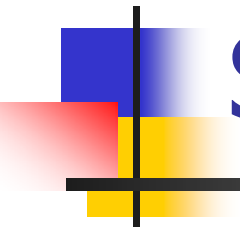


Sensors in the Natural World

Information Filters

- Sensory organs act as information filters.
  - Extract only part of the total information available
  - form a representation or physical encoding which facilitates the answers to some questions while making others impossible to answer
- Simple light sensors function like a set of goal-oriented detectors, e.g. frog eyes
  - are designed to detect motion not interpret static images.

Vision

- Vision is the process of converting sensory information into the knowledge of shape, identity or configuration of objects.
- Other sensors besides light sensors can also provide similar information:
  - bat sonar
  - pit viper heat detector
  - touch

Vision (more)

- Previous input and its interpretation and pre-wired processing can greatly affect current processing of sensory data.
- Seeing is the physical recording of the pattern of light energy received from the environment. It consists of:
  - selective gathering in of light
  - projection or focusing of light on a photoreceptive surface
  - conversion of light energy into a pattern of chemical or electrical activity

Costs and Benefits

- Sensing costs a system in terms of
  - energy,
  - organizational complexity and
  - the possibility of malfunction.
- The nature of useful information is related to organism needs and goals.
  - For example, plants only need information on light direction.
  - Their system compares the light energy received on differently oriented surfaces.

Receptors

- Sensitivity to environmental influences is a general characteristic of living cells.
- In addition to general sensitivity, most animals develop a range of specialized receptor cells, which often form parts of multi-cellular sense organs.
- Types of senses are called sensory modalities.

Sensory Modality Classifications

- 1.**Exteroceptors** - sensitive to external influences
- 2.**Interoceptors** - respond to internal factors
- 3.**Proprioceptors** - signal movements or positions of muscles, joints, etc.
- Classification can be based on the physical characteristic of the stimulus concerned, e.g. light, mechanical, chemical.
- **Phasic** receptors respond to changes in the environment.
- **Tonic** receptors relate to the absolute level of stimulation.
- Some receptors are a combination of phasic and tonic.
- Sensitivity to one modality can be exploited to provide information about another.

Sensory Modality Classifications (more)

- Receptors sensitive to gravity are called statocysts.
- These receptors function by using sensory cilia in a vesicle which contains one or more dense bodies to sense the position of these bodies.
- These organs can also sense acceleration.
- Note: insects lack these specialized organs and instead depend on the information from many sense organs associated with their joints to provide relevant information.

Specialists and Generalists

- Receptors which are specialists respond only to a restricted range of whatever they are sensing.
- For example, olfactory specialists have a restricted spectrum of response to odours with an acute sensitivity to only a single compound such as a pheromone.
- Generalist receptors respond to a wide variety of stimuli within the modality.
- But each generalist has its own pattern of sensitivity so a substance can be recognized by the unique combination of receptors activated.

Intensity Coding

- Information from sensors is usually not just ON or OFF, but also includes “how much".
- The range of stimulation intensity to which an organism is sensitive is often a controllable factor.
- Also different cells can operate across different parts of a wide range.

Sensory Processing Example

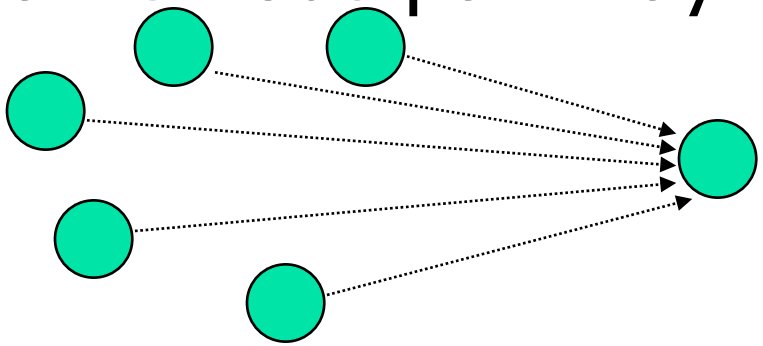
- In the locust, simple light sensing organs on the top of the head produce a poorly focused image.
- A massive amount of receptor information (about 1000 receptors) in each organ is funnelled through a small number of second-order neurons (25).
- During flight, the ocelli provide a rapid, overall assessment of the position of the horizon.

