Systems Neuroscience CISC 3250

Motor control

Professor Daniel Leeds

dleeds@fordham.edu

JMH 328A

Classes of motion

Voluntary

Involuntary

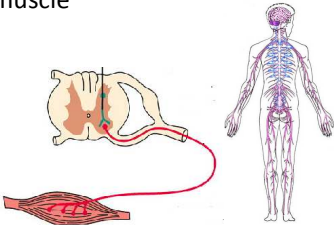|		
Somatic		Skeletal muscle
Autonomic	Sympathetic Fight of Flight	Smooth muscle
	Parasympathetic Resting state	Cardiac muscle

2

Pathways to motion in (typically) 2 synaptic steps

0 Command from primary motor cortex (M1)

1 Synapse onto neuron in spinal cord/cranial nerve

2 Synapse onto muscle

Efferent – motor message **out**
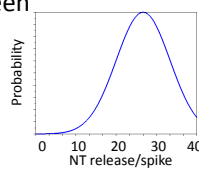
Afferent – perceptual message **in**

3

Precise motion in an imprecise world

Imprecise neurons

- Efferent signal for motion will present variable number of NT molecules per spike
- Number of spikes may vary between movement repetitions
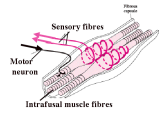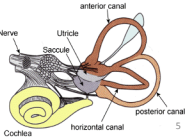
Unreliable world

- Wind blows while you pick up a bag
- You trip on unseen object while walking

Probability / NT release/spike
0 10 20 30 40

4

Monitoring body motion

- Seeing body move (covered in earlier lecture)
- Skin stretch (covered in earlier lecture)
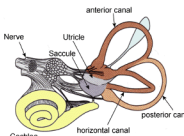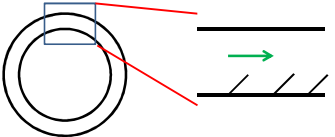- Muscle stretch/contraction – muscle spindles

Sensory fibres
Motor neuron
Intrafusal muscle fibres

- Head rotations – inner ear; semi-circular canals

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Vestibular system

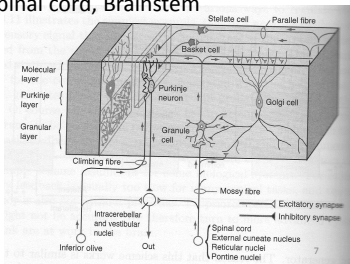Three canals on left and right side of head: anterior, posterior, horizontal

1. Head rotates
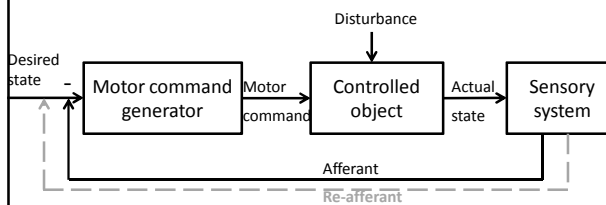2. Fluid flows
3. Hairs displaced

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Adjusting motion with the cerebellum

- Compare motor commands to actual motion
- Cerebellar inputs:
  - Climbing fiber from Inferior Olive (brainstem)
  - Mossy fiber from Spinal cord, Brainstem
- Cerebellar outputs:
  - Purkinje cells – inhibition to brainstem
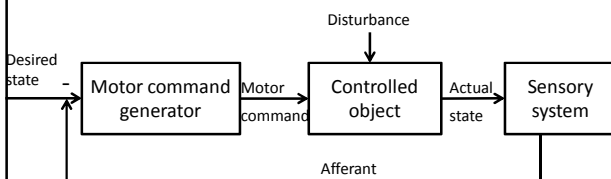

Control theory

Correcting errors in motion

Afferant – muscle sensors

Re-afferant – visual sensors

Motor command generation

swing leg forward -> rotate leg using muscle force

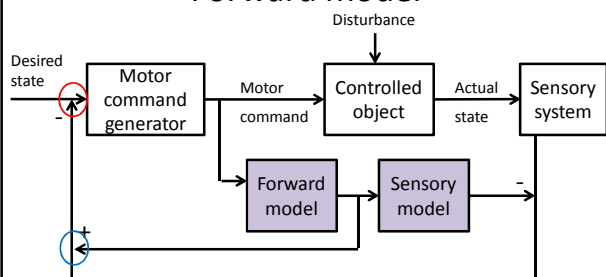

Expanded control theory

Challenge: Waiting for afferent feedback is slow

Solutions:
- Anticipate the problem – **forward model**
- Correct for the problem from the beginning – **inverse model**

Forward model

- Adjust motion based on predicted position
- Adjust predicted error based on actual position
- Adjust models (over longer experience)