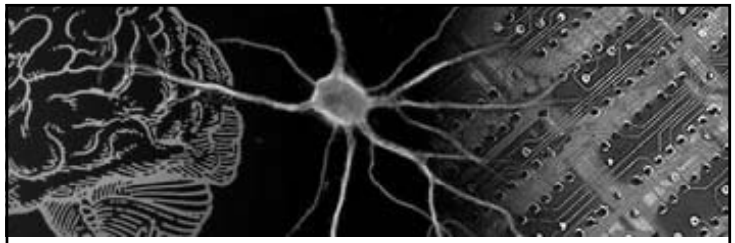


PSYC305

Applied Cognition & Neuroscience

Mātai hinengaro whaipainga

Lecture 4: Road Transport: Vision and Navigation

© Assoc Prof. John Perrone
Psychology Dept.
The University of Waikato

Topics:

1. Motion perception *
2. Human visual navigation *

* Background information for answering questions such as:

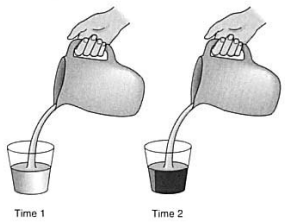
What visual information do we use for steering?
How do we negotiate corners safely?
How do we judge how fast we are going?
Can we design cars that drive themselves?

1. Motion Perception (Partial review of PSYC226 material).
   - •The information provided by movement
   - •Illusions of movement
   - • Neurons that respond to motion

Background Reading:
Chapter 8, 9. Goldstein Textbook (6th Edition)

Motion information is very important for survival.

See description of patient with motion agnosia (p. 270, Goldstein).



Patient with motion agnosia (Zihl et al., 1991) perceived no change in the level of water being poured into a cup. People suddenly appeared and disappeared.

The information provided by movement

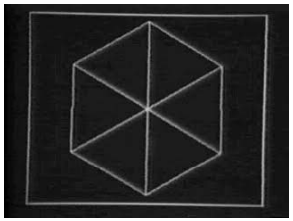
(1) Movement ….

+

Movement in our peripheral vision usually triggers an eye movement that brings the moving object's image into our fovea so that we can see it clearly.

The information provided by movement (continued)

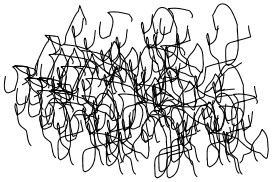
(2) Movement of an object relative to an observer provides information about the object's three-dimensional shape.



An unfamiliar object's shape often becomes obvious when we view it from multiple viewpoints.

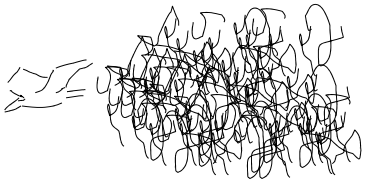
The information provided by movement (continued)

(3) Movement provides information that helps us _____ _____



A camouflaged animal remains invisible as long as it is still, but becomes instantly visible as soon as it moves. Movement _____figure (the animal) from _____ (the rest of the environment).

The information provided by movement (continued)



The information provided by movement (continued)

(4) Movement provides information that enables us to interact with the environment.

As we walk, drive or fly (see later video clips), the movement of elements of the environment provides information that keeps us on course and helps us avoid bumping into things (most of the time!)

Illusions of Movement

The study of motion perception is complex because …

•Movement aftereffects (e.g., the waterfall illusion)

(+see rotating dots demonstration)

Motion after-effects

The Water-fall illusion

Look at the falling water for about a minute

Bridal Veil Falls near Raglan

Motion after-effects

The Water-fall illusion

Then look at the rocks and see what happens!

Bridal Veil Falls near Raglan

Motion after-effects

The Water-fall illusion

Bridal Veil Falls near Raglan (video)

It does not work very well in video form, but see demonstration with dots (next slide)

Illusions of Movement (continued)

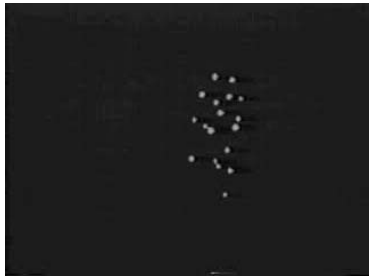
•Induced Movement

Watch what happens to the text as the dots move by.

