Product **Description**

Tobii® Technology

Tobii TX300 Eye Tracker

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Product Description for Tobii TX300 Eye Tracker

Revision 1.0, November 2010

Declaration of Conformity
This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules and EMC directive 2004/108/EEC. The product also conforms with the directive 2006/95/EEC for low voltage.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

CE

All Tobii Eye Trackers are CE-marked, indicating compliance with the essential health and safety requirements set out in European Directives.

The Tobii Eye Trackers are for use in office environments.

Introduction

Overview

This document describes the features and functionality of the Tobii TX300 Eye Tracker. The TX300 Eye Tracker is an integrated eye tracker that is supplied with a removable 23" TFT monitor. Removing the TFT monitor transforms the integrated eye tracker into a standalone eye tracker. The eye tracker requires some assembly before first time use and after transport.

The Tobii TX300 Eye Tracker is an unobtrusive eye tracker for detailed research of natural behavior. Its large head movement box allows the subject to move during tracking while maintaining accuracy and precision at a sampling rate of 300 Hz. This means that eye movements such as saccades and short fixations can be studied without using a chinrest. The TX300 has a built in user camera as well as a speaker which allows for recording of subjects' reactions to stimuli as well as playback of sounds. Tobii TX300 offers maximum flexibility with numerous software and stimuli set-up options.

Application areas

Tobii TX300 Eye Tracker is suitable for use in areas such as:

- Neuroscience studies, especially those combining eye tracking and EEG data
- Ophthalmology studies, especially those where large freedom of head movement is needed
- Reading studies, especially those where large freedom of movement is important
- Psychology research, especially developmental psychology and psycholinguistics
- A latency of less than 10 ms enables tests with a gaze-contingency paradigm.

Basic Operating Principles

During tracking, Tobii Eye Trackers use infrared diodes to generate reflection patterns on the corneas of the subject's eyes. These reflection patterns, together with other visual data about the subject, are collected by image sensors. Sophisticated image processing algorithms identify relevant features, including the eyes and the corneal reflection patterns. Complex mathematics is used to calculate the 3D position of each eyeball, and finally the gaze point on the screen; in other words, where the subject is looking.

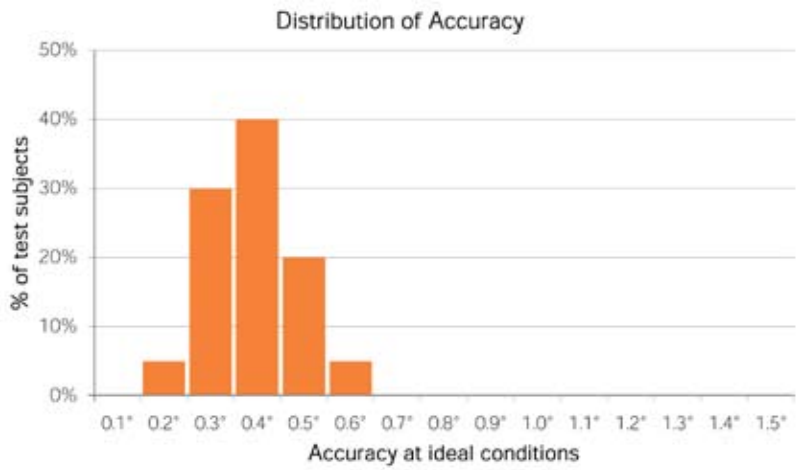
Technical specifications

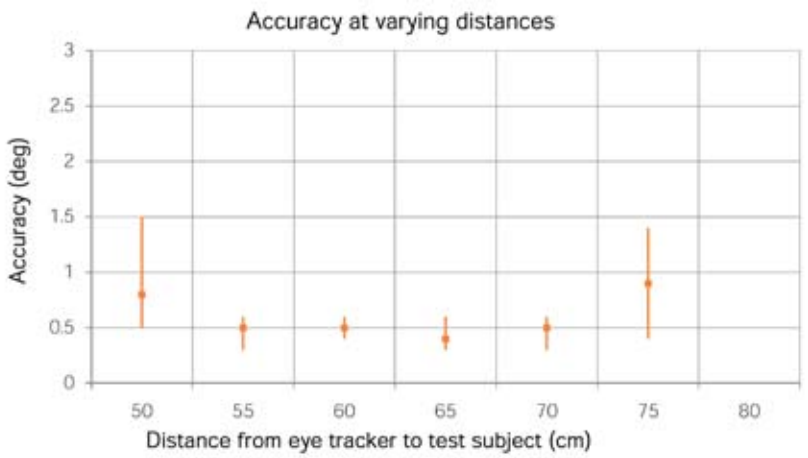
Tobii TX300 Eye Tracker

The characteristics of an eye tracker can be described in terms of gaze accuracy and gaze precision. 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 successive samples collected when the subject fixates at a specific point on a stimuli. More information regarding the accuracy and precision measurements can be found in Appendix II. A glossary can be found in Appendix I.

