



Real Time Eye Tracking

My Dagen 2017


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It began with a dream
that made us see further

A close-up photograph of a person's hand holding a small, rectangular electronic component. A soldering iron is positioned near the component, suggesting a process of assembly or repair. The background is dark and out of focus. The image is framed by yellow diagonal stripes on the left and right sides.

Our mission:

We believe in a better,
sustainable tomorrow
by bridging the gap
between man and machines



Smart Eye's vision is to be the
world leader in technology that
understands, supports and predicts
human actions and intentions.

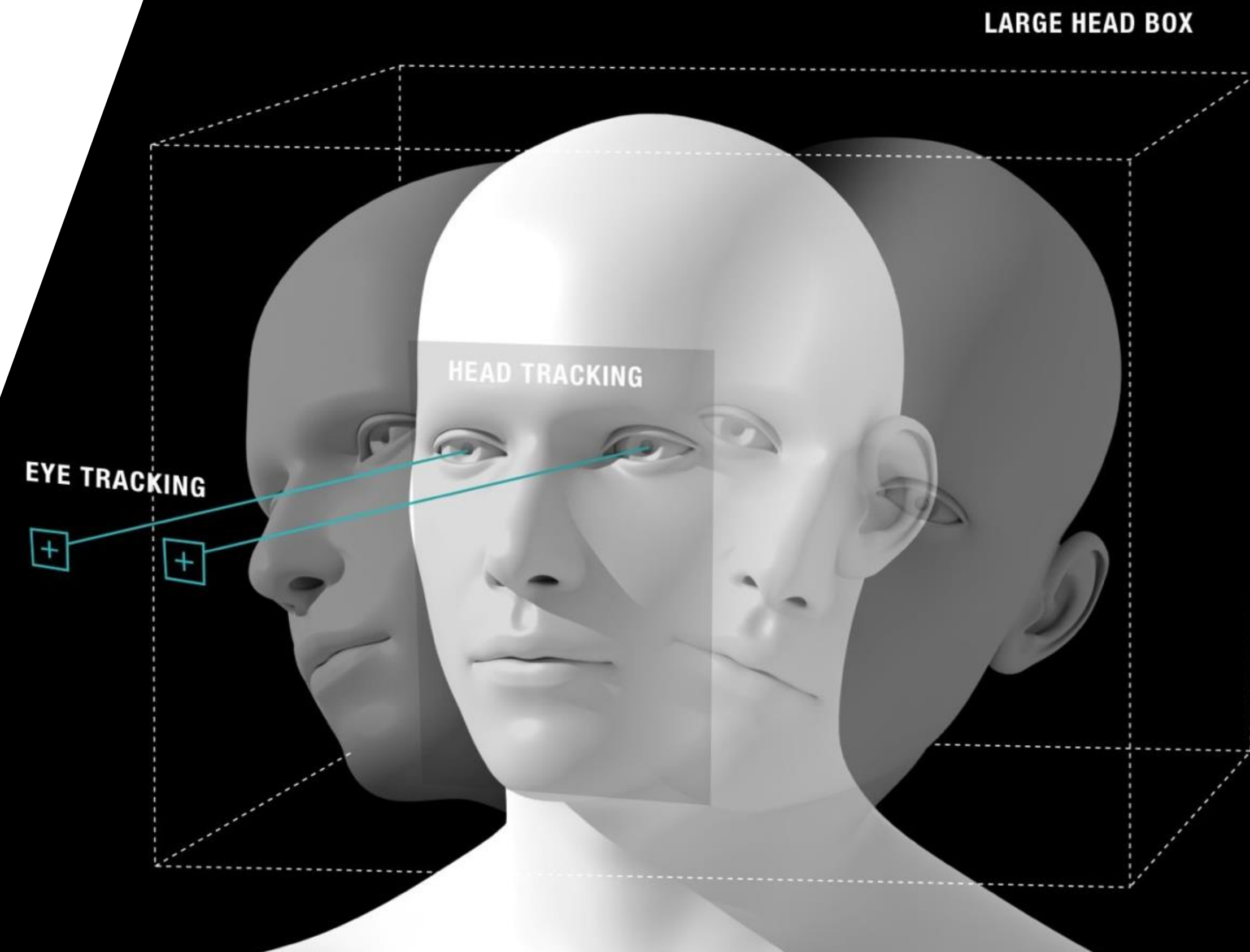
Smart Eye AB

- The Company -

- Founded in 1999
 - Focus originally to replace mouse, soon abandoned
 - PC performance good enough for real time tracking
- ~70 employees
- Most are MSc / PhD
- Office in Göteborg
- Market leader
- Non-intrusive Head- and Gaze Tracking
 - Vehicles
 - Real-life situations

Eye Tracking - What is it?

- Gaze Direction
- Head Pose, 3+3 DOE
- Eyelid Opening
- Pupil Diameter
- Extras
- Identity
 - Feelings (Happy/Angry/Surprised/Sad/...)
 - Agitation/stress level
