Different goals, different models: How to use models to sharpen up your questions

Ron Kenett and Chris Gotwalt

KPA Insights through analytics

jmp STATISTICAL DISCOVERY

Agenda

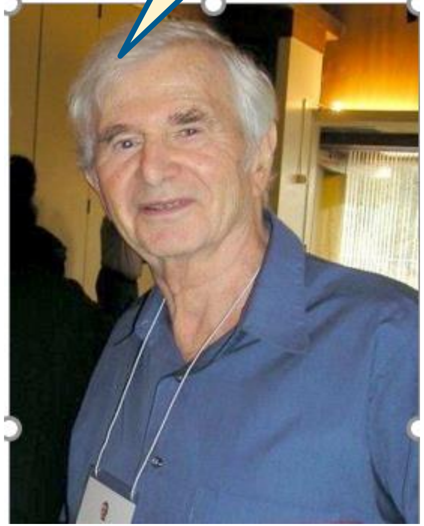
- Intro and a simple example – Ron
  - What is the role of models?
  - The sensor data case study
- A complex example and conclusions – Chris
  - Variable importance and SHAP values
  - More complex models

All models are wrong, but some are **useful**


George Box
(1919 – 2013)

Yes, but which ones?

The purpose of models is not to fit the data but to **sharpen the question**


Sam Karlin, 1924-2007

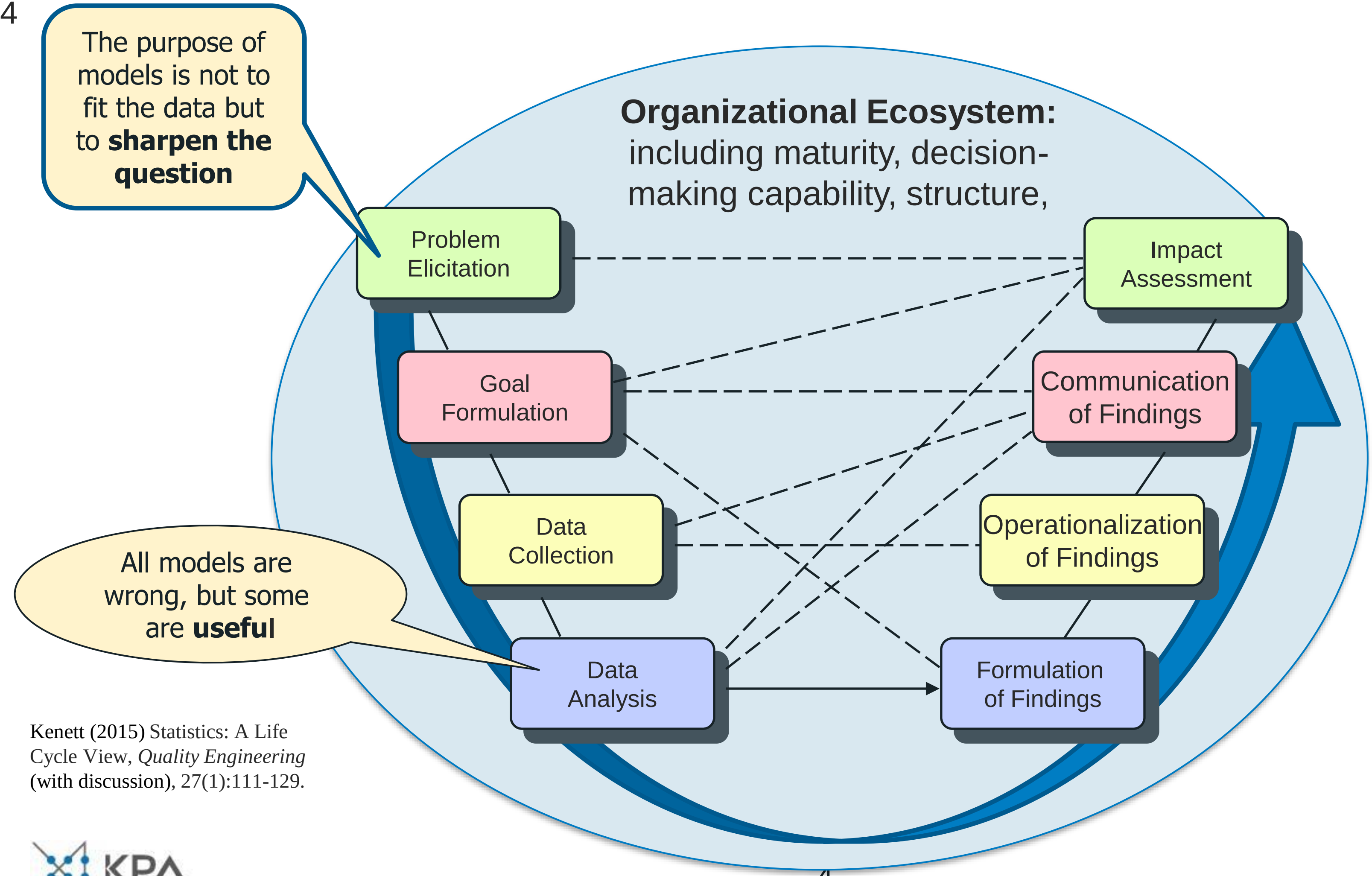
Yes, but how?

This is the key difference between a model and a computer program

RSK


Pablo Picasso, 1881-1973

"Computers are useless. They can only give you answers"



Kenett (2015) Statistics: A Life Cycle View, *Quality Engineering* (with discussion), 27(1):111-129.

KPA Insights through analytics

jmp STATISTICAL DISCOVERY

63 sensors, one response

SENSORS.jmp

SENSORS
Source
Decisio...of status

Columns (65/1)

sensor0...tc. (63/0)
testResult
status

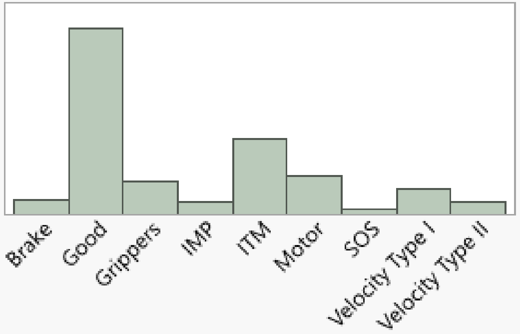
Rows
All rows 174

	sensor01	sensor02	sens
1	395.333333	735.771429	556.
2	657.8	385.87619	833.
3	604.104762	678.171429	743.
4	348.771429	621.590476	506
5	333.009524	624.771429	540.
6	752.342857	241.028571	840.3
7	287.390476	718.428571	410.
8	463.180952	631.07619	590.
9	270.095238	542.514286	391.
10	359.266667	707.780952	546.
11	387.27619	635.952381	483.
12	497.514286	684.47619	694.
13	372.438095	520.857143	541.
14	516.390476	550.485714	613

Boosted Tree

Random Forrest

testResult

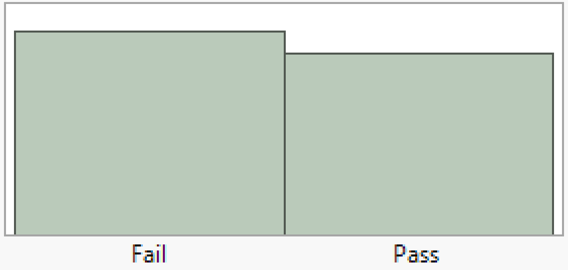


Frequencies

Level	Count	Prob
Brake	6	0.03448
Good	82	0.47126
Grippers	14	0.08046
IMP	5	0.02874
ITM	33	0.18966
Motor	16	0.09195
SOS	2	0.01149
Velocity Type I	11	0.06322
Velocity Type II	5	0.02874
Total	174	1.00000

N Missing 0
9 Levels

status



Frequencies

Level	Count	Prob
Fail	92	0.52874
Pass	82	0.47126
Total	174	1.00000

N Missing 0
2 Levels

KPA Insights through analytics

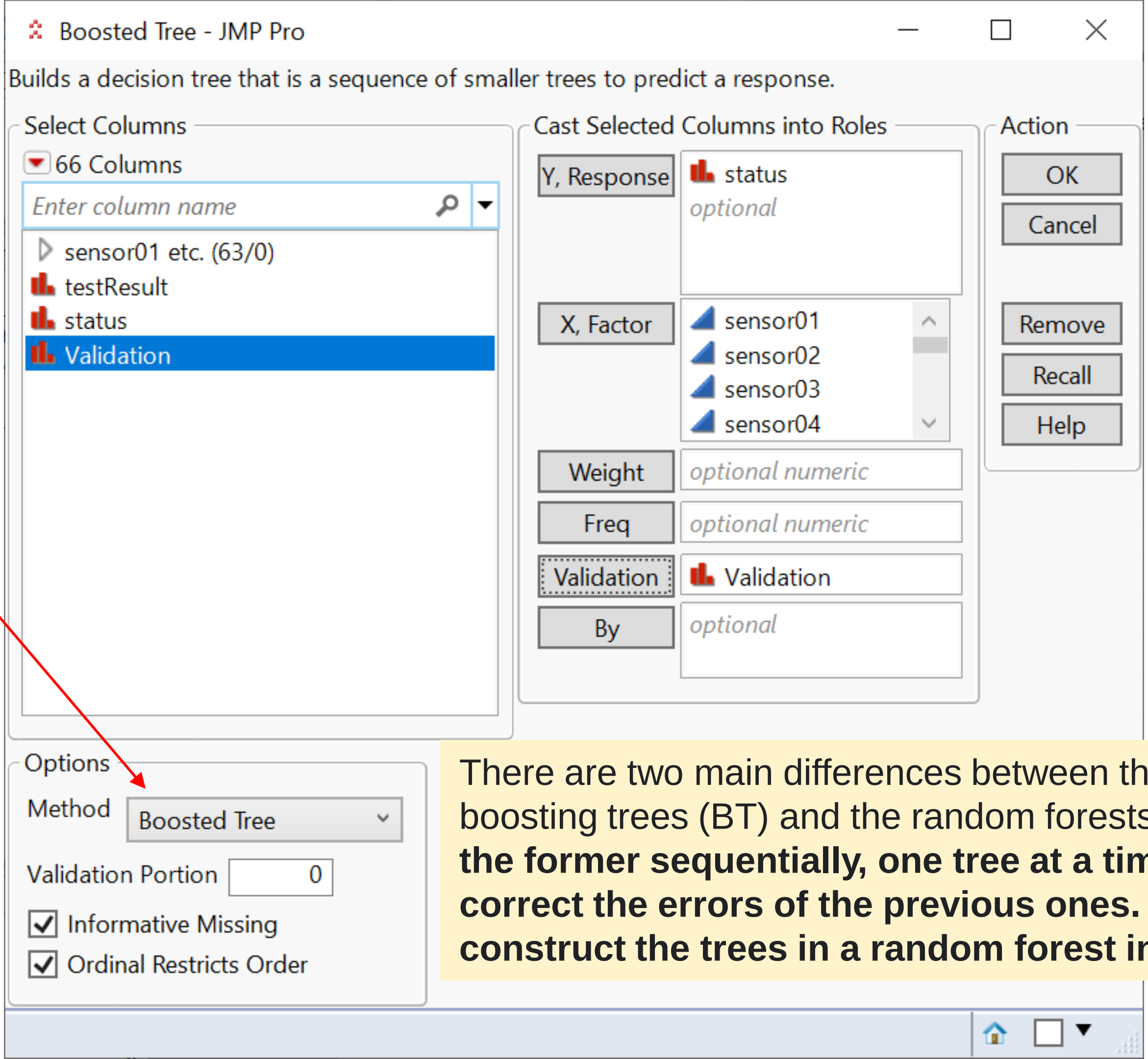
jmp STATISTICAL DISCOVERY

Goal: Determine system status from the sensor data

SENSORS.jmp

Achieving this goal would enable us to create on-line quality control and avoid the cost and delays of testing

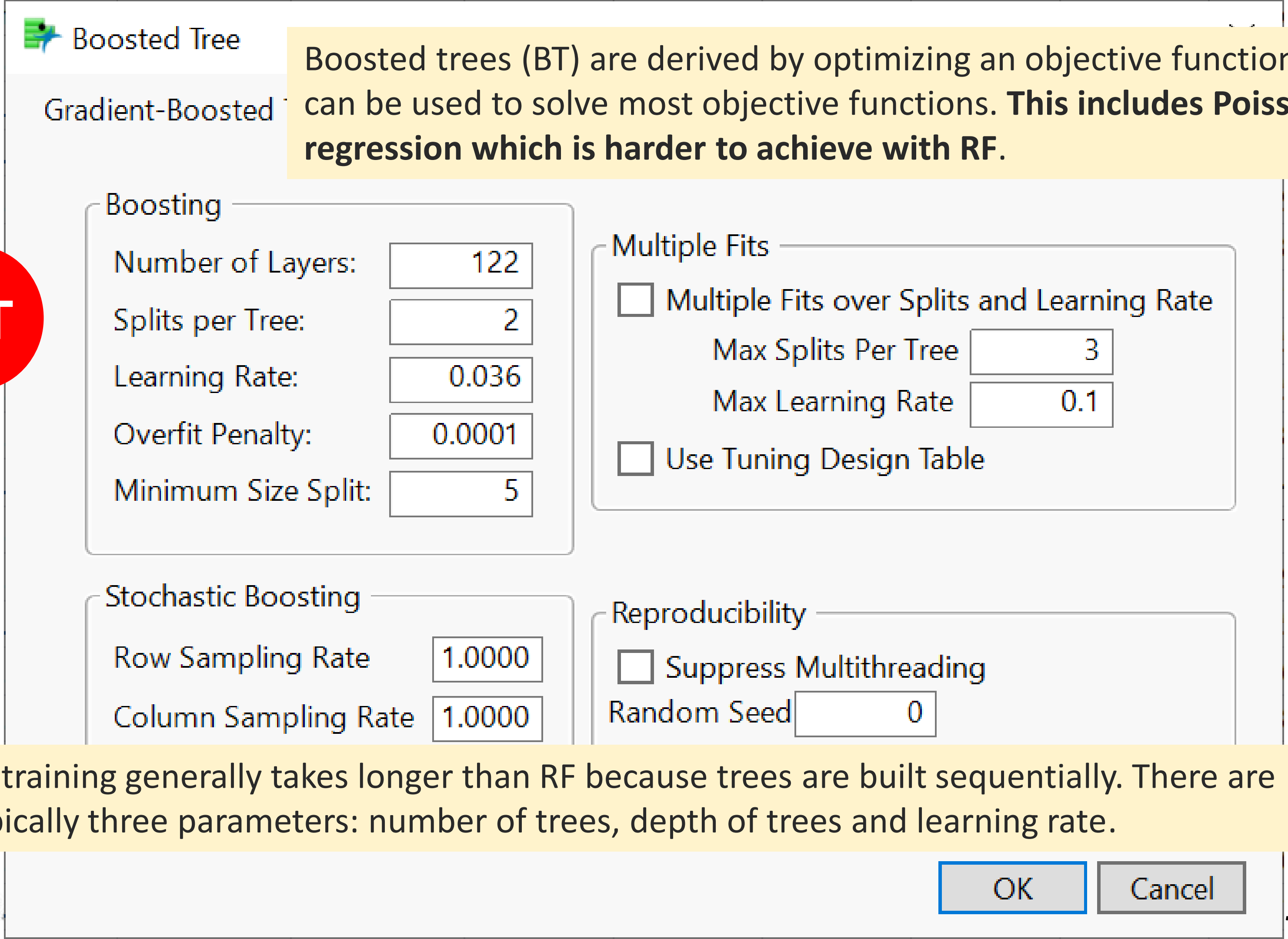
BT



There are two main differences between the gradient boosting trees (BT) and the random forests (RF). **We train the former sequentially, one tree at a time, each to correct the errors of the previous ones. In contrast, we construct the trees in a random forest independently**

Boosted trees (BT) are derived by optimizing an objective function. They can be used to solve most objective functions. **This includes Poisson regression which is harder to achieve with RF**.

BT



BT training generally takes longer than RF because trees are built sequentially. There are typically three parameters: number of trees, depth of trees and learning rate.

