On the Usage of Gaze Information for NonCommand Interactive Applications

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Outline

- Introduction on Human Attention and Gaze.

- Gaze tracking techniques and applications:
  - Technological issues.
  - Interaction issues.

- A preliminary application:
  - Implementation.
  - Observations.

- Gaze behavior during reading tasks.

- Proposed extensions to the application.

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Human Attention or "Interest"

Constrained interface between
two powerful information processors

Need to increase bandwidth
across the channel
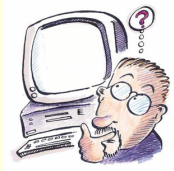
Some facts
- Eyes are extremely rapid
- Eye movements are natural $\Rightarrow$ Little conscious effort is needed
- Target acquisition requires to look first before to acting
- Direction of gaze implicitly indicates the point of interest

Detecting Human Attention is Possible

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Problems and Issues in Gaze Tracking and Applications

- Technological issues:
  - Tracking methods and their accuracy.
  - Refinement of noisy data.

- Interaction issues:
  - Eyes are perceptual devices, not control ones:
    Midas touch problem and dwell-time usage.
  - Need for a new interaction scenario/technique:
    Noncommand Interfaces.

- An Open issue:

  Can we infer human thoughts from gaze information?

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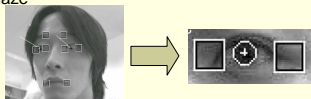## Technological Issues: vision only based tracking [Matsumoto et al. 1998]

- Using template matching technique to track the head and Hough transform to track the cornea

Advantages:
- Non-intrusive method and does not cause discomfort.
- Tracks both head pose and gaze vector

Drawbacks:
- Less accurate ($\pm 3°$)
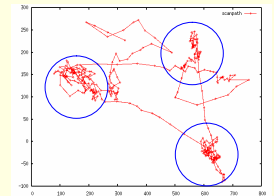- Need initial setting

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Technological Issues: processing raw gaze data [Duchowski 2003]

- Various eye movements
  - Convergence
  - Fixations
  - Saccades
  - Pursuit motion
  - Drift and micro-saccades, …

- Refining raw data:
  - Filter the noise (Butterworth)

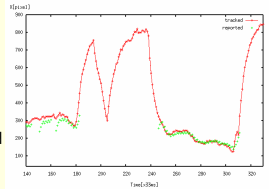 $$|H(jw)|^2 = \frac{1}{1+\left(\frac{w}{w_c}\right)^{2n}}$$

  - Distinguish Fixations from Saccades

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Technological Issues: saccade/fixation detection
[Duchowski 2003]

- Velocity-Threshold
  - Saccades >300 [deg/sec].
  - Fixations <100 [deg/sec].
  - Usual threshold 200 [deg/sec].

- Dispersion-Threshold
  - $D = \dfrac{\max(x) - \min(x)}{\max(y) - \min(y)}$
 - Threshold set such that visual angle is between 0.5 [deg] and 1[deg].

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Interaction Issues: using the filtered data

- Command based Interface [Jacob 1993]
  - Straightforward applications: Objects selection {Menu selection, Window scrolling, …} ⇒ Pointing.
  - Midas Touch problem: Eyes are not a control device.
  - Use *dwell time* to trigger a selection.

- Non-Command Interfaces [Nielsen 1993]
  - The computer monitors user's actions instead of waiting for his/her command.
  - Potential Applications: User Support ⇒ Detect difficulties and provide translation support of difficult words
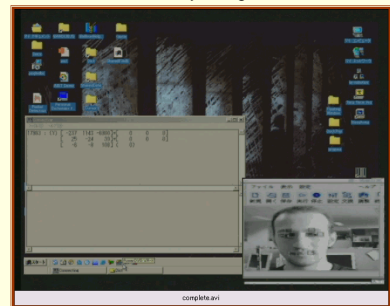
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Application Overview
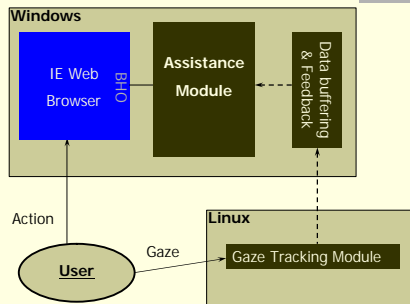
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Preliminary Implementation
[Khiat et al. 2003]

Pro-Active Dictionary Using Head Direction

x 2

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Observations

- Continuous consciousness to direct head or gaze

- Unnatural task for human beings.

- Eye movements are not always under voluntary control.

Need information from the user's natural [eye] movements instead of requiring him/her to make specific ones

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In the Reading Context: how to detect user difficulties?
[Hyrskykari et al. 2003]

Gaze pattern during normal reading

Gaze pattern when difficulties encountered

Need an Experimental Validation

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## Gaze Patterns in Reading: data collection experiment

- Experiment tools:
  - EMR-NC™ gaze tracker
  - WebTracer recording software
  - MRI-EMR-NC™ data viewing software

EMR-NC

- Experiment conditions:
  - 9 subjects were asked to read 3 texts each
  - The subjects had 3 different levels of English proficiency
  - The texts were separated into 3 different levels of difficulty
  - The reading order was done arbitrarily.
  - Subjects indicate an understanding problem with a mouse click when this one occurs

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Gaze Patterns in Reading: data example

Gaze Data Plot   Gaze Data Separated in X and Y
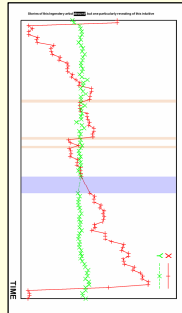
Raw Gaze Data

Processed Data
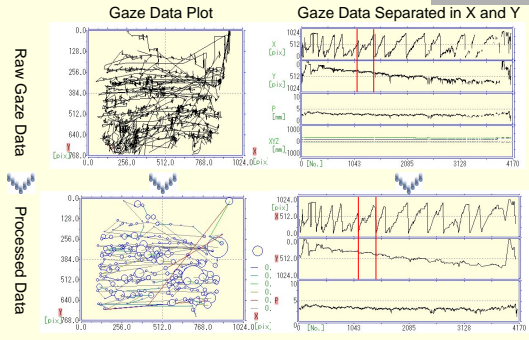
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Gaze Patterns in Reading: closer look at a single line

[Khiat et al. 2004]

- Observations:
  - Presence of regressions.
  - Variable distance to the moments of the problem.
  - Average of regression number is 1.3 (for the 40 cases analyzed).
  - Sometimes no regression is noticed before the problem occurs (10% of the cases)

  Regressions can be used to detect problem's occurrence

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Proposed context grounding

- Gaze information not enough all alone
  - Propose a grounding with a context [indicated by gaze]

- Implicit preprocessing of the viewed scene (text).
  - Associate a difficulty rate to each word.
  - Difficulty rate based on the frequency of usage.

  - Preprocessing step can be also used for:
    Text parsing, conversion to basic form, link appropriate reading, …and so on.

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Thank you

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