The Design and Development of a Multiplayer Augmented Reality Framework for Superhuman Sports

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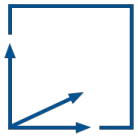
23.06.2022



Final: Master of Informatics Games Engineering

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Advisor: Eichhorn Christian

Motivation

- What is Superhuman Sports?
- *"The field of superhuman sports combines competition and physical elements from traditional sports with technology to overcome the somatic and spatial limitations of our human bodies" - Kunze K. et al.* [1]

Motivation

- Superhuman Sports use technology to make their participants “device-integrated” humans (or superhumans)
- Players can do superhuman things (e.g. flying, high jumping, or augmented vision)
- Started in 2015 in Japan by *Superhuman Sports Society* [2]

超人
スポーツ協会
Superhuman Sports Society

Motivation

- Examples of well-recognized Superhuman Sports: *Bubble Jumper* [3] and *HADO* [4]

Problem Description

- Superhuman Sports are not mainstream yet
- They require complex systems with different technologies (e.g. robotics, networking, AR, etc.)
- This causes a gap between developers and Superhuman Sports technologies

Goal

- Present a framework that facilitates the development of superhuman sports games
- Focusing on Multiplayer AR cross-platform games
- Thus closing the gap between developers and superhuman sports technologies

Approach

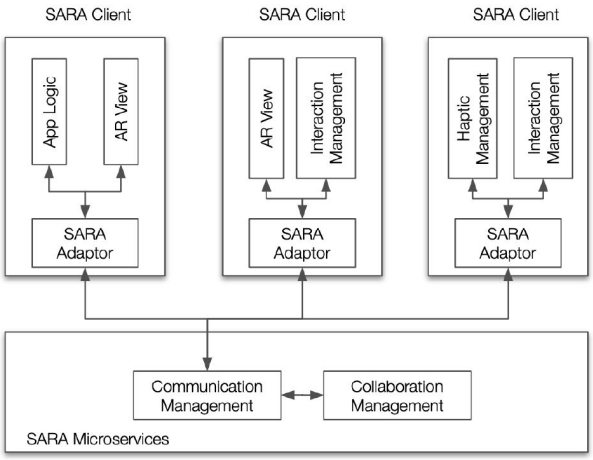
- Uses ARSSP (Augmented Reality Superhuman Sports Platform) [5] as a foundation
- Extending the framework and working on its limitations
- Evaluate the new ARSSP by assessing how well it realizes the superhuman sports game

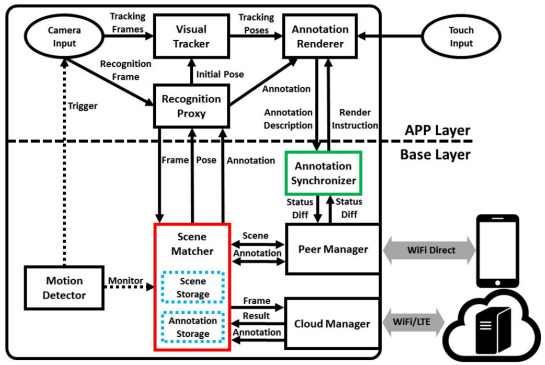
Existing Solutions / Related Work

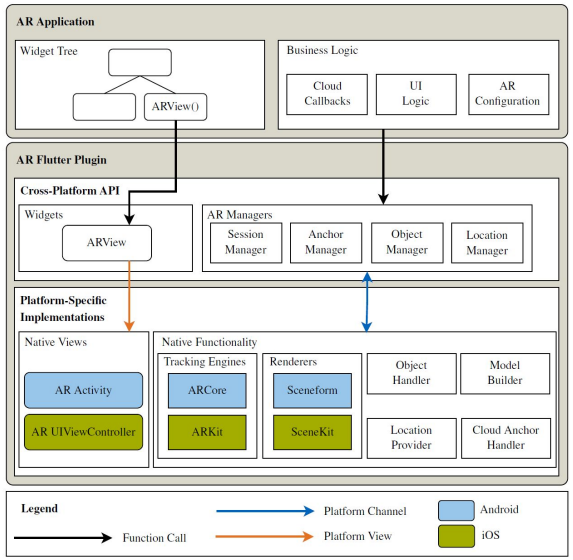
- Reviewed Topics:
  - **Other Multiplayer AR Frameworks**

