Identification of Improvement Potentials to Promote Sustainability of Energy Efficiency of Outdated Cutting Machine Tools

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Introduction

- The demand for new products including machine tools itself lead to great need on raw material and energy resources as well as financial resources. This demand can hardly be met sustainably by means of existing technologies merely. Simultaneously, there exist many outdated machine tools which can still be used effectively.
- Thus, it’s pretty important to find out such abnormalities and correct them in real-time so we get optimal end mill performance.

Abstract/Objective

When we are using existing machine tools we don't know when a drill bit will wear off or not so if a process is going on and the drill wears off we have to stop the process and start it again with new bit for the same material so waste of time waste of energy and waste of material.

We develop an algorithm to rectify this error in real time.

Specifications

- The table shows technical specifications.
- We use decision tree classifier based on f1 score ,accuracy etc…
- Also using xgboost algorithm

Machine type	CNC Milling Machine	CNC Universal Milling Machine
Manufacturing year	1986	2008
Manufacturer (GmbH)	Deckel	Deckel Maho Seebach
Designation	FP4NC	DMU 50
Base area [m]	2 x 1.6	1.2 x 1.4
Number of machine axes	4	3 + 2
CNC control system	Grundig/Dialog 4	Heidenhain/ ITNC 530
Travels X/ Y/ Z [mm]	560/ 500/ 450	500/ 450/ 400
Feed speed [mm/min]	Up to 3600	Up to 24000
Max spindle power [kW]	4.0	13.0
Spindle revolution [RPM]	Up to 3150	Up to 10000
Tool holder system	SK 40	SK 40

