Game Theory and Game Balance

EECS 494

10/30/06 by J. Laird and Sugih Jamin

Based on a talk by Michael van Lent

Game Balance

Three kinds of game balance:

- Player/player
  - A player's performance is based on skill (and a little luck)
    - Races are balanced in StarCraft
    - Characters are balanced in fighting games
- Player/game
  - A player shouldn't find the game too hard or too easy to win
    - Difficulty of puzzles in adventure games
    - Number of monsters in action games
- Cost/power
  - A game feature's cost must match its power
    - Broodwar adjusted the cost/power balance of many units

Approaches to Game Balance

- Ensure that a few random elements don't determine outcome
  - Skill matters
- Symmetry isn't much fun
  - All players have identical choices
  - Features identical except for 2 parameters (power and cost)
- Good gameplay involves a variety of interesting choices
  - In Starcraft players choose from three races
    - Each race has 13 types of units, 18 buildings, special powers and weaknesses
    - Huge variety of strategies
- Need to insure that no race or strategy is unbeatable
  - Rock - Paper - Scissors model
  - Game Theory
  - Lots of playtesting

Game Theory

- What is game theory?
  - Field of economics/mathematics
  - Also psychology (Theory of Social Situations)
  - Mathematical theory of bargaining or action selection
  - Cooperative and Non-cooperative
- Attempt to find a set of strategies that will maximize my payoff no matter what my opponent does
  - Assumes rational players (you and the opponent)
  - Assumes each player knows everything about the game
  - Assumes the “payoff” is a complete measure of worth
  - A strategy is a complete plan for playing the entire game

Prisoner's Dilemma

(years in jail)

A \ B	Don't confess	Confess
Don't confess	A=1; B=1	A=10; B=0
Confess	A=0; B=10	A=5; B=5

Prisoner's Dilemma

		B: Don't confess	B: Confess
A	Don't confess	A=1; B=1	A=10; B=0
	Confess	A=0; B=10	A=5; B=5

- What strategy should A choose to minimize jail time?
  - Confess = less jail time no matter what the other person does
    - Nash Equilibrium
  - If both players work together each gets only 1 year
  - But can you trust the other player?
- Example of Public Goods Problems
  - Giving to charity
  - Pricing between companies
  - Social Security

Game Theory for Game Balance

- Game theory insures that no "strategy" is dominant
- Payoff matrix

	Rock	Paper	Scissors
Rock	0	+1	-1
Paper	-1	0	+1
Scissors	+1	-1	0

- Zero Sum game
  - One player's loss is another player's gain
- No single best strategy (no dominant)
  - Each column sums to zero
  - Optimal strategy is a mixed strategy (choose randomly)

Game Theory for Game Balance

- What if different moves have different costs?
  - Each move bets money - winner takes all (Zero Sum)
    - Rock: $3, Paper: $2, Scissors: $1
  - Player B plays paper and player A plays rock
    - Player B outcome: +$3
    - Player A outcome: -$3
    - Player B ends up $6 ahead

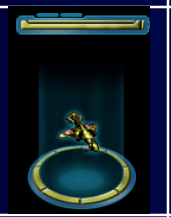
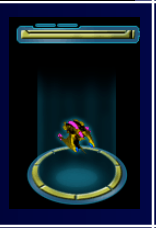
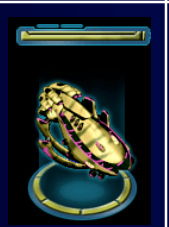
	Rock	Paper	Scissors
Rock	0	+6	-2
Paper	-6	0	+4
Scissors	+2	-4	0

- Optimal strategy (Nash Equilibrium) is mixed
  - paper and scissors more frequently chosen
  - must still choose rock occasionally

Starcraft Balance

			
	Zerg Wins	Human Wins	Human Wins
	Zerg Wins	Human Wins	Human Wins
 	Zerg Wins	Zerg Wins	Zerg Wins

Starcraft Balance

			
	Protoss Wins	Human Wins	Human Wins
	Protoss Wins	Protoss Wins	Human Wins
	Protoss Wins	Protoss Wins	Human Wins

Alpha Centauri

- 9 vehicle types
- Dominance determined by
  - Who attacks first
  - Terrain of attacks
  - State of vehicle (in air or on ground)
  - Morale of vehicle
  - Weapon (10 levels) and shielding (8 levels) technology

