KNOWLEDGE ACQUISITION *for* KNOWLEDGE-BASED SYSTEMS

KNOWLEDGE-BASED SYSTEMS

VOL. 1

edited by b. gaines & j. boose

Knowledge Acquisition for Knowledge-Based Systems

Knowledge-Based Systems
Volume 1

edited by

B. R. Gaines
Department of Computer Science,
University of Calgary,
Calgary, Alberta T2N 1N4
Canada

and

J. H. Boose
Boeing Computer Services,
P.O. Box 24346,
Seattle, Washington 98124–0346,
U.S.A.

1988

ACADEMIC PRESS

Harcourt Brace Jovanovich, Publishers
London San Diego New York Berkeley Boston
Sydney Tokyo Toronto

ACADEMIC PRESS LIMITED
24/28 Oval Road
LONDON NW1 7DX

United States Edition published by
ACADEMIC PRESS INC.
San Diego, CA 92101

British Library Cataloguing in Publication Data

Gaines, B. R. (Brian R)
Knowledge acquisition tools for expert systems.—(Knowledge-based systems; v.1).
1. Artifical intelligence. Applications of computer systems
I. Title II. Boose, John H. III. Series
006.3

ISBN 0-12-273251-0

Typeset by The Universities Press (Belfast) Ltd.
Printed in Great Britain at the University Press, Cambridge

Knowledge Acquisition for Knowledge-Based Systems

Knowledge-Based Systems

One of the most successful and engaging initiatives in Artificial Intelligence has been the development of knowledge-based systems (or, expert systems) encoding human expertise in the computer and making it more widely available. Knowledge-based system developments are at the leading edge of the move from information processing to knowledge processing in Fifth Generation Computing.

The Knowledge-Based Systems Book Series publishes the work of leading international scientists addressing themselves to the spectrum of problems associated with the development of knowledge-based systems. The series will be an important source for researchers and advanced students working on knowledge-based systems as well as introducing those embarking on expert systems development to the state-of-the-art.

Volume 1 has been compiled from the following issues of International Journal of Man–Machine Studies:

Volume 26	Number 1	January 1987
Volume 26	Number 2	February 1987
Volume 26	Number 4	April 1987
Volume 27	Number 2	August 1987
Volume 27	Number 3	September 1987
Volume 27	Number 4	October 1987

Contributors

N. J. BELKIN *The School of Communication, Information, and Library Studies, Rutgers University, New Brunswick, NJ 08903, U.S.A.*

J. H. BOOSE *Boeing Computer Services, P.O. Box 24346, Seattle, Washington 98124–0346, U.S.A.*

H. M. BROOKS *The School of Communicative Information, and Library Studies, Rutgers University, New Brunswick, NJ 08903, U.S.A.*

B. G. BUCHANAN *Department of Computer Science, Stanford University, Stanford, CA 94305, U.S.A.*

W. BUNTINE *New South Wales Institute of Technology and Macquarie University, Computing Science, N.S.W. I.T., P. O. Box 123, Broadway, 2007 Australia*

T. BYLANDER *Laboratory for Artificial Intelligence Research, Department of Computer and Information Science, The Ohio State University, Columbus, Ohio 43210, U.S.A.*

J. CENDROWSKA *c/o The Faculty of Mathematics, The Open University, Walton Hall, Milton Keynes, MK7 6AA, U.K.*

B. CHANDRASEKARAN *Laboratory for Artificial Intelligence Research, Department for Computer and Information Science, The Ohio State University, Columbus, Ohio 43210, U.S.A.*

W. J. CLANCEY *Department of Computer Science, Stanford University, Stanford, CA 94305, U.S.A.*

J. G. CLEARY *Department of Computer Science, University of Calgary, 2500 University Drive, Alberta T2N 1N4, Canada*

D. A. CLEAVES *Fire Economics and Management Research, USDA Forest Science, Pacific Southwest Forest and Range Experiment Station, 4955 Canyon Crest Drive, Riverside, CA 92507, U.S.A.*

