

Heuristics and A* implementations

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Abstract

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Domain

Six domains were tested in the implementations. In this section, I explain this domains.

Blocksworld

Dinner

Dompteur

DWR

Logistics

TSP

Heuristics

In this section, I discuss the different heuristics implemented in the Jupyter notebook. The implementation uses the *pddl* package to parse the tested PDDL domains and problems.

h_{max} heuristic

In a nutshell, this heuristic returns the maximum cost to achieve a goal. From an initial state, the heuristic returns the longest path to reach all goals.

```
1 from pddl.heuristic import Heuristic
2
3 class MaxHeuristic(Heuristic):
4     def h(self, actions, state, goals):
5         reachable = state
6         goals_missing = goals[0]
7         max_cost = 0
8         while not goals_missing.issubset(
9             reachable):
10            last_state = frozenset(
11                [a for a in actions if a.
12                 positive_preconditions.issubset(
13                     reachable)]
```

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```
11         )
12         new_reachable = reachable.union([pre
13             for a in last_state for pre in a.
14             add_effects])
15         if new_reachable == reachable:
16             return float("inf")
17         reachable = new_reachable
18         max_cost += 1
19         return max_cost
```

Listing 1: h_{max} implementation

In the Listing 1, the function h returns the maximum cost to reach the *goals* from an initial *state*, considering a set of possible *actions*.

The first reachable states are the initial states, as shown in line 5. The next two lines define the goals¹ and the maximum cost to achieve the goals from the reachable state. Therefore, if all goals are in the initial state, the maximum cost is 0 and the return in line 8 is *False*.

When the goals are not in the reachable state, the algorithm takes two step:

- line 9: get all actions in which the preconditions are applicable to the current set of reachable actions.
- line 12: get the effects from the actions applicable to the current reachable state. Each time the algorithm performs this step, the reachable state becomes larger, that is, it is more likely that the goals are in the reachable state.

At least, in line 13, it is tested whether the new reachable states are the same as the current reachable state. If true, there are no more states to reach and the heuristic has not achieved the goals. Therefore, *inf* is returned. When there are more states to test, the maximum cost is increased until all goals are reached.

h_{add} heuristic

In a nutshell, this heuristic returns the sum of all the costs to reach the goals. The Listing 2 shows the algorithm that performs this heuristic.

¹The goals received as a parameter are divided into positive and negative. Negative goals are those with the negative sign (*not*) in the PDDL. To perform the heuristic I only consider the positive goal.

```

1 from pddl.heuristic import Heuristic
2
3 class AdditiveHeuristic(Heuristic):
4     def h(self, actions, state, goals):
5         reachable = state
6         goals_missing = goals[0]
7         goals_reached = None
8         last_state = None
9         add = 0
10        costs = {p: 0 for p in state}
11        while last_state != reachable:
12            goals_reached = goals_missing.intersection(reachable)
13            if goals_reached:
14                add += sum(costs[g] for g in goals_reached)
15            goals_missing = goals_missing.difference(goals_reached)
16            if not goals_missing:
17                return add
18            last_state = reachable
19            for action in actions:
20                if action.positive_preconditions.issubset(last_state):
21                    new_reachable = action.add_effects.difference(reachable)
22                    for effect in new_reachable:
23                        costs[effect] = sum(costs[pre] for pre in action.positive_preconditions) + 1
24            reachable = reachable.union(new_reachable)
25        return float("inf")

```

Listing 2: h_{add} implementation

Similar to the h_{max} heuristic, the first reachable state will be the initial state and the cost of reaching goals that are in the initial state, is 0 (line 10). As we need to add the cost of reaching all goals, it is necessary to maintain a set of all goals that have not yet been achieved.

When a goal is reached in the current reachable state (line 12), the cost of all goals reached is added to the variable *add*, as shown in line 14.

After reaching all the goals, the variable *add* is returned (line 17). If some goal cannot be reached, at some point in the execution, the previous state will be equal to the reachable state, and then return *inf* (line 25).

The first step to get the next reachable state is to filter only the actions applicable to the current state and obtain the effects of those actions (line 21). After that, the cost of each effect is calculated and added to the variable *cost* (line 23).

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Leave the setcounter for section number depth commented out and set at 0 unless you want to add section numbers to your paper. If you do add section numbers, you must uncomment this line and change the number to 1 (for section numbers), or 2 (for section and subsection numbers). The style file will not work properly with numbering of subsections, so do not use a number higher than 2.

