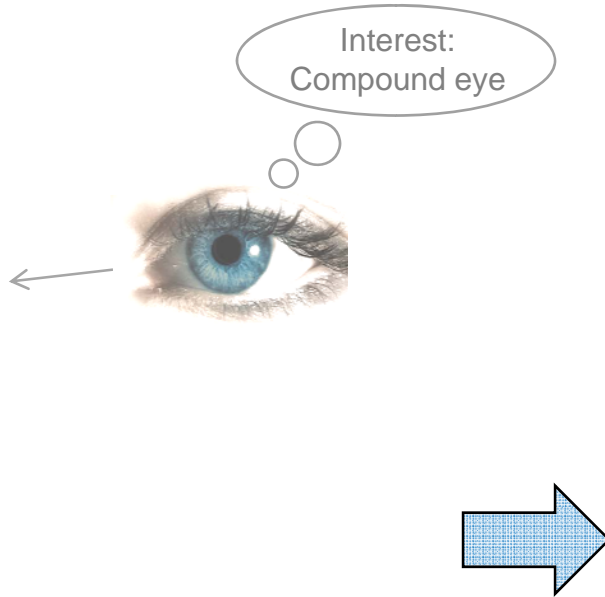
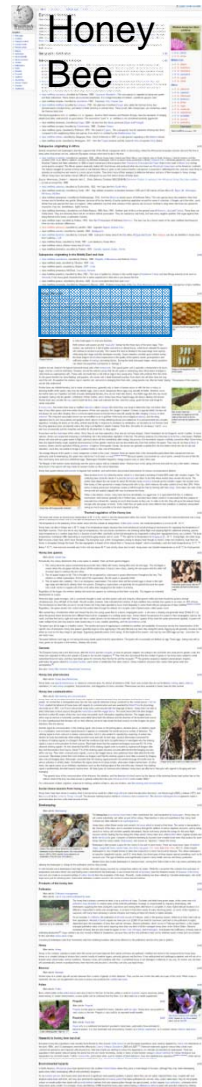

Gaze-Based Filtering of Relevant Document Segments

Georg Buscher, Andreas Dengel
DFKI, Kaiserslautern, Germany

WSSP, 20.04.2009

Summary Snippets in Re-Finding Scenarios



Browser history

Classical Summary

[Honey bee - Wikipedia, the free encyclopedia](#)

Honey bees (or honeybees) are a subset of bees, primarily distinguished by the production and storage of honey and the construction of perennial, ...



Personalized Summary

[Honey bee - Wikipedia, the free encyclopedia](#)

[Visual Perception](#)

Eye(s). Honey bees have two compound eyes that make a large part of the head surface. Each compound eye is composed of individual cells (ommatidium, ...



Research Questions

fluid and the surrounding water. Hence creatures which have returned to the water — penguins and seals, for example — lose their refractive cornea and return to lens-based vision. An alternative solution, borne by some divers, is to have a very strong cornea.^[1]

Reflector eyes [edit]

An alternative to a lens is to line the inside of the eye with "mirrors", and reflect the image to focus at a central point.^[1] The nature of these eyes means that if one were to peer into the pupil of an eye, one would see the same image that the organism would see, reflected back out.^[1]

Many small organisms such as rotifers, copepods and platyhelminths use such organs, but these are too small to produce usable images.^[1] Some larger organisms, such as scallops, also use reflector eyes. The scallop *Pecten* has up to 100 millimeter-scale reflector eyes fringing the edge of its shell. It detects moving objects as they pass successive lenses.^[1]

There is at least one vertebrate, the spruukfish, whose eyes include reflective optics for focusing of light. Each of the two eyes of a spruukfish collects light from both above and below; the light coming from the above is focused by a lens, while that coming from below, by a curved mirror composed of many layers of small reflective plates made of guanine crystals.^[1]

Compound eyes [edit]

A compound eye may consist of thousands of individual photoreception units. The image perceived is a combination of inputs from the numerous units (referred to as ommatidia), which are located on the eye's surface, thus resulting in slightly different views. Eyes with simple eyes, compound eyes possess a very large field of view, they detect movement and, in some cases, the polarization of light.^[1] Because the units are so small, they can also detect small objects and movements. The resolution of the image perceived is limited. This resolution can be countered by increasing lens size, but this is not possible with compound eyes. For simple eyes, humans would require compound eyes which would be the size of their head.

