The project should be a small research undertaking, with “research” broadly understood; the emphasis could be more on researching and surveying the literature than in contributing your own ideas, or it could be on pursuing some ideas of your own, presenting some results of this effort, and proposing further research. You might also put the primary emphasis on developing an interesting program: AI is partly an engineering enterprise! The topic should tie in with the subject matter of CSC 444, i.e., it should have something to do with logical approaches to an AI problem. By “logical” I generally mean quantified logic, though this stipulation might be relaxed for projects involving Bayes nets or SAT-solving. (Even in these specialty areas, however, some related but more “logical” options are available, such as Markov logic networks, or the use of SAT-solving to solve problems in planning, quantified reasoning, action logic, etc.)

This year, one 444 project opportunity of particular departmental interest are contributing to a “Winograd Schema Challenge” project being led by grad students Omid Bakshandeh and Nasrin Mostafazadeh. The challenge is intended to promote creation of commonsense reasoning capabilities, and the goal of our group is to create a submission to the annual competition (deadline January 15); for details see http://commonsensereasoning.org/winograd.html. Let Omid and Nasrin know if you are interested in such a project.

But whether your project is focused on writing or system building, there should be evidence both of delving into the literature (with more breadth in the case of a project that is primarily a literature survey), and of having given your topic some independent critical thought and having developed your own perspective on what the main achievements and important directions for further work are. As some sort of guide about how much reading is expected, you should probably study about 3-5 articles carefully (explaining the gist of these in your own words, and highlighting strengths and shortcomings). Articles might be journal articles, book chapters or conference articles, though the latter are often too sketchy to enable a real technical grasp of the subject matter. Make sure that your perspective is up to date, not limited to some “classical” readings.

The project report should be around 3500-4500 words in length (though there’s no penalty for overruns). The exposition of relevant literature should be as specific as possible. Particular examples are usually more informative than high-level descriptions. You should write your report as if you were using it as lecture notes for one or two lectures to a class like CSC 244/444 on your chosen topic, making sure that your listeners/readers would acquire sufficient knowledge about your topic to be able to answer some technical questions about it on an exam.

Be sure to make clear which of the ideas and opinions you present are your own, and
which ones are taken from your sources (which of course should be properly cited). For any programs you develop, be sure to motivate and explain your approach (in relation to your readings), to document the code clearly, to show ample examples of what the program does, to discuss its capabilities and limitations and what has been learned.

In all cases, provide a concluding section that summarizes your perspective on the work studied and carried out, and on promising directions for further work.

In accord with the above guidelines, grading will be based on

- *effort* (breadth and depth of study and research demonstrated by the essay/project),
- *cogency* (quality of organization and writing, clarity and persuasiveness of the presentation, quality and performance of the programs, if any), and
- *originality* (independence of viewpoint, critical judgement, insight, ability to formulate and develop ideas).

**Sources**

Good sources for your readings are

- The Brachman & Levesque text; browse the book to get an advance idea of what might interest you; look especially at further readings suggested at the end of chapters, and at material not scheduled to be covered in the course.
- The Russell and Norvig supplementary text; this covers quite a few topics not covered in B & L.
- The *AI Journal*; this is a high-quality journal with detailed technical papers in the full range of AI topics, but with emphasis on representation and reasoning. Tables of contents, abstracts, and many articles can be obtained on-line: see the web at URL http://www.journals.elsevier.com/artificial-intelligence/
- *JAIR* - the *Journal of AI Research*; this is a high-quality fully on-line journal – a new and helpful trend in journals! The URL for web access is http://www.jair.org/
- The journal *Cognitive Science*; this contains mostly articles concerned with cognitive modelling (by neural nets or more conventional computational techniques), learning, tutoring systems, etc., but also some more “mainstream AI” articles. See http:// cognitivesciencesociety.org/journal_csj.html
- The Canadian journal *Computational Intelligence*, which is general in scope and generally of very good quality. Web page at http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-8640
- The *KR’91-KR’14* Proceedings; the full title is the *Proc. of the 1st - 9th Int. Conf. on Principles of Knowledge Representation and Reasoning*; this is the premier conference in the KR&R field, and the papers are generally detailed enough to be useful. See the web at http://www.kr.org/ for information on upcoming and past conferences, including calls for papers and the list of talks at past conferences. The proceedings are listed at http://www.kr.org/index.php?page=proclist
• The **AAAI Proceedings**; full name: the *Proc. of the Nat. Conf. on Artificial Intelligence* (sponsored by the AAAI - the Am. Assoc. for AI). This is the main US conference on AI, held annually, and covering the full AI spectrum. This gives you a very good overview of what’s happening on the research frontiers; the articles are sometimes too concise to give you adequate technical depth. The AAAI home page is at http://www.aaai.org and you can find past conference proceedings for both AAAI conferences and other major conferences at http://www.aaai.org/Library/conferences-library.php.

