Artificial Intelligence: An Introduction

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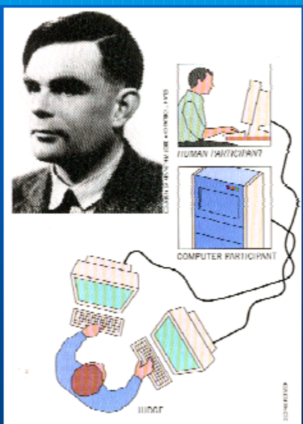
Can Machines Think?



TURING TEST for artificial intelligence was proposed in 1950 by British mathematician Alan M. Turing (photograph). In the test, a human judge would hold a three-way conversation with a computer and another human. If the judge could not distinguish between the responses of the human and those of the computer, the machine would pass the test.

The Turing Test

Computing Machinery and Intelligence [Turing, 1950]

Chess Playing

Garry Kasparov and Deep Blue. © 1997

화성탐사 로봇 소저너

자연 언어 처리

- 다의성 (Polysemy)
  - I keep the money in the bank.
  - I walk along the bank of the river.
- 중의성 (Ambiguity)
  - Time flies like an arrow.
  - I saw a man with a telescope.
- 다양성 (Diversity)
  - She sold him a book for five dollars.
  - He bought a book for five dollars from her.
- 관련 지식
  - 어휘적 지식, 문법적 지식, 상황, 문맥 지식

전문가 시스템

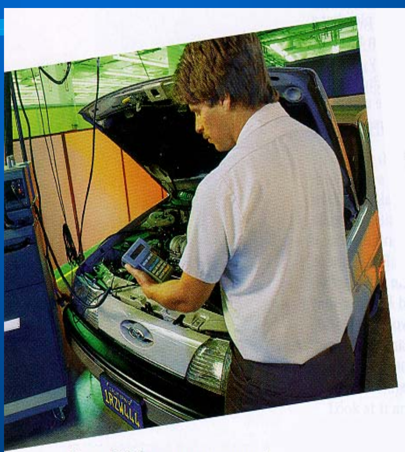
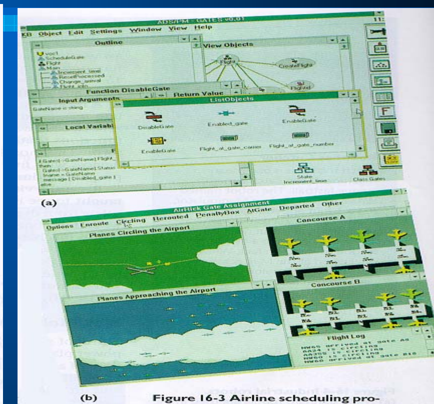


Figure 16-2 An expert system on the job. This expert system helps Ford mechanics track down and fix engine problems.

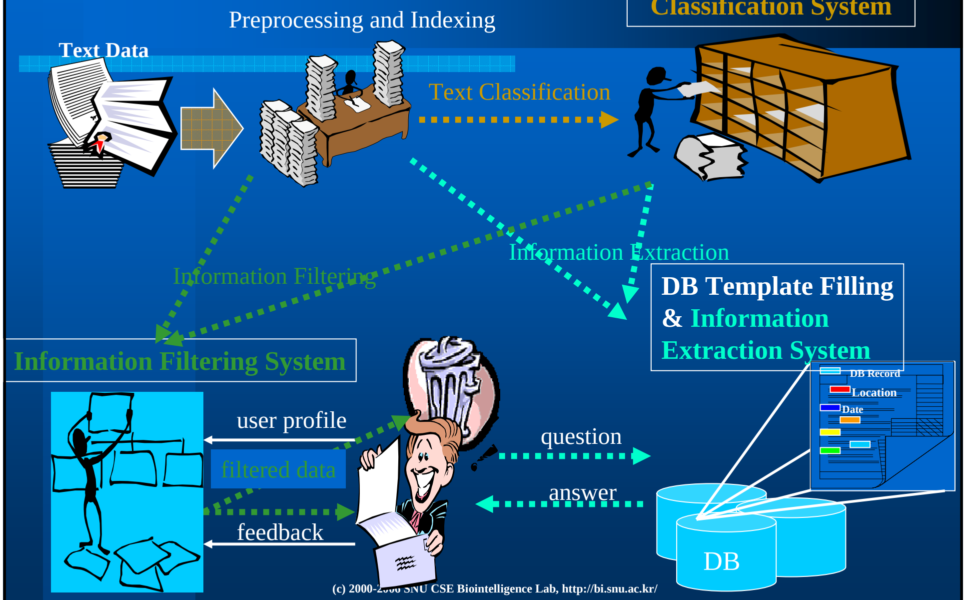


(a)

(b)

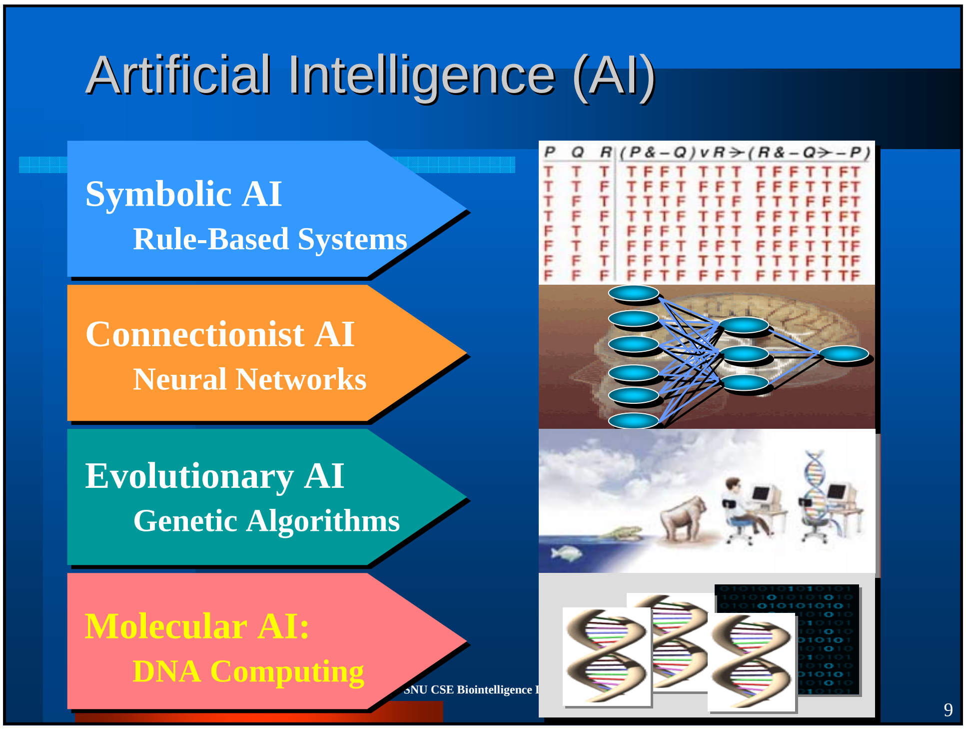
Figure 16-3 Airline scheduling program produced with the aid of an expert system. This system offers a graphical user interface to help solve a complex airport scheduling problem. (a) This screen illustrates the system's ability to display multiple views of objects and the relationships between them. (b) Various screen windows show planes circling the airport, the number of planes approaching the airport, gate information, and two concourses with planes at their gates.

