User Modeling Bibliography

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A user model can be defined as a computer representation of some aspects of a computer user. Such models have been used in many areas of AI, such as computer-aided instruction, where they are used to represent the knowledge and misconceptions of students [Brown and Burton, 1978]. In natural language processing, the pragmatic component usually contains a kind of user model [Cohen, 1985].

My Ph. D. thesis topic is to build formal tools for modeling users. I am concerned mostly with the representation of a user's knowledge and belief. This bibliography contains the references I have accumulated so far. Since I've chosen articles and books which are related to my specific approach to the problem of user modeling, the bibliography contains several references which do not directly address user modeling. For example, since my approach is to model a user as a theory-formation system based on Theorist, developed at the University of Waterloo, I refer to the key Theorist references and to the related Philosophy-of-Science literature.

Most references in the bibliography are annotated briefly. Each reference has a few keywords listed in order to classify them. The first keyword of each reference is an acronym which refers to the major areas represented. These keywords have been used to create a short table of cross-references listed by keyword and author. The

following areas are included:

CAI	Computer-Aided Instruction
ES	Expert Systems
KR	Knowledge Representation
LP	Logic Programming
NL	Natural Language
PS	Philosophy of Science
UM	User Modeling

Computer-aided instruction is relevant since a student model, a specific kind of user model, is used to decide what to teach. Expert systems are relevant since they require a user model in order to provide answers and explanations as appropriately as possible. Knowledge representation is relevant since its question of how to represent beliefs and knowledge is similar to the user modeling problem. My approach uses logic; hence logic programming is useful. In natural language research, a user model plays an important part of the pragmatic analysis. The philosophy of science is relevant since my theory formation approach has an analogue in science. I use the category 'user modeling' for some of the references to denote that they straddle several areas.

A few of the entries contain acronyms. Usually I have spelled out the name in full, but the following conferences are left in acronym form:

AAAI	American Association for Artificial Intelligence
CSCSI	Canadian Society for Computational Studies of Intelligence
IJCAI	International Joint Conference on Artificial Intelligence

Note that the papers presented at the conference in Maria Laach were not published in a proceedings, so they will be difficult to obtain. Further publication is being discussed.

I offer my apologies to any author who feels that his or her work has been misrepresented by my comments. I also apologize for the many references that could have been included here but were not. If you have a list of important references that are related to the topics in this bibliography, please send them.

I would like to thank Robin Cohen for her many suggestions, and to thank Marlene Jones and David Poole for commenting on earlier versions.

BIBLIOGRAPHY

Airenti, Gabriella, Bruno G. Bara, and Marco Colombetti, "Modelling the Relationship Between User and System in Man-Machine Dialogue," *presented at the Invitational International Workshop on User Modelling*, Maria Laach, West Germany, August, 1986.

NL (dialogue) They make a distinction between behavioural and conversational cooperation. Several rules define how conversations usually go (on three levels: linguistic, conversational, and behavioural). The user model stores the user's view of the behavioural game (the plan being carried out).

Allen, James, "A Plan Based Approach to Speech Act Recognition," University of Toronto, Dept. of Computer Science, Tech. Report No. 131, Toronto, Ontario, 1979.

NL (plan recognition) An earlier version of other publications.

Allen, James, "Recognizing Intentions from Natural Language Utterances," in *Computational Models of Discourse*, ed. M. Brady and R. Berwick, pp. 107-166, MIT Press, Cambridge, MA, 1982.

NL (plan recognition) The claim is made that helpful behaviour arises because one agent recognizes the other agent's plans, and removes obstacles in it. They use a transcript of interaction at the Union Station information booth to support this. Using standard planning techniques they can detect others' plans and possible obstacles, and answer accordingly. They use mutual belief to answer indirect speech acts.

Allen, James, A. Frisch, and D. Litman, "ARGOT: The Rochester Dialogue System," *Proceedings of AAAI-82*, pp. 66-70, Pittsburgh, PA, 1982.

NL (plan recognition) A discussion of a dialogue system, ARGOT, that recognizes multiple goals in the domain of setting up computer systems. ARGOT has three subsystems: a task goal reasoner, a communicative goal reasoner, and a linguistic reasoner. Communicative goals are used to find plans, as in the pragmatics literature.

Allen, James F. and C. Raymond Perrault, "Participation in dialogues understanding via plan deduction," *Proceedings of CSCSI-78*, Toronto, Ontario, 1978.

NL (plan recognition) An earlier version of other publications.

Allen, James F. and C. Raymond Perrault, "Analyzing Intention in Utterances," *Artificial Intelligence*, vol. 15, pp. 143-178, 1980.

NL (plan recognition) An earlier version of Allen's 1982 paper.

Appelt, Douglas E., *Planning English Sentences,* Cambridge University Press, Cambridge, MA, 1985.

NL (goals, speech acts) His Ph. D. Thesis in book form. He discusses the need for goal analysis in recognizing referring expressions.

Appelt, Douglas E., "Planning Natural Language Referring Expressions," *Proceedings of the 20th annual meeting of the Association for Computational Linguistics (ACL)*, Toronto, Ontario, June, 1982.

NL (goals, speech acts) A short version of some of his thesis work. He describes a language planning (generation) system, similar to KAMP (discussed in his thesis), to generate referring expressions to satisfy multiple goals. It uses Moore's possible worlds semantics to represent several agents' mutual beliefs, and builds on Cohen and Perrault's work on planning speech acts.

Austin, J. L., *How to Do Things with Words,* Harvard University Press, Cambridge, MA, 1962.

NL (speech acts) The pioneering work viewing speech acts as actions performed by speakers to achieve intended effects.

Boguraev, B. K., "User Modelling in Cooperative Natural Language Front Ends," in *Social Action and Artificial Intelligence*, ed. Gilbert, Heath, pp. 124-143, Gower Press, London, 1985.

NL (user models) He argues that user models are necessary for natural-language interfaces to allow cooperative dialogue. He describes much of the current work.

Bowen, Kenneth A. and Robert A. Kowalski, "Amalgamating Language and Metalanguage in Logic Programming," in *Logic Programming*, ed. K. L. Clark, S-A Tarnlund, Academic Press, 1982.

LP (meta-programming) The object language of logic-programming is extended to include a metalanguage dealing with the object level provability relation. It is shown to be useful for data base management.

Bowen, Kenneth A. and Tobias Weinberg, "A Meta-Level Extension of Prolog," *Symposium on Logic Programming*, pp. 48-53, Boston, MA, July, 1985.

LP (meta-programming) The metalanguage predicate (demo) is redescribed, with emphasis on its power to represent search strategies as first class objects. Thus, a program can be explicitly controlled, and parts of the proof can be extracted. The real power of this system, so they say, is the new methodology where all aspects of the program are characterized axiomatically.

Bowen, Kenneth A., "Meta-Level Programming and Knowledge Representation," *New Generation Computing*, vol. 3, pp. 359-383, 1985.

LP (meta-programming) The application of representing theories as first order objects is further explained with the database management example, including the use of integrity constraints and default rules. Similarly, it is applied to frames and scripts to modify values in a structured theory. The point of all this is to show the wide range of uses to which one can put such a metalanguage.

Brown, John Seely, Richard R. Burton, and F. Zdybel, "A model-driven Question and Answering system for mixed initiative CAI," Technical Report No 22, University of California, Los Angeles, CA, 1972.

CAI (student modeling) They maintain a simple user model using an external state vector which indicate presuppositions behind student questions.

Brown, John Seely, Richard R. Burton, C. Hausmann, Ira P. Goldstein, B. Huggins, and Mark L. Miller, "Aspects of a Theory for Automated Student Modelling," Technical Report, Bolt, Beranek, and Newman, Inc., 1977.

