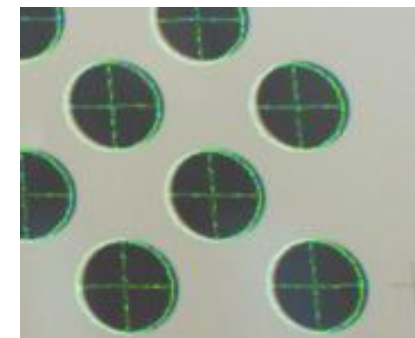
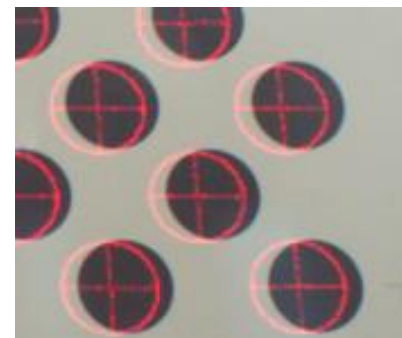


Simultaneous Direct and Augmented View Distortion Calibration of Optical See-Through Head-Mounted Displays

Yuta Itoh and Gudrun Klinker
IEEE ISMAR 2015, 30th Sep. 2015



Head-Mounted Displays (HMDs)

Non Optical See-Through



Optical See-Through (OST-HMD)



Toward consistent AR



From **TRICKSTAR's Ironman 3 VFX trailer**

DIRECTOR: Shane Black, PRODUCERS: Victoria Alonso, Mitchell Bell, Stephen Broussard, Lous D'Esposito, Jon Favreau, Kevin Feige, Alan Fine, Stan Lee, Dan Mintz, Charles Newirth, Lars P. Winther, STUDIO: Marvel Studios, Walt Disney Studios

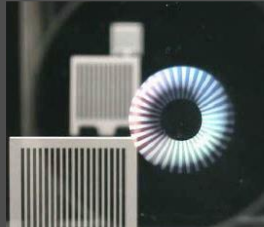
Consistent AR with **OST**-HMDs

Visual

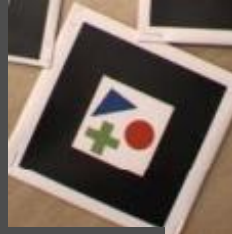


D) Final result

[Kiyokawa '01]

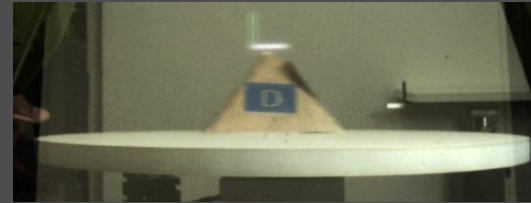


[Liu '08]

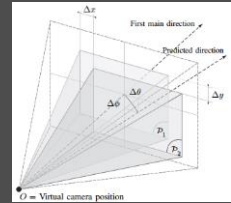


[Lee '09]

Temporal

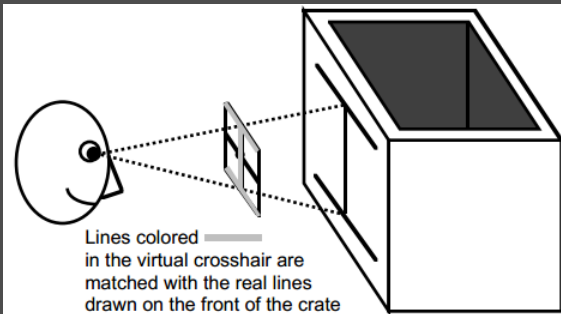


[Zheng '14]

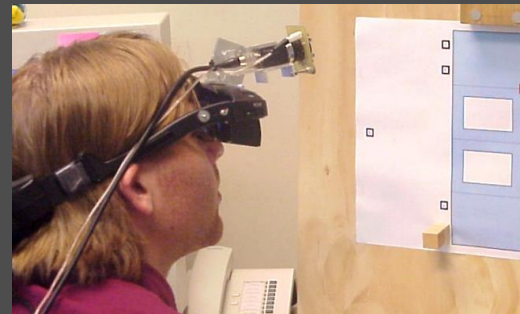


[Didier '05]

Spatial



[Azuma '95]



[Tuceryan '00] [Genc '02]

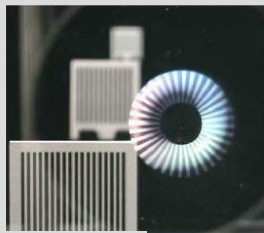
Consistent AR with **OST**-HMDs

Visual



D) Final result

[Kiyokawa '01]



[Liu '08]

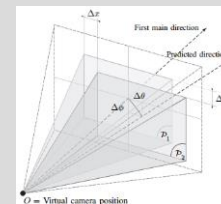


[Lee '09]

Temporal

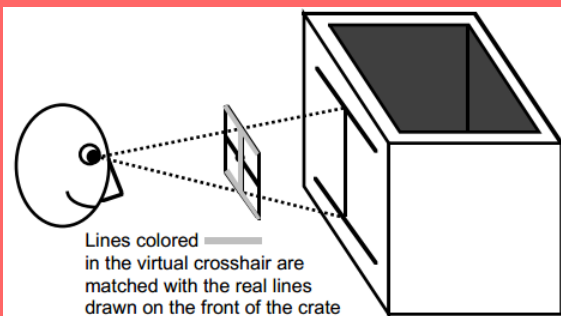


[Zheng '14]

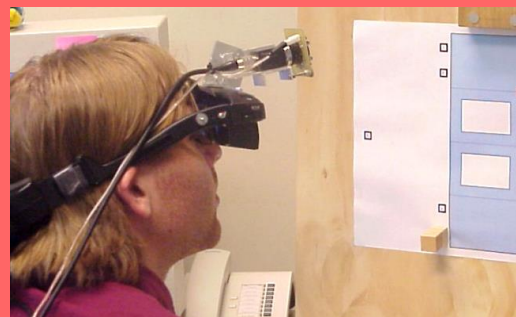


[Didier '05]

Spatial

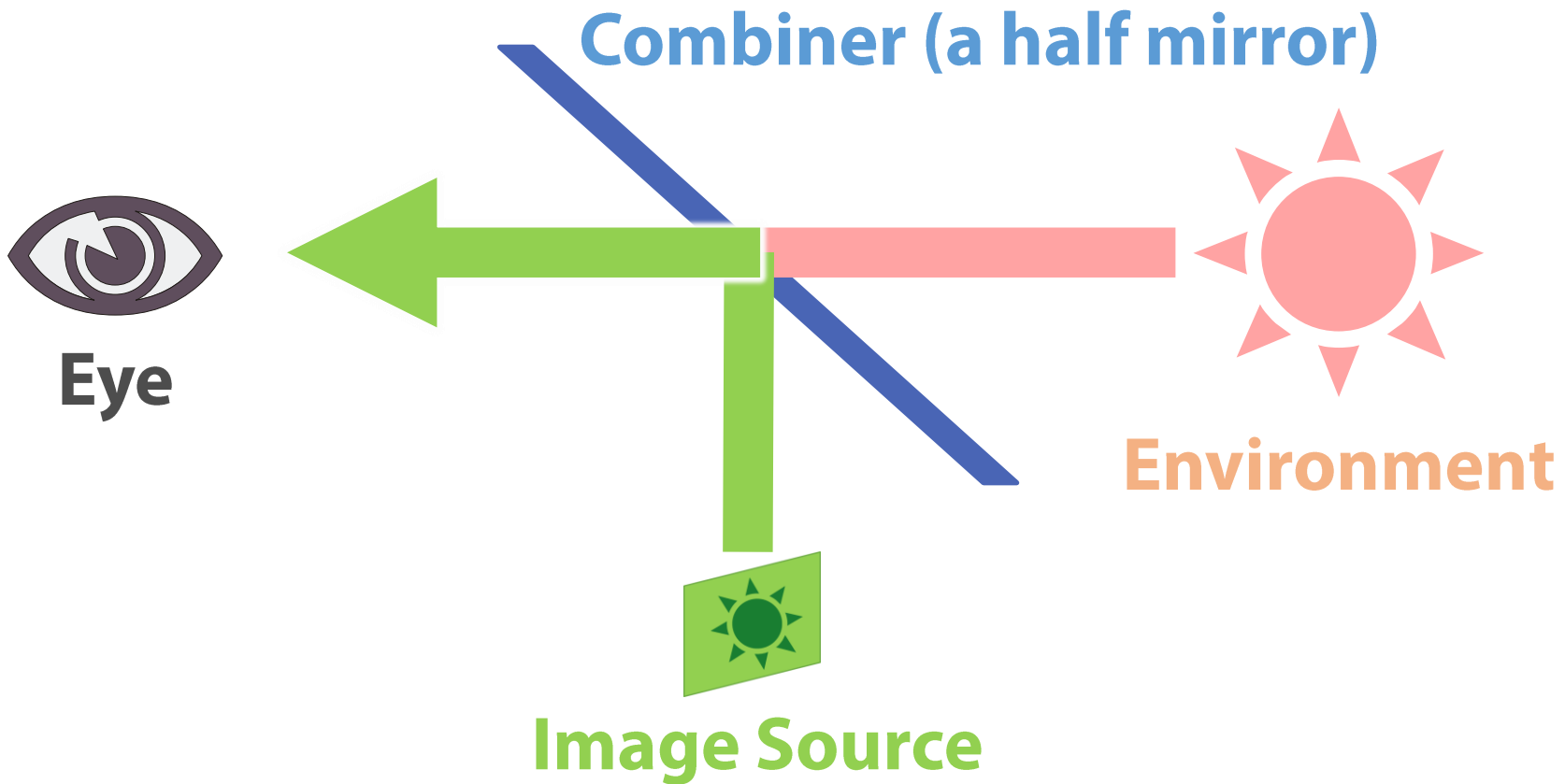


[Azuma '95]

