Multiple Depth Sensor Setup and Synchronization for Marker-less 3D Human Foot Tracking in a Hallway

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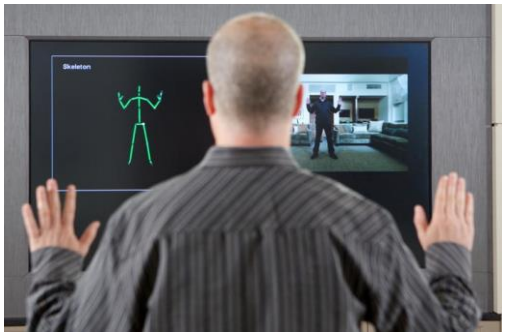
Introduction

Motion Capture Systems

- Marker / wearable
- Marker-less

Vicon Markers



Kinect: Marker-less
https://www.digitaltrends.com
/apple/apple-primesense/

- Markers/Sensors causes discomfort to patients
- External sensors could effect the human natural gait [1]

[1] M. R. Patterson et al., "Does external walking environment affect gait patterns?," 2014 36th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. EMBC 2014, pp. 2981–2984, 2014.

*Vicon Markers – Taken from www.vicon.com/motion-capture/life-sciences

*Kinect: Marker-less - Taken from https://www.digitaltrends.com/apple/apple-primesense

Marker-less Motion Capturing in a Hallway

Depth sensors

- 3D data in real-time
- Well-known for marker-less human tracking
- A state-of-art Kinect depth sensor was poor at foot tracking [2]

Hallway

- Patients, Staff, and Visitors move through hospital, rehabilitation, and long term care hallways [3]
- This space can be smartly utilized for stride analysis

[2] M. R. Kharazi, A. H. Memari, and A. Shahrokhi, "Validity of Microsoft Kinect TM for measuring gait parameters," no. 11, pp. 25–27, 2015.
[3] J. Colley, H. Zeeman, and E. Kendall, "'Everything happens in the hallways': Exploring User Activity in the Corridors at Two Rehabilitation Units," Heal. Environ. Res. Des. J., vol. 11, no. 2, pp. 163–176, 2018.

Objective

- To find an appropriate **physical setup** for depth sensors to capture a walking human's foot surface in a hallway.
- Achieved based on simulations using **Blender** Animation Software [4].

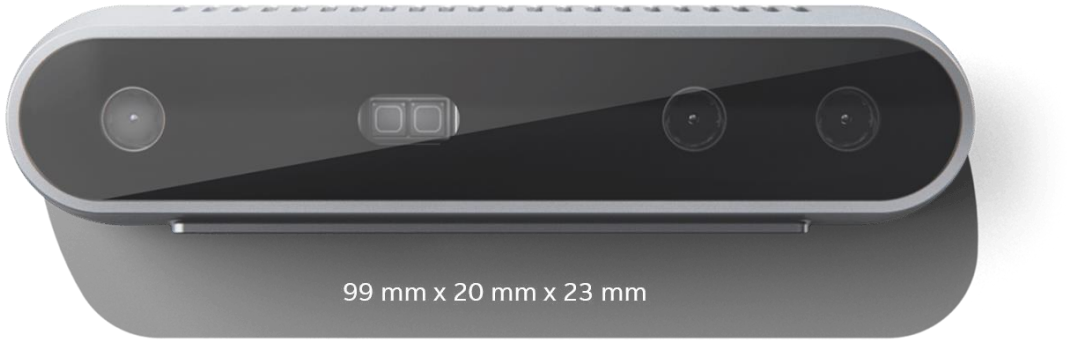
[4] "Blender Software," 2.79b, 2017. [Online]. Available: https://www.blender.org/. [Accessed: 30-Sep-2018].

