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KNOWLEDGE DISCOVERY AND INTELLIGENT SYSTEMS

Analysis of the Effectiveness of G3PARM Algorithm

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Outline

- Introduction
- Model description
- Experiments
- Results
- Conclusions
- Future research lines

Introduction

- Association rules mining (ARM): a Data Mining technique
- Classical algorithms for mining association rules:
  - Apriori
  - FP-Growth
- Genetic Programming: computer programs
- Grammar Guided Genetic Programming (G3P)
- Our proposal is a G3P-based approach for ARM

Model description

- G3PARM = G3P Association Rules Mining
- Designed for the extraction of association rules
- Based on the use of a context-free grammar
- Each individual represents a rule
- An auxiliary population:
  - Exceed a minimum threshold for two different measures
  - Maximum auxiliary population size

Model description

Context-free grammar

$G = (\Sigma_N, \Sigma_T, P, Rule)$ with:

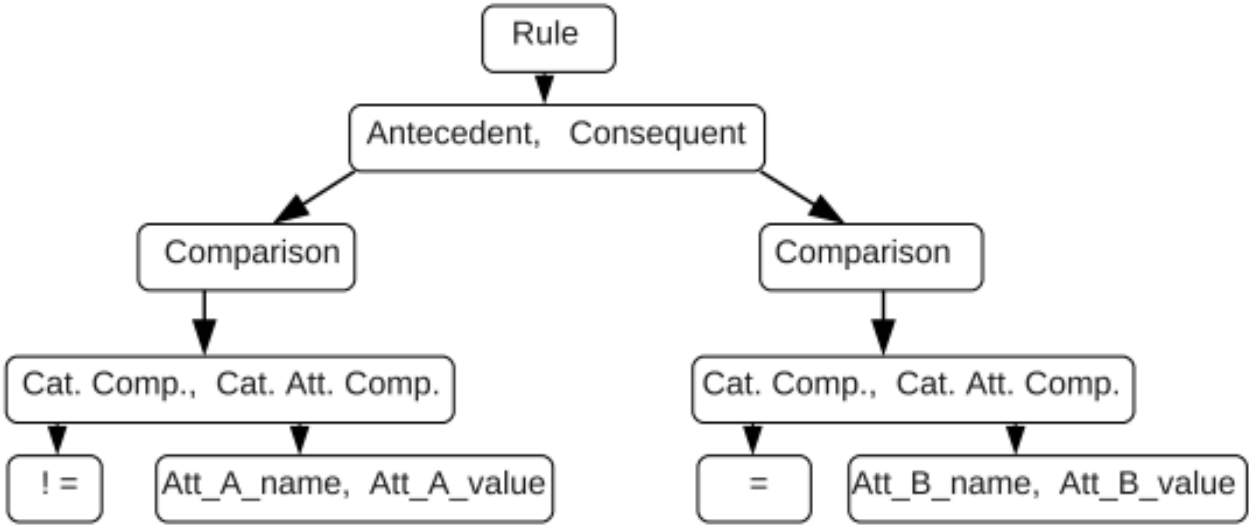
Σ_N = {Rule, Antecedent, Consequent, Comparison, Categorical Comparator, Categorical Attribute Comparison }

Σ_T = {AND, "! =", "=", "name", "value"}

P = {Rule = Antecedent, Consequent ;
Antecedent = Comparison | AND, Comparison, Antecedent ;
Consequent = Comparison ;
Comparison = Categorical Comparator, Categorical Attribute Comparison ;
Categorical Comparator = "! =" | "=" ;
Categorical Attribute Comparison = "name", "value" ;}

