

**A PRIMER ON
ARTIFICIAL INTELLIGENCE EXPERT SYSTEMS
IN THE PETROLEUM INDUSTRY**

BY

E.R.CRAIN, P. ENG.

**D&S PETROPHYSICAL, A DIVISION OF
D&S PETROLEUM CONSULTING GROUP LTD.**

CALGARY, ALBERTA

THE INFERENCE ENGINE

THE RULE INTERPRETER, OR CONTROL STRATEGY, IS OFTEN CALLED THE PROBLEM SOLVING PARADIGM OR MODEL IN THE AI LITERATURE. OTHER TERMS USED ARE THE INFERENCE ENGINE, THE SOLUTION PROTOCOL, REASONING, OR DEDUCTION.

EXAMPLE:

THE CHAINING OF IF-THEN RULES TO FORM A LINE OF REASONING

SOME OBSERVATIONS ON THE TRADITIONAL WISDOM

- EXPERT SYSTEM DEVELOPMENT IS AN INCREMENTAL PROCESS (PROGRESSIVE RELEASES)
- EXPERTS ARE THEMSELVES MOVING TARGETS
- CAREFUL DEFINITION IS IMPOSSIBLE BEFOREHAND, SUGGEST A CONTINGENT DEFINITION INSTEAD
- TOO MUCH TIME SPENT IN KNOWLEDGE ACQUISITION
- KNOWLEDGE ENGINEERS ARE NOT DOMAIN EXPERTS
- NEED MORE THAN ONE EXPERT

TYPES OF APPLICATIONS

- **CONSTRUCTION AND MANUFACTURING**
DESIGN, PLANNING, SCHEDULING, CONTROL
- **EDUCATION**
INSTRUCTION, TESTING, DIAGNOSIS
- **EQUIPMENT**
DESIGN, MONITORING, DIAGNOSIS, MAINTENANCE, REPAIR, OPERATION,
INSTRUCTION
- **IMAGE ANALYSIS AND INTERPRETATION**

REQUIREMENTS FOR EXPERT SYSTEM FEASIBILITY

- THERE IS A HIGH PAYOFF RELATIVE TO THE EFFORT NEEDED TO CREATE THE SYSTEM.
- THE PROBLEM CAN ONLY BE SOLVED WITH THE HELP OF AN EXPERT'S KNOWLEDGE.
- AN EXPERT IS AVAILABLE WHO IS WILLING TO FORMALIZE THIS KNOWLEDGE.
- THE PROBLEM MAY HAVE MORE THAN ONE RATIONAL ACCEPTABLE ANSWER.
- THE PROBLEM, SOLUTION, AND INPUT DATA DESCRIPTIONS CHANGE RAPIDLY OVER TIME OR SPACE.
- THE PROBLEM IS NEVER FULLY DEFINED.

CHAINING

- FORWARD

STARTS FROM A SET OF CONDITIONS AND MOVES TOWARD SOME CONCLUSION

EXAMPLE

CONFIGURING A CUSTOM TAILORED MINICOMPUTER FROM A LIST OF DESIRED FEATURES

- BACKWARD

CONCLUSION IS KNOWN (eg., IT IS A GOAL TO BE ACHIEVED), BUT THE PATH TO THAT CONCLUSION IS NOT KNOWN

EXAMPLE

A BOTANICAL DESCRIPTIONS LEADS TO A SPECIES NAME BY MATCHING THE PLANT DESCRIPTION TO A DATA BASE PATTERN

TYPES OF APPLICATIONS

MILITARY

- MISSION PLANNING, MONITORING, TRACKING AND CONTROL
- COMMUNICATION
- SIGNAL ANALYSIS
- COMMAND AND CONTROL
- INTELLIGENCE ANALYSIS
- TARGETING
- WEAPON SYSTEMS
 - TARGET IDENTIFICATION, ELECTRONIC WARFARE, ADAPTIVE CONTROL

EXPERT SYSTEMS

EXPERT SYSTEMS APPLY REASONING AND PROBLEM SOLVING TECHNIQUES TO KNOWLEDGE ABOUT A SPECIFIC PROBLEM DOMAIN IN ORDER TO SIMULATE THE APPLICATION OF HUMAN EXPERTISE. THEY OPERATE AS ADVISOR/ASSISTANTS.

