

Local interpretability of random forests for multi-target regression

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Multi-Target Learning

Multiple Targets per instance

Targets can be dependent or independent of each other

$T = \{t_j : j=1 \dots q\}$ the set of targets in a multi-target learning task and $D = \{(x_i, Y_i), i=1, \dots, m\}$ the set of multi-target training examples where x_i is the feature vector and $Y_i = T$ the set of target for the i -th example.



Air quality monitoring



Traffic management



Electronic health record analysis



Real estate



Random Forests

Ensemble of Decision Trees

High performance on tabular data

Great performance on multi-target regression

Intrinsically not explainable

Explainability



The ability of extracting the reasoning behind decisions of ML models



Useful for the majority of ML applications

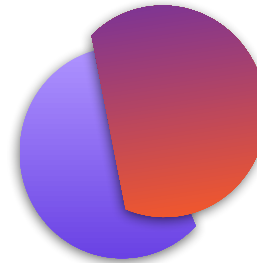


Necessary when affecting human lives or incur economic costs



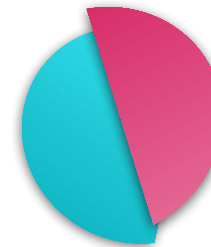
Intrinsically explainable models have lower performance

Model Agnostic



Model Specific

Local



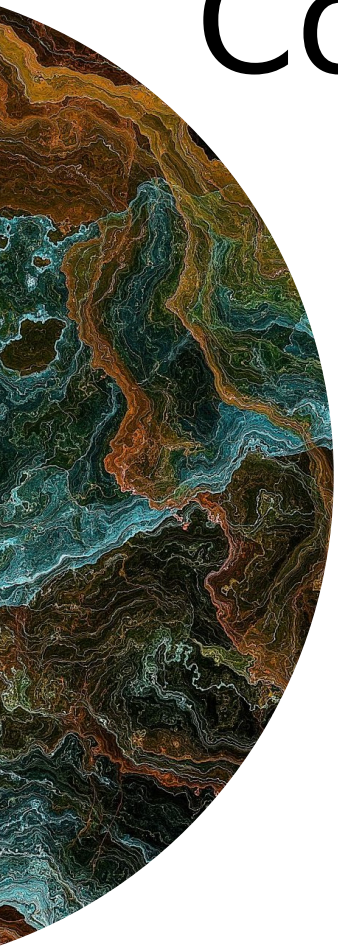
Global

Conclusiveness

A rule will be conclusive if and only if the following restrictions are met:

1. if the instance's values for the excluded features are modified to any possible value, then the prediction will not be influenced,
2. if the value of one of the included features is modified within the specified range, then the prediction will not be influenced

days off work = 10





Allowed Error

An RF model with a set of trees , casting votes.

Ability to reduce trees and form smaller rules, while predictive error stays within limits.

Allowed Error

An RF model with a set of trees , casting votes.

Ability to reduce trees and form smaller rules, while predictive error stays within limits.

Prediction of excluded trees altered to min/max pred of the tree.

$$L_{\text{error}} = \text{mae}(\text{preds}, \text{preds}_{\text{red}})$$

$$L_{\text{error}} < \text{Allowed error}$$

Local Error

LionForests

RF Model

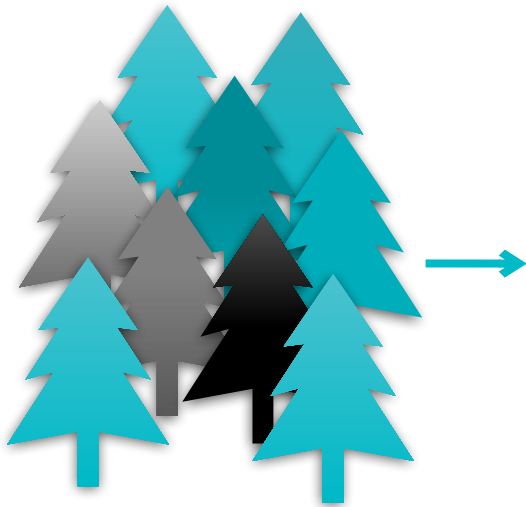


"If $0 \leq f_1 \leq 0.5$ and $-1 \leq f_2 \leq 0.2$ and $0 \leq f_3 \leq 7$ then

