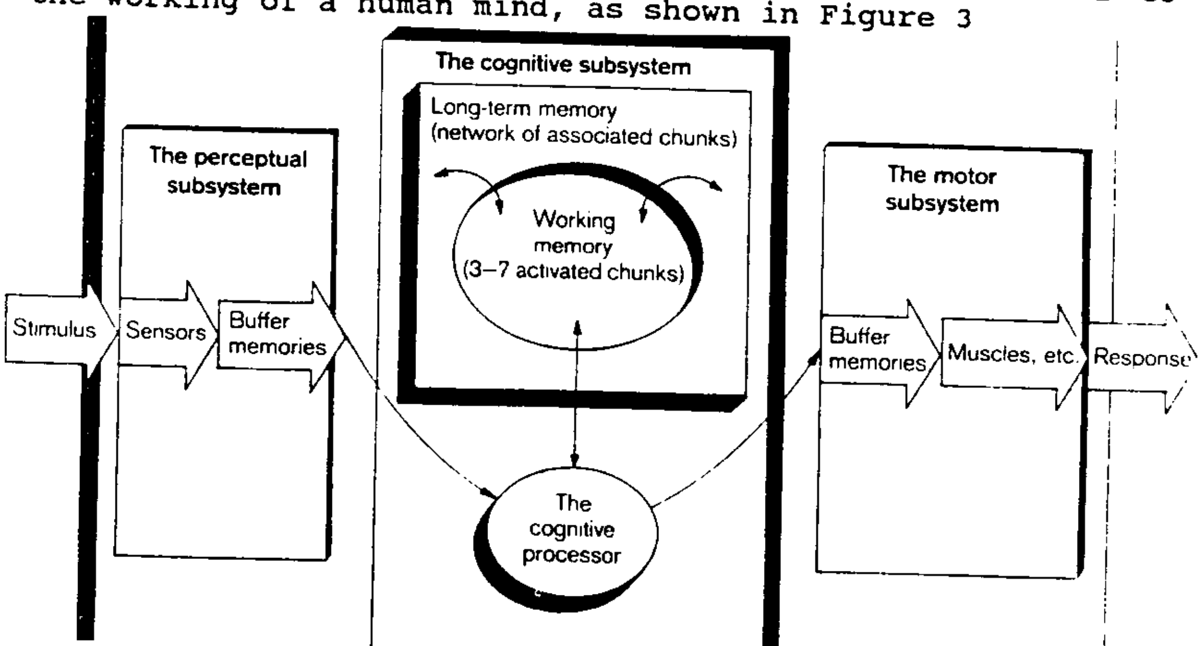


Figure 3. An Overview of the Human Information Processing System (Source: Harmon and King, 1985)

COMPONENTS OF AN EXPERT SYSTEM

An expert system usually incorporates three components:

Knowledge Base. This is the problem solving of "know how" aspect of the system. The experienced project manager is able to provide his knowledge in a series of "rules".

Inference Engine. The "engine" which processes the knowledge and directs the reasoning process of the system. It controls the direction and order of inferencing.

Database: Holds the record of the rules and definitions used to build the system. Expert system "shells" i.e. computer programs which contain the necessary processing logic, allow the project manager to input data using descriptive. English phrases, thereby avoiding the need for the individual to have any programming experience.

The knowledge is represented as rules:

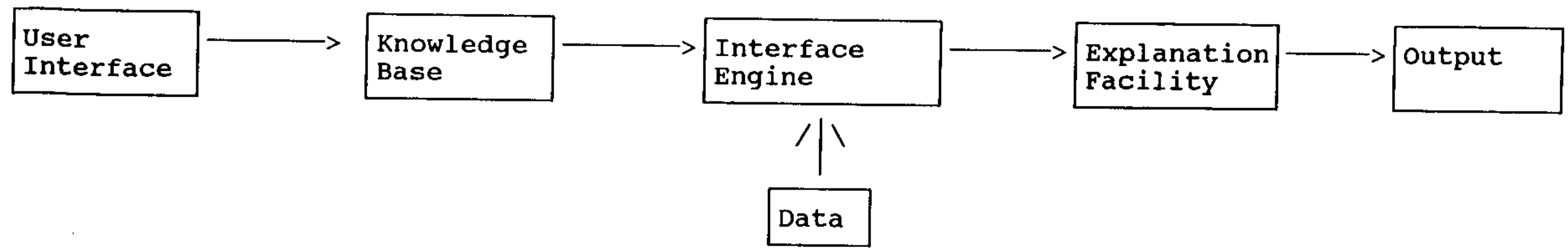
If...(Rules) Then...(Action)

If A is true and A implies B then ------> B is true	If a house is built in Kendall and being located in Kendall implies prime sales the prime sales are achievable per house in Kendall.

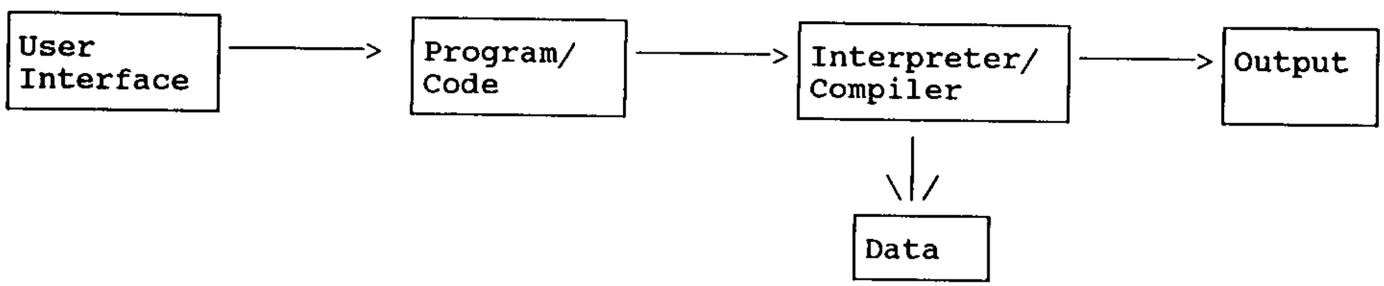
Expert Systems vs. Conventional Programs

Expert Systems	Conventional Programs
Knowledge Base	Program
Inference Engine	Interpreter
Expert System Shell	Programming Language
Knowledge Engineers	Software Engineers