Compound eyes are found in various groups: apposition eyes which form multiple inverted images, and superposition eyes which form a single image.^[1] Compound eyes are found in arthropods, and are also present in annelids and some bivalves.^[1] Compound eyes in arthropods at least grow at their margins by the addition of new ommatidia.^[1]

Apposition eyes [edit]

Apposition eyes are the most common form of eye and are generally the ancestral form of compound eyes. They are found in all arthropod groups, although they may have evolved more than once within this phylum.^[1] Some annelids and bivalves also have apposition eyes. They are also possessed by *Arachnida*, the parasitic crab, and there are suggestions that other invertebrates descend from simple eyes by reduction from a compound starting point.^[1] (Some caterpillars appear to have evolved compound eyes from simple eyes in the opposite fashion.)

Apposition eyes work by gathering a number of images, one from each eye, and combining them in the brain, with each eye typically contributing a single point of information.

The typical apposition eye has a lens focusing light from one direction on the rhabdom, while light from other directions is absorbed by the dark wall of the ommatidium. In the other kind of apposition eye, found in the *Strepsiptera*, lenses are not fused to one another, and each forms an entire image; these images are combined in the brain. This is called the schizochroal compound eye or the neural superposition eye. Because images are combined additively, this arrangement allows vision under lower light levels.^[1]

Superposition eyes [edit]

The second type is named the superposition eye. The superposition eye is divided into three types; the refracting, the reflecting and the parabolic superposition eye. The refracting superposition eye has a gap between the lens and the rhabdom, and no side wall. Each lens takes light at an angle to its axis and reflects it to the same angle on the other side. The result is an image at half the radius of the eye,

highly relevant

less relevant

not of interest

○ When is the user reading?

○ Which eye movements indicate relevance?

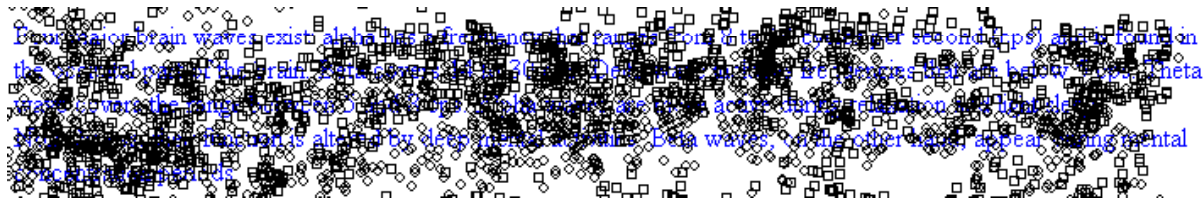
Outline

➔ Reading Detection Algorithm

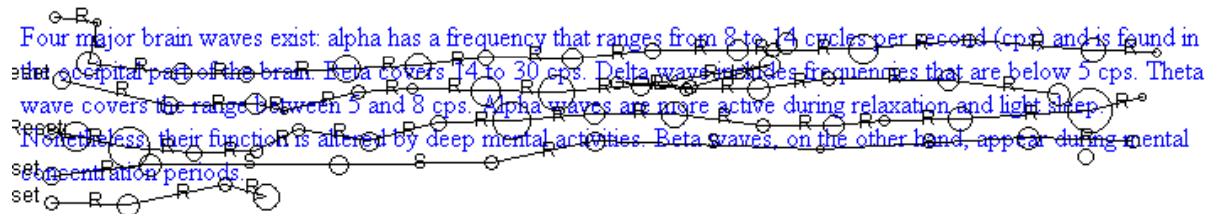
- Eye Movement Measures
- Study Design
- Results

