USING **PRIORS** TO COMPENSATE GEOMETRICAL PROBLEMS IN HMET

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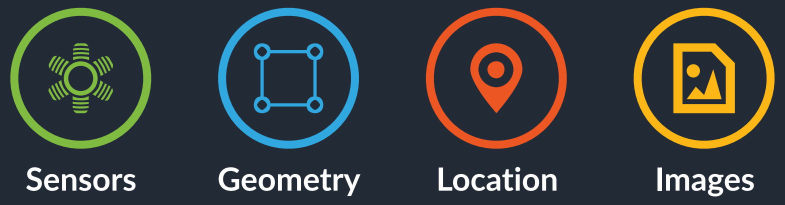
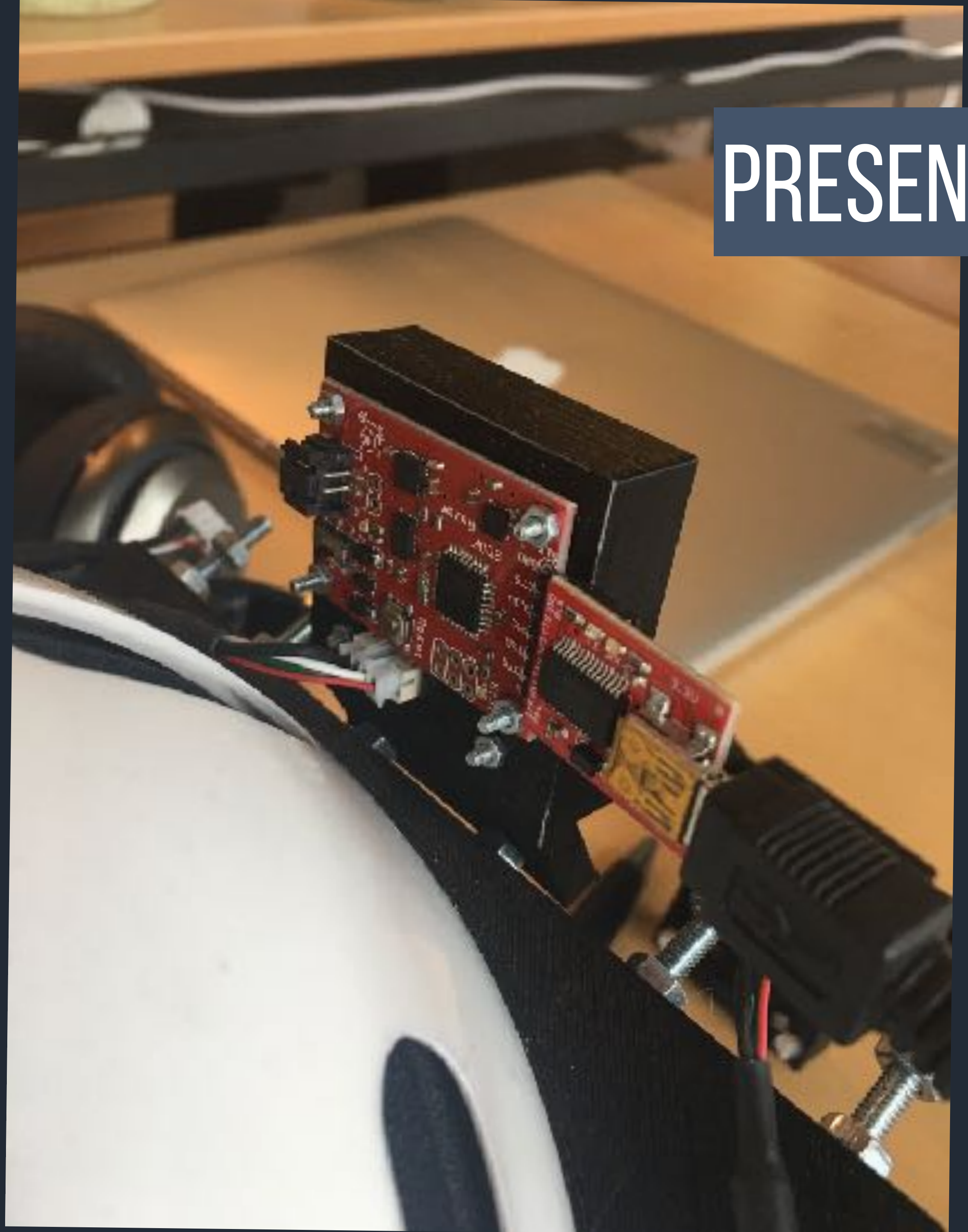
WHY TO USE PRIORS?

> "The use of available information known from the problem at hand (aka *priors*) allows to enhance the accuracy, precision, robustness and performance of head-mounted eye tracking in the wild"





PRESENTATION **OUTLINE**

1. Parallax Compensation Model
   Using the known distance between the subject and the focused target as priors

2. Head Rotation Compensation Model
   Using the three-dimensional angles from the subject's head as priors

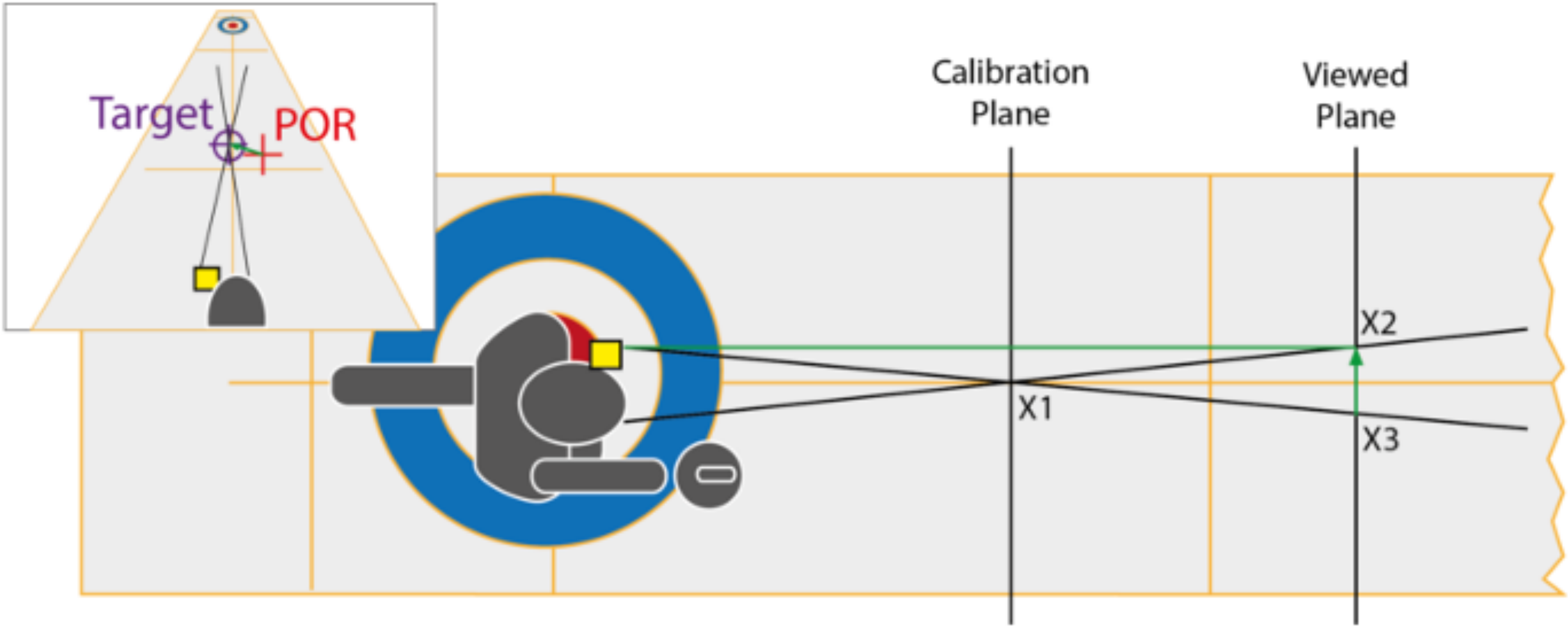
3. Video Example
   Showing the results of using priors in a real eye tracking scenario

