First-person Vision

Topic Presentation: Yousi Lin

First person “egocentric” vision:

First Person Vision (FPV) is a transformative system that can monitor, record and assist people in their daily lives at work or at play in a truly symbiotic manner.

- Linked to ongoing experience of the camera wearer
- World seen in context of the camera wearer’s activity and goals

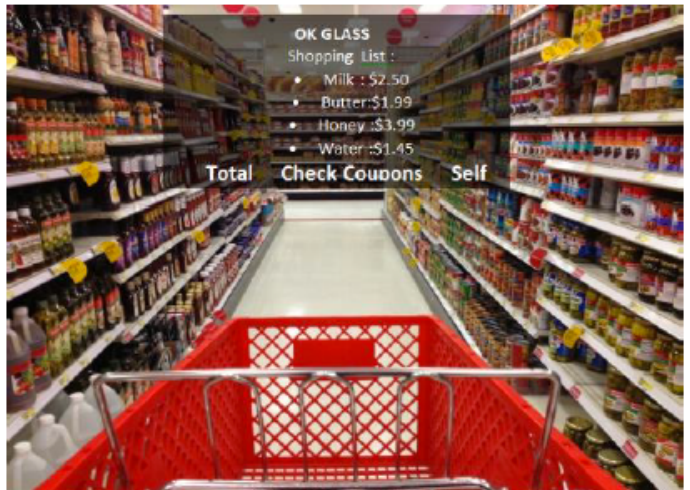
Some of the more important works and commercial announcements in FPV.

SenseCam: released by Microsoft Research in 2006.

GoPro Hero: first one released in 2010.

Google Glasses: released by Google in 2012.

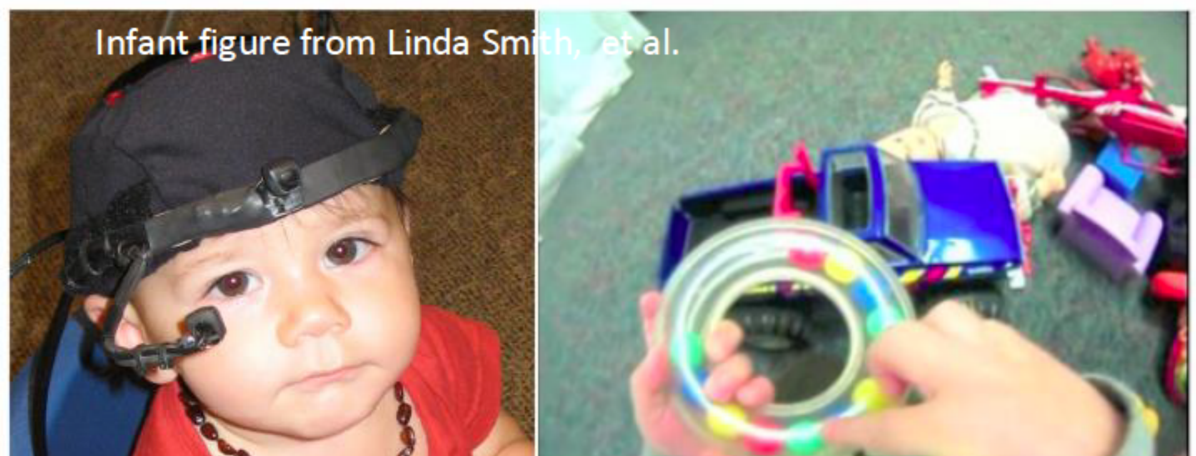
New era for first-person vision



Augmented reality

Health monitoring

Law enforcement



Science

Robotics

Life logging

Kristen Grauman, UT Austin

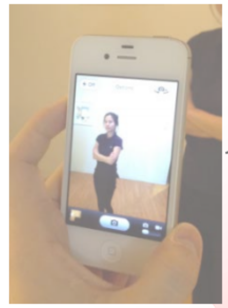
GoPro

Be a HERO.

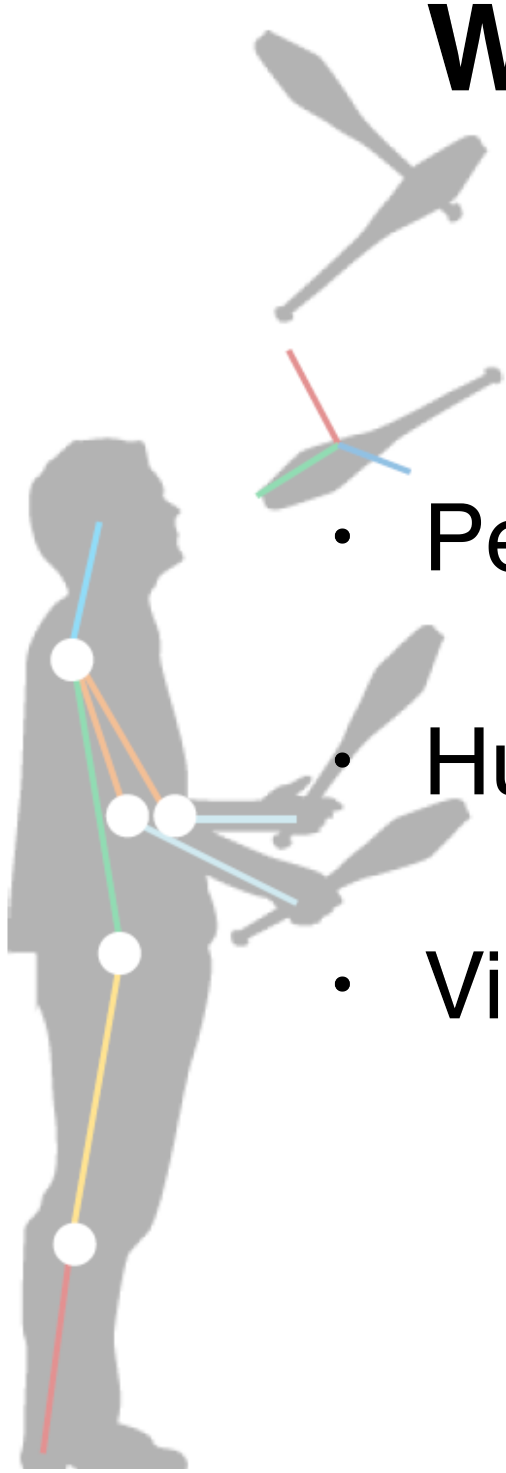
OF THE WORLD

POWERED BY pinkbike

Guillermo | Tijuana



What can a first person camera tell us about the wearer?



- Personal/social attention
- Human kinematics (object/pose/action)
- Visual sensorimotor behaviors

First person camera

slide credits: CVPR 2016 Tutorial: First Person Vision

Learning to Predict Gaze in Egocentric Video

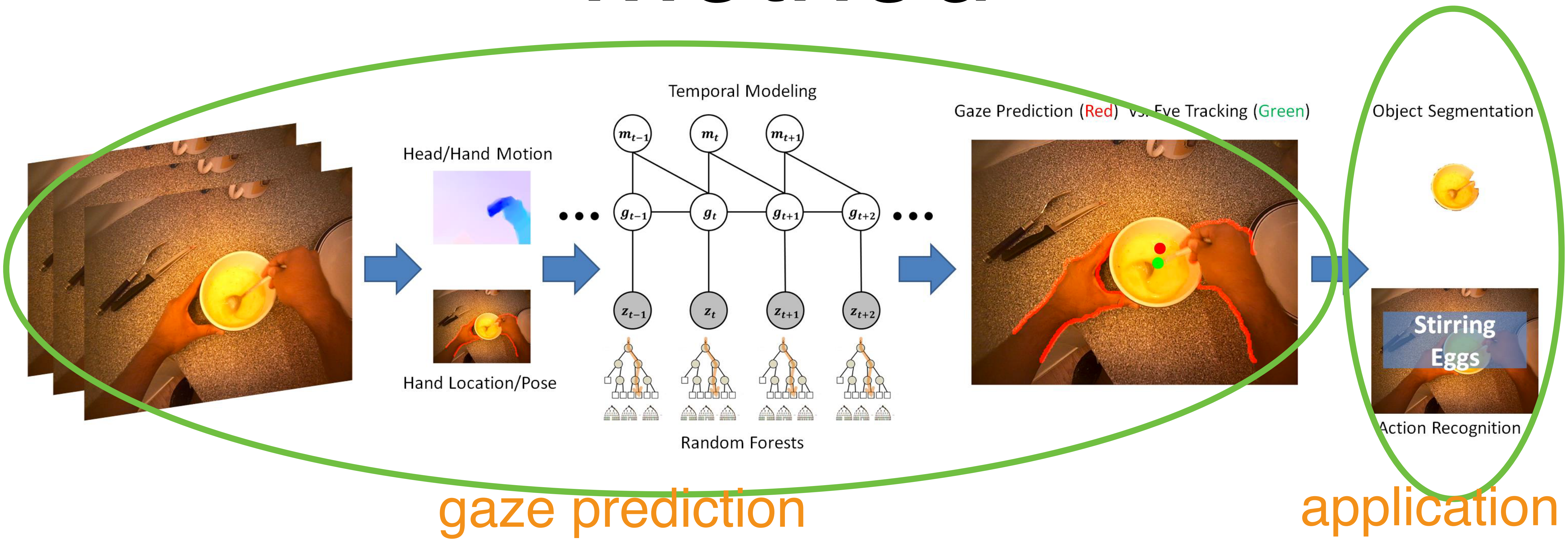
Yin Li, Alireza Fathi, James M. Rehg School of Interactive Computing, Georgia Tech
Proceedings of the 2013 IEEE International Conference on Computer Vision