CAI (student modeling)

Brown, John Seely and Richard R. Burton, "Diagnostic Models for Procedural Bugs in Basic Mathematical Skills," *Cognitive Science*, vol. 2, pp. 155-192, 1978.

CAI (diagnosis) This work centres on an expert system, Buggy, that diagnoses procedural bugs in basic mathematical skills of a student. Its purpose is to build a model of the bugs of the student. Its premise is that students have an algorithm (possibly faulty) with which they subtract. The 110 possible bugs are arranged in a lattice (also called a procedural network in this case). The student model is the algorithm that the system thinks the student is using, based on the student's answers to various subtraction problems.

Brown, John Seely and Richard R. Burton, "An Investigation of Computer Coaching for Informal Learning Activities," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 79-98, Academic Press, New York, NY, 1982.

CAI (tutoring) They discuss the philosophy of tutoring systems in education and how they have designed WEST to tutor for the game "How the West was won." They discuss specific problems of determining the user's skill, such as the student not always being consistent, and the ad hoc strategies (gradual strengthening and weakening of hypotheses) to combat these problems.

Brown, John Seely and Richard R. Burton, "A Tutoring and Student Modelling Paradigm for Gaming Environments," *Symposium on Computer Science and Education*, pp. 236-246, Anaheim, CA, 1976.

CAI (student modeling)

Bryant, Ross, "Tutorial Diagnosis of Subtraction Errors," Research Report CS-86-09, University of Waterloo, Department of Computer Science, Waterloo, Ontario, September, 1986.

CAI (diagnosis) He reviews the Buggy system of Brown and Burton, and proposes that a better way to perform the diagnosis would be to monitor the student more closely by providing an interactive tutor which monitors a full screen so the student can do the rough work on the screen.

Burton, Richard R., "Diagnosing Bugs in a Simple Procedural Skill," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 157-184, Academic Press, New York, NY, 1982.

CAI (diagnosis) This paper redescribes the BUGGY method of diagnosing a student's subtraction errors, and discusses the more recent two years of testing the systems DEBUGGY and IDEBUGGY (the interactive version).

Carberry, Sandra, "Tracking User Goals in an Information-Seeking Environment," *Proceedings of AAAI-83*, pp. 59-63, Washington, DC, 1983.

NL (plan recognition) She discusses her system TRACK which develops a hierarchical structure of goals and actions to capture user's plans as an information-seeking dialogue progresses. Many specific rules for assuming the plans and updating them are given.

Carberry, Sandra, "Dynamic Construction and Application of User Models," *presented at the Invitational International Workshop on User Modelling*, Maria Laach, West Germany, August, 1986.

NL (plan recognition) She attempts to infer task-related plans from a dialogue, by having a structure of possible plans and subgoals, and searching breadth-first. User models are applied to understand ill-formed queries.

Carbonell, Jaime G., "The Role of User Modelling in Natural Language Interface Design," Report CMU-CS-83-115, Dept. of Computer Science, Carnegie-Mellon University, Pittsburgh, PA, 1983.

NL (user modeling) NL is needed to make friendly interfaces so computers will be easier to use, and UM's are needed since users are different. His approach is a synthesis of previous NL techniques: augmented transition networks, semantic grammars, and expectation-based parsing, in what he calls multi-parsing.

Carbonell, Jaime R. Sr., "Mixed Initiative Man-computer Instructional Dialogues," Ph.D. thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1970.

CAI (user modeling). He uses a semantic network of the expert knowledge, and attached tags to it to store the answers of the student.

Carbonell, Jaime G. and Jill Fain, "Modelling the Natural Language Interface User: Task Knowledge and Linguistic Usage Patterns," *presented at the Invitational International Workshop on User Modelling*, Maria Laach, West Germany, August, 1986.

NL (ambiguity) Two roles of user models are discussed: linguistic disambiguation and interpreting idiosyncratic language.

Carbonell, Jaime G. Jr., "Computer Models of Human Personality Traits," Technical Report, Carnegie-Mellon University, CMU-CS-79-154, 1979.

NL (story understanding) Understanding personality traits is seen as an important part of story understanding. Traits are analyzed in terms of personal goal trees and planning strategies. Personality traits affect an agent's goals and tactics in various ways.

Carbonell, Jaime G. Jr., "Ideological Belief System Simulation," Yale University, Research Report #111, New Haven, CT, May, 1977.

NL (Story understanding). The goal of this research is to simulate story-understanding from an ideological point of view, either right or left wing. Rather than represent ideology as a script, as Abelson did with some bad side effects, Carbonell uses hierarchies of goals.

Carr, B. P. and Ira P. Goldstein, "Overlays: A Theory of Modelling for Computer Aided Instruction," MIT Technical Report 210, 1977.

CAI (student modeling) Overlays are described. (See other references by Goldstein, which describe Genetic Graphs, an improvement to overlays.)

Carroll, John M. and Jean McKendree, "Interface Design Issues For Advice-giving Expert Systems," *Communications of the ACM*, vol. 30, no. 1, January, 1987.

ES (advice) They review the expert system advice-giving literature with respect to the knowledge required and the contingencies for and content of effective advice. Their basic conclusion is that more behavioural research is necessary to make advice-giving really work.

Chin, David N., "User Modeling in UC, the UNIX Consultant," *Proceedings of the CHI'86 Conference*, pp. 24-26, Boston, MA, April, 1986.

ES (tutoring) The user model for use in UC, a unix consultant, is described. It uses a double stereotype. That is, it has a stereotype of users and of the knowledge. (I.e.: only parts of the knowledge are relevant to particular types of users. This is supposed to increase efficiency.) Four levels of expertise are represented.

Clancey, William J., "Dialogue Management for Rule-based Tutorials," *Proceedings of IJCAI-6*, pp. 155-161, Tokyo, 1979.

ES (dialogue) Clancey's system, GUIDON, addresses the dialogue management problem: carrying on a coherent, task-oriented mixed-initiative dialogue. It uses discourse knowledge, domain knowledge, and a record of past discourse. The user model is an overlay of standard behaviour.

Clancey, William J., "The Epistemology of a Rule-Based Expert System: A Framework for Explanation," Stanford University, Report No. STAN-CS-81-896, Stanford, CA, 1981.

ES (tutoring) GUIDON is developed to teach medical students, using MYCIN. It was discovered that the rules of MYCIN contained much embedded information about strategy and various interdependencies of rules. Thus a new framework is supplied which will make such things explicit. Then they will be easier to change and suitable for application to teaching.

Clancey, William J., "Tutoring rules for guiding a case method dialogue," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 201-225, Academic Press, New York, NY, 1982.

ES (tutoring) Similar to the above paper.

Clark, Herbert H. and Catherine R. Marshall, "Definite Reference and Mutual Knowledge," in *Elements of Discourse Understanding*, ed. Aravind K. Joshi, Bonnie Webber, Ivan Sag, pp. 10-64, Cambridge University Press, Cambridge, MA, 1981.

NL (nested belief)

Clark, Keith L., "Negation as Failure," in *Logic and Data Bases*, ed. H. Gallaire and Jack Minker, pp. 293-322, Plenum Press, New York, NY, 1978.

LP (negation) The inference rule "negation of failure" is described as a way to implement negation in logic databases. His definition of "completed database" is shown to correspond to negation as failure.

Cohen, Philip R., "On Knowing What to Say: Planning Speech Acts," Ph.D. Thesis, Technical Report No. 118, University of Toronto, Toronto, Ontario, January, 1978.

NL (speech acts) He has developed a model for speech generation. The main aspect of the model is the idea that speech acts are viewed as actions in a plan. The user model is important because when putting a speech act REQUEST or INFORM into a plan, one is making some user model assumption. Thus, beliefs are represented.