(Also see the Goldstein textbook for description of dot on TV set demonstration)

<u>Biological Motion:</u>

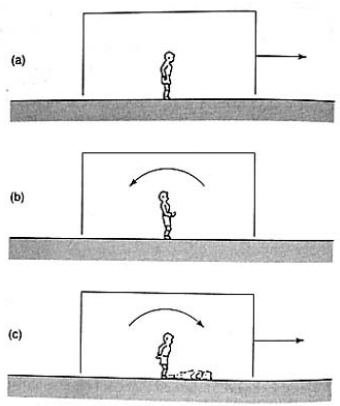
Experiments carried out by _____(_____) with 'point light walkers'.



Random collection of dots or something else?

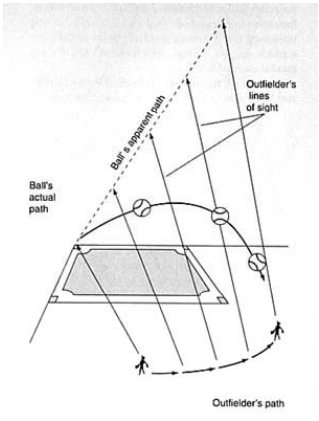
Movement creates perceptual grouping

The importance of vision and motion for maintaining balance.



Lee and Aronson (1974) swinging room demonstration.

Motion perception principles applied to sports



From: McBeath, Shaffer & Kaiser, 1995.

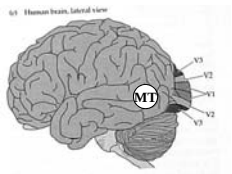
Neurons that respond to motion

Directionally selective neurons.

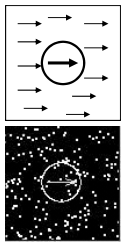
•Respond to movement in one direction only

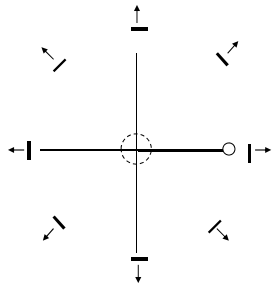
•Found in striate cortex (_____) and the Middle Temporal area (MT).

Area MT is important in movement perception

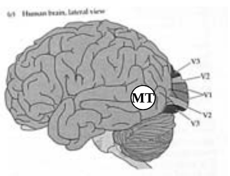


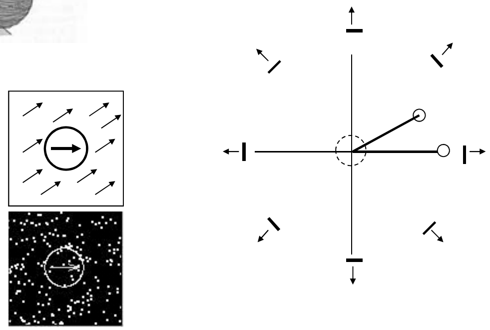
Motion sensitive neurons in the Middle Temporal (MT) area of the brain.



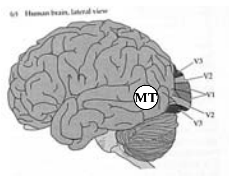


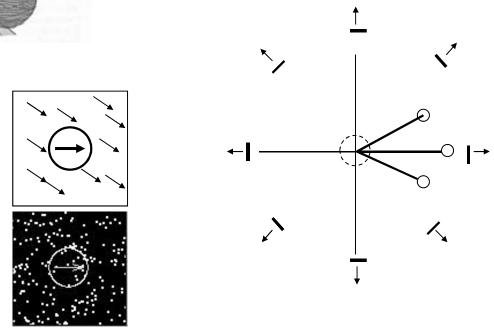
Motion sensitive neurons in the Middle Temporal (MT) area of the brain.



