A Soft-Computing Approach to Knowledge Flow Synthesis and Optimization

Tomáš Řehořek Pavel Kordík

Computational Intelligence Group (CIG),
Faculty of Information Technology (FIT),
Czech Technical University (CTU) in Prague

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Common tasks in Predictive Data Analysis:

1. **Data Preprocessing**
   - Feature Selection,
   - Transformation of Input Space (e.g. PCA)
   - Methods can be put into a Chain
2. **Model Selection**
   - **Selection of Algorithms**
     - k-NN, Naive Bayes, Decision Tree, Neural Networks, . . . ,
     - *Ensemble Techniques* (Majority Vote, Bagging, Stacking. . .)
   - **Parameter Tuning**
     - Distance Measure and k in k-NN,
     - Minimal Gain for Split in Decision Tree

Introduction: Knowledge Flows in Predictive Analysis

Dependence on Data

The optimal choice of Preprocessing and Modeling methods is **data-dependent**:

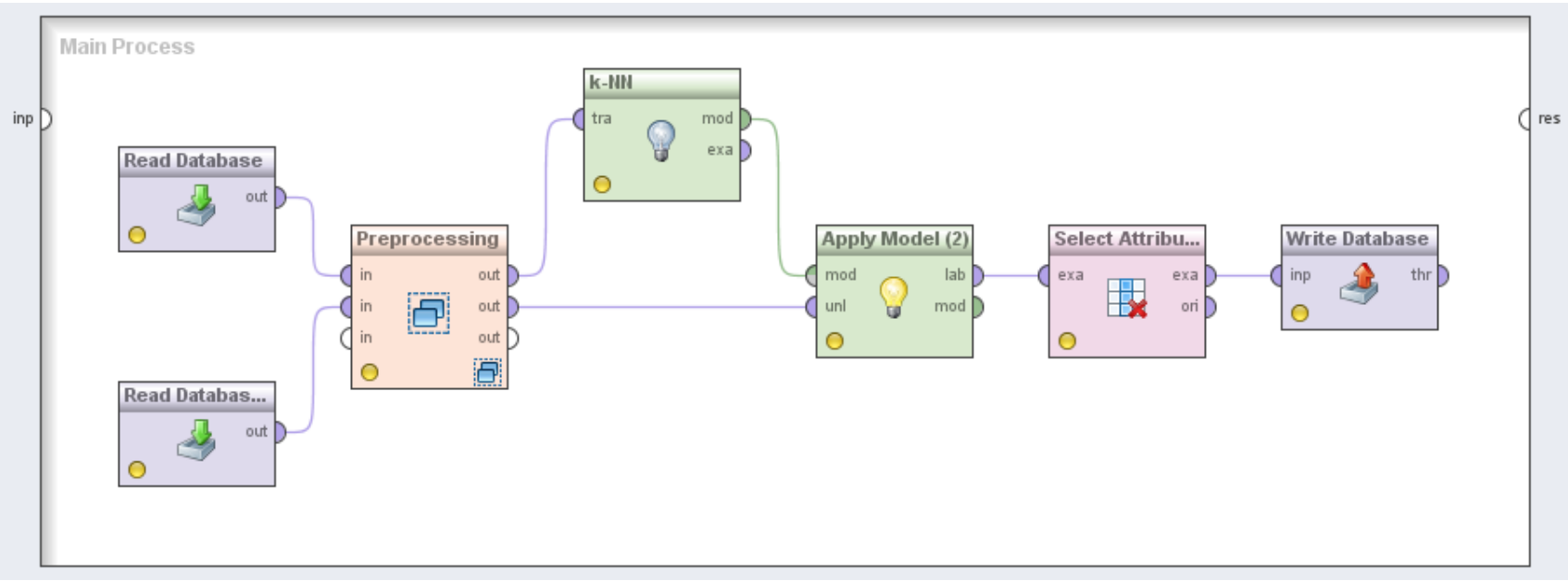
- Different Datasets require different preprocessing and are suitable for different modeling algorithms

