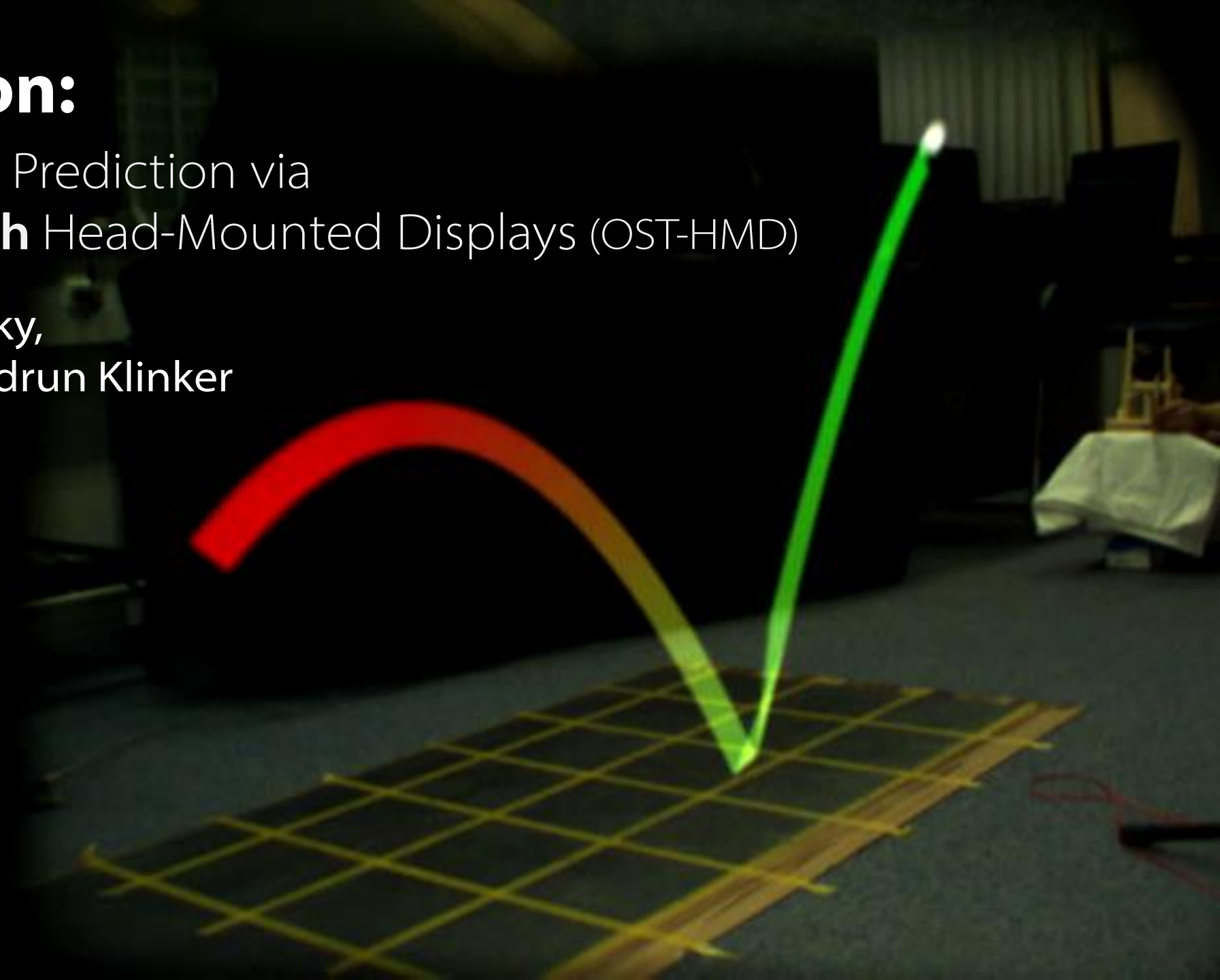


Laplacian Vision:

Augmenting Motion Prediction via
Optical See-Through Head-Mounted Displays (OST-HMD)

Yuta Itoh, Jason Orlosky,
Kiyoshi Kiyokawa, Gudrun Klinker



Augmented Human 2016

Naiive Physics (Hayes et al. 1978):

our untrained perception of basic physical phenomena

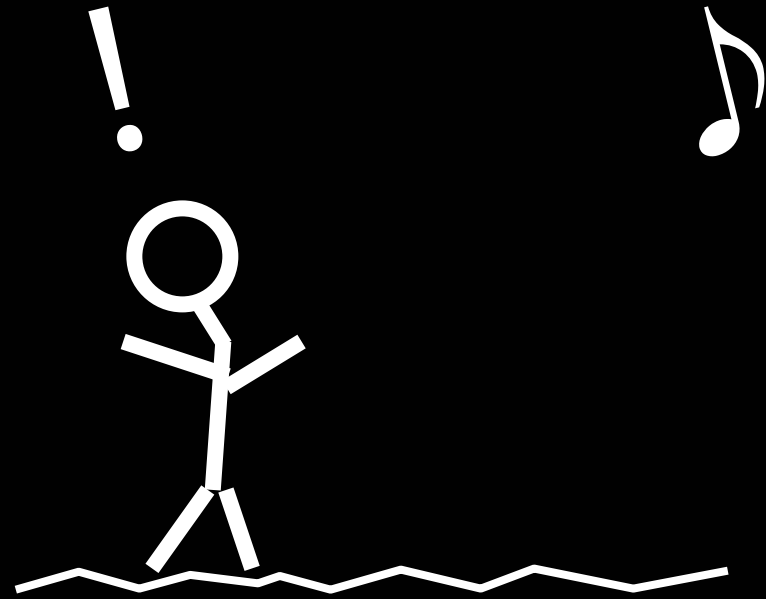


Photo: Steve-65

In daily life...



Photo: AEQWF



Naïve physics is, however, imperfect



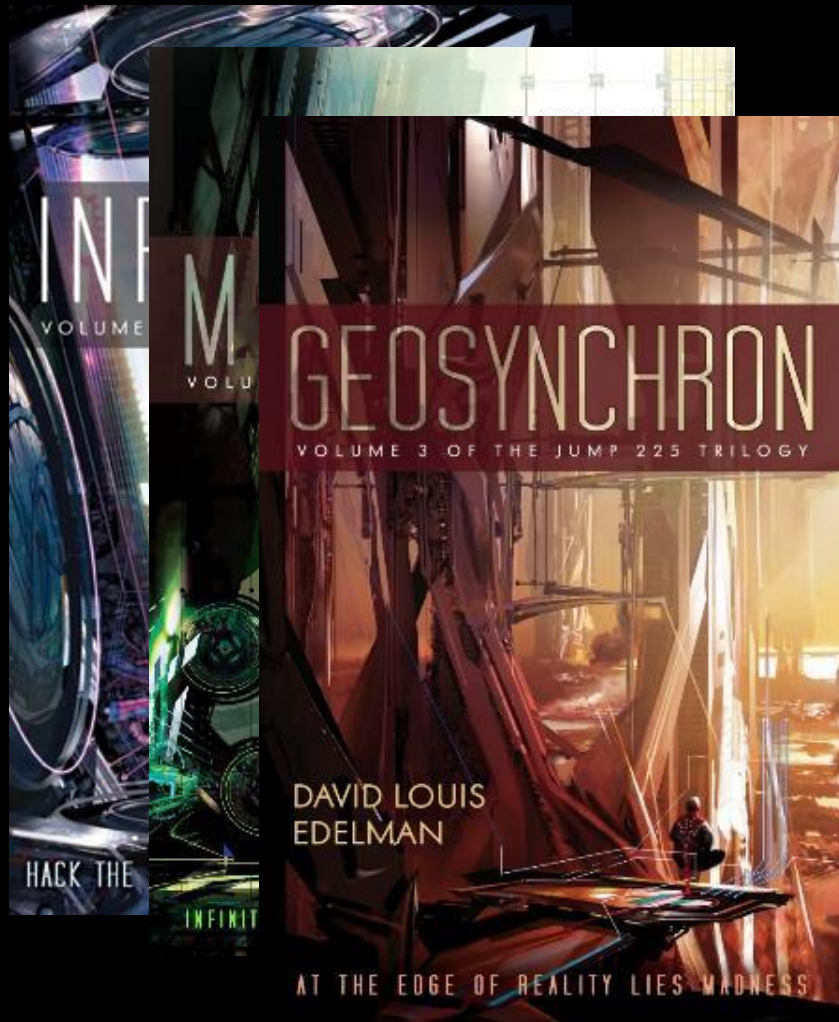
<http://www.failepicfail.com/>

In Science Fiction, a precog sees his short-term future...



Next, Nicholas Cage, TM & © Paramount (2007)

...or brain implants enable you to **calculate** it



Jump 225 Trilogy, David Louis Edelman, 2006-2010



Wizard's brain, Reiichi Saegusa, 2001-present

Laplace's demon: a causal determinism



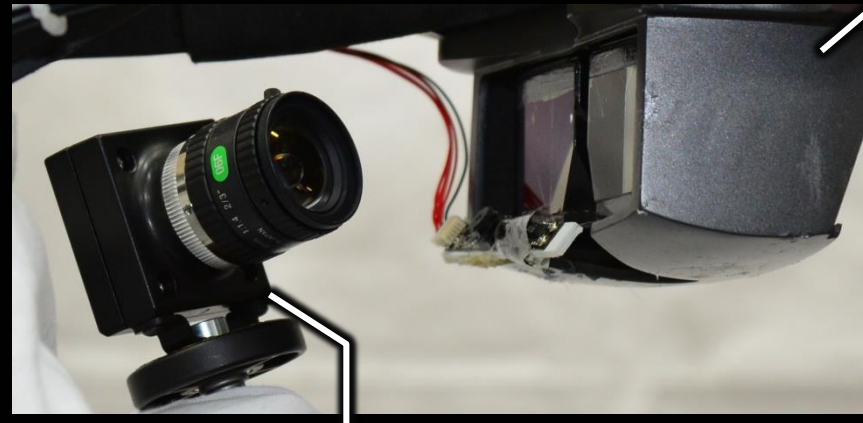
If the Demon knows the precise **location and momentum** of every atom in the universe, their **past and future values** for any given time are entailed; they **can be calculated** from the laws of classical mechanics.

