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A Bibliography on Knowledge-Based Expert Systems in Engineering

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A BIBLIOGRAPHY ON KNQWLEDGE-BASED EXPERT SYSTEMS IN ENGINEERING

by

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Introduction

The number of papers published in the applications of knowledge-based expert systems (KBES) to engineering problems in the last decade reflects the interest being shown in the engineering community. The intent of this report is to provide an annotated bibliography of the applications of KBES in engineering. The first four sections deal with applications in Civil (including Architecture and Geology), Chemical, Electrical and Computer, and Mechanical Engineering. Seme papers which are common to engineering design, in general, are outlined in Section 5. A number of domain independent tools are discussed in Section 6. Section 7 contains a list of books for general reading. A list of relevant conferences and journals is provided in Section a

The bibliography is by no means complete and the author would appreciate pointers to other literature in the area for inclusion in a future update. A forthcoming special issue of ACM SIGART newsletter on applications of Artificial Intelligence to engineering problems will have further references. Some of these references are taken from NTIS citations from the INSPEC data base; these references contain the word [NTIS]..

1 Architecture, Civil Engineering, and Geology

Bennett, J.$_v$ Creary, L, Engelmore, R. and Melosh, R.
SACON: A Knowledge-based Consultant for Structural Analysis
Technical Report STAN-CS-78-699, Stanford University, September 1978.

Bennett, J. and Engelmore R.
SACON: A Knowledge-based Consultant for Structural Analysis
In *Proceedings Sixth IJCAI,* pages 47-49, 1979.

SACON is an expert program that advises a structural engineer in the use of modeling options for MARC, a non-linear structural analysis program. It is implemented in EMYCIN. It does not have any interface with the analysis program.

Bonnet, A., and Dahan, C.
Oil-Well Data Interpretation Using Expert System and Pattern Recognition Techniques

[1]A number of additions have been made to the bibliography first published in SIGART newsletter, July 84.

In *Proceedings Eighth IJCAI,* pages 185-189, 1983.

LITHO, a program for interpreting oil well data is described. The output from the program is a litholog, a description of rocks encountered in a well. LITHO is being developed at Schlumberger, France. The knowledge-base contains about 500 rules.

Cobb, J. E.

A Microcomputer Approach to Contract Management Using AI

Unpublished Master's Thesis, University of Colorado, Boulder, CO, **1984.**

The knowledge-base and logic for the development of DSCAS, which is intended to provide legal advice for construction claims, is developed. Currently DSCAS is designed for "Differing Site Conditions" clause of the U. S. Government standard general conditions to a construction contract.

Cuena, J.

The Use of Simulation Models and Human Advice to Build an Expert System **for the** Defense and Control **of** River **Roods**

In *Proceedings Eigth IJCAI,* pages **246-249,1983.**

A conceptual framework for an expert system to aid in the operation of flood control and plan civil defense in flood prone areas is provided. The rules are described based on a set of mathematical models. System currently pursued by Spanish Ministry of Public **Works.**

David, H.

An Analysis of Expert Thinking

International Journal Man-Machine Studies, **Vol. 18, pages 1-47., 1983.**

Deals with how human experts acquire, understand and use knowledge in the domain of geology, in particular petroleum geology.

Davis, R. et al

The Dipmeter Advisor: Interpretation of Geologic Signals

In *Proceedings Seventh IJCAI,* **pages 846-849,1981**.

Paper presents a feasibility study on the use of **expert** systems for well log analysis. **The** paper published in the eighth IJCAI describes a more recent implementation.

Duda, R. O., Gaschnig, J. and Hart, P. E.

Model Design in the Prospector System for Mineral Exploration

In Michie, D. (editor), *Expert Systems in the Micro Electronic,Age*, **pages 153-167, University of Edinburgh, Scotland, 1979.**

PROSPECTOR aids the geologist to select mineral deposits. Currently it has more than 1000 rules in its knowledge-base.

Eastman, C. M.

Automated Space Planning

***Artificial Intelligence* Vol. 4, No. 1, Spring 1973.**

One of the first papers that addresses the application of heuristics to space planning.

Fenves, S. J. and Rehak, D. R.

Role of Expert Systems in Construction Robotics

Presented at the *Workshop Conference on Robotics in Construction,* ***Carnegie-Mellon University,*** **Pittsburgh, PA, USA, June 17-20,1984.**

Potential applications of KBES in construction **robotics are explored.**

Describes the implementation details of the Differing Site Condition Analysis System (DSCAS), which is implemented in ROSIE. See reference by Cobb.

Lansdown, J.

Expert Systems: Their Impact on the Construction Industry
RIBA Conference Fund, U. K., 1982.

Presents a number of potential applications for KBES in the construction industry.

Lopez, L. A., Elam, S. L, and Christopherson, T.

SICAD: A Prototype Implementation System for CAD
In *Proceedings of the ASCE Third Conference on Computing in Civil Engineering,* San Diego, California, pages 84-93, **April 1984.**

Describes a framework for the development of a KBES for providing an interface between standards governing engineering design and CAD programs.

MacCallum, **K. J.**

Creative Ship Design by Computer
In Rogers, D. F., Nehrling, B. C. and Kuo, C. (editors), *Computer Applications in the Automation of Shipyard Operation and Shipyard Design IV,* IFIP82, **North-**Holland Publishing Company, **1982.**

MacCaJlum, K. J.

A Knowledge-base for Engineering Design Relationships
In *Expert Systems 82,* Technical Conference of the BCS SGES, U. **K.,** 1982.

Deals with the development of a KBES for ship design. Also attempts to incorporate an element of learning in the system.

Manheim, M. L.

HIERARCHICAL STRUCTURE: A Model of Design and Planning Processes
MIT Press, Cambridge, Mass., 1966.

The concept of hierarchical design **was** first implemented by Manheim for determining **highway** locations. A classical **work in the area.**

Markusz, Z.

Design in Logic
***Computer Aided** Design,* **Vol. 14, No. 6, Pages 335-343, November 1982.**
(other references to this work can be found in *Logic Programming* **Clark, K. L. and Tamlund, S. A. (editors), Academic Press, 1982.)**

Describes the use of logic in architectural design. Implementation language is PROLOG.

Metosh, R. J., Marcal, P. V. and Berke, L.

Structural Analysis Consultation using Artificial Intelligence
In *Research in Computerized Structural Analysis and Synthesis,* **NASA, Washington, D. C, October 1978.**

Illustrates an application of **SACON.**

Ohsuga, S.

A New Method of Model Description - Use of Knowledge Base and Inference
In Bo, K. and Lillehagen, F. M. (editors), *CAD Systems Framework,* IFIP83, **North-Holland Publishing Company, 1983.**

Fjellheim, R. and Syversen, P.

