SOFT COMPUTING AND OPTIMIZATION TECHNIQUES - INTRODUCTION

AP5251

What is Computing?

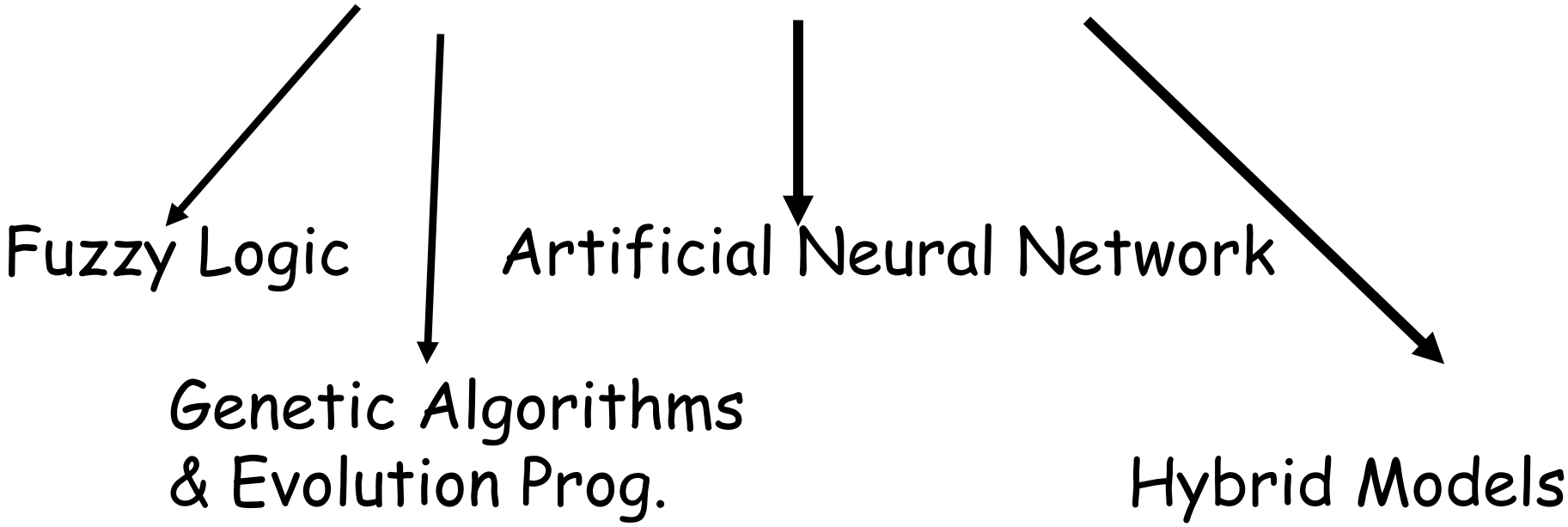
- *The discipline of computing is the systematic study of algorithmic* processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application.

- Types of computing
  - Hard computing
  - Soft Computing

What is Soft Computing (SC)?

- Soft Computing is a field that currently includes
- Fuzzy Logic
- Neural Networks
- Evolutionary computation (EC), including:
  - Evolutionary algorithms
    - Genetic algorithms; Differential evolution
- Meta-heuristic and Swarm Intelligence
  - Ant colony optimization; Particle swarm optimization
- Ideas about probability including:
  - Bayesian network
- Other related methodologies
  - Case-Based Reasoning
- Soft Computing combines knowledge, techniques, and methodologies from the sources above to create intelligent systems

