# Discrimination of Gaze Directions Using Low-Level Eye Image Features

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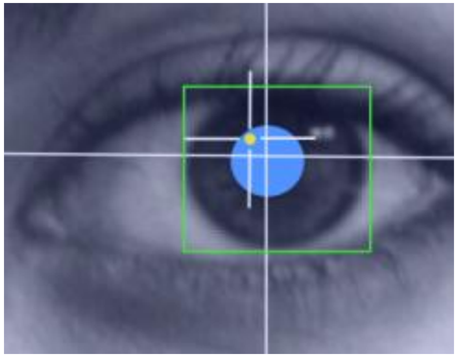
# Introduction

- Eye tracking applications:
  - gaze communication, gaze-based typing, usability studies and etc.

- Most video-based eye trackers:
  - **Non-mobile** and **restrict free movements** of the users.
  - require **high resolution** video cameras or **infrared** illumination required.
  - Mobile eye trackers require robust gaze estimation.

# Gaze estimation

- Model-based approaches:
  - use explicit geometric model of the eye
  - typically require **specialized hardware** and **infra-red** illumination
  - not suitable for outdoors or under strong ambient light



- Appearance-based approaches:
  - directly map the image contents (appearance of the eye region) to screen coordinates (PoR)
  - Camera calibration is typically not required

# Motivation

- Appearance-based (Natural light):
  - new challenges -- light changes in the visible spectrum, lower contrast images

- Instead of using raw pixels, different features can be extracted from input images.

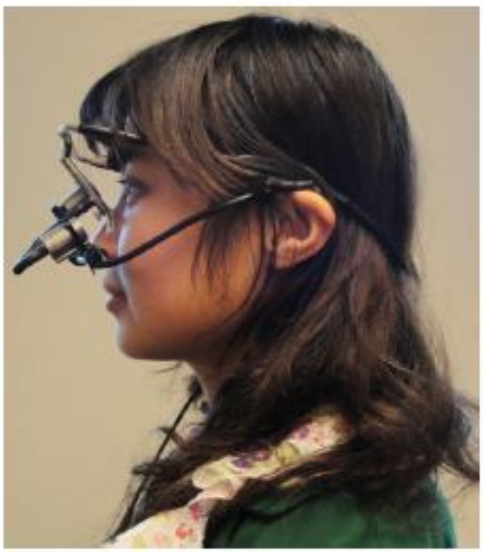
- Image features have been widely investigated in computer vision but haven't been extensively explored in eye tracking research

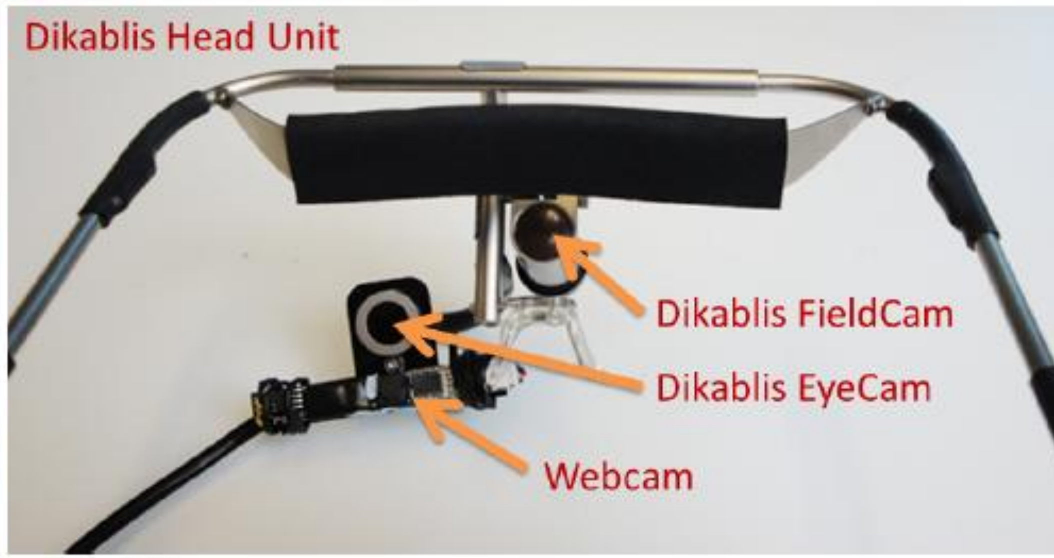
# Goals

- To obtain **a set of discriminative features** for gaze direction estimation
- **Mapping images to discrete output spaces** using powerful **machine learning** techniques.
- Capture data using a **video camera** under **natural settings**