An Expert System for SESAM-69 Program Selection

Computas Report 83-6010, January 1983. (A. S. Computas, P. O. Box, 310, 1322 HOVIK, Norway)

Describes an expert system front end for a large finite element program SESAM-69, developed by A. S. Computas. Patterned after SACON. Implemented in EMYCIN.

Gaschnig, J., Reboh, R. and Reiter, J.

Development of a Knowledge-Based Expert System for Water Resource Problems

Technical Report SRI Project 1619, SRI International, August 1981.

Describes an intelligent interface (HYDRO) for selecting numerical values of parameters that are input to a simulation program (HSPF).

Gero, J. S. and Coyne, R.

The Place of Expert Systems in Architecture

In *Proceedings CADD-84,* **U. K.f 1984.**

An introduction to expert systems, along with some prototype applications. Implications to synthesis are explored.

Hammond, P. and Howarth, R.

***A** Rule-Based Approach to Geological Knowledge*

Research Report, Imperial College of Science and Technology, U. K., 1984.

Consists of two knowledge-bases. The first one was directly transferred from PROSPECTOR, while second was written by an expert for determining the suitability of sites for dam construction. Implemented in PROLOG.

Hollander, C. R., Iwasaki, Y.f Courteille, J-M., Fabre, M.

The Drilling Advisor

In *Proceedings of Trends and Applications on Automating Intelligent **Behavior: Applications and Frontiers,*** **pages 21-27, May 1983.**

Provides diagnosis and therapy for problems encountered by the drilling mechanism while drilling. Currently the system has around 250 rules for diagnosing possible problems associated with the drill being stuck *in* the bore hole. It is implemented in KS300, a copyrighted version of EMYCIN.

Ishizuka, M., Fu, K. S. and Yao, J. T. P.

Inexact Inference for Rule-based Damage Assessment of** Existing **Structures

Technical Report CE-STR-81-5, Purdue University, February 1981 (also see Seventh IJCAI proceedings).

Ishizuka, M., Fu, K. S. and Yao, J. T. P.

Rule-based Damage Assessment System for Existing Structures

***SM Archives* Vol. 8, pages 99-118, Martinus Nijhoff Publishers, The Hague, 1983.**

The above two papers describe SPERIL-I, a rule-based expert system. SPERIL-I addresses the issue of damage assessment of structures after earthquakes and other possible hazardous events.

Kruppenbacher, T. A.

The Application of Artificial Intelligence To Contract Management

Unpublished Master's Thesis, University of Colorado, Boulder, CO, 1984 (also US Army Corps of Engineers CERL, Technical Manuscript P-166, August 1984).

University, Rochestor, MI, April 1983 (For an extended version see Computers and Structures, January 1985)

Applications of KBES to various phases of structural design are discussed.

Stanford, G.

Potential Applications of Expert Systems in Geotechnical Engineering
Master's Thesis, Department of Civil Engineering, Carnegie-Mellon University, April, 1983.

Potential applications in geotechnical engineering, specifically in the domain of Landslide engineering, are addressed. The author also relates his experience of knowledge acquisition from a domain expert and from literature.

Weiss, S. M. and Kulikowski, C. A.

Building Expert Programs for Controlling Complex Programs
In *Proceedings 2nd NCAI*, pages 322-326, 1982.

A KBES for well log analysis is described.

2 Chemical Engineering and Material Sciences

Banares, R.

Development of a Consultant for Physical Property Predictions
Master's Thesis, Department of Chemical Engineering, Carnegie-Mellon University, May 1982.

A KBES for selecting appropriate analytic program that is used to evaluate the physical properties of certain chemical substances is described.

Basden, A. and Kelly, B. A.

An Application of Expert Systems Techniques in Materials Engineering
In *Proceedings Colloqium on Application of Knowledge-Based Systems*, London, U. K., 1982 (See also International Jl. of Man-Machine Studies).

Describes a prototye KBES to predict the risk of stress corrosion cracking.

Chester, D. L., Lamb, D. E. and Dhurjati, P.

An Expert System Approach to On-line Alarm Analysis in Power and Process Plants
In *Proceedings Computers in Engineering, A. S. M. E.*, pages 345-351, August 1984, Las Vegas, Nevada.

FALCON, currently under development, is a KBES for diagnosing faults in a process plant. It combines both the causal model and the (surface) production rule approach. Implementation language is Franz LISP.

Grimes, L. E., Rychener, M. and Westerberg, A. W.

The Synthesis and Evolution of Networks of Heat Exchange that Feature the Minimum Number of Units
Chemical Engineering communications, Vol. 14, 1982.

HEATEX aids in the construction of networks that minimize energy requirements by allowing the exchange of heat among various process streams.

Lindsay, R., Buchanan, B., Feigenbaum, E. and Lederberg, J.

Applications of Artificial Intelligence for Chemical Inference : The Dendral Project

A methodology to represent the model building process in building design is proposed. Knowledge is represented in terms of expanded predicate logic and interfaced with a relational database.

Rehak, D.

Expert Systems in Water Resource Management
In James, W. and Torno, H. (editors), *Proceedings ASCE Conference on Emerging Techniques in Storm Water Flood Management,* Niagara on the Lake, Ontario, Canada, October 31 - November 4,1983.

Current systems in water resource management are described.

Rehak, D. and Lopez, L. A.

Computer-AidedEngineering:ProblemsandProspects
Civil Engineering System Laboratory Research Series 8, University of Illinios, July 1981.

Potential use of KBES for the development of an integrated structural design system is addressed.

Rivlin, J. M., Hsu, M. B. and Marcal, P. V.

Knowledge-basedConsultantforFiniteElementAnalysis
Technical Report AFWAL-TR-80-3069, Flight Dynamics Laboratory (FIBRA), Wright-Patterson Airforce, May 1980.

A KBES implemented in FORTRAN and interfaced to the MARC non-linear analysis program.

Radford, A. D., Hung, P. and Gero, J. S.

New Rules of Thumb from Computer-Aided Structural Design: Acquiring Knowledge for Expert Systems
In *Proceedings CADD-84,* U. K.$_f$ 1984.

Pareto's optimization technique is proposed as an aid to the knowledge-acquisition process and illustrated using the floor system design as a paradigm.

Smith, R. G., and Baker, J. D.

The Dipmeter Advisor System: A Case Study in Commercial Expert System Development
In *Proceedings Eigth IJCAI,* pages 122-129,1983.

The development of Dipmeter Advisor, a KBES for ofl-weH interpretation, is described. Dipmeter Advisor is being developed by Schlumberger-Doll research, Connecticut, U.S.A.

Sriram, D., Maher, M. L, BieJak, J. and Fenves, S. J.

Expert Systems for Civil Engineering - A Survey
Technical Report R-82-137, Department of Civil Engineering, Carnegie-Mellon University, June 1982.

