Analysis Of Quality Control Data: Faults Prediction In Case of Significant Noise and Imbalance

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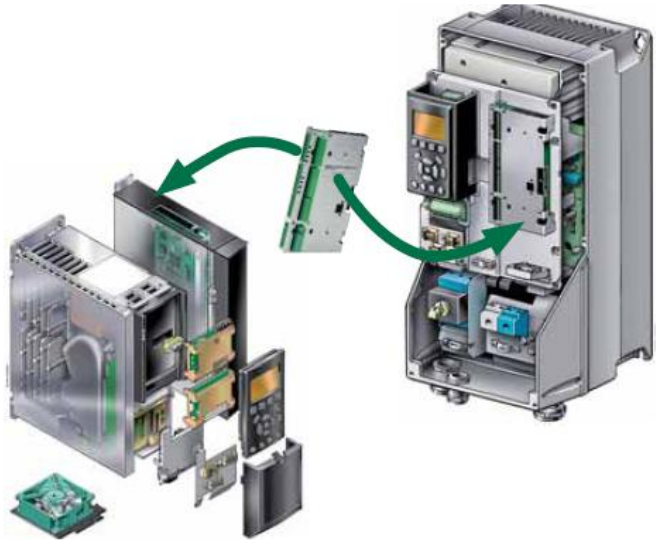
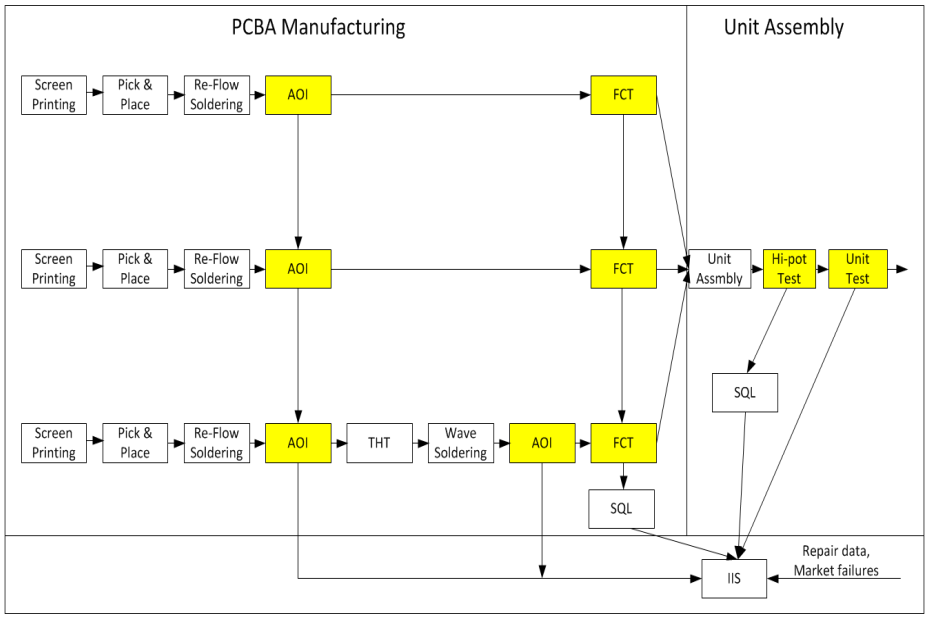
Manufacturing Process (Of Industrial Partner)





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Manufacturing Process (Of Industrial Partner)

Objective:

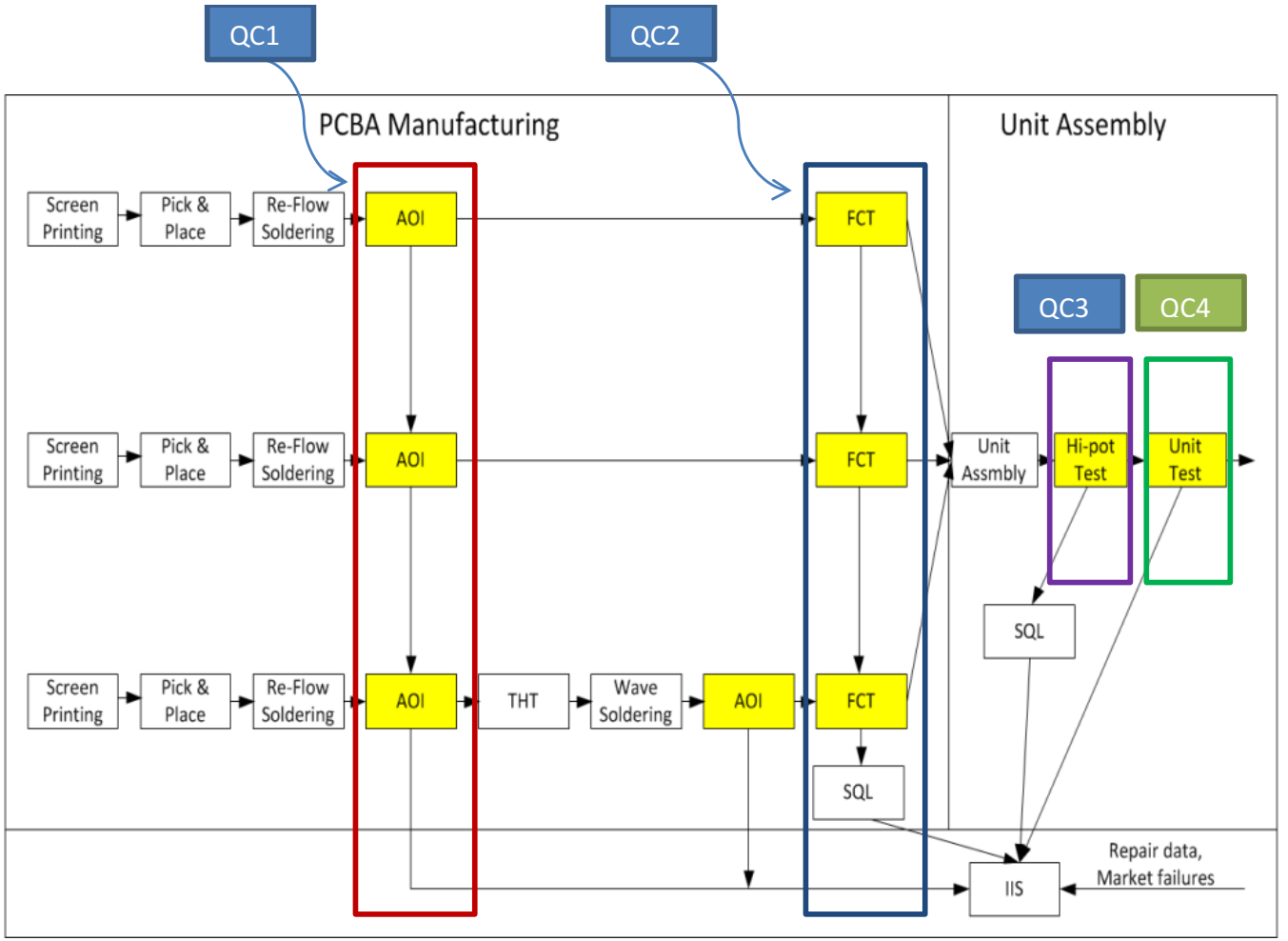
- Prediction of quality at last quality control stage

Challenges:

- Multi stage Manufacturing Process
- Heterogeneous Data streams

Gains:

- Optimization of resources
- Process understanding



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Exploratory Analysis

A	B	C	D	E	F	G	H	I
Nr	Board 1 Vision	Board 1 Function	Board 2 Vision	Board 2 Function	Board 3 Function	VLT HSP	VLT Unit	Freq
1	F	F	F	F	F	F	F	0
2	P	F	F	F	F	F	F	0
3	R	F	F	F	F	F	F	0
4	F	P	F	F	F	F	F	0
5	P	P	F	F	F	F	F	0
6	R	P	F	F	F	F	F	0
7	F	R	F	F	F	F	F	0
8	P	R	F	F	F	F	F	0
9	R	R	F	F	F	F	F	0
10	F	F	P	F	F	F	F	0
11	P	F	P	F	F	F	F	0
12	R	F	P	F	F	F	F	0
13	F	P	P	F	F	F	F	0
14	P	P	P	F	F	F	F	0
15	R	P	P	F	F	F	F	0
16	F	R	P	F	F	F	F	0
17	P	R	P	F	F	F	F	0
18	R	R	P	F	F	F	F	0
19	F	F	R	F	F	F	F	0
20	P	F	R	F	F	F	F	0

DTU Technical University of Denmark

MADE Manufacturing Academy of Denmark

Danfoss

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Exploratory Analysis

Data Set 1

Test	Fail	Pass	Repair
AOI1	0	17505	1719
AOI2	52	18799	373
FT1	0	15527	3697
FT2	309	18892	23
FT3	299	18925	0
HV	2	19202	20
UT	4	19013	207