Soft Computing Techniques and Application

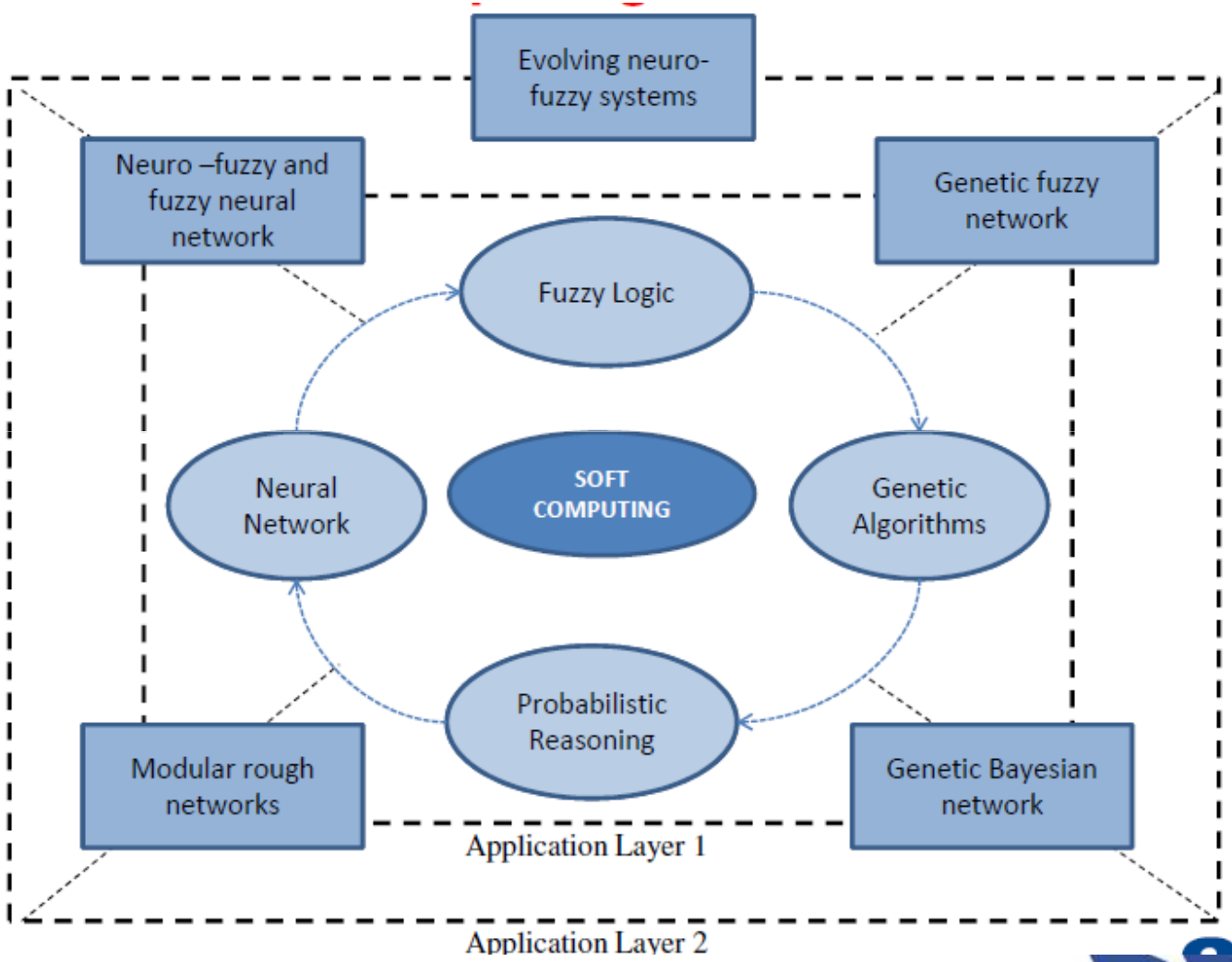


What is Soft Computing (SC)?

SC	=	EC	+	NN	+	FL
Soft Computing		Evolutionary Computing		Neural Networks		Fuzzy Logic
Zadeh 1981		Rechenbery 1960		McCulloch 1943		Zadeh 1965

EC	=	GP	+	ES	+	EP	+	GA
Evolutionary Computing		Genetic Programming		Evolution Strategies		Evolutionary Programming		Genetic Algorithms
Rechenbery 1960		Koza 1992		Rechenberg 1965		Fogel 1962		Holland 1970

What is Soft Computing (SC)?



Soft Computing

- “The essence of soft computing is that unlike the traditional, hard computing, soft computing is aimed at an accommodation with the pervasive imprecision of the real world. Thus, the guiding principle of soft computing is to exploit the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, low solution cost, and better rapport with reality” - Lotfi Zadeh

Hard Computing Vs oft Computing

Hard Computing	Soft computing
Precisely stated analytical model	Tolerant to imprecision, uncertainty, partial truth, approximation
Based on binary logic, crisp systems, numerical analysis, crisp software	Fuzzy logic, neural nets, probabilistic reasoning.
Programs are to be written	Evolve their own programs
Two values logic	Multi valued logic
Exact input data	Ambiguous and noisy data
Strictly sequential	Parallel computations
Precise answers	Approximate answers

How does SC Relate to Other Fields

What is AI?