Cohen, Philip R. and C. Raymond Perrault, "Elements of a Plan-based Theory of Speech Acts," *Cognitive Science*, vol. 3, pp. 177-212, 1979.

NL (plan recognition) As above, speech acts are seen as parts of plans that the speakers are trying to carry out. They develop this theory and criticize Searle's view.

Cohen, Philip R. and Hector J. Levesque, "Speech Acts and the Recognition of Shared Plans," *Proceedings of CSCSI-80*, pp. 263-271, 1980.

NL (speech acts) This paper is superceded by their next paper.

Cohen, Philip R. and Hector J. Levesque, "Speech Acts and Rationality," *Proceedings of CSL*, pp. 49-59, 1985.

NL (speech acts) A theory of communication is developed from a theory of rational interaction. Using a modal-logic-like formalism, a rational agent is formalized. Goals and Plans and illocutionary acts are incorporated. One result with this formalism is that illocutionary acts are not primitive.

Cohen, Robin, "A Computational Model for the Analysis of Arguments," Ph.D. thesis, Department of Computer Science, University of Toronto; also Technical Report CSRG-151, 1983.

NL (arguments) She develops a framework for understanding arguments, which uses models of belief.

Cohen, Robin, "The Need for Pragmatics in Natural Language Understanding," *Proceedings of CSCSI: Theoretical Advances in Natural Language Understanding Workshop*, May, 1985.

NL (user models) User models are absolutely critical in natural language understanding systems. She discusses the history of their use in interfaces to interactive systems, and how she uses them for understanding arguments.

Cohen, Robin and Marlene Jones, "Incorporating User Models into Expert Systems for Educational Diagnosis," *Technical Report CS-86-37, University of Waterloo*, Waterloo, Ontario, 1986.

ES (user models) They propose partitioning the knowledge base of an expert system to support different answers to different users. The main recommendations are 1) to use defaults to initiate a UM, 2) to allow for difference between user and system knowledge, and 3) to track the user's goals.

Davidson, J., "Natural Language Access to Databases: User Modelling and Focus," *Proceedings of CSCSI-82*, pp. 204-211, Saskatoon, Saskatchewan, May, 1982.

NL (focus) He describes the system PIQUE which maintains a segment of a database in focus as a model of the user's focus.

deKleer, Johan, "An Assumption-Based TMS," *Artificial Intelligence*, vol. 28, no. 1, 1986.

KR (truth maintenance) He describes how TMS systems work to efficiently find consistent solutions, and why ATMS systems are more efficient. They keep track of the context (assumptions used) in which each datum holds. Two additional papers in the same volume discuss extensions to ATMS, and comparisons with other approaches.

Doyle, Jon and P. London, "A Selected Descriptor-Indexed Bibliography to the Literature on Belief Revision," *SIGART Newsletter (Special Interest Group on AI from ACM)*, vol. 71, pp. 7-23, 1980.

KR (belief revision) A brief overview of the area of belief revision, breaking the area down into many aspects, most which have some relationship to user modelling.

Etherington, David W., "Formalizing Non-Monotonic Reasoning Systems," Technical Report 83-1, University of British Columbia, Vancouver, B.C., 1983.

KR (defaults) He formalizes Reiter's Default Logic.

Etherington, David W. and Raymond Reiter, "On Inheritance Hierarchies With Exceptions," in *Readings in Knowledge Representation*, ed. Ronald J. Brachman and Hector J. Levesque, pp. 329-334, Morgan Kaufmann Publishers, Inc., Los Altos, CA, 1985; also appears in proceedings of AAAI-83, pp. 104-108, Washington, D. C., 1983.

KR (defaults) They use defaults to formalize the reasoning over inheritance hierarchies. They criticize proposed parallel algorithms for such hierarchies.

Fagin, Ronald and Joseph Y. Halpern, "Belief, Awareness, and Limited Reasoning: Preliminary Report," *Proceedings of IJCAI-9*, pp. 491-501, Los Angeles, CA, August, 1985.

KR (logical omniscience) To deal with the problem of logical omniscience, they propose three new logics. Different sources of non-omniscience are considered in the various approaches to the problem (awareness, resource-bound, relevant rules, and focus).

Finin, Tim W. and David Drager, "GUMS1: A General User Modeling System," *Proceedings of CSCSI-86*, pp. 24-30, Montreal, Quebec, May, 1986.

ES (user modeling) They describe an architecture of a domain independent system for building and maintaining long term models of individual users. It includes representing facts, defaults, and stereotypes.

Genesereth, Michael R., "An Automated User Consultant for MACSYMA," Ph.D. thesis, Harvard University, 1978.

CAI (tutoring) He uses a canonical user model in his system to tutor a MACSYMA user.

Genesereth, Michael R., "The Role of Plans in Automated Consultation," *Proceedings of IJCAI-6*, pp. 311-319, Tokyo, Japan, 1979.

CAI (tutoring)

Genesereth, Michael R., "The Role of Plans in Intelligent Teaching Systems," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 137-156, Academic Press, New York, NY, 1982.

CAI (diagnosis) He discusses analyzing the plan of the student by monitoring the student's intermediate steps, and reconstructs them to analyze the student's beliefs and misconceptions. The approach is illustrated for his automated MACSYMA advisor. Plans are viewed as dependency graphs relating plans and goals.

Genesereth, Michael R., "The Use of Design Descriptions in Automated Diagnosis," *Artificial Intelligence*, vol. 24, pp. 411-436, 1984.

KR (diagnosis) He describes DART, a device independent diagnostic program that works from design descriptions.

Genesereth, Michael R. and J. J. Finger, "RESIDUE: A Deductive Approach to Design Synthesis," Report No. STAN-CS-85-1035, Stanford University, Stanford, CA, January, 1985.

KR (design) A new approach to deductive design synthesis in which designs are represented as sets of constraints. It is compared to default reasoning and Assumption-based Truth Maintenance. The method used is similar to the one used in DART, referred to above.

Goebel, Randy G., David L. Poole, and Koichi Furukawa, "Using definite clauses and integrity constraints as the basis for a theory formation approach to diagnostic reasoning," Research Report CS-85-50, University of Waterloo, Waterloo, Ontario, December, 1985.

KR (Theorist) A description of Theorist-S: a simpler version of Theorist [Poole]. Theorist-S is more like Prolog. To allow for finding inconsistencies, the Prolog clauses used in Theorist-S are parti-

tioned into ordinary assertions and integrity constraints. Theories must satisfy the constraints.

Goldstein, Ira P., "The Genetic Graph: a Representation for the Evolution of Procedural Knowledge," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 51-77, Academic Press, New York, NY, 1982.

CAI (genetic graphs) He uses a genetic graph approach, where the student model is an overlay of the genetic graph (a representation of the skill being learned including deviations on the expert knowledge). A tutor decides what to teach based on the state of the overlay.

Grice, H. P., "Utterer's Meaning and Intentions," *Philosophical Review*, vol. 68(2), pp. 147-177, 1969.

NL (dialogue) He introduces the famous maxims of cooperative dialogue.

Grosz, Barbara J., "The Representation and Use of Focus in Dialogue Understanding," Technical Report 151, SRI International, Menlo Park, CA, 1977.

NL (focus)

Hadley, Robert F., "Fagin and Halpern on Logical Omnisciences: A Critique with an Alternative," *Proceedings of CSCSI-86*, pp. 49-56, Montreal, Quebec, May, 1986.

KR (logical omniscience) He offers a philosophical approach to solve the logical omniscience problem. After discussing the problems with other approaches, he offers his approach which says that there may be no logic of belief. Instead we can talk about interchangeability. Beliefs are interchangeable if they have identical intensions, procedurally construed (syntax may play a role in the procedure).

Halpern, J. Y. and Y. O. Moses, "A Guide to the Modal Logics of Knowledge and Belief," *Proceedings of IJCAI-9*, Los Angeles, CA, August, 1985.

