Daily Activity Recognition Combining Gaze Motion and Visual Features

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Outline

- Introduction
- Proposed Method
- Experiment
- Conclusion

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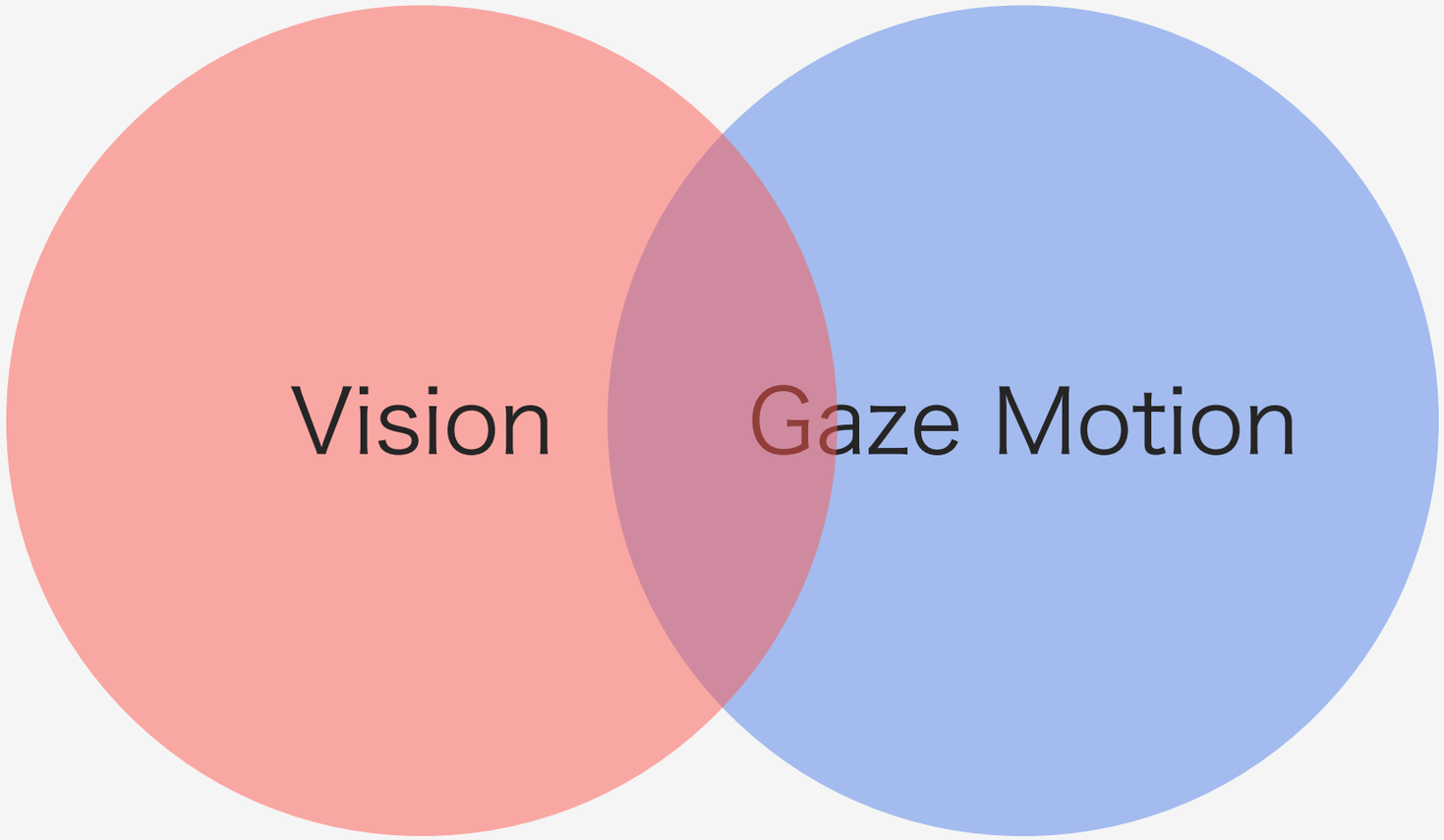
- **Introduction**
- Proposed Method
- Experiment
- Conclusion

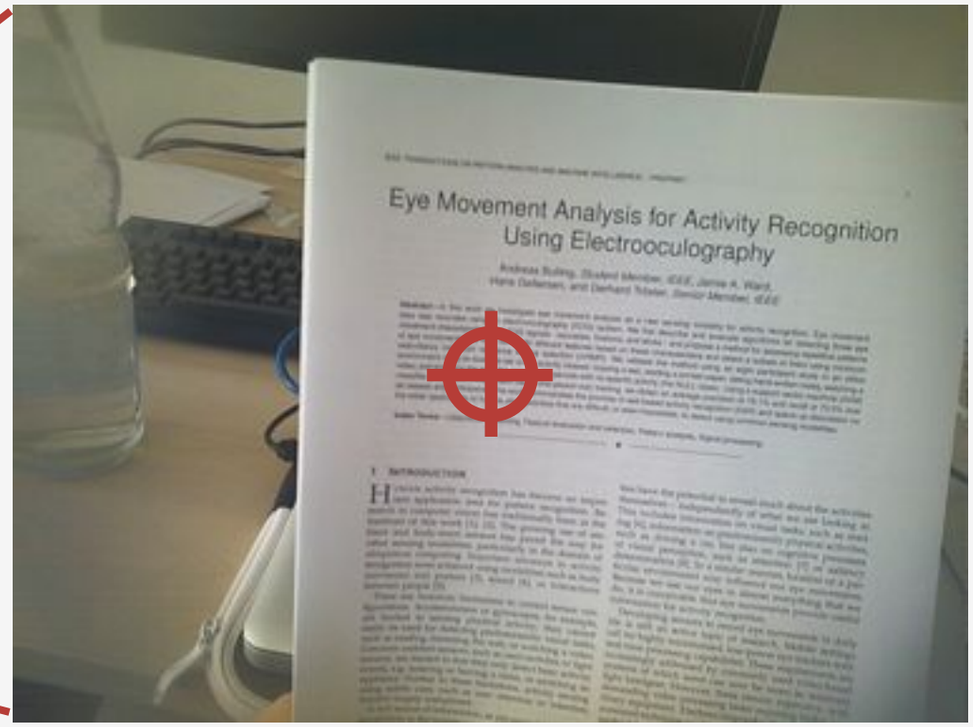
Focus



- Activity recognition draws public attention
- Focus on vision-based and Gaze motion-based method
- These methods deal with activities that involve eye movements

Eye Tracker

Gaze Position
(Where the User Fixates)



Scene Image

- An eye tracker is useful for recognizing activities that involve eye movements
- Record a scene image video as well as the gaze position data

Related Works

- Gaze motion-based activity recognition:
  - Bulling et al., “Eye movement analysis for activity recognition using electrooculography.”[1]
- Vision-based activity recognition:
  - Hipny et al., “Recognizing Egocentric Activities from Gaze Regions with Multiple-Voting Bag of Words.”[2]

They used only each modality (Motion or Vision)

[1] Bulling, Andreas, Ward, Jamie, Gellersen, Hans, and Töster, Gerhard. Eye movement analysis for activity recognition using electrooculography. IEEE transactions on pattern analysis and machine intelligence, 33, 4 (2011), 741-53.

[2] Hipiny IM, Mayol-Cuevas W. Recognising Egocentric Activities from Gaze Regions with Multiple-Voting Bag of Words. CSTR-12-003. 2012.

Purpose

Activity

- can be expressed by "how eyes move”
- can also be expressed by "what eyes see”

We use both vision-based and gaze motion-based modality for activity recognition

Purpose

- Propose a method combining gaze motion-based method and vision-based method

- Verify the hypothesis:
  Both combination of vision and gaze motion can improve recognizing activities that involve eye movements

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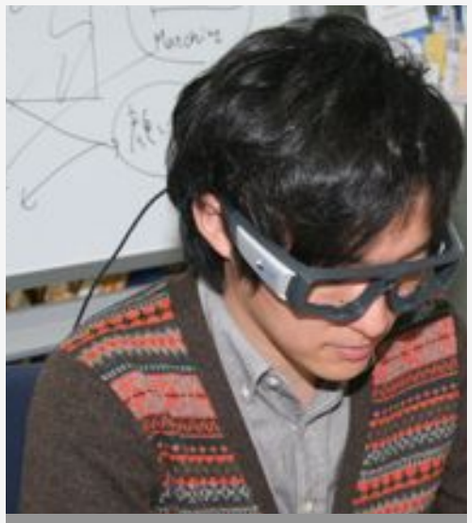
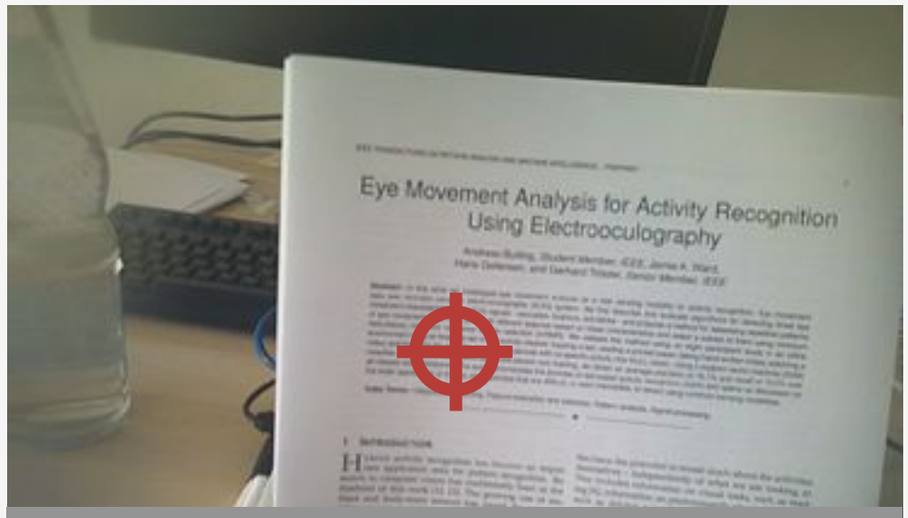
Overview