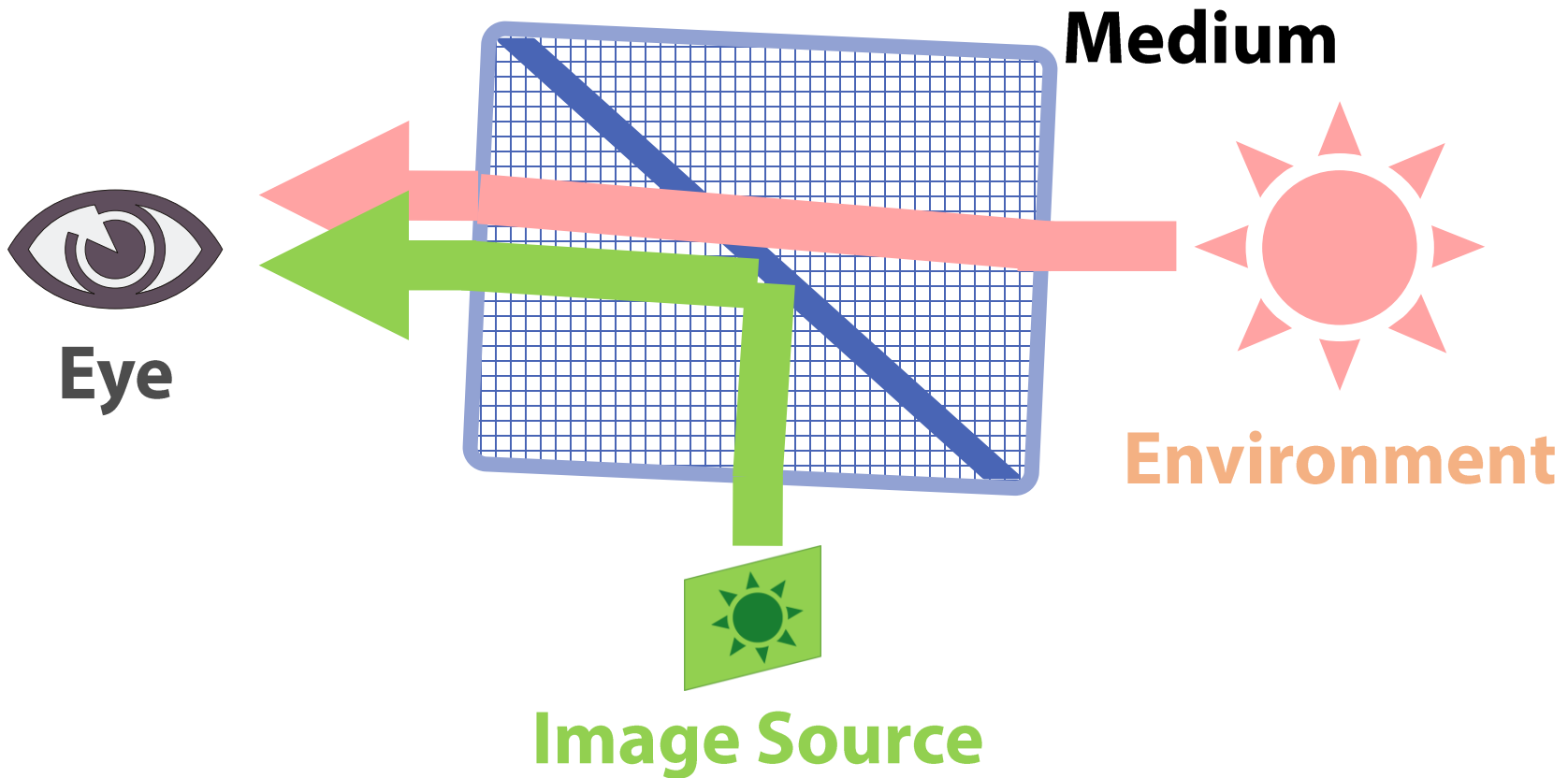


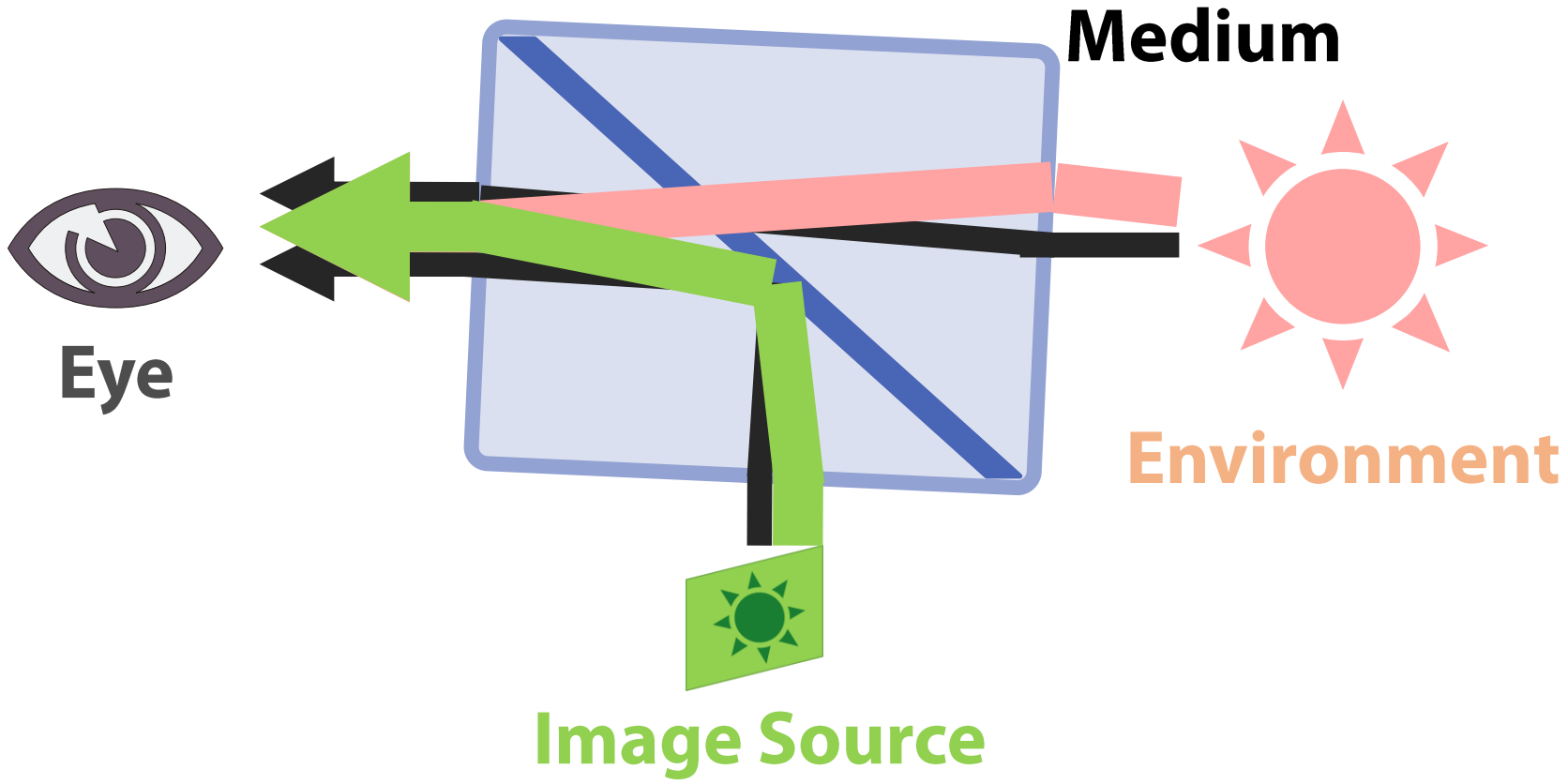
[Tuceryan '00] [Genc '02]

