

Lecture 15:

Supervised learning

Artificial Intelligence

CS-GY-6613

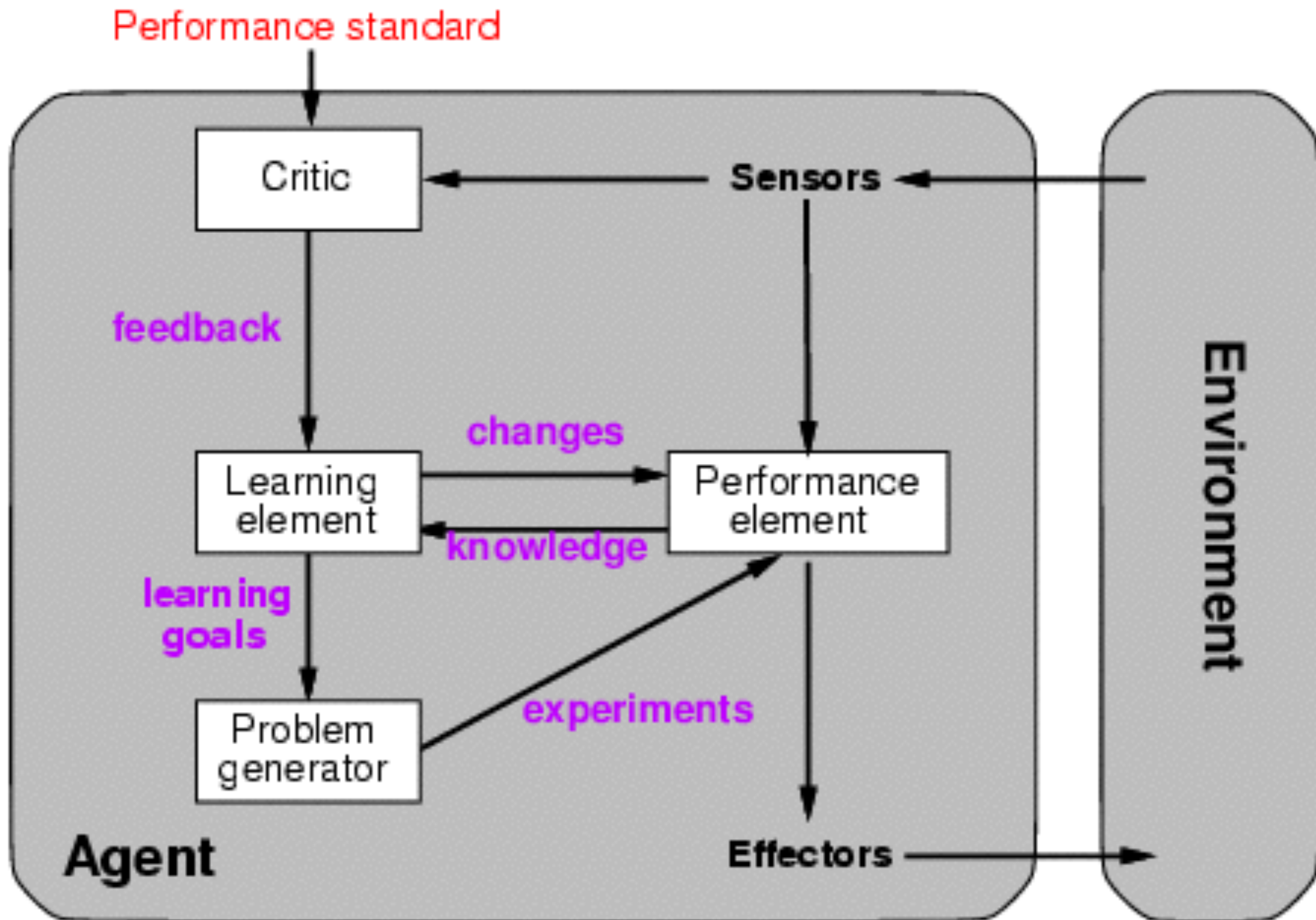
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Why learning?

