Learning Agent

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References

- S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach, 2nd/3rd edition, International Edition
- Pattern Classification, Second Edition: 1 (A Wiley-Interscience publication) by Richard O. Duda, Peter E. Hart and David G. Stork
- T. Mitchell, 1999, Machine Learning

Overview

- Review
- Learning Agent
  - Why (KA bottleneck), what, how (task,feedback, rep)
- Supervised Learning
  - Target function, hypothesis, inductive learning, $\boldsymbol{h \approx f}$
  - Classification, regression, unseen data
  - Features, decision boundary
  - Application
- Data mining

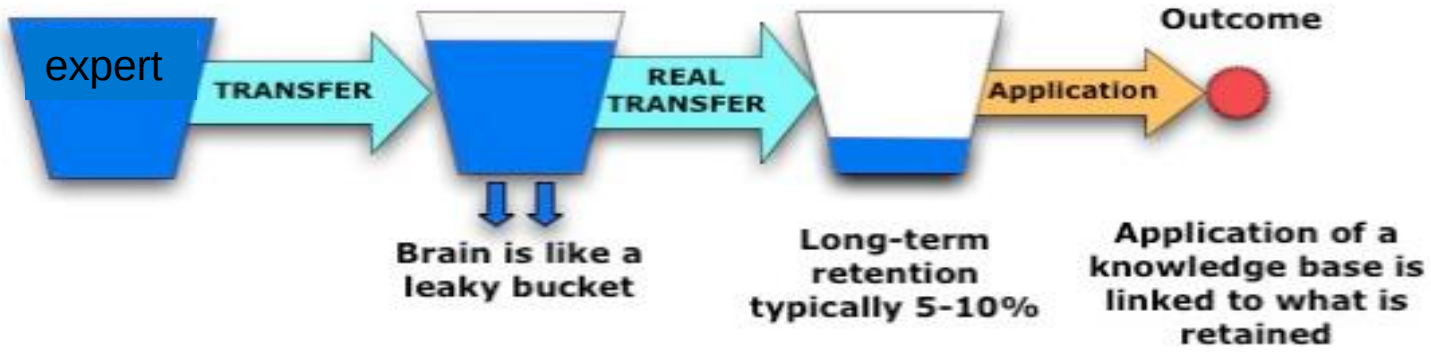
Review

Percepts used to get solution (acting)

- Problem Solving Agent
  - Design: formulate problem → search solution → execute
  - Agents know world dynamics, states are finite, deterministic, utility for a sequence of states is sum over path
- Knowledge-based Agent
  - Agents know world dynamics, states are infinite, deterministic
  - Design: knowledge base + inference engine
  - Manual knowledge acquisition (for knowledge base): elicitation + representation

Knowledge Acquisition Bottleneck

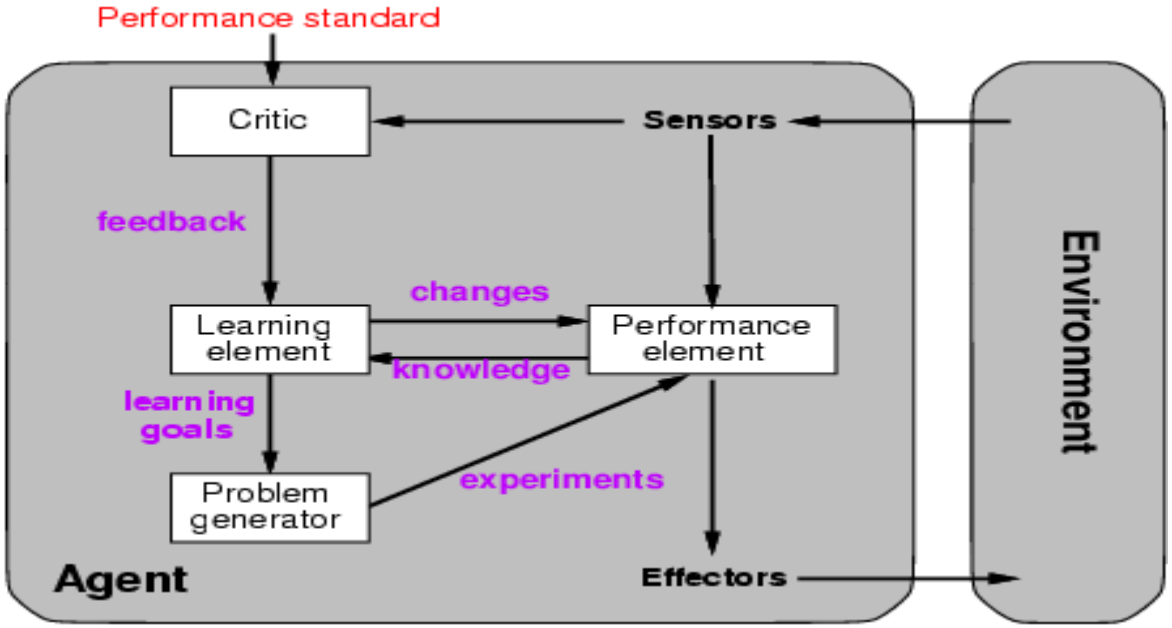
- Knowledge elicitation:
  - slow speed
  - Inability of expert to express the knowledge they posses
- Knowledge representation: knowledge mismatch
  - Perbedaan struktur pengetahuan pakar dan struktur pengetahuan program



http://www.profoundlearning.com/Content/EducationSolutions/educationKnowledgeTransfer.html

Learning Agent

- Learning from observations
- Percepts also used for improving the agent's ability to act in the future



- Performance element: selecting external actions (general agent)
- Learning element: making improvements
- Critic: how well the agent is doing
- Problem Generator: suggest the exploratory actions

Why Learning?

- Learning is essential for unknown environments,
  - i.e., when designer lacks omniscience, agent doesn't know world dynamics
- Learning is useful as a system construction method,
  - i.e., expose the agent to reality rather than trying to write it down
- Learning modifies the agent's decision mechanisms to improve performance

Learning from observations

- Learning: **changes** in the system that are **adaptive** in the sense that they enable the system to do the task or tasks drawn from the same population **more efficiently** and **more effectively** the next time.
  - Kemampuan yang penting agar dapat beroperasi pada lingkungan yang tidak diketahui → **lazy designers**
  - Berguna sebagai metode pembangunan sistem
  - Mengubah mekanisme pengambilan keputusan untuk memperbaiki performansi

Design of A Learning Element

- Which components of the performance element are to be learned
  - Type of performance element: reflex agent, logical agent, knowledge-based agent, …
  - Component to be learned → learning goal
- What feedback is available to learn these components → supervised, unsupervised, reinforcement
- What representation is used for the components → learning algorithm
- Availability of prior knowledge

Taxi Driver Agent & Feedback

http://www.gettyimages.com/detail/83988175/Stone

http://www.stahle.com/

- Good/bad traffic day recognition
  - Develop own concepts
  - No feedback
- Brake decision: mapping condition-action rule
  - f: states → boolean (brake or not)
  - Feedback: instructor shouts
- Buses recognition: Infer the world from percepts
  - f: images → boolean
  - Feedback: labeling bus images
- Desirable/undesirable behavior recognition from tip indication
  - Feedback: tip from customer at the end of journey