KR (modal logic) They discuss how modal logics can be used to model knowledge and belief. The decision procedures and efficiency is considered. They also discuss modelling common knowledge.

Hanks, Steven and Drew McDermott, "Default Reasoning, Nonmonotonic Logics, and the Frame Problem," *Proceedings of AAAI-86*, pp. 328-333, Philadelphia, PA, 1986.

KR (Frame problem) They describe the Yale shooting problem, which allegedly reveals a fundamental problem with nonmonotonic logics.

Hayes, Patrick J. and John McCarthy, "Some Philosophical Problems from the Standpoint of Artificial Intelligence," *Machine Intelligence*, vol. 4, 1969.

KR (philosophy) They discuss how AI is relevant to many philosophy problems. They take the stand that the way to construct intelligent machines is to build fact manipulators. Two aspects of the problem arise: epistemology and heuristics. The epistemological aspect is discussed here. Some of the problems they discuss are still relevant today.

Hayes, Patrick J. and M. A. Rosner, "ULLY: A Program for Handling Conversations," *AISB Conference Proceedings*, 1976.

ES (user models) ULLY models behaviour at parties. It builds a model, but does not actually exploit it.

Hayes, Patrick J., "In Defence of Logic," *Proceedings of IJCAI-5*, Cambridge, MA, 1977.

KR (logic) He defends the use of logic. Logic is not a system as procedural languages are; it is a collection of ideas on how to express a certain kind of knowledge in a certain kind of world. Logic is an analysis of meaning (by a model-theoretic semantics). It allows the representation of knowledge and control in the same language. Other complex representations miss the boat on these things.

Hintikka, Jaakko, *Knowledge and Belief,* Cornell University Press, Ithaca, NY, 1962.

KR (modal logic) He discusses the common use of modal logic to model knowledge and belief. A possible worlds system using the modal logic S4 is viewed as a good model.

Hughes, G. E. and M. J. Cresswell, *An Introduction to Modal Logic,* Methuen and Company Ltd., London, England, 1968.

KR (modal logic) The classic reference describing many modal logics.

Israel, David J., "What's Wrong with Non-Monotonic Logic?," *Proceedings of AAAI-80,* pp. 99-101, Stanford, CA, 1980.

KR (logic) Israel claims that the work in non-monotonic logic, especially that of Reiter, is based on a confusion of proof-theoretic with epistemological issues. The research is based on the belief that logic is crucially involved in the fixation and revision of belief, whereas, in truth, logic only tells you when you must revise your beliefs. Hypotheses are not propositions we accept only after deciding that they are compatible with everything else we believe. He suggests that one should look to the philosophy of science and to epistemology for help.

Israel, David J., "The role of logic in Knowledge Representation," *Computer*, vol. 16 (10), October, 1983.

KR (logic) An addendum to Hayes and Moore's discussion of the problem. It is much like the above paper.

Jackson, P. and P. Lefrere, "On the Application of Rule-based Techniques to the Design of Advice-giving Systems," *International Journal of Man-Machine Studies*, vol. 20, pp. 63-86, 1984.

NL (plans) They discuss how to build systems that can give advice to computer users. Techniques of rule-based systems are used. The technique requires representing a user's goals, beliefs, and plans.

Jameson, Anthony and W. Wahlster, "User Modelling in Anaphora Generation: Ellipsis and Definite Descriptions," *Proceedings of the European Conference on Artificial Intelligence (ECAI-82),* pp. 222-227, Orsay, France, 1982.

NL (generating anaphora) They deal with the problem of generation of anaphora, using an anticipation feedback loop which compares subtrees to decide whether the generated sentence will be ambiguous.

Jameson, Anthony, "A Model of Impression Monitoring and Image Maintenance," *presented at the Invitational International Workshop on User Modelling,* Maria Laach, West Germany, August, 1986.

NL (user modeling) Imp is a system which tries to sell something to the user (such as an interviewee selling himself to an interviewer). The representation uses numbers to represent what the user and the system know. These numbers are combined, based on a psychological model, to decide what to say in order to convince.

Jones, Karen Sparck, "Realism about User Modelling," *presented at the Invitational International Workshop on User Modelling,* Maria Laach, West Germany, August, 1986.

NL (user models) She advocates a very limited form of user models, since deep models cannot be adequately bounded. Too much information is relevant, and the skimpy input isn't enough to obtain the relevant indirect information.

Jones, Karen Sparck, "User Models and Expert Systems," Technical Report No. 61, University of Cambridge Computer Laboratory, Cambridge, England, December, 1984.

ES (user models) A long report describing many aspects of user models. One of its main concerns is to show that NL is not necessarily required for effective user modelling. Different types of users and models are considered.

Jones, Karen Sparck, "Issues in User Modelling for Expert Systems," *Proceedings of AISB-85*, 1985; reprinted in Artificial Intelligence and its Applications, (eds. Cohn and Thomas), New York, Wiley, 1986.

ES (user models)

Jones, Marlene and David L. Poole, "An Expert System for Educational Diagnosis Based on Default Logic," *Proceedings of the Fifth International Conference on Expert Systems and Their Applications*, pp. 673-683, Avignon, France, 1985.

KR (Theorist) An explanation of the details of diagnosis in the education disabilities domain. They discuss the hierarchy of hypotheses, and how certain theories are preferred over others.

Joshi, Aravind K., Bonnie Webber, and Ralph M. Weischedel, "Default Reasoning in Interaction," *AAAI Workshop on Nonmonotonic Reasoning*, pp. 373-384, New York, NY, October, 1984.

NL (defaults) A later, shorter version of the following paper.

Joshi, Aravind K., Bonnie Webber, and Ralph M. Weischedel, "Preventing False Inferences," *Proceedings of COLING-84*, pp. 134-138, Stanford, CA, 1984a.

NL (misconceptions & defaults) They are concerned with preventing false inferences made by Reiter-like defaults in a user model. The user model contains defaults, whose usage may have to be blocked by negating the default consequent.

Joshi, Aravind K., Bonnie Webber, and Ralph M. Weischedel, "Living up to Expectations: Computing Expert Responses," *Proceedings of AAAI-84*, pp. 169-175, Austin, TX, 1984b.

NL (misconceptions) As above, they develop a formal method to add enough to a response so as to prevent the user from making incorrect deductions. The formalism is a simple nested belief, not yet using defaults.

Joshi, Aravind K. and Bonnie Webber, "Beyond Syntactic Sugar: Next Steps in NL Interaction," *Proceedings of the Third Jerusalem Conference*, pp. 590-594, Jerusalem, Israel, May, 1984.

NL (misconceptions) They argue that NL should not just be pretty syntax, but must respond to misconceptions due to disparate beliefs and avoid misleading utterances. Three kinds of misconceptions discussed in other research are described.

Joshi, Aravind K., "Mutual Beliefs in Question Answering Systems," in *Mutual Belief*, ed. N. Smith, Academic Press, New York, NY, 1982.

NL (beliefs)

Kaplan, S. Jerrold, "Indirect Responses to Loaded Questions," *Proceedings of the Second Conference on Theoretical Issues in Natural Language Processing*, pp. 202-209, Champagne-Urbana, 1978.

NL (misconceptions) An earlier version of his work.

Kaplan, S. Jerrold, "Appropriate Responses to Inappropriate Questions," in *Elements of Discourse Understanding*, ed. Aravind K. Joshi, Bonnie Webber, Ivan Sag, pp. 127-144, Cambridge University Press, Cambridge, MA, 1981.

NL (misconceptions) Similar to the following.

Kaplan, S. Jerrold, "Cooperative Responses from a Portable natural Language Database Query System," in *Computational Models of Discourse*, ed. M. Brady and R. Berwick, pp. 167-208, MIT Press, Cambridge, MA, 1982.