P. J. DANIELS *Admiralty Research Establishment, Ministry of Defence, Queens Road, Teddington, Middx. TW11 0L9, U.K.*

J. P. DELGRANDE *School of Computing Science, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6*

B. R. GAINES *Department of Computer Science, University of Calgary, Calgary, Alberta T2N 1N4, Canada*

S. GARBER *3M, St Paul, Minnesota, U.S.A.*

E. HOLLNAGEL *Computer Resources International, Copenhagen, Denmark*

P. E. JOHNSON *Department of Management Sciences, University of Minnesota, Minneapolis, Minnesota, U.S.A.*

M. KLEYN *Schlumberger-Doll Research, Old Quarry Road, Ridgefield, CT 06877–4108, U.S.A.*

Y. KODRATOFF *Inference and Learning Group, Laboratoire de Recherche en Informatique, A. 410 du CNRS, Université de Paris-Sud, Bât. 490, 91404 Orsay, France*

J. KORNELL *General Research Corporation, P.O. Box 6770, Santa Barbara, CA 93111–6770, U.S.A.*

M. LAFRANCE *Department of Psychology, Boston College, Chestnut Hill, MA 02167, U.S.A.*

D. C. LITTMAN *Cognition and Programming Project, Department of Computer Science, Yale University, New Haven, CT 06520, U.S.A.*

M. MANAGO *Inference and Learning Group, Laboratoire de Recherche en Informatique, A. 410 du CNRS, Université de Paris-Sud, Bât. 490, 91405 Orsay, France*

A. A. MITCHELL *Faculty of Management Studies, University of Toronto, Toronto, Ontario M56 IV4, Canada*

M. J. PAZZANI *UCLA Artificial Intelligence Laboratory, 3531 Boelter Hall, Los Angeles, CA 90024 and The Aerospace Corporation, P.O. Box 92957, Los Angeles, CA 90009, U.S.A.*

E. J. PETTIT *Merit Technology, Inc., 5068 W. Plano Parkway, Plano, TX 75075–5009, U.S.A.*
M. J. PETTIT *Software Consulting Services, 2733 Riviera Drive, Garland, TX 75040*
J. R. QUINLAN *Artificial Intelligence Laboratory, Massachusetts Institute of Technology, 545 Technology Square, Cambridge, MA 02139, U.S.A.*
R. SMITH *Schlumberger-Doll Research, Old Quarry Road, Ridgefield, CT 06877–4108, U.S.A.*
D. C. WILKINS *Department of Computer Science, Stanford University, Stanford, CA 94305, U.S.A.*
H. WINSTON *Schlumberger-Doll Research, Old Quarry Road, Ridgefield, CT 06877–4108, U.S.A.*
E. WISNIEWSKI *Schlumberger-Doll Research, Old Quarry Road, Ridgefield, CT 06877–4108, U.S.A.*
D. D. WOODS *Westinghouse Research & Development Center, Pittsburgh, PA 15235, U.S.A.*
I. ZUALKERNAN *Department of Computer Science, University of Minnesota, Minneapolis, Minnesota, U.S.A.*

Preface

The initial success of expert system developments and the development of a number of reasonably domain-independent software support systems for the encoding and application of knowledge have opened up the possibility of widespread usage of expert systems. In particular, Fifth Generation Computing System development programs worldwide assume this will happen and are targeted on knowledge processing rather than information processing. However, what Feigenbaum has termed *knowledge engineering,* the reduction of a large body of knowledge to a precise set of facts and rules, has already become a major bottleneck impeding the application of expert systems in new domains. We need to understand more about the nature of expertise in itself and to be able to apply this knowledge to the elicitation of expertise in specific domains.

The problems of knowledge engineering have been stated clearly:

> "Knowledge acquisition is a bottleneck in the construction of expert systems. The knowledge engineer's job is to act as a go-between to help an expert build a system. Since the knowledge engineer has far less knowledge of the domain than the expert, however, communication problems impede the process of transferring expertise into a program. The vocabulary initially used by the expert to talk about the domain with a novice is often inadequate for problem-solving; thus the knowledge engineer and expert must work together to extend and refine it. One of the most difficult aspects of the knowledge engineer's task is helping the expert to structure the domain knowledge, to identify and formalize the domain concepts." (Hayes-Roth, Waterman & Lenat 1983)

The knowledge acquisition bottleneck has become the major impediment to the development and application of effective knowledge-based systems. Many research groups around the world have been working on knowledge acquisition methodologies, techniques and tools to overcome this problem. In 1985, members of a number of these groups realized that there had been rapid progress in knowledge acquisition research and application. However there was subtantial duplication of effort and limited communication between researchers, and therefore it would be valuable for a workshop to be held that would encourage the sharing of results and experience.