• The **IJCAI Proceedings**; full name: the *Proc. of the Int. Joint Conf. on Artificial Intelligence*. This is the main international AI conference, held in odd-numbered years since 1969. It’s the oldest regular conference in AI, and is comparable in quality and scope to AAAI conferences. The IJCAI home page is at http://www.ijcai.org/. Last time I looked, proceedings from IJCAI-69 to IJCAI-13 were available.

• The **CSCSI and CAIAC Proceedings**; full name: *Canadian Society for Computational Studies of Intelligence*, renamed *Canadian Artificial Intelligence Association*. The conference is usually held at 2-year intervals. Web page: https://www.caiac.ca/. This used to provide access to the programs of CSCSI-96 to CSCSI-07, and ordering info for past conferences, but most links seem to have vanished. However, programs of past conferences can be found at http://www.informatik.uni-trier.de/ley/db/conf/ai/.

  Some conference proceedings are available in the Lecture Notes in Artificial Intelligence series of Springer Verlag; look for titles “Advances in Artificial Intelligence” and “AI 2012”, “AI 2009”, and the like (though some of these are for Australian, Mexican, etc.) conferences. The Canadian AI conferences are smaller than AAAI or IJCAI, but generally of good quality.

• Look at http://www.aiinternational.org/societies.html for some further AI-oriented organizations (and hence further publications), such as the Eur. Coordinating Comm. on AI, which sponsors the European AI Conferences (ECAI), where further high quality papers may be found; the IEEE Computer Society and their AI-oriented journals; and others.

• A wiki page was created for SIGAI (until recently, SIGART) (Special Interest Group in AI) in Dec. 2007. You can reach it at http://sigai.wikispaces.com/.

  The main SIGAI page is at http://sigai.acm.org/.

  The Newsletter name has been changed from SIGART Newsletter to “AI Matters”: http://sigai.acm.org/aimatters/ and

  https://www.movesinstitute.org/2014/05/28/ai-matters-a-new-sigai-newsletter/

• Some “classic” papers are to be found in various “Readings” collections: Brachman & Levesque, *Readings in Knowledge Representation* (Morgan Kaufmann, 1985); Webber & Nilsson, *Readings in Artificial Intelligence* (Tioga, 1981); Collins & Smith, *Readings in Cognitive Science* (Morgan Kaufmann, 1988); Allen, Hendler & Tate, *Readings in Planning* (Morgan Kaufmann, 1990); Ginsberg, *Readings in Nonmonotonic Reasoning* (Morgan Kaufmann, 1981). For some more recent books, some of which are relevant, see the Morgan & Claypool *Synthesis Lectures on*
Google has of course become a nearly universal tool for finding information on any topic, and often leads you to references you might easily have missed. (In a Google literature search you may come across citeseer (http://citeseerx.ist.psu.edu/index.jsp), which is a very good, broad-coverage index of the scientific literature.) But beware: Google will often lead you to personal and course pages of variable quality. While these can be very useful, your references should primarily be from the refereed literature, which is much more reliable. Also, keep in mind that you cannot lift passages from references or sites you locate and insert them in your essay as if they were your own words. This would be plagiarism, a serious violation of U of R’s academic honesty policy. Express everything you want to say in your own words – even if you feel one of the references says it better (though of course explicit quotation from a book, journal, conference paper, or even website, with a citation, is perfectly ok).