# Hardware

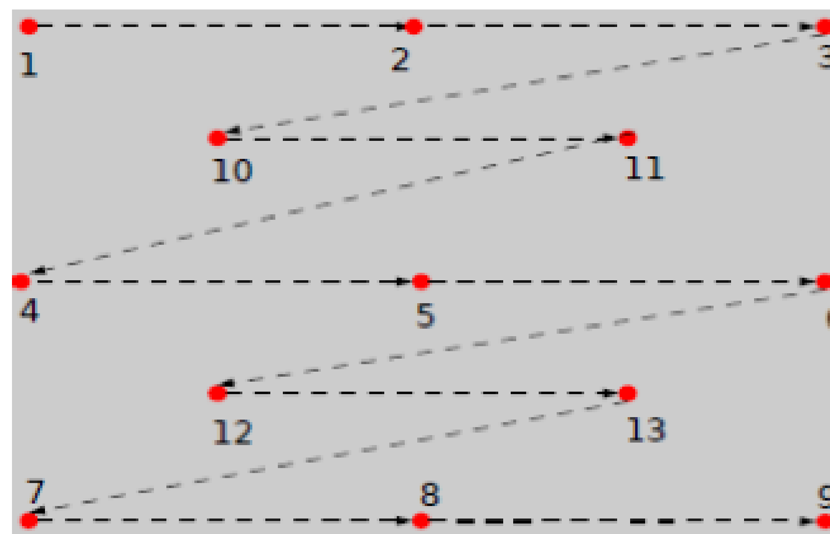
- The eye camera and the webcam were adjusted to point to the participant's left eye to get close-up eye images






# Setup

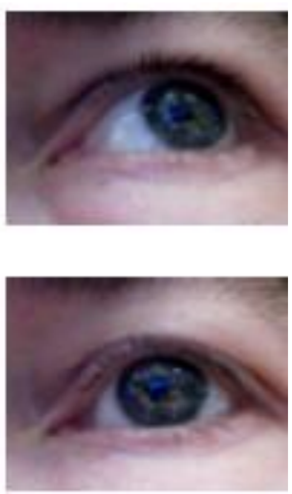
- In a real office, under normal lighting conditions
- Participants were seated 60cm away from the computer screen
- A red point (0.5° visual angle) is shown on a light grey computer screen ( 43° in horizontal and 27.6° in vertical of visual angle)

# Data collection

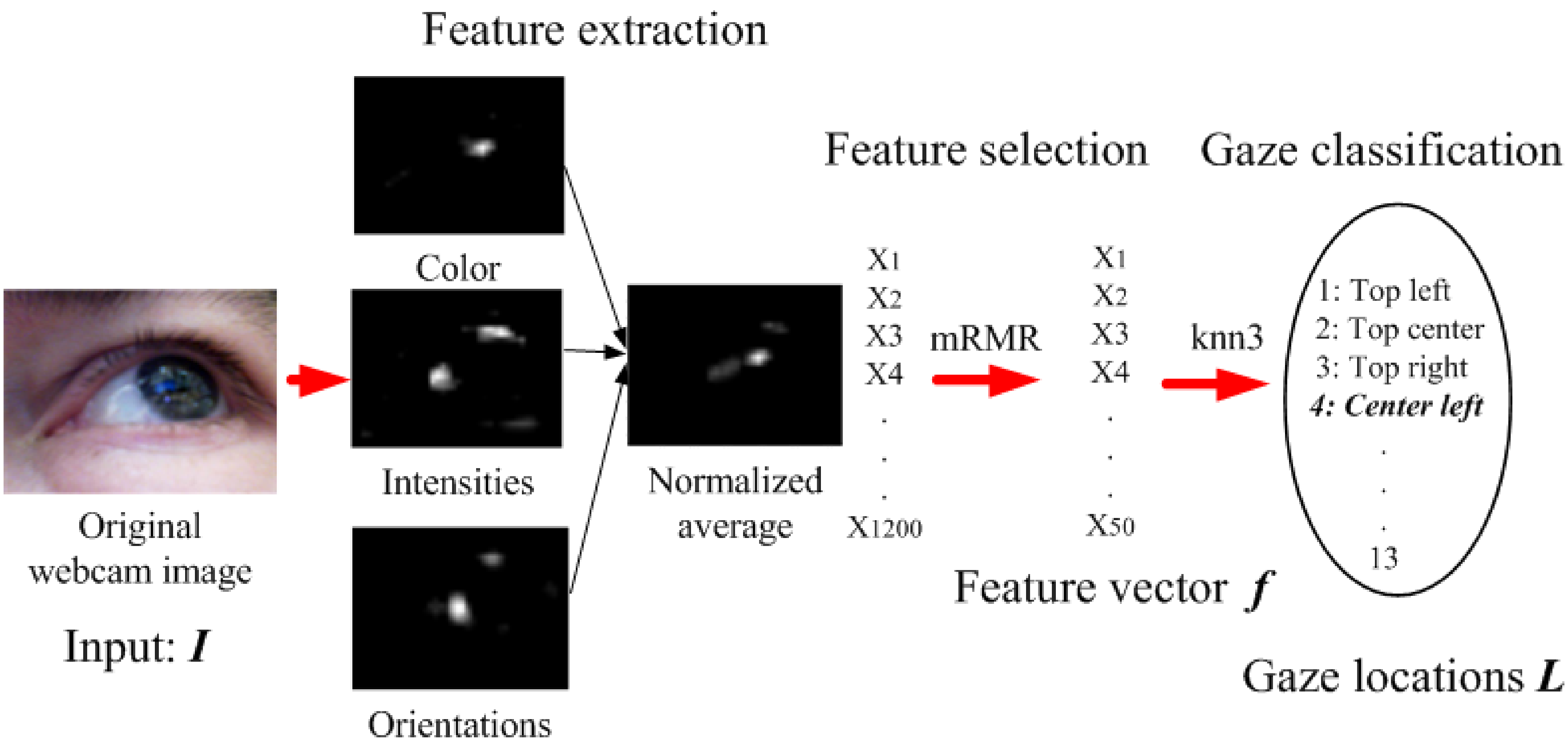
- 17 people (5F, 12M) with various eye colors
- Dikablis eye tracker capture ground truth gaze coordinates
- Recorded webcam images, Dikablis eye/field images and gaze coordinates are synchronized