Boosted Tree for status

Specifications

Target	status	Number of training rows:	131
Validation Column:	Validation	Number of validation rows:	43
Number of Layers:	122		
Splits per Tree:	2		
Learning Rate:	0.036		
Overfit Penalty:	0.0001		

Overall Statistics

Measure	Training	Validation	Definition
Entropy RSquare	0.9981	0.5788	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.9991	0.7352	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Mean -Log p	0.0013	0.2909	∑ -Log(ρ[j])/n
RASE	0.0025	0.2649	$\sqrt{\sum(y[j]-\rho[j])^2/n}$
Mean Abs Dev	0.0013	0.0875	∑ |y[j]-ρ[j]|/n
Misclassification Rate	0.0000	0.0930	∑ (ρ[j]≠ρMax)/n
N	131	43	n

Confusion Matrix

Training

Actual status	Predicted Count Fail	Predicted Count Pass
Fail	69	0
Pass	0	62

Validation

Actual status	Predicted Count Fail	Predicted Count Pass
Fail	20	3
Pass	1	19

Training

Actual status	Predicted Rate Fail	Predicted Rate Pass
Fail	1.000	0.000
Pass	0.000	1.000

Validation

Actual status	Predicted Rate Fail	Predicted Rate Pass
Fail	0.870	0.130
Pass	0.050	0.950

BT

9.3%

Column Contributions

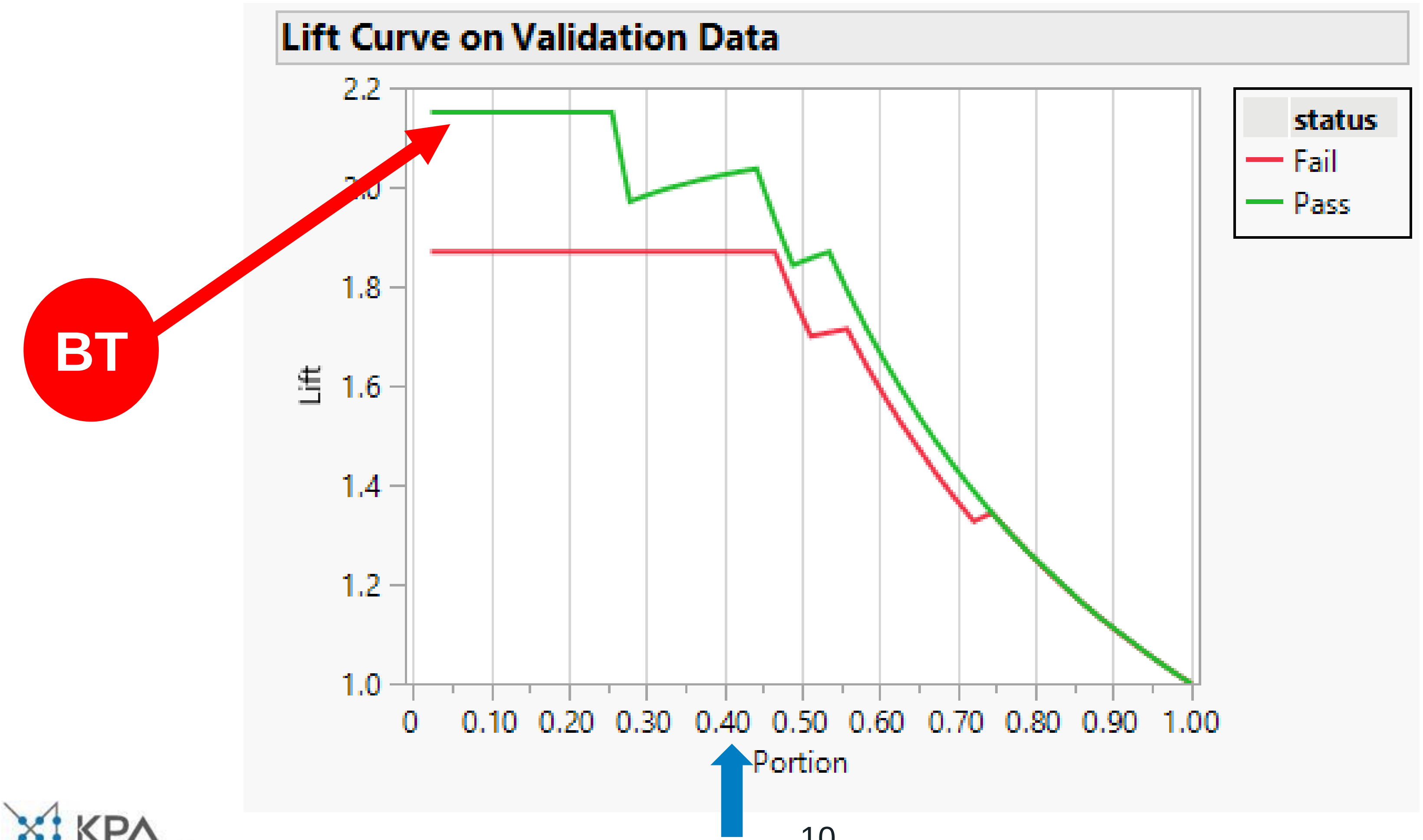
Term	Number of Splits	G^2	Portion
sensor56	82	4634.8525	0.2065
sensor18	27	4200.54219	0.1872
sensor11	21	2735.54419	0.1219
sensor61	19	2431.70533	0.1084
sensor48	17	2414.82121	0.1076
sensor57	22	2016.84895	0.0899
sensor58	10	1456.34648	0.0649
sensor59	8	726.693834	0.0324
sensor26	2	343.87221	0.0153
sensor52	2	323.166652	0.0144
sensor09	6	286.922646	0.0128
sensor01	9	194.974174	0.0087
sensor55	2	165.247012	0.0074
sensor24	4	151.216612	0.0067
sensor07	4	128.858022	0.0057
sensor12	4	117.421132	0.0052
sensor15	2	44.7671089	0.0020
sensor44	1	37.6713347	0.0017
sensor54	1	15.5711294	0.0007
sensor27	1	12.8974036	0.0006

Actual Validation Pass = 20

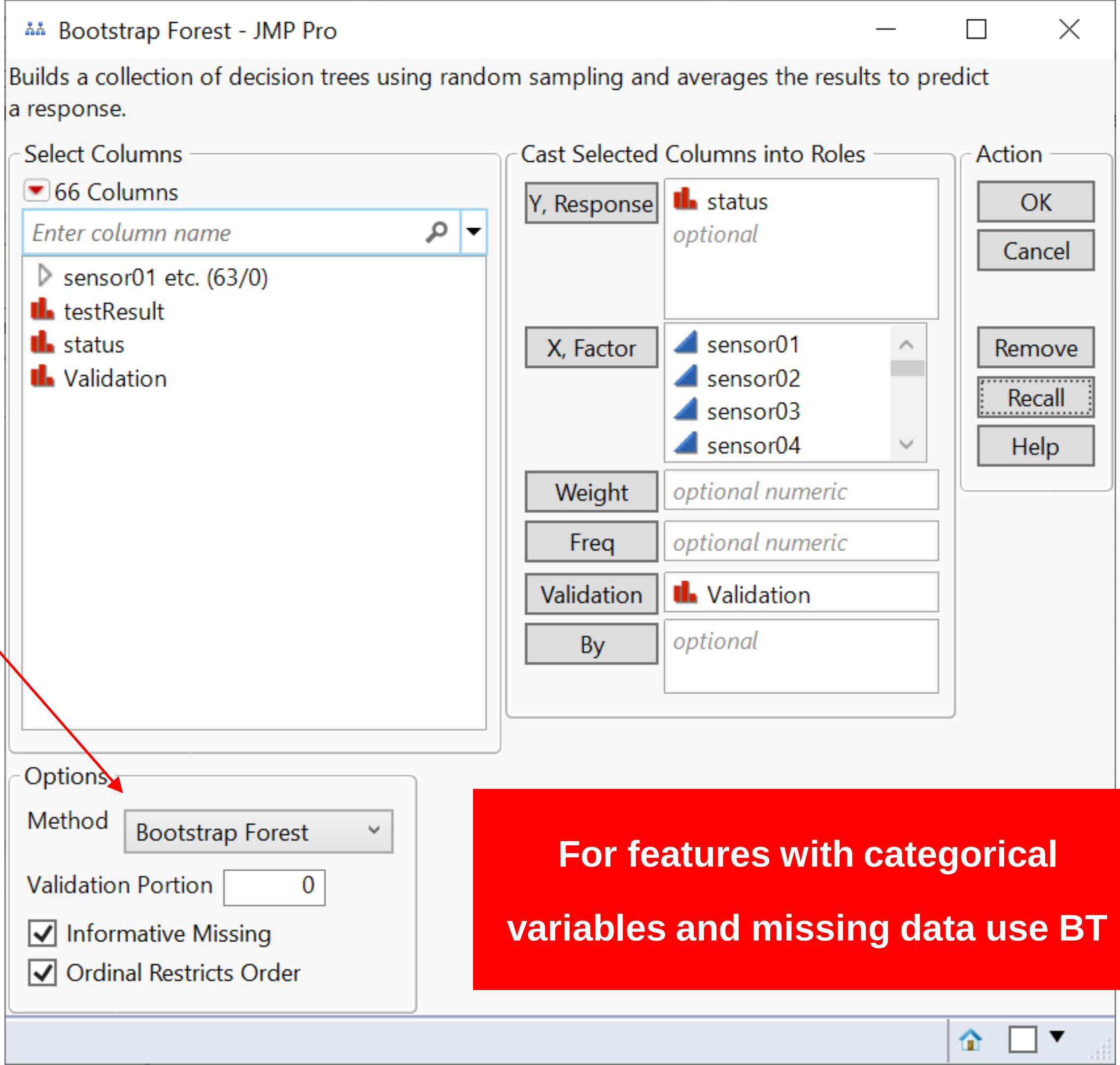
of these, predicted Pass = 19

False predicted Pass = 3 (13%)

…some overfitting


Lift Curve on Validation Data
status
Fail
Pass
Lift
Portion
2.2
1.8
1.6
1.4
1.2
1.0
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
BT

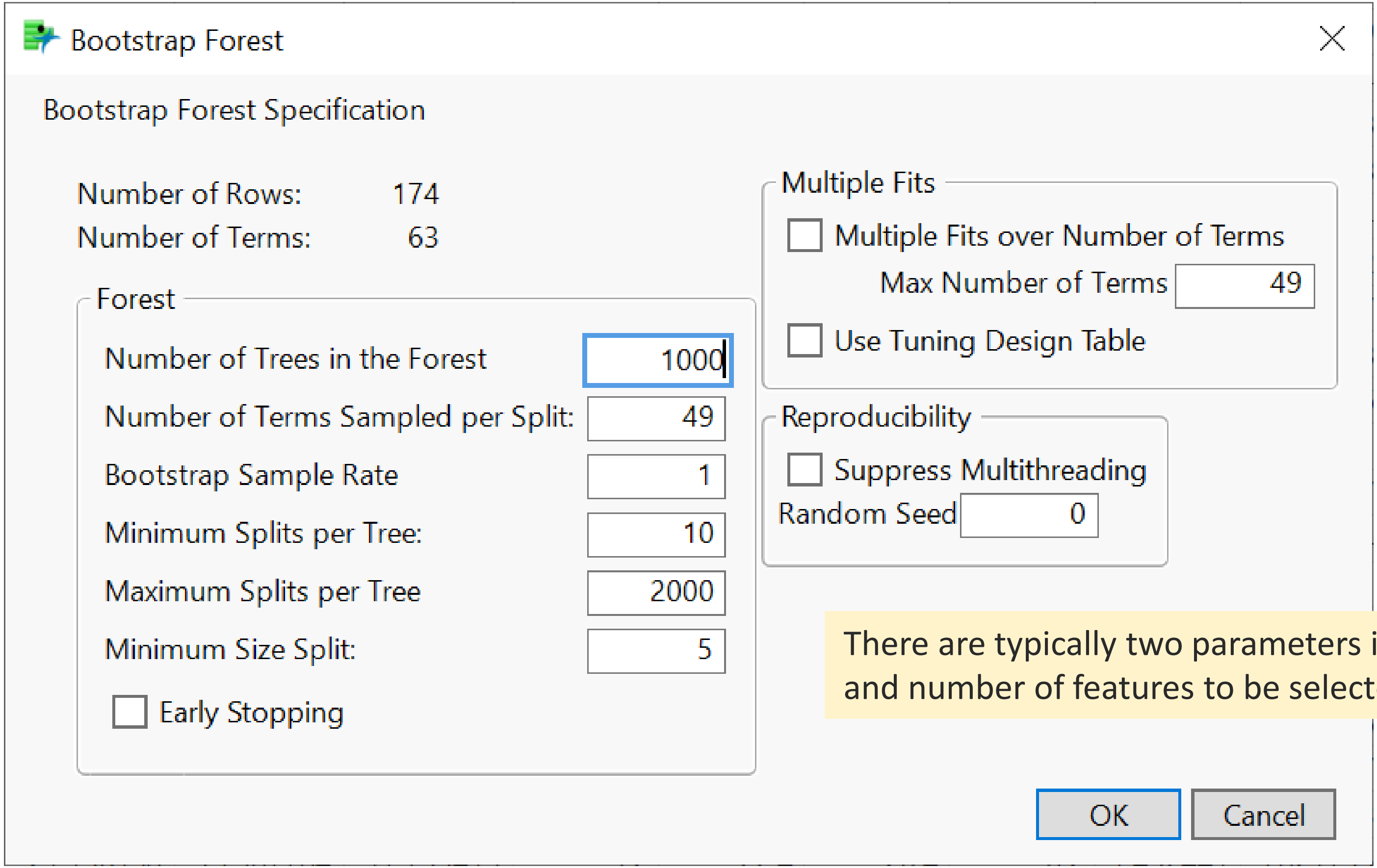
RF



For features with categorical variables and missing data use BT

RF

RF algorithm with a large number of trees is slow. For categorical variables with different number of levels, RF are biased in favor of attributes with more levels. RF is much easier to tune than BT



There are typically two parameters in RF: number of trees and number of features to be selected at each node.

Bootstrap Forest for status

Specifications

Target	status	Training Rows:	131
Validation Column:	Validation	Validation Rows:	43
		Test Rows:	0
Number of Trees in the Forest:	1000	Number of Terms:	63
Number of Terms Sampled per Split:	49	Bootstrap Samples:	131
		Minimum Splits per Tree:	10
		Minimum Size Split:	5

Overall Statistics

Measure	Training	Validation	Definition
Entropy RSquare	0.9186	0.6736	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.9601	0.8089	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Mean -Log p	0.0563	0.2254	∑ -Log(ρ[j])/n
RASE	0.1016	0.2543	$\sqrt{\sum(y[j]-\rho[j])^2/n}$
Mean Abs Dev	0.0491	0.1253	∑ |y[j]-ρ[j]|/n
Misclassification Rate	0.0076	0.0698	∑ (ρ[j]≠ρMax)/n
N	131	43	n

Confusion Matrix

Training

Actual status	Predicted Count Fail	Predicted Count Pass
Fail	68	1
Pass	0	62

Actual status	Predicted Rate Fail	Predicted Rate Pass
Fail	0.986	0.014
Pass	0.000	1.000

Validation

Actual status	Predicted Count Fail	Predicted Count Pass
Fail	20	3
Pass	0	20

Actual status	Predicted Rate Fail	Predicted Rate Pass
Fail	0.870	0.130
Pass	0.000	1.000

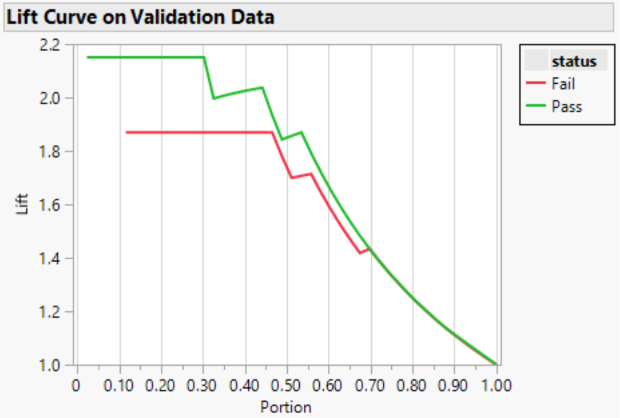
Actual Validation Pass = 20

of these, predicted Pass = 20

False predicted Pass = 3 (13%)

RF

6.9%



KPA Insights through analytics

jmp STATISTICAL DISCOVERY

Bootstrap Forest for testResult

Specifications

Target	testResult	Training Rows:	131
Validation Column:	Validation	Validation Rows:	43
		Test Rows:	0
Number of Trees in the Forest:	1000	Number of Terms:	63
Number of Terms Sampled per Split:	49	Bootstrap Samples:	131
		Minimum Splits per Tree:	10
		Minimum Size Split:	5

Overall Statistics

Measure	Training	Validation	Definition
Entropy RSquare	0.8203	0.5474	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.9669	0.8703	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Mean -Log p	0.2871	0.7564	∑ -Log(ρ[j])/n
RASE	0.3070	0.4699	√ ∑(y[j]-ρ[j])²/n
Mean Abs Dev	0.1982	0.3136	∑ |y[j]-ρ[j]|/n
Misclassification Rate	0.0534	0.2326	∑ (ρ[j]≠ρMax)/n
N	131	43	n

RF

23.4%

Actual Validation Good = 20

of these, predicted Good = 20

False predicted Good = 5 (20%)

For detailed testResults

Confusion Matrix

Training

Actual testResult	Predicted Count Brake	Good	Grippers	IMP	ITM	Motor	SOS	Velocity Type I	Velocity Type II
Brake	2	0	0	0	0	1	0	0	0
Good	0	62	0	0	0	0	0	0	0
Grippers	0	1	7	0	1	0	0	0	0
IMP	0	1	0	3	0	0	0	0	0
ITM	0	1	0	0	25	1	0	0	0
Motor	0	0	0	0	0	13	0	0	0
SOS	0	0	0	0	1	0	1	0	0
Velocity Type I	0	0	0	0	0	0	0	9	0
Velocity Type II	0	0	0	0	0	0	0	0	2

Validation

Actual testResult	Predicted Count Brake	Good	Grippers	IMP	ITM	Motor	SOS	Velocity Type I	Velocity Type II
Brake	0	1	0	2	0	0	0	0	0
Good	0	20	0	0	0	0	0	0	0
Grippers	0	1	1	0	2	1	0	0	0
IMP	0	1	0	0	0	0	0	0	0
ITM	0	0	0	0	6	0	0	0	0
Motor	0	0	0	0	0	3	0	0	0
SOS	0	0	0	0	0	0	0	0	0
Velocity Type I	0	0	0	0	0	0	0	2	0
Velocity Type II	0	2	0	0	0	0	0	0	1