Methodology & Flow

- Depth Sensor
- Blender Animation Simulations
- Simulation Results
- Physical Validation

Depth Sensor – Intel Real Sense D415 [5]

- *High Depth Resolution (848 x 480)*
- *High Speed (60 fps)*
- *Long Range (10 m)*
- *No Interference*

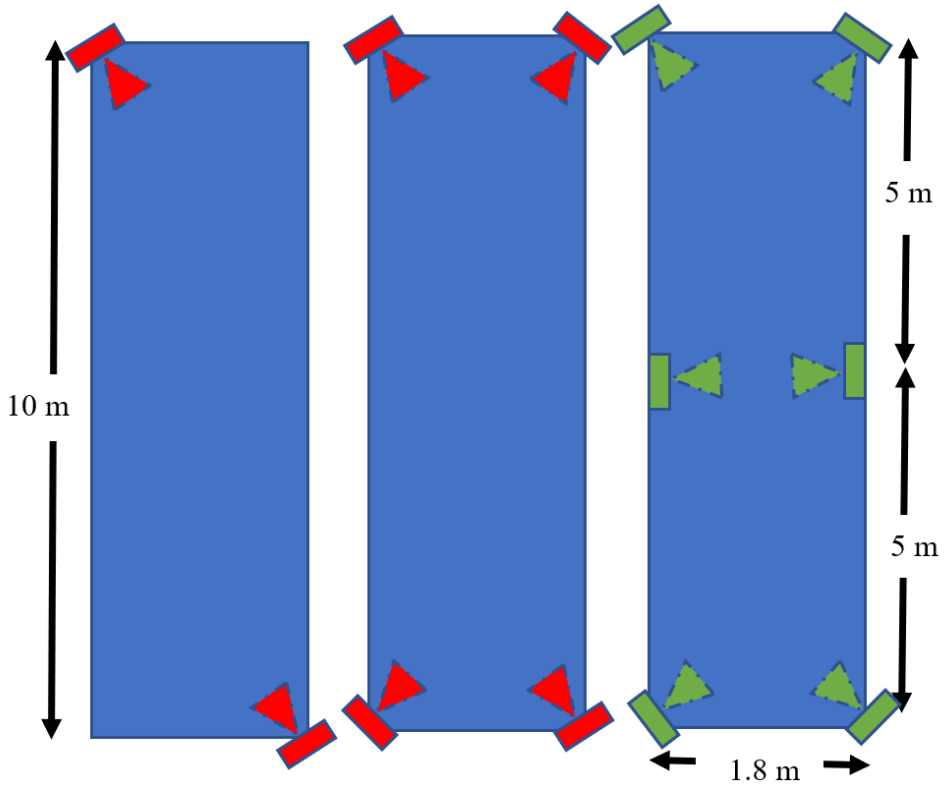


[5] "Intel RealSense D415." [Online]. Available: https://realsense.intel.com/depth-camera/#D415_D435. [Accessed: 28-Jan-2019].