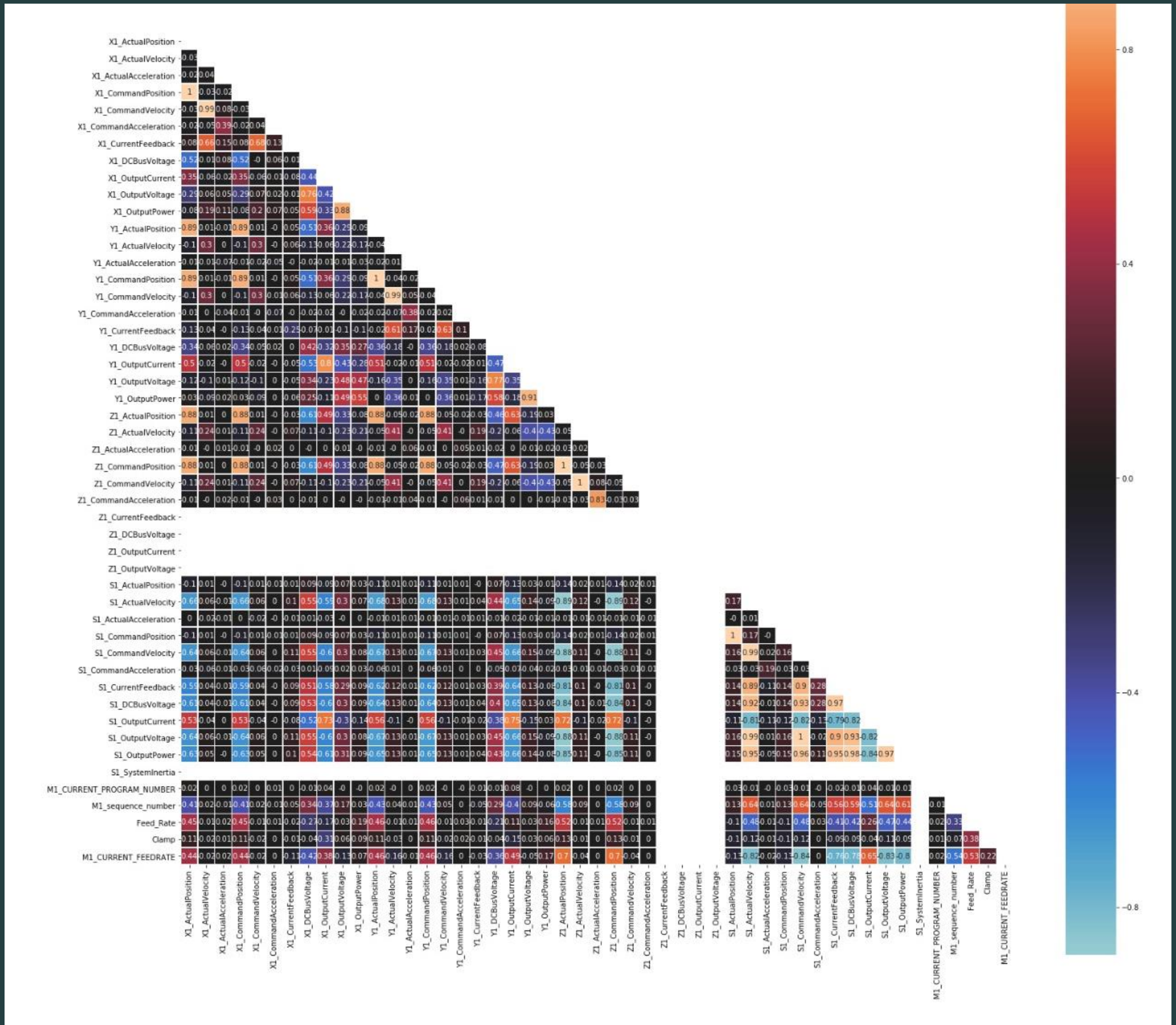
Limitations of the existing systems

- Real time errors can't be detected on current systems
- Only when process is completed, we will know if there are any errors.
- Our Algorithm helps users to find error and fix them in real time

Design Methodology

- XGBoost is a decision-tree-based ensemble Machine Learning algorithm that uses a gradient boosting framework.
- In prediction problems involving unstructured data (images, text, etc.) ... A