EXPERT SYSTEMS PROGRAM



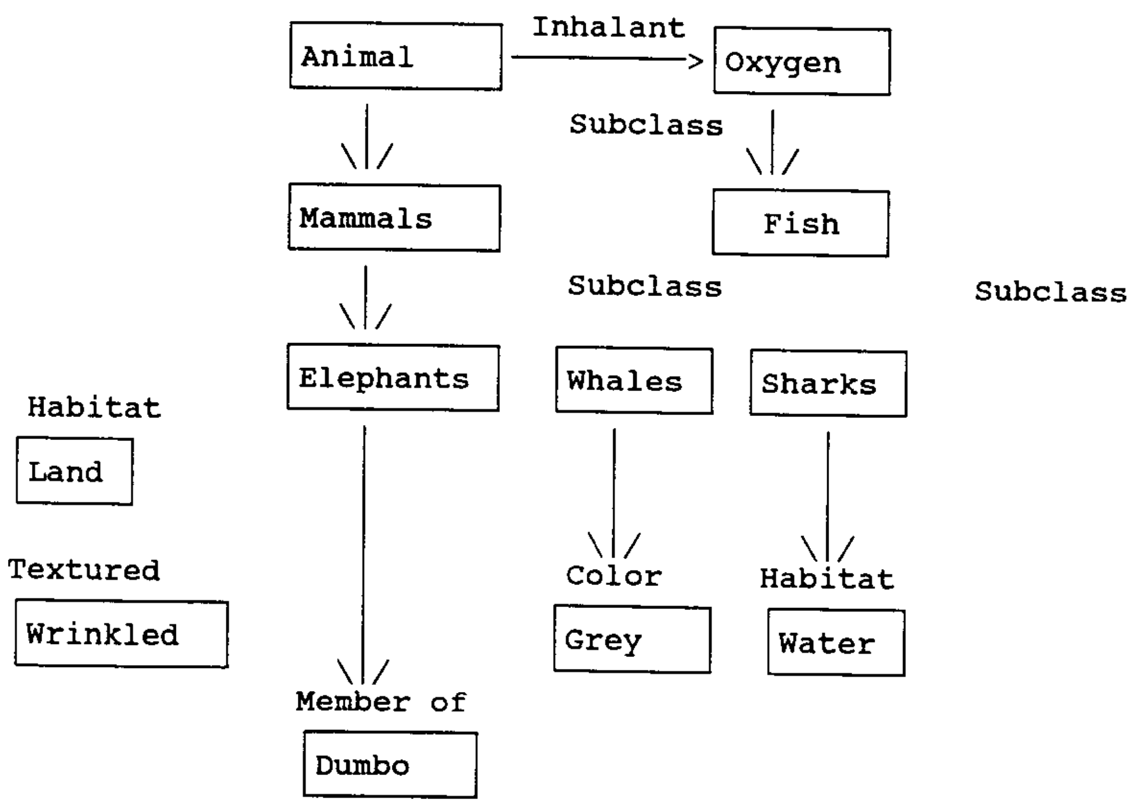
CONVENTIONAL SOFTWARE PROGRAM



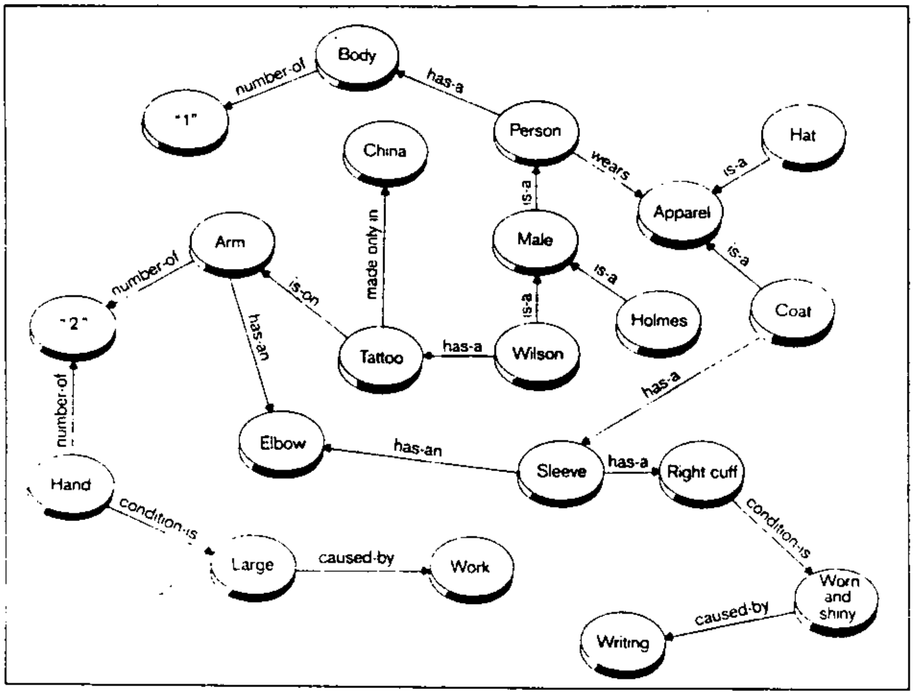
Advantages of Expert Systems

1. Proficiency at arriving at quick, accurate solution to problems
2. Proficiency at explaining the results to the layperson
3. Proficiency at learning from experience
4. Proficiency at restructuring knowledge to fit the environment
5. Capability to make exceptions
6. Awareness of their limitations

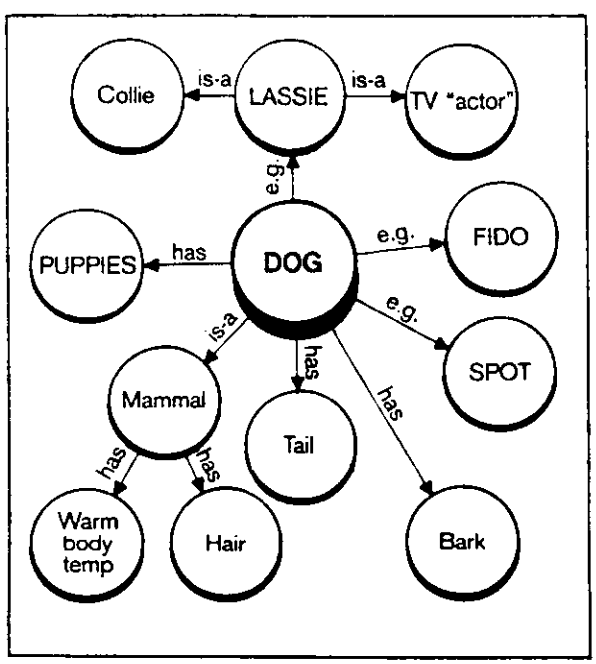
SEMANTIC NETS



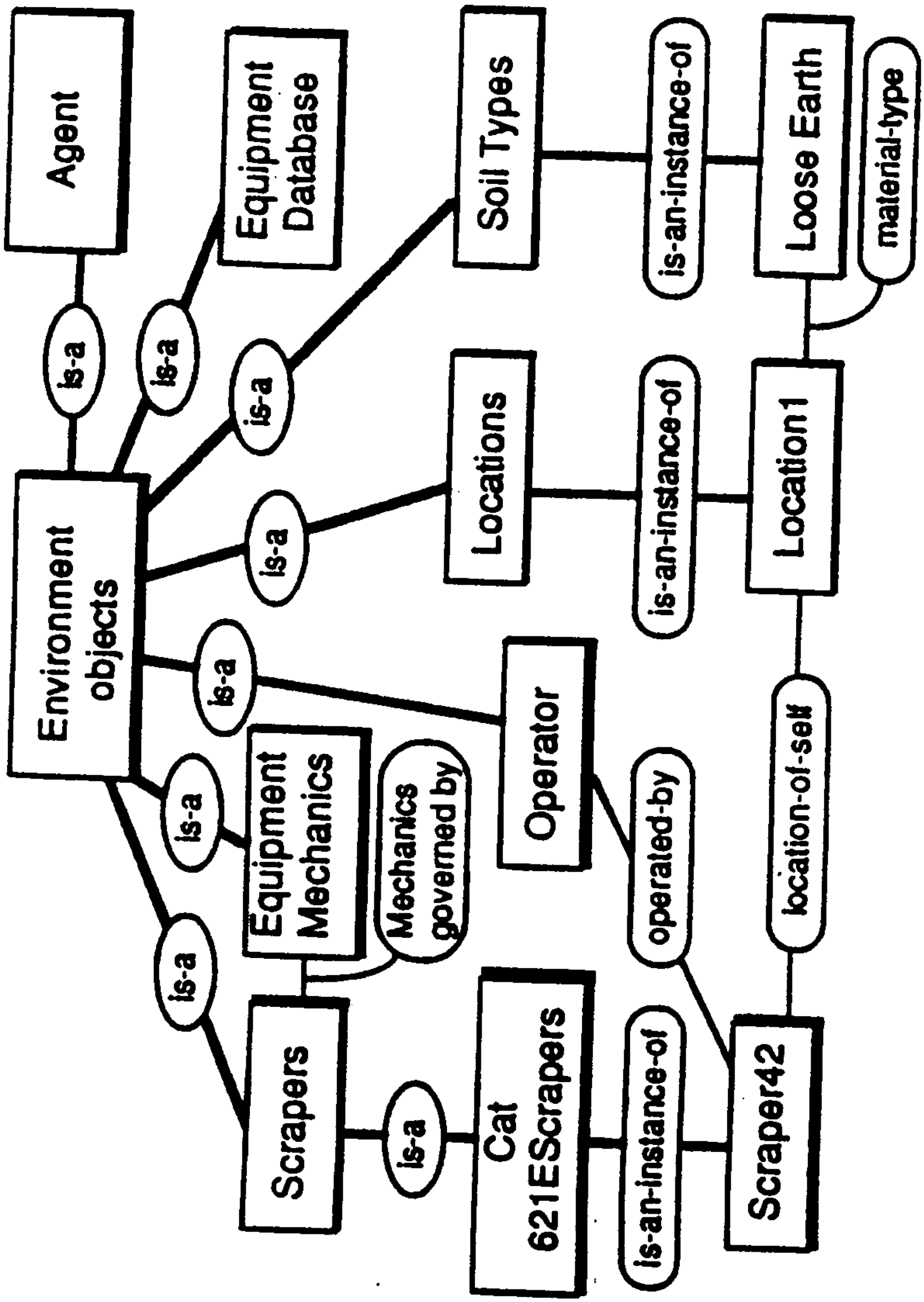
Consider an examples of a detective's knowledge base



Next we should understand how humans solve problems. The information is stored and synthesized by a biological system -the human brain-. People encode information, store information, and recall information from the memory. With this information, they think. The input to the brain enters through stimuli, such as eyes, ears, etc. The following figure explains human information process.



Scrapers Loading Example (Boyd Paulsen)



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Glossary of Terms

Artificial Intelligence (AI): The subfield of computer science which is concerned with symbolic reasoning and representations of knowledge. AI methodologies are widely and successfully used for developing expert systems.

Attribute: A characteristics of a concept or an object, represented as a slot within a unit.

Backward Chaining: Backward chaining is reasoning from an unproven hypothesis backwards in search of the facts that would prove it. In an expert system, backward chaining is used to supply needed facts to the database, either by finding the information in another form or by interrogating the user.

Bug: A bug is a flaw in a program, named after an unfortunate lepidopteran that fried in the wiring of an early computer.

Data Driven: Data-driven reasoning or processing refers to symbolic reasoning processes which are triggered by changes in data and which then cause other processes to occur. Forward-chaining is sometimes referred to as data-driven because assertions made by a rule can trigger other rules whose premises match the assertion.

Domain: The domain of an expert system is the application area it serves. For instance, an expert system might serve the domain of mathematical problem solving, or the domain of mineral exploration, or the domain of financial planning.

