Evolutionary Computation and Machine Intelligence

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What is Evolutionary Computation
What is Machine Intelligence
How EC works
Learning
Robotics
Examples
Future research

EC is a probabilistic search procedure to obtain solutions starting from a set of candidate solutions, using improving operators to "evolve" solutions. Improving operators are inspired by natural evolution.

Survival of the fittest.

The objective function depends on the problem.

EC is not a random search.

GA pseudo code

```
initialise population P
while not terminate
  evaluate P by fitness function
  P' = selection.recombination.mutation of P
  P = P'
```

terminating conditions:
1 found satisfactory solutions
2 waiting too long

Simple Genetic Algorithm

represent a solution by a binary string {0,1}*
selection:
  chance to be selected is proportional to its fitness
recombination
  single point crossover

recombination

select a cut point cut two parents, exchange parts

```
AAAAAA      111111
AA AAAA     11 1111   cut at bit 2
AA1111      11AAAA    exchange parts
```

mutation

single bit flip

```
111111   -->   111011   flip at bit 4
```

Evolution Strategy

represent solutions with real numbers

GA compare to other methods

“indirect” -- setting derivatives to 0
“direct” -- hill climber
enumerative – search them all
random – just keep trying
simulated annealing – single-point method
Tabu search

What problem GA is good for?

Highly multimodal functions
Discrete or discontinuous functions
High-dimensionality functions, including many combinatorial ones
Nonlinear dependencies on parameters (interactions among parameters) -- “epistasis” makes it hard for others
Often used for approximating solutions to NPcomplete combinatorial problems

What is Machine Intelligence?

. . . Exactly what the computer provides is the ability not to be rigid and unthinking but, rather, to behave conditionally. That is what it means to apply knowledge to action: It means to let the action taken reflect knowledge of the situation, to be sometimes this way, sometimes that, as appropriate. . . .

Allen Newell

What is Machine Intelligence?

“It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable. “

What is intelligence?

“Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines. “

John McCarthy

Creation of machines that can "think"

perception
reasoning
planning
acting (manipulation)

machine vision

Learning

machine learning

building hypothesis from positive and negative examples.

artificial neuron networks

building approximate function mapping from inputs to outputs: classification, memorisation etc.

Robotics

integrate sensing and action to achieve some tasks

Applications of Machine intelligence

game playing
speech recognition
understanding natural language
computer vision
expert systems

