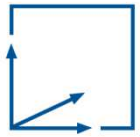
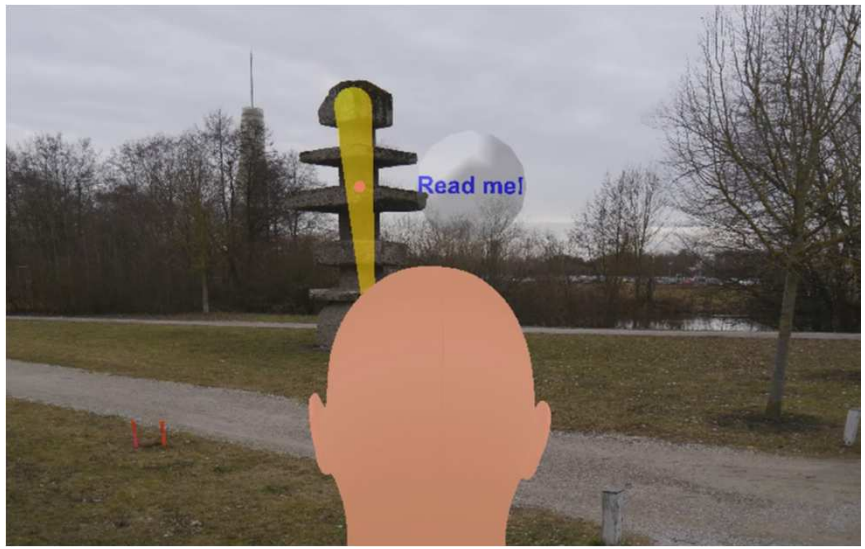
Boundary Conditions for Information Visualization with respect to the User's Gaze



Marcus Tönnis, Gudrun Klinker
{toennis,klinker}@in.tum.de

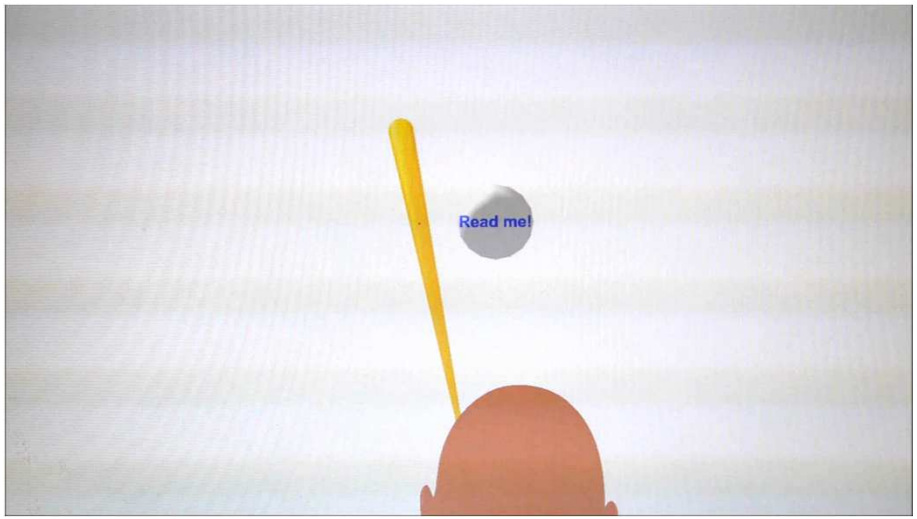
Motivation

- Information placed w.r.t. the user's gaze
  - Is always near to the visual attention of the user
  - Bears the potential for fast information retrieval
    - No need to search for world- or screen-fixed location
    - Known position relative to line of sight
    - Application
      - Heart-rate monitoring during surgery
      - Automotive speed monitoring
      - Task description in complex and dense lists



General Issue and Concept

- Information directly at the user's gaze
  - Constantly in foveal field of view
  - Constantly occludes the world
- A rigid angular offset to line of sight
  - Impossible to capture
  - Prohibits information access
- Approach: Information has angular offset w.r.t. line of sight
  - Look around freely
  - Capture information when necessary



Issues under Investigation

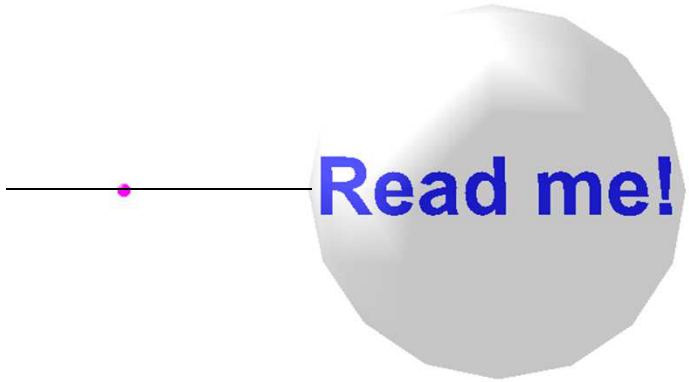
- Boundary conditions
  - Information placement
  - Alignment of information
  - Motion behavior of information
- Information capture

