FLEXIBLE NEURAL TREE AS AN EFFECTIVE TOOL FOR THE FUNCTION APPROXIMATION AND FEATURE SELECTION

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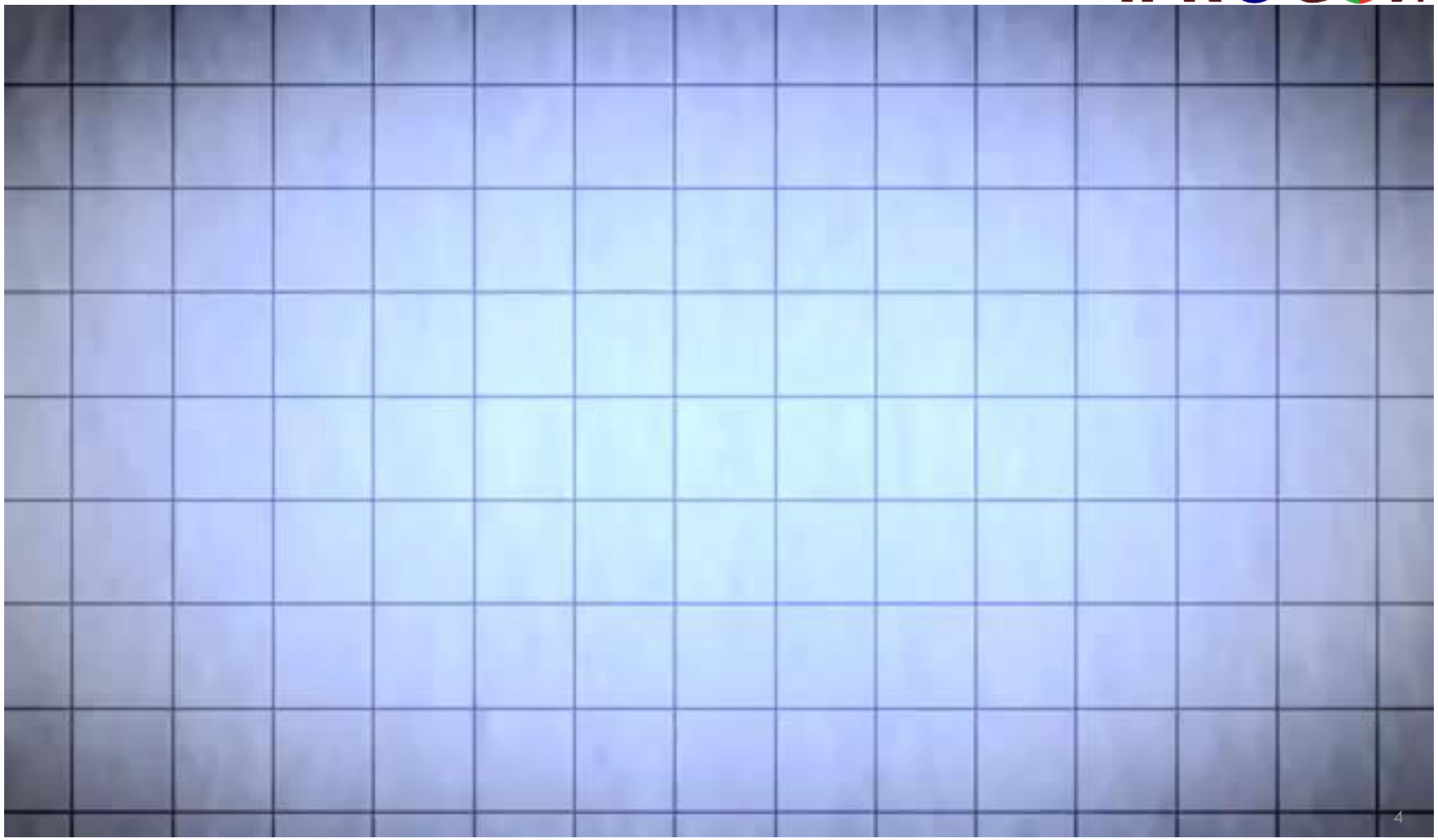
CONTENT

