Introduction to CI

Technologies learned from living thing

Neural Networks

Fuzzy

Genetic Algorithm
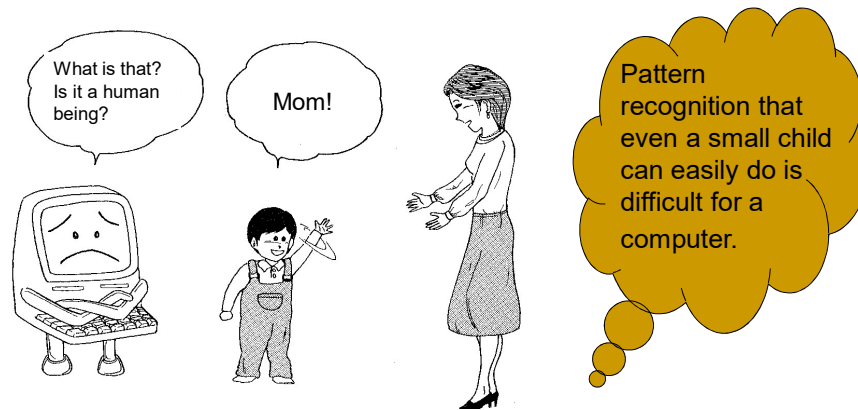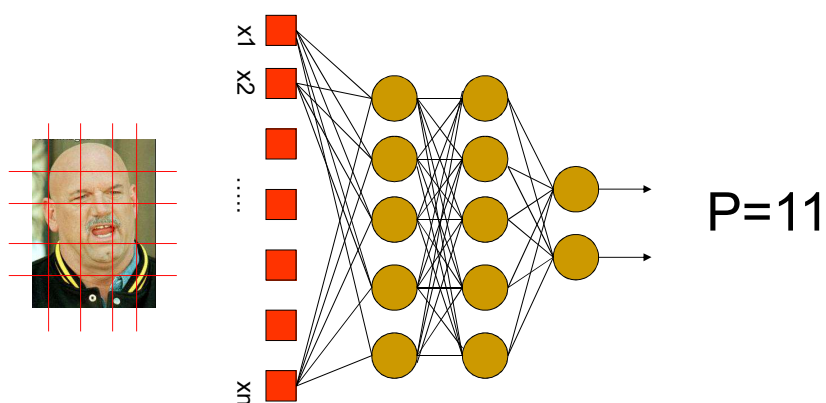
模糊
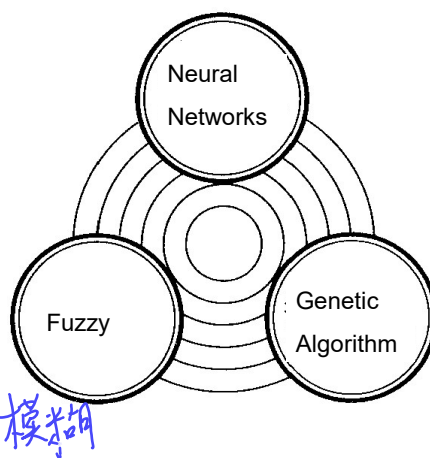
Neural network imitates the brain; *Fuzzy* imitates human's subjective information processing method; *Genetic algorithm* imitates the evolution mechanism living thing. A common feature is that all of these are technologies learned from living thing.

1.1 Why Neural Network, why now?

- Human and Computer

What is that? Is it a human being?

Mom!

Pattern recognition that even a small child can easily do is difficult for a computer.

- Face Detection Using Neural Network
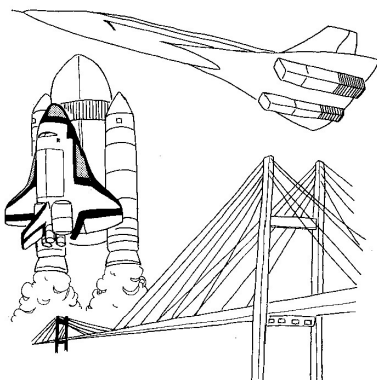
P=11

$$y = f(\mu)$$
$$\mu^* = f^{-1}(y^*)$$

1.2 Why Fuzzy, why now?

PID Control

■ **Expression by mathematic formula**

Description with math formula

$$F = ma \qquad F(\omega) = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(t)\, e^{-j\omega t}\, dt$$

In current science and technology, we usually "describe a plant by mathematic formula, then control it based on the description"


■ **Problem that cannot be described mathematically**

Radius of wheel,

ratio of the gear,

the speed,

the slope,

⋮

?

In order to describe the movement of a bicycle, it is necessary to consider the radius of the wheel, ratio of the gear, the speed, the inclination, and hands and feet's position of the rider at every movement, etc. It becomes impossible. However, one doesn't actually use a math model to control the bicycle.
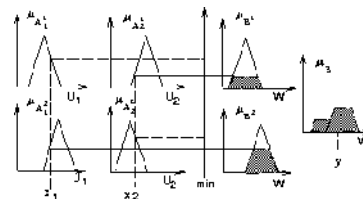
• ## Fuzzy Expert System

Basic Architecture of Fuzzy Systems
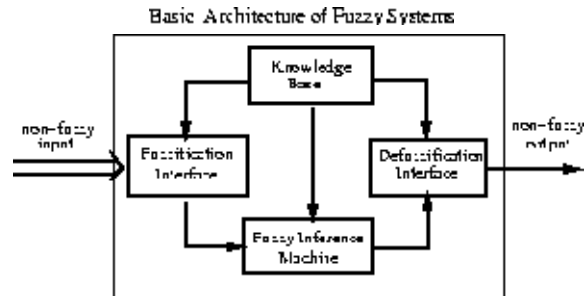
Fuzzy rules:

if x_1 is A_1^1 and x_2 is A_2^1 then y is B^1

if x_1 is A_1^2 and x_2 is A_2^2 then y is B^2

where A_i^j and B^j are fuzzy sets whose membership functions are $\mu_{A_i^j}$ and μ_{B^j}, respectively.
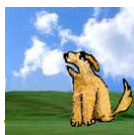

1.3 Why Genetic algorithm?

■ ## Darwin's Theory of Evolution

Natural selection

- Natural selection acts to preserve and accumulate minor advantageous genetic mutations.
- The inferior (disadvantaged) members of the same species would gradually die out, leaving only the superior (advantaged) members of the species.

Superior one   Inferior one

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GA Components

A problem to solve, and ...

GA {

- Encoding technique   *(gene, chromosome)*
- Initialization procedure   *(creation)*
- Evaluation function   *(environment)*
- Selection of parents   *(reproduction)*
- Genetic operators   *(mutation, recombination)*
- Parameter settings   *(practice and art)*

- ## Genetic Algorithm

    An optimization algorithm imitates the genetics and the evolution mechanism of living thing.

An optimization algorithm imitates the genetics and the evolution mechanism of living things

selection   crossover   mutation

The inferior dies out   The genes are exchanged   The genes are mutated

Living things evolve with the selection, crossover and mutation

Sub-optimum

start
initialize the population
fitness calculation
evolution
selection / crossover / mutation
last generation?   No   Yes
stop