"AI is the study of agents that exist in an environment and perceive and act." (S. Russell and P. Norvig)

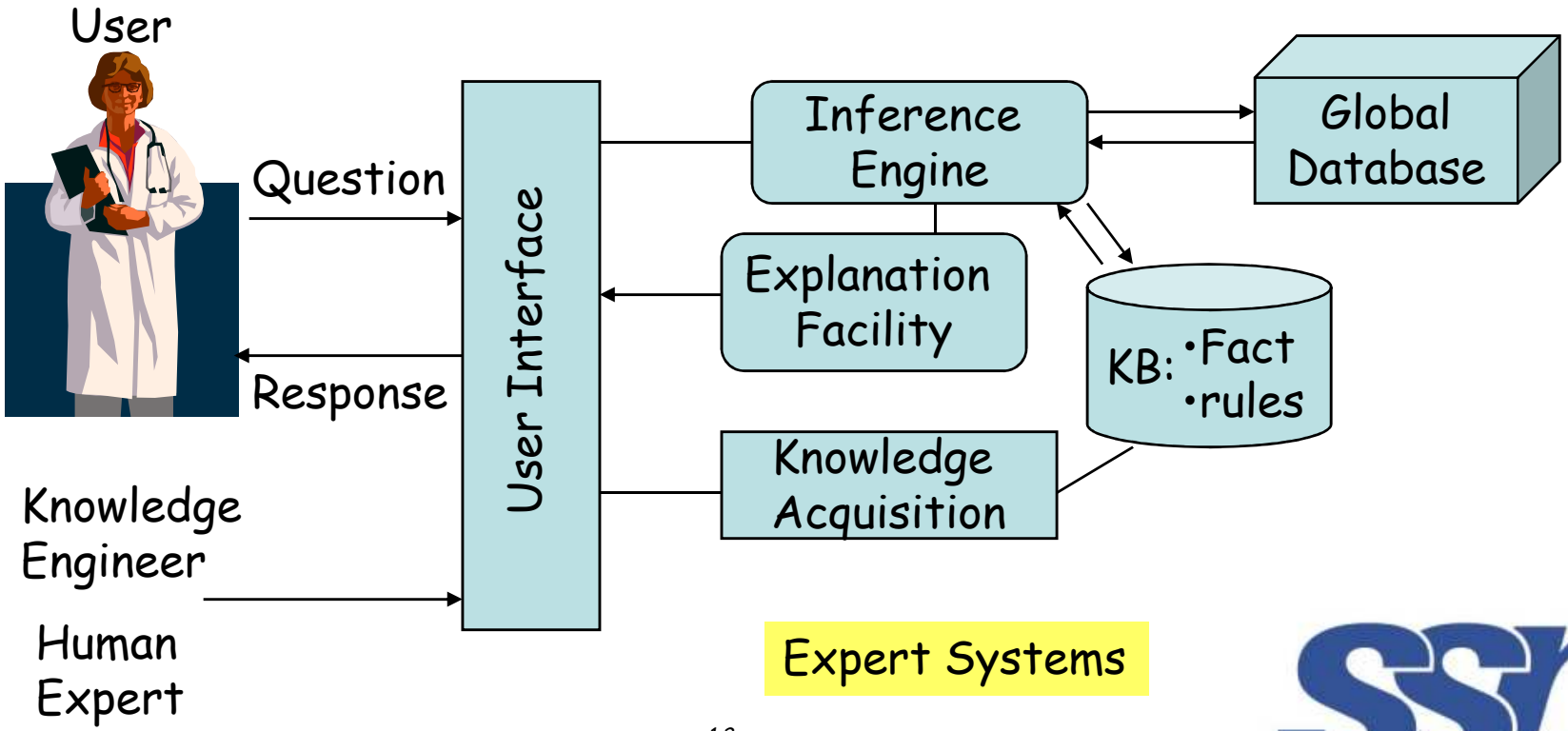
"AI is the art of making computers do smart things." (Waldrop)

"AI is a programming style, where programs operate on data according to rules in order to accomplish goals." (W. A. Taylor)