Traditional approach: Explore the data in **trial-and-error** manner

- Even data mining experts follow this scenario

Modern approach to express the whole process: **Knowledge Flows (KFs)**

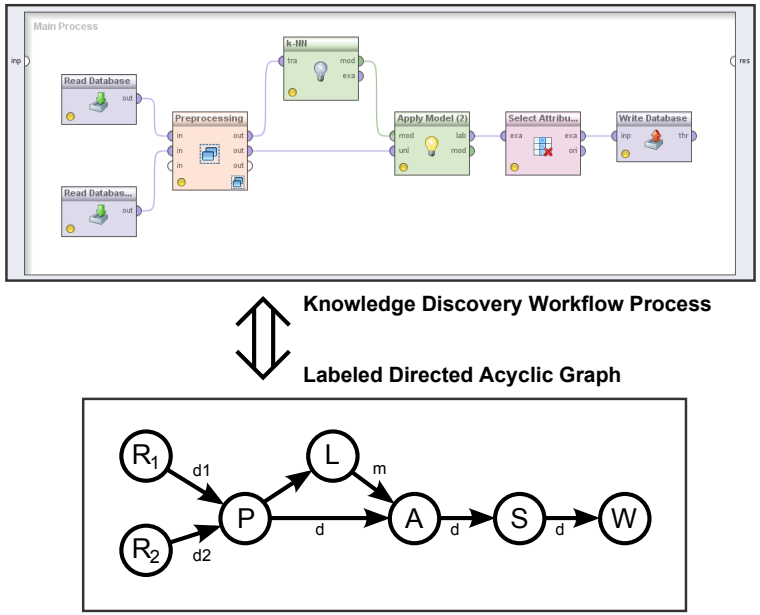
- *Directed Graphs* of interconnected, properly configured **Actions**
- Example: KFs in *RapidMiner 5* learning environment:



Optimization of Knowledge Flows

Evolving Good Graphs

Our Approach: KFs are viewed as **Directed Acyclic Graphs (DAGs) with labeled nodes**.



These graphs are **subject to optimization** by means of **evolutionary computation**.

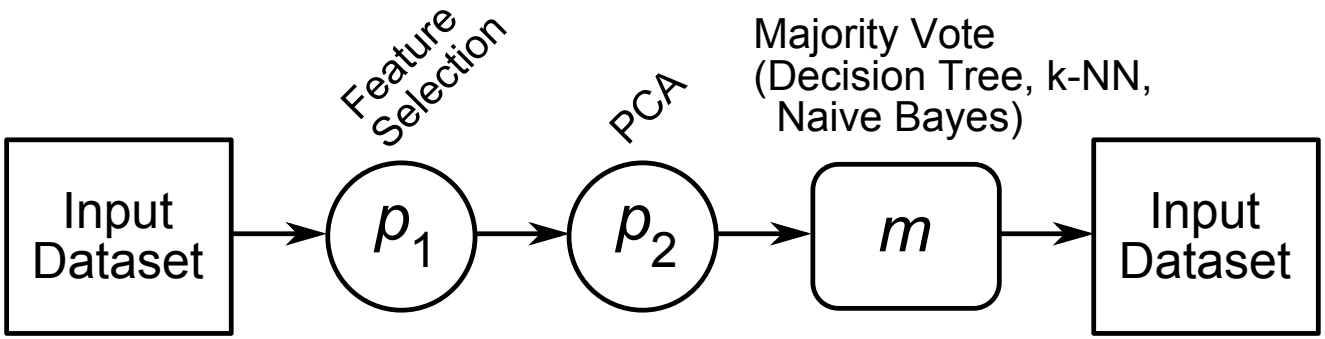
Problem Statement: Finding Optimal Predictive Analysis KF for a given Dataset

Given a Dataset **D** of examples from $\mathbb{R}^n \times \mathcal{L}$, find:

1. Sequence $p_1, \ldots, p_k$ of properly configured **preprocessing actions**,
2. Properly configured **learning algorithm** (or possible hierarchical ensemble of such algorithms) m

such that model obtained as $m\left(p_k\left(\ldots p_1\left(\mathbf{D}\right)\ldots\right)\right)$ has **minimal generalization error**.

Example:



Methodology

Embryonic STGP [Koza1997]

