Game Balancing

CS 4730 – Computer Game Design

Credit: Some slide material courtesy Walker White (Cornell)
Dungeons and Dragons

• D&D is a fantasy roll playing system
• Dungeon Masters run (and sometimes create) campaigns for players to experience
• These campaigns have several aspects
  – Roll playing
  – Skill challenges
  – Encounters
• We will look at some simple balancing of these aspects
Probabilities of D&D

• Skill Challenge

• Example: The player characters (PCs) have come upon a long wall that encompasses a compound they are trying to enter

• The wall is 20 feet tall and 1 foot thick

• What are some ways to overcome the wall?

• How hard should it be for the PCs to overcome the wall?
Probabilities of D&D

- How hard should it be for the PCs to overcome the wall?
- We approximate this in the game world using a Difficulty Class (DC)

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Probabilities of D&D

• Easy – not trivial, but simple; reasonable challenge for untrained character
• Medium – requires training, ability, or luck
• Hard – designed to test characters focused on a skill

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Balancing

- Balancing a game is can be quite the black art
- A typical player playing a game involves intuition, fantasy, and luck – it’s qualitative
- A game designer playing a game... it’s quantitative
  - They see the systems behind the game and this can actually “ruin” the game a bit
Building Balance

• General advice
  – Build a game for creativity’s sake first
  – Build a game for particular mechanics
  – Build a game for particular aesthetics

• Then, after all that...
  – Then balance
  – Complexity can be added and removed if needed
  – Other levers can be pulled

• Complexity vs. Depth
What makes a game balanced?

- When evaluating a game for balance, we typically look at three aspects:
  - Fairness
  - Stability
  - Engagement
Fairness

• A game is considered fair if each of an evenly matched group of players has an a priori equal chance of winning for any given starting position

• In a normal fair game for two players, each player should win about 50% of the time with both players playing at the same level
Fairness

• What does it mean for two players to be equally matched?
Fairness

• What does it mean for two players to be equally matched?
  – Similar heuristics
  – Ability to search the outcome tree the same distance ahead
  – Knowledge of probabilities
What’s the Probability of Winning?

- Consider older games
- Consider modern games
- What’s the probability of winning?
- How does save games affect this probability?
The “Going First” Problem

• A traditional problem in fairness is the “who goes first” problem
• Assume you have a game in which the player that goes first wins 2/3 of the time
• How would you fix this problem?
The “Going First” Problem

• Rotate who goes first
  – Who lost last game?
  – Randomize
  – Age / skill

• Disadvantaged player gets some extra resources

• Reduce effectiveness of the first turn
  – Limited move set
Balancing a One Player Game

- Changing the difficulty of the game over time is called *pacing*
- How do we measure difficulty?
- What’s the difference in scale vs. kind for pacing?
Reinforcing Behaviors

- As players do things in games, we want to either reinforce or punish certain behaviors to establish appropriate balance and pacing
- Positive feedback encourages a behavior to be repeated in the future
- Negative feedback discourages a behavior to be repeated in the future
- Adjusting feedback adjusts the game balance
Reinforcing Behaviors

• Consider basketball
  – When you scores, the other team gets the ball
  – This is negative feedback
  – We don’t want a team to be able to get ahead too quickly

• Consider Mario Kart
  – When you’re in the lead, you get crappy items
  – This is negative feedback
  – Rubber-bandung is also negative feedback
Reinforcing Behaviors

• Consider RPGs
  – If you use a sword a lot, it might level up
  – Leveling up a sword makes it hit harder or more accurately
  – If the sword is better than the axe, you’ll use it more
  – This is positive feedback
Perfect Imbalance

• But what happens if that sword gets too powerful?
• What does in mean to have “perfect imbalance” in a game?
• How does it affect the way we look at and adjust the systems in our games?
Balancing For Skill

• Some actions/verbs of high power can (and should) have low skill requirements
• However, the progression should promote increasing skill to then move to other actions with power
• First Order Optimal strategies in gaming
Reinforcing Behaviors