4. Questions and Answers
   Answering the question from the audience and showing the final conclusions

PARALLAX COMPENSATION MODEL

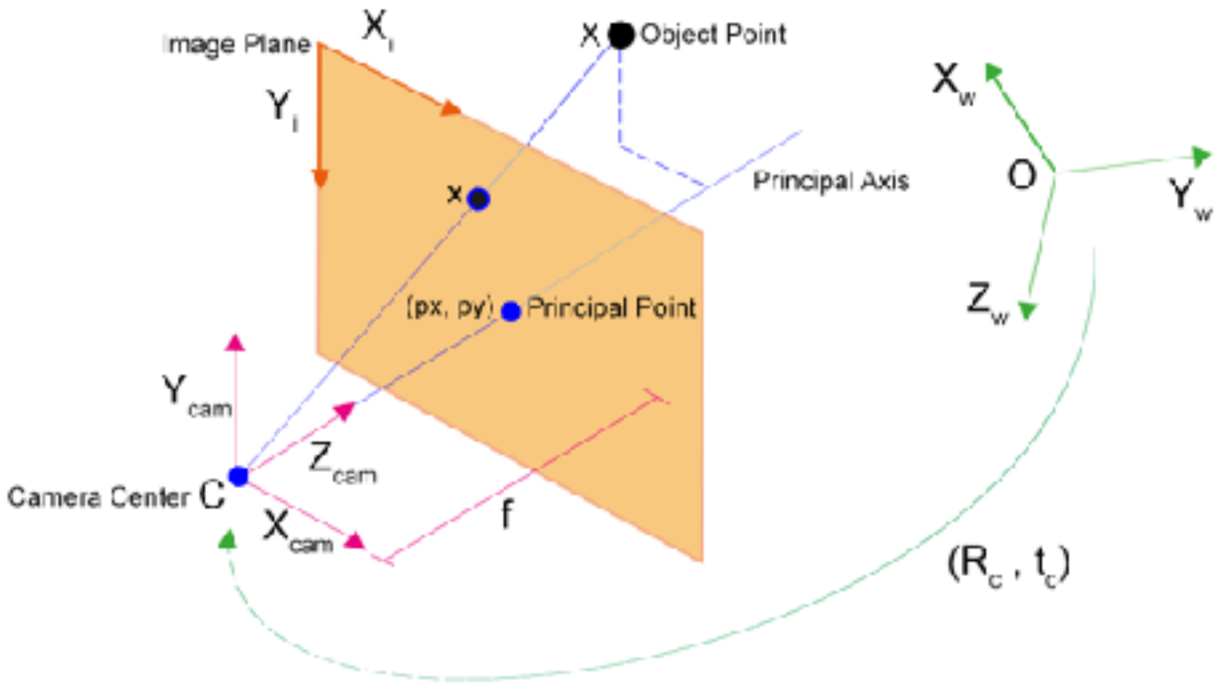
Influence of Parallax Error in Gaze Estimation

Parallax error is a geometric problem due to the projection centers of scene and eye cameras, and the subject's eye ball center are not co-axial. It causes significant gaze estimation errors when the observed targets move at different depth places.



PROPOSED COMPENSATION MODEL

Pure Translation Motion



> Pure translation is a planar motion where there is no rotation

PURE TRANSLATION EQUATION

$$g' = g + Kt/Z$$

EVALUATION OF PROPOSED MODEL

Using Real Gaze Data

THE PARTICIPANTS USED AN UNCALIBRATED HEAD-MOUNTED EYE TRACKER TO COLLECT THEIR BINOCULAR GAZE DATA

Apparatus

Head-mounted eye tracker with 3 scene cameras and 1 eye camera attached to a helmet

Participants

A sample of 20 participants (15 males and 5 females) recruited from the ITU

Procedure

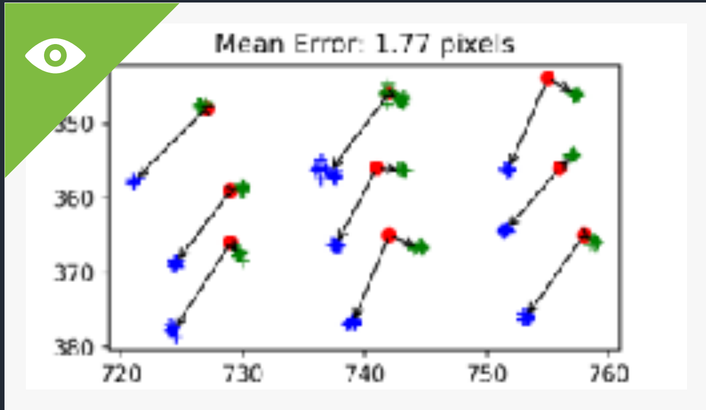
Look at nine targets in a moved white board from 2 to 18 meters in steps of 2 meters

Assessment

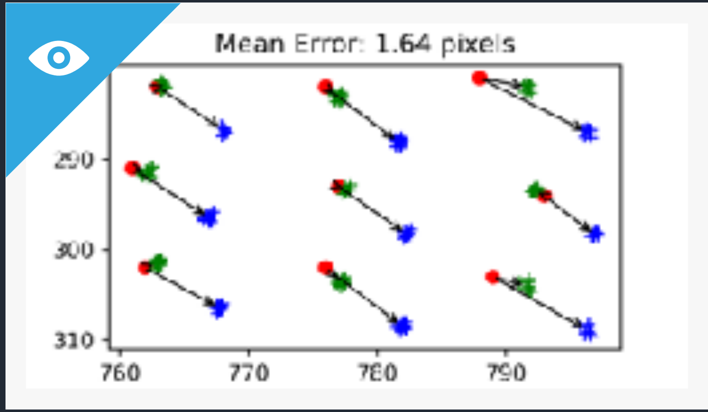
Magnitude and orientation, binocular and monocular, scene camera location and improvements

