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Towards Gaze-Based Assistance on Maps: Recognizing Activities from Eye Movements

Peter Kiefer, Ioannis Giannopoulos, Martin Raubal

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ICC Pre-Conference Workshop

Eye-Tracking: Why, When, and How?

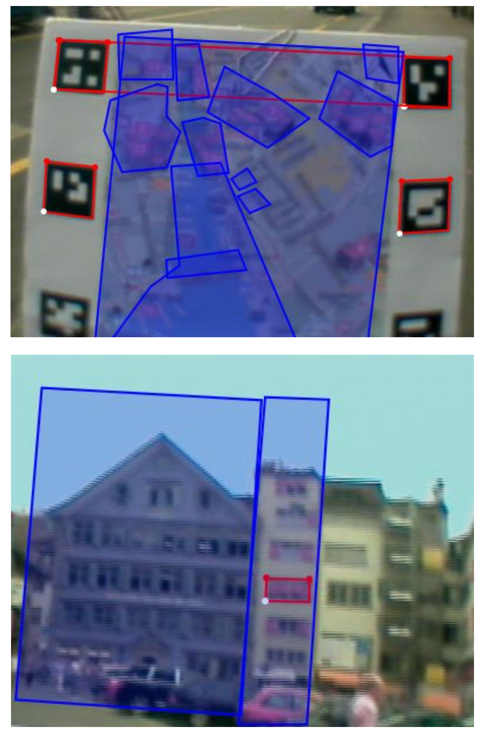
References

- The following slides are mainly based on
  - Kiefer, P., Giannopoulos, I., and Raubal, M. (2013): Using Eye Movements to Recognize Activities on Cartographic Maps. In: Proceedings of the 21st SIGSPATIAL International Conference on Advances in Geographic Information Systems, ACM: New York, NY, USA, accepted

- Some content is also taken from
  - Kiefer, P., Giannopoulos, I., and Raubal, M. (2013): Where am I? Investigating map matching during self-localization with mobile eye tracking in an urban environment. Transactions in GIS, in print
  - Kiefer, P. and Giannopoulos, I. (2012) Gaze map matching: Mapping eye tracking data to geographic vector features. In Proceedings of the 20th SIGSPATIAL International Conference on Advances in Geographic Information Systems, pages 359-368, ACM: New York, NY, USA
  - Giannopoulos, I., Kiefer, P., and Raubal, M. (2012) GeoGazemarks: Providing gaze history for the orientation on small display maps. In: Proceedings of the 14th International Conference on Multimodal Interaction, ICMI '12, pages 165-172, ACM: New York, NY, USA

Mobile Eye Tracking
Geoinformation Engineering, ETHZ

- Main focuses
  - Outdoor wayfinding studies
  - **Gaze-based interaction**



Kiefer et al., TGIS (2013, in print)

Outdoor wayfinding studies

Gaze-Based Interaction

- Eye Tracking: Why?
  - Create «better» cartographic user interfaces and maps
  - Bidirectional view on interfaces

→ Gaze as input modality

- Hardware: available/coming
- Interaction concepts?


Home › News by technology › Portable devices › Google patents eye-tracking for Google Glass

Google patents eye-tracking for Google Glass

Eye gestures to unlock Google's headset

By Scott Nichols August 7th 2012 COMMENTS

Tweet

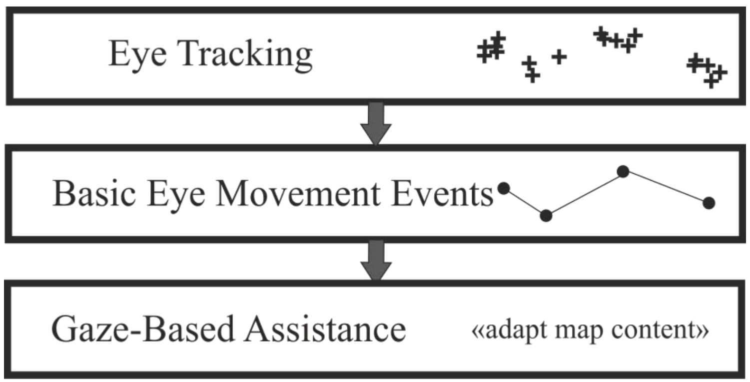
New patent could let you control Google Glass with your eyes

http://www.techradar.com/news/portable-devices/google-patents-eye-tracking-for-google-glass-1091428