Goal: Understanding first person's behavior using gaze

Why: Gaze is a very important signal

How: Predicting the camera wearer's gaze using egocentric cues

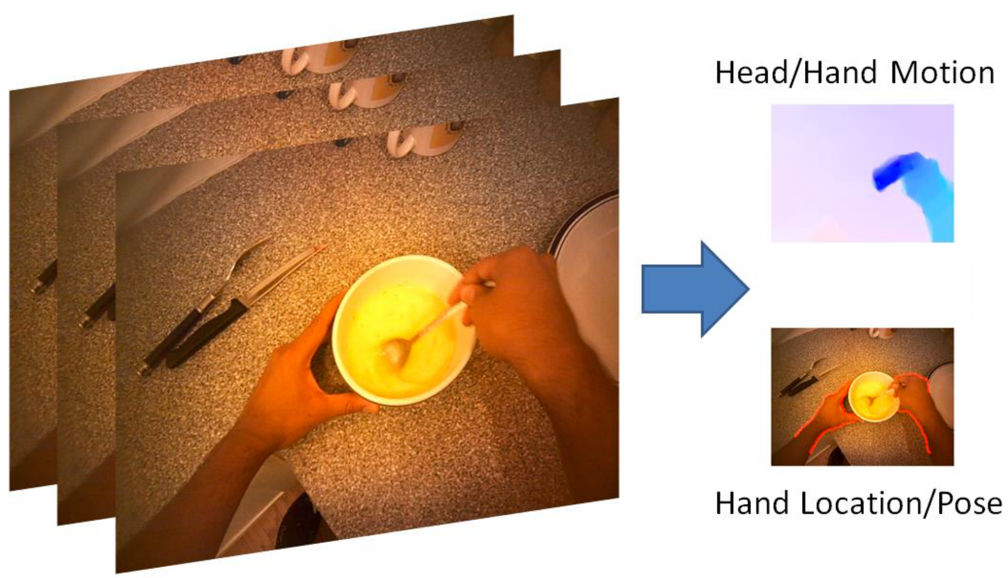
Method



- Modeling the first person's head-eye / hand-eye coordination
- Only use egocentric cues, e.g. hand pose, head movement
- A temporal dynamic model for fixations

