

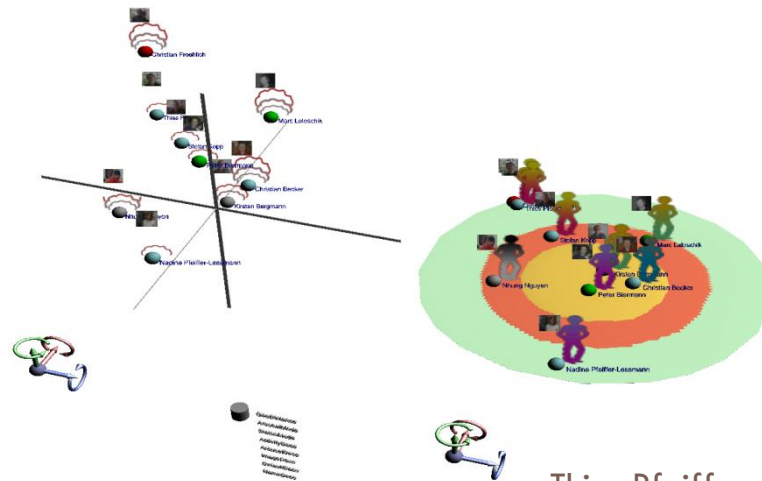


3D FIXATIONS IN REAL AND VIRTUAL SCENARIOS

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Background

- multimodal human computer interaction
- situated natural communication (gaze, gesture, speech)
- natural interaction with dense information displays

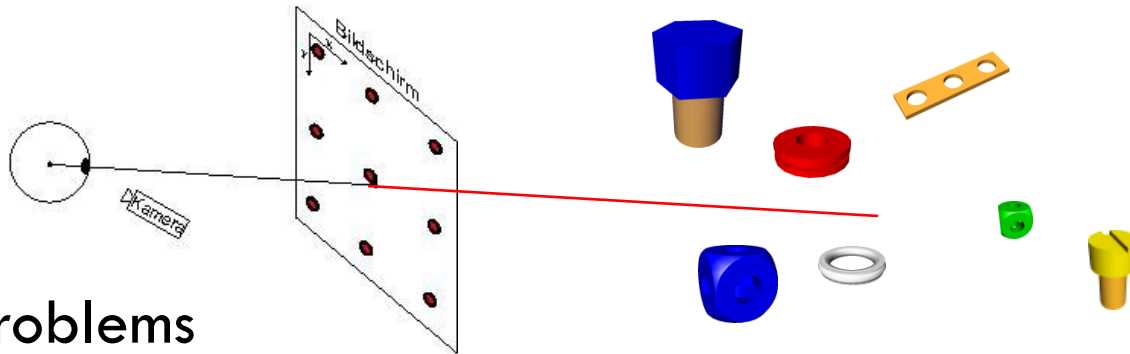


Motivation

- Why should we be interested in automatic reconstructions of the fixated area within 3D space?
 - ▣ gaze is essential in natural communication
 - turn-taking (negotiating who's up to speak next)
 - focus of attention (resolving references, deictic gaze)
 - ▣ basic research
 - visual world paradigm in 3D (e.g. spatial relations regarding the distance from the observer)
 - ▣ application
 - virtual agents (Duchowski et al. 2004)
 - optimized rendering in virtual reality (Lübke et al. 2000)
 - selecting / picking objects
(Tanriverdi und Jacob 2000; Duchowski et al. 2002; Barabas et al. 2004)

State of the Art

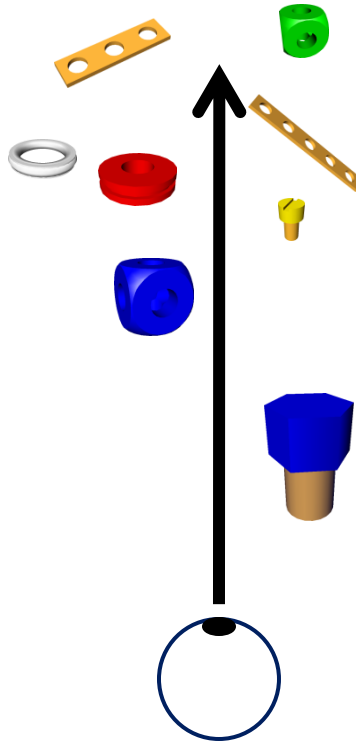
- monocular fixations extended to 3D
 1. calculate 2D fixations on a display
 2. extrapolate by casting a ray from the eye through the fixation into the scene



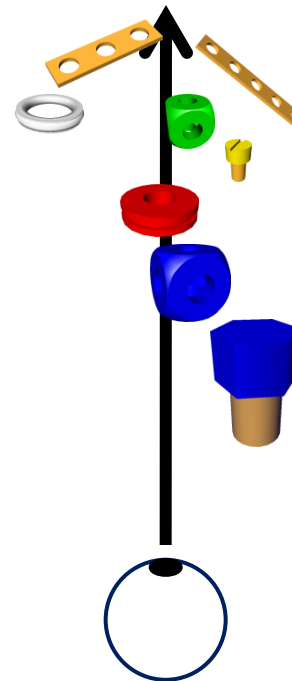
- problems
 - ▣ naive 3D fixations only possible when the ray hits an object
 - ▣ foreground vs. background problematic
 - ▣ ambiguities

