Lecture 6

Uncertainty & Risk
Uncertainty and Risk

- **Risk**: outcome of action is uncertain
  - Perhaps action has random results
  - May depend upon opponent’s actions
    - Need to know what opponent will do

- Two primary means of risk in a game
  - Chance and *randomness*
  - Imperfect *information*
Uncertainty ≠ Skill

- Outcomes may depend on player skill
  - Hand-eye coordination challenges
  - Reaction-time/twitch challenges
  - Knowledge of optimal strategies

- Varying skill level ➔ uncertain outcomes
  - But challenges themselves are predictable
  - Player can train at challenge over time
  - Not the subject of this lecture
Randomness in Games

• Pure randomness is not a good game
  • Remember coin flipping
  • Player has no *meaningful choice*

• But many games *are* random
  • *Candyland, Snakes & Ladders*
  • Poker, other forms of gambling
  • Tetris and other matching, stacking games
Randomness: Candy Land
Randomness: Poker
Randomness with Choice

- Tetris pieces are random, but
  - Have a choice in how to position them
  - “Hedge your bets” to prepare for bad drops

- RPG combat is die roll influenced by
  - Armor the defender wears
  - Weapons the attack uses
  - Combat maneuvers employed
Randomness in RPGs

Uncertainty & Risk
Pig: A Random Game

- Play progresses clockwise
- On your turn, throw the die:
  - If roll 1: lose turn, score zero
  - Anything else: add it to score
    - Can also roll again (and lose)
    - If stop, score is “banked”
- First person to 100 wins.
Strategic Randomness

• Pig has meaningful choice
  • Player can choose to bank
  • Risk nothing for a higher score

• How is the choice meaningful?
  • Certain decisions are better than others
  • Certain decisions are more fun than others
  • Psychological effect on other players
Expected Value

• Outcome of actions is never the same
  • But the sum averages out over many tries
  • Strategy: compare average outcomes

• **Expected Value** = outcome × % success
  • If many outcomes, sum them together
  • Example: Average die roll is 3.5
    \[1 \times \frac{1}{6} + 2 \times \frac{1}{6} + 3 \times \frac{1}{6} + 4 \times \frac{1}{6} + 5 \times \frac{1}{6} + 6 \times \frac{1}{6} = 3.5\]

• Only applies if can do action *repeatedly*
# Expected Value of Pig

<table>
<thead>
<tr>
<th># Throws</th>
<th>Survival</th>
<th>Expected Gain</th>
<th>Expected Value</th>
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<tr>
<td>1</td>
<td>83%</td>
<td>3.33</td>
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<tr>
<td>2</td>
<td>69%</td>
<td>2.78</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<td>1.61</td>
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<td>1.12</td>
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<td>8</td>
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<td>.93</td>
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<td>.77</td>
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<tr>
<td>10</td>
<td>16%</td>
<td>.65</td>
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<td>50</td>
<td>0.01%</td>
<td>0.0004</td>
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Uncertainty & Risk
Expected Value and Warcraft

Uncertainty & Risk
Is Expected the Best?

- Gambling is **bad**
  - House controls expected value (but varies between games)
  - House wins everything

- So why do people gamble?
  - Expected value only true over many tries
  - “Luck” is a factor in (very) short games
  - Uncertainty is fun!
Psychology of Randomness

- Players favor longshots
  - Rare event that has very high payoff
  - Will work towards it even if not optimal
  - Especially if failure is cheap

- Players have “Monte Carlo syndrome”
  - After a bad run, expect a good result
  - Otherwise, the game is “unfair”
Psychology of Randomness

- **Payoff** influences the perception
  - Players remember events with bigger payoff
  - Will think it is “more likely”
  - Even if two events equally likely

- **Corollary**: Lightning never strikes twice
  - A bad outcome is unlikely to happen again
  - A good outcome will probably happen again
Psychology of Nonrandomness

- Players can view the nonrandom as random

- **Example**: paper-scissors-rock
Psychology of Nonrandomness

• Players can view the nonrandom as random

• **Example**: paper-scissors-rock
  • Opponent is *uncertain*, not *random*
  • But there is no choice is better than others
  • How do you choose?

• Any game with heavy negative feedback

• “Random” = lack of meaningful choice
Instability vs. Random

- **Physics** can be sensitive!
  - Small input change = big output change
  - Games can "feel random"

- **Instable challenges**
  - Difficult to repeat success
  - Very difficult to tune
  - But popular trend in modern puzzle games
Imperfect Information

- Player may lack information about that game
  - May not know complete game state
  - May not know all of the rules
- Can reason about \textit{likelihood}
  - Rules eliminate certain possibilities
  - Model opponent psychology
  - But less precise than probability
Example: Fog of War
Making Information Imperfect

- **Hide information**
  - Fog of war
  - Hidden moves
  - Hidden die rolls

- **Generate random noise**
  - (Partial) scanner jamming
  - Inaccurate troop measurements
Information Types

- Information known to all players
- Information known to one player
- Information know only to the game
  - Example: the next card in a deck
- Randomly generated information
  - Example: die rolls
Information in Clue
Computers and Information

• Very good at managing information
  • Can easily hide information from players

• Can hide very complex information
  • Humans have hard time hiding and managing
  • Also, too easy to cheat if hidden

• Particularly good at
  • Information known only to one player
  • Information know only to the game
Randomness vs Imperfect Information

- Randomness used heavily in board games
  - Nice way to introduce uncertainty/risk
  - Easier to manage than imperfect information
- But not as important for computer games
  - Imperfect information is easy to manage
  - Complex rules (physics) may seem random

**Deterministic** rules are easier to tune
- Even board games realize this (*Puerto Rico*)
### Digital vs. Nondigital Games

#### Digital Games
- **Advantages**
  - Hiding Information
  - Complex mechanics
  - Long-distance play
- **Disadvantages**
  - Adaptability
  - Product life span

#### Nondigital Games
- **Advantages**
  - “House Rules”
  - Portability/life span
  - Multiplayer psychology
- **Disadvantages**
  - Complex mechanics
  - Hidden information
Summary

• Uncertainty and risk are **important**
  • Otherwise player is (eventually) unchallenged
  • No possibility of strategic choice

• Ways of introducing uncertainty/risk
  • Through skill-based challenges
  • Through randomness
  • Through incomplete information
  • Latter is primary strength of computers