Learning Type based on Feedback

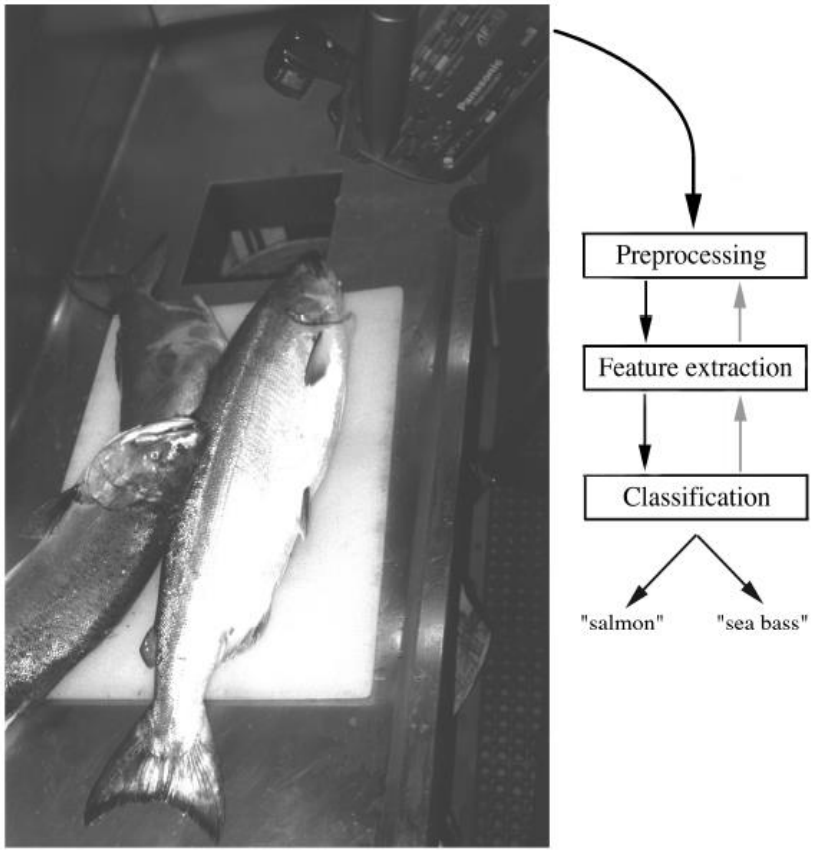
- Unsupervised learning (no feedback):
  - Diberikan: set of example, no labeling
  - Kelompokkan example ke "natural" clusters
  - Contoh: good/bad traffic day recognition
- Supervised learning :
  - Diberikan: set of example, correct answers for each example (example label) → I/O pairs
  - Prediksi output dari input baru dengan menggunakan fungsi hasil learning yang memetakan input ke output
  - Contoh: brake decision, bus recognition
- Reinforcement learning:
  - Agen: observasi → action {rewarded/punished}
  - Pilih aksi dgn memaksimalkan reward
  - Contoh: behavior recognition by tip indication

Supervised Learning

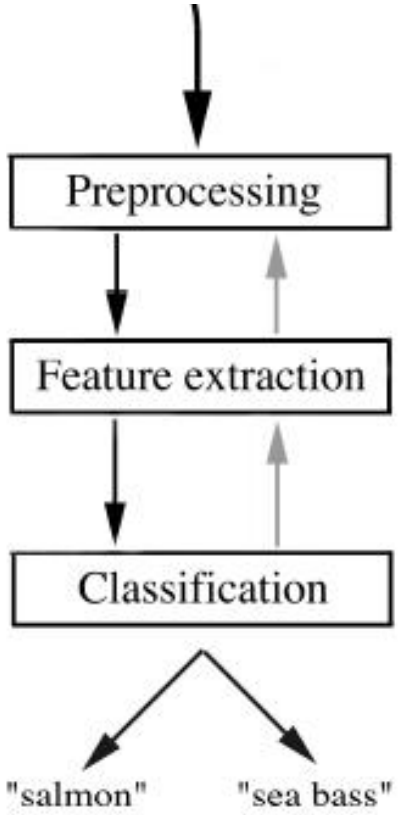
Fish Packing Plant

- Input:
  - Sea Bass:
  - Salmon

- Goal: automate sorting incoming fish on conveyor belt



Agent Pemisah Ikan



- Comp. of PE: fish classification
- Feedback: labeling fish
- Klasifikasi: model klasifikasi
  - Hasil supervised learning

Supervised Learning

- Learn a function from training data
- Input: training-set <data, label> → <x,y>
- Function of target learning: f: x→ y
- Problem: find a hypothesis *h* s.t *h* ≈ *f*
- Learning a (possibly incorrect) general function or rule from specific input-output pairs is called inductive learning
  - Not analytical or deductive learning

Supervised Learning (2)

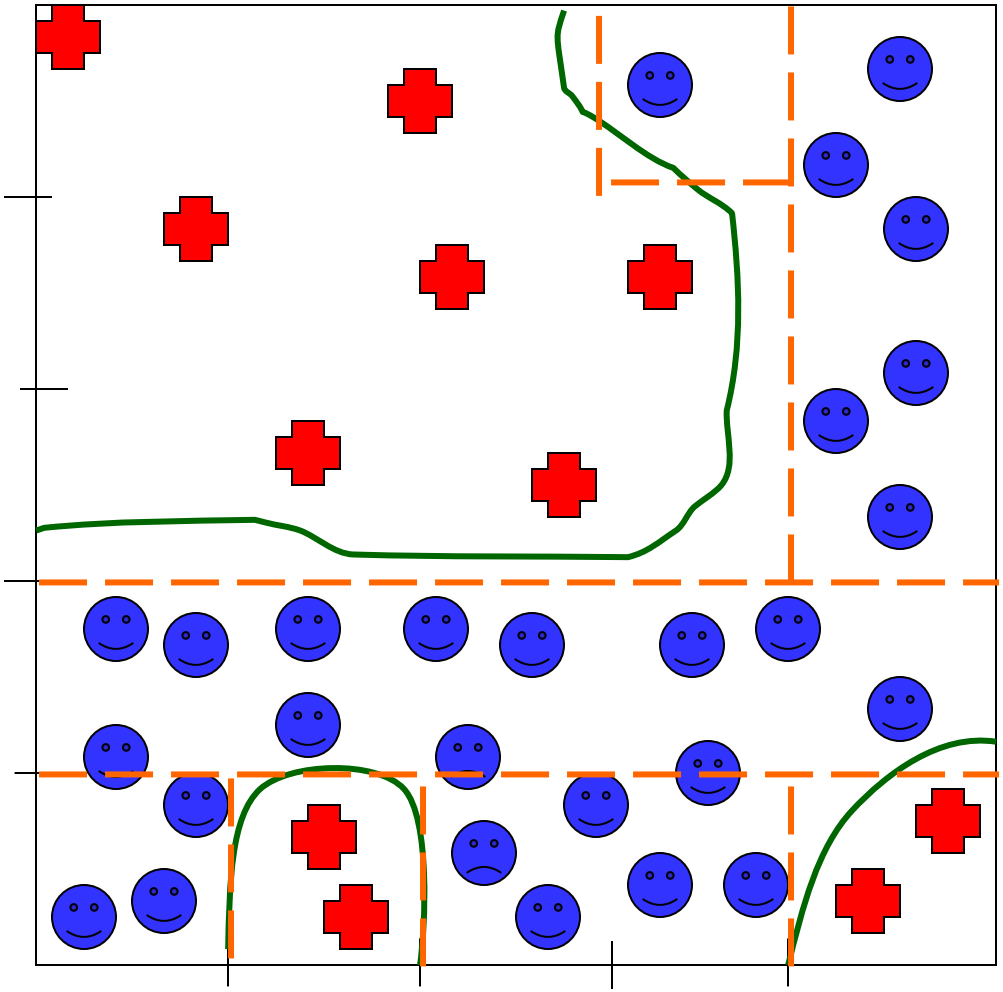
- Process: inductive learning
- Learning output: h (class description)
  - f: x → y
  - Function f can be stochastic: P(Y|x)
- Learning problem:
  - Classification: domain (y) is a finite set of values (boolean, classes)
  - Regression: domain (y) is number (temperature, stock prices)
- Usage: classify unseen data based on class description

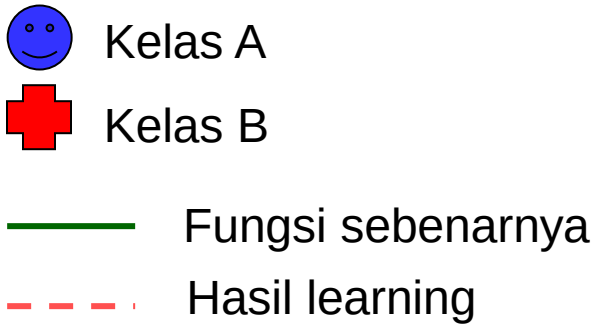
Data Set (Examples)

