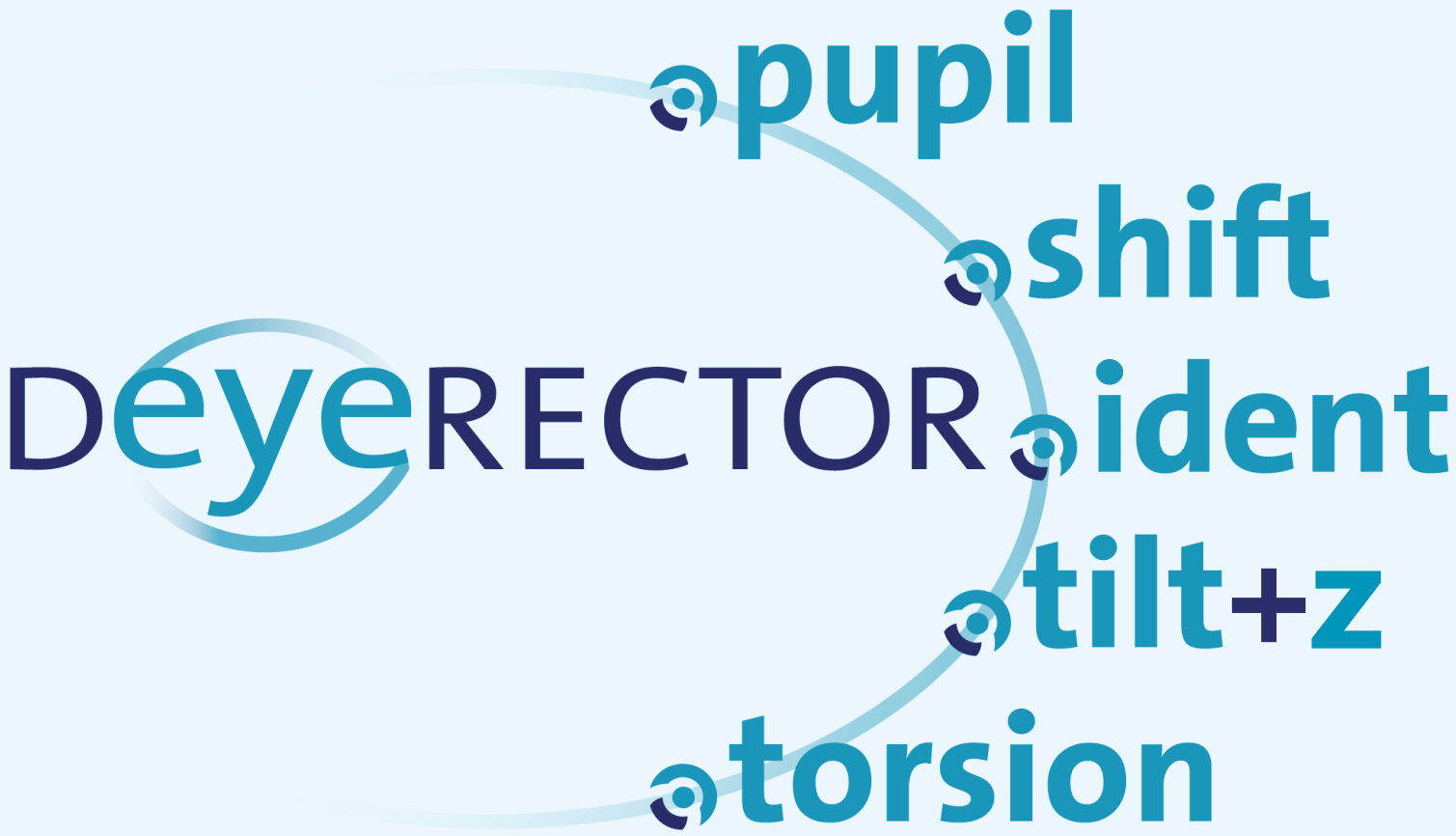
CHRONOS VISION
Your partner for vision based decisions



DeyeRECTOR Eye Tracker

- ✓ High speed pupil or limbus tracking up to 1500 Hz with minimal latency
- ✓ The powerful DeyeRECTOR software suite offers a full range of eye tracking measurements and functions such as shift, torsion, tilt+z and ident
- ✓ No proprietary but independent hardware
- ✓ Optimized tracking performance for applications in the field of refractive surgery and other medical or industrial applications

MADE IN GERMANY

DeyeRECTOR

3rd Generation Eye Tracker

CHRONOS VISION has been developing and manufacturing fast eye tracking systems for over 25 years and has built up extensive core expertise in the area of measuring and analyzing eye movements for a wide range of medical and industrial applications.