Laplacian Vision: a vision augmentation system to assist motion prediction.

Optical See-Through HMD

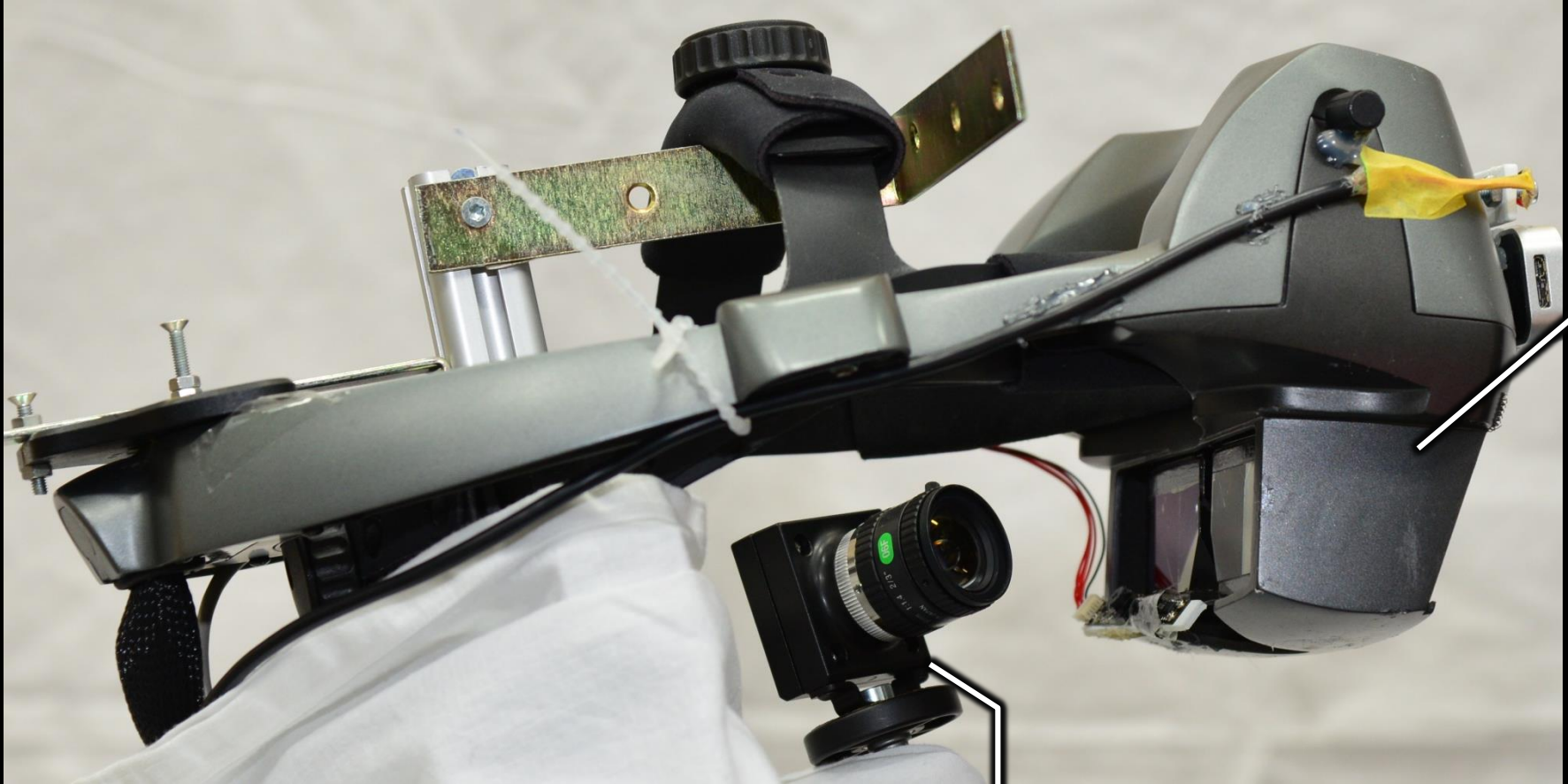


Shot directly through the system



User-view camera

OST-HMD



User-view camera

Related work: projection mapping

Projector



Koike & Yamaguchi,
AH'15

Custom DLP projector



Charette et al., ICCP'12

Saccade Mirror



Saccade Mirror

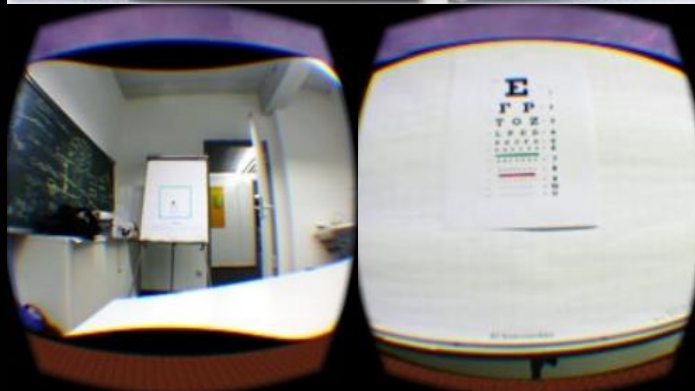
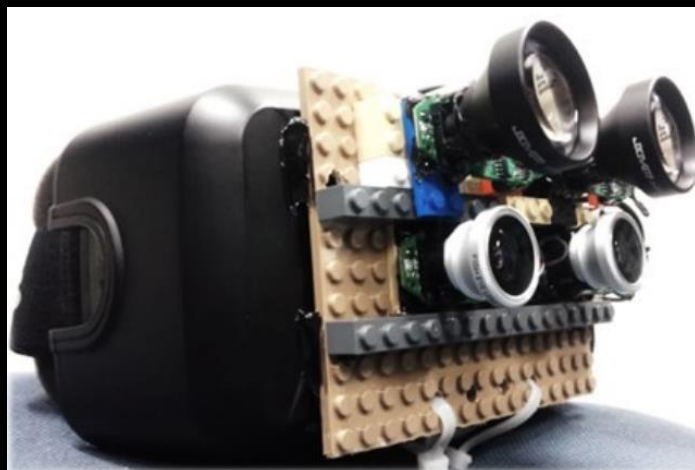
Dynamorph Lens



Okumura et al., ICME'12

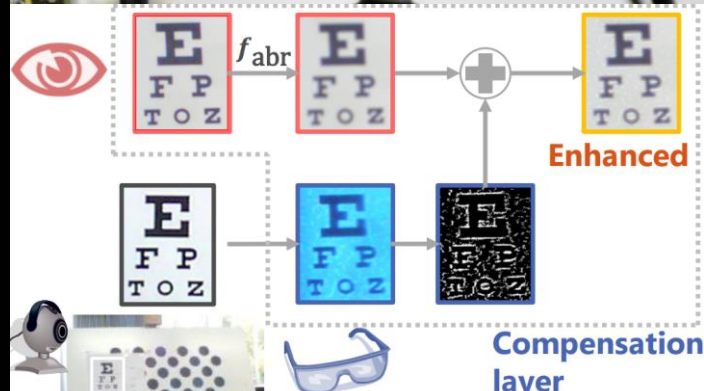
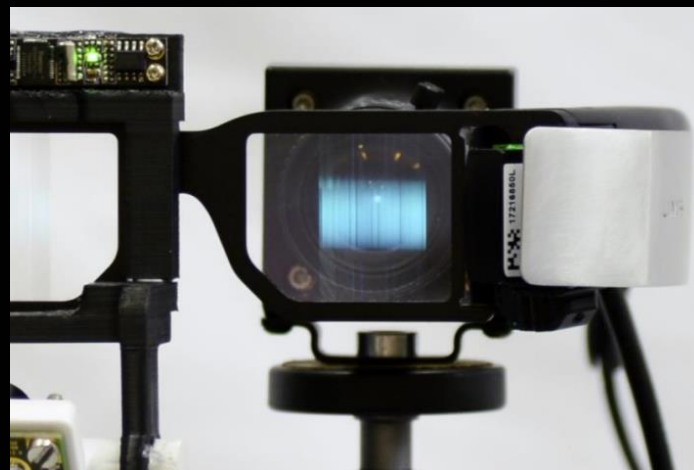
Related work: human vision enhancement