Information Placement

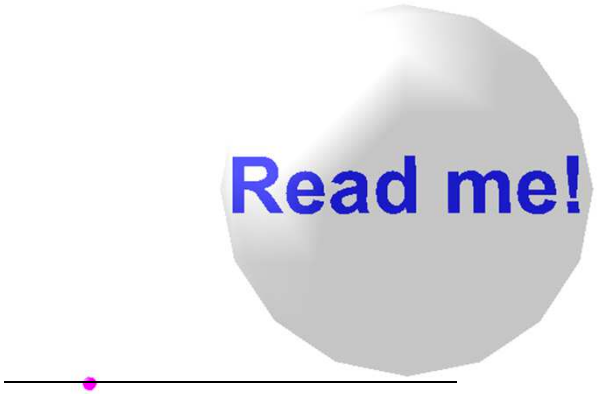
- Offset direction
  - Direction might depend on application
  - Decision on direction left to application developer
- Angular distance
  - Minimum
    - Outside foveal field of view
    - No peripheral fixation
  - Maximum
    - Noticeable at all
    - Not in peripheral field of view (no brightness changes perceived)
    - Comfortably reachable by a glance
  - Expert study settled 8 degree

Alignment of Information

- Alignment of direction
  - Two main frames of reference
    - World-mounted
    - Head-mounted



