Artificial Intelligent systems

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Introduction

- AI
- Machine learning / expert systems / Pattern recognition systems
- Computational Intelligence
    - ANN, FL, EC
    - Hybrid intelligent systems
- Applications:
    - Prediction
    - Classification
    - Optimization

Definition of Intelligence

Webster's New Collegiate Dictionary defines intelligence as "**1a**
(1) : The ability to learn or understand or to deal with new or trying situations : REASON; *also* : the skilled use of reason
(2) : the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (as tests)."

Another Definition of Intelligence

The capability of a system to adapt its behavior* to meet its goals in a range of environments. It is a property of all purpose-driven decision makers.

- David Fogel

* implement decisions

Artificial Intelligence

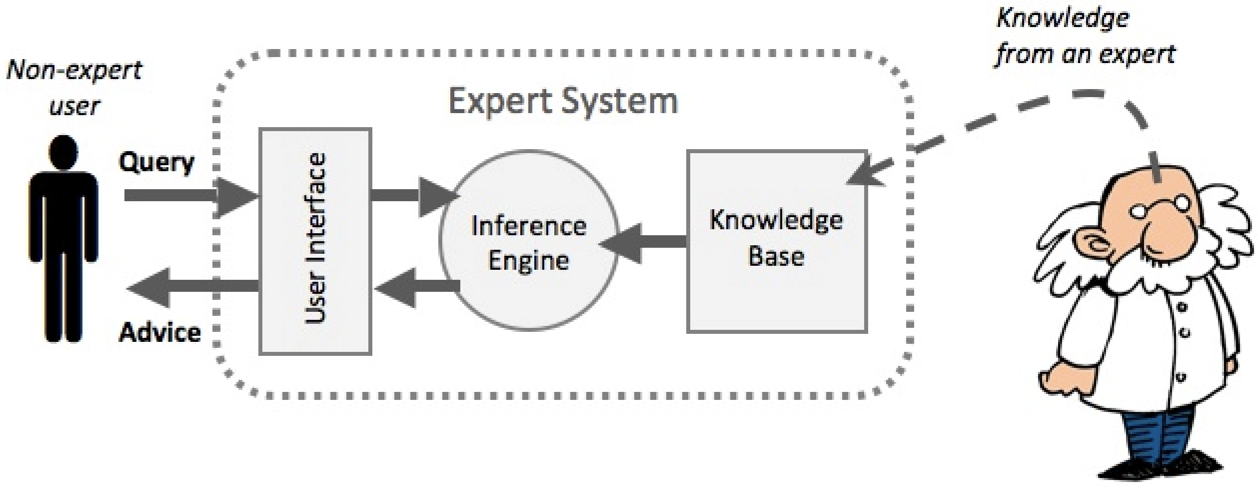
- Webster dictionary - Study of how to produce *machines* that have some of the qualities that the human mind has, such as the abililty
  - to understand language,
  - recognize pictures, solve problems, and learn

Making machines intelligent

- How can we build machines that can become intelligent by using data available:
- Some of the systems are called as:
  - Expert systems
  - Machine learning systems
  - Pattern recognition systems.

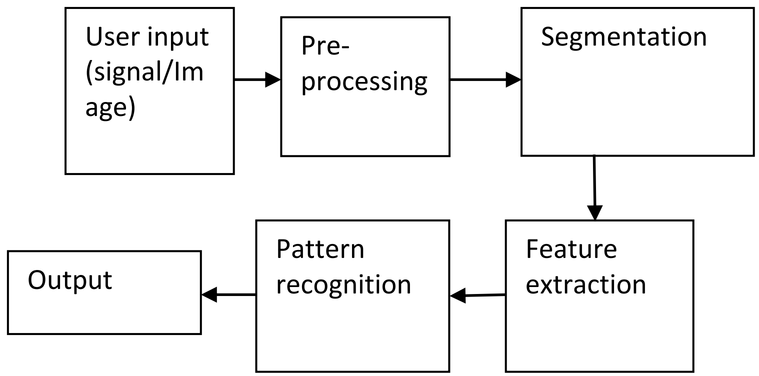
Expert systems

- Inference engine extracts IF THEN type of rules
- Also called as rule based systems.

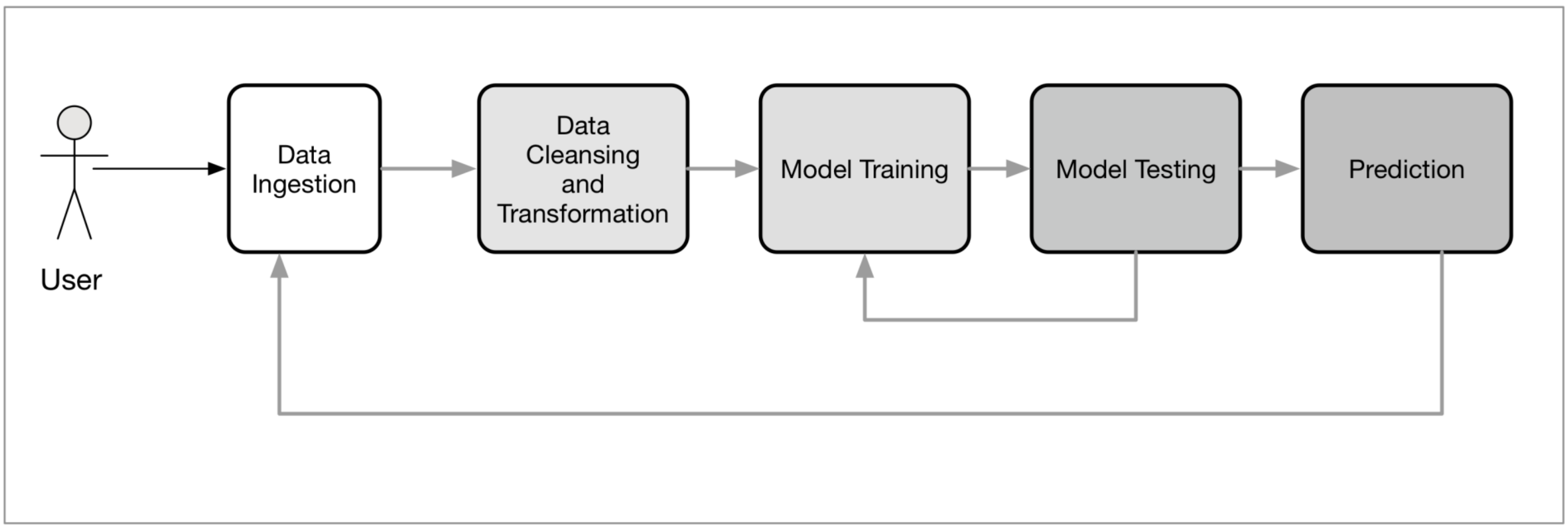


Pattern recognition system

- Usually signal /Image data used



Machine learning systems



Supervised, Unsupervised and reinforcement learning

Tools for making human like intelligent systems

Uncertainity in data

- **Uncertainities** arises from deficiencies in data available
- **Human perception** – measurements are crisp whereas human perception is fuzzy*
- **Need algorithms** for dealing with imprecision, vagueness, uncertainity, approximate reasoning and partial truth.
  - Human like decision making capabilities => Computation intelligence

L. A. Zadeh, "From computing with numbers to computing with words from manipulation of measurements to manipulation of perceptions," *IEEE Trans. Circ. and Syst.,* 1999.