Gaze accuracy (Preliminary measurements)		
	Monocular	**Binocular**
At ideal conditions[1)]	**0.5°**	**0.4°**
At 25° gaze angle	**0.5°**	**0.4°**
At 30° gaze angle	**0.6°**	**0.5°**
At 1 lux	**1.1°**	**0.9°**
At 300 lux	**0.5°**	**0.4°**
At 600 lux	**0.6°**	**0.4°**
At 1000 lux	**0.6°**	**0.5°**
White stimuli background (300 lux)	**0.8°**	**0.6°**

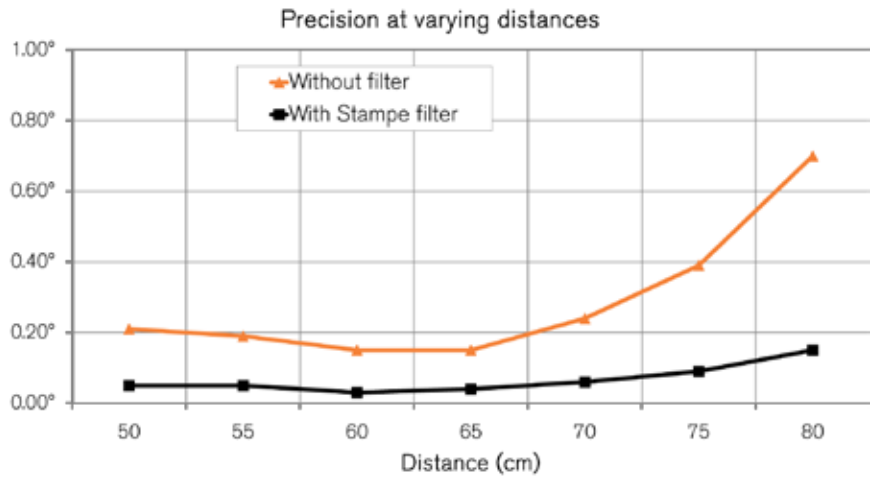
[1)] Accuracy under ideal conditions is measured in the centre of the head movement box with the subject fixed in a chinrest. Data is collected immediately after calibration, in a controlled laboratory environment with constant illumination, with 9 stimuli points at gaze angles of ≤18°.





Gaze precision (Preliminary measurements)		
	Monocular	**Binocular**
With Stampe filter[1)]	**0.06°**	**0.04°**
Without filter	**0.22°**	**0.15°**

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

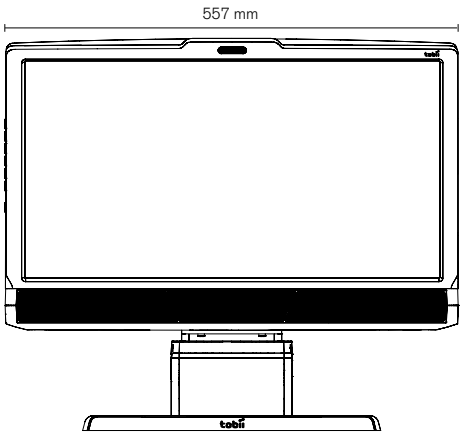


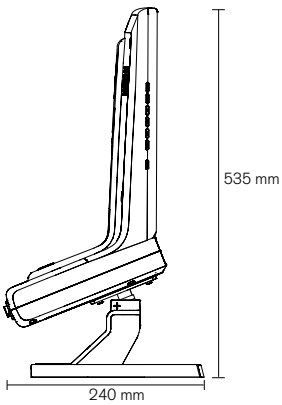
Eye tracking specifications (Preliminary measurements)		
Sampling	**Sampling rate** (binocular)	**300 Hz**
	Sampling rate variability	**0.3%**
Latency	**Processing latency**	**1.0 - 3.3 ms**
	Total system latency	**<10 ms**
Timestamp precision	**Via sync-out port**	**<0.1 ms**
	As specified in each data sample	**Std dev 40 µs**
Time to tracking recovery	**For blinks**	**Immediate**
	After lost tracking	**10 - 165 ms**
Head movement	**Freedom of head movement at 65 cm** (width x height)	**37 x 17 cm (15 x 7”)**
	Operating distance (eye tracker to subject)	**50-80 cm (20-31”)**
	Max head movement speed	**50 cm/s (20”/s)**
Max gaze angle		**35°**
Tracking technique		**Dark pupil tracking**

A glossary can be found in Appendix I.