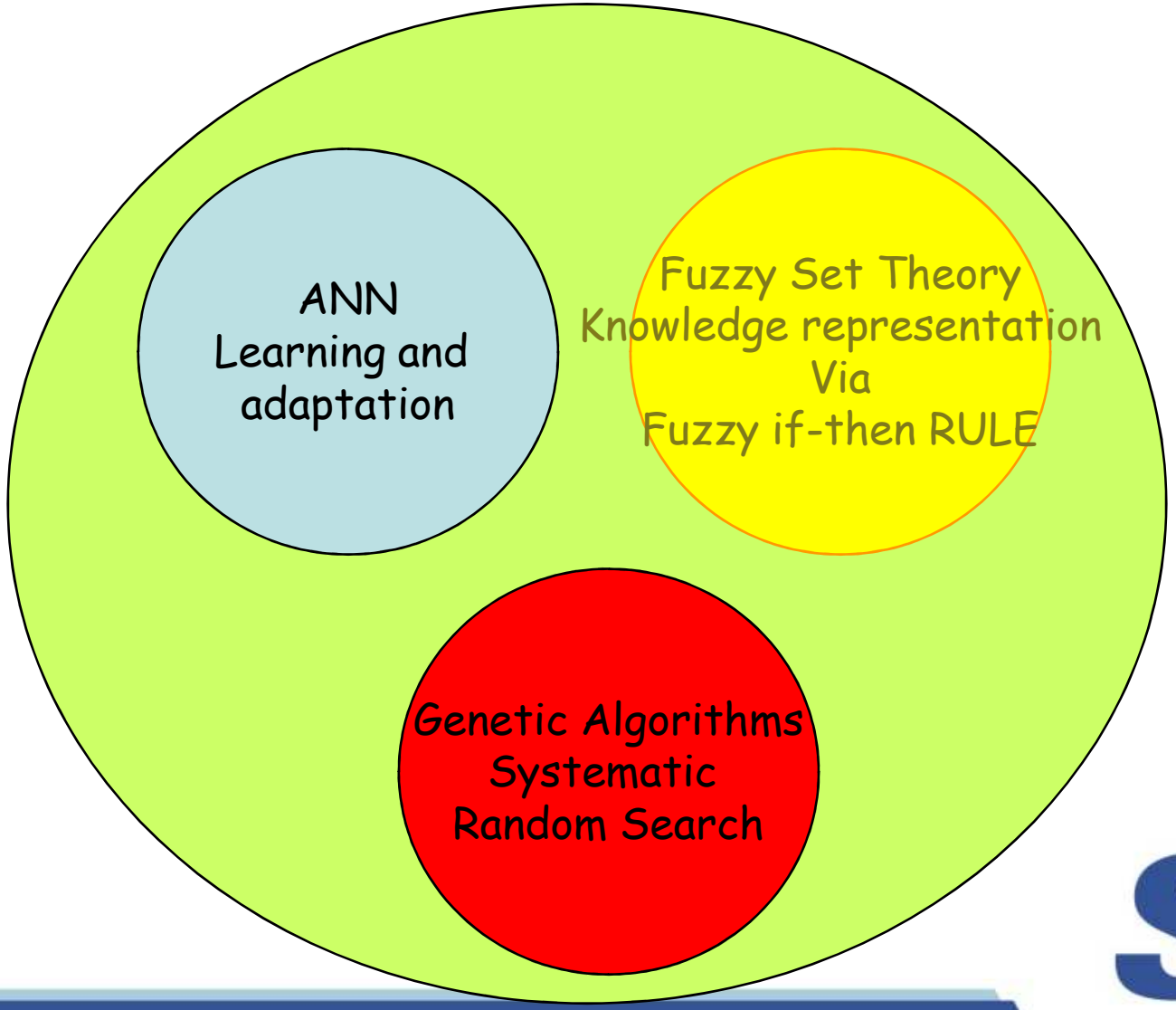
"AI is the activity of providing such machines as computers with the ability to display behavior that would be regarded as intelligent if it were observed in humans." (R. McLoed)