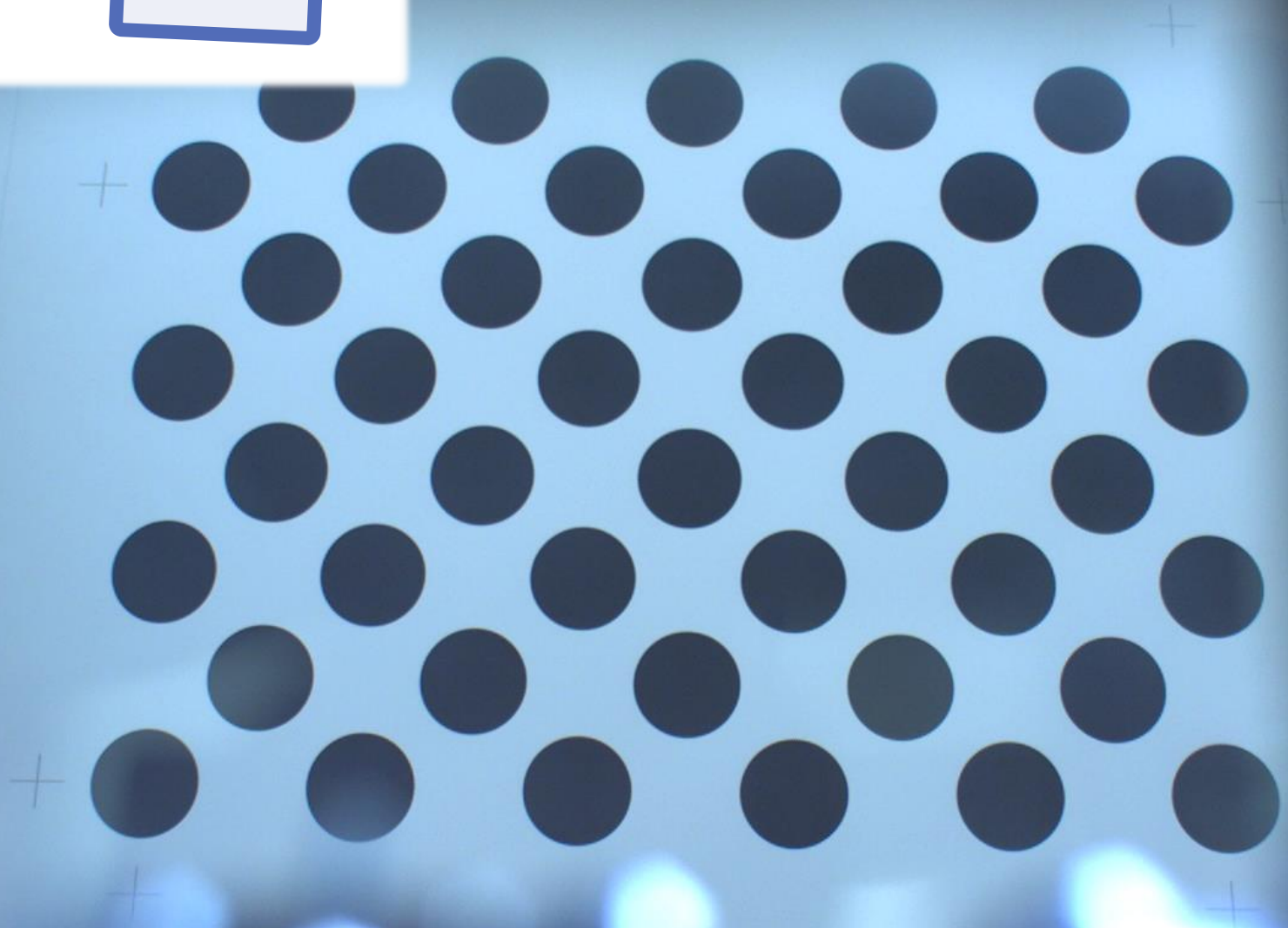
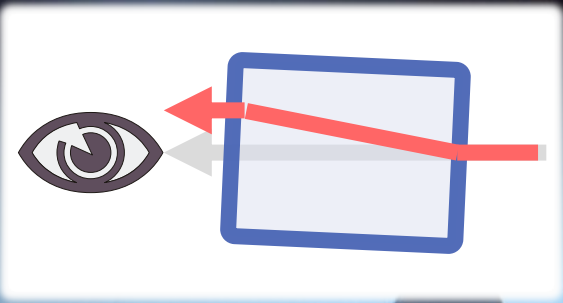
How OST-HMDs work?

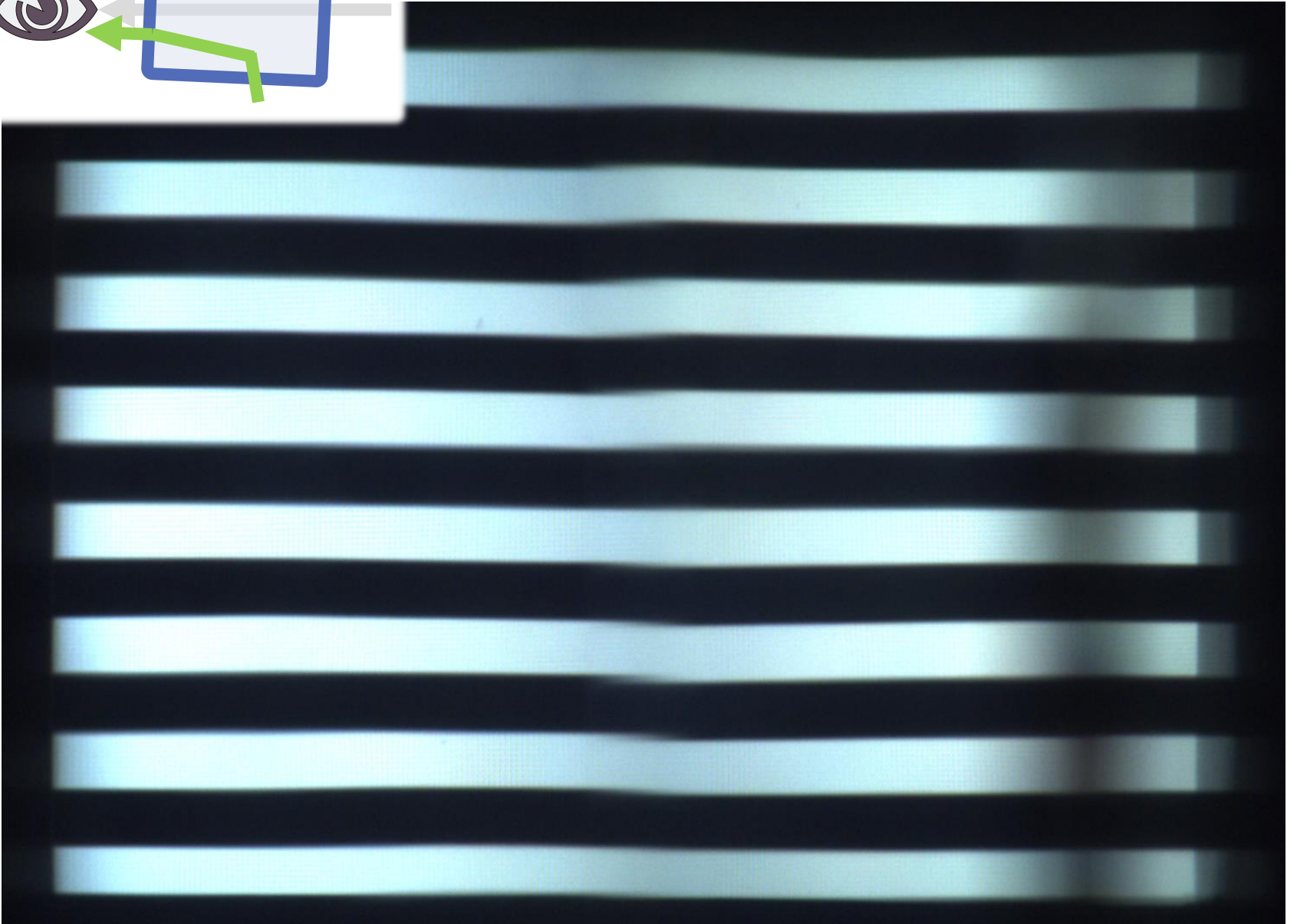
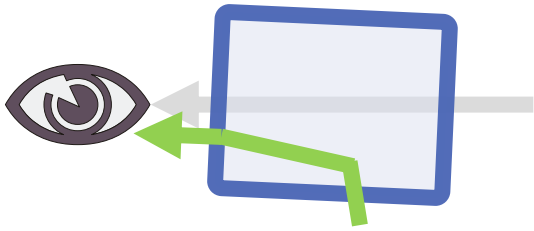