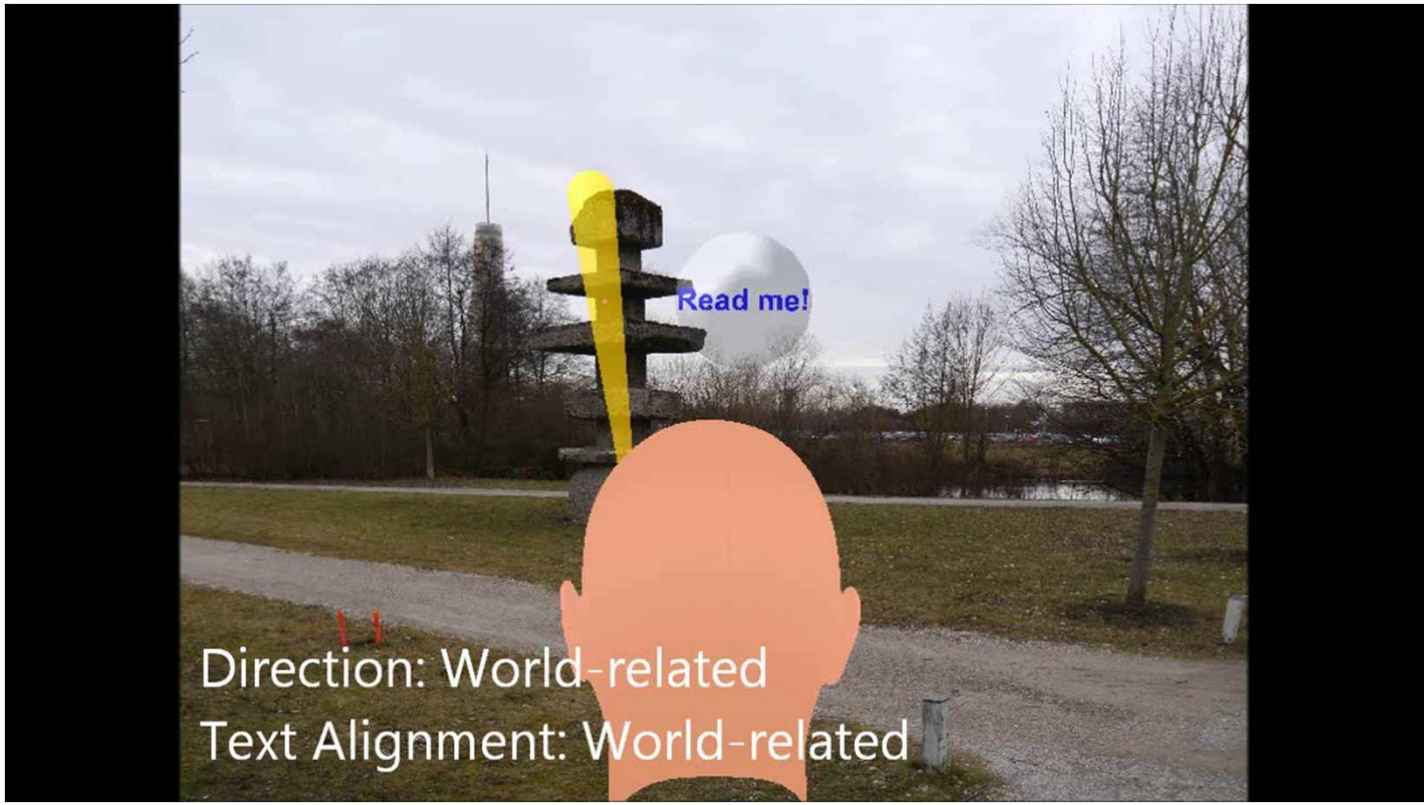
World-mounted



Head-mounted

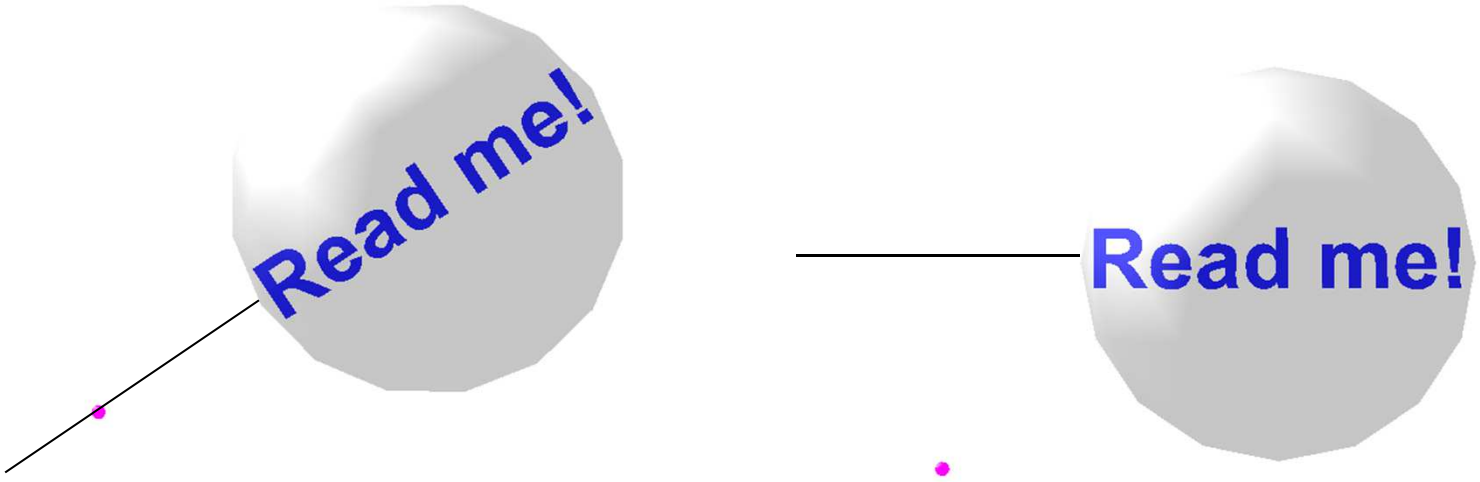
Alignment of Information

- Alignment of direction



Alignment of Information

- Alignment of information content
  - Two main frames of reference
    - Head-mounted
    - World-mounted