Ambiguities

□ Underspecification

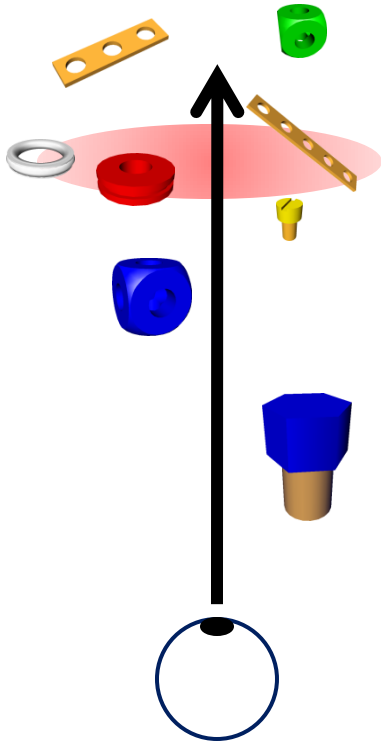


□ Overspecification

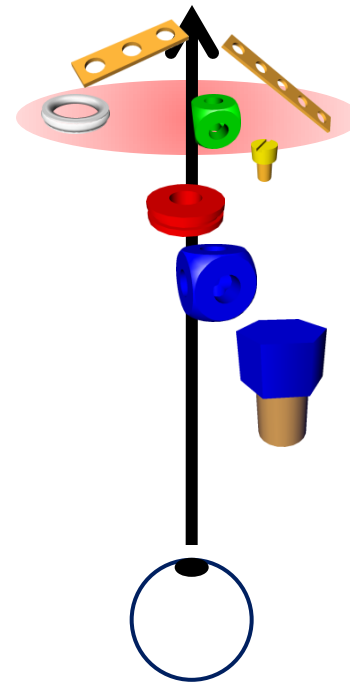


Ambiguities

□ Underspecification

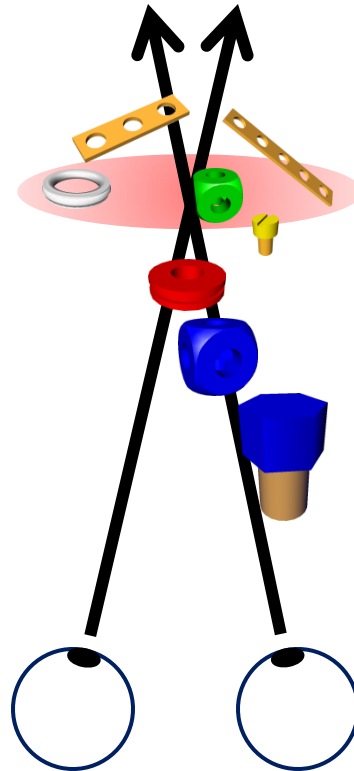


□ Overspecification