Field of view



Orlosky et al. TVCG'15

Eyesight



Itoh & Klinker AH'15

X-ray vision

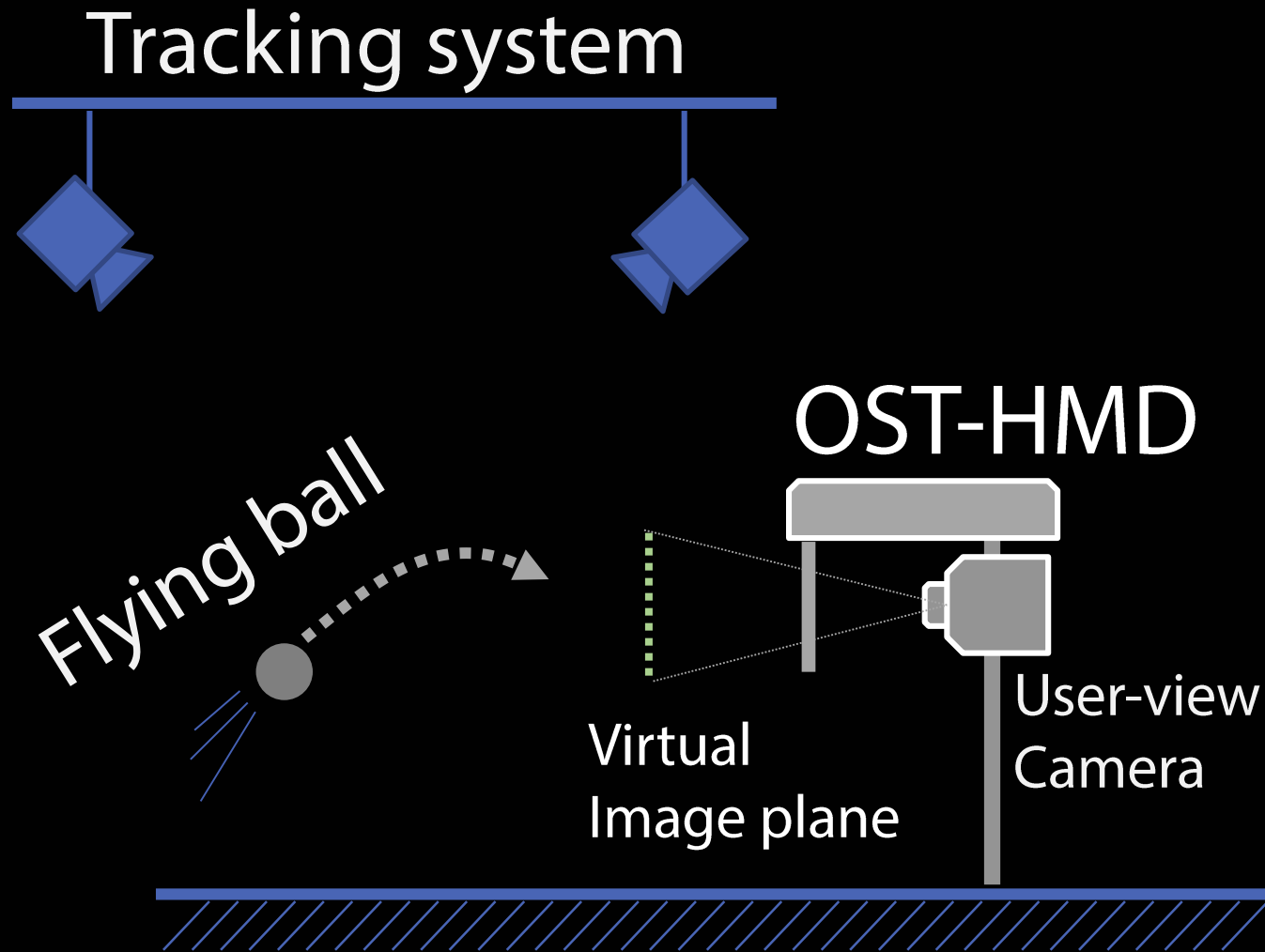


Avey et al. VR'09

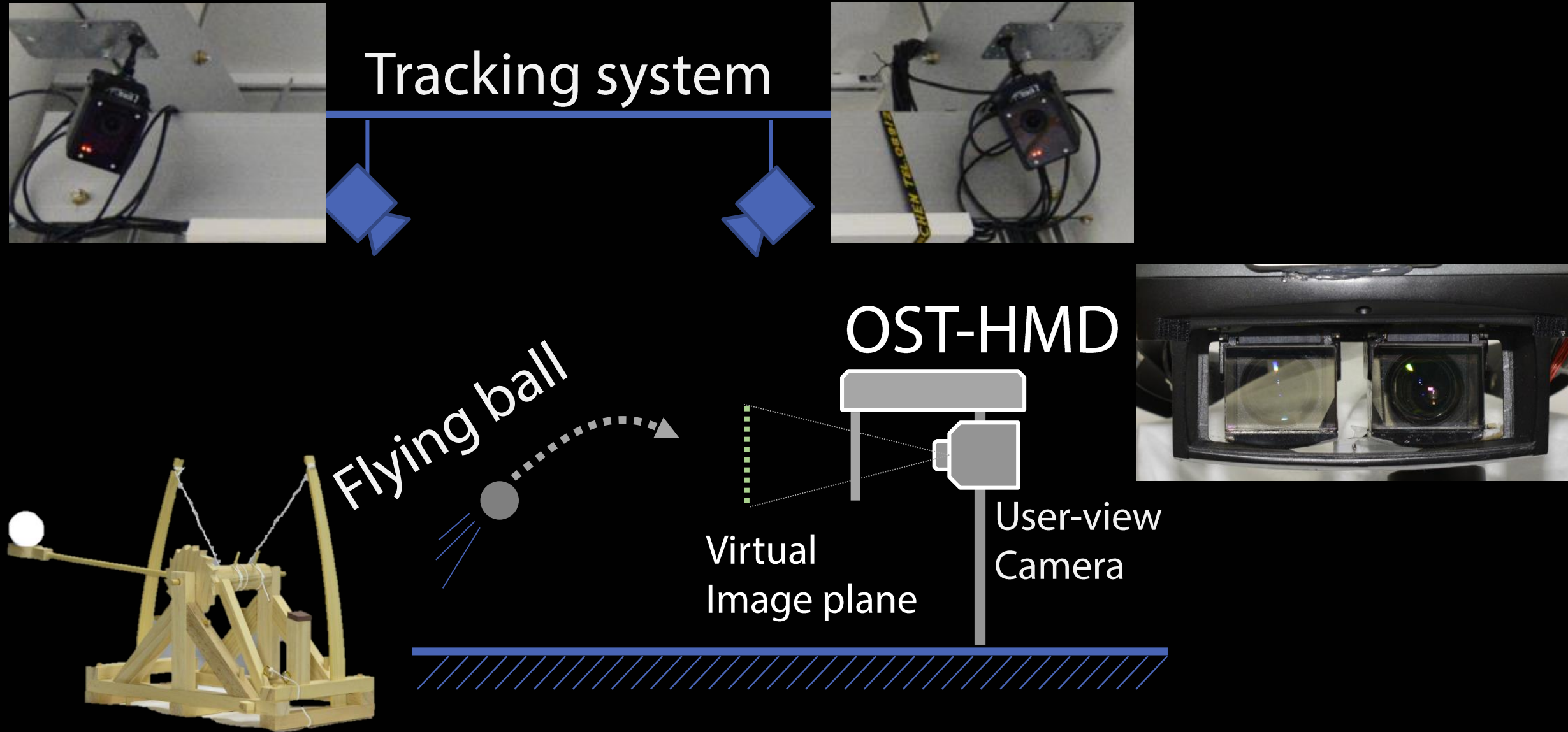
Related work: "Aftermath" (AR + physics prediction)