Written as an introduction to KBES for civil engineers. A number of current expert systems, KBES building tools and potential applications in structural and geotechnical engineering are described.

Sriram, D., Maher, M. and Fenves, S

Applications of Expert Systems in Structural Engineering
In *Proceedings Conference on Artificial Intelligence,* pages 379-394, Oakland

A number of interesting concepts in design are presented. Palladio is an attempt to provide an integrated design environment for circuit design.

Birmingham, W. P.

MICON: A Knowledge Based Single Board Computer Designer
Research Report No. CMUCAD-83-21, SRC-CMU Center for Computer-Aided Design, December 1983.

MICON designs a single board computer from hardware requirements. Implemented in OPS5.

Cantone, R. R., Pipitone, F. J., Lander, B., and Marrone, M. P.

Model-based Probabilistic Reasoning for Electronic Troubleshooting
In *Proceedings Eigth IJCAI,* pages **207-211,1983.**

IN-ATE is a KBES for guiding the novice technician through electronic trouble-shooting. It is being developed at the Naval Center for Applied Research, U. S. A. The paper discusses a technique to automatically produce a binary decision tree of test points to be checked by the technician.

Chen, S.

On Intelligent CAD Systems for VLSI Design
In *Proceedings IEEE International Conference on Computer Design: VLSI in Computers,* **pages 405-407, New York, 1983.**

Issues in the applications of KBES to VLSI design are discussed. Distributed KBES are proposed for VLSI design.

[Chip]

Expert System
CHIP (Germany), No. 8, pp. 52-4, August 1984 [NTIS].

Describes a prototype KBES, being developed on a 16 bit microprocessor, currently under development at NIXDORF, a German computer manufacturer.

Davis, R.

Diagnosis Via Causal Reasoning: Paths of Interaction and the **Locality Principle**
In *Proceedings 3rd NCAI,* **pages 88-94, Washington, D. C, 1983. (See also IEEE Computer, October 1983, Int. Journal of Man-Machine Studies, November, 1983 and Proceedings of 4th NCAI)**

Implementation of a KBES exploiting the causality in electrical circuits is described. The concept of *locality* is used to explain the reason for the difficulty of diagnosing bridge faults and for the need for multiple representations.

de Kleer, J.

Causal and Teleogical Reasoning in Circuit Recognition
Phd Thesis, M. I. T., AI Laboratory, 1979 (also AI MEMO TR - 529).

Dinbas, M.

A Knowledge-based Expert System for Automatic Analysis and Synthesis in CAD
In *Proceedings IFIPS Congress,* pages 706-710,1980.

PEACE, a KBES for analysis and synthesis of electronic circuits, is described.

Freeman, M., Hirschman, L, McKay, D., Miller, F., and Sidhu, D.

Logic Programming Applied to Knowledge-based Modeling and Simulation

McGraw-Hill Book Company, 1980

DENDRAL is a KBES, written in INTERLISP, that aids the chemist in the determination of the molecular structure of organic compounds. It proved the feasibility of developing KBES and laid the foundation for the development of a large number of rule-based expert systems.

Peate, J.

Building Human Judgement into Computer Programs
Process Engineering, January 1984.

A general discussion on the potential applications of KBES in chemical engineering.

Powers, G. J.

Non-numerical Problem Solving Methods in Computer-Aided Design
In *IFIPS Conference on Computer-Aided Design*, Eindhoven, The Netherlands, 1972.

Outlines applications of AI techniques to design.

3 Electrical and Computer Engineering

Bellon, C., Robach, C., and Saucuer, G.

An Intelligent Assistant for Test Program Generation: The SUPERCAT system
In *Proceedings IEEE International Conference on Computer-Aided Design*, pages 32-33, September 1983.

A conceptual framework for a KBES to assist in generating test programs for complex VLSI circuits.

Basden, A. and Kelly, B. A.

DART: An Expert System for Computer Fault Analysis
In *Proceedings Seventh IJCAI*, pages 843-845, 1981.

DART is designed to provide advice to IBM filed personnel on diagnosis in computer installations. Implemented in EMYCIN.

Bowen, J. A.

Automated Configuration of Backplane-based Microcomputers
In *Proceedings CADD-84*, U. K., 1984.

A program that automates the design of hardware for a dedicated microprocessor is described.

Brodsky, S. and Tyle, N.

Knowledge-based Expert Systems for Power Engineering
In *Proceedings of the 15th Pittsburgh Modeling and Simulation Conference*, Pittsburgh, April 1984.

Paper presents a brief review of the development and application of expert systems in areas related to electric power engineering. The specific examples discussed include nuclear power plant monitoring, power system restoration and hydro-electric plant design. In addition, several problems are examined as candidates for future expert systems.

Brown, H., Tong, C., and Foyster, G.

Palladio: An Exploratory Environment for Circuit Design
Computer, Vol. 16, No. 12, pages 41-58, December 1983.

King, J. J.

Artificial Intelligence Techniques for Device Trouble Shooting
Technical Report CSL-82-9 (CRC-TR-82-004), Hewlett-Packard Company, August 1982.

This report addresses the current state of art of AI in electronic device troubleshooting with a comparison with conventional fault analysis.

King, J. J.

An Investigation of Expert Systems Technology for Automated Troubleshooting of Scientific Instrumentation
Technical Report CSL-82-12 (CRC-TR-82-007), Hewlett-Packard Company, August 1982.

KBES methodology is applied to troubteshoot a gas chromatograph/mass spectrometer, concentrating on a failure mode called radio frequency overdrive.

Knapp, D., Granacki, J. and Parker, A.

An Expert Synthesis System
In *Proceedings IEEE International Conference on Computer-Aided Design,* **pages** 32-33, September **1983.**

Describes the architecture of a KBES for synthesis of VLSI designs. The system has four modules: a knowledge-base of design techniques, a data structure representing the hardware being designed, a history of the design process, and a man-machine interface.

Kowalski, T. and Thomas, D.

The VLSI Design **Automation** Assistant: **Prototype System**
In *Proceedings 20th Design Automation Conference,* **pages 479-483 IEEE-ACM, Miami, 1983.**

The VLSI DAA uses temporarily ordered subtasks to allocate VLSI subsystems. The input to the system is an algorithmic dataflow description of a VLSI system and the output is a list of technology-independent registers, operators, data paths and control signals.

Krueger, M. W., Cullingford, R. E. and Bellavance, D. A.

Control Issues in a Multiprocess Computer-Aided Design System Containing Expert Knowledge
In *Proceedings of the IEEE International Conference on Cybernetics and Societyi* pages 139-143, Atlanta - Georgia, 1981 [NTIS].