웹 정보검색



History of AI

- Early enthusiasm (1950's & 1960's)
  - Turing test (1950)
  - 1956 Dartmouth conference
  - Emphasize on intelligent general problem solving
- Emphasis on knowledge (1970's)
  - Domain specific knowledge
  - DENDRAL, MYCIN
- AI became an industry (late 1970's & 1980's)
  - Knowledge-based systems or expert systems
  - Wide applications in various domains
- Searching for alternative paradigms (late 1980's - early 1990's)
  - AI's Winter: limitations of symbolic/logical approaches
  - New paradigms: neural networks, fuzzy logic, genetic algorithms, artificial life
- Resurge of AI (mid 1990's – present)
  - Internet, Information retrieval, data mining, bioinformatics
  - Intelligent agents, autonomous robots
- Recent trends:
  - Probabilistic computation
  - Biological basis of intelligence
  - Brain research, cognitive science


Artificial Intelligence (AI)
Symbolic AI
Rule-Based Systems
Connectionist AI
Neural Networks
Evolutionary AI
Genetic Algorithms
Molecular AI:
DNA Computing
SNU CSE Biointelligence
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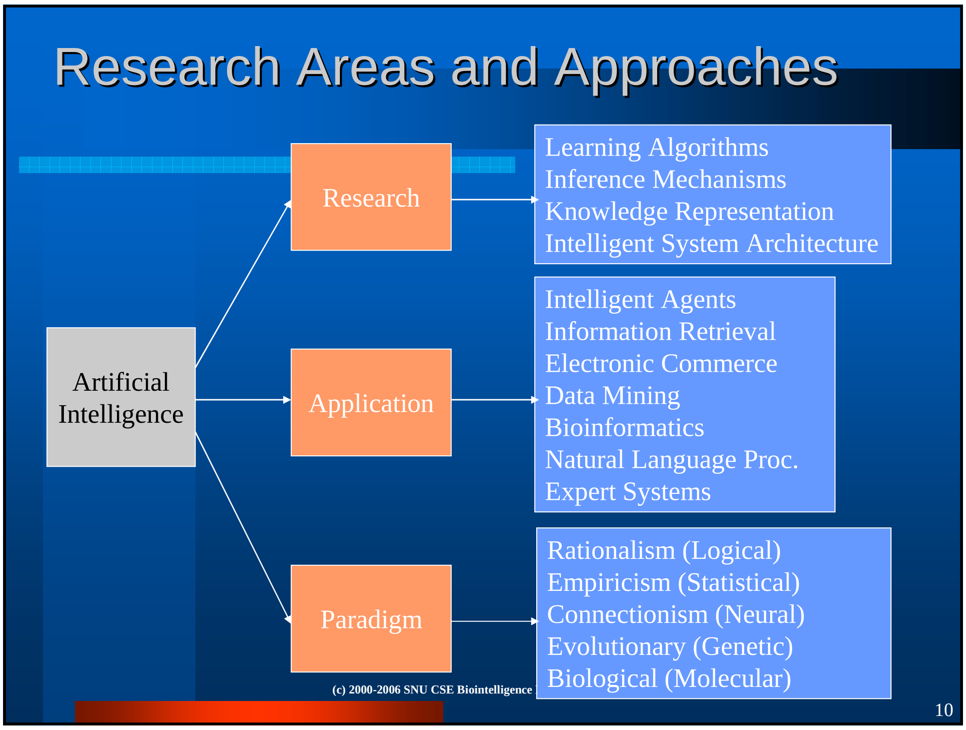
Research Areas and Approaches
Artificial Intelligence
Research
Application
Paradigm
Learning Algorithms
Inference Mechanisms
Knowledge Representation
Intelligent System Architecture
Intelligent Agents
Information Retrieval
Electronic Commerce
Data Mining
Bioinformatics
Natural Language Proc.
Expert Systems
Rationalism (Logical)
Empiricism (Statistical)
Connectionism (Neural)
Evolutionary (Genetic)
Biological (Molecular)
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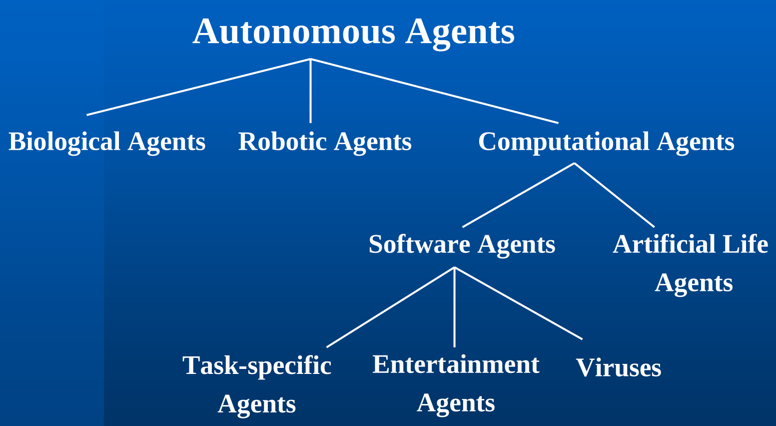
지능형 에이전트



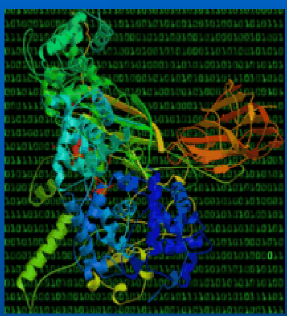
Applications of Intelligent Agents (1)

- E-mail Agents
  - Beyond Mail, Lotus Notes, Maxims
- Scheduling Agents
  - ContactFinder
- Desktop Agents
  - Office 2000 Help, Open Sesame
- Web-Browsing Assistants
  - WebWatcher, Letizia
- Information Filtering Agents
  - Amalthaea, Jester, InfoFinders, Remembrance agent, PHOAKS, SiteSeer

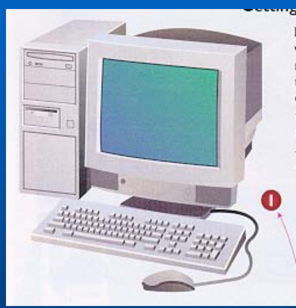
Applications of Intelligent Agents (2)

- News-service Agents
  - NewsHound, GroupLens, FireFly, Fab, ReferralWeb, NewT
- Comparison Shopping Agents
  - Mysimon, BargainFinder, Bazzar, Shopbor, Fido
- Brokering Agents
  - PersonalLogic, Barnes, Kasbah, Jango, Yenta
- Auction Agents
  - AuctionBot, AuctionWeb
- Negotiation Agents
  - DataDetector, T@T

Computers Meet Biosciences



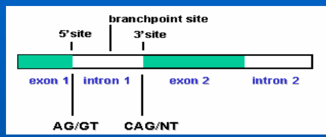
BT IT



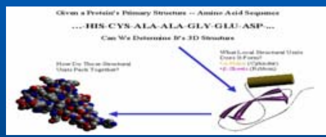
Bioinformation Technology (BIT)

AI in Life Sciences

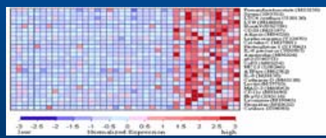
Sequence analysis
- Sequence alignment
- Structure and function prediction
- Gene finding



Structure analysis
- Protein structure comparison
- Protein structure prediction
- RNA structure modeling