The American Association for Artificial Intelligence agreed to sponsor such a workshop. John Boose of Boeing Advanced Technology Centre and Brian Gaines of the Knowledge Science Institute at the University of Calgary agreed to organize it. Other researchers agreed to contribute effort to the organization and refereeing of papers, resulting in a program and local arrangements committee of: Jeffrey Bradshaw, Boeing Advanced Technology Centre, William Clancey, Stanford University, Catherine Kitto, Boeing Advanced Technology Centre, Janusz Kowalik, Boeing Advanced Technology Centre, John McDermott, Carnegie-Mellon University, Ryszard Michalski, University of Illinois, Art Nagai, Boeing Advanced Technology Centre, Gavriel Salvendy, Purdue University, and Mildred Shaw, University of Calgary.

The response to the call for papers for the Workshop on Knowledge Acquisition for Knowledge-Based Systems (KAW) was overwhelming. The intention was to hold a discussion-intensive meeting of some 35 highly involved researchers. In practice over 120 papers were submitted and some 500 applications to attend were received from some 30 countries. Apart from increasing the refereeing and organizational problems beyond all expected bounds, this response indicated the magnitude and impact of the knowledge acquisition bottleneck and the worldwide interest.

These submissions resulted in 60 people attending the first *Knowledge Acquisition for Knowledge-Based Systems Workshop* (*KAW*) from November 3–7, 1986, at the Banff Centre in Banff, Canada. Each of the 120 papers submitted was refereed by five to seven referees and 42 papers were finally selected. Much of the rejected material was of high-quality and it would have been possible to base a major conference on the material and requests to attend. However, it was decided that the priority at that stage should remain that of establishing in-depth communication between research groups.

It was also clear that it was important to disseminate the workshop material as widely as possible, and arrangements were made to publish revised versions of the papers in the *International Journal of Man–Machine Studies* after the Workshop. These papers have now been gathered together as the first two volumes of the *Knowledge-Based Systems* series.

The table below shows the format of the first KAW. It was very effective in establishing a network linking the community of knowledge acquisition researchers

Knowledge Acquisition for Knowledge-Based Systems *AAAI Workshop, Banff, November 1986*	
Structure	Residential workshop Accomodation, meals and sessions together Attendance limited to 60 (originally 35) 120 papers submitted, 43 accepted Several hundred requests to attend
Overview/ Summary Papers	Gaines—Overview of Knowledge Acquisition Clancey—Cognition and Expertise McDermott—Interactive Interviewing Tools I Boose—Interactive Interviewing Tools II Salvendy—Analysis of Knowledge Structures Michalski—Learning
Mini-Conference	Cognition & Expertise 6, Learning 8 Analysis of Knowledge Structures 7 Interactive Interviewing Tools 16
Workshops on Major Issues	Cognition & Expertise Interactive Interviewing Tools Learning Knowledge Representation
Panels on other Issues	Knowledge Acquisition Methodology/Training Reasoning with Uncertainty
Papers and Books	Preprint volume of all papers to attendees Four special issues of IJMMS in 1987 Two books, Academic Press 1988

worldwide. It resulted in two further KAWs in 1987, a second one at Banff again sponsored by the American Association for Artificial Intelligence (AAAI), and the first European KAW (EKAW) in London and Reading, England, sponsored by the Institute of Electrical Engineers. Papers from these workshops have again been published in the *International Journal of Man–Machine Studies* and constitute the third volume of the *Knowledge-Based Systems* series.

In 1988, the third AAAI-KAW was held at Banff in November with a theme of integration of methodologies, and the second EKAW was held at Bonn, Germany, in June with sponsorship from the Gesselschaft für Mathematik and the German Chapter of the ACM. A specialist workshop on the Integration of Knowledge Acquisition and Performance tools was held at the AAAI Annual Conference in St Paul in August. Sessions and tutorials on knowledge acquisition have become prevalent at a wide variety of conferences concerned with knowledge-based systems worldwide.

These two volumes based on the first AAAI-KAW at Banff contain a wide range of material representing foundational work in knowledge acquisition problems, methodologies, techniques and tools from the major research groups worldwide. All those contributing hope that access to this material will enable other researchers and practitioners to expedite their own developments through the shared knowledge and experience documented here.