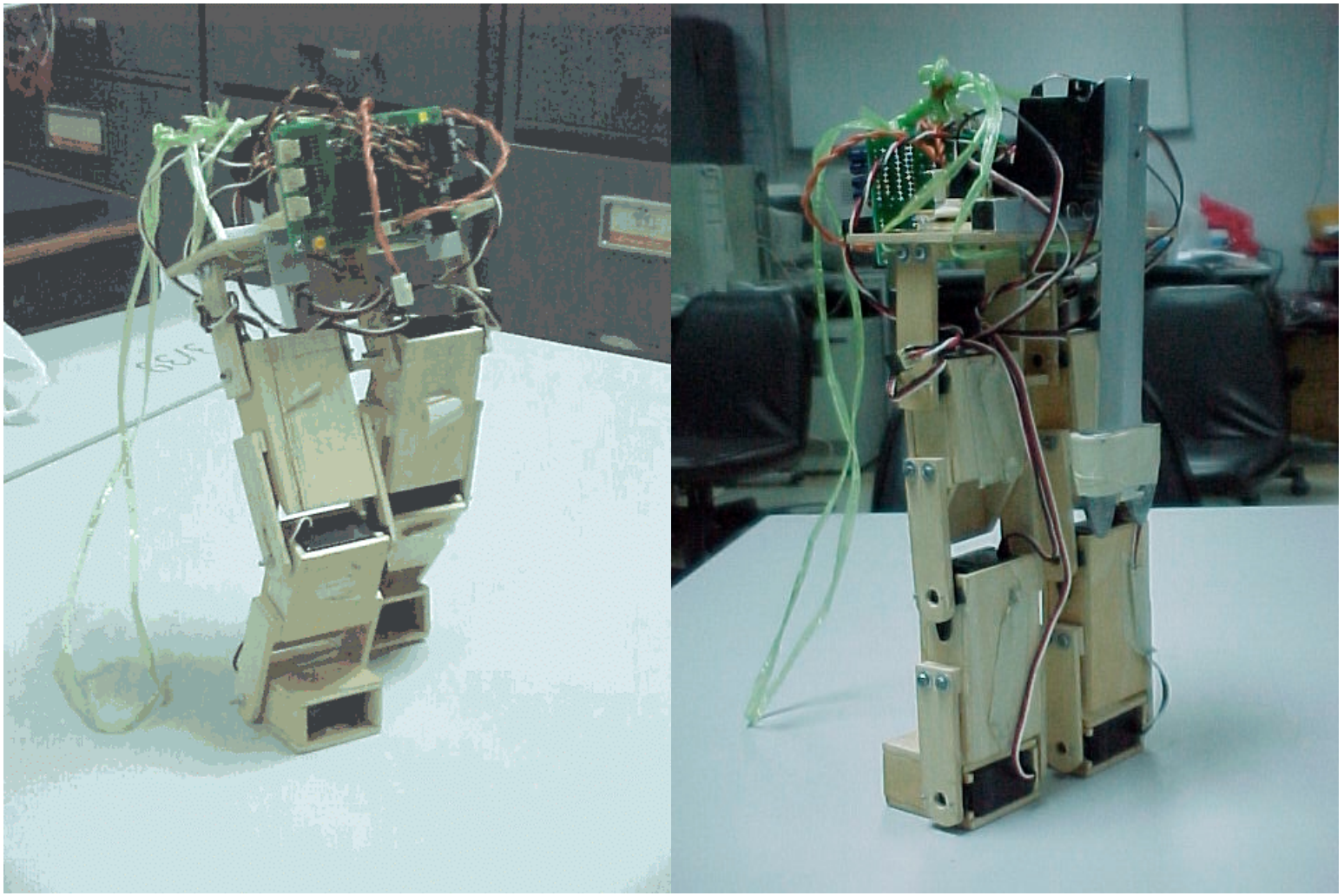
agent-based systems
autonomous systems
collaborative robots (perhaps with human)
adaptive systems
assistant to human (such as secretary)

