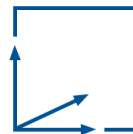


Interactive Wall Tracking System for Digital Sports Games

Janosch Landvogt

16.09.2021



Final: Bachelor, Informatics: Games Engineering

Supervisor: Prof. Gudrun Klinker

Advisor: M.Sc. Sandro Weber

Presentation Structure

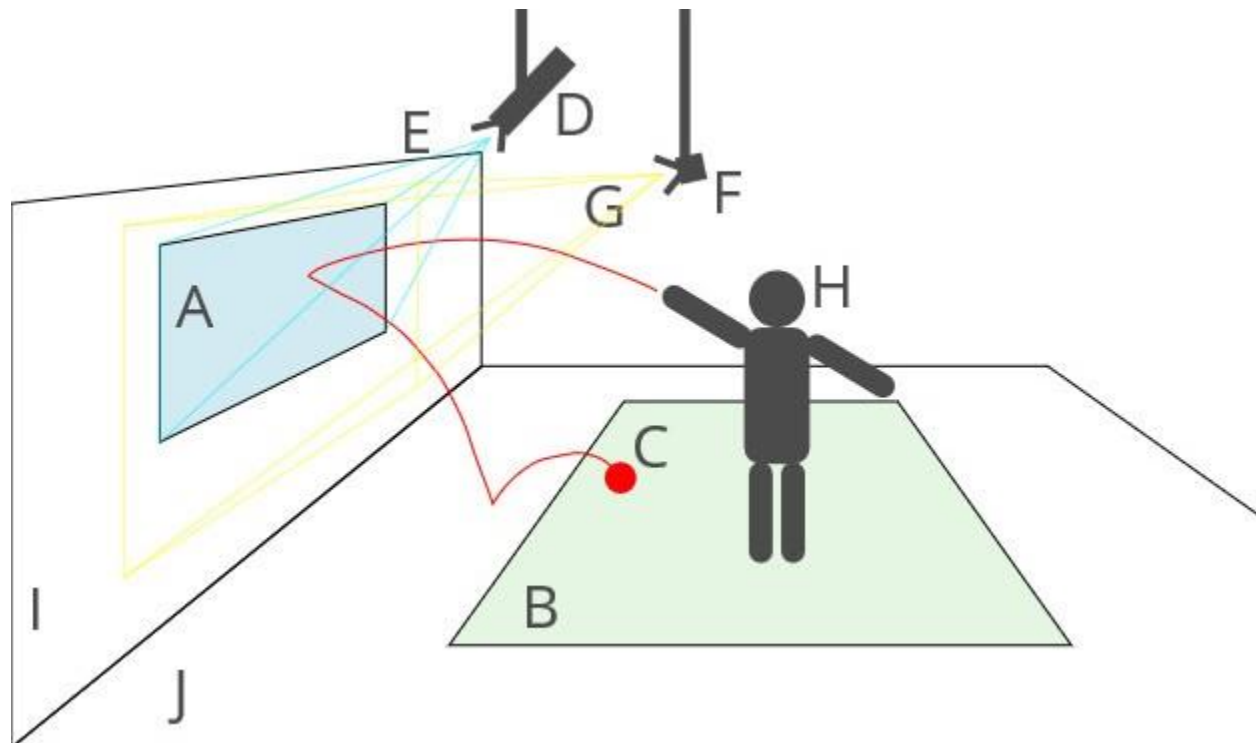
- Motivation
- Demo Videos
- Problem Description (General Algorithm)
- Most Interesting Research Issues
- Conclusion

Motivation

- Interactive Wall Tracking System for Digital Sports Games
- Where: Indoor playgrounds
- What: Entertainment, Ball pit balls, besides others
- Who: Children and teenagers
- When: Time of digital change
- Why:
 - Ball and wall usage
 - Promote health and mind benefits
 - Re-evaluate existing systems (Grid-based)

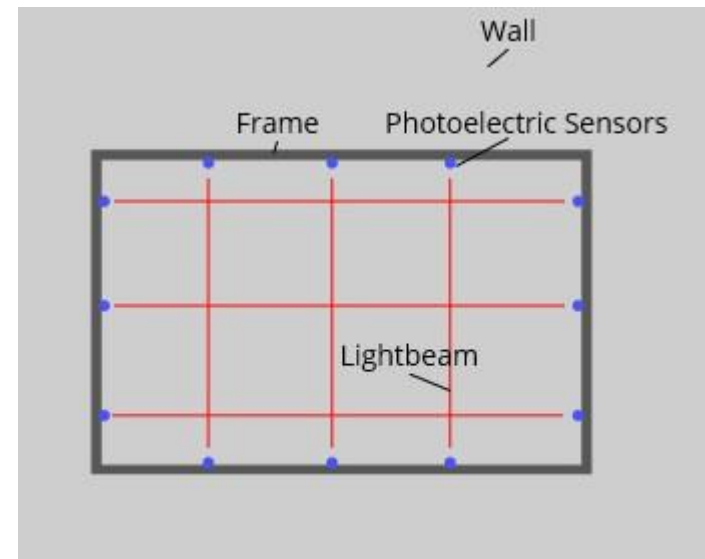
Motivation

- How:



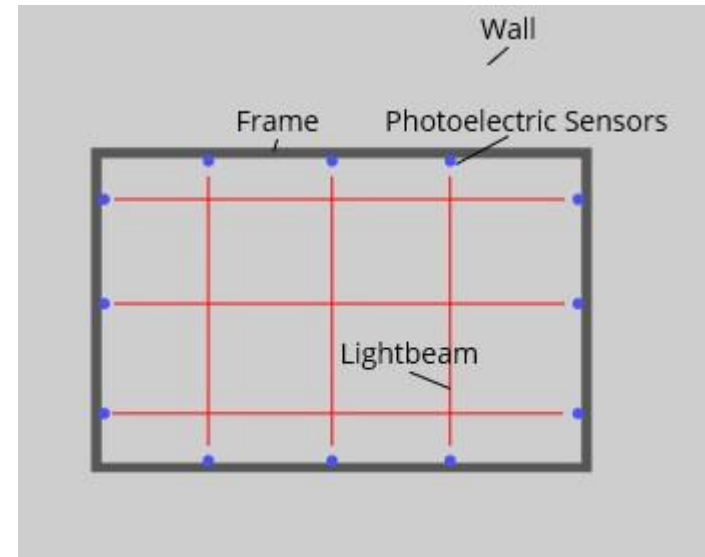
Existing Solutions / Related Work

- General ball detection use cases (TV Sports)
- Grid-based Approach
- Advantages:
 - Throwable object independent
 - Hands, Ball, any size, any time
 - Interference area is very small