- + local **154** *" \pm error"*
- + model-specific
- + simple rules
- + natural language
- + wider ranges
- + less features
- + conclusive

LionForests

RF Model



Reduce until
local error > allowed error

P_1 : if $f_1 \leq 2$ and ... then 90
 P_2 : if $f_2 \leq 0.2$ and ... then 211
 P_3 : if $f_4 \leq 1$ and ... then 0
 P_4 : if $f_1 \leq 5$ and ... then 178
 P_5 : if $f_5 \leq 20$ and ... then 67
 P_6 : if $f_1 \leq 3$ and ... then 4
 P_7 : if $f_2 \leq 12$ and ... then 9
 P_8 : if $f_1 \leq 1$ and ... then 236
 P_9 : if $f_2 \leq 13$ and ... then 180

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 P_4 : if $f_1 \leq 5$ and ... then 178
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 P_9 : if $f_2 \leq 13$ and ... then 180

LionForests

- P₁: if $f_1 \leq 2$ and ... then 90
- P₄: if $f_1 \leq 5$ and ... then 178
- P₅: if $f_5 \leq 20$ and ... then 67
- P₈: if $f_1 \leq 1$ and ... then 236
- P₉: if $f_2 \leq 13$ and ... then 180

Extract Feature Ranges
from the Paths

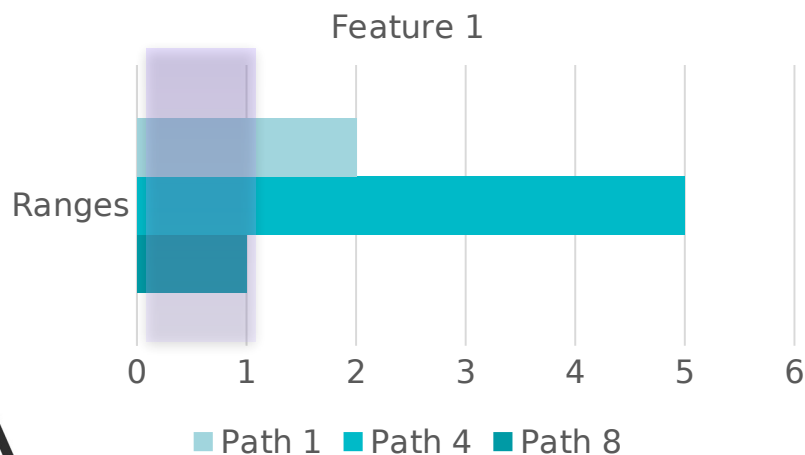
$$0 \leq f_1 \leq 1$$

$$-1 \leq f_2 \leq 10$$

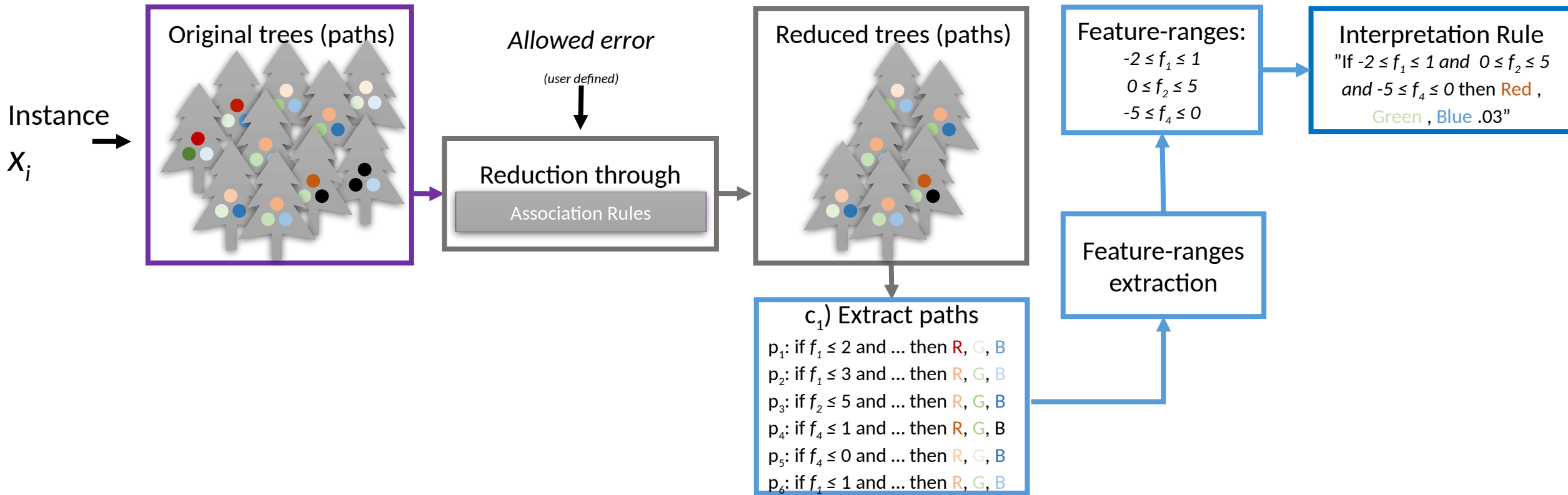
$$0 \leq f_5 \leq 20$$

Extract the Final
Interpretation Rule

*"If $0 \leq f_1 \leq 1$ and $-1 \leq f_2 \leq 10$ and $0 \leq f_5 \leq 20$ then
170 ± error"*



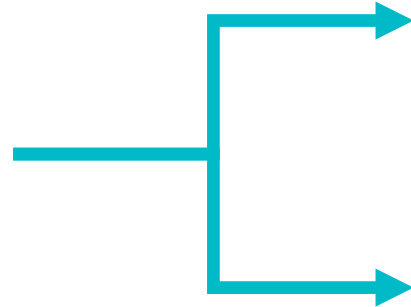
Multi-Target LionForests (XMTR)



Multi-Target LionForests (XMTR)



Allowed error
(user defined)