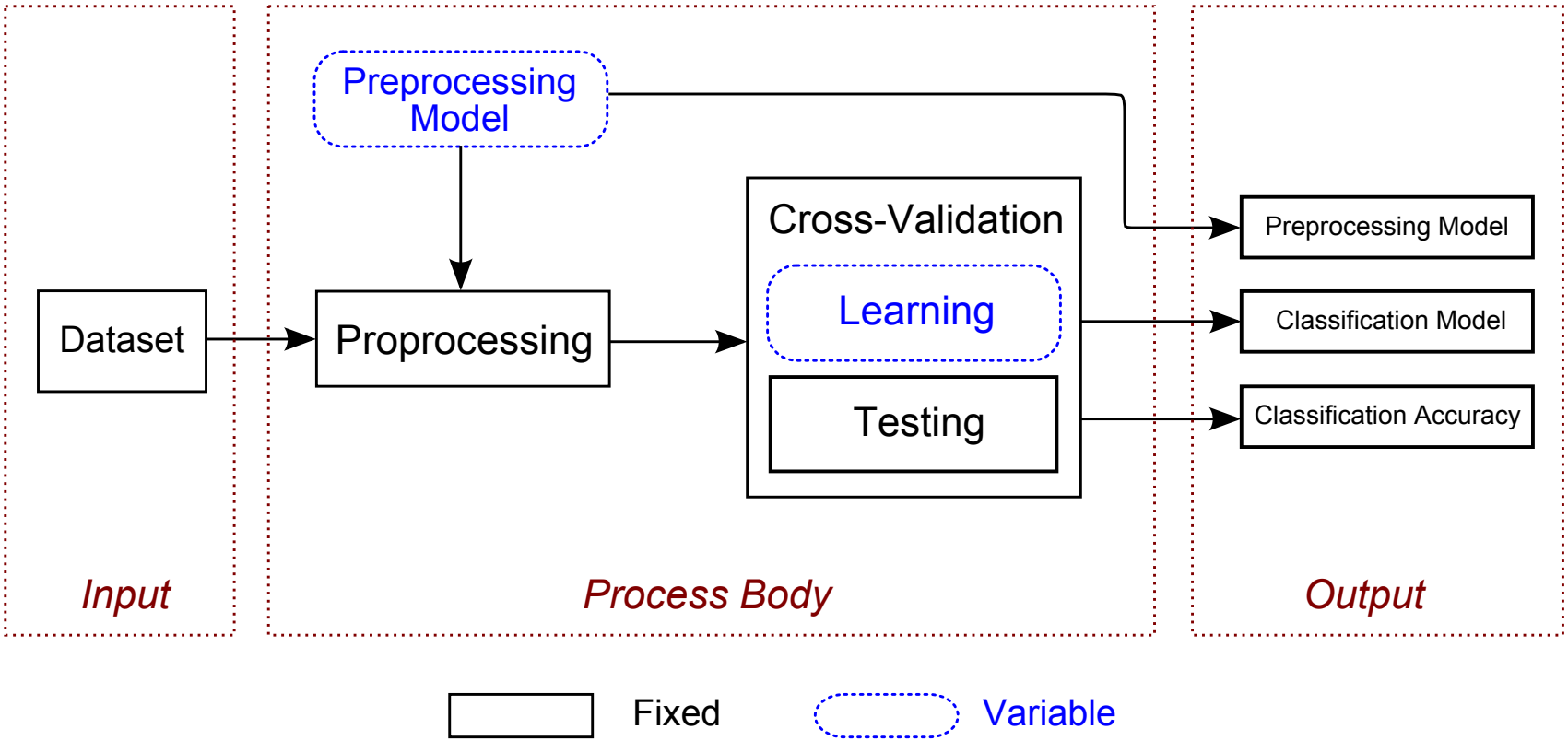
We use **Embryonic Strongly Typed Genetic Programming**

- Proposed by J.R.Koza for evolving Analog Electrical Circuits [Koza1997]
- Encodes the graph in form of **rooted tree**
  - The tree codes a plan for developing a complete graph from a simple graph referred to as the **embryo**
- Fitness function: **classification accuracy** $\frac{1}{|T|} \sum_{(\mathbf{x},\ell) \in T} \begin{cases} 0, & m(\mathbf{x}) \neq \ell \\ 1, & m(\mathbf{x}) = \ell \end{cases}$