 - Mouth movements (Talking/Yawning/...)



Eye Tracking - Why?

- Driver/Pilot Behavior
- Usability Studies / HMI Evaluation
- Marketing
- Web pages, Magazines, Ads, Packages
- Cognition Research
- Training
- Active Safety in Vehicles
- Drowsiness, an early warning
- Inattention



Products

- Smart Eye Pro
 - 2-8 cameras, research grade, semi automatic
- DR120
 - 2 cameras integrated into a computer monitor
- AntiSleep
 - Mono-camera, fully automatic
- Embedded
 - Embedded version, HW cost << USD100
- Add-ons & integration
 - Scene Camera, Time Synchronization, Remote Logging, Remote Control, EEG Integration, Interfaces to simulator engines & analysis software

Philosophy

- No strings attached
- Must work in real situations
- All kinds of light
- Large head movements
- Glasses, sunglasses and contact lenses
- Flexible installation
- Small cameras
- Free placement



Market

- Worldwide
- Industry
 - Volvo, Nissan, Ford, Daimler Chrysler, GM, Toyota, Audi, Saab, Mercedes, Subaru, VW, Airbus, SNCF, KEPRI
- Universities and research institutes
 - NASA, US Army, Deutsche Luft und Raumfahrt, Operator Performance Laboratories, Beckman Institute, Flygsimulatorcentrum, VTI, Skogforsk, Sahlgrenska University Hospital



Movie Time...