Existing Solutions / Related Work

- Grid-based Approach
- Disadvantages:
 - Fixed wall mount needed
 - Decalibration of sensors
 - No players distinguishable



Goals of this Thesis

- Develop the proposed system
- Analyse the product
- Put the system into perspective to grid-based approach
- Evaluate use case benefits of each system
- Adjust approach to solve issues

Problem Description: General

- Detection/ Tracking of thrown plastic balls
- Using OpenCV Computer Vision Library
- Design system to be used in an indoor playground

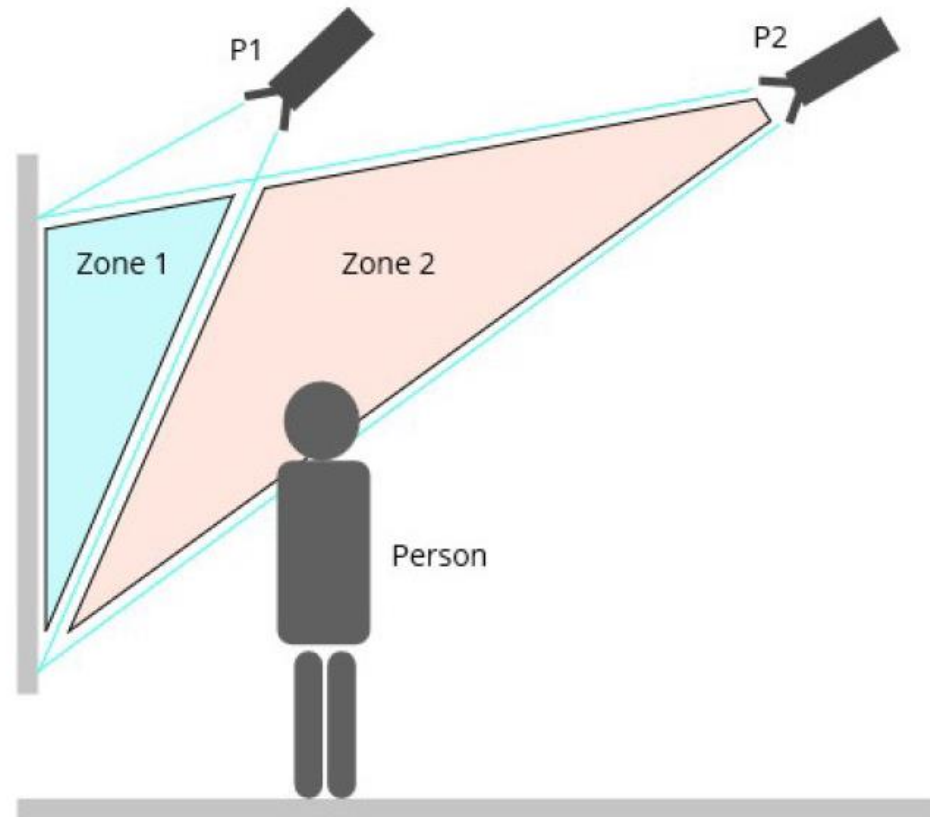


Demo Videos!