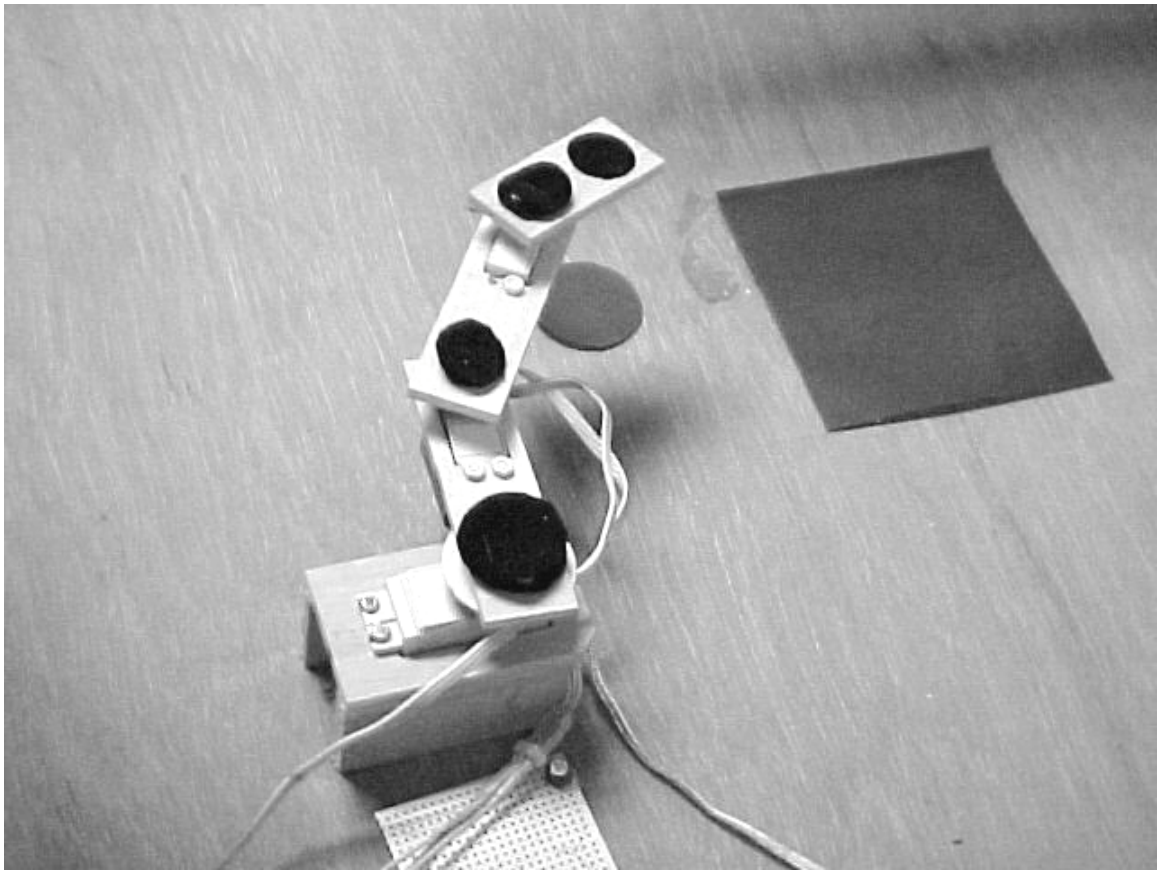
EC + MI

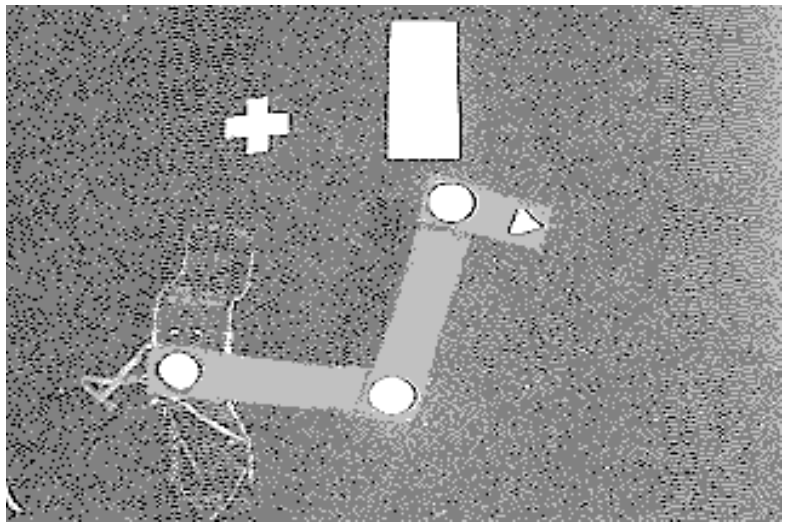
robot programming
evolutionary robotics

Examples

evolving robot arm programs
evolving programs for biped robots
learning automata
SET index forecasting







T = { s+, s-, e+, e-, w+, w-, HIT?, SEE?, INC?, DEC?, OUT?}.
F = { IF-AND, IF-OR, IF-NOT}.

(IF-AND w+ w+ e+ (IF-AND (IF-NOT (IF-NOT OUT? s- w+) (IF-AND e+ s- e-
(IF-OR (IF-NOT w+ s+ e+) s+ e- e-)) (IF-OR (IF-NOT SEE? w- e-) w+ e+ e+))
w- (IF-OR SEE? (IF-OR e- (IF-OR (IF-OR HIT? e+ s+ e-) INC? w- e-) s+ w+)
(IF-AND (IF-NOT w- e- e-) w- w- w+) s-) e+)))