Example

- ***Parking a Car :*** Generally, a car can be parked rather easily because the final position of the car is not specified exactly. If it were specified to within, say, a fraction of a millimeter, it would take hours or days of maneuvering and precise measurements of distance and angular position to solve the problem.
  - High precision carries a high cost
- The challenge is to exploit the tolerance for imprecision by devising methods of computation which lead to an acceptable solution at low cost.
- Computational Intelligence (Soft computing)

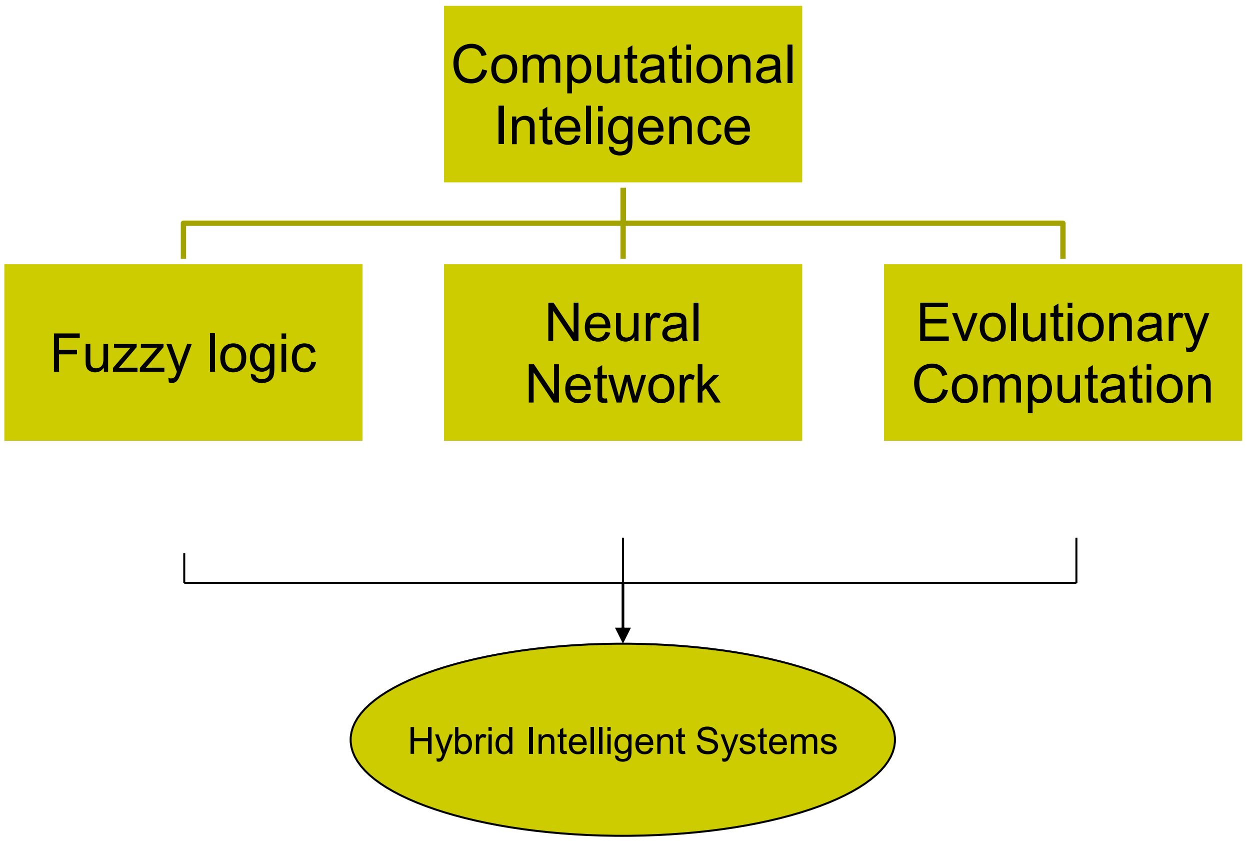
Tools for making human like intelligent systems

- Bio/Human-inspired computational tools:
  - Search -Evolutionary computation
  - Learning - Neural Networks
  - Logic and deduction - Fuzzy logic
  - Hybridization of the tools - Shortcoming of each technique may be overcome by combining

Computational Intelligence

- Computational intelligence (CI) is a successor of Artificial Intelligence.
- CI relies on nature inspired algorithms such as Fuzzy systems, Neural Networks and Evolutionary computation.
- CI combines elements of learning, adaptation, evolution to create intelligent programs / Systems.

Computational Intelligence



Origins in biological systems

Origins in biological systems.
– Artificial neural networks: model biological
neural systems.
– Evolutionary computation: model the process of natural evolution.
– Swarm intelligence: model social behavior
of organisms living in swarms or colonies.
– Fuzzy logic: model the vagueness of human reasoning in the environment.

Hard vs. Soft computing

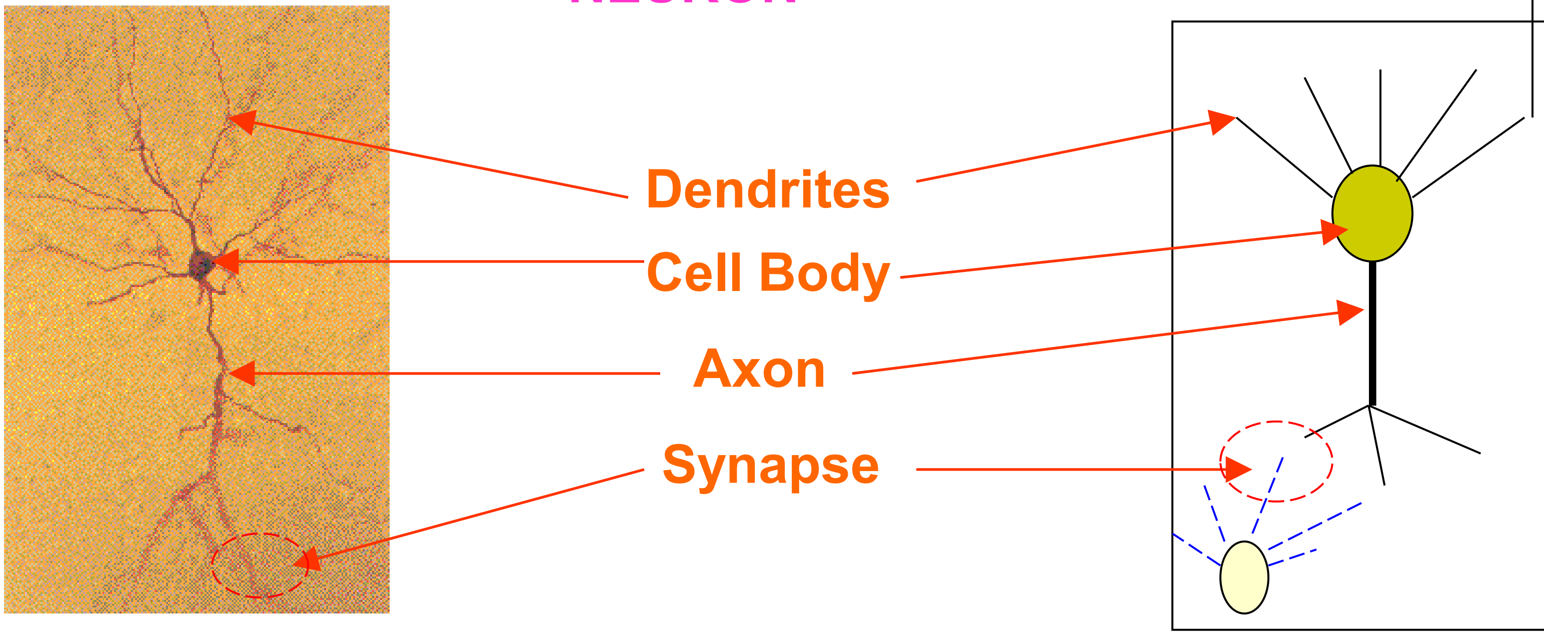
- Hard computing or *conventional computing* requires precise model and is based on binary logic and numerical analysis.
- Cannot evolve its own programs
- Requires exact imput data

- Tolerant to imprecision, uncertainity and partial truth much like human mind. Based upon fuzzy logic and neural networks.
- Evolve own programs by evolutionary computing
- Can take in ambigous and noisy data

Artificial Neural Neworks

- A broad class of models that mimic functioning inside the human brain
- There are various classes of NN models.
- They are different from each other depending on
  - Problem types
    Prediction, Classification , Clustering
  - Structure of the model
  - Model building algorithm
- Example: Feed-forward Multi Layered Neural Network - Is used for Prediction and Classification problems

Most important functional unit in human brain – a class of cells called – **NEURON**