Problem Description: Technical

- Initial System Setup
 - Projector Placement

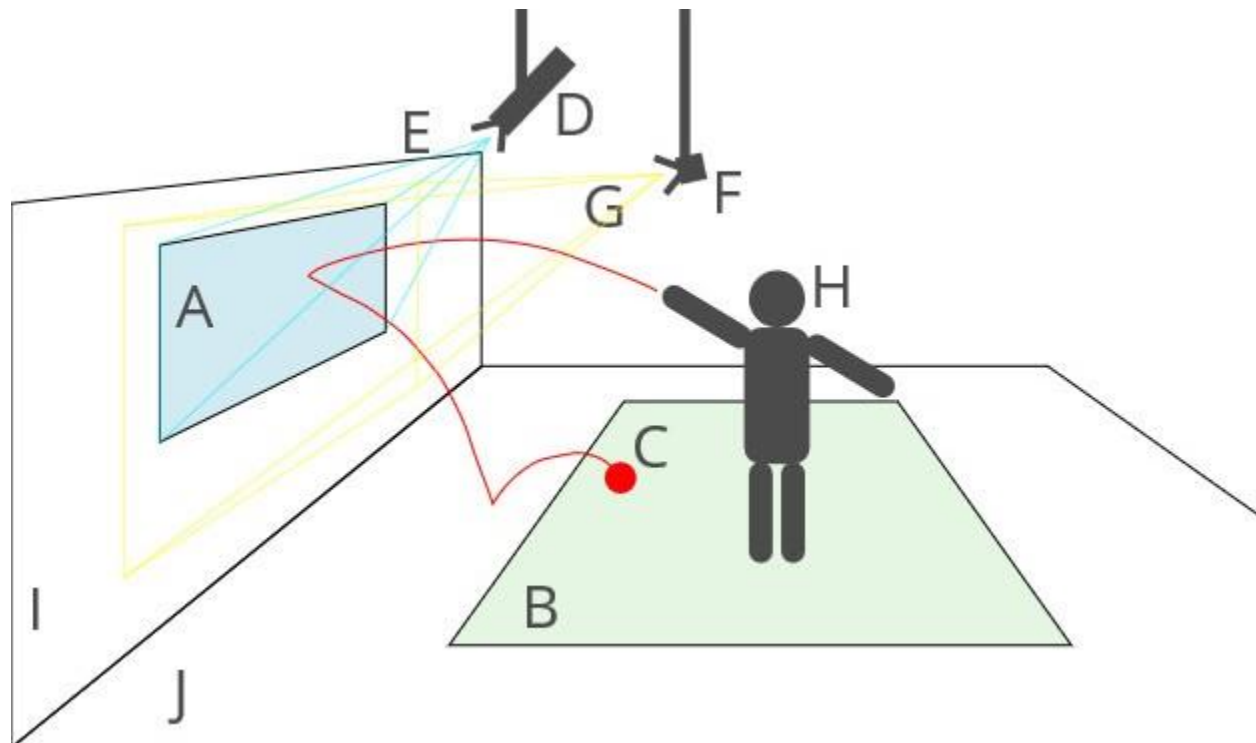
Problem Description: Technical



Problem Description: Technical

- Initial System Setup
 - Projector Placement
 - Camera Positioning

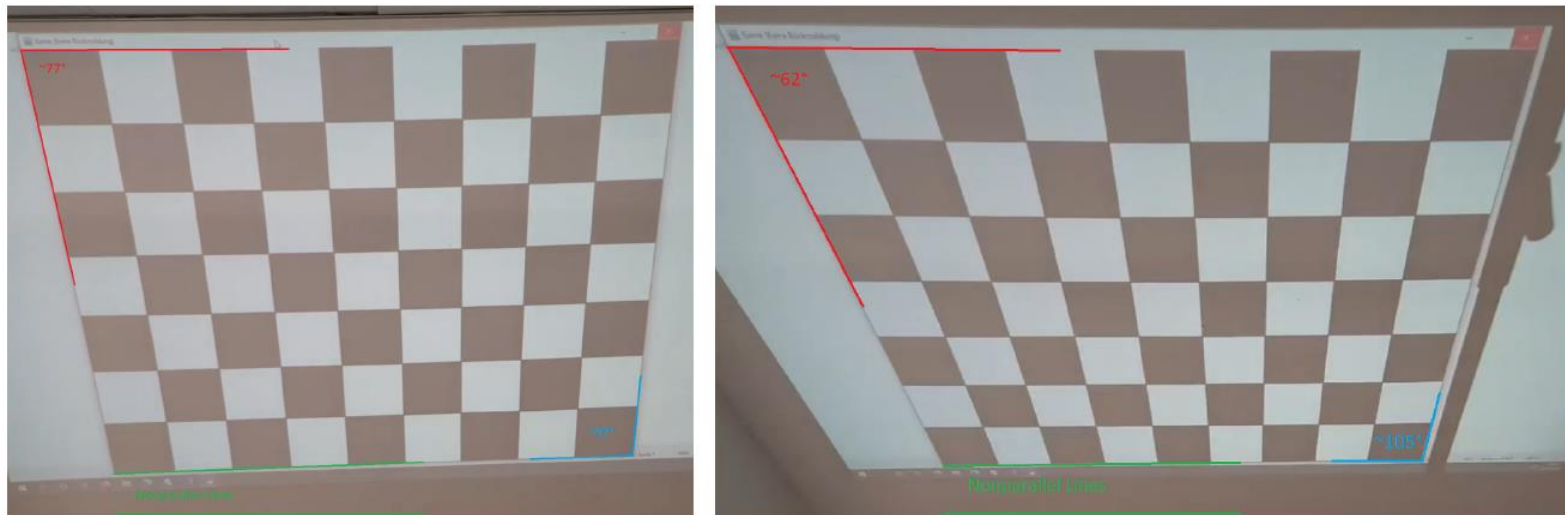
Problem Description: Technical



Problem Description: Technical

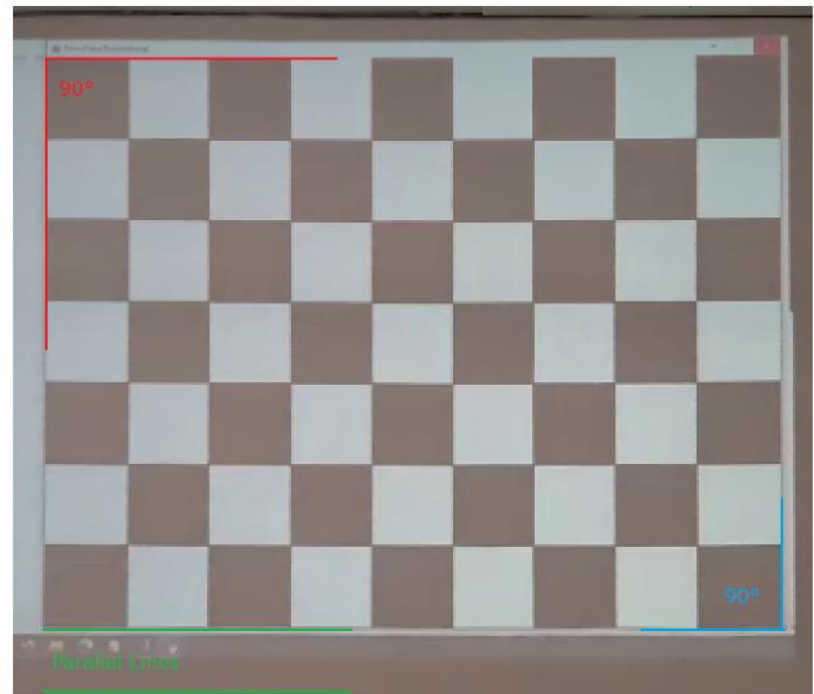
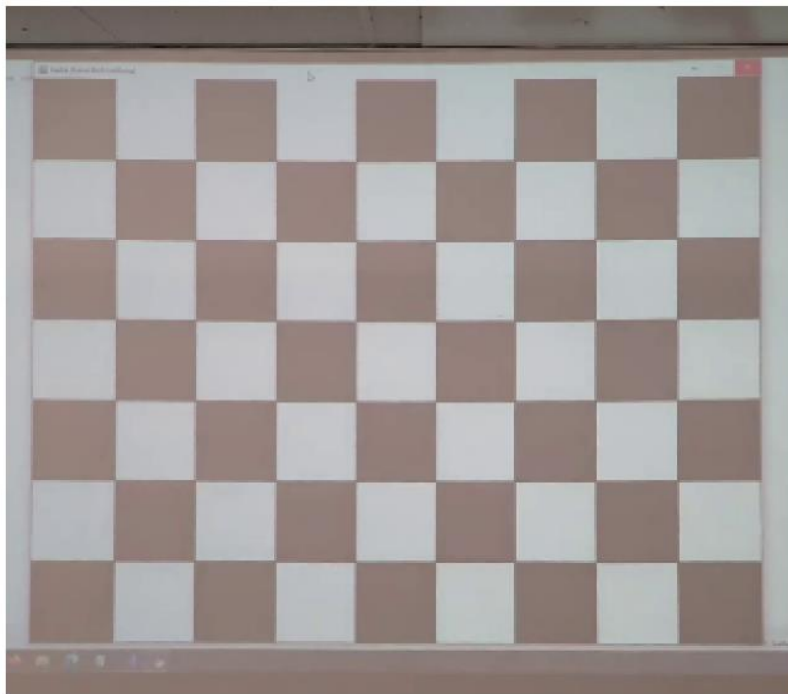
- Initial System Setup
 - Projector Placement
 - Camera Positioning
 - Camera Calibration