Starting with the first head-mounted eye tracking system for the **International Space Station ISS** and subsequent commercialization, its successor OneK+ was based on proprietary **on-chip technology** with impressively low latency and tracking rates above 1000 Hz.

The new **DeyeRECTOR** Eye Tracker is the 3rd generation eye tracker from CHRONOS VISION with increased performance based on new hardware and a revised **DeyeRECTOR software suite**.

Advantages of non-proprietary Components

With the new DeyeRECTOR Eye Tracker, CHRONOS VISION is making a **paradigm shift** by deliberately avoiding proprietary hardware or interface components. Instead, the DeyeRECTOR Eye Tracker works with a commercial high speed USB3 camera and a powerful standard PC and achieves impressive performance improvements compared to previous systems.

For the customer or device manufacturer, dispensing with a closed, inaccessible system has **enormous advantages**, as typical risks such as supplier dependency, delivery reliability and second source availability can be drastically reduced. Proprietary components such as customized camera hardware, special PC components or incompatible interfaces always mean that adaptations to the newest technical innovations cannot be revised or can only be adapted with considerable delays and high financial costs.

The DeyeRECTOR system uses a commercial USB3 camera with **USB3 Vision v1.0 standard**, which can be easily replaced in the event of discontinuation or by new, more powerful compatible camera models once available. The processing unit is not an in-house development, but a powerful commercial PC that must fulfill a certain minimum configuration in order to guarantee the specified eye tracking performance. The system interfaces USB3 and RS232 are established and widely used.

New developments and innovation leaps in camera and PC technologies can be adapted promptly, so that the DeyeRECTOR eye tracker system always remains future-proof.

Fields of Application

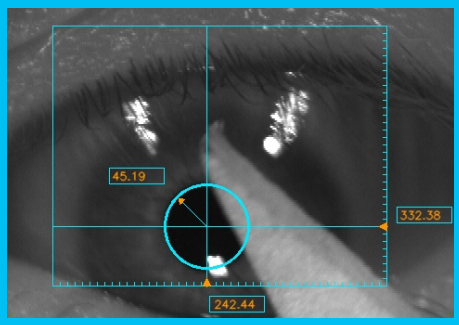
The greatest possible precision in controlling the laser is fundamental to the success and quality of laser eye surgery. But even the best accuracy is useless if the positioning information lags behind the real eye position during laser treatment.

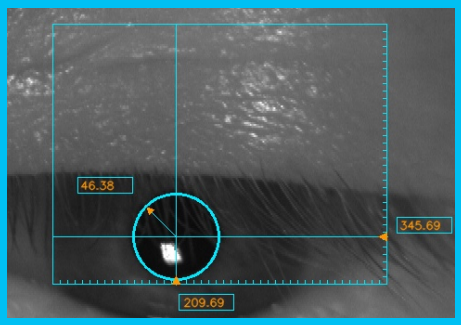
The DeyeRECTOR Eye Tracker was developed as an **OEM component for refractive surgery** device manufacturers and combines both high-precision measurement of the eye position and a virtually latency-free response during refractive eye surgery.

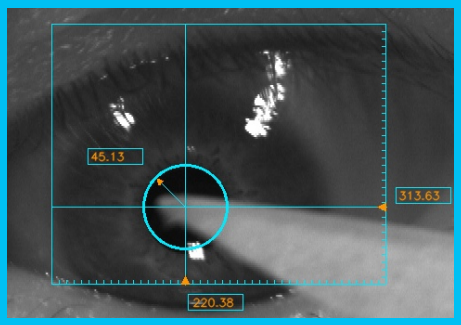
Despite specializing in refractive surgery applications, CHRONOS VISION has developed a wide range of application solutions for other **medical and industrial purposes** where fast and reliable eye tracking is a key factor for success.

Robust Algorithm

Considerable attention has been given to enhancing the performance of the DeyeRECTOR Eye Tracker algorithm with regard to disturbances like occlusions, instruments in the field of view, spurious reflections or hematoma.