EVALUATION OF PARALLAX COMPENSATION MODEL

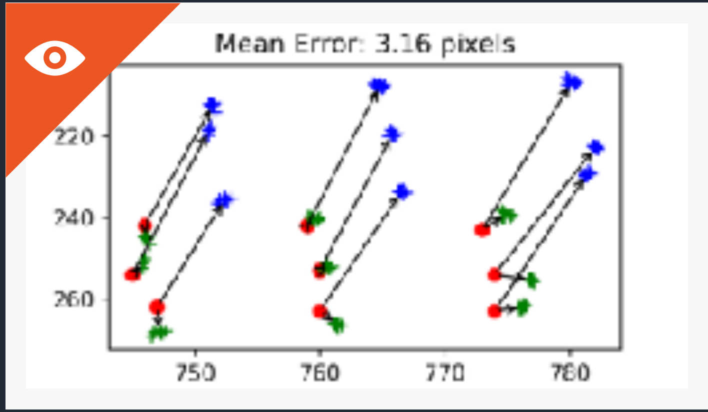
Gaze Error Distribution and Improvements Achieved Using the Proposed Model



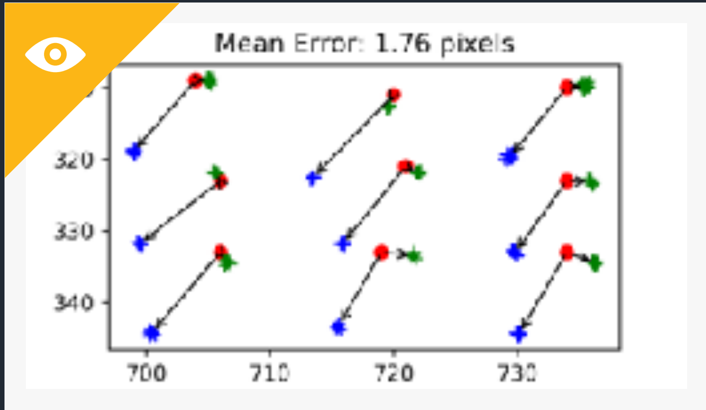
Participant #01 (Before 11.55)



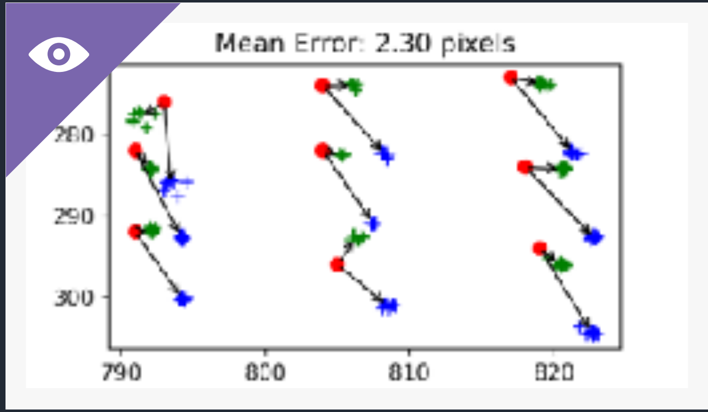
Participant #02 (Before 8.07)



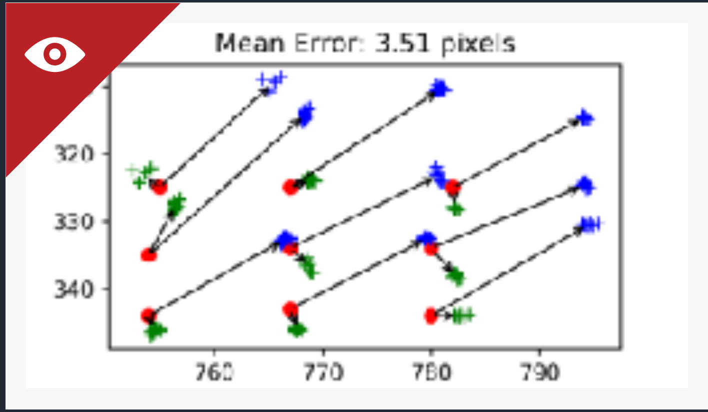
Participant #03 (Before 32.85)



Participant #04 (Before 11.60)



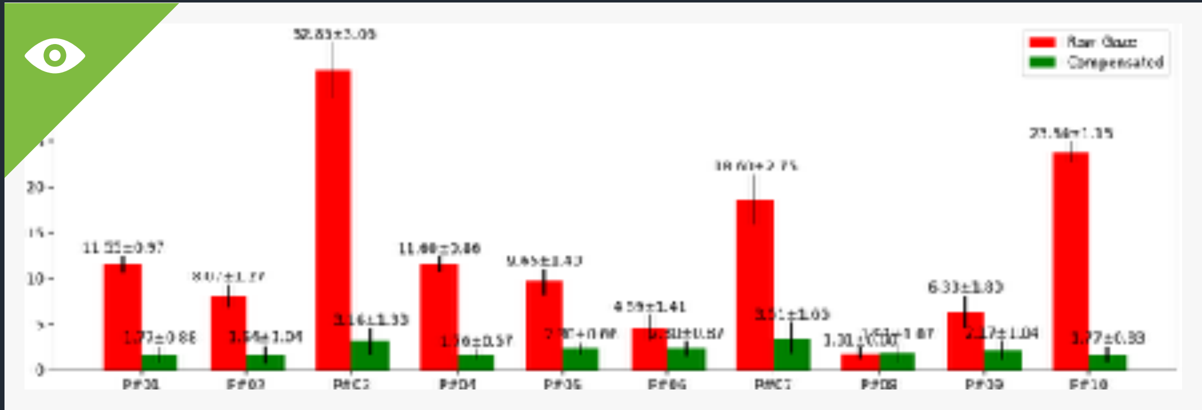
Participant #05 (Before 9.65)



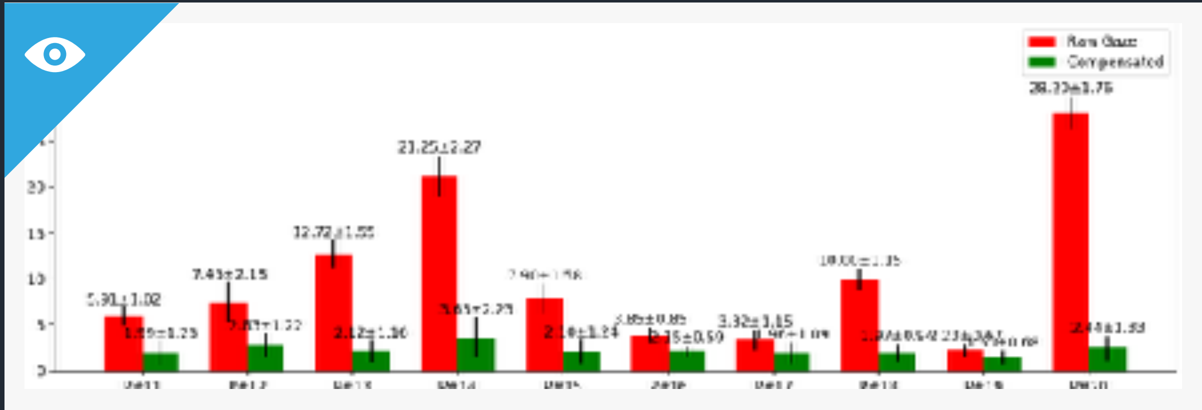
Participant #07 (Before 18.60)

