For validly analyzing human visual attention, it is often necessary to proceed from computer-based desktop set-ups to more natural real-world settings. However, the resulting loss of control has to be counterbalanced by increasing participant and/or item count. Together with the effort required to manually annotate the gaze-cursor videos recorded with mobile eye trackers, this renders many studies unfeasible.

We tackle this issue by minimizing the need for manual annotation of mobile gaze data. Our approach combines geometric modelling with inexpensive 3D marker tracking to align virtual proxies with the real-world objects. This allows us to classify fixations on objects of interest automatically while supporting a completely free moving participant.

**Introduction**

For validly analyzing human visual attention, it is often necessary to proceed from computer-based desktop set-ups to more natural real-world settings. However, the resulting loss of control has to be counterbalanced by increasing participant and/or item count. Together with the effort required to manually annotate the gaze-cursor videos recorded with mobile eye trackers, this renders many studies unfeasible.

We tackle this issue by minimizing the need for manual annotation of mobile gaze data. Our approach combines geometric modelling with inexpensive 3D marker tracking to align virtual proxies with the real-world objects. This allows us to classify fixations on objects of interest automatically while supporting a completely free moving participant.

**Main Steps**

- Model stimuli in virtual reality
- Estimate the head position using marker tracking
- Align virtual with real markers to create an overlay
- Represent gaze directions as rays and test for intersections with the stimuli

**Goals**

- Reduce effort for the analysis of gaze data in mobile settings
- On-line and off-line analysis
- Support for additional tracking solutions
- Evaluation of the systems accuracy, stability and performance

**Hardware**

**SMI Eye Tracking Glasses 1.0**

- Binocular mobile 3D gaze tracking
- 720p scene camera with 30 Hz

**ART DTrack2**

- Used for comparison
- Sample rate of 60 Hz
- Millimeter accuracy

**Evaluation**

The EyeSee3D approach was evaluated in the context of an experiment analyzing gazing behavior in a face-to-face interaction of two human interlocutors.

**Evaluation of the Tracking**

- Markers could be detected in 81.8% of the 228,150 recorded frames. Thus 129.5 of 158.4 minutes can be classified automatically.
- About 40% of the durations where no marker was detected are <100 ms, thus not relevant for many analyses.
- In comparison with the ART tracking system, the position deviation was 1.23 cm on average (sd: 0.90 cm). The mean angular deviation was 2.2°(sd: 1.46°).

**Evaluation of the Classification**

- We compared the automatic analysis with manual annotation for one participant: The agreement was 64.3% which is good, but not yet satisfying.
- Human annotators seem to have heuristics for resolving ambiguities.
- A coding manual for ambiguous cases in gaze annotations is needed.

---

**The Approach**

**Mobile Eye Tracking**

- Eye cameras detect pupils and calculate gaze directions.
- 3D gaze directions are computed in a coordinate system relative to the position and orientation of the scene camera.

**Head-Pose Estimation**

- The scene camera is calibrated, thus known geometries detected in the 2D image can be transformed to their actual 3D pose.
- Fiducial augmented reality markers are detected in the camera images.
- Based on detected markers, the head-pose transformation is calculated.

**Geometric Model**

- 3D proxy geometries are modelled to approximate the objects of interest. They are anchored relatively to the fiducial markers.
- The virtual model is aligned to the real world based on the known locations of the markers.
- Gaze directions are modelled as rays: Fixated objects can be identified by detecting a collision between the ray and their proxy geometry.

---

Thies Pfeiffer, CITEC
Patrick Renner, AI Group
Bielefeld University
{tpfeife, prenner}@techfak.uni-bielefeld.de

http://www.cit-ec.de

---

**Scan to access the video!**