Webcam



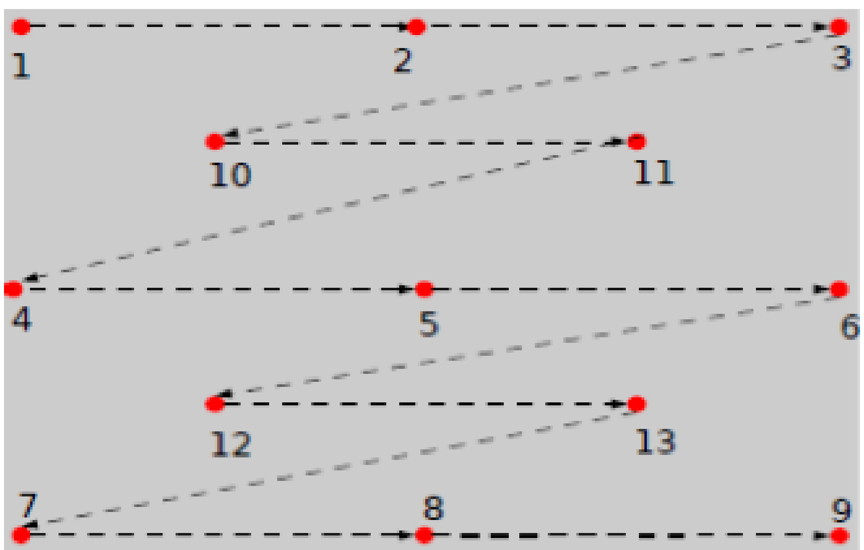
Ground Truth

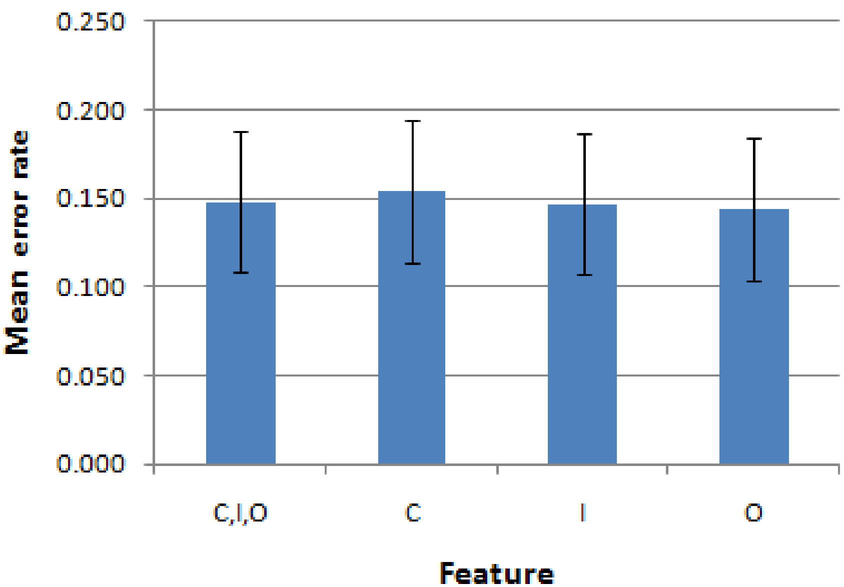
# Discrimination of gaze directions: overview



# Results

- 13 different gaze locations are evaluated
- Person-dependent evaluation: 70% training,  30% testing
- Average error rate per participant: [9.1%, 21.8%]
  - Except one participant: 27.2% -- due to blinking



# Blinking

- Participant 12  blinked very frequently during the recording due to exhaustion
- Blinking can affect the gaze estimation performance
- The eye appearance changes during blinking
  - occlusions -- eye lashes and eye lids

# Discussion

- No single feature outperforms the others
- While combing all features improves recognition performance in most cases, for some it results in an increase of the error rate
- The recognition system misclassifies when two classes are spatially close to each other.

# Future work

- Try different classifiers and machine learning algorithms
- Include other image features and different color models for gaze estimation.
- Improve the feature selection procedure

# Summary

- Used vision/video-based approach with machine learning to achieve robust eye tracking.
  - With a mean recognition performance of 86%
- Captured data of 17 participants looking at discrete screen positions with a webcam
- Used low level image features (color,  intensity and orientation) and machine learning algorithms to achieve gaze classification