The TX300 Eye Tracker is an integrated eye tracker with a removable 23" TFT monitor. Removing the TFT monitor transforms the integrated eye tracker into a standalone eye tracker.

Overall dimensions





Screen unit

Screen size	23"
Screen resolution (Max)	1920 x 1080 pixel
Aspect ratio	16:9
Display colors	16.7 M (Hi-FRC)
Vertical Sync Frequency	49-75 Hz
Horizontal Sync Frequency	54.2-83.8 kHz
Response time	typical 5 ms
Luminance, white	typical 300 cd/m²
User Camera	Built in (640 x 480 @ 30fps)
Weight	4 kg (8.8 lbs)
Connectors	DVI/VGA USB (User camera) Power connector

Eye Tracking unit

Eye tracking processing unit	Embedded
Speaker	3 W (mono)
Weight	6 kg (13.2 lbs)
Unit Size (without desk stand)	55 x 24 x 6 cm (22 x 9 x 2")
Connectors	LAN (TCP/IP over Ethernet - data samples) 12 pin connector (LVDS - sync out) 3.5 mm audio plug (audio in) 50Ω terminated BNC connector (currently not in use) Power connector

Data sample output

Eye tracker data sample output

Different applications can be connected over TCP/IP (LAN connector) as clients to the eye tracker to, e.g., gather eye gaze data in real-time and perform calibrations. Applications that can be used together with the eye tracker include the Tobii Studio™ analysis software, third party analysis products such as E-Prime® or your own custom written software for analysis, gaze-contingent applications or eye control applications. For more information on how to create your own applications, please refer to the Tobii Software Development Kit (SDK) product description.

Below is a list of data that can be accessed through the output of the eye tracker. In Tobii Studio™ analysis software this data can be accessed through a Raw data text export function, and easily imported into a spreadsheet for further analysis.

Timestamp	Timestamp in milliseconds stating the mid-exposure time when the sample was collected by the eye tracker's image sensors.
Gaze PointXLeft	Horizontal screen position of the gaze point for the left eye.
GazePointYLeft	Vertical screen position of the gaze point for the left eye.
CamXLeft	Horizontal location of the left pupil in the camera image (0 is left edge, 1 is right edge).
CamYLeft	Vertical location of the left pupil in the camera image (0 is top, 1 is bottom).
DistanceLeft	Distance from the eye tracker to the left eye. The distance is given in mm on a straight axis right out from the eye tracker plane.
PupilLeft	Size of the pupil (left eye) in mm. The distance and pupil size measurements are calculated to be as close to real values as possible. However, individual differences in the eyes of subjects or the strength of glasses/contact lenses will affect the size values. The measures still reflect changes in pupil size accurately.
ValidityLeft	The validity code indicates the system's confidence in whether it has correctly identified which eye is left and right for the specific sample. The validity is 0 if the eye is found and the tracking quality good. If the eye cannot be found by the eye tracker the validity code will be 4. The value is for the left eye.
Gaze PointXRight	The horizontal screen position of the gaze point for the right eye.
GazePointYRight	Vertical screen position of the gaze point for the right eye .
CamXRight	Horizontal location of the right pupil in the camera image (0 is left edge, 1 is right edge).
CamYRight	Vertical location of the right pupil in the camera image (0 is top, 1 is bottom).
DistanceRight	Distance from the eye tracker to the right eye. The distance is given in mm on a straight axis out from the eye tracker plane.
PupilRight	Size of the pupil (right eye) in mm. The distance and pupil size measures are calculated to be as close to real values as possible. However, individual differences in the eyes of subjects or the strength of glasses/contact lenses will affect these values. However, the measures still reflect changes in pupil size accurately.
ValidityRight	The validity code indicates the system's confidence in whether it has correctly identified which eye is left and right for the specific sample. The validity is 0 if the eye is found and tracking quality is good. If the eye cannot be found by the eye tracker, the validity code will be 4. The value is for the right eye.

Eye Tracking Setups

The following chapters describe a number of recommended setup configurations that are suitable for different types of studies. Your particular needs may differ from these standard configurations, but they should provide valuable insights. More detailed information is available in the Eye Tracker User Manual delivered with the product.