Domain Expert: To endow an expert system with knowledge about a particular domain sufficient for the system to model expert decision-making processes requires the participation of a person who has expertise in the domain being modeled. This person is the domain expert. He or she often works with a knowledge engineer, who is familiar with building expert systems, to express domain-specific information for that expert system.

Expert Systems: Computer programs which are designed to perform a complicated task which has economic or scientific value with an expert level of competence. Hallmark characteristics of expert systems include ability to explain to users the way that they make decisions and flexibility to accommodate changes in the knowledge with which they make decisions.

Fact: A fundamental unit of knowledge. For example, a fact might consist of the proposition "This car is red" which is declared to be "true" but only from the viewpoint "on Wednesday". On Thursday, we may find that the car has been repainted.

Forward Chaining: Forward chaining is reasoning from facts to conclusions. In an expert system, a forward-chaining rule detects facts in the database and takes an action because of them.

Frame-based Representations: The AI methodology of describing knowledge about the concepts and objects of a domain using "frames", or datastructures with names, relations to each other and attributes. Units provide one implementation of frames.

Goal-driven: Goal-driven typically refers to backward changing reasoning. Goal-driven processing starts with an explicit goal, matches the goal to rules or frames, and then attempts to prove or achieve the goal by providing or instantiating the rule or frame.

Heuristic: Loosely, a rule of thumb. A heuristic rule guides in a direction which promises success but does not guarantee it. Success of a heuristic is not guaranteed, which is why a problem that can be solved by one algorithm requires many heuristics. Human expertise, which we seek to capture in expert systems, is much more likely to take the form of heuristics than algorithms.

Hierarchy: (also see Taxonomy). In the context of knowledge engineering, a hierarchy is assumed to be taxonomic. A hierarchy is a classification of objects according to assumed relationships, such that the relationships imply directional links indicating incrementally inclusive levels within the classification. For example, a taxonomic hierarchy of automobiles might be composed of foreign cars and domestic cars. Foreign cars might be composed of Toyota, Volvo, and Nissan; domestic cars might be composed of Chrysler, GM, and Ford. GM might then be composed of Chevrolet, Pontiac, and Cadillac. In this way, detail can be more specific in the wider base of the hierarchy; and automobiles, as a parent of every object in this hierarchy, must maintain a more general level of detail.

Hybrid AI Development Tool: A system which allows the user to employ different AI methodologies for representing knowledge, reasoning with that knowledge and explaining the domain and the problem-solution process to users.

Inference: A step in building a logical chain, usually expressed as "IF" this is true, THEN that must be true also."

Inheritance: Inheritance is a mechanism by which hierarchically higher-level units in a knowledge base can share information with lower-level units in the knowledge base. The relationship is analogous to a parent-child relationship; the parent units have information in their slots which the child units inherit. For example, a higher-level unit describing the class of objects. Transistor, might have a slot for NUMBER OF LEADS. That slot could be given the value 3 at that higher-level, and lower units representing individual transistors could automatically inherit that value in their NUMBER OF LEADS slot. However, if a particular transistor class or member has some other NUMBER OF LEADS the value can be changed explicitly in the unit representing that object.

Knowledge Acquisition: Knowledge acquisition is a process of gathering declarative, procedural, and structural information from a domain expert for building a knowledge base. This is often the most difficult process in building an expert system for two reasons: experts sometimes find it difficult to explicitly define and articulate the knowledge they use and their own reasoning techniques, and the experts' time is usually at a premium.

Knowledge Base (KB): A collection of facts about a domain and rules which can be used to find implications of those facts. Within the KEE system, a KB includes a set of related units.

Knowledge Domain: A knowledge domain is an area of interest for a particular application. Typically, the knowledge domain must be bounded to include only information which is useful in reasoning about that domain.

Knowledge Engineer: A person who implements an expert system. A knowledge engineer must posses two essential skills. He/she must be able to interview experts to obtain the raw knowledge from which to structure the knowledge base and formulate the rule base. He/she must also have the programming skills necessary to convert the raw knowledge into a form a computer can understand.

Knowledge Engineer: Knowledge Engineer is the software engineering discipline focusing on construction expert systems.

LISP: LISP, an acronym for "List Processor", is a programming language based on a "list" construct. LISP provides flexible representation of data and algorithmic procedures as symbolic expressions; manipulation of these symbols is well-supported in LISP. Functions in LISP programs can be interpreted, in addition to compiled, which facilitates rapid prototyping when constructing a knowledge-based system.

LISP-MACHINE: A LISP machine is a computer with specially-designed architecture optimized for handling constructs in the LISP programming language. LISP-machine usually have high-resolution, bitmapped displays screens and a mouse for pointing at objects displayed on the screen.

List: An ordered sequence of elements, usually found within a pair of matching parentheses. For instance, (A B C) is a list composed of the elements A, B, and C. The first element in the list is usually a function, while the other elements are arguments to be acted upon by that function.

Message: Object-oriented programming involves associating behavioral information with each object. A specific behavior is invoked by sending a message to the object requesting that behavior or the result of that behavior.

Method: A procedure which is placed in a unit within the inheritance hierarchy. Thus, rules of inheritance define the way that methods are inherited from the place in which they are defined to descendant units. Methods in the KEE system are usually written in LISP.

Object: (see also Schema). An object is a structure of information which described a physical item, a concept, or an activity. Each object is represented as a frame, containing declarative, procedural, and structural information associated with the object.

Object-oriented Programming: Frame-based knowledge representations can support the association of behavioral information with object descriptions. The behavior descriptions are in the form of LISP procedures or classes of production rules. The behavior is invoked by sending a message to the object, or by accessing or changing an attribute of the object. This style of behavior specification, called object-oriented programming, has many advantages over traditional "function-oriented" programming and is particularly well-suited for building simulation models. It allows much of the information in a program to be stored declaratively, in the frames, where it is easily accessible, understandable, and modifiable.

Predicate: A predicate is a function which return a truth value. Predicated are used to select among conditional alternatives.

Reasoning: The process of identifying the implications which are implicit in a known fact.

Recursion: See Recursion. Recursion is the process by which a function calls itself. Sometimes a function bites off more than it can chew and has no recourse but to try again and take progressively smaller and smaller bites until it can finally do something constructive.

Rule: A procedural response triggered by a pattern rule. From an intuitive standpoint this is an IF-THEN situation. IF pattern is matched, THEN schedule procedure for execution. In practice, a rule that has been activated by a pattern match may be in competition with other activated rules. The inference engine decides which of the activated rules should be executed, and in what order to execute them.

Representation: The process of describing knowledge in ways which can be used by the computer for reasoning and which can be communicated to the knowledge representation include frame-based representation of descriptions of concepts and objects, rule-based representation of heuristic knowledge, and descriptions of algorithms within a programming language such as LISP.

Schema (pl. Schemata): A structure within a knowledge base that relates objects or classes of objects that share certain properties. Schemata capture information in two ways: by sorting attributes of the concept (Rover weighs 25 pounds) and by relating the concept to similar concepts (Rover is an instance of the general concept "dog".)

Semantic net: A semantic net is a model of human associative memory. Each semantic net consists of nodes and links between the nodes which represent relationships.

Semantics: A circumlocution for people who can't spell meaning.

Send a Message: Request a unit to perform some action specified by a method. in the KEE system, Messages can be send directly by the user who employs the mouse pointing device to send a message to a selected unit, and they can be sent by other methods and by the rule system while testing a rule premise or after all premises in a rule are satisfied.

Slot: A technical name for a datastructure which describe an attribute of some unit. Slots have a name. They may also have a set of possible values, an actual value, a rule specifying the way that slots values are to be combined by inheritance, and some known limits on the number of values they may have (i.e. cardinality).

Taxonomy: (all see Inheritance). Most domains require the representation of the domain objects in a taxonomy, which is the classification of objects according to assumed relationships. Frame-based representations support taxonomies by allowing the objects' attributes to be inherited from the objects' classes to subclasses and members.

Unit: A technical name for a frame, or a datastructure which describes the attributes of abstract concepts and concrete objects and ideas. Units use slots to describe individual attributes.

Expert Systems: New Tools for Construction

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Introduction

Expertise is needed at different stages in the life of a construction project. Expert knowledge is essential in performing various tasks involved in construction. Technology is now available for storing some of this expert knowledge in computers. The idea is to make this stored knowledge or expertise available for use by relatively less experienced persons. These systems of stored knowledge, commonly known as expert systems, can also be useful to experienced professionals. They can use the systems to enhance the quality and improve the productivity of their performance.

"Expert-system" is a relatively recent computer software technology based on Artificial Intelligence (AI) principles. At one extreme, expert systems have been claimed to have the capability of replacing human experts, and at the other, they have been criticized for being just another version of traditional algorithmic programs. In reality, however, these systems seem to be somewhere in between.

Expert systems are certainly more "intelligent" than traditional algorithmic computer programs, but that intelligence-level is far below the level of human experts. In general, algorithmic computer programs are designed to do a large number of repetitive and tedious computations. In contrast, expert systems are meant to support experts through structuring their thought process and/or to provide non-experts with advice and information. The central part in an expert system, is the knowledge base, where heuristic, rules of thumb or expert knowledge is stored in such a way that it can be accessed by the user of the system to receive meaningful and useful information.