Model description

Syntax-tree structure

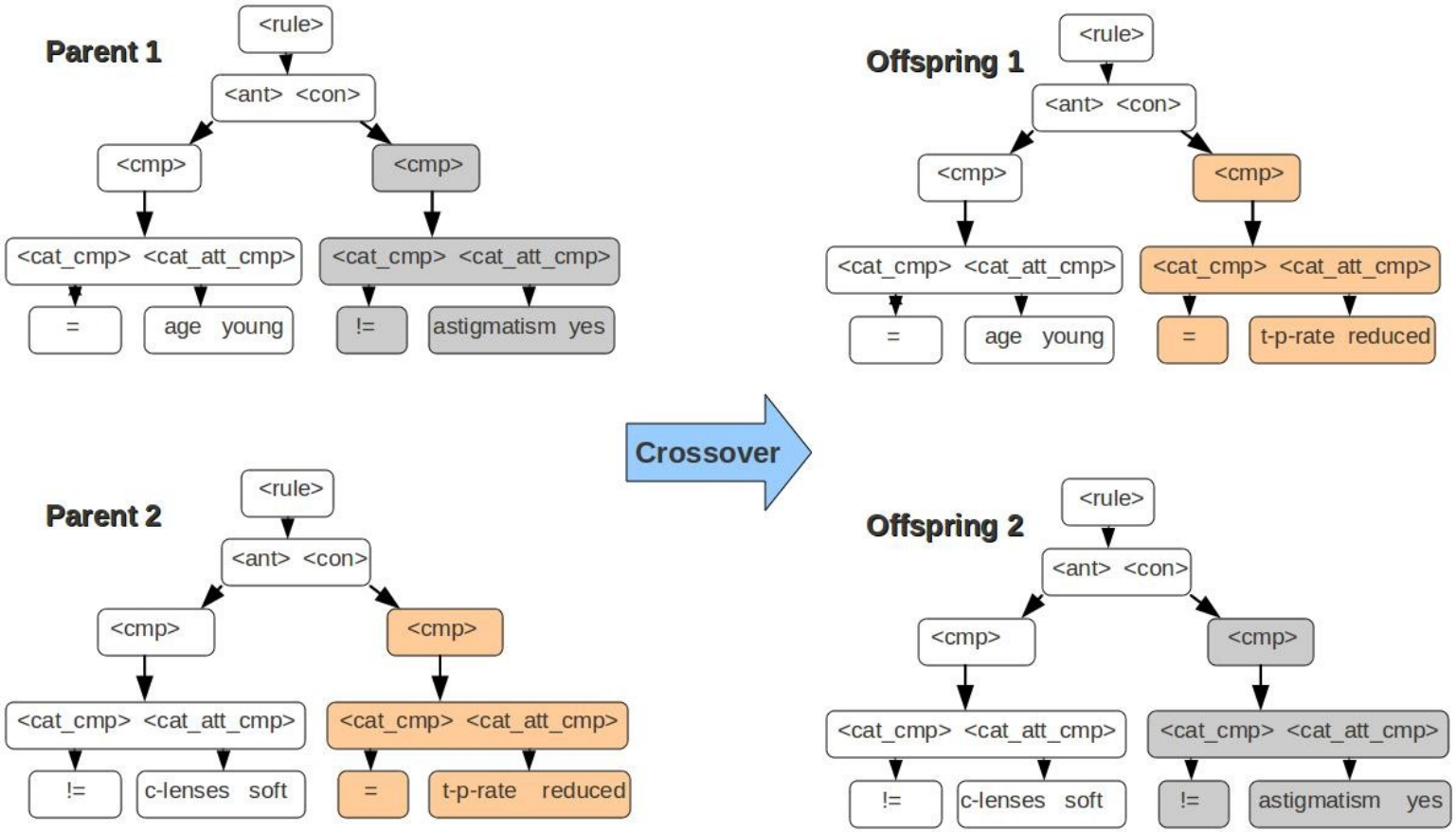


Phenotype:

(!= Att_A_name Att_A_value) → (= Att_B_name Att_B_value)