Methodology

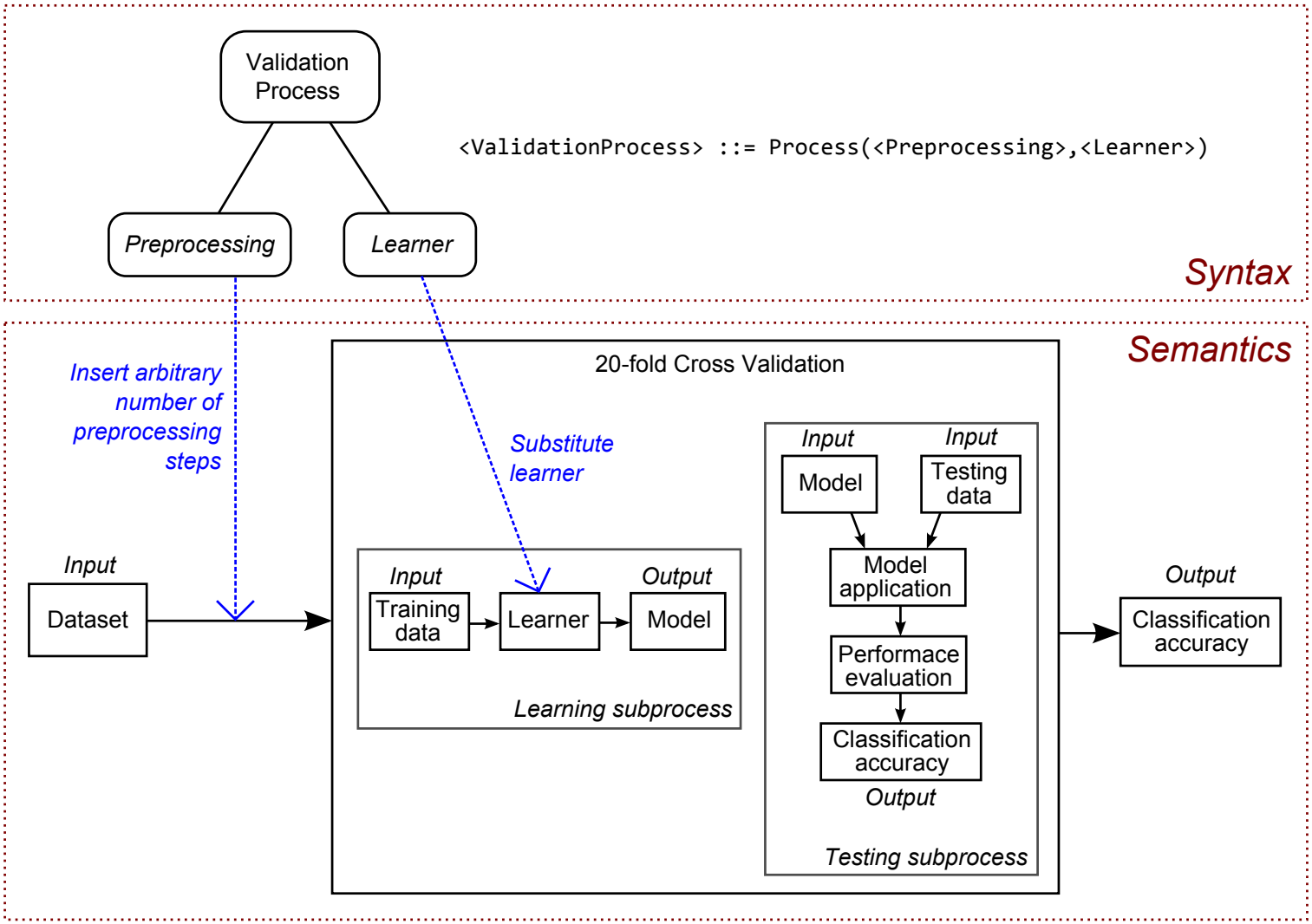
Embryonic KF in RapidMiner 5

- We use the RapidMiner 5 software to measure fitness
- Embryonic Knowledge Flow for our experiment:



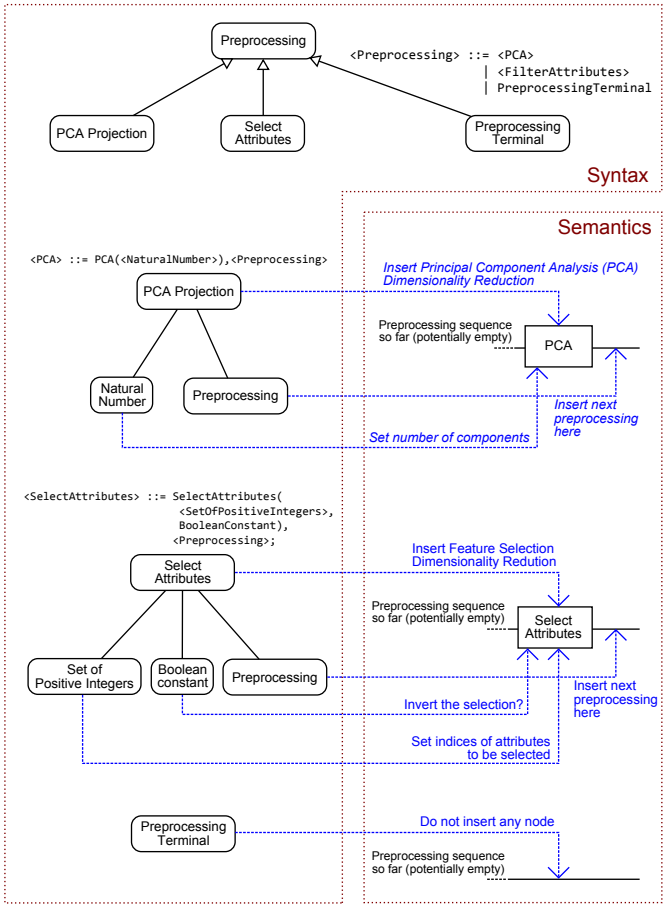
Methodology

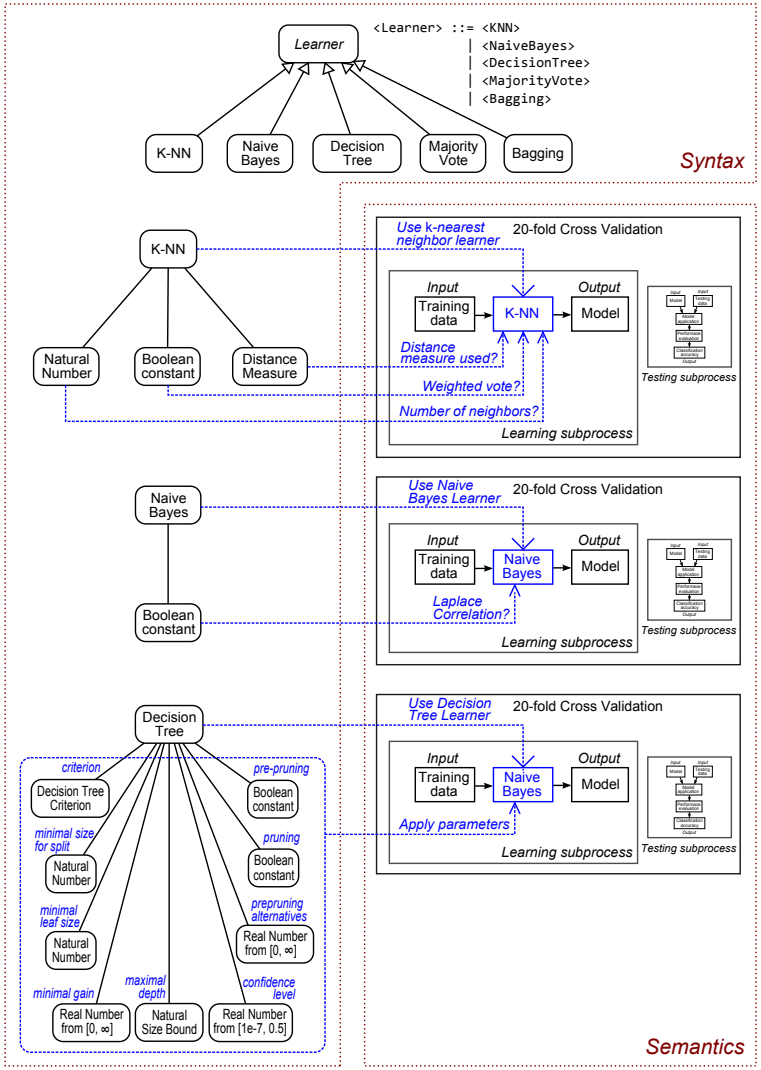
STGP Grammar: Validaton Process



Methodology

STGP Grammar: Preprocessing, Modeling

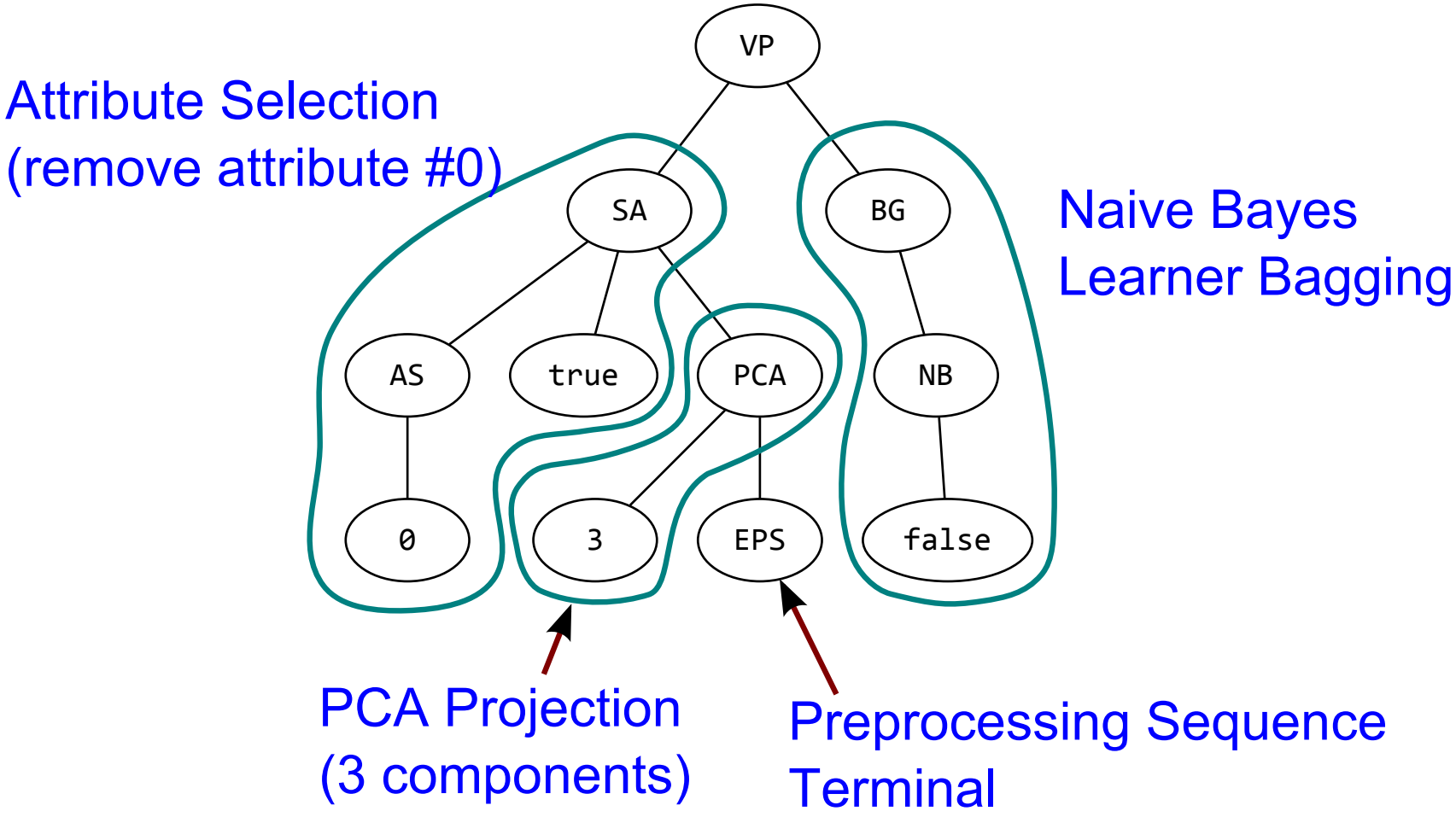