Fighting Game Balance

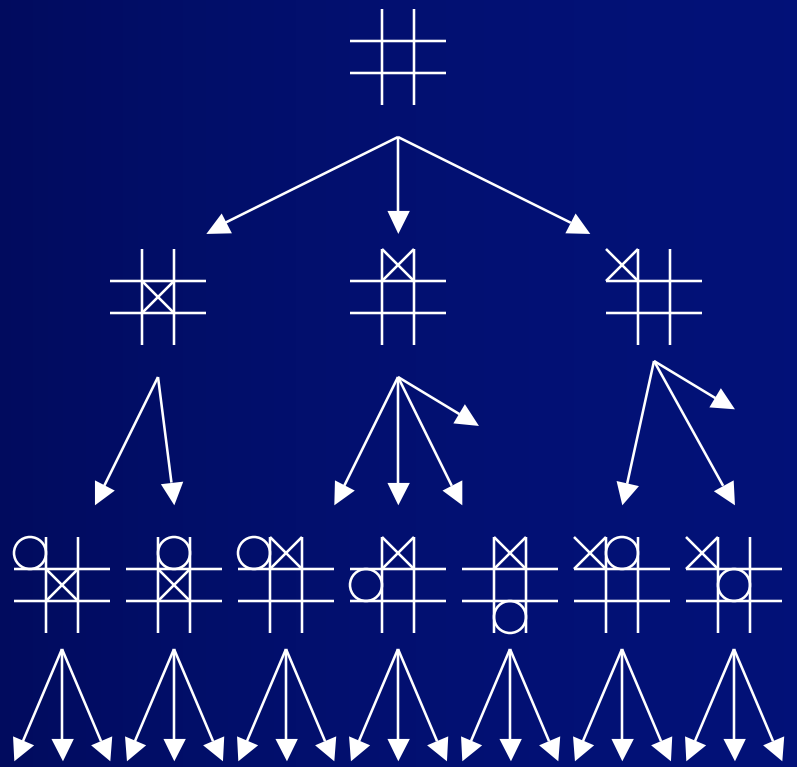
- Soul Caliber has 12 characters each with about 100 moves
  - How to be sure no character dominates another?
- Create a bunch of huge game matrices
  - One matrix for each pair of characters
  - Each move is a strategy
- Make sure the optimal strategy is mixed in each case
  - Can’t win by repeating a single “unbeatable” move

Game Theory and Computer Games

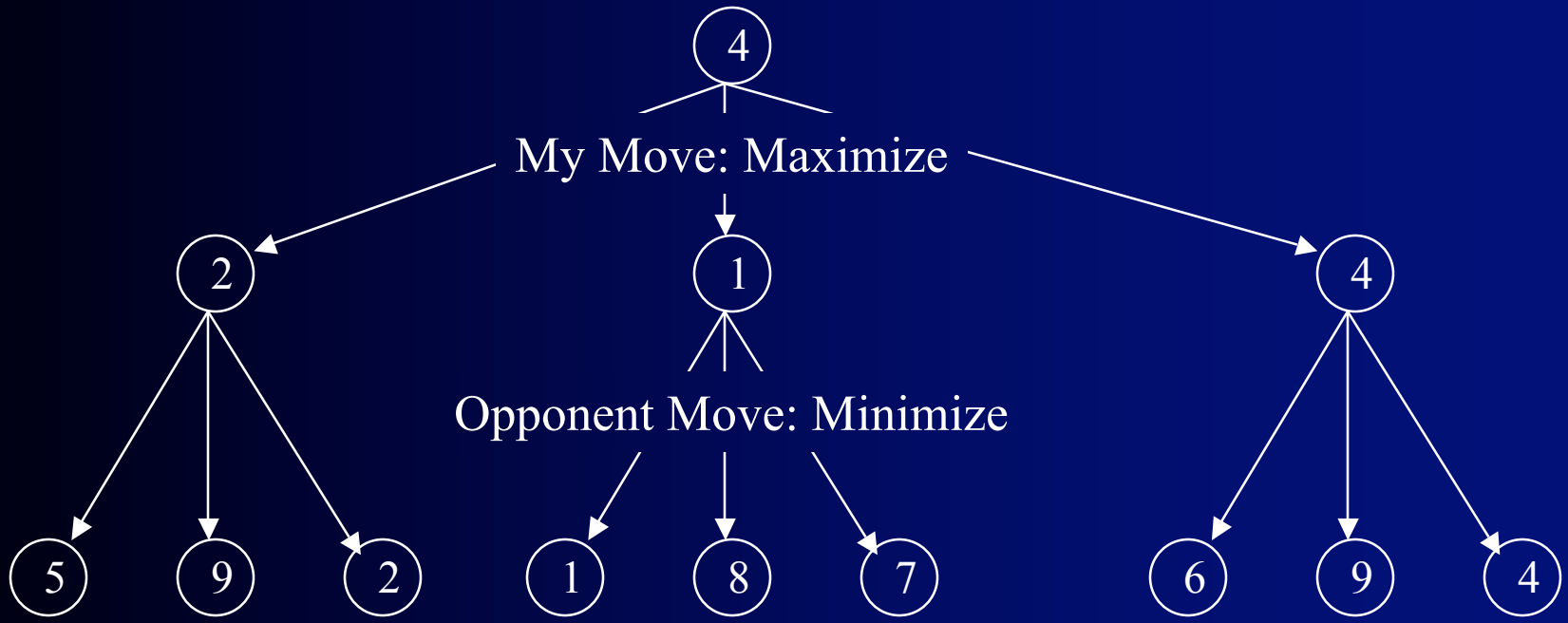
- Classical game theory has limited applications
  - Far too many “strategies”
  - Usually hidden information
  - Can be used for game balance
- Combinatorial game theory
  - Assumes sequential moves
  - Still requires no hidden information
  - Applies to parlor games
    - Chess
    - Checkers
    - Go
    - Connect 4 (Solved)
  - Interactive games have too many “moves” in any situation