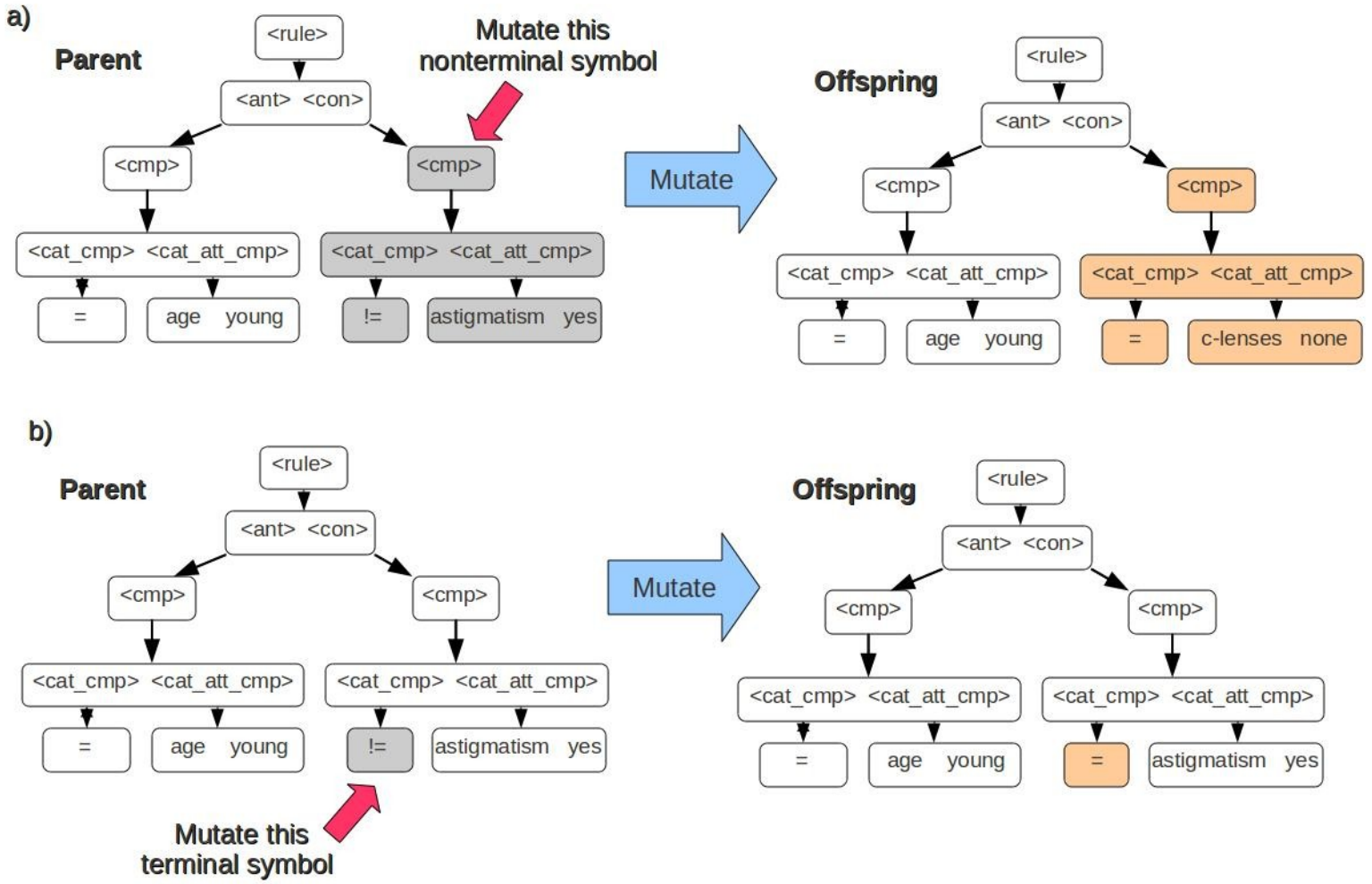
Model description

Crossover



Model description

Mutation



Model description

Measures and fitness function

- G3PARM uses two measures:
  - Support measure: proportion of the number of transactions *T* including the antecedent *A* and the consequent *C* in a dataset *D*.

$$supp(A \rightarrow C) = \frac{|\{A \cup C \subseteq T, T \in D\}|}{|D|}$$

  - Confidence measure: proportion of the number of transactions which include *A* and *C* in transaction which include *A*.

$$conf(A \rightarrow C) = \frac{|\{A \cup C \subseteq T, T \in D\}|}{|\{A \subseteq T, T \in D\}|}$$

- Fitness function = support measure

Model description

G3PARM algorithm

Algorithm 1 G3PARM algorithm

Require: $max\_generations, N$
Ensure: A
1: $P \leftarrow random(N)$
2: $A \leftarrow \emptyset$
3: $num\_generations \leftarrow 0$
4: **while** $num\_generations < max\_generations$ **do**
5: $Parents \leftarrow$Select parents $(P \cup A)$
6: Crossover $(Parents)$
7: Mutation $(Parents)$
8: Update auxiliary population (A, P)
9: $num\_generations++$
10: **end while**
11: **return** A

Algorithm 2 Update auxiliary population

Require: A, P
Ensure: A
1: $A' \leftarrow P \cup A$
2: Order (A')
3: Eliminate duplicate (A')
4: $A \leftarrow$ Threshold(A')
5: **return** A