EVALUATION OF PARALLAX COMPENSATION MODEL

Improvements Achieved Using the Proposed Model



Average gaze error of Participants #01 to #10



Average gaze error of Participants #11 to #20

Improvement of **80.59%**

RESULTS IN A REAL EYE TRACKING SCENARIO

Parallax Compensation Model

RAW GAZE ESTIMATION

Green cross is the participant's gaze estimated with homography

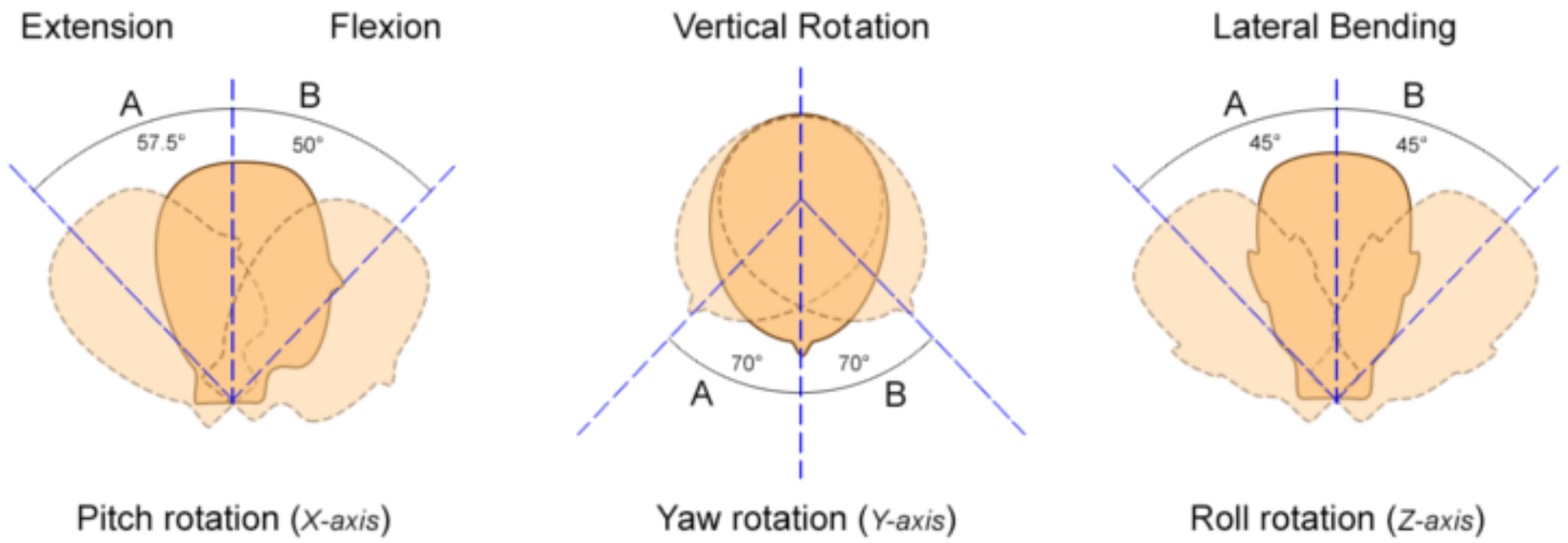
COMPENSATED GAZE ESTIMATION

Gaze estimation using the proposed parallax compensation model

HEAD ROTATION COMPENSATION MODEL

Influence of Head Rotation in Gaze Estimation

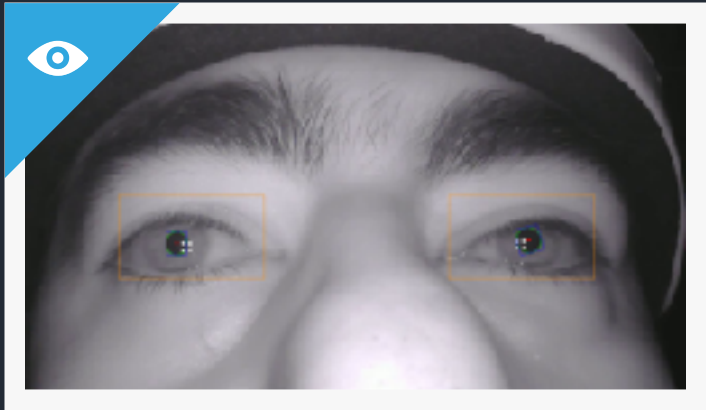
During laboratory experiments, we observed a significant influence of natural head rotation in the gaze estimation, especially head movements around roll axis (i.e. Z-axis in the right-hand rule)



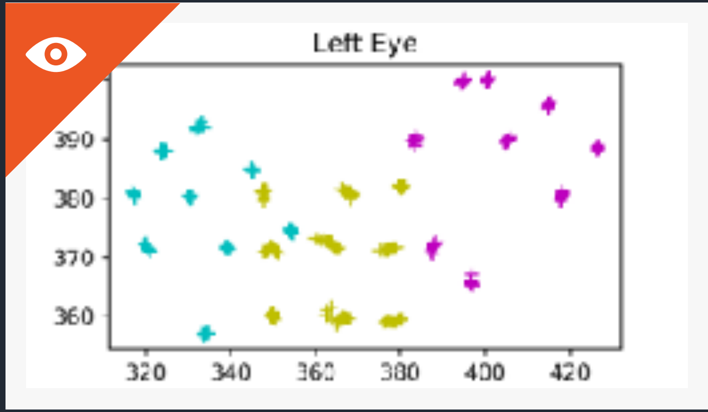
INFLUENCE OF HEAD ROTATIONS

The Eyes Perform More Complex Movements

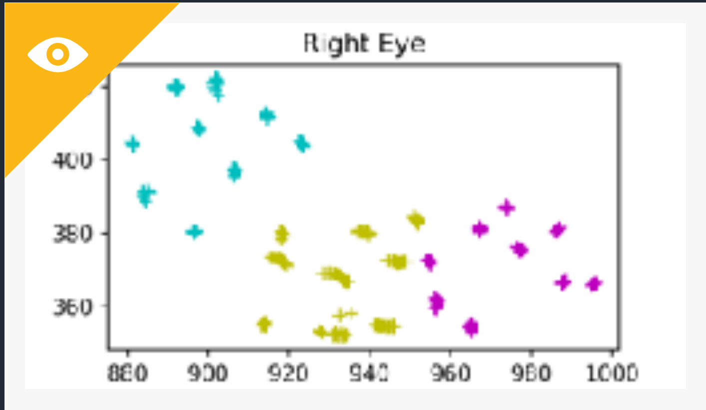
Participant #05 (Turn to the Left)



Participant #05 (Turn to the Right)



Participant #05 (Left Pupil Centers)



Participant #05 (Right Pupil Centers)

EVALUATION OF PROPOSED MODEL

Using Real Gaze Data

THE PARTICIPANTS USED AN UNCALIBRATED HEAD-MOUNTED EYE TRACKER WITH AN ORIENTATION SENSOR

Apparatus

Head-mounted eye tracker with 3 scene cameras, 1 eye camera and 1 orientation sensor