Describes CAOHELP, a KBES for the design of digital logic circuits. Scripts are used to generate explanation of text and graphic demonstrations.

Lenat, D. B., Sutherland, W. L, and Gibbons, J.

Heuristic Search for New Microcircuit Structures: An Application of Artificial Intelligence
***The AI Magazine,* pages 17-33, Summer 1982.**

The knowledge-acquisition bottleneck in expert system development can be removed if the system learns to augment its knowledge-base. EURISKO, a system that learns by discovery, is applied to the synthesis of semiconductor devices.

Maclean, C. and Wilde, P.

Knowledge-based Electronic Circuit Diagnosis
In *Proceedings Expert Systems 83,* Technical Conference of the BCS SGES, Cambridge, U. K., December 198a

In *Proceedings Conference on Artificial Intelligence,* pages 177-193, **Oakland University, Rochester, MI, April 1983.**

Prolog is used to develop an automated configurer for Burroughs main frame computers.

Fujita, T. and Goto, S.

A Rule-based Routing System

In *Proceedings IEEE International Conference on Computer Design: VLSI in Computers,* **pages 451 -454, New York, 1983.**

An interactive routing system is described. The designer's knowledge is represented in clause form of first order predicate logic.

Fusaoka, A., Seki, H. and Takahashi, K.

Description and Reasoning of VLSI Circuit in Temporal Logic

New Generation Computing, **Vol. 2, pages 79-80,1984.**

A method for describing and reasoning about the behavior of VLSI circuits within the - framework of extended temporal logic is described.

Hartely, R. T.

CRIB: Computer Fault-Finding Through Knowledge Engineering

***Computer,* pages 76-83, March 1984.**

Describes the development of a system for computer fault diagnosis.

Horstmann, P. W.

Expert Systems and Logic Programming for CAD

VLSI Design, **pages 37-46, November 1983.**

(see also the paper in 21 st Design Automation Conference, pages 144-151)

Logic programming is applied to solve VLSI design problems in the areas of design for testability, functional simulation, fault diagnosis, and automatic test generation. PROLOG was used to implement a prototype system for design for testability.

Genesereth, M. R.

Diagnosis using Hierarchical Design Models

In *Proceedings 2nd NCAI,* pages 278-283, Pittsburgh, 1982.

The hierarchy inherent in most computer systems is used to develop a KBES. The use of this hierarchy helps to reduce the search space.

Grinberg, M. R.

A Knowledge-based Design System for Digital Electronics

In *Proceedings 1st NCAI,* pages 283-285, Stanford, 1980 (also University of Maryland, Phd thesis).

Semi-Automatfc Digital Designer (SADD) uses the idea of structured modular circuit design using an interactive user interface. The design is divided into three phases: 1) specification acquisition; 2) circuit design; and 3) circuit simulation.

Kirn, J. and McDermott, J.

TALIB: An IC Layout Design Assistant

In *Proceedings 3rd NCAI,* **pages 197-201, Washington, D. C, 1983.**

TAUB performs automatic circuit layout and interconnections by generating plan steps at different levels of abstraction spaces and opportunistically refining each plan at one level to more specific steps at the lower level.

Describes the potentials for KBES for the analysis and design of microprocessor applications. Also discusses MAPLE, a prototype system.

Stallman, R. and Sussman, Q. J.

Forward Reasoning and Dependency-directed Backtracking in a System for Computer-Aided Circuit Analysis

***Artificial Intelligence,* Vol. 9, pages 195-196,1977.**

ARS, a rule-based language, is used to implement a system for computer-aided circuit analysis. Antecedent reasoning is used to deduce facts. The deduced facts **have** associated justifications, which are used by the system in the analysis of failures and to reduce the search space.

Steinberg, L. and Kelly, V. E.

The CRITTER System: Analyzing Digital Circuits by Propagating Behaviors and Specifications

In *Proceedings 2nd NCAI,* pages 284-289, Pittsburgh, August 1982.

(see also 21st Design Automation Conference, pages 419-425).

CRITTER can reason about digital hardware designs through the use of declarative representation of the components at different levels of abstraction. It can evaluate the correctness and robustness of digital designs.

Steinberg, L. and Mitchefl, T.

A Knowledge-Based Approach to VLSI CAD: The Redesign System

In *Proceedings ACM IEEE 21st Design Automation Conference,* pages 412-418, New Mexico, 1984.

Summarizes the Rutgers AI/VLSI group's work on REDESIGN, an interactive aid for functional design of **digital** circuits.

Stefik, M., Bobrow, D., Bell, B., Brown, H., Conway, L, and Tong, C.

The Partitioning of Concerns in Digital System Design

Technical Report VLSI-81 -3, XEROX PARC, CA 94304,1981.

Discussion on the abstraction hierarchies in digital design.

Stefik, M. and Conway, L

Towards the Principled Engineering of Knowledge

***The AI Magazine*, pages 4-16, Summer 1982.**

VLSI domain is used as a paradigm for explaining the structuring of design knowledge.

Stefik, M. and de Kleer, J.

Prospects for Expert Systems in CAD

***Computer Design,* Vol. 22, No. 5, pages 65-76, April 1983 [NTIS].**

The importance of KBES for CAD is emphasized through the paradigm of digital design.

Sumner, G. C.

Knowledge-based Systems Maintenance Applications (ATE)

In *Proceedings of IEEE International Automatic Testing Conference, pages* 472-473, Fortworth - Texas, 1982 [NTIS].

Describes **the** usefulness **of** KBES **for electronic maintenance problems.**

Sussman, G. J.

Electrical Design: A Problem for Artificial Intelligence Research

McClelland, E. C, Van Home, P. R.

Fast Voltage Prediction Using a Knowledge Based Approach
***IEEE Transactions on Power Apparatus and Systems,* Vol. PAS-102, No 2, February 1983.**

The system is being **implemented** in **prototype** form on **the New** York Pool **real-time computer system.**

McDermott, J.

R1: A Rule-based Configurer of Computer Systems
***Artificial Intelligence,* Vol. 19, No. 1, pages 39-88, September 1982.**

R1 configures Vax **computer** systems. Implemented in OPS, and one **of** the **few KBES that** is **used in industry.**

Mitchell, T., Steinberg, L, Kedar-cabelli, S., Kelly, V., Shulman, J., and Weinrich, T.

An Intelligent Aid for Circuit Redesign
In *Proceedings 3rd NCAI,* Pages 274-278, Washington, D. C, 1983.

REDESIGN assists the user in redesigning electrical circuits by focusing on an appropriate portion of the circuit, generating and ranking possible changes within the circuit

Pao, Y. and Ou, S.

Rule-based Approach to Electrical Power Systems Security Assessment
In *Proceedings of IEEE Conference on Pattern and Image Processing,* pages 340-342,1981.