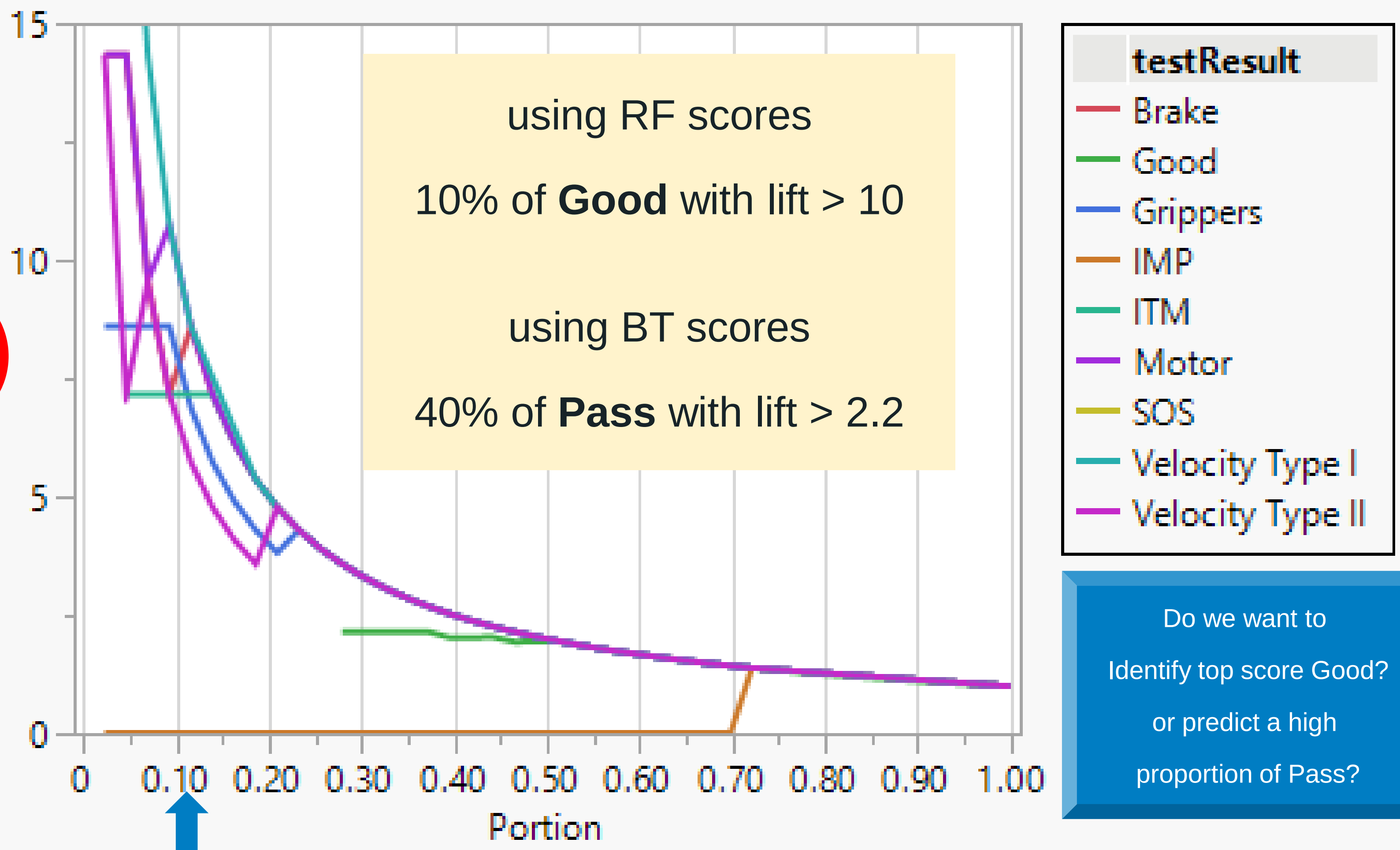
Training

Actual testResult	Predicted Rate Brake	Good	Grippers	IMP	ITM	Motor	SOS	Velocity Type I	Velocity Type II
Brake	0.667	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000
Good	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Grippers	0.000	0.111	0.778	0.000	0.111	0.000	0.000	0.000	0.000
IMP	0.000	0.250	0.000	0.750	0.000	0.000	0.000	0.000	0.000
ITM	0.000	0.037	0.000	0.000	0.926	0.037	0.000	0.000	0.000
Motor	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
SOS	0.000	0.000	0.000	0.000	0.500	0.000	0.500	0.000	0.000
Velocity Type I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000
Velocity Type II	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Validation

Actual testResult	Predicted Rate Brake	Good	Grippers	IMP	ITM	Motor	SOS	Velocity Type I	Velocity Type II
Brake	0.000	0.333	0.000	0.667	0.000	0.000	0.000	0.000	0.000
Good	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Grippers	0.000	0.200	0.200	0.000	0.400	0.200	0.000	0.000	0.000
IMP	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ITM	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
Motor	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
SOS	.	.	.	.	.	.	.	.	.
Velocity Type I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000
Velocity Type II	0.000	0.667	0.000	0.000	0.000	0.000	0.000	0.000	0.333

Lift Curve on Validation Data



RF

using RF scores

10% of **Good** with lift > 10

using BT scores

40% of **Pass** with lift > 2.2

Do we want to Identify top score Good? or predict a high proportion of Pass?

ATISTICAL
SCOVERY

BT

Boosted Tree for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor56	82	4634.8525	0.2065
sensor18	27	4200.54219	0.1872
sensor11	21	2735.54419	0.1219
sensor61	19	2431.70533	0.1084
sensor48	17	2414.82121	0.1076
sensor57	22	2016.84895	0.0899
sensor58	10	1456.34648	0.0649
sensor59	8	726.693834	0.0324
sensor26	2	343.87221	0.0153
sensor52	2	323.166652	0.0144
sensor09	6	286.922646	0.0128
sensor01	9	194.974174	0.0087
sensor55	2	165.247012	0.0074
sensor24	4	151.216612	0.0067
sensor07	4	128.858022	0.0057
sensor12	4	117.421132	0.0052
sensor15	2	44.7671089	0.0020
sensor44	1	37.6713347	0.0017
sensor54	1	15.5711294	0.0007
sensor27	1	12.8974036	0.0006

RF

Bootstrap Forest for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	579	54.9167342	0.5024
sensor61	198	18.7389273	0.1714
sensor52	145	13.1320295	0.1201
sensor53	56	5.26374221	0.0482
sensor44	33	2.53070023	0.0232
sensor48	42	2.45696551	0.0225
sensor46	31	2.08993095	0.0191
sensor11	114	1.34630042	0.0123
sensor54	12	1.01688952	0.0093
sensor58	111	0.73127415	0.0067
sensor07	61	0.68014104	0.0062
sensor26	89	0.5292647	0.0048
sensor12	40	0.51092374	0.0047
sensor50	8	0.41943383	0.0038
sensor57	75	0.3901658	0.0036
sensor01	44	0.35310066	0.0032
sensor05	47	0.3400086	0.0031
sensor21	8	0.30245908	0.0028

RF

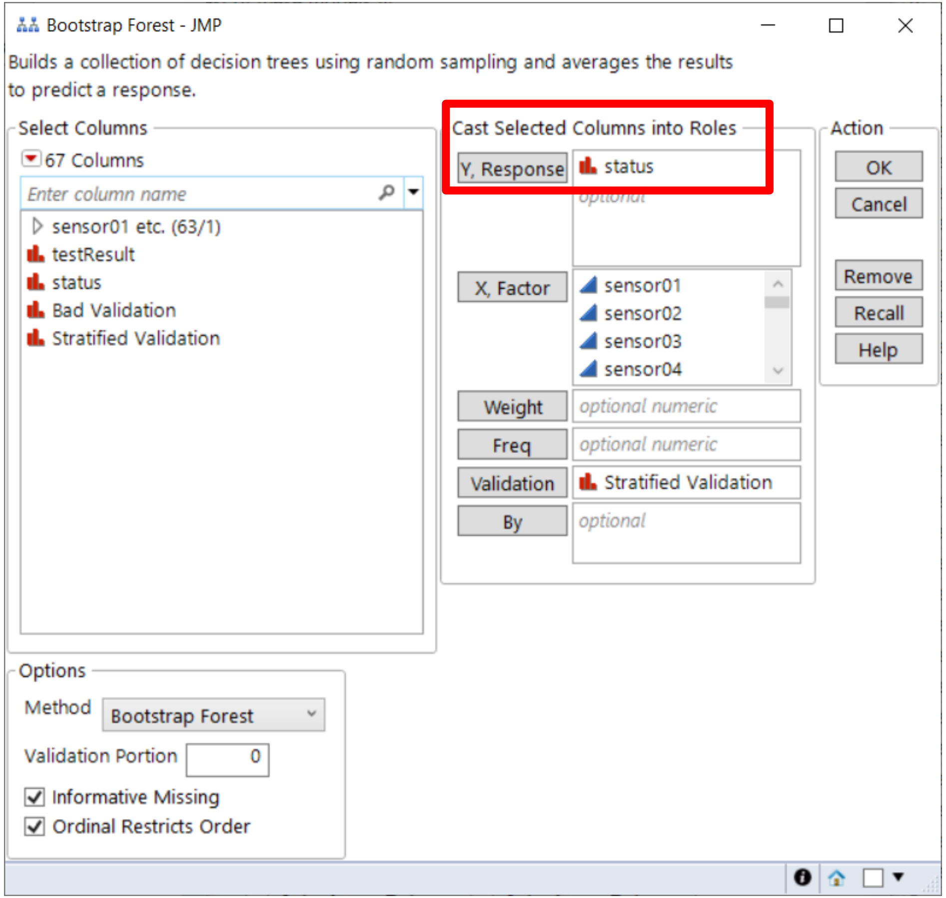
Bootstrap Forest for testResult

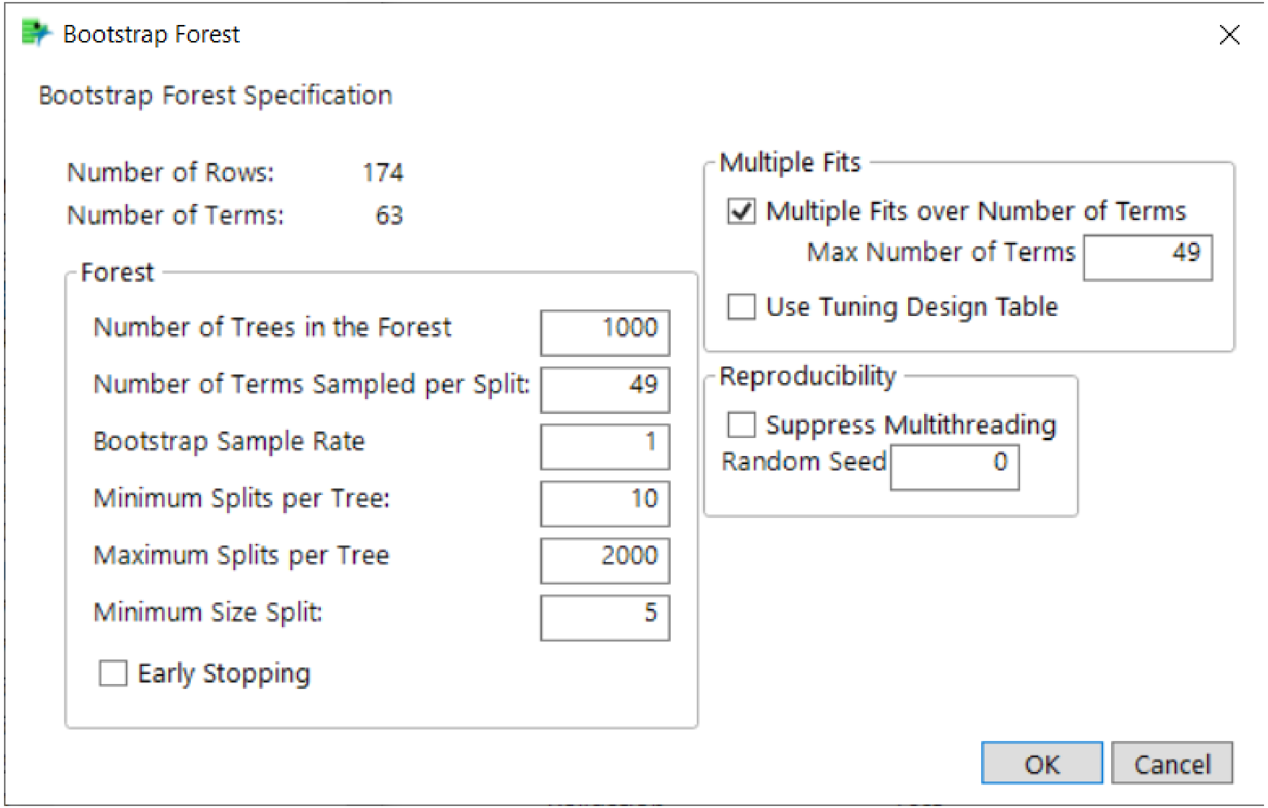
Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	5	54.8827138	0.2325
sensor52	3	29.2773568	0.1240
sensor48	2	18.0919607	0.0766
sensor61	1	12.7377835	0.0540
sensor04	4	11.2268386	0.0476
sensor62	3	9.74427579	0.0413
sensor19	4	8.91209343	0.0378
sensor17	2	7.31785078	0.0310
sensor40	1	6.4025967	0.0271
sensor50	1	5.95404634	0.0252
sensor63	1	5.83025113	0.0247
sensor28	1	5.71751006	0.0242
sensor42	1	5.48313999	0.0232
sensor41	1	[illegible]	0.0220
sensor36	[illegible]	[illegible]	[illegible]
sensor07	[illegible]	[illegible]	[illegible]
sensor05	[illegible]	[illegible]	[illegible]
sensor57	4	[illegible]	0.0180
sensor53	2	3.88027473	0.0164

For detailed testResults

What is your goal?


Bootstrap Forest - JMP
Builds a collection of decision trees using random sampling and averages the results to predict a response.
Select Columns
67 Columns
Enter column name
sensor01 etc. (63/1)
testResult
status
Bad Validation
Stratified Validation
Cast Selected Columns into Roles
Y, Response
status
optional
X, Factor
sensor01
sensor02
sensor03
sensor04
Weight
optional numeric
Freq
optional numeric
Validation
Stratified Validation
By
optional
Action
OK
Cancel
Remove
Recall
Help
Options
Method
Bootstrap Forest
Validation Portion
0
Informative Missing
Ordinal Restricts Order


Bootstrap Forest
Bootstrap Forest Specification
Number of Rows: 174
Number of Terms: 63
Forest
Number of Trees in the Forest 1000
Number of Terms Sampled per Split: 49
Bootstrap Sample Rate 1
Minimum Splits per Tree: 10
Maximum Splits per Tree 2000
Minimum Size Split: 5
Early Stopping
Multiple Fits
Multiple Fits over Number of Terms
Max Number of Terms 49
Use Tuning Design Table
Reproducibility
Suppress Multithreading
Random Seed 0
OK
Cancel

RF

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	522	36.5630568	0.3709
sensor53	248	19.0040464	0.1928
sensor55	163	9.18530792	0.0932
sensor48	107	7.43395874	0.0754
sensor52	88	4.51699905	0.0458
sensor54	65	3.1209684	0.0317
sensor61	48	3.08165918	0.0313
sensor11	76	2.20715869	0.0224
sensor21	44	1.8102253	0.0184
sensor46	31	0.98045171	0.0099
sensor24	37	0.97068784	0.0098
sensor50	33	0.77981921	0.0079
sensor44	15	0.75054722	0.0076
sensor26	67	0.74422853	0.0075
sensor17	36	0.52835424	0.0054

Binomial Ridge with Validation Column

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare
Intercept	-5.678926	10.351753	0.3009571	0.5833
sensor57	0.0074349	0.0192829	0.1486652	0.6998
sensor58	-0.004759	0.0174843	0.0740924	0.7855
sensor22	0.0001382	0.0007282	0.0360128	0.8495
sensor59	0.0027809	0.0155676	0.0319105	0.8582
sensor23	0.0001047	0.0007698	0.0184902	0.8918
sensor49	-0.023623	0.1845799	0.0163801	0.8982
sensor20	0.0000964	0.0010633	0.0082211	0.9278
sensor21	8.8042e-5	0.0011147	0.006238	0.9370
sensor29	0.0001312	0.0017377	0.0056977	0.9398
sensor17	0.3125492	4.2247778	0.005473	0.9410
sensor56	-0.00097	0.0160737	0.0036419	0.9519
sensor41	-0.000499	0.0085741	0.0033923	0.9536
sensor37	-0.000381	0.0074011	0.0026455	0.9590
sensor63	0.0080211	0.1920101	0.0017451	0.9667

Binomial Lasso with Validation Column

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare
sensor17	1.0154108	0.4506304	5.077413	0.0242*
Intercept	-3.287154	2.1404982	2.3583615	0.1246
sensor21	0.0003969	0.0003088	1.6521055	0.1987
sensor52	0.0493613	0.0486158	1.0309056	0.3099
sensor20	0.0001786	0.0002831	0.3980931	0.5281
sensor18	0.3648566	0.6438341	0.3211415	0.5709
sensor29	8.7425e-5	0.0003001	0.0848859	0.7708
sensor01	6.9577e-5	0.000528	0.0173639	0.8952
sensor02	0	0	0	1.0000
sensor03	0	0	0	1.0000
sensor04	0	0	0	1.0000
sensor05	0	0	0	1.0000
sensor06	0	0	0	1.0000
sensor07	0	0	0	1.0000
sensor08	0	0	0	1.0000

Binomial Elastic Net with Validation Column

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare
Intercept	-4.563879	2.0946723	4.7471847	0.0293*
sensor17	0.9999637	0.7369391	1.8412183	0.1748
sensor52	0.0524902	0.0574976	0.8334072	0.3613
sensor29	0.0002216	0.0002958	0.5615393	0.4536
sensor20	0.0002296	0.0003917	0.3437918	0.5576
sensor21	0.0002095	0.000441	0.2255527	0.6348
sensor22	0.0001835	0.0004571	0.1611644	0.6881
sensor18	0.3325641	0.8331405	0.1593361	0.6898
sensor01	0.0001942	0.0006893	0.0793924	0.7781
sensor04	0.0001689	0.0006879	0.0602512	0.8061
sensor11	-5.539e-5	0.0011937	0.0021528	0.9630
sensor57	9.2889e-5	0.014103	4.3382e-5	0.9947
sensor02	0	0	0	1.0000
sensor03	0	0	0	1.0000
sensor05	0	0	0	1.0000

Binomial Elastic Net with Validation Column

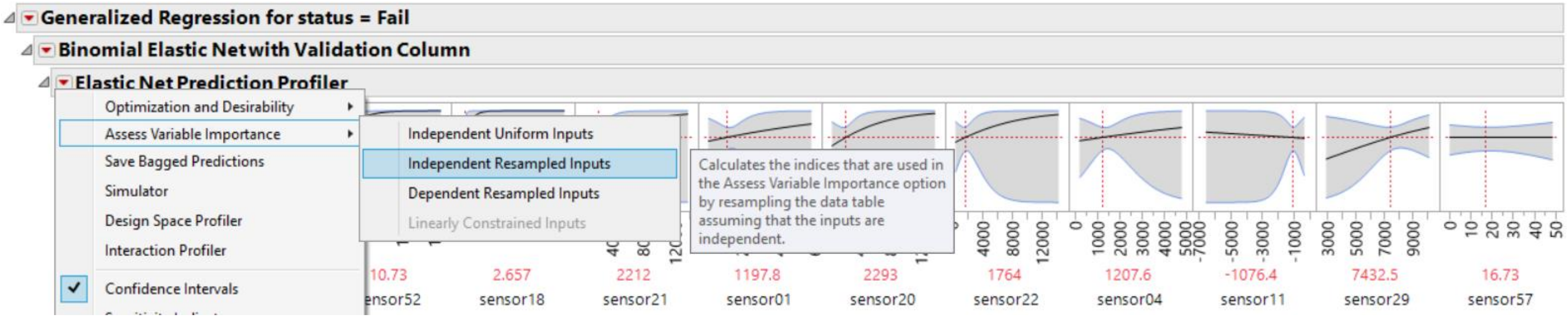
Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare
Intercept	-4.563879	2.0946723	4.7471847	0.0293*
sensor17	0.9999637	0.7369391	1.8412183	0.1748
sensor52	0.0524902	0.0574976	0.8334072	0.3613
sensor29	0.0002216	0.0002958	0.5615393	0.4536
sensor20	0.0002296	0.0003917	0.3437918	0.5576
sensor21	0.0002095	0.000441	0.2255527	0.6348
sensor22	0.0001835	0.0004571	0.1611644	0.6881
sensor18	0.3325641	0.8331405	0.1593361	0.6898
sensor01	0.0001942	0.0006893	0.0793924	0.7781
sensor04	0.0001689	0.0006879	0.0602512	0.8061
sensor11	-5.539e-5	0.0011937	0.0021528	0.9630
sensor57	9.2889e-5	0.014103	4.3382e-5	0.9947
sensor02	0	0	0	1.0000
sensor03	0	0	0	1.0000
sensor05	0	0	0	1.0000