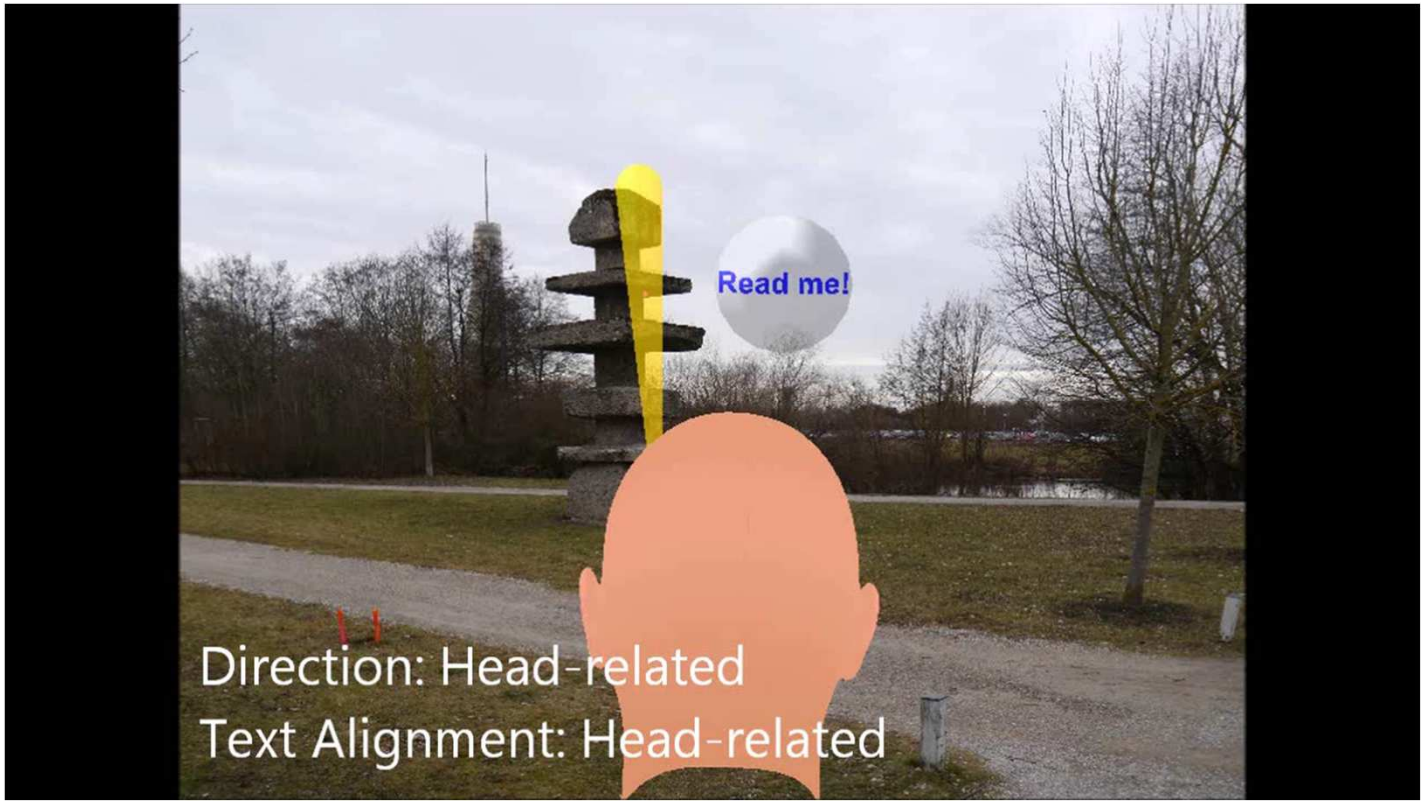


Head-mounted

World-mounted

Alignment of Information

- Alignment of information content

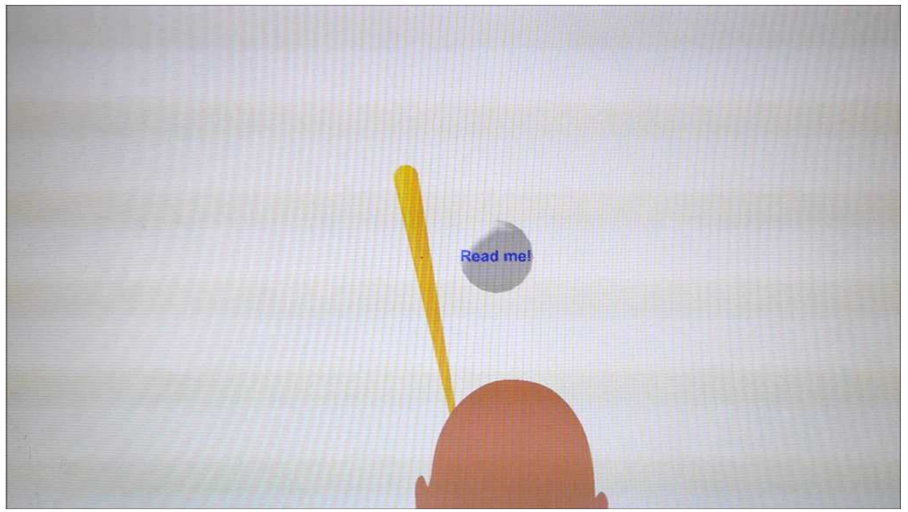


Motion Behavior of Information

- Relative positioning of information
- Three alternatives / variants
  - Rigid offset
  - Velocity-based floating
    - Gaze may not surpass information
    - Gaze may surpass information

Information Capture

- Rigid offset
  - Information constantly 8 degree off
  - Capture by analysis of eye motion history
  - Three states required for capture
    1. Gaze must not have moved for at least 50 ms
    2. Saccade must have been performed within 50 ms
    3. Target location must have been fixated for 200 ms and lie within 2.8 degrees around location of information