Expression analysis
- Gene expression analysis
- Gene clustering

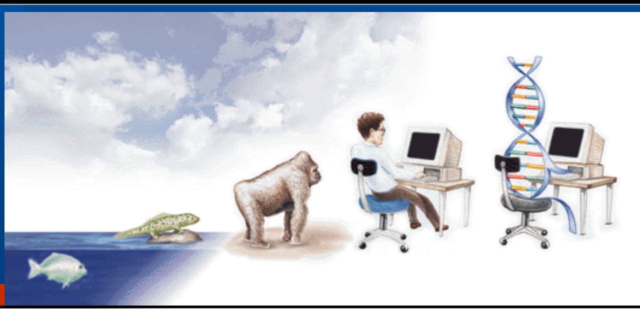


Pathway analysis
- Metabolic pathway
- Regulatory networks

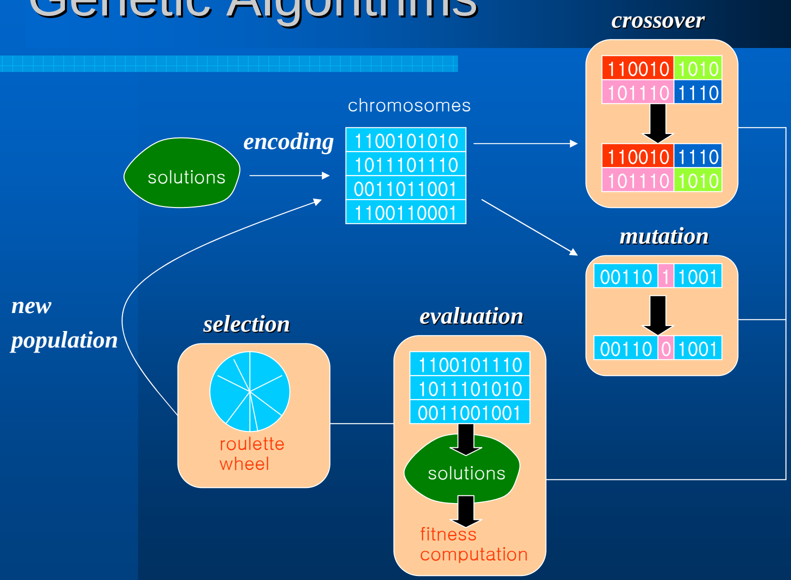
Evolutionary Computation: Nature as Computer

"Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring."

Origin of Species "Charles Darwin (1859)"



Genetic Algorithms



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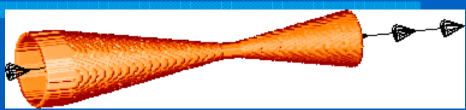
Application Example 1

Hot Water Flashing Nozzle (1)

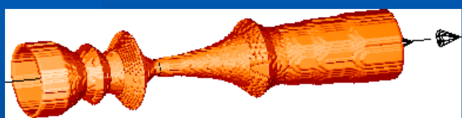
Hans-Paul Schwefel performed the original experiments

Start

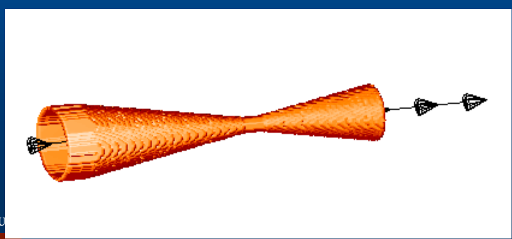


Hot water entering

Steam and droplet at exit



At throat: Mach 1 and onset of flashing



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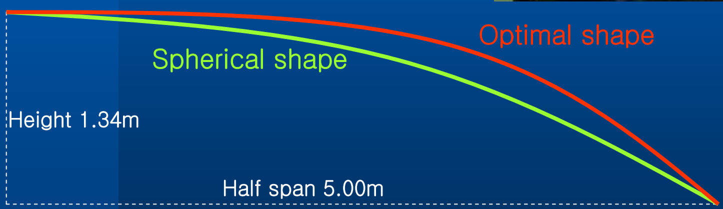
Application Example 3

Concrete Shell Roof

under own and outer load (snow and wind)



max $|m_\varphi| \rightarrow$ min

Orthogonal bending strength

Savings : 36% shell thickness

27% armation

Application Example 13

Cooperating Robots (3)

Cooperating Autonomous Robots

Application Example 14

Co-evolving Soccer Softbots (1)

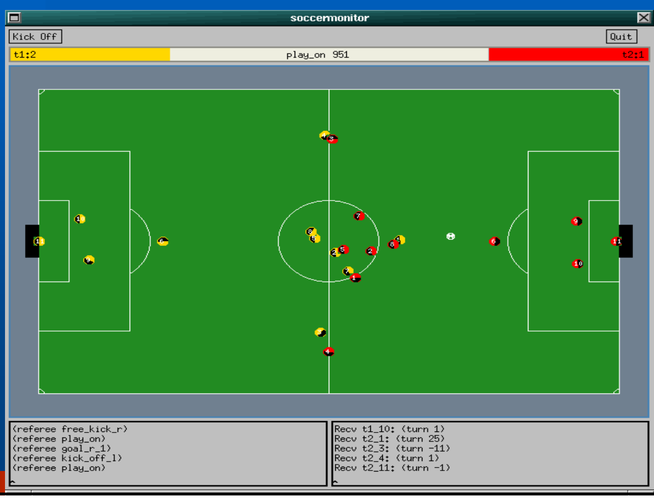
Co-evolving Soccer Softbots With Genetic Programming

- At RoboCup there are two "leagues": the "real" robot league and the "virtual" softbot league
- How do you do this with GP?
  - GP breeding strategies: *homogeneous* and *heterogeneous*
  - Decision of the basic set of function with which to evolve players
  - Creation of an evaluation environment for our GP individuals

Application Example 14

Co-evolving Soccer Softbots (2)

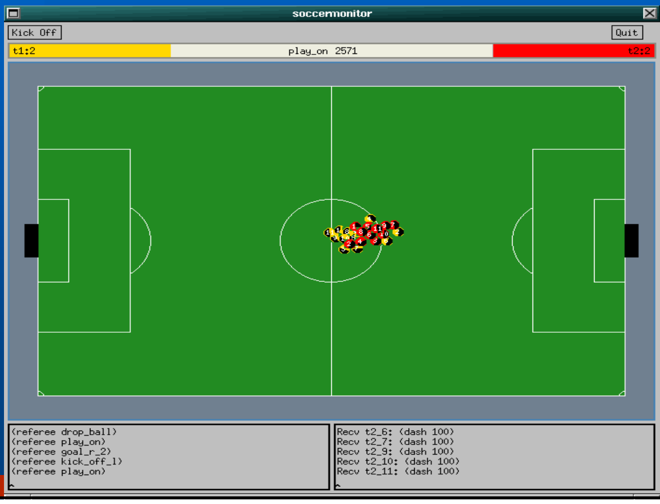
- Initial Random Population



Application Example 14

Co-evolving Soccer Softbots (3)