Existing Solutions / Related Work

- Other Multiplayer AR Frameworks:
  - SARA (**S**hared **A**ugmented **R**eality experiences and **A**pplications) [5]
  - CARS (**C**ollaborative **A**ugmented **R**eality for **S**ocialization) [6]
  - Cloud-based AR Flutter Plugin (in TUM) [7]





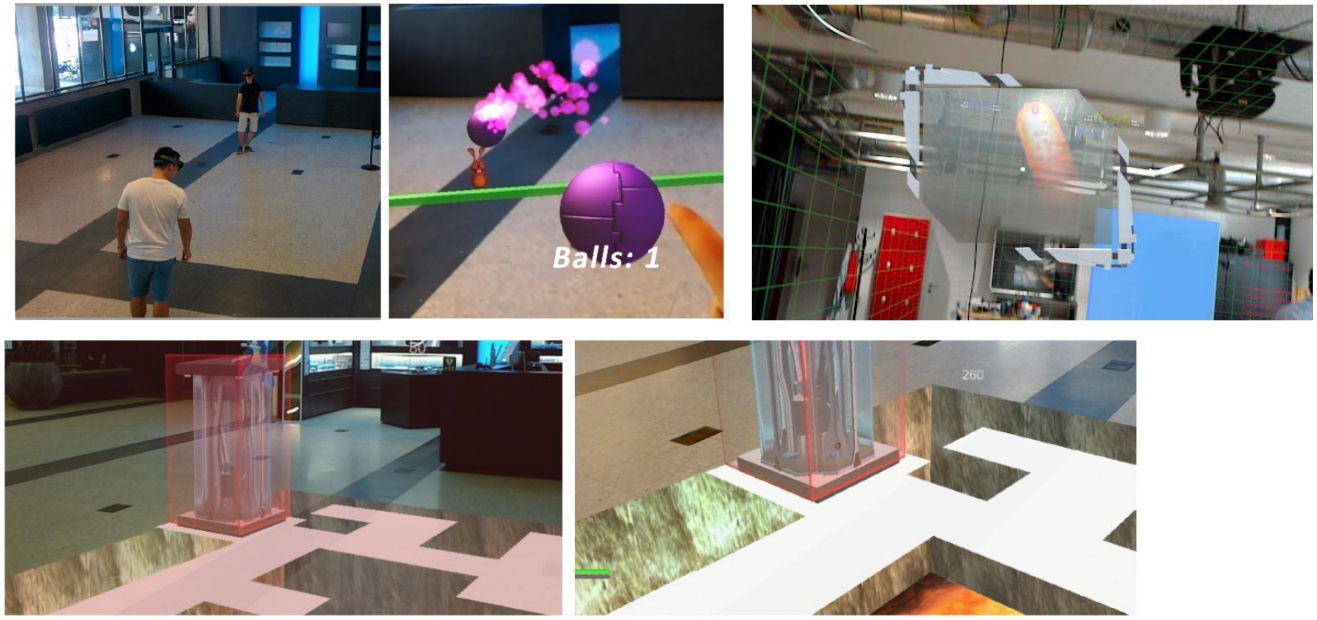


Existing Solutions / Related Work

- Reviewed Topics:
  - Other Multiplayer AR Frameworks
  - **Example Superhuman Sports games**