Optical aberration is the problem

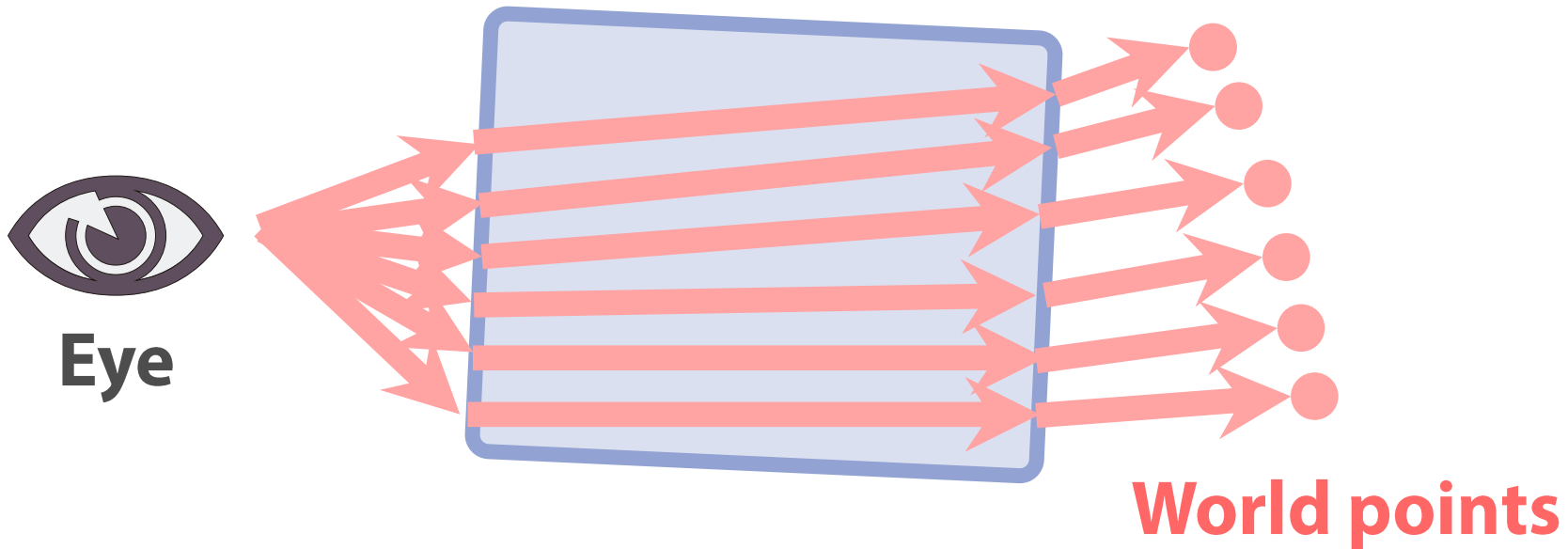








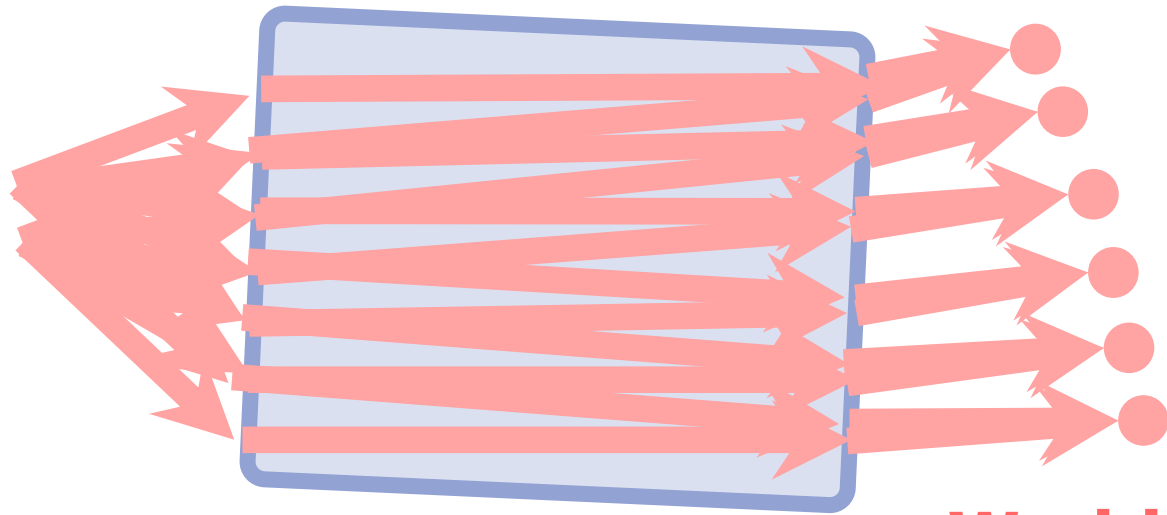
Previous work -> direct view dist.



[Itoh '15]