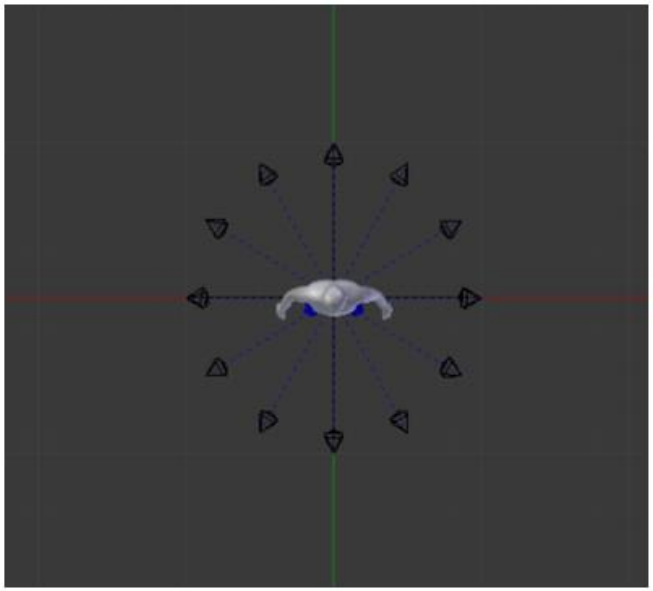
Blender Animation

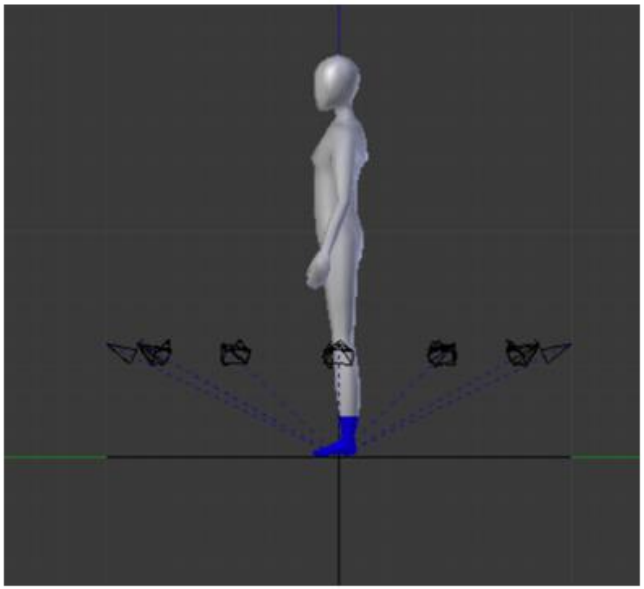
- Human model
  Height 1.78 m
- Light Source *as*
  Depth sensor
- Hallway
  10 m x 1.8 m x 2.7 m