Over the past few years, many expert systems have been developed for use in different areas of construction engineering and management. Expert systems have been developed or are in the process of development for applications in planning, scheduling, monitoring, financial decision-making, risk modeling, technical advising, and many others (Ashley and Levitt 1987, and Mohan 1990).

Expert Systems in Construction

In construction, expert opinions are necessary in different domains at almost every stage of a project's life cycle, from inception to completion. Human experts in all necessary domains are neither easily affordable nor readily available. Computers can help fill the gap by providing some expertise, knowledge and support through expert systems.

Following is a list of reasons why construction problems might be good candidates for the application of expert system technology (Levitt 1987, Minkarah and Ahmad 1989, Mohan 1990):

- o Each construction project is unique; the process is not repetitive. Each project is different in design, layout, materials used, construction methods, time, crews, weather, and management. A construction manager involved in the process cannot normally use structured decision support systems. Each decision-making process in construction, requires a new set of different input variables making algorithmic solutions inapplicable to the day-to-day construction problems.

- o The construction process is subject to a great deal of variance. Internal factors such as change of methods, equipment, etc. and external influences such as weather, regulatory agencies, and economic conditions make construction environment very uncertain and unpredictable.

- o Variables involved in managerial issues are qualitative, subjective, and of a fuzzy nature. For this reason, numerical programs cannot handle subjective decision-making problems adequately. A rule-of-thumb approach to decision-making is more appropriate than a technical approach in such situations.

- o Construction is a dynamic process. The conditions are everchanging as the construction advances to completion. Algorithmic programs that recommends crisp solutions cannot be very useful in situations where things are continuously changing.

- o For optimum utilization of resources, for ensuring safe construction practices, and for saving time, construction managers are under significant pressures to reach quick and correct resolutions. Enough time is not usually available for a detailed analysis of all the influencing factors before making a decision. Such decisions are often made on the spot so that the construction process is not interrupted. Expert systems can provide quick yet reliable decisions in such situations.

- o The construction industry lacks continuity and proper transfer of skills acquired by experienced managers. The expert knowledge is lost when these managers retire or move to another company. Expert systems will be able to provide a smooth transition in these kind of situations.

- o Many construction professionals and managers do not have enough computer knowledge and/or management science background to be able to use, maintain and update algorithmic computer programs.

Some Expert System Development Efforts in Construction

Mohan (1990) summarized the state-of-the-art expert systems in construction, detailing the input-data requirements, system output, knowledge structure, control strategy, hardware and software used in the building of each of the expert systems, address of the system building organization, and the name of the key contact.

It should be mentioned here that many expert system development efforts have never been reported and published due to restrictions imposed by the company policies. These companies are perhaps concerned about losing their competitiveness by exposing strategies and expertise through expert systems. The number and nature of these expert systems are very difficult to ascertain. It is quite possible that, these systems are being used on a regular basis by the developer companies.

Potential Areas in Construction for the Applications of Expert Systems Technology

Following is a partial list of problem types where expert systems can be useful and effective in construction, given the present state of technology. A combination of the following types and any other type is also possible.

- Problems where management science techniques are used. Expert systems can be used to explain different technical terms, interpret results, teach the users and ask for meaningful input variables. In this kind of applications expert systems would act as an intermediate layer between the numerical computer program and its user who may or may not be a technical person. Sophisticated management science techniques would thus become more accessible, meaningful and useful to construction professionals.

- Problems that are diagnostic in nature. Expert system can be used as an aid in troubleshooting by using search techniques. This kind of expert systems would clarify the problem in greater detail and draw the attention of the users to issues that were previously overlooked.

- Problems that are ill-structured and for which several possible interpretations exist. These types of problems are characterized by lack of precise knowledge regarding the number of factors and/or variables involved, their interrelationship and extent of influence on the decision criteria. An expert system designed to handle these types of problems would present all possible solutions and indicate the consequences with a measure of probability, if applicable.

The above list is by no means a complete one; users may find other types of applications that are worthwhile. The emphasis is on the enormous potential of this new technology and on the possibility of improving management techniques by using it.

Mohan (1990) identified thirteen major tasks in construction planning, engineering and management as potential candidates for expert system development:

Design of Construction Methods - The various candidate topics include configuration of crews; choice of construction methods; man-machine trade-offs; choice of transportation mode(s) for the movement of materials, personnel, and equipment;

selection of optimum sizes, configurations, and methods of joining of various components in modular construction; and deep excavation problems.

Concrete Mixing and Placement - The subsystems that need decisions include mix design to meet performance standards for a variable set of site conditions and materials; choice of a placement method; configuration of crushing, batching, and transportation equipment; and design of formwork.

Constructibility Evaluation - Some important issues include analysis of the constructibility of designs, choice of construction materials, selection of the best design-function-cost combination, bid packaging, choice between prefabricated and in-situ construction, and feedback into the design process.

Temporary Facilities Layout - Optimal layout of temporary facilities that can have a significant effect on productivity such as access roads, parking areas, change rooms, material lay-down areas, fabrication shops, site office, and hoisting equipment.

Project Planning, Scheduling, and Control - Some candidate tasks in this area include developing variable time-cost estimates of activities; generation of construction schedules; critical-path analysis; resource allocation; time and cost control; diagnosing reasons for time, cost, and resource overruns; prescribing remedial actions; cost estimating; and construction-process monitoring.

Project Management - Several kinds of expert systems that could be built in this area include choice of a project-delivery strategy, selection of a contract type, design checking and management of design changes, construction-contract formulation, project-financing options, A/E and CM selection, prequalification of contractors, bidding strategies, bid evaluation, evaluating progress payments, evaluating claims, management of risks, evaluating the quality of a constructed component or facility, formulation of general conditions, and formulation of technical specifications.

Construction Quality Control - Several candidate tasks for expert-systems application include sample size, sample location, time of sampling, permissible tolerances, construction-quality-control methods, lab tests for quality assurance, and acceptance of subquality work.

Construction Company Management - The various candidate topics that can help a construction company include bidding strategy, financial planning, and equipment-policy decisions.

Equipment Selection, Diagnosis, and Repair - The various candidate problems in this area include selection of equipment types, sizes, and combinations; diagnosis and monitoring of equipment condition; repair; preventive maintenance, and operational procedures based on crew behavior.

Human Resources Management - The various candidate topics in this area include designing project- and company-organization structures; personnel management; labor relations; safety management; and productivity-improvement techniques.

Operational Problems in Constructed Facilities - Some important problems that are usually solved using heuristics include causes and remedial actions for functional failures such as leaking, sweating, poor ventilation, and temperature control; causes and remedial actions for structural failures such as foundation settlement and cracking; posthazard damage assessment of facilities; and reconstruction and rehabilitation methods.

Materials Management - Some candidate topics in this area include choice of materials, scheduling order and movement of materials, materials handling and testing, and storing and use of explosives.

Legal Issues - The various potential areas that can be useful to the construction industry include generation of contract documents, maintaining historical data bases of settled cases and matching them with the current situation, settlement of claims and disputes, generating negotiating strategies, and changing management conditions.

What Not to Expect from Expert Systems

There have been widely varying expectations about the ability of expert systems. As with any new technique, expert systems are victims of both unrealistic optimism and skeptical pessimism. It is important to remember that expert systems are just tools. They are only as good as a person's ability to use the tools. Expert systems cannot guarantee success but have the potential to increase effectiveness and efficiency of the tasks involved in a construction process.

It is vitally important to recognize that expert systems:

- o cannot have common sense;
- o cannot totally replace people;
- o cannot take the place of judgment;
- o can handle a very narrow domain area; and
- o are constrained by both software and hardware.

The Future

Expert systems are in the early stages of development. But they have already made their presence felt! It is impossible to think of tomorrow's management without expert systems. It is also very difficult to predict exactly how tomorrow's management will reshape itself by using the rapidly changing and advancing expert system technology. But in construction certain trends are evident.

Table 1 shows a classification of some potential areas for expert system development in construction (Minkarah and Ahmad 1989). The information contained in Table 1 is classified according to their likelihood of being developed in either of the two possible levels, organization (or company) and industry. Some problems are of general nature and requires similar treatment regardless of a particular company. Consequently, this type of problems are suitable to address at the industry level. The other type of problems that are strategy-dependent and need unique treatment should be considered at the individual organization level.

Table 1. Possible Expert System Applications in Construction Management

(a) Development at Organization Level
1. Developing remedial actions for project control
2. Selecting an overall contracting approach or strategy
3. Selecting contract clauses to incorporate
4. Identifying and refining project financing or insurance options
5. Prequalifying or selecting prospective contractors or designers
6. Project organization design
7. Marketing strategy decisions such as whether to submit a bid for a project or how much to mark it up
8. Personnel management decisions
9. Company organization design
10. Financial planning
11. Construction equipment policy decisions
(b) Development at Industry Level
1. Developing time and cost estimates of construction tasks
2. Planning the sequence of construction operations
3. Allocating constrained resources to activities
4. Monitoring time and resource consumption
5. Diagnosing reasons for cost, time, or resource overruns
6. Forecasting durations and costs of remaining activities on projects
7. Evaluating progress payments
8. Evaluating potential claims on litigation situations
9. Quality assurance
10. Safety management

With the availability of easy-to-use development tools, knowledge based systems will be developed more at the organization level rather than at the industry level. In most cases experts themselves would be the developers of the systems. These systems would be used by these experts and others as references whenever a problem would arise.

