

# What is Learning?

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- Herbert Simon: “Learning is any process by which a system improves performance from experience.”
- What is the task?
  - Classification
  - Problem solving / planning / control

# Classification

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- Assign object/event to one of a given finite set of categories.
  - Medical diagnosis
  - Credit card applications or transactions
  - Fraud detection in e-commerce
  - Worm detection in network packets
  - Spam filtering in email
  - Recommended articles in a newspaper
  - Recommended books, movies, music, or jokes
  - Financial investments
  - DNA sequences
  - Spoken words
  - Handwritten letters
  - Astronomical images

# Problem Solving / Planning / Control

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- Performing actions in an environment in order to achieve a goal.
  - Solving calculus problems
  - Playing checkers, chess, or backgammon
  - Balancing a pole
  - Driving a car or a jeep
  - Flying a plane, helicopter, or rocket
  - Controlling an elevator
  - Controlling a character in a video game
  - Controlling a mobile robot

# Measuring Performance

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- Classification Accuracy
- Solution correctness
- Solution quality (length, efficiency)
- Speed of performance

# Why Study Machine Learning?

## Engineering Better Computing Systems

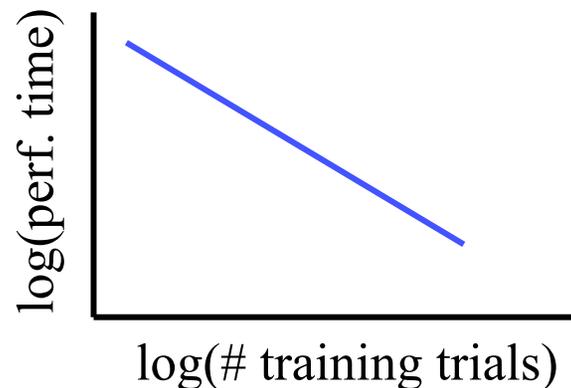
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- Develop systems that are too difficult/expensive to construct manually because they require specific detailed skills or knowledge tuned to a specific task (*knowledge engineering bottleneck*).
- Develop systems that can automatically adapt and customize themselves to individual users.
  - Personalized news or mail filter
  - Personalized tutoring
- Discover new knowledge from large databases (*data mining*).
  - Market basket analysis (e.g. diapers and beer)
  - Medical text mining (e.g. migraines to calcium channel blockers to magnesium)

# Why Study Machine Learning? Cognitive Science

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- Computational studies of learning may help us understand learning in humans and other biological organisms.
  - Hebbian neural learning
    - “Neurons that fire together, wire together.”
  - Human’s relative difficulty of learning disjunctive concepts vs. conjunctive ones.
  - Power law of practice



# Why Study Machine Learning?

## The Time is Ripe

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- Many basic effective and efficient algorithms available.
- Large amounts of on-line data available.
- Large amounts of computational resources available.

# Related Disciplines

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- Artificial Intelligence
- Data Mining
- Probability and Statistics
- Information theory
- Numerical optimization
- Computational complexity theory
- Control theory (adaptive)
- Psychology (developmental, cognitive)
- Neurobiology
- Linguistics
- Philosophy

# Defining the Learning Task

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Improve on task, T, with respect to performance metric, P, based on experience, E.

T: Playing checkers

P: Percentage of games won against an arbitrary opponent

E: Playing practice games against itself

T: Recognizing hand-written words

P: Percentage of words correctly classified

E: Database of human-labeled images of handwritten words

T: Driving on four-lane highways using vision sensors

P: Average distance traveled before a human-judged error

E: A sequence of images and steering commands recorded while observing a human driver.

T: Categorize email messages as spam or legitimate.

P: Percentage of email messages correctly classified.

E: Database of emails, some with human-given labels

# Designing a Learning System

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- Choose the training experience
- Choose exactly what is to be learned, i.e. the *target function*.
- Choose how to represent the target function.
- Choose a learning algorithm to infer the target function from the experience.