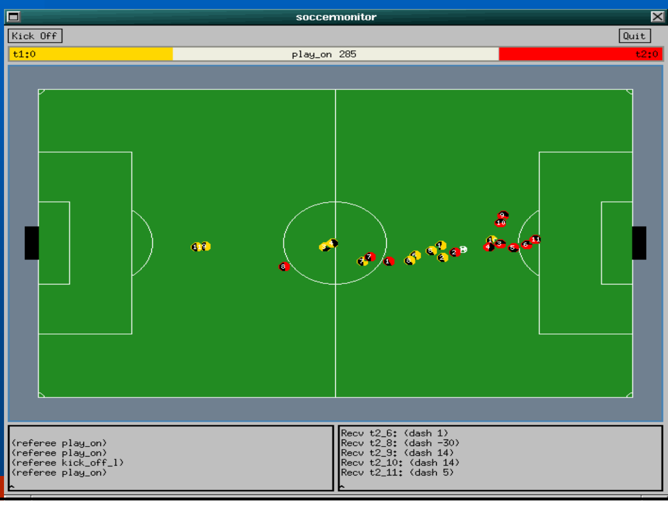
- Kiddie Soccer



Application Example 14

Co-evolving Soccer Softbots (4)

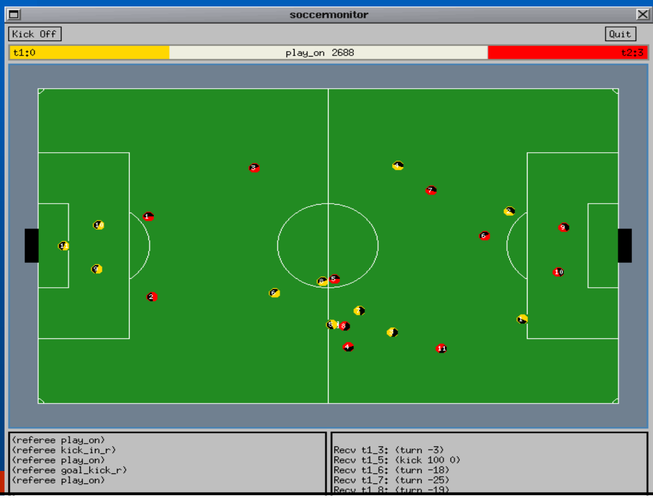
- Learning to Block the Goal



Application Example 14

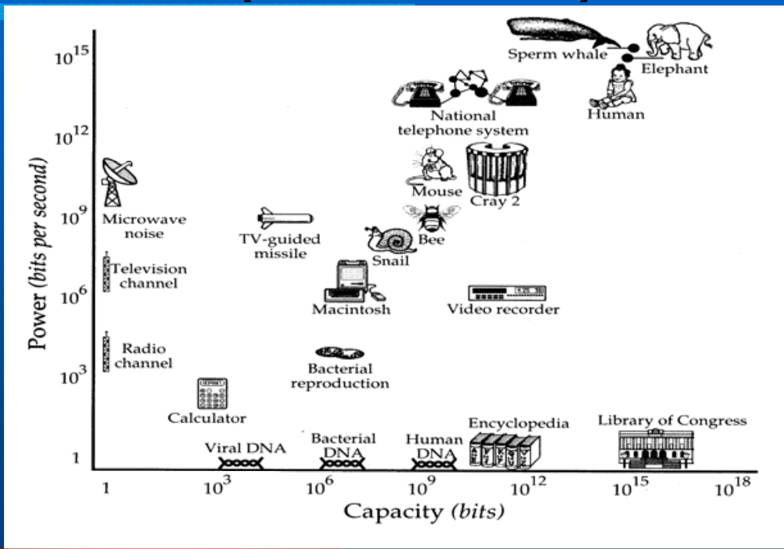
Co-evolving Soccer Softbots (5)

- Becoming Territorial



1000-Pentium Beowulf-Style Cluster Computer for Parallel GP

컴퓨터와 생명체의 계산 속도와 기억 용량의 비교(Moravec, 1988)



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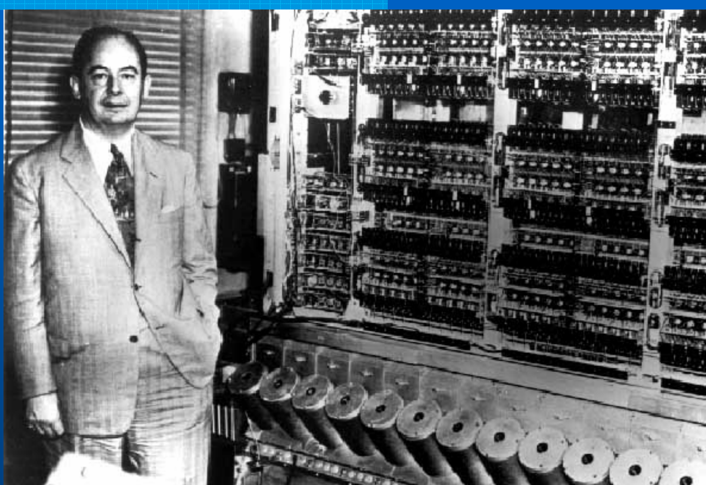
Von Neumann's *The Computer and the Brain (1958)*



John von Neumann (1903-1957)

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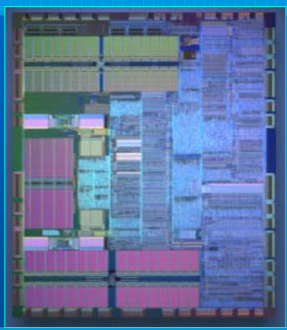
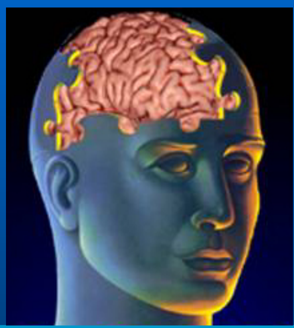
The Computer and the Brain

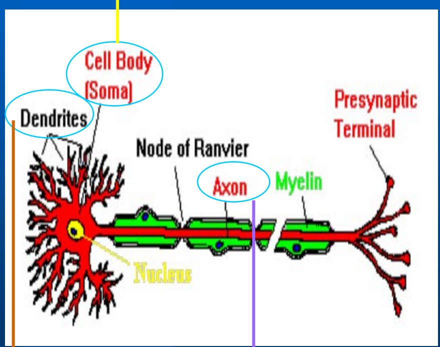


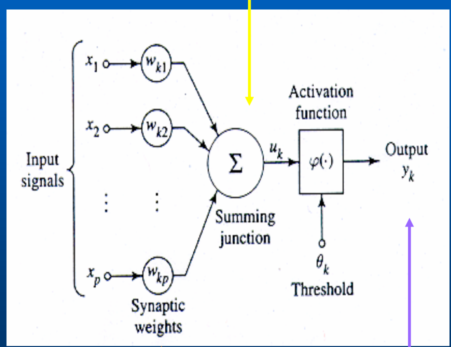


- Less than 1 million processors (10^{-9} sec each, neuron: 10^{-3} sec)
- Central processing
- Arithmetic operation (linearity)
- Sequential processing
- Silicon-based (dry)