Singular value

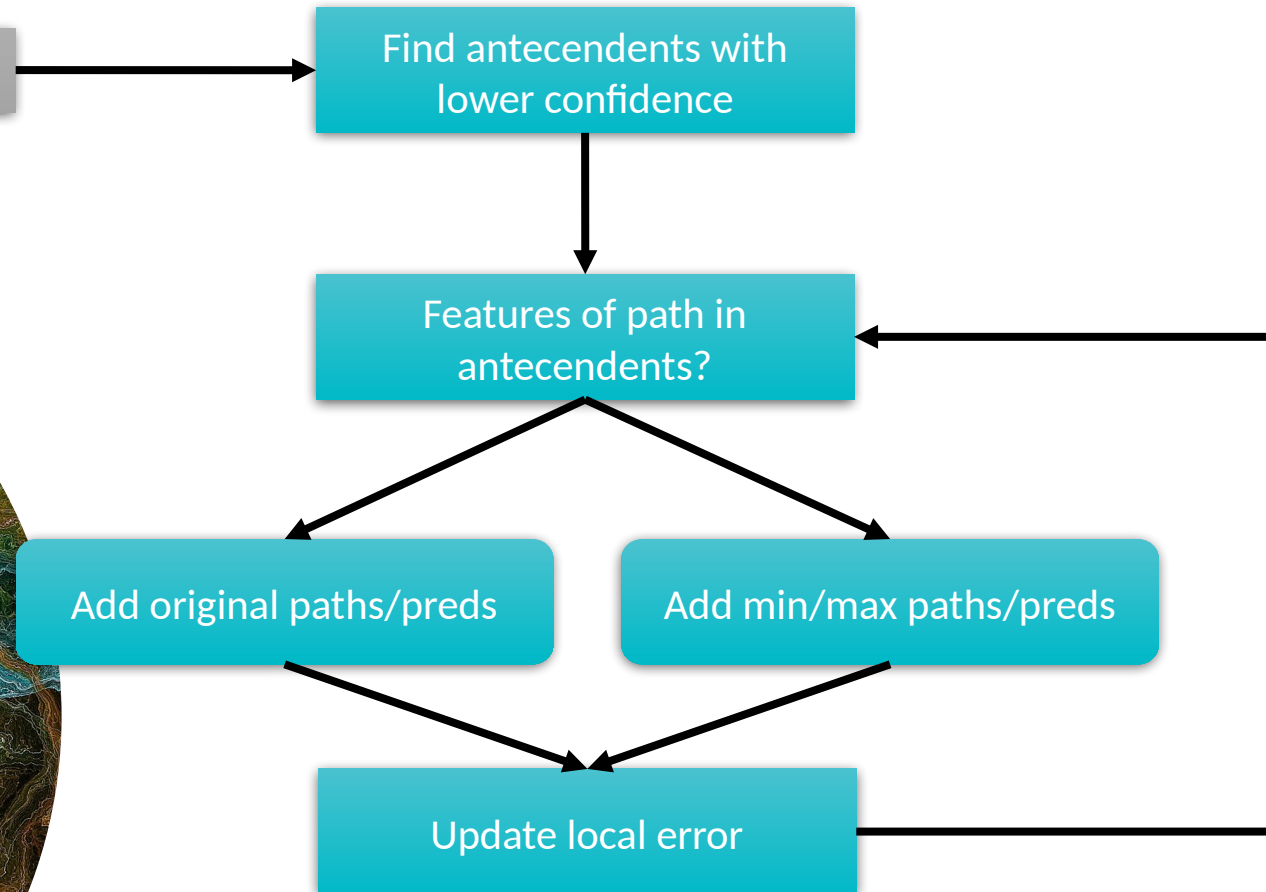


Tailored for each
target

Multi-Target LionForests (XMTR)