Reading Detection – Overview

1. Starting point: Noisy gaze data from the eye tracker



2. Fixation detection and saccade classification

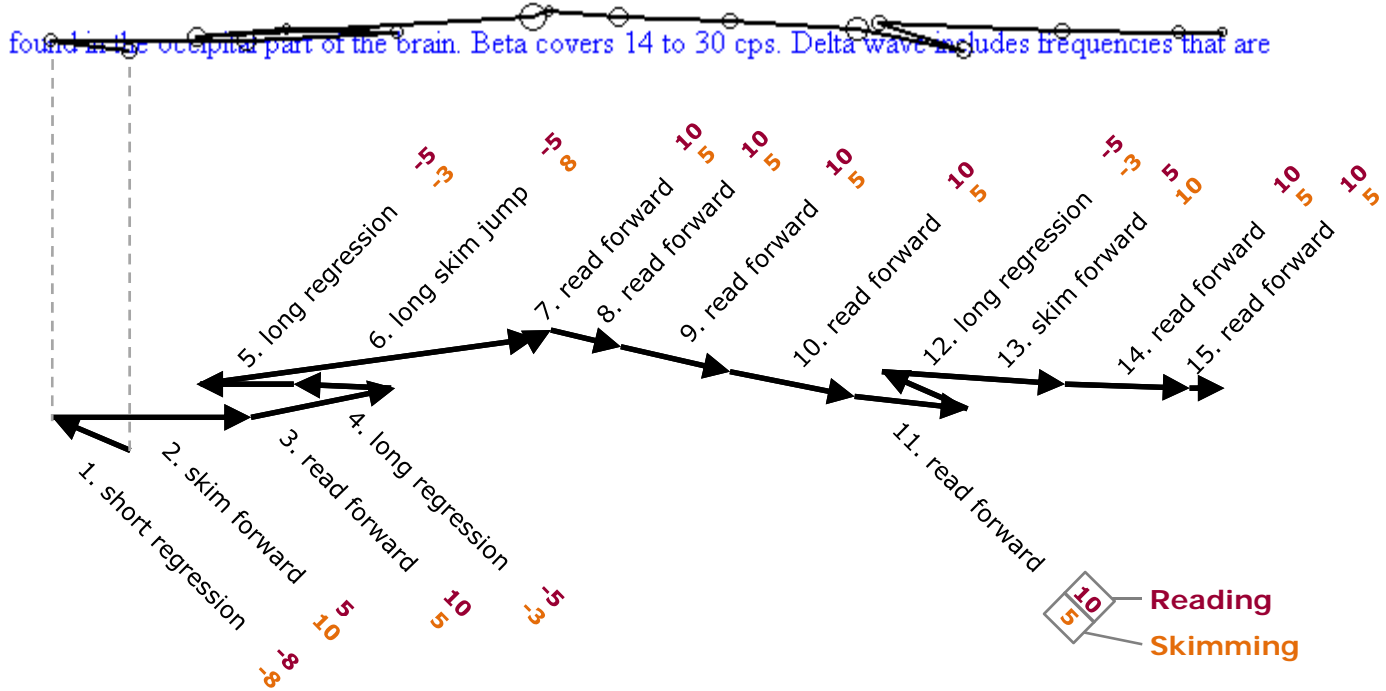


3. Reading (red) and skimming (yellow) detection line by line

Four major brain waves exist: alpha has a frequency that ranges from 8 to 14 cycles per second (cps) and is found in the occipital part of the brain. Beta covers 14 to 30 cps. Delta wave includes frequencies that are below 5 cps. Theta wave covers the range between 5 and 8 cps. Alpha waves are more active during relaxation and light sleep. Nonetheless, their function is altered by deep mental activities. Beta waves, on the other hand, appear during mental concentration periods.