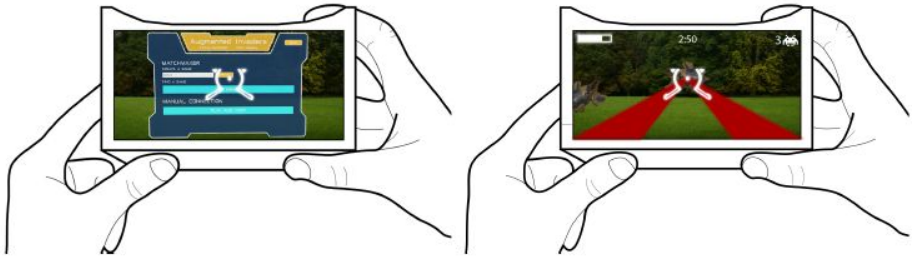
Existing Solutions / Related Work

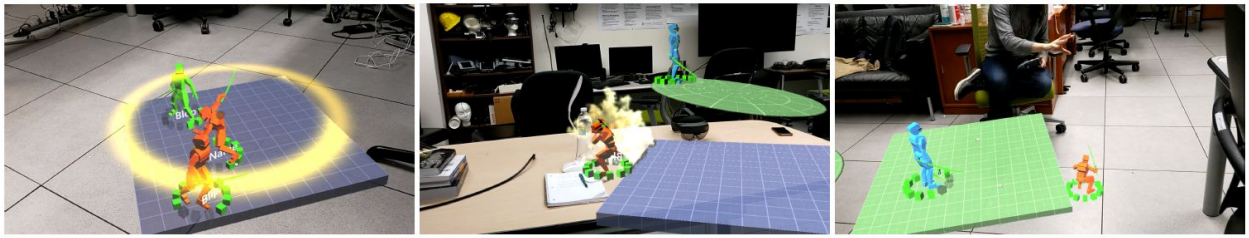
- Example Superhuman Sports games
  - VRable [8]
  - League of Lasers [9]
  - STAR (Superhuman Training in Augmented Reality) [10]



Existing Solutions / Related Work

- Example Multiplayer AR games
  - Holofight [11]
  - ARSoccer [12]
  - Augmented Invaders [13]
  - Brick [14]