Data Set 2

Test	Pass	Repair	Fail
AOI (Vision)	2213905	606315	0
FT (Function)	2059030	21813	40115
H.V (High Volt)	724244	2012	241
M.Load (Unit)	709287	21800	569

- **Primality of failure or repair at Unit test (UT)**

- Data Set 1: 0.0108
- Data Set 2: 0.0307

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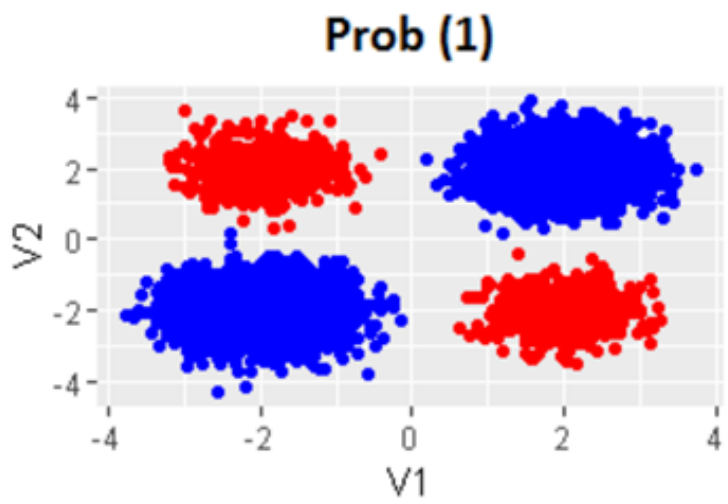
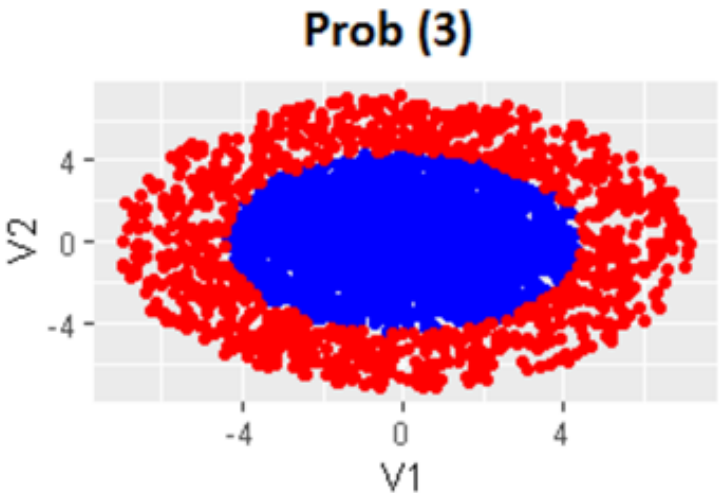
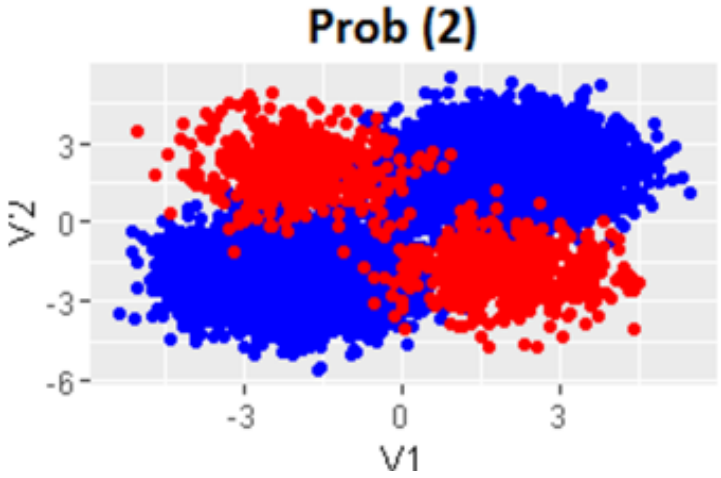
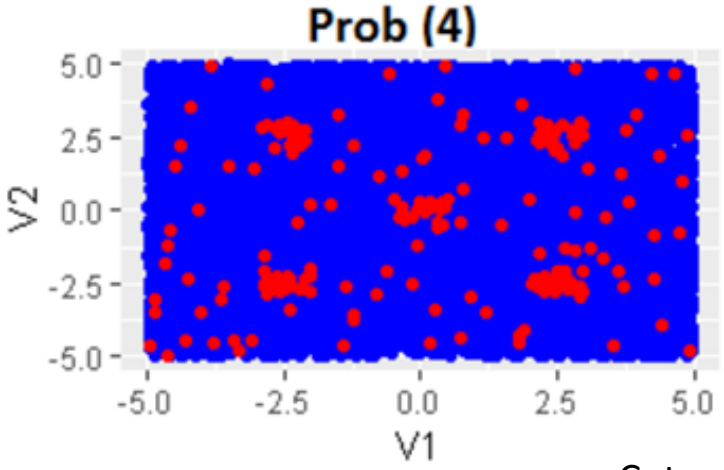
Imbalance and Noise vary among classification problems