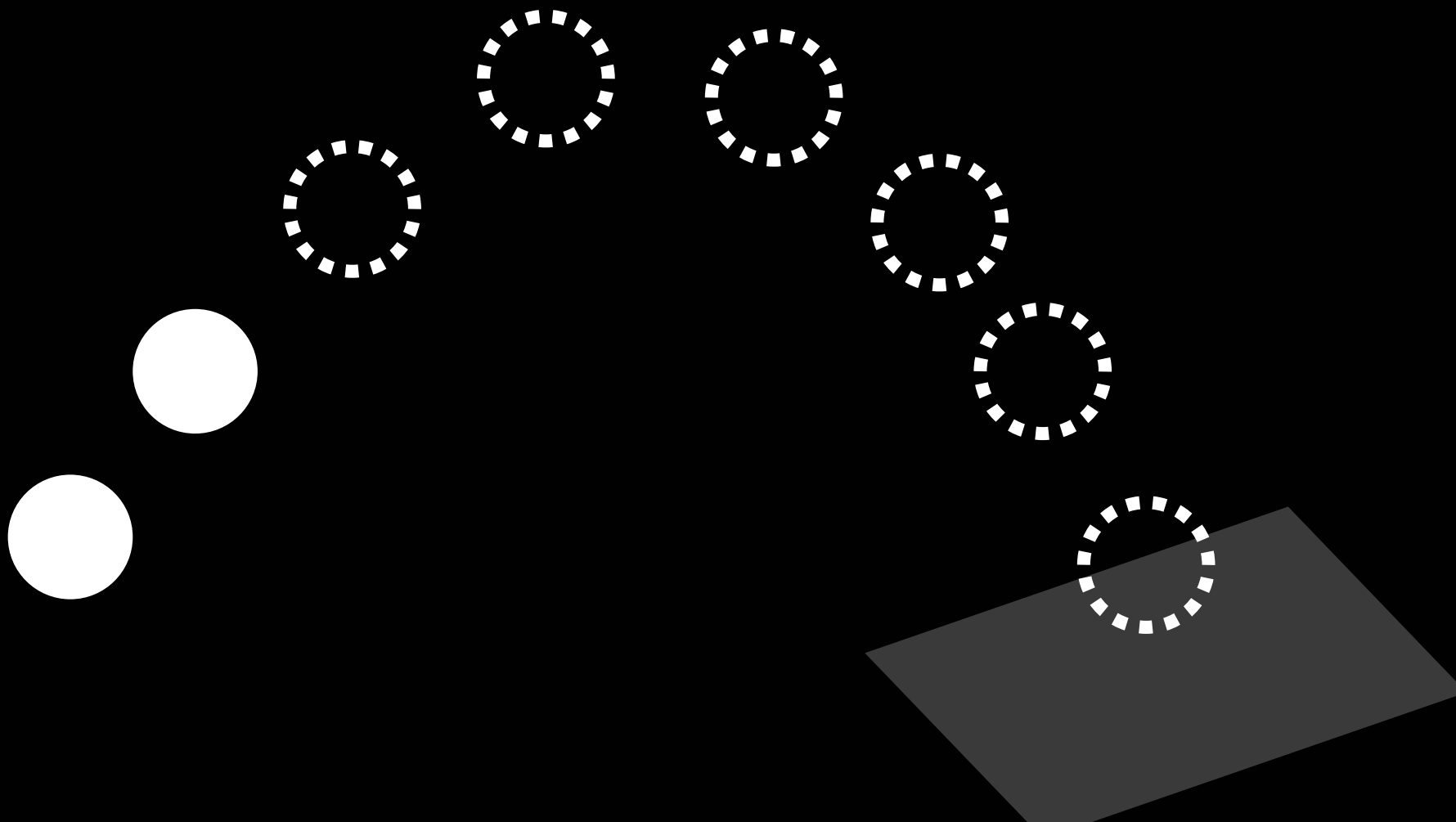
A proof-of-concept system



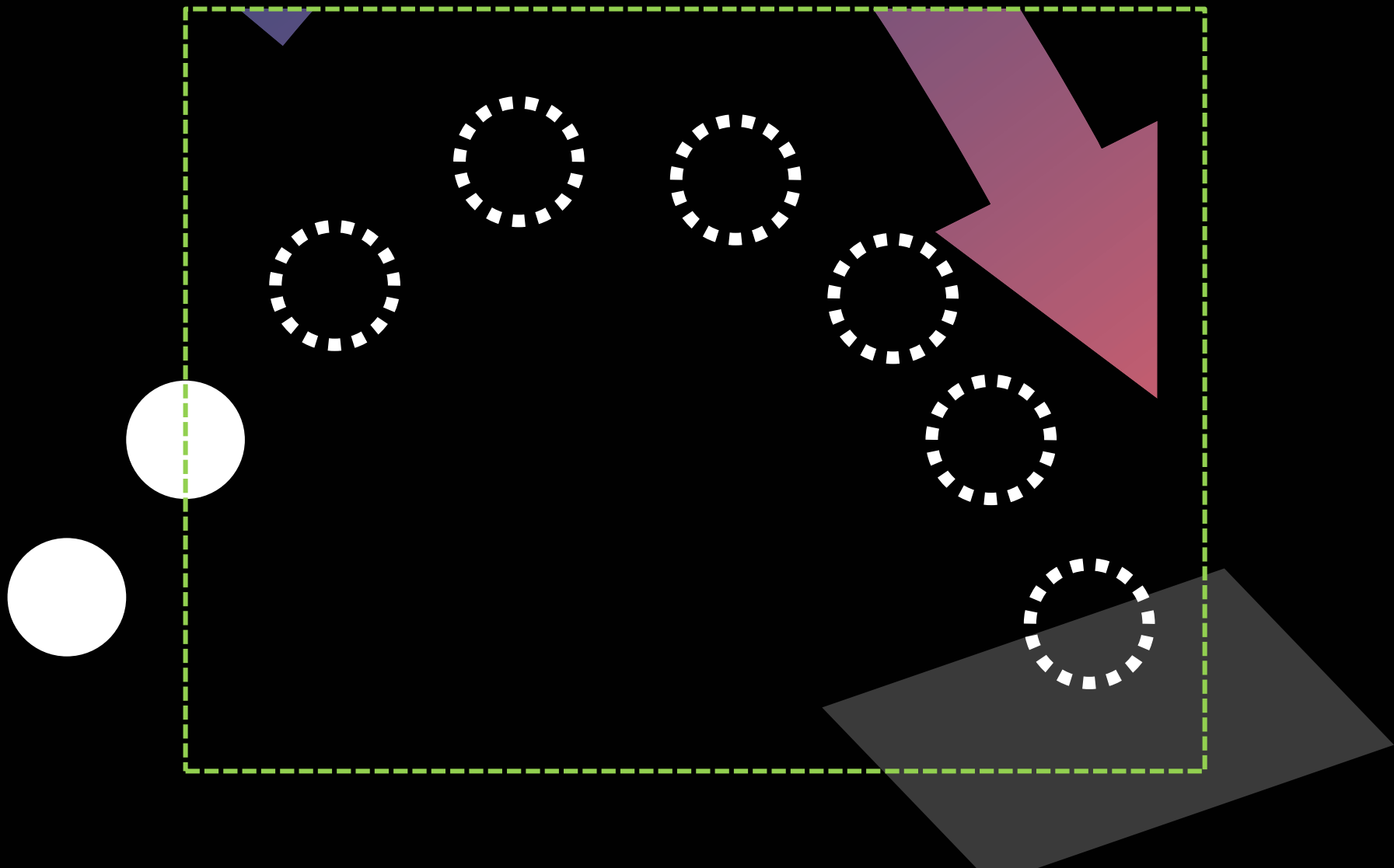
A proof-of-concept system



Future path estimation of a flying ball in **real time**



Calibrated HMD rendering matrix to the viewpoint



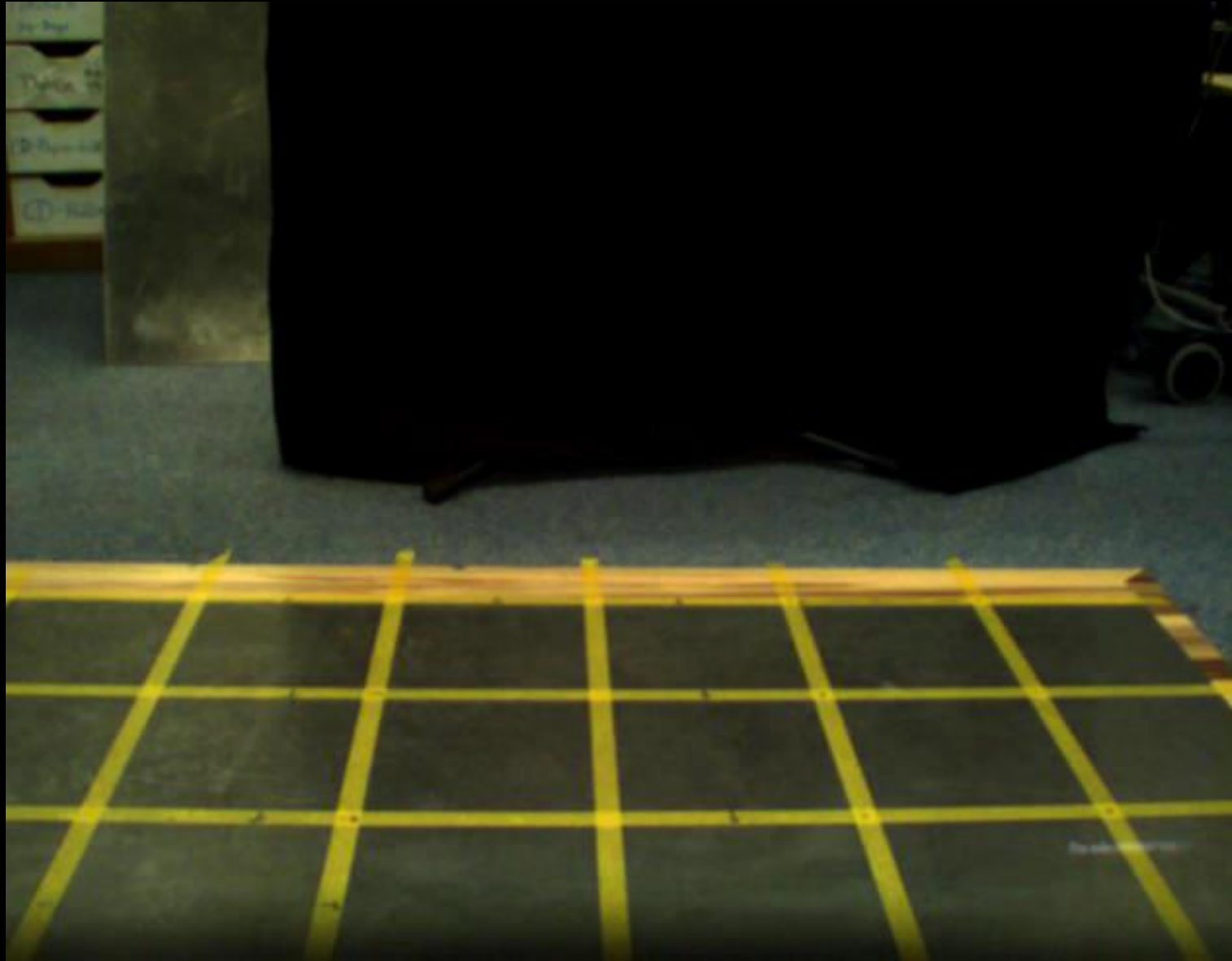
Example 1



Example 2