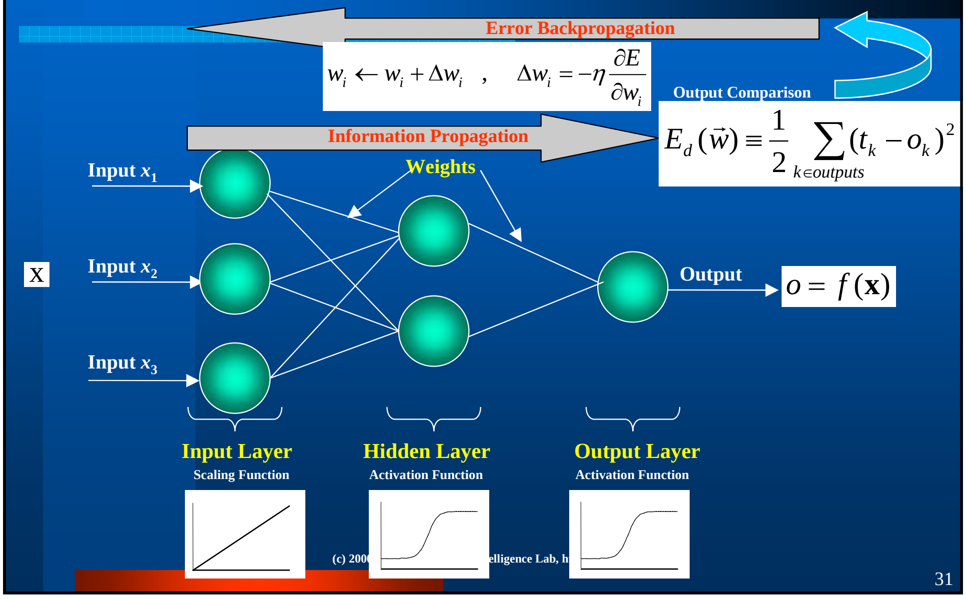
- 10 billion neurons (100 trillion synapses)
- Distributed processing
- Nonlinear processing
- Parallel processing
- Carbon-based (wet)

From Biological Neurons to Artificial Neurons



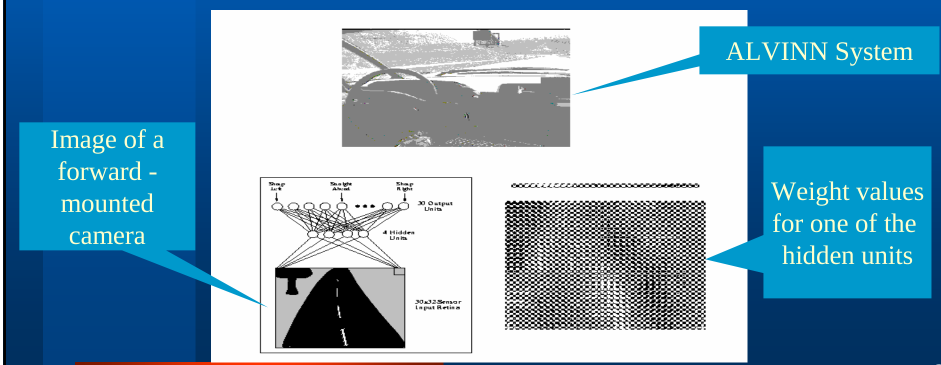


Multilayer Perceptron (MLP)

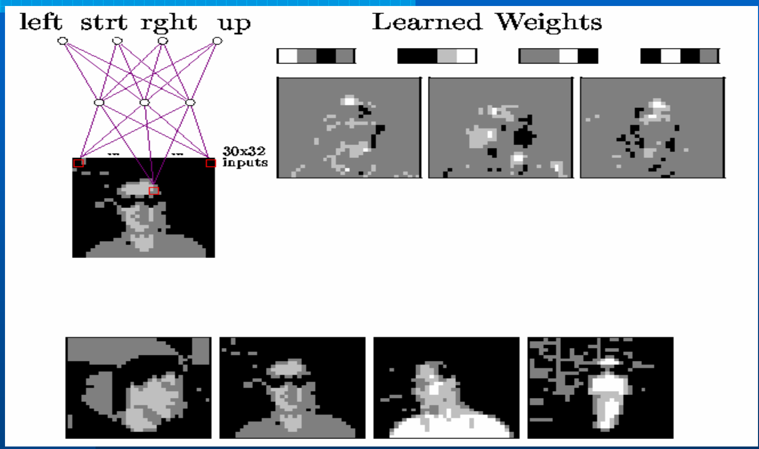


Application Example: Autonomous Land Vehicle (ALV)

- NN learns to steer an autonomous vehicle.
- 960 input units, 4 hidden units, 30 output units
- Driving at speeds up to 70 miles per hour



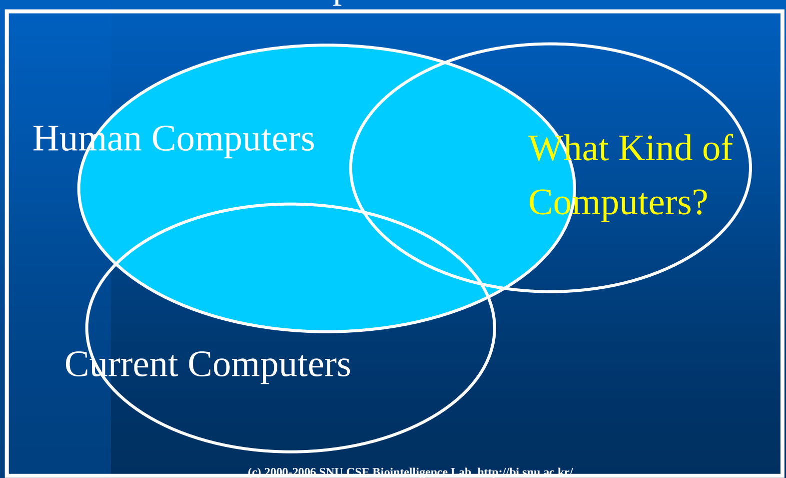
Neural Nets for Face Recognition



960 x 3 x 4 network is trained on gray-level images of faces to predict whether a person is looking to their left, right, ahead, or up.