Egocentric Cues

Eye, Head and Hand Coordinations



- Center Prior (Head Orientation)
- Head Motion
- Hand Location

They did not use low-level image features or high level task information

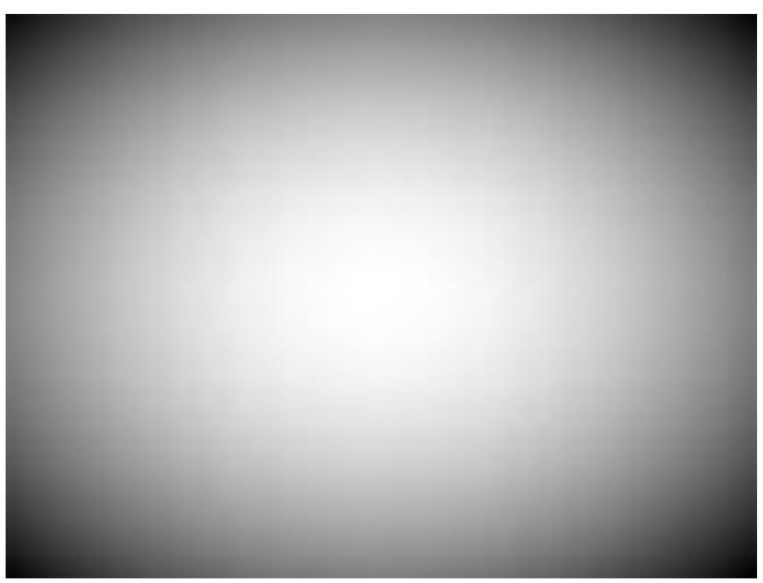
1. Head-Eye Coordination

Center Prior: Head Orientation

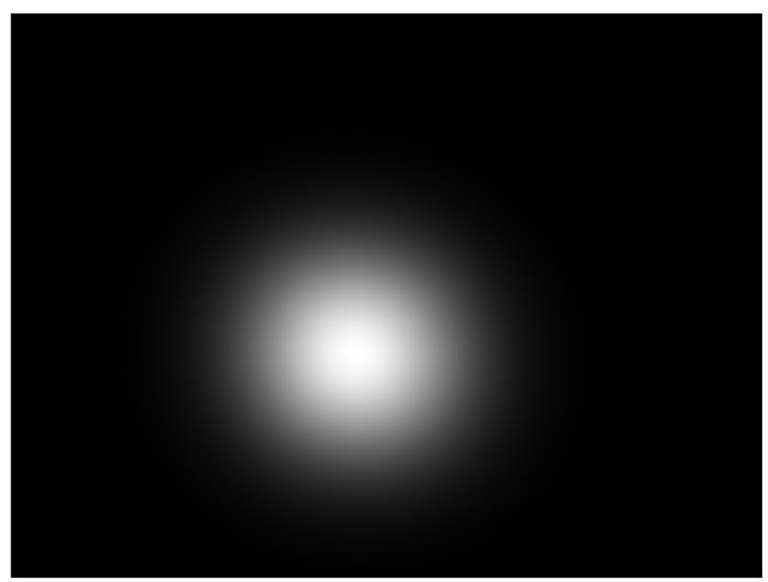
Monitor Based Tracking

Egocentric Gaze Tracking

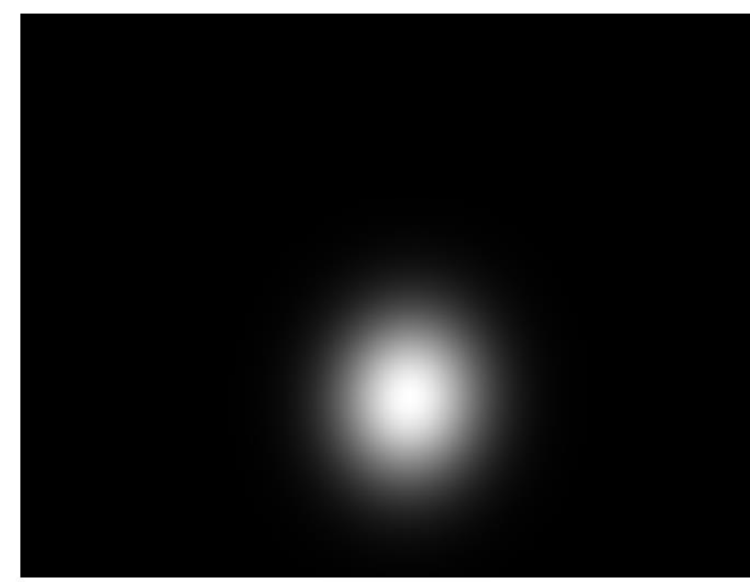
MIT



GTEA Gaze

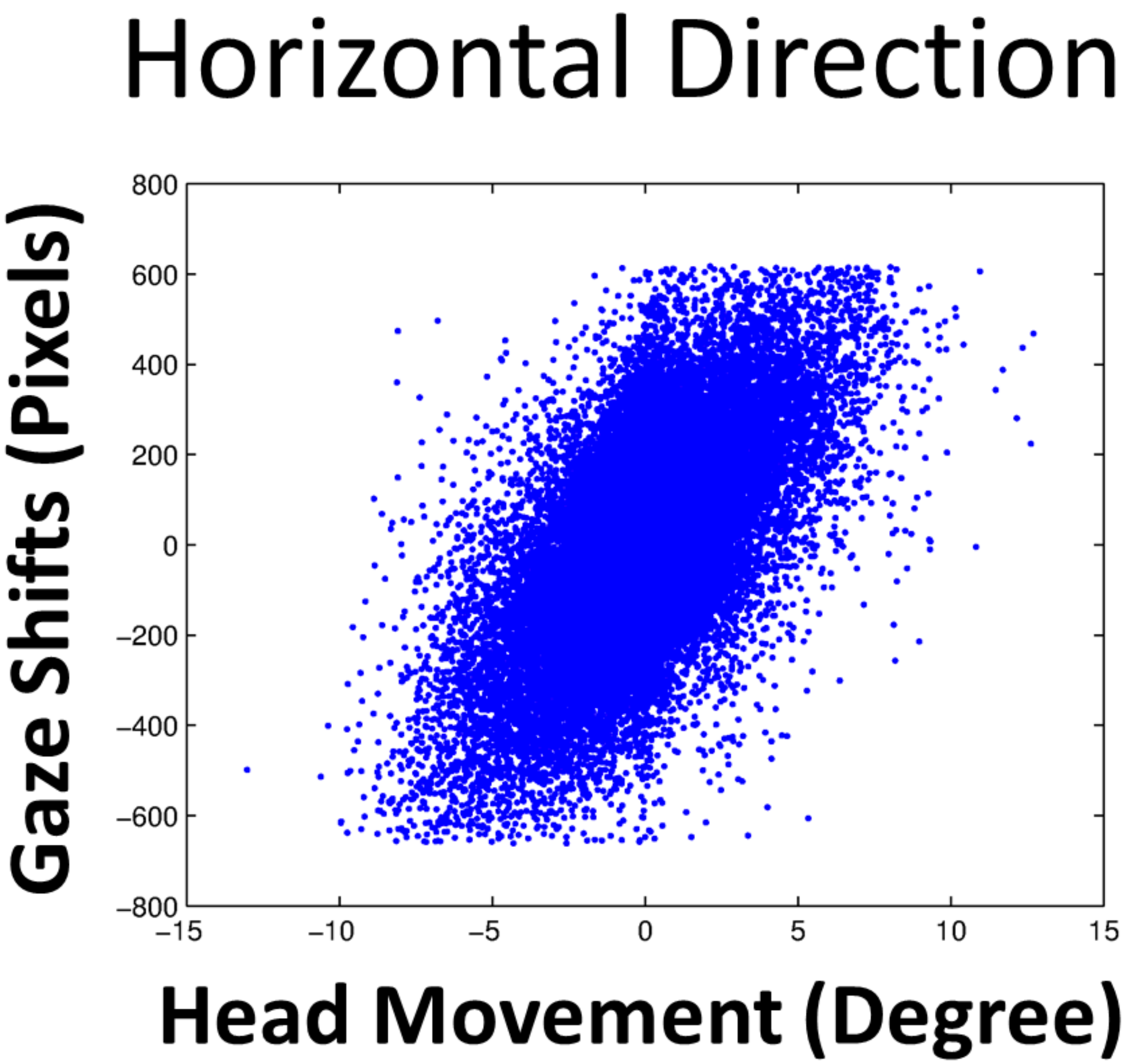


GTEA Gaze+



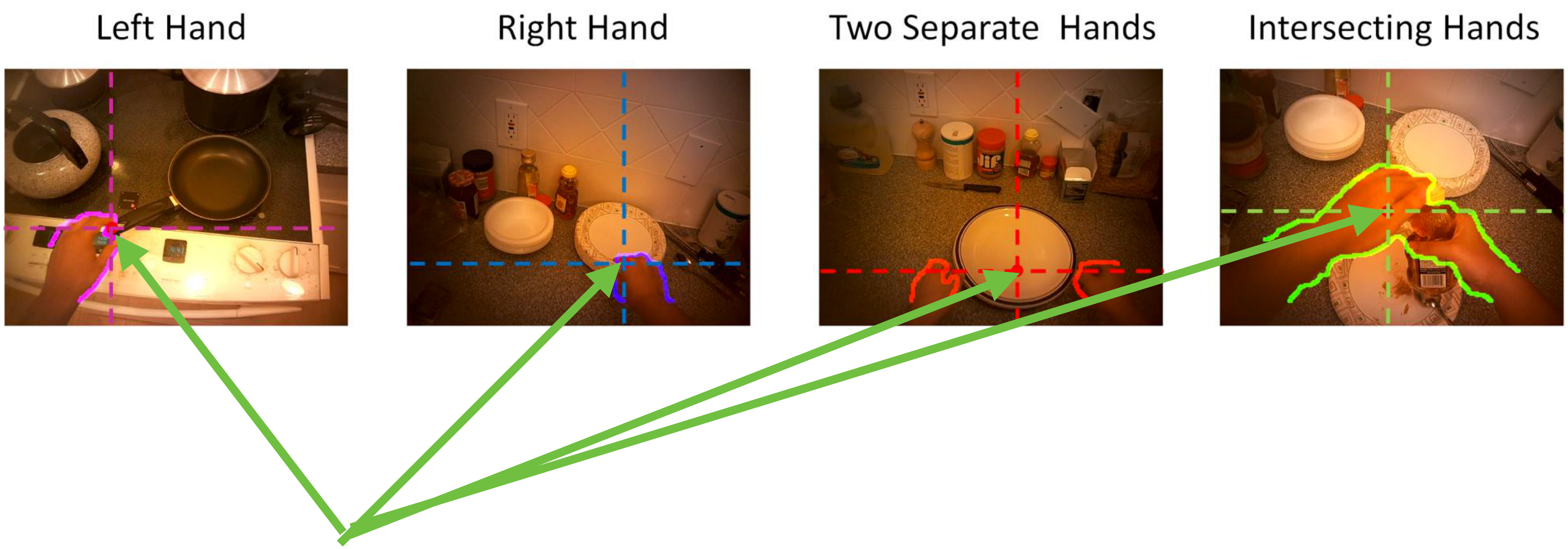
1. Head-Eye Coordination

Head Motion



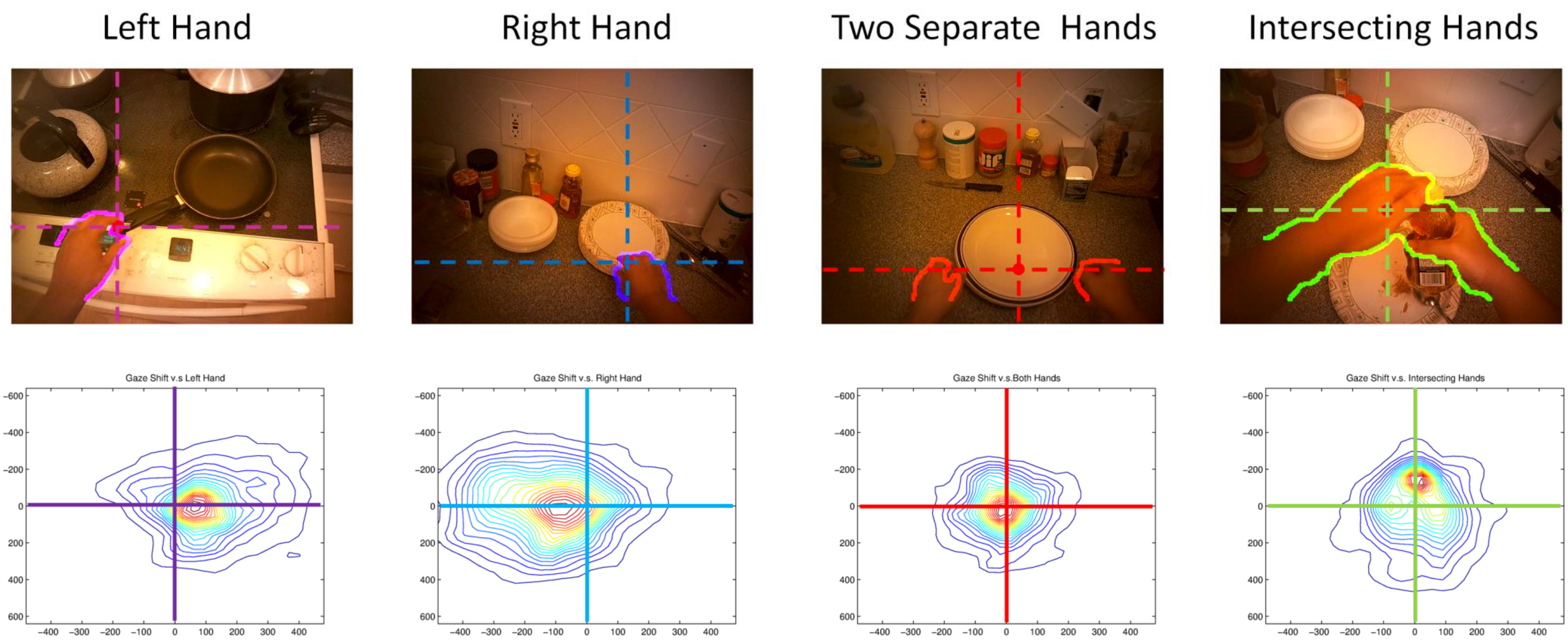
- Large head motion is always accompanied by a large gaze shift
- Linear correlation of head motion and gaze shift in horizontal direction