- So far in the course: we have specified the mechanism by which the agent should decide how to act
- So far in the course: the world is mostly known
- The agent might not know what the world is like, or what policies work well in the world
- The world may change
- You don't want to do all the programming

A (complex) learning agent



What could be learned?



What could be learned?

- How to drive from point A to point B, without hitting pedestrians
- What a human (or a cat, or bush) looks like
- Hand gestures
- How to drive in the style of a particular human (or according to that human's preferences)
- Which routes from A to B are actually fastest
- How far back you want your seat, temperature for the AC, favorite radio channel...
- Estimating distances

What could be learned?

The screenshot shows the Google Translate web interface. At the top, the Google logo is on the left, and the user's name 'Julian' with a profile picture is on the right. Below the logo, the word 'Translate' is in red. To the right of 'Translate' are a red 'G+' icon and a star icon. The main interface has two language selection bars. The left bar shows 'English', 'Armenian', 'Italian', and 'English - detected' with a dropdown arrow. The right bar shows 'English', 'Swedish', and 'Italian' with a dropdown arrow. A blue 'Translate' button is to the right of the right bar. Below the language bars, there are two text boxes. The left box contains the text 'machine translation' and has a close button (X) in the top right corner. Below this box are icons for a speaker and a pencil. The right box contains the Swedish translation 'maskinöversättning'. Below this box are icons for a star, a document, a speaker, and a share icon, followed by a 'Wrong?' link with a pencil icon. Below the text boxes, the section 'Definitions of machine translation' is shown. It includes the word 'noun' and the definition: 'translation carried out by a computer. "When you put speech recognition together with machine translation , you get terrible results."' Below the definition, the text 'See also' is followed by 'machine, translation'. At the bottom, there is a large, light gray downward-pointing chevron.

Google

Julian

Translate

G+

English Armenian Italian English - detected

English Swedish Italian

Translate

machine translation

maskinöversättning

Definitions of machine translation

noun

translation carried out by a computer.
"When you put speech recognition together with machine translation , you get terrible results."

See also

machine, translation

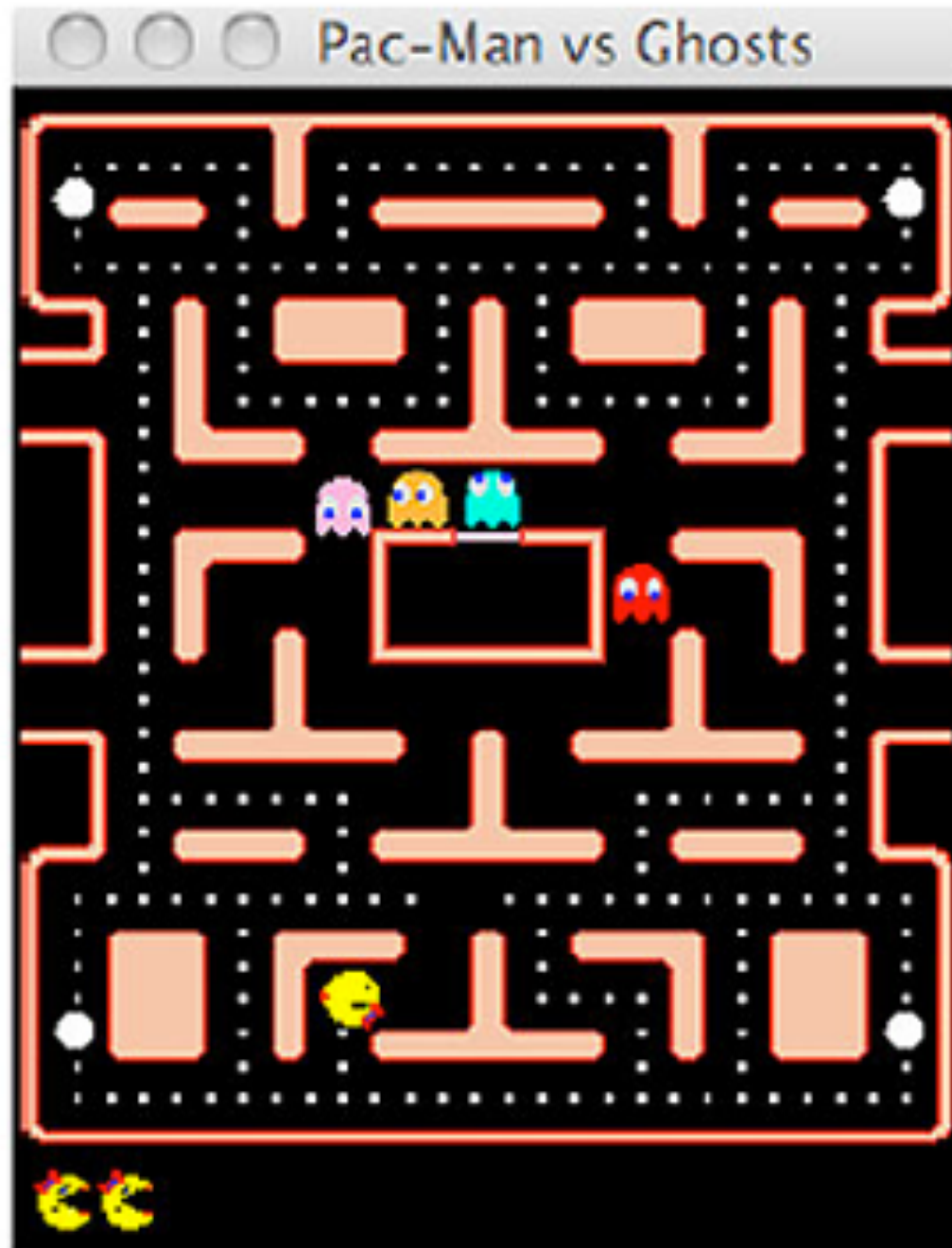
What could be learned?



