Toward a Causal Model for Automatic Game Balancing

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Overview

• Goals of Research
• Needs of Automatic Game Balancing
• Toward a Causal Model
  – Defining a Causal Model
  – Building the Model
  – Validating the Model: Player Study
• Future Work: Applying the Model
Goals of Research

• Make game balancing more scientific
  – Justify changes made to game
  – Model relationships between game factors
  – Create function to optimize

• Build automatic game balancing system
  – Analyze game session
  – Adjust game accordingly
  – Increase fun by balancing game

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Needs of Automatic Game Balancing System

• Quantitative
  – Need explicit objective function
  – No way to get data from user post release

• Utilize accessible data from system
  – Available data: health, accuracy, etc.
  – Bio-sensors impractical

• Right level of abstraction
  – High level not useful
  – Need to encompass all games

• Changes made justified by data
Needs of Automatic Game Balancing System

- Quantitative
  - Need explicit objective function
  - No way to get data from user post release
- Utilize accessible data from system
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  - Bio-sensors impractical
- Right level of abstraction
  - High level not useful
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- Changes made justified by data
Prior Work

- Flow (Csikszentmihalyi)
- EVE (Burns)
- MDA (Hunicke, LeBlanc, Zubek)
- GameFlow (Sweetser and Wyeth)
- Predator/Prey Heuristic (Yannakakis and Hallam)

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Causal Model

- Abstract model using cause and effect
- **Factors**: Represent variables in model
- **Causal links**: express cause and effect relationship between factors
- Clearly model interaction of game factors

```
Factor
Time Practicing
  Causal link
  Causal link
Factor
Mentor’s Experience
```

```
Factor
Skill
```

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Three Layered Causal Model

1st Layer: Generic

Fun

Ambience

Game Metrics

Perceived Fairness

NPC Performance

Avatar Performance

Player

Avatar Abilities

Environment

NPC Abilities

NPC Intelligence

2nd Layer: (Genre) Sports

Game Metrics:
- Margin of Victory
- Absolute MOV
- Duration

Avatar/NPC Performance:
- Avg. Distance to Ball
- Adjusted ADB

Avatar/NPC Actions:
- Move Left
- Move Right

NPC/Avatar Actions:
- Jump
- Lateral Speed

Environment:
- Gravity

Opponent:

variables code tracks (score, kills, deaths, etc.)

Causal Model: Layer 1

1st Layer: Generic

Fun

Artistic and stylistic aspects of game

Factors defining player of game (age, gender, gaming experience, mood, etc.)

Chance of winning and losing

NPC Performance

NPC Abilities

NPC Intelligence

Player

Avatar Actions

Avatar Parameters

NPC Actions

NPC Parameters
11/19/09

Causal Model: Layer 1+2

1st Layer: Generic

Fun

Ambience

Game Metrics

Perceived Fairness

Difference in Performance

Avatar Performance

NPC Performance

Player

Avatar Abilities

Environment

NPC Abilities

NPC Intelligence

Avatar Actions

Avatar Parameters

NPC Parameters

NPC Actions

2nd Layer: Genre: Sports

Difference in Parameters

Causal Model: Layer 3
Instantiating Game Metrics

Game Metrics
• Margin Of Victory
• Absolute MOV
• Duration

Player 1 Score

Duration

Player 2 Score

Elapsed: 00:00:03.84
Causal Model: Layer 3
Instantiating Avatar/NPC Actions and Parameters

Avatar/NPC Actions
- Jump
- Move Left
- Move Right

Avatar/NPC Parameters
- Jump Height
- Lateral Speed

Causal Model: Layer 3
Instantiating Performance

Performance
- Average Distance to ball (ADB)
- Time to Ball
Causal Model: Layer 1+2+3

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Grouping Slime Volleyball Factors

1st Layer: Generic
- Fun
  - Ambience
  - Game Metrics
  - Measured Fairness

2nd Layer: (Genre) Sports
- Avatar Performance
- NPC Performance
- Difference in Parameters
  - Avatar Abilities
  - NPC Abilities
  - Avatar/NPC Actions
  - NPC Intelligence

3rd Layer: (Game-Specific) Slime Volleyball
- Game Metrics
  - Margin of Victory
  - Absolute MOV
  - Duration
- Avatar/NPC Actions
  - Jump
  - Move Left
  - Move Right
- Avatar/NPC Parameters
  - Jump Height
  - Lateral Speed
- Environment
  - Gravity

Avatar/NPC Performance
- Avg. Distance to Ball
- Adjusted ADB

Slime Volleyball Study Setup

- 136 participants
- Collected information on player
  - Age
  - Gender
  - Gamer Type
- Varied factors in model for each player
- Asked to rate game after playing
  - Fun
  - Perceived fairness
- Ambience as unmeasured variance
### Slime Volleyball Study

#### Pre-game Survey

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Gamer Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 20</td>
<td>Male</td>
<td>Casual</td>
</tr>
<tr>
<td>20 to 25</td>
<td>Female</td>
<td>Normal</td>
</tr>
<tr>
<td>26 to 30</td>
<td></td>
<td>Hardcore</td>
</tr>
<tr>
<td>31 plus</td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Post-game Survey

- How much fun was this match? (0-9)
  - 0: No Fun
  - 9: Very Fun
- How fair was this match? (0-9 where 0 means computer had advantage, 5 was an even match, and 9 means you had the advantage)
  - Perceived Fairness
  - Binned Fairness
  - Absolute Fairness
Slime Volleyball Study
Analysis

• Justify causal links with correlations
  – Highly correlated ($r > 0.32$)
  – Remove if not justified

• Test causal links not in model
  – Correlation
  – Add if justified

• Determine how much variance we account for

Slime Volleyball Study
Using Correlations

• Correlation does not imply causality!!!
  – Correct
  – We are not using correlation to create causal links

• Building causal model from prior knowledge
  – Academic experience
  – Research
  – Game playing experience

• Using correlations to support proposed causality
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Future Work: Applying the Model

- What in the model will be altered?
  - Only alter values in nodes
  - Alter values and structure of model
- How should the model be altered?
  - Linear Regression
  - Reinforcement Learning
  - Other
- What game should be used to test automatic game balancing system?
  - Utilizes all nodes
  - Expand to other genre
  - Able to change node values easily
- Finished in May 2010 for Master Thesis

Ongoing Study

- Instantiating new causal model
- Participants needed
    - A25 Fuller Laboratory
    - Play on local machine
  - [http://users.wpi.edu/~jeffmoffett](http://users.wpi.edu/~jeffmoffett)
    - Download game
    - Play from home
    - Email results
Questions?