• Both types of feedback have their own place in games
• We use different feedbacks to move players along or to increase challenge
Stability

• A game is considered stable if:
  – Feedback is negative at the opening, slightly positive at midgame, and very positive at endgame
  – It has multiple viable strategies to win (called stable Nash equilibria)
Stability Curve

A sample feedback curve for a two-player game.
Curve of Progression

![Graph showing the curve of progression with Player Advantage on the y-axis and Game Duration on the x-axis. The line starts at point A, rises in a step-like pattern, and reaches point B.]
No Feedback Provided
Curve of Progression

Player Advantage

Game Duration
Too Little Positive Feedback
Curve of Progression
Too Much Positive Feedback

![Graph showing player advantage over game duration with peaks and troughs.]

Player Advantage

Game Duration
Curve of Progression

Player Advantage

Game Duration
Powerful Negative Feedback

Player Advantage

Game Duration
Curve of Progression

Game Duration

Player Advantage

A

B
Ideal Game Progression

Game Duration

Player Advantage

A

B
Multiple Strategies

• For good balance (and for engagement), there should be multiple ways to reach the win condition
  – Doesn’t necessarily mean there needs to be multiple win states, but that can be done as well

• We can mathematically reason about winning outcomes

• Def of “utility” = anything used to measure progress toward victory
Multiple Strategies

- Player optimal outcome - my utility is as high as possible
- Pareto optimal outcome - my utility cannot increase without decreasing another player's
- Equitable outcome - everyone's utility is the same and as high as it can be
- Efficient outcome - the sum of everyone's utility is as high as it can be
- Nash optimal outcome - my utility is as high as it can be, given other players played to their own interests
Multiple Outcomes

- Some of these outcomes are not necessarily feasible for all games
- Some require at least one player to play to lose
- Nash optimal is the most common as it assumes all players are playing to win and your ability to win is limited by how well others play (to some degree)
Thinking Down the Tree

-1  2  -3  0  3  7  -4  -7  -2  4  0  1  -5  6  -6  5
Thinking Down the Tree

• When players play this game, they use a minimax algorithm working backward from the optimal outcomes for their goal

• This is a zero-sum game, where one score affects the other

• The only real outcome here is a tie if players are playing rationally

• Thus the game is not balanced because there is only one possible outcome
But who plays to win?

• Really! Who plays a game to win?
• In a 4 person game, your odds of winning are terrible
• Do you play a game if you know you’re going to win every time?
But who plays to win?

• You play a game for the experience!
• Games that are unfair or unstable are not engaging
• Can you think of some examples?
Going with the...

- Once you establish fairness and balance, you need to establish *game flow*
- Flow is technically a state of mind recognized by psychologists
  - A challenging activity that requires skill and concentration with a well-defined goal and direct responses
  - Merging action and awareness that increases self-confidence and a loss of self-consciousness (and sense of time)
Going with the...

- Pattern recognition helps with this
- We see repeated patterns all the time in games
- It allows us to enter that flow state of mind
Other Parts of Engagement

- Adversity – things to overcome
- Desire – the want of something
- Empowerment – enforcing one’s will
- Value – something that has meaning
- Drama – fantasy and storytelling
- Randomness – relieves the player from having to go too far down the decision tree (try to avoid “analysis paralysis”)
Differences in Scale vs. Kind

- Why does this matter?
- How does this play into engagement?
Optimizing for Real People

• Everyone playing to win is good...
• ... but “successful” play must merge with “enjoyable” play
• Camping is a great strategy
  – But it can be boring
  – And it can really piss off other people
Optimizing for Real People

• We want the strategies that lead to a player winning to also be strategies that result in all players being entertained and achieving social harmony

• If both players camp in an FPS, this is technically a player optimal outcome but it really isn’t fun

• A Pareto outcome here (both non-camp) is more optimal
Optimizing for Real People

• Thus, we need to decrease the utility of camping to increase the likelihood of non-camping

• How are you balancing your game?