Idea: determine the depth of the fixation

Ambiguities

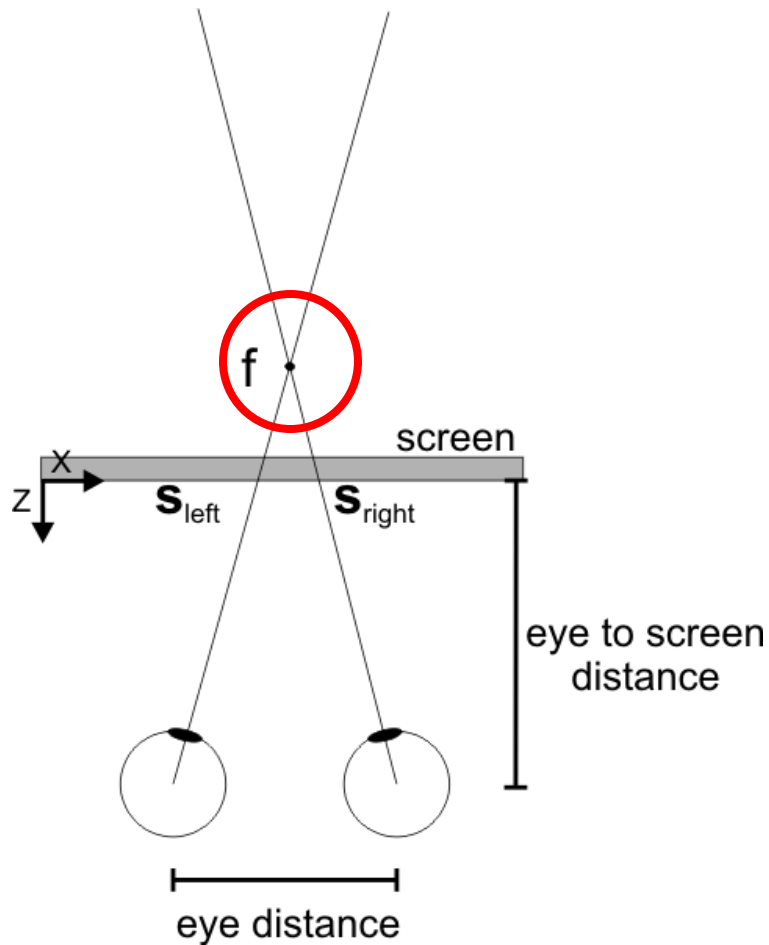


Idea: determine the depth of the fixation

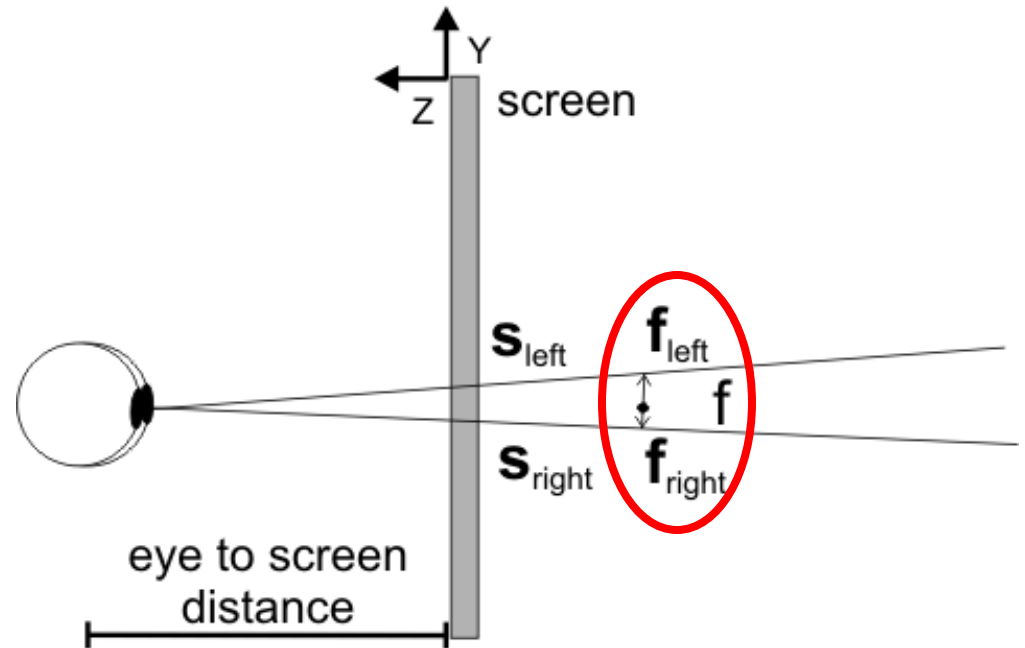
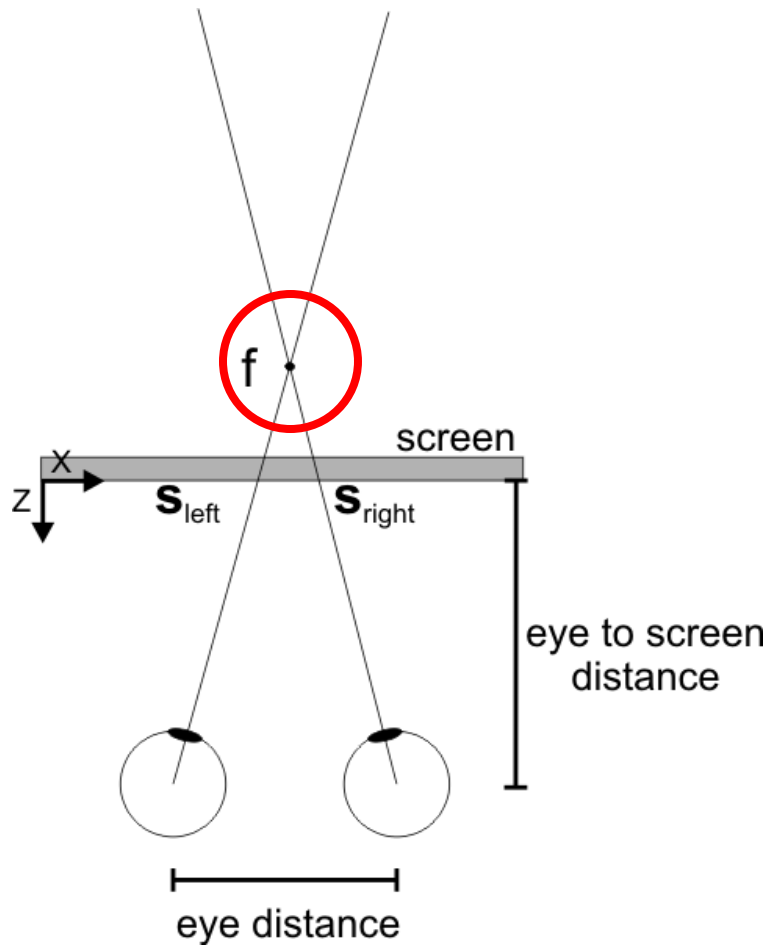
Open Questions

