Eye-Based Interaction in Graphical Systems: Theory & Practice

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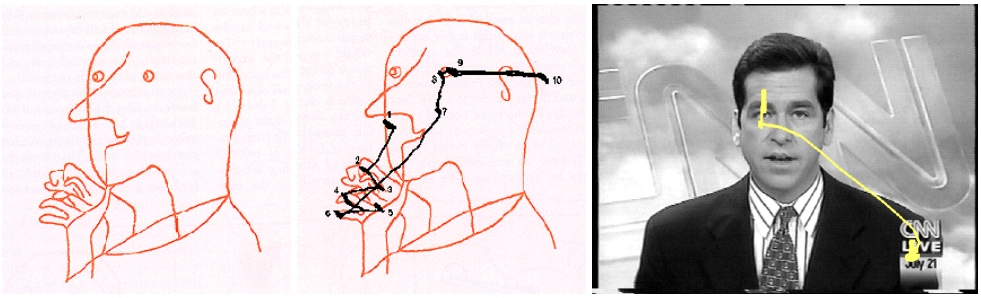

Figure 1: Examples of *scanpaths* over "Old Man Figuring" (adapted from [NS71a]) and CNN news footage.

This course covers interactive techniques associated with the use of an eye tracker, an input device delivering real-time coordinates of the user's gaze. While eye tracking technology is itself not new and eye trackers have been successfully incorporated in virtual environments (mainly by the military) over 20 years ago, eye trackers have not been easily accessible to the general graphics community. Moreover, eye trackers have traditionally been considered "unwieldy". Currently available off-the-shelf video eye trackers have greatly improved in their accuracy and ease of use and integration. Interest in the use of eye tracking devices is currently re-surging, as the devices are being applied in areas of interface usability studies, training simulators, and as interaction devices.

The course provides insight into the development, operation and use of eye-based systems in interactive applications. Theoretical aspects of dynamic human vision are covered to introduce participants to the characteristics of eye movements and visual attention. The course also covers:

- Basics of eye movements and eye movement signal characterization.
- Specifications of eye tracking hardware, emphasizing state-of-the-art video eye trackers.
- Design of software drivers and integration of eye trackers in graphical systems.
- Principal modes of eye-based systems (interactive and diagnostic) and techniques for developing these real-time and off-line programs.
- Example eye-based systems supporting 2D psychophysical imaging, 3D virtual reality training, and computer-supported VRML collaboration.

There is potential for a wide array of eye-based graphical applications. Examples include psychological studies where gaze imparts unique evidence of one's visual attention, human factors research where gaze is tracked to examine training effectiveness, and development of graphical systems for interaction and collaboration.

For updates and additional information, see: `<http://www.vr.clemson.edu/eyetracking/sigcourse>`

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Course Schedule

13:30 Welcome; Introduction to the Human Visual System (HVS) (60 min)

1. Neurological substrate of the HVS (30 min)
   (a) Physiological description (15 min) **Duchowski**
      i. the eye and extra-ocular muscles
      ii. the retina
      iii. the optic tract
      iv. the magno- and parvo-cellular visual channels
      v. the occipital cortex and beyond
   (b) Functional description (15 min) **Vertegaal**
      i. visual attention
      ii. eye movements
      iii. foveo-peripheral vision
2. Visual perception (15 min) **Vertegaal**
   (a) spatial vision
   (b) temporal vision
   (c) color vision
3. Eye movements (15 min) **Duchowski**
   (a) saccades
   (b) smooth pursuits
   (c) fixations
   (d) nystagmus

14:30 Eye Tracking Systems (60 min)

1. The eye tracker (30 min) **Vertegaal**
   (a) early developments (scleral coils, contact lenses, etc.)
   (b) video-based eye trackers
   (c) system use
2. Integration issues (30 min) **Duchowski**
   (a) application system design, hardware, software
   (b) system calibration
   (c) data collection
   (d) data analysis

15:30 Potential Gaze-Contingent Applications (60 min)

1. Virtual Reality **Duchowski**
2. Collaborative systems **Vertegaal**
3. Psychophysics **Vertegaal**
4. Human factors **Duchowski**
5. Advertising **Duchowski**
6. Digital displays **Vertegaal**

16:30 Hands-On Demonstration of the GAZE Groupware System (30 min)

1. The GAZE Groupware System (30 min) **Vertegaal**

Course Speakers

Andrew Duchowski is an assistant professor in the Department of Computer Science at Clemson University, Clemson, SC. He received his BSc and PhD degrees in Computer Science from Simon Fraser University, Burnaby, Canada, and Texas A&M University, College Station, TX, respectively. At Texas A&M, he completed a dissertation under the direction of Dr. Bruce H. McCormick, entitled, "Gaze-Contingent Visual Communication". Dr. Duchowski's research and teaching interests include visual attention and perception, eye movements, computer vision, graphics, and virtual environments. He is currently investigating gaze-contingent virtual reality systems and has just completed teaching a new interdisciplinary course entitled "Eye Tracking Methodology".

Roel Vertegaal is an assistant professor in Human-Computer Interaction (HCI) at Queen's University in Canada. His Master's research in Computer Science at Bradford University, UK, was on the use of input devices in Computer Music. His PhD work in HCI at Twente University, Netherlands, focused on eye input for multimodal collaborative systems and the role of visual attention in human communication. His current research is on the psychology and design of Nonverbal Communication Interfaces. Having pioneered eye-based interfaces for sociable interaction, Dr. Vertegaal gave numerous invited presentations at venues including ACM Expo'97, CSCW, CHI, IBM Almaden, Interval and Xerox PARC.

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