Some possible topics

The following are some miscellaneous topics that happen to interest me (besides the Winograd Schema Challenge project mentioned at the outset); so these are topics with which I’m in a better position to help than some others. But don’t regard this list as anything but a small sampling of possibilities! Also, the references mentioned are just the ones I’ve happened to come across – don’t assume that these are at all complete or up to date! By the way, overlap between CSC 400 projects and CSC 444 projects is ok, though the two reports should emphasize different aspects of a larger project, and the total work done should be significantly more (at least 50% more) than for a 400-only or 444-only project.

1. Implement a simple consequence reasoner in Epilog. (This requires some facility with logic, and willingness to go somewhat beyond FOL + resolution in the knowledge representation and reasoning technology. A reference to an overview paper is given below.) The Epilog inference engine is locally developed and available: You create (say) an “epilog” directory, and while in that directory, do

```
svn co file:///u/epilog/svnroot/EPILOG2
```

which will provide you with a fresh copy of EPILOG2 within your “epilog” directory. To use EPILOG2, you do

```
cd epi2
```

and read the “README” file, which contains ‘Use’ instructions. (If this says to use ’alisp’, replace this by ’acl’ (Allegro Common Lisp)). After loading and doing

```
(in-package :epilog)
```

you can store formulas using the ‘s’ function, e.g.,

```
(s '(Romeo.name love.v Juliet.name))
(s '(all x (all y ((x love.v y) => (x flirt-with.v y)))))
```

These sample formulas are essentially FOL (first-order logic) formulas, except that they use infix form for predication, i.e., the predicate follows the “subject” argument of the predication, much as in English (and many other languages). Also note the “.name” extensions indicating that the symbols with those extensions are names (logically, individual constants, and the “.v” extension indicating that the
symbol with that extension is a (verbal) predicate. Other extensions are conventionally used for adjectival predicates (e.g., “happy.a”), nominal predicates (e.g., “teenager.n”), and prepositional predicates (e.g., “above.p”). Given the above knowledge, epi2 will be able to answer a question such as “Does someone flirt with Juliet?” which you would pose to epi2 as follows:

\[(q \ (p \ '(\text{some} \ x \ (x \ \text{flirt-with.v} \ \text{Juliet.name})))\)

where the ‘q’ stands for question and the ‘p’ ensures normalization of the question-formula before epi2 tries to prove or disprove it. (A successful proof yields an output containing “Yes” and a successful disproof yields an output containing “No”; failure to find a proof or disproof is signaled by a NIL output.) It is also possible to get answers to wh-questions, not only yes-no-questions, in epi2. For example, we can ask “Who flirts with Juliet?” as follows:

\[(q \ (p \ '(\text{wh} \ x \ (x \ \text{flirt-with.v} \ \text{Juliet.name})))\)

but pulling out the actual answer is a bit complicated. Suppose we “setq result” to whatever the preceding question yields; then the actual answer (Romeo.name) is obtained by

\[
\text{(setq ans }
\text{(node-name (second (car (extract-unifier-for-answer (car result))))))}
\]

But we can get inferences like the “flirting” inference without having to ask a question by making use of forward (input-driven) inference, using the basic forward inference capability. As explained in the README file, the forward-inference capability is being upgraded by Adam Purtee (apurtee@cs.rochester.edu) – see him for current details.