Problem Description: Technical



Camera image with distortion

Problem Description: Technical

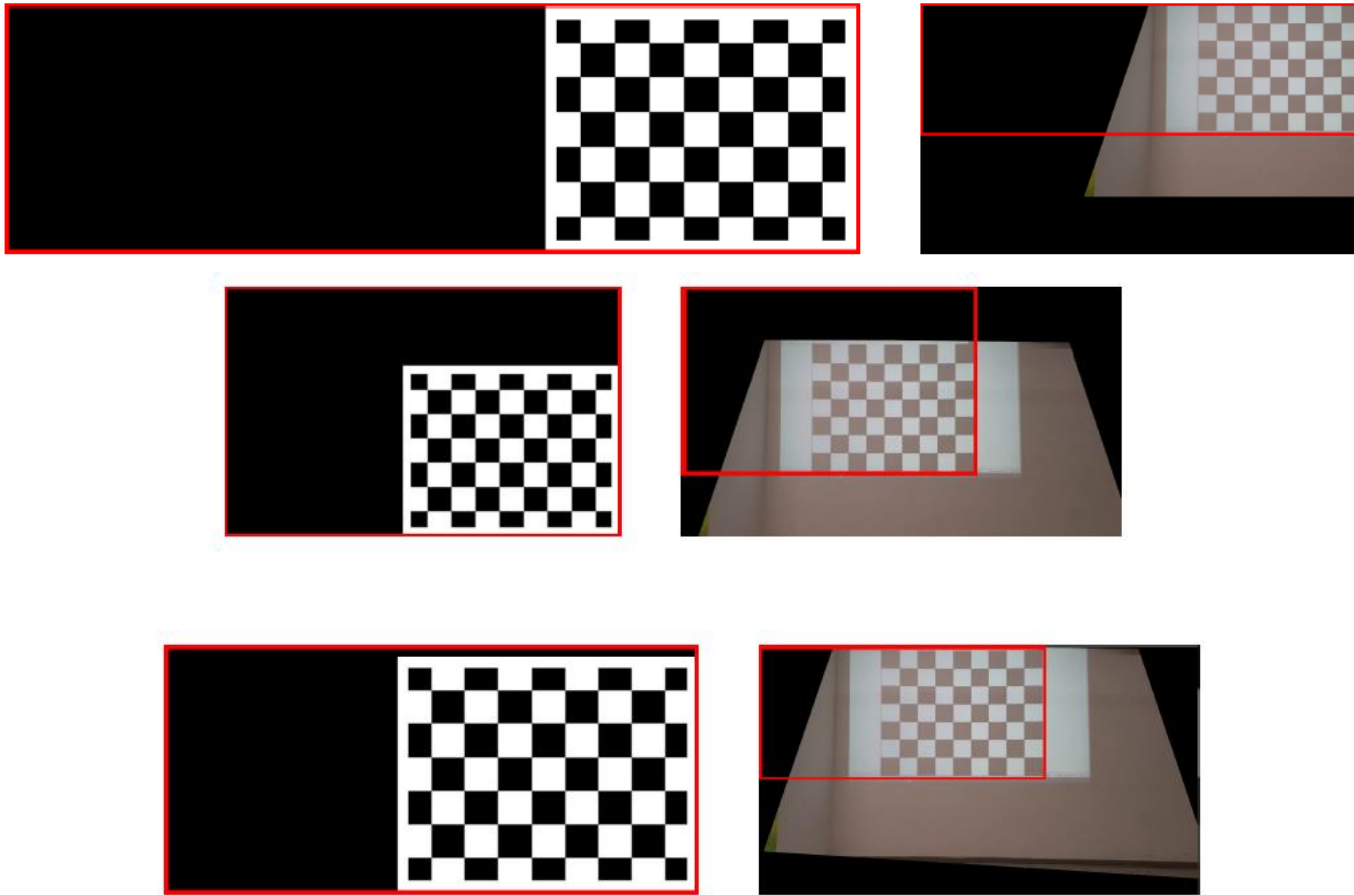


Camera image after distortion correction

Problem Description: Technical

- Initial System Setup
 - Projector Placement
 - Camera Positioning
 - Camera Calibration
 - Checkerboard and Image Calibration