Shirley, M. and Davis, R.

Generating Distinguishing Tests Based on Hierarchical Models and Symptom Information
In *Proceedings IEEE International Conference on Computer Design: VLSI in Computers,* New York, 1983.

A methodology is developed to diagnose faulty components in digital hardware when a list of candidates that are likely to fail is given. A three step process is described.

Shubin, H. and Ulrich, J. W.

IDT: An Intelligent Diagnostic Tool
In *Proceedings 2nd NCAI,* pages 290-295, Pittsburgh, August 1982.

IDT was developed to identify faults in POP 11/03 computers. It helps the technician to identify the fieJd replaceable unit to fix the fault

Spaanenburg, L

Digital IC Design at Twente University
In *LSIM-83 Proceedings, 1983 University/Government/Industry Microelectronics Symposium,* pp. 47-51, Twente Univ. of Technology, Enschede, Netherlands, 1983 [NTIS].

Experiences and future enhancements towards a VLSI design assistant are described.

Smith, M. F., and Bowen, J. A.

Knowledge and Experience-Based Systems for Analysis and Design of Microprocessor Applications Hardware
***Microprocessors and Microsystems,* Vol. 16, No. 10., pages 515-519, December 1982 (see also Jl. Microcomputer Appl., Vol. 6, No. 2, pp 155-161,1983).**

In *Proceedings Eigth IJCAI,* pages 116-121,1983.

ACE was developed to aid in automated cable maintenance. It takes input from CRAS (Cable Repair Administration System) to analyze a large number (in hundreds) of telephone cable maintenance reports. It is written in 0PS4.

Williams, T. L, Orgren, P. J., and Smith, C. L.

Diagnosis of Multiple Faults in a Nationwide Communications Network

In *Proceedings Eigth IJCAI,* pages 179-181,1983.

NDS (Network Diagnostic System) is a KBES for identifying faults in a nationwide communications network (COMNET).

Zippel, R.

An Expert System for VLSI Design

In *Proceedings of the IEEE Symposium on Circuits and Systems,* pages 191-193, Newport Beach, CA, 1983 [NTIS].

Discusses the motivation for the development of a KBES for VLSI design. Also provides some guidelines for the development of this system.

4 Mechanical and Industrial Engineering

Bocquet, J. C. and Tichkiewitch. S.

An "expert system" for Identification of Mechanical Drawings

In Ellis, T. M. R., and Semenkov, O. I. (editors), *Advances in CAD/CAM,* PROLAMAT82, Leningrad USSR, May 1982, Published by North-Holland Publishing Company, 1983.

Describes an automatic methodology to transform a given Mechanical drawing into a 3-D data base. The production rule approach is used.

Bonissone, P. P.

DELTA: An Expert System to Troubleshoot Diesel Electrical Locomotives

In *Proceedings ACM,* New York City, pages 44-45, October 24-26,1983.

DELTA is a prototype KBES, implemented in FORTH, developed at General Electric Corporate R & D to troubleshoot diesei electric locomotives. It contains about 530 rules.

Bonissone, P. P.

Outline of the Design and Implementation of a Diesel Electrical Engine Troubleshooting Aid

In *Expert Systems 82,* Technical Conference of the BCS SGES, Brunei University, U. K, **14-16 September, 1982.**

Brown, D. C. and Chadrasekaran, **B.**

An Approach to Expert Systems for Mechanical Design

In *Proceedings of Trends and Applications on Automating Intelligent Behavior: Applications and Frontiers,* pages 173-180, Sponsored by IEEE and NBS, 1983.

Three categories of design are identified. The first two categories require innovation from the designer, while the third category deals with well-established design alternatives. A hierarchy of conceptual specialists is used to solve the problem in a distributed manner. An example in the area of mechanical design is presented. It is equally applicable to other areas of design.

In *Proceedings Fifth IJCAI,* pages 894-900,1977.

Intelligent recovery in a problem solver for electrical design is described. The engineering design process is recast in terms of *Problem Solving by Debugging Almost-Right Plans.* Failures are used to reduce search.

Sussman, G. J.

SLICES: At the Boundary between Analysis and Design
AI Memo 433, M. I. T., 1977.

SLICES combines the notion of equivalence, used by electrical engineers to reduce the complexity in a circuit, with identification of parameters. The system uses appropriate SLICES along with analysis by propagation of constraints to assign component values to a circuit

Sussman, G. J.' and Steele Jr., G. L.

CONSTRAINTS • A Language for Expressing Almost-Hierarchical Descriptions
Artificial Intelligence, Vol. 14, pages 1-39,1980.

Constraint propagation is used to synthesize and analyze electrical networks.

Sussman, G. J., Holloway, J. and Knight, T. E.

Design Aids for Digital Integrated Systems - An Artificial Intelligence Approach
In *Proceedings IEEE International Conference on Circuits and Computers,* October 1980.

Taylor, G. S. and Ousterhout, J. K.

Magics's Incremental Design-Rule Checker
In (Proceedings ACM IEEE 21st Design Automation Conference), pages 160-165, New Mexico, 1984.

Although, not strictly an expert system the approach presented here would be useful in the development of KBES for design.

Taylor, J. H., Frederick, D. K., and James, J. R.

An Expert System Scenario for Computer-Aided Control Engineering
In *Proceedings of the American Control Conference,* San Diego, AC, 1984.

A framework for a KBES in control system design is provided.

Tong, C.

A Framework for Circuit Design
In *Proceedings COMPCON84,* New York, February 1984.

Discusses a framework for circuit design that contains design descriptions such as *components, plans, goats,* and *tradeoffs.* Also addresses the issue of control knowledge in design. The concepts presented are also relevant in other areas of design.

Tsukiyama, M. and Fukuda, T.

An Application of Knowledge Base to Control Systems
In *Proceedings of the IEEE International Conference on Cybernetics and Society*\ pages 342-346, Atlanta - Georgia, 198T [NTIS].

KBES structure is developed as a network organization of modules. These modules contain both production rules and calculation tools.

Vesonder, G. T., Salvatore, J. S., Zielinski, J. E., Miller, F. D., and Copp, D. H.

ACE: An Expert System for Telephone Cable Maintenance

Gini, G., Gini, M. and Morpurgo, R.

A Knowledge-Based Consultation System for Automatic Maintenance and Repair
In Ellis, T. M. R., and Semenkov, O. I. (editors), *Advances in CAD/CAM*, PROLAMAT82, Leningrad USSR, May 1982, Published by North-Holland Publishing Company, 1983.

The potentials of KBES for diagnosis and repair of mechanical systems are explored.

Hollan, J. D., Hutchins, E. L. and Weitzman, L.

