Specification of Gaze Precision and Gaze Accuracy

Tobii has adopted a comprehensive method for gaze accuracy and precision measurements to facilitate performance comparisons of different remote eye tracking systems. This Tobii TX300 specification is a condensed version of the results from these measurements. The test specification and the complete test report for TX300 can be downloaded at tobii.com.

Gaze accuracy describes the angular average distance from the actual gaze point to the one measured by the eye tracker. *Gaze precision* describes the spatial variation between individual gaze samples.

Gaze accuracy and gaze precision are typically measured in degrees of visual angle. One degree accuracy corresponds to an average error of 11 mm (0.45") on a screen at a distance of 65 cm (26").

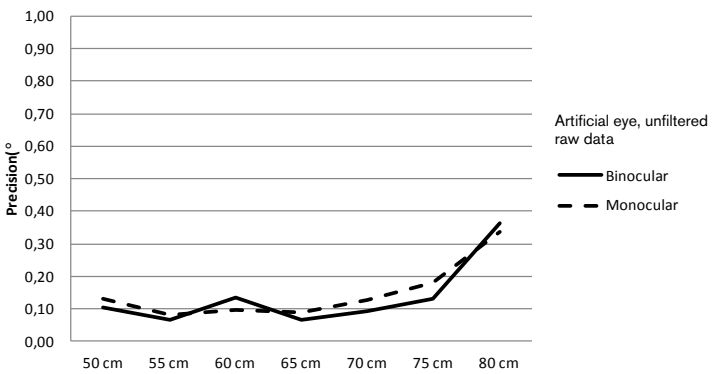
Gaze precision

Precision measurements are done using artificial eyes to eliminate artifacts from human eye movements. Tobii specifies precision both with and without noise reduction filters. All precision measurements are done at 300 Hz sampling rate and a distance of 65 cm (26"). Precision is calculated as root-mean-square (RMS) of successive samples.

	Monocular[1)]	Binocular[1)]
Precision without filter [3)]	0.09°	0.07°
Precision with Stampe filter [2)]	0.01°	0.01°

Precision at varying distances

Precision is dependent on distance from the eye tracker. The graph below illustrates precision results for different distances.

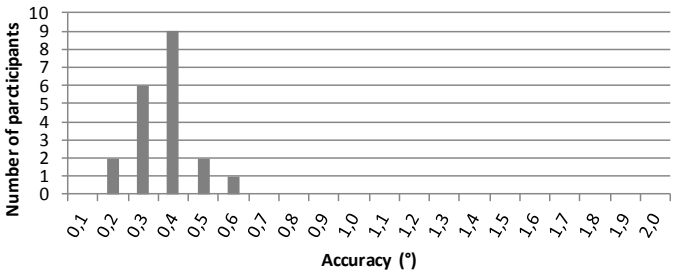


Gaze accuracy

Accuracy is measured under ideal conditions, as well as under various conditions that influence a non-restrictive eye tracking test, e.g. change of gaze angles, light conditions or head position. All measurements are performed in a carefully controlled lab environment.

	Monocular	Binocular
Accuracy under ideal conditions [4)]	0.5°	0.4°

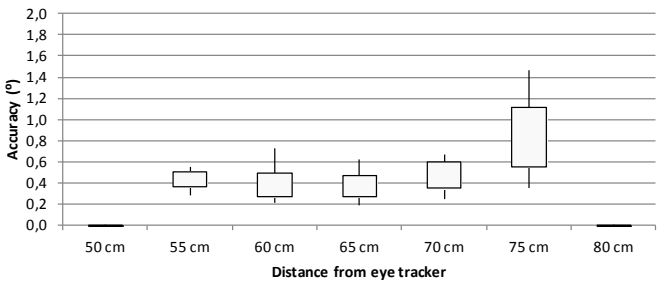
Distribution of Accuracy under ideal conditions



	Monocular	Binocular
Accuracy at large gaze angles [5)]		
25° gaze angle	0.4°	0.3°
30° gaze angle	0.8°	0.6°
Accuracy at varying illumination [6)]		
1 lux (darkness)	0.8°	0.6°
300 lux	0.5°	0.4°
600 lux	0.7°	0.5°
1000 lux	0.7°	0.5°
White stimuli background (300 lux)	0.8°	0.6°

Binocular accuracy at varying distances [7)]

The bars show min, max and average accuracy for all test subjects at different distances from eye tracker to test subject.