AI and Soft Computing: A Different Perspective

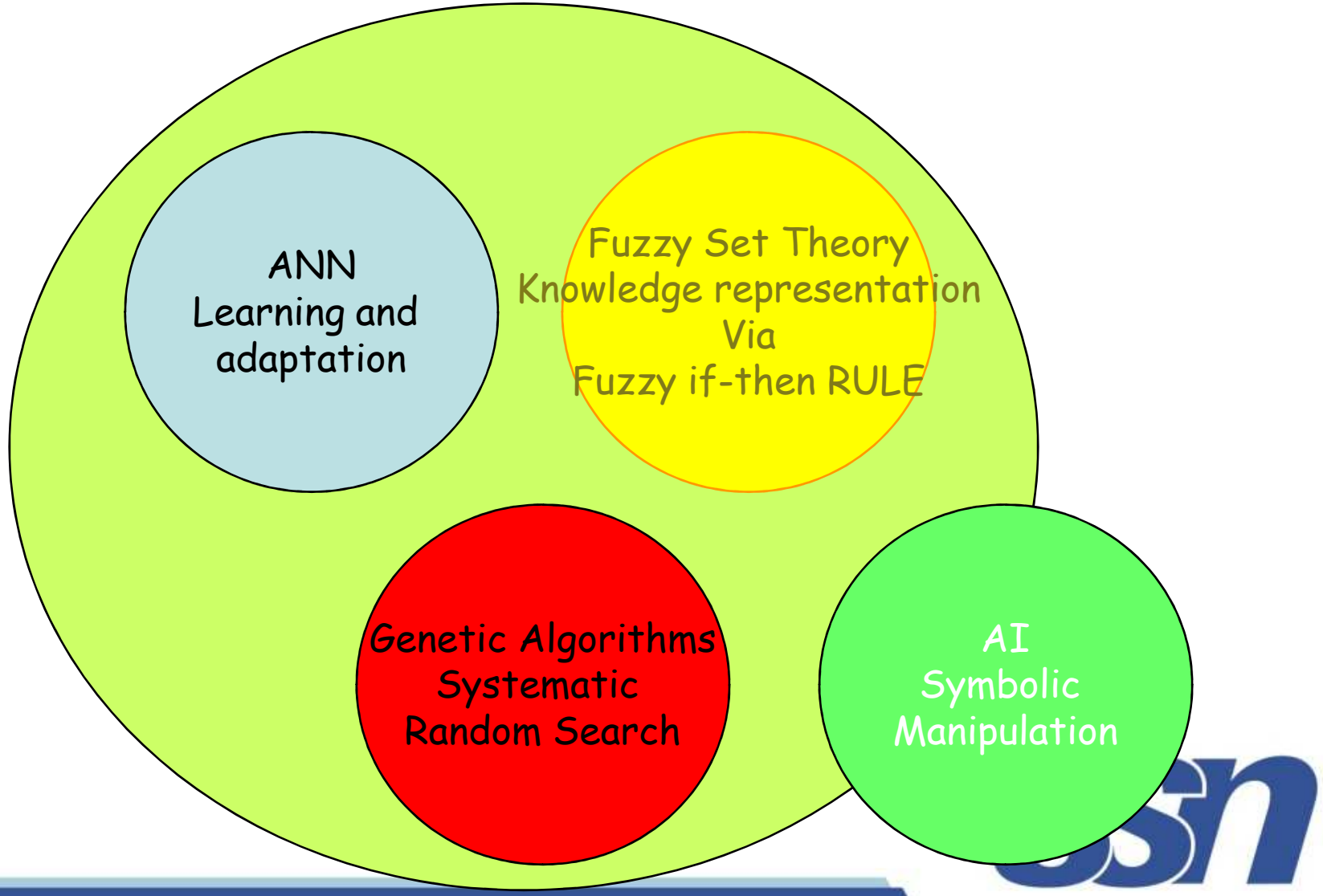
- AI: predicate logic and symbol manipulation techniques



