

Knowledge Representation and Reasoning

COMP5450M

Assignment 2: KRR Group Tasks: Prolog and Winograd

Due Wednesday 6th December, 2023

General Information

This assignment is to be done in groups of *three*. Details of the arrangements for forming groups will be posted in the module announcements on Minerva (you will also get copies of all announcements by email).

Your mark for this assignment contributes to a 20% portion of your total module grade. It is divided into two equally weighted parts. All group members must collaborate on and take responsibility for both parts of the assignment.

A. Problem Solving using Prolog (10% of module grade)

This assignment is specified in more detail on Gradescope. You will find a link from Minerva to the assignment, or you could go directly to Gradescope and should find it in this module's assignment listing. You will find more information about exactly what to submit within the assignment submission page on Gradescope.

Consider the following *Greedy Robbers River Crossing Puzzle*

Three robbers are running from the scene of a bank robbery. They are each carrying a bag of cash. The amounts in the three bags are: £3000, £5000 and £8000. Blocking their escape is a river, that the robbers need to cross. As luck would have it, there is a raft which will allow either one or two robbers to cross the river. If only one robber is on the raft they may also carry one of the bags across. So the possible types of crossing are: one robber, one robber and one bag, two robbers.

If they trusted each other, the robbers with all their bags could easily get to the other side of the river by making several trips. However, there is a problem. The robbers are greedy and selfish; so, if there is a chance of them getting more money than they had initially stolen, they will steal from the other robbers. So the robbers do not trust each other; and because of this the river crossings must satisfy the following conditions:

1. No robber can be alone on either side of the river with bags containing a total amount of cash that is more than was in the bag they initially had in their bag. (Otherwise they would run off with the cash.)
2. No two robbers can be on one side of the river with bags containing a total amount of cash which is more than the total amount in their original two bags. (In this case they would split the additional amount and run off.)

To solve this problem you must find a sequence of crossings that enable all three robbers and their three bags to get to the opposite side of the river.

Your Task

To answer this question you need to solve the *Greedy River Crossing Puzzle* using the Prolog `bb.planner` code that was introduced in the module. As in the module, it is recommended that you use the online **SWISH Prolog** interface available at: <https://swish.swi-prolog.org>. You can start with the template file available at: https://swish.swi-prolog.org/p/bb_river_crossing_template.pl You should save this as a different file name before working on your own version.

When using SWISH *you must ensure that when you save your file you uncheck the "Public" tick box*, so that your file is not readable by anyone else using SWISH. This should be the work only of *your own group* and it is your responsibility to ensure that your code cannot be accessed by any other student.

Marking Scheme

This part of the assignment will be marked out of 20, but your result will be scaled down to 1/2 of the raw mark, so will contribute to a 10% portion of your overall module grade.

Marks will be accorded for the following aspects:

Giving and explaining the state representation	2
Clear, declarative and efficient coding	8
Accurate specification of the transitions and valid state conditions	8
Code generates a correct solution	2

B. The Winograd Schema Challenge (10% of module grade)

In his pioneering investigation of language understanding, the AI researcher and computational linguist Terry Winograd had noticed that the interpretation of natural language sentences often depends on complex background knowledge. Based on one of Winograd's examples, Hector Levesque (with subsequent collaboration of Ernest Davis, Leora Morgenstern, Charles Ortiz and others) devised a set of language interpretation problem examples, which they proposed as a challenge problem for AI systems. (Details for the particular form of the Winograd problems are covered in one of the KRR module lectures.) In answering this question you will be taking a small step towards addressing the *Winograd Schema Challenge*.

In preparation for this part of the assignment you should revise the material on the Winograd Challenge in the module notes and also explore the following web sites:

- <http://www.cs.nyu.edu/davise/papers/WinogradSchemas/WS.html>
This is Ernie Davis' web page all about the *Winograd Schema Challenge* with links to schema sets and other relevant information.
- <https://cs.nyu.edu/faculty/davise/papers/WinogradSchemas/WSCollection.html>
This is Ernie Davis' original collection of 150 Winograd schemas.
The numbering of this set will be used to identify particular schemas.
- <https://cs.nyu.edu/faculty/davise/papers/WinogradSchemas/WSCollection.xml>
This is an XML version of the original Winograd schemas, which is less densely formatted than the previous version and may be a bit easier to read.

Assignment Part B Task

Your task for this part of the assignment is:

Write a short essay of approximately 2 pages (~ 1000 words) that discusses, in relation to *one* particular Winograd Schema, the possibilities and difficulties involved in resolving that schema using methods of Knowledge Representation and Reasoning.

You must choose one of the schemas from the following:

4. 5. 8. 9. 10. 11. 13. 14. 16. 17. 20. 21. 23. 24. 25.

As per the numbering on Ernie Davis' WSC corpus web-page, at

<https://cs.nyu.edu/~davise/papers/WinogradSchemas/WSCollection.html>.

Information about the expected mini-essay structure and marking scheme are given on the next page.

Structure and Content of your ‘Winograd Schema’ Mini-Essay

It is suggested that you divide your essay into the following sections:

Chosen Schema Start your report with the specification of the schema that you will be investigating. (You can just cut and paste from the list of choices that will be provided.)

Informal Analysis. Discuss your chosen schema informally. Try to explain what facts and reasoning principles would enable an intelligent agent to disambiguate the sentence by attaching the correct reference to the pronoun.

Formalisation using KRR Methods. Use the techniques of symbolic knowledge representation that you have learnt so far to give a formal specification of some of the facts axioms or inference steps that you consider to be key to resolving the reference in the case of your chosen Winograd schema. You may use standard first-order logic, Prolog code, or some other logic that you consider appropriate (e.g. temporal logic, tense logic, situation calculus or default logic). If you wish you could use different logical formalisms to represent different aspects of the reasoning, but make sure that the meaning of each formula you give is clear.

Note: It is not expected that your formal representation give a complete solution to the pronoun resolution problem. You do not need to derive a proof. You are just formalising key aspects of the knowledge and reasoning that would be involved. Try not to give axioms that only fit the particular Winograd problem but would not be valid in other circumstances.

Limitations. Discuss the limitations of the formal representation that you have outlined. In particular, consider whether your representation would be sufficient to support solution of the schema problem by a purely automatic theorem prover. In most cases I would expect the answer to be *no*, so you will be explaining what is missing from your representation.

Essay Length Limit

The main text of your short essay should fit onto 2 pages of A4 with a minimum font size of 11pt. You may use one further page to include a short bibliography and possibly an appendix listing some additional formulae that you refer to in the main text. It is suggested that you do not try to cram too much into your essay as this may result in lowering the mark you get for the clarity and coherence of your essay.

Marking Scheme

The essay will be graded according criteria:

| Criterion | Marks Available |
|--|-----------------|
| Overall clarity, coherence and presentation | 10 |
| Informal explanation of how the schema can be resolved | 10 |
| Proposed axioms and inference mechanisms | 12 |
| Discussion of difficulties and limitations | 8 |

Your mark out of 40 for this part of the assignment will be scaled by 1/4, so it will contribute to a 10% portion of your overall module grade.

How to Submit

The submission will be via Gradescope. Full instructions regarding how and what to submit will be posted on Minerva.