NL (misconceptions) CO-OP is a portable NL database query system which provides cooperative response to data retrieval questions (such as 'Which students failed CS105? It wasn't offered.') The form of the question, and a lexicon are enough to derive the cooperative response.

Kawai, Kazuhisa, Riichiro Mizoguchi, Osamu Kakusho, and Jun'ichi Toyoda, "A Framework for ICAI Systems Based on Inductive Inference and Logic Programming," *Proceedings of International Conference on Logic Programming,* London, England, 1984.

CAI (user modeling) They describe a system which uses Shapiro's program induction (MIS) and his program diagnosis (PDS) as a student model. MIS builds the model, and PDS finds its misconceptions and lack of knowledge.

Kobsa, Alfred, "Using Situation Descriptions and Russellian Attitudes for Representing Beliefs and Wants," *Proceedings of IJCAI-9,* pp. 513-515, Los Angeles, CA, August, 1985.

ES (belief) He describes the representation scheme of VIE-DPM, which allows the representation of beliefs and nested beliefs using KL-ONE.

Kobsa, Alfred, "The Architecture of a User Modelling Component in a Natural-Language Dialog System: Some Requirements and Some Questions," *presented at the Invitational International Workshop on User Modelling,* Maria Laach, West Germany, August, 1986.

NL (user modeling)

Kobsa, Alfred, "VIE-DPM: A User Model in a Natural-Language Dialogue System," *GWAI-84 (8th German Workshop on Artificial Intelligence),* Springer, Berlin, 1985.

NL (user modeling) A more detailed explanation of his system VIE-DPM.

Kobsa, Alfred and H. Trost, "Representing Belief Models in Semantic Networks," in *Cybernetics and Systems Research II,* ed. R. Trapple, North-Holland, Amsterdam, 1984.

NL (user modeling)

Kobsa, Alfred, "Three Steps in Constructing Mutual Belief Models from User Assertions.," *Proceedings of the 1984 European Conference on Artificial Intelligence,,* pp. 423-426, Pisa, Italy, 1984.

NL (user modeling)

Konolige, Kurt, "Experimental Robot Psychology," *Proceedings of ACAI,* 1985a.

KR (belief)

Konolige, Kurt, "A Deductive Model of Belief," *Proceedings of IJCAI-8,* pp. 377-381, Karlsruhe, West Germany, August, 1983.

KR (belief) He suggests a model of deductive belief. See the following reference for more detail.

Konolige, Kurt, "Belief and Incompleteness," in *Formal Theories of the Common-Sense World,* ed. Jerry Hobbs, 1985b.

KR (beliefs) This suggests a model of belief where beliefs are all things that can be deduced from the axioms. It handles consequential closure (logical omniscience) by starting with an incomplete set of axioms. Using Block Tableaux, he is equipped with a flexible set of axioms that can be manipulated for various effects on what is in the closure of beliefs.

Kowalski, Robert, *Logic for Problem Solving,* Elsevier Science Publishing Co., Inc., New York, NY, 1979.

LP (overview). He introduces and discusses logic programming.

Kuhn, Thomas S., *The Structure of Scientific Revolutions,* The University of Chicago Press, Chicago, IL, 1962.

PS He describes scientific progress as a continual upheaval of paradigms.

Kuhn, Thomas S., *The Essential Tension,* The University of Chicago Press, Chicago, IL, 1977.

PS A collection of essays on various topics, relating to his theory of scientific revolution. In one essay, he criticizes Popper's view, claiming falsifiability is too strict of a criterion.

Levesque, Hector J., "A Logic of Implicit and Explicit Belief," *Proceedings of AAAI-84*, Austin, TX, 1984.

KR (logical omniscience) He deals with the problem which arises KR, that some formal systems of belief force their agents to have logical omniscience. Hintikka's possible worlds, for example, have this undesirable property. To avoid it, Levesque distinguishes explicit and implicit belief. Implicit belief is deductively closed, but explicit belief uses relevance logic, allowing the agent to believe inconsistent things, and to not believe all consequences of his beliefs.

London, B. and William J. Clancey, "Plan Recognition Strategies in Student Modelling: Prediction and Description," *Proceedings of AAAI-82*, pp. 335-338, Pittsburgh, PA, 1982.

ES (plan recognition) Their user model of their system, GUIDON2, by using the knowledge base, hypothesizes several things that could be the user's plan (based on context) and then waits to see which it is.

Macmillan, S. A., "User Models to Personalize an Intelligent Agent," Ph. D. Thesis, School of Education, Stanford University, Stanford, CA, 1983.

User models

Mann, W. C., J. A. Moore, and J. A. Levin, "A Comprehension Model for Human Dialogue," *Proceedings of IJCAI-5*, pp. 77-87, 1977.

NL (dialogue)

Mark, W., "Representation and Inference in the Consul System," *Proceedings of IJCAI-7*, pp. 375-381, Vancouver, BC, 1981.

NL (interface)

Mays, E., "Correcting Misconceptions About Data Base Structure," *Proceedings of CSCSI-80*, pp. 123-128, Victoria, B. C., May, 1980.

NL (misconceptions)

McCarthy, John, "Circumscription--A form of non-monotonic reasoning," *Artificial Intelligence*, vol. 13, pp. 27-39, 1980.

KR (circumscription) Because of the problems of stating all qualifications, and the need for non-monotonicity, we can't just use deduction from logic in problem solving. Circumscription is an inference rule that allows us to assume things. Here, domain circumscription and predicate circumscription are described.

McCarthy, John, "Epistemological Problems of Artificial Intelligence," in *Readings in Knowledge Representation*, ed. Ronald J. Brachman and Hector J. Levesque, pp. 23-30, Morgan Kaufmann Publishers, Inc., Los Altos, CA, 1985; also appeared in proceedings of IJCAI-5, Cambridge, MA, pp. 1038-1044, 1977.

KR (circumscription) He reviews the philosophical problems mentioned ten years earlier. Two outstanding problems are the frame problem and the qualification problem. He introduces circumscription to deal with this.

McCoy, Kathleen F., "Correcting Object-Related Misconceptions," Ph. D. Thesis, MS-CIS-85-57, Dept of Computer and Information Science, University of Pennsylvania, Philadelphia, PA, 1985.

NL (misconceptions)

McCoy, Kathleen F., "Correcting Misconceptions: What to Say," *CHI'83 Conference Human Factors in Computing Systems*, Cambridge, MA, December, 1983.

NL (misconceptions)

McCoy, Kathleen F., "Reasoning on a User Model to Respond to Misconceptions," *presented at the Invitational International Workshop on User Modelling*, Maria Laach, West Germany, August, 1986.

NL (misconceptions) She discusses correcting misconceptions about attributes of objects. Several aspects of the misunderstood object are represented, and one is designated as active. The system responds with respect to the misconception of the active aspect.

McCoy, Kathleen F., "The Role of Perspective in Responding to Property Misconceptions," *Proceedings of IJCAI-9*, pp. 791-793, Los Angeles, CA., 1985.

NL (misconceptions) Similar to the above paper.

McDermott, Drew and Jon Doyle, "Non-Monotonic Logic I," *Artificial Intelligence*, vol. 13, pp. 41-72, 1980.

KR (truth maintenance) They develop a logic to model beliefs of active processes, requiring belief revision (to allow reasoning with incomplete knowledge).

McKeown, Kathleen R., Myron Wish, and Kevin Matthews, "Tailoring Explanations for the User," *Proceedings of IJCAI-9*, pp. 794-798, Los Angeles, CA., 1985.

NL (goals). They deal with organizing knowledge to determine goals and deciding when to respond to goals (since sometimes the goals are too tentative). Their system allows a hierarchy of goals; in fact, the knowledge structure is a hierarchy of goals. This hierarchy allows the system to induce higher-level goals from lower-level ones.