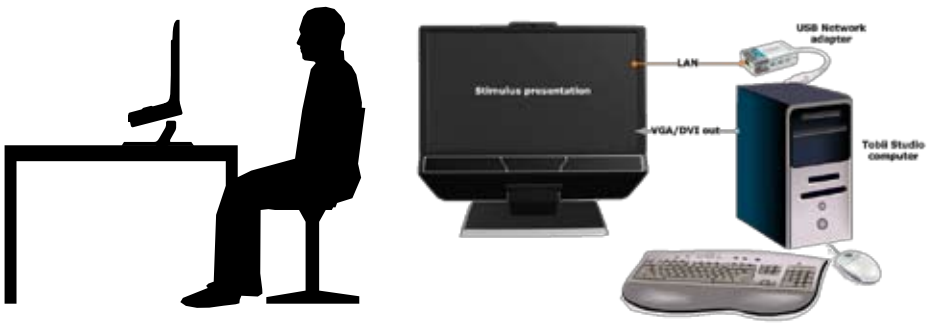
For specific information about custom configurations, or minimum system recommendations, please contact your Tobii sales representative or Tobii technical support. The minimum system recommendations document can be downloaded at www.tobii.com.

Tobii setups with an integrated eye tracker and screen

This basic setup is the simplest setup when using on screen stimuli, such as images, movies, web or screen advertising. On screen stimuli is commonly used in web usability testing, reading research, psychology research, etc.

The pictures below illustrate the single screen setup a USB-LAN adapter. It is also possible to connect the eye tracker directly to the computer's LAN connector. To create a portable lab, replace the computer in the setup drawing with a laptop or shuttle computer.

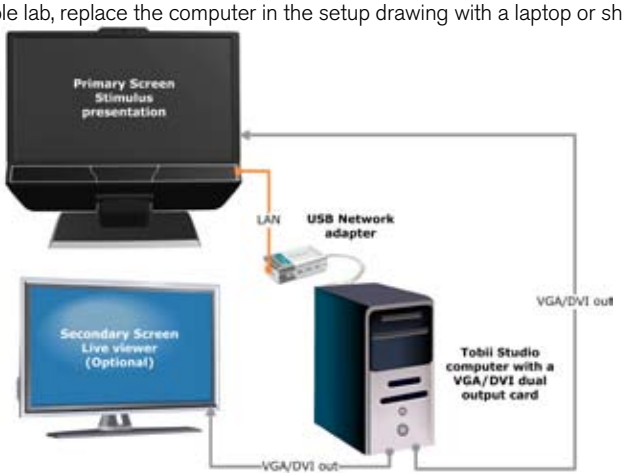
The eye tracker is connected via a USB LAN adapter.



Local Live Viewer

This setup requires the Tobii Studio Professional or Enterprise version. The setup below is used when the test is to be supervised from a screen next to the eye tracker setup where the moderator can see the eye movements of the subject in real time during testing. It is suitable when using such on-screen stimuli as images, movies, web or screen for advertising and usability testing, psychology research, reading research, etc.
In many studies, it is important to see the participant's reactions, record the conversation between the test leader and test participant, as well as the test participant's feedback when using a think-aloud protocol. This setup option makes it possible to use the built-in user camera and connect a microphone to record the participant's image and sound.

To create a portable lab, replace the computer in the setup drawing with a laptop or shuttle computer.



Tobii setups with a standalone eye tracker

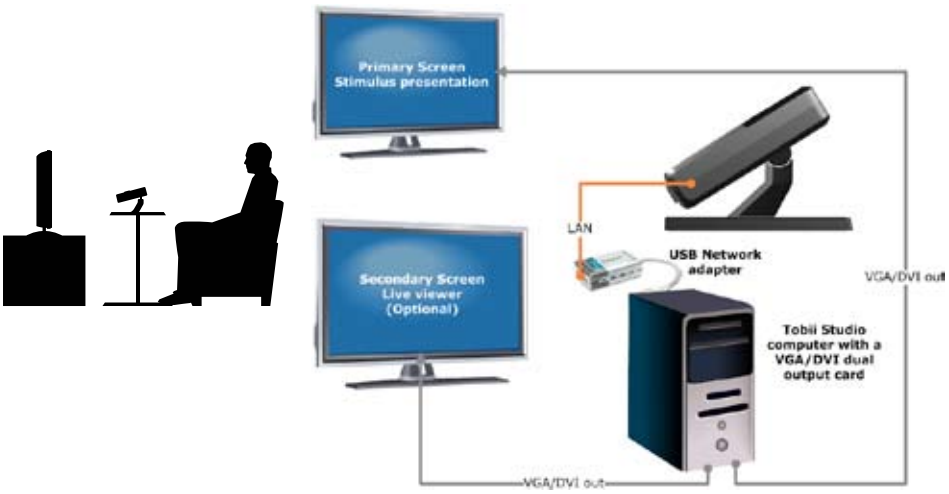
Monitor, TV and Projection screen

The Tobii standalone eye trackers facilitate eye tracking using multiple types of stimuli such as TV, monitor and projection screen. The drawing depicts a monitor, but it can be replaced by a TV or projection screen as long as the input comes from the computer.