The above example is very simple, but the goal would be to build up a more substantial axiom base, and be able to make some reasonably interesting inferences, about whatever subject or entities you choose. or you could ask for some existing axioms sets to start with; available ones include a base of verb axioms, noun hierarchy axioms, and axioms concerned with the sorts of situations and relationships that are typically referred to in captions of family photos, among others). It would also be interesting to see an attempt to write new kinds of verb axioms that take into account the types of the arguments of the verb. For example, consider the verb “open” (represented as the predicate “open.v”). The methods, preconditions, and consequences of opening something seem quite different depending on whether that thing is a door, a mouth, a wine bottle, a drawer, a fan, an establishment, a conference or other social event, etc. It would be nice to be able to draw the right conclusions about those methods, preconditions, and consequences, given that a certain type of thing was opened. The same goes for many other verbs – perhaps for all verbs.

**EPILOG** allows more than FOL, and one of the most important capabilities is that “episode” terms (terms denoting events, situations, processes, etc.) can be “attached” to sentences. For example,

\[(s \ '((\text{Romeo.name} \ \text{love.v} \ \text{Juliet.name}) \ ** \ E1))\]

attaches the episode E1 to the earlier formula; it denotes the *episode of Romeo loving Juliet*. We could say that E1 had a particular duration, or came after
Romeo and Juliet met (also an episode), etc.:
\[
\text{(s '((duration-in-weeks.f E1) = 7))}
\]
\[
\text{(s '((Romeo.name meet.v Juliet.name) ** E0))}
\]
\[
\text{(s 'E1 right-after.p E0))}
\]

etc. There are other logical constructs that can be used in epi2, such as ones expressing beliefs, modification (e.g., that Romeo madly loves Juliet), and more. Given the capacity for referring to events characterized by a particular formula, we can also write down causal laws, such as that if a person drops a glass on a hard floor, it breaks; and if an object breaks, then it is broken at the end of that event; etc. An outline of the constructs available in episodic logic, the logic used by EPILOG, can be found at the beginning of the paper “Episodic Logic meets Little Red Riding Hood,” at


More recent papers that also provide quick overviews of the EL syntax used by EPILOG and inference examples can be found among the Selected Publications at http://www.cs.rochester.edu/u/schubert/, including

http://www.aclweb.org/anthology/W/W14/W14-2411.pdf and


If you would like to do such a project, the goal would be to learn how to use EPILOG, including some of the nonstandard (non-FOL) capabilities, and to make an assessment of how convenient or inconvenient EPILOG is for expressing facts formally that are easily stated in English, and how well it works (e.g., speed and completeness) in generating forward inferences and/or answering questions. Besides the ideas mentioned above, you could try some of the resolution problems that come up in assignments, to see if EPILOG can solve them. You would also scout the literature to see what representations for the meaning of natural language you could find that are somehow comparable to episodic logic (and preferably, implemented), and make some comparisons. Note that a paper evaluating EPILOG’s performance as an FOL theorem prover exists, entitled “Evaluation of Epilog: A reasoner for Episodic Logic”, Commonsense’09, June 1-3, 2009, Toronto, Canada: http://www.cs.rochester.edu/u/schubert/papers/evaluation-of-epilog-commonsense09.pdf, also available at http://commonsensereasoning.org/2009/papers.html

2. “Natural Logic (NLog)” (esp. in the context of “textual inference”). This is a type of reasoning that is closely based on the structure of natural language. For example, from the premise “I know that you won’t forget to give me a call”, NLog allows immediate inference of “You will contact me”, based on the lexical facts that knowing something implies that it is true, that forgetting to do something implies not doing it (and this is reversed under negation), and giving someone a call implies contacting them. Besides exploiting such lexical facts, NLog makes use of the notion of positive and negative environments (“polarity”) and “upward and downward entailment” properties of quantifiers, connectives, and other types of words.

I’d be interested in seeing someone dig into the post-2010 literature on this, particularly since our own EPILOG system uses a representation very close to ordinary language, and polarity-based reasoning close to NLog methods. Bill MacCartney, working with Chris Manning at Stanford, completed his thesis on this topic in
2009, and had some excellent previous papers with Manning (including the “best paper” at COLING’08). The thesis is


We have delved into connections to EPILOG in our work here, e.g.,
K. Stratos, L.K. Schubert, & J. Gordon, “Episodic Logic: Natural Logic + reasoning”, Int. Conf. on Knowledge Engineering and Ontology Development, (KEOD’11), Oct 26-29, Paris, 2011; and
This is very recent and very interesting.