Game Trees

- Represent a game as a tree
  - Nodes are game states
  - Branches are moves
  - Leaves are wins/losses
- Choose next move by searching the tree
  - Search n levels deep
    - n depends on time available
  - Evaluate board positions
  - Propagate evaluations up



MiniMax



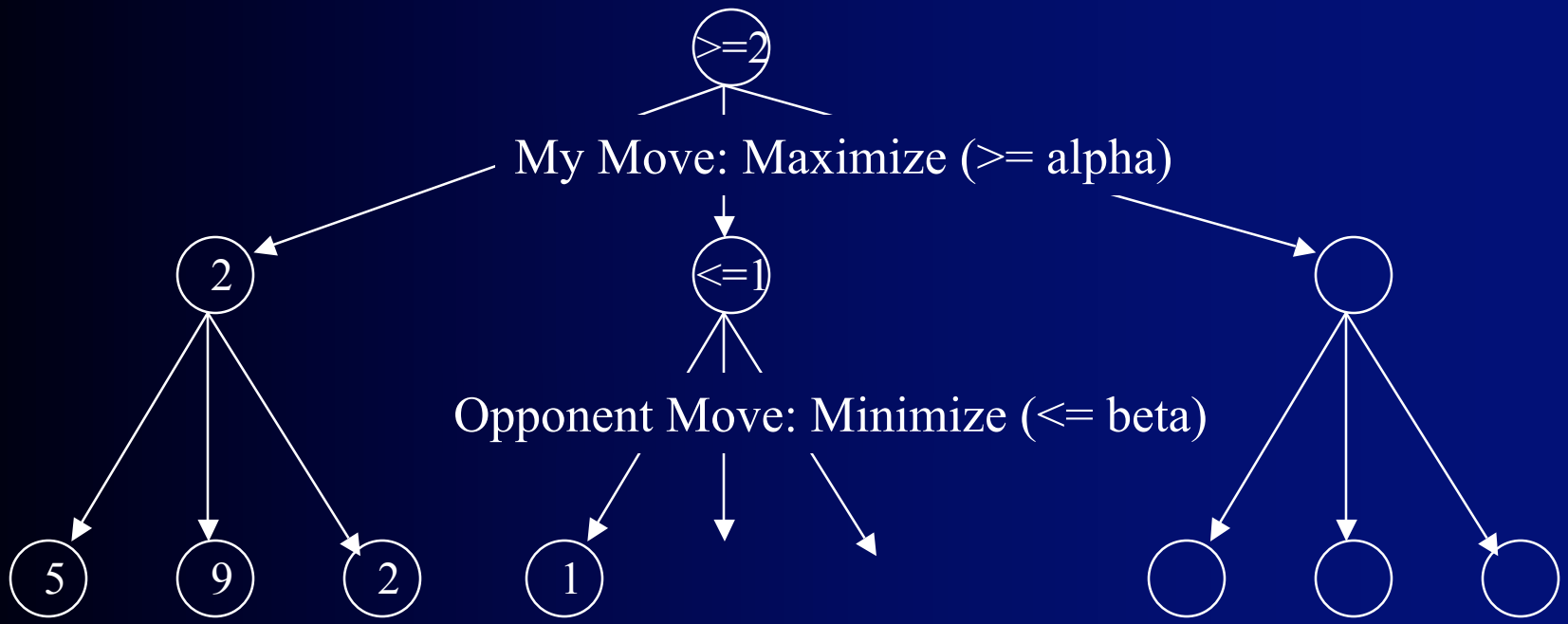
My Move: Maximize

Opponent Move: Minimize

My Move: Maximize

Complication: what evaluation function to use?

Alpha Beta Pruning



My Move: Maximize

Opponent Move: Minimize

My Move: Maximize

Complication: horizon effect, can't see far enough

Making a “fun” racing game

- As designers, we want to recreate racing, not just driving around on a track
- Competition is a crucial part of that
- Need to increase likelihood of a close race
- So we could count on players getting good or, essentially, we could cheat

How do we cheat well?

- We have to slow the front, speed the back
- Easiest way is just with speed
  - Cars in front slow down, in back, speed up
- This can be very obvious to players
  - Violate “fairness” and “consistency”
- And, worse, risks removing player feel of interaction

Dynamic Difficulty Adjustment

- This is a fairly well studied thing
- Game monitors player behavior
- As player struggles, game changes to try and help the player through it
- If player does well, game becomes harder
- Examples?

Risks of DDA approaches

- It seems obvious adaptive models are better for tuning an experience
- However, if a player realizes they are involved, they can exploit them
- Slowing down until the end of the race, for instance

Players use the rules

Players learn to win at the provided rule-system, not the ideas in your head

- They don't learn the manual
- They don't play what you thought was cool
  - If the way to "win" is to fight, you can say "hide" all you want, but they will fight
- They don't only do "reasonable" things
- They poke and prod the systems, and exploit any weaknesses they can find
  - If there are bugs in the rules, they will find and exploit them, even if they enjoy it less