Mercer, Robert and Raymond Reiter, "The Representation of Presuppositions Using Defaults," *Proceedings of CSCSI-82*, pp. 103-107, Saskatoon, Saskatchewan, May, 1982.

NL (misconceptions) Gazdar provides a linguistic theory where presuppositions are based on inconsistency. A potential presupposition is represented here as a default rule.

Mercer, Robert and R. Rosenberg, "Generating Corrective Answers by Computing Presuppositions of Answers, not of Questions," *Proceedings of CSCSI-84*, pp. 16-19, London, Ontario, May, 1984.

NL (misconceptions) They describe how, in order to answer a question, the system must also respond to the presuppositions. It is better to use the rule, "don't say anything not provably true in the answer", instead of "deny all false presuppositions of the question."

Minsky, Marvin, "A Framework for Representing Knowledge," in *Readings in Knowledge Representation*, ed. Ronald J. Brachman and Hector J. Levesque, pp. 245-261, Morgan Kaufmann Publishers, Inc., Los Altos, CA, 1985; also appears in Mind Design, John Haugeland (ed.), pp. 95-128, Cambridge, MA, The MIT Press, 1981.

KR (frames) He presents the idea of frames as an AI tool and cognitive memory model, and criticizes the use of logic.

Moore, Robert C., "Semantical Considerations On Nonmonotonic Logic," Artificial Intelligence Center Technical Note 284, SRI International, Menlo Park, CA, June, 1983.

KR (nonmonotonic logic) Different kinds of default logic are suited for different kinds of reasoning. He shows that McDermott and Doyle's belief revision is not good for invalid inference (default reasoning), since all of its inferences are valid. Rather, it performs auto-epistemic reasoning (reasoning about ones own beliefs).

Moore, Robert C., "Reasoning about Knowledge and Action," Ph.D. thesis, Massachusetts Institute of Technology, 1979.

KR (belief) He models belief and deals with the problem of logical omniscience. See other references for more details.

Moore, Robert C. and Gary G. Hendrix, "Computational Models of Belief and the Semantics of Belief Sentences," Technical Note 187, SRI International, Menlo Park, CA, June, 1979.

KR (belief) They provide a computational model of belief, based on a more philosophical approach.

Moore, Robert C., "Reasoning about Knowledge and Action," Technical Note 191, Artificial Intelligence Center, SRI International, Menlo Park, CA, October, 1980.

KR (knowledge and action) See the following reference.

Moore, Robert C., "A Formal Theory of Knowledge and Action," in *Formal Theories of the Common-Sense World*, ed. Jerry Hobbs, 1985.

KR (knowledge and action) He imagines an agent planning to do an act. Acts require knowledge and action, hence we need both in a formal theory. He uses the examples of opening a safe and performing a litmus test since both require knowledge and action. The model of knowledge used is similar to the modal logic S4.

Moore, Robert C., "The Role of Logic in Knowledge Representation and Commonsense Reasoning," in *Readings in Knowledge Representation*, ed. Ronald J. Brachman and Hector J. Levesque, pp. 335-341, Morgan Kaufmann Publishers, Inc., Los Altos, CA, 1985; also appeared in proceedings of AAAI-82, pp. 428-433, Pittsburgh, PA, 1982.

KR (logic) He defends the view that logic is very important in KR. To actually capture real commonsense reasoning in a system, logic has to play a much more active role.

Morik, Katharina and C-R Rollinger, "The Real Estate Agent--Modeling the User by Uncertain Reasoning," *AI Magazine*, vol. 6 (2), pp. 44-52, Summer, 1985.

ES (user modeling)

Morik, Katharina, "Modeling the User's Wants," *presented at the Invitational International Workshop on User Modelling*, Maria Laach, West Germany, August, 1986.

NL (user models) She shows how modelling of the user's wants determines the system's recognition and generation of speech acts. She also describes HAM-ANS and how user models would differ in different settings, depending on how the system changes the world, and what is changed in the world.

Nadathur, Gopalan and Aravind K. Joshi, "Mutual Beliefs in Conversation Systems: Their Role in Referring Expressions," *Proceedings of CSCSI-82*, pp. 603-605, Saskatoon, Saskatchewan, May, 1982.

NL (referring expressions) Part of a user model is mutual belief. Here it is shown that there are cases where dialogue can occur when mutual belief is not present, but something weaker is. Thus, Perrault and Cohen (below) give too strong of a necessary condition for using referring expressions.

Paris, Cecile L., "Description Strategies for Naive and Expert Users," *Proceedings of ACL-85 (The Association for Computational Linguistics)*, Chicago, IL, 1985.

NL (description)

Paris, Cecile L., "Tailoring Object Descriptions to the User's Level of Expertise," *presented at the Invitational International Workshop on User Modelling*, Maria Laach, West Germany, August, 1986.

NL (description) An approach to tailoring object descriptions based on the user's expertise. The kind of information in a description varies, not just the amount of information.

Perrault, C. Raymond, Philip R. Cohen, and James F. Allen, "Speech Acts as a Basis for Understanding Dialogue Coherence," *Proceedings of Second conference on Theoretical Issues in Natural Language processing (TINLAP)*, pp. 125-132, Urbana-Champaign, IL, July, 1978.

NL (speech acts)

Perrault, C. Raymond and Philip R. Cohen, "It's for your own good: a note on inaccurate reference," in *Elements of Discourse Understanding*, ed. Aravind K. Joshi, Bonnie Webber, Ivan Sag, Cambridge University Press, Cambridge, MA, 1981.

NL (referring expressions) It is recognized that there is a difference between what a definite description refers to and what a speaker intends to refer to. They criticize Searle's attempt to explain this (because he didn't account for the belief of the two agents), and provide necessary and sufficient conditions defining when a speaker can be said to have referred to an entity in uttering a referring expression, by considering the beliefs of the speaker (and nested beliefs).

Perrault, C. Raymond, "An Application of Default Logic to Speech Act Theory (extended abstract)," *Proceedings of Structure of Multi-Modal Dialogues Including Voice*, pp. 1-16, Venaco, France, Sept, 1986.

NL (speech acts & defaults) He uses default logic to specify axioms that can be used to describe what is true about beliefs and goals of agents after uttering various kinds of speech acts. It is a response to Cohen & Levesque's work, complaining that their monotonic system has counter-intuitive results and too complex axioms. The defaults are helpful since they are sensitive to the context of the utterance, so consequences only hold if not contradictory. This works for asserting, lying, convincing, and informing.

Pollack, Martha E., Julia Hirschberg, and Bonnie Webber, "User Participation in the Reasoning Processes of Expert Systems," *Proceedings of AAAI-82*, pp. 358-361, 1982.

NL (plan inference) They use a transcript of a talk show dialogue to demonstrate how an expert must have full NL capabilities in order to work. Mainly, the expert needs to recognize goals and respond appropriately to them.

Pollack, Martha E., "Generating Expert Answers Through Goal Inference," in *Research on Interactive Acquisition and Use of Knowledge*, ed. B. Grosz and M. Stickel, Final Report, SRI International, Menlo Park, CA, 1983.

NL (plan inference)

Pollack, Martha E., "Good Answers to Bad Questions: Goal Inference in Expert Systems," *Proceedings of CSCSI-84*, pp. 20-24, London, Ontario, 1984.

NL (plan inference) She discusses how intended goals can be found, not assuming the question asked was appropriate. The resulting 'linking-rules' and 'action-description formulae' were motivated by actual transcripts.

Pollack, Martha E., "A Model of Plan Inference that Distinguishes between the Beliefs of Actors and Observers," *Proceedings of ACL-86 (24th Annual Meeting of the Association for Computational Linguistics)*, pp. 207-214, 1986.