AREAS OF ARTIFICIAL INTELLIGENCE

- HELP UNDERSTAND THE HUMAN THINKING PROCESS BY MODELLING IT WITH COMPUTERS
- MAKE BETTER COMPUTER HARDWARE BY MODELLING THE COMPUTER MORE CLOSELY AFTER THE HUMAN BRAIN
- MAKING COMPUTERS ACT MORE HUMAN OR EASIER FOR HUMANS TO USE
- ROBOTICS, PATTERN RECOGNITION OR ARTIFICIAL VISION
- NATURAL LANGUAGE UNDERSTANDING, AUTOMATIC TRANSLATION, AND AUTOMATIC COMPUTER PROGRAMMING

SUMMARY

●
INTRODUCTION TO ARTIFICIAL INTELLIGENCE

WHAT IS AN EXPERT SYSTEM ?

USING AN EXPERT SYSTEM

THE KNOWLEDGE BASE

THE INFERENCE ENGINE

A NOT SO TRIVIAL EXAMPLE

PROBLEM SOLVING TECHNIQUES

● LANGUAGES AND TOOLS

PETROLEUM INDUSTRY EXAMPLES

DRILLING ADVISOR

PROSPECTOR

DIPMETER ADVISOR

EXPERT LOG ANALYSIS SYSTEM ELAS

MUDMAN

SOME OBSERVATIONS ON THE CONVENTIONAL WISDOM

● APPENDIX 1 - DEFINITIONS OF INFERENCE AND SEARCH TECHNIQUES

APPENDIX 2 - TOOLS OF THE TRADE

APPENDIX 3 - BIBLIOGRAPHY

TYPES OF APPLICATIONS

- **PROFESSIONS (LAW, MEDICINE, ENGINEERING, ACCOUNTING, LAW ENFORCEMENT)
CONSULTING, INSTRUCTION, INTERPRETATION, ANALYSIS**
- **SOFTWARE
SPECIFICATION, DESIGN, VERIFICATION, MAINTENANCE, INSTRUCTION**

THE KNOWLEDGE BASE

- KNOWLEDGE REPRESENTATION

PRODUCTION RULES

IF..THEN

FRAMES

DESCRIPTIVE

SEMANTIC SETS

CLASSIFICATION

- FACTS AND PARAMETERS

REFERENCE DATA

PERFECT MEMORY

GRACEFUL FORGETING

UNCERTAINTY

BELIEF RETRACTION

USING AN EXPERT SYSTEM

- GETTING ANSWERS TO PROBLEMS
 - USER AS CLIENT,
- IMPROVING OR INCREASING THE SYSTEM'S KNOWLEDGE
 - USER AS TUTOR,
- HARVESTING THE KNOWLEDGE BASE FOR HUMAN USE
 - USER AS PUPIL.

WHAT IS AN EXPERT SYSTEM ?

- KNOWLEDGE BASE
RULES, PROCEDURES, HEURISTICS, ALGORITHMS,
FACTS, DATA, PARAMETERS, CONSTANTS
- INFERENCE ENGINE
PROBLEM SOLVING CONTROL STRUCTURE
- GLOBAL DATA BASE
CURRENT STATUS, RAW DATA, ANSWERS

PRODUCTION RULE EXAMPLE

**IF MATRIX DENSITY IS GREATER THAN SANDSTONE MATRIX DENSITY
AND LITHOLOGY IS DESCRIBED AS SHALY SAND
THEN SUSPECT A HEAVY MINERAL OR CEMENTING AGENT
OR SUSPECT INADEQUATE SHALE CORRECTIONS
OR SUSPECT POOR LOG CALIBRATIONS**

PETROLEUM INDUSTRY APPLICATIONS

- WELL LOG ANALYSIS
- PROPERTY EVALUATION
- RESERVOIR SIMULATION
- DRILLING OPERATIONS
- GEOLOGIC INTERPRETATION

USES OF EXPERT SYSTEMS

- DIAGNOSE
- MONITOR
- ANALYZE
- INTERPRET
- CONSULT
- PLAN
- DESIGN
- INSTRUCT
- EXPLAIN
- LEARN
- CONCEPTUALIZE

PROBLEM SOLVING TECHNIQUES

- CONSULTATION OR DIAGNOSIS/PRESCRIPTION/TREATMENT MODEL
- MOST PETROLEUM RELATED EXPERT SYSTEMS USE SOME FORM OF CONSULTATIVE MODEL.