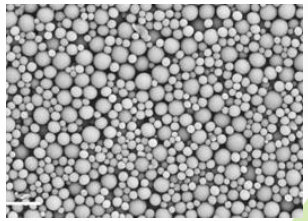
- Introduction (IPROCOM).
- Approaches to deal with IPROCOM data
- Feed-Forward Neural Network
- Flexible Neural Tree (FNT)
- Metaheuristic Framework FNT Optimization
- FNT Software Demonstration
- Conclusion and Future Scope

INTRODUCTION

- IPROCOM : A multidisciplinary and inter-sectoral consortium funded by European Commission under the FP7-PEOPLE-2012-ITN Programme.
- IPROCOM aims to develop robust in-silico process models that can be used to predict the properties of intermediate (ribbons/granules) and final products (tablets/pellets/components) based on the properties of individual particles



MODEL REQUIRED FOR IPROCOM



Particle Properties

(Material type, density, size, shape and etc.)

Powder Properties

(Flowability, compactibility) + (Roller gap and roller speed)

Ribbon Properties

(Density, Hardness, Porosity) + (Milling speed etc.)

Granule Size Distribution + (die filling process)

Tablet Properties

(Compressibility)

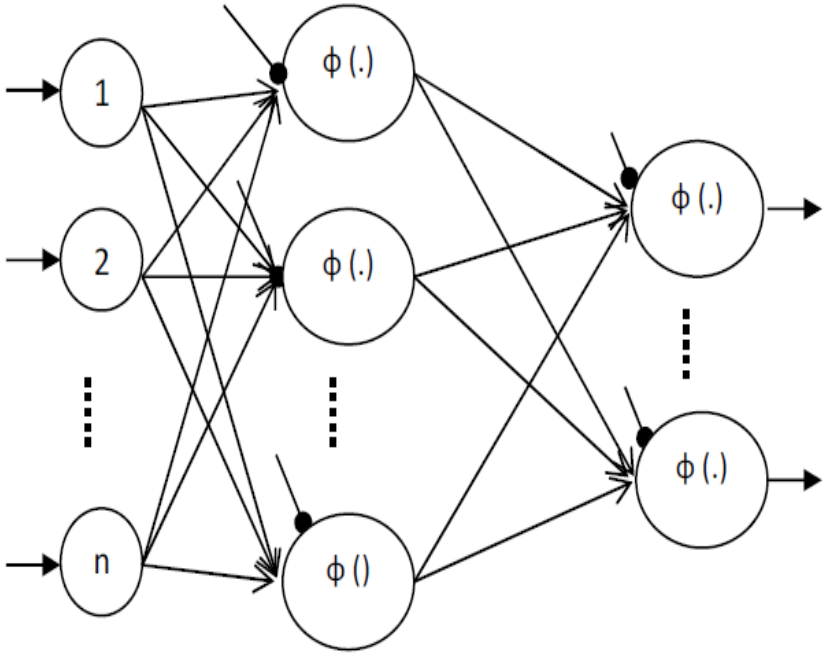
1 2 3 4

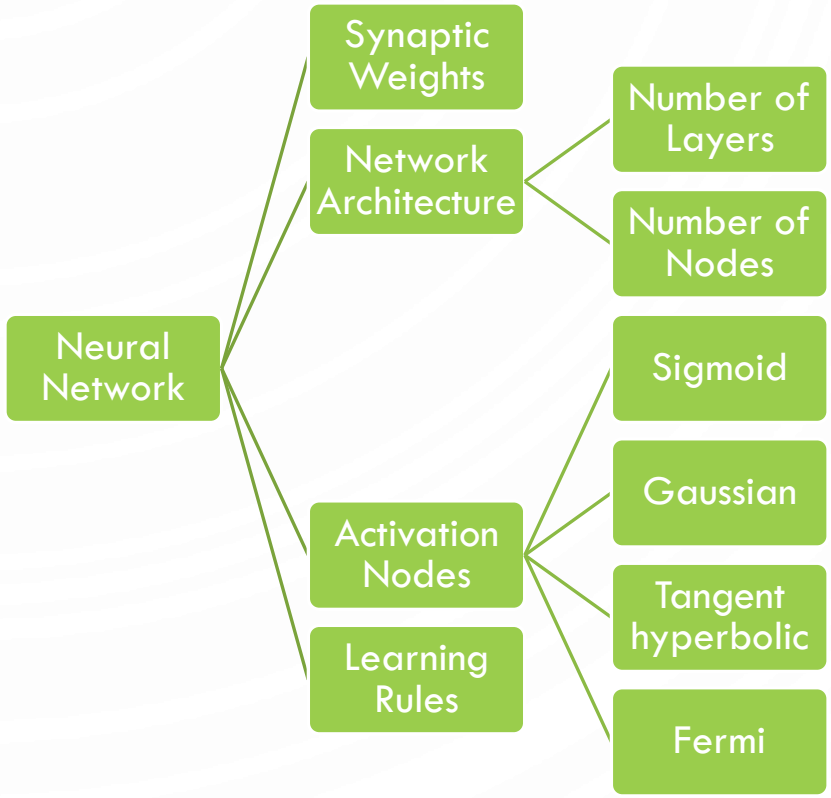
APPROACH TO DEAL WITH THE PROBLEM

- Approximation:
  - Constructing step-by-step prediction models. It depends on how data can be obtained.
  - Constructing a fusion of many predictors.
- Feature Selection:
  - Identification of critical input features at each stages.
  - Example:
    - Size of particles can be measured with three different instruments and can produce different results.
    - Shape of particles can be measured with three different instruments and can produce different results.
    - Hence it's become necessary to identify most significant features (independent variable)

FEED-FORWARD NEURAL NETWORK (NN)

- **Neural Network (NN)** (McCulloch and Pitts,1943) is the most desirable computational tool for solving nonlinear and complex optimization, pattern recognition, function approximation, classification, etc., problems.





AN OPTIMUM NEURAL NETWORK

- Optimization of Network Parameters (Synaptic Weights)
- Optimization of Network Architecture
- Optimization of Network Active Nodes
- Optimization of Learning Rules

XIN YAO, Evolving Artificial Neural Networks, PROCEEDINGS OF THE IEEE, VOL. 87, NO. 9, SEPTEMBER 1999

FLEXIBLE NEURAL TREE

Flexible Neural Tree, an adaptive data structure, performs automatic feature selection and function approximation.

[Yuehui Chen, Bo Yang, Jiwen Dong, Ajith Abraham, Time-series forecasting using flexible neural tree model, Information Sciences, Volume 174, Issues 3–4, 11 August 2005, Pages 219-235, ISSN 0020-0255].