- Web Page Layout
- Scene Camera Drive

Sample installations



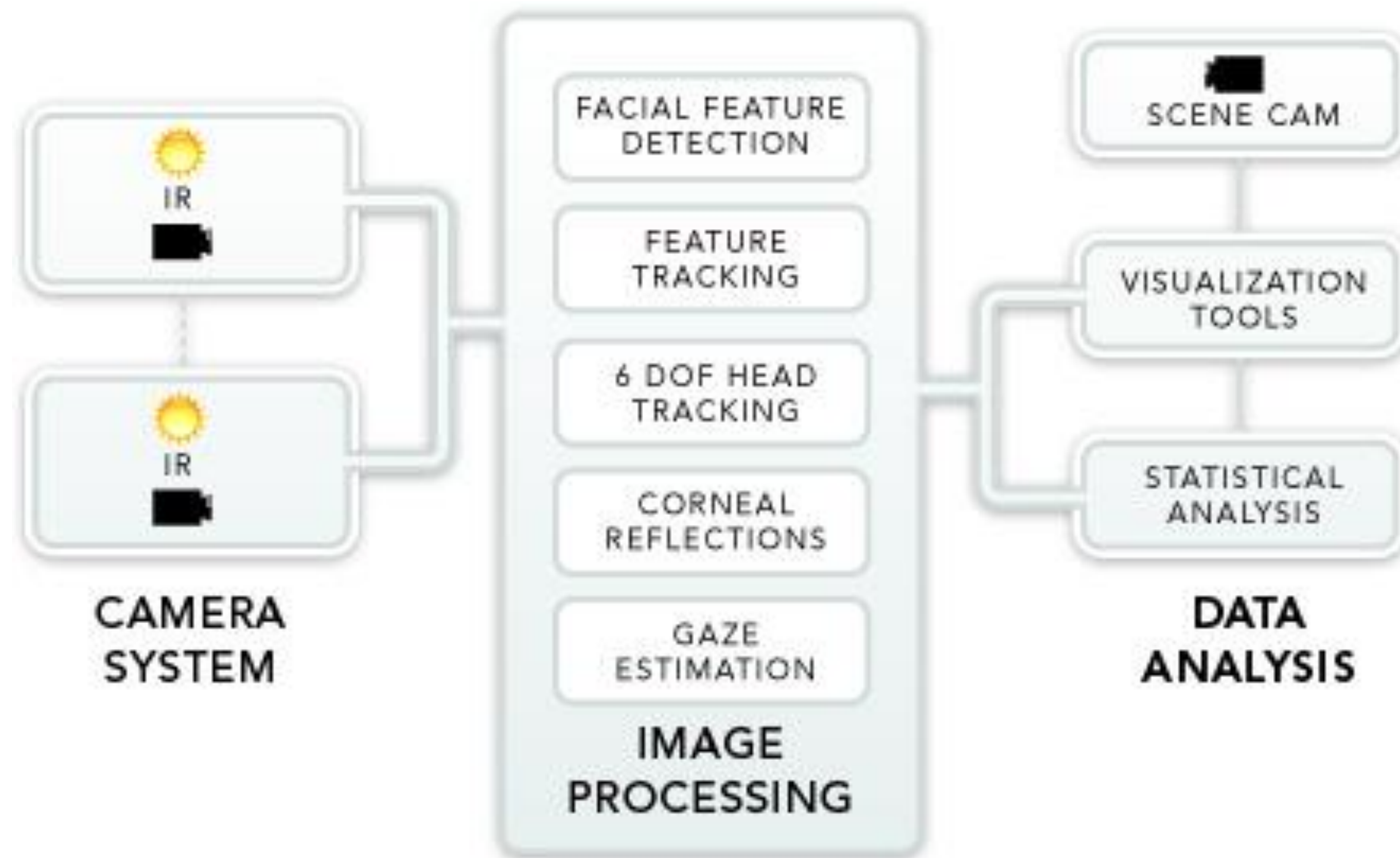








How does it work?



Challenges

- Environment
 - No light, Direct sun, Quickly varying light, Vibration
- Facial Appearance
 - Age, Gender, Beard, Hairstyle, Glasses, Make-up, Sunglasses, Wrinkles, Moles, Piercings/tattoos..
- Human Behavior
 - Head rotations, Talking, Cellphone, Eating, Grooming, Gestures, Occlusions..
- Technical
 - xGB/min, (soft) real time