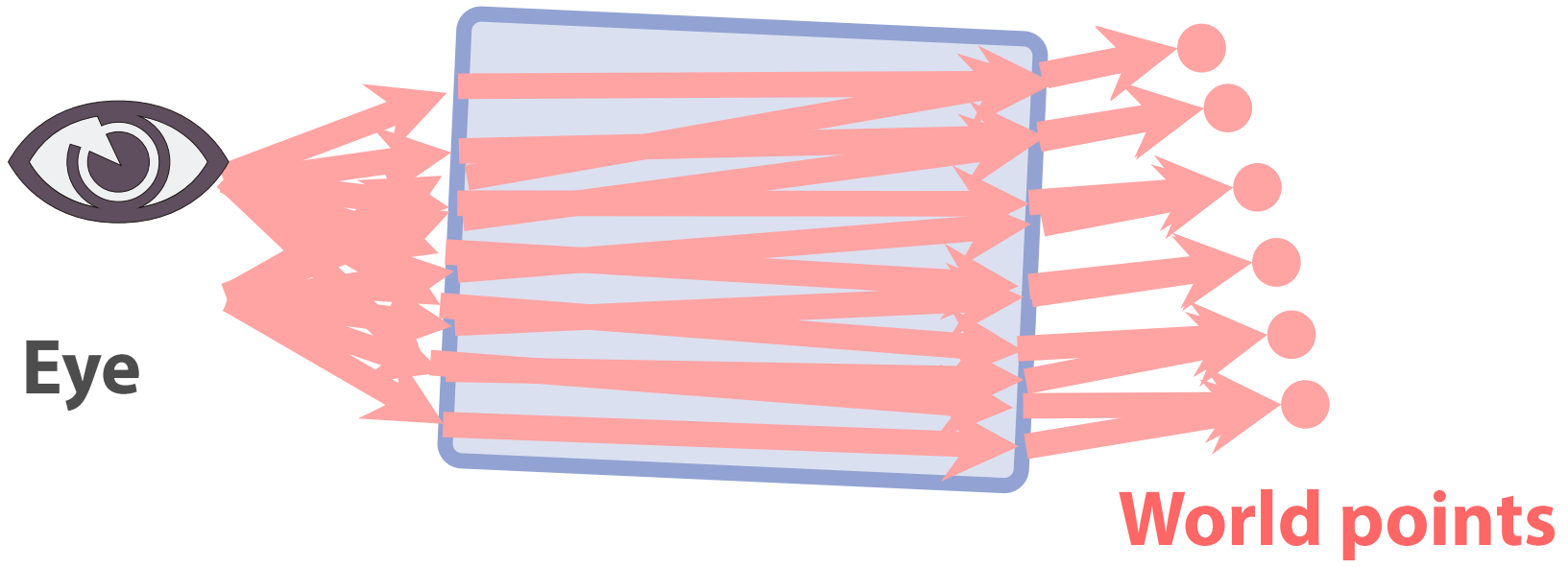


Eye

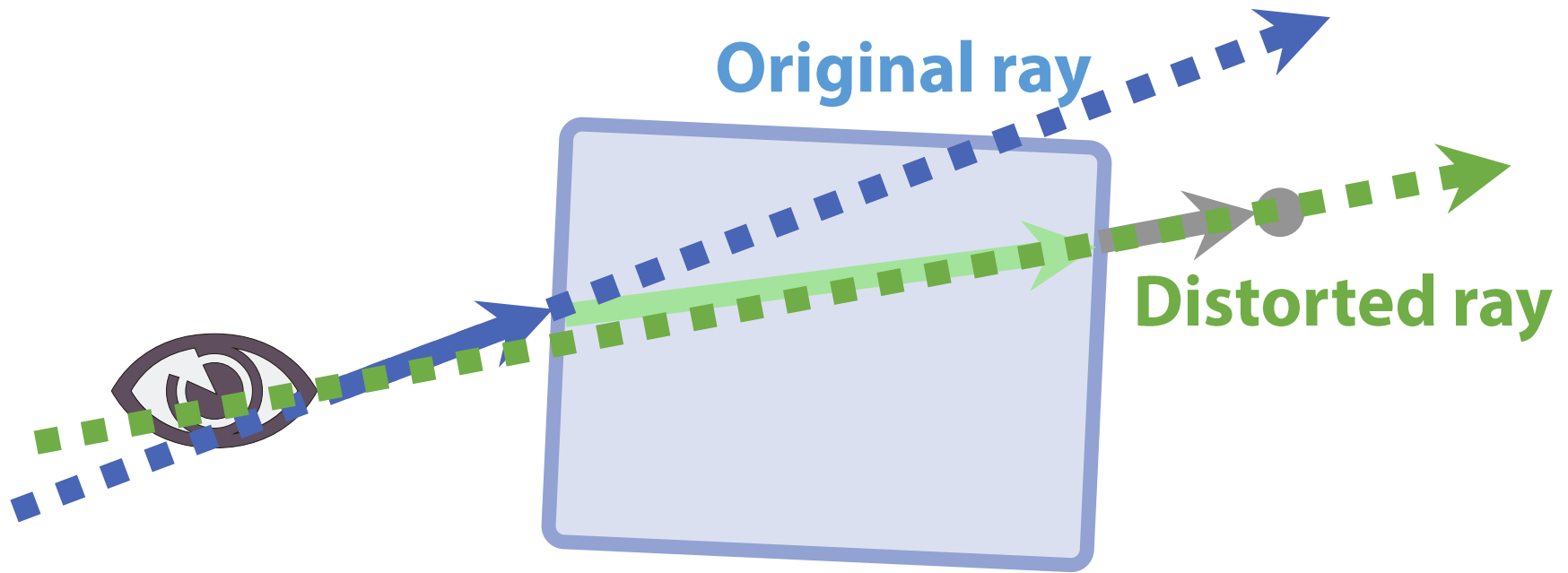


World points

[Itoh '15]



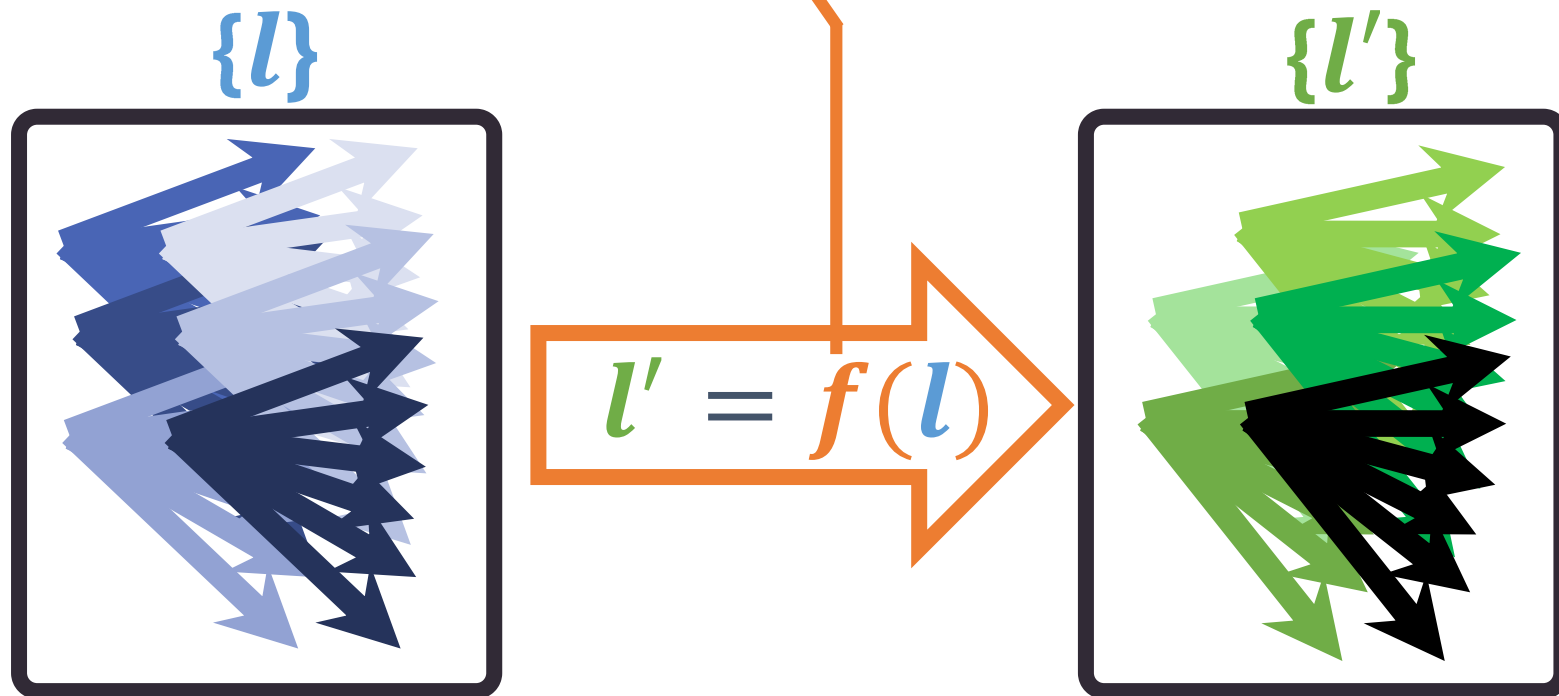
[Itoh '15]



[Itoh '15]

4D-to-4D regression

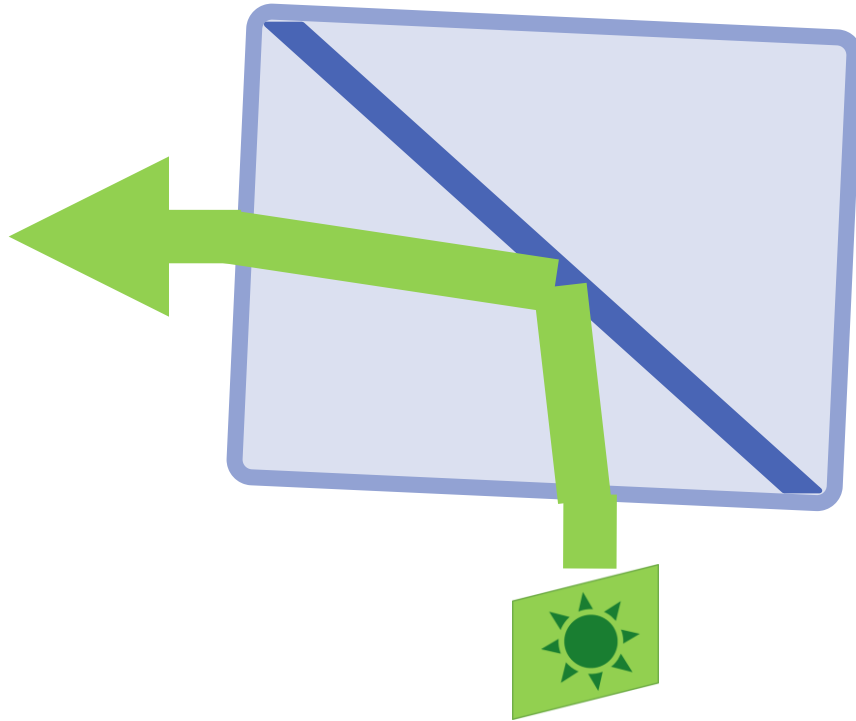
Kernel regression



[Itoh '15]