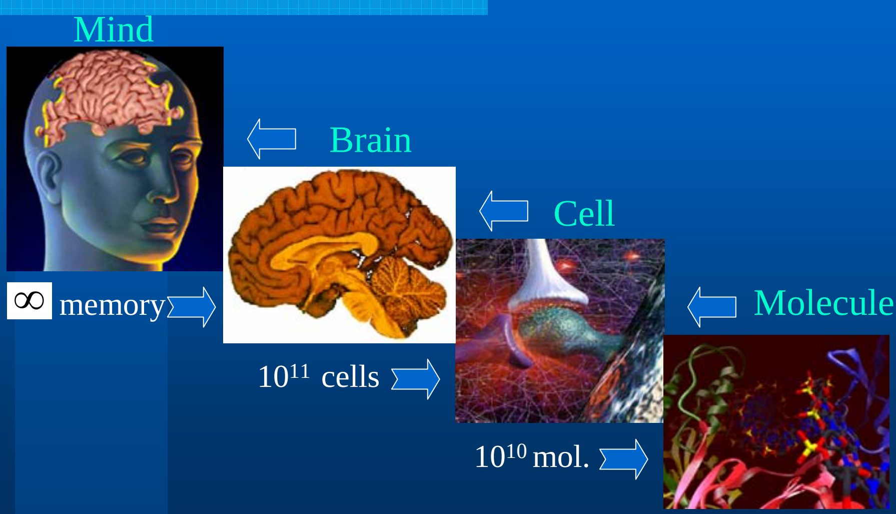
Humans and Computers

The Entire Problem Space

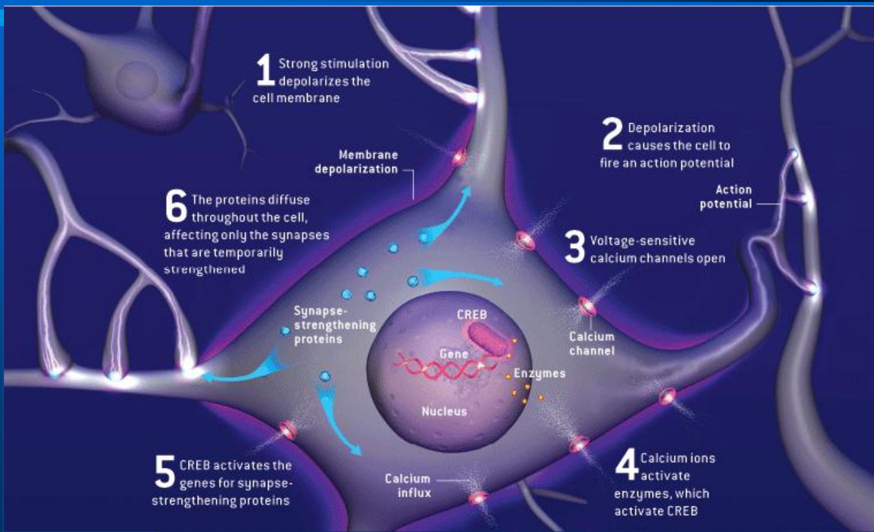


What is the information processing principle underlying human intelligence?

Mind, Brain, Cell, Molecule



Molecular Basis of Learning and Memory in the Brain



Principles of Information Processing in the Brain

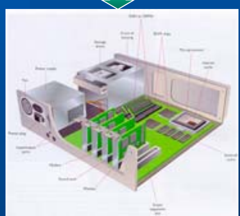
- The Principle of Uncertainty
  - Precision vs. prediction
- The Principle of Nonseparability “UN-IBM”
  - Processor vs. memory
- The Principle of Infinity
  - Limited matter vs. unbounded memory
- The Principle of “Big Numbers Count”
  - Hyperinteraction of 10^{11} neurons (or > 10^{17} molecules)
- The Principle of “Matter Matters”
  - Material basis of “consciousness”

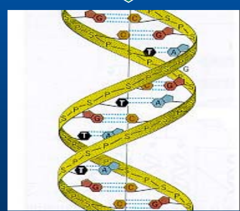
[Zhang, 2005]

Unconventional Computing

- Quantum Computing
  - Atoms
  - Superposition, quantum entanglements
- Chemical Computing
  - Chemicals
  - Reaction-diffusion computing
- Molecular Computing
  - Molecules
  - "Self-organizing hardware"

Molecular Computing: BioMolecules as Computer



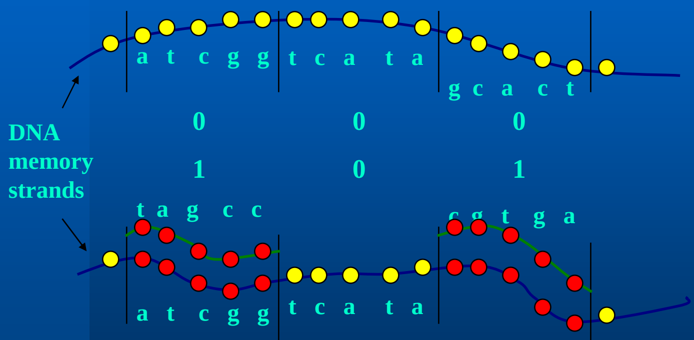


011001101010001

ATGCTCGAAGCT

DNA Molecules for Information Storage and Processing

Writing: make DNA sequences



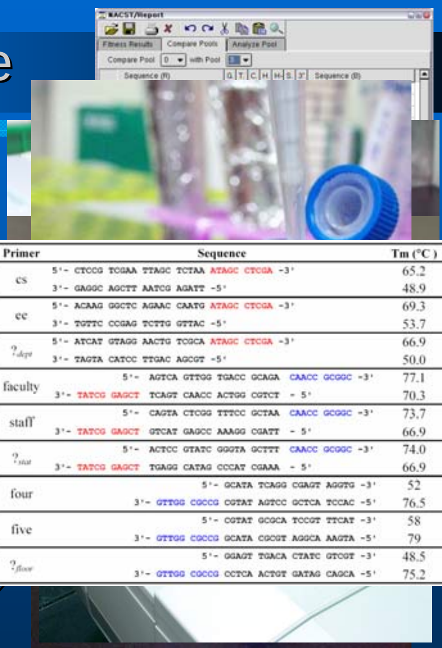
Reading: hybridization and readout

Bio-Lab Procedure

1. Sequence Design and Synthesis
2. Hybridization
3. Ligation

Initial Version Space

4. Learning (Affinity Separation)
5. Classification



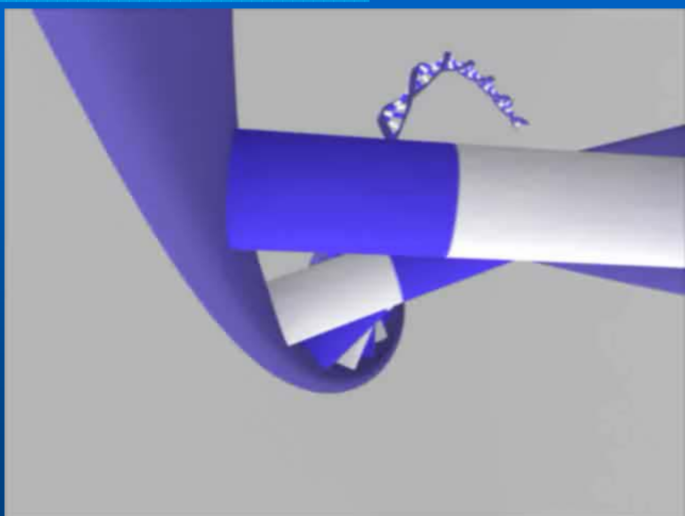
Primer	Sequence	Tm (°C)
cs	5'- CTCCG TCGAA TTAGC TCTAA ATAGC CTCGA -3'	65.2
	3'- GAGGC AGCTT AATCG AGATT -5'	48.9
ee	5'- ACAAG GGCTC AGAAC CAATG ATAGC CTCGA -3'	69.3
	3'- TGTTC CCGAG TCTTG GTTAC -5'	53.7
$?_{dept}$	5'- ATCAT GTAGG AACTG TCGCA ATAGC CTCGA -3'	66.9
	3'- TAGTA CATCC TTGAC AGCGT -5'	50.0
faculty	5'- AGTCA GTTGG TGACC GCAGA CAACC GCGGC -3'	77.1
	3'- TATCG GAGCT TCAGT CAACC ACTGG CGTCT - 5'	70.3
staff	5'- CAGTA CTCGG TTTCC GCTAA CAACC GCGGC -3'	73.7
	3'- TATCG GAGCT GTCAT GAGCC AAAGG CGATT - 5'	66.9
$?_{stat}$	5'- ACTCC GTATC GGGTA GCTTT CAACC GCGGC -3'	74.0
	3'- TATCG GAGCT TGAGG CATAG CCCAT CGAAA - 5'	66.9
four	5'- GCATA TCAGG CGAGT AGGTG -3'	52
	3'- GTTGG CGCCG CGTAT AGTCC GCTCA TCCAC -5'	76.5
five	5'- CGTAT GCGCA TCCGT TTCAT -3'	58
	3'- GTTGG CGCCG GCATA CGCGT AGGCA AAGTA -5'	79
$?_{floor}$	5'- GGAGT TGACA CTATC GTCGT -3'	48.5
	3'- GTTGG CGCCG CCTCA ACTGT GATAG CAGCA -5'	75.2