wide range of applications: Can be used to solve regression, classification, ranking, and user-defined prediction problems.

Implementation



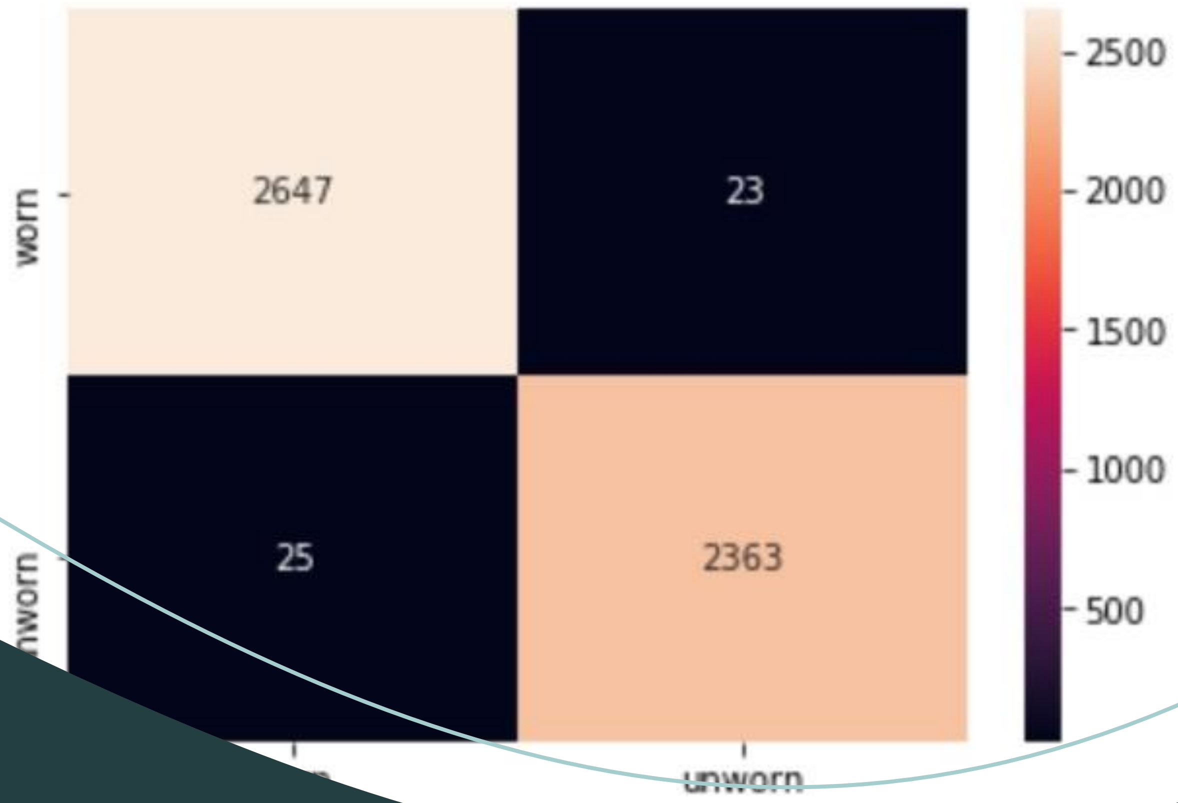
```
The number of instances with X1_ActualPosition==198 is :
4360
The number of instances with M1_CURRENT_FEEDRATE ==50 is :
6253
The number of instances with X1_ActualPosition==198 and M1_CURRENT_FEEDRATE ==50 is :
3182
the possible values of M1_CURRENT_FEEDRATE is:
[50.0, 6.0, 20.0, 15.0, 12.0, 3.0]
```