NL (plan inference) A model of plan inference is described which allows for distinguishing beliefs of actors and observers. Plans can be seen as ill-formed or as completely incoherent. In the latter, the system can't understand the intended motivation for parts of the plan. Some discussion of the plan inference process is provided.

Poole, David L., "A Logical System for Default Reasoning," *AAAI Workshop on Nonmonotonic Reasoning*, pp. 373-384, New York, NY, October, 1984.

KR (Theorist) He presents Theorist (before it was called Theorist), motivating it by its applicability to reasoning about exceptions, scientific reasoning (such as diagnosis), and problem solving using generalizations. It is compared with Reiter's defaults, various computational mechanisms (negation as failure, dependency-directed backtracking, and reverse skolemization), and database consistency.

Poole, David L., Randy G. Goebel, and Romas Aleliunas, "Theorist: a Logical Reasoning System for Defaults and Diagnosis," Research Report CS-86-06, Waterloo, Ontario, February, 1986.

KR (Theorist) Theorist is introduced. They argue that theory formation from a fixed set of possible hypotheses is good for viewing many problems (including diagnosis, default reasoning, learning, user modelling, and mundane tasks with choices). An implementation is described.

Poole, David L., "Default Reasoning and Diagnosis as Theory Formation," Technical Report CS-86-08, University of Waterloo, Waterloo, Ontario, March, 1986.

KR (Theorist) Theorist is presented for default reasoning and diagnosis. It is compared to Reiter's normal defaults, and to Reiter's diagnosis of circuits. The circuit diagnosis is gone into in great detail, and compared with other systems.

Popper, Karl R., *Conjectures and Refutations: The Growth of Scientific Knowledge,* Harper & Row Publishers, New York, NY, 1963.

PS His thesis is that we learn by our mistakes, or that growth of knowledge proceeds by discovering empirically why its current theories are incorrect, and then changing the theory so it accounts for the previous theory's shortcomings. Falsification of theories demarcates science from non-science.

Quine, W. V. O. and J. S. Ullian, *The Web of Belief,* Random House, New York, NY, 1978.

PS He discusses many aspects of belief and revision of belief. He argues the necessity of hypothesis, and gives five criteria we use for preferring some criteria over others.

Reiser, B. J., J. R. Anderson, and R. G. Farrell, "Dynamic Student Modelling in an Intelligent Tutor for LISP Programming," *Proceedings of IJCAI-9,* Los Angeles,CA, August, 1985.

CAI (tutoring) To tutor LISP programming, it has a generic student model of rules and faulty variations. The individualized model is simply an overlay of weightings to measure how well the student knows a rule.

Reiter, Raymond, "A Logic for Default Reasoning," *Artificial Intelligence,* vol. 13, pp. 81-132, 1980.

KR (defaults) Because of the observed need to make default guesses, a default logic is proposed and developed. Extensions are formally defined, and a proof theory (based on resolution) is provided.

Rich, Elaine, "User Modelling Via Stereotypes," *Cognitive Science,* vol. 3, pp. 329-354, 1979a.

ES (stereotypes) A good summary of her PhD thesis work. (See below.)

Rich, Elaine, "Building and Exploiting User Models," Ph.D. thesis, Carnegie-Mellon University, Pittsburgh, PA, April, 1979b.

ES (stereotypes) The thesis describes some general thoughts on the subject of user models, and the details of a particular model, built by Rich into a system called GRUNDY which recommends which book its user should read, based on its model of the user. GRUNDY models the user by asking a few questions, and then evoking a stereotype.

Rich, Elaine, "Users are Individuals: Individualizing User Models," *International Journal of Man-Machine Studies,* vol. 18, pp. 199-214, 1983a.

ES (stereotypes) GRUNDY is redescribed. Other user modelling issues are discussed, such as the need for implicitly deriving a model.

Rich, Elaine, Doug Sleeman, William R. Swartout, Doug E. Appelt, Kurt Konolige, and N. S. Sridharan, "User Modelling panel," *Proceedings of IJCAI-9,* Los Angeles,CA, August, 1985.

User modelling This panel discusses many aspects of the problem. Rich: various dimensions of user models exist. Sleeman: the shortcoming of overlay models. Swartout: feedback for explanations, rather than user models. Appelt: goal recognition. Konolige: the hard part is finding the model. Sridharan: different kinds of models are appropriate to different uses.

Schmidt, C. F., N. S. Sridharan, and J. L. Goodson, "The Plan Recognition Problem: An Intersection of Psychology and Artificial Intelligence," *Artificial Intelligence*, vol. 11, pp. 45-83, 1978.

NL (plan recognition)

Schuster, Elaine, "Grammars as User Models," *Proceedings of IJCAI-9*, Los Angeles,CA, August, 1985.

ES (tutoring) This paper refers to the specific problem of having a user model in teaching a second language. The user model is canonical, and it is merely a set of all ways that a person could go wrong in translation.

Self, John A., "Student Models in Computer-Aided Instruction," *International Journal of Man-Machine Studies*, vol. 6, pp. 261-276, 1974.

CAI (student models) The raison d'etre of CAI is to provide individualized teaching (to evaluate a teaching function, which contains a student model as one input). User models are part of the essence of CAI. He gives a history of early CAI. His own method is to model the student using a procedure which is a perturbation of the expert's procedure.

Self, John A., "Concept Teaching," *Artificial Intelligence*, vol. 9, pp. 197-221, 1977.

CAI

Shrager, J. and Tim Finin, "An Expert System that Volunteers Advice," *Proceedings of AAAI-82*, pp. 339-340, Pittsburgh, PA, 1982.

ES (advice) The system volunteers advice on the basis of recognizing prespecified bad ways of doing things (bad plans). A history of user's inputs may change the advice.

Sidner, Candace L. and David J. Israel, "Recognizing Intended Meaning and Speakers' Plans," *Proceedings of IJCAI-7*, pp. 203-208, Vancouver, BC, 1981.

NL (plan inference) They provide a model for recognizing a speaker's intended meaning in determining a response. They recognize the importance of goals and plans, and so they relate the literal meaning to some intended meaning. They start with Grice's theory of speaker meaning and add more beliefs about context.

Sidner, Candace L., "What the Speaker Means: The Recognition of Speaker's Plans in Discourse," *Computers and Mathematics with Applications*, vol. 9, pp. 71-82, 1983.

NL (plan inference)

Sleeman, Doug and John Seely Brown (eds.), in *Intelligent Tutoring Systems*, pp. 79-98, Academic Press, New York, NY, 1982.

CAI Many of the papers in the book discuss the problem of student modeling.

Sleeman, Doug, "Assessing Aspects of Competence in Basic Algebra," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 185-200, Academic Press, New York, NY, 1982.

CAI (student modeling) He discusses the Leeds Modelling System which forms a student model for Algebra diagnosis. The system was compared with conventional human diagnosis. Rules and malrules are presented.

Sleeman, Doug and R. J. Hendley, "ACE: A System which Analyses Complex Explanations," in *Intelligent Tutoring Systems*, ed. Doug Sleeman, John Seely Brown, pp. 99-118, Academic Press, New York, NY, 1982.

CAI (student modeling) They implemented a system to model a student who is solving problems of interpreting nuclear magnetic resonance spectra. Thus, it is representing procedures.

Smith, Brian Cantwell, "Reflection and Semantics in Lisp," *Conference Record of 11th POPL*, pp. 23-35, Salt Lake City, Utah, 1984, also available as Xerox PARC Intelligent Systems Laboratory Technical Report ISL-5, Palo Alto, CA, 1984.

LP (reflection) He describes 3-Lisp, an architecture for a reflective system, a system which reasons about its own operations. The basic idea is to define infinitely-nested procedural self-models, which can be finitely implemented.