This writer also speculates that a good number of the future expert systems in construction will be coupled systems, combining expert systems with algorithmic systems (e.g. expert system for CPM scheduling).

Expert systems for use in solving decision-making problems at the company management level (for example, financial decision-making) would be developed using traditional management science concepts. These systems might be viewed as extensions of decision support systems.

Levitt (1987) observes that the area of diagnostics for inspection, maintenance, and repair is likely to be one where many small systems, residing on desktop or portable personal computers, will be developed.

Ease of use, capability to interface with external programs, increase in the capacity of memory storage, and decline in the cost of both hardware and software indicate that a considerable number of useful expert systems will be developed in the near future.

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DEVELOPMENT OF AN EXPERT SYSTEM

I. INTRODUCTION

The following section presents a step-by-step instruction for developing an Expert System for "monitoring asphalt-paving construction"[1] using VP-Expert development tool. The system provides an advice to the inexperienced inspectors concerning how to identify and correct deficiencies in the asphalt construction operation. The example is presented only for illustrative purposes and represents only a portion of the system described and referenced in the footnote.

II. DEFINITION OF THE PROBLEM DOMAIN

The paving inspector must have information on many areas such as conformance with standard specifications, preparation of existing pavements for overlay, quality control of the arriving asphalt material, placement techniques and compaction among others. However, this system will be limited to giving ADVICE about adjustment of the screed crown of the paving machine. The screed crown provides the material necessary to compensate for the material that migrated to the side of a lane during compaction. Two factors are identified by experts as important criteria in determining if the screed crown of the paving machine is correctly set. The two factors are the *surface contour of the paving lane*, and the *appearance of the paving mat*. Table 1 illustrates this concept.

TABLE 1: SCREED CROWN ADJUSTMENT

PAVEMENT SURFACE	*MAT APPEARANCE*	*ACTIONS*
1. Humped	Tightly compacted in center	Reduce tail crown,* Increase lead crown**
2. Humped	Tightly compacted on edges	Reduce tail crown,* Decrease lead crown**
3. Humped	Uniform	Reduce tail crown*
4. Level	Tightly compacted in center	Increase lead crown**
5. Level	Tightly compacted on edges	Decrease lead crown**
6. Level	Uniform	No adjustment
7. Concave	Tightly compacted in center	Increase tail crown,* Increase lead crown**
8. Concave	Tightly compacted on edges	Increase tail crown,* Decrease lead crown**
9. Concave	Uniform	Increase lead crown**

* Actions to be taken for adjusting the tail crown
** Actions to be taken for adjusting the lead crown

---

[1] The example is taken from William, T.P., Parks, R.C. and LiMarzi, J.J. "Expert System for Asphalt-Paving Construction Inspection". Journal of Computing in Civil Engineering. ASCE. Vol 4. Oct 1990.

III. STRUCTURE OF THE KNOWLEDGE BASE

In order to decide on the actions for adjusting the screed crown, the expert should know the *condition of the pavement* surface and the *appearance of the mat*. The system will also require the knowledge of these conditions. The pavement surface can be **humped, level** or **concave**, while the mat appearance can be **tightly compacted in center**, tightly **compacted on edges** or **uniform**. After analyzing this knowledge, an action can be recommended on the adjustment of the lead and tail crowns, which are to **reduce, increase** or **not to adjust** at all. The following table illustrates the variable and values used in this expert system.

TABLE 2: VARIABLES AND VALUES

VARIABLE NAME	*REPRESENTS*	*VALUES*
PAVEMENT_SURFACE	Pavement surface	HUMPED LEVEL CONCAVE
MAT	Mat appearance	COMPACTED_CENTER COMPACTED_EDGES UNIFORM
LEAD	Adjustment of lead crown	REDUCE INCREASE DO_NOT_ADJUST
TAIL	Adjustment of tail crown	REDUCE INCREASE DO_NOT_ADJUST

IV. BREAKDOWN OF THE SYSTEM

In order to develop the expert system using VP-Expert, it is necessary to understand the format of the knowledge base. The knowledge base consists of three main parts as follows:

1. ACTIONS
2. RULES
3. USER INTERFACE COMMANDS

In order to facilitate the understanding of the system, the RULES will be created first, then the USER INTERFACE COMMANDS and finally the ACTIONS.

V. CREATING THE RULES OF THE EXPERT SYSTEM

The goal is to find the values of LEAD, which represent the action to be taken for adjusting the lead crown, and TAIL, which represent the action to be taken for adjusting the tail crown, using the knowledge available from the PAVEMENT_SURFACE and MAT appearance. In order to achieve this goal, some rules have to be considered:

IF Pavement Surface is humped
THEN reduce tail crown

IF Pavement Surface is concave
THEN increase tail crown

IF Pavement Surface is humped
AND Mat appearance is tightly compacted in center
THEN increase lead crown
:
:

<u>To create the rules follow these steps:</u>

1. Press function key [F6] (or select FileName from the command menu in the bottom of the screen)

2. Write the name of the file you want to create, type 'asphalt' and press the **Enter** key

3. Press the function key [F3] or select Edit from the command menu

4. Type the first rule as follows:

```
RULE 1  IF    PAVEMENT_SURFACE = HUMPED
        THEN  TAIL = REDUCE;
```
(Do not forget the semicolon ";" at the end of the rule)

5. Type the second rule as follows:

```
RULE 2  IF    PAVEMENT_SURFACE = CONCAVE
        THEN  TAIL = INCREASE;
```

6. Now type the third rule:

```
RULE 3  IF    PAVEMENT_SURFACE = HUMPED
          AND MAT = COMPACTED_CENTER
        THEN  LEAD = INCREASE;
```

7. Save this program by pressing [ALT] and [F6] keys at the same time

8. Press [Y] at the prompt to save the program

In order to save time, all the RULES have been included into a file named <ASPHALT2.KBS>.

9. To access the <ASPHALT2.KBS> file, Press function key [F6]

10. Select <ASPHALT2.KBS>, then press function key [F3].

11. Use the arrow keys to look at the rules. There are 12 rules in the knowledge base.

VI. USER INTERFACE COMMANDS

At this point, the rules have been incorporated into the system. Still the program needs to ask for the values of the variables PAVEMENT_SURFACE and MAT. This is done by using ASK and CHOICE commands. ASK statements are used to prompt the user for information not contained in the knowledge base, while the CHOICES statement creates a menu of options to accompany the question during a consultation. The user is required to choose from this menu.

1. Move to the end of the file using the arrow keys
2. Type the following lines:

```
ASK PAVEMENT_SURFACE: "WHAT IS THE SURFACE CONTOUR OF THE PAVING LINES?";

CHOICES PAVEMENT_SURFACE: HUMPED, LEVEL, CONCAVE;


ASK MAT: "WHAT IS THE APPEARANCE OF THE PAVING MAT?";

CHOICES MAT: COMPACTED_CENTER, COMPACTED_EDGES, UNIFORM;
```

NOTE: The ASK statements display on the screen the question regarding the pavement surface and mat appearance respectively and the CHOICES display a menu of the values the variables can have. The user is required to select from these menus the value of PAVEMENT_SURFACE and MAT respectively.

3. Save the updated version of the program by pressing **[ALT] + [F6]**
4. Press [Y] at the prompt to save the program

Now the system has to ask the user for information regarding the pavement surface and the mat appearance to draw a conclusion, however the program can not run without stating the ACTIONS (Goal).

VII. ACTIONS

This portion of the knowledge base is necessary to define the goal of the program. In this case the program should know that it needs to FIND the values of the LEAD and TAIL variables using the knowledge base developed earlier. The file named <ASPHALT3.KBS> contains the 12 RULES of the knowledge base in addition to the USER INTERFACE COMMANDS. To include the actions do the following steps:

1. Press function key [F6]
2. Select <ASPHALT3.KBS>
3. Press function key [F3]
4. Move the cursor to the top of the file using the arrow keys
5. Type the following lines:

```
RUNTIME;
ACTIONS
FIND LEAD
FIND TAIL
;
```

6. Save the updated version by pressing [ALT] + [F6] and [Y] at the prompt

VIII. RUNNING THE PROGRAM (CONSULTING)

The expert system is now complete and can be executed. The file named <ASPHALT4.KBS> contains the 12 RULES of the knowledge base in addition of the USER INTERFACE COMMANDS and the ACTIONS block. To run the program follow these steps:

1. Press function key [F6]
2. Select <ASPHALT4.KBS>
3. Press function key [F4]. The screen will be cleared
4. Press function key [F2]. The program will begin to run. At the top of the screen the message contained in the first ASK statement will be displayed, followed by the options provided in the first CHOICES statement. The user is required to select the value of the PAVEMENT_SURFACE variable
5. Use the arrow keys to select LEVEL
6. Press the [Enter] key. A small triangle will appear to the right of LEVEL
7. Press the [End] key. The program will now display the message contained in the second ASK statement, followed by the options provided in the respective CHOICES statement. The user is required to select the value of the MAT variable
8. Use the arrow keys to select COMPACTED_EDGES
9. Press the [Enter] key
10. Press the [End] key. The program finishes execution of the knowledge base.