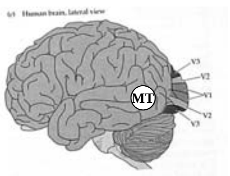


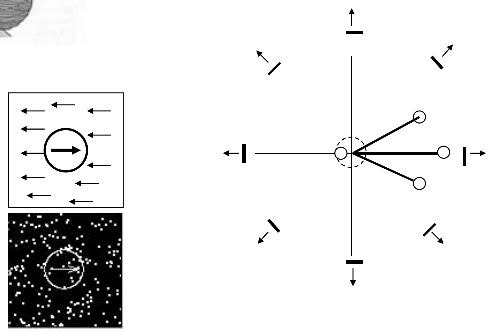
Motion sensitive neurons in the Middle Temporal (MT) area of the brain.



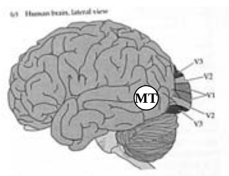


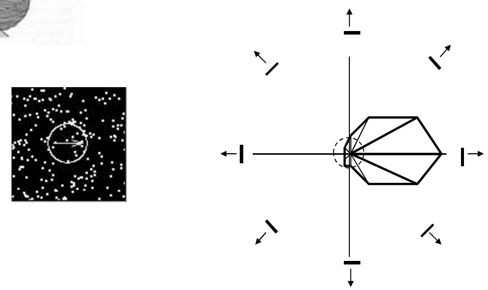
Motion sensitive neurons in the Middle Temporal (MT) area of the brain.





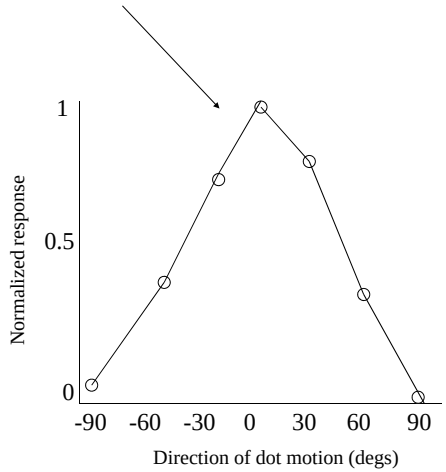
Motion sensitive neurons in the Middle Temporal (MT) area of the brain.



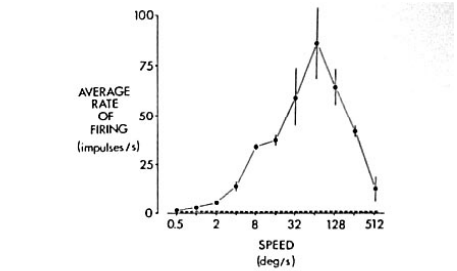


Direction tuning within MT
(e.g., Albright, 1984)

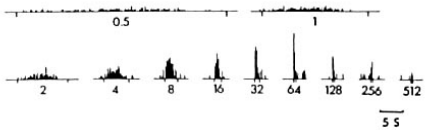
_____for a typical MT neuron



Speed selectivity (tuning) in Middle Temporal (MT) neurons

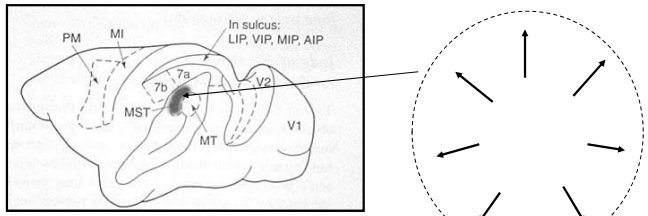


Data from:
Maunsell &
Van Essen (1983)



See also:
Perrone & Thiele (2001)
Nature Neuroscience, 4.