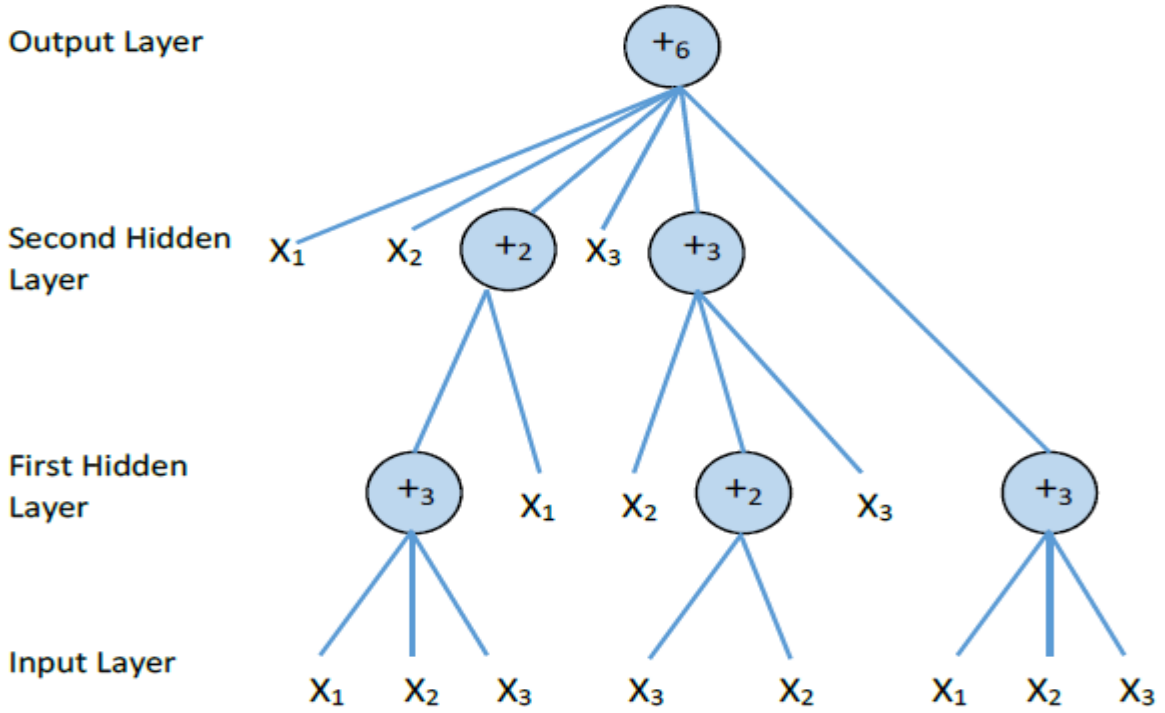


Figure: A typical representation of neural tree with function instruction set $F = \{+2; +3; +4; +5; +6\}$, and terminal instruction set $T = \{x_1; x_2; x_3\}$.

FLEXIBLE NEURAL TREE

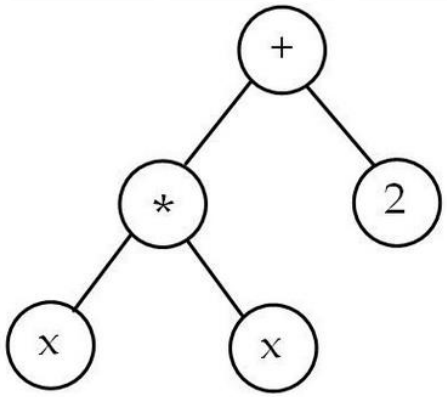
- **Analogy with Neural Network**
  - **Function Node:** Resembles the Active Nodes.
  - **Leaf Node:** Indicates the Input Nodes
  - **Edge:** Indicates the Synaptic Weights
  - **Root Node:** Indicates Output Node.
- **Structure Optimization:** Finding an optimal or near-optimal neural tree is formulated as a product of evolution. For that purpose a Genetic Programming may be used.
- **Parameter Optimization:** Particle Swarm Optimization (PSO), Artificial Bee Colony etc. may be used for the parameter optimization.
- **Input Feature Selection:** Leaf Nodes represent input features that may be selected randomly