STEAMER: An Interactive Inspectable Simulation-Based Training System
The AI Magazine, pages 15 - 27, Summer 1984

The STEAMER project deals with the application of AI tools for instruction purposes. STEAMER is used to teach Navy personnel on the use of steam propulsiion systems. STEAMER also provides a nice graphical interface.

Mamdani, E. H.

Rule-based Methods for Designing Industrial Process Controllers
In *Proceedings Colloqium on Application of Knowledge-Based Systems*, London, U. K., 1982.

Fuzzy techniques are used in the development of a KBES for process control applications. Method is currently used commercially for the control of cement kilns.

Motoda H., Yamada, N. and Yoshida, K.

A Knowledge Based System for Plant Diagnosis
In *Proceedings of the International Conference on Fifth Generation Computer Systems*, Japan, November 7-9, 1984.

McKibbin, M, L.

Will AI Clash with MIS in the Factory
Infosystems, Vol. 30, No. 8, pp 99, August, 1983 [NTIS].

Potentials for expert systems for planning, scheduling, and other areas of manufacturing are discussed.

Nau, D. S. and Chang, T.

Prospects for Process Selection Using Artificial Intelligence
Computers in Industry, Vol. 4, pages 253-263, 1983.

Discusses potential uses of KBES in process planning for manufacturing tasks.

Nelson, W. R.

REACTOR: An Expert System for Diagnosis and Treatment of Nuclear Reactor Accidents
In *Proceedings 2nd NCAI*, pages 296-301, Pittsburgh, August 1982.

REACTOR is being developed at EG & G, Idaho, for assisting operators in the diagnosis and treatment of nuclear reactor accidents.

Phillips, R. H., Zhou, X-D., Mouleeswaran, C. B.

An Artificial Intelligence Approach to Integrating CAD and CAM Through Generative Process Planning
In *Proceedings Computers in Engineering, A. S. M. E.*, pages 332-337, August 1984, Las Vegas, Nevada.

The PROLPLAN system, a KBES for process planning, and its interface with a CAD

de Kleer, J. and Bobrow, D. G.

Qualitative Reasoning With Higher-order Derivatives

In *Proceedings 4th NCAI,* pages 86-91, Austin, Texas.

Six fundamental laws which govern the time behavior of a physical system or device are identified. An application to a pressure regulator is discussed.

Descotte, Y. and Latombe, J. C.

GARI: An Expert System for Process Planning

In Boyse, J. W. and Pickett, M. S. (editors), *Solid Modeling by Computers: From Theory to Applications,* Plenum Press, New York, 1984.

GAR! generates machine planning of mechanical parts. It uses a planner that develops a plan by iteratively constraining a loosely specified initial plan. The constraints are drawn from a knowledge-base provided by experts.

Dixon, J. R. and Simmons, M. K.

Expert Systems for Engineering Design: Standard V-Belt Drive Design as an Example of the Design-Evaluate-Redesign Architecture

In *Proceedings Computers in Engineering, A.S. M.E.,* pages 332-337, August 1984, Las Vegas, Nevada.

Describes a framework for experts systems for engineering design. Uses a Blackboard-type architecture. The system, called VEXPERT, is exemplified through the design of v-belt drives. Implemented in OPS5 and Franz LISP.

Dixon, J. R. and Simmons, M. K.

Computers that Design Expert Systems for Mechanical Engineers

C. *I. M. £.*, pages 10-17, November 1983.

An overview of potential applications in some areas of mechanical engineering is presented.

Fox, M. S.

The Intelligent Management System: An Overview

Technical Report CMU-RI-TR-81-4, Robotics Institute, Carnegie-Mellon University, **August 1981.**

The Intelligent Management System (IMS) project at C-MU is described. The purpose of IMS is to provide managers and planners assistance in day to day tasks. The report describes a number of features, such as modelling of organizations, user interfaces, etc., of the IMS.

Fox, M., LowenfiekJ, S. arid Kleinosky, P.

Techniques for Sensor-Based Diagnosis

In *Proceedings Eighth IJCAI,* **pages 158-163, August 198a**

PDS, a forward chaining ruled-based system for implementing KBES for real-time diagnosis of machine faults, is described. PDS is implemented over SRL.

Freed, D. and Wright, D.

FAXS: An Expert System for the Analysis of Mechanical Failures

In *Proceedings Computers in Engineering, A.S. M. £.*, pages 338-342, **August** 1984, Las Vegas, **Nevada.**

FAXS is being developed to aid the engineering student or other people in failure analysis and prevention. It uses a MYCIN-type probabilistic scheme to deal with inexact inferences. On going research is focused on merging FAXS with CAD and stress analysis programs. Implemented in Fortran 77.

A case for the maintenance of dependency structures in design is presented, with examples from VLSI domain. The concepts presented are equally applicable for other domains.

Bundy, A.

Intelligent Front Ends
D. A. I. Research Paper No. 227, Department of Artificial Intelligence, University of Edinburgh, England, July 1984.

Describes the techniques used for developing intelligent front ends for existing software, such as finite element analysis programs.

De Swaan Arons, H.

Expert Systems in the Simulation Domain
Mathematics and Computer Simulation (Netherlands), Vol. 25, No. 1, pages 10-16, February 1983 [NTIS].

Explores the possibilities of the application of KBES to simulation problems.

Dixon, J. R., Simmons, M. K., and Cohen, P. R.

An Architecture for Application of Artificial Intelligence to Design
In *Proceedings ACM IEEE 21st Design Automation Conference*, pages 634-640.
(for similar views see papers by Rehak, et. al. in Gero (eds))

The Blackboard model for engineering design is presented.

Gero, J.(editor)

Knowledge Engineering in Computer-Aided Design
IFIP WG-5.2, September 1984, Budapest, Hungary, Published by North-Holland Publishing Company.

Contains a number of recent papers on the application of KBES in engineering. Papers encompass Civil, Architecture, Mechanical and Electrical engineering applications.

Lafue, G. M and Mitchell, T. M.

Data-base Management Systems and Expert Systems for CAD
Technical Report No LCSR-TR-28, Rutgers University, 1982.

The use of database management systems and KBES is discussed with reference to the REDESIGN system.

Latombe, J-C. (editor)

Artificial Intelligence and Pattern Recognition in Computer Aided Design
North-Holland Publishing Company, New York, 1978.

Contains a number of good papers on the application of AI to engineering design problems.

Lowrance, J. D. and Garvey, T. D.

Evidential Reasoning: An Implementation for Multisensor Integration
SRI International, Technical Note 307, December 1983.

The Dempster-Shafer theory of evidence is used to develop a system for integrating information from multiple sources.

Maher, M.. L., Sriram, D. and Fenves, S. J.

Tools and Techniques for Knowledge-based Expert Systems for Engineering Design

systems are described. Sample studies from are carried out on a small sample of rotational machined parts. A rule-based approach is used.