What could be learned?

- How much a board position is worth
- What action to take in a specific situation
- What action a particular person would take in a specific situation
- Who is likely to win a game between two people, and how long it takes

What could be learned?



What could be learned?

- What actions a ghost would take
- The value of a state
- Dangerous positions
- What action to take in a specific situation

Types of learning

- **Supervised learning**

Learning to predict or classify labels based on labeled input data

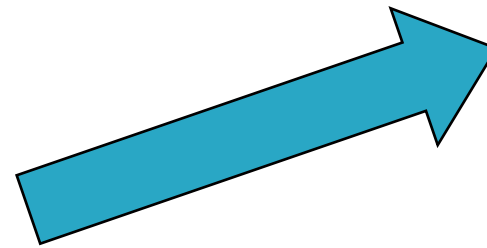
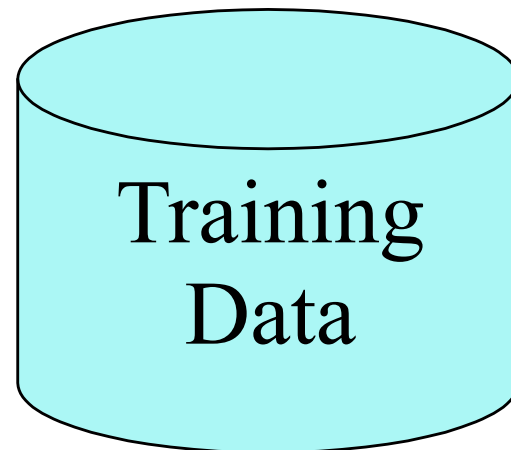
- **Unsupervised learning**