- What features can be used to reconstruct (in parts) the fixated area in 3D space?
 - accommodation
 - vergence
- What algorithms can be used?
 - geometric
 - adaptive (PSOM)
- How accurate does the eyetracker need to be?
 - low-res vs. high-res

Geometric Approach

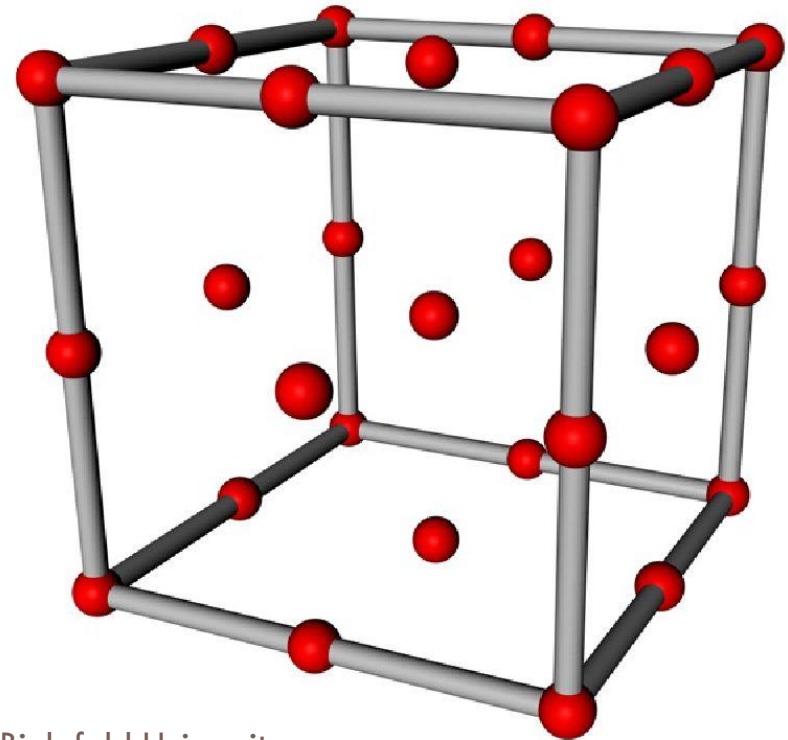


Geometric Approach



Parameterized Self-Organizing Map

- developed by Ritter in 1993
- applied to anaglyphic stereo images by Essig et al. in 2006
- PSOM
 - ▣ input
 $(x_l, y_l), (x_r, y_r), x_r - x_l$
 - ▣ output
 (x, y, z)



Eyetrackers – Technical Details



	Arrington PC60	SMI EyeLink I
temporal resolution	30 Hz / 60 Hz	250 Hz
optical resolution	640x480 / 320x240	not specified
mean error	0.25° - 1.0°	< 1.0°
Accuracy	0.15°	0.01°
compensation of head movement	not included	± 30° horiz. ± 20° vert.

Study

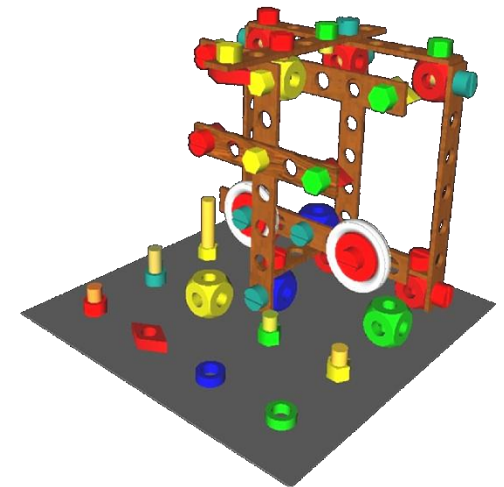
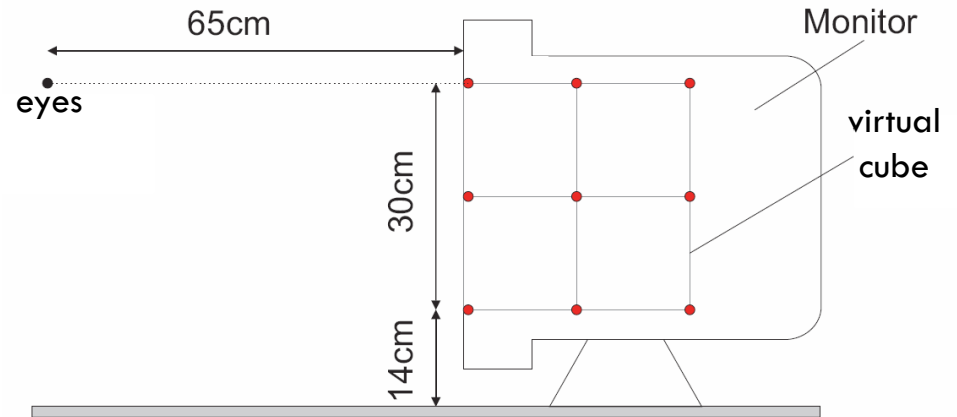
- 10 students tested
- **Hypotheses**
 - (a) **PSOM is better:**