At the end of the consultation, the program will not display the values of LEAD and TAIL because their display was not indicated in the knowledge base.

IX. UPDATING THE PROGRAM

To make the program more user friendly by displaying messeges, follow these steps:

1. Press function key [F3]
2. Move the cursor to the line containing the semicolon before RULE 1 using the arrow keys
3. Insert a line after by pressing [Ctrl] and [Enter] keys at the same time
4. Move the cursor to the line above the semicolon (;)
5. Type the following line:

   DISPLAY "ADVICE: {TAIL} TAIL CROWN AND {LEAD} LEAD CROWN"

   The value of the TAIL and LEAD variables will be inserted between the brackets {}
6. Save the updated file: [ALT] + [F6] and [Y]

The file called <ASPHALT5.KBS> contains the updated version of the knowledge base including RULES, USER INTERFACE COMMANDS, ACTIONS BLOCKS and DISPLAY statements. To run follow these steps:

1. Press function key [F6]
2. Select <ASPHALT5.KBS>
3. Press function key [F4]
4. Press function key [F2]
5. Use the arrow keys to select LEVEL
6. Press the [Enter] key
7. Press the [End] key
8. Use the arrow keys to select COMPACTED_EDGES
9. Press the [Enter] key
10. Press the [End] key. The program will now display the following message:
    "DO NOT ADJUST TAIL CROWN AND DECREASE LEAD CROWN"

X. TRACING THE CONSULTATION

This command causes VP-Expert to record the consultation so it can be displayed as a text or graphic tree using the **Tree** option on the Main Menu. Tracing lets the system developer to understand how the goals are obtained. To trace the consultation do the following steps:

1. Press function key **[F6]**
2. Select <ASPHALT5.KBS>
3. Press function key **[F4]**
4. Press function key **[F6]** (Set)
5. Now press function key **[F2]** to select **Trace**. The following message will appear: *"Trace is on"*
6. Now, choose Quit **[F6]** to return to the Main Menu
7. Press function key **[F2]** to start the consultation
8. Select LEVEL for the *Pavement surface*
9. Select COMPACTED_EDGES for the *Mat appearance*
10. After finishing the consultation select **[F8]** to return to the Main Menu
11. Now press function key **[F5]** to select the **Tree** option. A new menu appears at the bottom of the screen. The **Text** command displays a text tree while the **Graphics** command displays a graphic representation of the consultation
12. Press function key **[F2]** to view the text tree
13. Abandon this file by pressing the keys **[ALT]+[F8]** then **[Y]** at the prompt. The Tree Menu will reappear at the bottom of the screen
14. Now press the function key **[F3]** to view the graphics tree. The screen will be cleared and a small graphics tree will appear at the top left corner.
15. Zoom the graph by pressing the **[Space Bar]** key
16. Use the arrow keys to browse through the graph
17. After viewing how the system found the goals, press the **[Esc]** key to quit. The Tree menu will reappear at the bottom of the screen
18. Select function key **[F4]** to return to the Main Menu

XI. THE EXPERT SYSTEM THINKING PROCESS

The consultation just performed used a single consultation window, which is typical of an "end user", or "runtime" consultation. However, when developing an expert system, there are two more windows you can use: the *Rules window* and the *Values window*.

The *Rules window*, in the lower left portion of the screen, provides a window to the knowledge base. It allows the developer to observe the activity of the *VP-Expert* "inference engine" (in effect, the intelligence of the expert system) as it interacts with the knowledge base during a consultation.

The *Values window*, in the lower right corner of the screen, notes the values --both intermediate and final-- derived during the course of the consultation.

To run the consultation that displays the Rules and Values windows, follow these steps:

1. Press function key **[F6]**
2. Select <ASPHALT6.KBS>
3. Press function key [F3]. Observe that the **RUNTIME** command has been deleted from the knowledge base
4. Abandon the Edit mode by pressing the keys **[ALT]+[F8]** then **[Y]** at the prompt
5. Run the consultation by pressing the function key **[F4]** then **[F2]**. This time a three-window consultation appears
6. Make selections as desired. Observe the rules that the system executes and the values it assigns to the variables
7. At the end of the consultation press function key **[F8]**

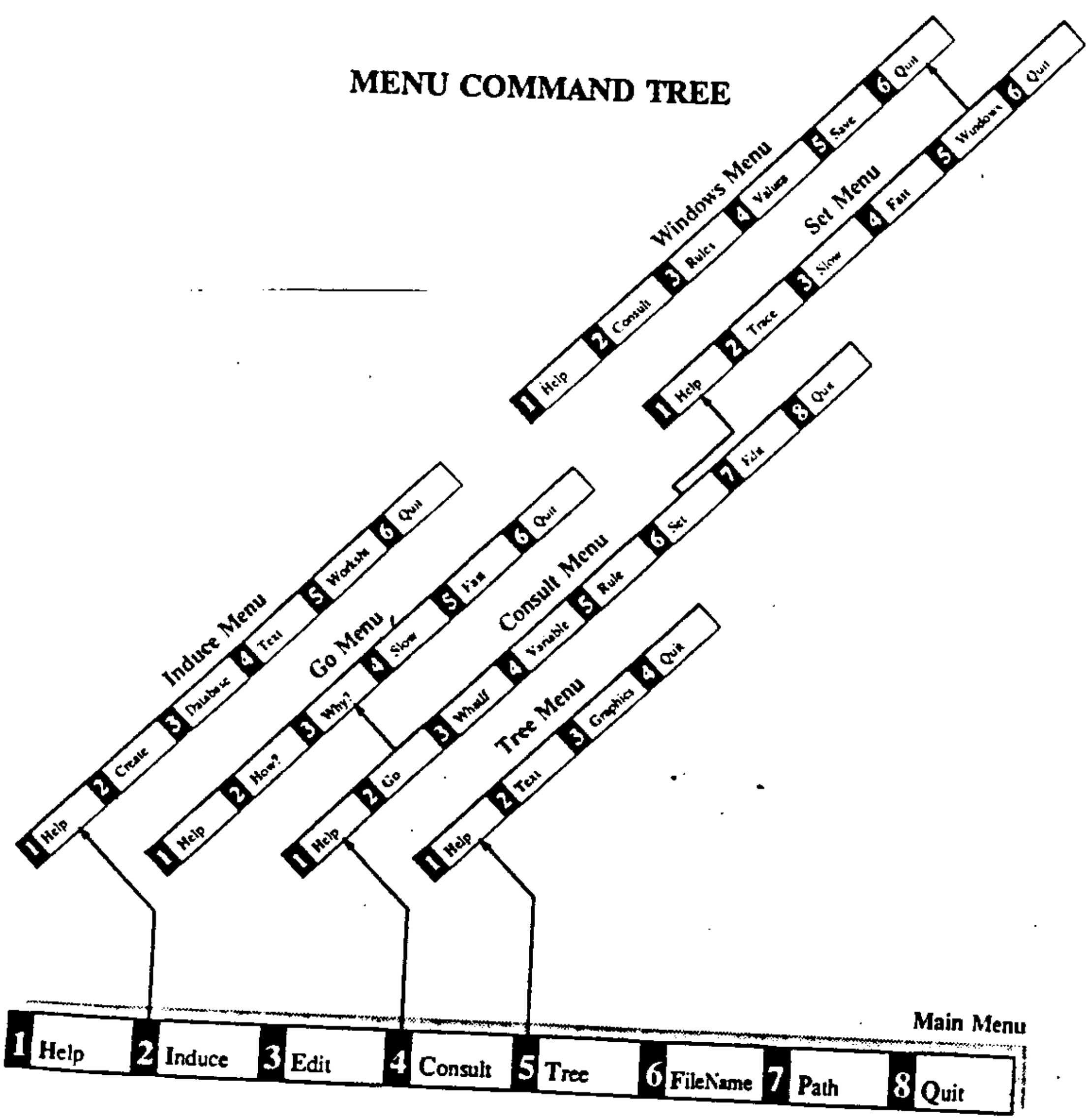
```
RUNTIME;
ACTIONS
FIND LEAD
FIND TAIL
DISPLAY "ADVICE: {TAIL} TAIL CROWN AND {LEAD} LEAD CROWN"
;

RULE 1
        IF      PAVEMENT_SURFACE = HUMPED
        THEN    TAIL = REDUCE;

RULE 2
        IF      PAVEMENT_SURFACE = CONCAVE
        THEN    TAIL = INCREASE;

RULE 3
        IF      PAVEMENT_SURFACE = HUMPED AND
                MAT = COMPACTED_CENTER
        THEN    LEAD = INCREASE;

RULE 4
        IF      PAVEMENT_SURFACE = HUMPED AND
                MAT = COMPACTED_EDGES
        THEN    LEAD = DECREASE;

RULE 5
        IF      PAVEMENT_SURFACE = HUMPED AND
                MAT = UNIFORM
        THEN    LEAD = DO_NOT_ADJUST;

RULE 6
        IF      PAVEMENT_SURFACE = LEVEL
        THEN    TAIL = DO_NOT_ADJUST;

RULE 7
        IF      PAVEMENT_SURFACE = LEVEL AND
                MAT = COMPACTED_CENTER
        THEN    LEAD = INCREASE;
```

```
RULE 8
        IF      PAVEMENT_SURFACE  =  LEVEL AND
                MAT  =  COMPACTED_EDGES
        THEN    LEAD  =  DECREASE;

RULE 9
        IF      PAVEMENT_SURFACE  =  LEVEL AND
                MAT  =  UNIFORM
        THEN    LEAD  =  DO_NOT_ADJUST
                TAIL  =  DO_NOT_ADJUST;
RULE 10
        IF      PAVEMENT_SURFACE  =  CONCAVE AND
                MAT  =  COMPACTED_CENTER
        THEN    LEAD  =  INCREASE;
RULE 11
        IF      PAVEMENT_SURFACE  =  CONCAVE AND
                MAT  =  COMPACTED_EDGES
        THEN    LEAD  =  DECREASE;
RULE 12
        IF      PAVEMENT_SURFACE  =  CONCAVE AND
                MAT  =  UNIFORM
        THEN    LEAD  =  DO_NOT_ADJUST;

ASK     PAVEMENT_SURFACE: "WHAT IS THE SURFACE
        CONTOUR OF THE PAVING LINES?";

CHOICES     PAVEMENT_SURFACE: HUMPED,LEVEL,CONCAVE;

ASK     MAT: "WHAT IS THE APPEARANCE OF THE PAVING
        MAT?";

CHOICES     MAT: COMPACTED_CENTER, COMPACTED_EDGES,
        UNIFORM;
```