Smith, Brian Cantwell, "Prologue to Reflection and Semantics in a Procedural Language," in *Readings in Knowledge Representation*, ed. Ronald J. Brachman and Hector J. Levesque, pp. 31-39, Morgan Kaufmann Publishers, Inc., Los Altos, CA, 1985; also appeared in Ph. D. dissertation and Technical Report MIT/LCS/TR-272, MIT, Cambridge, MA, 1982.

LP (reflection) A prologue to Smith's Ph.D. thesis. He claims a system needs to explicitly represent its own operations and structures (the Reflection Hypothesis).

Soulhi, S., "Representing Knowledge about Knowledge and Mutual Knowledge," *10th International Conference on Computational Linguistics*, pp. 194-199, Stanford, CA, 1984.

NL (speech acts) To represent speech acts in a multi-agent context, he uses modal logic KT4 by Sato. It is attempting to improve on Cohen's work.

VanArragon, Paul, "Using Scientific Theory Formation for User Modelling," unpublished Ph. D. Thesis proposal, University of Waterloo, Waterloo, Ontario, November, 1986.

KR (user modeling) He describes the use of a theory-formation system (Theorist) as an architecture for user modeling.

VanArragon, Paul and David L. Poole, "Theory Formation as an Architecture for User Modeling," Technical Report, University of Waterloo, Waterloo, Ontario, 1987.

KR (user modeling) They describe the use of a theory-formation system (Theorist) as an architecture for user modeling. It is applied to the problem of preventing misconceptions.

vanBeek, Peter, "Towards User Specific Explanations from Expert Systems," M. Mathematics thesis, Department of Computer Science, University of Waterloo, Waterloo, Ontario, 1986.

NL (goals) He attacks the problem of providing explanations for expert systems. He shows that Joshi, Webber, and Weischedel's model of how to respond cooperatively must also account for higher-level goals.

vanBeek, Peter and Robin Cohen, "Towards User Specific Explanations from Expert Systems," *Proceedings of CSCSI-86*, pp. 194-198, Montreal, Quebec, May, 1986.

NL (goals) A shorter version of the above thesis.

Wahlster, W. and A. Kobsa, "Dialog-Based User Models," *to appear in IEEE, Special Issue on Natural Language Processing.*

NL (user models). They discuss the history of user models, and explain how many systems work.

Wahlster, W., "User Models in Dialogue Systems," *Invited talk at COLING-84 (to appear in Computational Linguistics);*, 1984.

NL (user models)

Wallis, Jerold W. and Edward H. Shortliffe, "Explanatory Power for Medical Expert Systems: Studies in the Representation of Causal Relationships for Clinical Consultations," Stanford University, Report No. STAN-CS-82-923, Stanford, CA, 1982.

ES (explanation) They focus on explanations by expert systems for different types of users. This requires knowledge of what is complex and important, and the causal mechanisms in rules. The approach is like that of GUIDON. User's expertise is rated on four levels. Sum-areas of expertise are also rated numerically, but dynamically. The dialogue must allow for self-correction of ratings.

Wasson, Barbara J., "Student Models: The Genetic Graph Approach," M.M. thesis, University of Waterloo, Research Report CS-85-10, Waterloo, Ontario, May 1985.

CAI (genetic graphs) She discusses the genetic-graph approach to user modelling for Intelligent CAI. She augments it for use in the domain of ballet.

Webber, Bonnie L. and E. Mays, "Varieties of User Misconceptions: Detection and Correction," *Proceedings of IJCAI-8*, vol. 2, pp. 650-652, Karlsruhe, West Germany, August, 1983.

NL (misconceptions) They are studying misconceptions--basically those that are presuppositions of a user's query to a database. They divide them into two groups for heuristic purposes. Misconceptions about what is the case and about what could be the case (in the student-advisor domain).

Wilensky, Robert, "Talking to UNIX in English: an Overview of an On-line UNIX Consultant," *The AI Magazine*, vol. 5, pp. 29-39, 1984, a similar paper in Communications of the ACM, Vol. 27, No. 6, June, 1984.

ES (tutoring) An underlying standard user is assumed.

Wilensky, Robert, James Mayfield, Anthony Albert, David Chin, Charles Cox, Marc Luria, James Martin, and Dekai Wu, "UC - A Progress Report," Report No. UCB/CSD 87/303, Berkeley, CA, July, 1986.

ES (tutoring) A description of UC, a unix consultant. It includes a section on the user model which is like the Chin paper, but gives a more detailed example.

Wilks, Yorick and J. S. Bien, "Speech Acts and Multiple Environments.," *Proceedings of IJCAI-6*, Tokyo, Japan, 1979.

NL (speech acts) An earlier version of their other paper on nested belief and speech acts.

Wilks, Yorick and J. Bien, "Beliefs, Points of View, and Multiple Environments," *Cognitive Science*, vol. 7, pp. 95-119, 1983.

NL (nested beliefs) They deal with how to calculate the nested levels of belief, given only one level. They don't worry so much about how each level is structured, but deduction is assumed.

Young, R. M. and T. O'Shea, "Errors in Children's Subtraction," *Cognitive Science*, vol. 2, pp. 153-177, 1982.

CAI (diagnosis) They suggest modifications to Buggy's method of diagnosing subtraction errors. Their user model is a small collection of relevant production rules.

Cross References

Natural Language (Plans and goals)
Allen Appelt Carberry P.Cohen Jackson
McKeown Pollack Schmidt Sidner vanBeek

Natural Language (Beliefs and misconceptions)
Joshi Kaplan Mays McCoy Mercer Webber Clark Joshi Wilks

Natural Language (User models)
Boguraev Carbonell R.Cohen Jameson Jones Kobsa Morik Wahlster

Natural Language (Speech Acts)
Appelt Austin P.Cohen Perrault Soulhi Wilks

Natural Language (Dialogue)
Airenti Grice Mann

Natural Language (Others)
Carbonell (ambiguity) Carbonell (story understanding)
R.Cohen (arguments) Davidson (focus) Grosz (focus)
Jameson (generating anaphora) Joshi (defaults)
Mark (interface) Nadathur (referring expressions)
Paris (description) Perrault (referring expressions)

Computer-Aided Instruction (Diagnosis)
Brown Bryant Burton Genesereth Young

Computer-Aided Instruction (Tutoring)
Brown Genesereth Reiser

Computer-Aided Instruction (Genetic Graphs)
Goldstein Wasson

Computer-Aided Instruction (Student modeling)
Brown Carr Kawai Self Sleeman

Knowledge Representation (Defaults and Nonmonotonic logic)
deKleer (truth maintenance) Doyle (belief revision)
Etherington (defaults) Goebel (Theorist) Jones (Theorist)
McCarthy (circumscription) McDermott (truth maintenance)
Moore (nonmonotonic logic) Poole (Theorist) Reiter (defaults)

Knowledge Representation (Logical Omniscience)
Fagin Hadley Levesque

Knowledge Representation (Modal Logic)
Halpern Hintikka Hughes

Knowledge Representation (Logic)
Hayes Israel Moore

Knowledge Representation (Others)
Genesereth (design) Hanks (frame problem)
Hayes (philosophy) Konolige (belief) Minsky (frames)
Moore (knowledge and action) VanArragon (user modeling)

Expert Systems (User models)
R.Cohen Finin Hayes Jones Morik

Expert Systems (Tutoring)
Chin Clancey Schuster Wilensky

Expert Systems (Others)
Carroll (advice) Clancey (dialogue) Kobsa (belief)
London (plan recognition) Rich (stereotypes)
Shrager (advice) Wallis (explanation)

Logic Programming
Bowen (meta-programming) Clark (negation)
Kowalski (overview) Smith (reflection)

Philosophy of Science
Kuhn Popper Quine

User Modeling
Macmillan Rich