Rajagopalan, R.

Qualitative Modeling in the Turbojet Engine Domain
In *Proceedings 4th NCAI,* **pages 86-91, Austin, Texas.**

Presents a causal model of a turbojet engine based on the relationship between engine parameters. This is used to implement an engine simulation.

Reddy, Y. V. and Fox, M. S.

KBS: An Artificial Intelligence Approach to Flexible Simulation
Technical Report CMU-RI-TR-82-1, Robotics Institute, Carnegie-Mellon University, February 1982.

KBS (Knowledge-Based Simulation) system is a knowledge representation system for simulating complex organizations. Features include interactive model creation and alteration, simulation monitoring and control, graphics display, and selective instrumentation.

Underwood, W. E.

A CSA Model-based Nuclear Power Plant Consultant
In *Proceedings 2nd NCAI,* **pages 302-305, Pittsburgh, August 1982.**

The Common Sense Algorithm representation is used to model the physical system. Diagnostic rules are also represented in this formalism.

5 General Engineering Applications

Apte, C.

Expert Knowledge Management for *Multi-level Modelling with an Application to Well-Log Analysis*
Technical Report, LCSR, Rutgers University, 1982.

Deals with the implementation of a KBES incorporating heuristic **knowledge and - algorithmic tools.**

Barbuceanu, M.

Object-Centered Representation and Reasoning: An Application to Computer-Aided Design
SIGART Newsletter, **Vol. 87, pages 33-39, January 1984.**

Discusses the usefulness of using an object-oriented approach to CAD problems. This approach provides a powerful framework for building KBES in the areas of design and planning.

Basden, A.

On Application of Expert Systems
International Journal of Man-Machine Studies, **Vol. 19, pages 461-477,1983.**

A number of issues on building KBES are addressed. Specific reference is **made to** SCCES, Stress Corrosion-Cracking Expert

Batali, J.

Dependency Maintenance in the Design Process
In *Proceedings IEEE International Conference on Computer Design:* ***VLSI*** *in* ***Computers,*** **pages 405-407, New York, 1983.**

Wade, J. and Shubin, H.

A Generalized Approach to Diagnostic Problems
In *Expert Systems 82,* BCS SGES, England, 1982.

A general discussion of approaches to building diagnostic expert systems, with an emphasis on the advantage of keeping knowledge-base and the inference-mechanism separate.

6 Domain Independent Tools

The tools described here are available at a modest charge from the developer. A more complete description of various tools can be found in the paper by Maher, et. al., described in Section 5.

Balzer, R., Erman, L, London, P. and Williams, C.

Hearsay-Ill: A Domain Independent Framework for Expert Systems
In *Proceedings 1st NCAI,* Stanford, 1980.

Hearsay-Ill is a domain independent version of the Hearsay-11 speech understanding system. It is written in AP3, a relational database language embedded in Interlisp. It is useful in situations that demand multiple sources of knowledge. Contact Steven Fickas, (Fickas@USC-ISI) Oregan State University.

Bobrow, D. and Stefik, M.

The Loops Manual
Xerox Corporation, 1983 (See Al magazine Vol. 4, No 3., 1983 for a description of LOOPS).

LOOPS is an integration of *procedure-oriented, object oriented, access-oriented* and *rule-oriented* programming paradigms. It offers a powerful framework for building expert systems. Currently it is available only on the XEROX machines that run Interiisp-D. Contact Mark Stefik, Xerox PARC, 3333 Coyote Hill Road. Palo .Alto, CA 94304 (Stefik@XEROX.PARC).

Clocksin, W. F. and Mellish, C. S.

Programming in Prolog
Springer-Verlag, **1981.**

Prolog is a logic-based programming language that is widely used in Europe for building KBES. According to the authors,"Prolog is a practical and efficient implementation of many aspects of 'intelligent* program execution, such as non-determinism, parallelism, and pattern-directed procedure call". The fifth generation computer protect started in Japan will use Prolog as the implementation language. For a Dec-10 version write to D. Warren at SRI International (Warren@SRI-AI).

Forgy. C. L.

OPS5 Users Manual
Technical Report No: CMU-CS-8M35, Carnegie-Mellon University, **August 1981.**

OPS5 is a production system language for rule-based programming. A number of versions of this language exist The latest version, OPS83, will incorporate a number of important features that were not implemented in the earlier version. OPS83 is written in the C language. Currently maintained by Charles Forgy, Department of Computer Science, Carnegie-Mellon University, Pittsburgh PA 15213 <Forgy@CMU-CS-A).

Reboh, Rene[1]

Knowledge Engineering Techniques and Tools in the Prospector Environment
Technical Report 8172, SRI International, June 1981.

Advances in Engineering Software, October 1984.

Describes the application of OPS5, SRL and PROLOG to engineering design problems.

McDermott, J.

Domain Knowledge and the Design Process
Design Studies Vol. 3, No. 1, pages 31-36, 1982 (also appeared in Proceedings 18th Design Automation Conference, Nashville, TN, 1981).

R1 and XSEL are used to illustrate the importance of domain knowledge in the design process.

Preiss, K.

Data Frame Model for Engineering Design Process
Design Studies Vol. 1, No. 4, pages 231-243, 1980.

The frame based approach to engineering design is discused. Has many interesting concepts.

Reddy, D. Sriram, Maher, M. L. Tyle, N., Banares, R., Rychener, M. and Fenves, S.J.

Knowledge-based Expert Systems for Engineering Applications
In *Proceedings IEEE Conference on Systems, Man and Cybernetics*, India, 1983-1984.

A number of KBES currently under development at C-MU in the areas of Civil, Chemical and Electrical Engineering are described.

Rychener, M. D.

Expert Systems for Engineering Design: Experiments with Basic Techniques
In *Proceedings of Trends and Applications on Automating Intelligent Behavior: Applications and Frontiers*, pages 21-27, 1983 (Sponsored by IEEE and NBS).

The author's experience with the development of expert systems for engineering design is discussed.

Simon, H. A.

The Sciences of the Artificial
MIT Press, Cambridge, MA, USA, 1969.

The chapter on design describes the design process in detail.

Sleeman, D. and Brown, J. S. (editors)

Intelligent Tutoring Systems
Academic Press, London, U. K., 1982.

Contains a number of articles on expert system approaches to intelligent computer-aided instruction.

Swift, K. and Mathews, A.

Expert Computers in Engineering Design
Engineering (UK), Vol. 223, No. 9, pp 673-8, 1983 [NTIS].

The DACON system for assembly automation and POLYCOAT systems for designing coatings are discussed.

Tokoro, M., Ishikawa, Y., Maruichi, T. and Kawamura, M.