MANDATORY FORMATTING RULES

- The ACTIONS block must begin with the word **ACTIONS**-- in upper, lower, or mixed case
- Rules must begin with the keyword **RULE** followed by a space and a label that does not exceed 40 characters
- Spaces are not allowed in rule labels, variable names, or values
- Text specified statements that create on-screen messages (e.g., **ASK**, **DISPLAY**, etc.) must be in double quotes (")
- The ACTIONS block, rules, and statements must end with a semicolon (;)
- *"Comment Lines"* in the knowledge base (i.e., lines which should be ignored by the inference engine) must begin with an exclamation mark (!)

MENU COMMAND TREE



Expert Systems in Construction

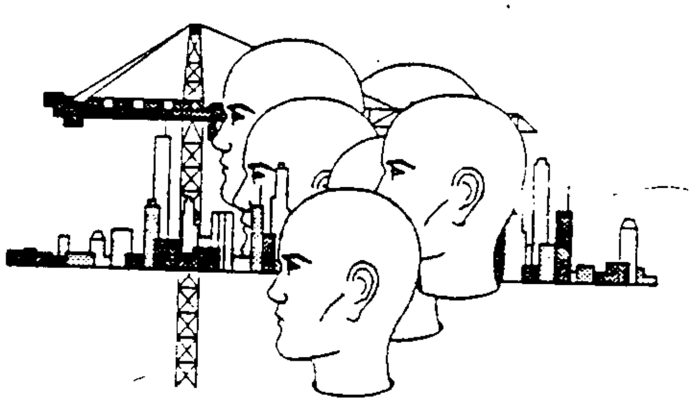
A One-Day Workshop

Presented by

The Department of Construction Management of
the College of Engineering and Design at
Florida International University

through a grant from the

Building Construction Industry Advisory Committee
and
the Department of Education of the State of Florida



April 26, 1991

WORKSHOP DESCRIPTION

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This one-day workshop involves lectures, case studies, and actual hands-on computer use of simple construction expert systems using a demonstration expert systems program.

SPONSORSHIP

This workshop is sponsored by the State of Florida Building Construction Advisory Committee, via a grant funded by the State of Florida Dept. of Education.

BUILDING CONSTRUCTION INDUSTRY ADVISORY COMMITTEE

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FLORIDA INTERNATIONAL UNIVERSITY

Florida International University, a member of the State University System of Florida, is a comprehensive, doctoral granting, public, multi-campus institution offering a broad array of undergraduate, graduate and professional programs. Through its 12 colleges and schools, FIU offers more than 180 baccalaureate, master's, and doctoral degree programs, conducts basic and applied research, and provides public service.

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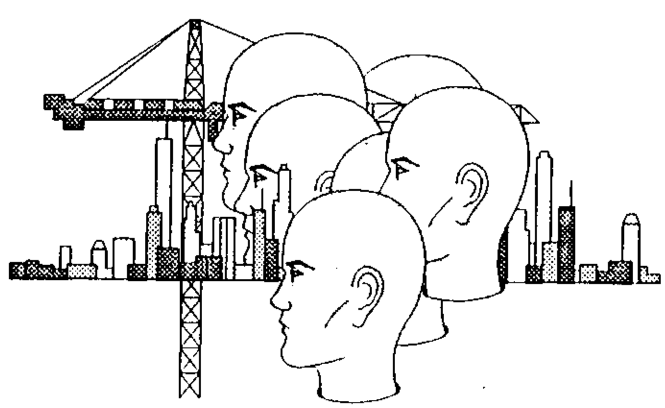
Presents

A One-Day Workshop on

EXPERT SYSTEMS IN CONSTRUCTION



December 14, 1990

WHAT ARE EXPERT SYSTEMS ?

An expert system is a computer program designed to serve as a tool for supporting decision making. Expert systems have an almost unlimited number of applications in construction. They include estimating, planning, permiting, crew and equipment configuration, and many others. Development and use of new technologies such as robotics and construction expert systems are possible ways to arrest and reverse the decades long trends of low productivity and ever shrinking profit margins in the U.S. construction industry.

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WHO SHOULD ATTEND

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WORKSHOP AGENDA

8:30- 9:00	Registration
9:00- 9:45	Basic Concepts
	History of AI and ES's
	Architecture of ES's
	Knowledge Representation
	Control Strategies in ES's
	ES's Development Process
9:45-10:15	Construction Applications
	Planning and Scheduling
	Estimating
	Claims Analysis
	Construction Advisors
10:15-10:30	Break
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	Site Condition Claims
	Foundation Safety
	Diagnosis of Retaining Walls
12:00- 1:30	Lunch (on your own)
1:30- 3:00	Create a Sample Expert System
3:00- 3:15	Break
3:15- 4:00	Robotics in Construction
4:00- 4:45	Future Trends
	Hardware Technology
	Software Technolgy
	Potential Applications
	Discussion

LOCATION

The workshop will be held on the FIU, University Park campus in the VH building, Room 301 (School of Design Computer Lab).

REGISTRATION

There is a $20.00 charge for handout materials. Registration should be made in advance by completing the registration form attached to the Department of Construction Management, FIU, VH 230, University Park, Miami, FL 33199. Attendance at the workshop will be limited to 30 participants. For questions, please call (305) 348-3172 during working hours (8:30 to 4:30). Attendees will receive continuing education units (CEU's) and a certificate of completion.

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(This document was printed using funds from BCIAC grant number CE 89-2)

EXPERT SYSTEMS SEMINAR ENROLLMENT

December 14, 1990

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Metro Dade Fire Department
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Miami, Fla. 33173

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Miami, Florida, 33173

Deborah Friberg
Metro Dade Parks Department
11395 S.W. 79 Street
Miami, Florida, 33173

Wilfredo Fernandez
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Hialeah, Florida, 33013

Richard Johns
Metro Dade Parks Department
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Miami, Florida, 33173

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Miami, Florida, 33177

Dewey Stine
Metro Dade Parks Department
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Miami, Florida, 33173

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Coral Gables, Florida, 33134

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Arthur Gower
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Miami Beach, Florida, 33139

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Ft. Lauderdale, Florida, 33315

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Miami Beach, Florida, 33139

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Miami Beach, Florida, 33139

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Miami, Florida, 33174

Jorge Leon
GUI International, Inc.
4108 Laguna
Coral Gables, Florida, 33143

Department of Construction Management
University Park
Florida International University
Miami, Florida 33199

Stamp

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Presents

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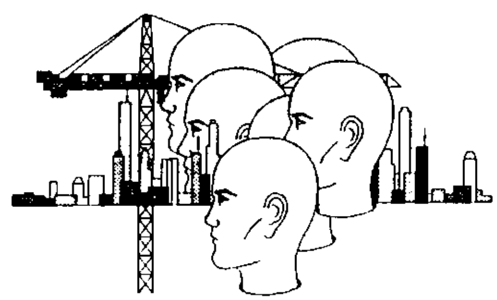

March 15, 1991

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WHO SHOULD ATTEND

This workshop is intended for any person involved in construction or construction related activities.