Blender Animation – *Simulation Setups*

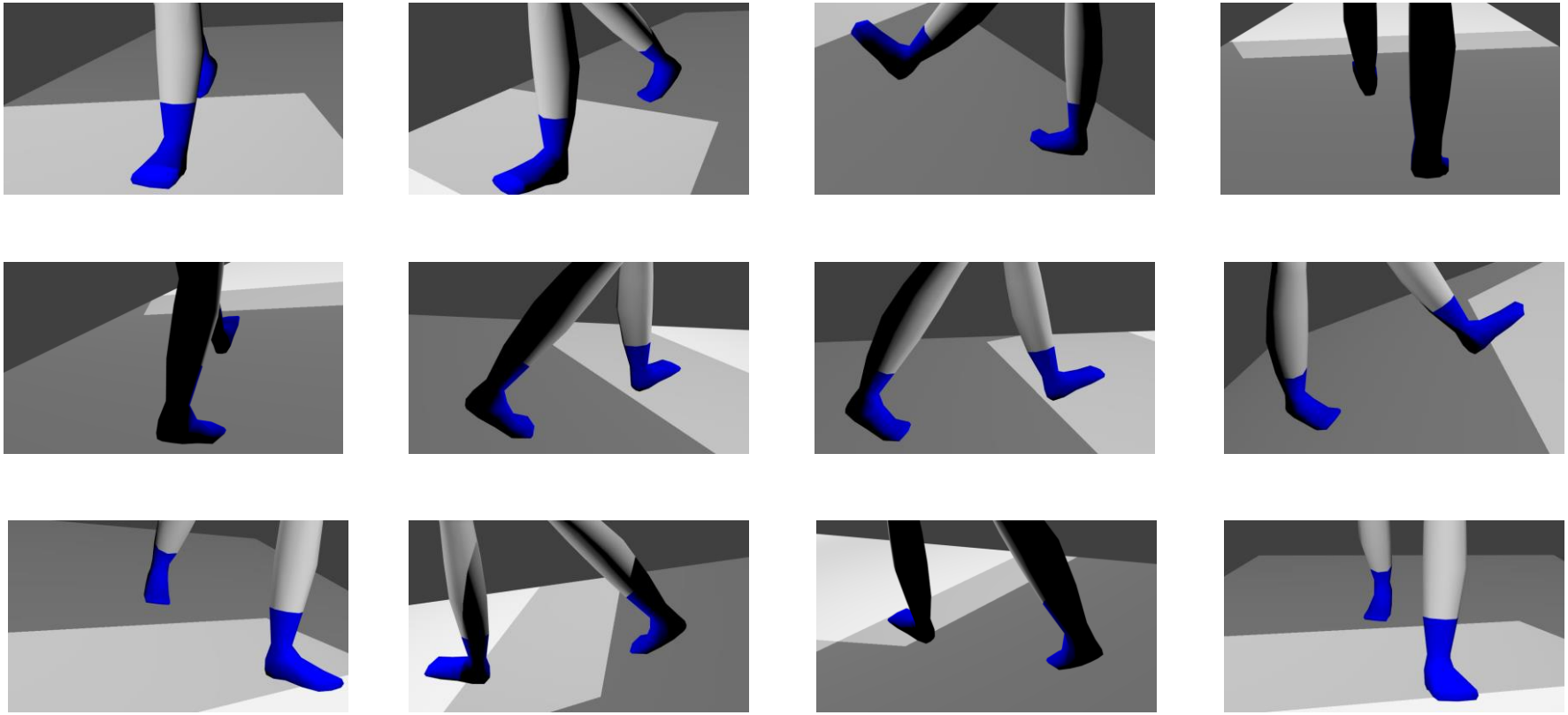


Blender Animation – *Virtual Cameras*

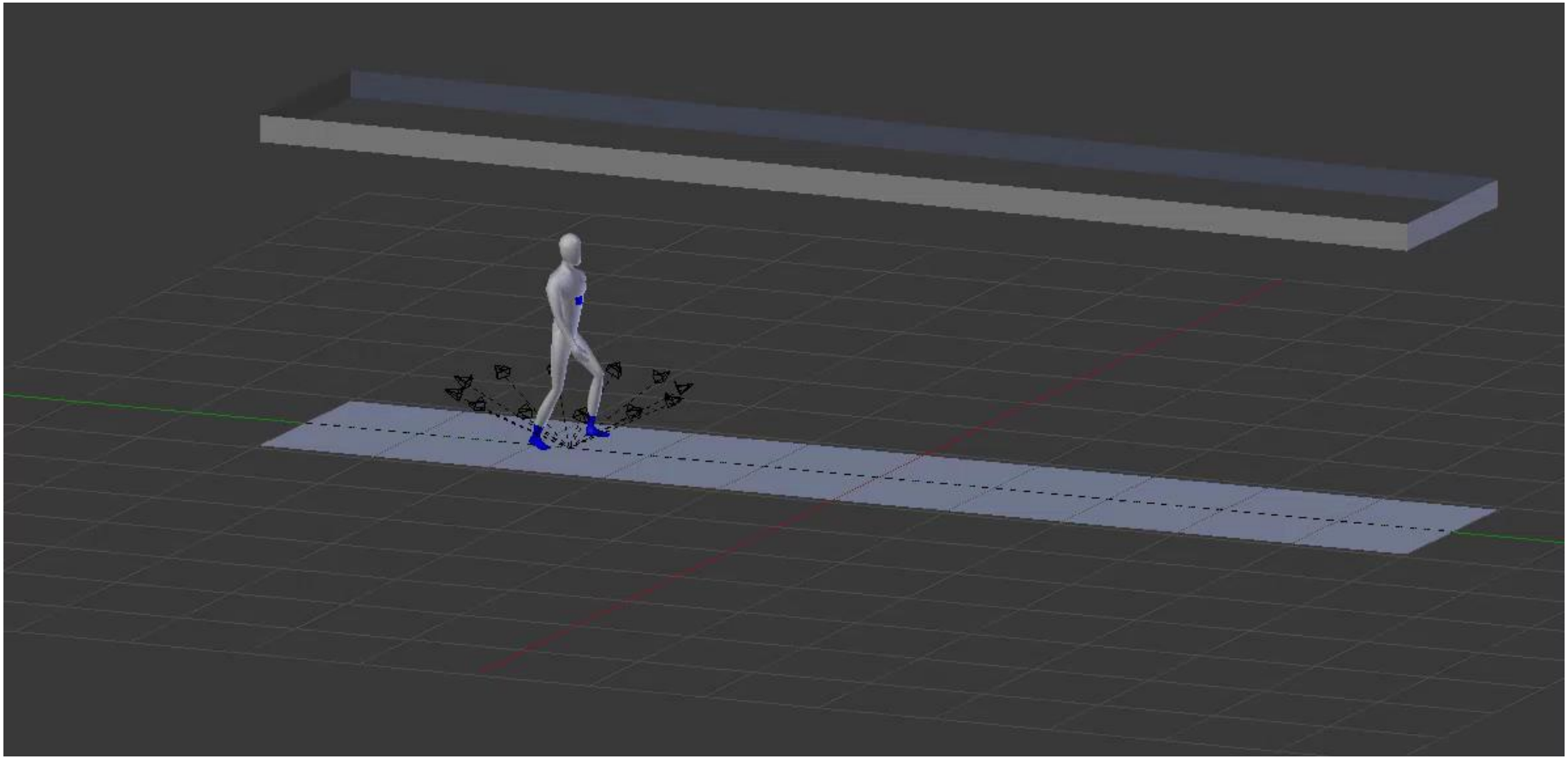




Blender Animation – *Visibility*

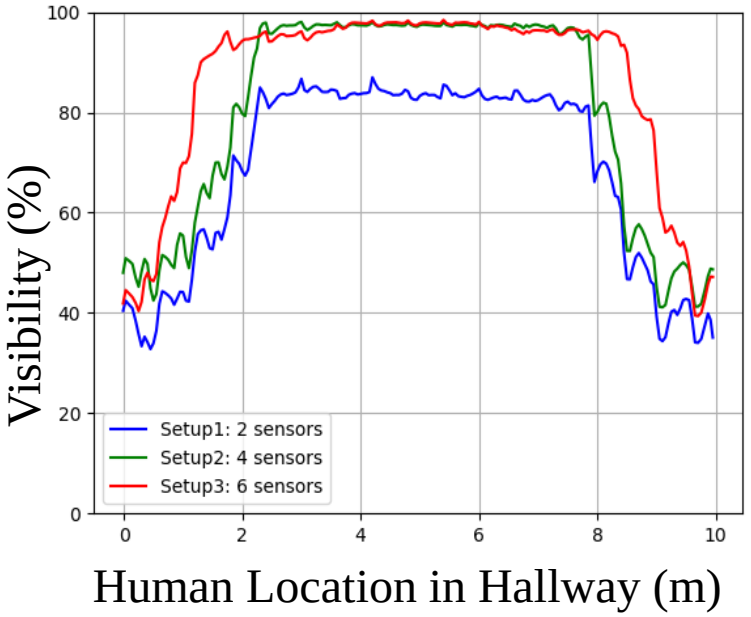