An Object Oriented Approach to Knowledge Systems
In *Proceedings of the International Conference on Fifth Generation Computer Systems*, Japan, November 7-9, 1984.

The Knowledge-Acquisition System (KAS) is a combination of powerful inference techniques and a system of representing the meaning of concepts that it deals with. Knowledge is represented in terms of spaces (a type of frame) and semantic networks. Bayesian reasoning is used in the inference mechanism. It is useful for diagnostic type of problems and is implemented in Interlisp. This system was extended (called HYDRO) to incorporate numerical calculations. Contact Rene Reboh (currently with Syntelligence), SRI International, Palo Alto, Stanford (Reboh@SRI-AI).

van Melle, W.

A Domain Independent Production-Rule System for Consultation Programs
in *Proceedings Sixth IJCAI,* pages 923-925, August 1979 (see also the EMYCJN **manual, available from Stanford University Computer Science Department).**

EMYCIN is a domain independent version of MYCIN. It is useful for building diagnosis based expert systems. Knowledge is represented in object-attribute tuples. For more information write to Department of Computer Science, Stanford University, Stanford, CA 94305.

Weiss, S. M. and Kulikowski, C. A.

EXPERT: A System for Developing Consulation Models
In *Proceedings Sixth IJCAI,* **pages 942-947,1979.**

It is probably the only KBES tod developed in FORTRAN. It is useful for classification and diagnostic type of problems. It can be interfaced with other existing FORTRAN software. Hence, it seems to be a good tool for engineers who wish to interface expert systems with engineering software, written in FORTRAN. Contact Shalom Weiss or Casimir Kulikowski, Department of Computer Science, Rutgers University, N. J. (Wetss@Rutgers).

Wright, J. M. and Fox, M.

SRL: Schema Representation Language
Robotics Institute Technical Report, Carnegie-Mellon University, 1983.

A frame-based language implemented in Franzlisp. This language is being extented to include rule-based programming (PSRL). SRL is maintained by the Intelligent Systems Laboratory, Robotics Institute, Carnegie-Mellon University, Pittsburgh, PA 15213 (Fox@CMU-RI-ISL1).

Fain, J., Goriin, D., Hayes-Roth, F., Rosenschein, S. J., Sowizral, H., and Waterman, D.

The ROSIE Language reference manual
Technical Report N-1647-ARPA, Rand Corporation, Santa Monica, California 90406,1981.

ROSIE is a general purpose programming language, implemented in Interlisp, that supports stylized English input to create assertionai descriptions. Knowledge is represented in the form of facts and rule sets. ROSIE also provides the user a wide range of options to express n-ary relations. ROSIE has been successfully used to build a number of expert systems, specially for diagnostic and interpretation type of problems. Contact Henry Sowizral*

7 General Reading

Barr, A. and Feigenbaum, E. (editors)*The Handbook of Artificial Intelligence,* Vol-I to Vol-II
William Kaufmann Inc., Los Altos, California, 1981-1982.

These volumes will be useful for anyone interested in AI. Volume 1 covers the basic topics in AI. Volume II focuses on applications of AI (mostly expert systems), programming languages and automatic programming. The final Volume in this series (Volume III) is

edited by Cohen and Feigenbaum and contains articles on learning, theorem proving, models of cognition and theorem proving.

Begg, V.

Developing Expert CAD Systems
Unipub, New York, 1984

Provides a general treatment of the subject. No practical implementations are provided. The book focuses mainly on automating chip design. The chapter on design brings out a number of interesting issues.

Dym, C. L

Expert Systems: New Approaches to Computer-Aided Engineering
In *Proceedings Twenty-Fifth AIAA-ASME-ASCE-AHS Structures, Structural Dynamics and Materials Conference,* California, May 15,1984.

Presents a good overview of expert systems for the engineer.

Konopasek, M. and Jayaraman, J.

Expert Systems for Personal Computers - The TKISolver Approach
BYTE, pages 137-156, May 1984.

Presents a case for using the TKISolver program as an expert system framework.

Hayes-Roth, F., Waterman, D. and Lenat, D. (editors)

Building Expert Systems
Addison-Wesley Publishing Company, 1983.

It gives a good overview of expert systems. However, it is collection of papers and one can see a lot of repetition in the chapters. Further, the book does not have any description of logic-based expert systems.

Michie, **D.**

Expert Systems
Computer Journal (UK), Vol. 23, No. 4, pages 369-376, November 1980.

A general review of expert systems is provided, with emphasis on applications.

Nau.D.S.

Expert Computer Systems
Computer, **Vol. 16,** Pages **63-85, February 1983.**

Gives a good overview of expert systems.

Rich, E.

Artificial Intelligence
McGraw-Hill, 1983.

Weiss, S. **M.** and Kulikowski, **C.**

A Practical Guide to Designing Expert Systems
Rowman & Allanheld, pp 194, March **1984**

Addresses a number of practical issues in the building of expert systems. Only classification-type problems are covered.

Winston, P.

Artificial Intelligence
Addison-Wesley Publishing Company, **1984.**

Books by Rich and Winston are highly recommended for the novice.

8 Relevant Journals and Conferences

AI Journal - Artificial Intelligence Journal

Mostly papers on basic research. Quarterly Jounal.

The AI Magazine -

Papers are fairly general. Provides interesting reports on research in various institutions. Published quarterly.

Advances in Engineering Software -

Forthcoming issues may have some articles in the area. Published quarterly from UK.

BCS SGES - British Computer Society Specialist Group in Expert Systems

BCS SGES holds a conference every year on applications of expert systems.

CAD - Computer Aided Design, Published in U. K.

Papers in this journal deal mostly with work in European countries

C. I. M. E. - Computers in Mechanical Engineering

Papers relevant to engineering design are published. Published quarterly.

Computers and Structures

Forthcoming issues may have some interesting papers in the area. Published monthly.

EXPERT SYTEMS: The International Journal for Knowledge Engineering

New journal. A number of application articles are scheduled to appear in the coming year. Published quarterly

IEEE - Institute of Electrical and Electronics Engineers

IEEE holds a number of conferences in this area. The IEEE-ACM DA conferences have many interesting papers in the area.

IRP - International Federation for Information Processing

Lots of conferences in the area are held by IRP. For example, see the call for papers on page 11, SIGART, October 1963.

IJCAI - International Conference of Artificial Intelligence

Held once every two years. Many papers in applied AI are presented.

NCAI - National Conference on Artificial Intelligence

A yearly conference on AI.

SIGART - ACM Special Interest Group in Artificial Intelligence

A quarterly newsletter which deals with a wide variety of topics in AI.

9 Acknowledgments

Professor Fenves made a number of useful comments on various drafts of this paper. His encouragement for the compilation of this bibliography is greatly appreciated. Mike Rychener made many useful comments on a preliminary version of the paper.