

Building an Intelligent Agent for Hex Game

Abstract

Intelligent agents are used in variety of applications for computer programs today. One major application of these intelligent agents is in abstract strategy games. This study will be focusing on developing a program to simulate a human player in the board game Hex. Hex is a game of strategy in which two players compete to create “bridges” across a hexagonal playing field of any size. The first player to create the bridge will come out as the winner. The motivation for this project was that artificial intelligence is a major component in the field of computer science, and game theory is a major aspect of artificial intelligence. A further study into this topic allows for an advancement in knowledge of constraints and problems that could arise, how to get past these difficulties, and how to improve methods used. The approach taken for this study was to use a search algorithm, called alpha-beta pruning, and to develop a game board evaluation function to create the intelligent agent. This was accomplished using the Java programming language. In order to test this function, it was necessary to produce a graphical user interface depicting the game board in which a human player may interact and play on against the agent. The result was a computer game in which anyone can play on any platform against the agent. Within this project, it was found that intelligent agents are incredibly powerful and very necessary for the future of computer science.

Background

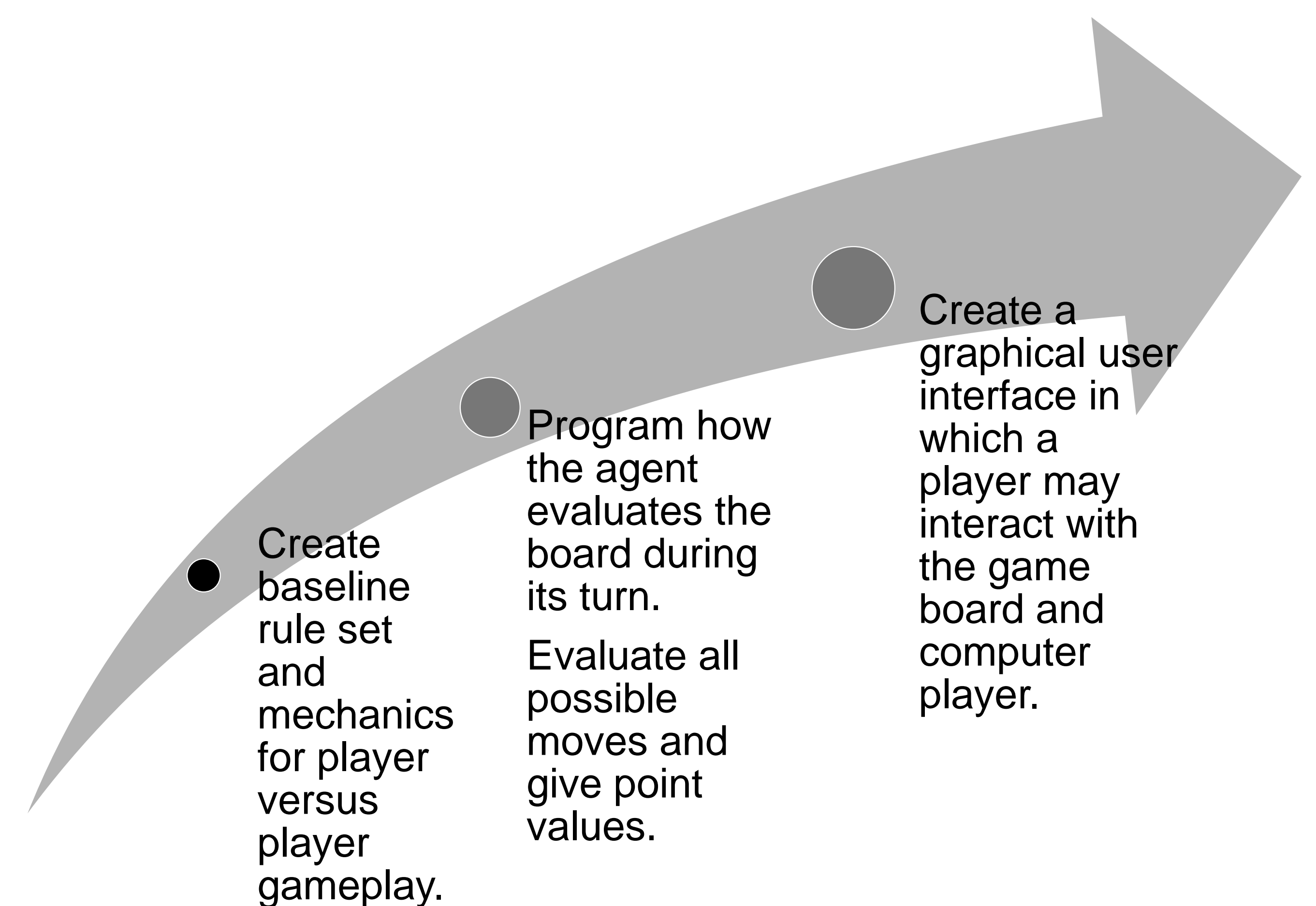
Hex is an abstract strategy board game played by two players using a hexagonal grid of any size. The game is played with black and white stone pieces and each player is assigned a color. The goal of the game is to form a connected path of a player's stones to link two opposing sides of the board marked by the player's color.

The game was invented by Danish mathematician Piet Hein and was first introduced at the Niels Bohr Institute in 1942; in Denmark the game is called Polygon. In 1947, the game was also invented independently by John Nash at Princeton University. The game was marketed by Parker Brothers in 1952, in which they called it Hex.

