Sokoban, Solved: Modeling Sokoban Puzzles as Search Problems

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1. Overview

- Create a program that uses different search algorithms to solve Sokoban
- Search algorithms like IDA* & MCTS have numerous real-world applications
  - AI planning, pathfinding in video games, autonomous vehicles
- Sokoban represents a complex domain in which to evaluate these algorithms
- Solving Sokoban is difficult - it is a NP-hard, PSPACE-complete problem

Figure 1: Initial State of the original level-1 Sokoban Puzzle

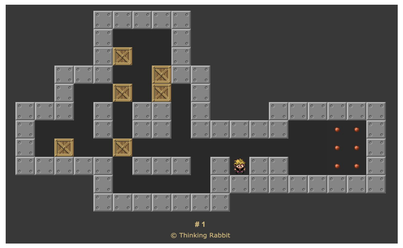
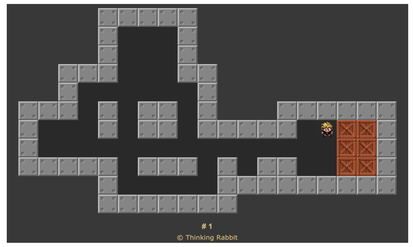


Figure 2: Solved State of the original level-1 Sokoban Puzzle



2. Sokoban Features

- A puzzle game created in 1981 by Hiroyuki Imabayashi published by Thinking Rabbit
- Sokoban is a Japanese word meaning “warehouse keeper”
- Objective: Players push boxes vertically or horizontally into designated goal spaces
- NP-hard, PSPACE-complete
  - At least as difficult as NP-complete problems and requires large memory spaces

Deadlocks: Need to detect a deadlocks as they would render puzzle unsolvable

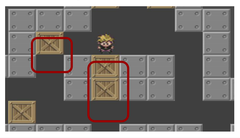


Figure 3: Two examples of deadlocks due to frozen boxes.

Tunnels: Model consecutive pushes along the tunnel as one move to reduce complexity

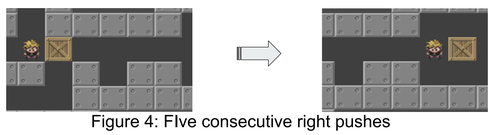
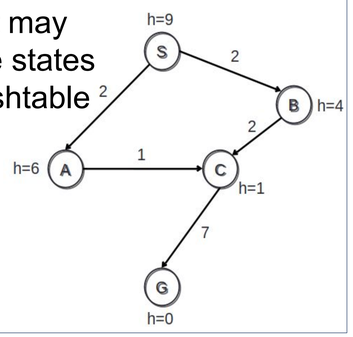


Figure 4: FIve consecutive right pushes

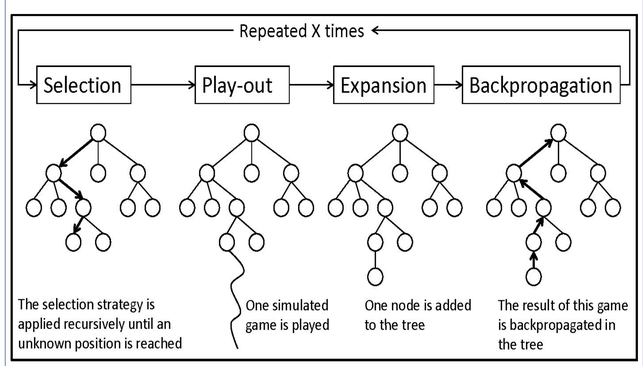
3a. Iterative Deepening A* (IDA*)

- Graph search algorithm that uses heuristic function as guide
- Trade off between time and space:
  - IDA* Saves storage space with DFS & pruning
    - Addresses the high space-complexity issue with with Sokoban.
  - Vanilla IDA* is more time-costly as it may revisit the same states
    - Transition hashtable to record visited states



3b. Monte Carlo Tree Search (MCTS)

MCTS does not require domain-specific knowledge, only legal moves and goal conditions (this lack of knowledge causes a performance hit)



4. Results

5. Conclusion

6. Acknowledgements & Sources

- We would like to thank Dr. Raghu Ramanujah for his guidance on this project
- Game figures: Original puzzle game written by Hiroyuki Imabayashi; © 1982 by THINKING RABBIT Inc. JAPAN; retrieved from sokoban.info