Participants

A sample of 10 participants (8 males and 2 females) recruited from the ITU

Procedure

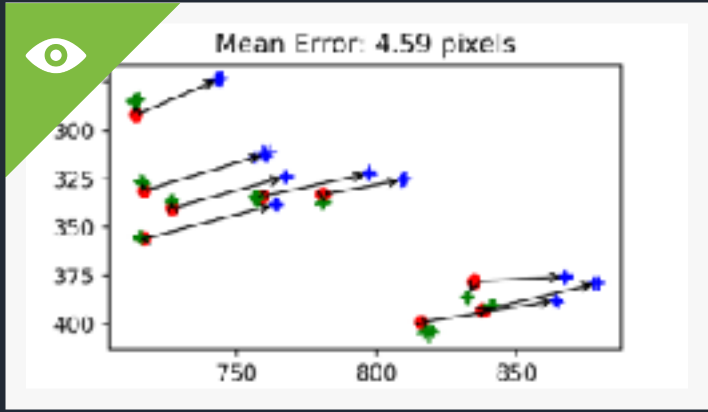
Look at a fixed target (9 targets in total) while rotating the head to the left and the right

Evaluation

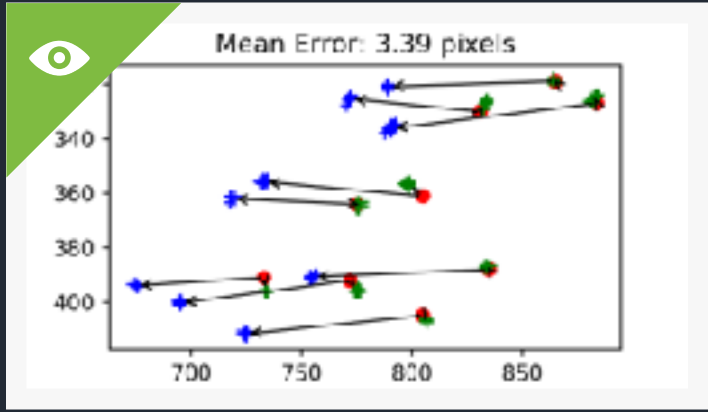
Magnitude and orientation, binocular and monocular, scene camera location and improvements

EVALUATION OF HEAD ROTATION COMPENSATION MODEL

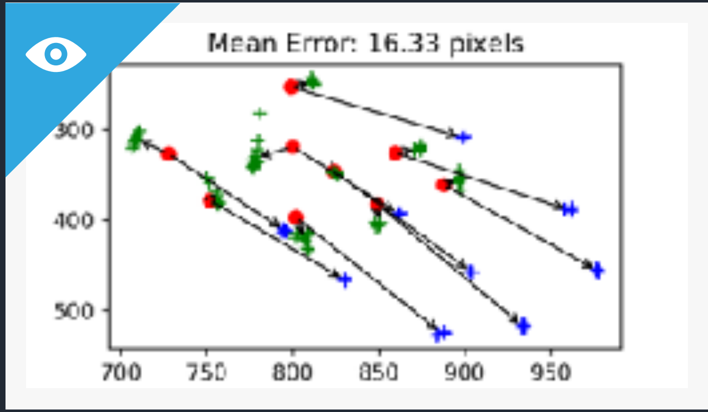
Gaze Error Distribution and Improvements Achieved Using the Proposed Model



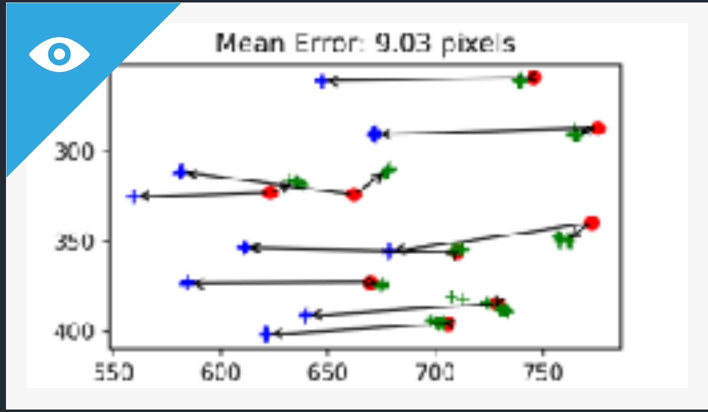
Participant #01 (Before 41.27)



Participant #01 (72.70)



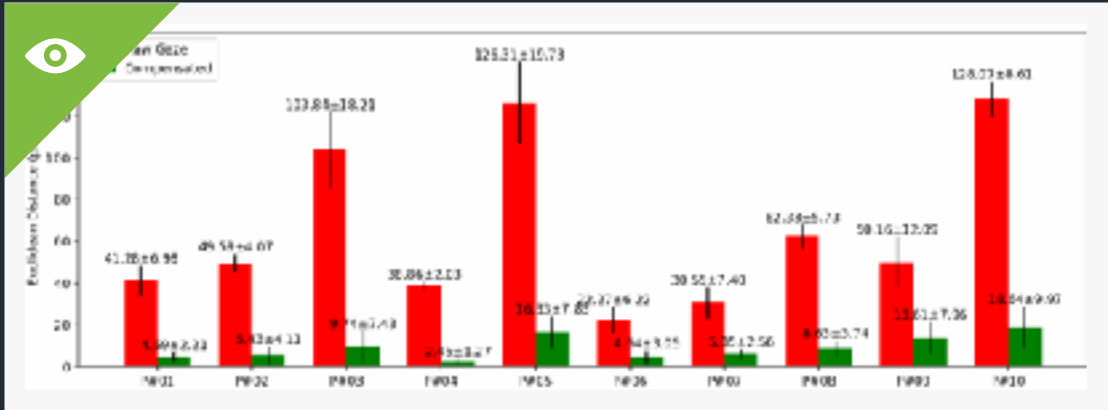
Participant #05 (Before 126.31)



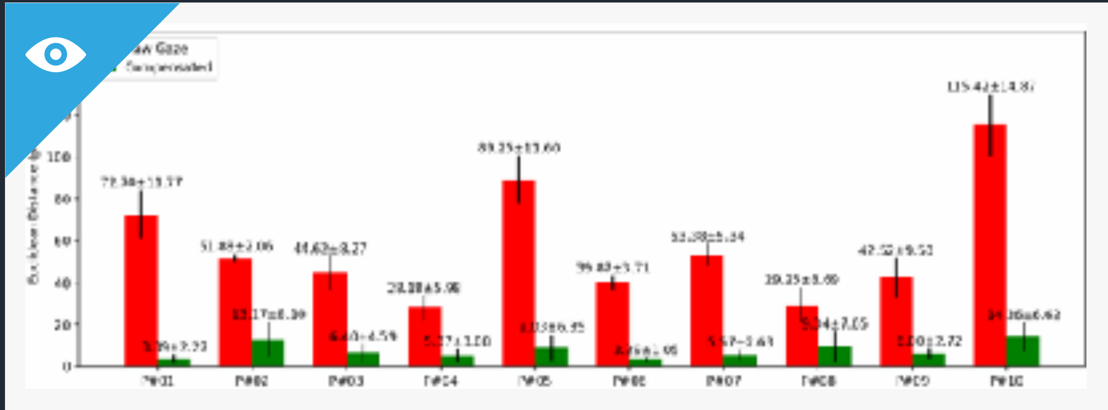
Participant #05 (Before 89.25)