2. Eye-Hand Coordination



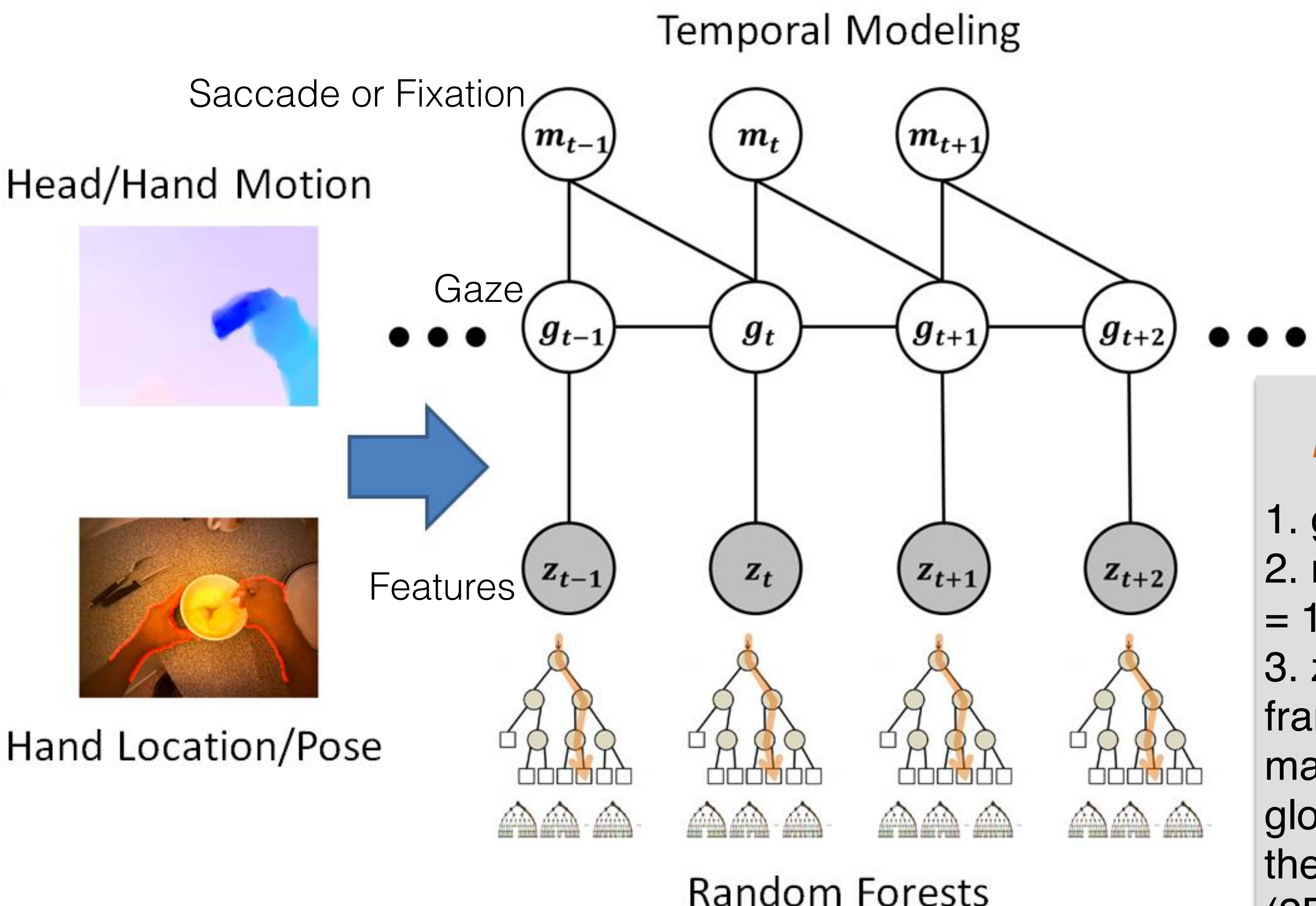
Manipulation Point: a control point where the person is most likely to manipulate an object

2. Eye-Hand Coordination



Peak of gaze distributions around hands, where manipulations are most likely to happen

Temporal Models



notation:

1. g_t: gaze point at frame t.
2. m_t: $m_t = \{0, 1\}$, where $m_t = 1$ denotes g_t is a fixation.
3. z_t: feature vector for frame t, which contains the manipulation point (2D), the global motion vector (2D), the hand motion vector (2D), the hand configuration (1D categorical).

The model: $$P(\{g_t, m_t\}_{t=1}^{K} | \{z_t\}_{t=1}^{K}) = \prod_{t=1}^{K} P(g_t|z_t) \prod_{t=1}^{K} P(m_t|g_{N(t)})$$

Single Frame Gaze Prediction:

$$P(g_t|z_t) \propto \exp\left(-\|g_t - \tilde{g}_t\|_{\Sigma_s}^2\right)$$

Fixations and Gazes:

$$P(m_t|g_{N(t)}) \propto \exp\left(-m_t \sum_{i \in N(t)} \|g_i - g_t\|_2^2\right)$$

$$m_t = \prod_{i \in N(t)} \frac{-sign(\|g_i - g_t\|_2^2 - c) + 1}{2}$$

Inference:

To get the gaze points and fixations, they applied Maximum Likelihood (ML) estimation of the first equation.

Learning:

1. train the single frame random regression tree

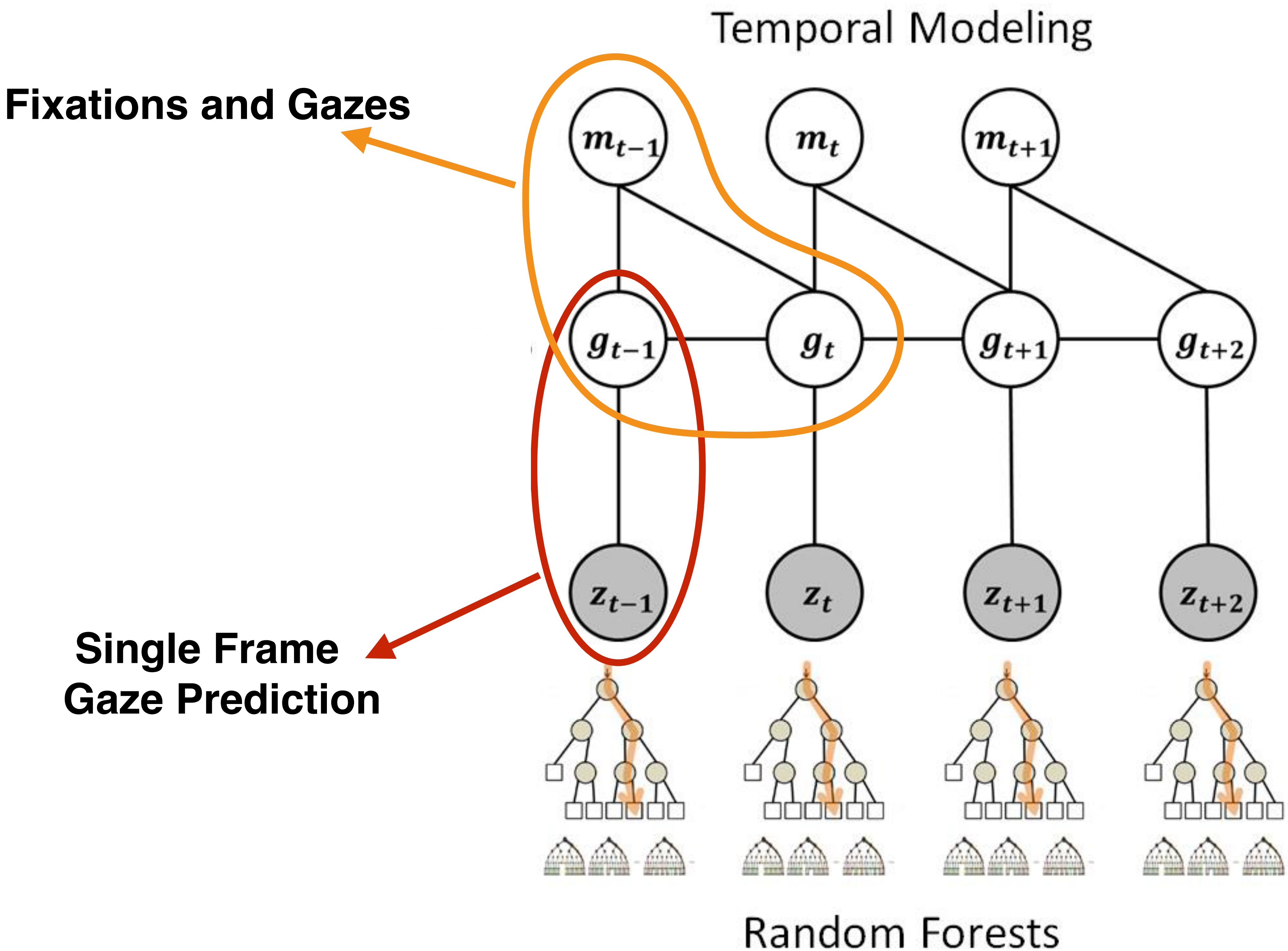
2. select the velocity threshold c, the covariance matrix Σs and the constant λ

notation:

1. $g_{N(t)}$: the temporal neighbors of g_t.

2. $\tilde{g}_t$: $\tilde{g}_t = f(z_t)$
3. Σ_s: covariance matrix
4. c: velocity threshold