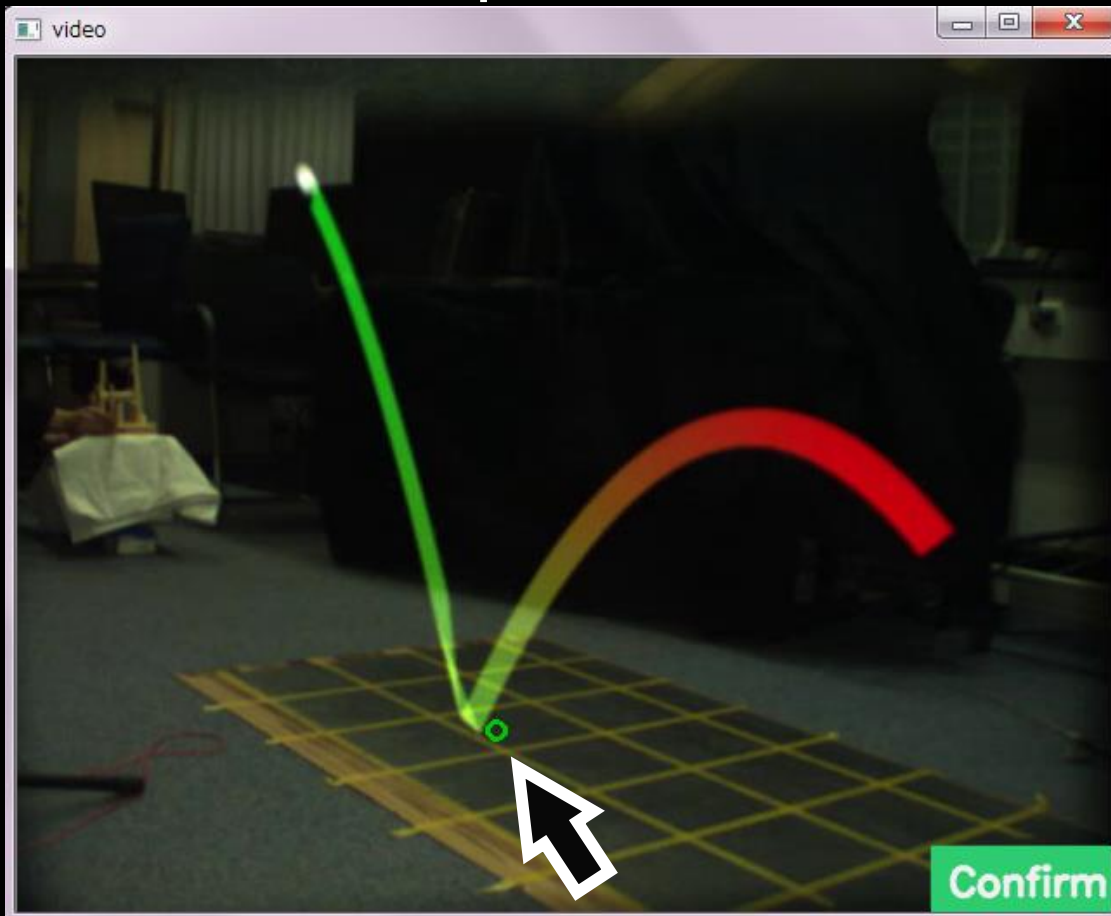
Example 3



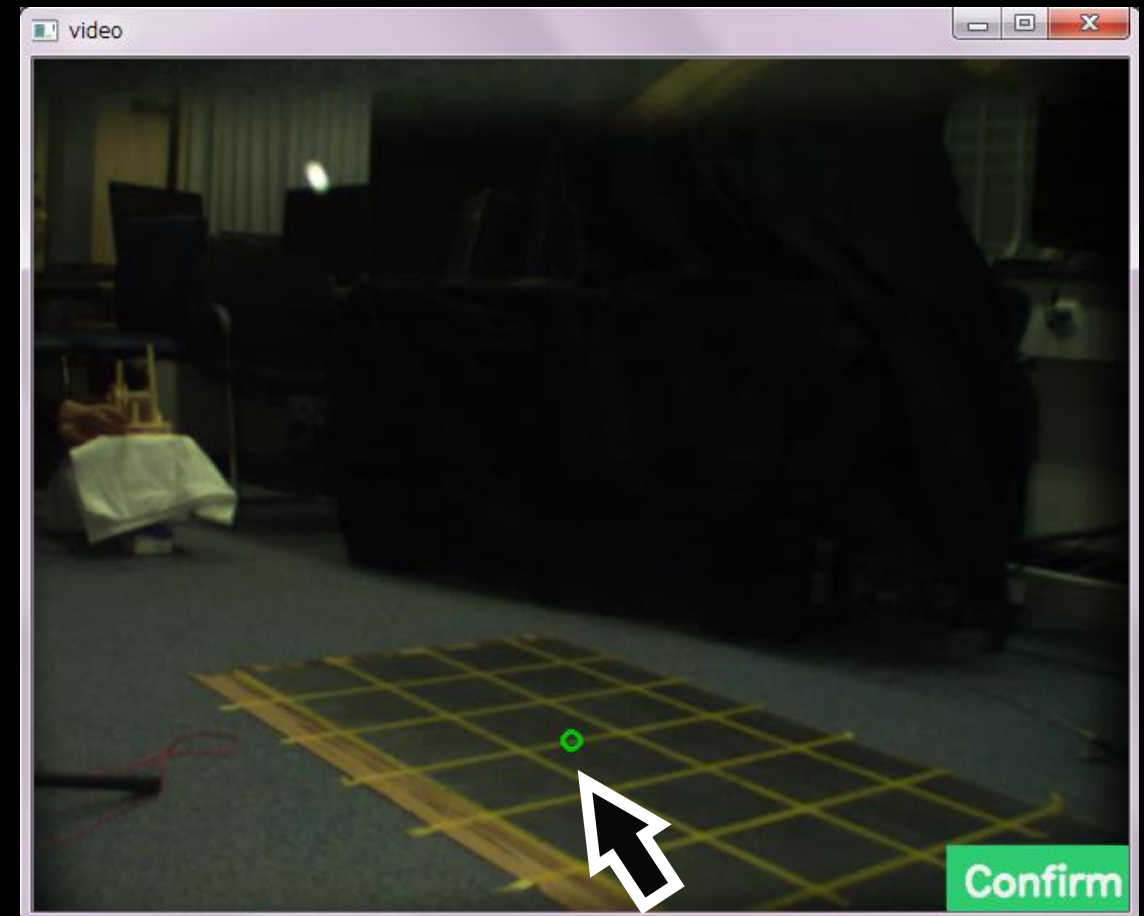
User study: a fall-point **prediction game**

29 subjects * 5 launches * **with/without**

With Laplacian vision

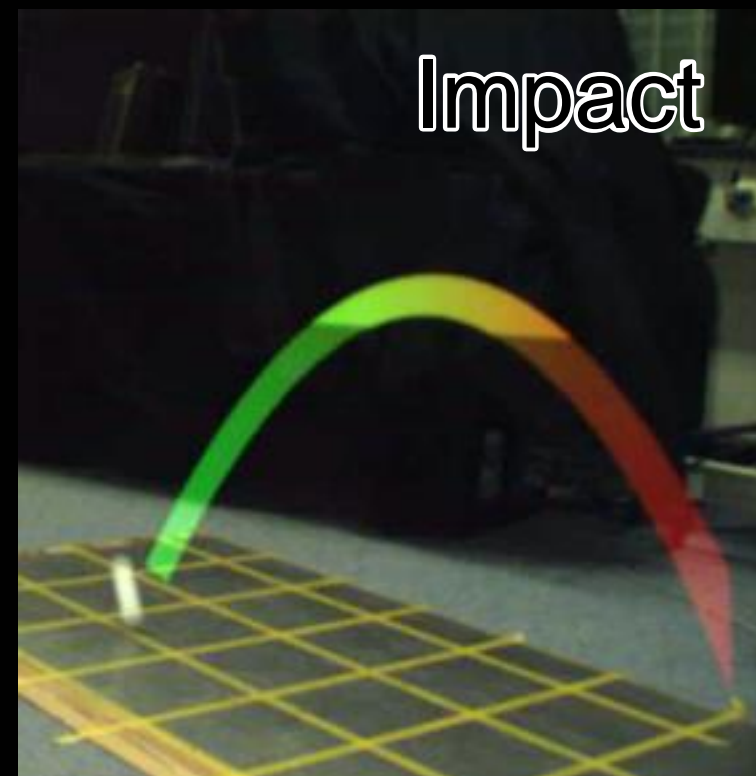
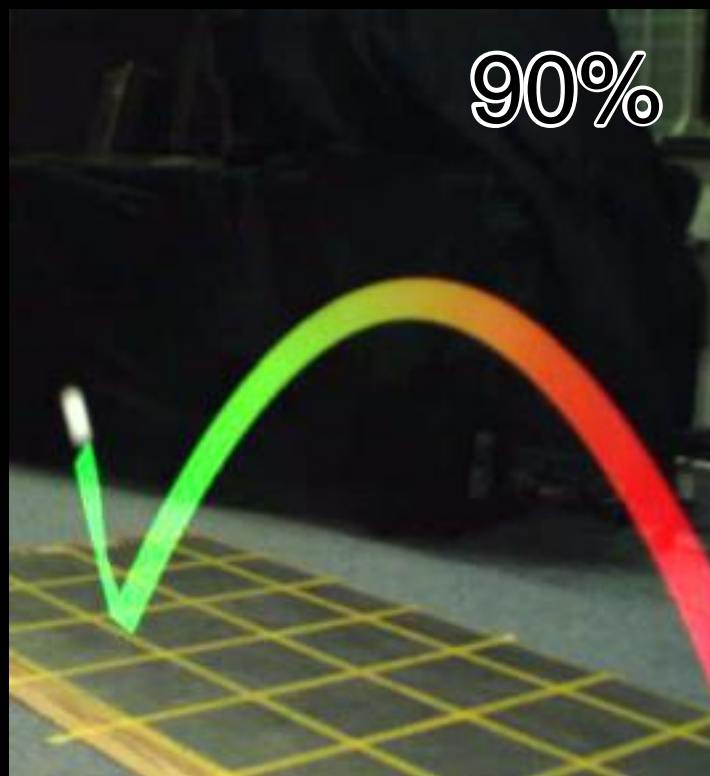
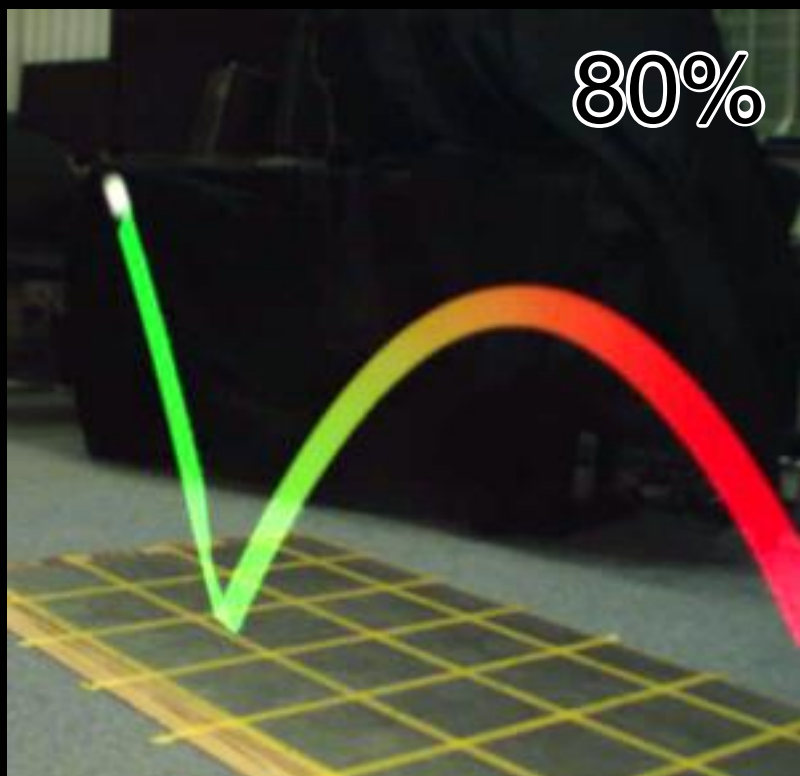