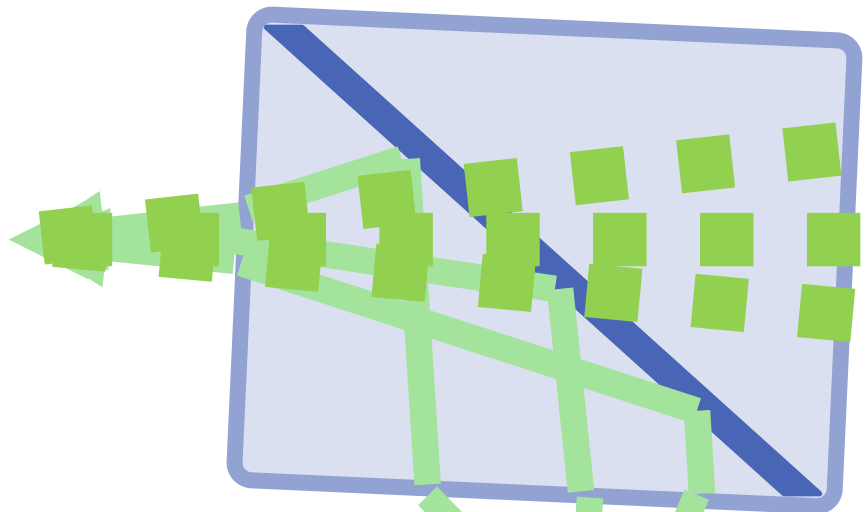
Eye



Projector



Eye

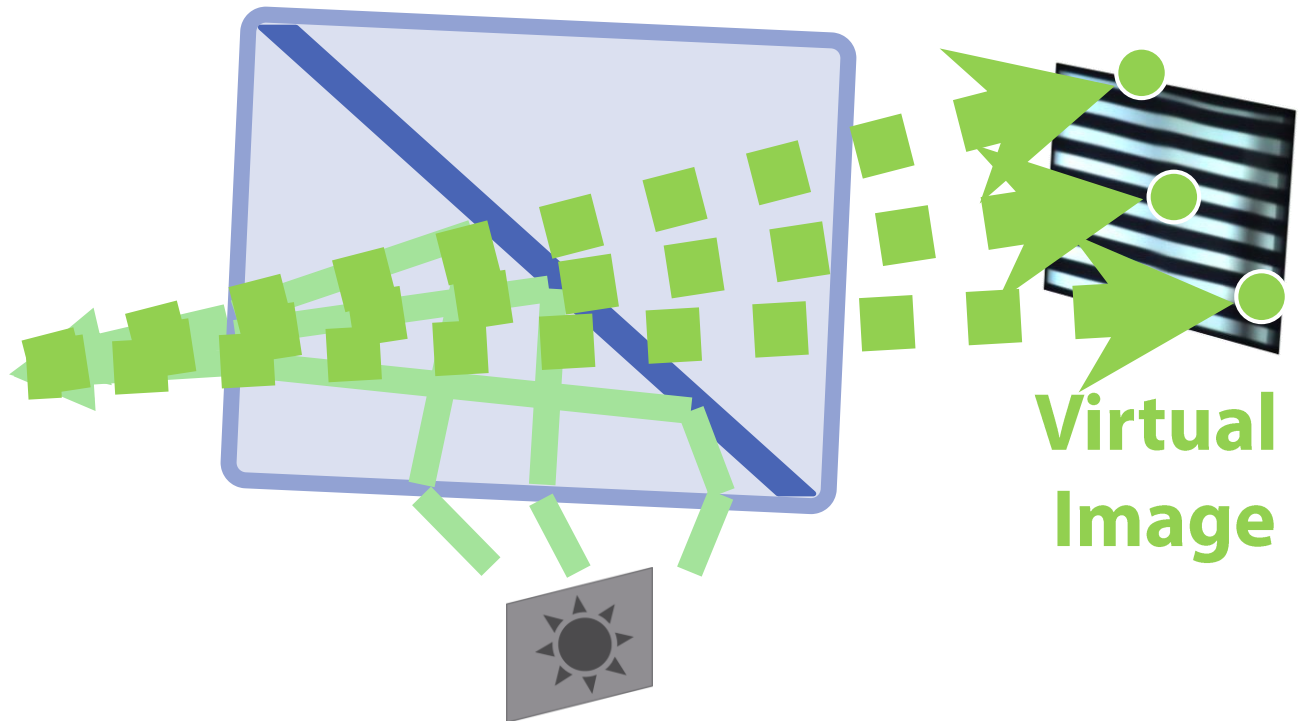


**Virtual
Image**

Projector



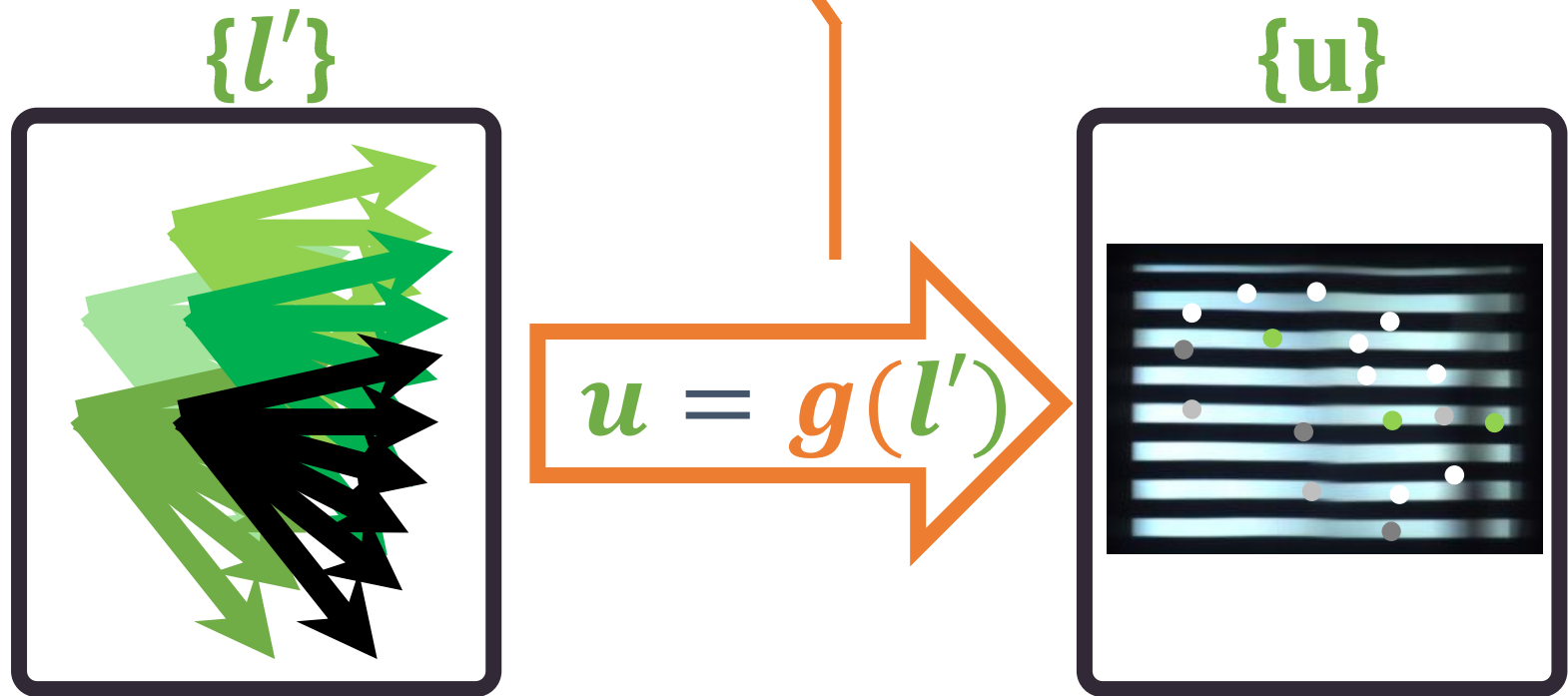
Eye



Projector

**Virtual
Image**

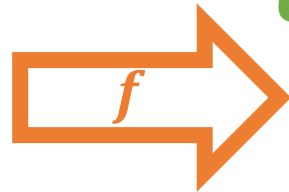
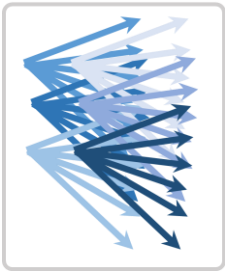
Kernel regression



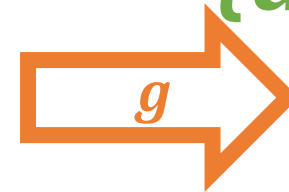
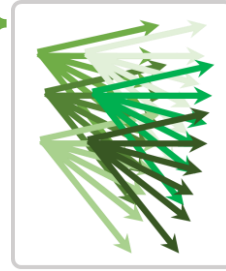
Direct View Distortion