Imaging Subsystem

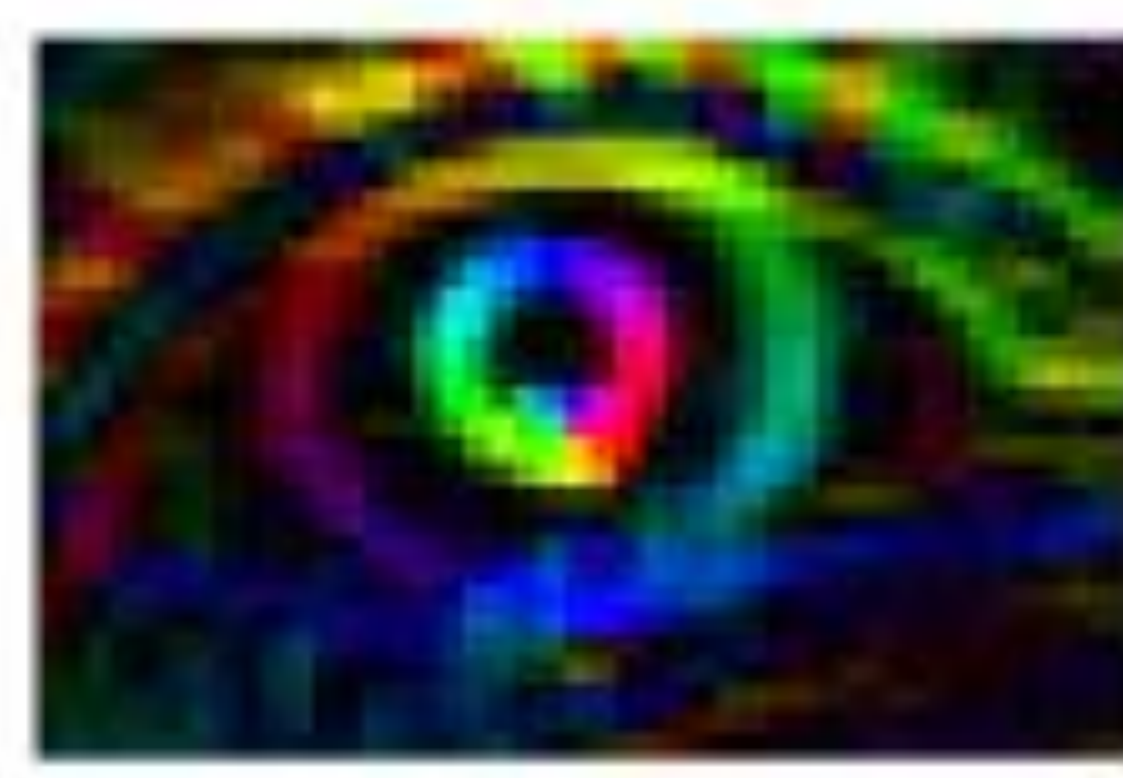
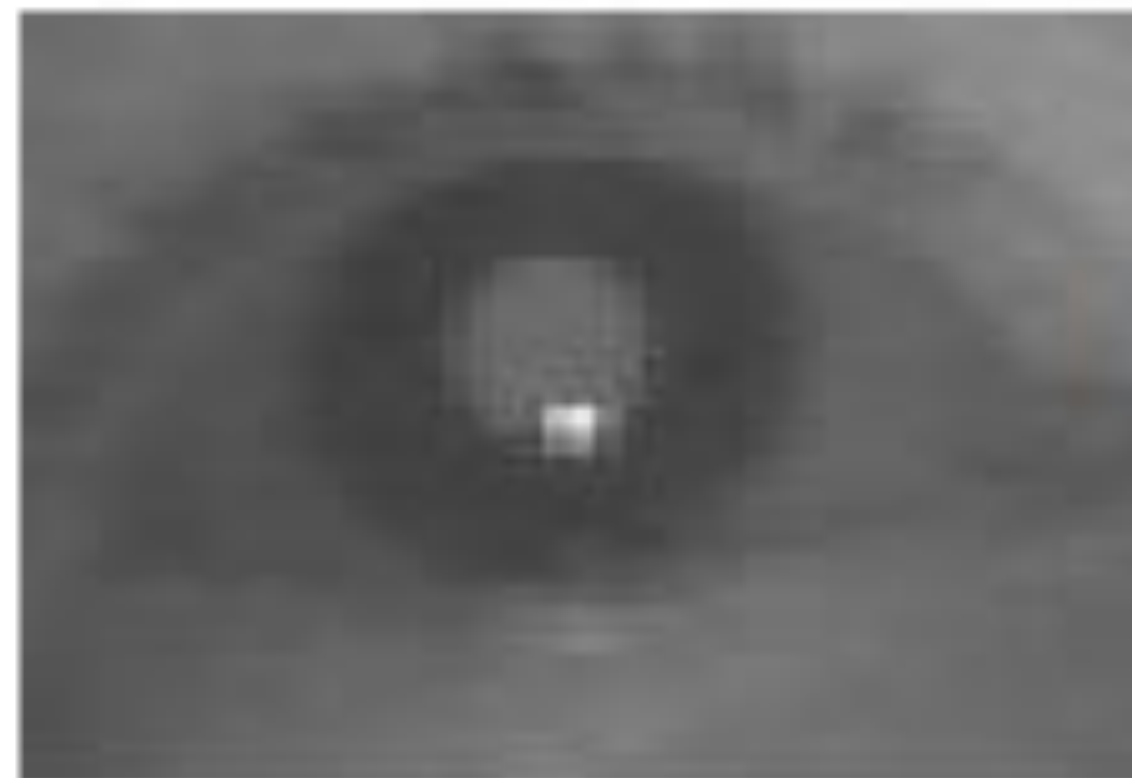
- Active lighting
- Near Infrared
- Suppress external light (especially sunlight)
- Reflex reduction mode
- Calibrated geometry
- Intrinsic (lens and image sensor)
- Extrinsic (camera placement)
- Synchronized cameras