Hippocampal Neurons
Source: heart.cbl.utoronto.ca/ ~berj/projects.html

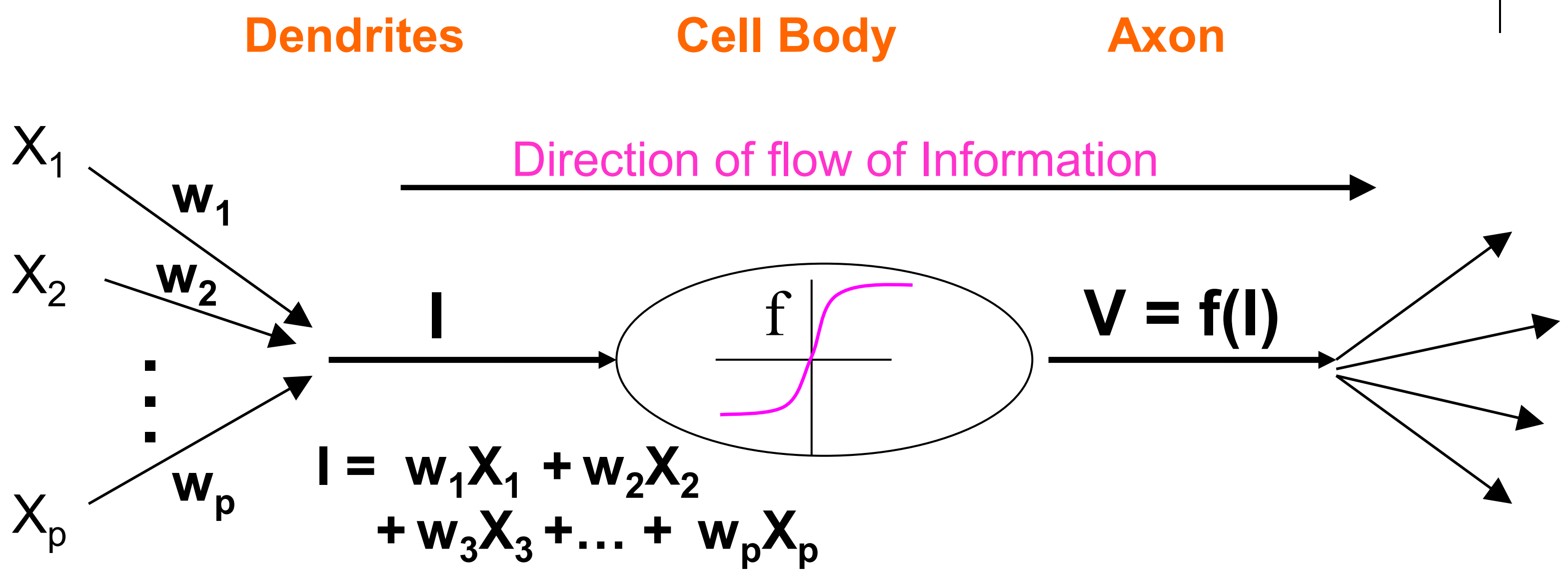
Schematic

- **Dendrites** – Receive information
- **Cell Body** – Process information
- **Axon** – Carries processed information to other neurons
- **Synapse** – Junction between Axon end and Dendrites of other Neurons

ANN -

- Artificial neural networks (ANN) are nonlinear information (signal) processing units
- Built from interconnecting elementary processing units called neurons.
- An artificial neuron is a pinput singleoutput signal processing element which can be thought of as a simple model of a non-branching biological neuron.

Artificial Neuron



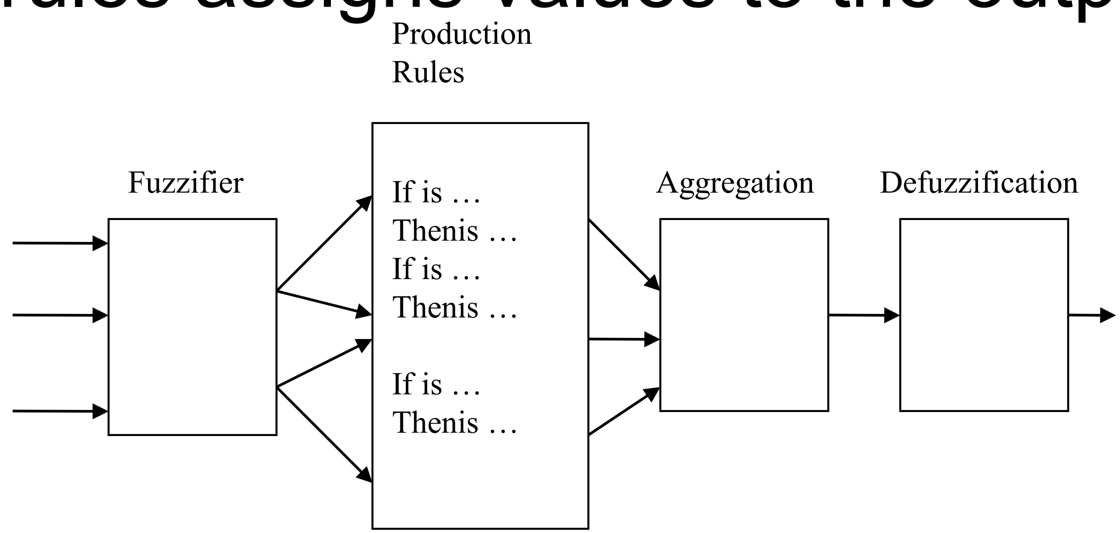
- *Receives Inputs X_1 X_2 … X_p from other neurons or environment*
- *Inputs fed-in through connections with 'weights'*
- *Total Input = Weighted sum of inputs from all sources*
- *Transfer function (Activation function) converts the input to output*
- *Output goes to other neurons or environment*

Fuzzy logic

- Much of the information taken is not very precisely defined - fuzzy input
- Fuzzy algorithms use "If-Then rules" stated in human language to process and combine Fuzzy and precise information together.
- Output is created by dufuzzifying.

Components – Fuzzy Logic

- *Fuzzy logic* gives us a mechanism for mapping input to output based upon a set of ”if-then” rules.
- *Fuzzy inference system (FIS)* interpresses the value in the input and based upon the set of ”if then” rules assigns values to the output vector.



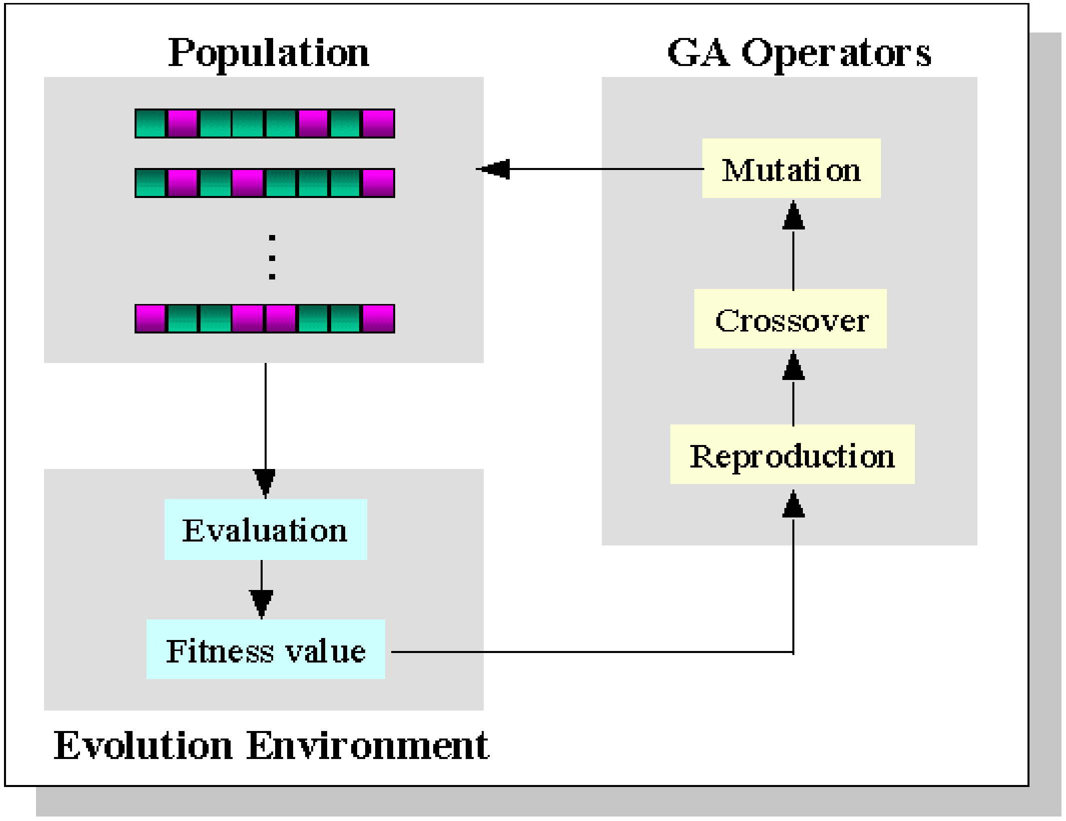
Evolutionary Computatation

- Search algorithms inspired from nature
- Computer programs that draw inspiration from natural evolution process.
- Darwin – principle of natural evolution