RF

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	522	36.5630568	0.3709
sensor53	248	19.0040464	0.1928
sensor55	163	9.18530792	0.0932
sensor48	107	7.43395874	0.0754
sensor52	88	4.51699905	0.0458
sensor54	65	3.1209684	0.0317
sensor61	48	3.08165918	0.0313
sensor11	76	2.20715869	0.0224
sensor21	44	1.8102253	0.0184
sensor46	31	0.98045171	0.0099
sensor24	37	0.97068784	0.0098
sensor50	33	0.77981921	0.0079
sensor44	15	0.75054722	0.0076
sensor26	67	0.74422853	0.0075
sensor17	36	0.52835424	0.0054


Generalized Regression for status = Fail
Binomial Elastic Net with Validation Column
Elastic Net Prediction Profiler
Optimization and Desirability
Assess Variable Importance
Save Bagged Predictions
Simulator
Design Space Profiler
Interaction Profiler
Confidence Intervals
Independent Uniform Inputs
Independent Resampled Inputs
Dependent Resampled Inputs
Linearly Constrained Inputs
Calculates the indices that are used in the Assess Variable Importance option by resampling the data table assuming that the inputs are independent.
10.73
2.657
2212
1197.8
2293
1764
1207.6
-1076.4
7432.5
16.73
sensor18
sensor21
sensor01
sensor20
sensor22
sensor04
sensor11
sensor29
sensor57

Elastic Net Prediction Profiler

Variable Importance: Independent Resampled Inputs

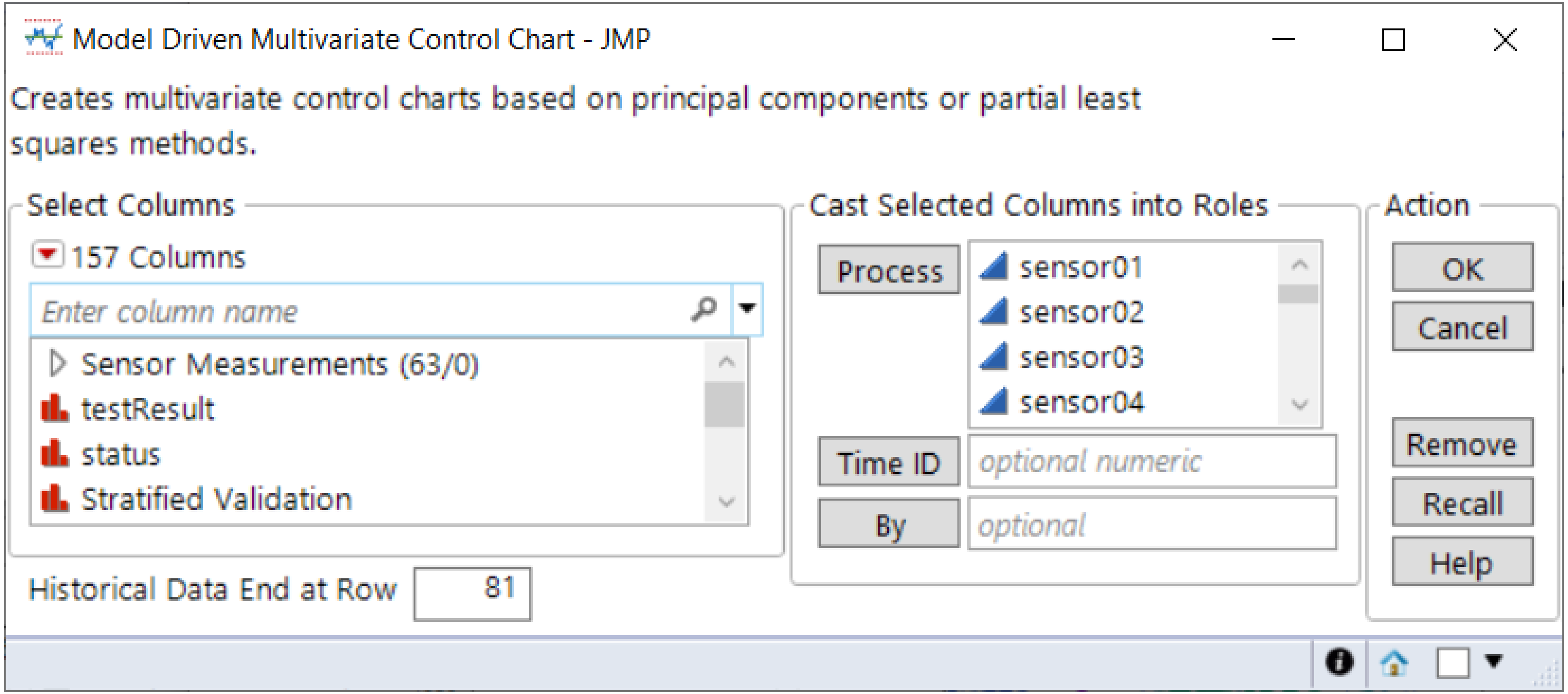
Summary Report

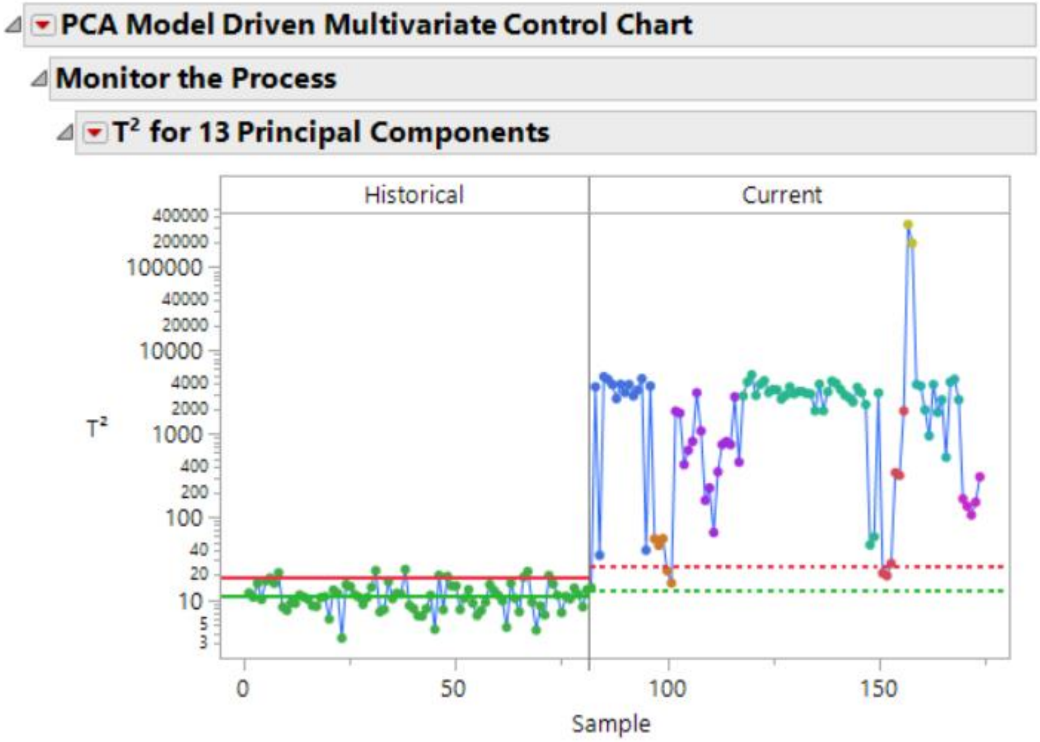
Column	Main Effect	Total Effect
sensor17	0.179	0.233
sensor52	0.178	0.227
sensor18	0.173	0.216
sensor20	0.098	0.136
sensor21	0.093	0.128
sensor22	0.036	0.063
sensor01	0.02	0.038
sensor29	0.02	0.036
sensor04	0.014	0.026
sensor11	0.001	0.002
sensor57	9e-6	3e-5

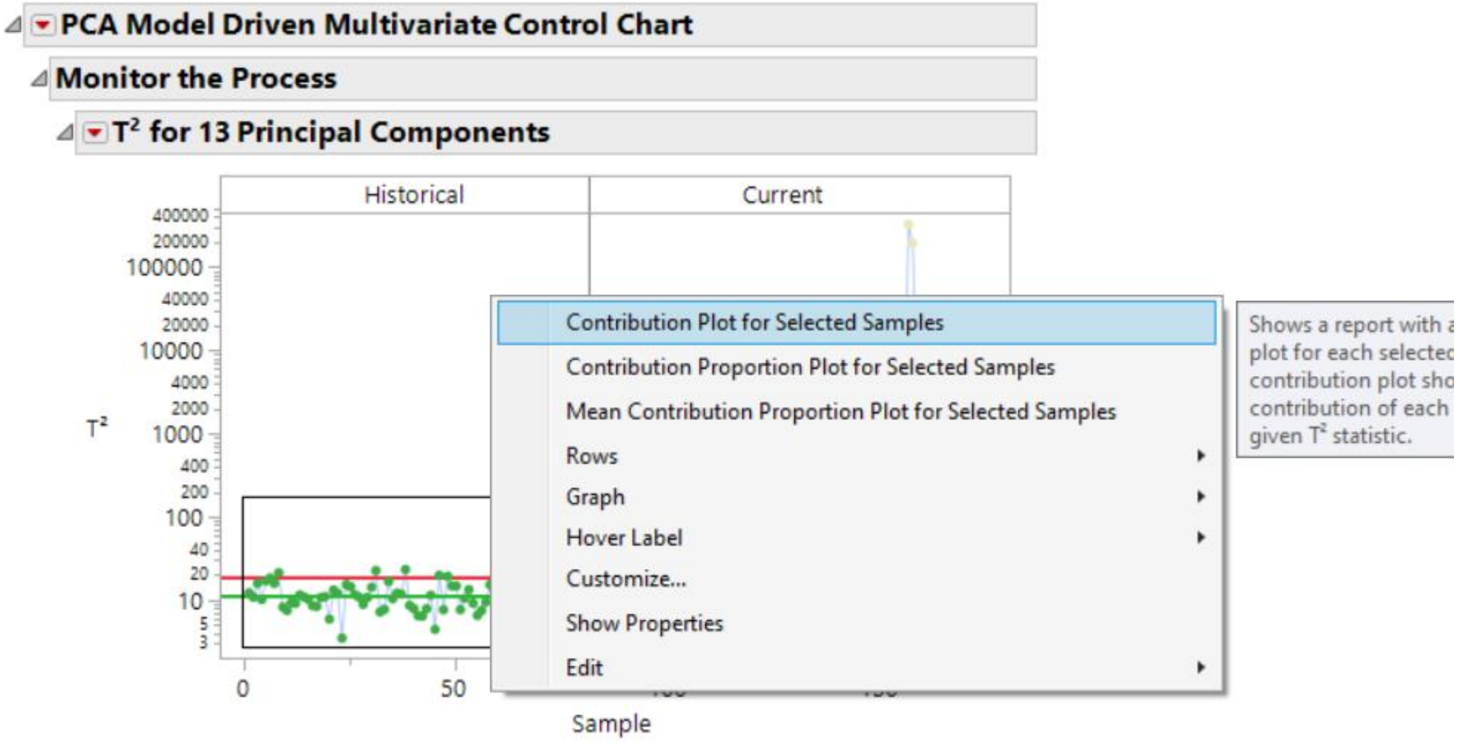
RF

Column Contributions

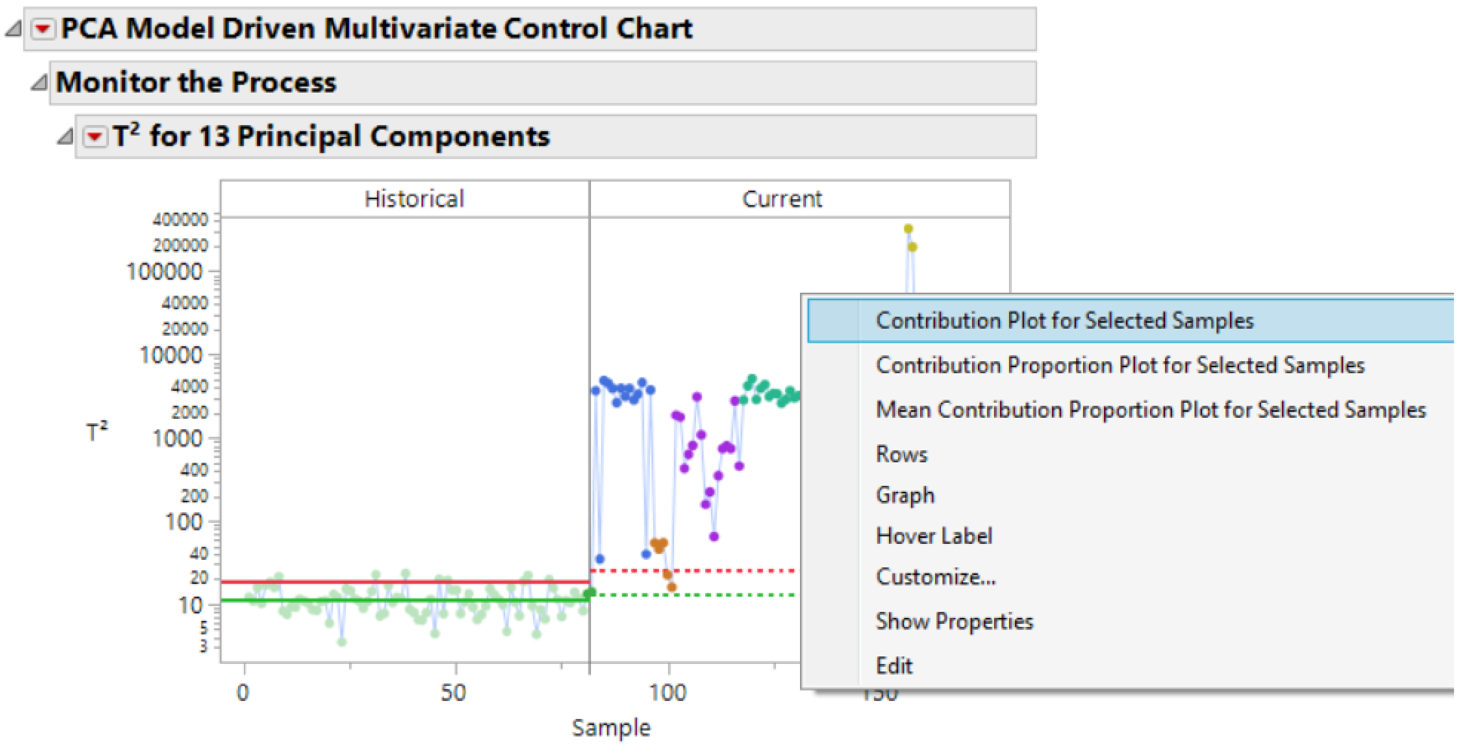
Term	Number of Splits	G^2	Portion
sensor18	522	36.5630568	0.3709
sensor53	248	19.0040464	0.1928
sensor55	163	9.18530792	0.0932
sensor48	107	7.43395874	0.0754
sensor52	88	4.51699905	0.0458
sensor54	65	3.1209684	0.0317
sensor61	48	3.08165918	0.0313
sensor11	76	2.20715869	0.0224
sensor21	44	1.8102253	0.0184
sensor46	31	0.98045171	0.0099
sensor24	37	0.97068784	0.0098
sensor50	33	0.77981921	0.0079
sensor44	15	0.75054722	0.0076
sensor26	67	0.74422853	0.0075
sensor17	36	0.52835424	0.0054


Model Driven Multivariate Control Chart - JMP
Creates multivariate control charts based on principal components or partial least squares methods.
Select Columns
157 Columns
Enter column name
Sensor Measurements (63/0)
testResult
status
Stratified Validation
Historical Data End at Row
81
Cast Selected Columns into Roles
Process
sensor01
sensor02
sensor03
sensor04
Time ID
optional numeric
By
optional
Action
OK
Cancel
Remove
Recall
Help

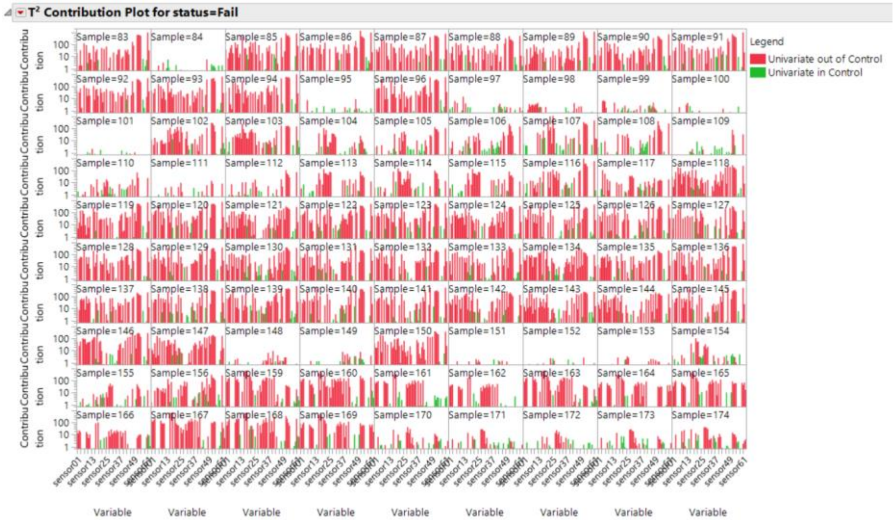

PCA Model Driven Multivariate Control Chart
Monitor the Process
T² for 13 Principal Components
Historical
Current
400000
200000
100000
40000
20000
10000
4000
2000
1000
400
200
100
40
20
10
5
3
T²
0
50
100
150
Sample