- Attribute-based representations
- Examples described by attribute values

Case	Age	Prescription	Astigmatism	Tear Production	Lens
1	young	myope	not astigmatic	reduced	none
2	young	myope	not astigmatic	normal	soft
3	young	myope	astigmatic	reduced	none
4	young	myope	astigmatic	normal	hard
5	young	hypermetrope	not astigmatic	reduced	none
6	young	hypermetrope	not astigmatic	normal	soft
7	young	hypermetrope	astigmatic	reduced	none
8	young	hypermetrope	astigmatic	normal	hard
9	pre-presbyopic	myope	not astigmatic	reduced	none
10	pre-presbyopic	myope	not astigmatic	normal	soft
11	pre-presbyopic	myope	astigmatic	reduced	none
12	pre-presbyopic	myope	astigmatic	normal	hard
13	pre-presbyopic	hypermetrope	not astigmatic	reduced	none
14	pre-presbyopic	hypermetrope	not astigmatic	normal	soft
15	pre-presbyopic	hypermetrope	astigmatic	reduced	none
16	pre-presbyopic	hypermetrope	astigmatic	normal	none
17	presbyopic	myope	not astigmatic	reduced	none
18	presbyopic	myope	not astigmatic	normal	none
19	presbyopic	myope	astigmatic	reduced	none
20	presbyopic	myope	astigmatic	normal	hard
21	presbyopic	hypermetrope	not astigmatic	reduced	none
22	presbyopic	hypermetrope	not astigmatic	normal	soft
23	presbyopic	hypermetrope	astigmatic	reduced	none
24	presbyopic	hypermetrope	astigmatic	normal	none

Teknik DM: Machine Learning

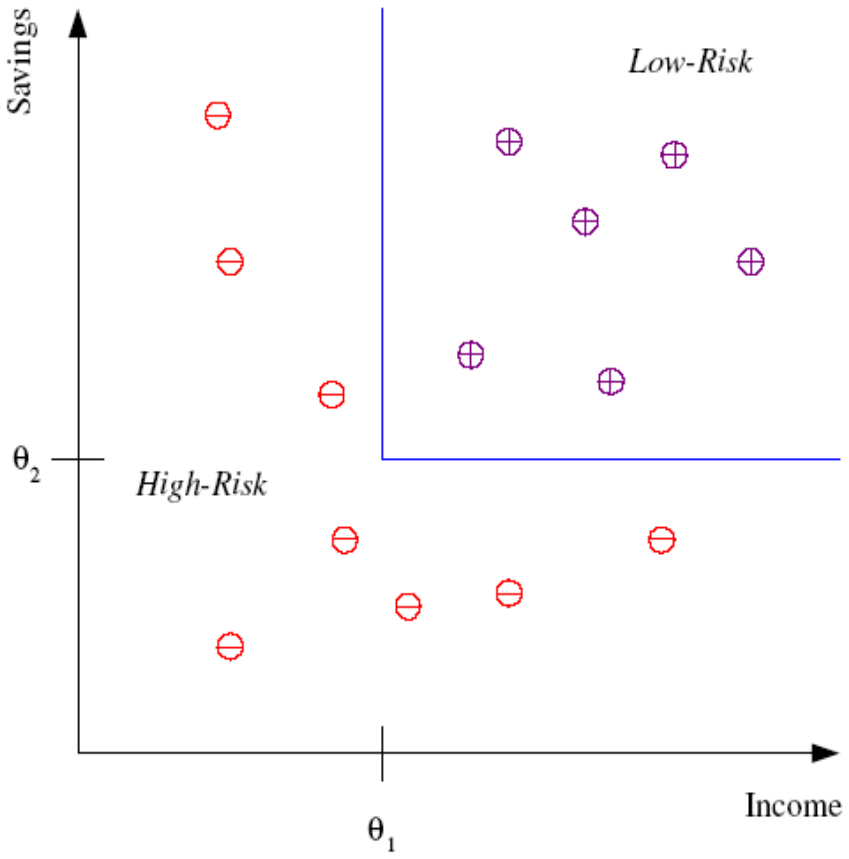




Learning: mencari pola
Pola: pendekatan fungsi

Credit Scoring

- Differentiating between low-risk and high-risk customers from their *income* and *savings*



Discriminant: IF *income* > θ_1 AND *savings* > θ_2

THEN low-risk ELSE high-risk

Knowledge-based Inductive Learning

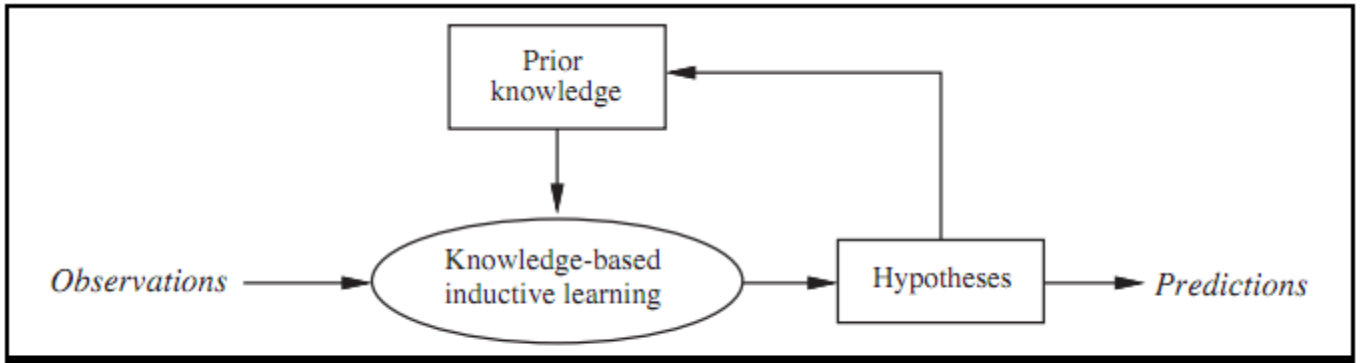


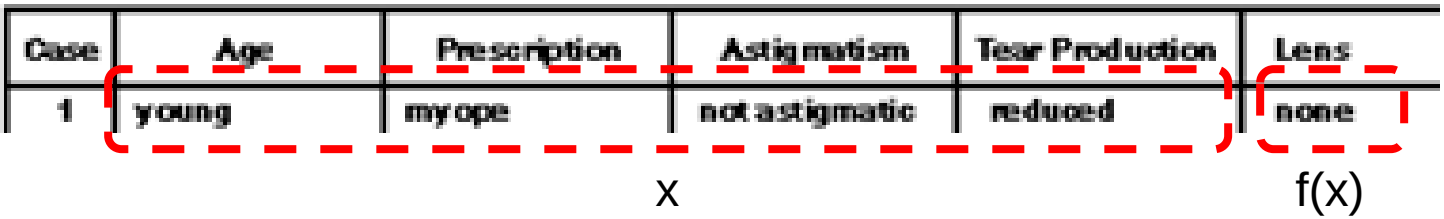
Figure 19.6 FILES: figures/cumulative-learning.eps (Tue Nov 3 16:22:36 2009). A cumulative learning process uses, and adds to, its stock of background knowledge over time.

- IF3170: a highly simplified model of real learning:
  - Ignores prior knowledge
  - Assumes examples are given

Inductive learning

Learn suatu fungsi dari contoh

An example is a pair $(x, f(x))$; f is the target function



Case	Age	Prescription	Astigmatism	Tear Production	Lens
1	young	myope	not astigmatic	reduced	none

x f(x)

Problem: find a hypothesis h such that $\boldsymbol{h \approx f}$

Consistent Hypotesis ?