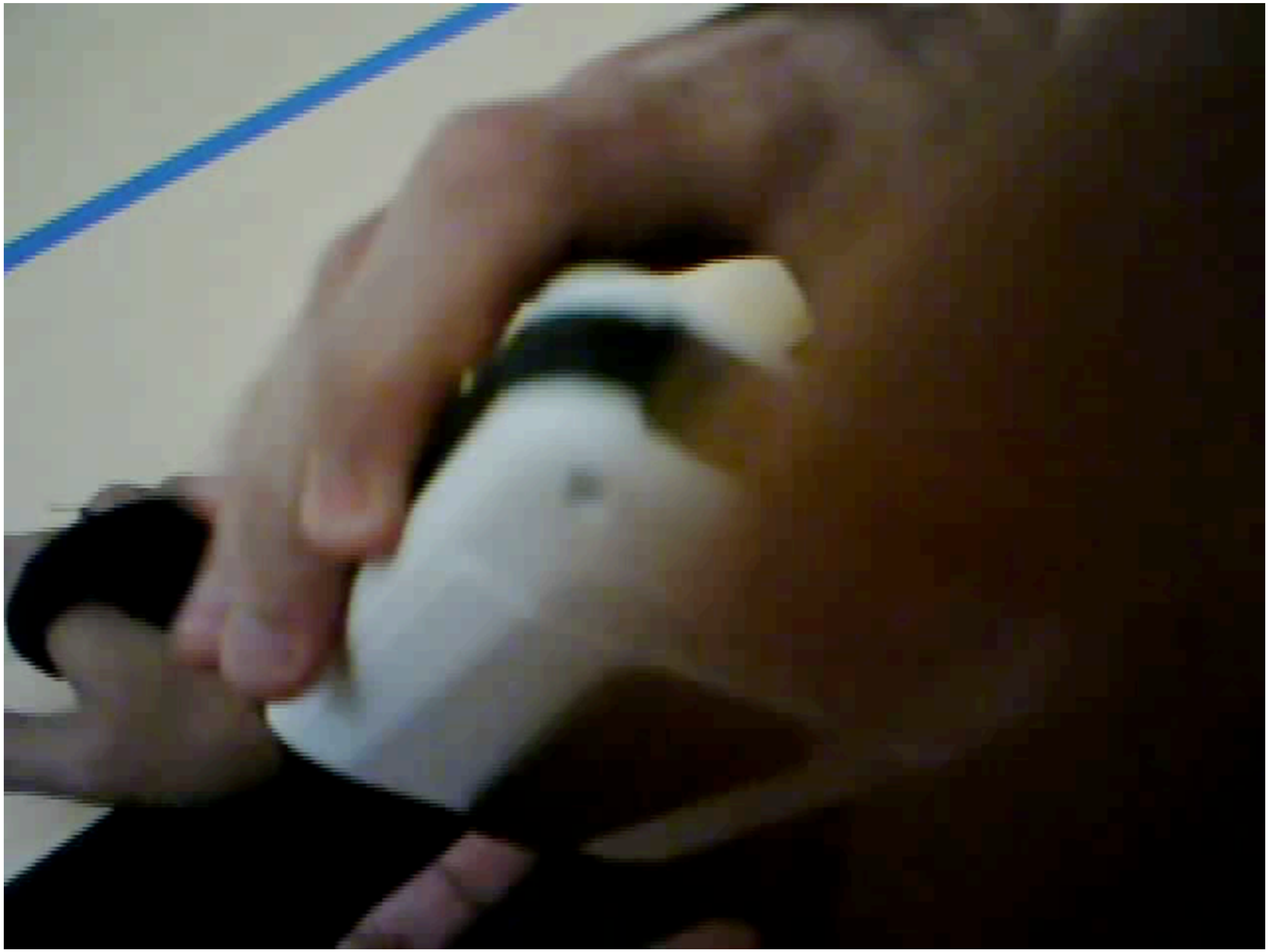
Temporal Models



GTEA Gaze Dataset

- 17 subjects
- Free choice meal preparation activities
- 42 objects

The first dataset of its kind

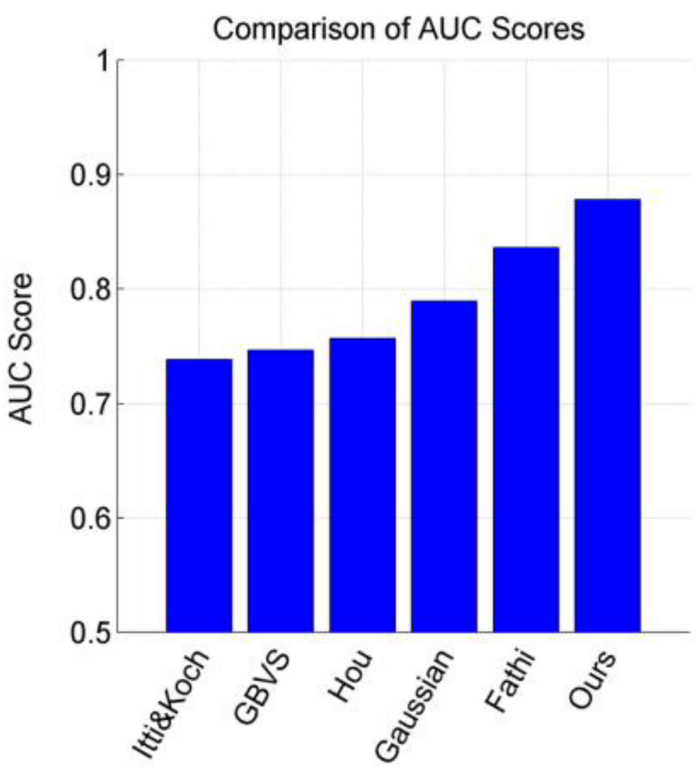


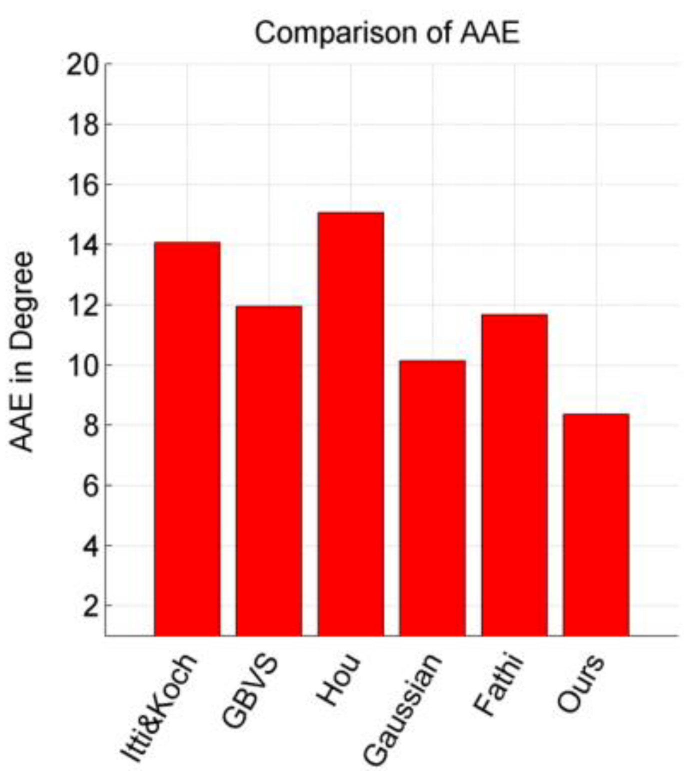
GTEA Gaze+ Dataset

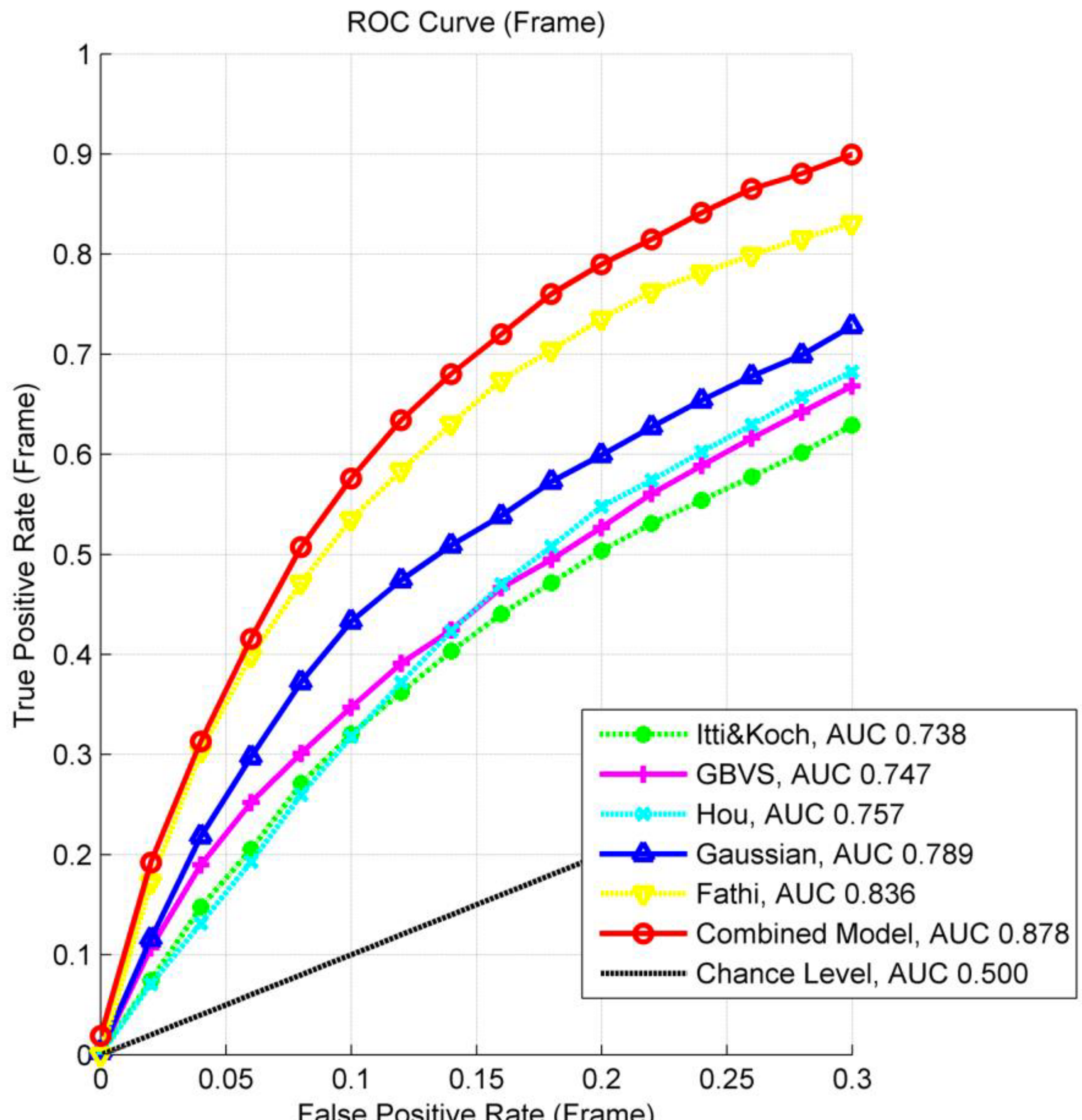
- 6 subjects
- 7 activities (Making pizza, hamburger, breakfast, greek salad, etc.)
- Each activity takes around 10 min, around 100 action in each activity

[redacted]