See G. Buscher, A. Dengel, L. van Elst: "Eye Movements as Implicit Relevance Feedback", in CHI '08

Reading Detection – Example



Plausibility of reading

$$S_r = -8 + 5 + 10 - 5 - 5 - 5 + 10 + 10 + 10 + 10 + 10 - 5 + 5 + 10 + 10 = 62$$

Plausibility of skimming

$$S_s = -8 + 10 + 5 - 3 - 3 + 8 + 5 + 5 + 5 + 5 + 5 - 3 + 10 + 5 + 5 = 51$$

62 > 51
 Reading behavior detected



Outline

- Reading Detection Algorithm

➔ Eye Movement Measures

- Study Design
- Results

Eye Movement Measures

- Fixation duration



- Fixation count

There is at least one vertebrate, the spookfish, whose eyes include collects light from both above and below the light coming from the mirror composed of many layers of small reflective plates made of t

VS

There is at least one vertebrate, the spookfish, whose eyes include collects light from both above and below the light coming from the mirror composed of many layers of small reflective plates made of t

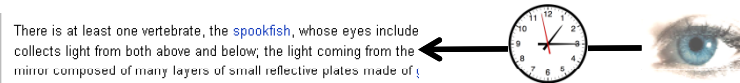
- Average saccade length



- Regression rate



- Viewing time



- Reading vs. skimming behavior



- Length of coherently read text

Compound eyes
 A compound eye may consist of thousands of individual photoreceptive units. The image is formed by the ommatidia (individual units), which are located on a convex surface. Unlike simple eyes, compound eyes possess a very large view angle, and can detect fast movements. Because the individual lenses are so small, the effects of diffraction impose a limit on resolution. To see with a resolution that requires increasing lens size and number — to see with a resolution that requires compound eyes which would each reach the size of their head.

VS

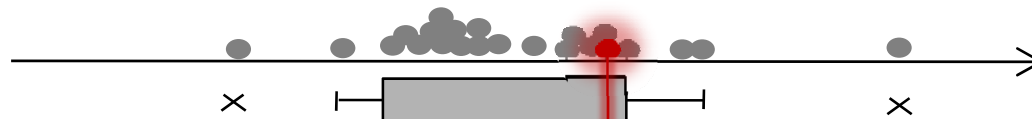
Compound eyes
 A compound eye may consist of thousands of individual photoreceptive units. The image is formed by numerous ommatidia (individual "eye units"), which are located on a convex surface, thus with simple eyes, compound eyes possess a very large view angle, and can detect fast movements. Because the individual lenses are so small, the effects of diffraction impose a limit on resolution. This can only be countered by increasing lens size and number — to see with a resolution that requires compound eyes which would each reach the size of their head.

“Whisker”-Personalization of the Measures

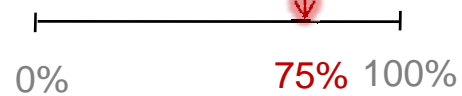
- Absolute value range of a measure for a specific user



- Boxplot



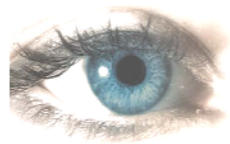
- “Whisker”-personalized interval for user