Gaze-Based Interaction

A) Explicit Interaction

- «What you look at is what you get»
- Midas touch problem



Based on Kiefer et al., ACM SIGSPATIAL (2013, accepted)

Gaze-based zooming/panning (Stellmach, Dachselt, 2012)

Gaze-Based Interaction

B) Implicit Interaction

- User does not intend to trigger an action
- System assists proactively, based on the gaze track

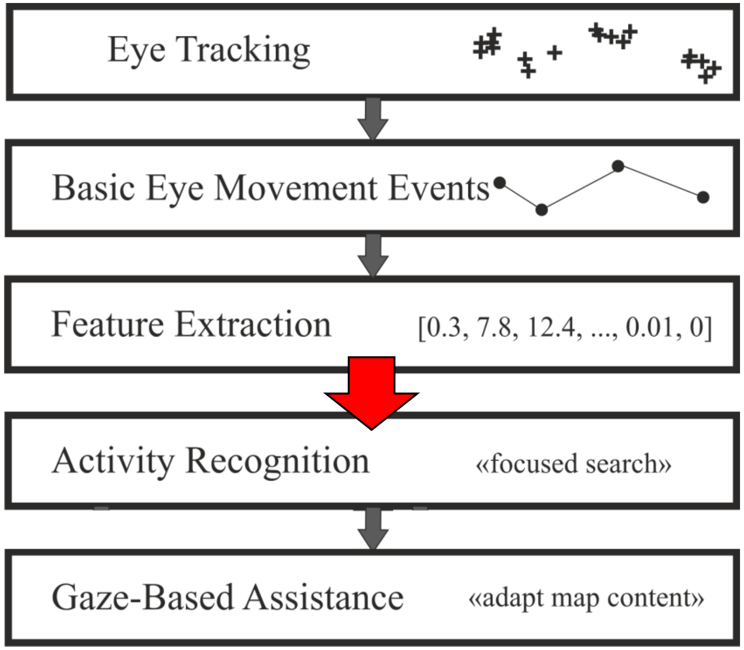
- Example
  - GeoGazemarks
  - Map usage history based on fixations
  - Help user for orientation

GeoGazemarks
Giannopoulos et al. (2012)

Gaze-Based Activity Recognition

- «Eye movements depend on task (activity)»
  - Infer activity from eye movement measures?
  - Dependency of map content, map design, person?

- Engineering perspective
  - RQ: Is it possible to build a classifier that solves the problem with sufficient accuracy?
  - (... for one type of map)



Gaze-based activity recognition
Kiefer et al., ACM SIGSPATIAL (2013, accepted)

