BOOK REVIEWS

Artificial Intelligence in the Petroleum Industry

Symbolic and Computational Applications

edited by Bertrand Braunschweig and Ron Day
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Ion Leon Batachia received the Diploma Degree in Computer Science from the Polytechnical Institute of Bucharest in 1987. For two years, 1987 - 1988 he worked as engineer at the Computing Centre of IMSAT Bucharest. January 1989 he started work at the Research Institute for Informatics. At present he is a senior researcher and is working towards obtaining a doctoral degree in Applied Infomatics. His main current scientific interests are decision support systems, embedded AI systems, (symbolic and computational AI topics) and object oriented analysis, design and programming.

The book is dedicated to artificial intelligence (AI) applications in the petroleum industry. Some of the chapters of the book are extended versions of the papers presented at the most recent CAIPEP and EuroCAIPEP conferences on AI in the petroleum industry. The primary goal of the book was to present to the petroleum community a selection of applications based on more recent AI techniques meant to solve the petroleum industry problems. The selected examples could serve as a starting point in the AI techniques application to a wider range of problems.

The petroleum industry has been among the first to use AI techniques (DIPMETER ADVISOR and PROSPECTOR are often mentioned as being examples of early classic systems). However, AI has not been accepted yet as a strategic technology within industry, and the usefulness of various AI techniques is not always well-understood. The book editors, Bertrand Braunschweig (Institut Français du Pétrole) and Ron Day (Arco E&P Technology) briefly introduce the techniques which the later chapters will address: **knowledge-based systems, neural networks, genetic algorithms, fuzzy logic, case-based reasoning, qualitative and model-based reasoning, and constraint satisfaction systems**. A summary of each application chapter follows, so that the reader can choose his path along the symbolic and computational applications contained in the book. The applications described fall into two major parts, depending on the type of the implemented AI method. **Part I, "Symbolic AI"**, contains applications which the modelling of reasoning, inspired by the mechanisms of logical thinking, is essential for. **Part II, "Computational AI"**, contains applications based on numerical algorithms or methods inspired by the domain evolution, i.e. neural networks, genetic algorithms. This Section of the book also includes the applications based on fuzzy logic. This technique is highly dependent on the computational aspects as it is on the modelling of human reasoning. Either part has as many subsections as the AI techniques described. With the maturing of AI, many researchers and developers have come to use "hybrid" systems, which employ several AI techniques. Hybridisation means the use of several AI techniques in the same global system, each technique for what it is good to, such that each of these techniques may correctly solve part of the problem, and support the working out of a coherent solution to the overall problem. Hybrid systems are currently receiving a lot of attention, and appear to yield good results. This is the reason why each part of the book has at least one article devoted to hybrid systems. It will be of interest to refer and present the applications which the book makes a selection of.

Symbolic AI

This part of the book contains **8 chapters**. Each one defines an application . The first three chapters are grouped together as *New Approaches in Interpretations*:

1. J. Hamburger *GeoCoS 3D: A Diagnosis System, Based on the Frog Formalism. To Help Geologists Set Up Valid Interpretations*

As the article abstract says, the aim of GeoCoS 3D project is to construct chronostratigraphic surfaces and to control consistencies of an interpretation. GeoCoS 3D is applied to cross-sectioning various data analysis: seismic cross-sections, wells, maps, etc. GeoCoS 3D is based on the FROG formalism which might improve the framework within which to represent any geological concept.

2. I.W. Harrison and J.L. Fraser, *SPIRIT: Integrating Knowledge-Based Techniques into Well Test Interpretation*

SPIRIT, a project for developing a new generation of Well Test Interpretation (WTI) software, presents a set of methods and techniques concurrently used to provide full solution to an engineering problem. SPIRIT integrates knowledge-based techniques for pattern matching and decision modelling. SPIRIT makes use of several types of information for interpreting a well test: pressure, seismic, petrophysical, geological and engineering.

3. G. Biswas, J. Weinberg and C. Li, *ITERATE: A Conceptual Clustering Method for Knowledge Discovery in Databases*

This is the only chapter on database mining in the book. This technique aims to automatically extract knowledge from databases; the generated knowledge can be expressed as rules, classes, relations or concept hierarchies. ITERATE applies to different data sets, with either symbolic or numerical attributes. Two of these data sets are pertinent to geological interpretation for oil.

Chapter 4 discusses an Automated Plan Generation. Automated Plan Generation deals with automatic building of a plan, to be defined as a structured network of tasks and resources, which satisfies a set of predefined or dynamically changing objectives.

4. D. H. Mitchell, *Automated Planning in the Oil Patch*

The author addresses major aspects in project planning, including some generic aspects of planning, the specific needs of the petroleum industry, the AI-based software problem-solving, and a working example.

The next two chapters are dedicated to Model-Based Reasoning.

5. U. Junker, *SISMONAUTE, A System for Detecting and Interpreting Wave Fronts in Seismic Simulations*

"SISMONAUTE" is a second-generation knowledge-based system which uses multiple representations for managing the complexity of the data involved in producing synthetic 2-D seismograms.

6. R. Milne and L. Travé-Massuyes. *Real Time Model Based Diagnostic of Gas Turbines*

This article describes the work of integrating various reasoning paradigms. It has been conducted under the ESPRIT project, TIGER, for gas turbines monitoring and diagnosis. The project combines the real-time rule-based diagnosis techniques with real-time situation assessment techniques and qualitative simulation model based diagnosis. These techniques are integrated via a task architecture.