Preliminary Results

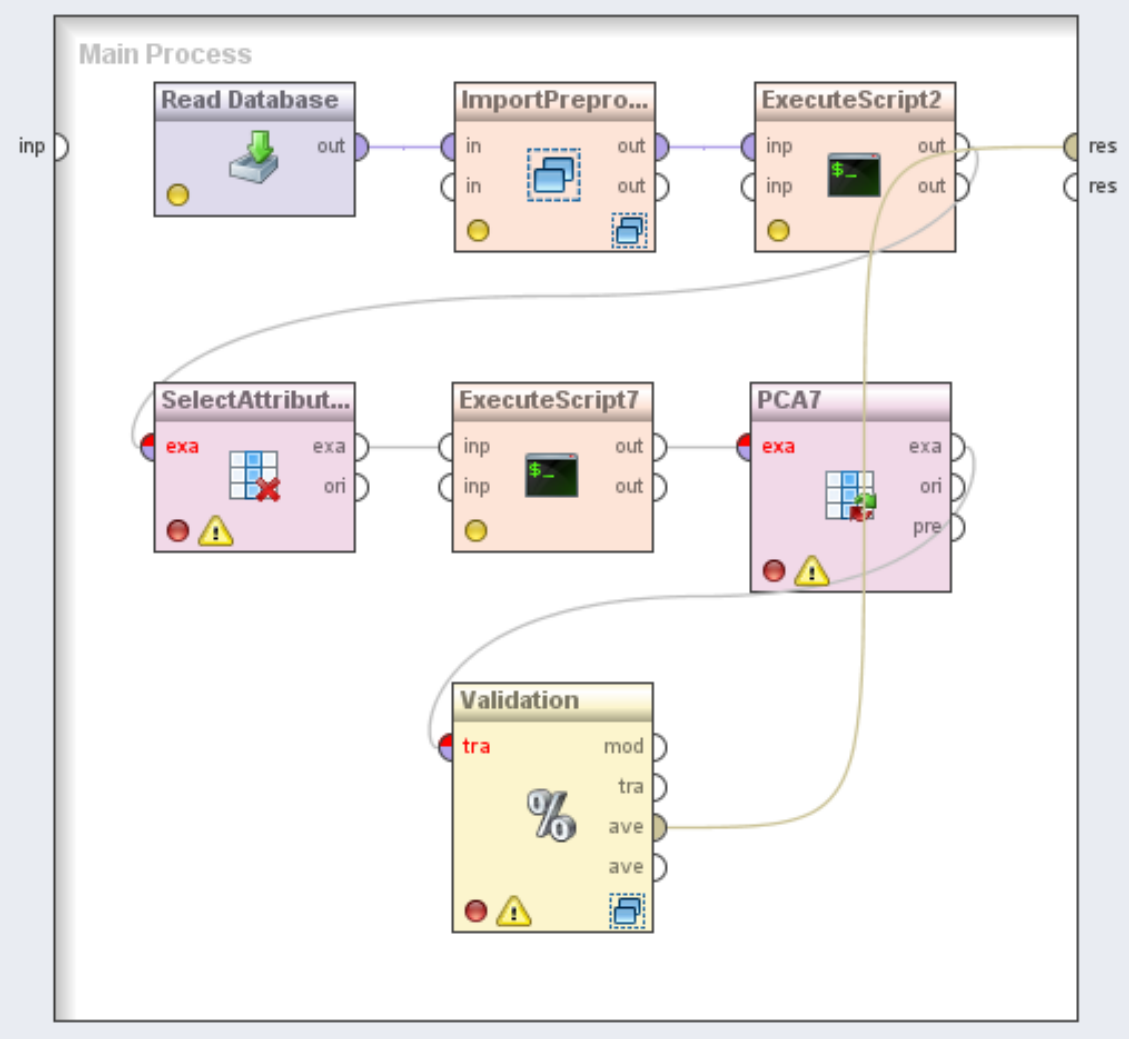
Ecoli Dataset: Sample Tree Evolved

Sample tree evolved on the Ecoli datatset



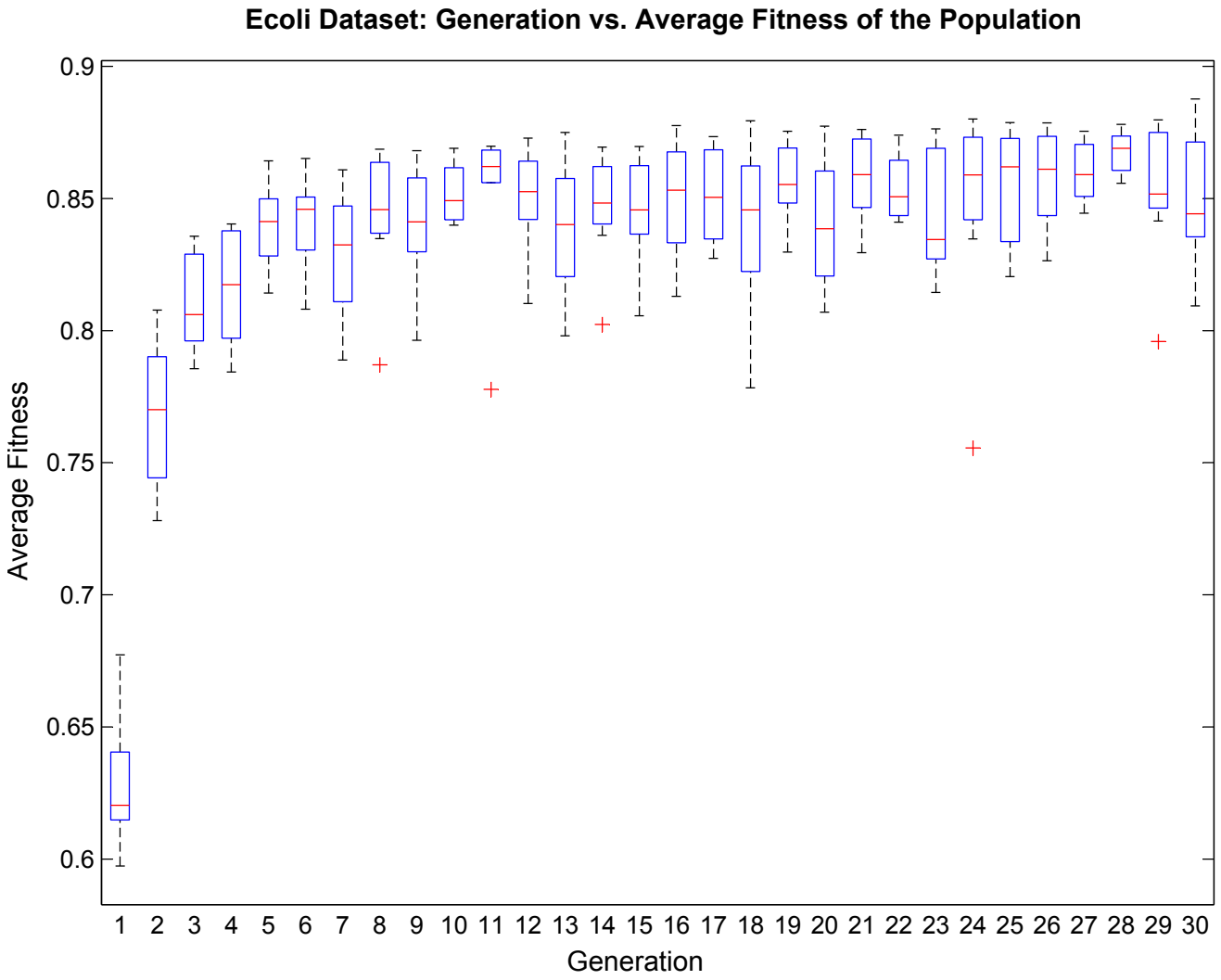