Finding patterns in unlabeled data

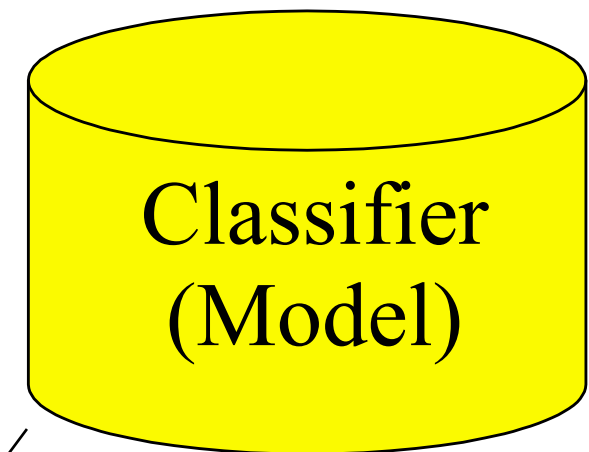
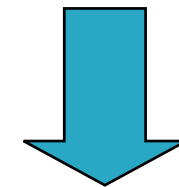
- **Reinforcement learning**

Learning well-performing behavior from state observations and rewards

Model construction



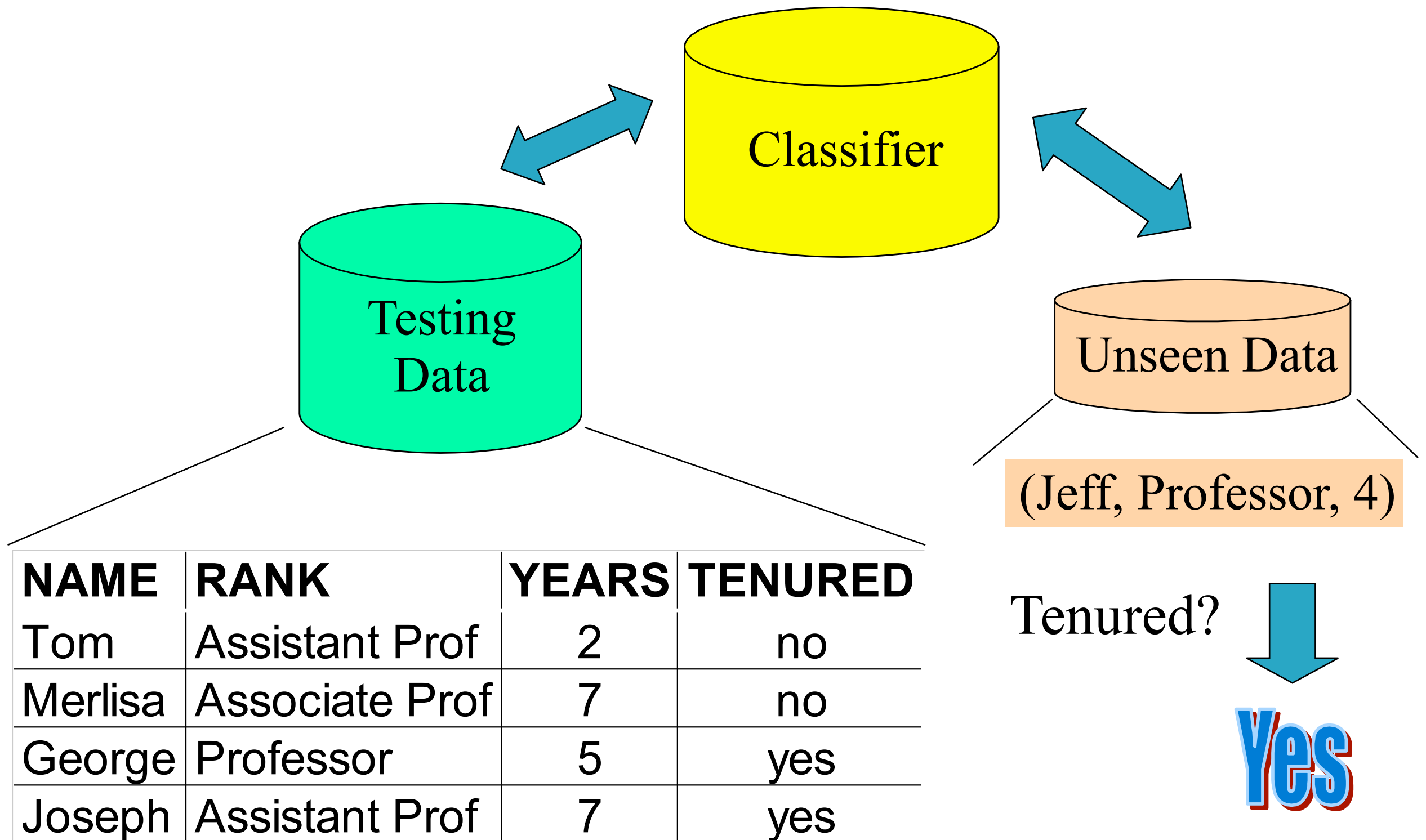
Classification
Algorithms



NAME	RANK	YEARS	TENURED
Mike	Assistant Prof	3	no
Mary	Assistant Prof	7	yes
Bill	Professor	2	yes
Jim	Associate Prof	7	yes
Dave	Assistant Prof	6	no
Anne	Associate Prof	3	no

IF rank = 'professor'
OR years > 6
THEN tenured = 'yes'

Using the model



Classification vs prediction

- Classification: binary or nominal labels
 - Examples: pregnant or not, from which country, which type of road sign
- Prediction: continuous labels
 - Examples: future stock price, life expectancy, distance to obstacle

Terminology (supervised learning)

- Each line of data: instance / data point / tuple
- The features of each instance: features / attributes
- That which should be learned: labels / targets
- Each instance has features and a label
- We train on the training set...
- ...and test on the testing set

What's desirable?

- Accuracy
classifier accuracy: predicting class label
predictor accuracy: guessing value of predicted attributes
- Speed
time to construct the model (training time)
time to use the model (classification/prediction time)
- Robustness: handling noise and missing values
- Interpretability
- Other measures, e.g., goodness of rules, such as decision tree size or compactness of classification rules