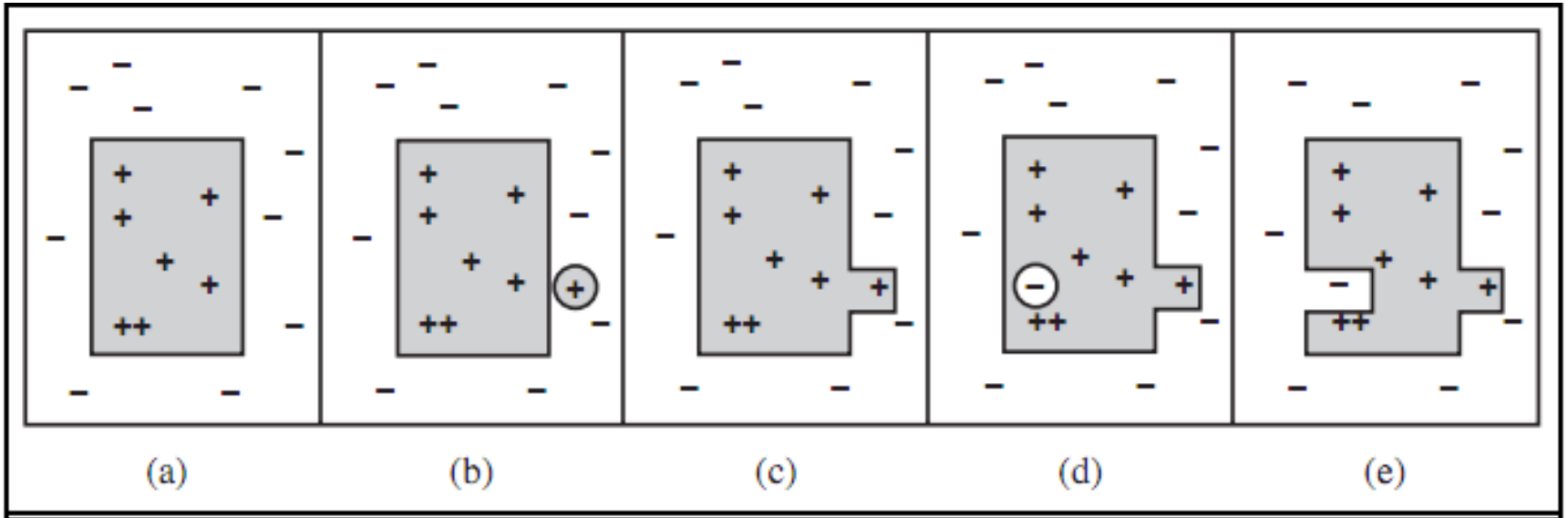
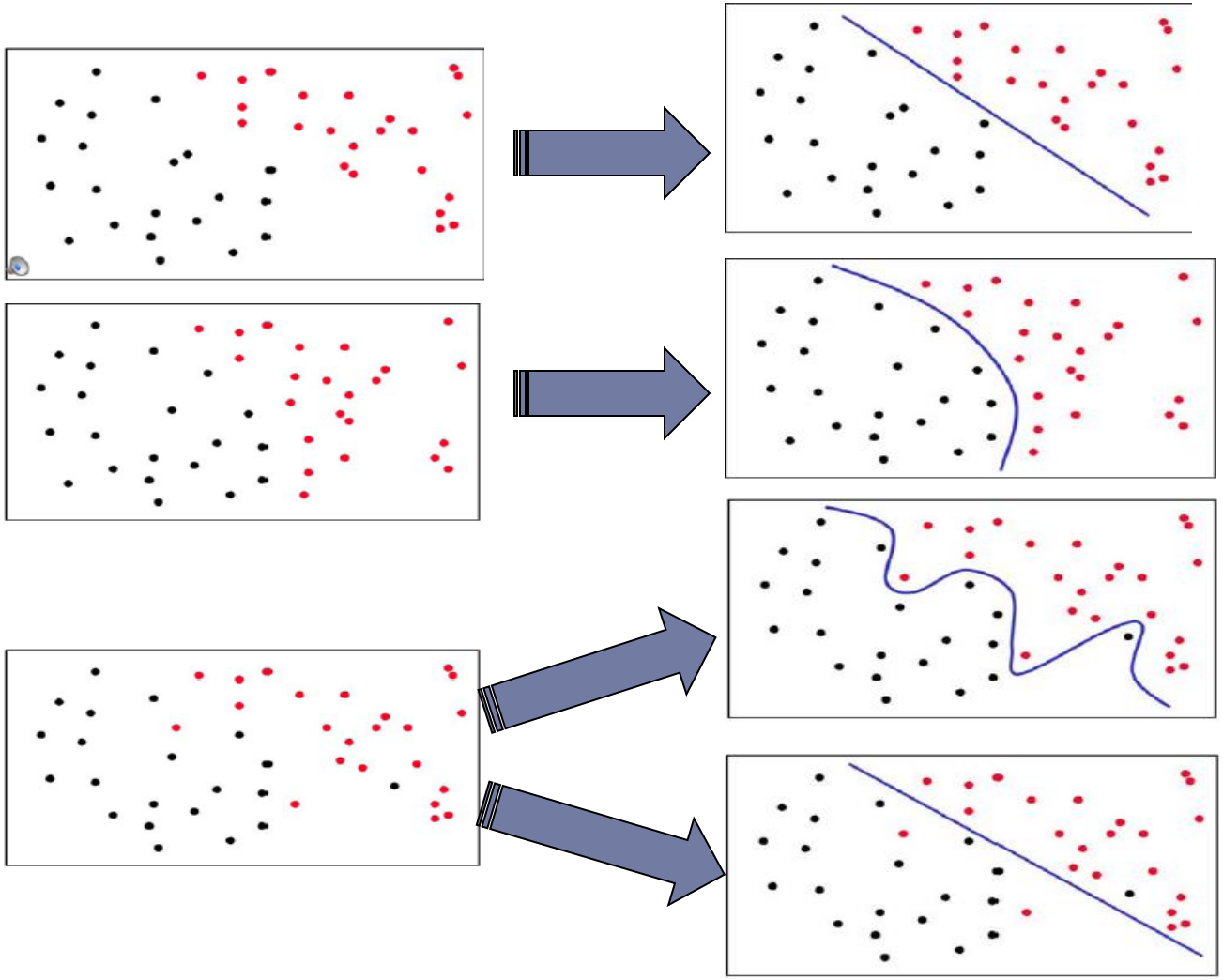


Figure 19.1 FILES: figures/cbh.eps (Tue Nov 3 16:22:32 2009). (a) A consistent hypothesis. (b) A false negative. (c) The hypothesis is generalized. (d) A false positive. (e) The hypothesis is specialized.

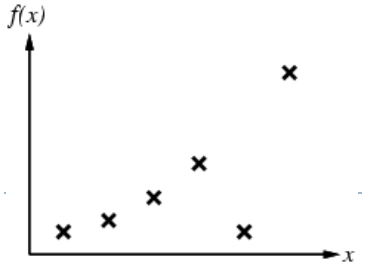
Inductive learning method

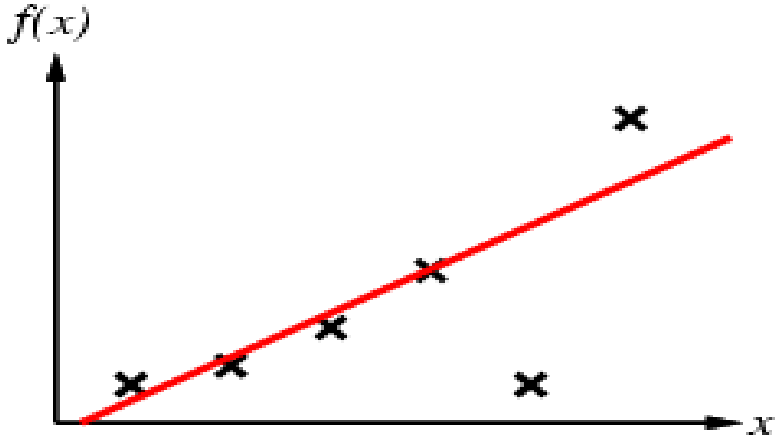
- Construct/adjust *h* to agree with *f* on training set
- (*h* is consistent if it agrees with *f* on all examples)
- Contoh: **curve fitting**