Molecular Computers vs. Silicon Computers

	Molecular Computers	Silicon Computers
Processing	Ballistic	Hardwired
Medium	Liquid (wet) or Gaseous (dry)	Solid (dry)
Communication	3D collision	2D switching
Configuration	Amorphous (asynchronous)	Fixed (synchronous)
Parallelism	Massively parallel	Sequential
Speed	Fast (millisec)	Ultra-fast (nanosec)
Reliability	Low	High
Density	Ultrahigh	Very high
Reproducibility	Probabilistic	Deterministic

Molecular Information Processing

- MP4.avi

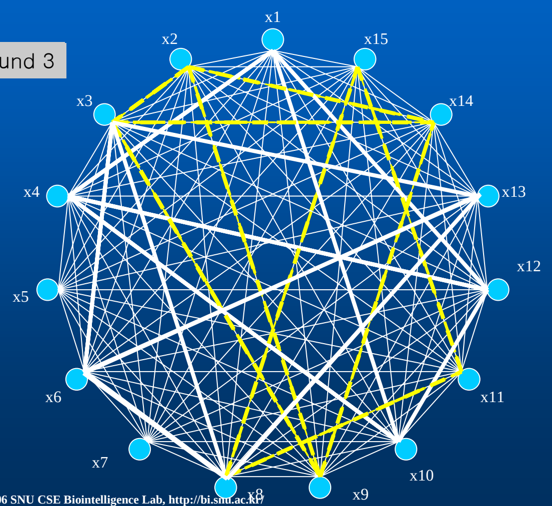


	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	y
1	=1	=0	=0	=1	=0	=0	=0	=0	=0	=1	=0	=1	=0	=0	=0	= 1
2	=0	=1	=1	=0	=0	=0	=0	=0	=1	=0	=0	=0	=0	=1	=0	= 0
3	=0	=0	=1	=0	=0	=1	=0	=1	=0	=0	=0	=0	=1	=0	=0	=1
4	=0	=0	=0	=0	=0	=0	=0	=1	=0	=0	=1	=0	=0	=0	=1	=1

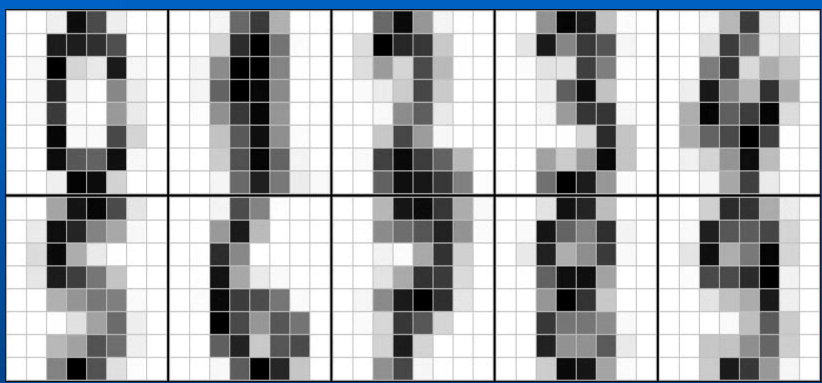
4 examples

Round 3

1	x_1	x_4	x_{10}	y=1
	x_1	x_4	x_{12}	y=1
	x_4	x_{10}	x_{12}	y=1
2	x_2	x_3	x_9	y=0
	x_2	x_3	x_{14}	y=0
	x_3	x_9	x_{14}	y=0
3	x_3	x_6	x_8	y=1
	x_3	x_6	x_{13}	y=1
	x_6	x_8	x_{13}	y=1
4	x_8	x_{11}	x_{15}	y=0

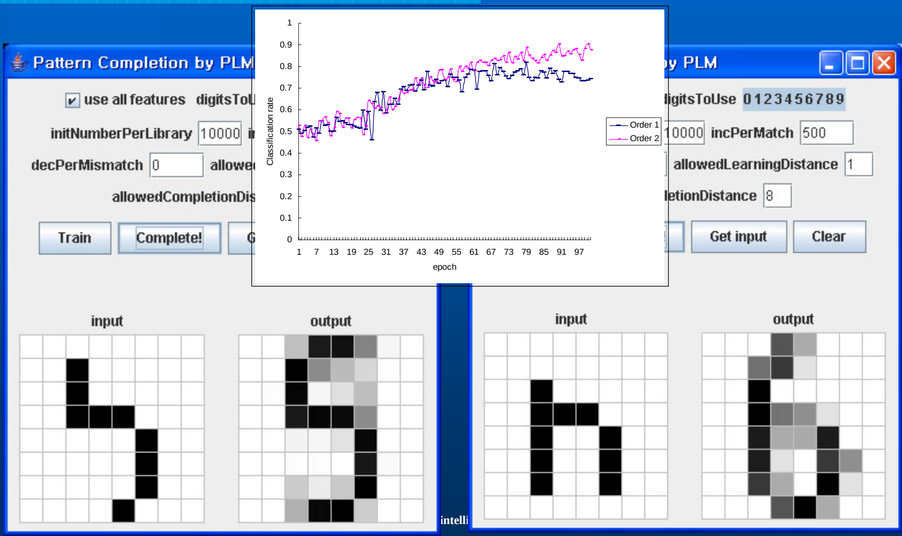


Benchmark Problem: Digit Images

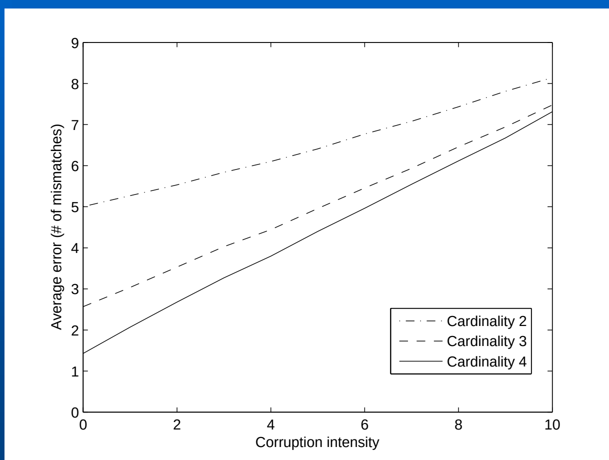


- 8x8=64 bit images (made from 64x64 scanned gray images)
- Training set: 3823 images
- Test set: 1797 images

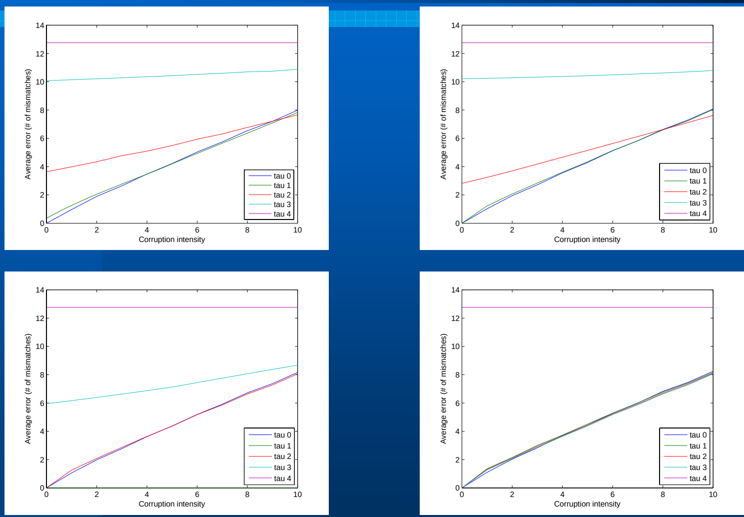
Pattern Information Processing



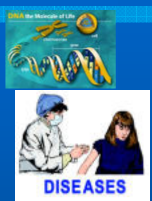
Effect of Memory-Chunk Size



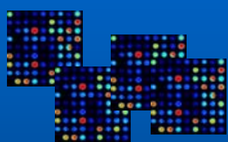
Effect of the Error Tolerance Level



Biological Application

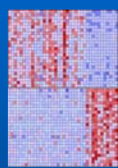


120 samples from
60 leukemia patients

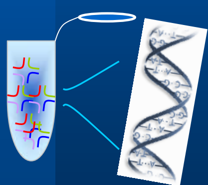


Gene expression data

&



Class: ALL/AML



Training with
6-fold validation

Diagnosis

[Cheok *et al.*, *Nature Genetics*, 2003]