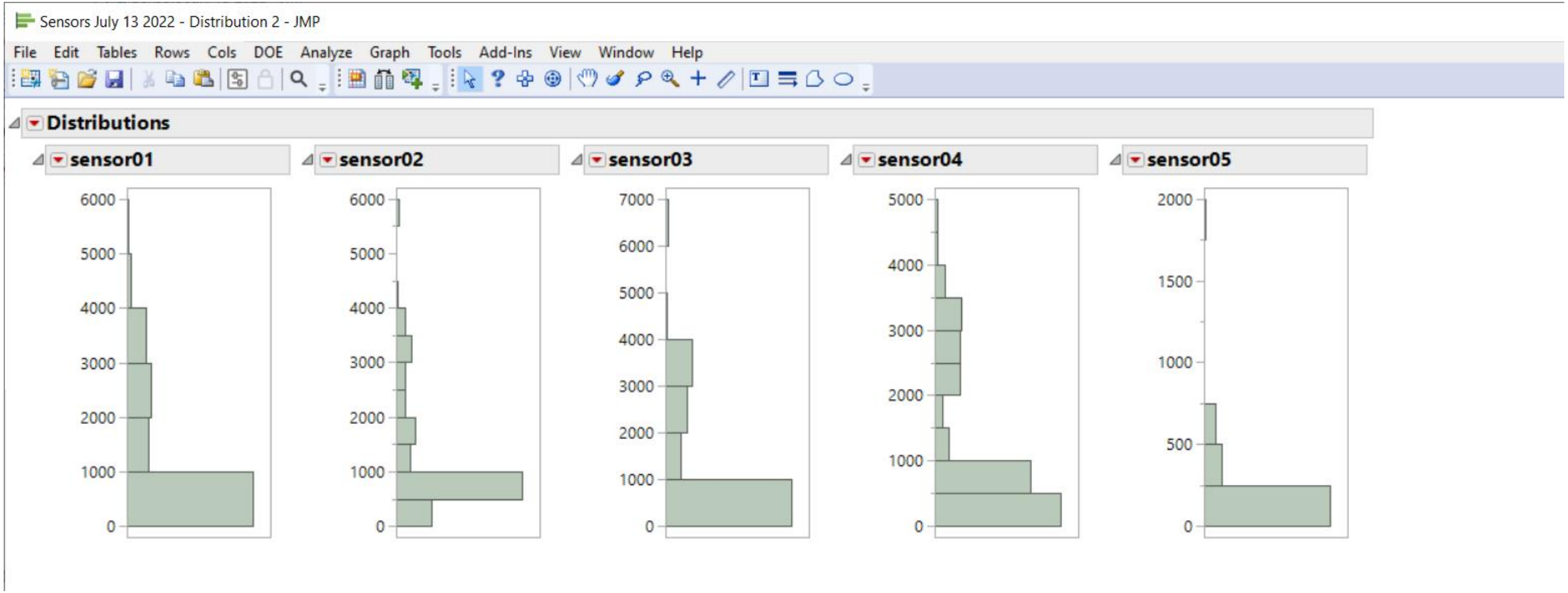


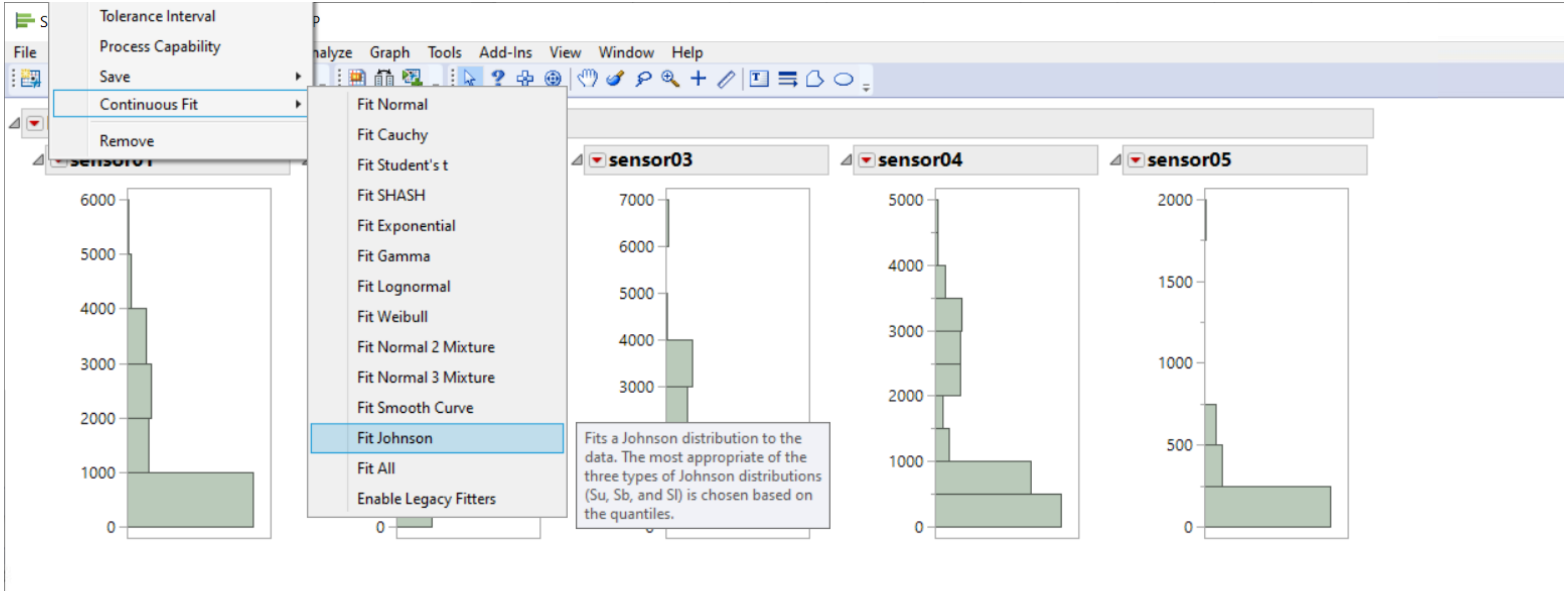
PCA Model Driven Multivariate Control Chart
Monitor the Process
T² for 13 Principal Components
Historical
Current
T²
Sample
Contribution Plot for Selected Samples
Contribution Proportion Plot for Selected Samples
Mean Contribution Proportion Plot for Selected Samples
Rows
Graph
Hover Label
Customize...
Show Properties
Edit
Shows a report with a plot for each selected contribution plot sho contribution of each given T² statistic.

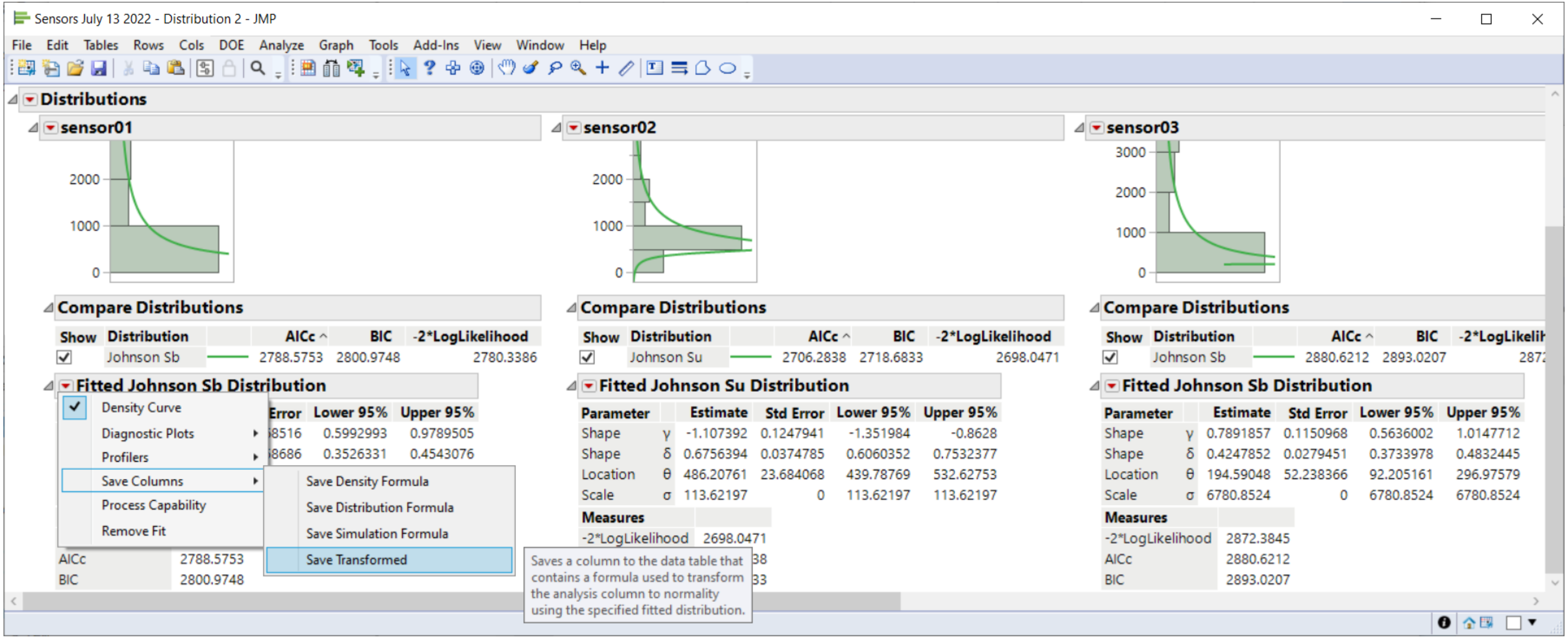

PCA Model Driven Multivariate Control Chart
Monitor the Process
T² for 13 Principal Components
Historical
Current
T²
400000
200000
100000
40000
20000
10000
4000
2000
1000
400
200
100
40
20
10
5
3
0
50
100
Sample
Contribution Plot for Selected Samples
Contribution Proportion Plot for Selected Samples
Mean Contribution Proportion Plot for Selected Samples
Rows
Graph
Hover Label
Customize...
Show Properties
Edit


T² Contribution Plot for status=Pass
Legend
Univariate out of Control
Univariate in Control


T² Contribution Plot for status=Fail
Legend
Univariate out of Control
Univariate in Control
Variable


Sensors July 13 2022 - Distribution 2 - JMP
File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help
Distributions
sensor01
sensor02
sensor03
sensor04
sensor05
6000
5000
4000
3000
2000
1000
0
7000
1500
500

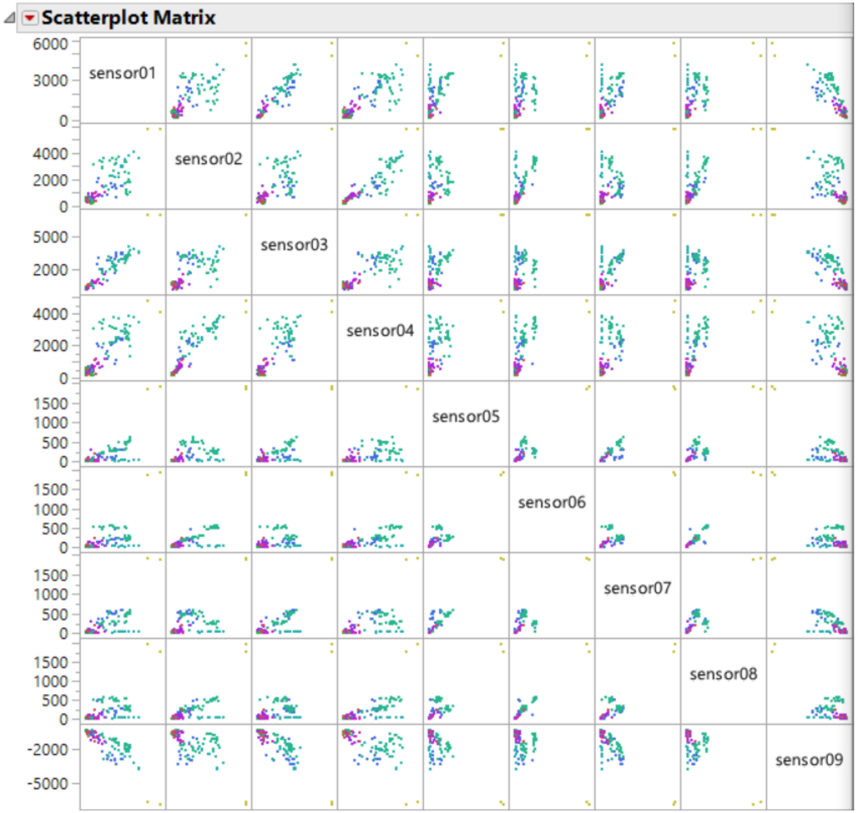

Tolerance Interval
Process Capability
Save
Continuous Fit
Remove
File
nalyze
Graph
Tools
Add-Ins
View
Window
Help
Fit Normal
Fit Cauchy
Fit Student's t
Fit SHASH
Fit Exponential
Fit Gamma
Fit Lognormal
Fit Weibull
Fit Normal 2 Mixture
Fit Normal 3 Mixture
Fit Smooth Curve
Fit Johnson
Fit All
Enable Legacy Fitters
Fits a Johnson distribution to the data. The most appropriate of the three types of Johnson distributions (Su, Sb, and Sl) is chosen based on the quantiles.
sensor03
sensor04
sensor05