EVALUATION OF HEAD ROTATION COMPENSATION MODEL

Improvements Achieved Using the Proposed Model



Average gaze error when the participants turned their head to the left

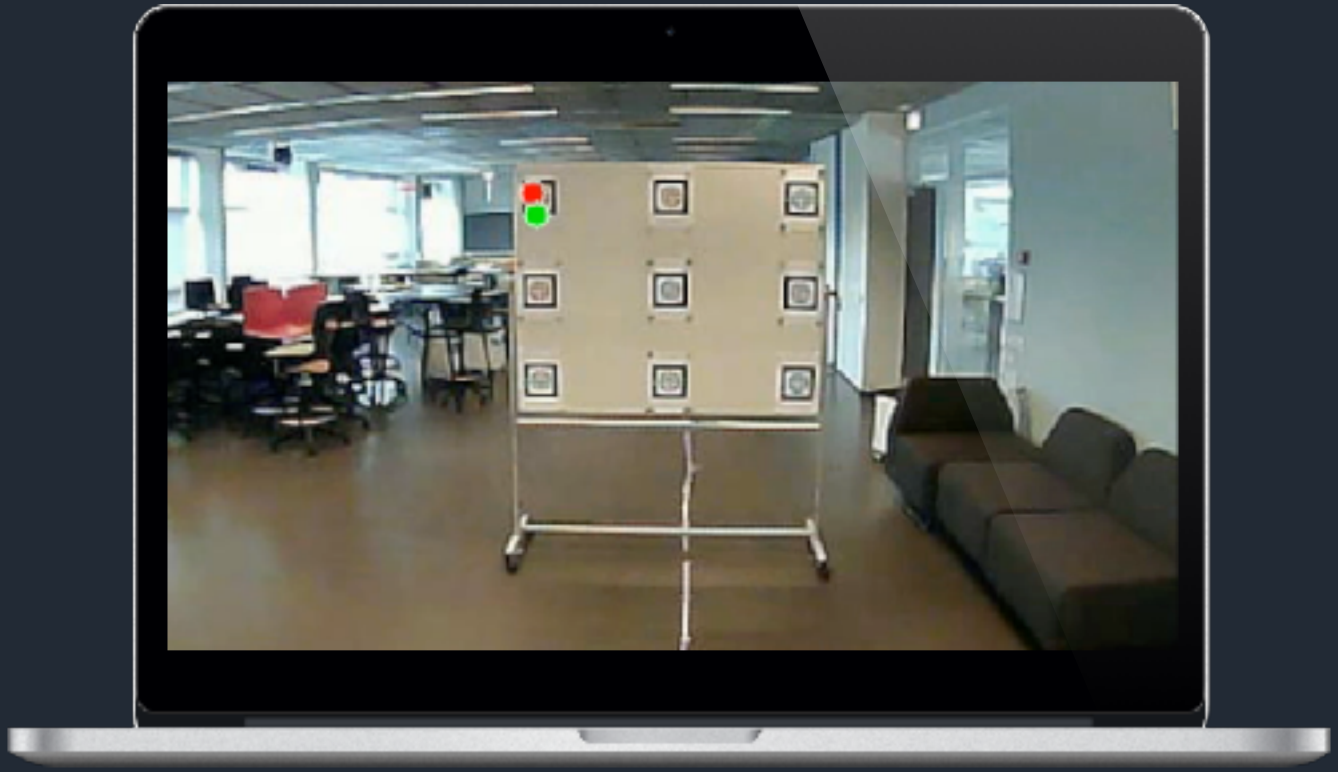


Average gaze error when the participants turned their head to the right

Improvement of **86.41%**

RESULTS IN A REAL EYE TRACKING SCENARIO

Head Rotation Compensation Model



RAW GAZE ESTIMATION

Red circle is the participant's gaze estimated with homography

COMPENSATED GAZE ESTIMATION

Gaze estimation using the proposed head rotation compensation model

93.00 % OF IMPROVEMENT

For participant #01, the proposed model improve the robustness in 93.00% for both head rotation (i.e. to the left and the right)

PRESENTATION SUMMARY

Using Priors to Compensate Geometrical Problems of HMET

USING PRIORS TO IMPROVE HEAD-MOUNTED EYE TRACKERS IN SPORTS ANALYSIS

Using Priors

Using additional information know from the problem at hand to improve eye tracking systems

Parallax

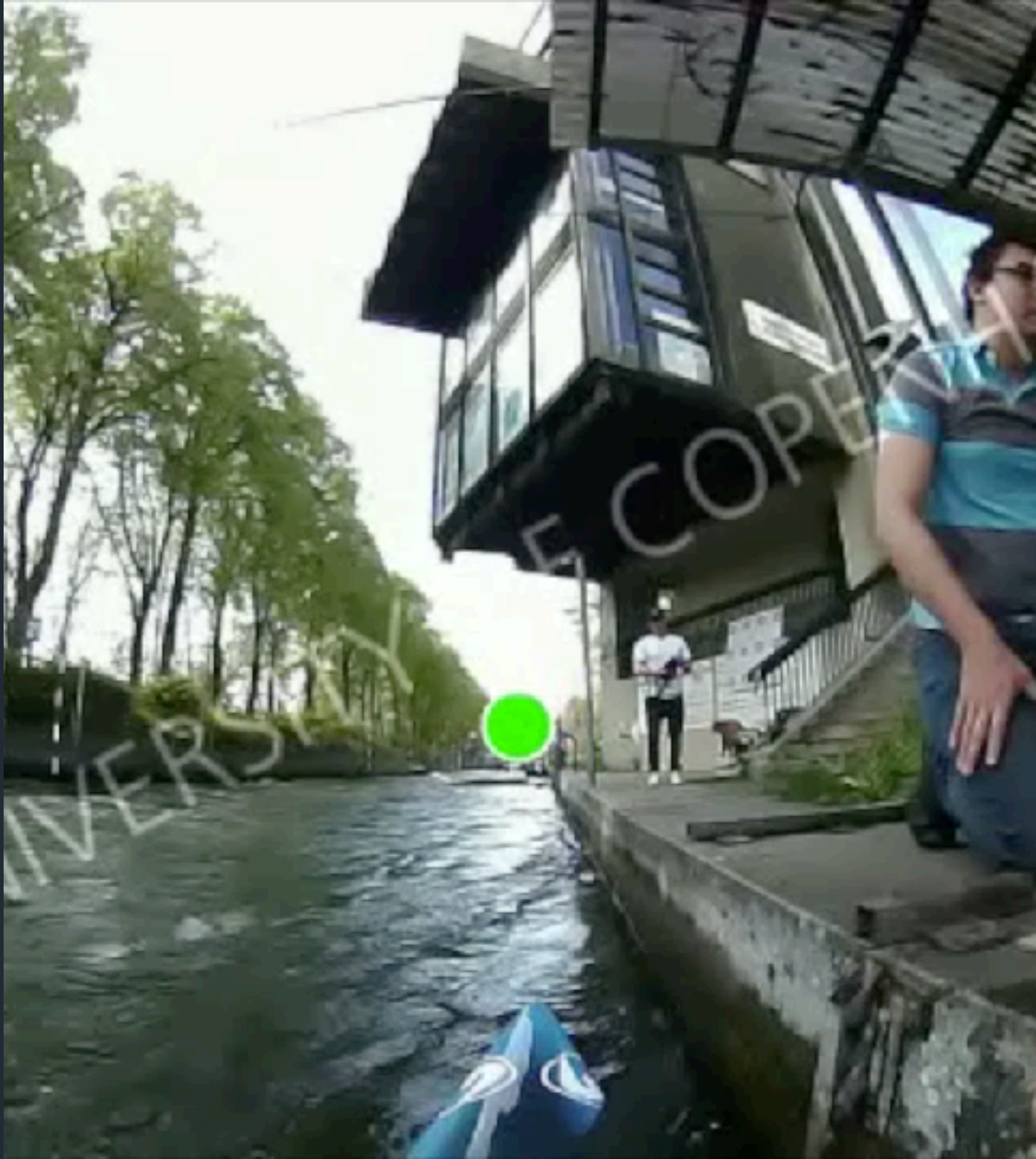
Using the distance between the user and the observed target, and angle kappa as priors

Head Rotations

Using the 3D dimensional head angles as priors to compensate the influence of head rotations

Other Approaches

Priors can be used in several steps of eye tracking, such as: gaze estimation, eye feature detection



THANK YOU!