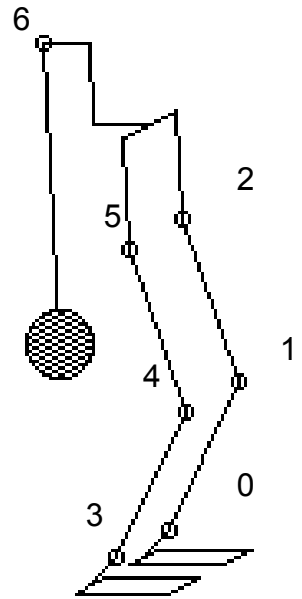


Fig. 3. Biped construction

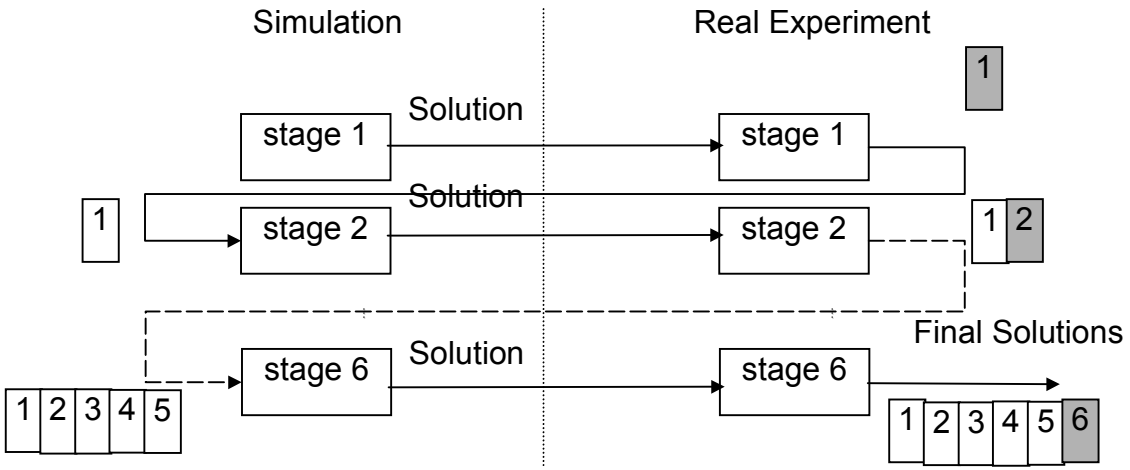


Fig. 5. Simulation + real world

Learning Automata

The problem of modeling the environment, that is, assuming a robot can sense and act in the world, models the world such that we can predict the consequence of the robot's action.

We conduct experiments on generating Finite State Machine from the observed sensing/action sequences.

Figure 1. Mimicking a FSM by observing its partial input/output sequences

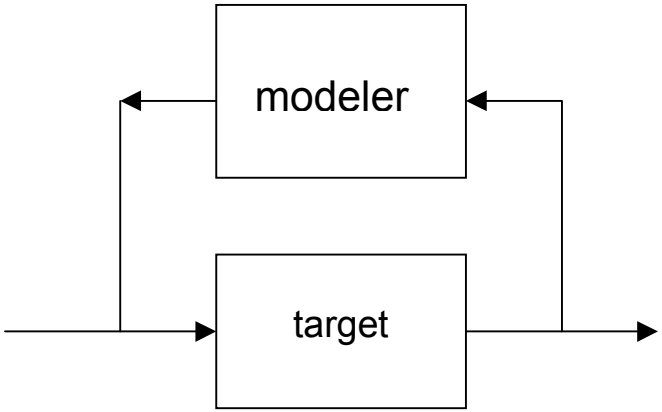


Table 1. Description of circuits in the experiment

Circuit	# of input bits	# of states		lower bound length		upper bound length
		Moore	Mealy	Moore	Mealy	
Frequency Divider	0	8	8	22	22	55
Odd Parity Detector	1	2	2	9	9	163
Modulo-5 Detector	1	6	5	45	35	163
Serial Adder	2	4	2	70	25	451