Data Scaling

	min	max
X1_ActualPosition	141.0	196.0
X1_ActualVelocity	-20.0	51.0
X1_ActualAcceleration	-1280.0	1440.0
X1_CommandAcceleration	-1000.0	1000.0
X1_CurrentFeedback	-23.0	27.0
X1_DCBusVoltage	0.0	0.0
X1_OutputCurrent	320.0	331.0
X1_OutputVoltage	0.0	75.0
X1_OutputPower	-0.0	0.0
Y1_ActualPosition	72.0	158.0
Y1_ActualVelocity	-33.0	50.0
Y1_ActualAcceleration	-1260.0	1460.0
Y1_CommandAcceleration	-1000.0	1000.0
Y1_CurrentFeedback	-28.0	31.0
Y1_DCBusVoltage	0.0	0.0
Y1_OutputCurrent	319.0	333.0
Y1_OutputVoltage	0.0	77.0
Y1_OutputPower	-0.0	0.0
Z1_ActualPosition	28.0	119.0
Z1_ActualVelocity	-52.0	51.0
Z1_ActualAcceleration	-1260.0	1270.0
Z1_CommandAcceleration	-1000.0	1000.0
S1_ActualPosition	-2150.0	2150.0
S1_ActualVelocity	-0.0	54.0
S1_ActualAcceleration	-150.0	150.0
S1_CommandAcceleration	-0.0	100.0
S1_CurrentFeedback	-8.0	75.0
S1_OutputCurrent	290.0	332.0
M1_CURRENT_PROGRAM_NUMBER	0.0	4.0
M1_sequence_number	0.0	135.0
Feed_Rate	3.0	20.0
Clamp	2.0	4.0
M1_CURRENT_FEEDRATE	3.0	20.0

```
Decision tree classifier mitrics:

Accuracy score: 99.1
Sensitivity score: 99.1
Specificity Score: 99.0
```



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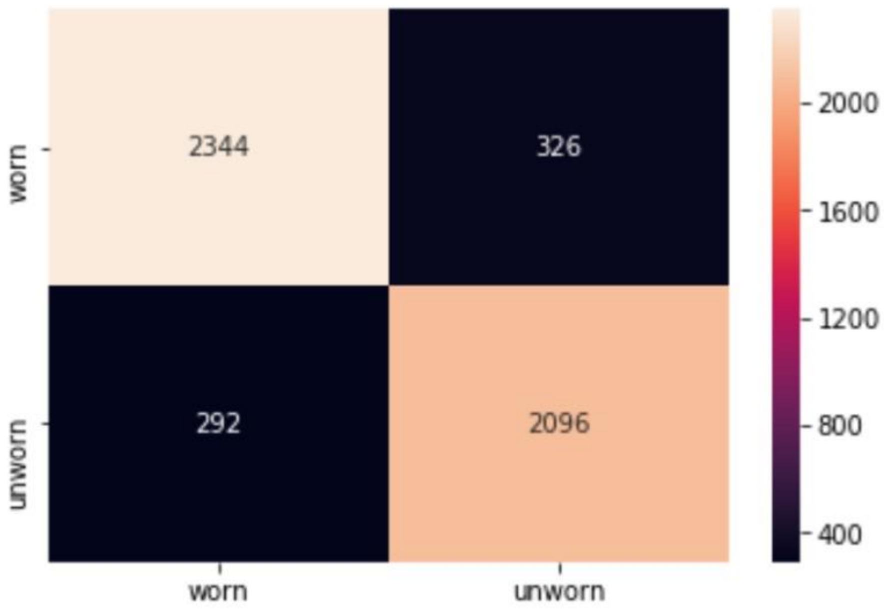
Support vector machine classifier mitrics:

Accuracy score: 87.8
Sensitivity score: 87.8
Specificity Score: 87.8
```



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Multi-layer perceptron classifier mitrics:

Accuracy score: 94.6
Sensitivity score: 94.5
Specificity Score: 94.7
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K-nearest neighbor classifier metrics:

Accuracy score: 90.7
Sensitivity score: 90.9
Specificity Score: 90.5
```

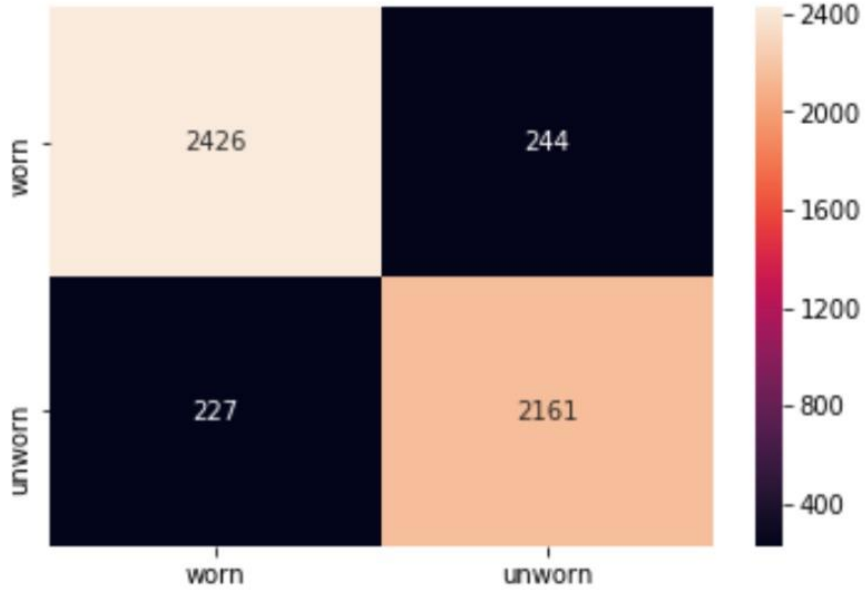

```