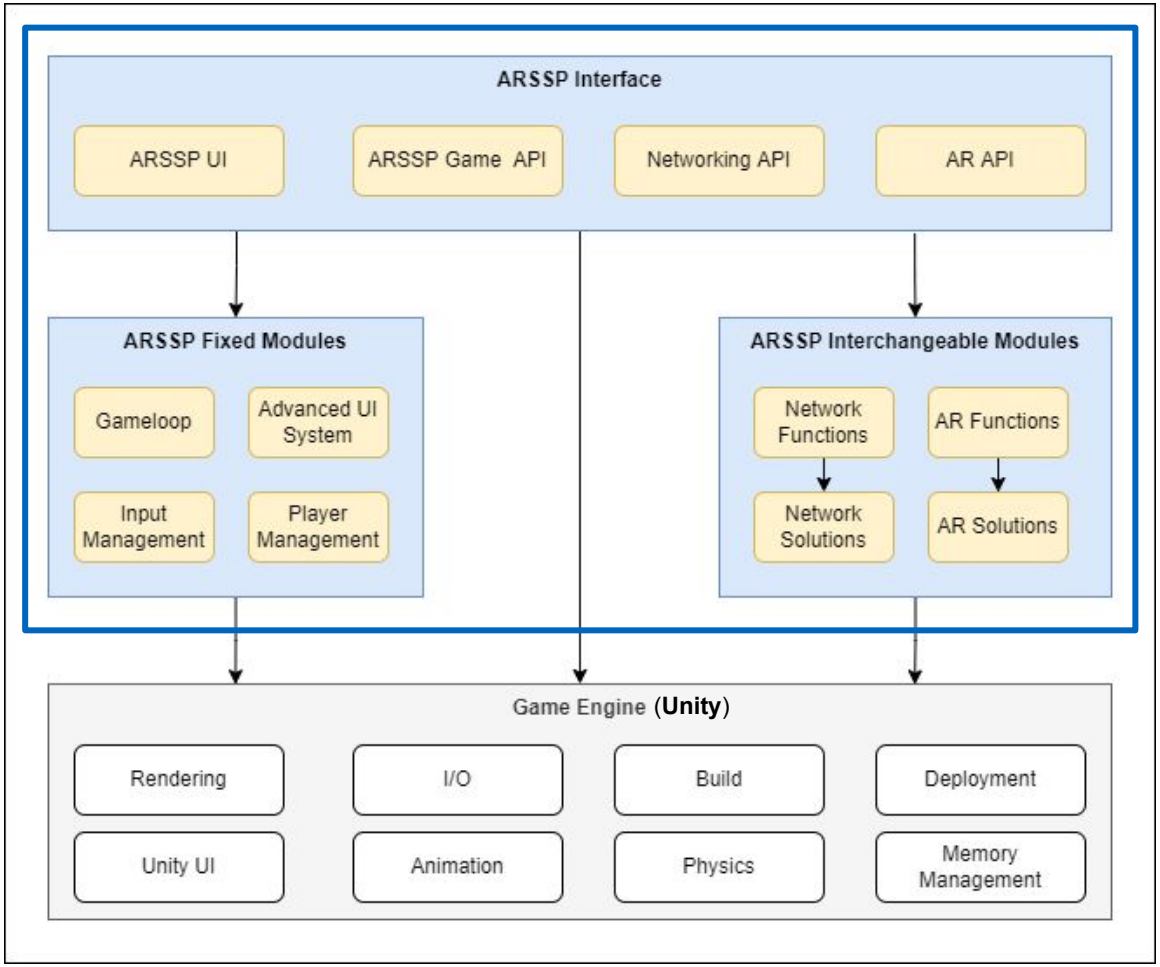




Implementation

1. The initial state of the ARSSP Framework
2. Modifications and new features implemented

Implementation



Implementation

- What ARSSP Provides:
  - **Networking API**: Ubi-Interact and Mirror
  - **AR API**: ARCore and ARKit
  - **UI API**: UI frames and menus
  - **Game Management**: players/controllers/game modes

- What is missing in ARSSP:
  - AR Framework:
    - Magic Leap and Hololens implementation in AR (MRTK and MLTK)
    - Native OpenCV support
  - Networking Framework
    - Integration of external hardware into the network system is not yet supported

Implementation

2. Modifications and new features implemented
    a. **Environment Upgrade**
    b. Magic Leap HMD Support
    c. HMD UI and Interaction Support
    d. Networking Lobby System
    e. External Hardware Integration
    f. OpenCV Support
    g. Template Creation

Implementation

- Environment Upgrade
  - Unity engine upgrade (2019.4 => 2020.3)
  - AR plugins and other packages
  - Networking Solutions (Ubi-Interact and Mirror)

Implementation

2. Modifications and new features implemented
    a. Environment Upgrade
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Implementation

- Magic Leap HMD Support

Implementation

2. Modifications and new features implemented
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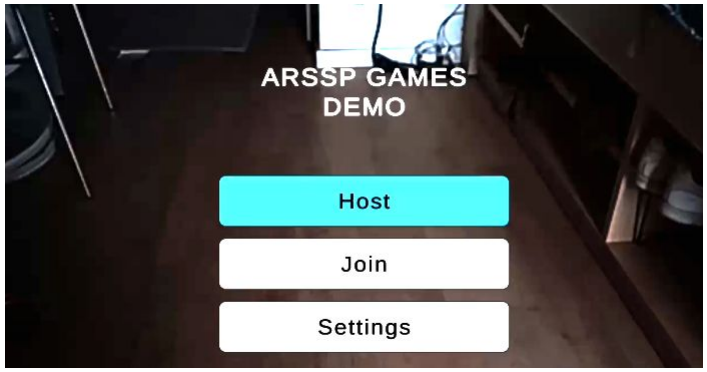
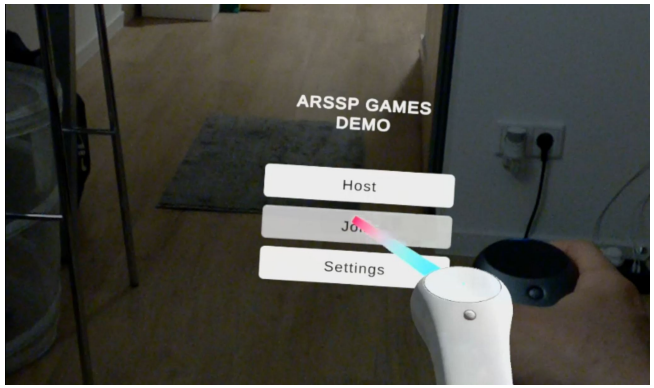
Implementation

