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MODELS OF OCULOMOTOR CONTROL

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THIS CHAPTER INCLUDES A REVIEW OF:

- Control system analysis

INTRODUCTION

Eye movements are accurate reflections of the brain's control strategy.

- The visual system can be considered from both a bioengineering and a non-engineering perspective.
- The bioengineering standpoint on the visual system does not always correspond with that of non-engineers due to their often-conflicting perspectives.
- Non-engineers can be overwhelmed by the complexity of the biomedical applications of the control theory.
- Combining these viewpoints and perspectives, however, has led to many great discoveries. Such discoveries include:
  - Diagnostic tools for clinical testing ranging from autorefractors and tonometers to automated visual field machines.
  - Guidelines for dysfunction in oculomotor systems
  - Clinically oriented research by visual scientists.

CONTROL SYSTEM ANALYSIS

This is a method used to analyse and explain ocular motility and specifically:

- Accommodation
- Vergence
- Saccades
- Pursuits
- Vestibulo Ocular Response (VOR) and Optokinetic nystagmus (OKN)

BLOCK DIAGRAM MODEL	**TERMS** **Input - Stimulus to drive the system** • Accommodation: Target distance in dioptres • Saccade: Target position (angle in degrees) • Pursuit: Target motion (deg/sec) • Vergence: Vergence stimulation due to disparity (prism dioptres) • VOR/OKN: Target velocity and head velocity (deg/sec) The blocks are the various components of control. The plant is the controlled physical component that results in the output. **Output - action of the extraocular and intraocular muscles** • Accommodation: change in focus • Saccade: change in angle of the eye (position) • Pursuit: change in velocity of the eye • Vergence: change in position of the eyes • VOR: change in velocity of the eyes
FEEDBACK CONTROL SYSTEMS	• Open Loop system: none of the output is fed back to the input • Closed Loop system: all or part of the output is fed back to the input which then alters the final output **Negative feedback** All or part of the output is subtracted from the input to give the error signal that drives the controller. This gives a more stable system. **Positive feedback** All or part of the output is added to the input to give the error signal, which results in instability.
DEAD SPACE	Dead space refers to that portion of the operating range of a control element over which there is no change in the output for a given input. Normally the input is greater than the threshold and a response occurs but in the dead zone, a change in stimulus is noted but is too small to warrant correction. For example, consider a saccadic movement that acts to hold a target within the foveal area. There will be no movement response if the stimulus stays within this area. Accommodation is responsible for the depth of focus that creates the dead zone.
GAIN	Gain refers to the ratio of the output magnitude to input magnitude where the response is equal to the stimulus. This is often very close to the value of 1 in oculomotor systems. In a perfect world it would be exactly 1. By not being exactly 1, it allows for a system to operate more efficiently; for example, accommodation can lag by depth of field. Saccadic movements can extend beyond the foveal area. Vergence can be someone inexact due to Panum's fusional area.