Exploring the Effects of Latency Compensation Techniques on Player Performance and Experience in FPS Games

Ivan Klevanski, Alex Mitchell, Yihong Xu, Sitsanok Young

Acknowledgements
Advisor: Professor Mark Claypool
NVIDIA: Ben Boudaound, Josef Spjut, Joohwan Kim
WPI Contributors: Samin Shahriar Tokey, Alexander Hayden, Ben Peters, Mattheus Faria, Miles Gregg, Jonathan Hsu, Pari Nguyen
Credit: Wesley Lo, Shiyu Wu, Haojun Yan for music compilation, playing, and editing
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Introduction

Motivation

- Latency affects user experience in networked games
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Motivation

- Latency affects user experience in networked games
- Delay between player's action and server feedback can cause unresponsiveness
- Mitigation techniques have been developed to compensate
- Limited public research and testing in this field
- Study focused on two compensation techniques: time warp and latency exposure
Introduction
First-Person Science (FPSci)

• Open-source, experiment-centric Single Player FPS game
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First-Person Science (FPSci)

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• Developed by NVIDIA for research purposes
Introduction
First-Person Science (FPSci)

• Open-source, experiment-centric Single Player FPS game
• Developed by NVIDIA for research purposes
• Designed to study a broad set of user interactions at low local latency
Introduction

Previous MQP

• Converted FPSci to a multiplayer game
Introduction

Previous MQP

• Converted FPSci to a multiplayer game
• Broadcasting Server
Introduction

Previous MQP

• Converted FPSci to a multiplayer game
• Broadcasting Server
• Client authoritative movement and shooting
Introduction

Previous MQP

- Converted FPSci to a multiplayer game
- Broadcasting Server
- Client authoritative movement and shooting
- Networking and packet infrastructure
Goal

- Add latency compensation techniques
- Conduct user studies and evaluate effectiveness
- Extend FPSci to support authoritative server
Implementation
## Authoritative Server Structure

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Authority</th>
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</thead>
<tbody>
<tr>
<td>Position</td>
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The diagram illustrates the flow and interaction between the client (C) and the server (S) in an authoritative server structure, emphasizing the control and data management distribution.
Authoritative Server
Location and Movement

Client
Movement Calculation

Server
Movement Validation
Authoritative Server
Location and Movement

Client
- Predict location
- Movement Calculation
- World Collision

Server
- Movement Validation
Authoritative Server
Location and Movement

1. Client
   - Predict location
   - Movement Calculation
   - World Collision

2. Request Movement

Server
- Movement Validation
Authoritative Server
Location and Movement

1. Client
   - Predict location
   - Movement Calculation
   - World Collision

2. Request Movement

3. Server
   - Speed Check
   - Movement Validation
   - Player Collision
Authoritative Server
Location and Movement

1. Client
   - Predict location
   - Movement Calculation
   - World Collision

2. Request Movement
   - Authoritative Player Locations

3. Server
   - Speed Check
   - Movement Validation
   - Player Collision

4. Location Broadcasting
Authoritative Server
Location and Movement

1. Client
   - Predict location
   - Movement Calculation
   - World Collision

2. Request Movement

3. Server
   - Speed Check
   - Movement Validation
   - Player Collision
   - Location Broadcasting

1 Round Trip Time (total)
Authoritative Shooting and Time Warp
Authoritative Shooting and Time Warp
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Authoritative Shooting and Time Warp
Authoritative Shooting and Time Warp

Runner  Server  Shooter

Frame 70
Authoritative Shooting and Time Warp

Runner move into view

Frame 70
Authoritative Shooting and Time Warp

Server receives movement, notifies shooter

Frame 75
Authoritative Shooting and Time Warp

Frame 80

Shooter receives movement, shoots Runner
Authoritative Shooting and Time Warp

Shooter receives movement, shoots Runner

Frame 80
Authoritative Shooting and Time Warp

Frame 85

Server receives shot
Authoritative Shooting and Time Warp

Server receives shot
Server rollback, confirms hit, broadcasts shot

Frame 85
Authoritative Shooting and Time Warp

Server receives shot
Server rollback, confirms hit, broadcasts shot

Frame 85
Authoritative Shooting and Time Warp

Frame 90

Both clients receive shot confirmation
Latency Exposure
Latency Exposure

• Also known as: ping display
**Latency Exposure**

- Also known as: ping display
Latency Exposure

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• Multi-threaded: not bounded to the game's tick rate
Latency Exposure

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- Multiple different latency statistics besides latest ping
Latency Exposure

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- Multi-threaded: not bounded to the game's tick rate
- Multiple different latency statistics besides latest ping
- Lots of configuration options:
  - Toggle-ability of feature as a whole
  - Other numeric parameters
Latency Exposure

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- Multi-threaded: not bounded to the game's tick rate

- Multiple different latency statistics besides latest ping

- Lots of configuration options:
  - Toggle-ability of feature as a whole
  - Other numeric parameters

- Statistics are logged to database file (both client-side and server-side)
User Study

• 3 weeks; 42 participants
User Study

- 3 weeks; 42 participants
- Player-versus-player 1v1
User Study

• 3 weeks; 42 participants
• Player-versus-player 1v1
• 20 rounds (2 groups of 10 rounds)
  • Groups' Time Warp settings vary (on/off)
  • First round in each group is discarded
How ping display affects quality of experience

Latency Group

Quality of Latency Experience

Displayed Ping

0
Ping Hidden
250
175
Ping Hidden
500
375
Ping Hidden
Accuracy with time warp on/off close-combat
Accuracy with time warp on/off close-combat

Latency Group

Hit Percentage

Time warp On/Off
Accuracy with time warp on/off close-combat

Latency Group

0  250  500

Hit Percentage

Time warp On/Off

off  on  off  on  off  on
Achievements

- Latency Compensation
  - Time Warp
  - Latency Exposure (Ping Display)
  - Latency Concealment
  - Extrapolation
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- Latency Compensation
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- Authoritative Server Structure
  - Movement
  - Shooting
  - Authoritative Validations
Achievements

• Latency Compensation
  • Time Warp
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  • Latency Concealment
  • Extrapolation

• Authoritative Server Structure
  • Movement
  • Shooting
  • Authoritative Validations
  • Data Logging
  • User Testing
  • Data Analysis
Questions?

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