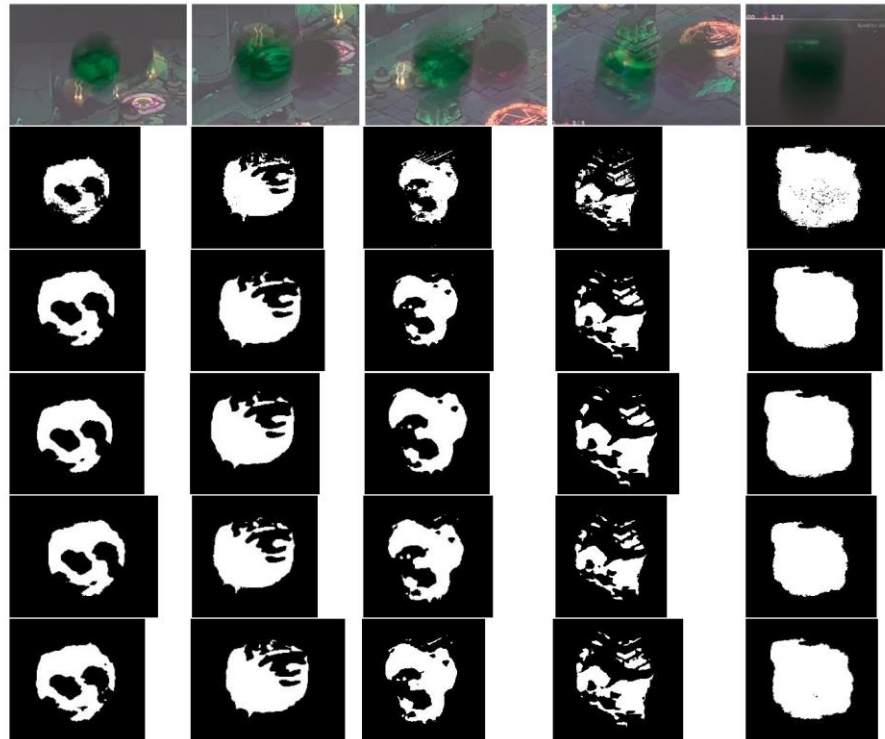
Problem Description: Technical



Problem Description: Technical

- Detection and Tracking Algorithm
 - Blurring
 - Comparison: Averaging, Gaussian, Median, Bilateral

Problem Description: Technical



All Rows: HSV color filter: lower-(35,80,30) upper-(90,255,90)

Row 1: Camera image of a green ball illuminated by the projectors colored game image

Row 2: No blurring

Row 3: Averaging; Code: `cv.blur(camFrame,(5,5))`

Row 4: Gaussian blurring; Code: `cv.GaussianBlur(camFrame, (11, 11), 0)`

Row 5: Median blurring; Code: `cv.medianBlur(camFrame, 5)`

Row 6: Bilateral filtering; Code: `cv.bilateralFilter(camFrame,5,1500,1500)`

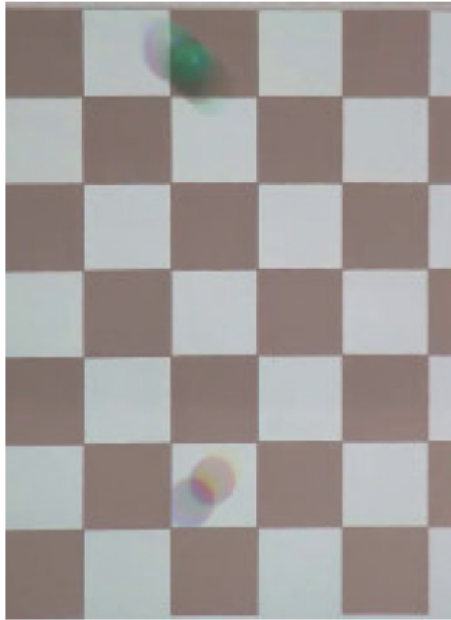
Problem Description: Technical



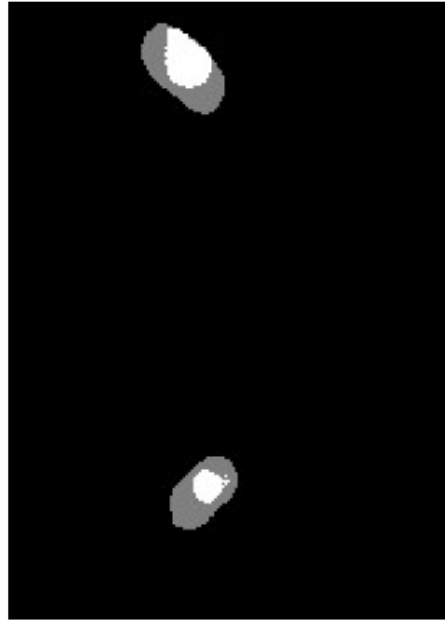
Problem Description: Technical

- Detection and Tracking Algorithm
 - Blurring
 - Comparison: Averaging, Gaussian, Median, Bilateral
 - Background Subtraction

Problem Description: Technical



(a) Camera image with moving ball and shadow



(b) KNN Background Subtraction Filter



(c) Camera image first blurred then masked out by background subtraction filter



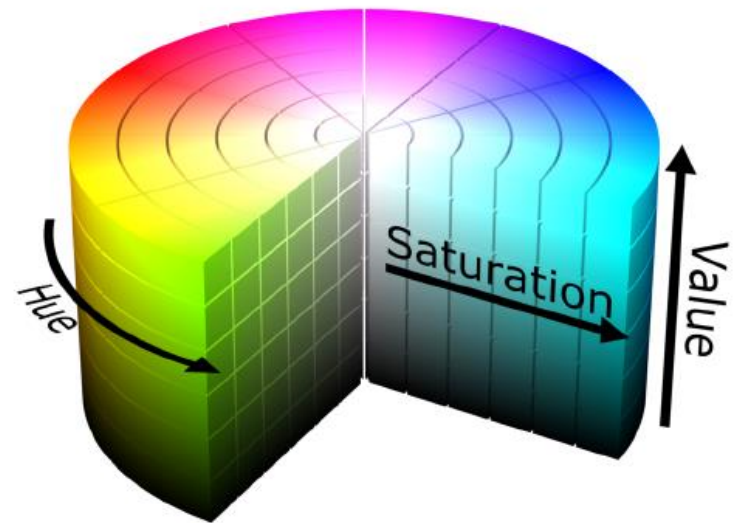
(d) HSV Color Filter for green ball

Problem Description: Technical

- Detection and Tracking Algorithm
 - Blurring
 - Comparison: Averaging, Gaussian, Median, Bilateral
 - Background Subtraction
 - Color Filtering

Problem Description: Technical

- HSV commonly used in computervision
- Intuitive and physically representative as RGB Color
- Example in dark lighting
- Example for color picker