Eye Tracker



Record Gaze Points
and Scene Images

Gaze Motion
Feature

Visual Feature

Classifier

Classifier

Output

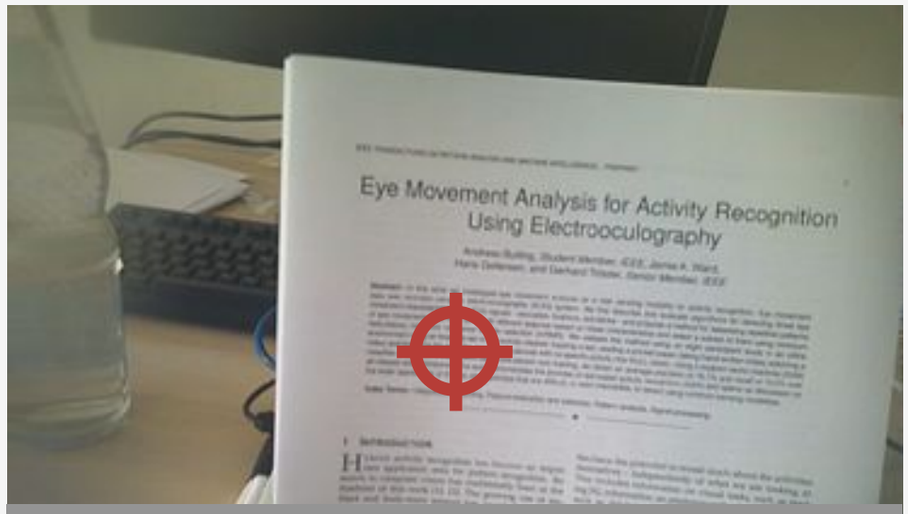
Output

Fusion

Result

Overview

Eye Tracker



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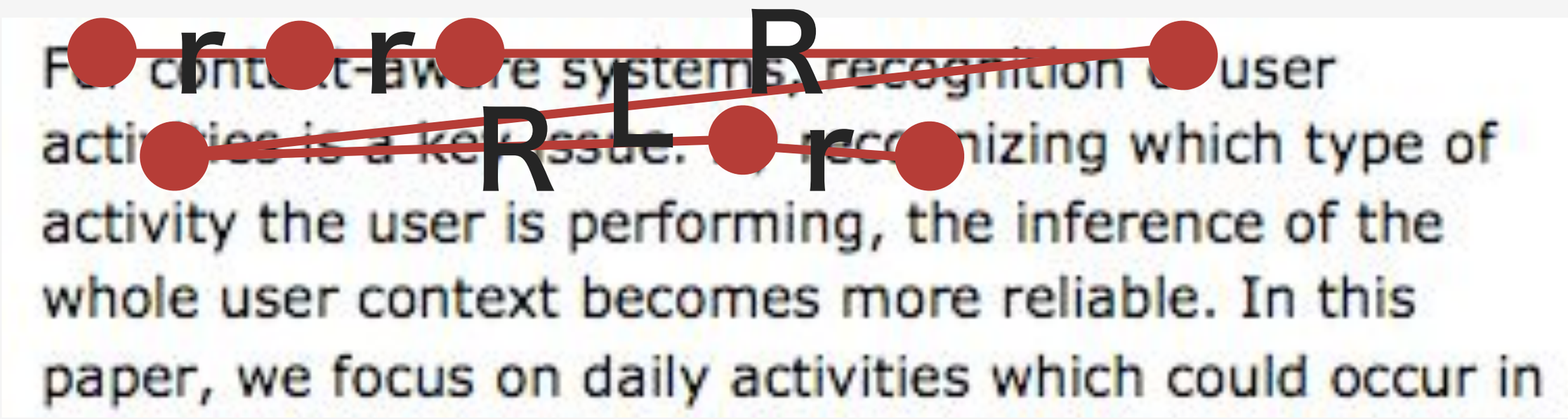
Gaze Motion Feature

- The method proposed by Bulling et al.



Saccade

Fixation

Convert

rrRLRr

Representing Size and Direction of Saccade

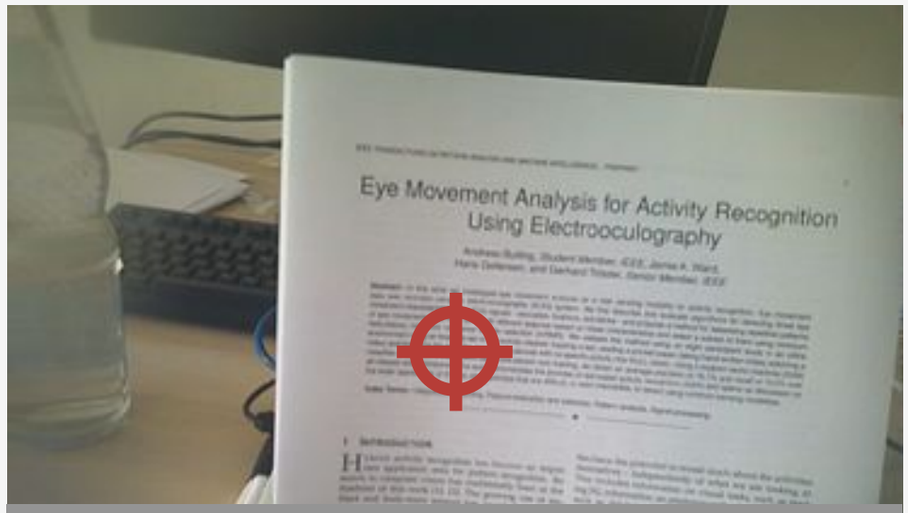
N-gram method

Statistical Fature

[1] Bulling, Andreas, Ward, Jamie, Gellersen, Hans, and Töster, Gerhard. Eye movement analysis for activity recognition using electrooculography. IEEE transactions on pattern analysis and machine intelligence, 33, 4 (2011), 741-53.

Overview

Eye Tracker



Record Gaze Points
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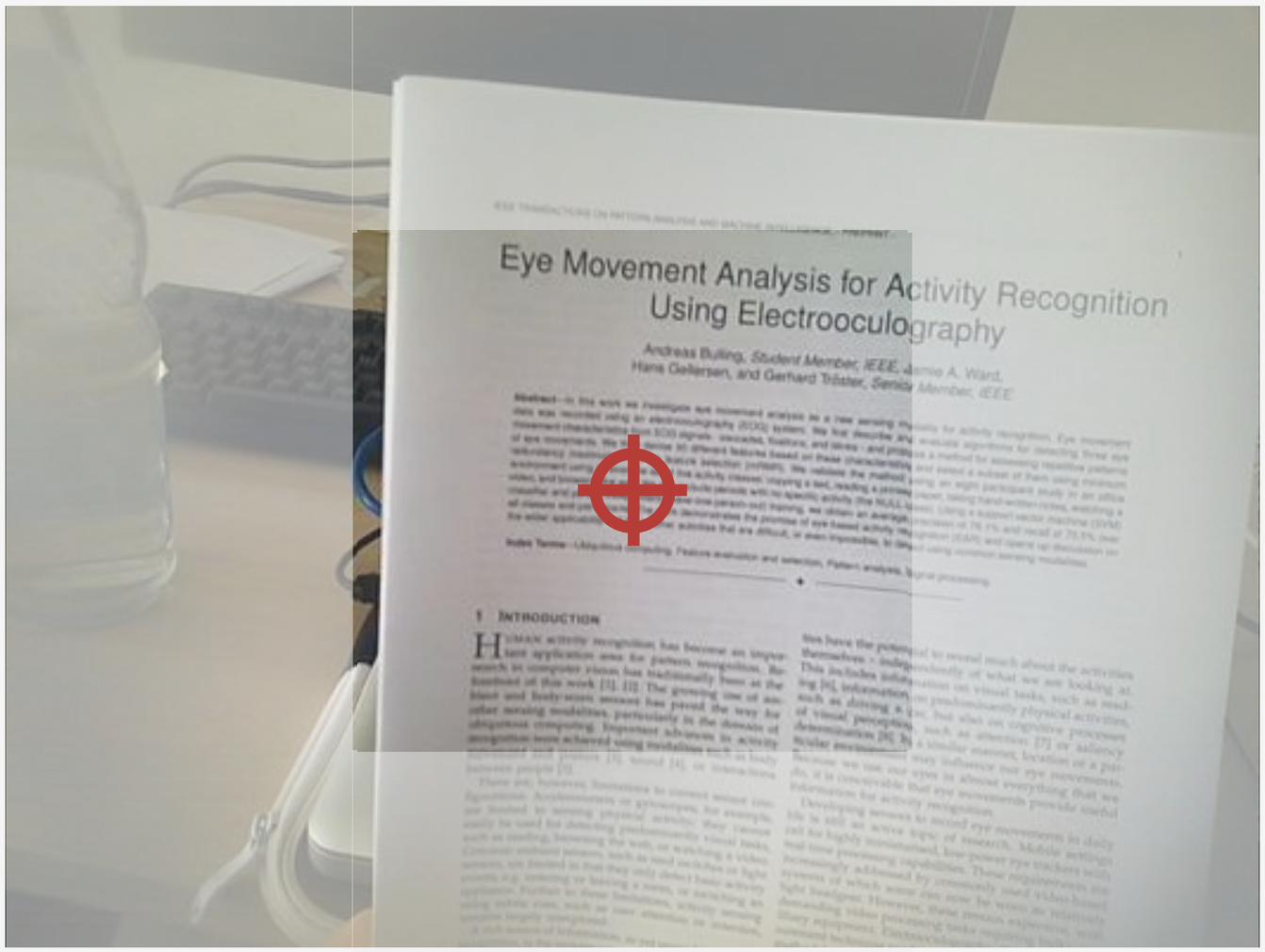
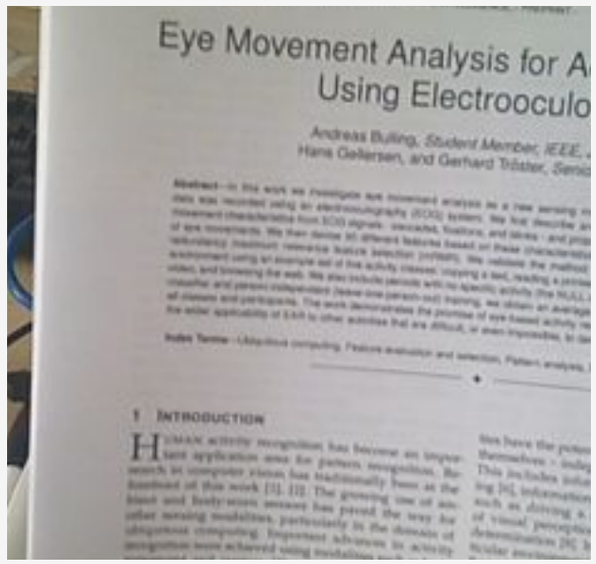
Visual Feature



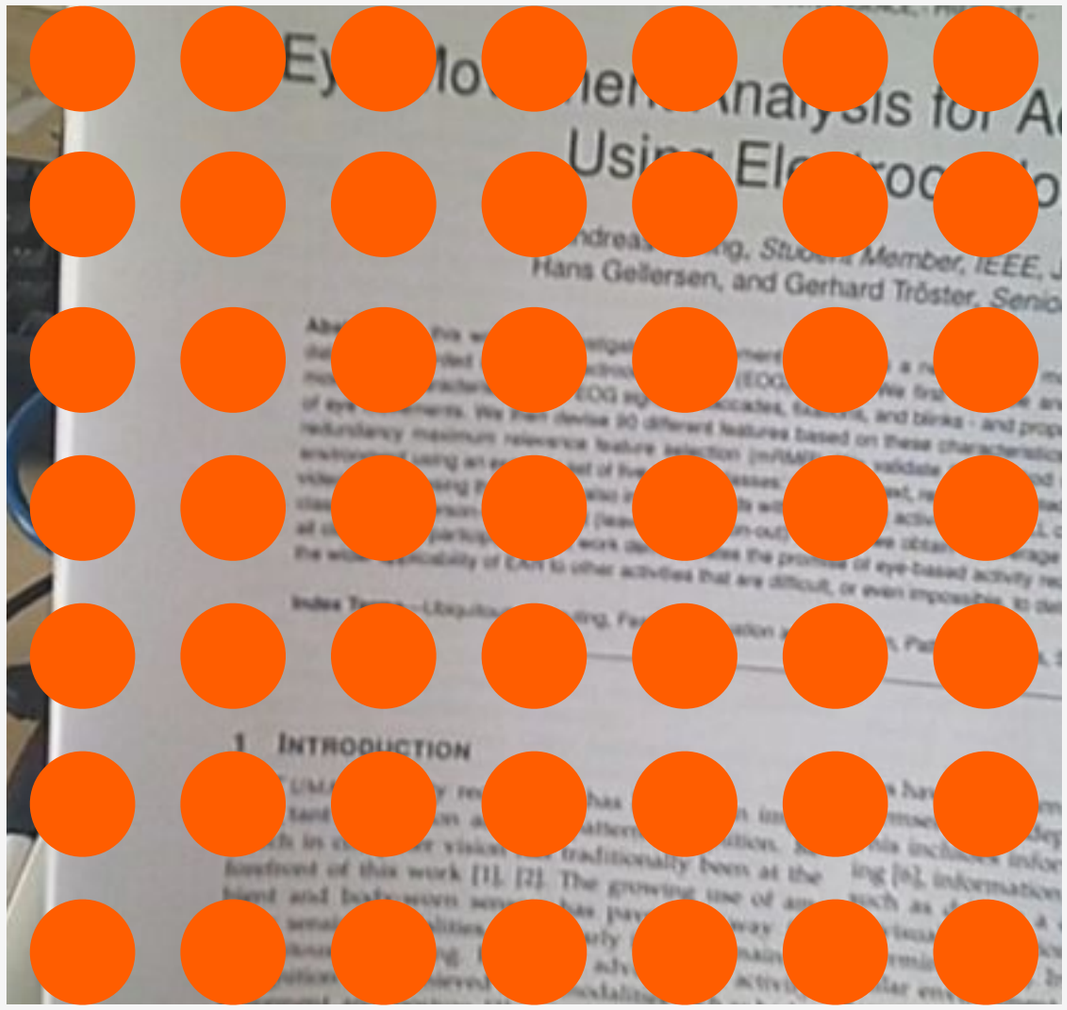
Crop a region around gaze points
to remove a irrelevant region