Theories and Proofs

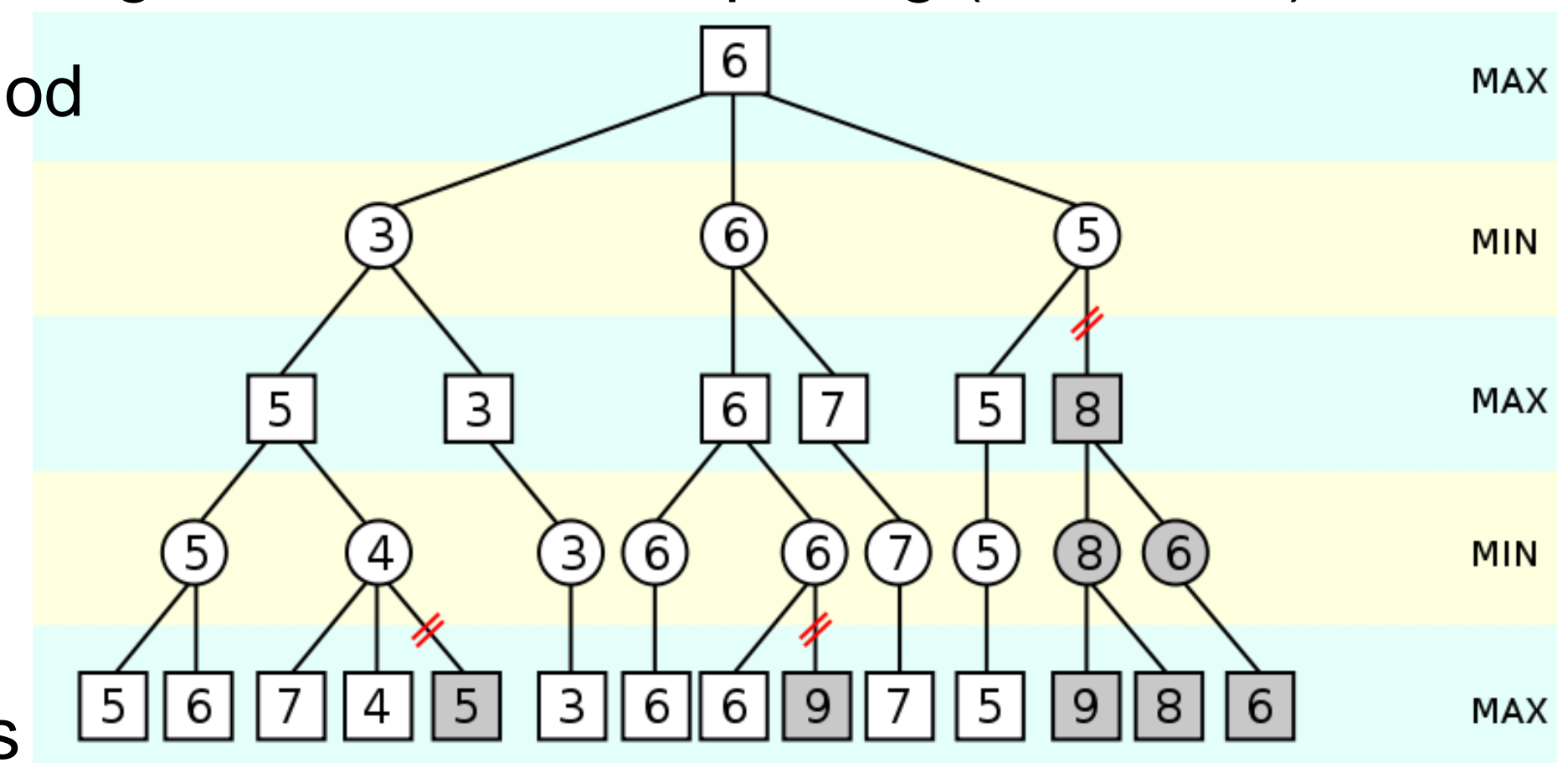
- ✓ John Nash proved that Hex cannot end in a tie. The only way to prevent your opponent from making a path is to make a path yourself.
- ✓ For a symmetric board there is always a winning strategy for the player who makes the first move. This is proven by the “strategy-stealing argument,” in which the first player can use the second player's strategy.
- ✓ In computation complexity theory, Hex has been proven to be PSPACE-complete. A problem is PSPACE-complete if it is in the PSPACE. PSPACE is a set of all decision problems that can be solved by a Turing machine in a polynomial amount of space.
- ✓ Hex has been solved for all symmetrical grids up to and including 9x9. This means that a perfect strategy has been found for the first player to move, in which he wins every time.

Development Process



Method

- ✓ Tools: Java Programming Language, Java Development Kit.
- ✓ Agent Algorithm: Alpha-Beta Pruning with Iterative Deepening (MINIMAX).
 - ✓ Alpha-Beta Pruning is a method of reducing number of nodes that are evaluated using the Minimax Algorithm.
 - ✓ Minimax is a decision rule for *minimizing* possible losses while *maximizing* potential gain.
- ✓ Graphical User Interface (GUI): Done with Swing.



Results and Illustrations

- ✓ Total lines of code: 1300+
- ✓ Time given to Agent Board Evaluation: 2 seconds
- ✓ 5-ply search

References

- Gardner, Martin (1959). Hexaflexagons and other Mathematical Diversions - The First Scientific American Book of Puzzles and Games. Simon and Schuster. pp. 73–75.
- Sackson, Sid. The Book of Classic Board Games. Palo Alto, California: Klutz Press, 1991.
- Stefan Reisch (1981). "Hex ist PSPACE-vollständig (Hex is PSPACE-complete)". *Acta Informatica* (15): 167–191.