Reduction through

Association Rules

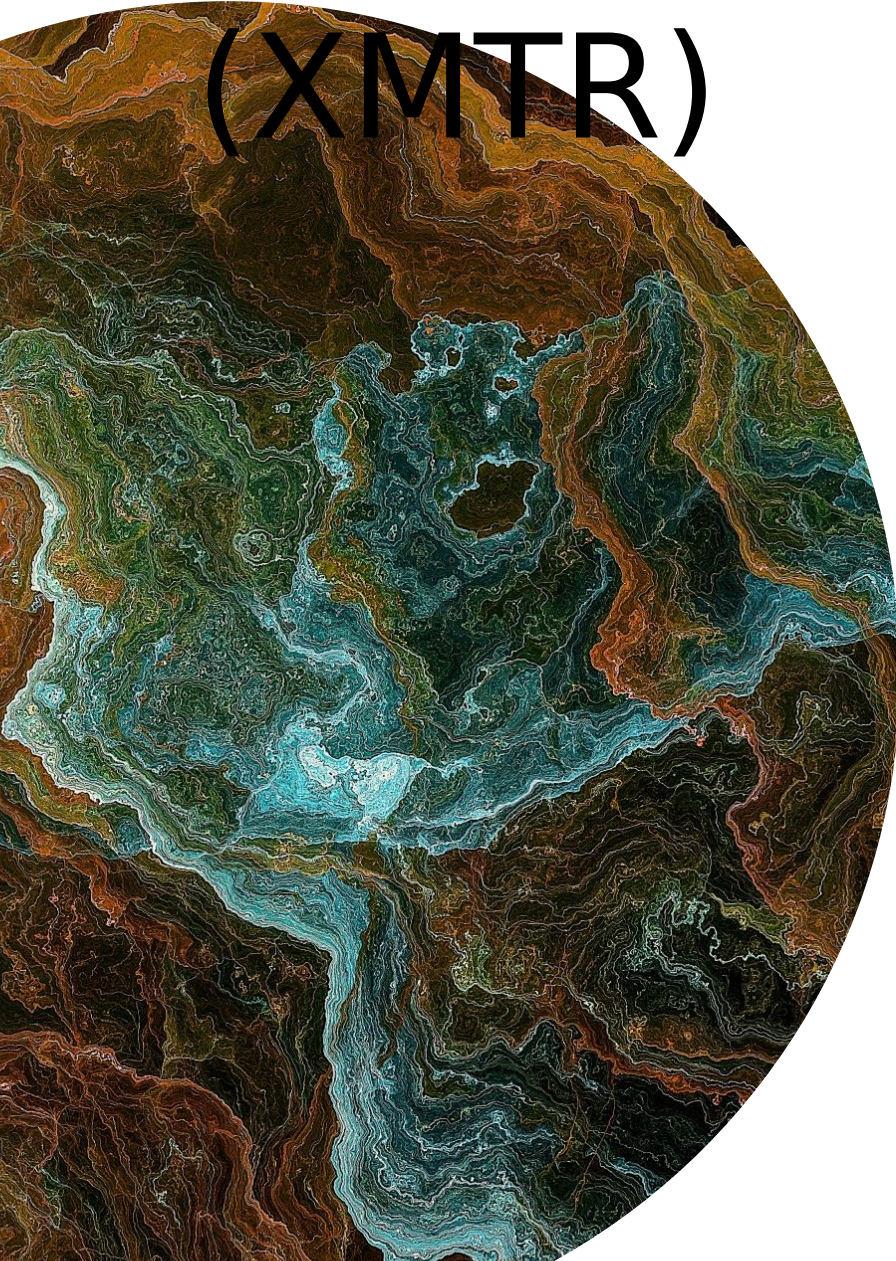


Until
local error < allowed error



Multi-Target LionForests

(XMTR)



Rule

composition

if $207 \leq \text{Feature}_1 \leq 208$ & $100 \leq \text{Feature}_2 \leq 107$ & $137 \leq \text{Feature}_3 \leq 151$ & $126 \leq \text{Feature}_4 \leq 141$

then Slump : $7.9_{\pm 0.8}$, Flow : $7.2_{\pm 0.7}$,
Compressive Strength : $4.9_{\pm 0.2}$



Datasets



Slump:

Instances: 103
features: 7
targets: 3



Andro:

instances: 49
features: 30
targets: 6



Facebook
metrics:

instances: 500
features: 18
targets: 4

1

Comparison
of XMTR, GS,
LS,
MARLENA.