Visual Feature



Crop a region around gaze points
to remove a irrelevant region

Local Feature Extraction

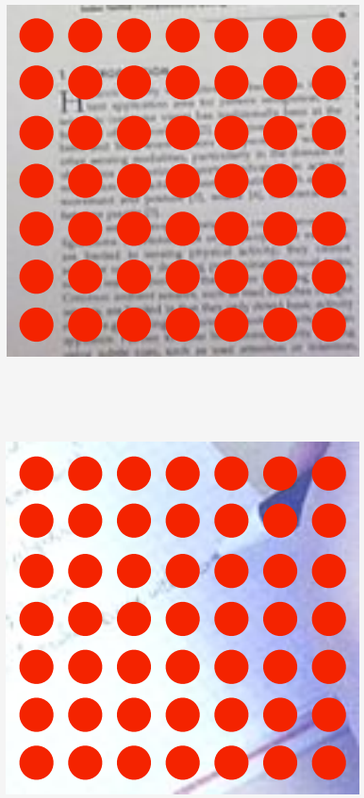


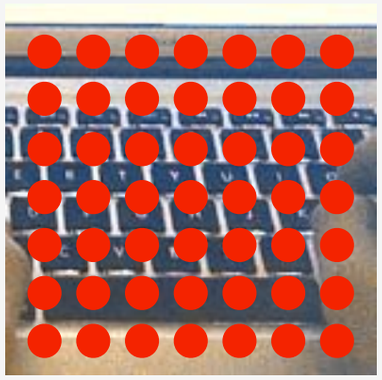
Intrest Points
by Dense Sampling

Extract Local Features
(PCA-SIFT)
From Each Point

Convert to Global Feature

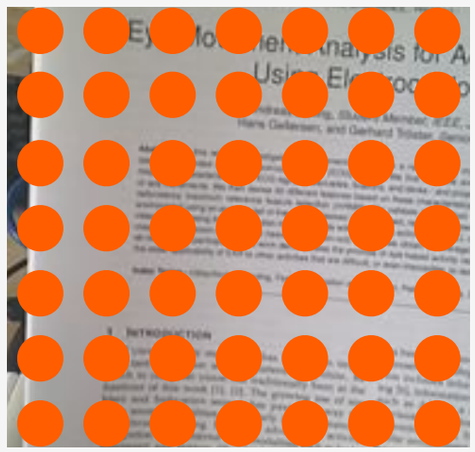
Learning Image





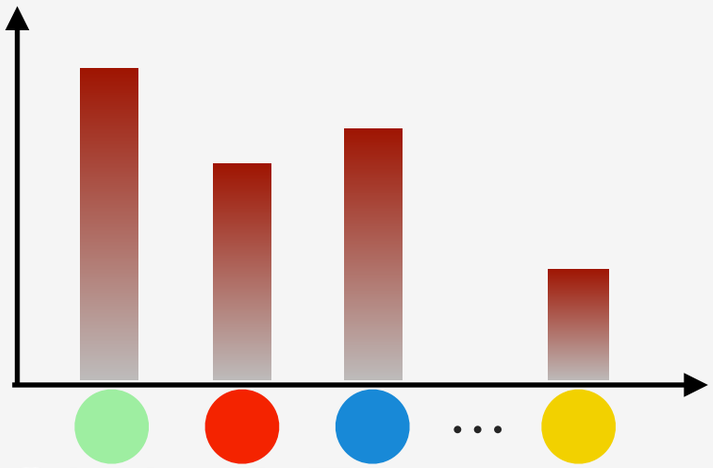
k-means clustering

k centroids (visual words)



Test Image

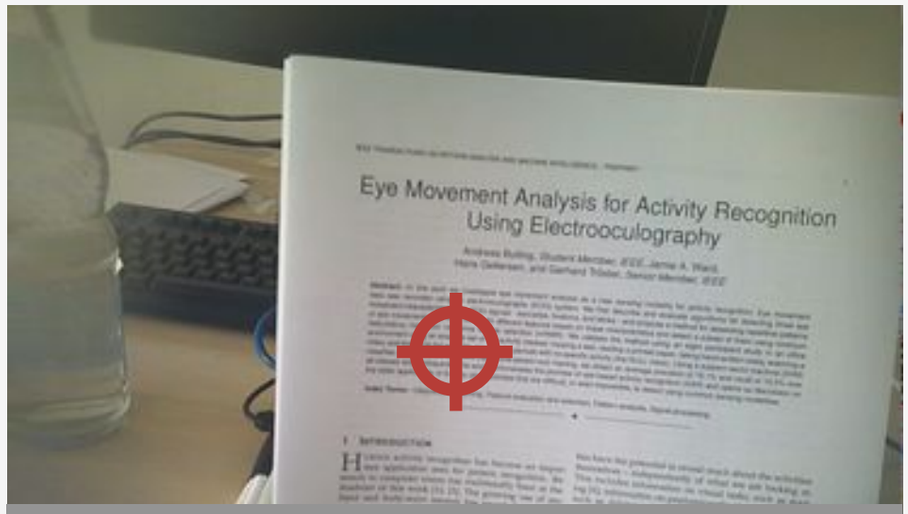
Nearest Neighbor Search to visual words



Global Feature

Overview

Eye Tracker



Record Gaze Points
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Classifier

Classifier

Output

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Fusion

Result

Classifier

Read

Write

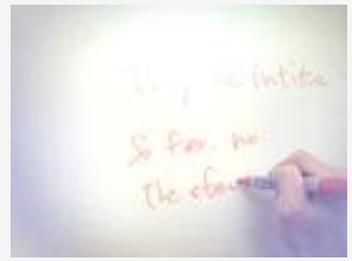
Type

Feature Vector For Learning

- SVM with Probability Estimation
- Two classifiers are made for visual and gaze motion features

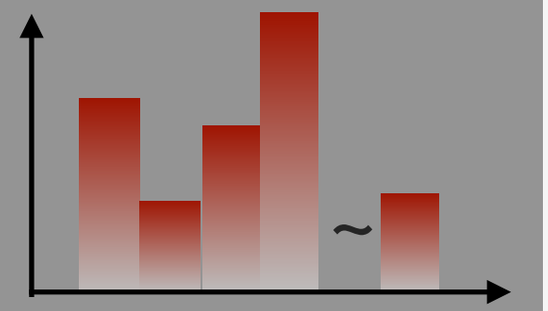
Classifier

Read



Write

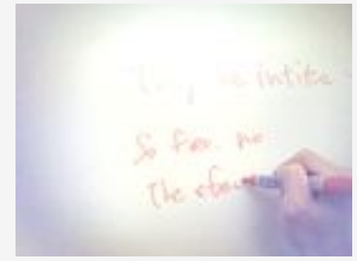
Type



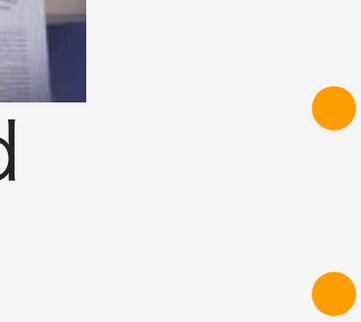
Feature Vector for Test

Classifier

Read



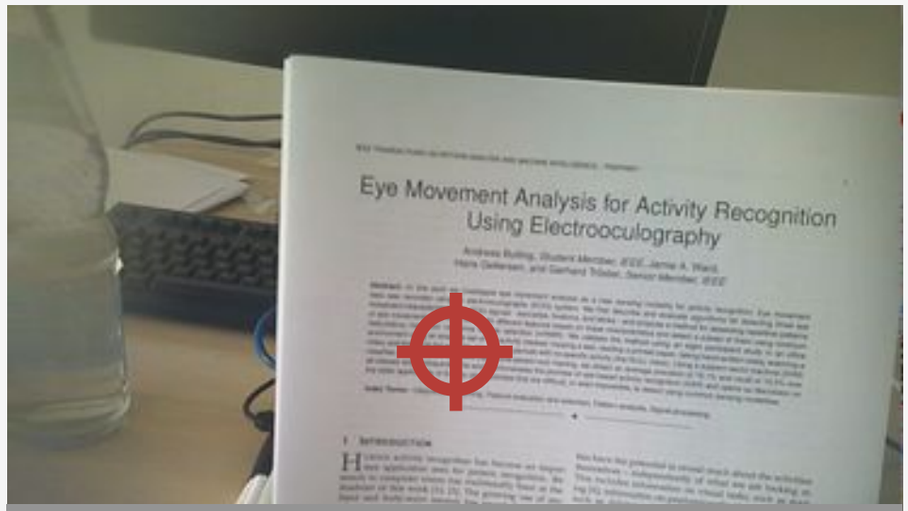
Write



Type

Overview

Eye Tracker



Record Gaze Points
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Gaze Motion
Feature