3. CLib – the Component Library. This refers to an ontology and basic conceptual knowledge base, containing such knowledge as that when \(x\) enters \(y\), it does so through some “portal” \(z\), and is first outside of \(y\), and after entering is inside of \(y\). I think the first general description of this was given in


and the project has continued under the direction of Bruce Porter (at U.Texas, Austin). A general description and assessment would be interesting to see – even more so if it turned out to be possible to acquire and experiment with this system (I think it is, and I could help with contacting Porter.)

4. From WordNet to Logic. WordNet is the online lexicon most widely used by AI researchers (see http://wordnetweb.princeton.edu/perl/webwn). However, it is an informal lexicon, and if we want to use it for reasoning, we need to formalize its contents as far as possible. WordNet expresses word senses as “synsets” – sets of words that can be used synonymously in a certain sense. For example, while “head” is listed as having 33 senses as a noun, the synset \{head, caput\} uniquely identifies the notion of a person’s or animals’s physical head, while e.g., \{head, chief, top dog\} uniquely identifies the notion of “the person who is in charge”. (Sometimes the sets of words in a synset do not by themselves uniquely identify a particular sense, but the senses are also distinguished via their unique WordNet names; also paraphrases/glosses and examples are provided.)

WordNet provides various semantic relations between word senses (synsets), most systematically hyponym/hypernym relations. For example a hyponym (special case) of “head”, in the sense of \{head, caput\}, is “human head”, and a hypernym (generalization) is “external body part”. (Note that short phrases like “human head” and
“external body part”, not just single words, occur as WordNet lexical items.) We can put such relations into a logical format by writing, for example,

\[
\begin{align*}
\forall x ((\text{human-head } x) & \implies (\text{head1 } x)), \\
\forall x ((\text{head1 } x) & \implies (\text{external-body-part } x)).
\end{align*}
\]

Interestingly, we can also often assume that distinct hyponyms of the same word sense are mutually exclusive. For example, “external body part” has various hyponyms, including of course \{head, caput\}, but also \{neck, cervix\}, \{breast, chest\}, etc. We can thus write

\[
\begin{align*}
\forall x ((\text{head1 } x) & \implies (\neg (\text{neck1 } x))), \text{ or equivalently} \\
\forall x ((\neg (\text{head1 } x)) & \text{ or } (\neg (\text{neck1 } x))),
\end{align*}
\]

and similarly for other hyponyms of “external body part”, taken pairwise. As it turns out, such logical transcriptions of WordNet relations are not always “safe”. For example, the hyponym chain gold dust → gold → noble metal might lead one to conjecture axioms to the effect

\[
\begin{align*}
\forall x ((\text{gold-dust } x) & \implies (\text{gold } x)), \text{ and} \\
\forall x ((\text{gold } x) & \implies (\text{noble-metal } x)).
\end{align*}
\]

But this would be wrong: while it’s true that all gold dust is gold, it’s not true that all gold is a noble metal (rather, the element, gold, is a noble metal), or transitively, that all gold dust is a noble metal. A clue to the difficulty lies in the fact that gold dust and gold are mass terms, whereas noble metal is a count noun. This is a point we have explored in recent research – see

http://www.cs.rochester.edu/u/jgordon/gordon+schubert.wordnet-hierarchy-axiomatization

Jonathan Gordon has also explored axiomatization of mutual exclusion axioms (of the type mentioned above), and some other WordNet relations such as antonymy and partonomy. However, this further work is less fully developed, and not yet adequately evaluated, and that is where opportunities for a project exist (potentially with real value for providing knowledge to a commonsense reasoner). A more challenging project would be to derive lexical axioms from WordNet glosses (word definitions). A partial implementation of a system for doing this (for verbs) exists – further information available upon discussion with LKS.