Examples

- Genetic Algorithm based upon 2 main principles
  - Survival of the fittest.
  - Population Variation.
- Particle Swarm Optimization (PSO)
  - Swarm optimization

Flow Chart



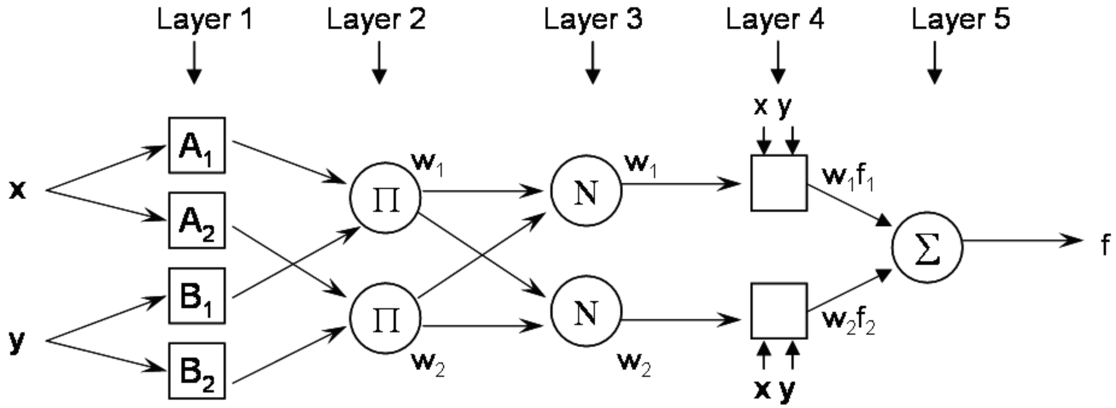
Population
GA Operators
Mutation
Crossover
Reproduction
Evaluation
Fitness value
Evolution Environment

Synergism in CI

- Each tool (ANN, GA; FL) has its own pros and cons
- Fuzzy logic
  - Good for appx. Reasoning
  - Not so good for optimization
- Synergetic sysnthesis gives rise to better tools – Hybrid intelligent systems
  - Complement limitation of one tool

Ex. Strongly coupled (Integrated)-Hybrid Intelligent Systems (HIS)

- Hybrid intelligent systems(HIS): Combines *learning capabilities* of ANN and *reasoning capabilities* of Fuzzy Logic for enhanced adaptive modeling. *Example:* ANFIS (Adaptive Neuro Fuzzy Inference System)



Benefits of using CI

- Not based on assumptions on pdf or distributions (can be imprecise)
- Ability to handle
  - nonlinearity and imprecision in data.
  - noisy and missing values better.
- Learning (ANN) and reasoning (FIS) capabilities much like human functioning.
- Derivative free optimization (EC) learnt from examples from nature.

Real life problems

Robotics

- **Robotics** : How can we predict the location of tumor at the time of radiation therapy ?

Medicine

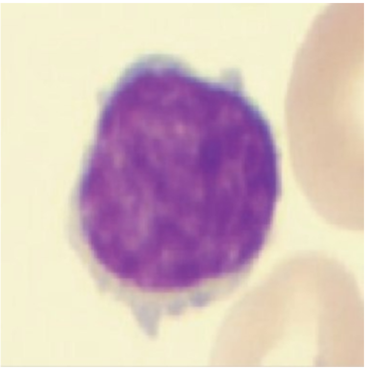
- How can we predict early treatment of patients without waiting for 5 yrs

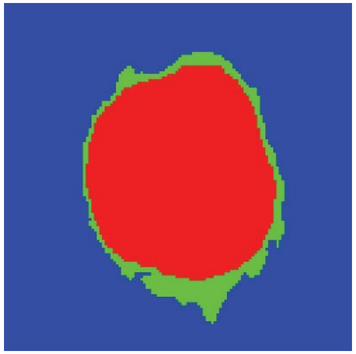
Images

- How can we find (small) hidden structures in images like oil spills/ bridges/structures in cell images ?

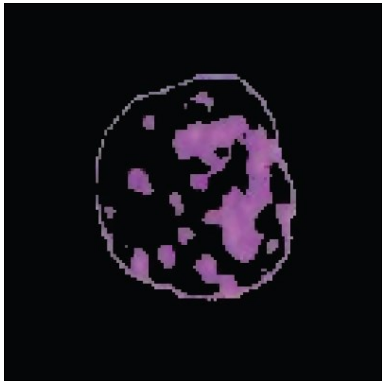
Blood smear image segmentation

- Blood cell image - Uncertainty arises due to color pixel similarity between cytoplasm and background (plasma) region.