Visual Feature

Classifier

Classifier

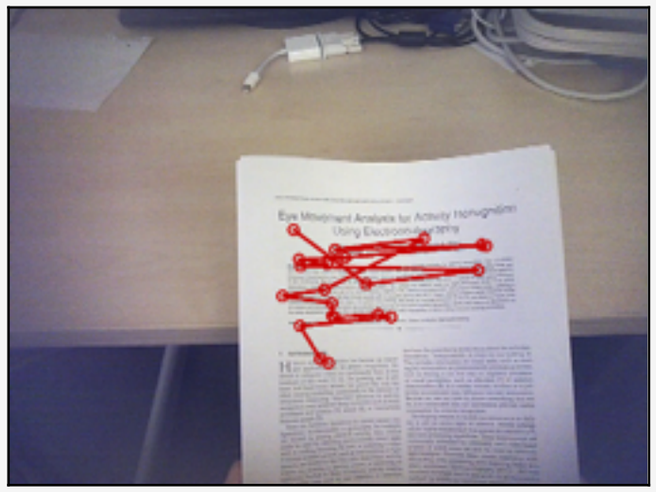
Output

Output

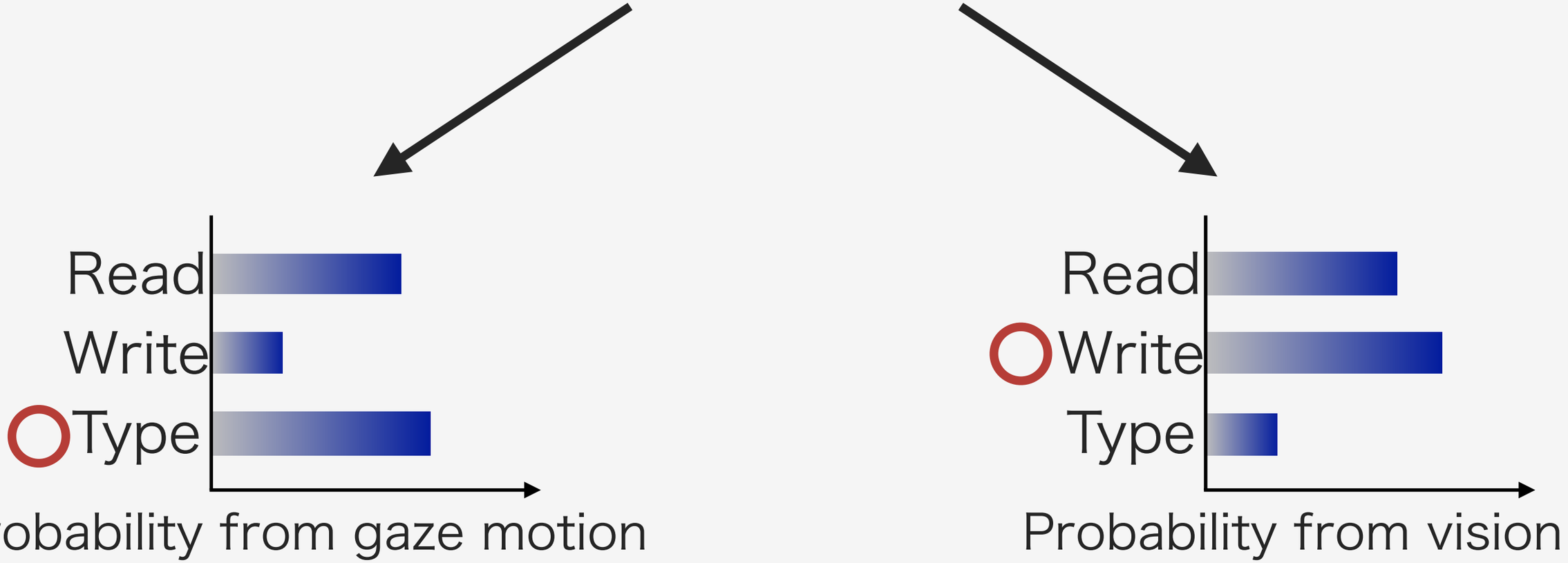
Fusion

Result

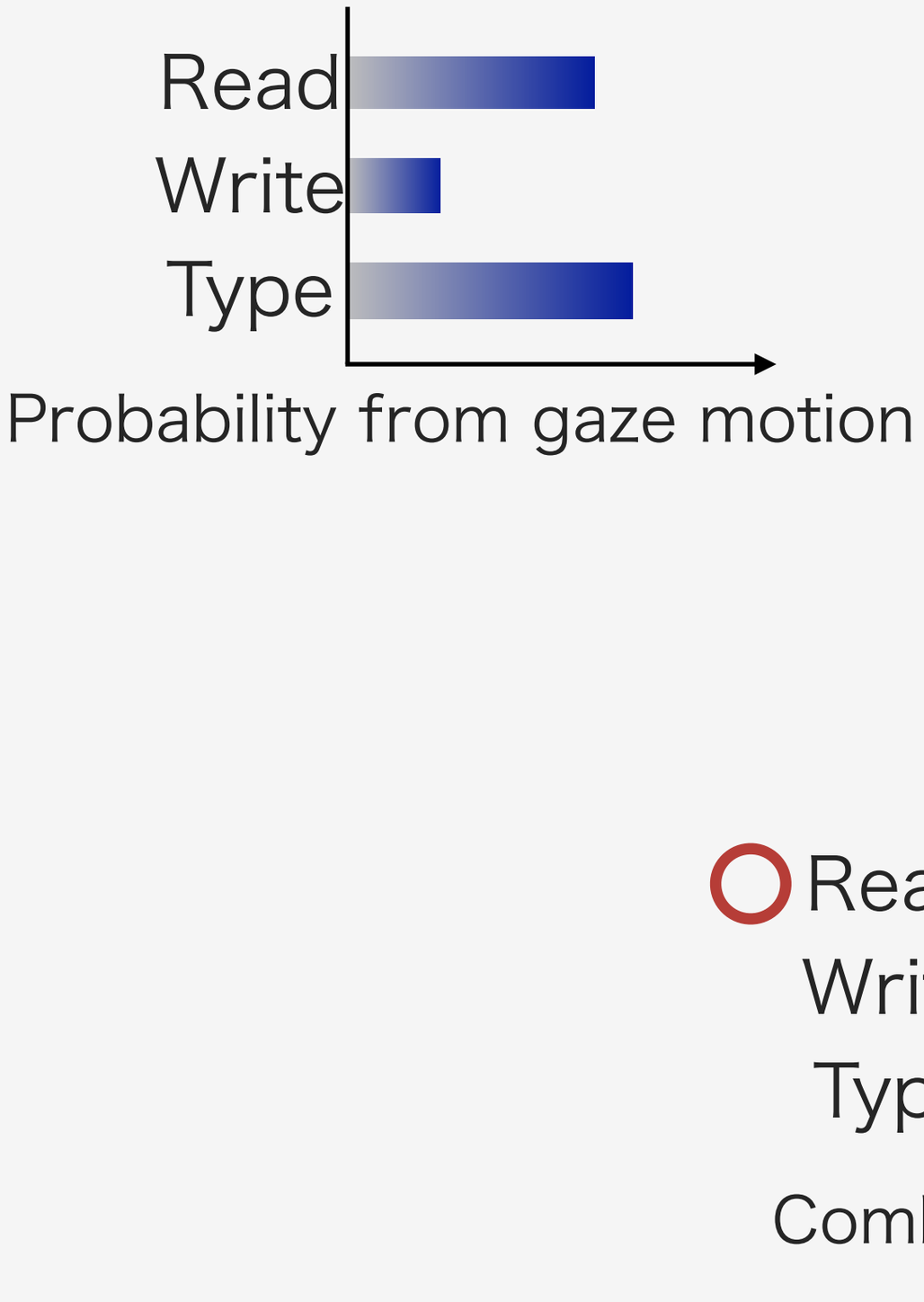
Fusion

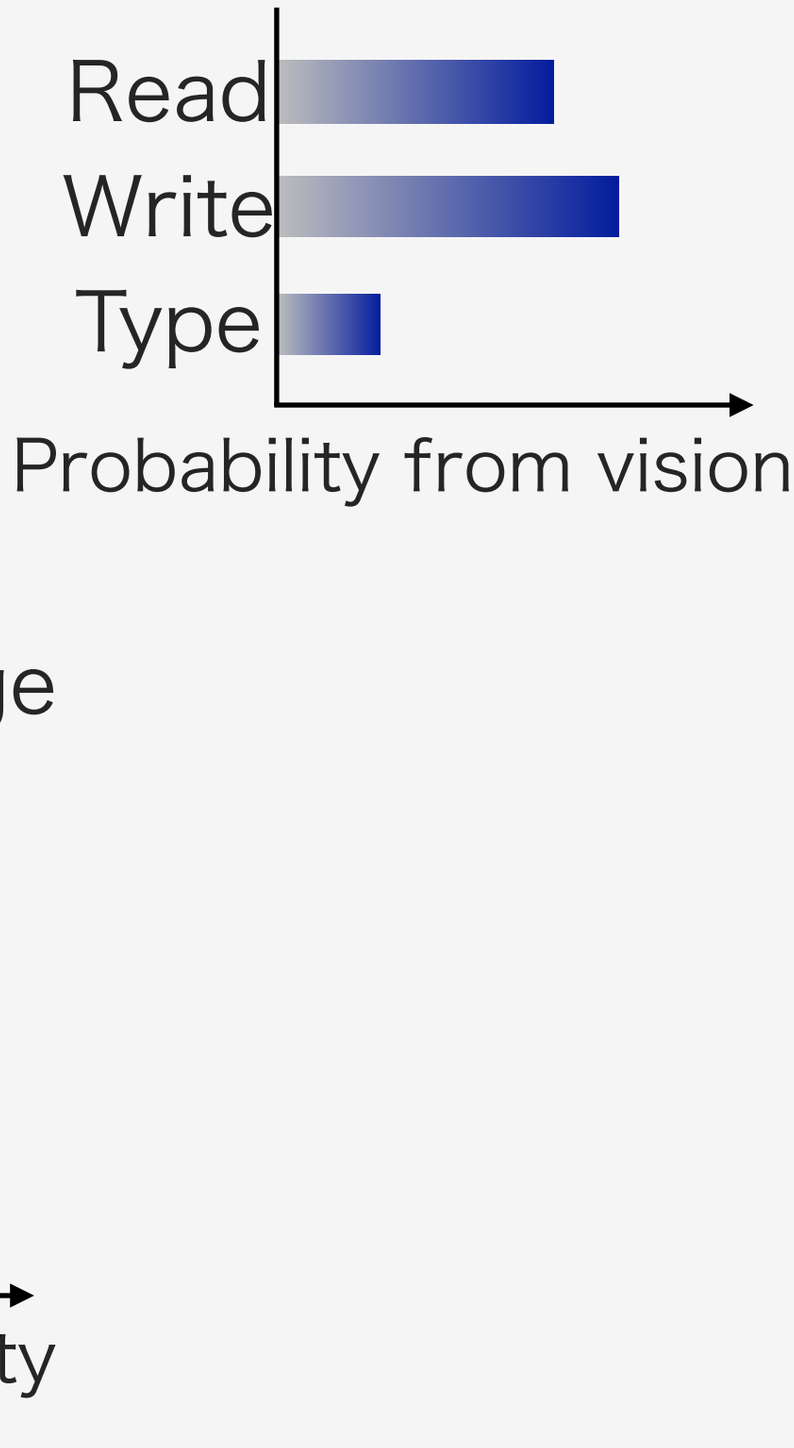


Read

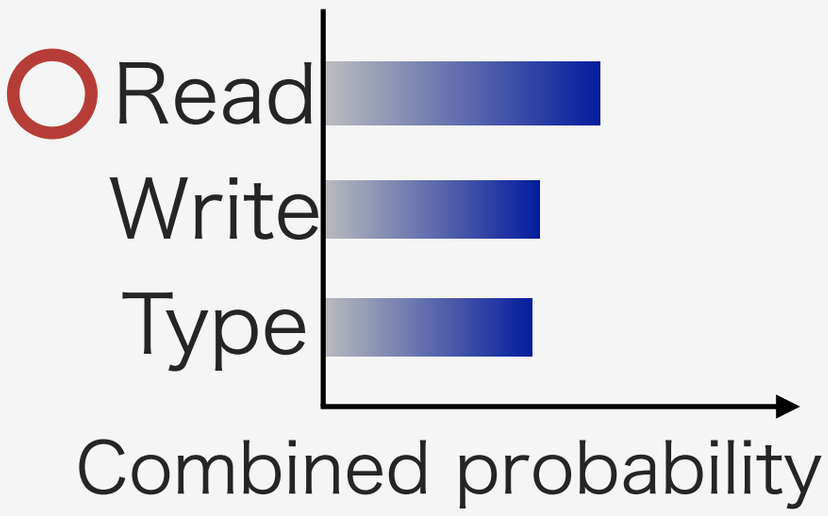

Read
Write
Type
Probability from gaze motion
Read
Write
Type
Probability from vision

Fusion





Average



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Experiments

- Baseline:
  Whether combined method performs better than individual vision-based and gaze motion-based method

- Cross-scene:
  Whether the combined method performs when target objects are different between training and test data

- Cross-user:
  Whether the combined method performs when test data contains a person different from training data

	Target Objects / Environments	User
Baseline	Same	Same
Cross-scene	Different	Same
Cross-user	Same	Different

Condition of All Experiments

- Sampling rate of the eye tracker: 30 Hz

- Resolution of the scene camera:
  1280 × 960 Pixels

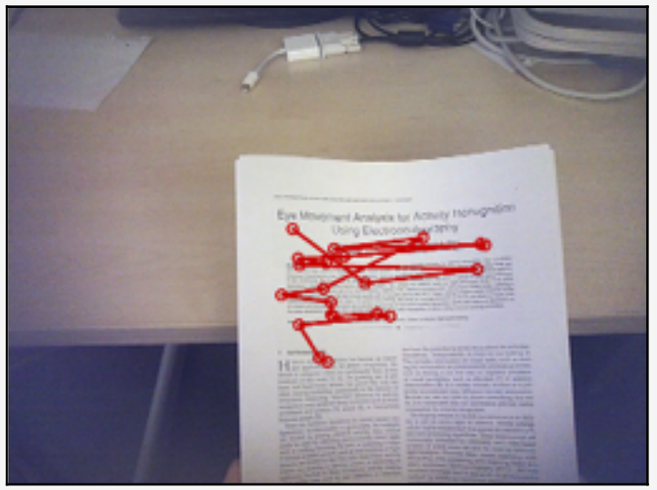
- Visual features are extracted from
  300 × 300 pixels around gaze points