5. Commonsense psychology. Make a study of the work that has been done by Jerry Hobbs and Andrew Gordon in formalizing our intuitive understanding of notions like knowing, remembering, finding out, forgetting, etc. One publication is


but there are more recent ones as well. Andrew Gordon is at the Institute for Creative Technologies, http://people.ict.usc.edu/~gordon/, where you can find more recent publications of interest such as

http://people.ict.usc.edu/~gordon/publications/CADE-WS15.PDF ,
http://people.ict.usc.edu/~gordon/publications/AAAI-SPRING15.PDF , and
6. Probabilistic planning. Survey some recent work in this area, e.g., in hierarchical probabilistic planning, or in knowledge-rich probabilistic planning (most past work has considered planning only in very narrowly defined worlds, rather than worlds where large amounts of knowledge would be relevant to, and play a role in, planning).

Another possible angle is to look at the possibility of applying the algebraic probability logic described in the UAI 2004 paper,


(again on my web page at http://www.cs.rochester.edu/~schubert/). This could be used for symbolic forward projection of probabilities in plans, as a way of determining probabilities of various properties holding at various times. This would be for someone who is quite mathematically inclined.

7. Other recent work in planning, including SAT-planning, fast-forward planning, plan abstraction, etc. SAT-planning is scheduled to be covered briefly in the course, but you could branch out from there to related work, or altogether different topics. Some themes and associated names that come to mind are (as mentioned) SAT-planning (e.g., Kautz & Selman, 1996, 1999, Ernst, Millstein & Weld, 1997), planning using integer programming (e.g., Bockmayr & Dimopoulos 1999, Vossen, Ball, Lotem, & Nau, 1999), the Graphplan approach (Blum & Furst, 1995, Koehler, Nebel, Hoffman & Dimopoulos, 1997, Long & Fox 1999, Gerevini & Serina, 2002), forward search (Bacchus & Kabanza, 2000, Jörg & Nebel, 2001, Refanides & Vlahavas, 2001), or methods employing state-space search (e.g., Bonet & Geffner, 1999, 2001). Another interesting effort in automatic abstraction in planning is that of Botea, Enzenberger, Müller, & Schaeffer (2005), Botea (2006), and Botea, Müller, & Schaeffer (2007). But these are by no means the most recent papers of interest! The planning competitions at the AIPS and ICAPS conferences give a state-of-the-art picture of the latest planning technology.

8. Survey and evaluate recent work on “continual planning”. See the special issue of *AI Magazine*, vol. 20, no. 12 (winter 1999); also, for example, “Integrated planning and execution for autonomous spacecraft,” by Chien et al. in *Proc. of the IEEE Aerospace Conference (IAC)*. But find more recent work as well. A recent paper by Liu & Schubert on self-motivated, continually planning agents may be of interest, and it provides numerous references to, and overviews of, related work:


9. Discovering “macro-operators” for accomplishing goals in planning domains by analyzing properties of, or experimenting with, various sequences of two or more operators applied in succession. There was some early work on ‘MACROPS’ by Nils Nilsson, and some more recent, possibly relevant work on discovering plan operator properties (see K.S. Tae, D.J. Cook, and L.B. Holder, “Experimentation-driven knowledge acquisition for planning”, *Computational Intelligence 15*(3), pp. 252-279, 1999). Also there has been work on finding useful sequences of operations in domains like Rubik’s cube, using an algebraic perspective (Richard Korf may be a relevant name here). No doubt there is other work, waiting to be found by
anyone who makes a more serious search. One relevant paper seems to be
Douglas J. Pearson and John E. Laird, “Incremental learning of procedural plan-
ning knowledge in challenging environments”, *Computational Intelligence* 21(4),
414-439