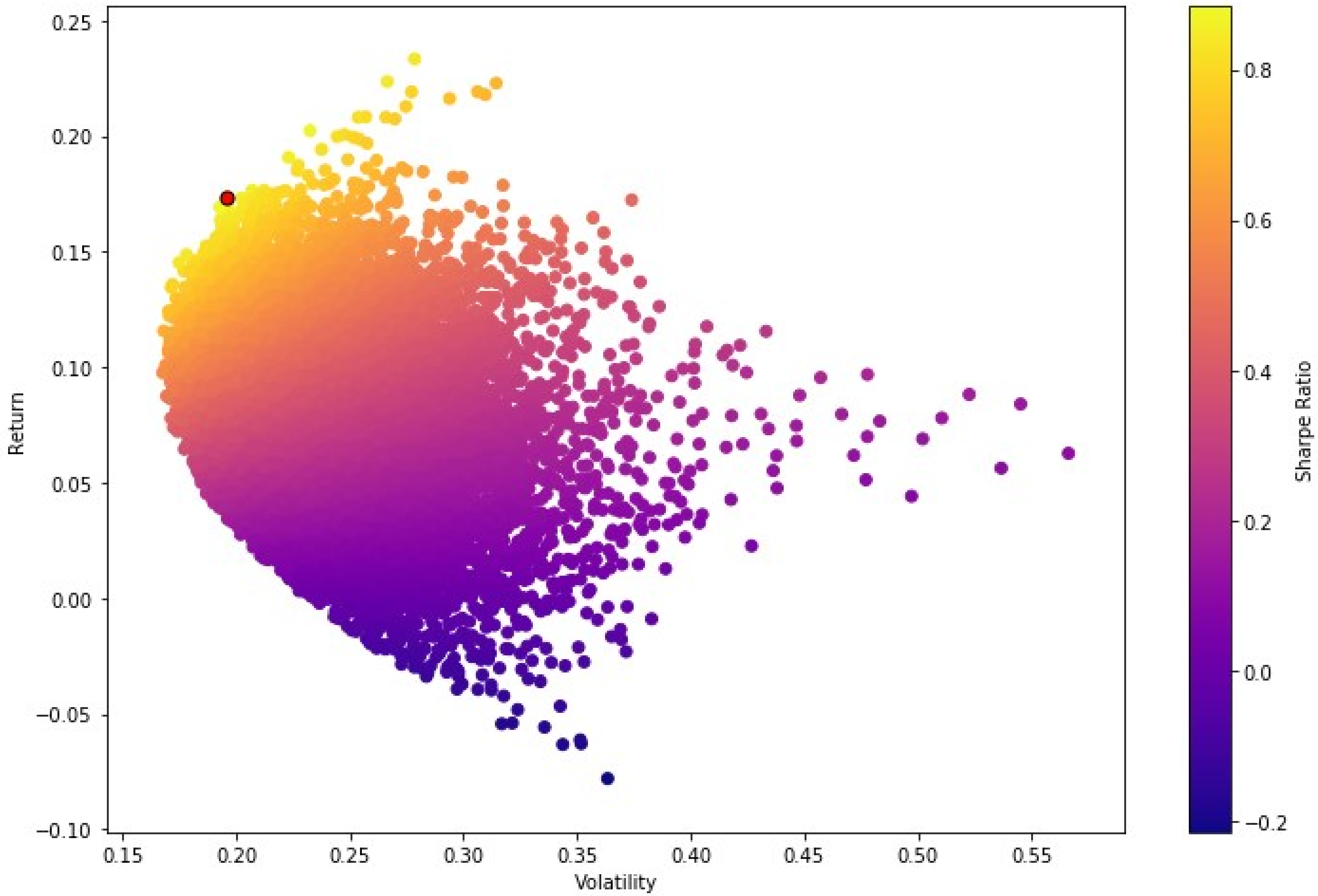
G. Truth



K-Means

FRCM

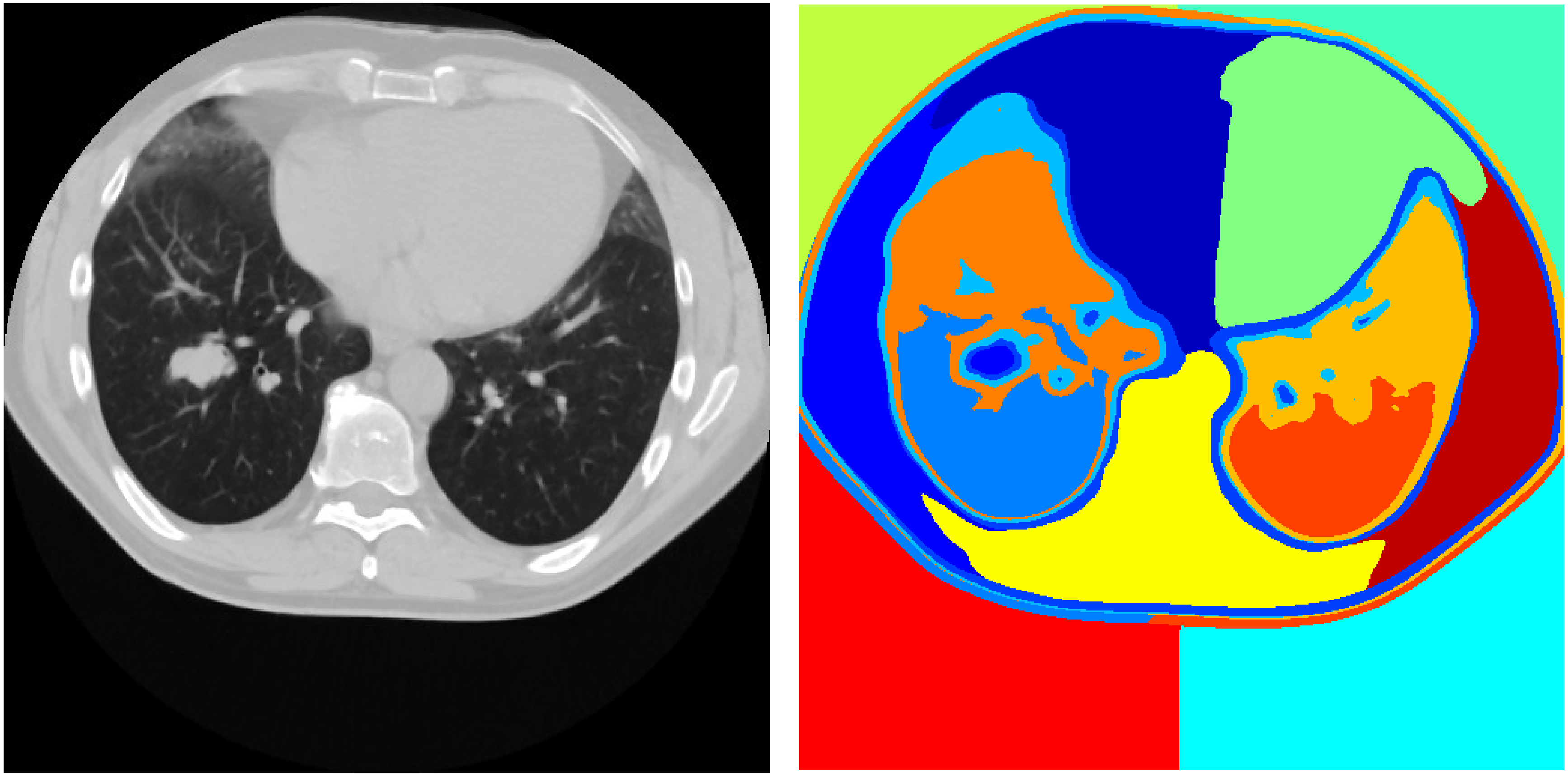
Oslo Bors – 5 companies



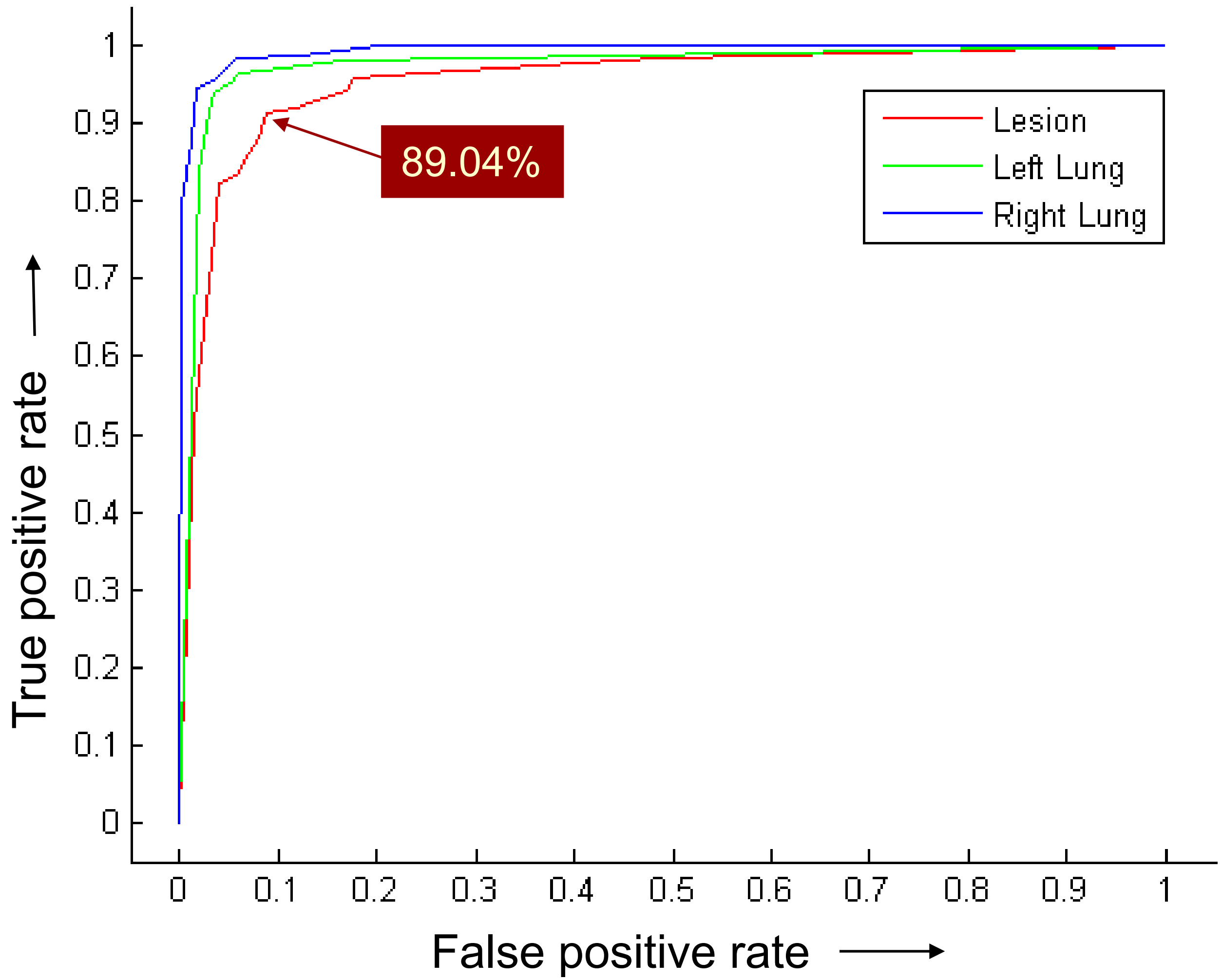
Examples of solution

- Pattern recognition system for

Pattern recognition system – Fuzzy c means clustering



Receiver Operating Curve (ROC)



Pattern recognition system

Actual vs. Predicted classes	LLUP	LLLO	LLOP	LLIP	RLUP	RLLO	RLOP	RLIP	LEIN1	LEOP 1	LEIP1	BACK
LLUP	97.40	-	-	2.60	-	-	-	-	-	-	-	-
LLLO	-	94.0	-	-	2.80	3.20	-	-	-	-	-	-
LLOP	-	-	98.80	-	-	-	1.20	-	-	-	-	
LLIP	-	-	-	100	-	-	-	-	-	-	-	-
RLUP	-	7.80	-	-	86.60	3.20	-	-	-	-	-	2.40
RLLO	-	-	-	-		100	-	-	-	-	-	-
RLOP	-	-	-	0.20	-	-	5.60	94.20	-	-	-	-
RLIP	-	-	-	0.60	-	-	4.0	94.60	0.80	-	-	-
LEIN1	-	-	-	-	-	-	2.20	-	97.80			-
LEOP 1	-	-	-	-	-	-	-	-	-	100	-	-
LEIP 1	-	-	-	-	-	-	-	-	1.0	-	99.0	-