- Category1: Blue
- Category2: Red

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Existing Methods

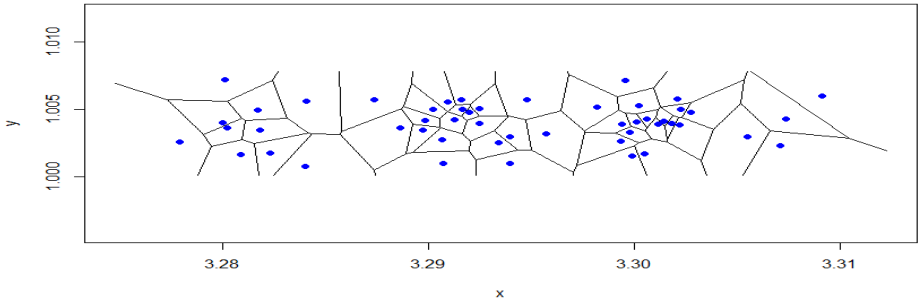
- State of the art

1. Pre processing methods
   - Resampling
   - Feature extraction (filter and wrapper techniques)

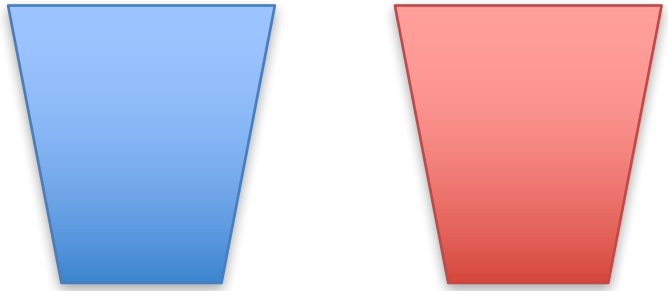
2. Cost Sensitive Methods
   - Boosting (adaboost, Gradient boost etc)

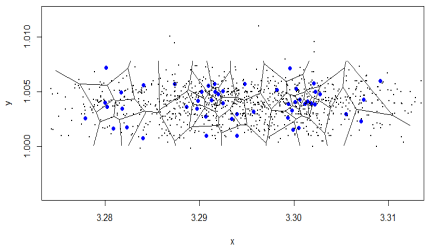
Proposed Methodology: Partition of Information Space and selection of best partition

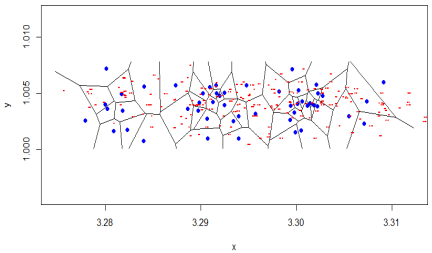
1. Partition of the feature space through Voronoi tessellation



2. Selection of the tiles according to their probability







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Proposed Methodology to solve imbalance classification problem