- Gaze motion features are extracted from
  700 gaze samples

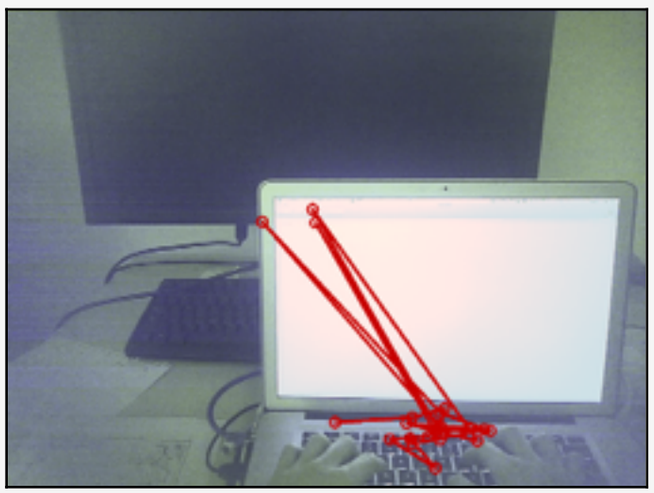
Activity List

Watch a video

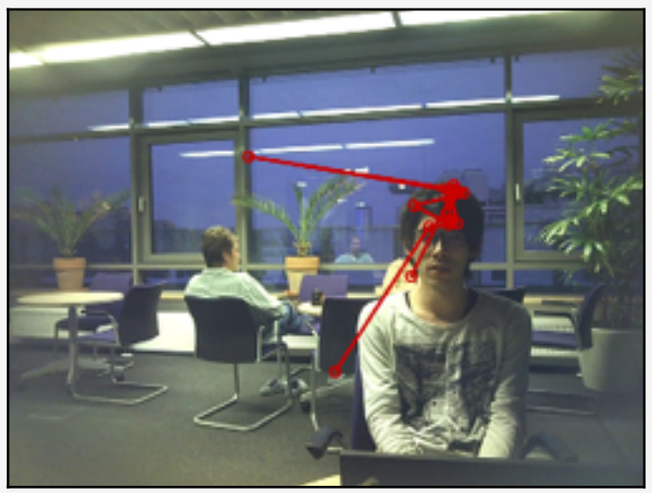
Write text



Read text



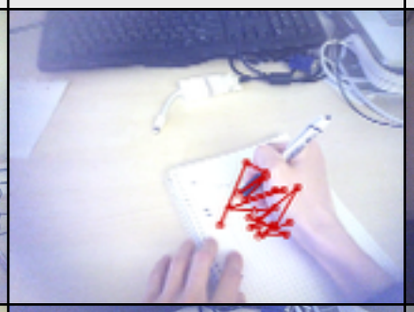
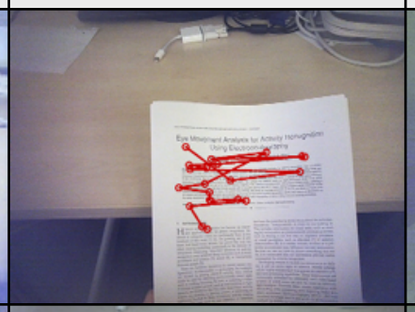
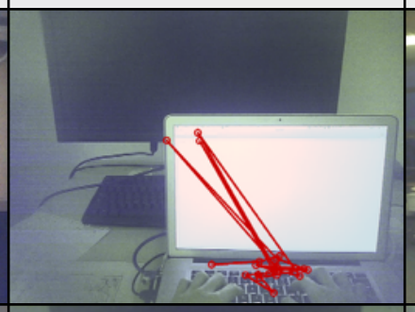
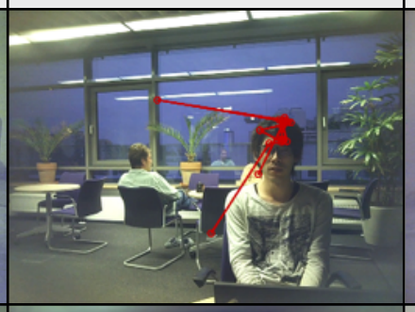
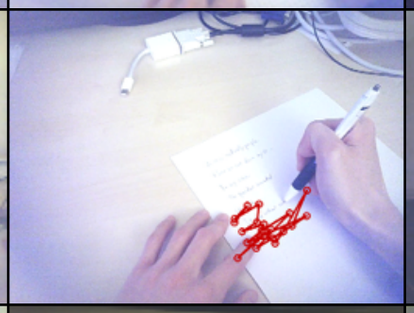
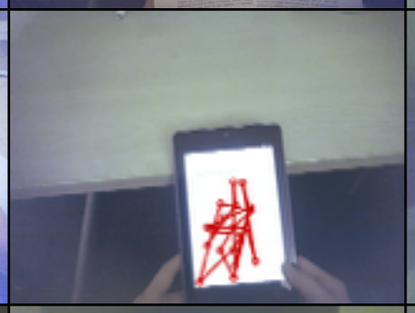
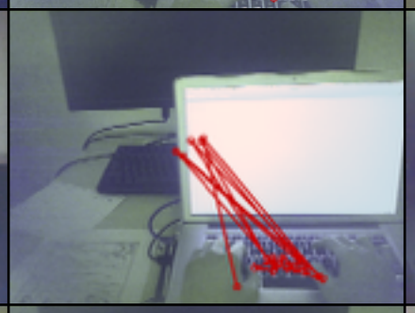
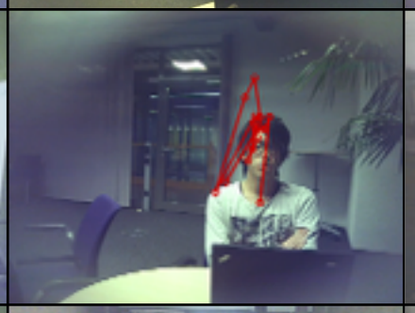
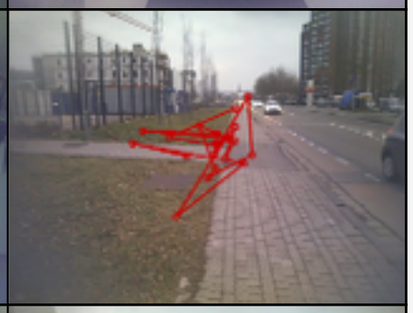
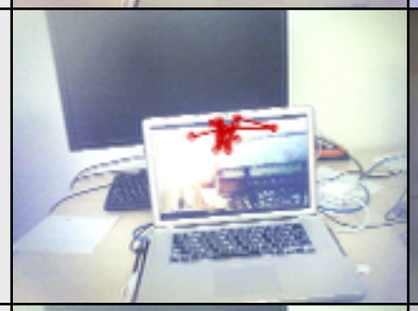
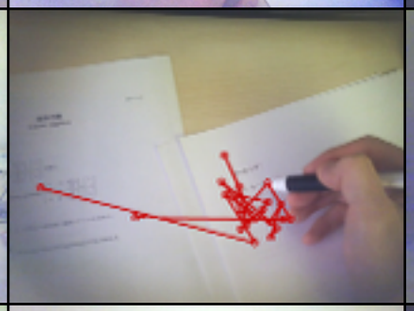
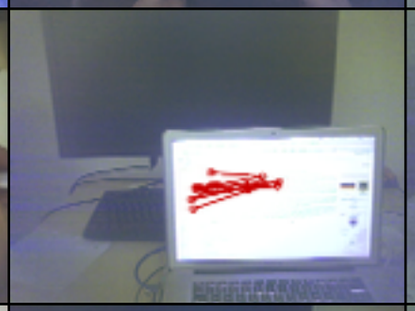
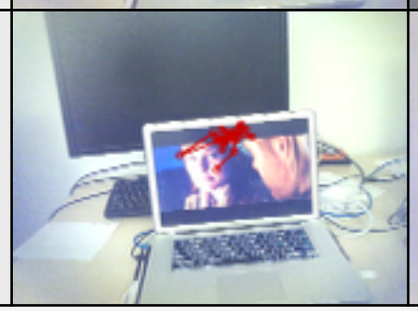
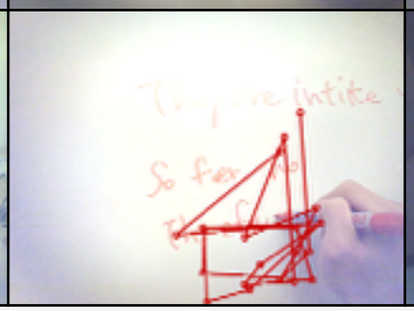
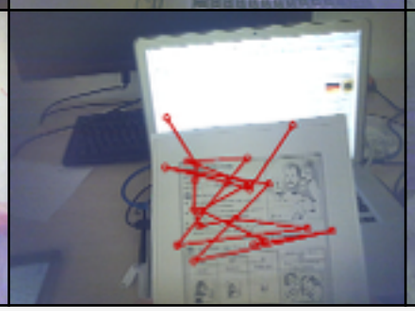
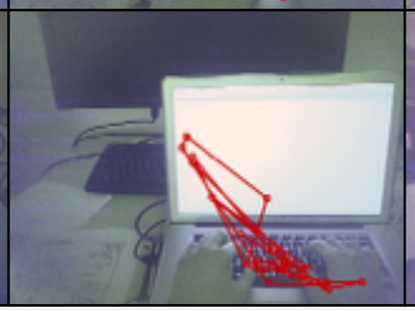
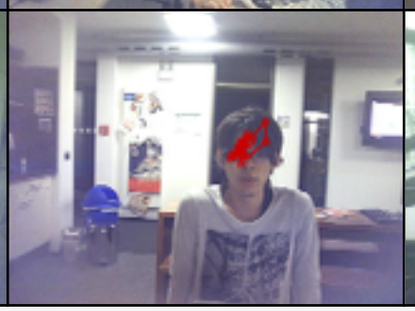
Type text



Have a chat

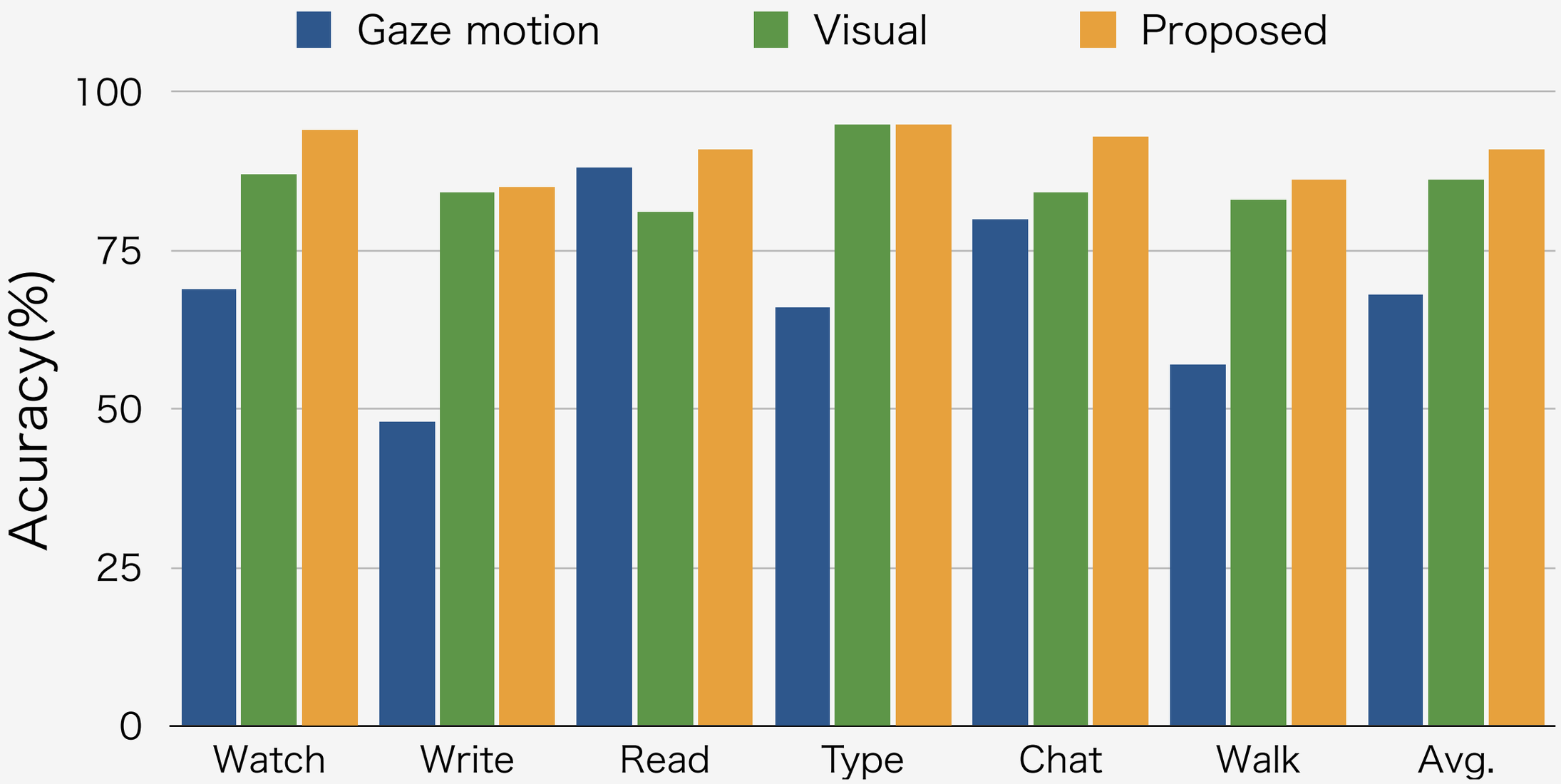
Walk

Baseline Experiment

	Wach a video	Write text	Read Text	Type text	Have a chat	Walk
Scene 1						
Scene 2						
Scene 3						
Scene 4						