Knowledge acquisition research is still in its early stages and there are many fundamental problems to be solved, new perspectives to be generated, tools to be developed, refined and disseminated, and so on—the work seems endless. Like many modern technologies, knowledge acquisition requires a large-scale cooperative international effort. It is virtually impossible for one research and dvelopment group to have world-class expertise in all the issues, technologies and experience necessary to develop integrated knowledge acquisition tools for a wide range of knowledge-based systems.

We wish to thank the many people who have been involved in organizing these workshops and the organizations that have given them sponsorship and publicity. We have a fundamental debt to those who put in place the computer communication networks worldwide, such as UseNet, that have made the world a global village and enable networks such as ours to operate effectively. We are particularly grateful to the AAAI for its role in sponsoring the North American Workshops and for providing such effective means of disseminating information to the massive community of those now involved in knowledge-based systems research.

We sometimes wonder how we have become so involved in the bureaucracy of organizing workshops and networks when our personal priorities are hacking new knowledge acquisition tools. However, the stimulation of discussions with colleagues at the workshops and across the networks is vital to the direction of our own research. We hope the books will make this stimulation widely available and bring a new generation of researchers into the knowledge acquisition network.

We have attempted to structure the material by dividing it between two books. However, we must make it very clear that the division between the books and into sections in this volume is our own. It is somewhat arbitrary in places, and was not discussed with the contributors. There are many cross-connections between papers in different sections. There is fundamental material in this volume and tool-oriented material in the other. The reader will find it worthwhile to browse through both volumes to get a feel for the many different perspectives present and interactions possible.

Brian Gaines and John Boose

Knowledge Acquisition for Knowledge-Based Systems

B. R. GAINES
Department of Computer Science, University of Calgary, Calgary, Alberta T2N 1N4, Canada

J. H. BOOSE
Boeing Computer Services, P.O. Box 24346, Seattle, Washington 98124–0346, U.S.A.

1. Introduction

This volume contains the papers concerned with foundations, knowledge engineering and inductive methodologies from the AAAI Knowledge Acquisition for Knowledge-Based Systems Workshop in November 1986, in Banff, Canada. We have grouped them under subject headings although there is much overlap between themes. There were keynote addresses, panels and group discussions at the workshop that addressed major themes but did not result in published papers. This paper attempts to capture the essential issues raised in these other presentations.

2. Plenary Papers

Plenary talks were given on the first day by members of the program committee. The speakers were asked to summarize papers in their area and give an overview of their views on the area. Topics covered relevant to this volume were:

2.1 AN OVERVIEW OF KNOWLEDGE-ACQUISITION AND TRANSFER, BRIAN GAINES, UNIVERSITY OF CALGARY

An overview of knowledge acquisiton research was presented. The world was described in terms of distinctions, and models of the world were described in terms of epistemological, construction, and action hierarchies. Knowledge support systems were seen as anticipatory systems that observed events and produced actions. The full paper is reproduced in this volume.

2.2 COGNITION AND EXPERTISE, WILLIAM CLANCEY, STANFORD UNIVERSITY

How do knowledge bases relate to what people know? What is knowledge engineering? How do its goals and methods relate to traditional science and engineering? How does a knowledge base—today and in principle—relate to what experts know? Given this, what knowledge acquisition methods will be most effective?

Knowledge engineering is a methodology for acquiring, representing and using computational, qualitative models of systems. Knowledge acquisition is an investigative, experimental process involving interviews, protocol analysis, and reformulation of written materials in order to design computational, qualitative models of systems.

Knowledge engineering methodology:

- Start with concrete cases, knowledge expressed in some representation.
- Search for patterns, specifically unexplained regularities.
- List patterns.
- Ask about origins, generative principles—laws, processes—that could generate all instances of patterns.
- What generative principles could generate the patterns themselves?

Examples from NEOMYCIN:

- Knowledge bases representations are becoming more fine-grained than experts can state.
- There is no reason to believe that there are principled, but inaccessible type and causal networks encoded in the brain.
- Behaviour may be regular without the expert's awareness and does not necessarily reflect instantiation of a single procedure or principle encoded in the brain.
- Background and efficiency constraints shape and bias expert behaviour, but representations of these are post-hoc and never 'complete'.