2

Rule
comparison

3

Time
performance

Metrics: Coverage, MAE, Rule Length, Time response

3 Sets of Experiments

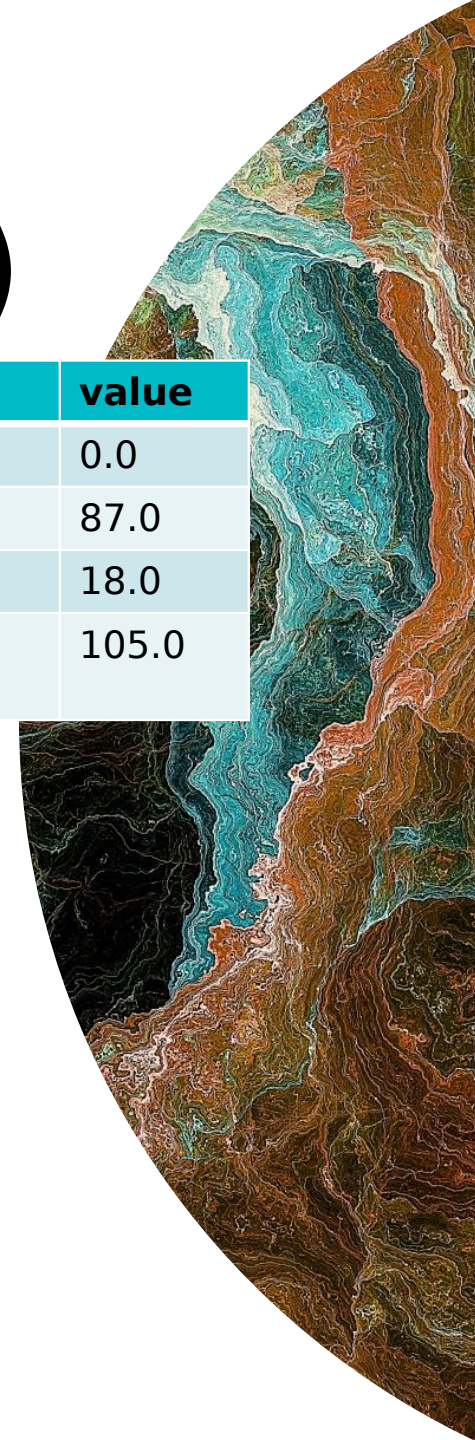
Experiment 1 (Quantitative)

	Coverage			MAE			R length		
	Slump	Andro	Facebook	Slump	Andro	Facebook	Slump	Andro	Facebook
XMTR #1	0.09	0.13	0.04	0.09	0.06	0.00	6.8	21.4	7.9
XMTR #2	0.09	0.17	0.04	0.17	0.25	0.02	6.7	20.4	7.6
XMTR #3	0.10	0.20	0.04	1.46	0.68	0.28	4.9	18.1	5.6
GS	0.20	0.35	0.19	0.22	0.34	0.02	3.9	4.3	3.6
LS	0.23	0.34	0.19	0.30	0.40	0.03	2.9	3.5	2.7
MARLENA	0.11	0.23	0.09	0.16	0.21	0.02	4.8	6.9	4.7

(#

Experiment 2 (Qualitative)

Feature	value	Target	value
F1: Page total likes	11609	T1: comment	0.0
	1	T2: like	87.0
F2: Category	3.0	T3: share	18.0
F3: Post Month	5.0	T4: total interactions	105.0
F4: Post Weekday	6.0		
F5: Post Hour	3.0		
F6: Paid	0.0		
F7: Lifetime Post Total Reach	3332.0		
F8: Lifetime Post Total Impressions	5797.0		
F9: Lifetime Engaged Users	463.0		
F10: Lifetime Post Consumers	406.0		
F11: Lifetime Post Consumptions	552.0		
F12: Lifetime Post Impressions by people who have liked your Page	4347.0		
F13: Lifetime Post reach by people who like your Page	2330.0		
F14: Lifetime People who have liked your Page and engaged with	341.0		



Experiment 2 (Qualitative)

Technique	Rule	Rule length
XMTR	if $236.0 \leq F13 \leq 9150.0$ & $341.0 \leq F9 \leq 597.0$ & $9.0 \leq F14 \leq 378.0$ & $567.0 \leq F12 \leq 19668.5$ & $570.0 \leq F8 \leq 6122.5$ & $2333.5 \leq F7 \leq 3346.0$ & $9.0 \leq F10 \leq 2244.5$ then T1: $3.8651_{\pm 0.0 \text{ error}}$, T2: $98.0023_{\pm 0.0 \text{ error}}$, T3: $18.0479_{\pm 0.0 \text{ error}}$, T4: $119.9155_{\pm 0.0 \text{ error}}$	7
MARLENA	if $F14 \leq 400.5$ & $F7 \leq 3373.97$ & $F8 \leq 6146.1$ & $F9 \leq 589.01$ & $F11 > 542.0$ then T1: 3.8651 , T2: 98.0023 , T3: 18.0479 , T4: 119.9155	5
	Features on both	F9, F14, F8, F7
	Features extra in XMTR	F12, F10, F13
	Features extra in MARLENA	F11