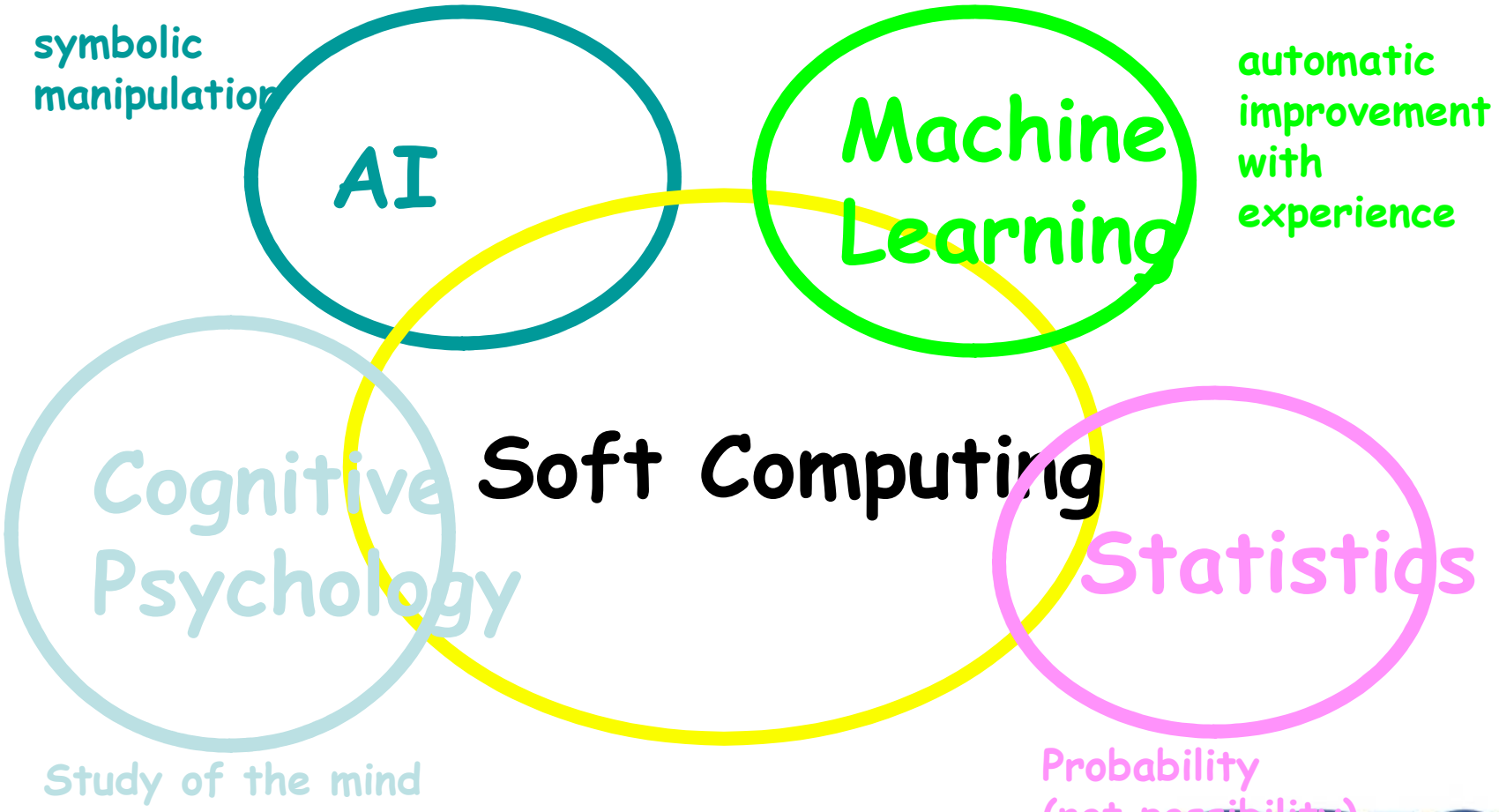
AI and Soft Computing



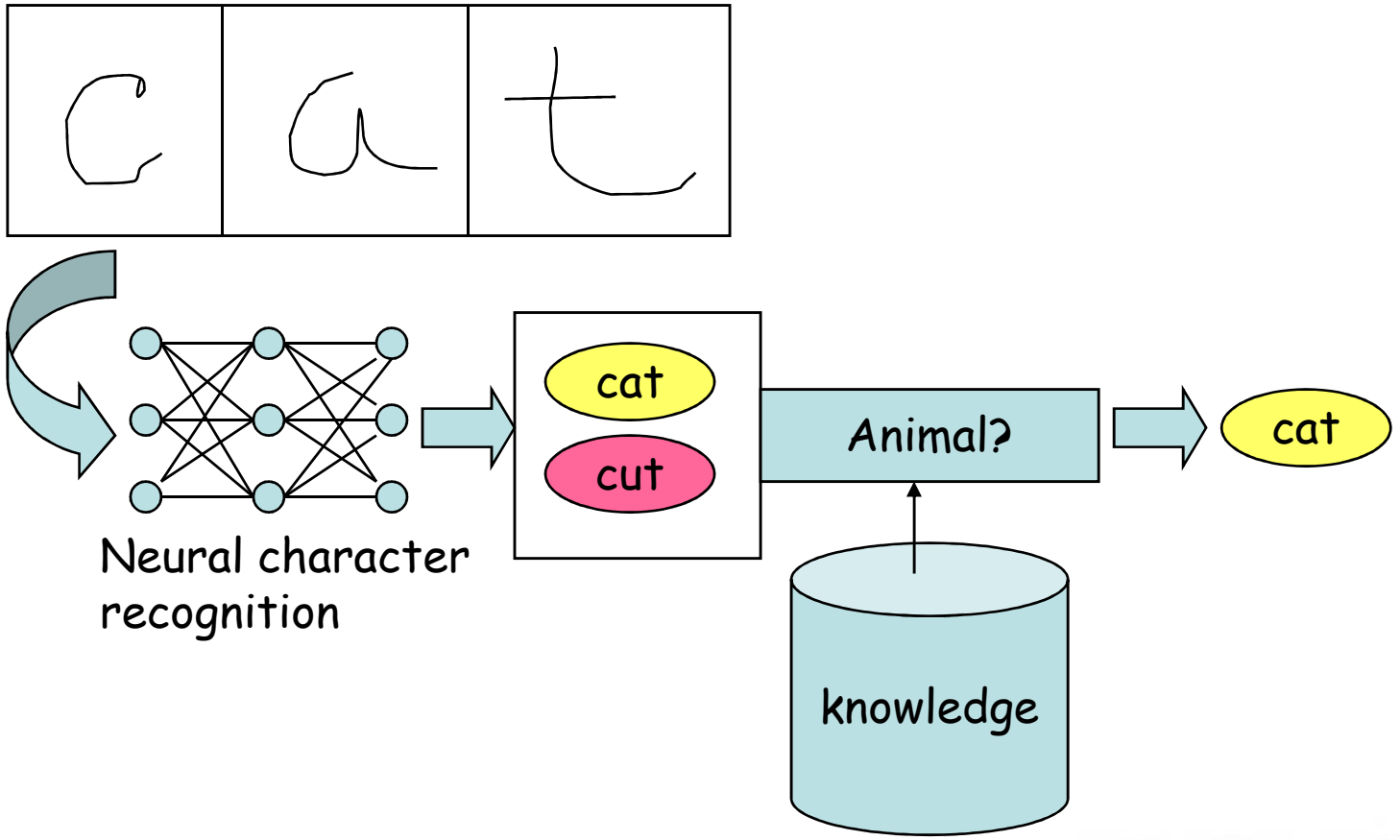
AI and Soft Computing



How does SC relate to other fields?



AI and Soft Computing - Example



Artificial Intelligence Vs Soft Computing

Methodology	Strength
Neural network	Learning and adaptation
Fuzzy set theory	Knowledge representation via fuzzy if-then rules
Genetic algorithm and simulated annealing	Systematic random search
Conventional AI	Symbolic manipulation

SC Techniques

- Neural Networks (NN) that recognize patterns & adapts themselves to cope with changing environments
- Fuzzy inference systems that incorporate human knowledge & perform inference & decision making