Without (i.e. the naïve vision)



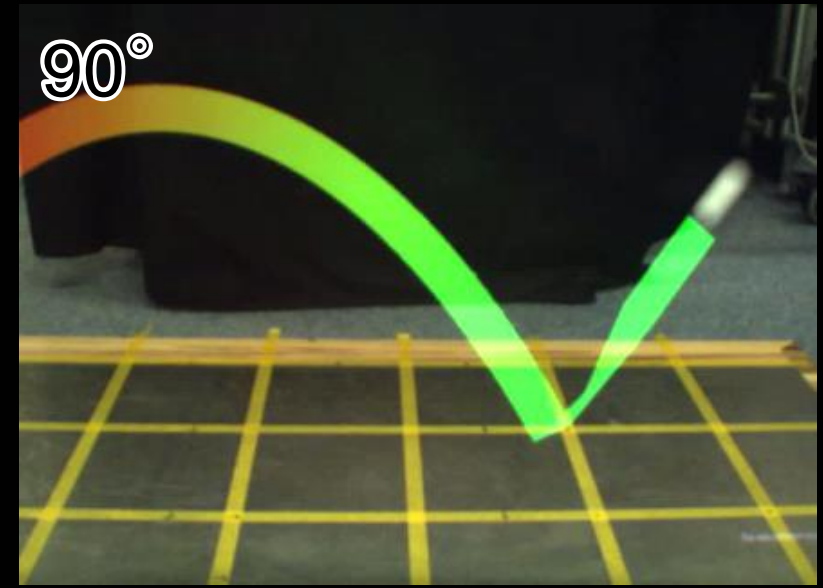
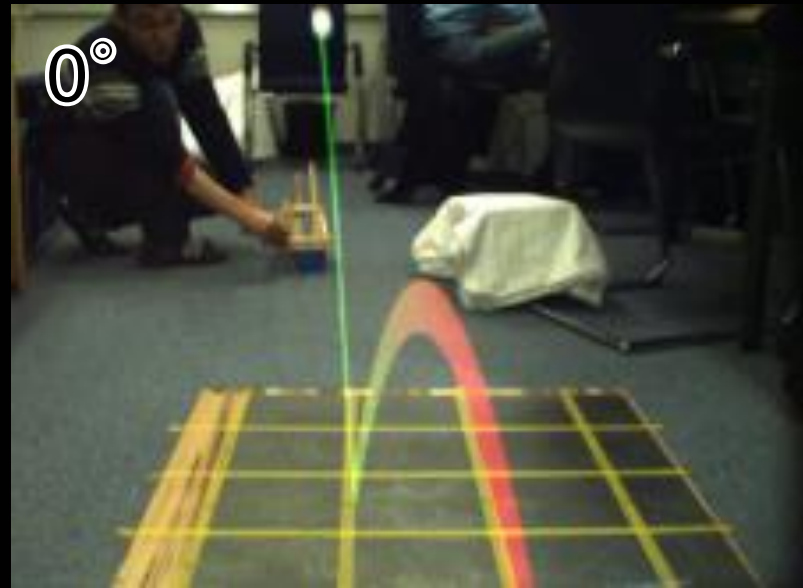
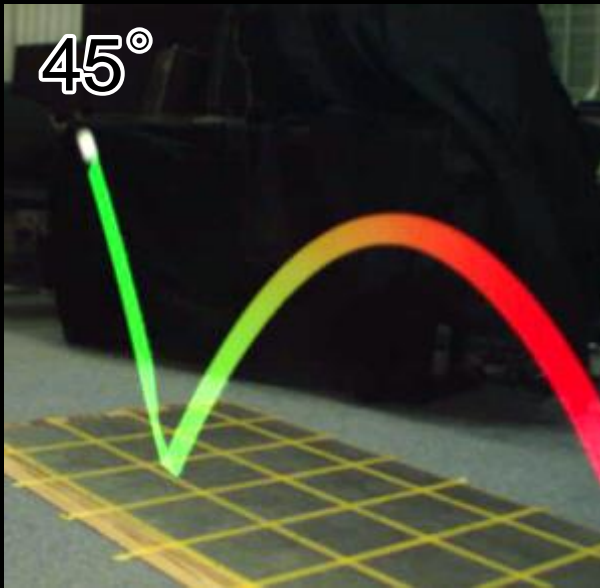
Video **Length** conditions

29 subjects * 5 launches * with/without * 3 lengths



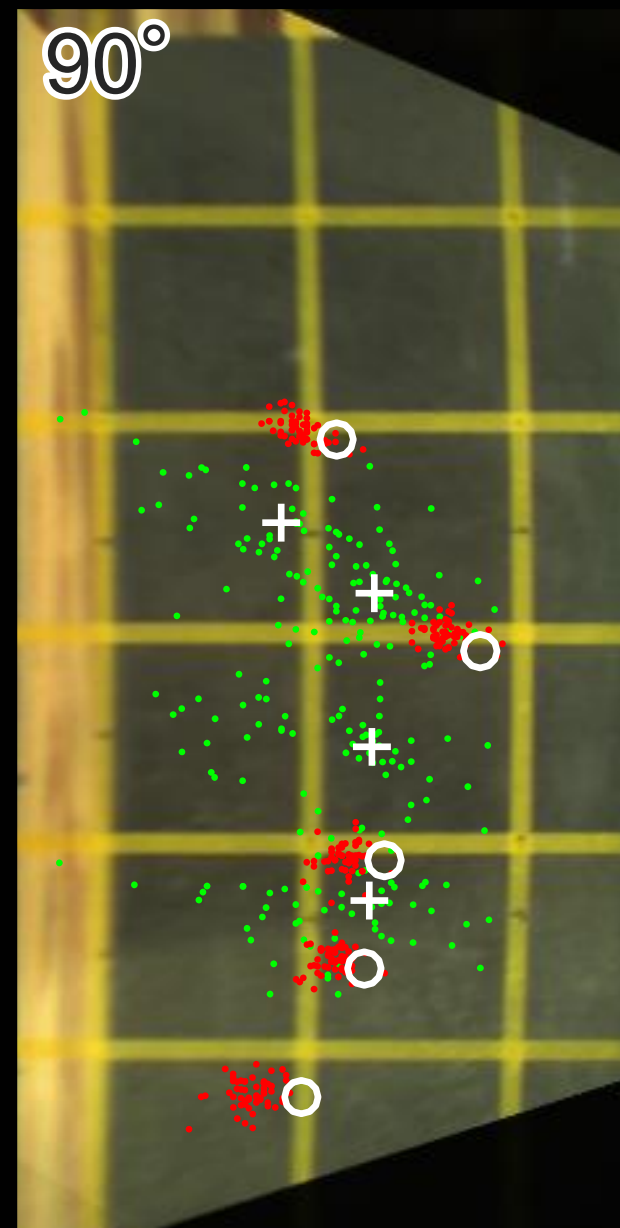
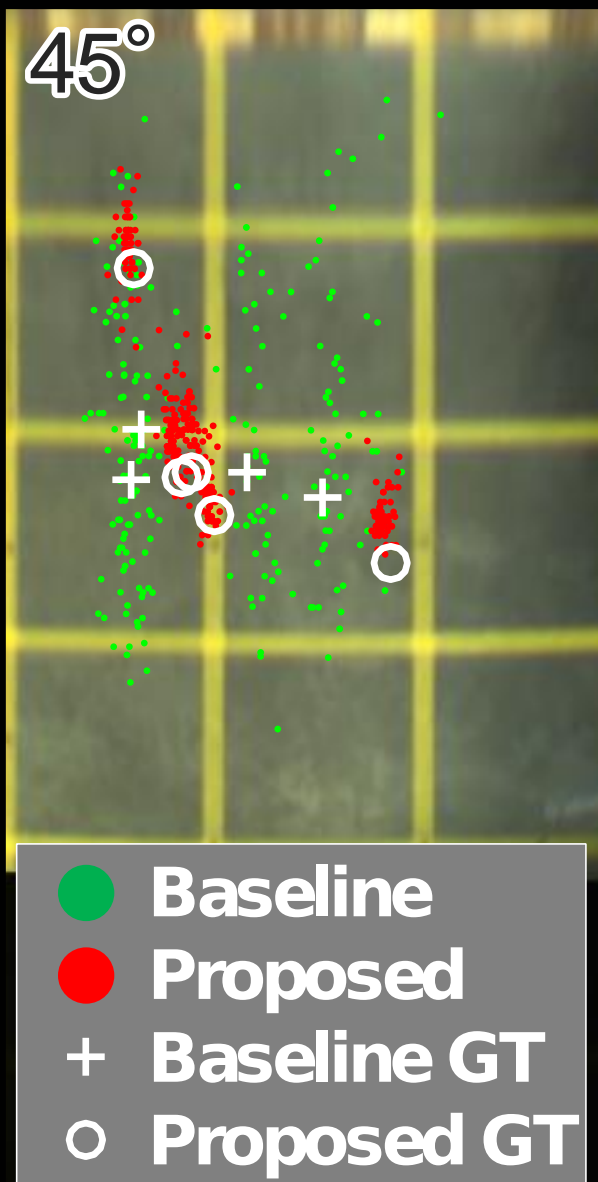
View **Angle** conditions

29 subjects * 5 launches * with/without * 3 lengths * 3 angles



Result: 3x accuracy improvement

Bird's-eye view



View Angle

Error [cm]