DeyeRECTOR Eye Tracker

The DeyeRECTOR system consists of a compact high-speed USB3 camera and a standard commercial PC on which the eye tracker algorithms are executed. The monochrome or color camera captures eye movements at up to **500 Hz** in **BASIC** mode and achieves tracking rates of up to **1500 Hz** using the **ADVANCED** option.

All DeyeRECTOR software modules operate under Linux on a standard PC and enable the tracking information to be provided to connected components with minimal latency via the USB3 or RS232 interface. The DeyeRECTOR Live Viewer simplifies access to the system configuration and offers a live view of the camera images.

Specifications

Camera

Standard	USB3 Vision v1.0 compatible
Sensor resolution	≈ 720 × 540 px
Selectable frame rates	e.g. 100, 250, 500 Hz
Sensor type	CMOS global shutter, monochrome/color
Data interface	USB 3.1 Gen 1
Lens mount	C-Mount
Housing dimensions	≈ 30 x 30 x 30 mm^3
Supply power	via USB3 (no additional power supply)
Weight	36 g (without lens)

Processing Unit

PC / Operating system	dedicated standard PC (i7 CPU ≥ 8 cores) with Linux OS alternatively a suitable customer PC
Eye Tracking software	DeyeRECTOR Suite
Tracking rates	DeyeRECTOR.pupil up to 500 Hz (**BASIC**) / 1500 Hz (**ADVANCED**) DeyeRECTOR.torsion up to 300 Hz DeyeRECTOR.tilt+z up to 500 Hz
Data transfer	tracking data via RS232 or USB3 at 1 Mbit/s image data via Gigabit Ethernet at e.g. 25, 50, 100, 150 Hz
Measurement resolution	typically sigma < 5 µm
Latency	< 1 ms

Display and Control Options

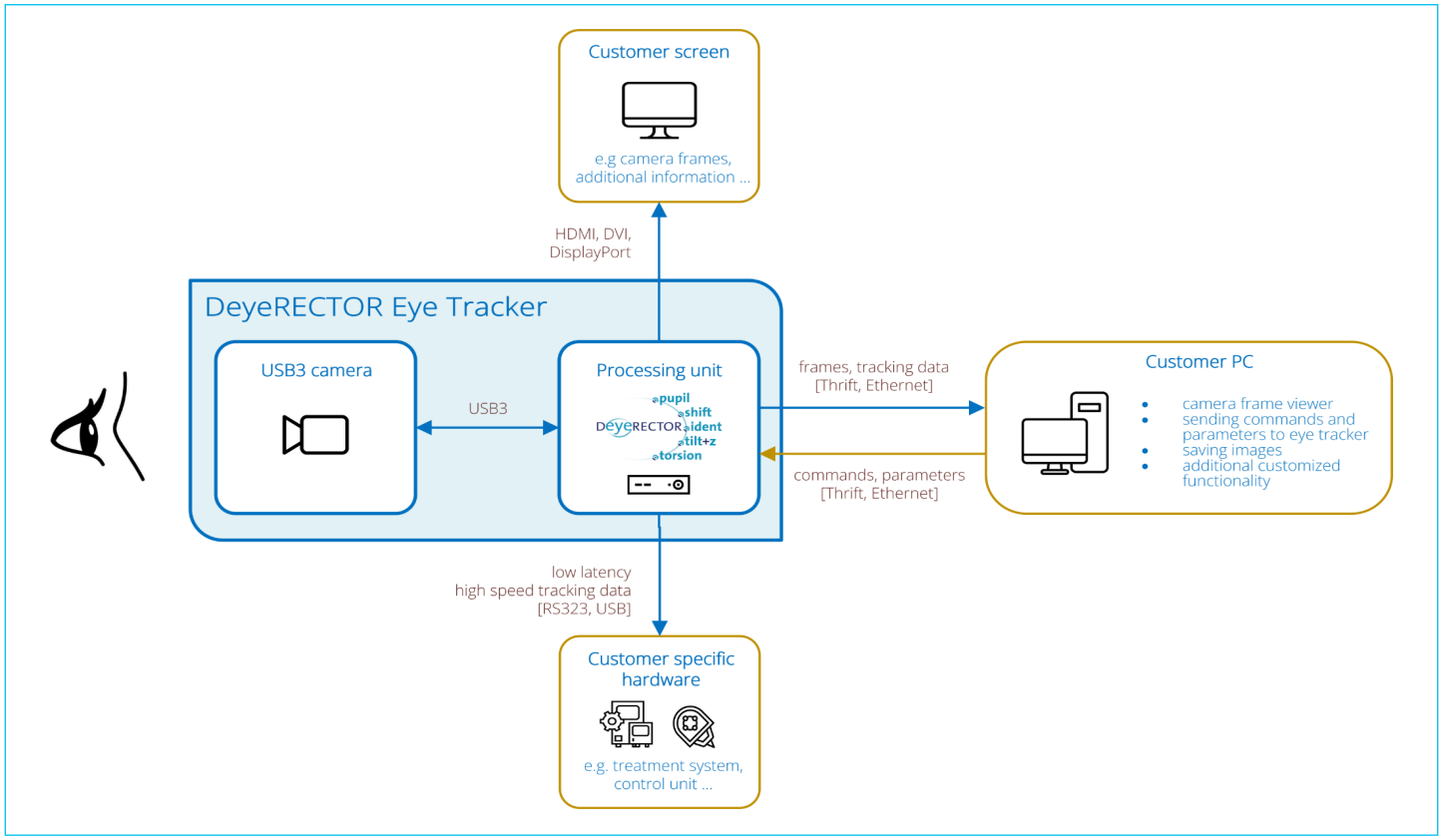
Option A	DeyeRECTOR Live Viewer running on ET Processing Unit
Option B	DeyeRECTOR Live Viewer running on separate Linux or Windows PC