Blender Animation

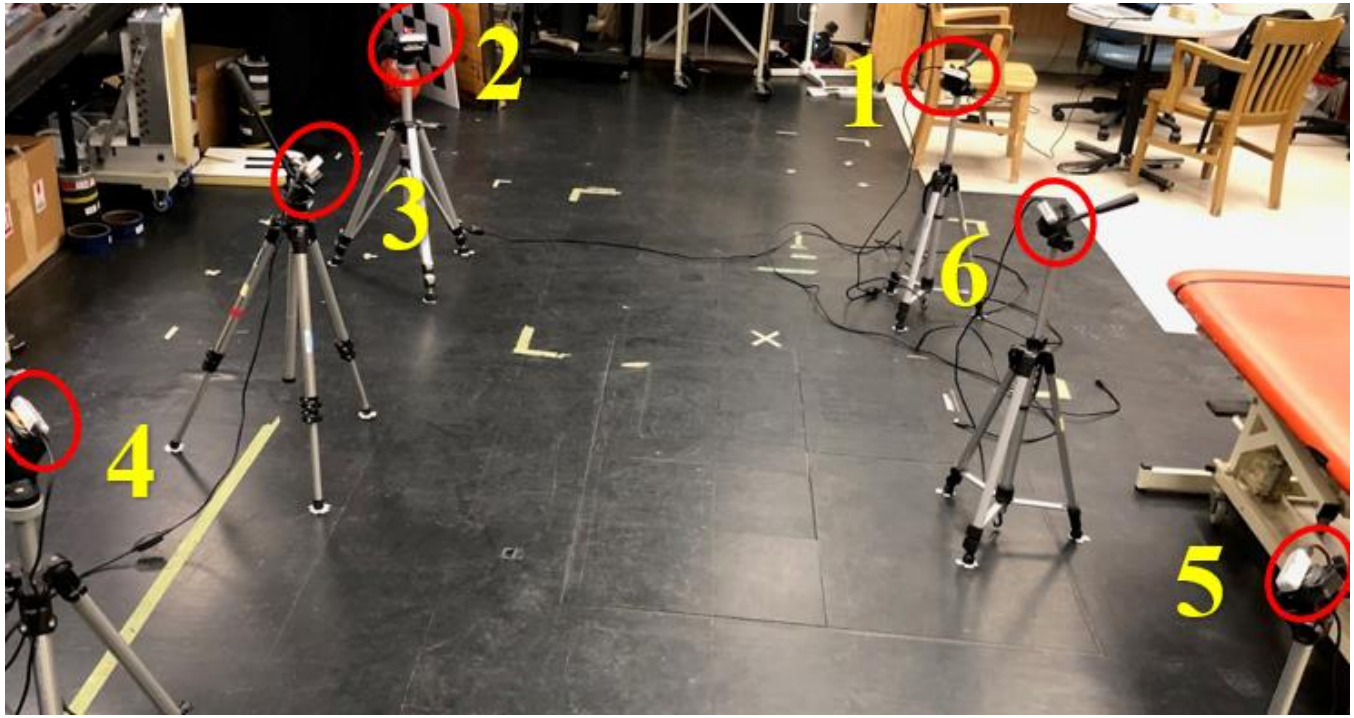


Blender Animation – *Results*

Setup	Capture Hallway Length	Average Foot Visibility (in capture area)
2 Sensors	5.6 m	83.33 %
4 Sensors	5.65 m	97.07 %
6 Sensors	7.15 m	96.18 %