Critical Research Issues

- Choice for ball colors

Critical Research Issues

- Choice for ball colors

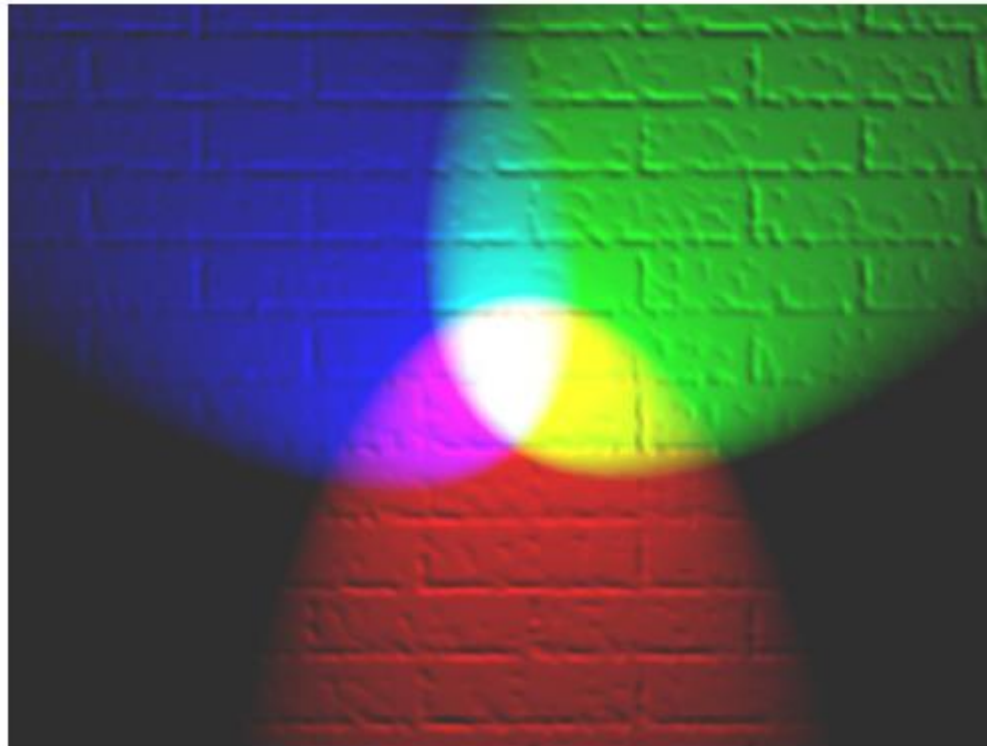


(a) Ball Pit Balls

(b) Sponge Balls

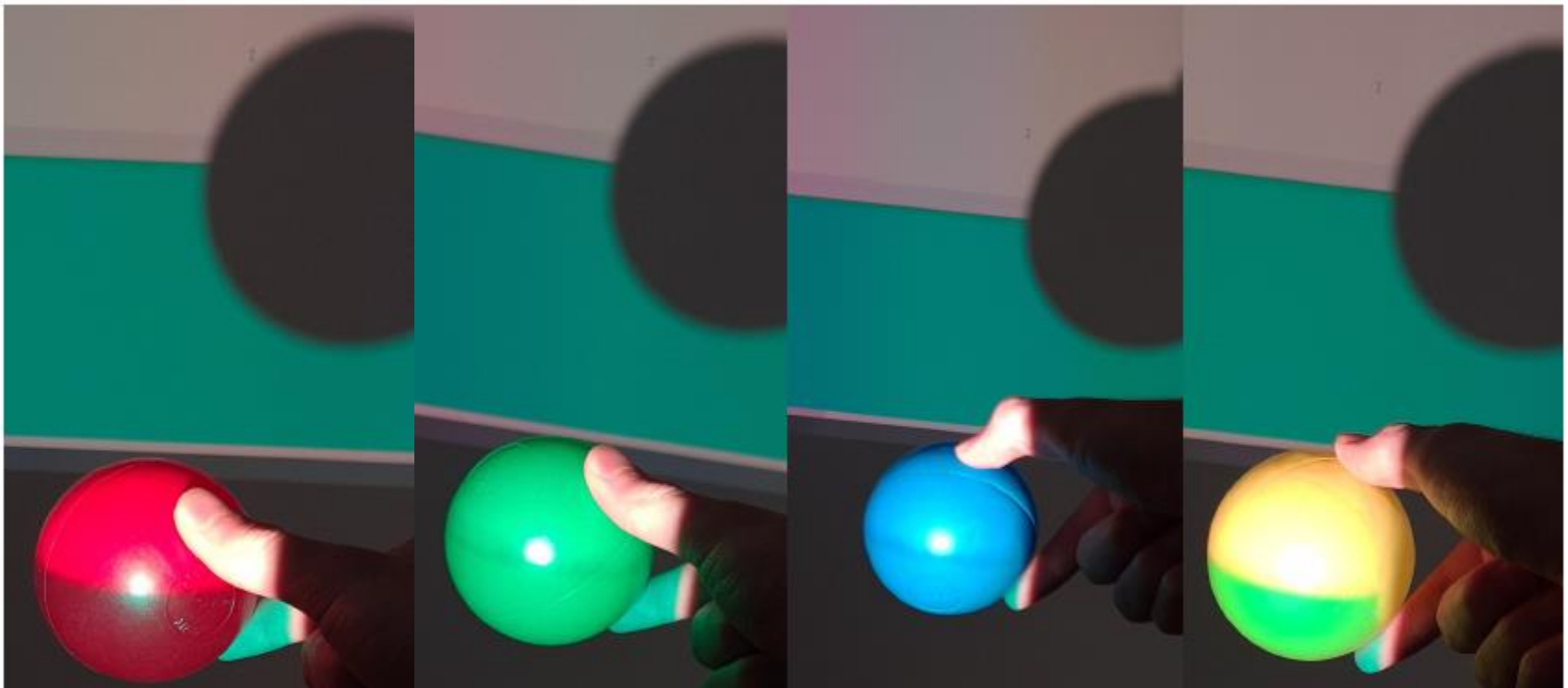
Critical Research Issues

- Choice for ball colors



Critical Research Issues

- Choice for ball colors



(a)

(b)

(c)

