

Learning Heuristics for 24 Puzzle

CS365 Presentation

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Problem

- 24 puzzle represents a large state space problem with about $25!/2$ solvable states ($\sim 10^{25}$).
- Can be solved using IDA* algorithm for which heuristics govern the time taken and nodes generated.

2	12	9	6	1
22	3	20	5	4
11	14	7	8	17
16	10	21		19
13	18	23	15	24

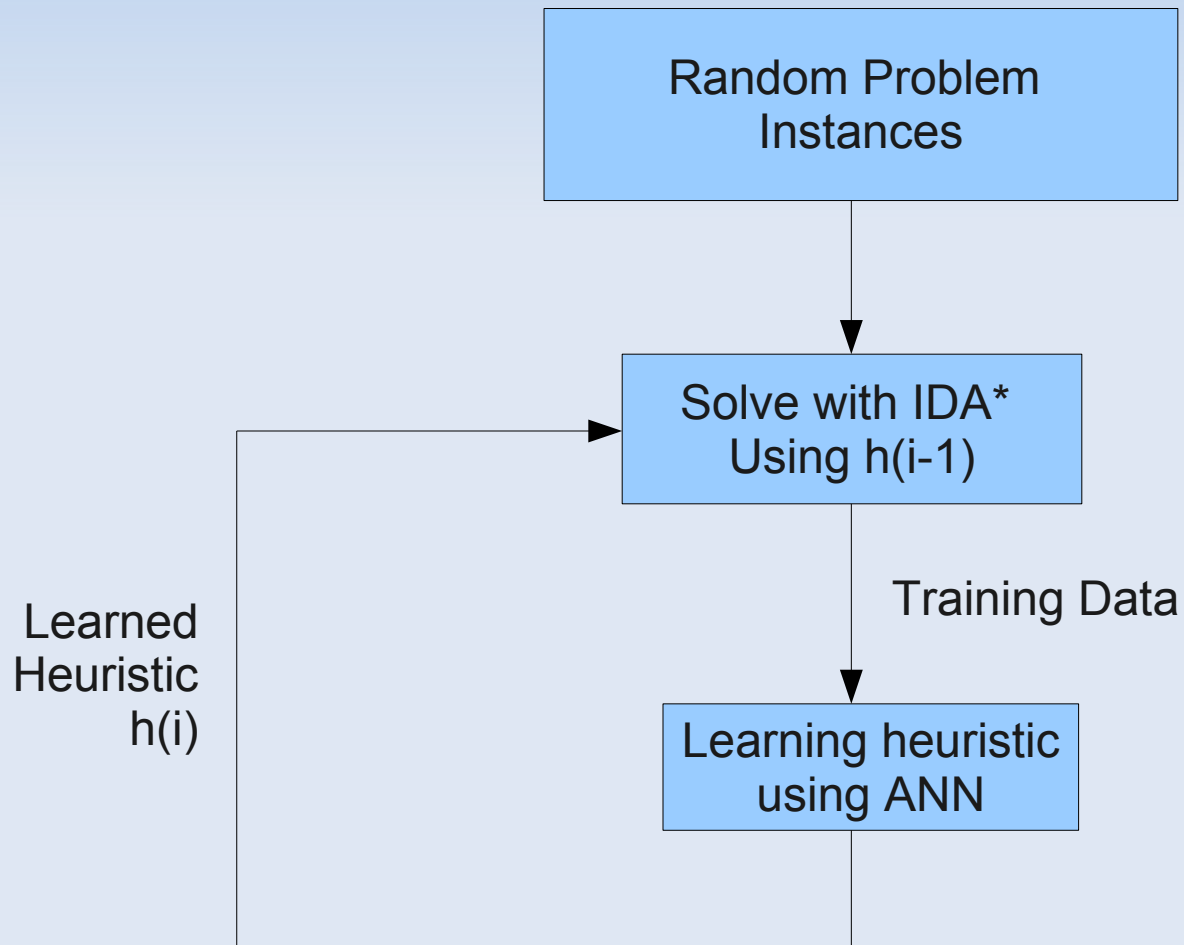
	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24