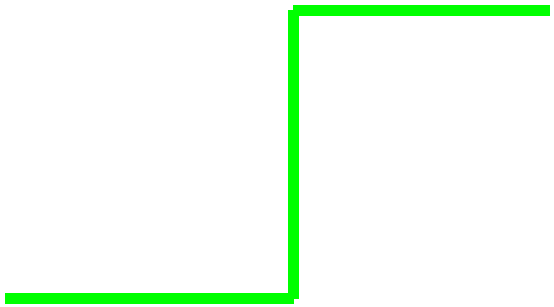
  Adaptivity + Expertise = NF & SC
- Optimization methods such as genetic algorithms (GA) & simulated annealing (SA), Particle Swarm Optimization etc

Fuzzy Logic

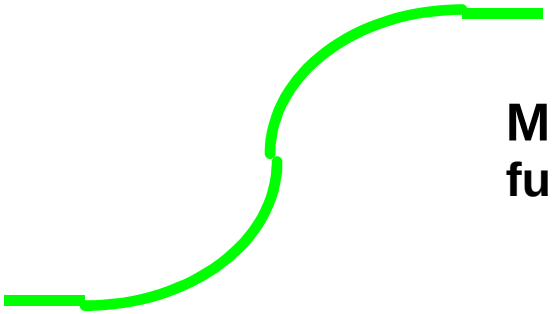
- Sets with fuzzy boundaries

A = Set of tall people

Crisp set A



Fuzzy set A



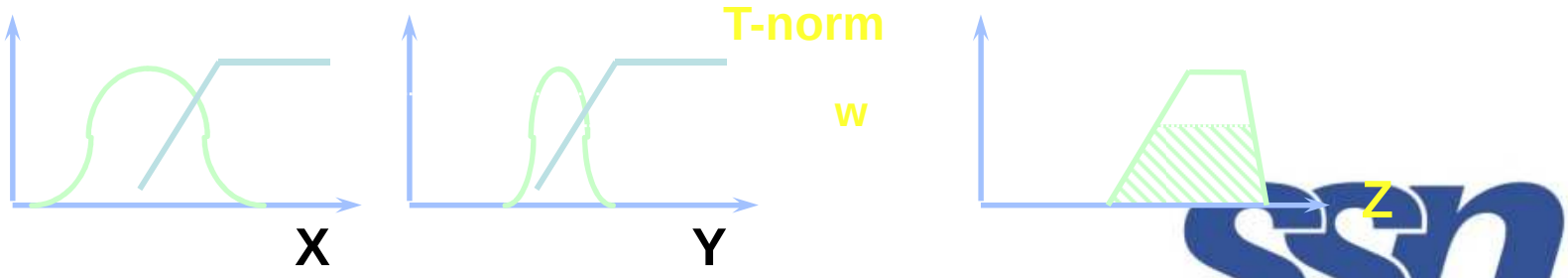
Membership function

Fuzzy set theory

Fuzzy set theory provides a systematic calculus to deal with imprecise or incomplete information

Fuzzy if-then rules are used in fuzzy inference systems

If <1> is tall and <1> is athletic then <1> is good basketball player.