The PSOM is more accurate than the geometric solution.
 - (b) **EyeLink is better:**

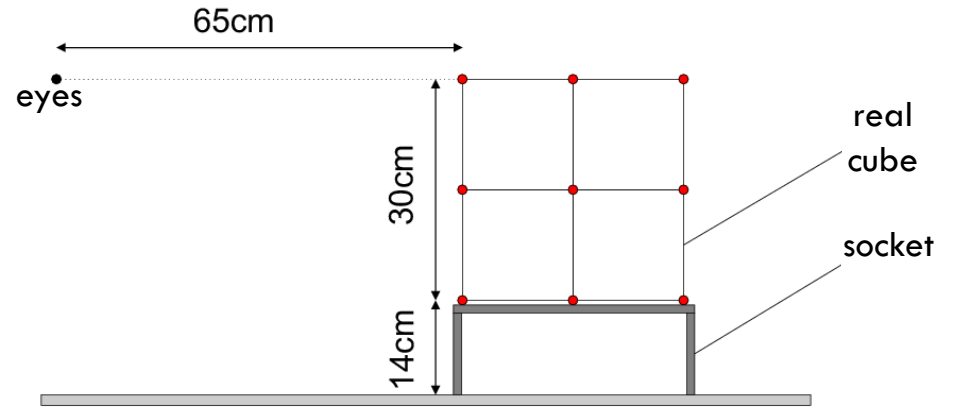
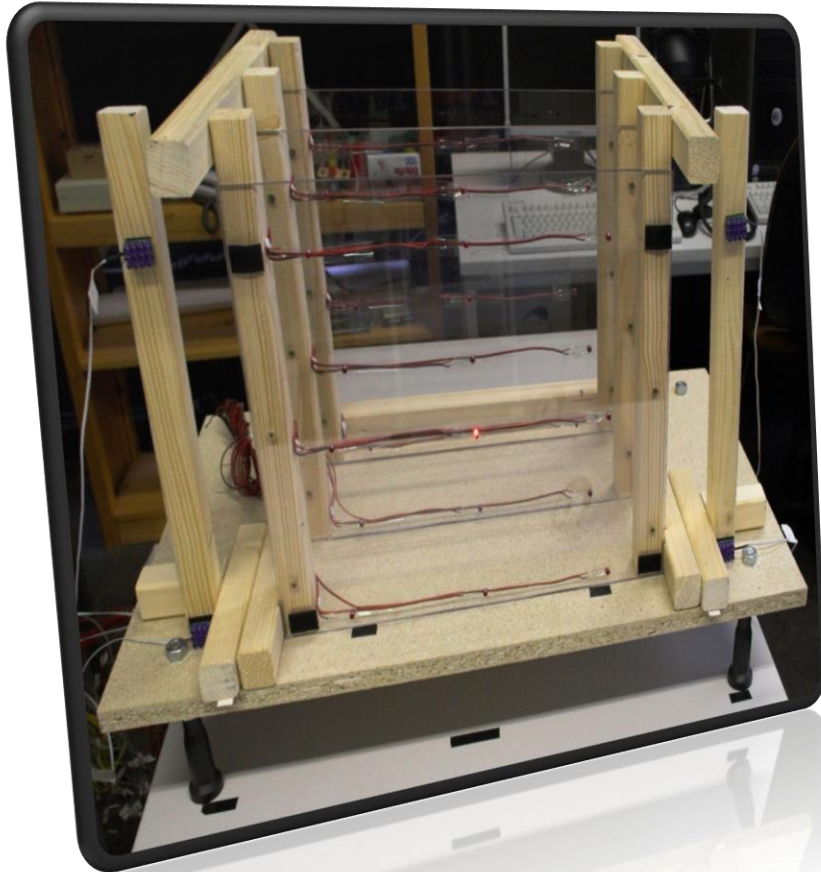
The SMI EyeLink I will deliver more accurate results than Arrington Research's PC60.
 - (c) **Real is better:**

In the real scenario we will be able to get more accurate results than in the virtual scenario.

