TECHNICAL ISSUES IN AI MODELING

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The following list of technical issues arises out of an attempt to pioneer unexplored expert system technologies in a large, real world domain. Solving many of these problems will require substantial breakthroughs in several research areas.

Entries are categorized into three broad groups: Impossible, Difficult, and Achievable. The categories represent my assessment of the current state of the art, and advances expected within this decade.

ACHIEVABLE

Using KEE and other toy tools:
The facilities in existing expert system tools severely limit the expressability of models that can be built. Modification of components such as the inference engine and possible worlds management is difficult.

Distributed expert systems:
Cooperative, distributed expert systems have not be constructed previously. No one knows how to do it.

Parallel languages for the Butterfly:
As yet untested. Critical programming metaphors are not yet incorporated into existing experimental parallel programming languages.

Simulation description language:
A research topic requiring substantial research development.

Scenario description language:
A research topic requiring substantial research development.

Multiple input/output and display languages:
Known technology, but a challenge to maintain sufficient rigor to make it work well.

Knowledge-based statistical systems:
Solutions are known, but this is still a new application area for expert systems. Will require a lot of effort.

View-based control structures:
Possible, but difficult engineering.

DIFFICULT

Knowledge engineering a domain requiring situational judgment:
Skills needed for expert situational judgment include positional assessment, timing, deception, and estimation of the intentions of the opposing player. Representations for these skills are not well understood and their implementation is not a solved research problem.

Representations of space and time:
Currently on the verge of being solved, these representation issues are as yet untested in real world systems.

Representation of trust and authority hierarchies:
Solved only for rigid decision-making. No ability to deduce the implications and assumptions associated with transfer of command.

Natural language control of expert systems:
Never done before. Natural language tools address a small subset of natural language, which implies that the user will need training in what to say and how to say it.

Parallel inference in expert systems:
Speed-up has been disappointing. Typical rule bases provide little identifiable parallelism.

Parallel decomposition of simulations:
Never done, highly labor intensive, relevant theories do not exist, existing simulation models certainly do not support parallel metaphors.

Knowledge-based simulation:
Never done before. Can be done if the simulation models are constructed concurrently with the knowledge base. Unlikely to be successful if knowledge is crafted to existing simulations, since this would result in a brittle system that could not be decomposed for explanation.

Independent player views:
Architectures and models exist, but defining the field of influence, flow of communication, and interactional dynamics for individual players will be both difficult and resource consumptive. Modeling players with divergent goals is an unexplored topic. Modeling players who are not constrained to the same set of rules is totally unexplored.

Simulation development:
The extent to which isolated simulations can be used to provide modeling information is unknown.

User modeling:
This area of active research has failed to make the progress necessary to

implement systems with intelligent user models. Likely to be rigid, easy to confuse, and hard to realign when in an inappropriate subspace of the user model. Many techniques must be explored, finding a good one will be labor intensive.

Explanation of parallel deduction:
Unexplored. This is likely to evolve into a long-term research effort. No metaphors exist for explaining conclusions reached by parallel processes.

Modeling multiple cooperative agents:
An active area of research. No consensus about methodology or representation has been reached.

Animation displays:
Hardware is in place and design concepts are known, but there is little experience in software implementation of descriptive animation. Identifying useful pictorial metaphors is likely to be the most difficult aspect of this task.

Knowledge-based natural language:
Not likely to be achieved for several years.

Model-based reasoning:
The techniques of MBR are not yet fully developed. Hierarchical systems can be handled. Interactive systems cannot. Planning over abstract reasoning spaces is a particular difficulty.

IMPOSSIBLE

Knowledge engineering the real world:
The scope and extent of knowledge needed for world modeling is huge. A formal model of such a wide diversity of information and relations does not exist. Interactions between ad hoc models may be extensive; there is no reason to expect that domains are factorable.

Implementing inference across real world databases:
Even if the domain can be specified, it will not be complete or closed. Extensive interactions will degrade the system's capability to follow and to explain the course of inference. Extensive knowledge will slow processing time.

Representation of deception:
An unsolved problem.

Representation of political judgment:
An area that has not be approached previously. May be undesirable to even consider this in a model.

Representation of common-sense reasoning:
Lots of current research, but still an unsolved problem.

Representation of and inference over information structures containing vast amounts of uncertainty:
No formal, non-statistical approach is known. Fuzzy logic and probabilistic approaches are inappropriate due to the vanishing probabilities of most events.

Inference over domains with vast amounts of missing knowledge:
No techniques are known.

Interface design that accommodates mental models:
A good MMI requires deep knowledge of the domain, substantial engineering, and a bit of insight. Eliciting and developing explicit mental models is the challenge of knowledge engineering. Integrating this knowledge into an interface requires multiple skills (technical, psychological, pedagogical), and is rarely achieved. The difficulty of this task is aggravated by the engineering/humanities split, and by the lack of models for organic systems.

Modeling judgment based on context and circumstance:
Computational models that are sensitive to context are non-existent. Such functionality implies modeling both global knowledge and self-awareness.

Non-syntactic explanation:
A very difficult problem in which little progress has been made.