METAHEURISTICS

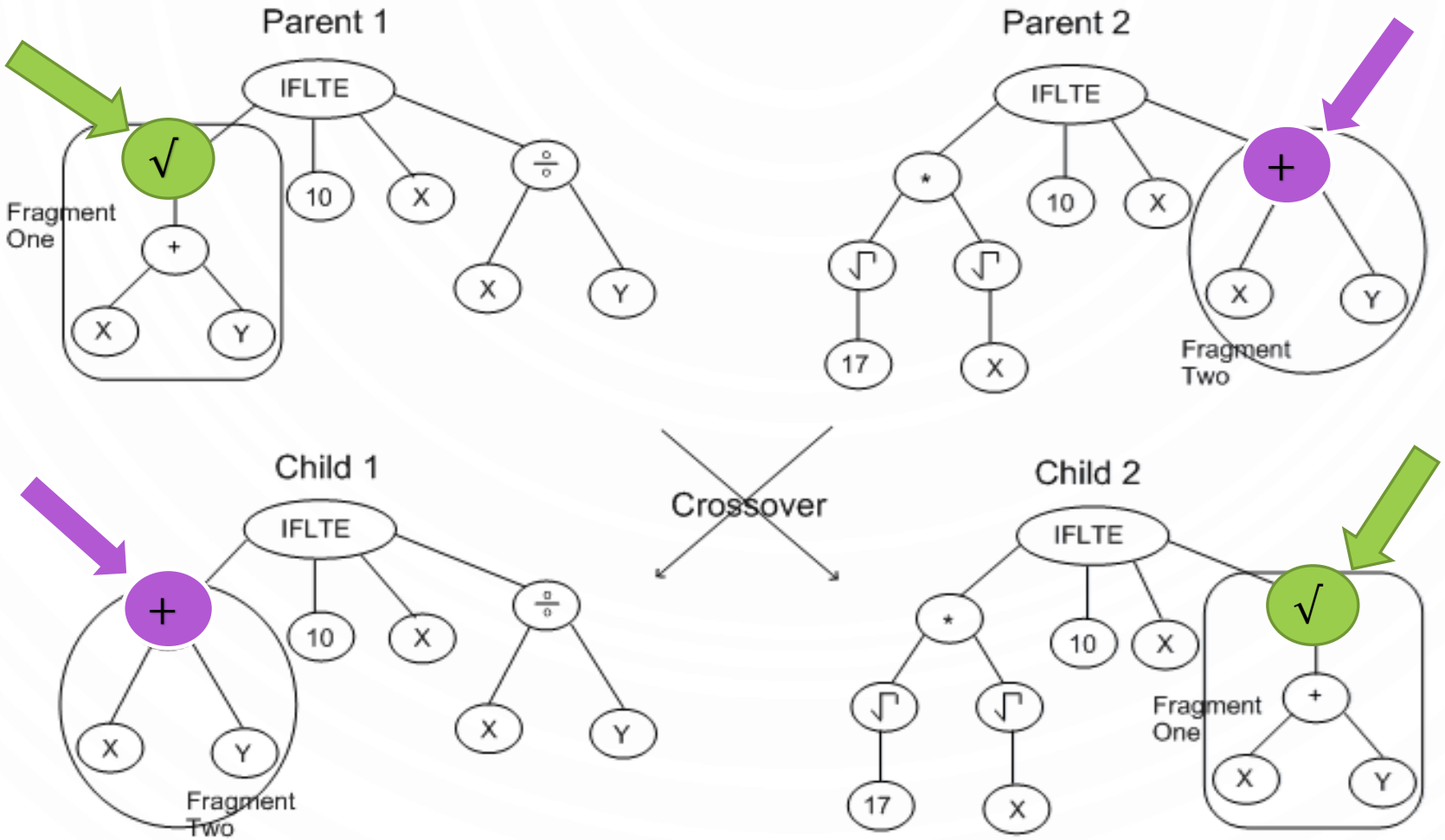
- To find a solution to a problem using certain rules or mechanism that may be inspired by the nature.
- The operators of metaheuristics
  - Transition: Searching for the solutions (exploration and exploitation).
  - Evaluation: Evaluating the objective function.
  - Determination: Deciding the search directions.
  - Verifying Goal: Convergence

EVOLUTIONARY ALGORITHMS

- Evolutionary Algorithms
  - Genetic population based meta-heuristic algorithm that finds optimal solution using the dynamics of evolutionary process. Basically uses genetic operates such as
    - Selection
    - Cross-over
    - Mutation.
- Genetic Programming(GP)
- Introduced by John Koza, 1992
- The basic concept of GP is to evolve a program instead of bit-string
- i.e. the Genetic operators are directly applied on the Phenotype rather than on the Genotype.
- It search for an optimum tree structure (Phenotype) in a program space.

