Chapter 8

**MOVEMENT AND ACTION**

Motion is a change in position over time and motion detection may have evolved to help our ancestors perceiving incoming predators and fleeing prey. Today, motion detection is important among actions such as driving cars, crossing the street, and playing sports. We must be able to perceive the direction and speed of motion. Motion thresholds are a function of what part of the retinae are seeing the motion; motion thresholds are poor in the foveal regions but are better in the periphery. Real motion is the motion created by continual change in the position of an object, whereas apparent motion is the appearance of real motion from a sequence of still images. Motion detection begins in the retinae where some amacrine cells are sensitive to motion. Both the M pathway and P pathway in the optic nerve are also sensitive to motion detection. When the eyes are stationary, Reichardt detectors enable the determination of direction and speed of motion by delaying input from one receptive field (to determine speed) to match the input of another receptor field (to determine direction). The corollary discharge theory describes what happens when the viewer tracks motion across a scene, suggesting that feedback from eye muscles as the eyes track an object is important to motion perception. Evidence for this theory comes from the movement of afterimages. There are two types of eye movements, saccades (used to look from one object to another) and smooth-pursuit movements (used for tracking). The MT in the extrastriatal area of the occipital lobe seems to integrate signals across V1 to detect large scale motion (such as a walking dog).

Motion perception provides information about what object is being observed, as can be seen in the point-light walker display studies. An affordance is the information in the visual world that specifies how that information is used, e.g., seeing a guitar affords playing music. J.J. Gibson believed that the goal of perception is to afford action—the movement of the organism. Visually guided movements are regulated by the lateral intraparietal (LIP) area, the planning and control of reaching movements of the arms is regulated by the medial intraparietal (MIP) area, and the act of grasping is regulated by the anterior intraparietal (AIP) area.

Introduction

* The movement associated with earthquakes induces fear, indicating that perceiving motion is vital for humans.
* **Motion** is defined as the relative change in position over time.
* Motion detection may have evolved to help our ancestors perceive incoming predators and prey running away.
* Today, motion detection is important in driving cars, crossing the street, playing sports, and watching sports, to name a few actions.
* Our visual system must be able to perceive several features of motion.
  + If moving objects are approaching us or moving away from us.
  + Motion across the three dimensions.
  + Speed of moving objects.

How Do We Perceive Motion?

Perceiving Motion: Motion Thresholds— How Slow and How Fast?

* Some motion is so slow it cannot be perceived and other motion is so fast it cannot be perceived.
* Motion thresholds are a function of what parts of the retinae are seeing the motion.
  + The foveal regions have rather poor motion thresholds.
  + However, the periphery has better motion thresholds.
* To detect movement, an object must move at least 1 minute of 1o across the retina.
  + The absolute threshold for detection is a function of the speed of the moving object and its distance away.
* In general, fast motion can be detected though we may not be able to track it.
  + However, some objects move so fast (e.g, a bullet shot) that we cannot see them.

Real and Apparent Motion

* **Real motion** is the motion in the world created by continual change in the position of an object relative to the frame of reference.
* **Apparent motion** is the appearance of real motion from a sequence of still images.
  + This occurs whenever stimuli separated by time and location are actually perceived as a single stimulus moving from one location to another.
  + Apparent motion includes beta motion (optimal motion), in which an object is perceived as moving on the basis of what is actually a series of stationary images being presented sequentially.
    - Beta motion is similar to phi motion (the basis for motion pictures).
    - In beta motion, the images are in different locations but similar in appearance but in phi motion there are different images in a single location.
    - In both beta and phi motion, images are turned on and off quickly to induce the perception of motion.
* In motion perception, the **correspondence problem** refers to how the visual system knows whether an object seen at Time 1 is the same object at Time 2.
* **Induced motion** means that one moving object may cause another object to look like it is moving.
  + The classic example of induced motion is the movement of clouds at night, which may make it seem as if the moon is moving in the opposite direction.
* Areas of V1 that respond to apparent motion are the same as those responsive to real motion.

The Neuroscience of Vision and Motion

Motion Detection in the Retina

* Some types of amacrine cells in the retina are sensitive to motion.
* In the optic nerve, both the M pathway and the P pathway are sensitive to motion perception.

The Complexity of Motion

* The two primary elements of motion, direction and speed, must be coded at the neural level.
* **Reichardt detectors** are neural circuits that enable the determination of direction and speed of motion by delaying input from one receptive field, to determine speed, to match the input of another receptive field, to determine motion.
* V1 neurons seem to be tuned to specific directions and speeds of motion.
* Motion-sensitive neurons with longer delay times are sensitive to slower motion, whereas motion-sensitive neurons with shorter delay times are sensitive to faster motion.

Corollary Discharge Theory

* Reichardt detectors work well when the eyes are stationary, but not so well when the viewer tracks motion across a scene.
* The corollary discharge theory is an important concept in understanding how our visual systems detects and tracks motion.
* The **corollary discharge theory** states that the feedback obtained from eye muscles as the eyes track an object is important to the perception of motion.
* When an object is tracked, such as a Frisbee flying across the yard, a command signal must be sent from the brain to the muscles that control eye movements.
* The theory states that, in addition to the muscles of the eye, this signal will be sent to areas of the brain responsible for motion detection.
* This signal is known as the corollary discharge and it provides the brain with updated information about the locations and speeds of moving objects.
* Evidence for the corollary discharge theory comes from the movement of afterimages.
  + If you look directly at a bright light and then close your eyes, you will see an afterimage of that light.
  + When you move your eyes, the afterimage stays on the same spot on the retina but motion is sensed.
* Physiological evidence for this theory comes from the discovery of real motion neurons, which respond only to movements of objects but not movements of eyes.
* In sum, corollary discharge theory means that one of the cues in determining motion is the movement of our own eyes.