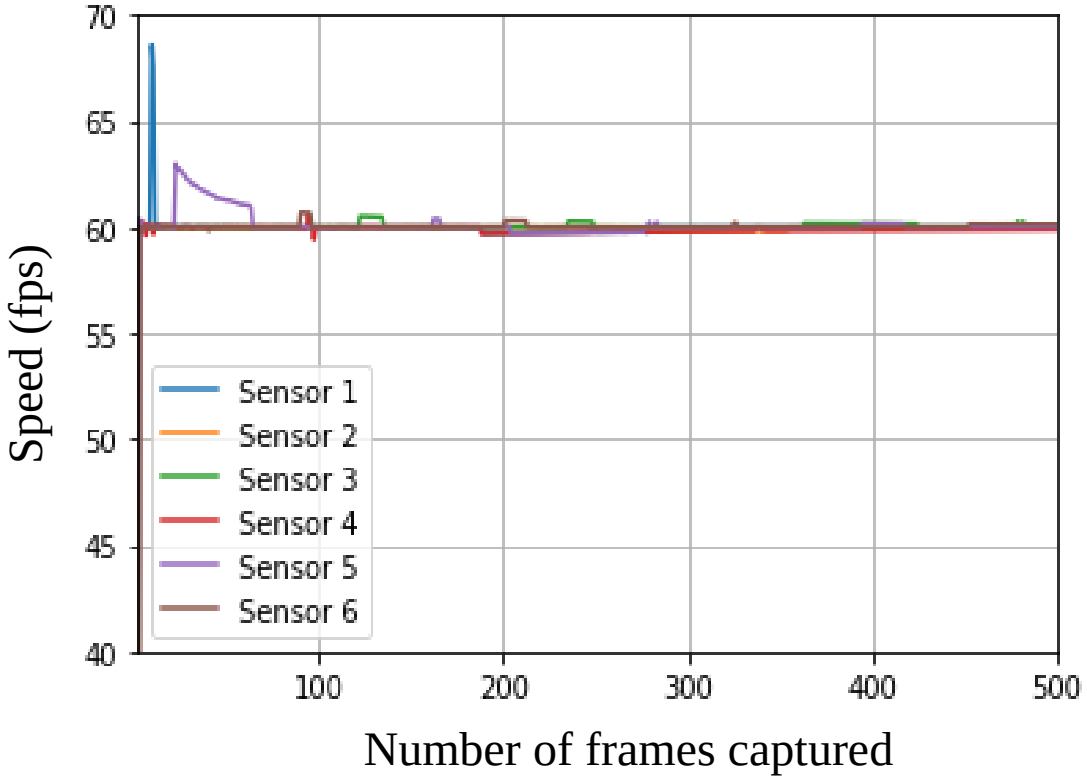


Physical Validation - Setup



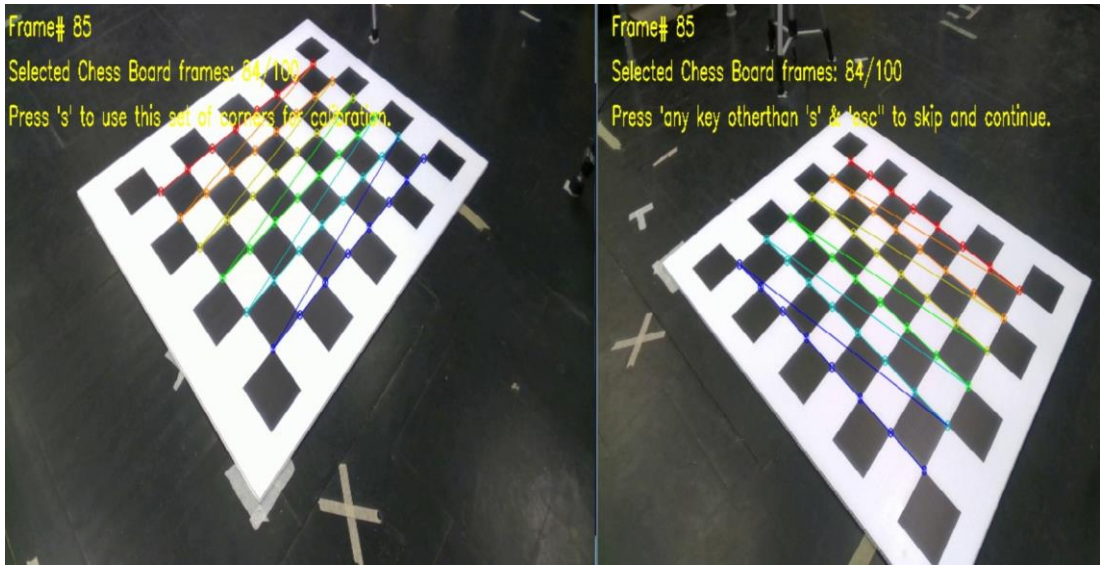
Physical Validation - Temporal Synchronization