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Rules comprised by the same attributes are considered equals:

1 AND 2 -> 3
2 AND 1 -> 3

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Minimum threshold for support and confidence measures

Experiments

Datasets

- To evaluate the usefulness of G3PARM, several experiments have been carried out on differents datasets:
  - Credit-g: 1000 instances and 21 attributes
  - HH: 22784 instances and 17 attributes
  - Mushroom: 8124 instances and 23 attributes
  - Segment: 1500 instances and 20 attributes
  - Sonar: 208 instances and 36 attributes
  - Soybean: 683 instances and 36 attributes
  - Wisconsin Breast Cancer: 683 instances and 11 attributes
- Discretization of datasets with numerical attributes.

Experiments

Experimental set-up

- G3PARM:
  - Population size: 50
  - Crossover probability: 70%
  - Mutation probability: 10%
  - Maximum derivation numbers: 24
  - External population size: 20
  - Support threshold: 70%
  - Confidence threshold: 90%
- Apriori and FP-Growth:
  - Support threshold: 70%
  - Confidence threshold: 90%

Results

Results obtained

Dataset	*Average_support* (1)	(2)	(3)	*Average_confidence* (1)	(2)	(3)	*%Instances* (1)	(2)	(3)
*CreditEqFre*10	0.780	0.709	**0.850**	**0.941**	0.855	0.939	0.987	0.987	**1.000**
*CreditEqFre*5	0.780	0.709	**0.850**	0.941	0.855	**0.953**	0.987	0.987	**1.000**
*CreditEqWid*10	0.780	0.709	**0.892**	0.941	0.855	**0.965**	0.987	0.987	**1.000**
*CreditEqWid*5	0.773	0.709	**0.858**	0.942	0.863	**0.961**	0.989	0.989	**1.000**
*HHEqFre*10	None	None	**0.803**	None	None	**0.913**	None	None	**1.000**
*HHEqFreq*5	None	None	**0.740**	None	None	**0.909**	None	None	**0.997**
*HHEqWid*10	0.761	0.761	**0.922**	0.950	0.950	**0.986**	**1.000**	**1.000**	**1.000**
*HHEqWid*5	0.765	0.765	**0.902**	0.955	0.955	**0.979**	**1.000**	**1.000**	**1.000**
Mushroom	0.824	0.817	**0.890**	0.968	0.960	**0.978**	**1.000**	**1.000**	**1.000**
*SegmentEqFre*10	**0.876**	**0.876**	0.813	**0.975**	**0.975**	0.926	0.996	0.996	**1.000**
*SegmentEqFre*5	**0.876**	**0.876**	0.817	**0.975**	**0.975**	0.974	0.996	0.996	**1.000**
*SegmentEqWid*10	0.815	0.815	**0.884**	0.968	0.968	**0.979**	**1.000**	**1.000**	**1.000**
*SegmentEqWid*5	0.860	0.860	**0.882**	0.964	0.964	**0.969**	**1.000**	**1.000**	**1.000**
*SonarEqFre*10	None	None	**0.782**	None	None	**0.909**	None	None	**1.000**
*SonarEqFre*5	None	None	**0.583**	None	None	**0.731**	None	None	**0.626**
*SonarEqWid*10	None	None	**0.958**	None	None	**0.887**	None	None	**1.000**
*SonarEqWid*5	0.747	None	**0.835**	0.942	None	**0.947**	0.846	None	**1.000**
Soybean	0.778	0.722	**0.822**	0.950	0.953	**0.957**	**1.000**	**1.000**	**1.000**
*WBCEqFre*10	None	None	**0.875**	None	None	**0.958**	None	None	**1.000**
*WBCEqFre*5	None	None	**0.806**	None	None	**0.928**	None	None	**1.000**
*WBCEqWid*10	0.821	0.821	**0.900**	**0.996**	**0.996**	0.971	0.821	0.821	**1.000**
*WBCEqWid*5	**0.872**	**0.872**	0.864	**0.996**	**0.996**	0.956	0.872	0.872	**1.000**
Ranking	2.204	2.522	**1.272**	2.159	2.431	**1.409**	2.340	2.386	**1.272**