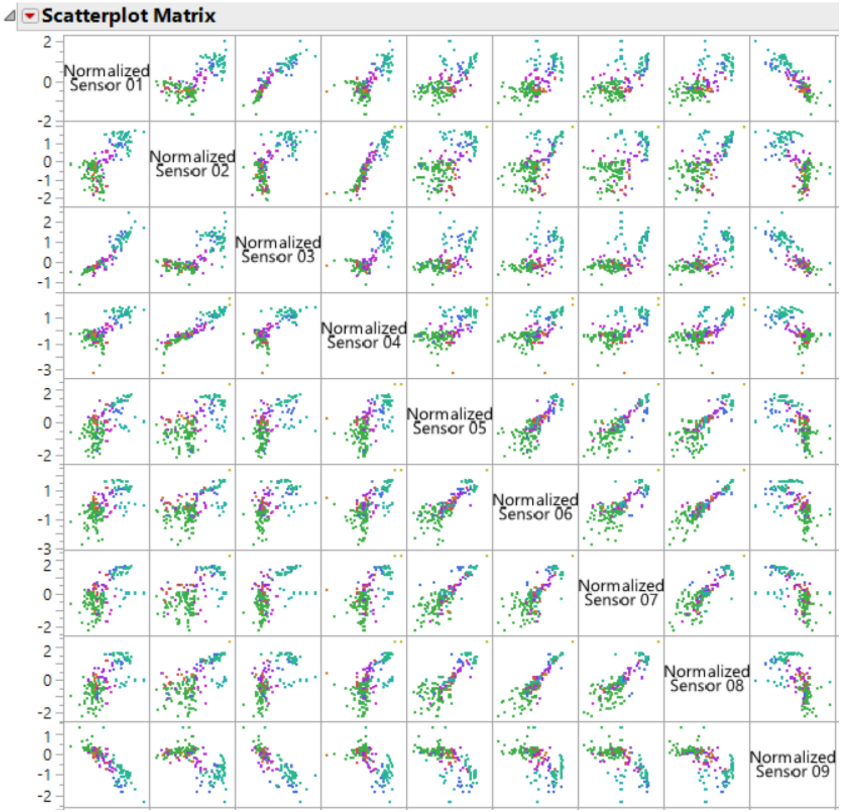


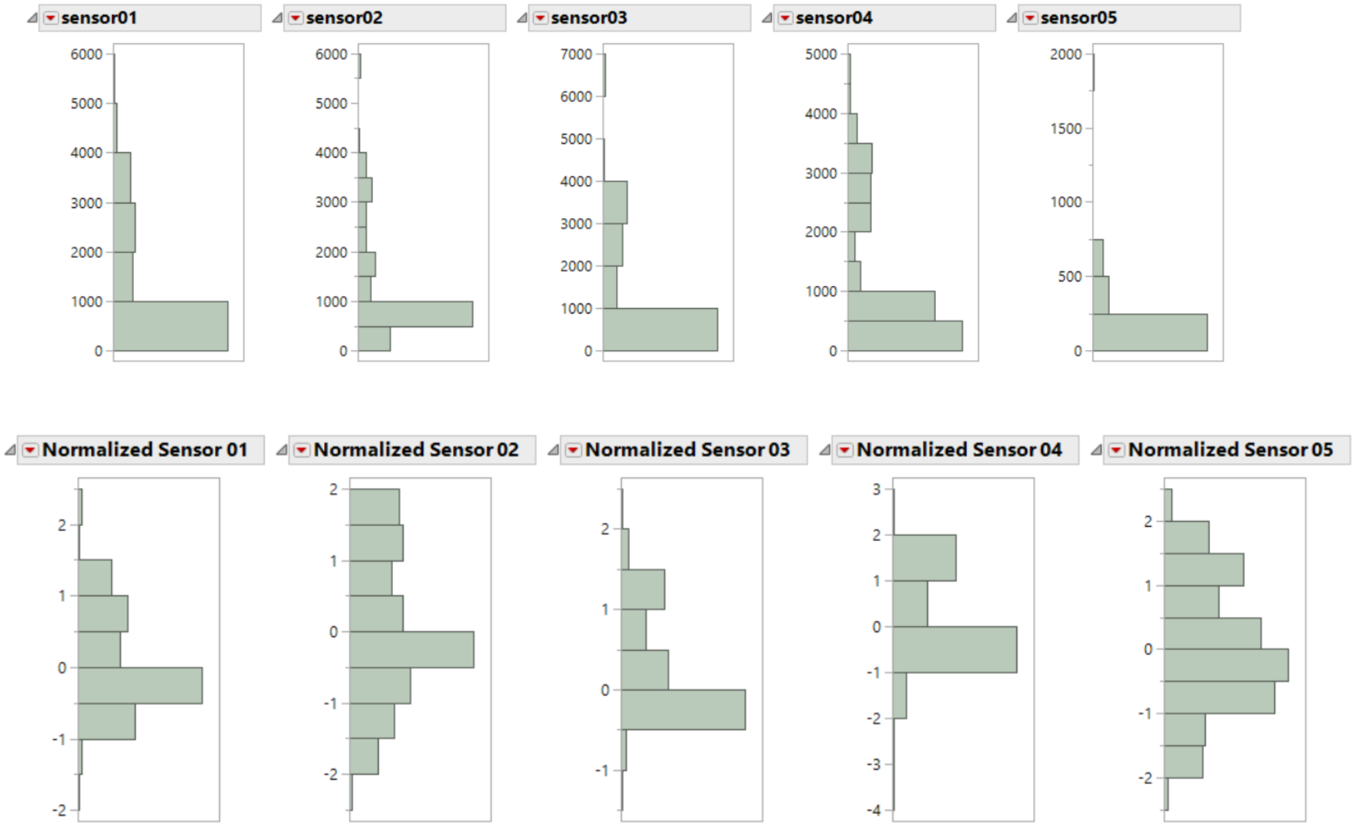
KPA
Insights through analytics

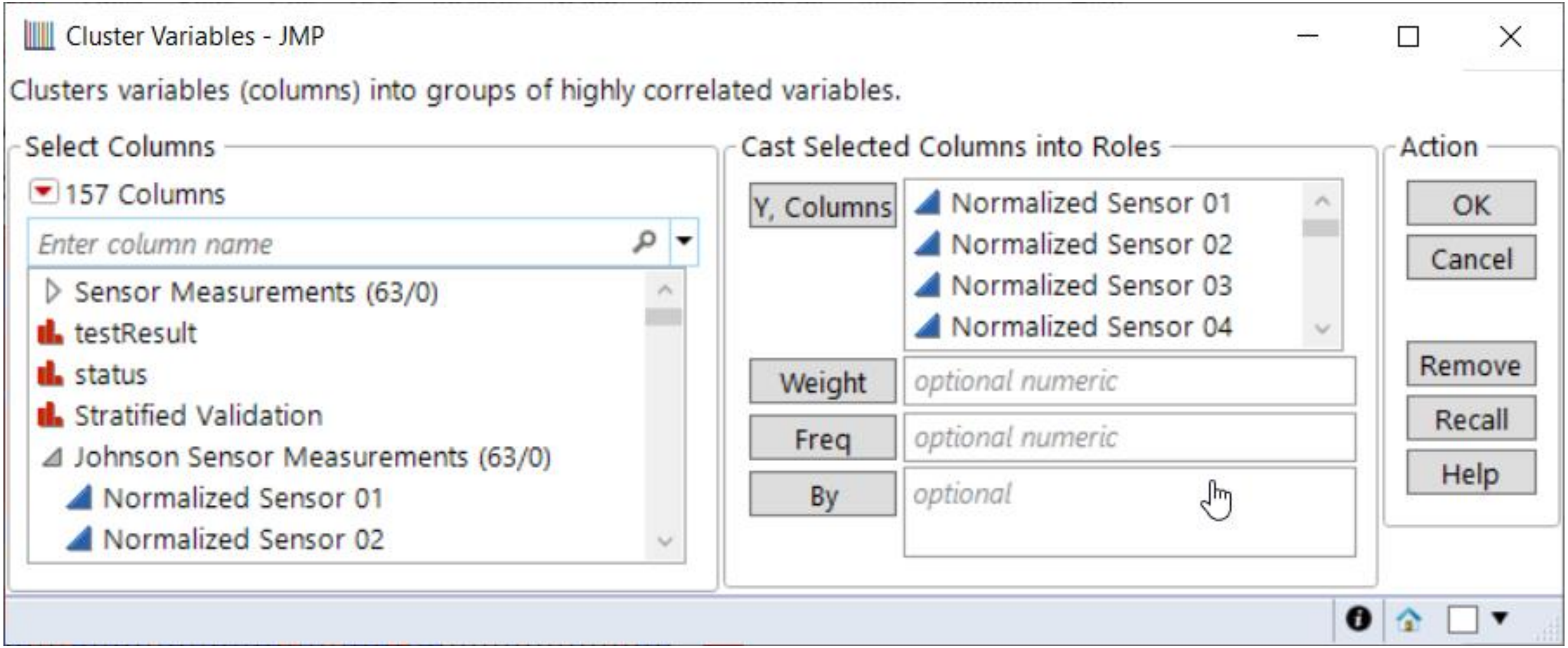
jmp STATISTICAL DISCOVERY

	Normalized Sensor 01	Normalized Sensor 02	Normalized Sensor 03	Normalized Sensor 04	Normalized Sensor 05	Normalized Sensor 06	Normalized Sensor 07	Normalized Sensor 08
1	-0.429462541	-0.023164209	-0.180868093	-0.045175325	0.2103355703	-0.013999938	-0.147937751	-0.000344392
2	-0.055300886	-1.63236901	0.0946350653	-1.649470993	-1.009090647	-1.042115859	-1.120255017	-1.525902819
3	-0.111839132	-0.187981022	0.0190318601	-0.321027105	0.0413421482	-0.274633425	-0.277695263	-0.53213534
4	-0.545119593	-0.394709423	-0.250233244	-0.502509817	-0.35310491	-0.19353877	-0.09709766	-0.969841771
5	-0.592368033	-0.381589246	-0.202267621	-0.067493582	-0.021463294	-0.083870644	-0.131019005	-0.055471228
6	0.0314637112	-2.059472445	0.0999572363	-1.329631387	-0.047036417	-0.310192693	-0.124253218	-0.525600034
7	-0.768441134	-0.068940672	-0.417092494	0.0214536018	-0.420836258	-0.424783097	-0.262673168	-0.762969287
8	-0.30113471	-0.3561646	-0.139427747	-0.229023302	-0.523040338	-0.000297651	-0.046667654	0.133640498
9	-0.860416254	-0.790455797	-0.458553392	-0.622679123	-1.647412021	-0.44909209	-0.591129387	-0.670397594
10	-0.516276499	-0.09857755	-0.194884031	-0.159489881	-1.334245723	-0.871892236	-0.866731627	-0.635561702
11	-0.447437398	-0.337014942	-0.285230865	-0.233164785	0.0729605379	-0.303294366	0.041864424	-0.947967663
12	-0.247673385	-0.168014048	-0.027250896	-0.184571798	-1.529483355	-1.024703913	-1.240298412	-0.993812537
13	-0.482567866	-0.919694837	-0.201434875	-0.716976459	-2.034307511	-0.532455295	-0.752553719	-0.648544939
14	-0.22067253	-0.744586147	-0.112670362	-0.494764669	-0.30377406	-2.456479871	-0.239149348	-1.247260093
15	-0.291032767	-0.084932408	-0.116938339	-0.205684568	-1.44825592	-1.926141272	-1.261958747	-1.125094932


Scatterplot Matrix
sensor01
sensor02
sensor03
sensor04
sensor05
sensor06
sensor07
sensor08
sensor09

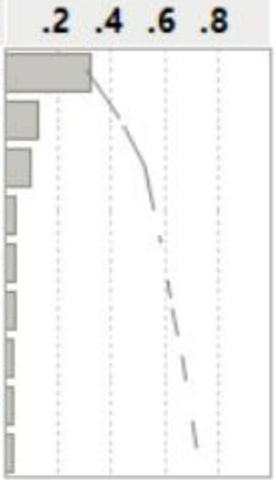

Scatterplot Matrix
Normalized Sensor 01
Normalized Sensor 02
Normalized Sensor 03
Normalized Sensor 04
Normalized Sensor 05
Normalized Sensor 06
Normalized Sensor 07
Normalized Sensor 08
Normalized Sensor 09


sensor01
sensor02
sensor03
sensor04
sensor05
Normalized Sensor 01
Normalized Sensor 02
Normalized Sensor 03
Normalized Sensor 04
Normalized Sensor 05


Cluster Variables - JMP
Clusters variables (columns) into groups of highly correlated variables.
Select Columns
157 Columns
Enter column name
Sensor Measurements (63/0)
testResult
status
Stratified Validation
Johnson Sensor Measurements (63/0)
Normalized Sensor 01
Normalized Sensor 02
Cast Selected Columns into Roles
Y, Columns
Normalized Sensor 01
Normalized Sensor 02
Normalized Sensor 03
Normalized Sensor 04
Weight
optional numeric
Freq
optional numeric
By
optional
Action
OK
Cancel
Remove
Recall
Help

Cluster Summary

Cluster	Number of Members	Most Representative Variable	Cluster Proportion of Variation Explained	Total Proportion of Variation Explained
1	25	Normalized Sensor 46	0.797	0.316
2	10	Normalized Sensor 36	0.77	0.122
3	7	Normalized Sensor 38	0.818	0.091
4	4	Normalized Sensor 31	0.622	0.04
5	5	Normalized Sensor 51	0.466	0.037
9	3	Normalized Sensor 62	0.747	0.036
8	3	Normalized Sensor 35	0.675	0.032
6	4	Normalized Sensor 63	0.478	0.03
7	2	Normalized Sensor 43	0.861	0.027



Proportion of variation explained by clustering: 0.731

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Normalized Sensor 46	0.915	0.514	0.174
1	Normalized Sensor 48	0.894	0.455	0.194
1	Normalized Sensor 50	0.905	0.517	0.197
1	Normalized Sensor 25	0.888	0.473	0.214
1	Normalized Sensor 44	0.869	0.427	0.229
1	Normalized Sensor 18	0.922	0.667	0.235
1	Normalized Sensor 08	0.87	0.471	0.246
1	Normalized Sensor 53	0.9	0.643	0.28
1	Normalized Sensor 24	0.844	0.465	0.291
1	Normalized Sensor 06	0.812	0.431	0.33
1	Normalized Sensor 61	0.878	0.639	0.336
1	Normalized Sensor 07	0.799	0.411	0.341
1	Normalized Sensor 05	0.798	0.412	0.343
1	Normalized Sensor 54	0.88	0.656	0.349
1	Normalized Sensor 27	0.76	0.354	0.371
1	Normalized Sensor 14	0.773	0.407	0.383
1	Normalized Sensor 13	0.739	0.362	0.408
1	Normalized Sensor 52	0.824	0.582	0.422
1	Normalized Sensor 55	0.851	0.667	0.449
1	Normalized Sensor 15	0.681	0.348	0.489
1	Normalized Sensor 26	0.685	0.36	0.492
1	Normalized Sensor 16	0.683	0.366	0.499
1	Normalized Sensor 21	0.72	0.588	0.679
1	Normalized Sensor 41	0.373	0.217	0.8
1	Normalized Sensor 20	0.655	0.623	0.915

RF

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Normalized Sensor 46	0.915	0.514	0.174
1	Normalized Sensor 48	0.894	0.455	0.194
1	Normalized Sensor 50	0.905	0.517	0.197
1	Normalized Sensor 25	0.888	0.473	0.214
1	Normalized Sensor 44	0.869	0.427	0.229
1	Normalized Sensor 18	0.922	0.667	0.235
1	Normalized Sensor 08	0.87	0.471	0.246
1	Normalized Sensor 53	0.9	0.643	0.28
1	Normalized Sensor 24	0.844	0.465	0.291
1	Normalized Sensor 06	0.812	0.431	0.33
1	Normalized Sensor 61	0.878	0.639	0.336
1	Normalized Sensor 07	0.799	0.411	0.341
1	Normalized Sensor 05	0.798	0.412	0.343
1	Normalized Sensor 54	0.88	0.656	0.349
1	Normalized Sensor 27	0.76	0.354	0.371
1	Normalized Sensor 14	0.773	0.407	0.383
1	Normalized Sensor 13	0.739	0.362	0.408
1	Normalized Sensor 52	0.824	0.582	0.422
1	Normalized Sensor 55	0.851	0.667	0.449
1	Normalized Sensor 15	0.681	0.348	0.489
1	Normalized Sensor 26	0.685	0.36	0.492
1	Normalized Sensor 16	0.683	0.366	0.499
1	Normalized Sensor 21	0.72	0.588	0.679
1	Normalized Sensor 41	0.373	0.217	0.8
1	Normalized Sensor 20	0.655	0.623	0.915

Column Contributions

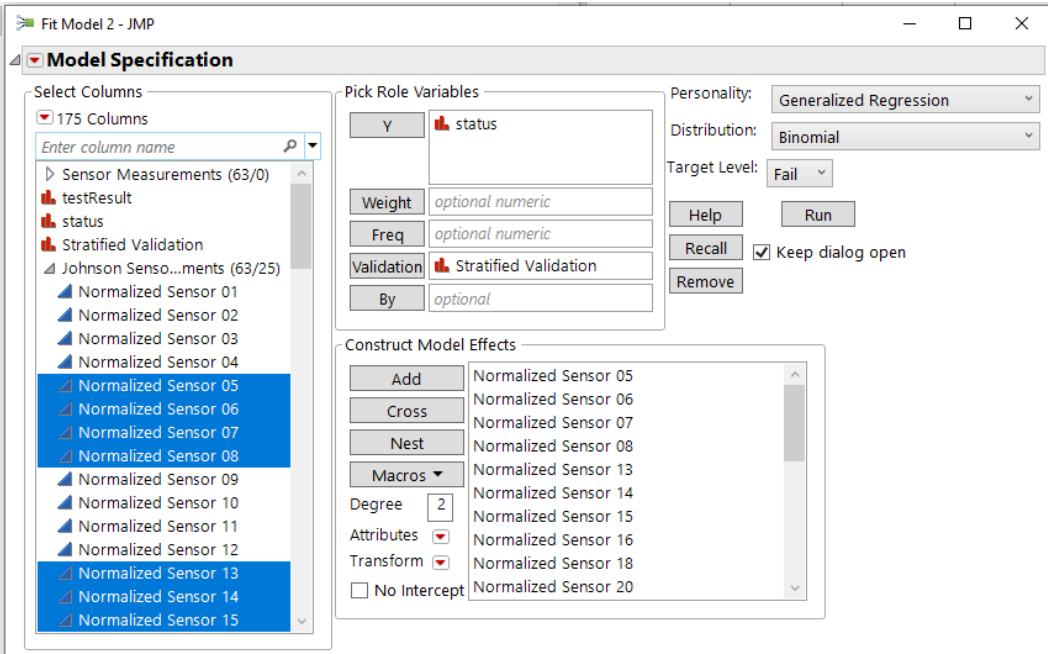
Term	Number of Splits	G^2	Portion
sensor18	522	36.5630568	0.3709
sensor53	248	19.0040464	0.1928
sensor55	163	9.18530792	0.0932
sensor48	107	7.43395874	0.0754
sensor52	88	4.51699905	0.0458
sensor54	65	3.1209684	0.0317
sensor61	48	3.08165918	0.0313
sensor11	76	2.20715869	0.0224
sensor21	44	1.8102253	0.0184
sensor46	31	0.98045171	0.0099
sensor24	37	0.97068784	0.0098
sensor50	33	0.77981921	0.0079
sensor44	15	0.75054722	0.0076
sensor26	67	0.74422853	0.0075
sensor17	36	0.52835424	0.0054

KPA Insights through analytics

jmp STATISTICAL DISCOVERY

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Normalized Sensor 46	0.915	0.514	0.174
1	Normalized Sensor 48	0.894	0.455	0.194
1	Normalized Sensor 50	0.905	0.517	0.197
1	Normalized Sensor 25	0.888	0.473	0.214
1	Normalized Sensor 44	0.869	0.427	0.229
1	Normalized Sensor 18	0.922	0.667	0.235
1	Normalized Sensor 08	0.87	0.471	0.246
1	Normalized Sensor 53	0.9	0.643	0.28
1	Normalized Sensor 24	0.844	0.465	0.291
1	Normalized Sensor 06	0.812	0.431	0.33
1	Normalized Sensor 61	0.878	0.639	0.336
1	Normalized Sensor 07	0.799	0.411	0.341
1	Normalized Sensor 05	0.798	0.412	0.343
1	Normalized Sensor 54	0.88	0.656	0.349
1	Normalized Sensor 27	0.76	0.354	0.371
1	Normalized Sensor 14	0.773	0.407	0.383
1	Normalized Sensor 13	0.739	0.362	0.408
1	Normalized Sensor 52	0.824	0.582	0.422
1	Normalized Sensor 55	0.851	0.667	0.449
1	Normalized Sensor 15	0.681	0.348	0.489
1	Normalized Sensor 26	0.685	0.36	0.492
1	Normalized Sensor 16	0.683	0.366	0.499
1	Normalized Sensor 21	0.72	0.588	0.679
1	Normalized Sensor 41	0.373	0.217	0.8
1	Normalized Sensor 20	0.655	0.623	0.915



KPA Insights through analytics

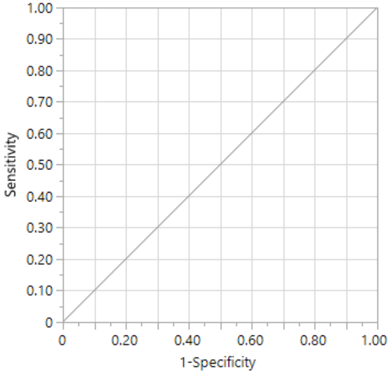
jmp STATISTICAL DISCOVERY

Generalized Regression for status = Fail

Binomial Elastic Net with Validation Column

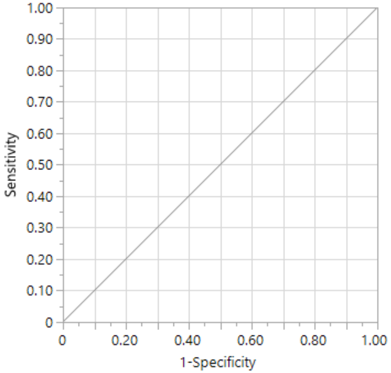
Binomial Elastic Net ROC Curve for status = Fail