EYEINFO RESEARCH GROUP

http://eye.itu.dk

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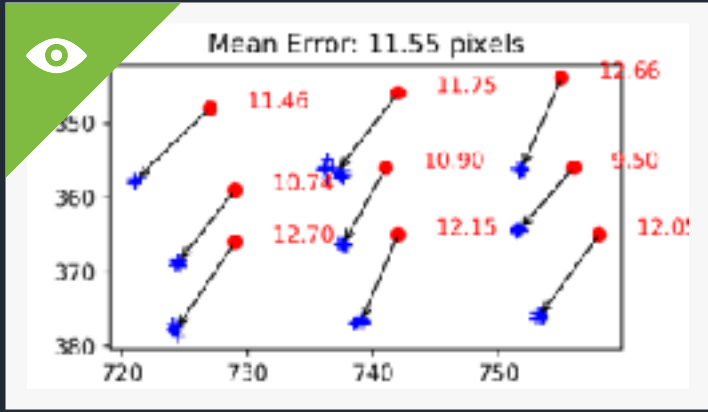
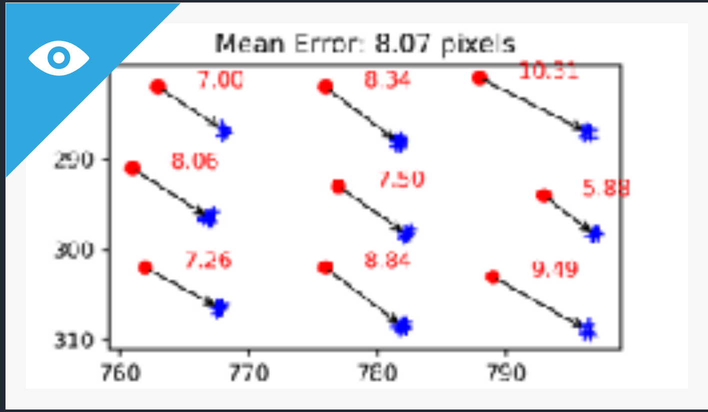
EVALUATION OF PARALLAX COMPENSATION MODEL

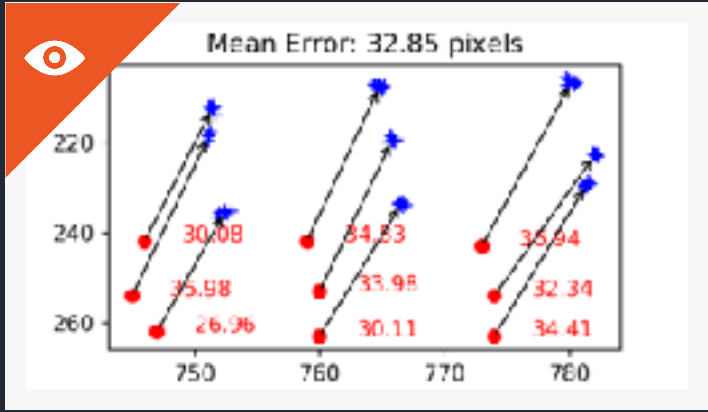
Orientation and Magnitude of Gaze Error Distribution