Augmented View Distortion

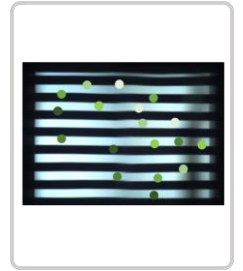
$\{l\}$



$\{l'\}$



$\{u\}$



$$u = g(l') = g(f(l))$$

Two experiment setups

Professional OST-HMD



Consumer OST-HMD

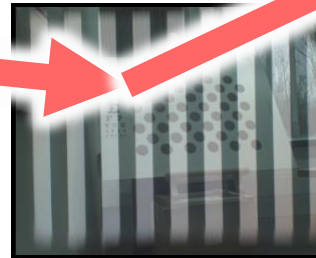


User perspective cameras

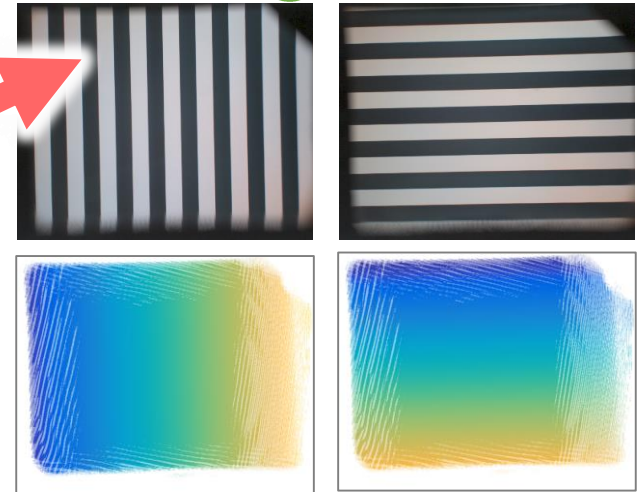
Image mapping for correspondences

Gray code + sinusoidal pattern

3D

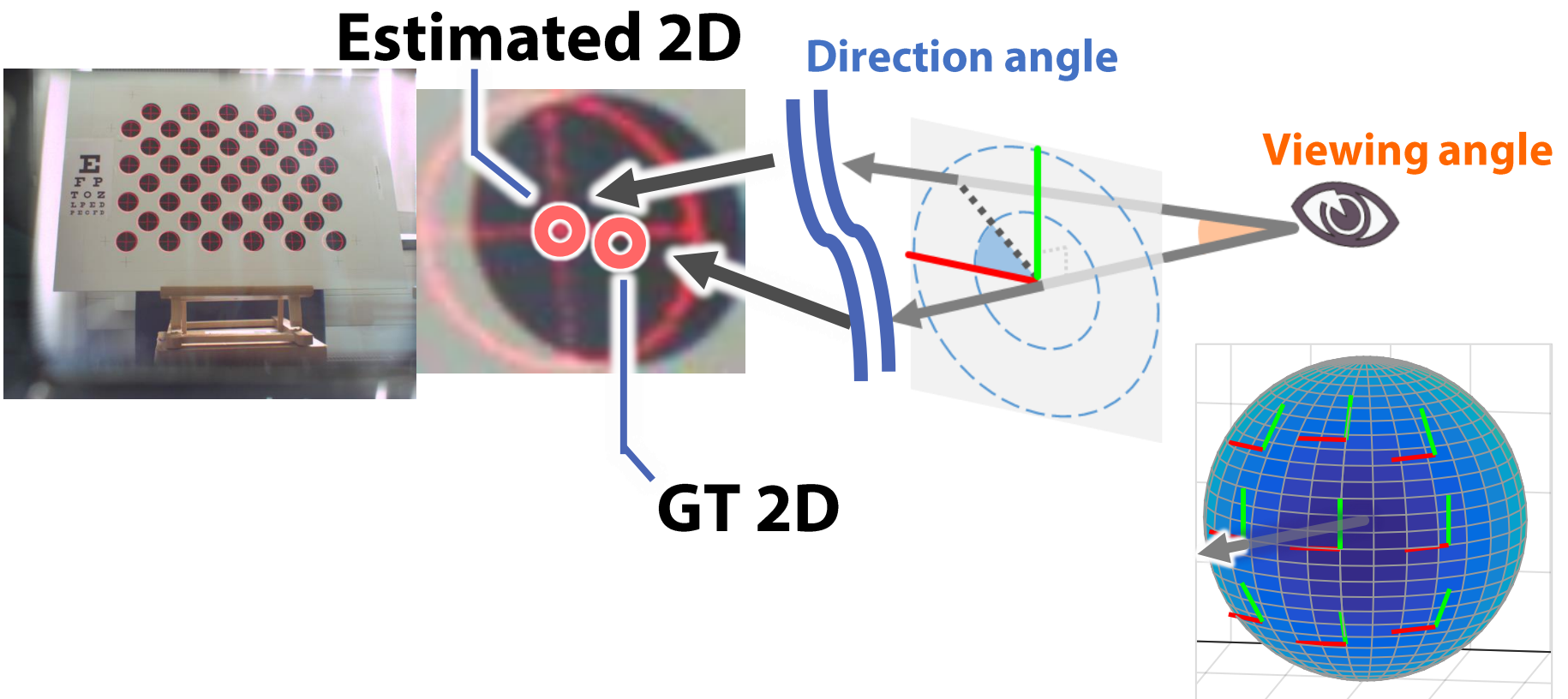


2D (image screen)



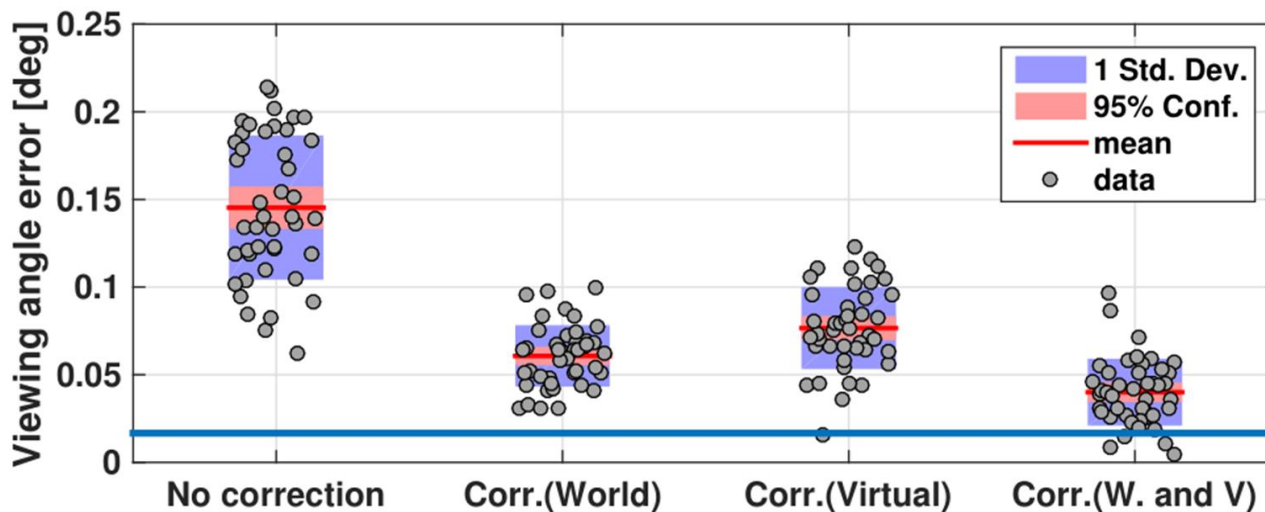
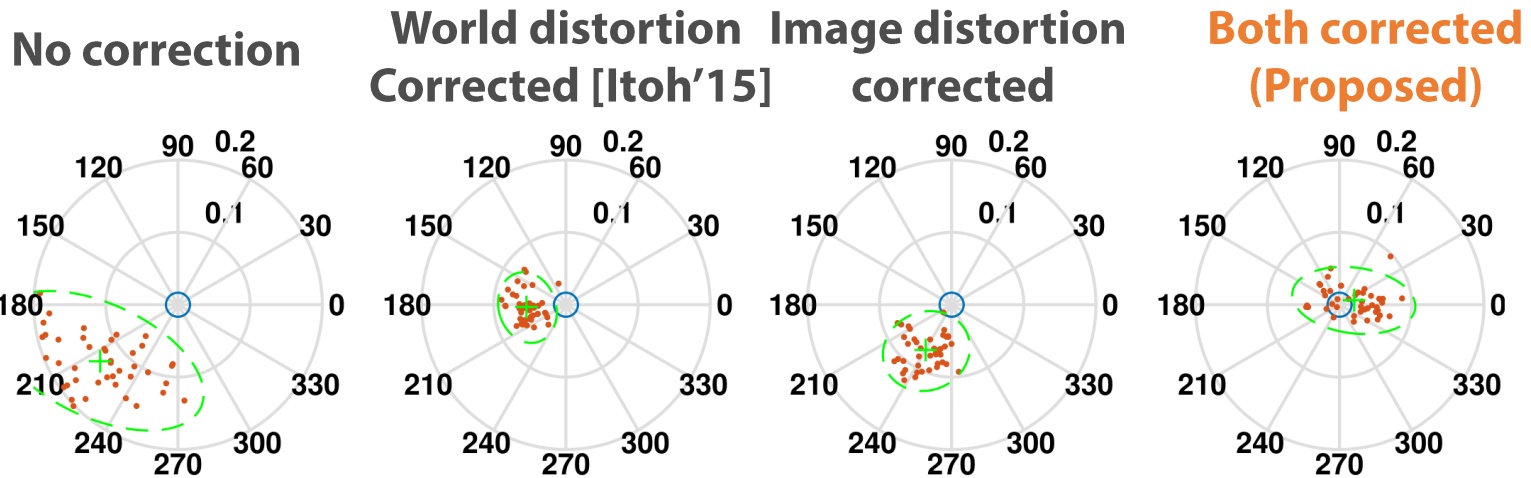
Viewing angle error