Head Tracking

- Tracking templates
- Corner-like features, Multiple views
- Predict search region using dynamics
- Contrast normalization, 2D sub-pixel correlation
- New features/views added while tracking
- Pose estimation
- Semi-rigid 3D head model
- Nonlinear optimization, Outlier removal
- Redundancy handles occlusions

Eye Tracking

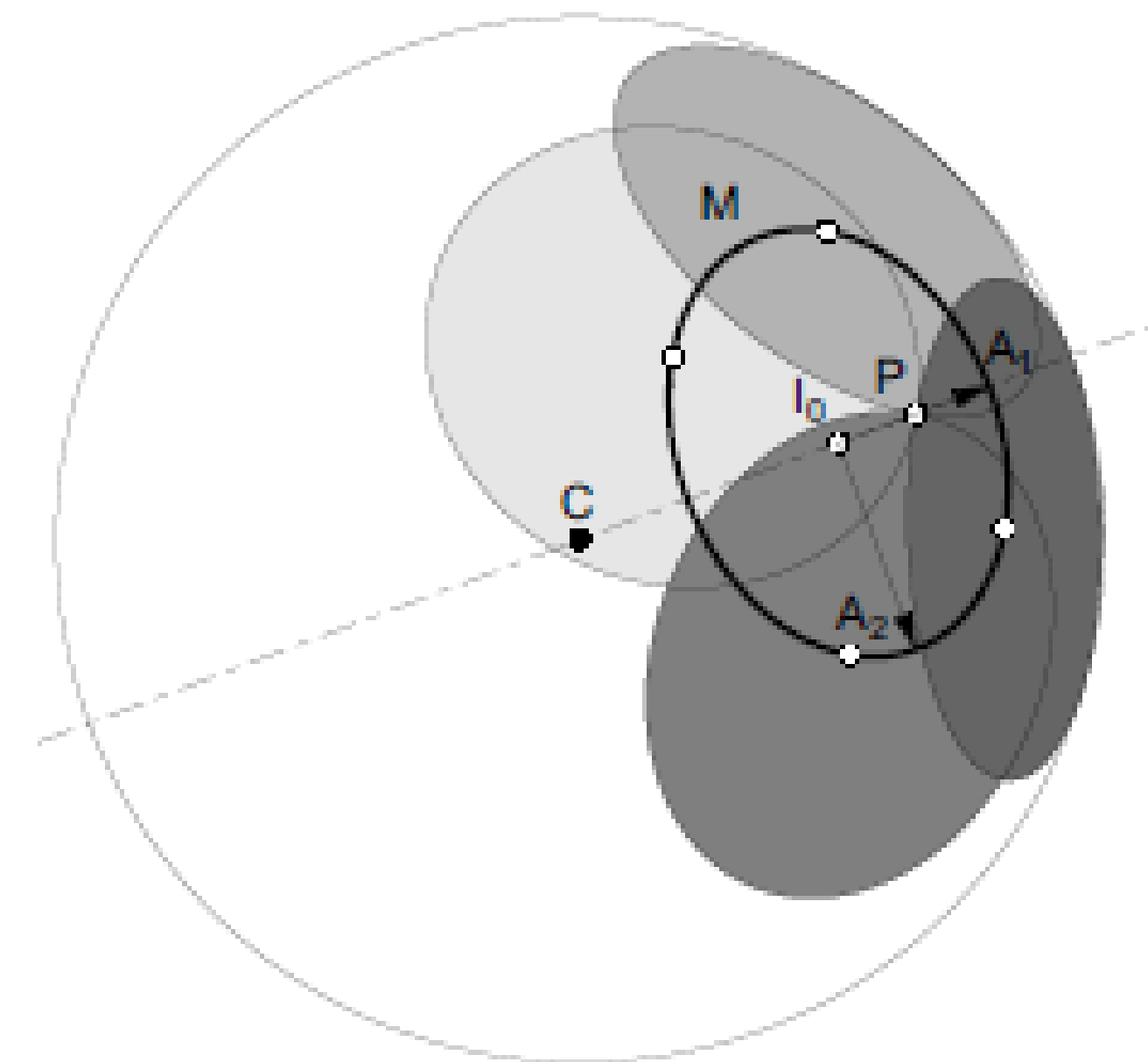
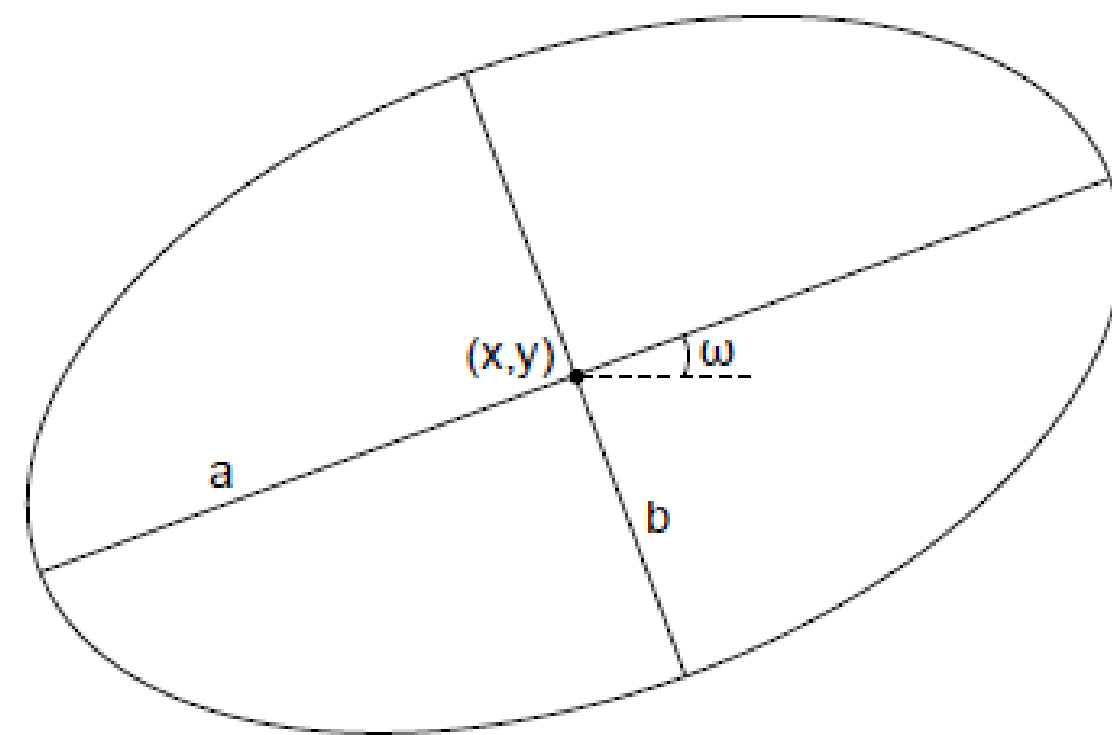
- Find eyeball and eyelid state
- Locate
 - Eye corners & eye center (geometry)
 - Iris, pupil and eyelid edges (gradients; strength, direction)
 - Specular reflections from illuminators (blobs; center, size)



Iris/Pupil Tracking

a special Hough transform using geometrical constraints

- Ellipse search
- 5DOF in the general case, numerically expensive..
- We know all dimensions and where the eye center is located (3DOF), so there are only 2DOF left !





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