Implications for knowledge acquisition:

- It is unclear how well manipulation of representations can approximate human reasoning.
- Be aware that an expert's justifications actually combine considered representations with preconceptions, 'authoritative rationalizations', and models derived by observing his own behaviour.
- Learning research should focus on representational breakdown (failure-driven).

All knowledge bases contain qualitative models (primarily non-numeric representations of processes). Human reasoning involves the use of representations, but reasoning behaviour is not generated directly from representations. Therefore, the knowledge acquisition bottleneck is not a problem of accessing and translating what is already known, but the familiar scientific and engineering problem of formalizing models for the first time.

Conclusions:

- Representation: Behaviour patterns are not necessarily generated from predefined, fixed criteria. Representation arises in explaining the breakdown of previous 'conceptions'.
- Expertise: Experts know how to solve problems and they know partial models of how they solve problems, but these are inherently distinct sources and forms of knowledge.
- Knowledge engineering: Knowledge base construction requires scientists, not mere scribes or programmers. Knowledge engineering proceeds most successfully when there is sufficient recurrence of problem situations and solutions to allow formalization of fixed, readily agreed upon, and apparently objective concepts and relations.

Summary of papers presented in this area:

Problems addressed in papers:

- Expert bias.
- Knowledge acquisition interview difficulty.
- Joint person-machine problem-solving.
- Formalizing initial model.

Approaches taken:

- Study correlation of belief with data and experience.
- Study knowledge engineering process.
- Study relation of system functionality to cognitive demand.
- Improve heuristics by explanation-based learning.
- Develop systematic notation.
- Apply logic representation to structure facts.

2.3 APPROACHES TO THE ANALYSIS OF KNOWLEDGE STRUCTURES, GAVRIEL SALVENDY, PURDUE UNIVERSITY

Thinking models were compared in terms of mental operators, strategy, declarative representation, content of representation, structure of procedural knowledge, and content of structures. Models included were problem solving, decision theory, network models, and stimulus-response.

2.4 LEARNING, RYSZARD MICHALSKI, UNIVERSITY OF ILLINOIS AT URBANA

Learning is constructing or modifying representations of what is being experienced (with the intention of being able to use them in the future). Dimensions of representations include validity (truthfulness, accuracy), effectiveness (usefulness), and abstraction level and type (explanatory power). These affect the quality of learning. Learning is building, modifying, and improving descriptions. Descriptions can be declarative descriptions, control systems, algorithms, simulation models, and theories. Different learning strategies were compared and contrasted. Relationships between similarity-based learning, explanation-based learning, constructive inductive learning, and apprentice systems were shown.

3. Working Group Summaries

Attendees participated in several small working groups that attempted to define the aims, objectives, problems, state-of-the-art, and future directions in their areas. The following summaries were presented at the workshop.

3.1 COGNITION AND EXPERTISE, WILLIAM CLANCEY, SPOKESPERSON

Aim:

- What aspects of human cognition are relevant to expertise?

Objectives:

- To determine how the study of cognition and expertise can contribute to the development of knowledge systems for support/collaborative-solving, replacement of people, and theory formation (new types of problem-solving).
- To determine how the development of knowledge systems can contribute to cognitive studies.

Problems and issues:

- People are imperfect and different.
- Modelling an aggregate versus an individual can be confusing.
- What aids/methods will help persons reveal/articulate their experience?
- Why do people fail and how can we best meet their needs?
- How can you interact with people in cooperative problem-solving to keep them engaged and responsible?
- How can consensus be reached when experience is distributed?
- How can tools, methodologies, and knowledge systems be evaluated?
- How can knowledge be modelled context-dependent in a dynamic environment?
- How can you decide what system, if any, is appropriate for a given person or situation?
- What is the space of performance niches?
- What type of discourse is a 'consultation'?
- How can known alternatives by synthesized/brought together in order to decide which is the best? How do we know we have seen all the possible alternatives?
- The 'real' discussion in the working group centred on: Can there be experts without novices? Could you be an expert if you could not adapt? How are skills and knowledge related? What is intuition?

State-of-the-art:

- The evolving distinction between consultation, expert, and knowledge systems is settling out.
- Many studies in expertise have been performed with feedback to knowledge acquisition tools and methods.
- Many candidate knowledge acquisition methodologies are ready for testing and distribution.
- We are realizing the essential need for abstractions, separate from the implemented model, and that languages and tools can blind us to alternative ways of viewing problem-solving.