REGISTRATION FORM
EXPERT SYSTEMS IN CONSTRUCTION
March 15, 1991

Please register the following person(s) for the workshop:

Name ______________________ Position ______________

Name ______________________ Position ______________

Organization ______________________ Phone ______________

Address ____

City ______________ State ______ ZIP ______________

Mail Registration Form and Check of $20.00 to:

Department of Construction Management, VH-230, University Park, FIU, Miami, Florida, 33199

Phone: (305) 348-3172, Fax: (305) 348-2766.

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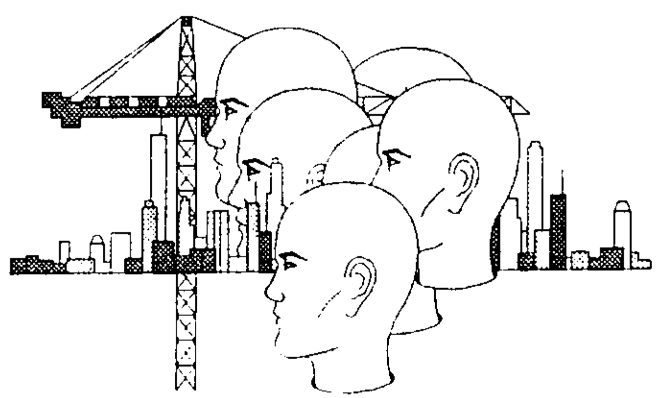

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Phone: (305) 348-3172, Fax: (305) 348-2766.

March 15, 1991

Stuart C. Aasen
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Miami, Florida, 33183

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#203
North Miami Beach, Florida, 33179

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Miami, Florida, 33170

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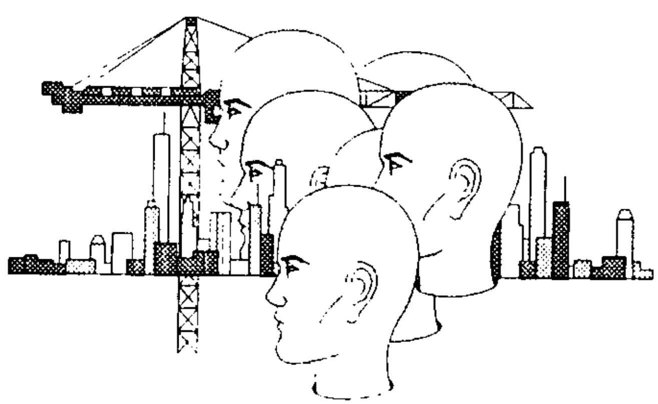

April 26, 1991

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April 26, 1991

Nauret Riverol
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Alina Vieta
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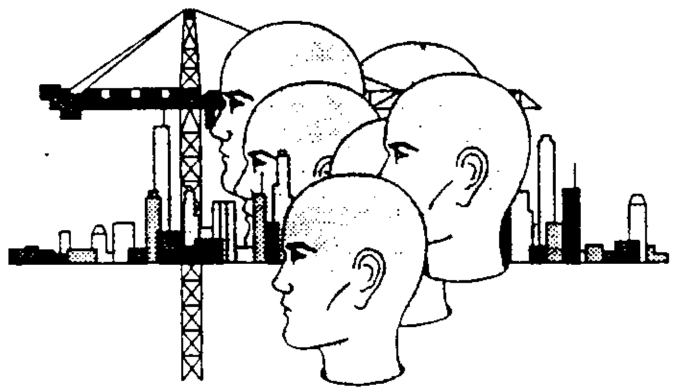
Mario Alfaro
11113 S.W. 3 Street
Miami, Florida, 33174

A Typical Workshop : Expert Systems in Construction.

A One-Day Workshop on

EXPERT SYSTEMS IN CONSTRUCTION



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8:30 - 9:00	Registration
9:00 - 9:45	Basic Concepts
9:45 - 10:15	Construction Applications
10:15 - 10:30	Break
10:30 - 12:00	Demonstration of E.S.
12:00 - 1:30	Lunch
1:30 - 3:00	Create a Sample E.S.
3:00 - 3:15	Break
3:15 - 4:00	Robotics in Construction
4:00 - 4:45	Discussion: Future Trends

BUILDING CONSTRUCTION INDUSTRY ADVISORY COMMITTEE
AND
DEPARTMENT OF EDUCATION OF THE STATE OF FLORIDA

EXPERT SYSTEMS IN CONSTRUCTION

Purpose

The purpose of the course and workshop is to introduce the theory and application of the emerging field of expert systems to construction industry practitioners at all levels. The course explains the theory of artificial intelligence (AI) in simple terms and language and how AI (expert systems and robotics) can be applied to construction for productivity improvements.

Organization of the Course

A one day lecture and workshop is considered appropriate. In the morning session, the instruction will explain the theory of artificial intelligence, using handout printed material, slides and video. The handout material is written is simple language.

The afternoon session will demonstrate simple expert systems. Participants will be instructed on developing a simple expert system. Video tapes will enhance the appreciation of expert systems and robotics.

Suggested Lecture Workshop Agenda

8:30 - 9:00	Registration
9:00 - 9:45	Basic Concepts
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TOPICS TO BE COVERED

1. Technology trends and their impact on AEC industry
2. Introduction to expert systems
3. CAD/CAE Construction applications
4. AEC software survey
5. Artificial Intelligence - application to planning and scheduling
6. Desing and Construction Automation
   Robotics Integration in Construction
7. Site layout planning using AI techniques
8. Project plans by reasoning
9. Knowledge based systems
10. Logic and reasoning approaches
11. Intelligent real time monitoring
12. Database for construction applications
13. Use of expert systems: Demonstrations

[illegible]

1. [illegible]

2. [illegible]

3. [illegible]

4. [illegible]

5. [illegible]

6. [illegible]

7. [illegible]

8. [illegible]

9. [illegible]

"hands on operation" of the expert systems
a more construction oriented simulation.

vas worth while coming to this workshop.
very useful in accruing the knowledge that
early, because people get tired after a long

organized and useful workshop that I have
thanks to FIU and organizers.

DEPARTMENT OF CONSTRUCTION MANAGEMENT

EXPERT SYSTEMS COMMENTS

MARCH 15, 1991

1. The presenters were very well prepared and knowledgeable of the subject matter.
   This is by far one of the most informative workshops I have attended.
   Perhaps expand into 1 1/2 to 2 days.

2. Many of the visuals had spelling errors.

3. This course gave some background on AI and the potential use of expert systems.
   It was difficult to see the screen while the instructor was next to it.
   I am considering the purchase of one of the expert systems programs to assist field personnel.

4. Although the general purpose was discussed, some are still not clear to me.
   The instructors are helpful in assisting especially with the computer applications.
   Because I would find participants are in some way involved in their work and related to the topics.

5. The course was my first introduction to ES and AI. The presenters conducted the workshop very well and the material built upon itself.

6. Introduction was made to all aspects and their current status was discussed.
   Provided information, no real practical value at this time.

DEPARTMENT OF CONSTRUCTION MANAGEMENT

EXPERT SYSTEMS COMMENTS

APRIL 26, 1991

1. Terrific overview of expert systems applications. I would have performed more in-depth discussions but accept time constraints and diverse interests of participants. Stimulate my interest in further investigation of expert systems applications.

2. Good idea to show students' work. Some of the theory was repeated by second lecturer. Very informative. Well worth the cost. Perhaps it should be shortened. Good idea to have frequent breaks. Since you advertise Expert Systems in Construction I would have liked to see more construction related applications.

3. Overall value was discovering a field I was not familiar with. More of this type workshops on computers.

DEPARTMENT OF CONSTRUCTION MANAGEMENT

EXPERT SYSTEMS IN CONSTRUCTION

MARCH 15, 1991
Miami, Florida

Several items will be rated on a scale ranging from 1 to 7 defined as follows:

1 Poor
2 Well Below Average
3 Below Average
4 Average (Acceptable)
5 Good
6 Very Good
7 Excellent

Please circle the numbers below which reflect your ratings.

(If there is insufficient space to answer any question, please continue on back of page).

1. Do you feel that the objectives of this workshop were met?
   Yes ___ No ___ If yes, comment: ______________________

   ____

   ____

   If no, why? ______________________________

2. Supervision and planning of the workshop was:

   1 2 3 4 5 6 7
   Poor Average Excellent

   Comments: ______________________________

   ____

   ____

3. Overall instruction was:

   1 2 3 4 5 6 7
   Poor Average Excellent

   Comments: ______________________________

   ____

   ____

4. Physical facilities were:

1	2	3	4	5	6	7
Poor			Average			Excellent

Comments: ______________________________

____

____

5. Was the material generally presented at the correct level for this group

Yes ____No____

Comments: ______________________________

____

____

6. The course visual materials were:

1	2	3	4	5	6	7
Poor			Average			Excellent

Comments: ______________________________

____

____

7. Please state the overall value of the workshop to you.

____

____

____

8. Suggestions for improvement.

____

____

____

9. What is your job title?______________________________