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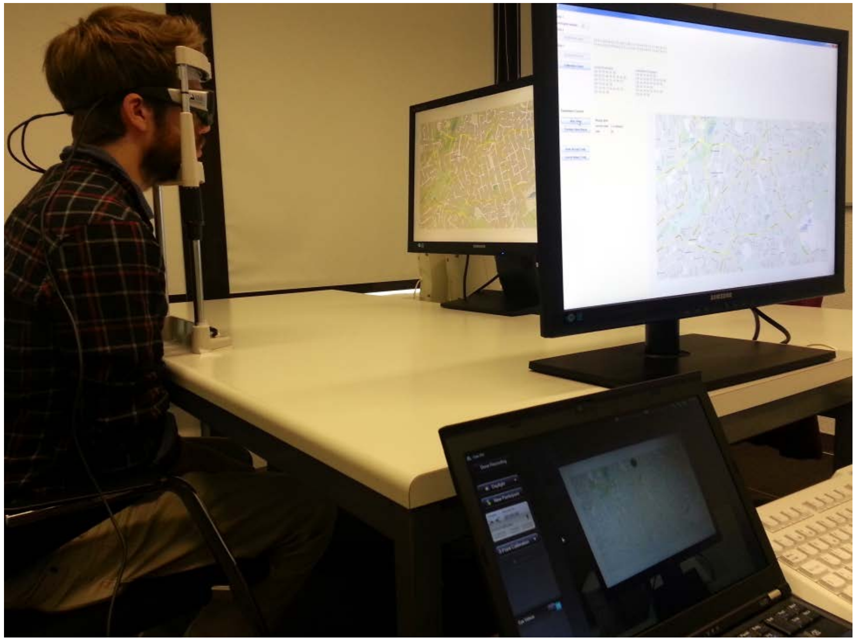
Actual class \ Predicted class	NULL	read	browse	write	video	copy
NULL	0.82	0.03	0.03	0.01	0.06	0.04
read	0.07	0.67	0.13	0.12	0.01	
browse	0.16	0.12	0.62	0.04	0.04	0.02
write	0.06	0.01	0.13	0.73	0.01	0.06
video	0.15	0.01	0.01		0.83	0.01
copy	0.12	0.01	0.13	0.06	0.01	0.68

Gaze-based activity recognition
for office activities
(Bulling et al., 2011)

Data Collection

- 6 Activities
  - Free exploration (6 stimuli)
  - Global search (9)
  - Route planning (8)
  - Focused search (5)
  - Line following (8)
  - Polygon comparison (4)
- Random order of stimuli
- Google Maps
- 17 participants (no experts)
- 587 valid recordings, each cut after 20 seconds



Data collection setup
Kiefer et al., ACM SIGSPATIAL (2013, accepted)

Sehen Sie Mickhausen (rechts oben) und Boos (links unten)?

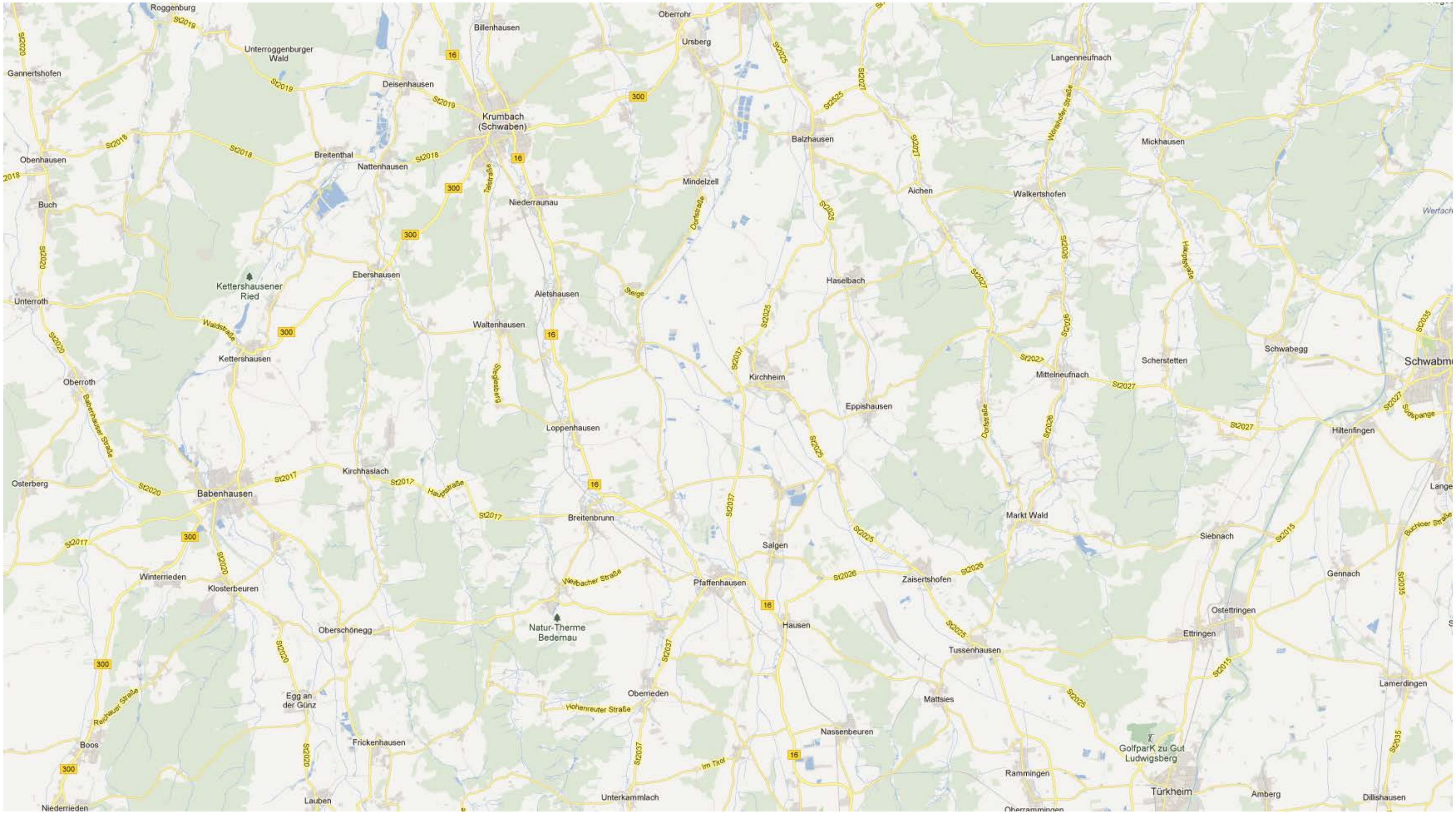
Bitte suchen Sie den kürzesten Weg von Mickhausen nach Boos.