Scenario – Virtual Reality



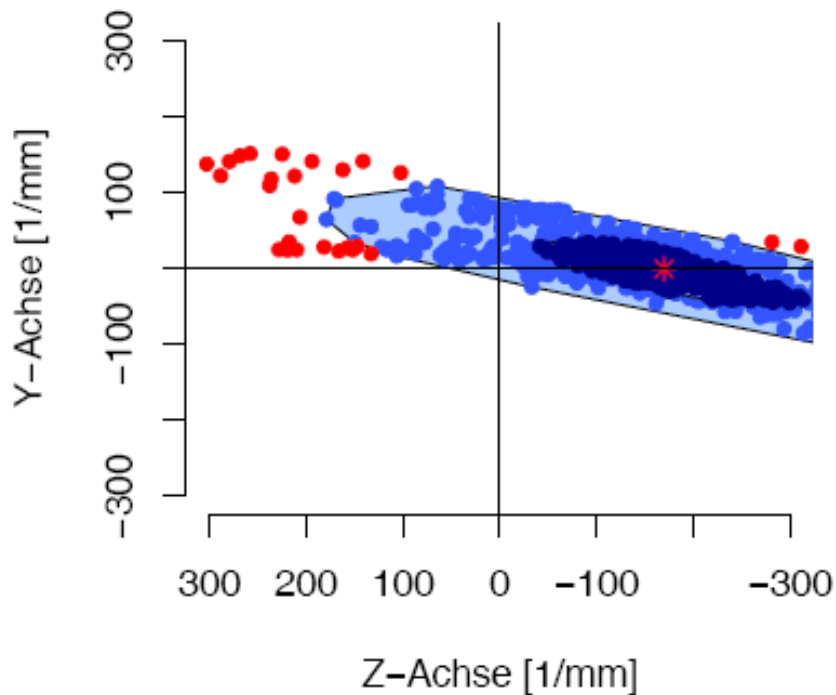
Scenario - Reality



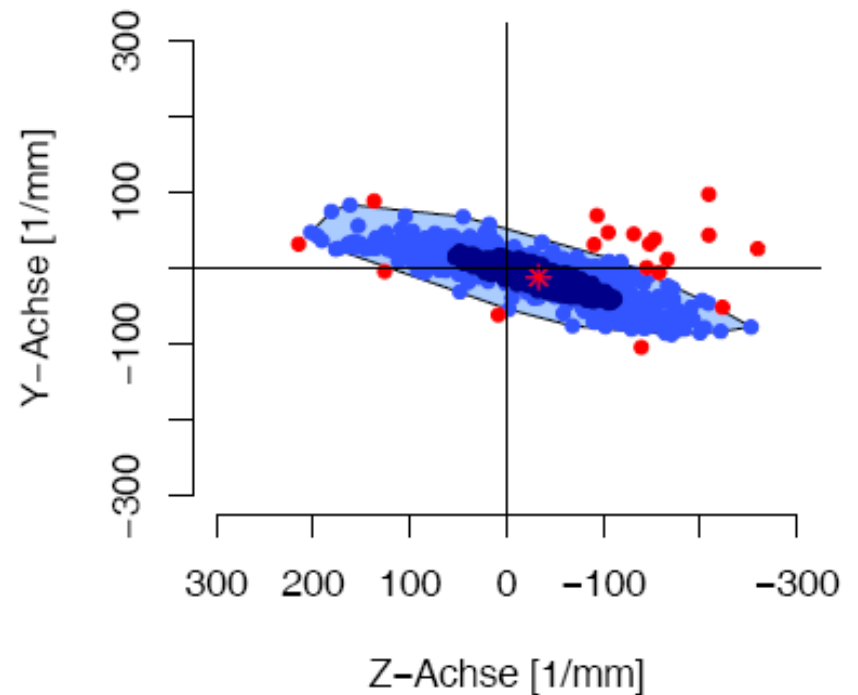
Results

Results: Geom. vs. PSOM

Geometrisch

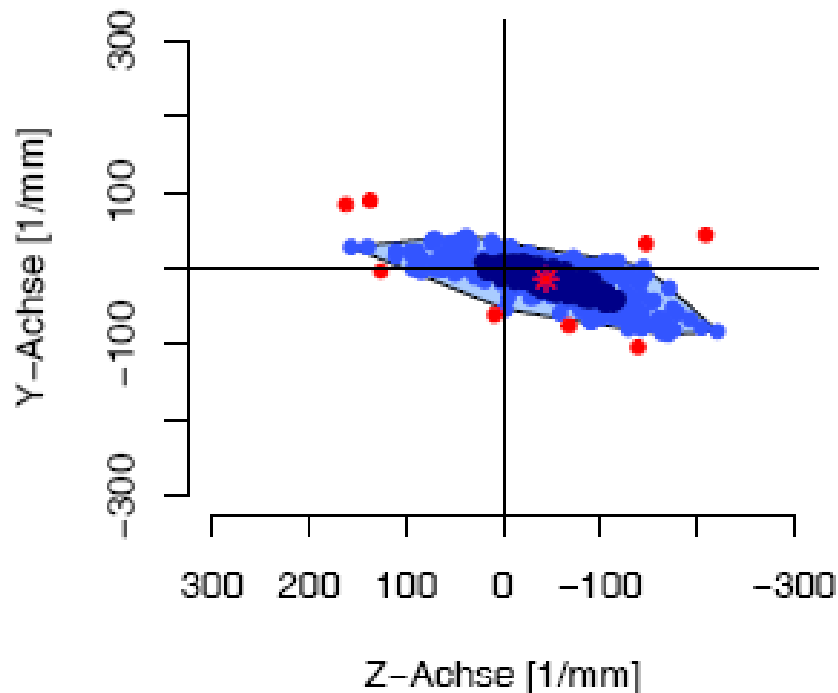