Outline

- Reading Detection Algorithm
- Eye Movement Measures
- ➔ Study Design
- Results

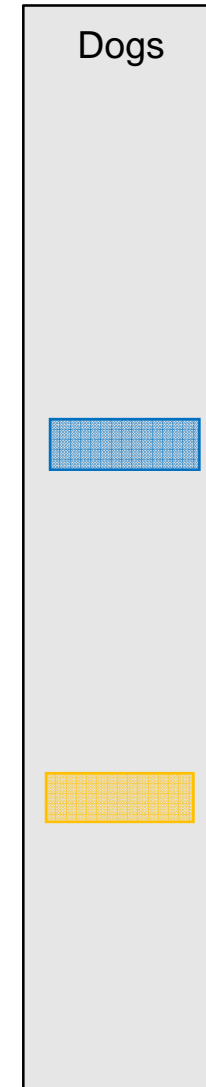
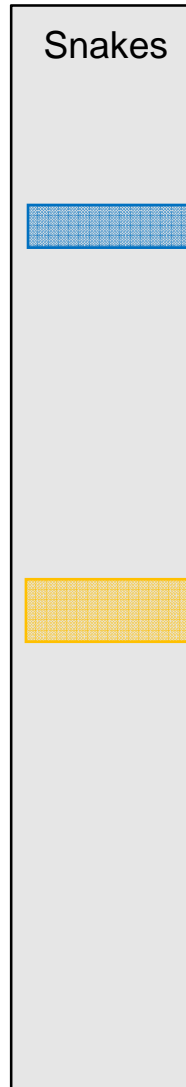
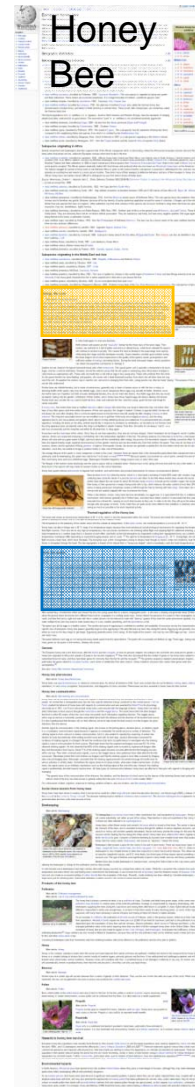
Study Design



→ Task: visual perception

→ Task: thermoregulation

- 4 lengthy Wikipedia articles
- 6% of each article highly relevant (for each task)
→ “ground truth”
- 25 participants



Outline

- Reading Detection Algorithm
- Eye Movement Measures
- Study Design

➔ Results

Results – Reading Detection

	unknown document	known document
precision	0.55	0.88
recall	0.88	0.84
f-measure	0.68	0.86

- High precision and recall for known documents
- Relatively low precision for unknown documents

Improvement by Gaze-Based Measures on Unknown Docs

	detected reading vs. skimming behavior >=						regression rate >=						average saccade length >=						length of coherently read text >=							
	0.1	0.2	0.3	0.4	0.5	0.6	0.1	0.2	0.3	0.4	0.5	0.6	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	50	100	150	200	250	300
precision	.11	.12	.16	.16	.16	.14	.13	.13	.21	.21	.14	.10	.02	.03	.05	.09	.13	.19	.22	.1	.02	.09	.11	.14	.14	.17
recall	-.06	-.12	-.18	-.30	-.41	-.53	-.03	-.15	-.32	-.55	-.75	-.87	-.02	-.03	-.04	-.09	-.20	-.44	-.73	-.90	-.01	-.01	-.02	-.03	-.07	-.11
f-measure	.04	.02	.00	-.08	-.15	-.27	.06	.0	-.07	-.27	-.52	-.71	.00	.01	.01	.01	-.02	-.17	-.48	-.78	.01	.05	.05	.07	.0	.04

- Best improvement of precision for average saccade length



- Best overall improvement (f-measure) for length of coherently read text

Compound eyes

A compound eye may consist of thousands of individual photoreceptors (the basic units of vision). Each ommatidium (individual "eye unit"), which is located on a convex surface, consists of a single lens, a single cell, and a single receptor. Compound eyes possess a very large view angle, and can detect fast motion. Because the individual lenses are so small, the effects of diffraction impose a limit on resolution. Resolution can only be increased by increasing lens size and number — to see with a resolution require compound eyes which would each reach the size of their head.

VS

Compound eyes

A compound eye may consist of thousands of individual photoreception units. The image is formed by the light rays passing through the individual units, which are located on a convex surface, thus with numerous ommatidia (individual "eye units"), which are located on a convex surface, thus with simple eyes, compound eyes possess a very large view angle, and can detect fast motion. Because the individual lenses are so small, the effects of diffraction impose a limit on resolution. This can only be countered by increasing lens size and number — to see with a resolution require compound eyes which would each reach the size of their head.

- And regression rate



- Fixation duration does not work well



Conclusion

- Difference between first-time- and second-time-reading
- Reading detection is an effective first relevance filter
- Best improvement for relevance estimation by
 - length of read text and
 - regression rate
- Fixation duration does not work well



Thank you for your attention!