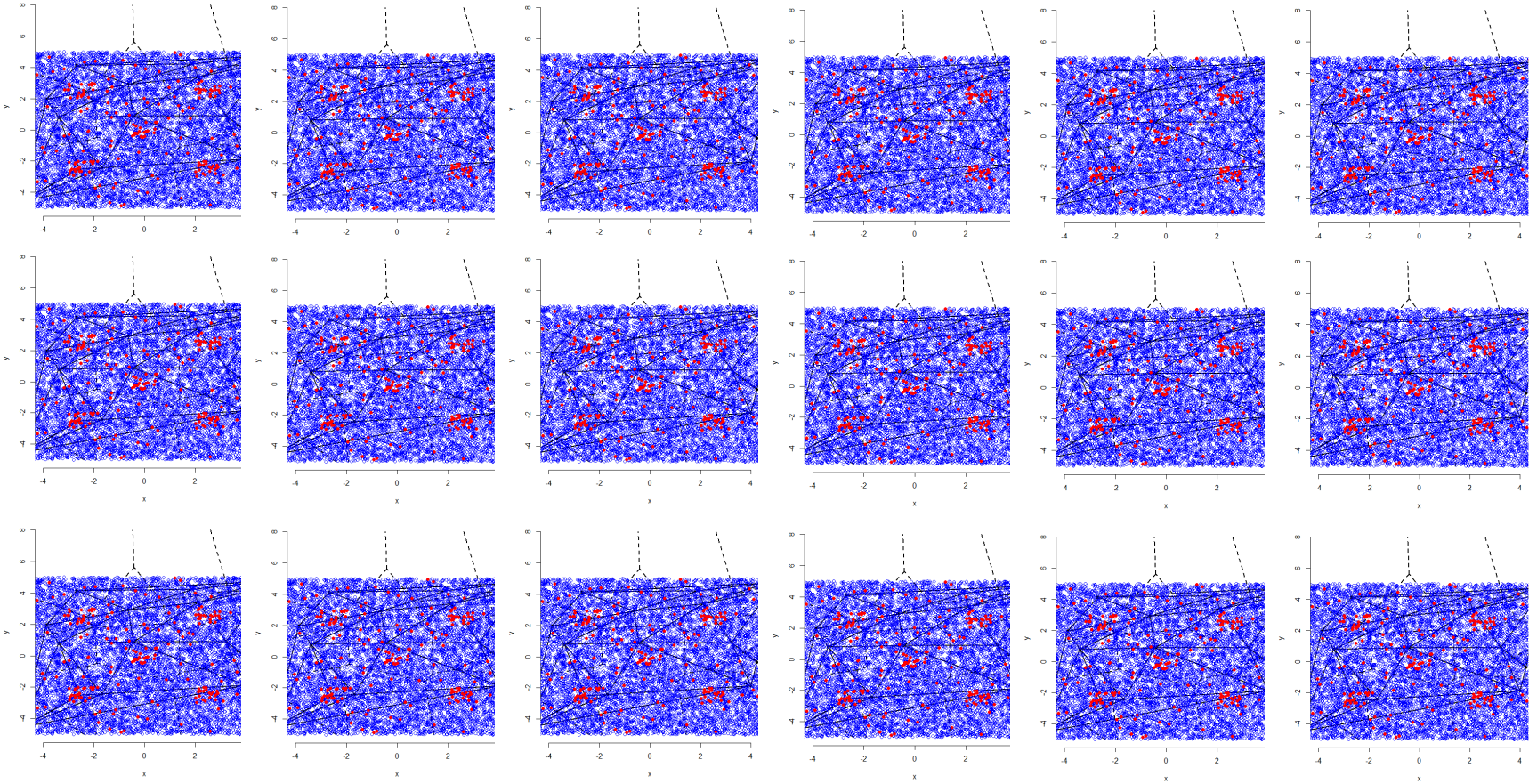
- Selection of Seed points

  Randomly
- LVQ to adjust the seed points

  SOM, the unsupervised way of finding the clusters
- LVQ output as final seed for voronoi tiles

  Voronoi tiles are based on the LVQ outputs
- Selecting voronoi tiles with the help of GA
  - Selection of the Number of tiles
  - Selection of Classes need objective function

Proposed Methodology: Partition of Information Space and selection of best partition



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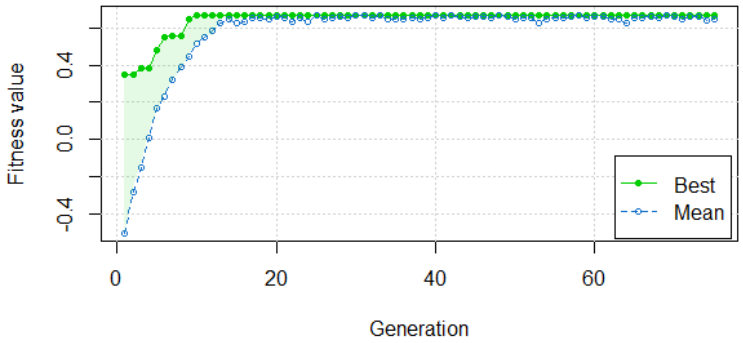
Assigning groups to the tiles (Results)