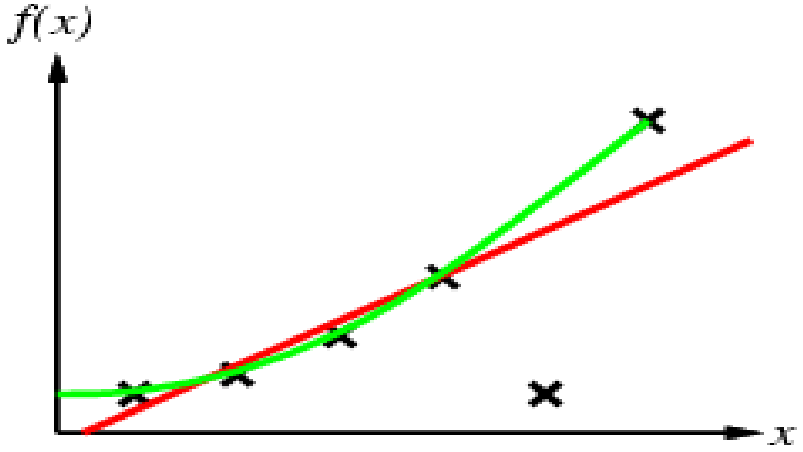
Curve Fitting: Contoh 1

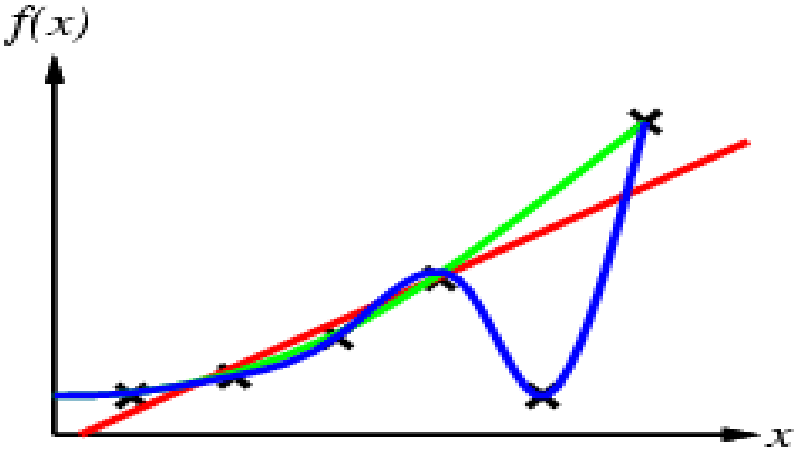


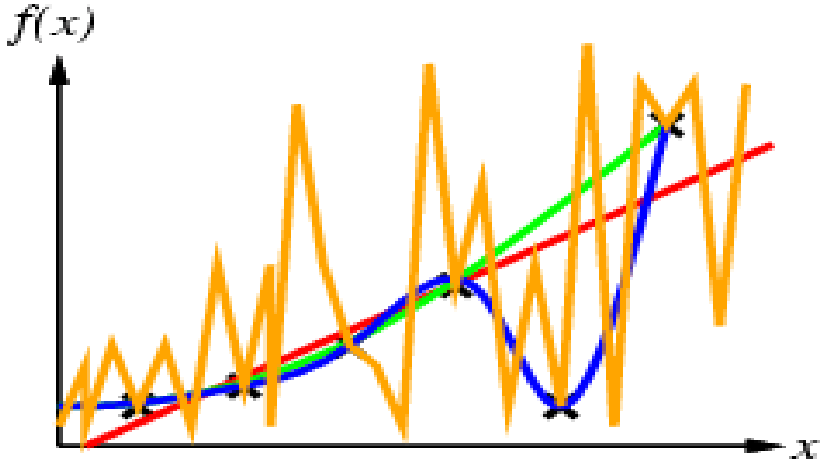
Curve Fitting: Contoh 2











Curve Fitting: Contoh 3

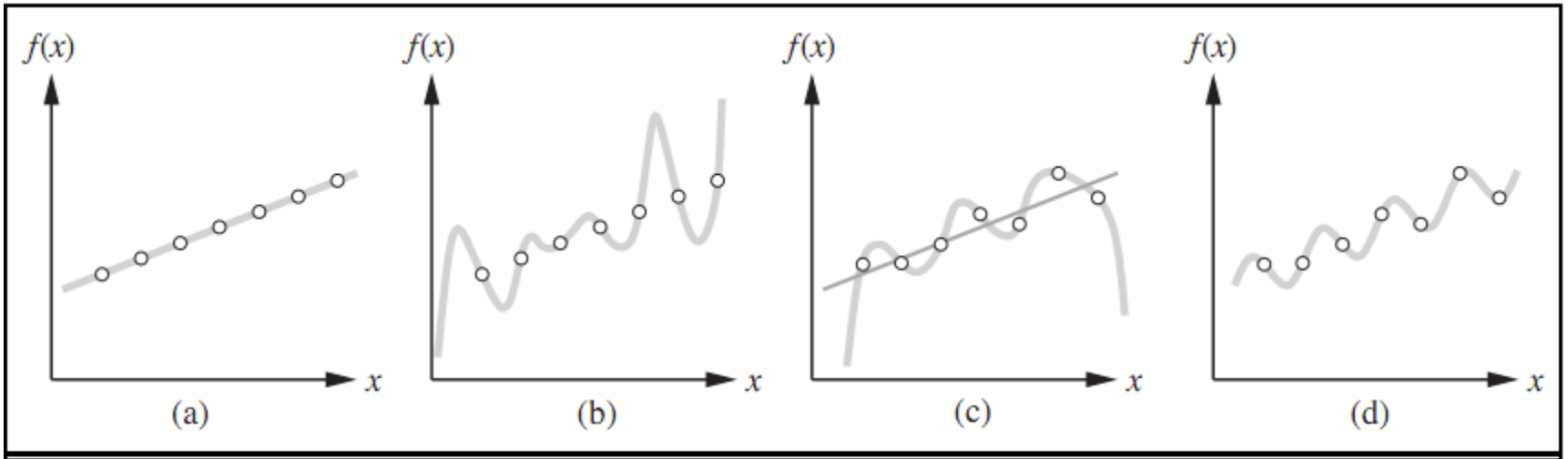
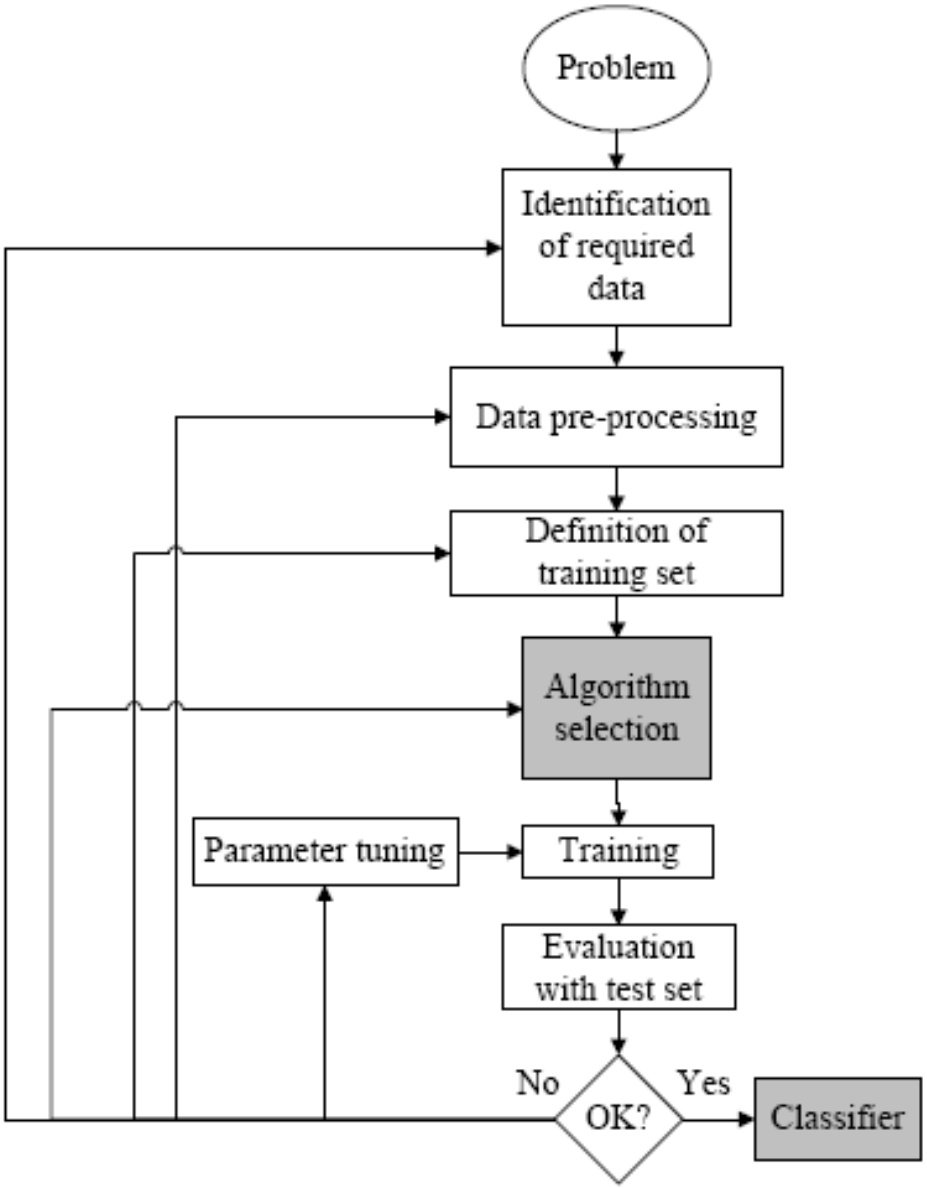