A precursor was Pearson’s thesis, Learning Procedural Planning Knowledge in

10. Concept formation and discovery in problem solving. When people solve non-
trivial problems, they spend a good deal of time exploring the problem domain,
forming helpful concepts and establishing general properties of the domain. This
is a very important research area if we want to boost the problem-solving ability of
computers. Some possibly relevant references – not up-to-date and in haphazard
order:

Scott, P. and Fleuriot, J. D. (2012) “A Combinator Language for Theorem Dis-
covery”, in *Proceedings of the Conferences on Intelligent Computer Mathemat-
ics (CICM 2012)*, Lecture Notes in Computer Science, Volume 7362, 371-385,
DOI:10.1007/978-3-642-31374-5_25. [Also maybe other work by Jacques Fleuriot,
http://homepages.inf.ed.ac.uk/jdf/]

ML-TR-33, Dept. of Computer Science, Rutgers Univ., 1990.


R. Davis and D. Lenat, Knowledge-Based Systems in Artificial Intelligence, McGraw-
Hill, 1982.


K. Haase, “Cyrano-3: An Experiment in Representational Invention”, Workshop

A. Bundy, S. Colton, and T. Walsh (1998), “HR - Automatic concept formation in
finite group theory”, to appear in the Int. Congress on Discovery and Creativity,
Gent, Belgium. [must be available by now]

(See also Colton’s PhD dissertation, “HR - Automatic Concept Formation in Fi-
nite Algebras”, PhD dissertation, Dept. of AI, U. Edinburgh, 80 South Bridge,
Edinburgh, EH1 1 HNj Scotland, simonco@dai.ed.ac.uk.)

T. Recio and M.P. Vélez, “Automatic discovery of theorems in elementary geome-

S. Colton, A. Bundy, and T. Walsh, “Automatic invention of integer sequences”,

S. Colton, A. Bundy, and T. Walsh, “HR: Automatic concept formation in pure

S. Colton, A. Bundy, and T. Walsh, “Automatic identification of mathematical
Peter Gaerdenfors, Conceptual Spaces, MIT Press 2000. (Relevant to concept formation, using geometrical models.)


11. Reasoning (seemingly) dependent on induction. David McAllester (formerly of MIT, now chief of Toyota Tech. Inst.) has worked on a system (“ONTIC”) for such problems, with applications to program verification in mind. He gives some examples that are simple for people but hard for machines:

“A king on an empty chess board can reach every square. A pawn can not reach the first rank without first becoming a queen. If I repeatedly remove objects from a box, the box will eventually become empty. Consider a “rotation” operation on a row of marbles where I take the first marble and put it at the end. If I rotate the row as many times as there are marbles they end up in the same order they started in. All of these examples are challenging for automated systems. For example, the rotation example can not be solved by the Boyer-Moore prover without a human providing a non-obvious induction invariant on the rotation operation.”


His 1995 talk, ”Obviousness: A Window on the Mind?” (Slides from a talk at http://www.research.att.com/~dmac/) gives additional interesting examples, some of them aimed against imagistic approaches.


12. Augmenting general reasoning with “imagistic” reasoning about motion of complex deformable objects. How do we know that a bunched-up sock can fit into a coffee cup, but not a bunched-up sweater? That a closed umbrella can easily be put in the trunk of a car, but an open one with difficulty or not at all? That a wet dishcloth makes a better flyswatter than a silk kerchief? Neither logical inference, nor computational geometry, seem like quite the right tools for realizing such reasoning in machines. A group of undergrads has recently worked on building an imagistic spatial specialist, using the Blender graphics software. However, highly deformable objects like kerchiefs, paper, strings, quantities of liquid (or loose aggregates, like sand) are not being addressed in this work. Some possibly relevant references (check out the first two, especially, which are recent):


1998 AAAI Fall Symposium on Formalizing Reasoning with Visual and Diagrammatic Representations, Oct. 23-25, Orlando, FL (see www.aaai.org/Symposia/Fall/). The meeting was chaired by Gerard Allwein (Indiana U.) and Kim Marriott (Monash U.).