Game Theory and Game Balance

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What is it?

- Branch of economics
- Psychological theory of social situations
- Mathematical theory of bargaining
- Attempts to find a set of strategies that maximize a player's payoff no matter what his or her opponent does

Assumptions

- Players are rational
- Players have full knowledge of the game and its rules
- The “payoff” is a complete measure of worth
- Strategies are complete plans for playing an entire game

Game Balance Types

- Player/Player
  - Player's performance is based on skill and a little "luck"
- Player/Gameplay
  - Player should not feel the game is too hard or too easy
- Gameplay/Gameplay
  - The cost of a game's features must match the power of acquiring the feature

Achieving Game Balance

- Ensure that skill matters, do not allow a few random elements to determine outcome
- Give all players access to the same features having varying power/cost
- Good game play involves allowing the players to make interesting choices
- Need to make sure that no strategy is unbeatable

Golden Rules

- Player/Player
  - Players should never be put in unwinnable situations through no fault of their own
- Player/Gameplay
  - Game should be fun to learn and fun to play (game is more fun when more is learned)
- Gameplay/Gameplay
  - All game options must be worth using sometimes and the cost must be commensurate with payoff

Player/Player Balance

- Symmetry in opponent skills and resources
  - player have the opportunity to do the best with what they start with
- Symmetry in level design
  - levels are functionally equal in difficulty for each player
- Symmetry in game design
  - all players have functionally equivalent choices presented during gameplay

Zero Sum Game

- One player's loss is another's win
- No strategy is dominant
- Each payoff matrix column sums to zero

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

Zero Sum Games

- Name two zero sum games
- Name two non-zero sum games
- What are the differences in outcomes?
- How does this affect gameplay?

Nash Equilibrium - 1

- If moves have different costs
  Rock: $3 Paper: $2 Scissors: $1
- Winner and loser payoffs might be based on move costs

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

Nash Equilibrium - 2

- The winning strategy will be a mixed strategy
  - Paper and scissors should be chosen more frequently than rock
  - Rock needs to be chosen occasionally

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

Improving Gameplay

- How would you improve a game like backgammon some that progress is not so dependent on chance?

- How does this affect gameplay?

Fighting Game Balance

- Many games have 10+ characters with 30+ moves each
- Create a bunch of payoff matrices
  - One for each pair of players
  - Each move can be thought of as a strategy
- Make sure that optimal strategy is mixed to ensure player can't win with one unbeatable move

Weaknesses of Approach

- Classical game theory has too many strategies
- Often requires use of “hidden” information
- Interactive games have too many moves in any given situation

Game Theory Heuristics

- Represent game as multi-branching search tree
- Evaluate game state at leaves (wins/losses) and propagate values to ancestors
- Mini-max
- Mini-max with alpha/beta pruning
- Credit assignment problems
- Horizon problems

Player/Gameplay Balance

- Want a fair game where the player feels that all features are worthwhile
- Balance game challenges against player's improving abilities
  - Reward the player
  - Let the machine do the work
  - Let player play with the game not against it (this is a usability issue)

Save Game Problem

- Often players complain about how hard it is to get the a “save” point
- Problem is not the mechanism used to allow a save
- Problem is symptomatic of arbitrary game behavior or a steep learning curve that makes it hard to progress using skill alone (i.e. trial and error with starting over at beginning the punishment for failure)

Gameplay/Gameplay Balance

- There should be an interesting set of non-dominant player choices
- Optimum choices are not easy to recognize since the require knowledge of previous player choices
- Not easy to see how frequently different choices will be worth making

Component/Attribute Balance

- Component balance
  - establishes the value of each game choice (Minsky's credit assignment problem)
  - embodied artifacts found game
- Attribute balance
  - manner in which the game choices interact (e.g. how important is speed relative to fire power in a war craft?)
  - must understand the uses of artifacts
  - subgame interactions