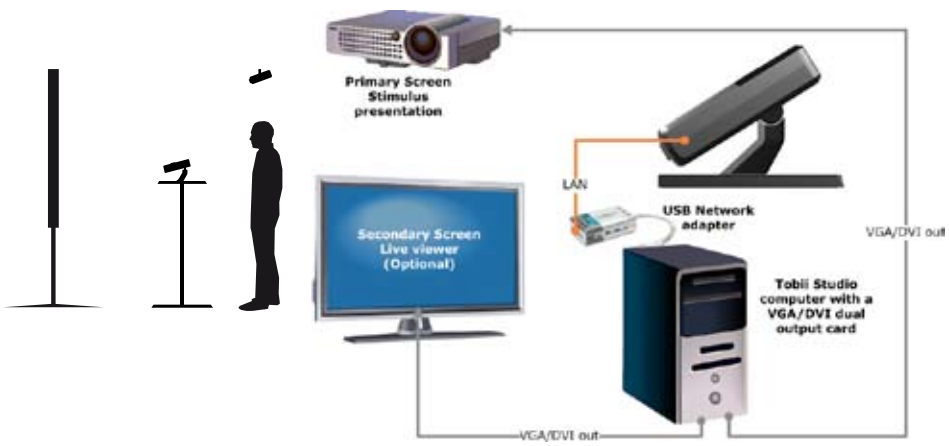
To record the participant's reactions, the conversation between the test leader and test participant and the test participant's feedback when using a think-aloud protocol, you need to connect an external user camera and microphone to the computer running Tobii Studio. The setups below do not include the user camera and user sound.

To use the user camera and sound option or the Live Viewer in Tobii Studio, a Professional or Enterprise edition of the software is required.

Monitor/TV setup



Projection screen setup

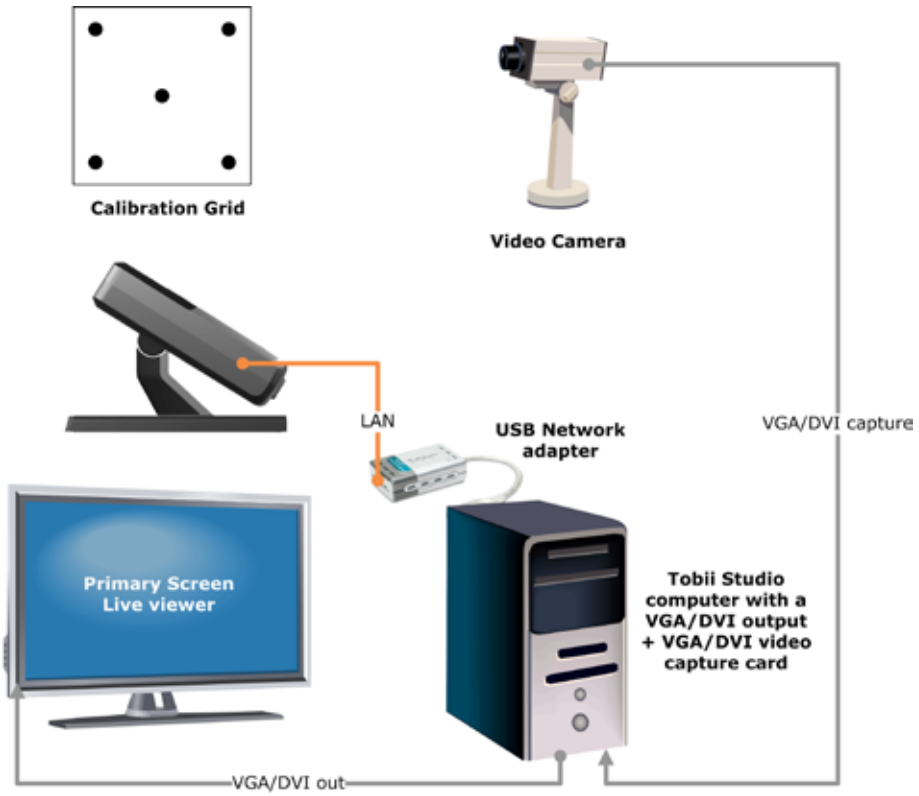


Physical objects and scene camera setup

The scene camera setup is suitable when using a Tobii standalone eye tracker for recording and analysing eye tracking data, when the stimulus is a physical object, like an object on a table or a PDA.

Please refer your Tobii standalone eye tracker manual for precise details on configuring the geometry for a physical object or scene camera setup.