Experiment 2 (Qualitative)

Feature	XMTR Range	From	To
F12	[567.0, 19668.5]	4347.0	19668.5
F10	[9.0, 2244.5]	406.0	2244.5
F13	[236.0, 9150.0]	2330.0	9150.0

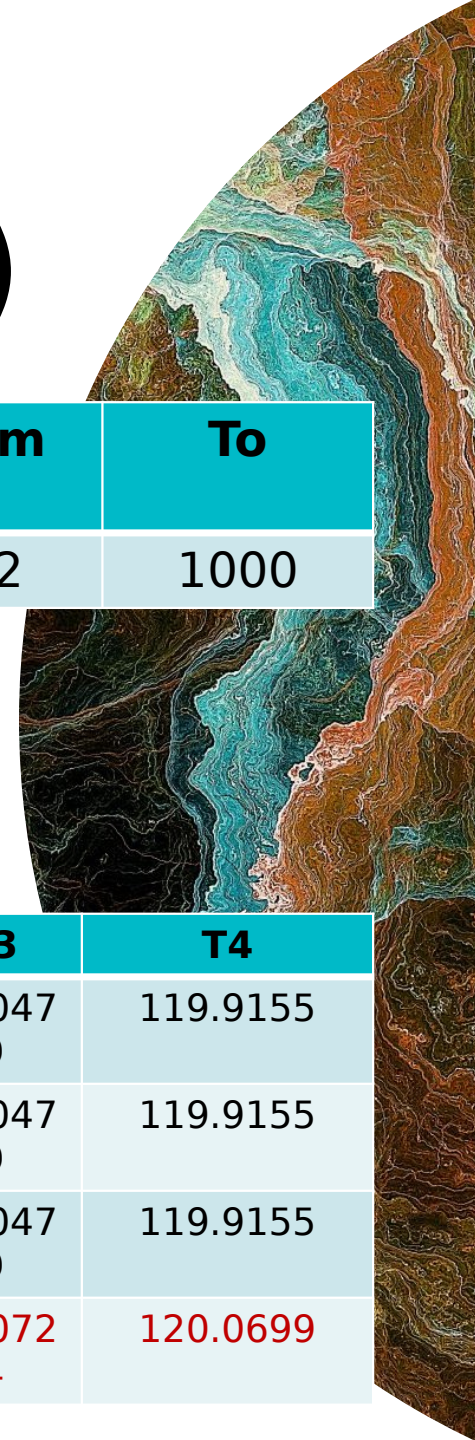


Method	T1	T2	T3	T4
XMTR _B	3.8651	98.0023	18.047 9	119.9155
XMTR _A	3.8651	98.0023	18.047 9	119.9155
MARLENA _B	3.8651	98.0023	18.047 9	119.9155
MARLENA _A	4.2413	105.396	19.215 9	128.8533

Feature	MARLEN A range	From	To
F11	> 542.0	552	1000



Method	T1	T2	T3	T4
XMTR _B	3.8651	98.0023	18.047 9	119.9155
XMTR _A	3.8651	98.0023	18.047 9	119.9155
MARLENA _B	3.8651	98.0023	18.047 9	119.9155
MARLENA _A	3.8704	98.1271	18.072 4	120.0699



Experiment 3 (Time)

Allowed error	Time	#Paths	Time	#Paths
0.05	0.93	482	0.58	495
0.1	1.89	466	1.03	488
0.15	2.73	449	1.30	481
0.2	3.61	436	1.75	473
0.25	4.38	418	2.01	466
0.3	5.22	401	2.57	457

(5000, 50, and 7)



Conclusions



Conclusiveness
property



Small errors



More flexibility

01

Automation
of Allowed
error
initialization

02

Categorical
feature
handling

03

Expand rule
reduction
methods

Future Work

Thank you for you time!

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