BACK	-	-	-	-	-	-	-	-	-	-	-	100

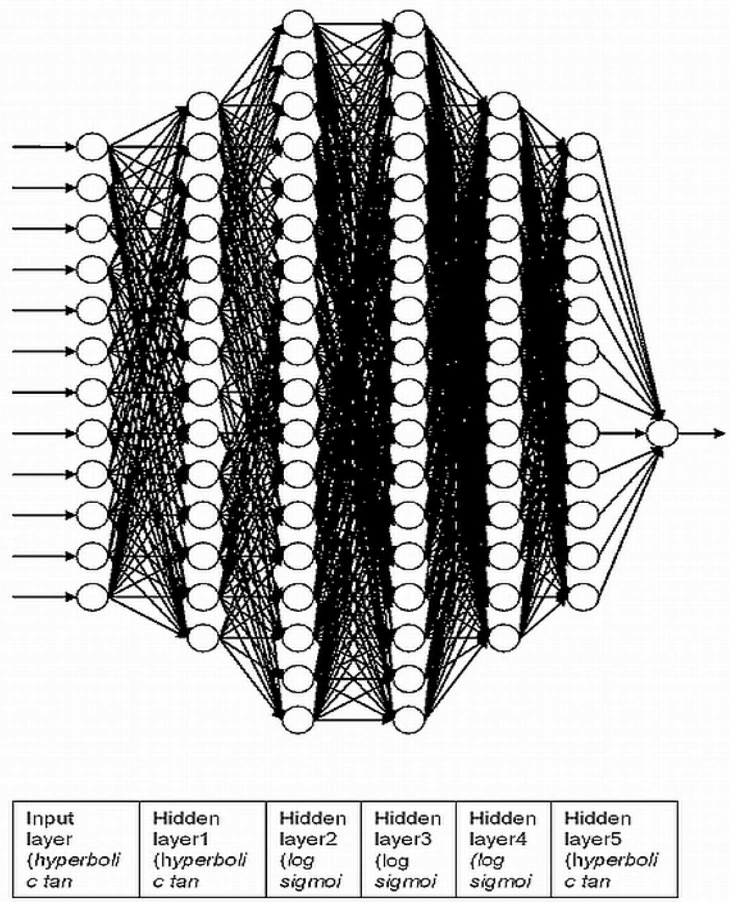
Machine learning system – example - ANN

- To check the feasibility of using back propagation neural network (BPNN) for predicting early treatment response by using mean apparent diffusion coefficient (ADC) values obtained from diffusion weighted magnetic resonance imaging

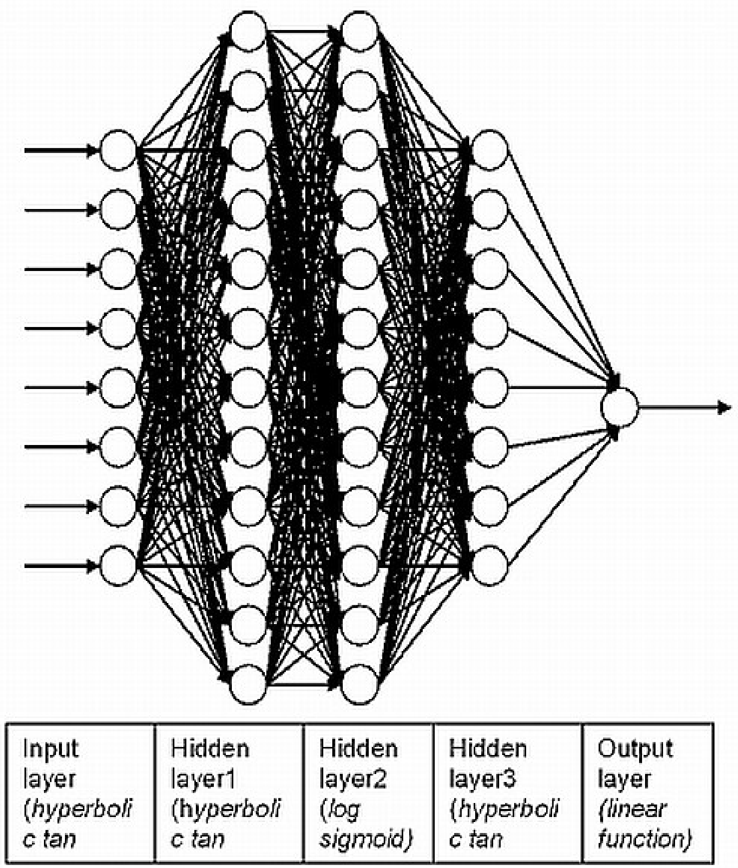
Data Collection

- Mice bearing X29 xenografts were allocated in 6 different treatment groups.
- They received different combinations of daily chemoradiation and/or radiotherapy for 2 weeks.
- DWMRI images were acquired and mean ADC values were calculated before, during and after treatment.
- ADC values from 6 weeks *(days 0,4,11,18, 25,32,46)* and treatment groups (1-6) were then used as input for BPNN analysis.