Do you see Mickhausen (top right) and Boos (bottom left)?
Please, search for the shortest route from Mickhausen to Boos.

Example for a route planning task

After a moment: «Please, fixate now on Mickhausen. The task begins in 3, 2, 1 ...»

Example for a route planning task



Example for a route planning task

Machine Learning

- 229 features based on
  - Blinks (5)
  - Fixations (17)
  - Saccades (11)
  - Saccadic direction (100)
  - Direction sequences (96)

- Leading to 587 instances of
  - [f_1, ... f_{229}, true-activity]
  - Training set (90%)
  - Test set (10%)
    - → [..., true-activity, assigned-activity]

- Support Vector Machine (SVM)
  - Standard machine learning approach
  - Toolboxes available online (LibSVM, RapidMiner)

- 10-fold cross validation

Results

		true activity						precision (%)
predicted activity		1	2	3	4	5	6	
	1	82	10	3	11	2	0	75.9
	2	14	112	5	18	3	0	73.7
	3	1	2	65	1	19	0	73.9
	4	4	7	5	54	1	0	76.1
	5	1	0	21	1	76	1	76.0
	6	0	0	1	0	0	67	98.5
	∑	102	131	100	85	101	68	
recall (%)		80.4	85.5	65.0	63.5	75.3	98.5	
accuracy = 77.7%								

(Kiefer et al., 2013, submitted)

1: free exploration, 2: search, 3: route planning,
4: focused search, 5: line following, 6: polygon comparison.

Kiefer et al., ACM SIGSPATIAL (2013, accepted)

Map vs. Office Activities

		true activity						precision (%)
		1	2	3	4	5	6	
predicted activity	1	82	10	3	11	2	0	75.9
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Bulling et al., 2011

Kiefer et al., ACM SIGSPATIAL (2013, accepted)

Outlook

- Other map designs
- Other tasks
- Segmentation
- Assistive system
  - Recognition in real-time
  - What is the minimum time needed? (currently 20 sec)
  - User-satisfaction?
- Combine with gaze-map matching
  - Kiefer and Giannopoulos (2012)
  - «Snap» fixations to vector features
  - e.g., **which** route is the person planning?
- Most discriminative features?

Thank you for your attention!