

ECE 2695: Adaptive Control (3 Credits, Fall 2008)

## Lecture 12: Introduction to Learning in Neural Systems

November 24, 2008

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### Outline

- Review of last lecture
- Learning and memory
- Feedback-error learning in the cerebellum
- Research presentation
  - A logic machine model of the basal ganglia (based on the work by Massaquoi and Mao)

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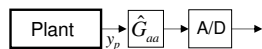
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### Review of last lecture

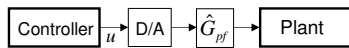
- Sampling and pre- and postfiltering
  - How to choose sampling rate?

$$\omega_0 h \approx ? \sim ?$$

- Why do we need prefiltering?



- Why do we need postfiltering?



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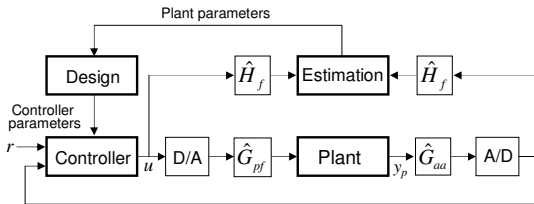
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### Review of last lecture

- Sampling and pre- and postfiltering
- Estimator implementation
  - Model structure
  - Data filters and excitation



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### Review of last lecture

- Sampling and pre- and postfiltering
- Estimator implementation
  - Model structure
  - Data filters and excitation
  - Parameter tracking

Question: Why is it necessary to discount old data?

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### Review of last lecture

- Sampling and pre- and postfiltering
- Estimator implementation
- Interaction between estimation and control
  - Computational delay
  - Integral action
  - Compatibility between identification and control

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## Learning and memory

- Definition
  - Learning is the process by which we acquire knowledge about the world, while memory is the process by which that knowledge is encoded, stored, and later retrieved
  - In humans the most important mechanisms by which the environment alters behavior are learning and memory

Question: Is learning always beneficial?

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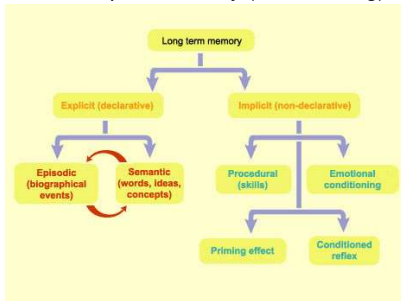
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## Learning and memory

- Definition
- Explicit and implicit memory (and learning)



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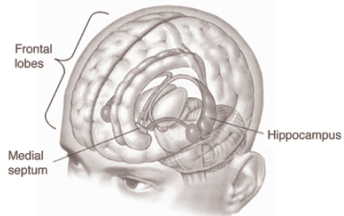
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## Learning and memory

- Definition
- Explicit and implicit memory (and learning)
  - The distinction between explicit and implicit memory was first revealed with lesions of the limbic association areas of the temporal lobe



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## Learning and memory

- Definition
- **Explicit and implicit memory (and learning)**
  - The distinction between explicit and implicit memory was first revealed with lesions of the limbic association areas of the temporal lobe
  - **Explicit memory is stored in association cortices**
    - Semantic (factual) knowledge is stored in a distributed fashion in the neocortex
    - Episodic (autobiographical) knowledge about time and place seems to be involve the prefrontal cortex
    - Explicit knowledge involves at least four distinct processes: encoding, consolidation, storage, and retrieval

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## Learning and memory

- Definition
- **Explicit and implicit memory (and learning)**
  - The distinction between explicit and implicit memory was first revealed with lesions of the limbic association areas of the temporal lobe
  - Explicit memory is stored in association cortices
  - **Implicit memory is stored in perceptual, motor, and emotional circuits**
    - Implicit memory can be nonassociative or associative
    - Certain forms of implicit memory involve the amygdala, cerebellum, and basal ganglia

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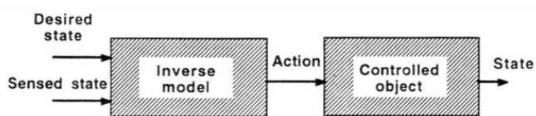
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## Feedback-error learning in the cerebellum

- **Internal models**
  - Inverse model and forward model



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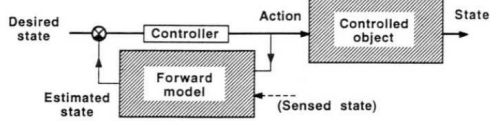
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### Feedback-error learning in the cerebellum

- Internal models
  - Inverse model and forward model



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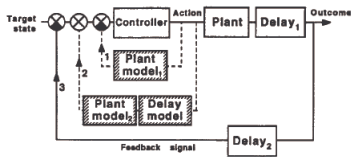
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### Feedback-error learning in the cerebellum

- Internal models
  - Inverse model and forward model
  - Smith predictor model of the cerebellum



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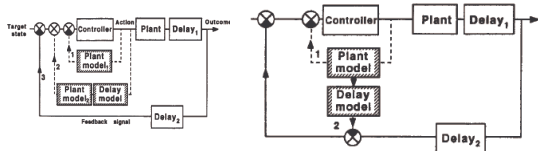
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### Feedback-error learning in the cerebellum

- Internal models
  - Inverse model and forward model
  - Smith predictor model of the cerebellum



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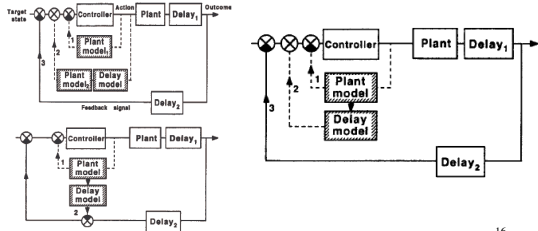
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## Feedback-error learning in the cerebellum

- Internal models
  - Inverse model and forward model
  - Smith predictor model of the cerebellum



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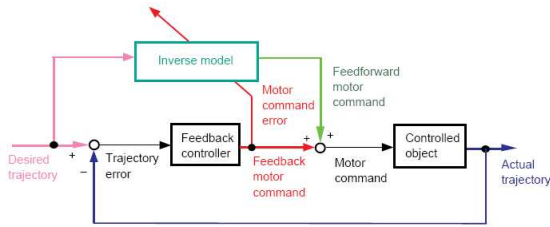
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## Feedback-error learning in the cerebellum

- Internal models
- Feedback-error learning



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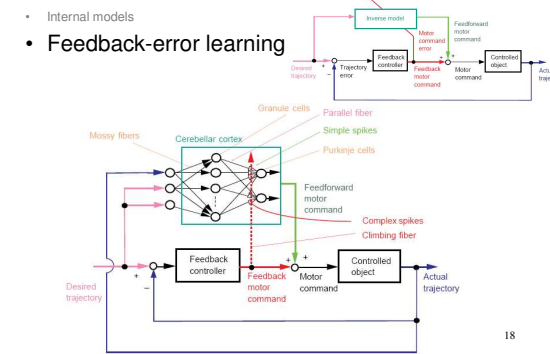
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## Feedback-error learning in the cerebellum

- Internal models
- Feedback-error learning



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Research presentation:  
a logic machine model of the basal  
ganglia (see Part II of Lecture 12)

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### References

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- E. R. Kandel, J. H. Schwartz, and T. M. Jessell, Principles of Neural Science, 4th Edition, McGraw-Hill, 2000.
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