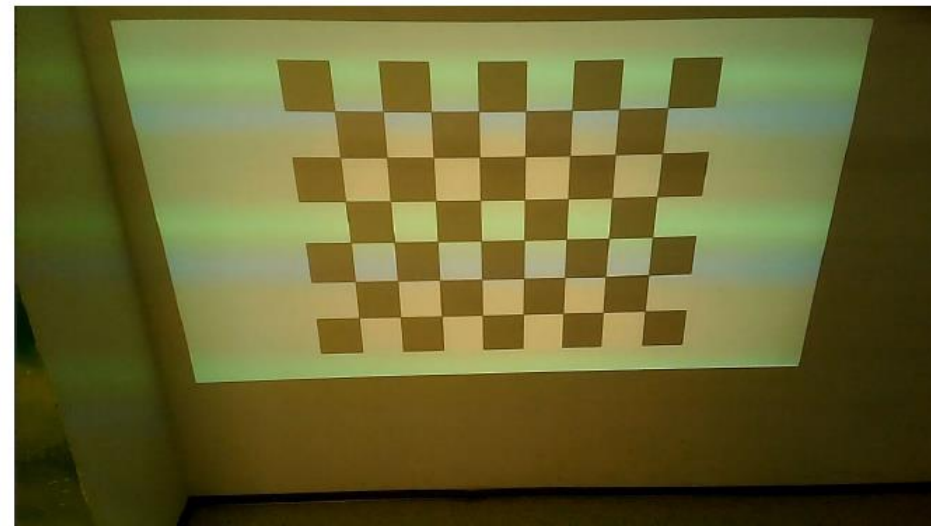
(d)

Critical Research Issues

- Choice for ball colors
- Rainbow Effect

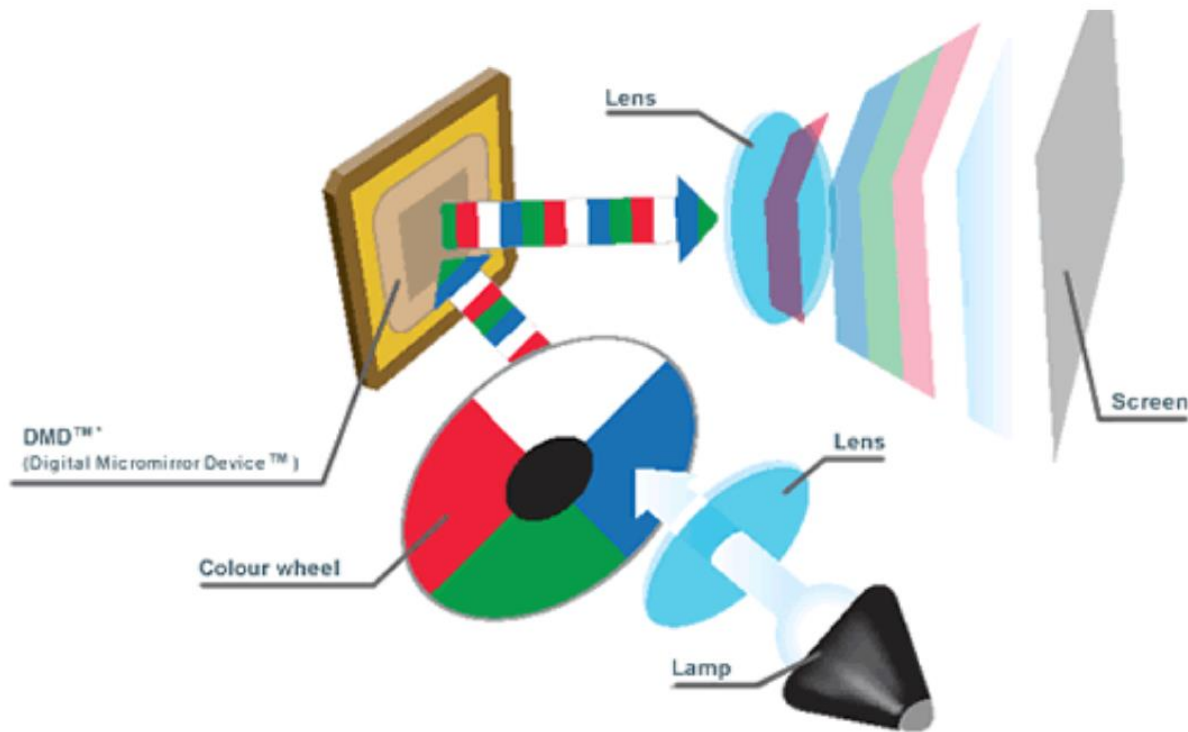
Critical Research Issues

- Samsung S20 vs Orbbec Astra Pro



Critical Research Issues

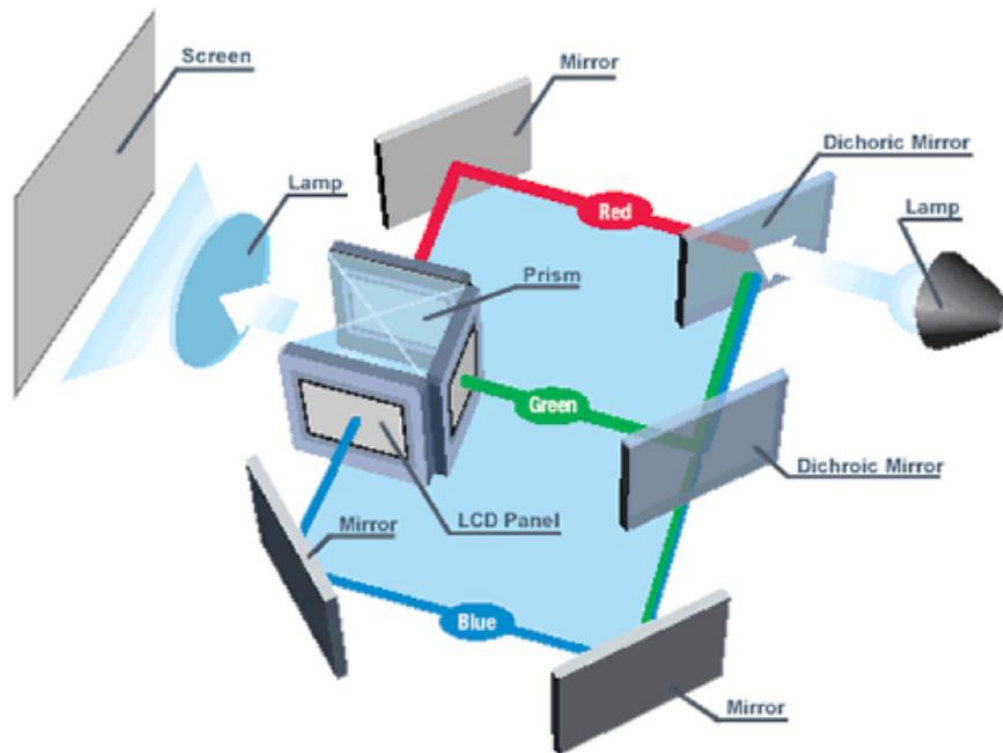
- Beamer DLP (Digital Light Processing)