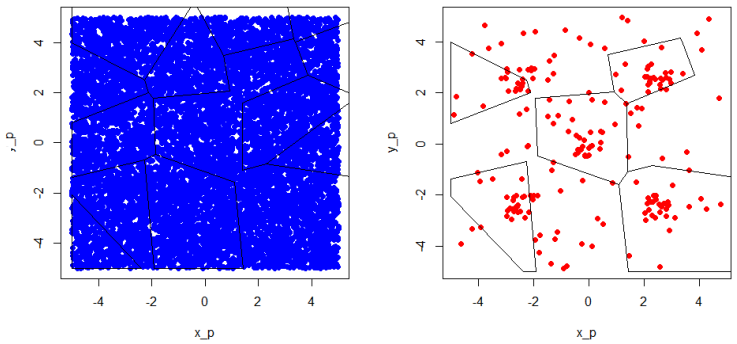
Status	Class B_{pass}	Class B_{fail}	
pass	$X_{pass,B_{pass}}$	$X_{pass,B_{fail}}$	$X_{pass.}$
fail	$X_{fail,B_{pass}}$	$X_{fail,B_{fail}}$	$X_{fail.}$
Total	$X_{.,B_{pass}}$	$X_{.,B_{fail}}$	$X_{..}$

Table 1: Contingency table for partion $\{B_{pass}, B_{fail}\}$



Objective Function

$$I = \frac{L_{fail} - U_{pass}}{(U_{pass} - L_{pass}) + (U_{fail} - L_{fail})}$$



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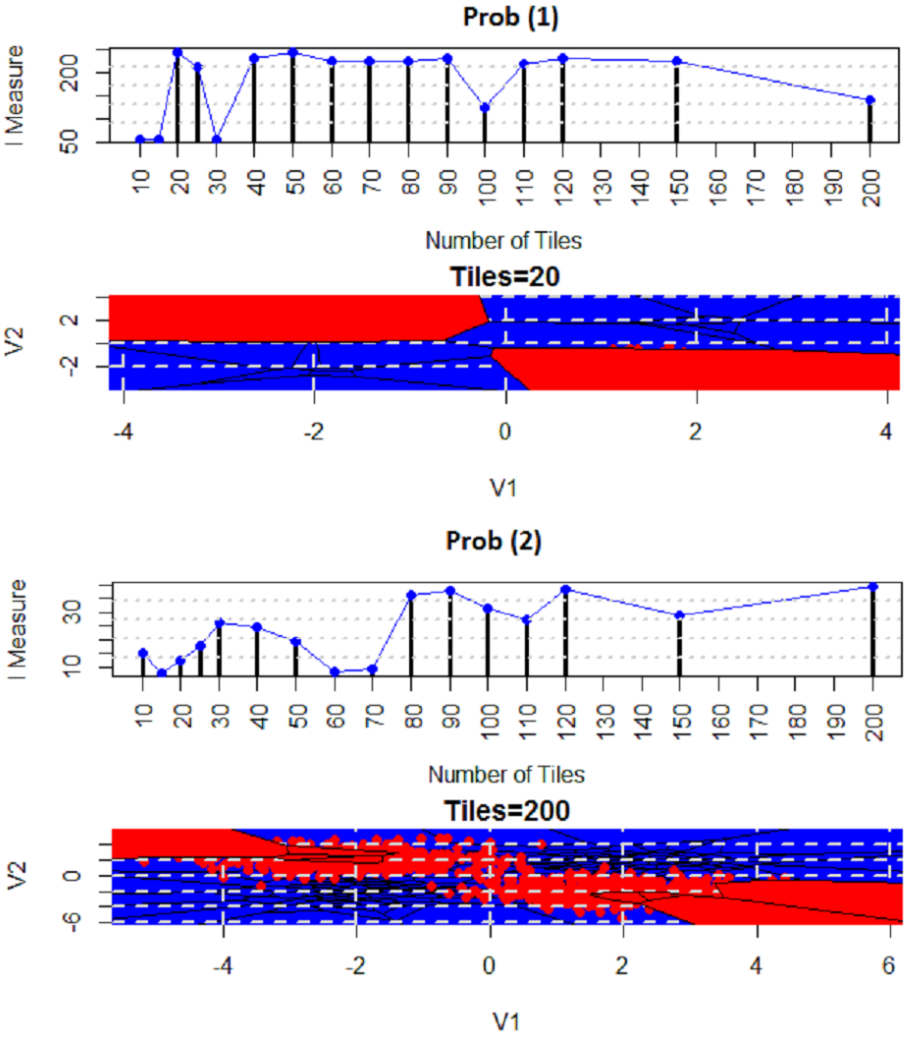
Classification through proposed Methodology (Results)