Results: Gaze Prediction

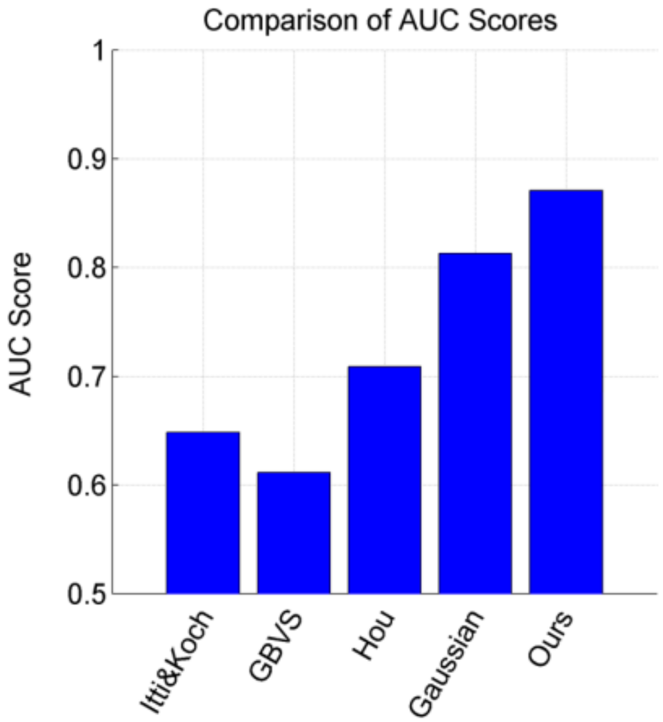


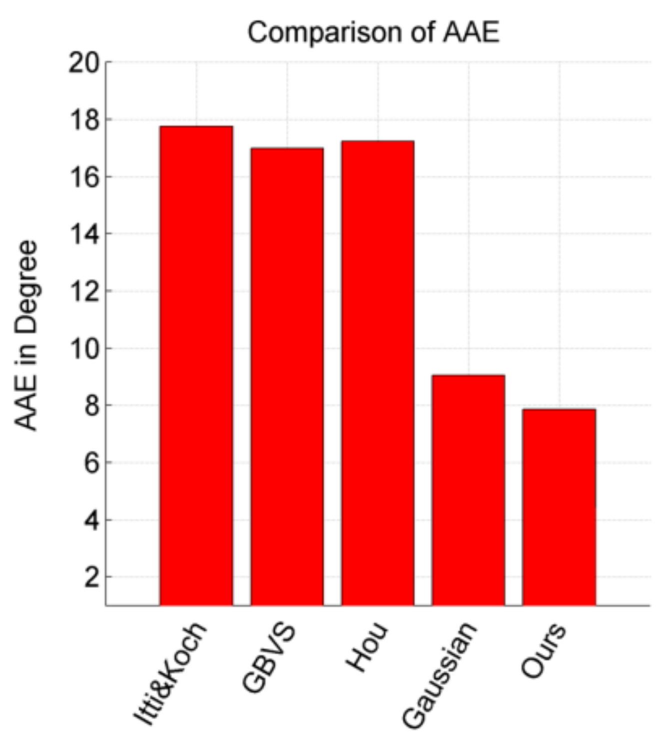


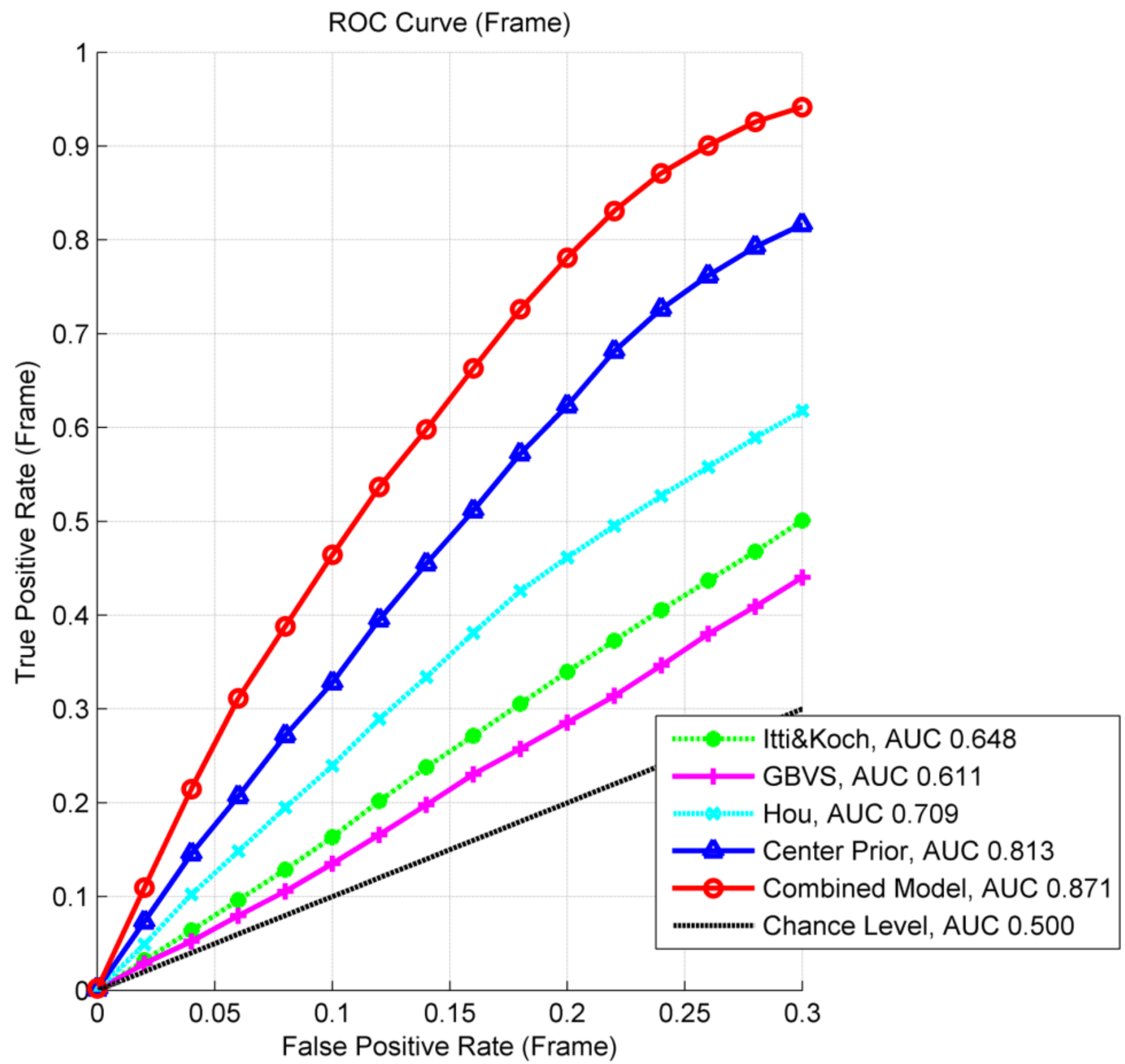


GTEA Gaze Dataset

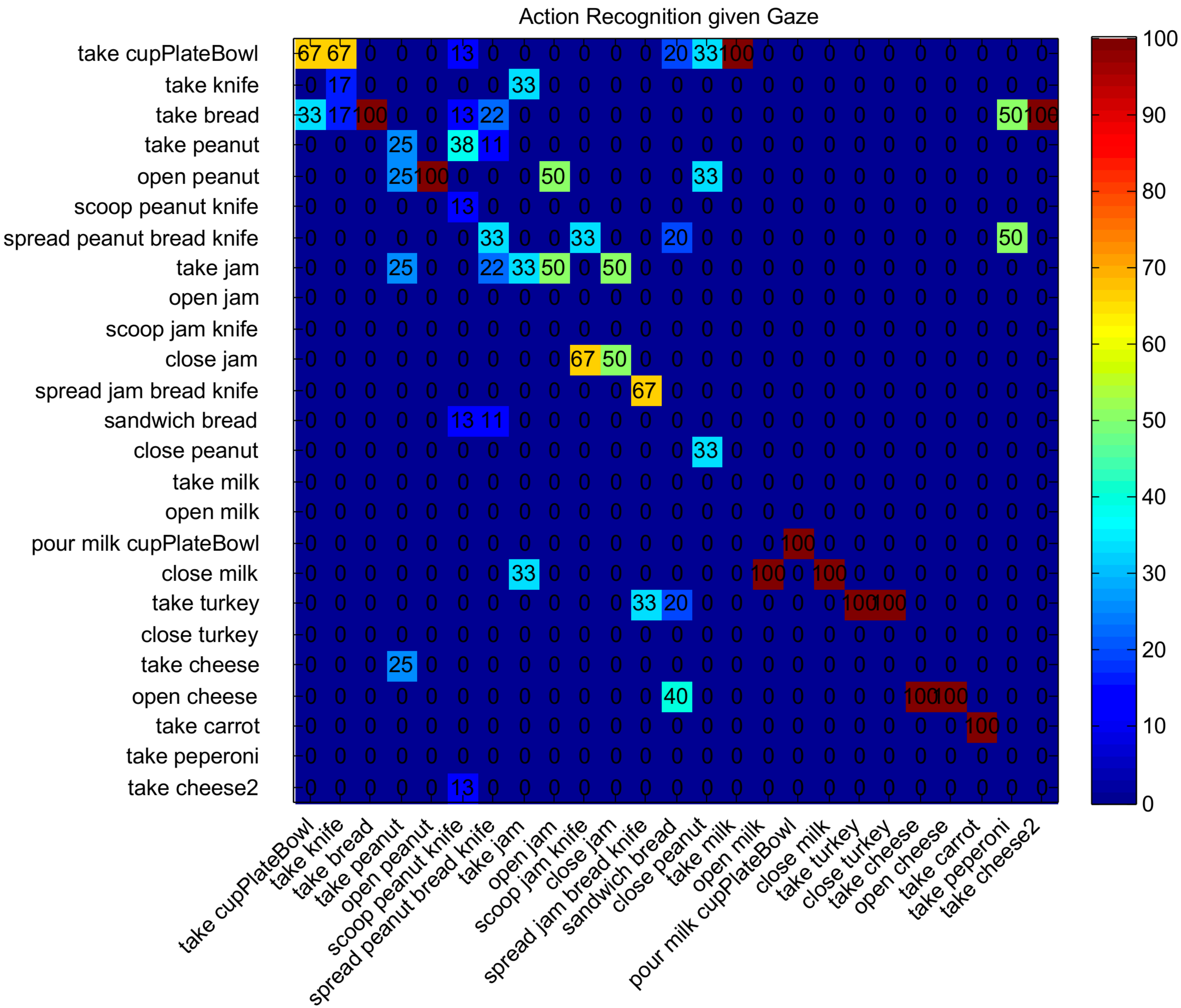
Results: Gaze Prediction





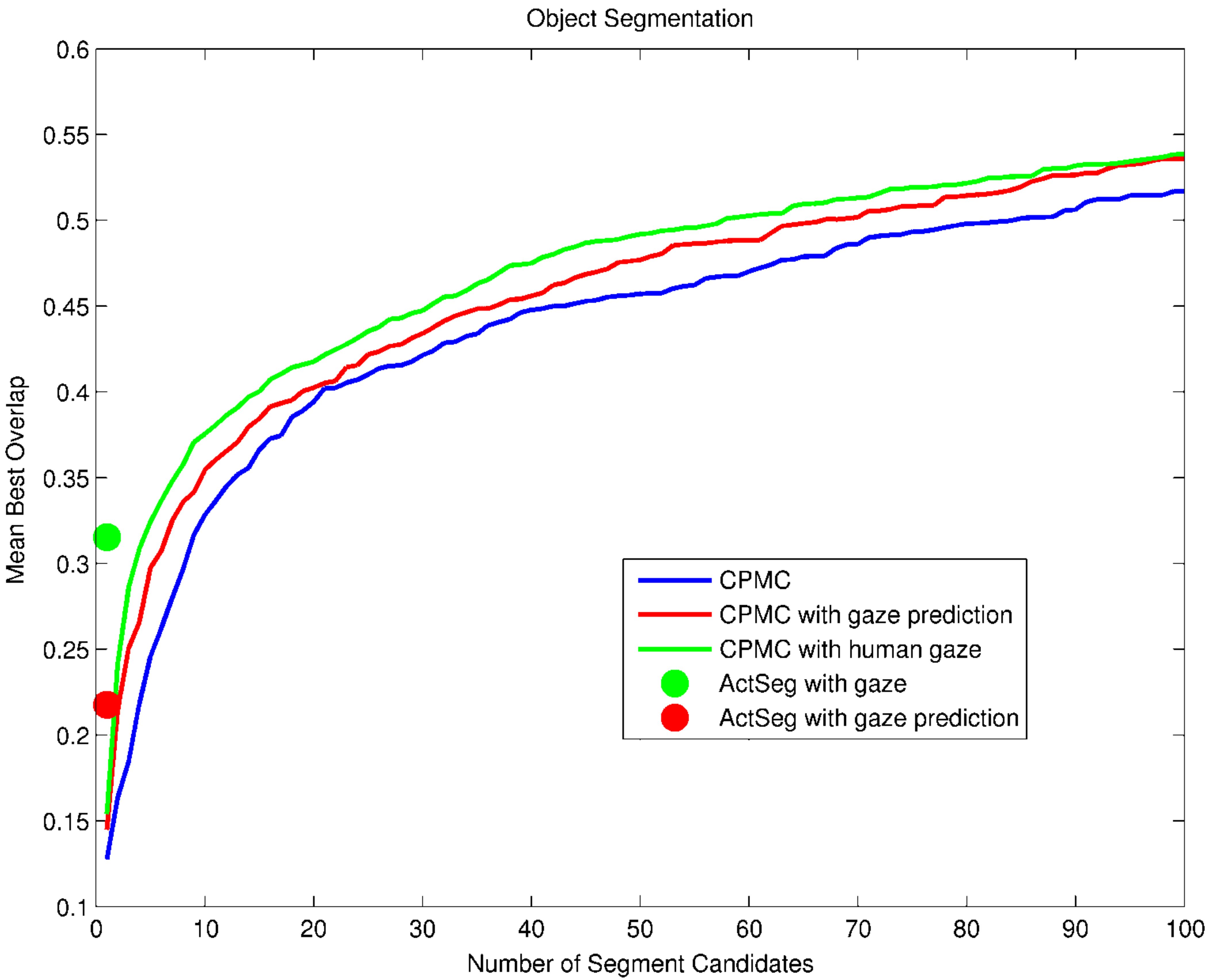


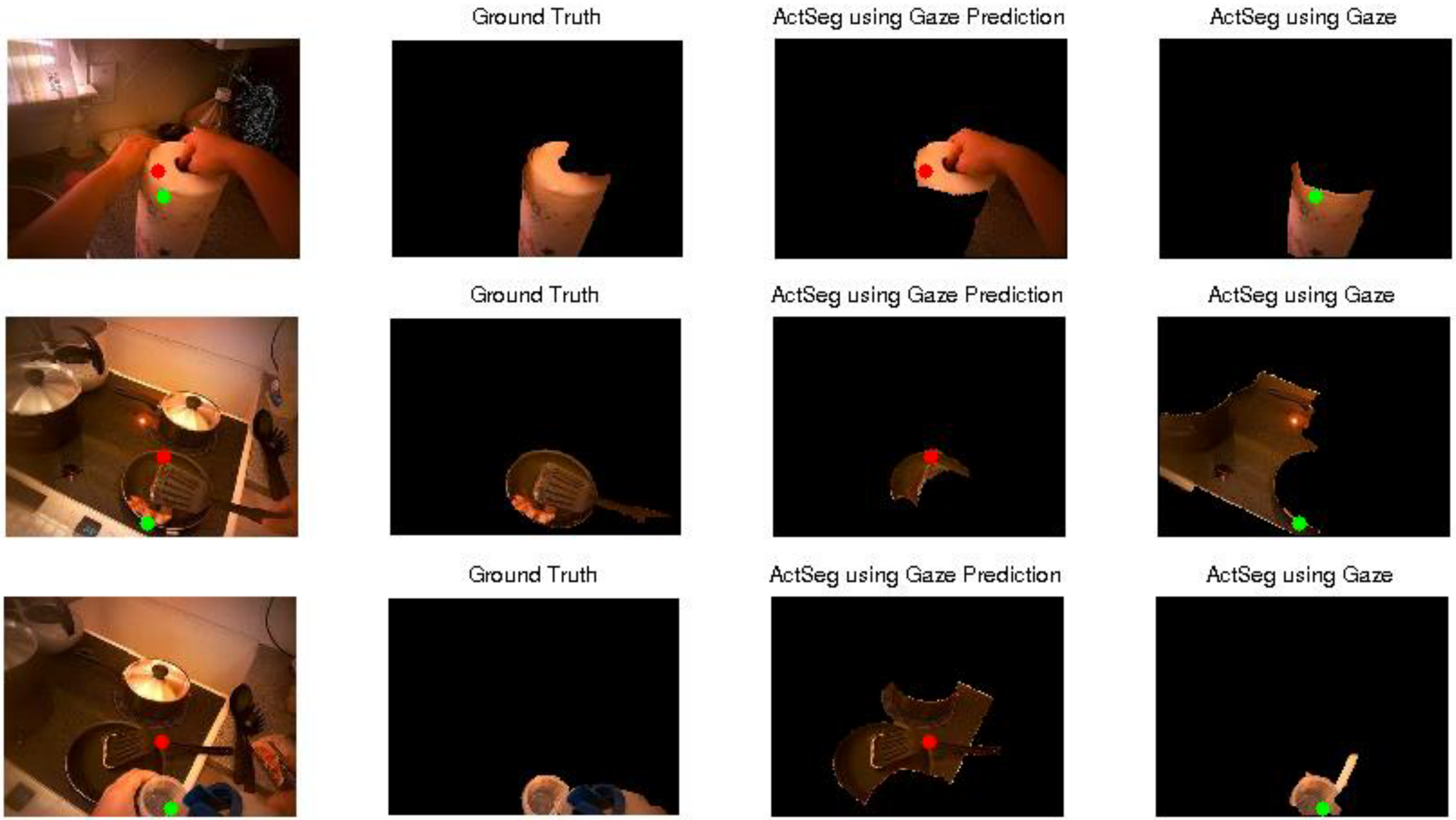
Application: Action Recognition



- Action recognition of 25 classes using predicted gazes 29% -> 32.8%
- Action recognition using human gaze s -> 49%

Application: Object Segmentation




Ground Truth
ActSeg using Gaze Prediction
ActSeg using Gaze
Ground Truth
ActSeg using Gaze Prediction
ActSeg using Gaze
Ground Truth
ActSeg using Gaze Prediction
ActSeg using Gaze

Conclusions

- A small circle of pixels around the point of gaze is sufficient to recognize daily actions in egocentric vision
- They treat gaze as a latent variable and showed that they could predict it when it cannot be measured
- Gaze prediction based on user's head movement and hand location is surprisingly effective

Thank you!