DeyeRECTOR Software Suite

The **DeyeRECTOR software suite** is designed as a software package in combination with the DeyeRECTOR Eye Tracker camera. It is intended as a set of **OEM components** or modules primarily for eye tracking applications in the field of ophthalmology and other medical or industrial applications.

The modules are perfectly matched and always aligned with the latest in technical and medical research.

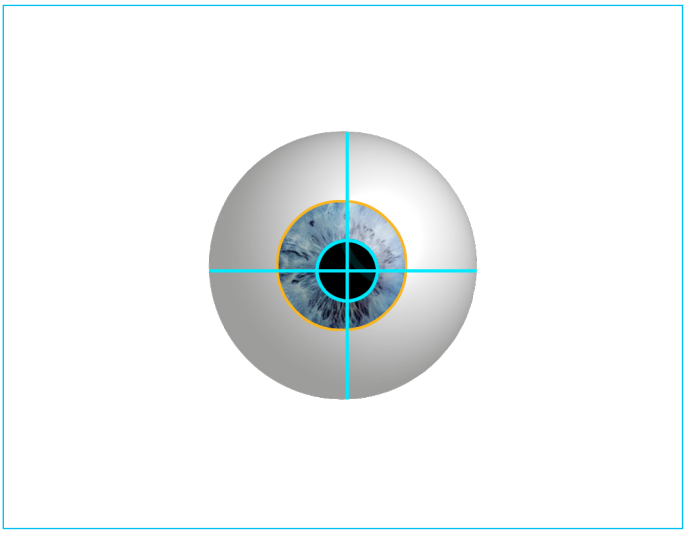
The interaction of the DeyeRECTOR Eye Tracker camera with the DeyeRECTOR modules and associated interfaces is illustrated below.



Modules Overview

DeyeRECTOR.**pupil**	radius plus x- and y-coordinates of pupil or limbus centre **Pupil-BASIC**: 100-**500 Hz** at 720 x 540 px **Pupil-ADVANCED**: up to **1500 Hz**
DeyeRECTOR.**shift**	compensation of current pupil position with respect to the limbus
DeyeRECTOR.**torsion**	torsional eye tracking up to **300 Hz**
DeyeRECTOR.**tilt+z**	up to **500 Hz** measurements of • horizontal and vertical tilt angles of the eye relative to the camera axis + • distance of camera to eye
DeyeRECTOR.**ident**	correct patient and eye identification