Another Example

- When a **male hoverfly** has a possible mate in its field of vision, it sets a course to intercept.
- To plot a course, need distance, velocity and course information of target
- probably not determined from observation.
- The fly “assumes" that the object in the visual field is
  - 1.the size of one of its own kind
  - 2.travelling at approximately the same velocity
- The size assumption leads to a determination of distance.
- The direction and speed at which the object moves across the visual field then indicates its course and the intercept can begin!

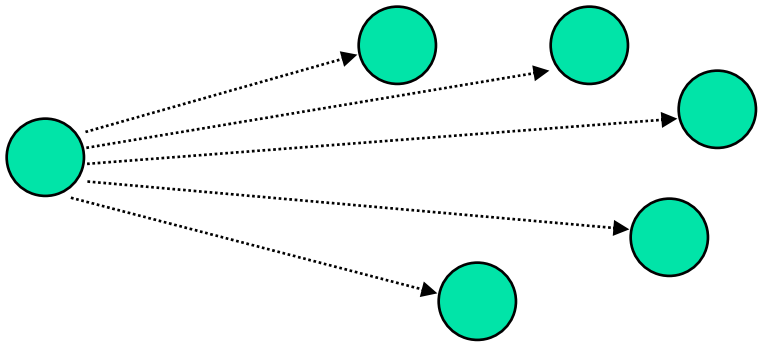
Convergence

- Convergence occurs when multiple sources of information are compressed into a much smaller domain.
- A sensory field is an array of receptors which provide sensory input to a cell or centre in a nervous pathway.



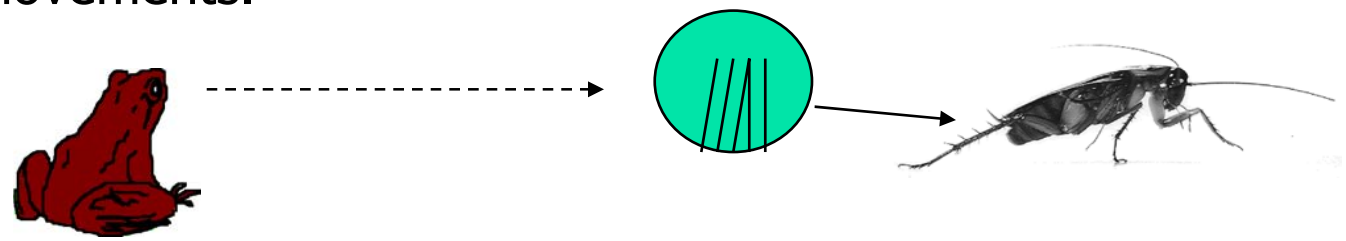
Divergence

- Divergence is the conveying of information from a single receptor cell, or group of cells, into the nervous system via multiple or parallel pathways.
- These pathways can be used to extract and segregate different types of information.
- Divergence also covers the concept of a system responding to a single sensory modality, but providing out to different centers and thus influencing different types of behaviour.



Labelled Lines

- This principle works on the premise that similar signals from different receptors are handled as if they were “labelled" by their origin.
- An example is the **escape response of the cockroach**.
- The lunging attack of a toad creates a current of air which is detected by sensory hairs on the *anal cerci* of the insect,
- The hairs are arranged in a number of columns which are sensitive to wind from different directions.
- The different columns form distinct combinations of connections with processing neurons so that the insect is aware of the location of the threat.
- The combinations of sensory input trigger appropriate movements.



The Photopine

- Sensors distributed over vehicle body
- As sensor touched a reflex response is immediate and determines area of contact.