Scene camera setup



Advanced setups for Tobii Eye Trackers

External video stimulus recording

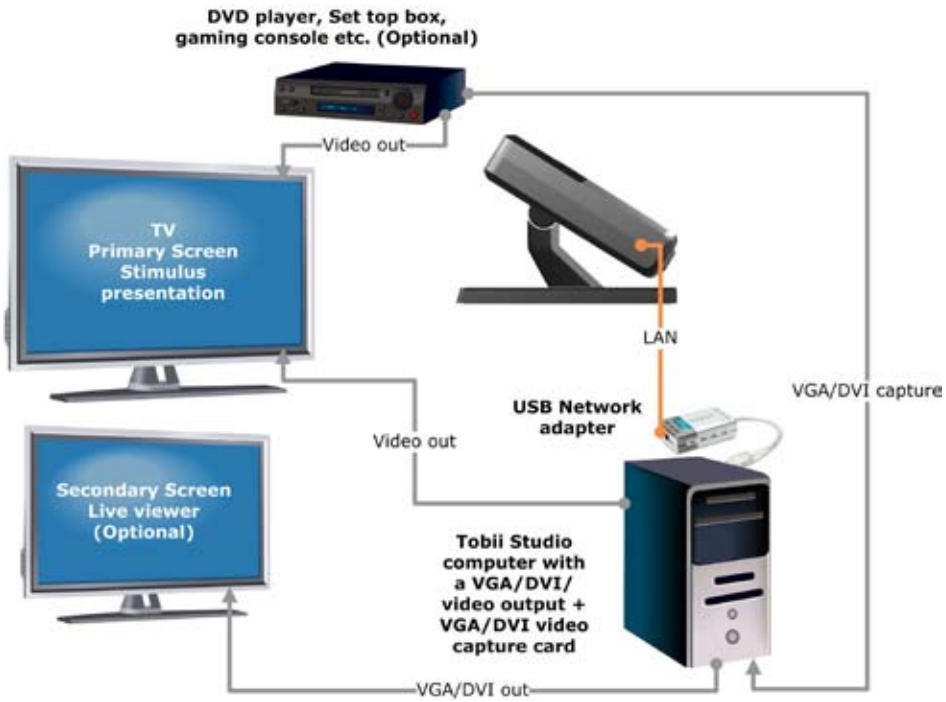
This setup is suitable when using a Tobii Eye Tracking system for eye tracking data analysis when the stimulus is presented from a separate computer or other RGB or VGA source. This could include usability testing on a computer game, or when stimulus is presented on a computer running a different operating system such as OSX, Linux or Unix.

Note that if the external application runs on the Windows operating system, and does not use 3D graphics acceleration, it may be more suitable and less complex to instead run this on the same computer as Tobii Studio, and use the Screen Recording option in Tobii Studio.

For this setup, the image from the Tobii Studio computer has to be displayed on the screen of a Tobii Eye Tracker during calibration (to display the calibration points). The external stimulus computer, however, should be shown on the Tobii Eye Tracker display during the actual test. Both computers must therefore be connected to the Tobii Eye Tracker. To switch between the inputs, press the source button on the Tobii Eye Tracker.

The video shown on the eye tracker display must be sent to Tobii Studio to record the video stream and synchronize it with the gaze data. If the stimulus is presented from an analogue video source, e.g., a VCR or an analogue video camera, a similar setup with slightly modified components can be used.

Tobii X series External Player setup



Tobii E-Prime® integration setup

E-Prime® is a leading software package for designing and conducting psychological experiments from Psychology Software Tools. There is a comprehensive package called "E-Prime® extensions for Tobii" for integrating the E-Prime® software with the Tobii eye tracking system. This enables you to use E-Prime® to design sophisticated stimulus, like gaze-contingent, conditional and counter-balanced experiments.

The Tobii extensions for E-Prime® offer a set of native E-Prime® objects tailored for the Tobii eye tracking system. These offer functions on two different levels:

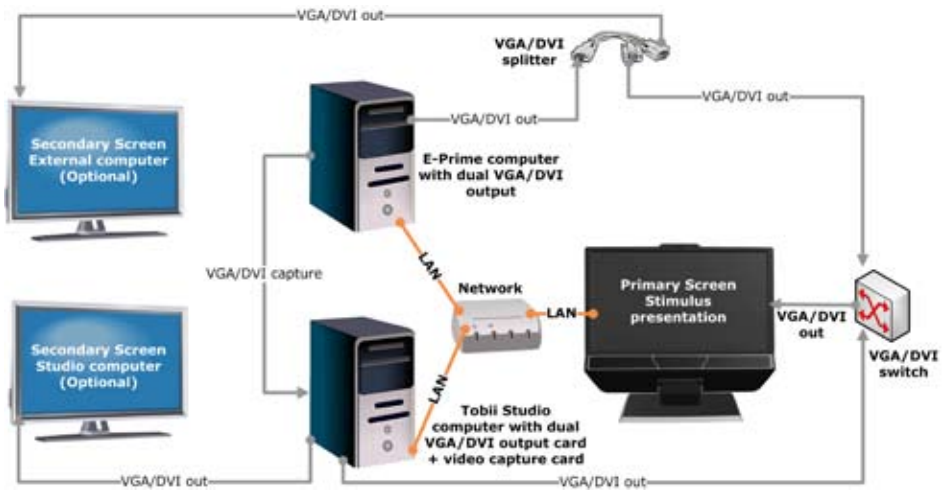
- TET level - In this mode, E-Prime® controls the Tobii Eye Tracker processing unit directly, without using Tobii Studio at all. E-Prime® performs calibrations, collects gaze data and saves this to file.
- Tobii Studio level - In this mode, E-Prime® remote controls Tobii Studio. Timing is synchronized between E-Prime® and Tobii Studio, data is collected by both E-Prime® and/or Tobii Studio. In this mode, Tobii Studio can be used for data visualization and analysis.