Sample State

Goal State

Method

Bootstrapping Procedure



CODE USED

- For generating Training Data:

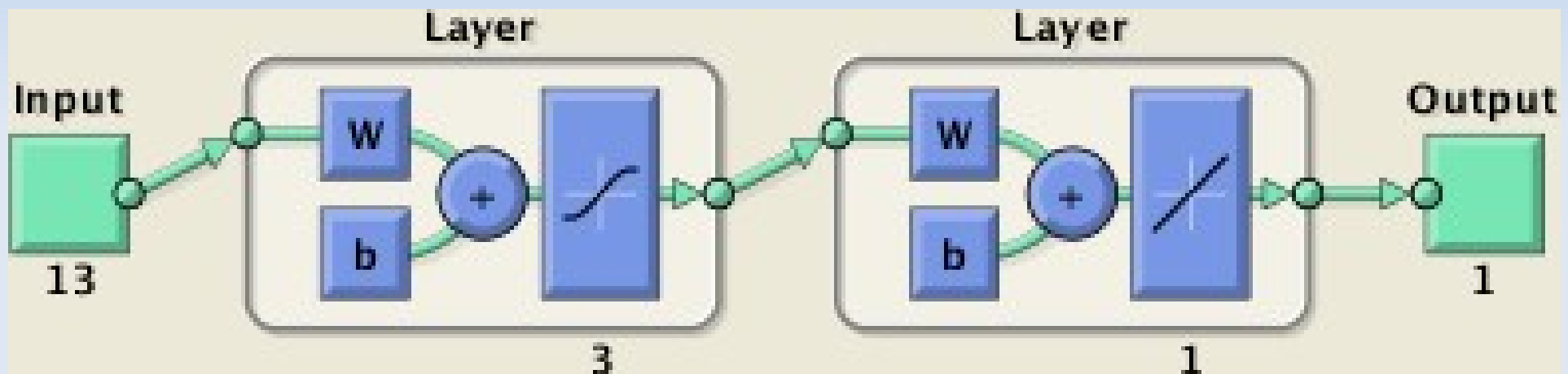
C++ implementation which takes problem set and solves using IDA* and generates training data of 13-feature vector and solution length.

- For Learning:

MATLAB implementation that takes the above training data and uses a feed-forward backpropagation neural network to learn a heuristic using built-in function newff.

Neural Heuristic

- A single hidden layer is used with three neurons.
- The input layer consists of 13 neurons (feature vector).
- Output layer consists of a single neuron.



For any neuron,

$$\text{Net-input} = (\text{input vector}) \cdot (\text{input-weights}) + \text{bias}$$

> The performance function used is MSE.

Bootstrapping Results

Bootstrapping Statistics For 5000 Problem Instances:

Iteration	Number Solved	Remaining Unsolved	Nodes Generated	Solving Time(sec)	Learning Time(sec)
0	3301	1699	659,791,749	2,167.42	2,139.64
1	1290	409	529,834,012	2,886.16	1,327.79
2	288	121	201,783,421	959.83	686.29
3	68	53	58,824,222	350.52	304.28

Comparison of Initial Heuristic & Final Heuristic
for Solving 50 random problem instances:

	Initial Heuristic	Final Heuristic
Time Taken(sec)	94.39	3.31
Total Nodes Generated	40,770,726	1,378,488

Further Work

- We are trying to implement Interleaving Procedure for solving single problem instances (similar to the way done in [1]).
- In this, the solving and learning procedures would go on one after another for some specified time limits until the given problem is solved.

References

- (1) Shahab Jabbari Arfaee, Sandra Zilles, Robert C. Holte. Learning Heuristic Functions for Large State Spaces. In Elsevier, 175:pages 2075–2098, 2011.
- (2) Jonathan Schaeffer, Ariel Felner, Mehdi Samadi. Learning from multiple heuristics. In proceedings of 23rd AAAI Conference on Artificial Intelligence(2008), pages 357-362, 2008.

Acknowledgement

- Code for the bootstrapping procedure was taken from Shahab Jabbari Arfaee, University of Alberta.
- The pictures and the results shown here were produced by us.

THANK YOU!