Computational Foundations of Cognitive Science

Lecture 22: Models of Eyetracking Data

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Eye-tracking

Let's apply what we've learned to some real data.

An *eye-tracker* makes it possible to record the eye-movements of subjects while they are performing a cognitive task:

- looking at a scene;
- driving a vehicle;
- using a computer;
- reading a text.

Mind's Eye Hypothesis: where subjects are looking indicates what they are processing. How long they are looking at it indicates how much processing effort is needed.

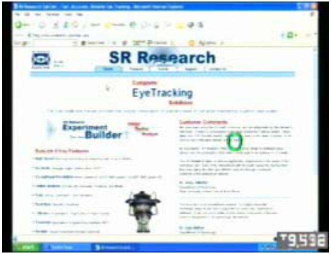
Eye-tracking

A head-mounted, video-based eye-tracker.

Eye-movements and Scene Perception

Eye-movements and Driving

Eye-movements and Computer Use



Mid-lecture Problem

Can you think of other applications of eye-tracking? Come up with cases in which recording eye-movements is useful to study:

- language processing
- visual cognition
- memory
- cognitive impairment

Eye-movements and Reading

Let's looks at eye-tracking data for *reading* in detail:

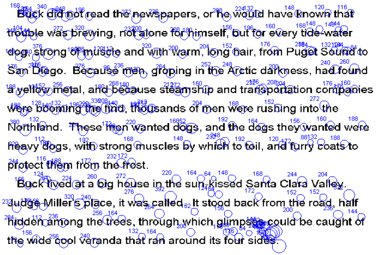
- eye-movements are recorded while subjects read texts;
- very high spatial and temporal accuracy;
- eye movements in reading are saccadic: a series of relatively stationary periods *(fixations)* between very fast movements *(saccades)*;
- average fixation time is about 200 ms; can be longer or shorter, depending on ease or difficulty of processing;
- typically we test a number of subjects, with a number of test sentences, and do a statistical analysis of the results.

Eye-movements and Reading

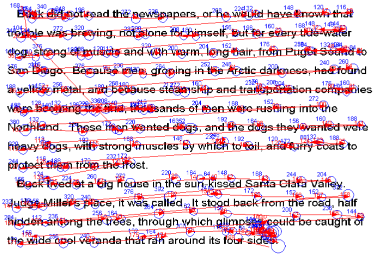
Buck did not read the newspapers, or he would have known that trouble was brewing, not alone for himself, but for every tide-water dog, strong of muscle and with warm, long hair, from Puget Sound to San Diego. Because men, groping in the Arctic darkness, had found a yellow metal, and because steamship and transportation companies were booming the find, thousands of men were rushing into the Northland. These men wanted dogs, and the dogs they wanted were heavy dogs, with strong muscles by which to toil, and furry coats to protect them from the frost.

Buck lived at a big house in the sun-kissed Santa Clara Valley. Judge Miller's place, it was called. It stood back from the road, half hidden among the trees, through which glimpses could be caught of the wide cool veranda that ran around its four sides.

Eye-movements and Reading



Eye-movements and Reading



Probability Distributions

Data: 23 subjects read a 2000 word text while their eye-movements were being recorded.

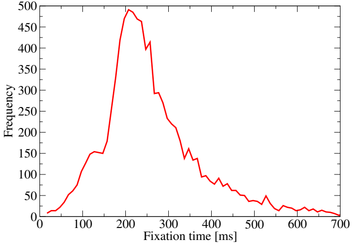
To analyze the data, define two random variables:

- X: time taken to read a word;
- Y: number of regressions made while reading a word;

Note that X is a *continuous* random variable, while Y is a *discrete* random variable.

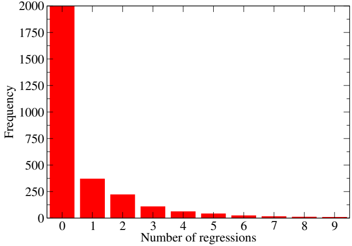
Plot the distributions; compute their means and standard deviations.

Distribution: Reading Time



$\mu = 269.58$, $\sigma = 132.88$. Almost normal distribution.

Distribution: Number of Regressions



$\mu = 1.31$, $\sigma = 1.81$. Almost a binominal distribution.

Probability Distributions

We can therefore *approximate* the empirical distributions as follows:

$$f(x) = n(x; 269.58, 132.88) = \frac{1}{132.88\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-269.58}{132.88}\right)^2}$$

$$= 0.003 e^{-\frac{1}{2}(0.008x-2.03)^2}$$

$$f(y) = b(y; 20, 0.01) - 10 = \binom{20}{y} 0.01^y 0.09^{20-y}$$

These distributions fit the empirical distributions reasonably closely. They give us an idea about the *process* that generated these distributions.

Summary

- Using an eye-tracker, we can accurately record where someone is looking, and for how long;
- this can be used to investigate cognitive processing, based on the mind's eye hypothesis;
- eye-tracking data can be used to study scene perception, reading, or applied tasks like driving;
- reading data can be described using probability distributions;
- reading times are approx. normally distributed; regressions are approx. binomially distributed.