PSOM

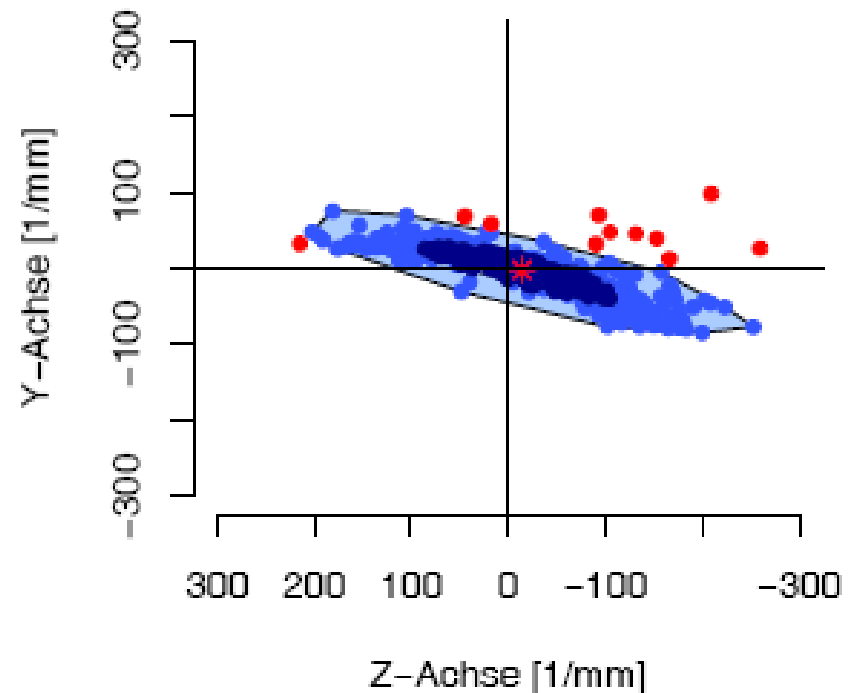


Results: SMI vs. Arrington

SMI PSOM



Arrington PSOM

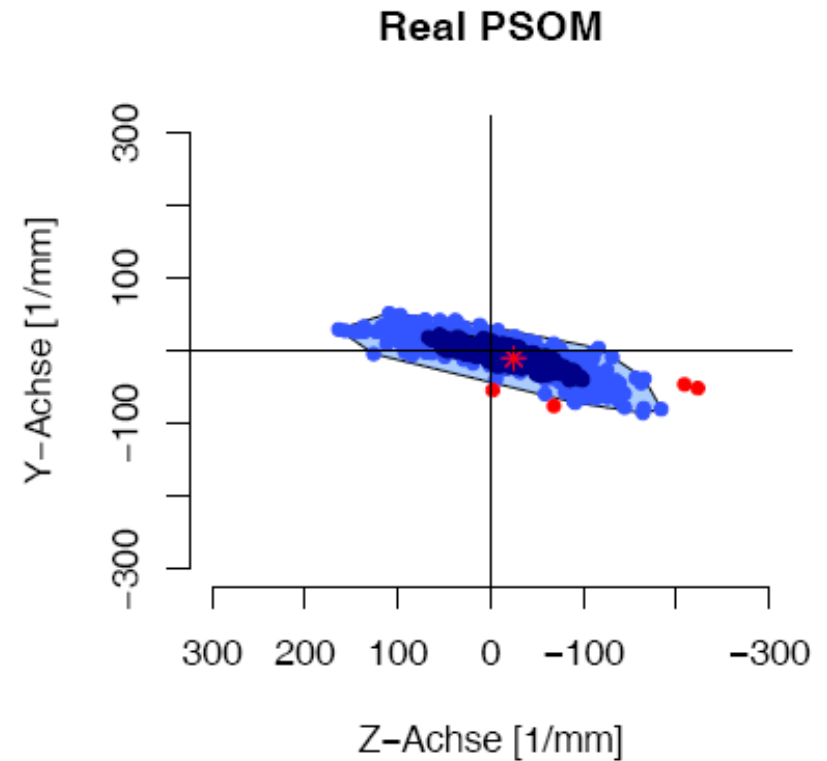
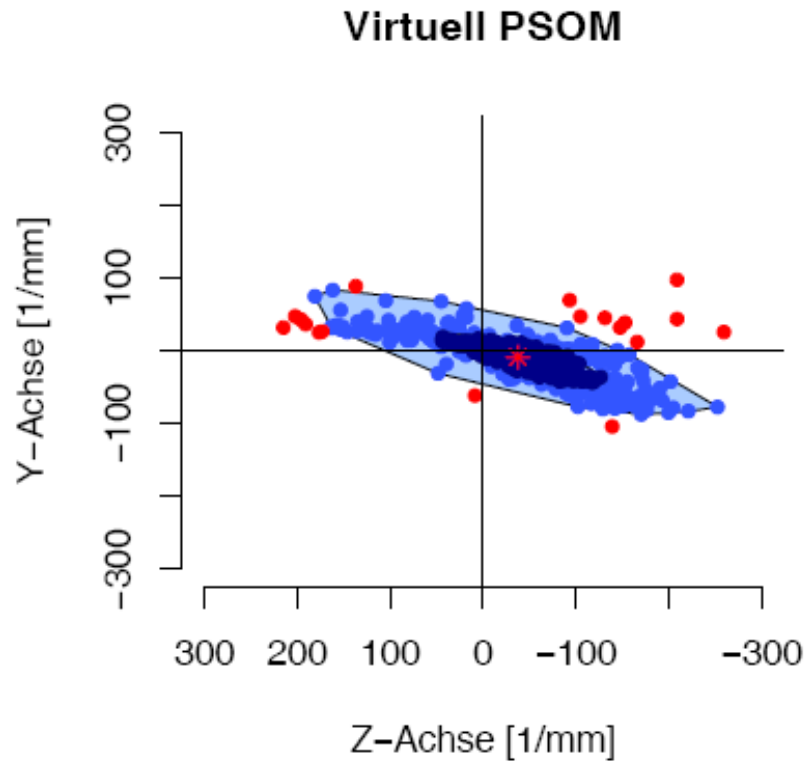