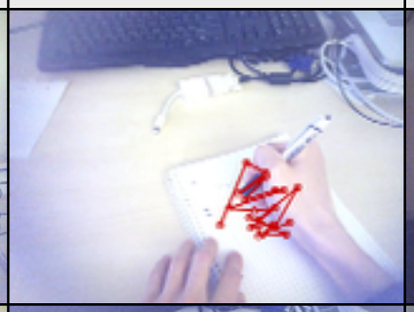
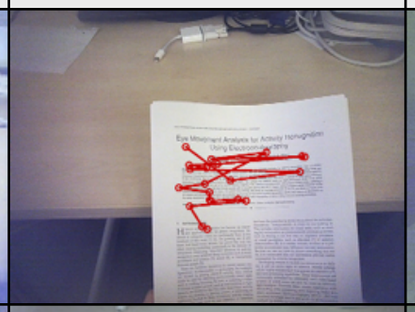
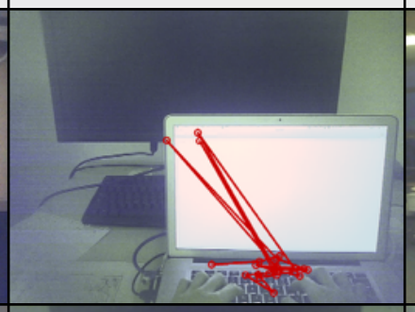
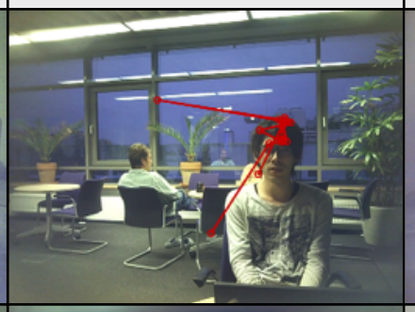
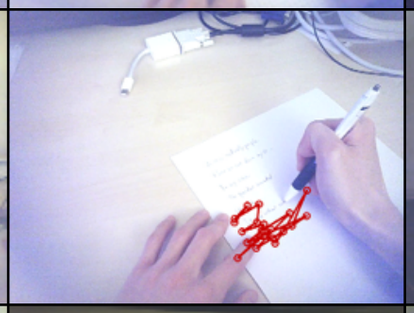
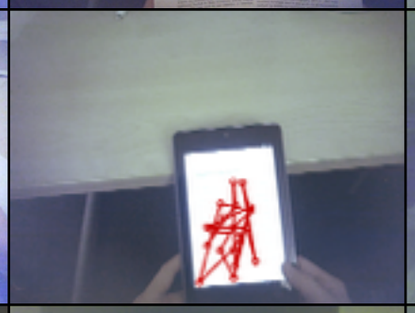
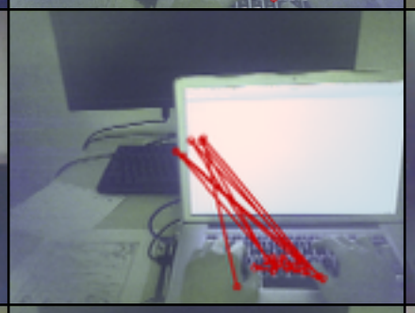
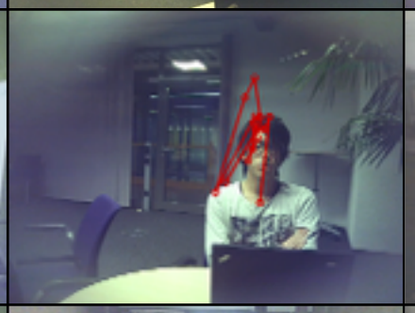
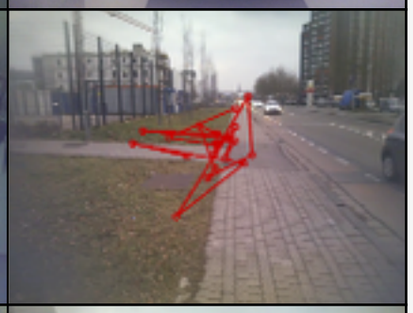
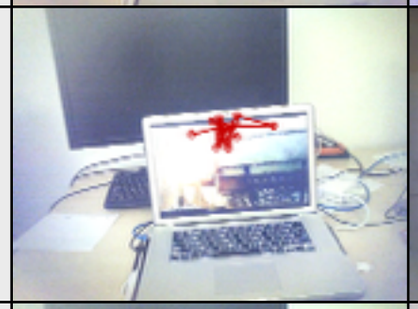
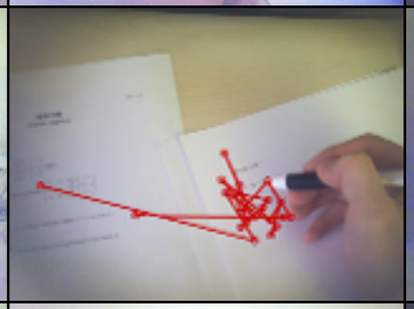
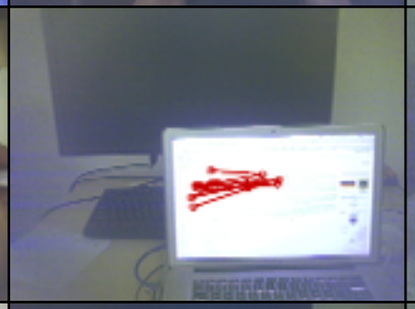
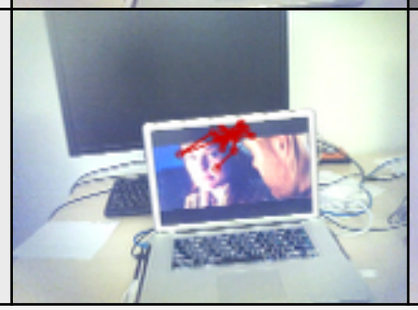
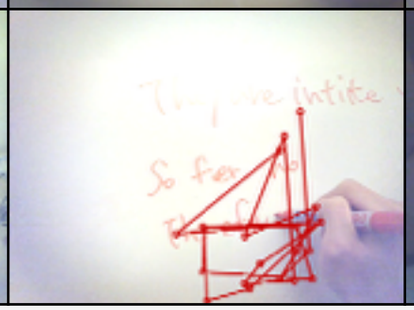
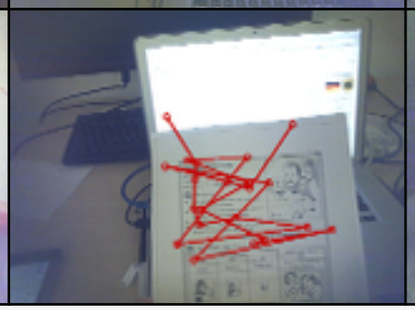
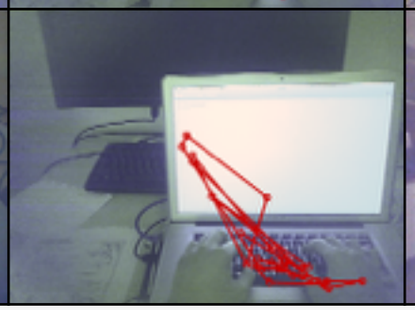
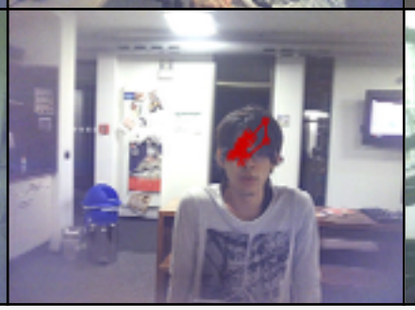
- 1 person
- Contains 4 different scenes
- The dataset was divided into 2 parts