- HMD UI and Interaction Support

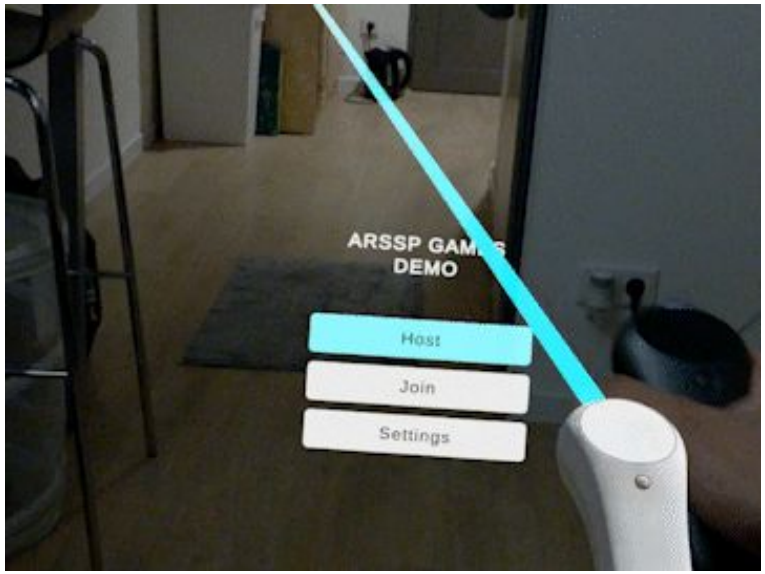




- Changing UI screenspace to UI worldspace
- Adding raycasting to the controller
- Making buttons intractable by adding colliders
- Making this process automated and generic for all UI

Implementation

- HMD UI and Interaction Support



  - Similar technique can be seen in reviewed games like: VRabl [8] and League of Lasers [9]

Implementation

2. Modifications and new features implemented
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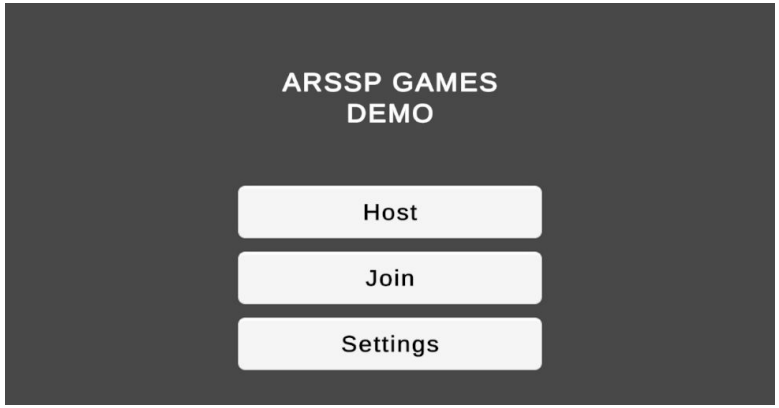
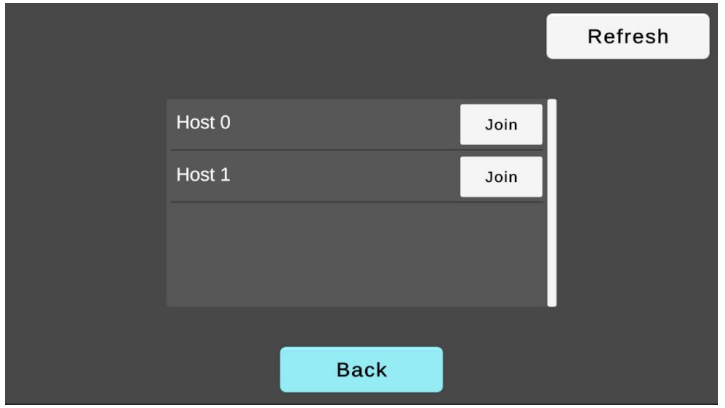
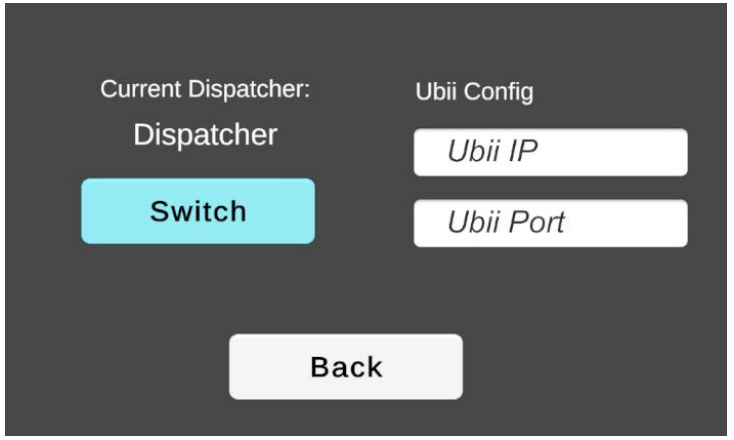
Implementation