DeyeRECTOR.pupil



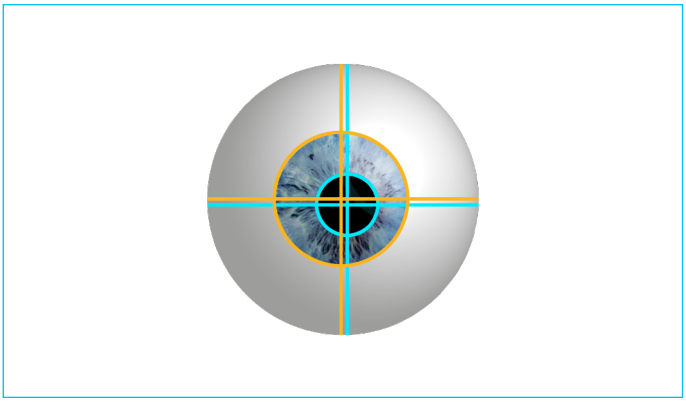
The **DeyeRECTOR.pupil** module determines the x- and y-coordinates of the pupil or optionally the limbus centre. Considerable attention has been given to enhancing the performance of the algorithm with regard to occlusions, instrument artefacts and spurious reflections. This component provides spatial tracking resolution of ≈ 0.01°, respectively ≈ ≤ 5 µm, is achieved.

The pupil module is provided with 2 options :

+ **Pupil-BASIC** with a selectable frame rate of 100-**500 Hz** at 720 x 540 pixel.
++ For demanding requirements the **Pupil-ADVANCED** option is offered for tracking rates up to **1500 Hz**.

The **DeyeRECTOR.pupil** module offers high speed pupil or limbus tracking with processing latency of less than 0.2 ms.

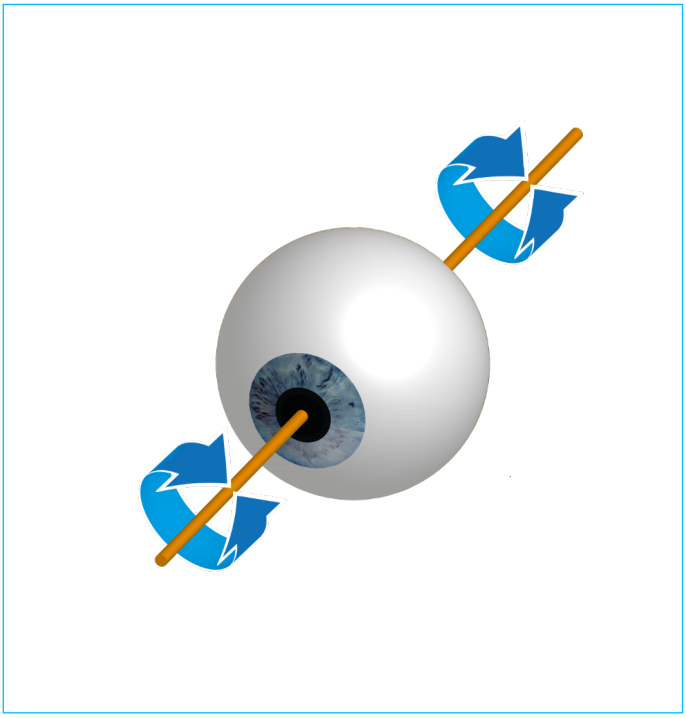
DeyeRECTOR.shift



Pupil size is known to be influenced by a number of physiological factors – typically patient vigilance, anxiety and visual accommodation, as well as lighting conditions and refractive optical effects. With changing size the pupil centre can shift relative to the cornea, or limbus; the resultant error in corneal coordinates leads to a sub-optimal outcome.

During observation or treatments the **DeyeRECTOR.shift** module compensates for this effect by correcting the current pupil position with respect to the limbus.