It is recommended to run the E-Prime® software on a separate computer, which communicates with the Tobii Eye Tracker processing unit and Tobii Studio software over TCP/IP. An RGB capture card can be used to capture a video of the stimulus presented by E-Prime® in Tobii Studio for visualizations and post-recording analysis.

For more information about E-Prime®, please visit www.pstnet.com.

Basic setup

Two computer setup



Accessories & Related Products

Hardware

All stationary Tobii eye trackers are shipped in sturdy cases that can be used for subsequent transportation.

The Tobii TX300 Eye Tracker is shipped with a digital angle gauge which can be used for the measurements needed when using the TX300 as a standalone eye tracker.

Software

Tobii Software Development Kit (Tobii SDK)

The Tobii SDK enables the development of application software for controlling and retrieving data from Tobii Eye Trackers. This is useful for highly customized experimental routines as well as many varieties of interaction applications based on eye tracking.

The SDK provides interfaces on different levels, suitable for different kinds of applications ranging from highly customized low level interfaces, to high level interfaces requiring a minimum of programming. Well-documented code samples provide a straight-forward introduction to the functionality of the SDK.

Tobii SDK is available free of charge and can be downloaded from http://appmarket.tobii.com where applications developed using the SDK can also be found.

Tobii Studio™ Gaze Analysis Software

Tobii Studio offers a comprehensive platform for recording and analyzing eye gaze and other data. It supports a broad range of studies ranging from usability testing and market research to psychology research and physiological experiments. Advanced tools for analysis and visualization allow for in-depth qualitative and quantitative analysis. Data is easily gathered for meaningful comparison, interpretation and presentation. For further information, please refer to the Tobii Studio™ product description.

E-Prime® and E-Prime® Extensions for Tobii

E-Prime® is a world leader in software for designing and running psychology experiments. Among other things, E-Prime® features programmable experiments, precise stimulus timing and integration with various data sources such as response boxes and EEG devices.

A particular Tobii Extensions for E-Prime® add-on enables E-Prime® to directly control Tobii Eye Trackers. Eye tracking experiments can be designed inside E-Prime® using drag and drop elements. This package is complete with sample paradigms and documentation. E-Prime® and Tobii Extensions for E-Prime® can be purchased through Tobii.

Tobii Toolbox for MATLAB®

The Tobii Toolbox for MATLAB® provides an interface between the MATLAB® software and Tobii Eye Trackers, via the Tobii Software Development Kit (Tobii SDK), in a Windows environment. It enables Tobii Eye Tracker users to run eye tracking experiments directly from MATLAB® and take full advantage of the stimulus presentation and data analysis power provided by MATLAB® and associated toolboxes.