2 Different BPNN Arch.

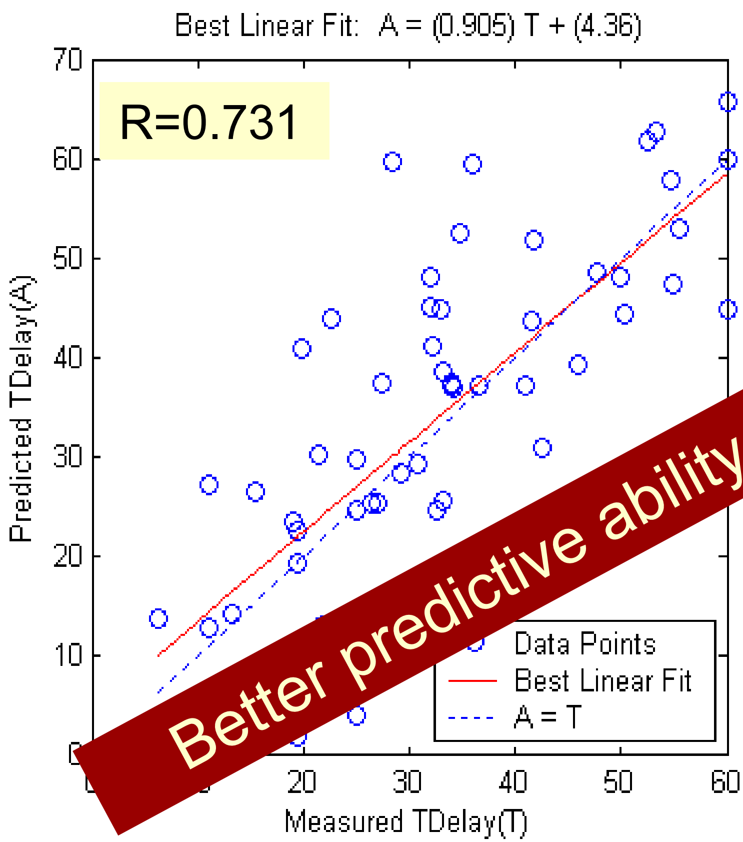


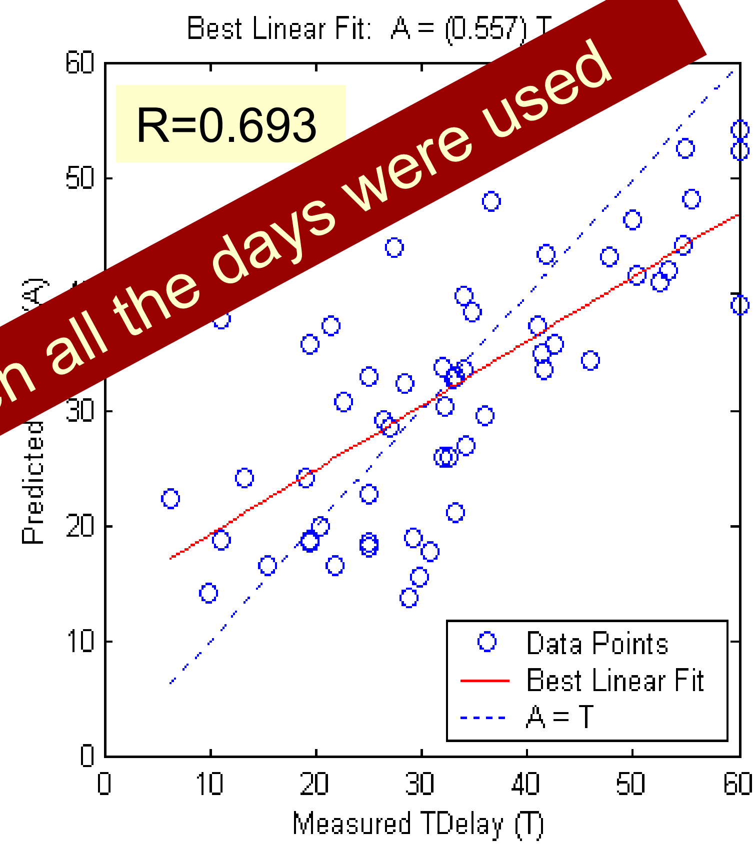
(days 0, 4,11,18, 25, 32 and 46)



(days 0,4,11)