- *Software Sync*
- *Ethernet*
- *Frame by Frame*
- *Client - Server*



Physical Validation - Spatial Synchronization

- *RGB Stereo Calibration*
- *Chess board pattern*
- *RGB to Depth co-ordinate Transformation*

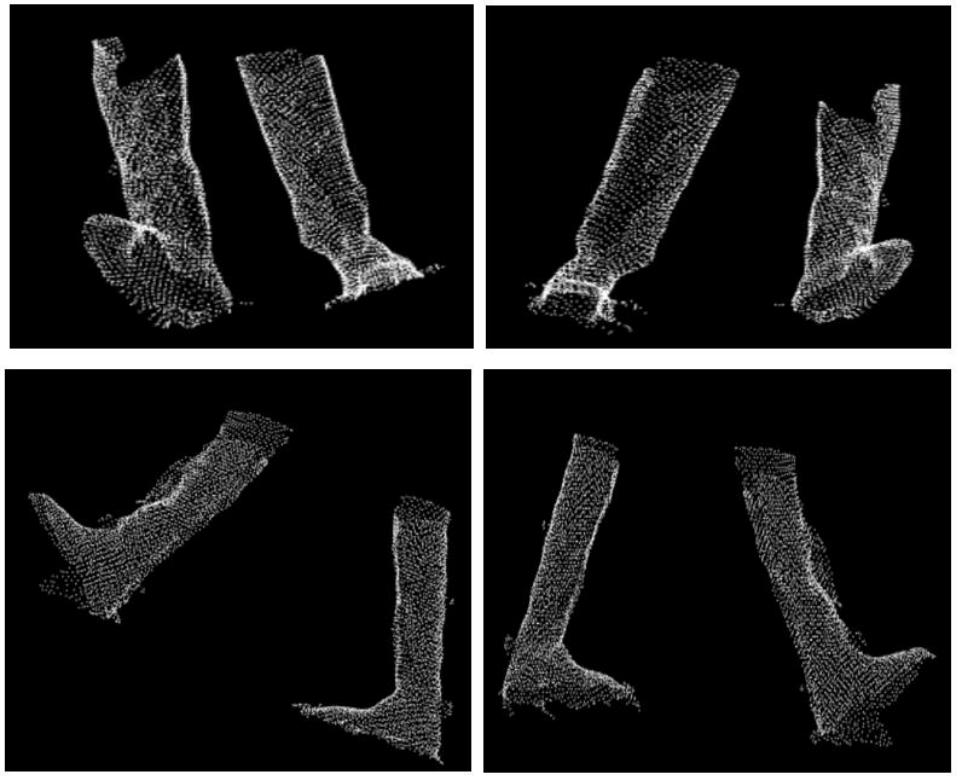


Spatial Synchronization - Results

Validation with a Basketball

Variable	Value
Physical Ball radius	**119.26 mm**
Number of point cloud points	2186.76
Number of sphere inlier points	1945.15
Calculated sphere radius	**111.26 mm**
Exterior standard deviation	6.90 mm
Interior standard deviation	12.24 mm
Root mean square error	**11.83 mm**

A Walking Human's Point Cloud



Conclusion

- A minimum of four sensors placed diagonal to the person are required for capturing foot surface in a hallway scenario.
- Intel RealSense D415 sensors which has no interference are suitable for this application.

Acknowledgement

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CREATE-BEST

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Thank You !
&
Questions ?