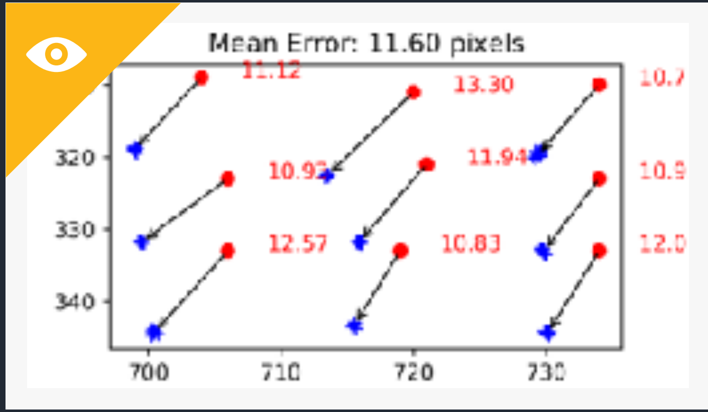
Participant #01



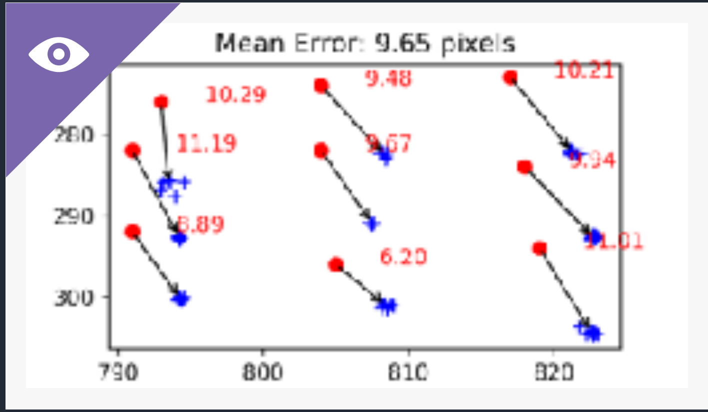
Participant #02



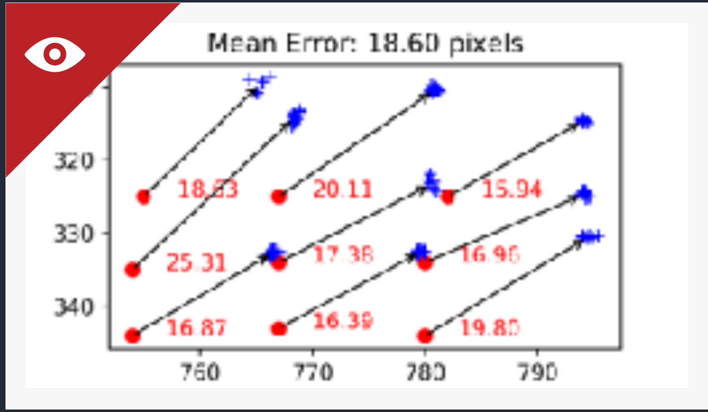
Participant #03



Participant #04



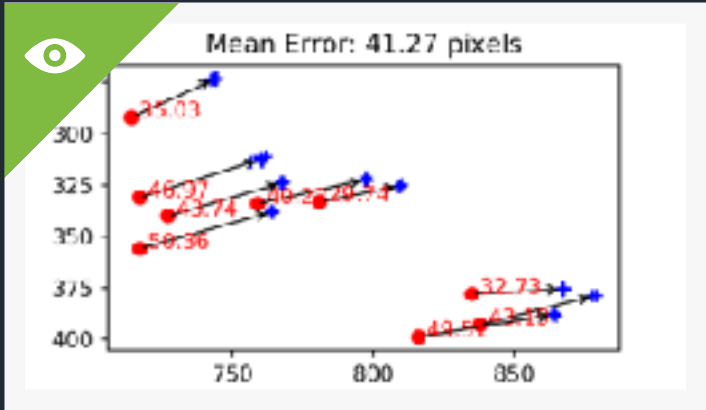
Participant #05



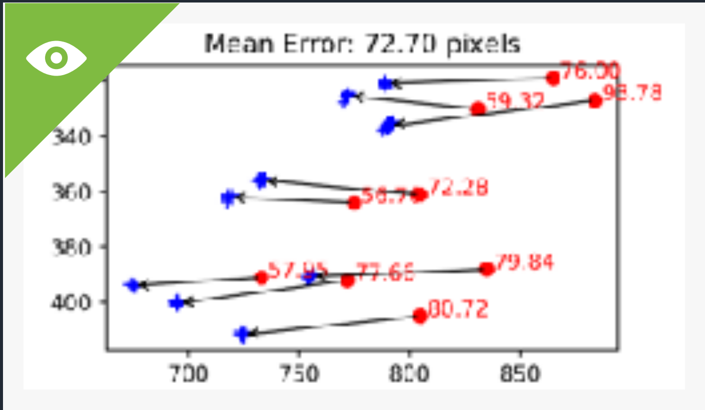
Participant #07

EVALUATION OF HEAD ROTATION COMPENSATION MODEL

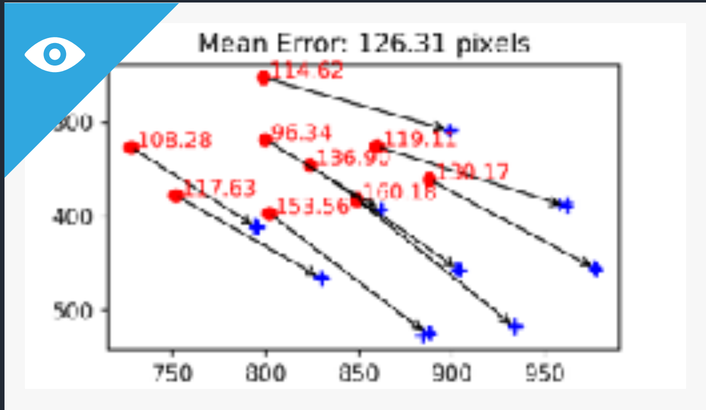
Orientation and Magnitude of Gaze Error Distribution



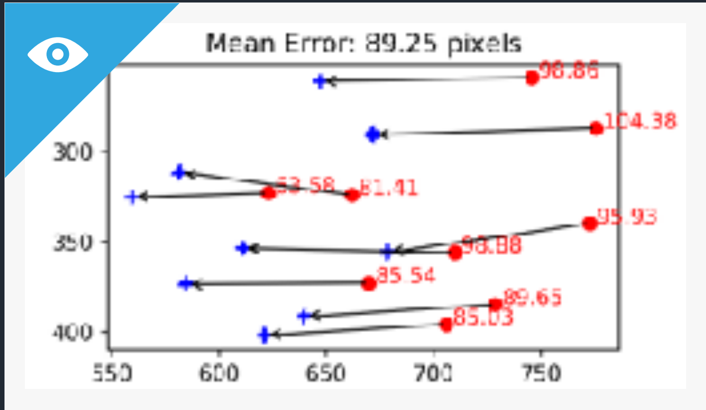
Participant #01 (Turn to the Left)



Participant #01 (Turn to the Right)



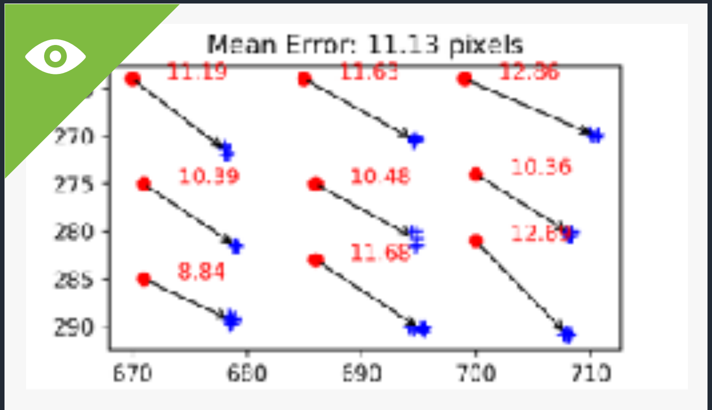
Participant #05 (Turn to the Left)



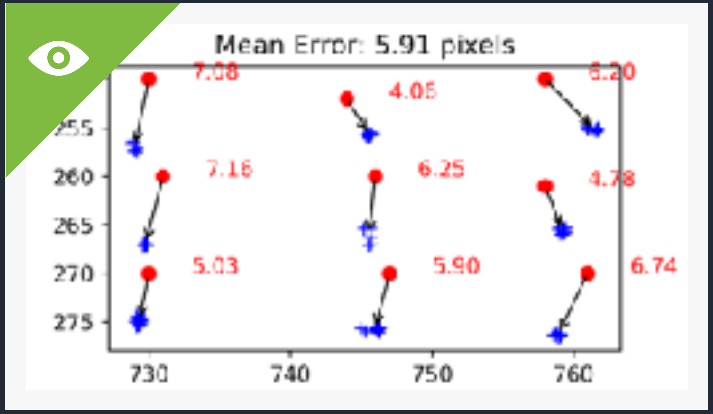
Participant #05 (Turn to the Right)

EVALUATION OF PARALLAX COMPENSATION MODEL

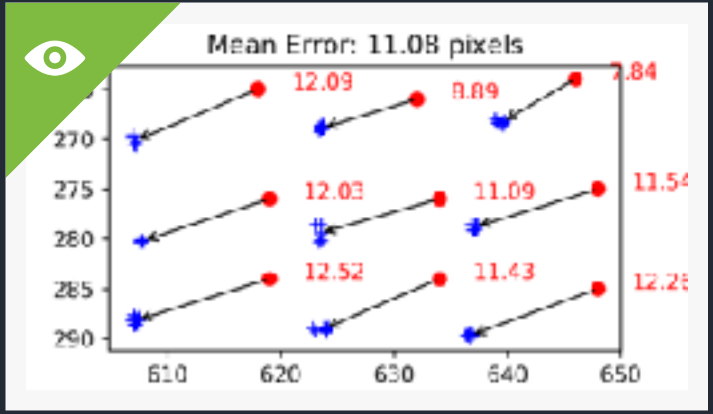
Scene Camera Location



Participant #11 (Left Scene Camera)



Participant #11 (Middle Scene Camera)



Participant #11 (Right Scene Camera)