- Networking Lobby System







Implementation

- Players can:
  - Host a game session
  - View available game sessions
  - Join a game session
  - Disconnect or leave a game session
  - Assign the player's team in the lobby
  - Assign if the player is ready or not in the lobby
  - Start the game
  - Adjust networking settings

- Very similar systems can be seen in reviewed games like Augmented Invaders [13] and Brick [14]

Implementation

- Networking Demo

Implementation

2. Modifications and new features implemented
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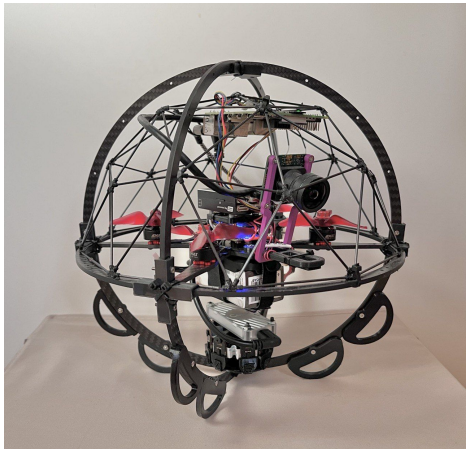
Implementation

- External Hardware Integration



Drone-ball from Catching the Drone [15]

Virtual-Super Leaping [16]

Implementation

- External Hardware Integration

Unity Ubi Client

Raspberry Pi Zero
OS: Raspbian
Runs Python Ubi Client

```
jsonBEvent = '{"$id": "1",
          "InvokingBEventName": "TEST_Vector3Test",
          "DebugEvent": true,
          "Arg1": {"$id": "2", "x": 5.045, "y": -3.24533, "z": 704.7499} }
```

Unity Ubi Client

Implementation

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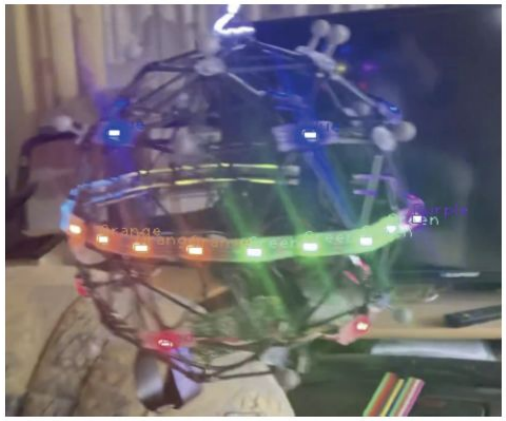
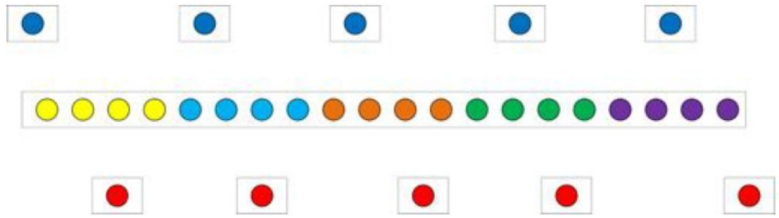
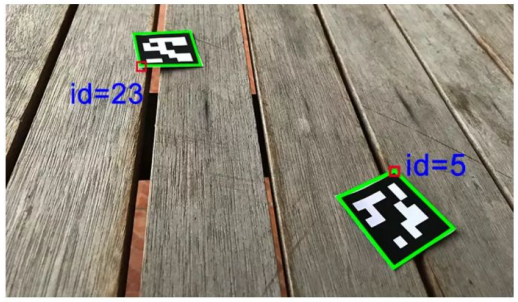
Implementation

- OpenCV Support





(a) The input image.



(b) The result image.