Medial Superior Temporal (MST) neurons



- _____
- _____

Saito et al., 1986
Tanaka & Saito, 1989
Duffy & Wurtz, 1991

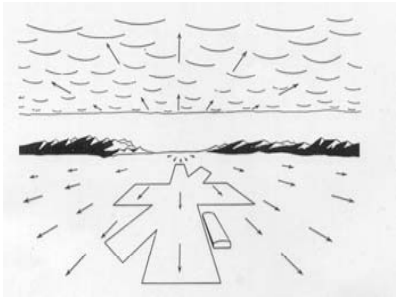
2. Human self-motion estimation

- The problem
- Translation and rotation
- Physiological-based models

<u>Background Reading:</u>
Warren & Hannon paper.

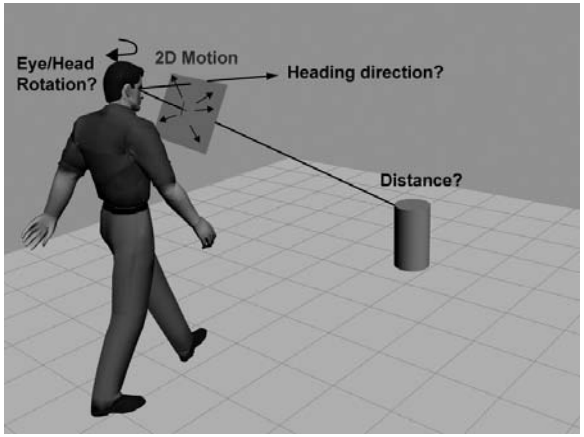
The visual self-motion estimation problem: What is it?

Retinal image motion is critical for solving the self-motion estimation problem.

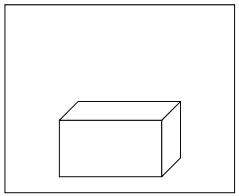


From: James Gibson (1950). *The Perception of the Visual World.*

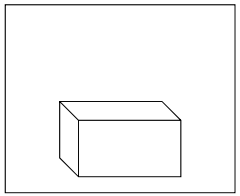
The self-motion estimation problem



What about static cues?

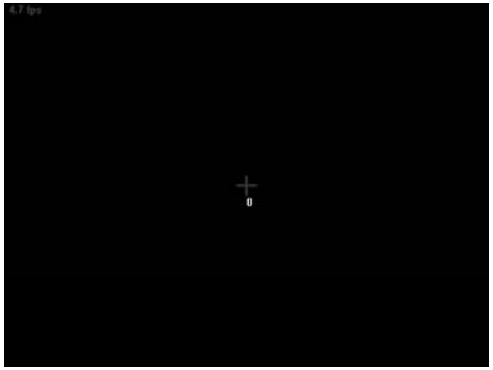


Frame 1



Frame 2

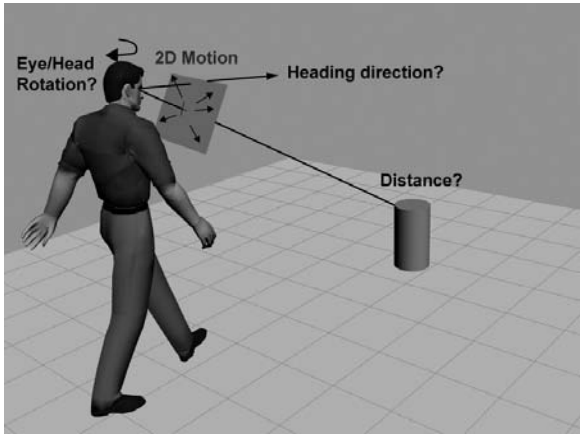
Self-motion estimation without static cues



Self-motion estimation without static cues

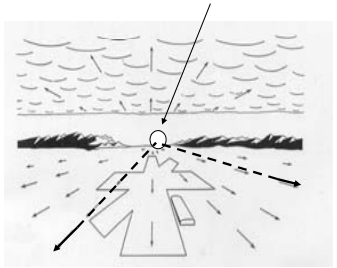
Vestibular and eye-movement information?
(See Warren & Hannon article).