Eye Movements

* **Saccades** are the most common and rapid of eye movements.
  + They are used to look from one object to another.
  + During the 50ms it takes to make the eye movement, we essentially cannot see anything new. Vision is suppressed during the movement.
* **Smooth-pursuit movements** are the voluntary movements used to track moving objects.
  + Smooth-pursuit movements are only used when there is an actual moving object in the environment; in an environment without movement, we make saccades.

MT: The Movement Area of the Brain

* **MT** (aka **V5**) is an area of the occipital cortex critical to motion perception.
* Though it is within the extrastriatal areas of the occipital lobe, MT stands for “medial temporal” because it is adjacent to the medial temporal lobe.
* MT receives input from V1, V2, and the superior colliculus.
* MT is sensitive to both direction and speed of motion, but not other perceptual characteristics such as color and orientation.
* MT integrates motion-sensitive cells across V1 to detect large scale motion (such as a walking dog).
* Newsome and colleagues conducted several studies in the 1980s and 1990s on rhesus monkeys showing that MT is sensitive to larger scale motion.
* fMRI studies have confirmed the role in humans.
* MT is also active during visual imagery that involves motion.
* When MT is damaged, a condition known as **akinetopsia** may occur, in which a patient is unable to detect motion despite intact visual perception of stationary stimuli.
  + Patients with this disorder have perception that resembles a series of still photographs moving one to the next in a type of motion blindness.

Motion Aftereffects

* Also known as the “waterfall illusion,” motion aftereffects are an illusion that is commonly seen in everyday life.
* After watching the falling of water for about a minute, if we look at a blank surface such as a white wall, we get a sense of motion going upward.
* A **motion aftereffect** is an illusion in which a stationary object is seen as moving in the opposite direction of real or apparent motion just observed.
* The motion aftereffect suggests there might be motion an opponent system in the occipital cortex, similar to that of color vision.

Form Perception and Biological Motion

* Motion perception provides information about what object is being observed.
* A method to examine the phenomenon of recognizing a person by their gait is called the **point-light walker display**, in which small lights are attached to the body of a person or other animal, which is then filmed moving in an otherwise dark environment.
  + Small lights are placed on a person’s body, at all the major joints.
  + When participants are shown still photographs of the light patterns, no form information was extracted.
  + When participants viewed videos of the light patterns while the person with the lights was walking, running, or dancing, the participants were able to detect the human form and distinguish between the types of movement.
  + Thus, patterns of motion can allow us to see or infer the presence of form.
* In fMRI studies, the perception of *biological* (e.g., a person or animal walking) motion in point-light displays is associated with activity in the posterior superior temporal sulcus in the temporal lobe.

Action

* An **affordance** is the information in the visual world that specifies how that information can be used.
  + For example, seeing a guitar affords playing music.
* According to the prominent vision theorist J.J. Gibson, perception is about finding these affordances in the world.
  + Perception is about everyday life and how perception can be used to guide action.
  + The goal of perception is to afford action, i.e., movement of the organism.
* Affordances mean that perception is determined partially by meaning or function.
* One of Gibson’s primary contributions was to the understanding of **optic flow**, a motion depth cue that refers to the relative motions of objects as the observer moves forward or backward in a scene.
  + The **gradient of flow** refers to the difference in the perception of the speeds of objects moving pas us in an optic flow display.
  + The **focus of expansion** is the destination point in an optic flow display, from which point perceived motion derives.

Visually Guided Eye Movements

* The parietal lobe seems to have critical networks for integrating the muscle, somatosensory, and visual systems, allowing the smooth transition from visual perception to guided action.
* In the posterior parietal lobe, the **lateral intraparietal (LIP) area** is involved in the control of eye movements.

Visually Guided Grasping

* The **medial intraparietal (MIP) area** is involved in the planning and control of reaching movements of the arms.
* The **anterior intraparietal (AIP) area** is involved in the act of grasping.

***In Depth: Motion Illusions***

* Illusions can be thought of as glitches in the system because our visual system is not perfect.
* While viewing an illusion, we do not see what is actually there, and we do see what is not.
* Illusions can reveal how our perceptual systems work.

Illusion 1: Rotating Snakes

* The rotating snakes illusion creates an illusion of motion from a static display.
* If you look at any particular “snake,” that snake is stationary but the rest of the “snakes” are in motion.
* Micro-saccades—extremely small saccades—appear to explain this illusion. That is, we make small saccades along the figure, but do not notice them.

Illusion 2: Illusory Rotation

* This illusion is also called the “spoked wheel” illusion.
* When watching the pattern in the illusion, what looks like a bicycle wheel is seen.
* The spokes of the wheel are thin gray lines, which do not move or change in brightness.
* Apparent movement comes from the wedges between the spokes.
* Once the illusion is set in motion, people see both the clockwise motion of the wedges and what looks like counterclockwise motion of the spokes.
* The spoked wheel display likely arises from the interaction of edge contrasts that the visual system is tuned to perceive and the detection of motion in the apparent motion display.

Illusion 3: The Furrow Illusion

* When looking at this static image, a circle with an odd patter of gray and white inside it is seen. There are also small yellow circles along the top and bottom half of the circle.
* When the image is set in motion, the yellow circles move from left to right or right to left across the larger circle.
* The same image causes a different perception of motion depending on whether it is viewed with foveal or peripheral vision.