Neural Networks

- Pattern matching technique where input patterns are matched with a specific output pattern. Modeled after the neurons in the brain.

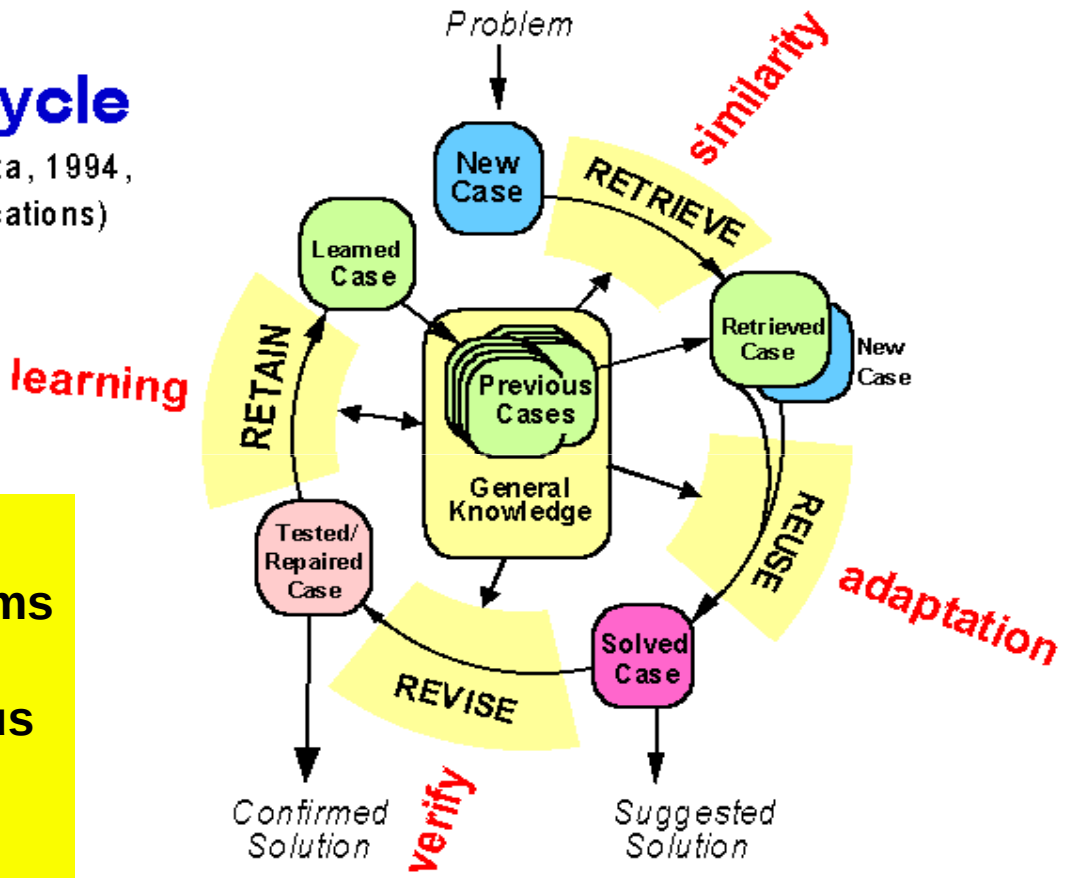
Network architecture

Weights on the links

Case-Based Reasoning

CBR Cycle

(Aamodt & Plaza, 1994, AI Communications)



A methodology of solving new problems by adapting the solutions of previous similar problems

Models the way experts reason using their experience

Soft Computing is a Hybrid Method

dog

Soft Computing Characteristics

Human Expertise (if-then rules, cases, conventional knowledge representations)

Biologically inspired computing models (NN)

New optimization techniques (GA, simulated annealing)

Model-free learning (NN, CBR)

Fault tolerance (deletion of neuron, rule, or case)

Real-world applications (large scale with uncertainties)