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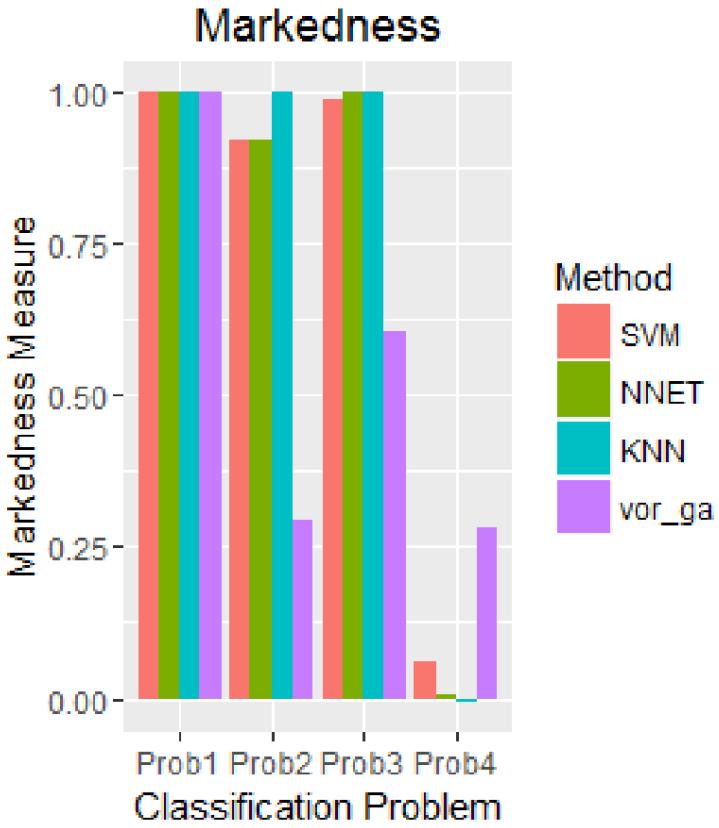
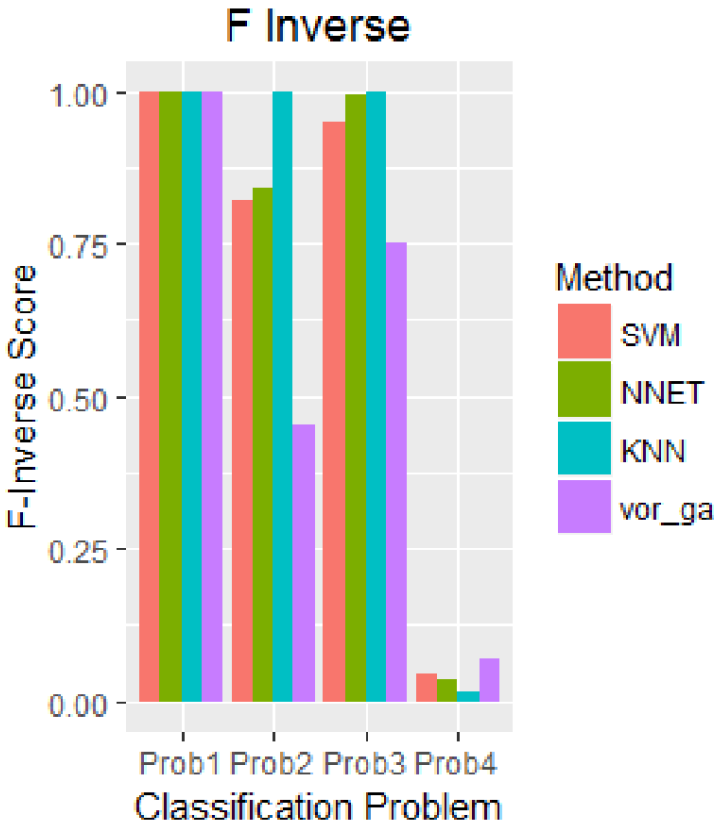
Performance of the proposed methodology (Results)





$$Markedness = Precision + Inverse\ Precision - 1 \quad (7)$$

Where,

$$Precision = \frac{Actual\ Positives \cap Predictive\ Positives}{Predictive\ Positives}$$

By above definition,

$$Precision = \frac{TP}{(TP+FP)} \text{ and } Inverse\ Precision = \frac{TN}{(TN+FN)}$$