Aspects of problem-solving to be identified and exploited in knowledge acquisition:

- Identify recurrence in social interaction and case history (background).
- Immediate context drives nature of expertise (data, competing activities).
- Goals, system functionality, and interface (person-machine interactions).
- Cognitive resources (memory, attention).
- Cognitive biases (associational and intuitional).
- Representational breakdown (failure-driven formalization)—watch experts in situations where they fail or have trouble.

Future directions:

- Might proliferate to many fields; growth just starting.
- Engineering, business, agriculture, education.
- Develop systems to aid experts in problem conceptualization, then as independent problem-solvers.
- Strong impact on natural language processing.
- Should respect history of innovation diffusion.

- Should emphasize study of computer-human interface and cooperative problem-solving.

Slogans (competing):

- "We want to know where you are coming from."
- "If you do not know what you are doing, you are probably doing it wrong."
- "If you know what you are doing, you are not learning anything."
- "The intelligence in an intelligent system lies in the tool builder or user, but not the programme itself."
- "No expertise without cognition."
- "Cognition and expertise—the link between theory and practice."
- "Leveraging intuition with a cognitive mirror."

3.2 LEARNING, RYSZARD MICHALSKI, SPOKESPERSON

Aims:

- Intelligent information system.
- Human learning; modelling sequences of learning tasks.
- Learning by analogy for defining primitives of the domain.
- Incremental knowledge construction in an imperfect world.
- Autonomous learning system; universal data compression.
- Explanation-based learning; problems of access to the constructed knowledge; the trade-off between storing and redefining the knowledge.
- Learning multiple concepts; learning prototypes; what is similarity?
- What is self-organizing activity?; changing representations to facilitate learning; constructive induction.
- Knowledge debugging and refinement: the 'end-game'; the inductive apprentice system.
- Interaction and combination of learning strategies; cognitive economy.

Objectives/issues:

What is learning? Can there be learning without improving performance (yes)? Can there be learning with a decrease in performance? Can there be learning without intention of storing the organized knowledge for future use? Can there be learning without the possibility of recalling or retrieving the representation?

Problems:

- Combining explanation-based learning and similarity-based learning systems.
- Dealing with noise and inconsistency.
- Evaluating representations.
- What can people learn easily?
- What can machines learn easily?
- Global and local credit (blame) assignment for knowledge bases; building an expert system for diagnosing a knowledge base.
- Trade-offs between different learning strategies.

State-of-the-art:

- Inductive learning—programs have been built.
- Analogy—programs have also been built, but less has been achieved.
- Achievements—inductive learning programs applied to practical problems; discovery systems.

- Explanation-based learning—examples more for guidance (need to be correct).

Future directions:

- Inductive learning systems are ready to be applied.
- Expert system shells with learning capabilities.
- Significant discovery (estimates from '20–100 years' to '5–10 years')
- Understanding fielding of problems (five years).
- Problem; not only to discover, but to explain.

Slogan:

- 'AI = Machine Learning. There is no future without learning'.

Panel Discussions

Panel discussion were held in two areas:

4.1 KNOWLEDGE ACQUISITION METHODOLOGY AND TRAINING

Panel:

- Tom Bylander, Michael Freiling, and Marianne LaFrance

Goal of work:

- Effective development of knowledge engineering skills.

Objectives of work:

- Develop awareness of the nature of expertise.
- Develop knowledge of knowledge acquisition sources.
- Develop awareness of experts' problems in transferring expertise.
- Develop skills in the application of specific methodologies.

Problems in achieving objectives:

- Lack of models of expertise.
- Piece meal nature of techniques and tools.
- Short training courses required.
- Inadequate interdisciplinary backgrounds of students.

State-of-the-art

- Structure methodologies for knowledge representation and acquisition.
- Interactive knowledge acquisition systems.
- Grid technique (LaFrance).

Future Developments

- Integration of techniques.

4.2 REASONING WITH UNCERTAINTY: IMPLICATIONS FOR KNOWLEDGE ACQUISITION

Panel:

- Brian Gaines, Ryszard Michalski, and Ross Quinlan.

Goal of Work:

- Effective acquisition and inference with uncertain knowledge.

Objectives of Work:

- Develop solid foundations for reasoning with uncertainty including representation, deductive reasoning and inductive knowledge acquisition.