45°

0°

90°

80%

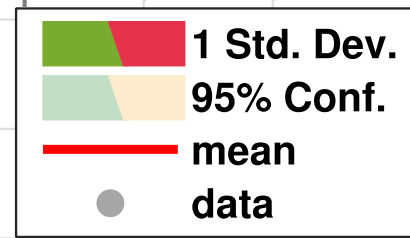
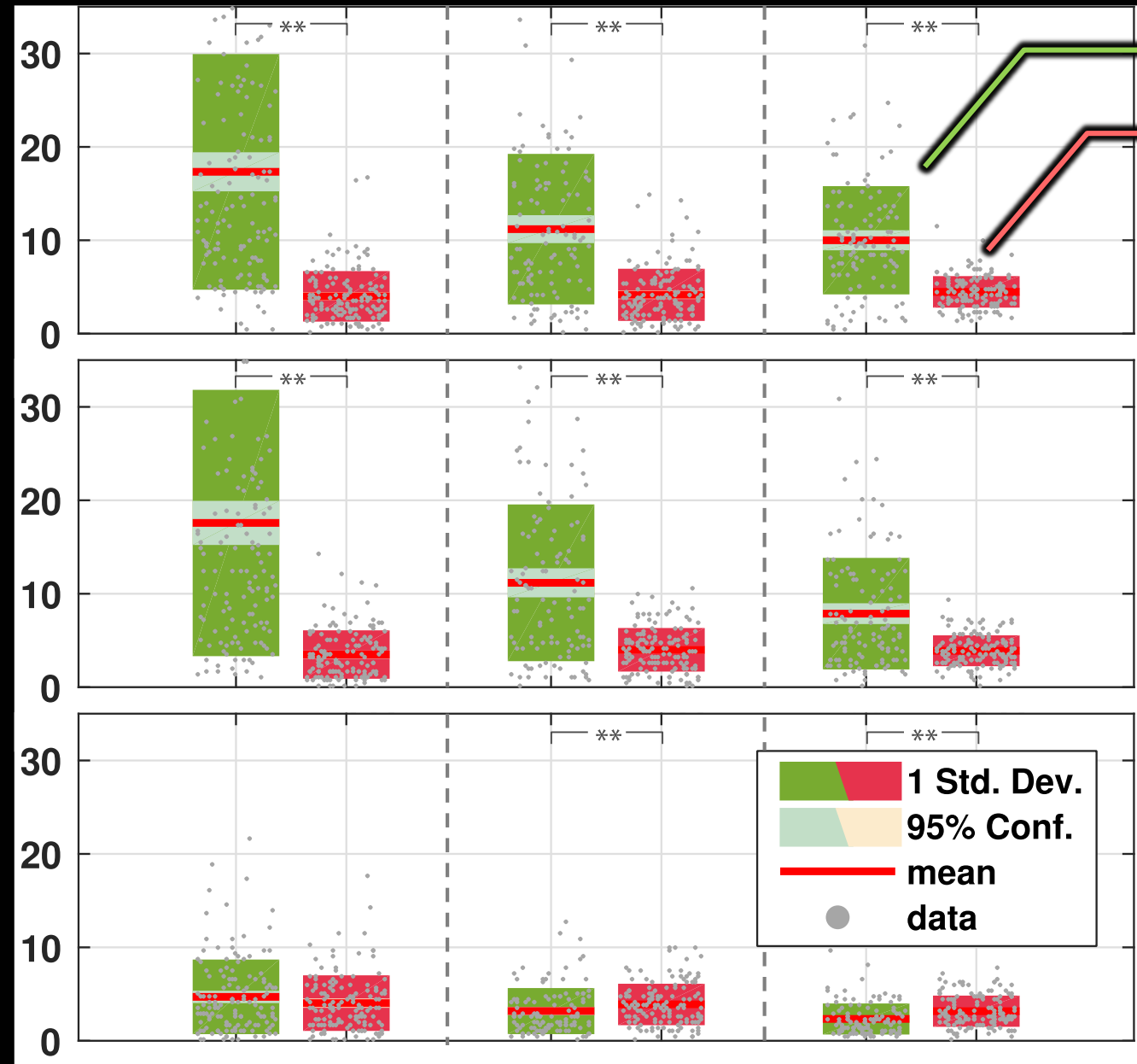
90%

100%

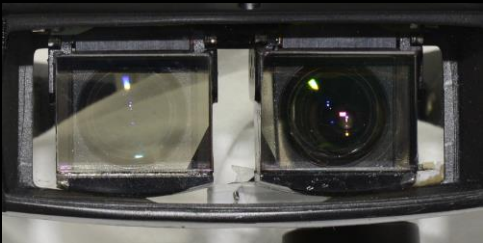
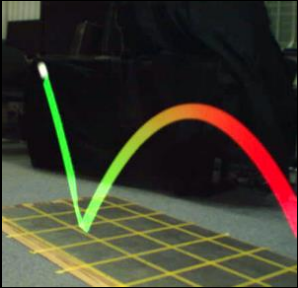
Baseline

Proposed

Video Length



Summary



- Assisting our **naïve physics** skill
- **Optical See-Through** HMDs with a real-time AR rendering
- Simulating the **physical behavior** of the user's environment



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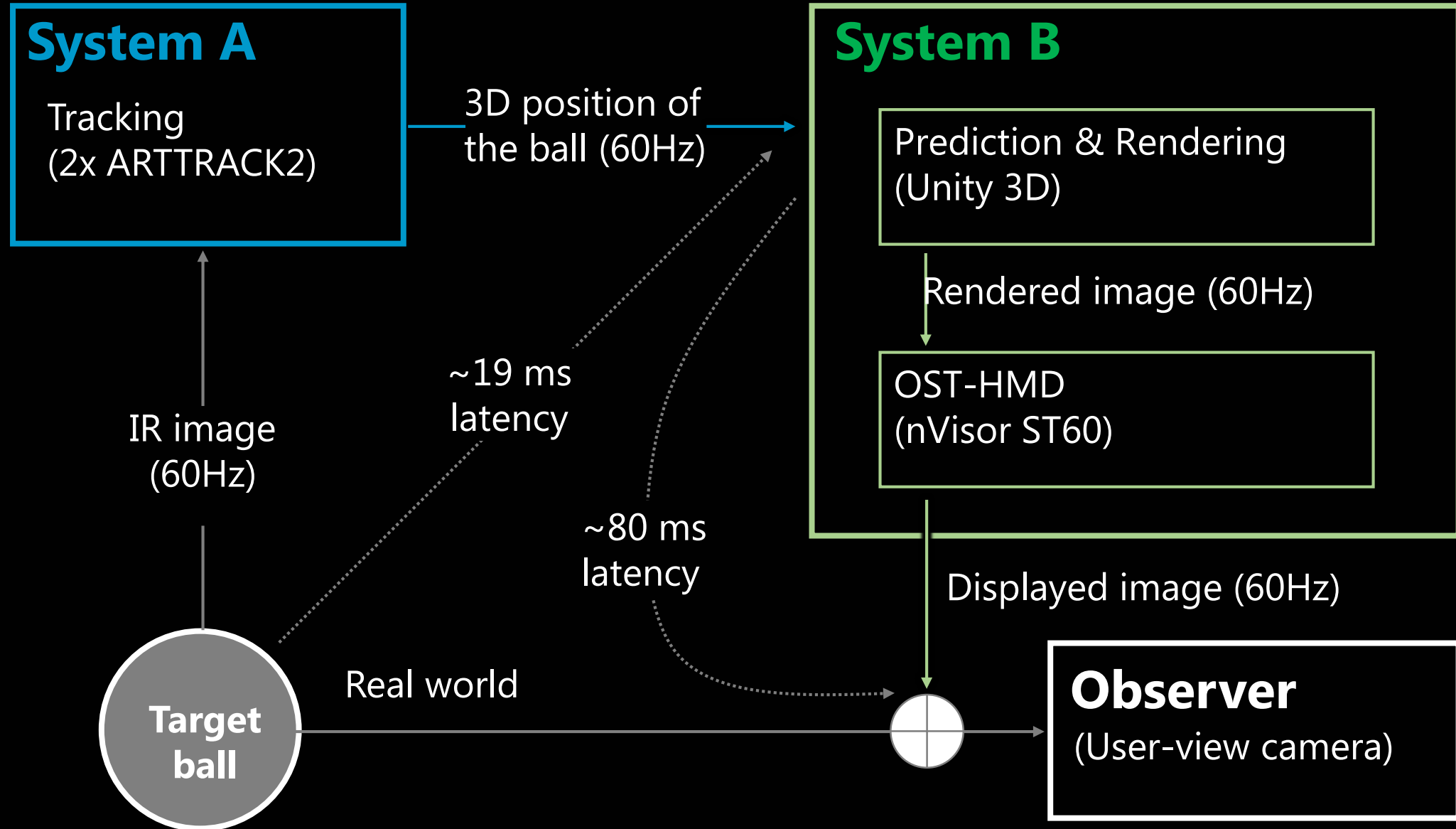
Human x OST-HMD x Physics