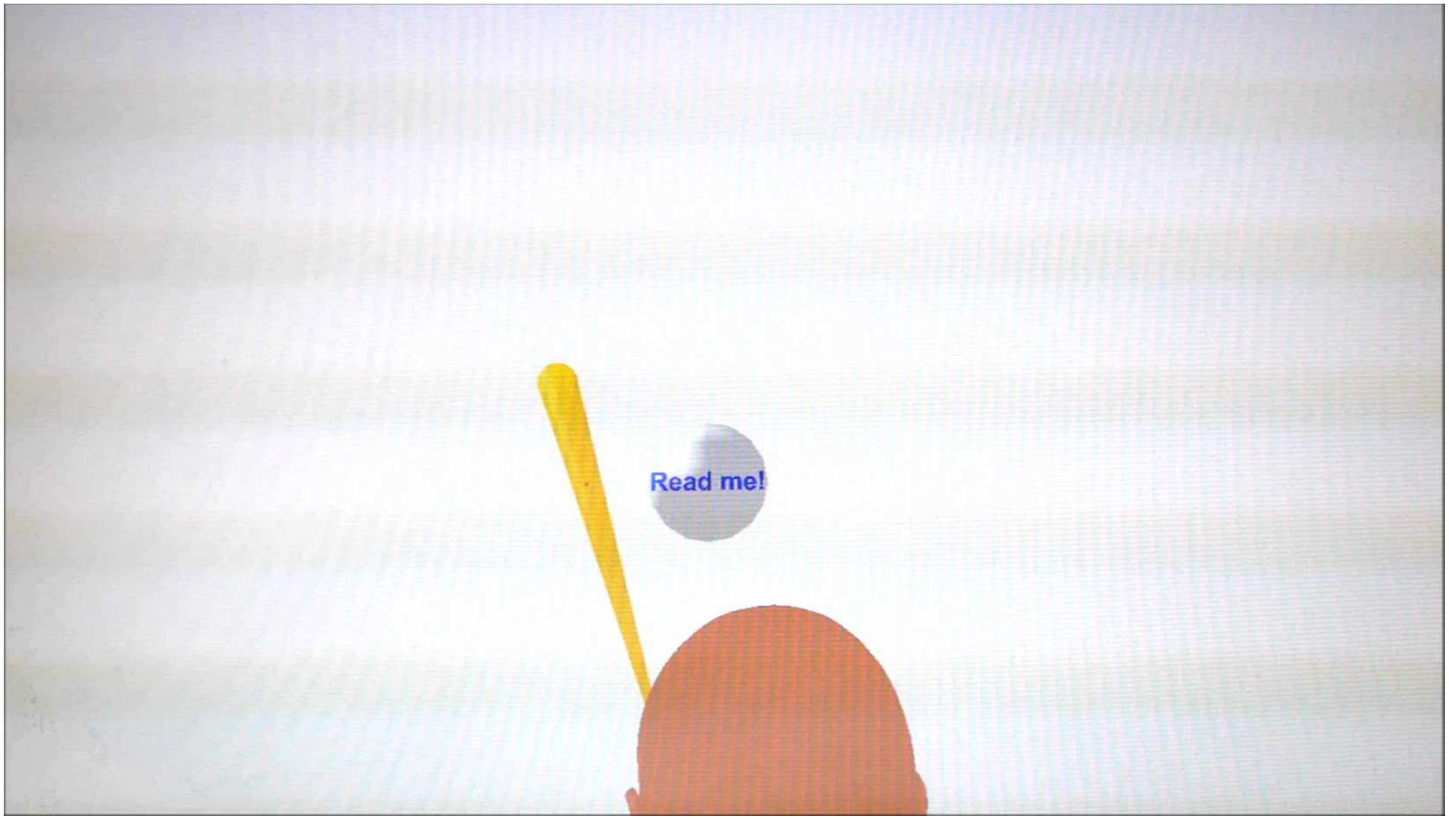


Information Capture

- Velocity-based floating
  - Average angular speed towards and away information is calculated over last 80 ms
  - Delta angle is derived from speed and rendering rate
  - General push-back mechanism
    - If angular speed below 50 degree per seconds
    - Push back at 5 degree per second
  - Capture
    - Collision of gaze with information for 100 ms
    - Common fixation time
  - Non-overexceeding variant: Gaze pushes information along
  - Overexceeding variant: Gaze can surpass information (floats back through line of sight)

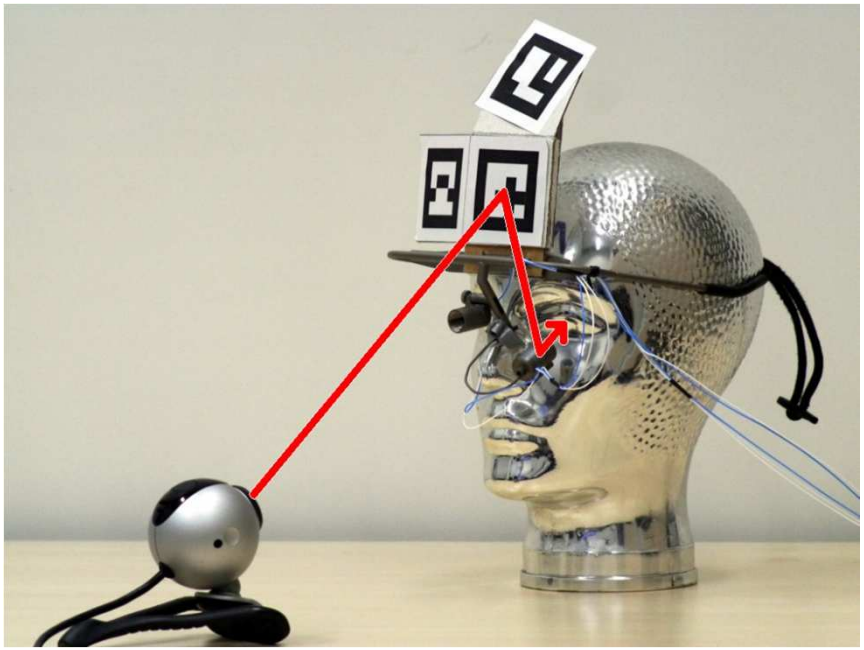
Information Capture

- Velocity-based floating



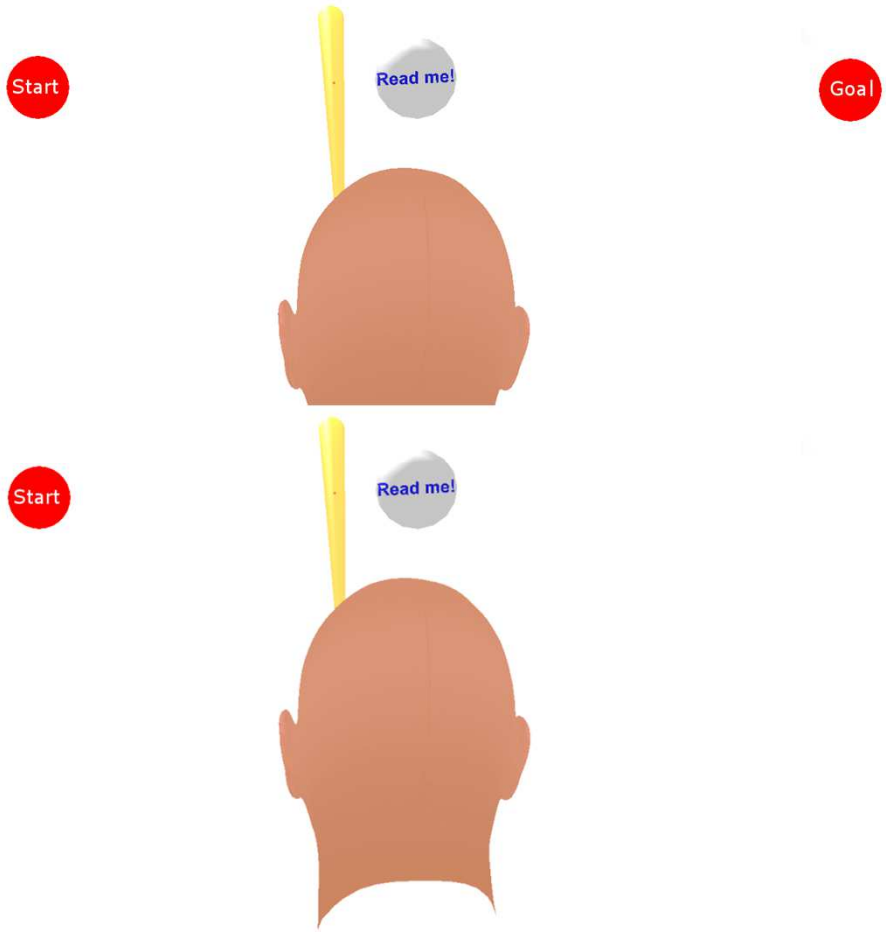
User Study

- 12 volunteers (mean age 29.8, SD 4.5)
- Procedure (1. part)
  - Calibration to individual user
  - Guided interview with questionnaire



