EYE TRACKING 101

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Content

1. How it Works?
2. Setting and Parameters
3. Before We Start
4. Some applications of Eye-Tracking (in Aviation)
1. How it works?

→ Pupil + Iris Detection

→ Corneal Reflection
Eye Tracking System - in UW-Madison ISyE Flight Simulation Lab
1.1 Eye Tracking Theory - SE

**Pupil + Iris Detection**

According to the pupil’s position and the iris’ shape to decide the POG

(Traditional Way – Head-mounted)

POG = Point of Gaze
1.2 Head-mounted Style Eye-Tracking System

[SensoMotoric Instruments GmbH, TAUCHI]

[Iota AB, EyeTrace Systems]

[Mooij Holding]

Source: Hyrskykari (2001)
1.3 Eye Tracking Theory - SE

**Corneal Reflection (Purkinje Effects)**

→ Identifying the PI’s position on cornea to decide the POG
1.4 Eye Tracking Theory - SE

Smart Eye: Eye Tracking System

2 Purkinje Images
Pupil / Iris Position
Point of Gaze
Movie Exhibition
2. Basic Setting & Parameters

→ 3 Angles: AoV, VAC, HAC

→ 4 Distances: DoC, DSO, HDCE, VDCE
2.1 Basic Setting: Noun - Cameras

Cameras

Detect the Point of Gaze

SONY HR-50, HR 8.0mm lens

CCD: 1/3” (4.8mm x 3.6mm)

Focal Length: 8mm
2.2 Basic Setting: Nouns - Screen

Screen

The Target

→ Factor to decide # of cameras

→ What is the size of Screen?
2.3 Basic Setting: Nouns - Object

Object

The Person in Experiment
2.4 Parameters: Angles - AoV

**Angles of Views**

1. Subject to the Camera Lens
2. 8mm (1/3” CCD) = 41°
3. Field of View, when
   
   DSO is 80 cm (31 inch):

   ![Diagram showing angles of view](image)
2.5 Parameters: Angles – VAC & HAC

**Horizontal Angles of Cameras (HAC)**

1. Subject to DoC and DSO
2. Limit to: 1° - 15°
3. Current Setting: 10°

**Vertical Angles of Cameras (VAC)**

1. Subject to DSO and VDCE
2. Limit to: 1° - 25°
3. Current Setting: 20°
2.6 Parameters: Distance – Doc & DSO

**Distance of Cameras (DoC)**

1. Key Control Factor
2. Limit to: 20-30cm / 8-12inch
3. Current Setting: 30cm (12inch)

**Distance from Screen to Object (DSO)**

1. Key Control Factor
2. Limit to: 55-125cm / 22-49inch
3. Current Setting: 80cm (31inch)
2.7 Parameters: Distance – HDCE & VDCE

**Horizontal Distance from CCD to Eyes (HDCE)**

1. Subject to DSO
2. Current Setting: 75cm (29inch)

**Vertical Distance from CCD to Eyes (VDCE)**

1. Key Control Factor
2. Limit to: ?? cm / ??inch
3. Current Setting: 33 cm (13inch)
2.8 Summary: Key Control Factors

- AOC
- VDCE
- DoC
- DSO
3. Before Implementation:

→ Screen Size?
→ HeadBox Size?
→ Eye-Tracking Process
3.1 Screen Size?

According to the System Limitation, when DSO = 1m (3.3ft)

2 camera system (60°)
1. Width: 60cm (2ft)
2. Height: 60cm (2ft)

3 camera system (90°)
1. Width: 90cm (3ft)
2. Height: 60cm (2ft)
3.2 Screen Size?

*How about this (1)?*

*It works!*
3.3 Flight Simulation Lab

For Example, in the Flight Simulation Lab

60 cm
24 inch

200 cm
79 inch
3.4 Move the Camera closer to object!
3.5 Put Screen below the Cameras?

*How about this (2)?*

*Unknown: Need to Test!*
3.6 HeadBox Size?

**HeadBox Size**

1. Subject to Lens and HDCE
2. When HDCE = 85cm, using 2 cameras

**HeadBox** = 48(L) x 36(W) x 36(H) cm  
= 19(L) x 14(W) x 14(H) inch
3.7 Before we start!

2 issues need to consider

1. What is our screen size?
   How many Areas Of Interest do we need?
   Do these AOIs need to be watch sensitively?

2. Can the objective move his/her head?
   What is the Headbox size?
3.8 Eye Tracking Process

**A. Prepare Stage**
1.1 Takes about 0.5 min
1.2 Using the Chessboard
2.1 Takes about 1 min
2.2 Require 7 snapshots (2C + 5R)
3.1 Takes about 10 mins
3.2 Manual Remark the facial features

**B. Experiment Stage**
4.1 Takes about 1 min
4.2 Require 8 calibration points

**C. Follow-up Action**

**Objective**
- Sit Properly
- Calibrate Camera
- Create Profile: Take
- Calibrate Gaze (4)
- Experiment Start

**Remote Control**
- Calibration Check
- Create Profile Mark
- Camera Recording

**Note**
- 15min
4. Some application of Eye-Tracking in Aviation

Eyes Movement Interaction

Visual Perception

Perception
Cognition
Action

Cognitive Processing

Oculomotor Control

4.1 Decision-Making

Perception → Cognition → Decision → Action Feedback

Source: fotosa.ru
4.2 Decision-Making: Example

Perception

<table>
<thead>
<tr>
<th>Cognition</th>
</tr>
</thead>
</table>

1. Weather Condition

2. Pilot’s experiences, Training Effectiveness

3. Decide: Go / No-Go

In this case:

Eye Tracking is using to detect which dwelling-order will effect the decision. (Cloud -> Sky -> Terrain)

Source: Sawyer & Shappell (2009)
4.3 Comparing New & Old Human-Computer Interface

Ex: *Is a new system more effective than the old one?*

<table>
<thead>
<tr>
<th>New</th>
<th>Old</th>
</tr>
</thead>
</table>

*In this case:*

Eye Tracking is using to collect the eyes’ scanning time to compare the new & old system. The same concept can implement to evaluate a new HCI.

*Source: Lavine et al (2002)*
4.4 Comparing More & Less Pilots’ Behavior

Ex: As an observing tool to compare pilots’ behavior -> An input to Training

Descent  📈  Cruise  📈  Climb

In this case:
Eye Tracking is using to collect the pilots’ eye gaze sequence during these three stages, and then to compare the behavior between More & Less pilots.

Thank you! Questions?