Chapter 7 and Chapter 8 are devoted to Hybrid Approaches: Case-Based Planning, Constraint Satisfaction

7. T. Kemme, *From Business Model To Constraint Satisfaction System: An Integrated Approach*

T. Kemme's paper makes a challenge to integrating several modern techniques and tools for solving complex Exploration and Production (E&P) Business problems. The example is taken from the domain of well correlation using sequence stratigraphy.

8. B. A. Bremdal, I. Brenne, B. M. Soether and H. G. Rueslatten, *Defining Analytic Strategies in Remote Sensing Using A Hybrid, Knowledge-Based Decision Support System*

The authors looked for ways to replace computer operators by geologists in image processing as generated by remote sensing. For this they included a means of computer based advice. The work described here rejected the traditional expert system approach in behalf of a knowledge-based decision support concept which materialised in a system called I2SAdvisor.

Computational AI

This part contains **8 chapters** centred on four major computational AI techniques: Neural Networks (Chapters 9 and 10), Fuzzy Expert Systems (Chapters 11 through 13), Genetic Algorithms (Chapters 14 and 15), Hybrid Systems (Chapter 16).

9. J.L. Baldwin and H. Malki, *Comparison of Neural Networks Training and Processing of Two Service Company's Data in A Single Wellbore*

The article deals with the applicability of neural networks to log interpretation, and addresses the problem of log data supplied by two different service companies. If a neural network can be

configured so as to reconcile the important differences between two series of logs taken in the same wellbore, then it is assumed that this neural network is capable of interpolating the data that are commonly available.

10. J. D. Keeler, *Prediction and Control of Chaotic Chemical Reactions Via Neural Networks Models*

Chemical reactions are high-dimensional and highly non-linear. The reactions are difficult to control due to their inherent sensitive dependence on initial conditions and external perturbations in factors such as impurities, temperature, feedstock, etc. To demonstrate the use in neural networks for control, the author investigates a very difficult test problem: control of a chaotic chemical CSTR (continuous-stirred-tank-reactor) reaction. The author proves that standard neural network paradigms are inadequate for this problem, while making a new approach to both predicting and controlling the CSTR even in the presence of external perturbations.

11. H.C.Chen, L.H. Li and J.H. Fang, *Evaluation and Ranking of Prospects by Fuzzy Multicriteria Decision Making Paradigm*

The authors present the implementation of fuzzy logic and multicriteria decision making in the XPROS1 and XPROS2 systems for appraisal. Several methods are used in the evaluation and ranking of prospects, revealing the benefits of the second-order criteria (such criteria are less important than the geological factors used for the appraisal) as a means for differentiating prospects from each other.

12. A. Bonarini, A. Corrao, L. Giacometti and L. Tomada, *A Fuzzy Logic Enhancement To A Support System for the Recognition of Sedimentary Environments From Core Analysis*

The article presents the research done at *AGIP* and *Politecnico di Milano* using an existing knowledge-based system for sedimentary environment recognition: LOBSTER. The authors upgraded the system into being more flexible by introducing fuzzy qualifiers, high - level user interface and explanation facilities.

13. H. Xiong and S.A. Holditch, *Using A Fuzzy Expert System To Choose Target Wells and Target Formations for Stimulation.*

Here the goal is to determine whether a particular well should be selected for a stimulation treatment. Each well is described by a set of numerical attributes, such as porosity, skin factor, net pay thickness, etc. These factors, in turn, are converted into fuzzy sets, which serve as the basis for a decision -making process based on a weighted average of these factors.

14. J. F. Schuette and D. R. Pevear, *Matchmod: A Genetic Algorithm To Interpret X-Ray Diffraction Patterns*

This paper illustrates how GAs can be used for solving a difficult inverse problem, the estimation of the composition and structure of a clay sample, given its X-ray diffraction pattern.

Forward models are available to compute a simulated diffraction pattern for a known mineral composition. The inverse problem consists of optimizing the composition so that the forward model produces a simulated pattern as faithful as possible to the experimental data.

15. B. Braunschweig, A. Barreau and E. Emami, *Genetic Algorithms for the Automatic Adjustment of Thermodynamic Models*

The paper presents a genetic algorithm approach to the automatic adjustment of the models used to predict the thermodynamic properties of reservoir fluids. In addition to the genetic algorithm solution, other different solution approaches are described including an expert system and two numerical optimization methods: a gradient approach, and the Simplex method. The GA solution, although being a very simple GA implementation, proved superior to the two numerical techniques. Several potential improvements are also offered .

16. T. Urwongse, *Predicting Petroleum Potential Using Analogs and Neural Networks*

This paper presents several attempts to use neural network and fuzzy logic queries, for facilitating the estimation of the amount of recoverable reserves in a basin. Statistical data provided by other similar basins are used. The research called on a database with information about numerous basins worldwide (GLOBES database).

The attempts presented by Urwongse are steps towards general use of fuzzy queries and non-linear approximators in large technical database systems.

The applications selected in the book are reserved not only to the petroleum community. The examples could be explored by anyone who is interested in AI applications. These examples could serve as sound backgrounds or frameworks for approaches to using AI techniques in a wide spectrum of problems.

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