Appendix I: Glossary

Definitions

Monocular/binocular	Monocular data shown is based on data from each eye individually. Binocular data is the average of the two eyes.
Gaze precision	Describes the spatial angular variation between individual and consecutive gaze samples. Gaze precision can be measured under various conditions. Gaze precision is sometimes also specified as 'spatial resolution'. For more details, see Appendix II
Gaze accuracy	Describes the angular average distance from the actual gaze point to the one measured by the eye tracker. Gaze accuracy can be measured under various conditions. For more details, see Appendix II.
Sampling rate	Number of data samples per second. The TobiiT/X Eye Trackers series have a stable data-rate of 60, 120 or 300 Hz; that is 60, 120 or 300 data samples per second are collected for each eye.
Sampling variability	Sampling variability specifies the maximum difference between the stated sampling rate and the actual sampling rate that can occur during an eye tracking test.
Processing latency	Describes the time required by the eye tracker processor to perform image processing and eye gaze computations.
Total system latency	The 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 the image exposure time, plus image read-out and transfer time, processing time and time to transfer the data sample to a client computer.
Timestamp precision via sync-out port	The temporal deviation of the signal on the sync-out port relative to the beginning of the actual exposure of the eye image.
Timestamp precision as specified in each data sample	The temporal deviation of the timestamp 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.
Time to tracking recovery for blinks	When a subject blinks, the eye tracker loses the ability to track eye gaze because the eye is covered by the eye lid. If the pupil is occluded for only a short period (a few hundred milliseconds), the system will regain tracking immediately when the pupil becomes visible again, but only if the subject has maintained approximately the same head position during the blink. Data during blinks are only lost when the pupil is occluded, i.e. during the eye lid movement itself or when the eye is closed.
Time to tracking recovery after lost tracking	An eye tracker working in a natural user environment may occasionally lose track of the subject's eyes, e.g., when the subject completely turns away from the tracker. If a period of a few hundred milliseconds elapses during which the eye tracker is unable to detect the eyes in close proximity to where they were last detected, the eye tracker will start searching for the eyes within the entire head movement box. The stated measurement is the typical time to tracking recovery in such a situation. If the eye tracker is unable to detect the eyes of the subject even after about one minute, the system will enter a "slow search" mode, leading to larger recovery times.
Freedom of head movement	Describes an area (height × width in cm) where at least one eye is within the eye tracker's field of view.
Operating distance	Describes the minimum and maximum distances between the subject's eyes and the surface covering the eye tracker sensors at which eye tracking can be done while maintaining robust tracking.
Max head movement speed	Describes the maximum head movement speed allowed while maintaining robust tracking. The specified number is for sideways head movement.
Max gaze angles	The maximum gaze angle for which the eye tracker can perform robust and accurate tracking on both eyes. The gaze angle is the angle ABC with A = center of the eye tracker (midpoint between the two eye tracking sensors), B = eye position (midpoint between the left and the right eye) and C = stimuli point.
Eye tracking technique	Tobii Eye Trackers use two different techniques to determine eye position: 1. Bright pupil eye tracking, where an illuminator is placed close to the optical axis of the imaging device, causing the pupil to appear lit up (the same phenomenon that causes red eyes in photos). 2. Dark pupil eye tracking where the illuminator is placed away from the optical axis, causing the pupil to appear black.
Eye tracking processing unit	Gaze data calculations are performed by firmware embedded in the eye tracker. Different applications can be connected over a LAN connection as clients to the eye tracker system to gather eye gaze data and other data in real-time, perform calibrations, etc.

Appendix II: Measurements

Accuracy and precision measurements

Gaze accuracy and precision are typically measured in degrees of visual angle. One degree accuracy corresponds to an average error of 12 mm (0.47") on a screen at a distance of 65 cm (27"). Data is presented as monocular or binocular. Monocular data is based on data from the subject's dominant eye only. Binocular data is the average of both eyes.

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 measurements are done at the default sampling rate of the eye tracker and at the optimum distance between the eye tracker and the subject. For TX300, the sampling rate was 300 Hz and the distance 65 cm (27"). Precision is calculated as root-mean-square (RMS) of successive samples.

Using a noise reduction filter can improve precision and it is often used when doing eye tracking analysis. For comparison, Tobii provides precision values both with and without applying a filter. The filter used is a Stampe stage 2 algorithm. More information about this filter can be found in Behavior Research methods, Instruments & Computers 1993, 25 (2), pp. 137-142.

As the distance from the eye tracker influences precision, measurements are also taken at various distances. Data from these measurements is binocular.

Gaze accuracy

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 several stimuli points across a screen. The accuracy figure presented is the mean accuracy from all subjects.

Good accuracy is difficult to achieve at large gaze angles, but is important when testing large stimuli. For instance, the upper corner of a 23" screen with the test subject at a distance of 65 cm (27") from the eye tracker corresponds to a 31° visual angle from the center of the eye tracker unit. Consequently, measurements are also presented for stimuli presentations at large gaze angles.

When luminance of the stimuli or the illumination in the lab changes, the size and shape of the pupil is affected. Unless compensated for, this may cause a significantly reduced accuracy. Testing the influence of surrounding light and stimuli luminance on accuracy is done in a laboratory environment with controlled light conditions. Stimuli points are presented on a black background so as not to influence ambient light conditions. Testing is also done with ambient light at a level deemed 'normal' office lighting where the background is changed to white with black stimuli points. The results from a test in which the background was changed has in previous Tobii product descriptions been referred to as Drift.

As with precision, the distance from the eye tracker influences accuracy. When testing this influence, calibration is done with the subject in the center of the head movement box (i.e. at a distance of 65 cm) and measurements are done thereafter. Measurements are performed with the test subject at precise and specific distances relative to the eye tracker, measured along the axis of the tracking sensors. Data from these measurements is binocular.