Figure 18.1 FILES: figures/xy-plot.eps (Tue Nov 3 16:24:13 2009). (a) Example $(x, f(x))$ pairs and a consistent, linear hypothesis. (b) A consistent, degree-7 polynomial hypothesis for the same data set. (c) A different data set, which admits an exact degree-6 polynomial fit or an approximate linear fit. (d) A simple, exact sinusoidal fit to the same data set.

Inductive learning method

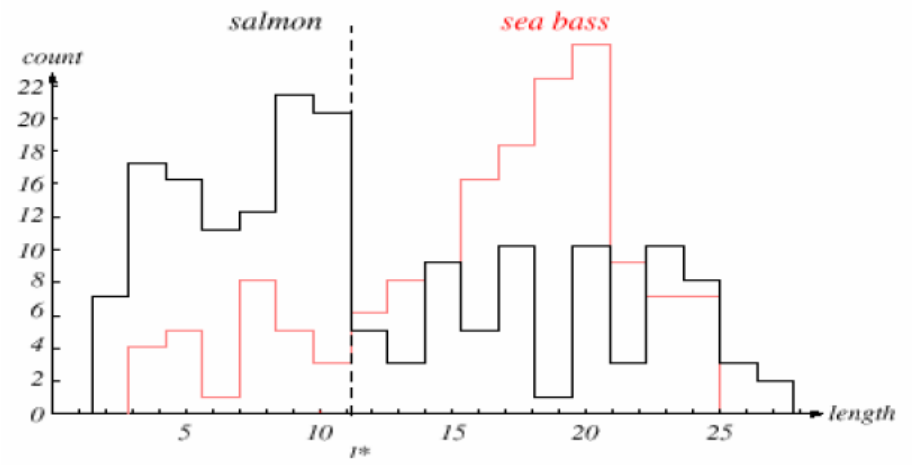
- Construct/adjust *h* to agree with *f* on training set
- (*h* is consistent if it agrees with *f* on all examples)
- **Ockham's razor:**
  - Pilih hipotesis yang paling sederhana yang konsisten dengan data

Supervised Learning Process



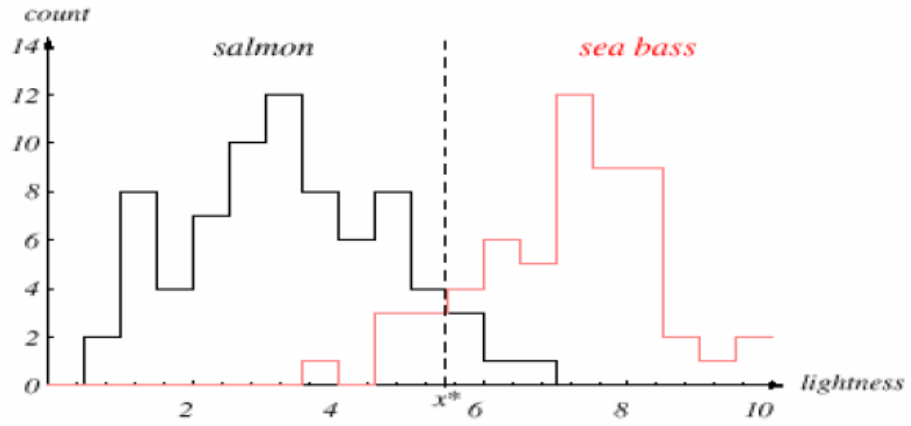
1 feature: Threshold Value

A sea bass is generally longer than a salmon.

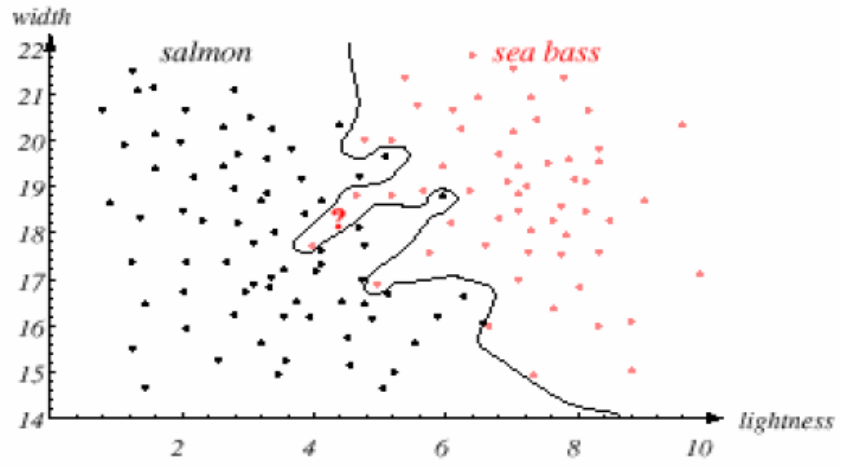


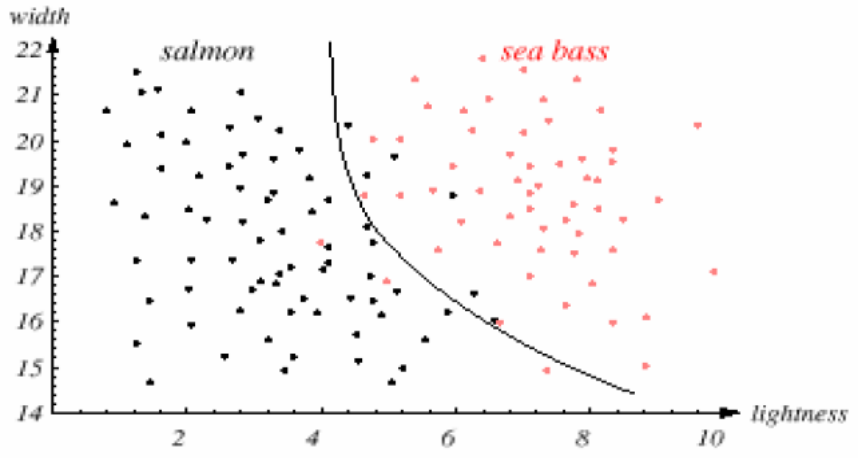
Poor performance
→ length is a poor feature

Lightness is better feature to classify the fish.



