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.

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 ⇒ 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

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?

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 (±3°)
- Need initial setting

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)
  \[
  |H(f)| = \frac{1}{1 + (f/fc)^2}
  \]
  - Distinguish Fixations from Saccades
Technological Issues: saccade/fixation detection

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

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

Interaction Issues: using the filtered data

- **Command based Interface** (Jacob 1993)
  - Straightforward applications: Objects selection (Menu selection, Window scrolling, …) $\Rightarrow$ 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 $\Rightarrow$ Detect difficulties and provide translation support of difficult words.

Application Overview

- **Windows**
  - IE Web Browser
  - Assistance Module
  - Gaze Tracking Module

- **Linux**
  - Gaze
  - Assistance Module
  - Gaze Tracking Module

Preliminary Implementation

- **Pro-Active Dictionary Using Head Direction**
  - [Khiat et al. 2003]

Observations

- Continuous consciousness to direct head or gaze
- Unnatural task for human beings.
- Eye movements are not always under voluntary control.

In the Reading Context: how to detect user difficulties?

- **Gaze pattern during normal reading**
  - [Hyryskari et al. 2003]

- **Gaze pattern when difficulties encountered**

Need an Experimental Validation
Gaze Patterns in Reading: data collection experiment

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

- **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

Gaze Patterns in Reading: closer look at a single line

- **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**

Gaze Patterns in Reading: data example

- **Gaze Data Plot**
- **Gaze Data Separated in X and Y**

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.

References


Thank you