User Study

- Procedure (2. part)
  - Performance tests (for all 3 variants)
    1. Start-Goal gazing
       - Assessment of accidental captures
         1. Look at start
         2. Look at goal
    2. Start-Capture
       - Assessment of time and number of glances to capture information
         1. Look at start
         2. Capture information

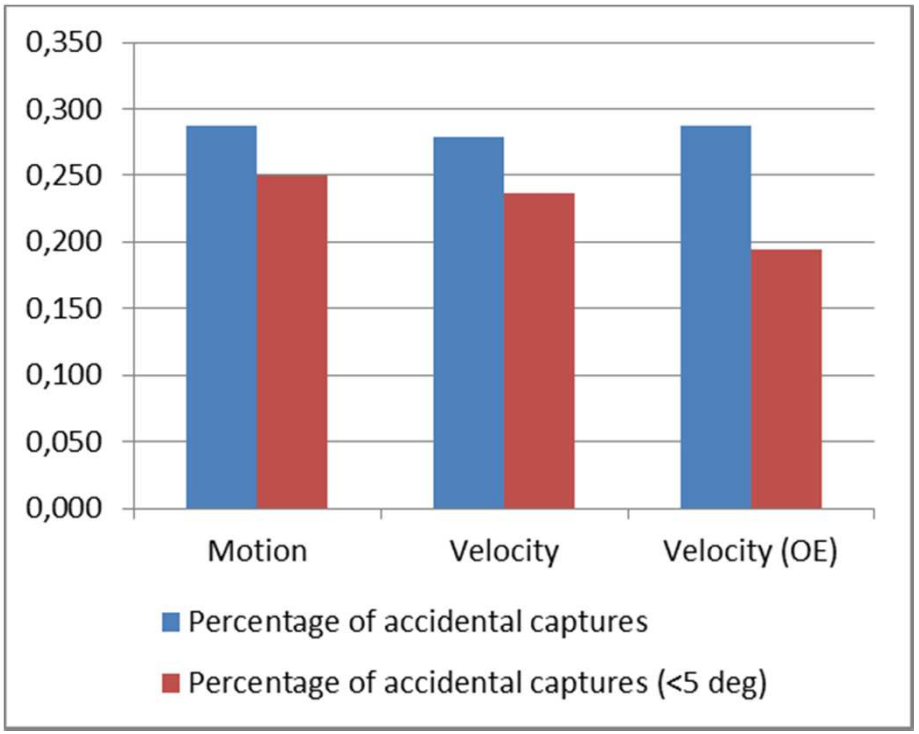


Results – Guided Interview, …

- Frames of reference
  - 91.7 % for world-related directional offset
  - 75 % for world-related information alignment
- Visible floating
  - 91.7 % for no floating of information
  - If floating, 75 % for no overexceeding of information

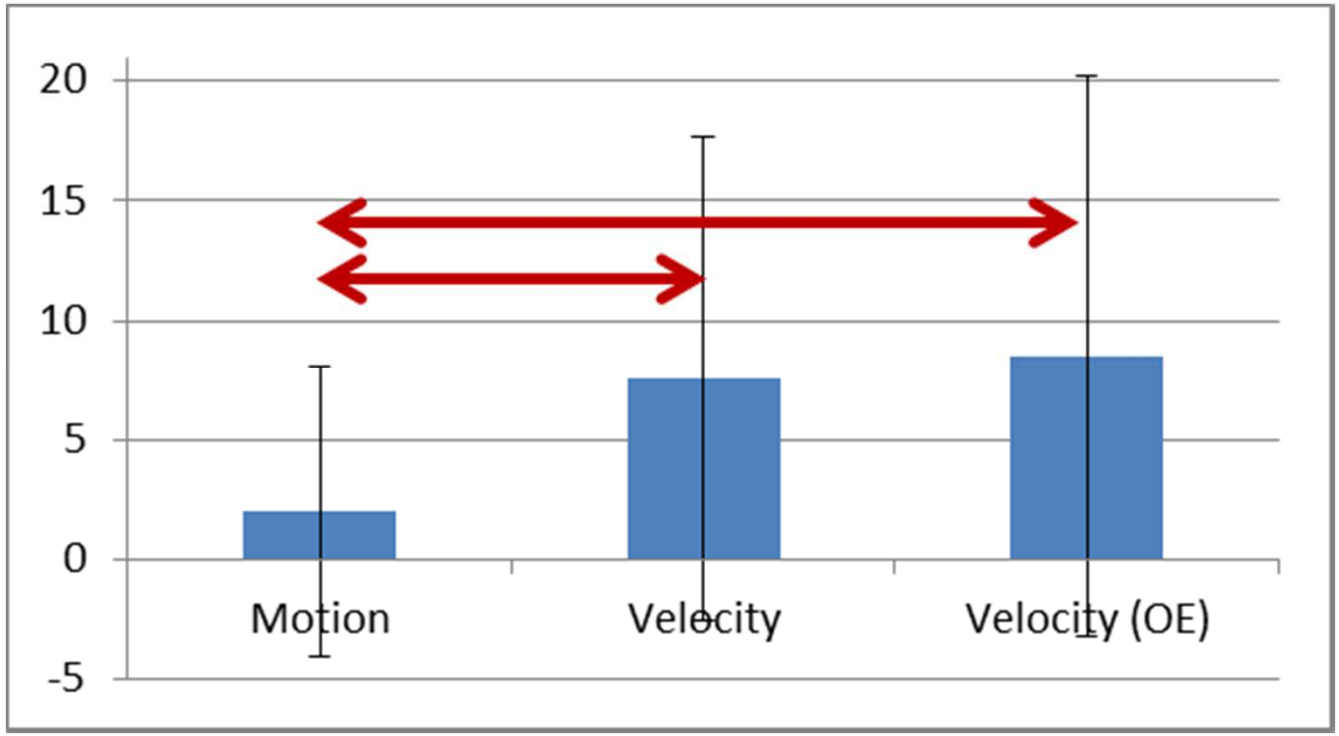
Results – Objective Measurements

- Start-Goal gazing (assessment of accidental captures)
  - No significant results