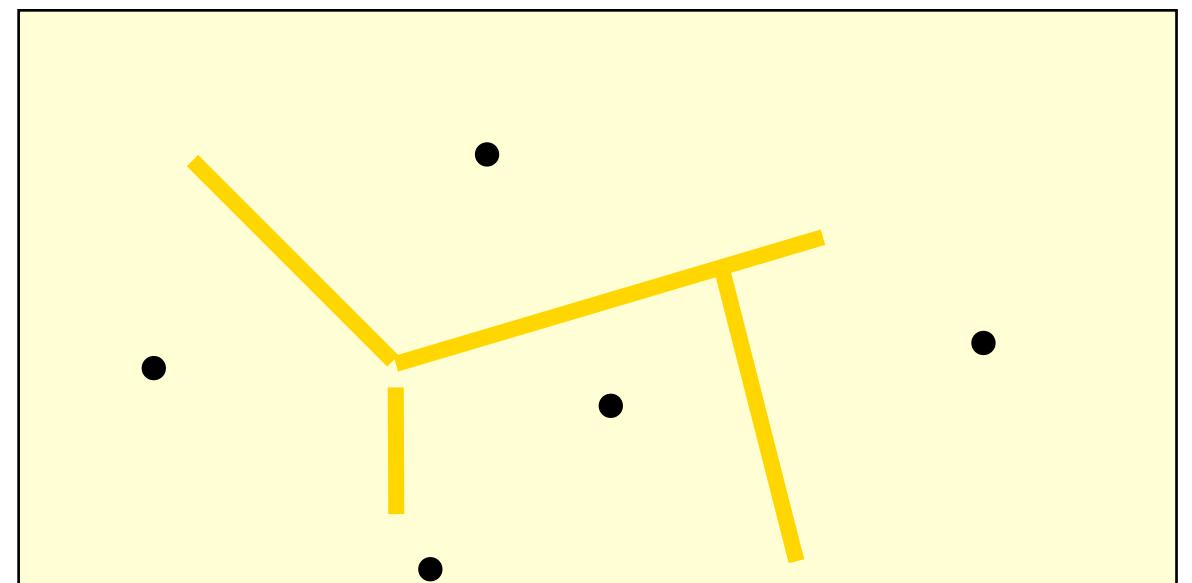
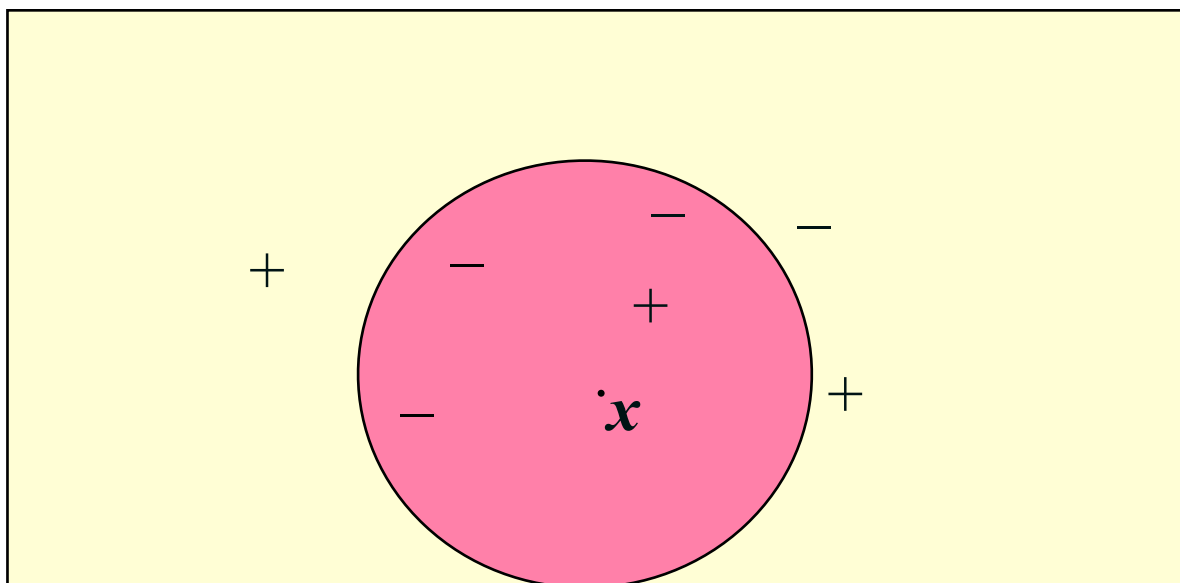
Lazy vs Eager learning

- Lazy learning: Simply stores training data (or only minor processing) and waits until it is given a test tuple
- Eager learning: Given a training set, constructs a classification model (smaller than the data) before receiving new data to classify
- Lazy: less time in training but more time in predicting

What's the simplest
imaginable working
classifier?

k-Nearest Neighbor Classification

- Simply look at the k instances in the training data which are closest to the instance you want to classify
- Choose the median/mean/mode of those values



k-Nearest Neighbor Classification

- All instances correspond to points in the n-D space
- The nearest neighbor is defined in terms of Euclidean distance, $\text{dist}(X_1, X_2)$
- Target function could be discrete- or real-valued
- For discrete-valued, k-NN returns the most common value among the k training examples nearest to x_q
- Voronoi diagram: the decision surface induced by 1-NN for a typical set of training examples

k-Nearest Neighbor Classification

- Distance-weighted nearest neighbor algorithm:
Weigh the contribution of each of the k neighbors according to their distance to the query x_q , and give greater weight to closer neighbors $w \equiv \frac{1}{d(x_q, x_i)^2}$
- Robust to noisy data by averaging k -nearest neighbors
- *Curse of dimensionality*: distance between neighbors could be dominated by irrelevant attributes
- To overcome it, stretch or shrink axes or eliminate the least relevant attributes

Distances

- Euclidean distance for continuous attributes

$$d(i, j) = \sqrt{(|x_{i_1} - x_{j_1}|^2 + |x_{i_2} - x_{j_2}|^2 + \dots + |x_{i_p} - x_{j_p}|^2)}$$

- Hamming distance for binary/nominal attributes:
how many of the attributes differ