Training



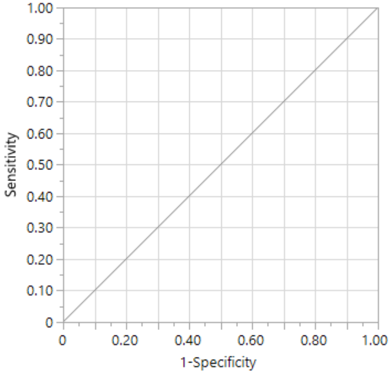
AUC
1.0000

Validation



AUC
1.0000

Test



AUC
1.0000

RF

Generalized Regression for status = Fail

Binomial Elastic Net with Validation Column

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare
Intercept	10.090548	1.8017642	31.364152	<.0001*
Normalized Sensor 18	13.755492	2.5555089	28.973268	<.0001*
Normalized Sensor 27	-4.513064	1.9010799	5.6356271	0.0176*
Normalized Sensor 41	-0.875506	0.4462948	3.8483516	0.0498*
Normalized Sensor 26	1.9403476	1.3346853	2.1134955	0.1460
Normalized Sensor 15	-0.622552	0.7173161	0.7532344	0.3855
Normalized Sensor 52	3.841615	4.4366523	0.7497507	0.3866
Normalized Sensor 21	0.94501	1.2462852	0.5749604	0.4483
Normalized Sensor 08	0.6791519	1.1816369	0.3303434	0.5655
Normalized Sensor 05	0.3684318	0.8110402	0.2063619	0.6496
Normalized Sensor 55	2.4557393	6.4177539	0.1464193	0.7020
Normalized Sensor 61	1.6776547	6.6668107	0.0633241	0.8013
Normalized Sensor 06	0.2655408	1.2046963	0.0485856	0.8255
Normalized Sensor 14	-0.113737	0.681085	0.0278868	0.8674
Normalized Sensor 53	0.4410189	5.6487227	0.0060956	0.9378
Normalized Sensor 54	0.6979234	9.6499351	0.0052308	0.9423
Normalized Sensor 16	-0.003632	0.3813282	9.0716e-5	0.9924
Normalized Sensor 07	0	0	0	1.0000
Normalized Sensor 13	0	0	0	1.0000
Normalized Sensor 20	0	0	0	1.0000

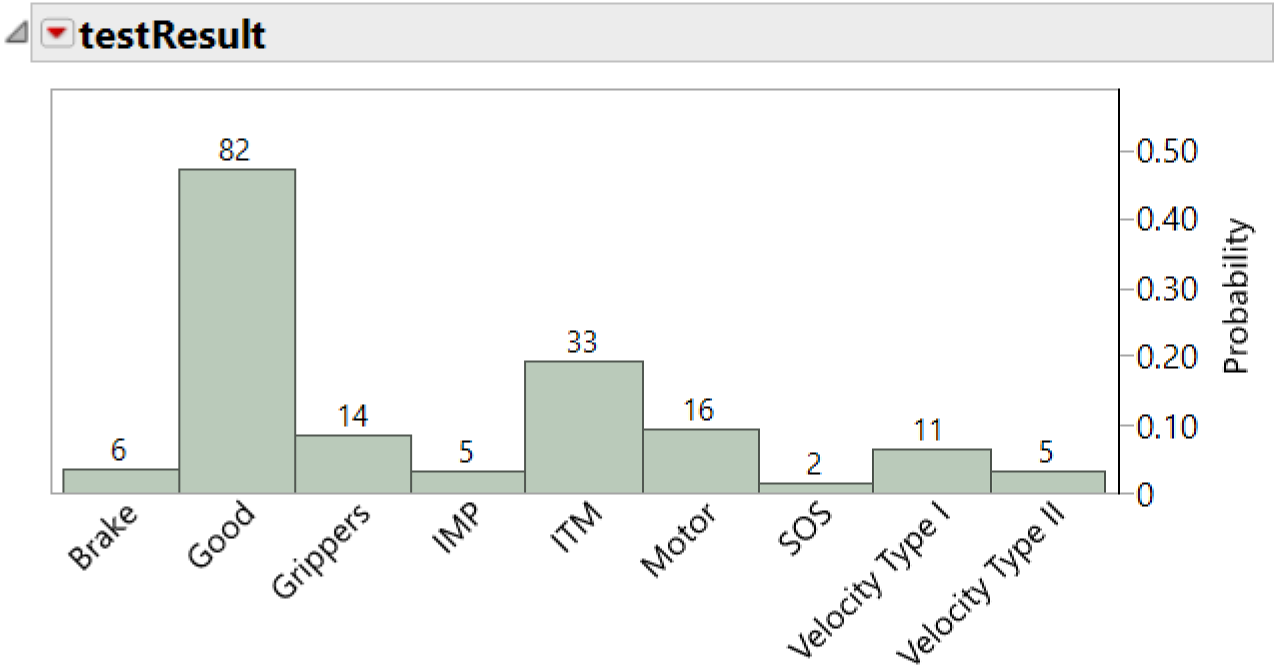
Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	522	36.5630568	0.3709
sensor53	248	19.0040464	0.1928
sensor55	163	9.18530792	0.0932
sensor48	107	7.43395874	0.0754
sensor52	88	4.51699905	0.0458
sensor54	65	3.1209684	0.0317
sensor61	48	3.08165918	0.0313
sensor11	76	2.20715869	0.0224
sensor21	44	1.8102253	0.0184
sensor46	31	0.98045171	0.0099
sensor24	37	0.97068784	0.0098
sensor50	33	0.77981921	0.0079
sensor44	15	0.75054722	0.0076
sensor26	67	0.74422853	0.0075
sensor17	36	0.52835424	0.0054

KPA Insights through analytics

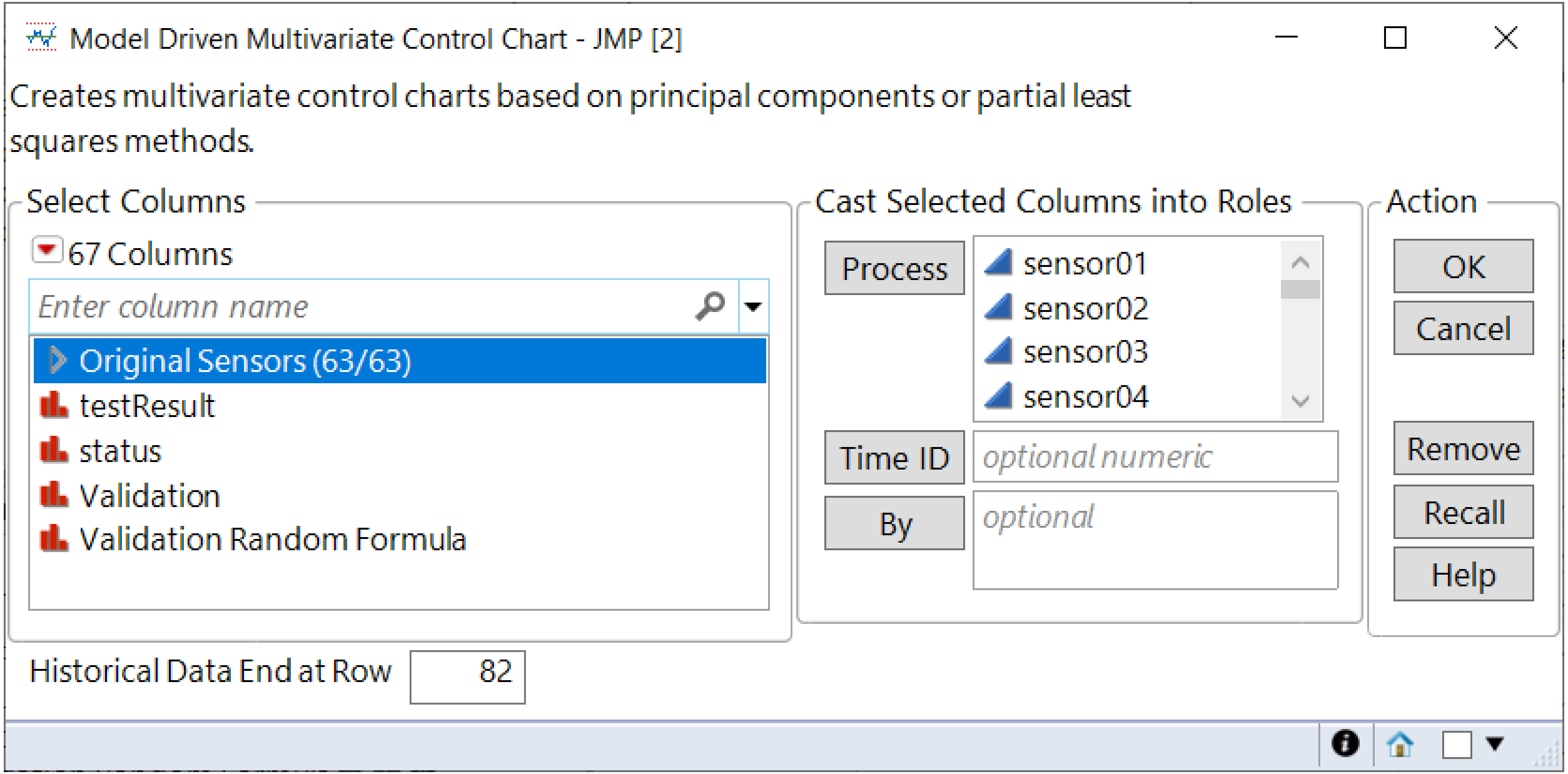
jmp STATISTICAL DISCOVERY

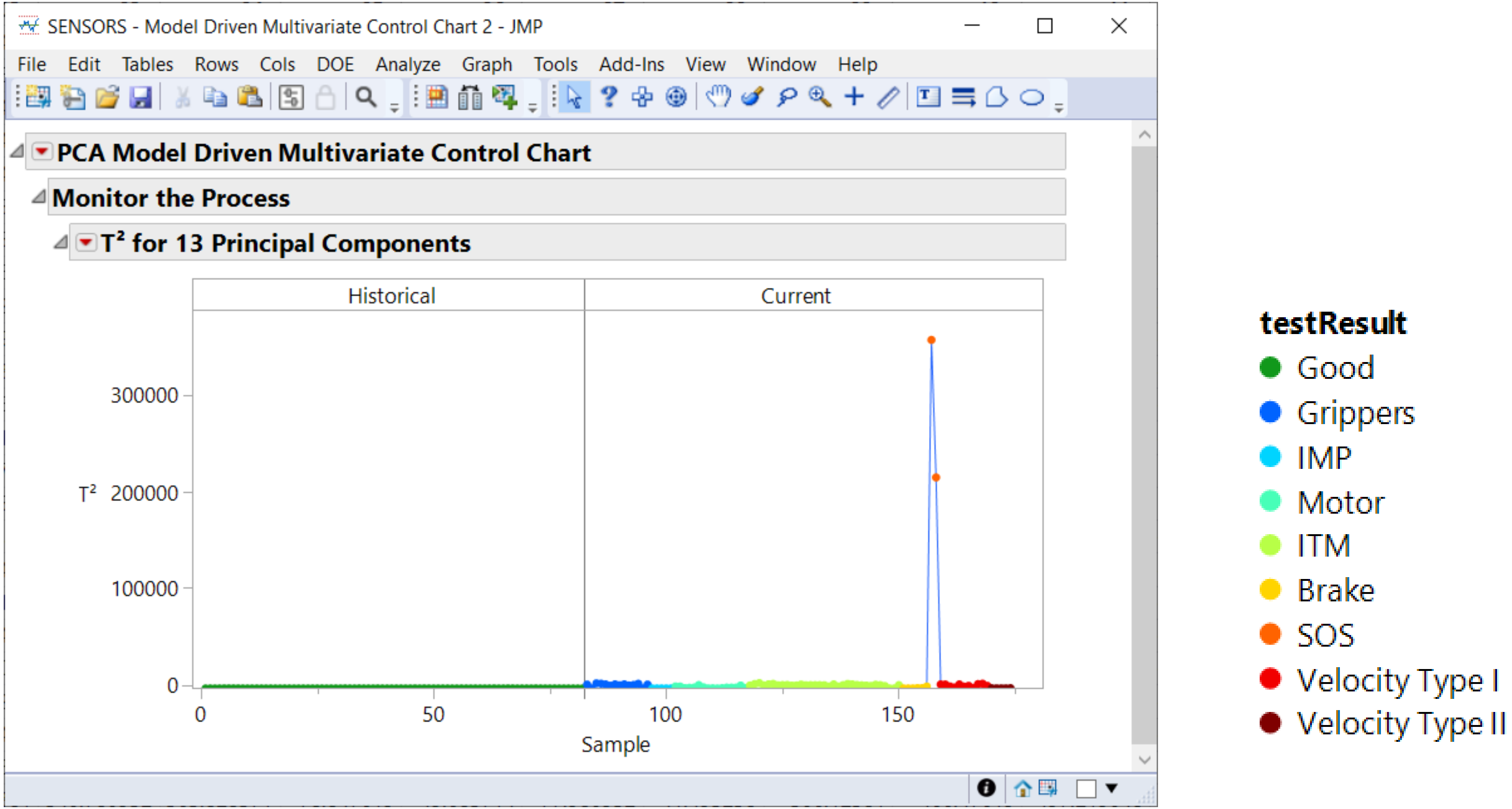
“Can the sensor data predict the outcome (test result)?”


testResult
82
6
14
5
33
16
2
11
5
0.50
0.40
0.30
0.20
0.10
0
Probability
Brake
Good
Grippers
IMP
ITM
Motor
SOS
Velocity Type I
Velocity Type II

"Can the sensor data predict the outcome (test result)?"

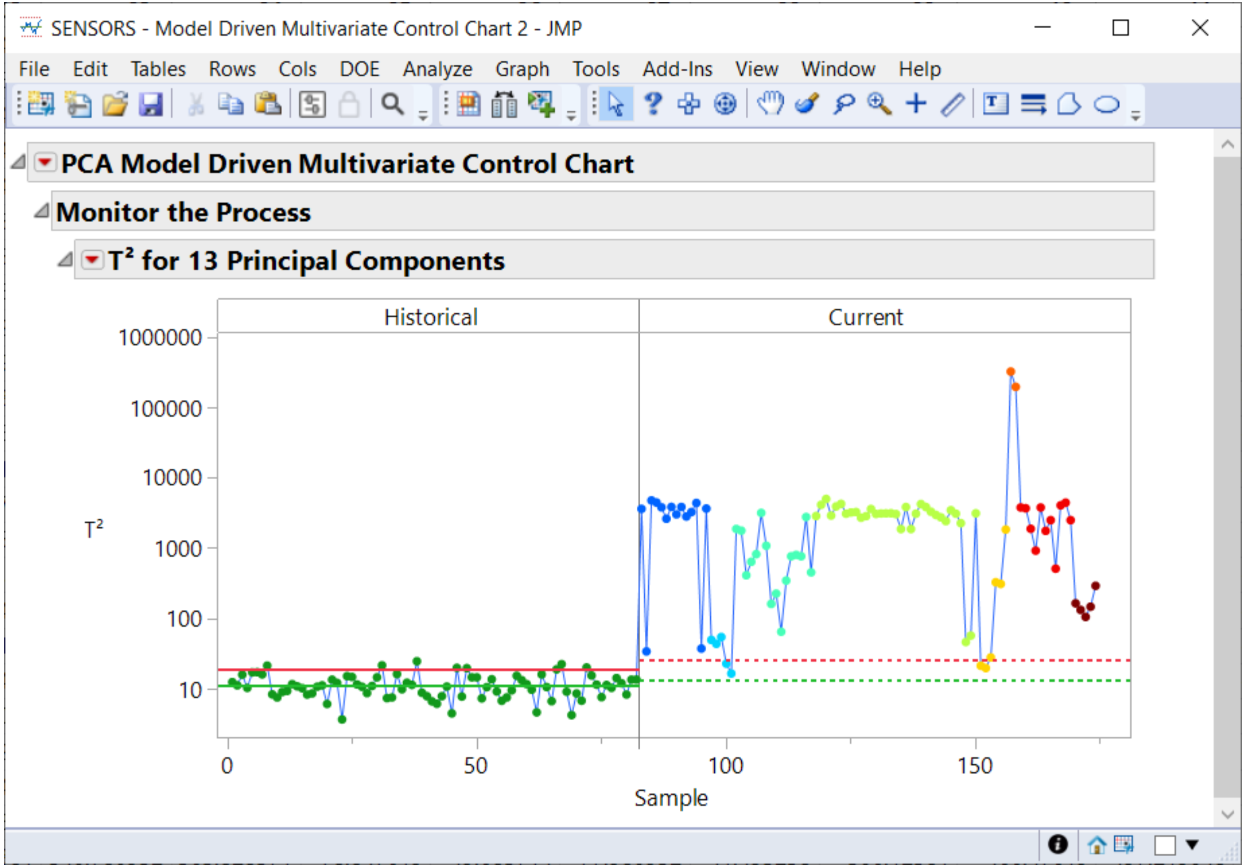
"Can the sensor data predict the 'Good' ones?"