(a) 1-chip system with sequential color

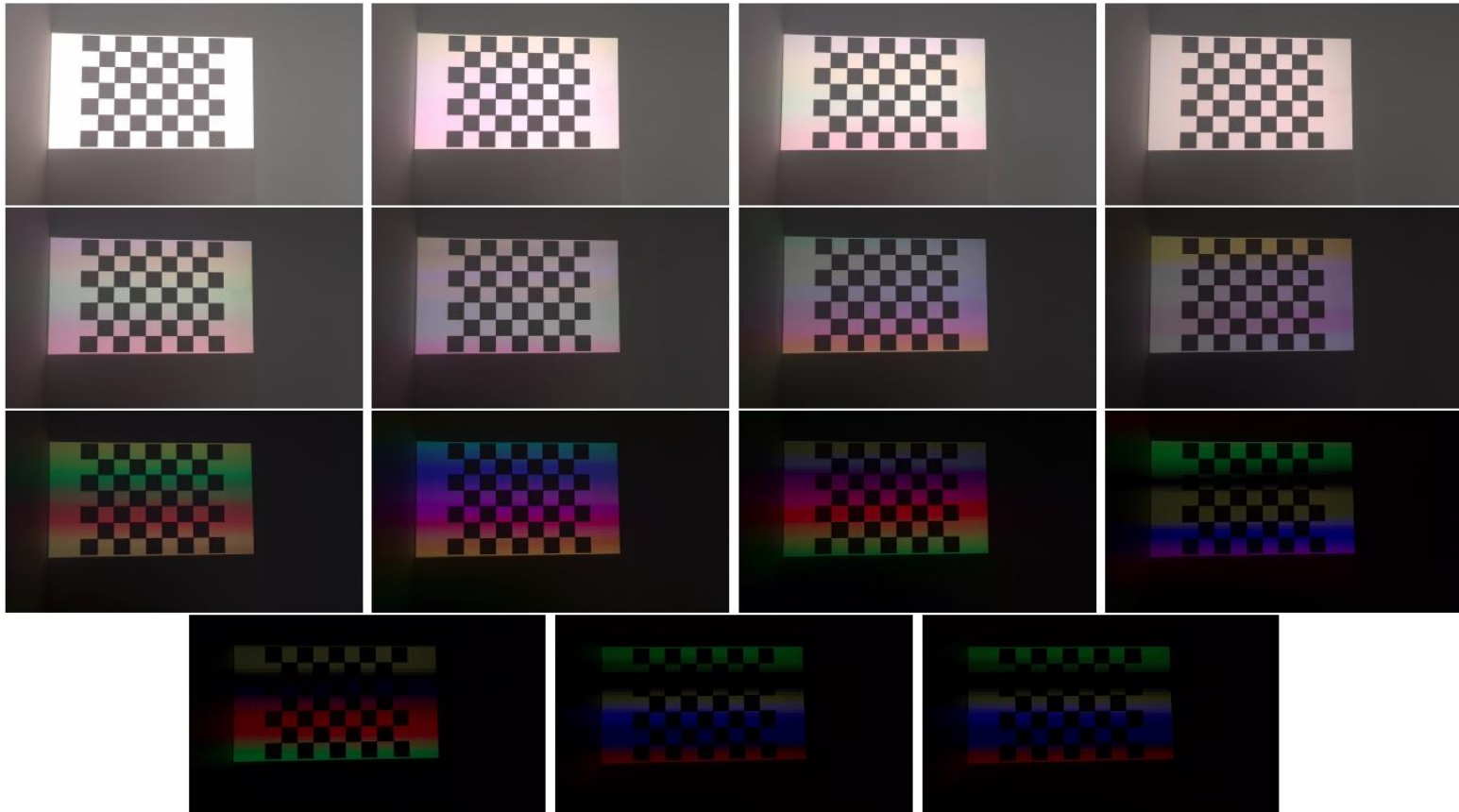
Critical Research Issues

- Beamer DLP (Digital Light Processing)



(b) 3-chip system with simultaneous color

Critical Research Issues



The pictures' exposure times while recording a 60hz projector with a Samsung Galaxy S20 are as follows from top right to bottom left: $\frac{1}{30}$, $\frac{1}{45}$, $\frac{1}{50}$, $\frac{1}{60}$, $\frac{1}{90}$, $\frac{1}{125}$, $\frac{1}{180}$, $\frac{1}{250}$, $\frac{1}{350}$, $\frac{1}{500}$, $\frac{1}{750}$, $\frac{1}{1000}$, $\frac{1}{1500}$, $\frac{1}{2000}$

Critical Research Issues

- Choice for ball colors
- Rainbow Effect
 - 3-Chip DLP Projectors are too expensive
 - Synchronize exposure time to projector hz
 - Camera requires fixable exposure time support

Conclusion

- Development of the proposed system was successful
- Camera-based approach overcame grid-based issues
- Camera-based approach introduced issues/ is more complicated than grid-based approach
- No clearly preferable system approach
 - Camera: more potential, bigger overhead
 - Grid: easier use, less

Discussion / Suggested Future Work

- Combination of depth camera and RGB image
 - OpenCV OAK-D
- Region of interest resolution optimization
- Using neural networks to track ball position

Additional Topics

- Multiball Tracking
- Networking
- Resolution Optimization
- Viewing Angle Error

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