```
\documentclass[letterpaper]article
% Required Packages
\usepackage{aaai}
```

```
\usepackage{times}
\usepackage{helvet}
\usepackage{courier}
\setlength{\pdfpagewidth}{8.5in}
\setlength{\pdfpageheight}{11in}
%%
% PDFINFO for PDFLATEX
% Uncomment and complete the following for metadata
% (your paper must compile with PDFLATEX)
\pdfinfo{
/Title (Input Your Paper Title Here)
/Author (John Doe, Jane Doe)
/Keywords (Input your paper's keywords in this optional
area)
}
%%
% Section Numbers
% Uncomment if you want to use section numbers
% and change the 0 to a 1 or 2
% \setcounter{secnumdepth}{0}
%%
% Title, Author, and Address Information
\title{Title}
\author{Author 1 \and Author 2\
Address line\
Address line\
\And
Author 3\
Address line\
Address line}
%%
% Body of Paper Begins
\begin{document}
\maketitle
...
%%
% References and End of Paper
\bibliography{Bibliography-File}
\bibliographystyle{aaai}
\end{document}
```

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\bibliographystyle{aaai}
\end{document}
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```
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```

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Address line \ \ ... \ \ Address line}
```

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```
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\And ... \And Author n \ \
Address line \ \ ... \ \ Address line}
```

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```
\author{Author 1 \ \ Address line \ \ ... \ \ Address line \ \
\AND
Author 2 \ \ Address line \ \ ... \ \ Address line \ \
\And
Author 3 \ \ Address line \ \ ... \ \ Address line \ \
}
```

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```
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```

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Engelmore, R., and Morgan, A. eds. 1986. *Blackboard Systems*. Reading, Mass.: Addison-Wesley.

Journal Article

Robinson, A. L. 1980a. New Ways to Make Microcircuits Smaller. *Science* 208: 1019–1026.

Magazine Article

Hasling, D. W.; Clancey, W. J.; and Rennels, G. R. 1983. Strategic Explanations in Consultation. *The International Journal of Man-Machine Studies* 20(1): 3–19.

Proceedings Paper Published by a Society

Clancey, W. J. 1983b. Communication, Simulation, and Intelligent Agents: Implications of Personal Intelligent Machines for Medical Education. In *Proceedings of the Eighth International Joint Conference on Artificial Intelligence*, 556–560. Menlo Park, Calif.: International Joint Conferences on Artificial Intelligence, Inc.

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Clancey, W. J. 1984. Classification Problem Solving. In *Proceedings of the Fourth National Conference on Artificial Intelligence*, 49–54. Menlo Park, Calif.: AAAI Press.

University Technical Report

Rice, J. 1986. Poligon: A System for Parallel Problem Solving, Technical Report, KSL-86-19, Dept. of Computer Science, Stanford Univ.

Dissertation or Thesis

Clancey, W. J. 1979b. Transfer of Rule-Based Expertise through a Tutorial Dialogue. Ph.D. diss., Dept. of Computer Science, Stanford Univ., Stanford, Calif.

Producing Reliable PDF Documents with L^AT_EX

Generally speaking, PDF files are platform independent and accessible to everyone. When creating a paper for a proceedings or publication in which many PDF documents must be merged and then printed on high-resolution PostScript RIPs, several requirements must be met that are not normally of concern. Thus to ensure that your paper will look like it does when printed on your own machine, you must take several precautions:

- Use type 1 fonts (not type 3 fonts)
- Use only standard Times, Nimbus, and CMR font packages (not fonts like F3 or fonts with tildes in the names or fonts—other than Computer Modern—that are created for specific point sizes, like Times~19) or fonts with strange combinations of numbers and letters
- Embed all fonts when producing the PDF
- Do not use the [T1]fontenc package (install the CM super fonts package instead)

Creating Output Using PDFL^AT_EX Is Required

By using the PDFL^AT_EX program instead of straight L^AT_EX or T_EX, you will probably avoid the type 3 font problem altogether (unless you use a package that calls for metafont). PDFL^AT_EX enables you to create a PDF document directly from L^AT_EX source. The one requirement of this software is that all your graphics and images must be available in a format that PDFL^AT_EX understands (normally PDF).