1) *Monocular data shown is based on data from each eye individually. Binocular data is the average of the two eyes.*

2) *Stampe (Behavior Research Methods, Instruments & Computers 1993, 25 (2), 137-142) describes a noise reduction filter commonly used for eye tracking data. In these measurements, the Stampe stage 2 algorithm has been applied.*

3) *Raw data, without any noise reduction filters.*

4) *Accuracy under ideal conditions is measured in the center of the head movement box with the subject fixed in a chinrest. Data is collected immediately after calibration, in a controlled laboratory environment with constant illumination, with 9 stimuli points at gaze angles <=18°. Measurements are done on 20 test subjects without lenses, glasses or droopy eyelids. Accuracy for one subject is calculated as the mean of several data samples for of all of the 9 stimuli points across a screen. The accuracy figure presented is the mean accuracy from all subjects.*

5) *Good accuracy is difficult to achieve at large gaze angles, but is important when testing large stimuli. For instance, the upper corners of a 23" screen with a test subject at a distance of 65 cm (26") corresponds to a 31° visual angle relative to the center of the eye tracker unit.*

6) *Illumination is measured in front of the respondents head in various directions. Then luminance of the stimuli or illumination in the lab changes, the size and shape of the pupil is affected. Unless compensated for, this may cause a significantly reduced accuracy.*

7) *Calibration is done with the subject in the center of the head movement box. Measurements are performed with the test subject at precise and specific distances relative to the eye tracker, measured along the axis of the eye tracking sensors. Data shown in the graph is binocular.*

Specification of Tobii TX300 eye tracker unit

Sampling rate (binocular)	300 Hz *
Sampling rate variability [1]	<0.3%
Processing latency [2]	1.0-3.3 ms
Total system latency [3]	<10 ms
Timestamp precision	
Via sync-out port [4]	<0.1 ms
As specified in each data sample [5]	Std dev 40 µs
Time to tracking recovery for blinks [6]	Immediate
Time to tracking recovery after lost tracking [6]	10-165 ms
Freedom of head movement at 65cm [7]	37 x 17 cm (15 x 7“)
Operating distance eye tracker to subject	50-80 cm (20-31”)
Max head movement speed [8]	50 cm/s (20”/s)
Max gaze angles	35 degrees
Tracking technique	Dark pupil
Data sample output *(for each eye)*	Timestamp Eye position Gaze point [9] Pupil diameter [10] Validity code [11]
Connectors	LAN *(TCP/IP - data samples)* 12 pin connector *(LVDS -sync-out port)* 3.5 mm audio plug *(audio in)*
Eye tracker processing unit	Embedded
Built-in speaker	3 W
Weight	6 kg
Size *(excl stand)*	55 x 24 x 6 cm (22 x 9 x 2“)

**) The Tobii TX300 can be run at either 60, 120 or 300 Hz*

1) The deviation in sampling rate (defined by time of eye image exposure), also under non-optimal tracking conditions.

2) Processing latency describes the time required by the eye tracker processor to perform image processing and eye gaze computations.

3) The average duration from mid-point of the eye image exposure, to when a sample is available via the API on the client computer (assuming a dedicated Gigabit Ethernet connection). This includes half of image exposure time, plus image read-out and transfer time, processing time and time to transfer the data sample to the client computer.

4) The maximum temporal deviation of the signal on the sync-out port relative to the beginning of the actual exposure of the eye image.

5) The standard deviation of temporal deviation of timestamp precision in the data sample received by the client application. This includes any offset in the clock sync between the eye tracker processing unit and a typical client computer.

Specification of Tobii TX300 screen unit

Screen size	23“
Aspect ratio	16:9
Screen resolution *(max)*	1920 X1080 pixels
Screen response time	typical 5 ms
Built-in web camera	640 x 480 @ 30 fps
Weight	4 Kg
Connectors	USB *(web camera)* DVI/VGA

Software options

The following software applications are compatible with the Tobii TX300:

- Tobii Studio
- Tobii SDK with free MATLAB and Python 2.7 bindings for Windows and Mac OS X
- E-Prime Extensions for Tobii
- All other applications, built on the Tobii SDK [12]

Hardware package

The Tobii TX300 hardware package includes the following:

- Eye tracker unit
- Screen unit
- Digital angle gauge

6) Describes the time it takes for the system to regain tracking after it has not detected the subject's eyes. For a short period of a few hundred ms, the system will regain tracking immediately, but only in the same approximate head position. This enables the system to re-acquire tracking instantly after blinks. Under normal tracking conditions, no samples are lost before, during or after blinks, other than samples that may be lost during the eyelid movement itself due to partial occlusion of the pupil. After a time period of a few hundred ms without detecting eyes, the system will instead start searching for the eyes in the head movement box, and will take the specified time to recover tracking. After about one minute, the system will enter a “slow search” mode which leads to larger recovery times.

7) Describes an area where at least one of the eyes is within the field of view of the eye tracker. Specified as width x height.

8) Describes the maximum head movement speed allowed while maintaining robust tracking. The specified number is for sideways head movements.

9) Both as absolute coordinates in mm relative to stimuli plane, and as normalized coordinates in the stimuli plane. From the eye position and the gaze point, the precise gaze angle can be calculated in degrees.

10) Pupil diameter, with accurate algorithms to compensate for the spherical corneal magnification effect as well as the distance to the eye.

11) The validity code indicates the system's confidence in whether it has correctly identified which eye is left and right eye for the specific sample

12) At the Application Market for Tobii Eye Trackers (appmarket.tobii.com) a large number of applications, built and the Tobii SDK, can be searched for and downloaded.

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