Baseline Experiment



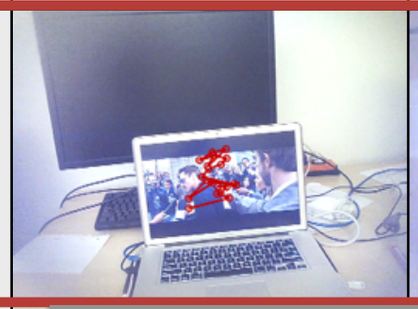
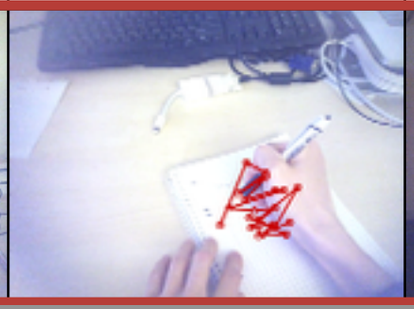
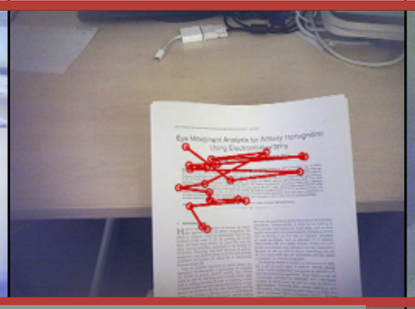
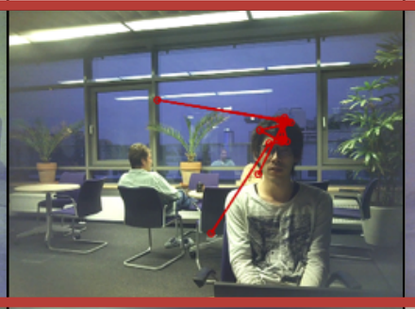
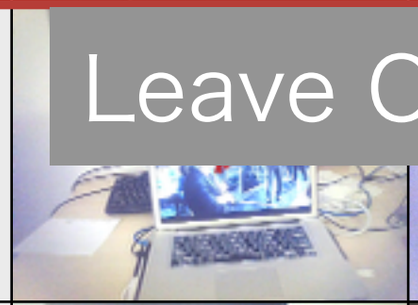
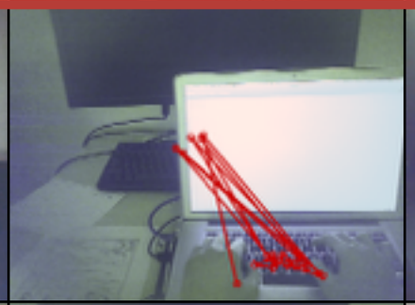
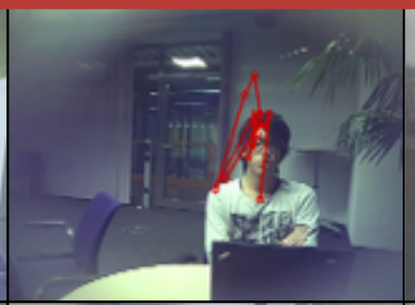
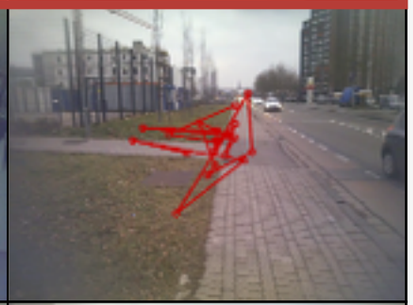
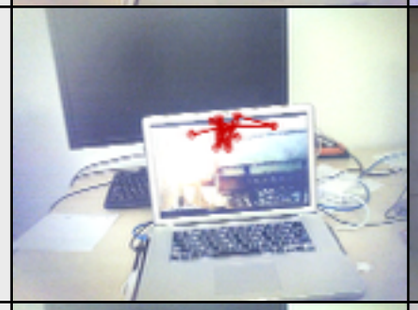
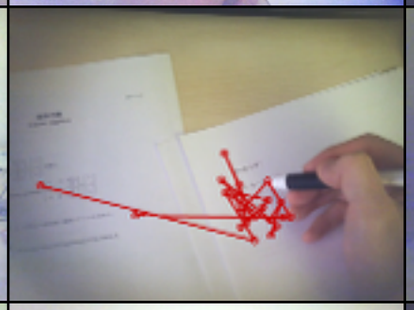
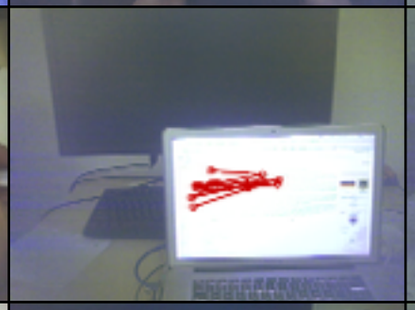
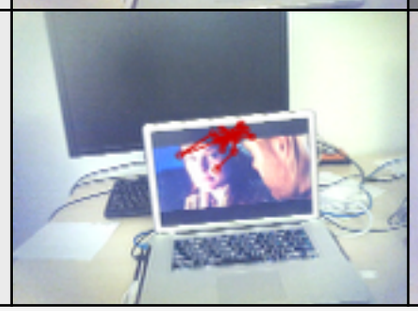
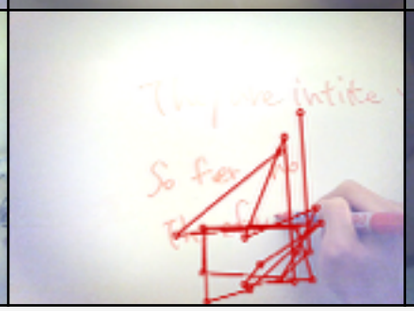
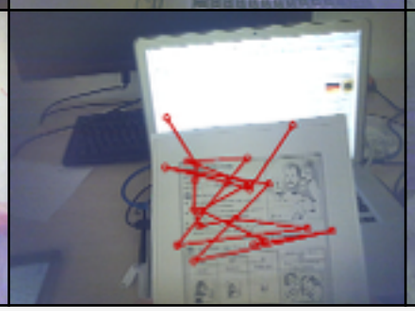
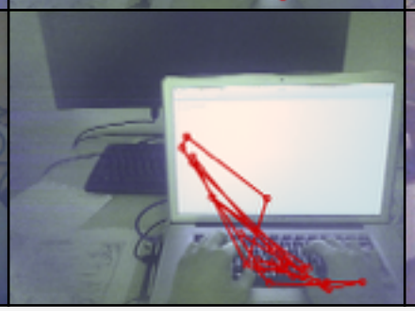
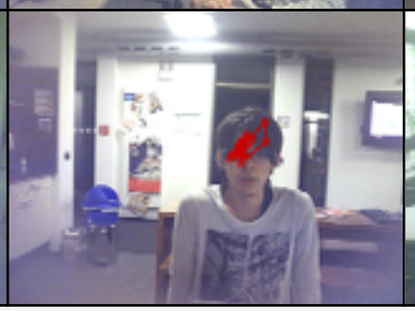
- The accuracy of the proposed method was the best

Cross-scene Experiment

	Wach a video	Write text	Read Text	Type text	Have a chat	Walk
Scene 1						
Scene 2						
Scene 3						
Scene 4						

- 3 people

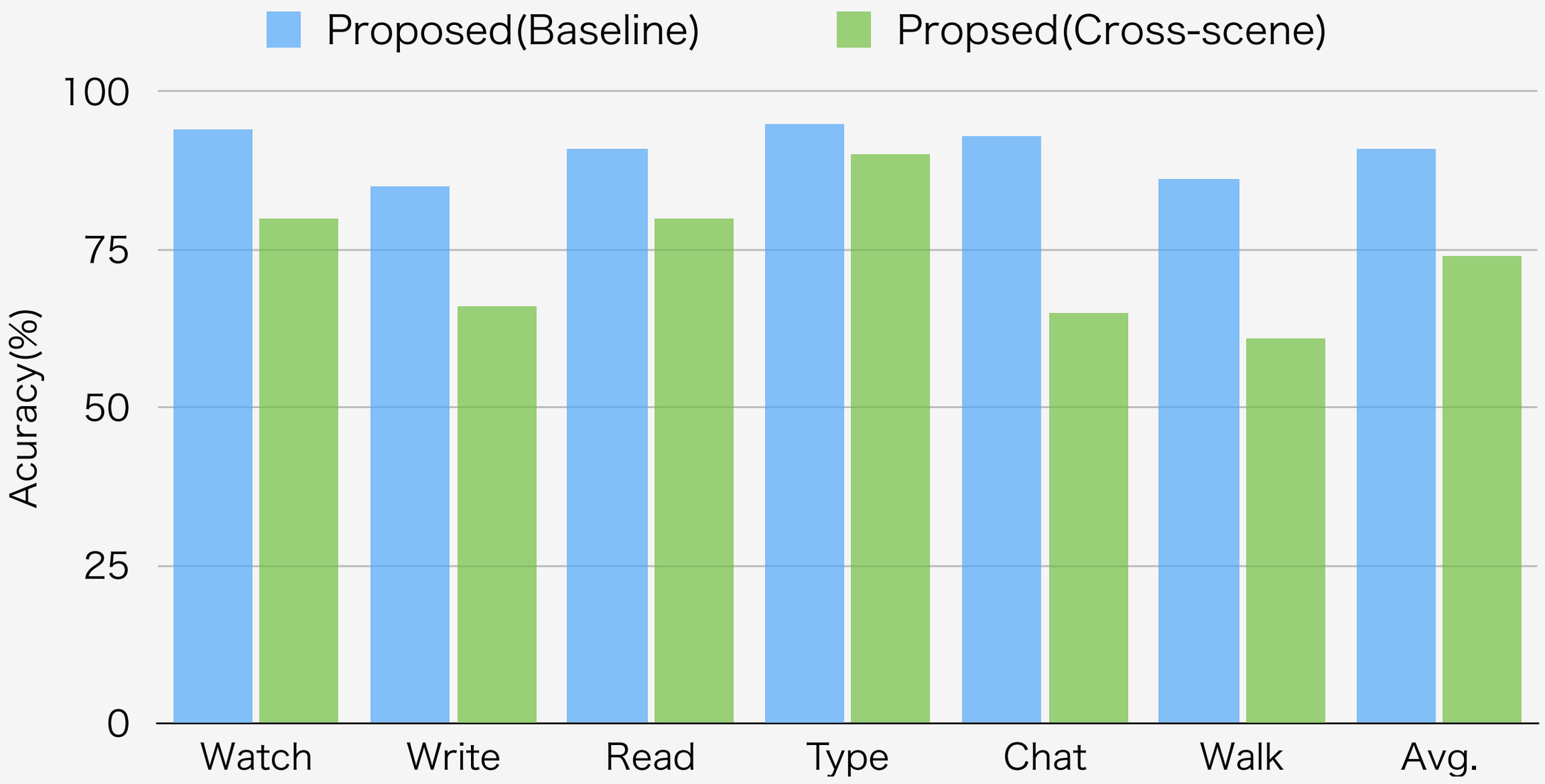
Cross-scene Experiment

	Wach a video	Write text	Read Text	Type text	Have a chat	Walk
Scene 1						
Scene 2						
Scene 3						
Scene 4						

Leave Out for Test Data

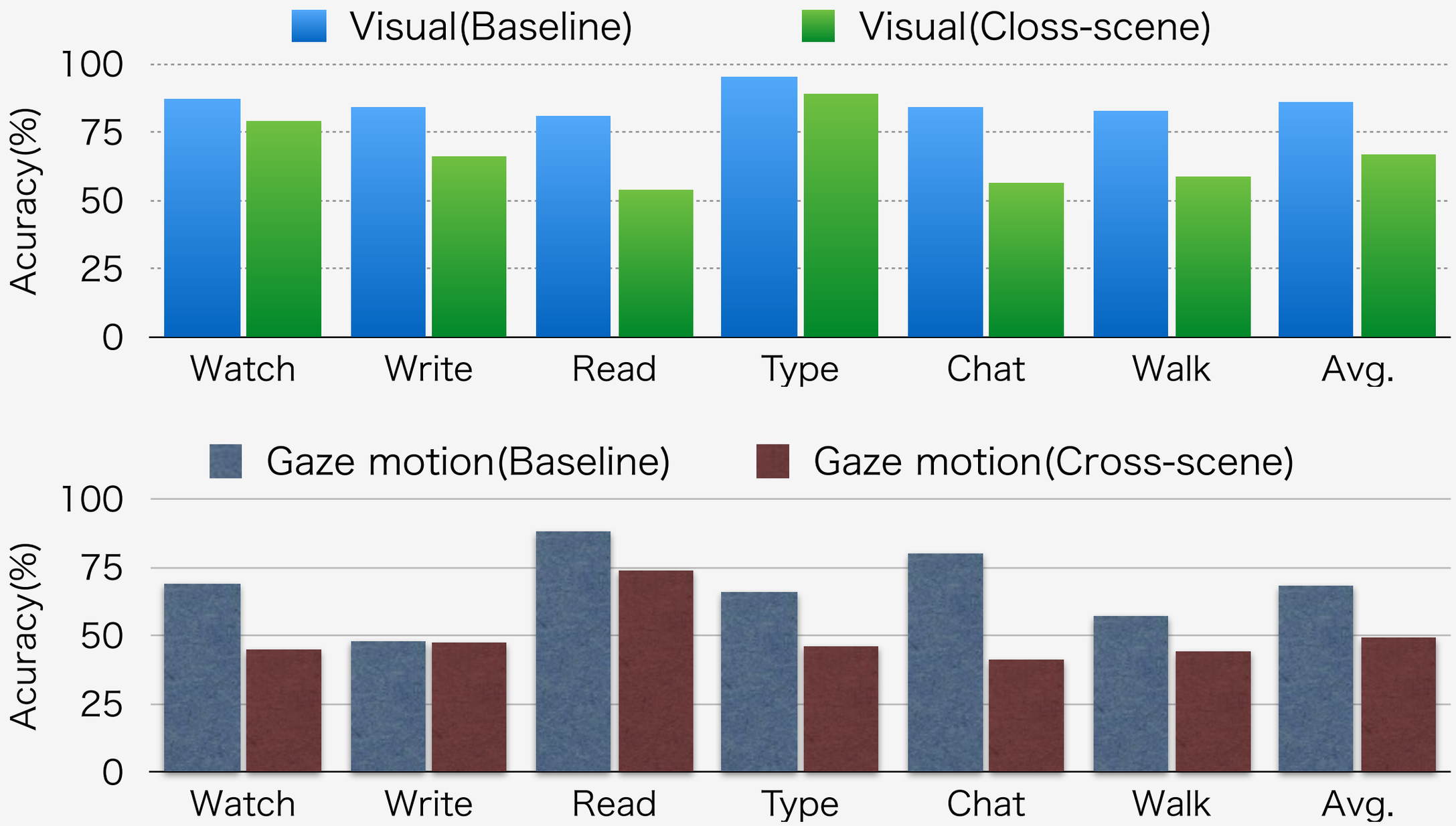
- 3 people
- Leave-one-out cross validation