Results



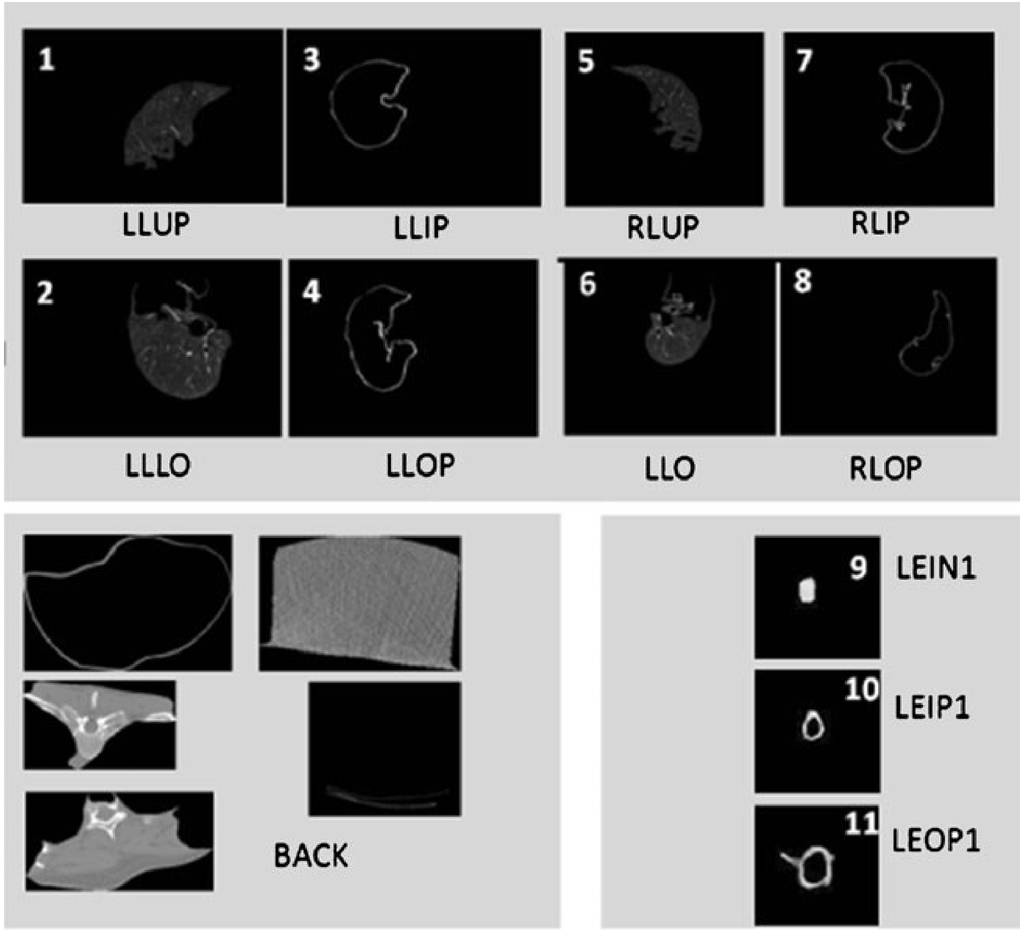


Better predictive ability when all the days were used

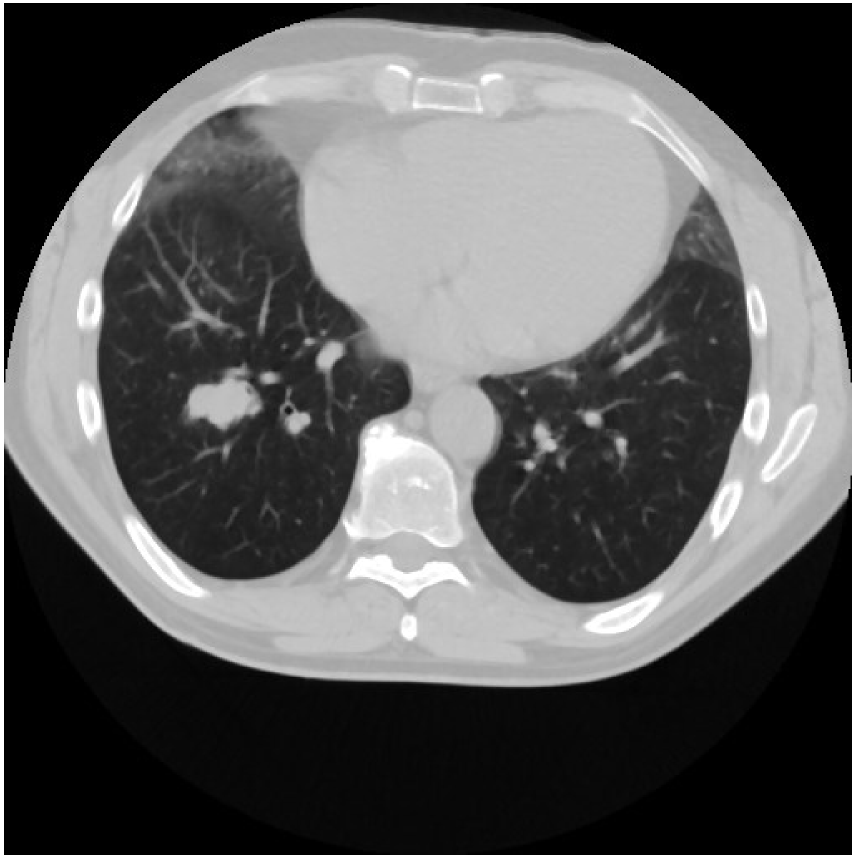
Conclusions

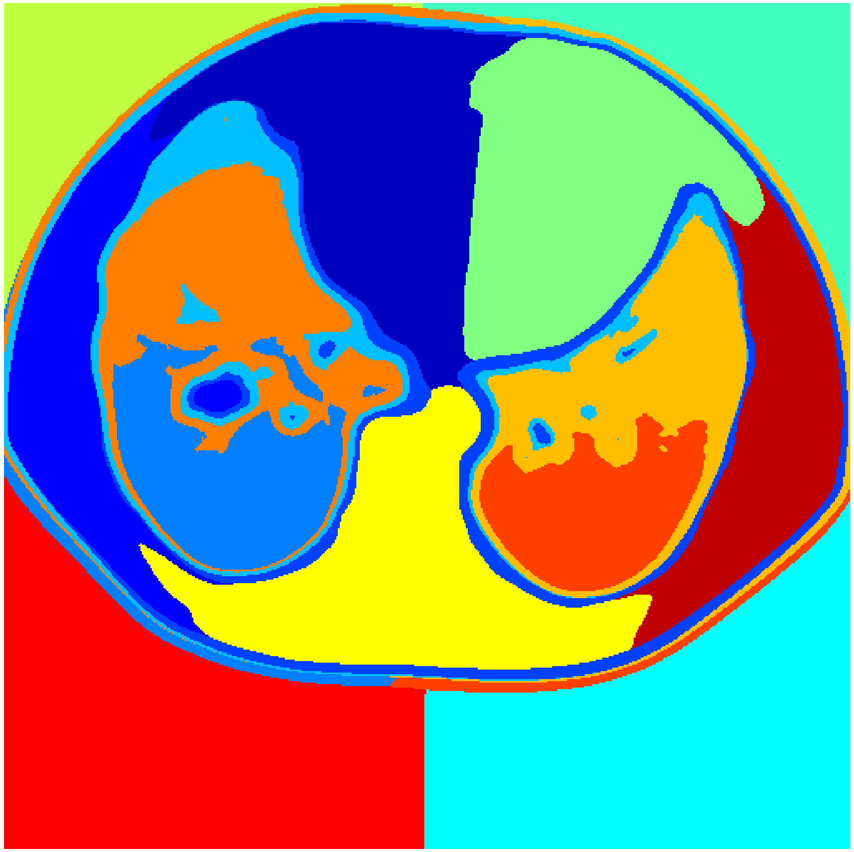
- Advantages
  - BPNN can *learn* to predict tumor doubling growth delay.
  - Shows feasibility of using BPNN for prediction of early response
- Further Improvements required
  - More data samples required for robust prediction

Expert system example



Cont…





Features extracted from the patch

- Eccentricity - F1
- Ratio – F2
- Complexity – F3
- Solidity – F4
- Orientation - F5
- Number of holes - F6
- Mean – F7
- Variance – F8
- Centroid X – F9
- Centroid Y – F10
- Area – F11

Rule based classifier

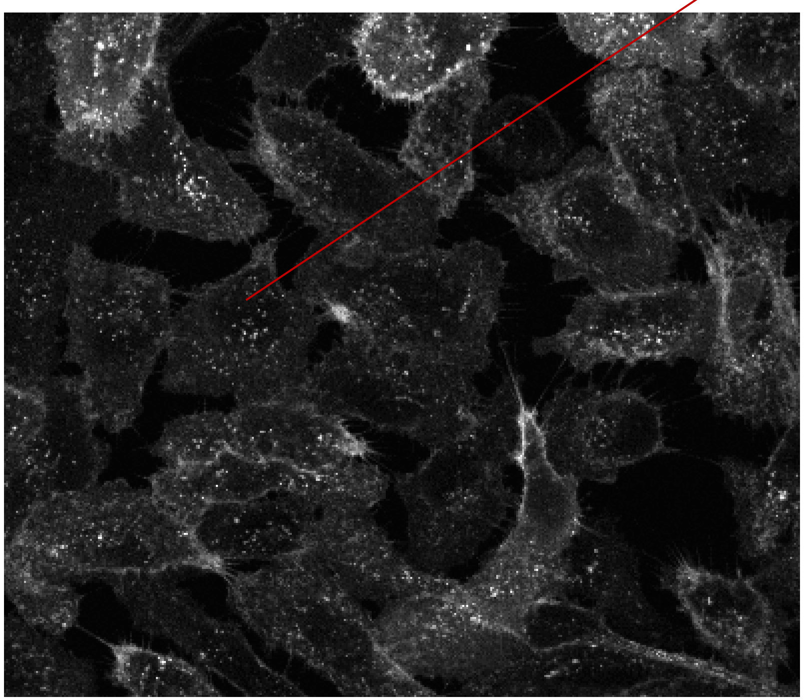
- (if *F1 is low) AND (ILC1) C1*
- (if *F1 is high) AND (ILC2) C2*
- (if *F2 is low) AND (ILC2) C2*
- (if *F2 is high) AND (ILC2) C1*
- (if *F3 is low) AND (ILC1) C1*
- (if *F3 is high) AND (ILC2) C2*
- (if *F4 is low) AND (ILC2) C1*
- (if *F4 is high) AND (ILC1) C1*
- *...*

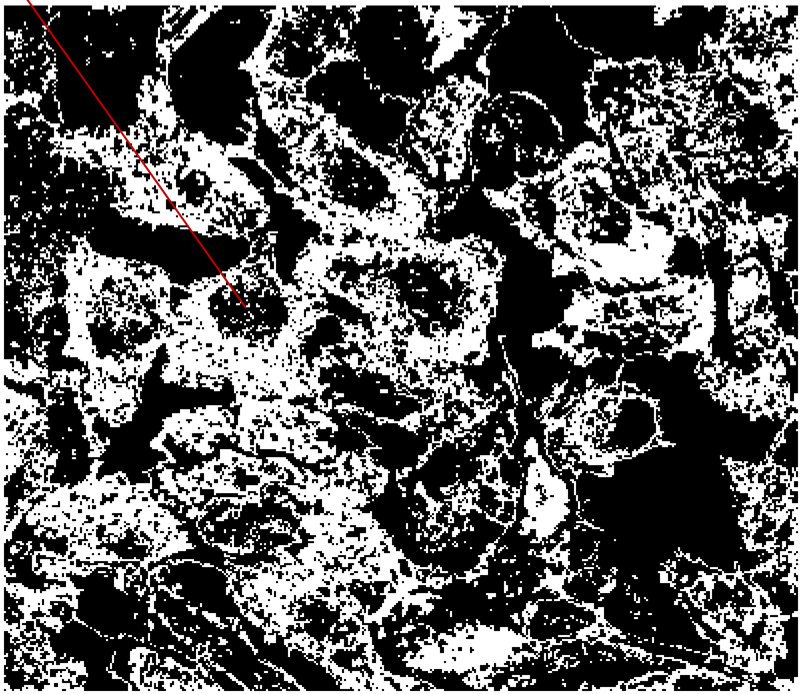
- (if F11 is high) AND (ILC2) C2

Imaging : FRCM Clustering

Imaging

- FRCM Clustering





Finance

Summary