Implementation

- Augmentation Demo

Implementation

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    a. Environment Upgrade
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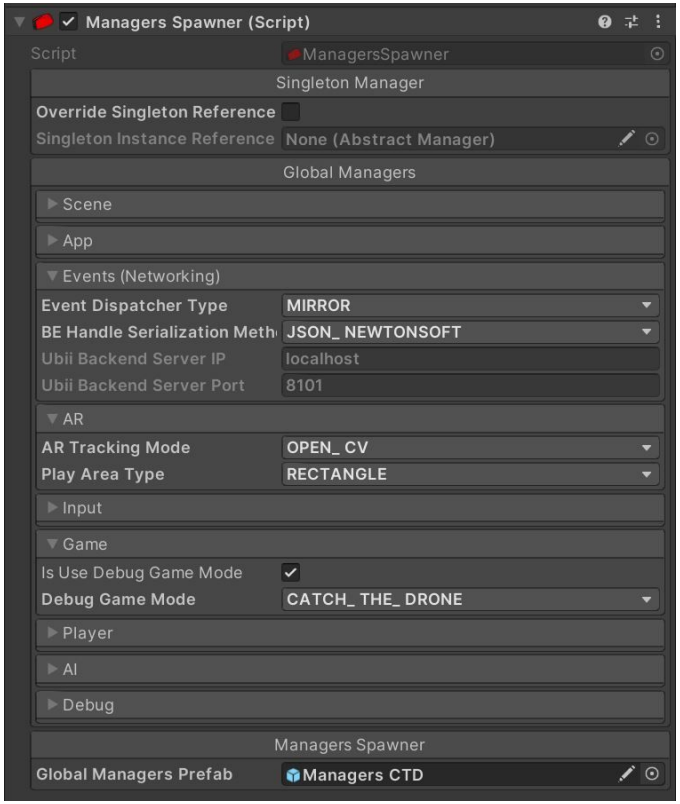
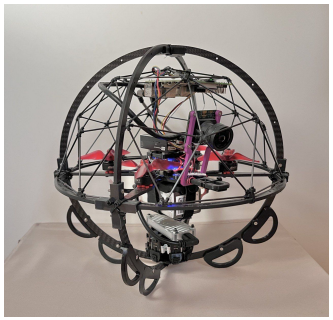
Implementation

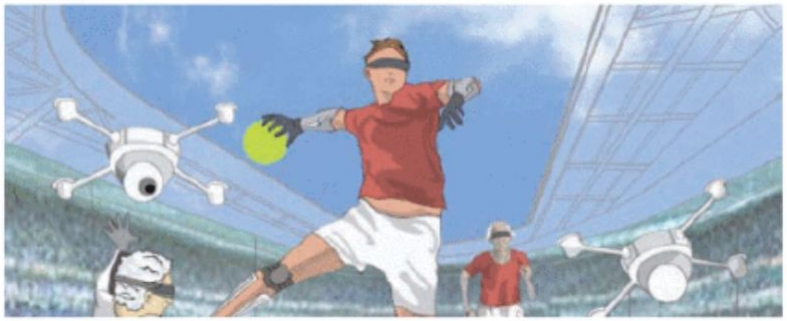
- Template



Evaluation

- Catching the Drone [15]





Evaluation

- Technical Criteria of Catching the Drone
  - Networking
    - (N.1) Has more than one networking solution.
    - (N.2) Cross-platform.
    - (N.3) Integrated with micro-controllers.
  - Augmentation
    - (A.1) Detects drone ball.
    - (A.2) Augments drone-ball.
    - (A.3) Has more the one AR solution
  - Game Logic
    - (G.1) Team assigning.
    - (G.2) Globalized scoring system.
    - (G.3) Drone-ball superhuman abilities.

Evaluation

- Technical Criteria of Catching the Drone
  - Networking
    - (N.1) Has more than one networking solution.
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  - Augmentation
    - (A.1) Detects drone ball.
    - (A.2) Augments drone-ball.
    - (A.3) Has more the one AR solution
  - Game Logic
    - (G.1) Team assigning.
    - (G.2) Globalized scoring system.
    - (G.3) Drone-ball superhuman abilities.

Conclusion

- **Goal:** Closing the gap between developers and superhuman sports technology
- **Approach:** Modify and improve the ARSSP framework
- **Result:** Evaluation shows that ARSSP brings us a step closer to fully implementing Multiplayer AR superhuman sports game.

Future Work

- Fully implementing Catching the Drone with the required hardware
- Improve ARSSP further

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Thank you!

Questions?