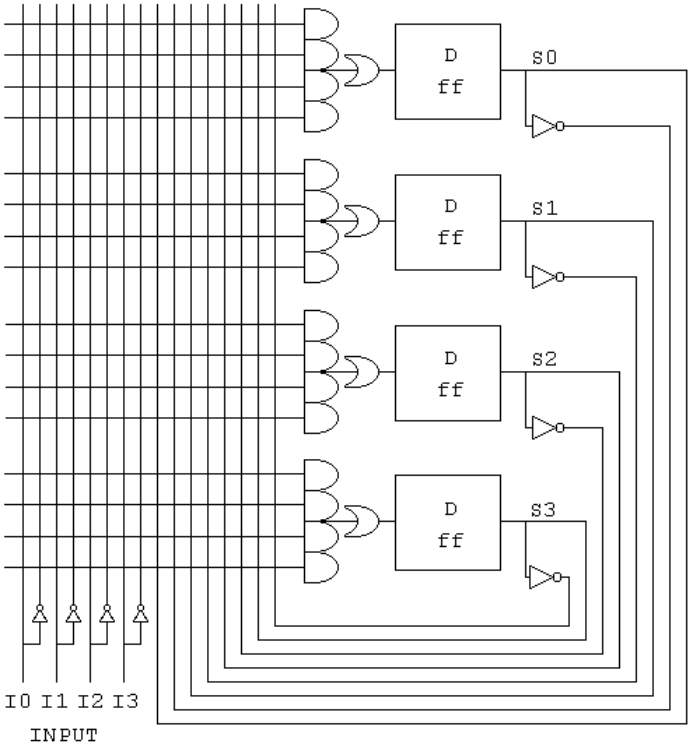
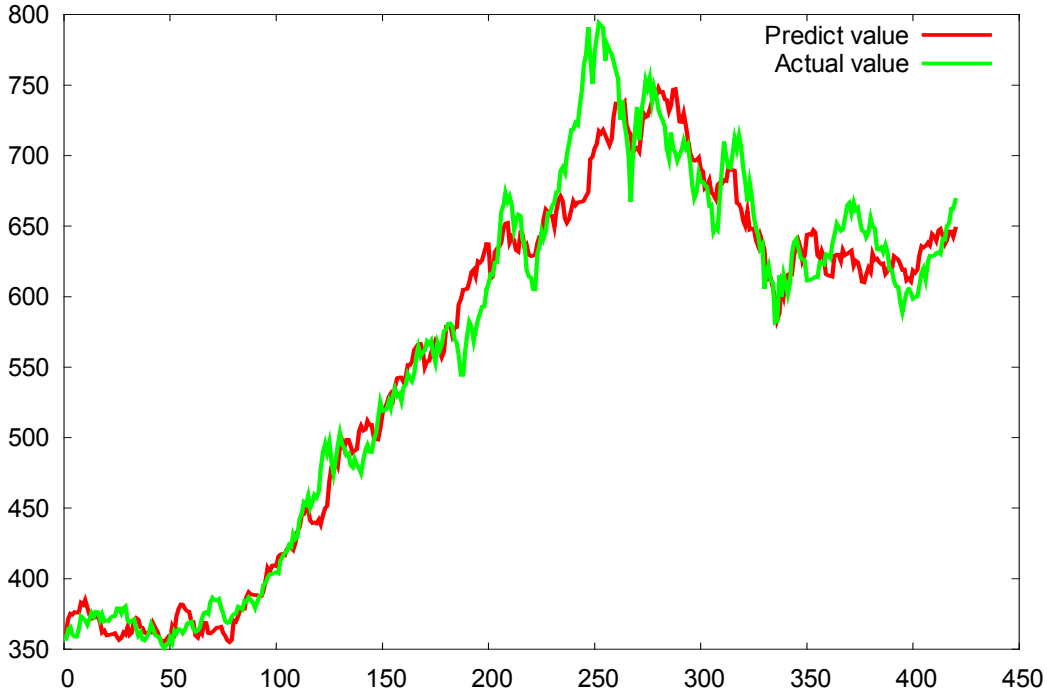
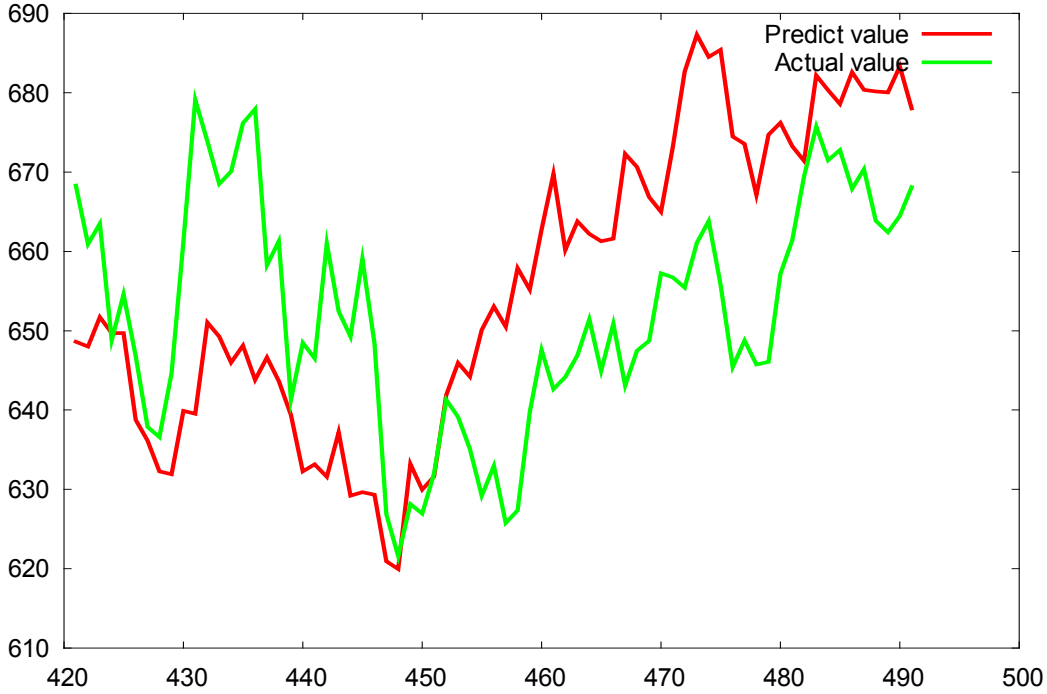