The visual self-motion estimation problem



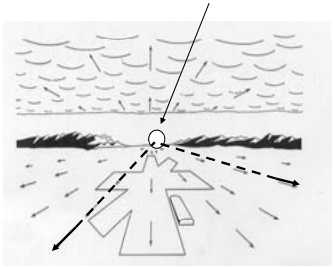
Solving the visual self-motion estimation problem.

Early theory:
Heading indicated by the _____
(Gibson, 1950)



Velocity vector flow field
(Optic flow field)

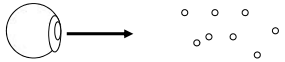
Solving the visual self-motion estimation problem.

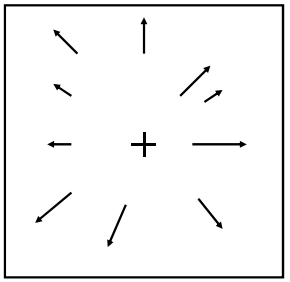


Why is the problem so hard?

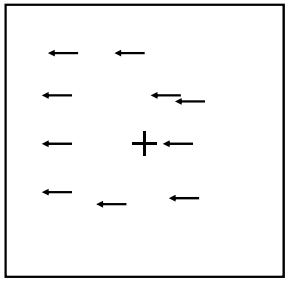
Velocity vector flow field
(Optic flow field)

Velocity vectors: Pure translation

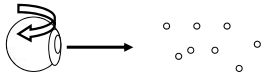


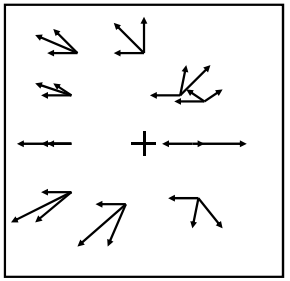


Pure rotation (eye turns to the right)

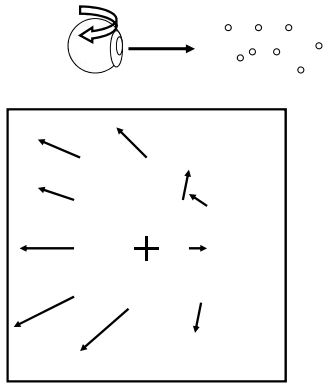


Translation + rotation



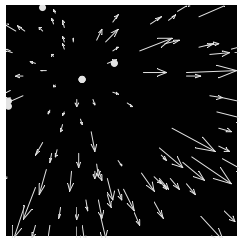


Translation + rotation

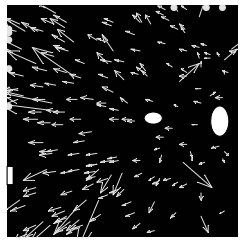


Heading direction = ?

The retinal image motion is much more complex when the eyes or head rotate during forward locomotion.

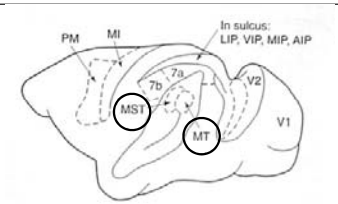


Pure translation



Translation + Rotation

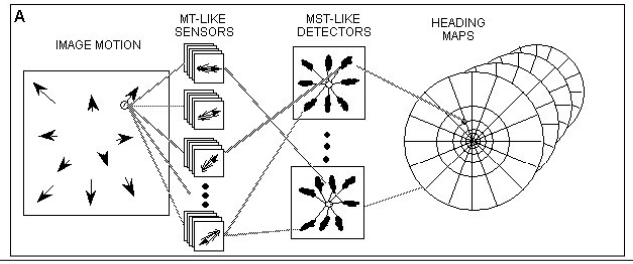
Solving the self-motion estimation problem using physiologically plausible mechanisms



MT
Middle
Temporal

→

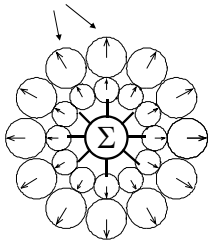
MST
Medial Superior
Temporal

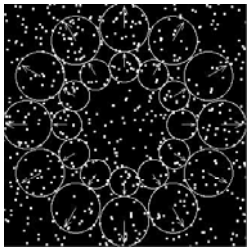


Overview of a physiologically-based model of self-motion estimation.
Perrone, 1992, *J. Opt. Soc. Am. A, 9.*
Perrone & Stone, 2004, *Vision Research, 34.*