Results

device	algorithm	normally distributed	mean	difference btw. algorithms	nominal error	standard deviation
Arr.	<i>geom.</i>	no, $p < 0,001$	-195,77 mm	sig. $p < 0,001$	sig. $p < 0,001$	526,69 mm
	<i>PSOM</i>	yes, $p = 0,943$	-18,75 mm		sig. $p = 0,005$	96,92 mm
SMI	<i>geom.</i>	no, $p = 0,038$	-248,55 mm	sig. $p < 0,001$	sig. $p < 0,001$	149,3 mm
	<i>PSOM</i>	yes, $p = 0,661$	-70,57 mm		sig. $p < 0,001$	60,06 mm

- **a) is true: PSOM is more accurate and more precise**
 - ▣ significant lower nominal error
 - ▣ lower standard deviation
- **b) is twofold:**
 - ▣ Arrington is more accurate
 - ▣ SMI is more precise

Results: Virtual vs. Real



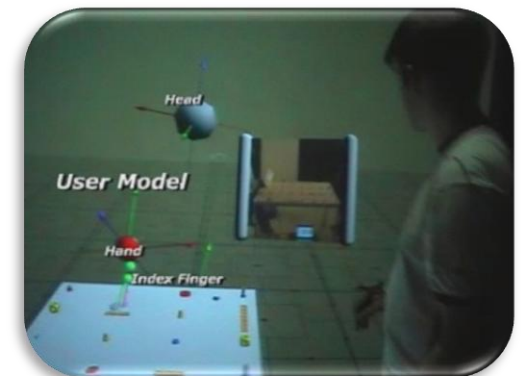
Results: Virtual vs. Real

Value	Virtual	Real
normally distributed	Yes, $p = 0.074$	Yes, $p=0.511$
mean	-44.66 mm	-17.24 mm
std. deviation	84.61 mm	69.37 mm

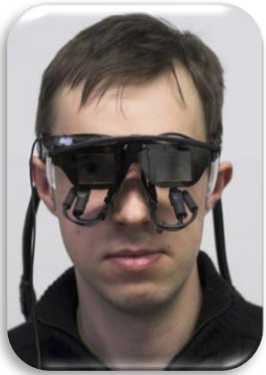
□ **c) is true: Real is better**

Discussion

- 3D fixations can be reconstructed measuring the vergence angle and applying a PSOM algorithm
- accuracy is good, precision is less than expected from literature (Essig et al. 2006)
 - ▣ but “real world” objects have been used (not dots)
- current advice for basic research
 - ▣ distribute critical objects at least 30cm apart when working with near objects
- next study will involve a larger scenario in VR (3m x 3m x 3m)



... in collaboration with



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Dipl. Informatiker



Dr. Marc E. Latoschik



Prof. Dr. Ipke Wachsmuth

The PASION logo features a stylized black outline of a mountain range above the word "PASION" in red capital letters. To the right of the logo is the text "Psychologically Augmented Social Interaction Over Networks". Further right is a diagram of a network with a central human figure and several blue nodes connected by lines, with concentric circles around the nodes.

European Union program under IST, January 2006 - December 2009