LANGUAGES AND TOOLS

LANGUAGES

LISP

PROLOG

FORTRAN

BASIC

ASSEMBLER

ROM

TOOLS

SMALL UP TO 400 RULES

ES/P ADVISOR, INSIGHT

LARGE, NARROW 500 OR MORE RULES, ONE MODEL

EMYCIN, EXPERT, TIMM, OPS5

LARGE, HYBRID MULTIPLE REASONING MODELS

KEE, LOOPS, ART

DISTINQUISHING AI FEATURES

- **CONVENTIONAL PROGRAMMING**
PROCEDURAL LANGUAGES SUCH AS BASIC
OR FORTRAN SEQUENTIAL CODE
- **INTELLIGENT PROGRAMMING**
PROGRAMS ARE DATA
COMMAND DRIVEN, FLEXIBLE SEQUENCE
- **ARTIFICIAL INTELLIGENCE**
SYMBOLIC PROCESSING
RELATIONSHIPS AND RULES

PROSPECTOR

COMPANY:	STANFORD
DEVELOPER:	STANFORD
TOOL:	KAS (EMYCIN-LIKE)
INFERENCEING:	SEMANTIC SETS/PRODUCTION RULES
CHAINING:	BACKWARD
PURPOSE:	MINERAL EXPLORATION
SIZE:	??? RULES
SYSTEM:	???

DIPMETER ADVISOR

COMPANY:	SCHLUMBERGER
DEVELOPER:	SCHLUMBERGER
TOOL:	INTERLISP-D
INFERENCEING:	PRODUCTION RULE AND ALGORITHM
CHAINING:	FORWARD
PURPOSE:	DETERMINE STRUCTURAL AND STRATIGRAPHIC FEATURES
SIZE:	90 RULES
SYSTEM:	XEROX 1108

DRILLING ADVISOR

COMPANY:	ELF/AQUITAINE
DEVELOPER:	TEKNOWLEDGE/ELF
TOOL:	KS300 (EMYCIN)
INFERENCING:	PRODUCTION RULES
CHAINING:	BACKWARD
PURPOSE:	DIAGNOSE DRILLING PROBLEMS (STUCK IN HOLE ONLY)
SIZE:	250 RULES
SYSTEM:	DEC 20 OR XEROX 1108

ELAS

COMPANY:	AMOCO
DEVELOPER:	RUTGERS UNIVERSITY
TOOL:	EXPERT
INFERENCEING:	PRODUCTION RULES
CHAINING:	BACKWARD
PURPOSE:	CONTROL INTERACTIVE LOG ANALYSIS PROGRAM
SIZE:	??? RULES
SYSTEM:	IBM AND VAX

MUDMAN

COMPANY:	NL BAROID
DEVELOPER:	CARNEGIE-MELLON
TOOL:	OPS5
INFERENCEING:	PRODUCTION RULES
CHAINING:	BACKWARD
PURPOSE:	DETERMINE OPTIMUM MUD SYSTEM
SIZE:	??? RULES
SYSTEM:	VAX

A NOT SO TRIVIAL EXAMPLE

- INSTANT RECOGNITION
- PATTERNS AND SHAPES
- LIST OF FEATURES
- HIDDEN FEATURES, ADDITIONAL DATA
- UNIQUE OR INCOMPLETE IDENTIFICATION
- KNOWLEDGE EXTRACTION

SOME OBSERVATIONS ON THE TRADITIONAL WISDOM

- NEED MULTIPLE DISCIPLINES
- NEED VARIED REAL EXAMPLES TO VALIDATE RESULTS
- EXPERTS DON'T USE SAME RULES WHEN NEW AREAS ARE WORKED
- RULES GIVE FALSE SENSE OF SECURITY
- RULE BASE TRIPLES DURING DEVELOPMENT AND TESTING
- NEED EXCELLENT HUMAN INTERFACE FOR TESTING AND USER ACCEPTANCE