Preliminary Results

Ecoli Dataset: Evolved KF in RapidMiner 5



Preliminary Results

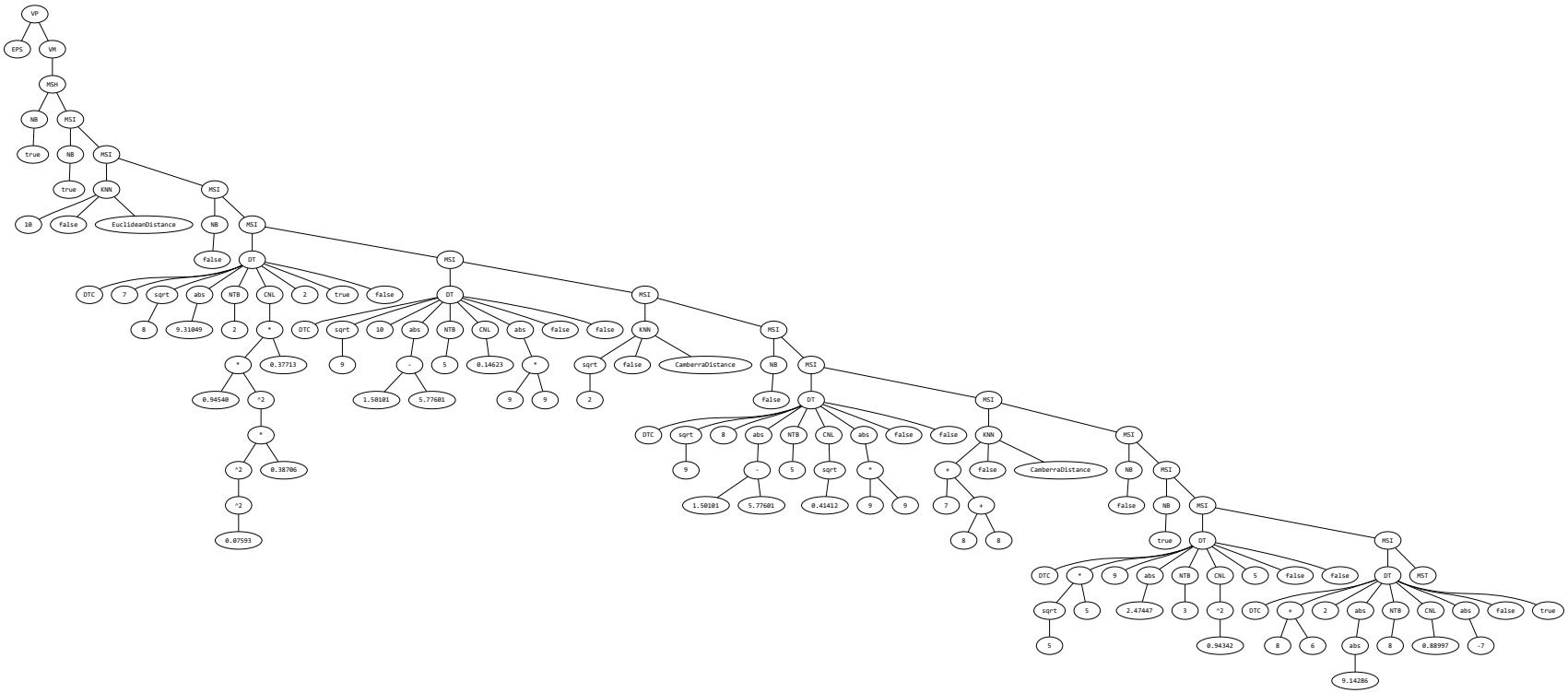
Ecoli Dataset: Generation vs. Average Fitness of the Population



Preliminary Results

Very Complex Tree Evolved of the Vehicle Dataset

A very complex tree evolved on the Vehicle dataset



Questions & Discussion

Thank you for you attention!

Tomáš Řehořek
tomas.rehorek@fit.cvut.cz