Augmented Human 2016



Appendix

Latency diagram

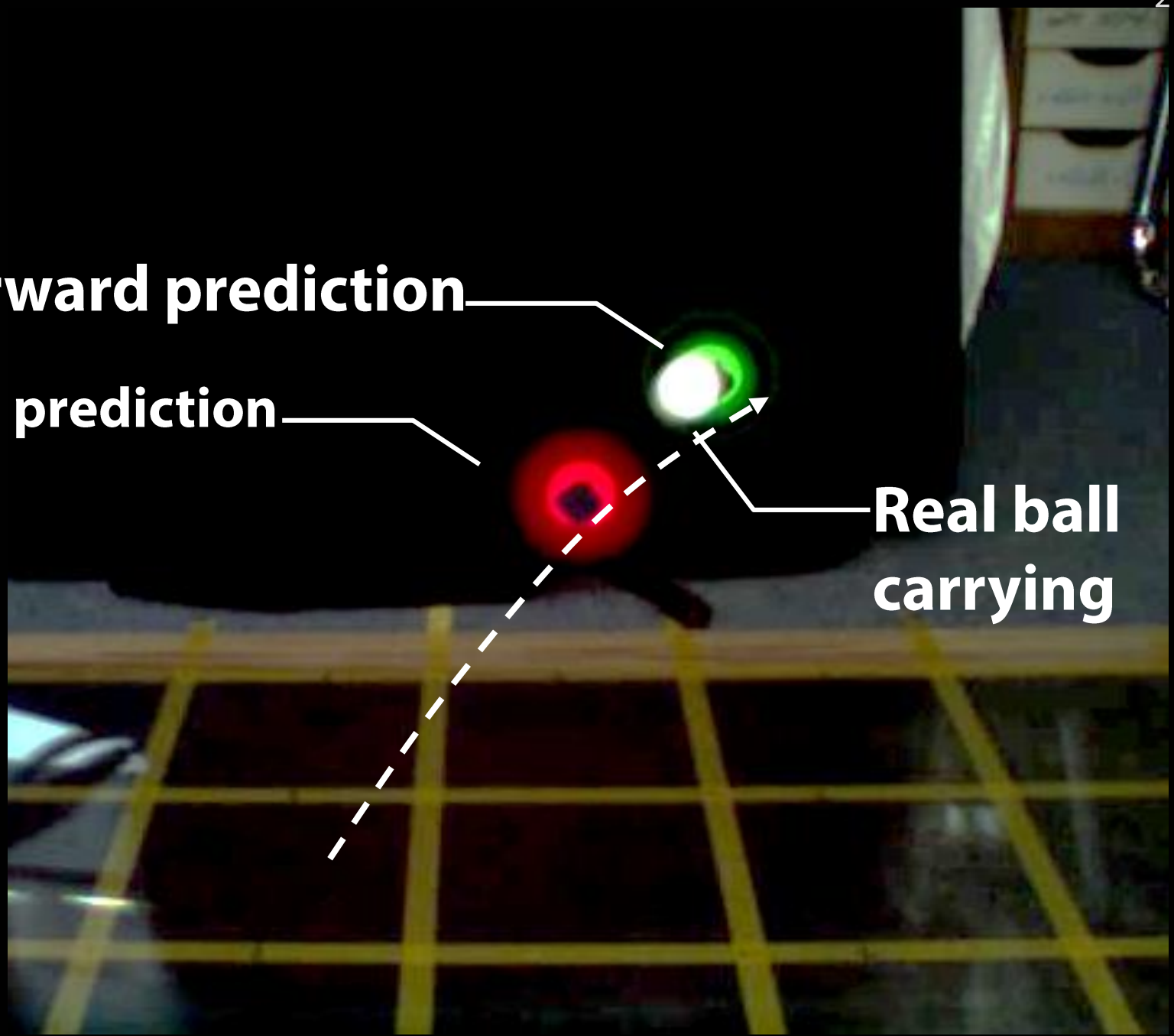


Forward prediction

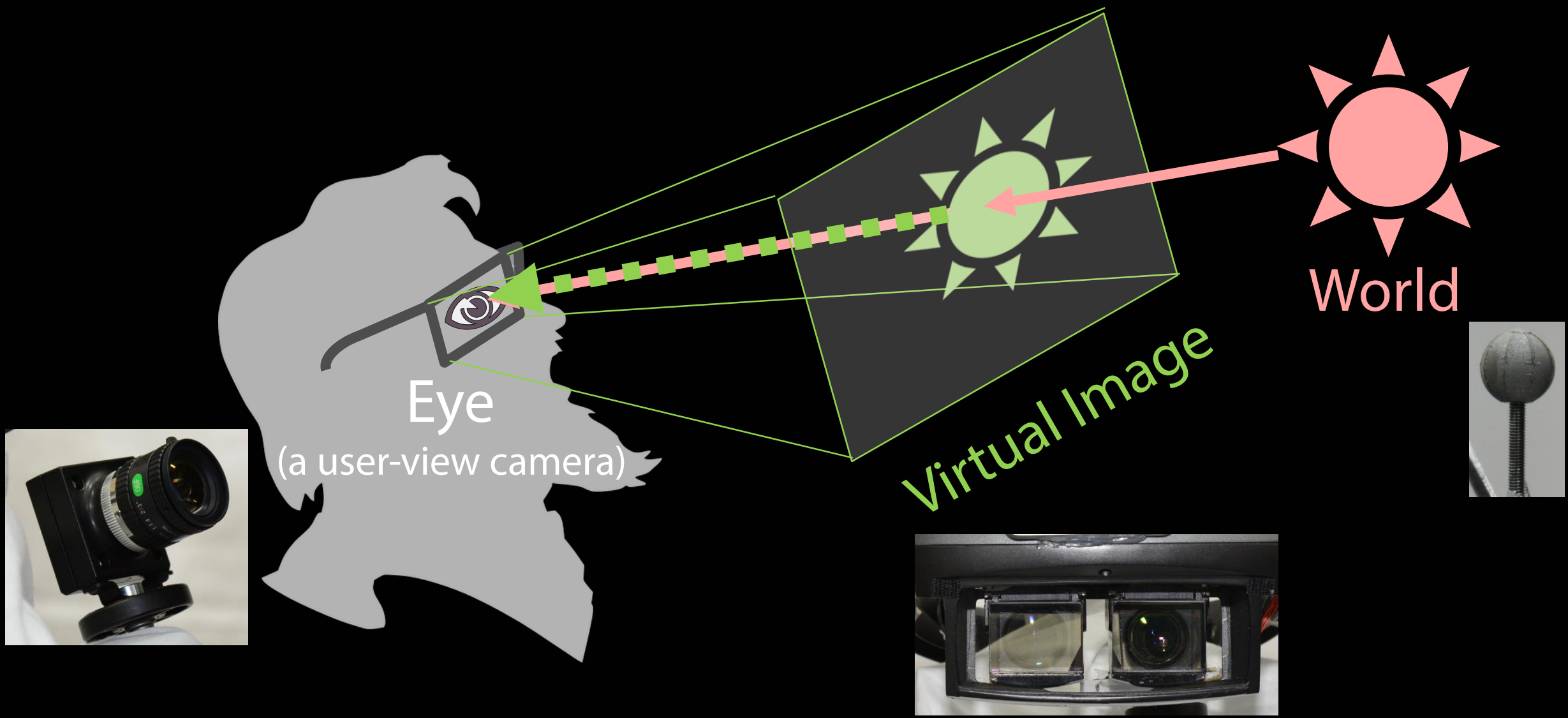
100 ms forward prediction

No prediction

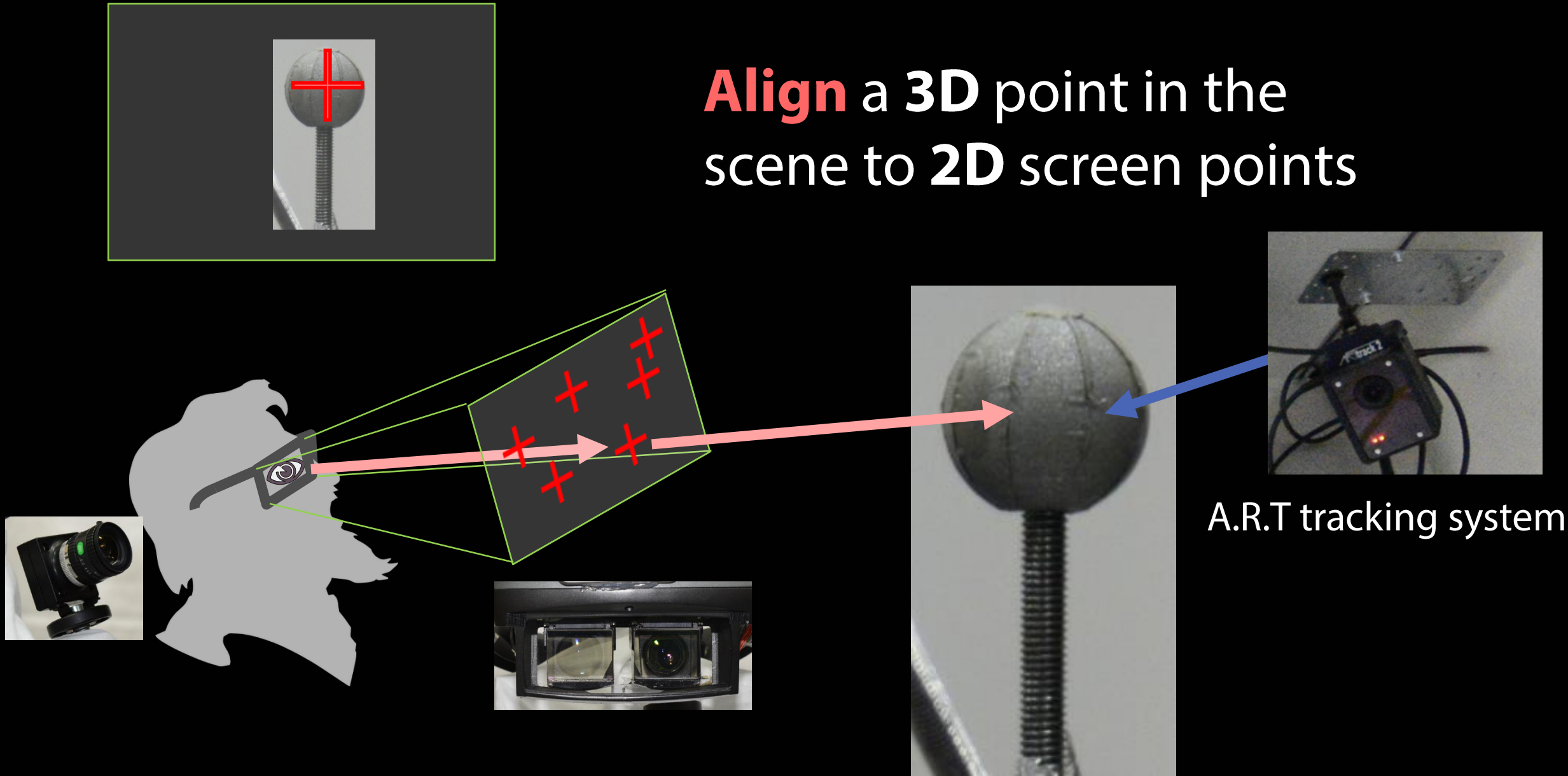
Real ball carrying



HMD Display Calibration



Single Point Active Alignment Method (SPAAM) [Tuceryan '00] [Genc '02]



Hardware