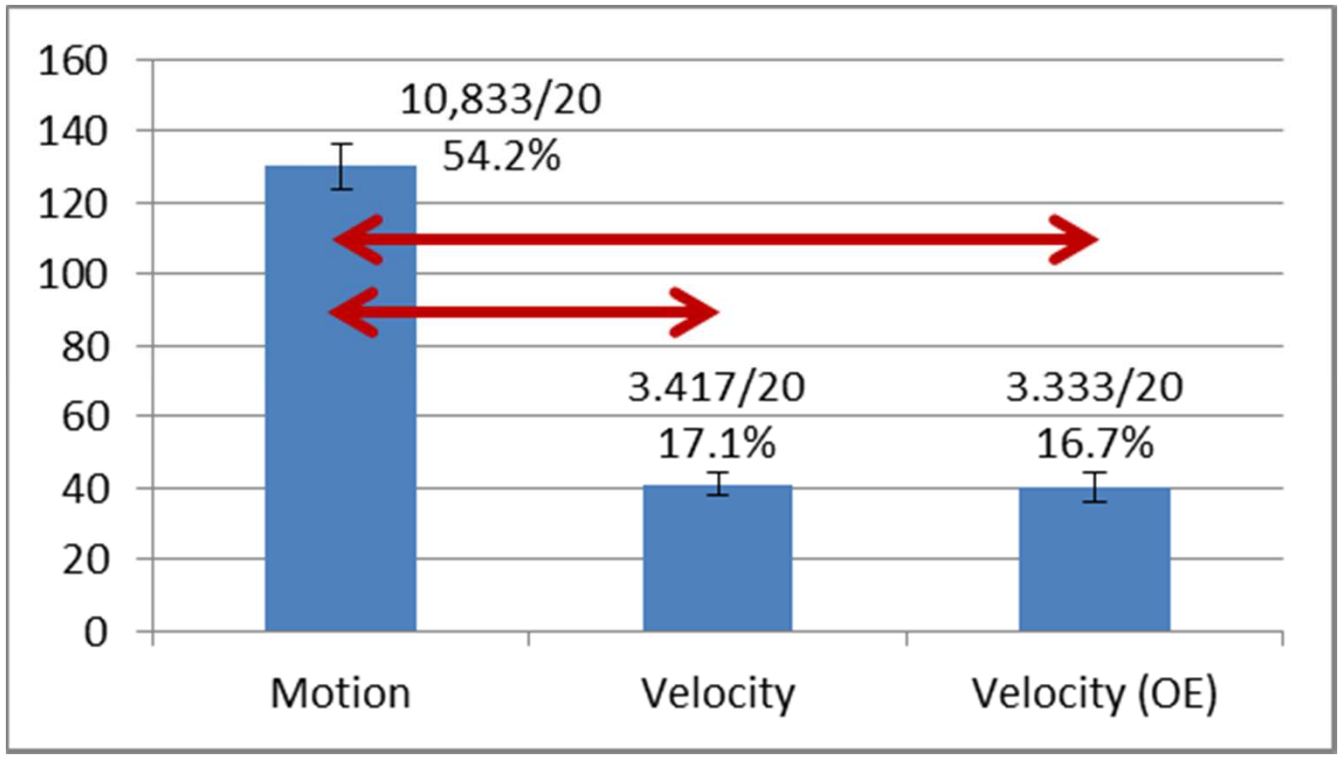
Results – Objective Measurements

- Mean number of saccades to information capture



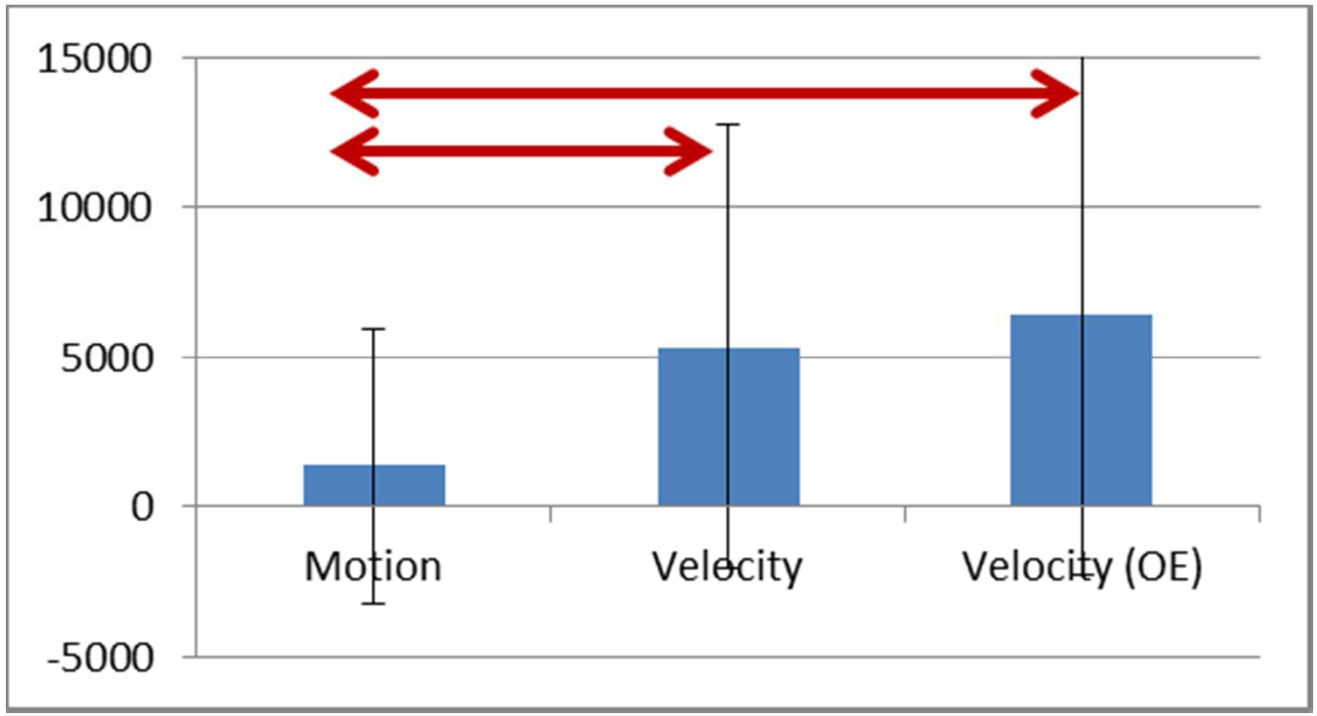
Results – Objective Measurements

- Number of captures with a single saccade



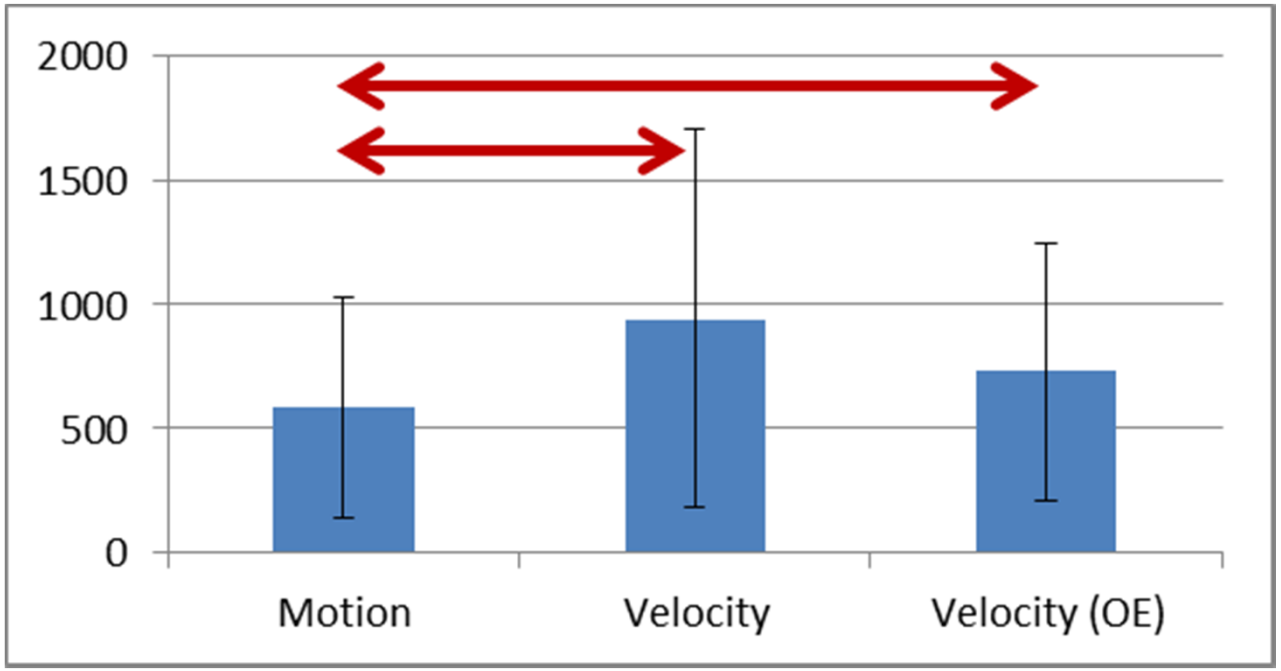
Results – Objective Measurements

- Time to information capture (ms)



Results – Objective Measurements

- Time to information capture with single saccade



Discussion

- Vast majority in favor for motion history algorithm (rigid offset)
- Yet no complete implementation of algorithm, however already
  - 54.8 % capture rate with a single glance
  - 583ms average capture time
- Observation
  - Comparably slow gaze turn when requested to ,,quickly`` look at information
  - Transporting the concept in spoken words is not an easy task

Conclusion

- Placing information with respect to the line of sight
  - New means for information visualization and interaction
  - Bears the potential to keep resuming times for the main task short
- Boundary conditions first
  - World frame of reference
  - Less animation is preferred
- Future work
  - Ruggedize capture algorithms
  - Test
    - With specific application tasks
    - Against conventional strategies such as screen- and world-fixed information placement

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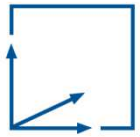

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