>1 Features: Decision Boundary





- Features: width, lightness
- Ideal decision boundary: 100% training accuracy
- Aim of classifier designing is to correctly classify novel input
- Need good generalization for future patterns
- Testing accuracy vs training accuracy

Decision Boundary for AND, OR, XOR

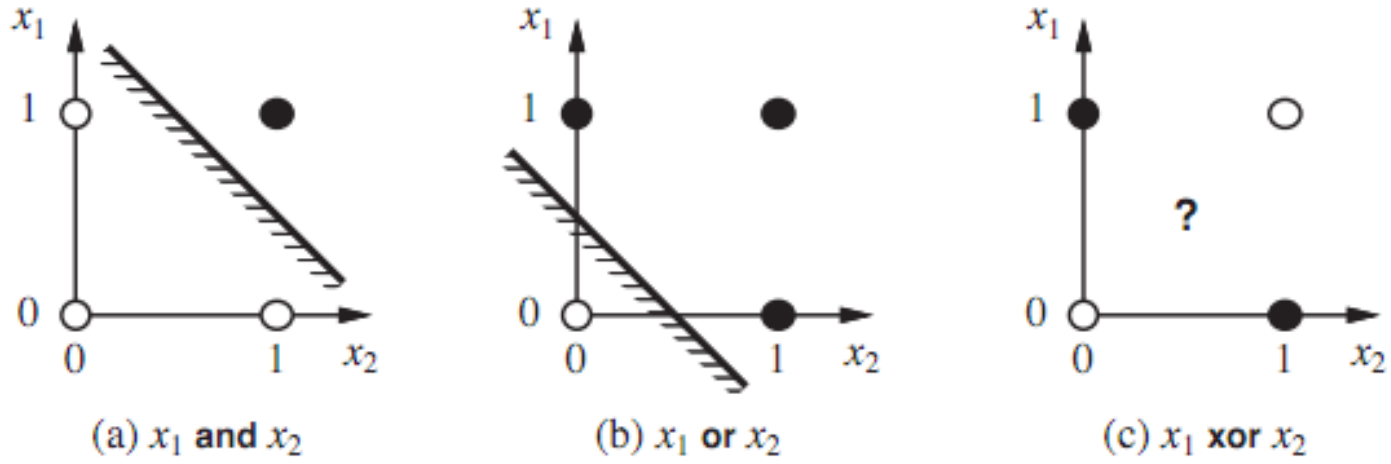


Figure 18.21 FILES: figures/perceptron-linear.eps (Tue Nov 3 16:23:17 2009). Linear separability in threshold perceptrons. Black dots indicate a point in the input space where the value of the function is 1, and white dots indicate a point where the value is 0. The perceptron returns 1 on the region on the non-shaded side of the line. In (c), no such line exists that correctly classifies the inputs.

Seismic Data for Earthquake/Nuclear Explosions

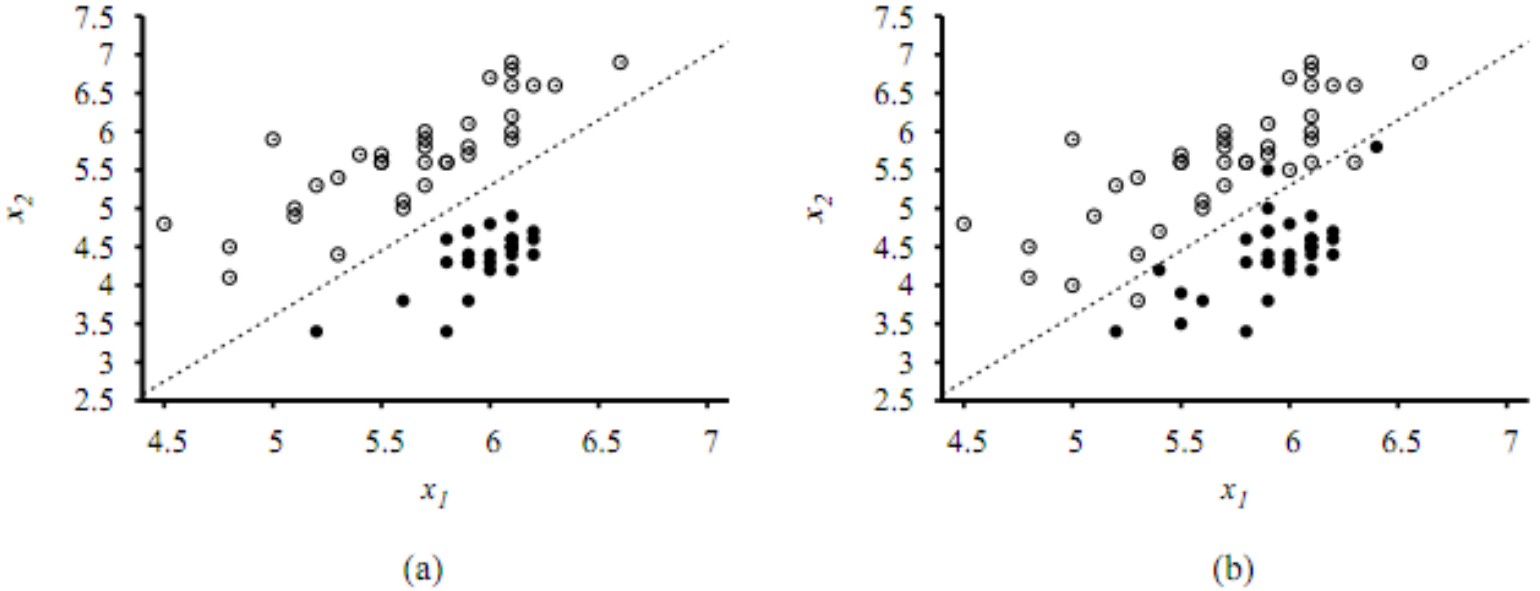


Figure 18.15 **FILES: .** (a) Plot of two seismic data parameters, body wave magnitude x_1 and surface wave magnitude x_2, for earthquakes (white circles) and nuclear explosions (black circles) occurring between 1982 and 1990 in Asia and the Middle East (?). Also shown is a decision boundary between the classes. (b) The same domain with more data points. The earthquakes and explosions are no longer linearly separable.

Decision Boundary: Circle

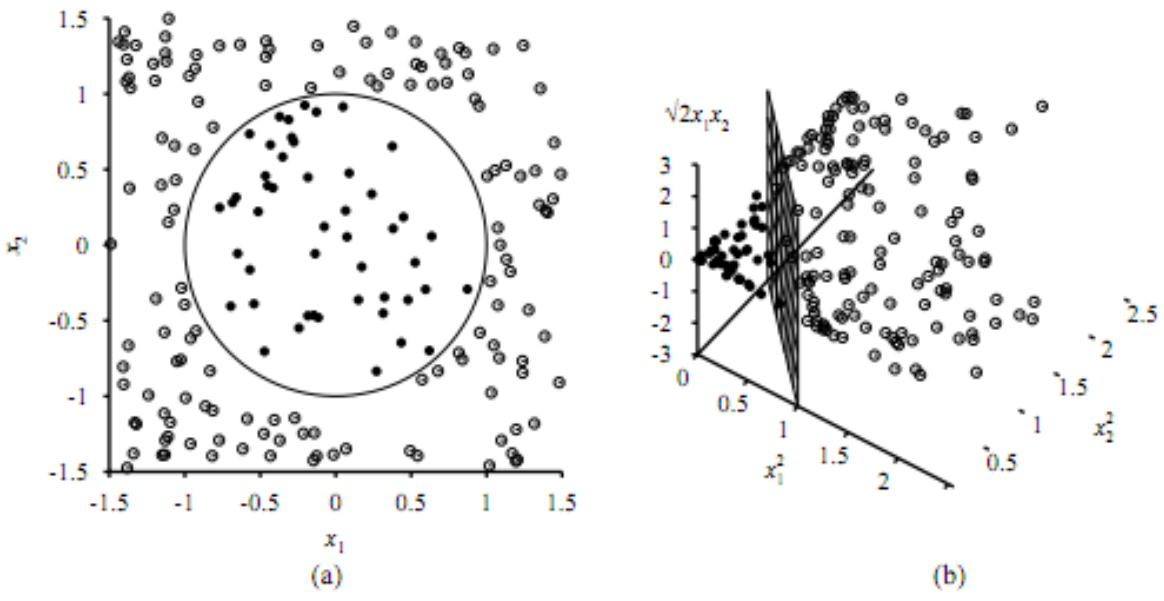


Figure 18.31 **FILES: .** (a) A two-dimensional training set with positive examples as black circles and negative examples as white circles. The true decision boundary, $x_1^2 + x_2^2 \leq 1$, is also shown. (b) The same data after mapping into a three-dimensional input space $(x_1^2, x_2^2, \sqrt{2}x_1x_2)$. The circular decision boundary in (a) becomes a linear decision boundary in three dimensions. Figure 18.29(b) gives a closeup of the separator in (b).