Constructing a heading detector from MT neurons

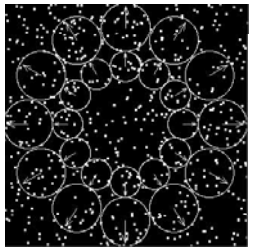
MT neurons tuned to directions indicated by arrows





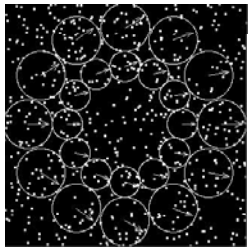
This type of detector has properties similar to an MST neuron.

Non-optimal heading



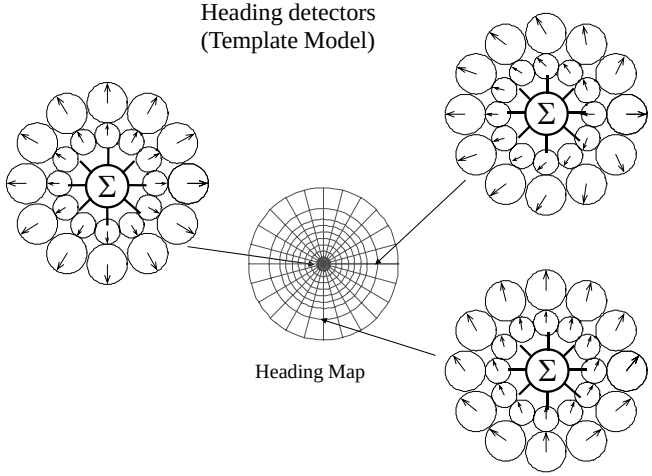
Detector tuned to (0º, 0º)
Heading = (-50º, 0º)

Leftward heading detector

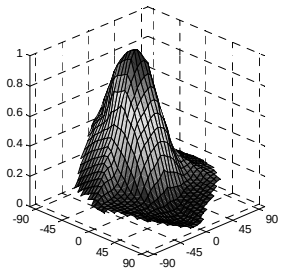


Detector tuned to (-50º, 0º)
Heading = (-50º, 0º)

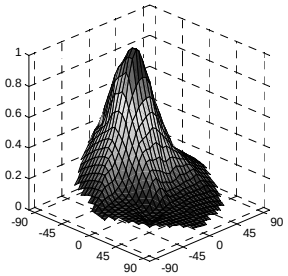
Heading detectors (Template Model)



Comparison of model and electrophysiological data



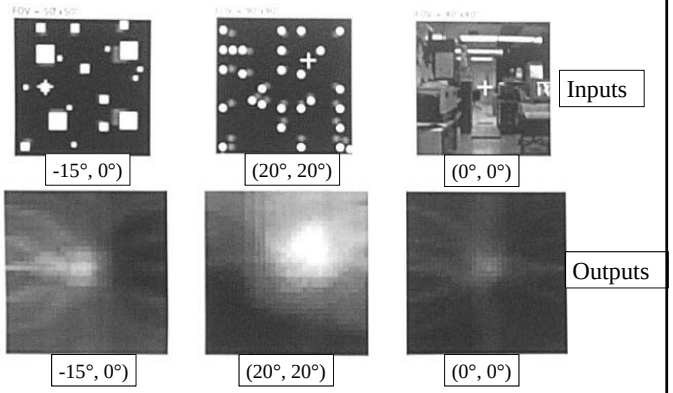
Template self-motion estimation model



MST data (rhesus monkey)

From: Perrone & Stone (1998). J. Neuroscience, 18.

Testing the template self-motion estimation model using image sequences:



Summary:

1. Motion perception *
2. Human visual navigation *

* Background information for answering questions such as:

What visual information do we use for steering?
How do we negotiate corners safely?
How do we judge how fast we are going?
Can we design cars that drive themselves?

Questions?