Da Vinci's Dream of Flying Machines

Engines of Flight



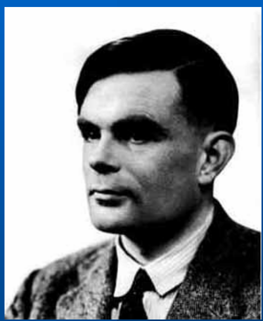



Piston Engine

Jet Engine

Rocket Engine

Turing's Dream of Intelligent Machines

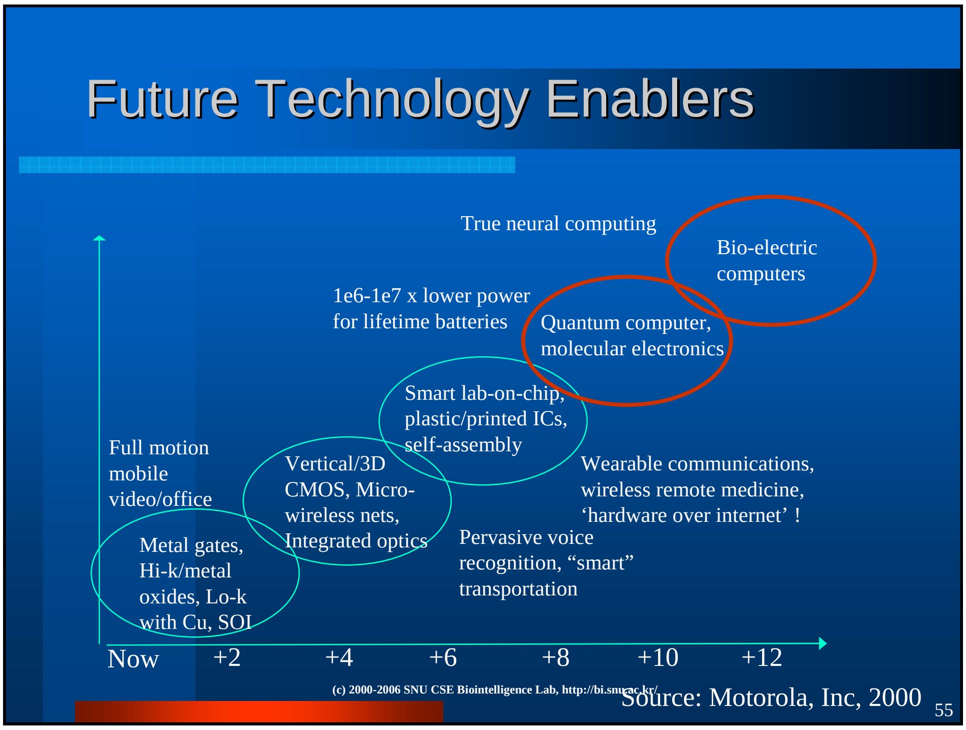


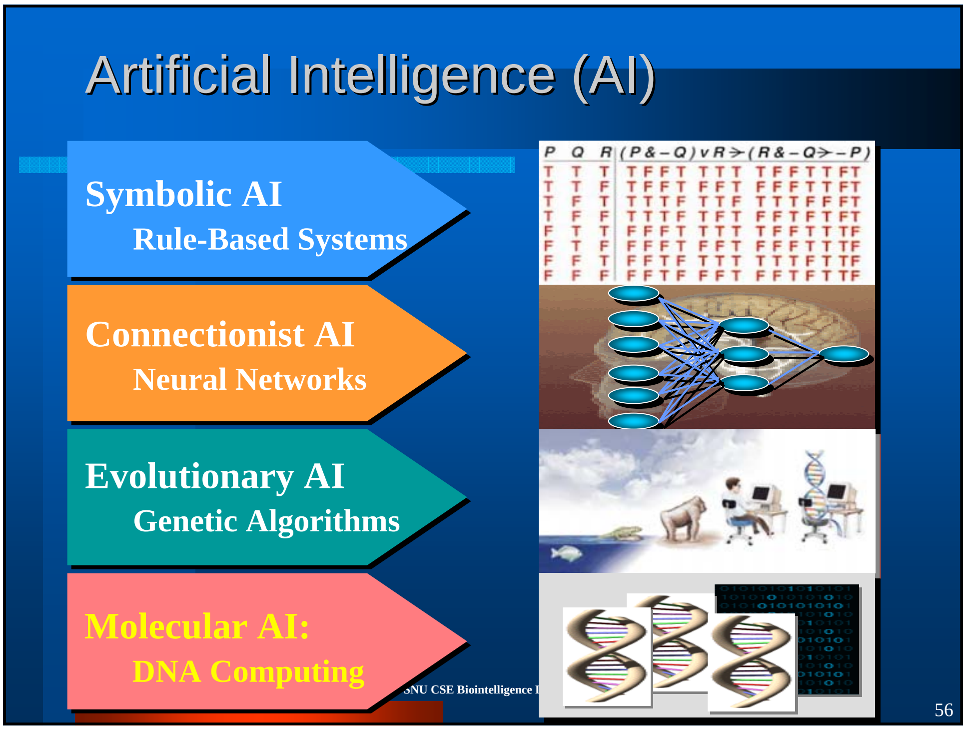
Alan Turing
(1912-1954)

Computing Machinery and Intelligence (1950)

TURING TEST for artificial intelligence was proposed in 1950 by British mathematician Alan M. Turing (photograph). In the test, a human judge would hold a three-way conversation with a computer and another human. If the judge could not distinguish between the responses of the human and those of the computer, the machine would pass the test.

Computers and Intelligence


Future Technology Enablers
True neural computing
Bio-electric computers
1e6-1e7 x lower power for lifetime batteries
Quantum computer, molecular electronics
Smart lab-on-chip, plastic/printed ICs, self-assembly
Full motion mobile video/office
Vertical/3D CMOS, Micro-wireless nets, Integrated optics
Wearable communications, wireless remote medicine, 'hardware over internet' !
Metal gates, Hi-k/metal oxides, Lo-k with Cu, SOI
Pervasive voice recognition, "smart" transportation
Now
+2
+4
+6
+8
+10
+12
(c) 2000-2006 SNU CSE Biointelligence Lab, http://bi.snu.ac.kr/
Source: Motorola, Inc, 2000
55


Artificial Intelligence (AI)
Symbolic AI
Rule-Based Systems
Connectionist AI
Neural Networks
Evolutionary AI
Genetic Algorithms
Molecular AI:
DNA Computing
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