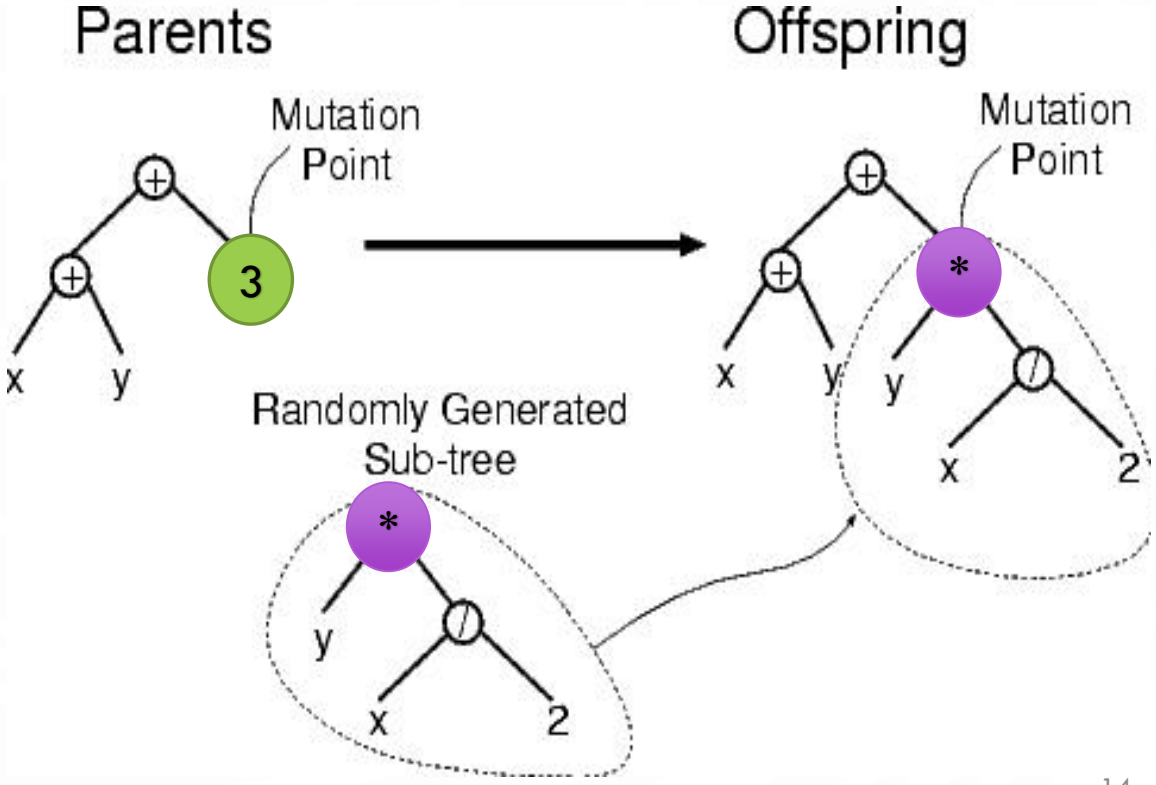


CROSS-OVER OPERATOR



MUTATION OPERATOR

- Mutation at a single leaf node.
- Mutation at all leaf nodes
- Mutation by punning a sub-tree and replace by randomly generated-Sub-tree
- Mutation by growing a tree/appending a randomly generated sub-tree



METAHEURISTICS FOR PARAMETER OPTIMIZATION

- **Deferential Evaluation** (Storn and Price, 1995) Evolutionary Algorithm based optimization algorithm [Operators – Selection and Crossover].
- Swarm Based Metaheuristics
- **Particle Swarm Optimization** (Eberhart and Kennedy, 1995) is a population based meta-heuristic algorithm imitates the mechanisms of the foraging behavior of swarms. Depends of velocity and position update of the particles in a swarm.
- **Artificial Bee Colony** (Karaboga, 2005) is a meta-heuristic algorithm inspired by foraging behavior of honey bee swarm. Depends of food position that is updated by the artificial bees in an iterative fashion.

ENSEMBLE

- A collective decision with consensus of many member is better than the decision of an Individual
- Two components of Ensemble
  - Construction of diverse and accurate models
    - Training models with different sets of data (Bagging)
    - Training models with different set of input features (Random Sub-space)
    - Training models with different set of parameters
  - Combining the models using a combination rules
    - Non-trainable
    - Trainable

ENSEMBLE OF FNTS

- Making Use of Final Population
  - Diversity:
    - Models in the final population can have different input features.
    - Models in the final population can have different structure.
    - Models in the final population can have different active nodes.
  - Combination of FNTs
    - Regression Problem: Mean of Output, Weighted Mean (Rank based or Trainable based)
    - Classification Problem: Majority Voting, Weighed Majority Voting (Rank based or Trainable based)

INTRODUCTION TO THE SOFTWARE

- Demonstration..

CONCLUSION AND FUTURE SCOPE

- An individual FNT model is efficient and effective alone to provide better result that other competitive approximation models
- Ensemble of FNT models improves the generalizing-ability of model
- FNT offers adaptive feature selection.
- Pareto-Based Multi-Objective treatment may help in obtaining efficient and simple (in terms of structure) model. Since an optimum FNT have conflicting objectives such as: FNT tree size (simplicity) and Tree accuracy

THANK YOU

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