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Logistic regression classifier mitrics:

Accuracy score: 60.1
Sensitivity score: 62.9
Specificity Score: 57.0
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Mixed naive bayes classifier metrics:

Accuracy score: 57.1
Sensitivity score: 100.0
Specificity Score: 9.2
```
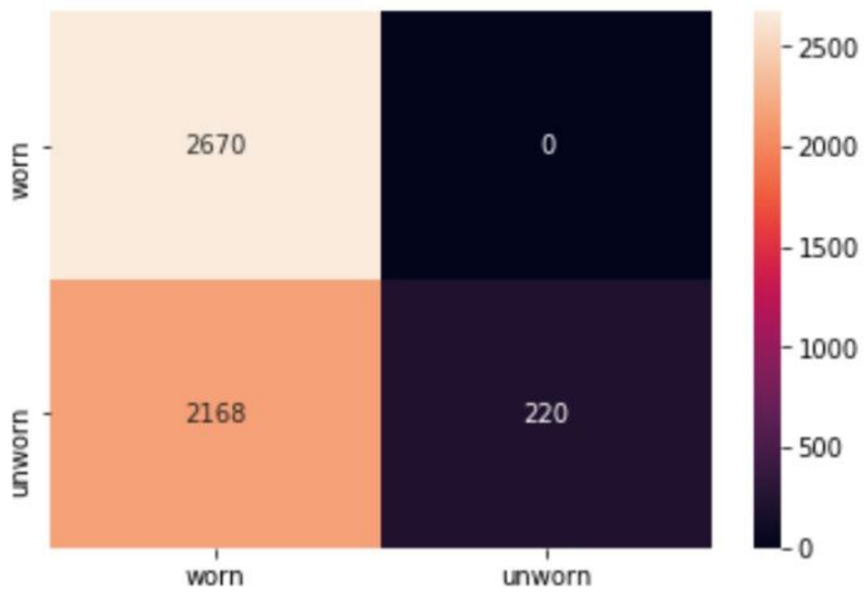
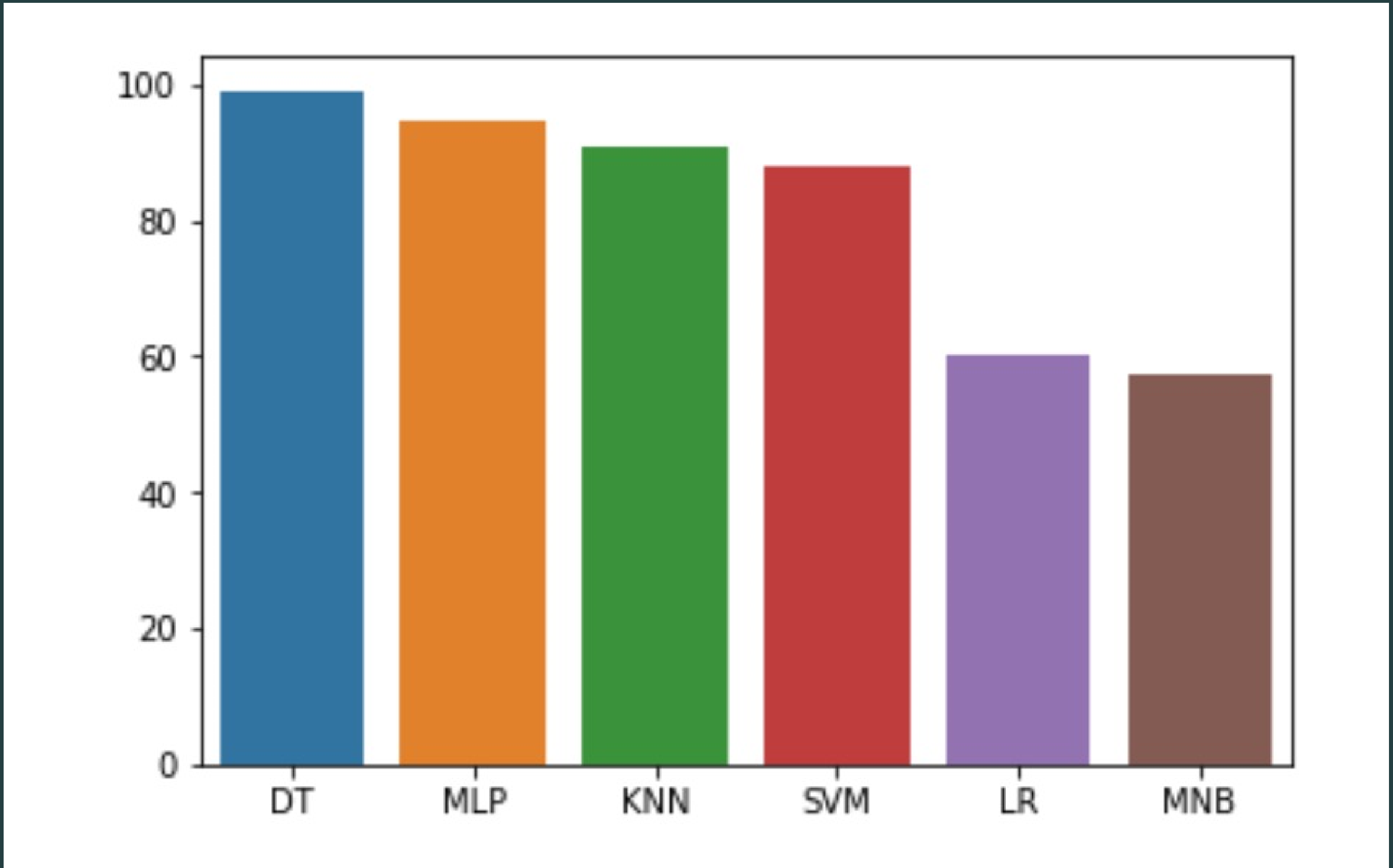
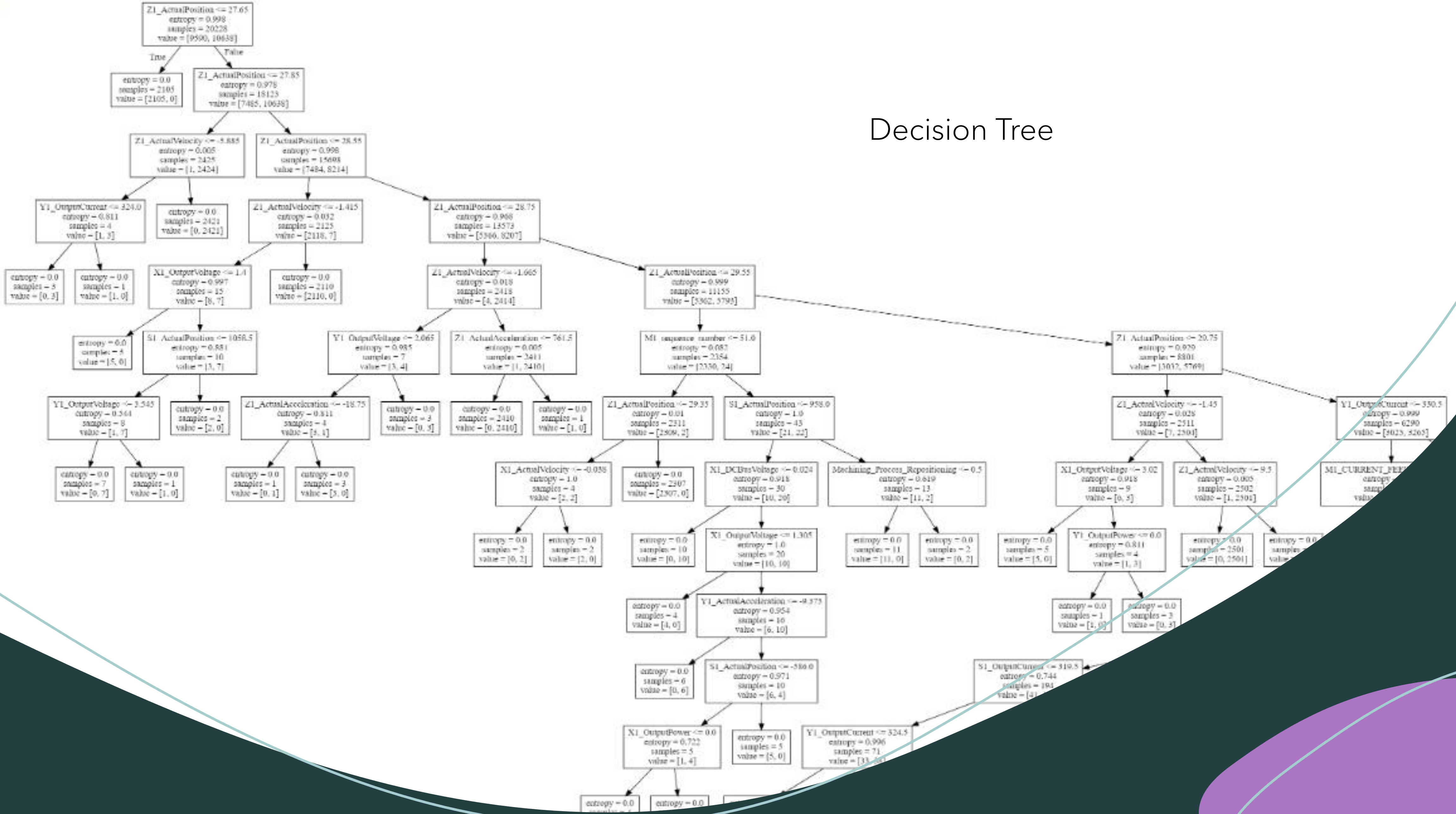




100
80
60
40
20
0
DT
MLP
KNN
SVM
LR
MNB

Decision Tree



Thank You! 😁