Cross-scene Experiment



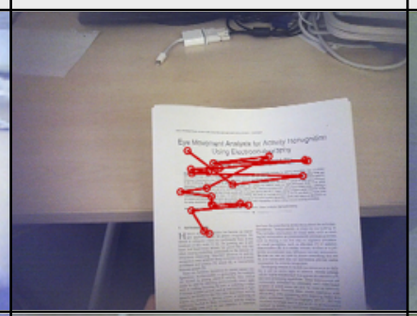
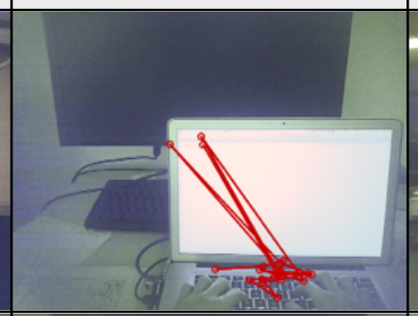
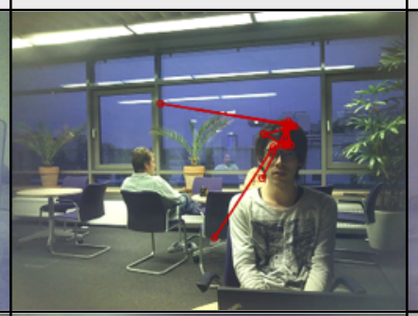
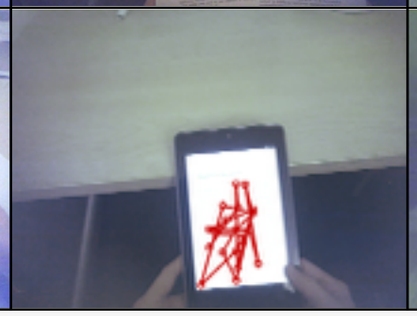
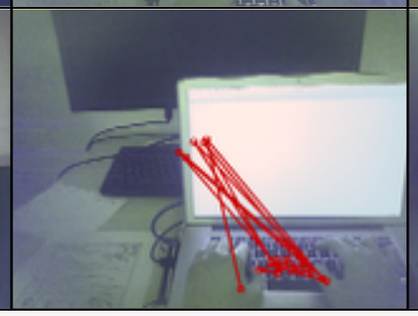
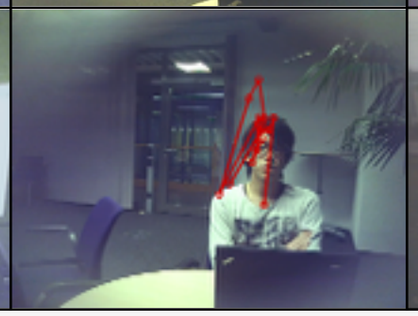
- The recognition rate of Cross-scene is lower than Baseline

Cross-scene Experiment



- Both of recognition rates dropped
- Gaze motion also depends on targets or environments

Cross-user Experiment

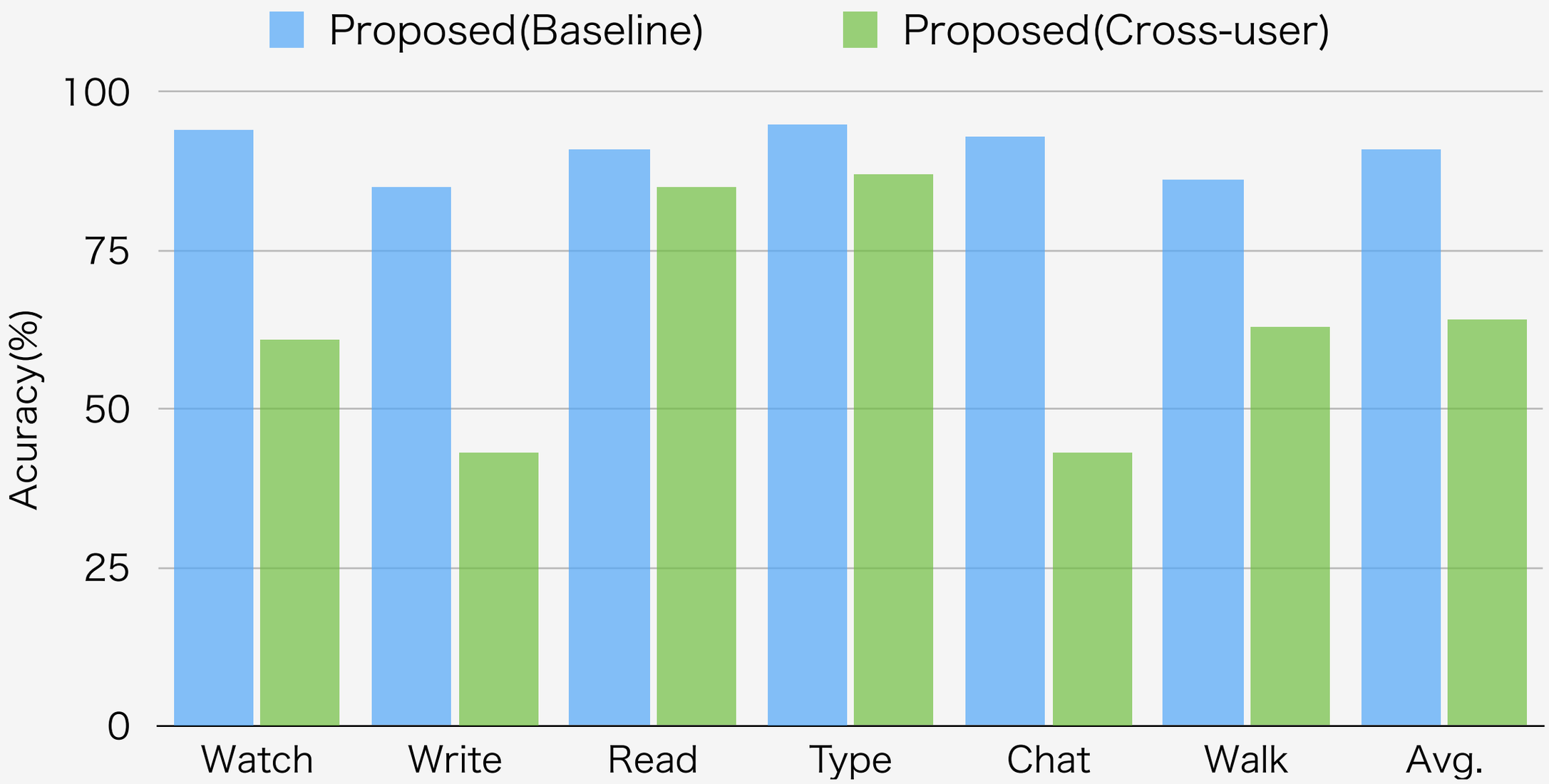
	Wach a video	Write text	Read Text	Type text	Have a chat	Walk
Scene 1						
Scene 2						

×

7 people

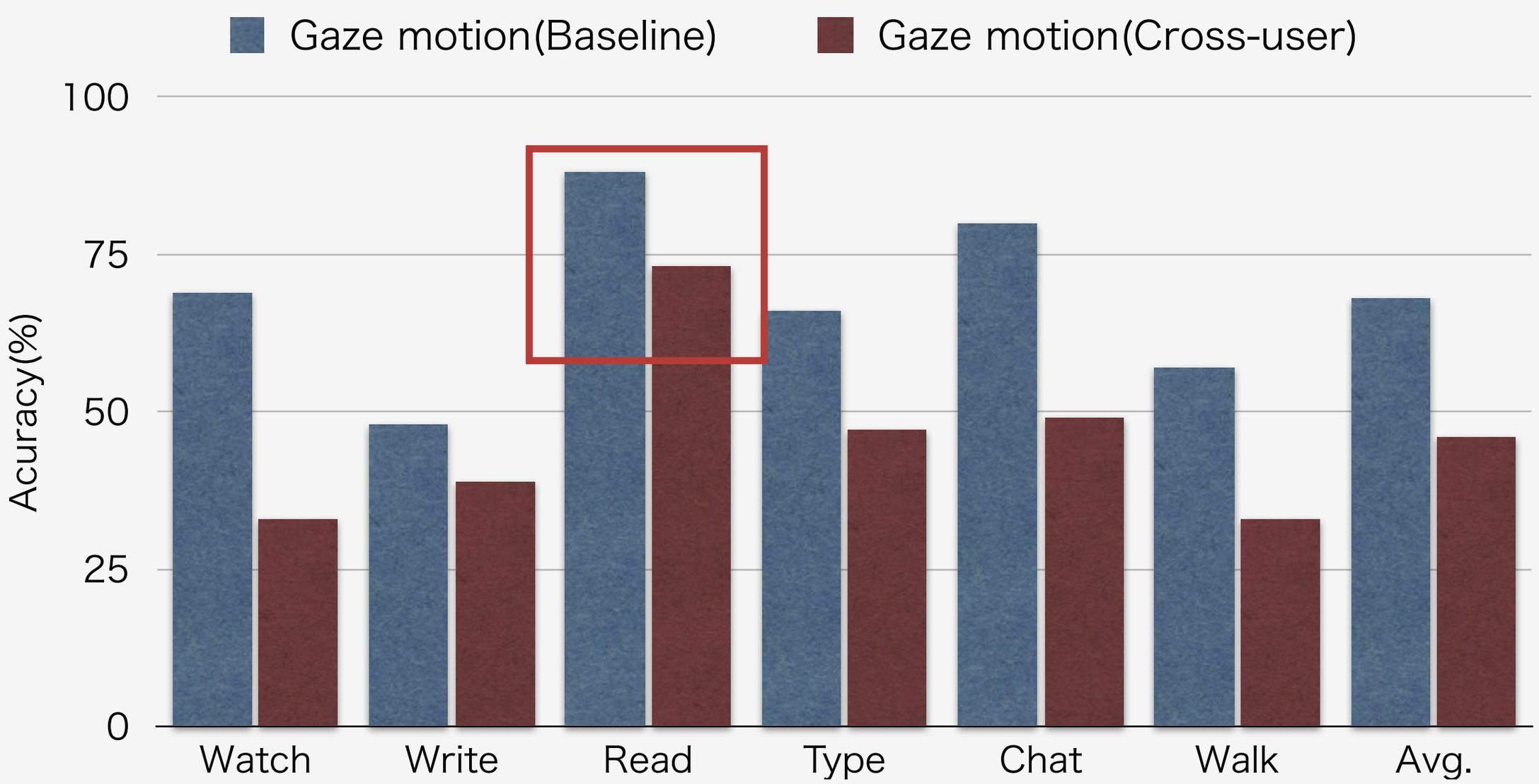
1 person: test　　The rest 6 people: training

Cross-user Experiment



- The recognition rate of Cross-user is lower than Baseline

Cross-user Experiment



- Gaze motions are different between people
- Gaze motions of “Read” activity are similar between different people

Outline

- Introduction
- Proposed Method
- Experiment
- Conclusion

Conclusion

- Combined gaze motion feature and visual feature to recognize daily activities that involve eye movements
- The results from the experiments show that the recognition accuracy is higher when we combine vision-based method and gaze motion-based method

Daily Activity Recognition Combining Gaze Motion and Visual Features

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Andreas Dengel, Koichi Kise

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OSAKA PREFECTURE UNIVERSITY

Deutsches
Forschungszentrum
für Künstliche
Intelligenz GmbH

Cross-User Experiment