- (1) Apriori
- (2) FP-Growth
- (3) G3PARM

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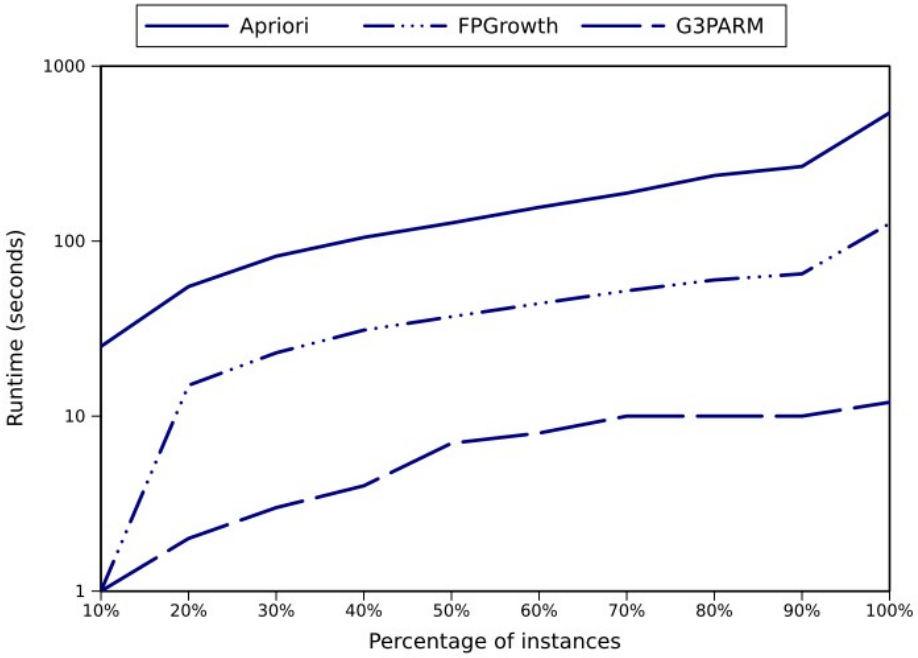
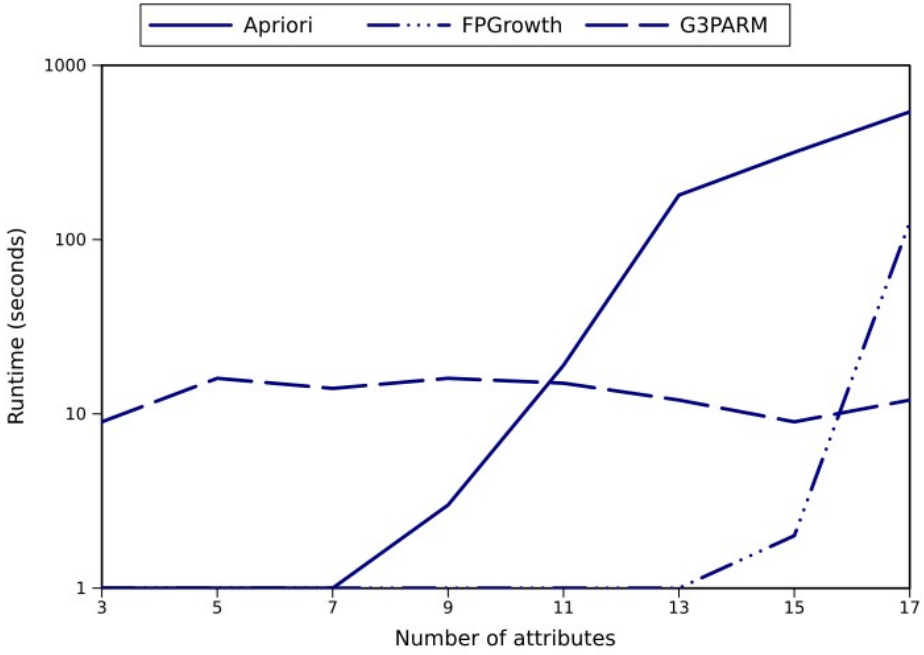
Results

Scalability

Different number of instances



Different number of attributes



Conclusions

- Novel G3P-based algorithm for mining association rules
- G3PARM obtains rules with:
  - High support
  - High confidence
  - High representative rules
- G3PARM scales quite linearly as we increase up the dataset size and the number of attributes

Future research lines

- Use of numerical attributes
- Modify our approach to work with infrequent pattern
- Multiobjective version using support and confidence as objectives to be optimized

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Thanks!

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