Directly comparable to visual acuity



With the professional OST-HMD

○ => Standard Visual Acuity (20/20)

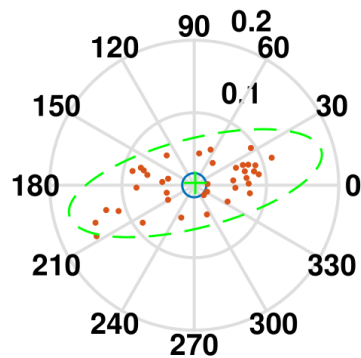


With the consumer OST-HMD

○ => Standard Visual Acuity (20/20)



No correction



World distortion
Corrected [Itoh'15]

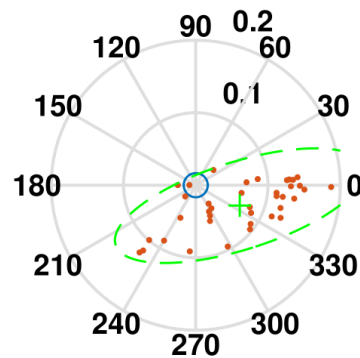
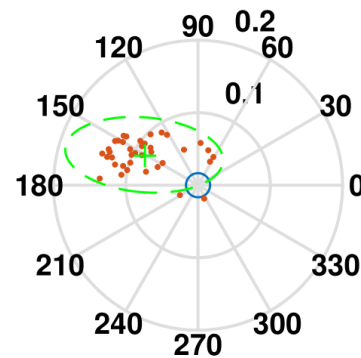
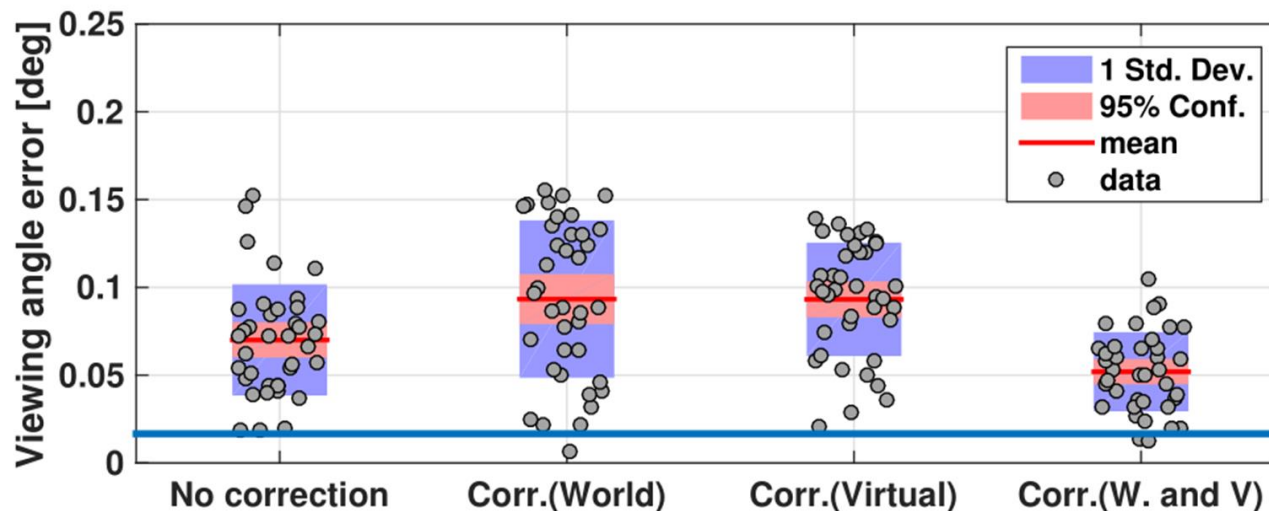
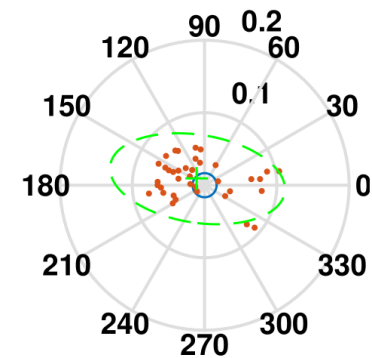


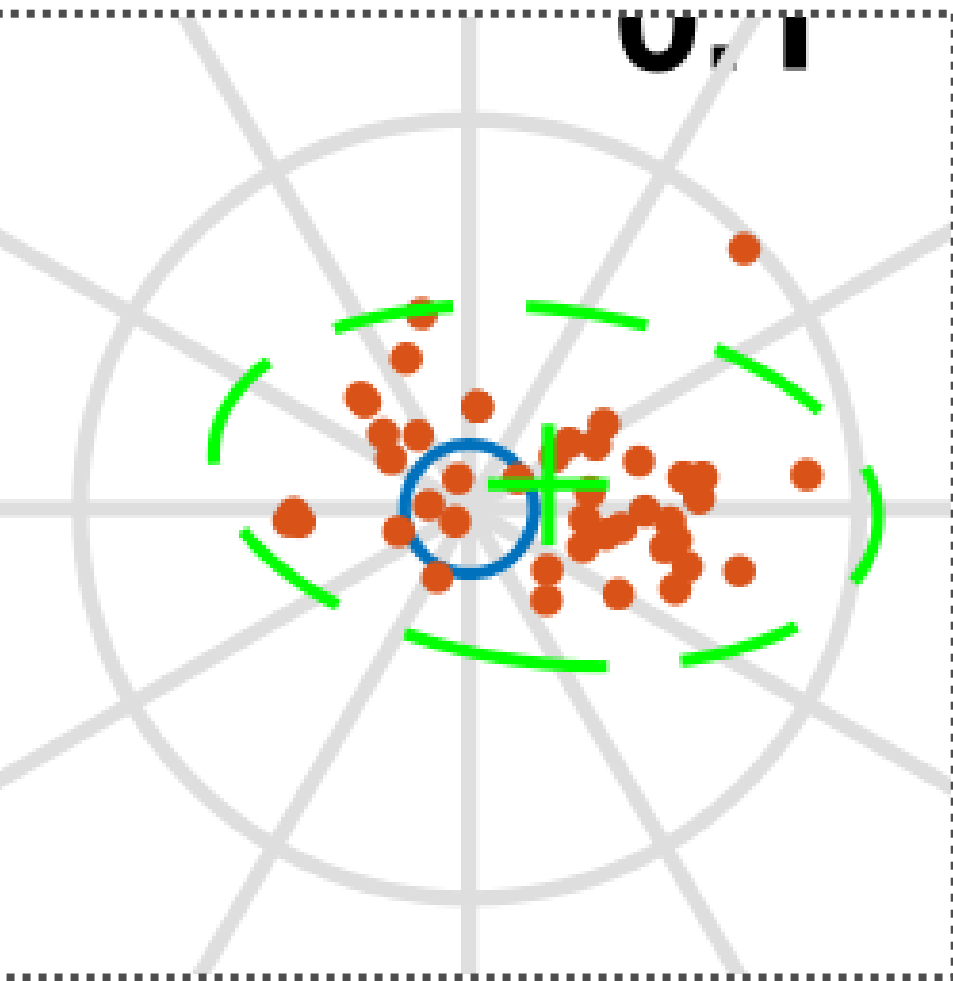
Image distortion
corrected



Both corrected
(Proposed)



Why still the gap?



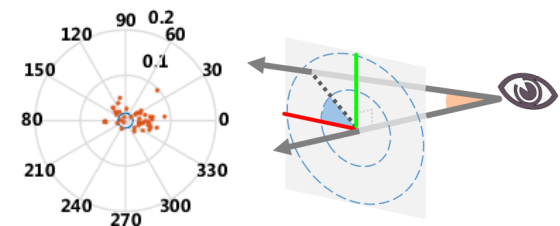
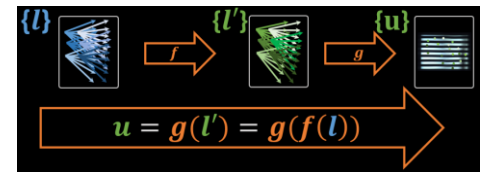
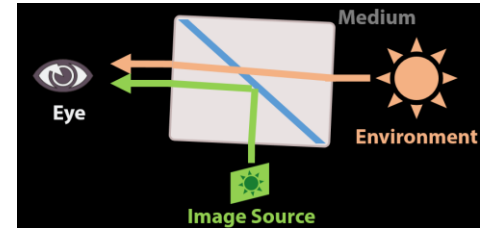
- Image screen model is too simplistic?
- Regression accuracy?

More details in the paper

Summary

- Correcting **Direct/Augmented distortions** in OST-HMDs
 - Only correcting **both** can improve the final reg. accuracy

- The results are comparable to **20/50** visual acuity.



We are seeking for **collaborations!**

itoh@in.tum.de

Thank you



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