PDFL^AT_EX's default is to create documents with type 1 fonts. If you find that it is not doing so in your case, it is likely that one or more fonts are missing from your system or are not in a path that is known to PDFL^AT_EX.

dvipdf Script Scripts such as dvipdf which ostensibly bypass the Postscript intermediary should not be used since they generally do not instruct dvips to use the config.pdf file.

dvipdfm Do not use this dvi-PDF conversion package if your document contains graphics (and we recommend you avoid it even if your document does not contain graphics).

Ghostscript

L^AT_EX users should not use GhostScript to create their PDFs.

Graphics

If you are still finding type 3 fonts in your PDF file, look at your graphics! L^AT_EX users should check all their imported graphics files as well for font problems.

Proofreading Your PDF

Please check all the pages of your PDF file. Is the page size A4? Are there any type 3, Identity-H, or CID fonts? Are all the fonts embedded? Are there any areas where equations

or figures run into the margins? Did you include all your figures? Did you follow mixed case capitalization rules for your title? Did you include a copyright notice? Do any of the pages scroll slowly (because the graphics draw slowly on the page)? Are URLs underlined and in color? You will need to fix these common errors before submitting your file.

Improperly Formatted Files

In the past, AAAI has corrected improperly formatted files submitted by the authors. Unfortunately, this has become an increasingly burdensome expense that we can no longer absorb. Consequently, if your file is improperly formatted, it may not be possible to include your paper in the publication. If time allows, however, you will be notified via e-mail (with a copy to the program chair) of the problems with your file and given the option of correcting the file yourself (and paying a late fee) or asking that AAAI have the file corrected for you, for an additional fee. If you opt to correct the file yourself, please note that we cannot provide you with any additional advice beyond that given in your packet. Files that are not corrected after a second attempt will be withdrawn.

L^AT_EX 209 Warning

If you use L^AT_EX 209 we will not be able to publish your paper. Convert your paper to L^AT_EX 2_ε.

Naming Your Electronic File

We request that you name your L^AT_EX source file with your last name (family name) so that it can easily be differentiated from other submissions. If you name your files with the name of the event or “aaai” or “paper” or “camera-ready” or some other generic or indecipherable name, you bear all risks of loss — it is extremely likely that your file may be overwritten.

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If you have any questions about the preparation or submission of your paper as instructed in this document, please contact AAAI Press at the address given below. If you have technical questions about implementation of the aaai style file, please contact an expert at your site. We do not provide technical support for L^AT_EX or any other software package. To avoid problems, please keep your paper simple, and do not incorporate complicated macros and style files.

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Additional Resources

L^AT_EX is a difficult program to master. If you've used that software, and this document didn't help or some items were not explained clearly, we recommend you read Michael Shell's excellent document (testflow doc.txt V1.0a 2002/08/13) about obtaining correct PS/PDF output on L^AT_EX systems. (It was written for another purpose, but it has general application as well). It is available at www.ctan.org in the tex-archive.

Acknowledgments

AAAI is especially grateful to Peter Patel Schneider for his work in implementing the aaai.sty file, liberally using the ideas of other style hackers, including Barbara Beeton. We also acknowledge with thanks the work of George Ferguson for his guide to using the style and BibT_EX files — which has been incorporated into this document — and Hans Guesgen, who provided several timely modifications, as well as the many others who have, from time to time, sent in suggestions on improvements to the AAAI style.

The preparation of the L^AT_EX and BibT_EX files that implement these instructions was supported by Schlumberger Palo Alto Research, AT&T Bell Laboratories, Morgan Kaufmann Publishers, The Live Oak Press, LLC, and AAAI Press. Bibliography style changes were added by Sunil Issar. \pubnote was added by J. Scott Penberthy. George Ferguson added support for printing the AAAI copyright slug. Additional changes to aaai.sty and aaai.bst have been made by the AAAI staff.

Thank you for reading these instructions carefully. We look forward to receiving your electronic files!