Applications for Supervised Learning

Given: Training examples (**x**; *f*(**x**)) for some unknown function *f*
Find: A good approximation to *f*.

Example Applications

- **Handwriting Recognition**
  - **x**: Data from pen motion.
  - *f*(**x**): Letter of the alphabet.

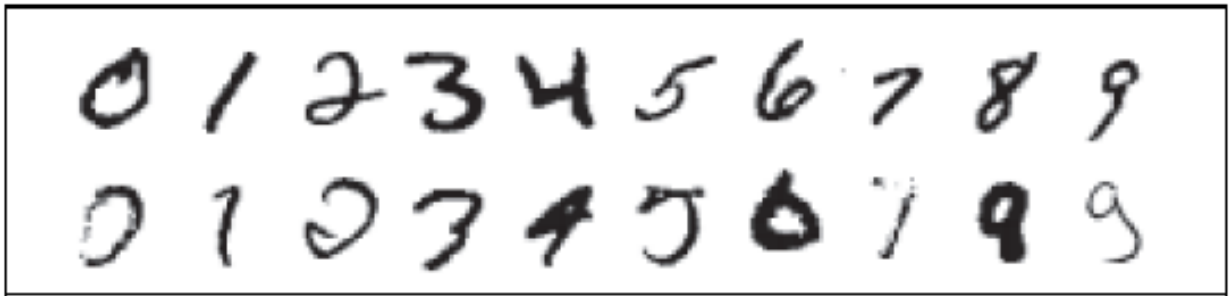


Figure 18.36 **FILES: figures/easy-hard.eps (Wed Nov 4 15:38:34 2009).** Examples from the NIST database of handwritten digits. Top row: examples of digits 0–9 that are easy to identify. Bottom row: more difficult examples of the same digits.

Applications for Supervised Learning

- **Disease diagnosis**
  - **x**: Properties of patient (symptoms, lab tests)
  - *f*(**x**): Disease (or maybe, recommended therapy)

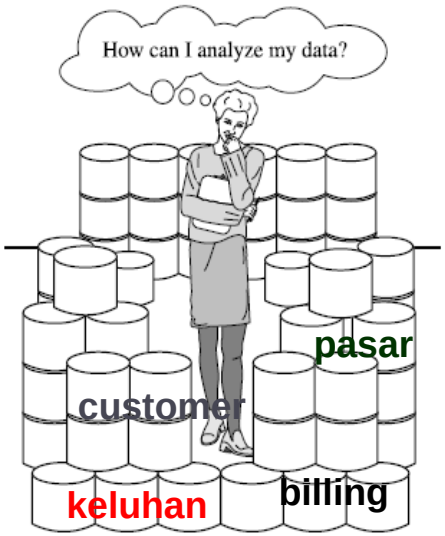
- **Face recognition**
  - **x**: Bitmap picture of person's face
  - *f*(**x**): Name of the person.

- **Music genre classification**
  - x: music file (musicXML, analog file, MIDI)
  - F(x): music genre

- **Sentiment analysis**
  - x: tweets / status facebook
  - F(x): sentimen (positif/negatif)

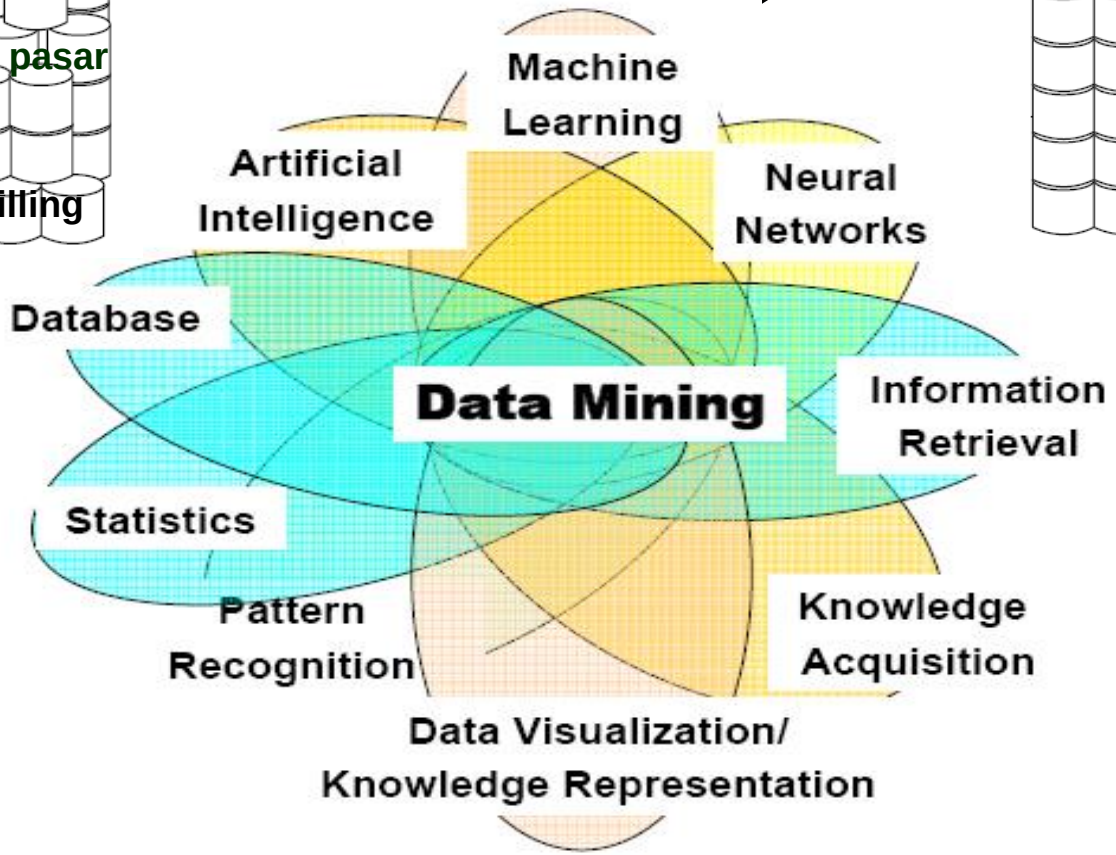
Applications for Supervised Learning

- **Spam Detection**
  - **x**: Email message
  - *f*(**x**): Spam or not spam.
- **Situations where there is no human expert**
  - **x**: Bond graph for a new molecule.
  - *f*(**x**): Predicted binding strength to AIDS protease molecule.
- **Situations where humans can perform the task but can't describe how they do it.**
  - **x**: Bitmap picture of hand-written character
  - *f*(**x**): Ascii code of the character
- **Situations where the desired function is changing frequently**
  - **x**: Description of stock prices and trades for last 10 days.
  - *f*(**x**): Recommended stock transactions
- **Situations where each user needs a customized function *f***
  - **x**: Incoming email message.
  - *f*(**x**): Importance score for presenting to user (or deleting without presenting).


How can I analyze my data?
pasar
customer
keluhan
billing

Data Mining


Knowledge


Machine Learning
Artificial Intelligence
Neural Networks
Database
Data Mining
Information Retrieval
Statistics
Pattern Recognition
Knowledge Acquisition
Data Visualization/
Knowledge Representation

THANK YOU