		Prediction outcome: p	Prediction outcome: n	Total
Actual value	p′	True Positive (TP)	False Negative (FN)	P′
	n′	False Positive (FP)	True Negative (TN)	N′
Total		P	N	

$$F_1 = \frac{2\mathrm{TP}}{2\mathrm{TP} + \mathrm{FP} + \mathrm{FN}}$$

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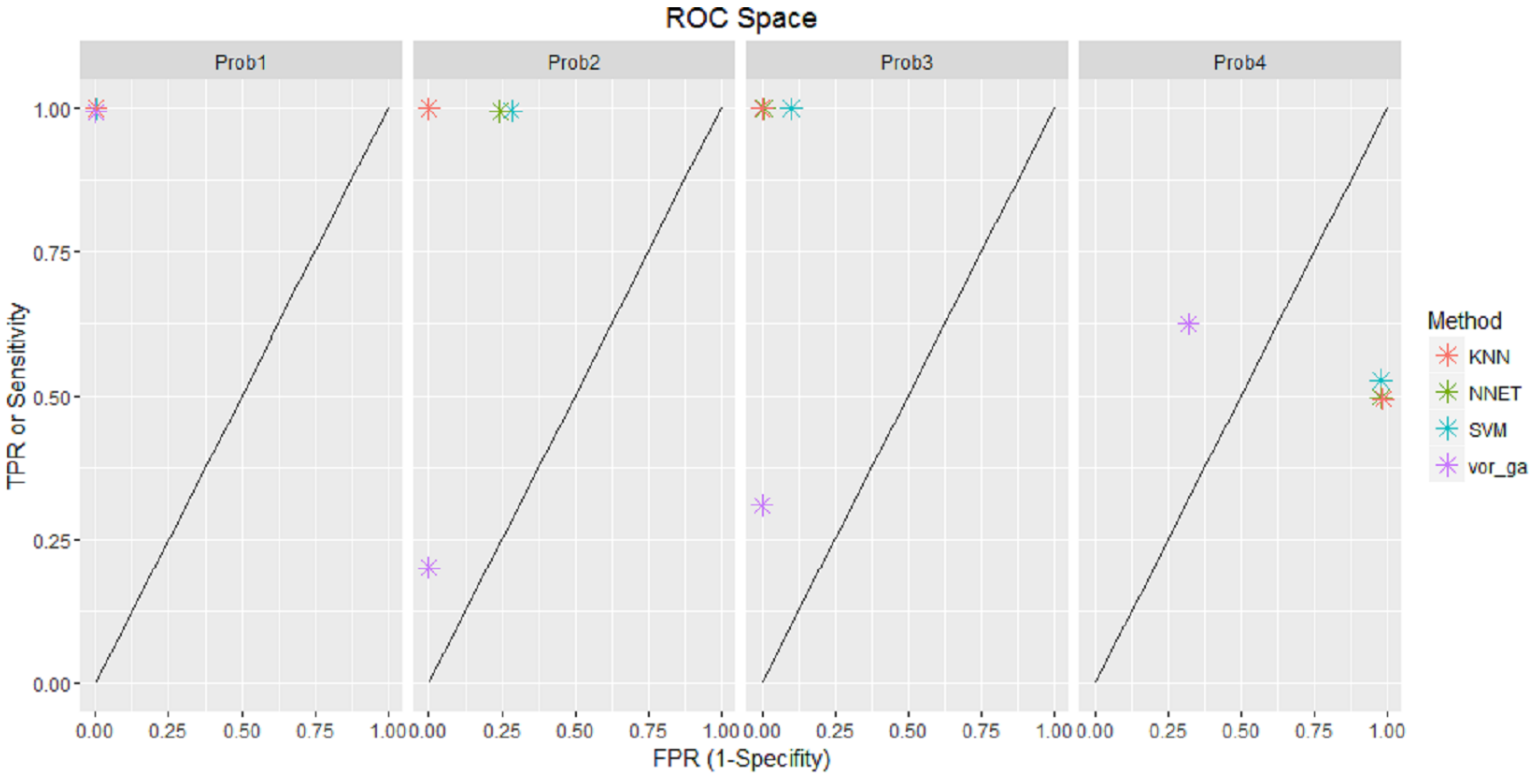
Performance of the proposed methodology (Results)



$$\mathrm{FPR} = \frac{\mathrm{FP}}{N} = \frac{\mathrm{FP}}{\mathrm{FP} + \mathrm{TN}} = 1 - \mathrm{TNR}$$

$$\mathrm{TPR} = \frac{\mathrm{TP}}{P} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}}$$

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Conclusion

- A Novel methodology to classify imbalanced and noisy data

- Application of methodology in Industrial manufacturing

✓ Optimized quality control
✓ Optimization of Resources
✓ More Knowledge/understanding about process dynamics

Vision of next generation factory