Contribution Title*

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Abstract. The abstract should briefly summarize the contents of the paper in 150–250 words.

Keywords: First keyword · Second keyword · Another keyword.

1 Problem Specification

1. **State:** For $k \in \{3, 4, 5\}$, A $k \times k$ matrix M with each entry $m_{i,j}$ being a unique integer from $\{0, 1, \cdots, 8\}$ where 0 represents the blank tile.
2. **Initial State:** Puzzle can start in any state *s*.
3. **Actions or *Actions(s)*:** Actions refer to the movements of the blank tile $m_{k,l}$ *Left, Right, Up, or Down*. More formally ...
4. **Transition Model or *Result(s,a)*:** $Result(s, a)$ swaps the pair of tiles specified in action *a* in the current state *s* and returns this new state *s'*.
5. **Goal State:** TODO: insert picture of goal state
6. **Path Cost:** Every step cost *c(s, a, s') = 1*, and the path cost is the summation of the step costs from the initial state to the goal state.

2 Technical Analysis of the Selected Algorithms and Heuristics

1. **nodes:** state *s*
2. **edges:** *Result(s, a)*, which has a step cost of 1

2.1 Rule to Check if a 8 puzzle is Solvable

It is not possible to solve an instance of 8 puzzle if number of inversions is odd in the input state. Inversion is defined as a pair of tiles form an inversion if the values on tiles are in reverse order of their appearance in goal state. Source here.

* Supported by organization x.

2.2 Uninformed Search

1. **Implementation:** IDS. Step costs are equal, thus it is optimal.
2. **Tree or graph?:** Graph search, in order to avoid infinite loops of states (since Graph search does not explore nodes which have already been explored.)
3. **Correctness:** IDS is complete (ie it will find a solution if it exists and b is finite (ie $b \leq 4$), thus it is correct.
4. **Complexity:** $O(b^d)$

2.3 Informed Search

1. **Implementation:** A^* search. It improves on greedy best first search (ie $f(n) = h(n)$) as it avoids expanding paths that are already expensive (ie $f(n) = g(n) + h(n)$).
2. **Tree or graph?:** Tree search. By Lemma 1, if $h(n)$ is consistent, then the values of $f(n)$ along any path are nondecreasing. Thus it does not matter if we add the explored node back into our frontier: there will exist another node n' such that $f(n') < f(n)$.
3. **Correctness:** A^* search is complete (ie it will find a solution if it exists and there is a finite no. of nodes with $f(n) \leq C^*$, where C^* is the cost of the optimal solution path.
4. **Complexity:** $O(b^{h^*(s_0)-h(s_0)})$

2.4 Manhattan Distance

To prove that Manhattan Distance is consistent.

Proof. Proof by Cases

1. $|h(n') - h(n) = 1|$ ($\because c(n, a, n') = 1$, any node n' is 1 step away from node n)
2. Case 1: $h(n') = h(n) + 1$
   (a) $h(n) \leq h(n) + 1 + 1 \implies h(n) \leq h(n') + c(n, a, n')$
3. Case 2: $h(n') = h(n) - 1$
   (a) $h(n) \leq h(n) - 1 + 1 \implies h(n) \leq h(n') + c(n, a, n')$
4. For both cases of $h(n')$, $h(n)$ is consistent. ($\bullet$)

2.5 Euclidean Distance

2.6 Number of tiles out of row + Number of tiles out of column

Relaxed Problem. A tile can move anywhere within the row or column. This guarantees admissibility.
TODO: Prove consistency (?). However, since both hamming and manhatten distance are consistent as shown (here), it's likely that this variant of hamming distance will be consistent too.

2.7 Linear conflict + Manhattan Distance

Add two to the Manhattan priority function whenever two tiles are in their goal row (or column) but are reversed relative to their goal position. Paper available (here).
This is likely to be consistent since it is a linear transformation of the manhattan distance.

3 Experimental Setup

1. **Number of Nodes Generated:** Time Complexity
2. **Size of Frontier:** Space Complexity
3. Plot puzzle difficulty or multiple iterations for the same puzzle difficulty against time/space complexity

4 First Section

4.1 A Subsection Sample

Please note that the first paragraph of a section or subsection is not indented. The first paragraph that follows a table, figure, equation etc. does not need an indent, either.

Subsequent paragraphs, however, are indented.

Sample Heading (Third Level) Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

Sample Heading (Fourth Level) The contribution should contain no more than four levels of headings. Table 1 gives a summary of all heading levels.

Table 1. Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (centered)	**Lecture Notes**	14 point, bold
1st-level heading	**1 Introduction**	12 point, bold
2nd-level heading	**2.1 Printing Area**	10 point, bold
3rd-level heading	**Run-in Heading in Bold.** Text follows	10 point, bold
4th-level heading	*Lowest Level Heading.* Text follows	10 point, italic

Displayed equations are centered and set on a separate line.

$$x + y = z \tag{1}$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. 1).

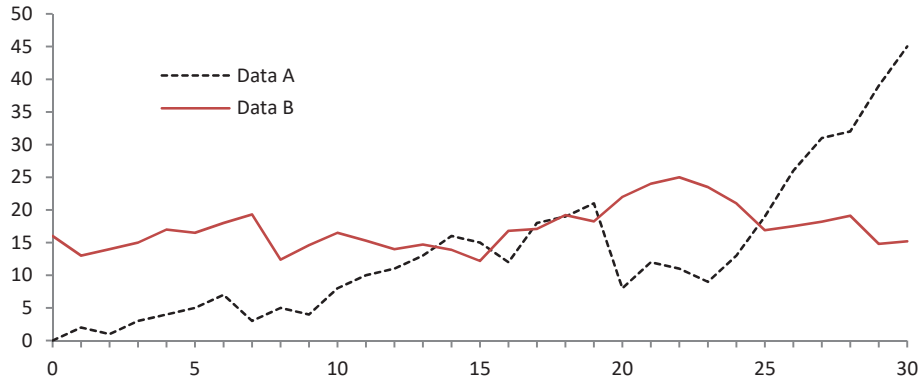

Fig. 1. A figure caption is always placed below the illustration. Please note that short captions are centered, while long ones are justified by the macro package automatically.

Theorem 1. *This is a sample theorem. The run-in heading is set in bold, while the following text appears in italics. Definitions, lemmas, propositions, and corollaries are styled the same way.*

Proof. Proofs, examples, and remarks have the initial word in italics, while the following text appears in normal font.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal articles [1], an LNCS chapter [2], a book [3], proceedings without editors [4], and a homepage [5]. Multiple citations are grouped [1,2,3], [1,3,4,5].

References

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