Figure 2. GAL structure used in the experiment

```
SET(t) =      2.3645 + 5.5208sin3(0.3138t-1) -
              1.5430hangseng(t-1) / -5.2054mlr(t-1) +
              2.8360cos2(0.6246t-1) * 4.6811sin(0.3651t-1) -
              1.5380cos3(0.7522t-1)-1.1618cos3(0.7724t-1) +
              3.3228sin3(1.5317t-1) - 2.4620cos(0.6676t-1) *
              2.3144mlr(t-1)
```



In an experiment with the stock exchange prediction, all daily data were obtained from two sources: the data of Thai stock index and Minimum Loan Rate from bank of Thailand and gold price data from Gold Trader Association. The series that used in the experiment started from January 2003 – December 2004, the data are 491 days. The data are divided into two groups: 420 days for training and 71 days for testing.


Predict value
Actual value
690
680
670
660
650
640
630
620
610
420
430
440
450
460
470
480
490
500

How far is AI from reaching human-level intelligence? When will it happen?

“A few people think that human-level intelligence can be achieved by writing large numbers of programs of the kind people are now writing and assembling vast knowledge basis of facts in the languages now used for expressing knowledge.

However, most AI researchers believe that new fundamental ideas are required, and therefore it cannot be predicted when human level intelligence will be achieved. “

John McCarthy

Future Research

My website
http://www.cp.eng.chula.ac.th/faculty/pjw/

References

Rimcharoen, S., Sutivong, D., and Chongstitvatana, P., "Curve Fitting Using Adaptive Evolution Strategies for Forecasting the Exchange Rate," Proc. of Electrical/Electronics, Computer, Telecommunications and Information Technology (ECTI) International Conference, Thailand, May 12-13, 2005.

Suwannik, W. and Chongstitvatana, P., "On-line evolution of robot program using a memoized function", IEEE Conf. on Mechatronics and Machine Vision in Practice, Chiangmai, Thailand, 10-12 Sept. 2002.

Niparnan, N. and Chongstitvatana, P., "An improved genetic algorithm for the inference of finite state machine", IEEE Int. Conf. on Systems, Man and Cybernetics, Vol.7, 2002, pp. 340-344, Tunisia, 6-9 Oct, 2002.

Suwannik, W. and Chongstitvatana, P., "Improving the robustness of evolved robot arm control programs with multiple configurations", 2nd Asian Symposium on Industrial Automation and Robotics, Bangkok, Thailand, May 17-18, 2001, pp.87-90.

Chaisukkosol, C. and Chongstitvatana, P., "Evolving control programs for a biped static walker", IEEE Inter. Conf. on Humanoid Robots, Waseda, Tokyo, November 22-24, 2001.

Chongstitvatana, P., Polvichai, J., "Learning a visual task by genetic programming", Proc. of IEEE/RSJ Inter. Conf. on Intelligent Robots and Systems, Osaka, Japan, 1996.

Introductory material

Goldberg, D., Genetic algorithms, Addison-Wesley, 1989.

Whitley, D., "Genetic algorithm tutorial", www.cs.colostate.edu /~genitor/MiscPubs/tutorial.pdf

www.aaai.org -- on Artificial Intelligence