DeyeRECTOR.torsion



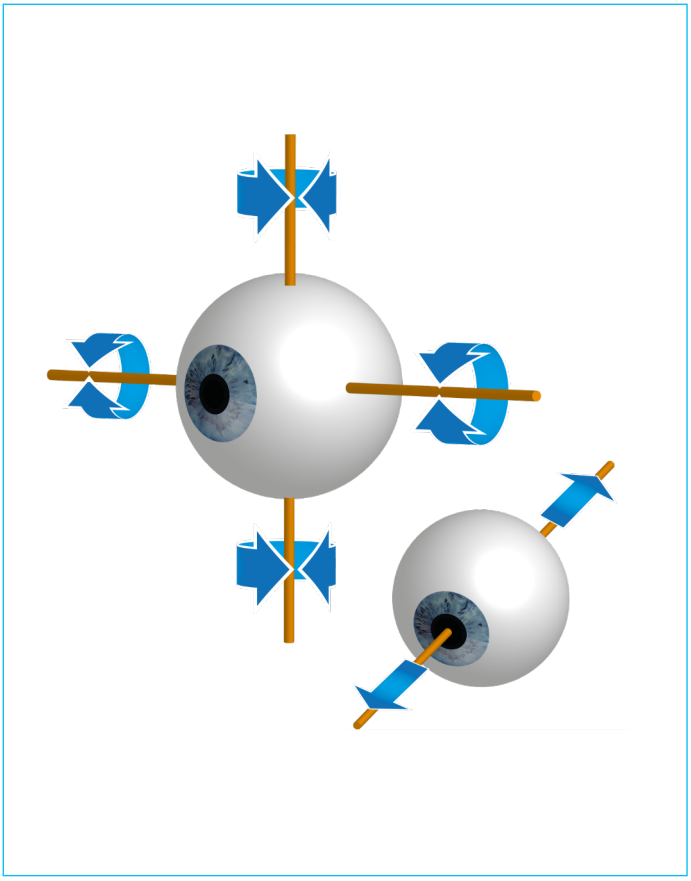
Ocular torsion, or cyclorotation, of the eyeball can significantly impair the outcome of a treatment, e.g. in the field of refractive surgery or IOL-operations.

Torsion can occur for a number of reasons. First, differences in head position relative to camera between the diagnosis and operation scenarios can lead to static changes in cyclorotation. Switching from head upright to supine can also induce small changes in torsional eye orientation, particularly in patients with latent vestibular disorders. The anaesthetics employed during surgery may also affect the tonus of the extra ocular muscles. In addition, dynamic cyclorotation can occur during surgery. Accurate measurement of ocular torsion is therefore important for optimising surgical outcome.

The **DeyeRECTOR.torsion** module provides robust and accurate measurement of static cyclorotation occurring between the diagnosis and operating units, as well as a continuous online measurement of dynamic torsional movements during surgery.

The **DeyeRECTOR.torsion** allows torsional tracking rates up to unique **300 Hz**.

DeyeRECTOR.tilt+z



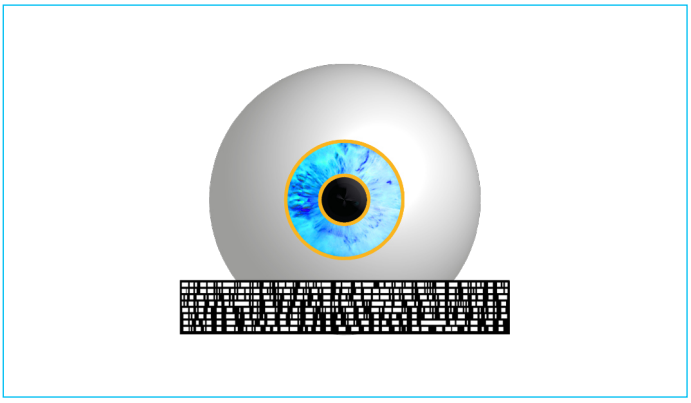
During observation or treatment the eye may also rotate around its horizontal and vertical axes. Unfortunately the resultant displacement of the pupil or limbus in the camera frame does not reflect the true motion of the treatment zone which is located at the corneal surface approximately 3.5 mm above the pupil.

As a consequence – if the procedure is based solely on the lateral position of the pupil – the applied laser pulses will ablate corneal tissue at incorrect positions. Refractive surgery that does not take such rotational movements into account can have a detrimental effect on the surgical outcome, as the resulting corneal shape may differ significantly from the intended correction.

The **DeyeRECTOR.tilt+z** module, based on patented technology, measures horizontal and vertical **tilt** angles of the eye relative to the camera axis with a resolution of 0.25°. In addition, the **DeyeRECTOR.tilt+z** provides a measure of the camera-eye distance (**z** coordinate) with an accuracy of better than 50 µm.

Both, **tilt** angles and **z** distance, are determined at a unique rate of up to **500 Hz** to ensure the measurement of these hard to detect and often neglected eye movements to fully capture the correct and complete position including the orientation of the eye.

DeyeRECTOR.ident



Based on state-of-the-art algorithms the **DeyeRECTOR.ident** module provides reliable patient recognition and eye identification. As with a fingerprint, individual patterns of the iris or sclera are extracted from images acquired immediately prior to treatment and compared with those determined during pre-treatment diagnosis.

In this way, the **DeyeRECTOR.ident** module ensures correct eye and patient identification and eliminates the likelihood of resulting errors.

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