Model Driven Multivariate Control Chart - JMP [2]
Creates multivariate control charts based on principal components or partial least squares methods.
Select Columns
67 Columns
Enter column name
Original Sensors (63/63)
testResult
status
Validation
Validation Random Formula
Cast Selected Columns into Roles
Process
sensor01
sensor02
sensor03
sensor04
Time ID
optional numeric
By
optional
Action
OK
Cancel
Remove
Recall
Help
Historical Data End at Row
82

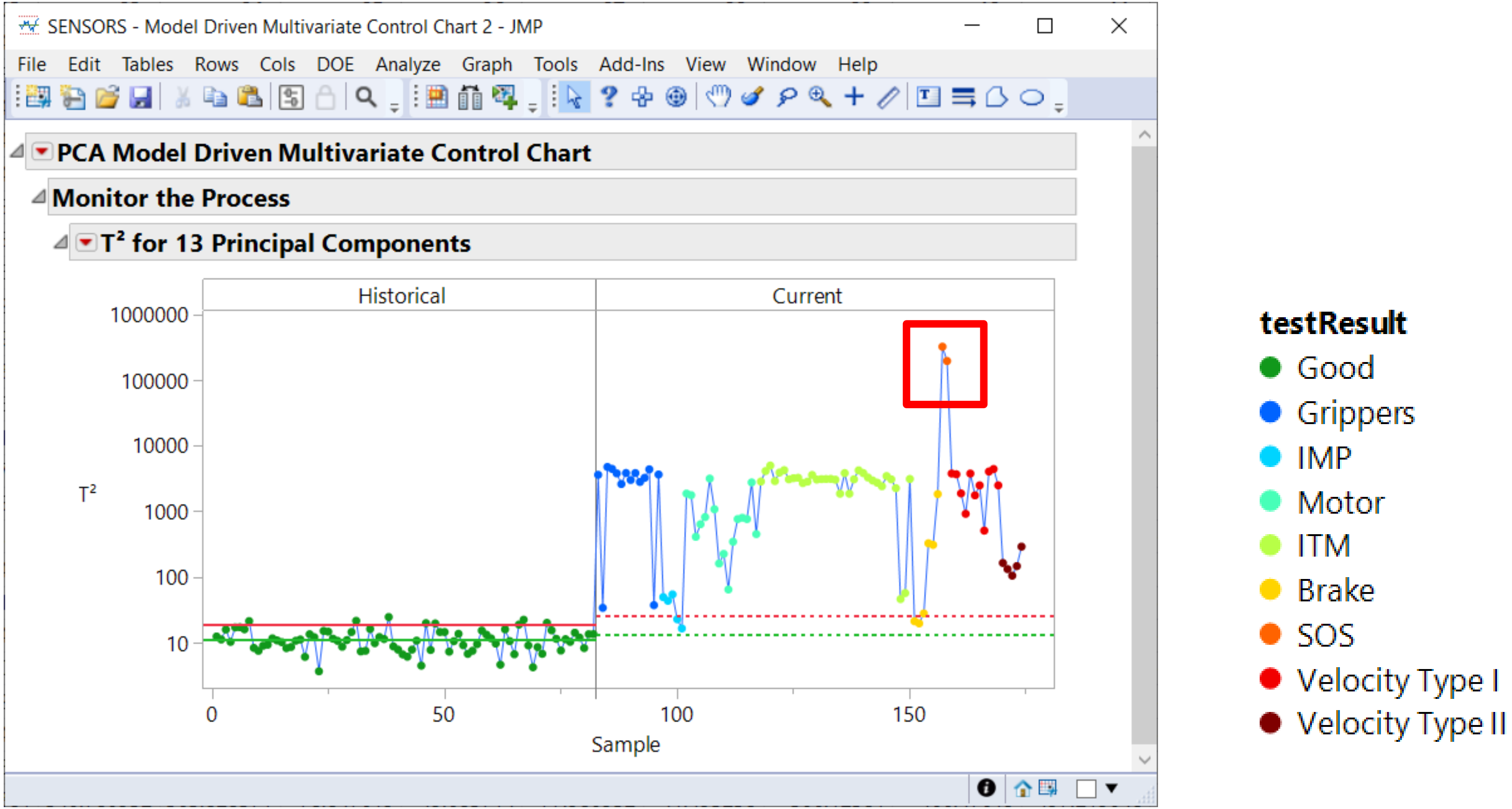


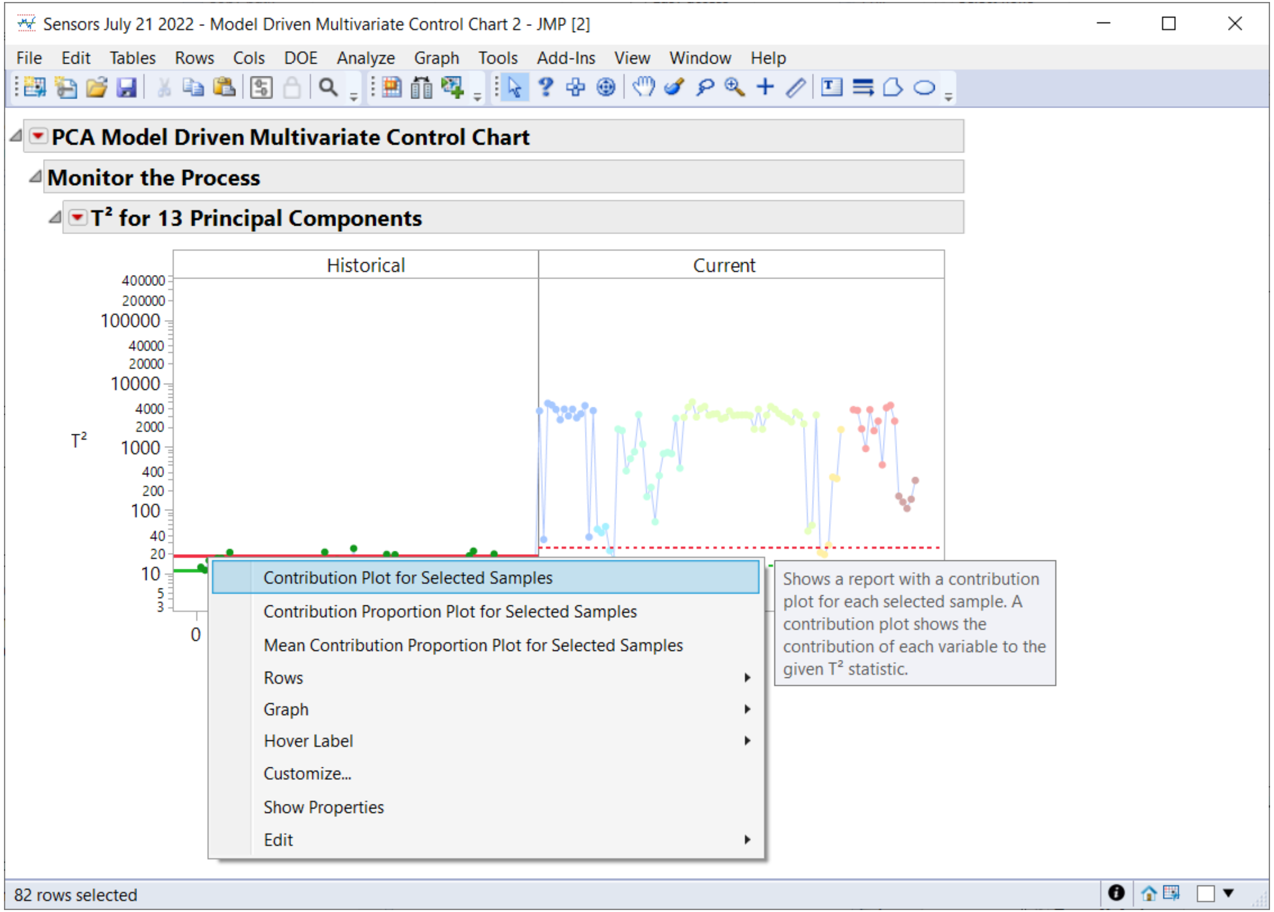
KPA
Insights through analytics

jmp STATISTICAL DISCOVERY

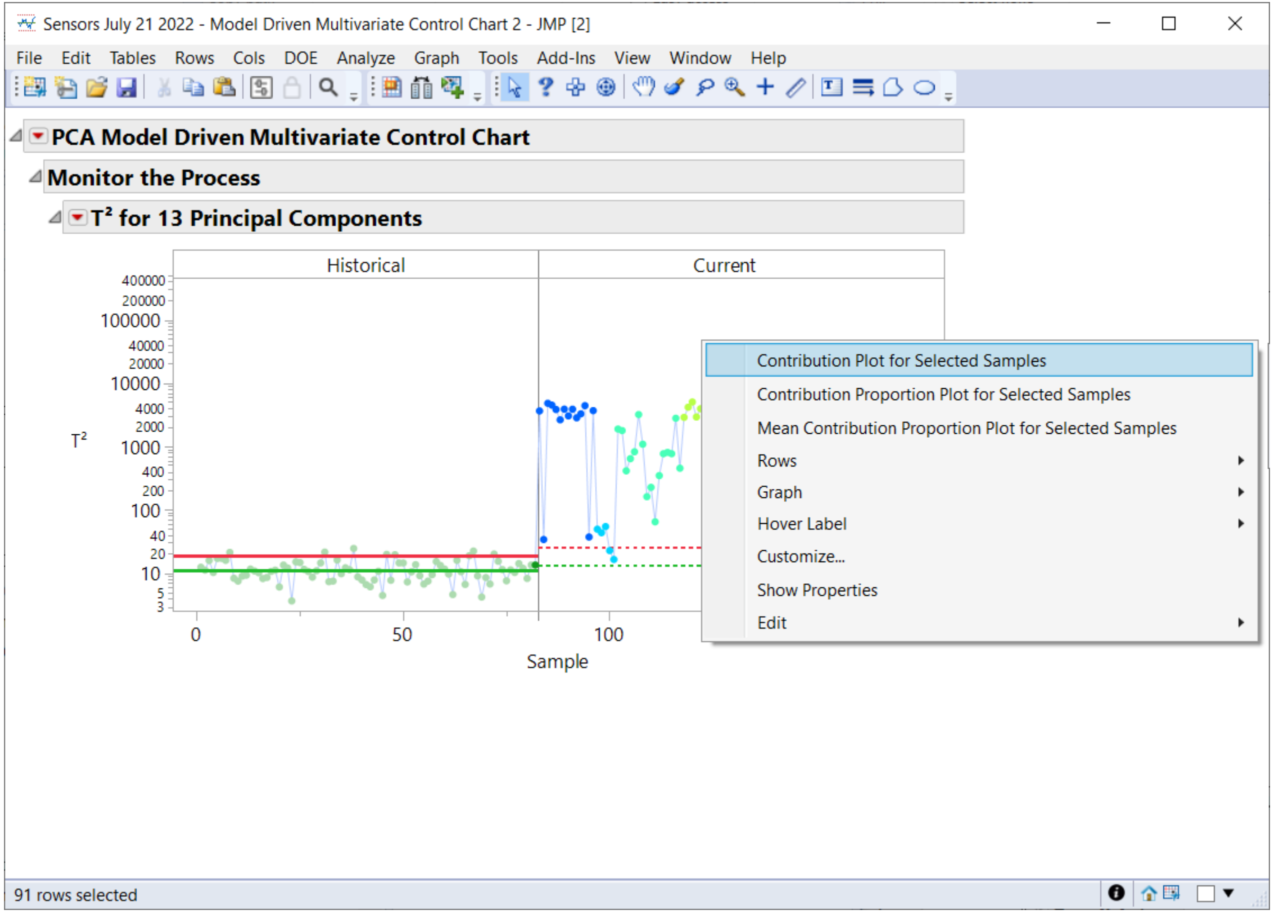


testResult
- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II

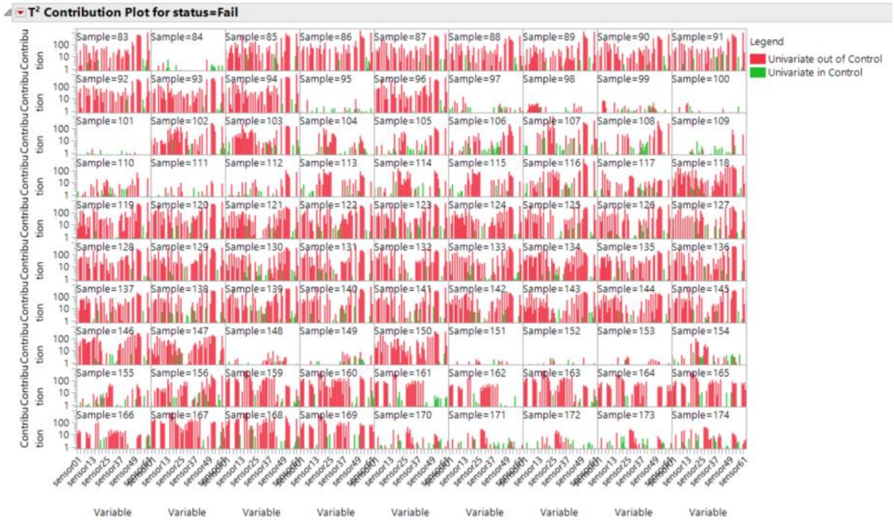

SENSORS - Model Driven Multivariate Control Chart 2 - JMP
File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help
PCA Model Driven Multivariate Control Chart
Monitor the Process
T² for 13 Principal Components
Historical
Current
1000000
100000
10000
1000
100
10
T²
0
50
100
150
Sample
testResult
Good
Grippers
IMP
Motor
ITM
Brake
SOS
Velocity Type I
Velocity Type II



Sensors July 21 2022 - Model Driven Multivariate Control Chart 2 - JMP [2]
File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help
PCA Model Driven Multivariate Control Chart
Monitor the Process
T² for 13 Principal Components
Historical
Current
T²
Contribution Plot for Selected Samples
Contribution Proportion Plot for Selected Samples
Mean Contribution Proportion Plot for Selected Samples
Rows
Graph
Hover Label
Customize...
Show Properties
Edit
Shows a report with a contribution plot for each selected sample. A contribution plot shows the contribution of each variable to the given T² statistic.
82 rows selected


Sensors July 21 2022 - Model Driven Multivariate Control Chart 2 - JMP [2]
File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help
PCA Model Driven Multivariate Control Chart
Monitor the Process
T² for 13 Principal Components
Historical
Current
T²
Sample
Contribution Plot for Selected Samples
Contribution Proportion Plot for Selected Samples
Mean Contribution Proportion Plot for Selected Samples
Rows
Graph
Hover Label
Customize...
Show Properties
Edit
91 rows selected


T² Contribution Plot for status=Pass
Legend
Univariate out of Control
Univariate in Control


T² Contribution Plot for status=Fail
Legend
Univariate out of Control
Univariate in Control
Variable

BT

RF

Boosted Tree for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor56	82	4634.8525	0.2065
sensor18	27	4200.54219	0.1872
sensor11	21	2735.54419	0.1219
sensor61	19	2431.70533	0.1084
sensor48	17	2414.82121	0.1076
sensor57	22	2016.84895	0.0899
sensor58	10	1456.34648	0.0649
sensor59	8	726.693834	0.0324
sensor26	2	343.87221	0.0153
sensor52	2	323.166652	0.0144
sensor09	6	286.922646	0.0128
sensor01	9	194.974174	0.0087
sensor55	2	165.247012	0.0074
sensor24	4	151.216612	0.0067
sensor07	4	128.858022	0.0057
sensor12	4	117.421132	0.0052
sensor15	2	44.7671089	0.0020
sensor44	1	37.6713347	0.0017
sensor54	1	15.5711294	0.0007
sensor27	1	12.8974036	0.0006

Bootstrap Forest for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	579	54.9167342	0.5024
sensor61	198	18.7389273	0.1714
sensor52	145	13.1320295	0.1201
sensor53	56	5.26374221	0.0482
sensor44	33	2.53070023	0.0232
sensor48	42	2.45696551	0.0225
sensor46	31	2.08993095	0.0191
sensor11	114	1.34630042	0.0123
sensor54	12	1.01688952	0.0093
sensor58	111	0.73127415	0.0067
sensor07	61	0.68014104	0.0062
sensor26	89	0.5292647	0.0048
sensor12	40	0.51092374	0.0047
sensor50	8	0.41943383	0.0038
sensor57	75	0.3901658	0.0036
sensor01	44	0.35310066	0.0032
sensor05	47	0.3400086	0.0031
sensor21	8	0.30245908	0.0028

BT

Overall Statistics

Measure	Training	Validation
Entropy RSquare	0.9981	0.5788
Generalized RSquare	0.9991	0.7352
Mean -Log p	0.0013	0.2909
RASE	0.0025	0.2649
Mean Abs Dev	0.0013	0.0875
Misclassification Rate	0.0000	0.0930
N	131	43

RF

Overall Statistics

Measure	Training	Validation
Entropy RSquare	0.9186	0.6736
Generalized RSquare	0.9601	0.8089
Mean -Log p	0.0563	0.2254
RASE	0.1016	0.2543
Mean Abs Dev	0.0491	0.1253
Misclassification Rate	0.0076	0.0698
N	131	43

Boosted Trees vs. Random Forest Folklore

BT

- Fast algorithm
- Highly accurate on big data

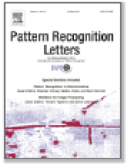
RF

- More accurate on small data
- Robust to messy/noisy data
- Often used for variable selection

ELSEVIER

Pattern Recognition Letters

Volume 31, Issue 14, 15 October 2010, Pages 2225-2236



Variable selection using random forests

Robin Genuer [a], Jean-Michel Poggi [a, b], Christine Tuleau-Malot [c]

BT

Boosted Tree for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor56	82	4634.8525	0.2065
sensor18	27	4200.54219	0.1872
sensor11	21	2735.54419	0.1219
sensor61	19	2431.70533	0.1084
sensor48	17	2414.82121	0.1076
sensor57	22	2016.84895	0.0899
sensor58	10	1456.34648	0.0649
sensor59	8	726.693834	0.0324
sensor26	2	343.87221	0.0153
sensor52	2	323.166652	0.0144
sensor09	6	286.922646	0.0128
sensor01	9	194.974174	0.0087
sensor55	2	165.247012	0.0074
sensor24	4	151.216612	0.0067
sensor07	4	128.858022	0.0057
sensor12	4	117.421132	0.0052
sensor15	2	44.7671089	0.0020
sensor44	1	37.6713347	0.0017
sensor54	1	15.5711294	0.0007
sensor27	1	12.8974036	0.0006

RF

Bootstrap Forest for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	579	54.9167342	0.5024
sensor61	198	18.7389273	0.1714
sensor52	145	13.1320295	0.1201
sensor53	56	5.26374221	0.0482
sensor44	33	2.53070023	0.0232
sensor48	42	2.45696551	0.0225
sensor46	31	2.08993095	0.0191
sensor11	114	1.34630042	0.0123
sensor54	12	1.01688952	0.0093
sensor58	111	0.73127415	0.0067
sensor07	61	0.68014104	0.0062
sensor26	89	0.5292647	0.0048
sensor12	40	0.51092374	0.0047
sensor50	8	0.41943383	0.0038
sensor57	75	0.3901658	0.0036
sensor01	44	0.35310066	0.0032
sensor05	47	0.3400086	0.0031
sensor21	8	0.30245908	0.0028

Make Validation Column

Stratified Validation Column

Randomly partitions the rows into training, validation and test sets while attempting to evenly distribute across levels of the stratification variable(s). Use this option when you want a balanced representation of a column's levels in each of the training, validation and test sets.

Stratification Columns: status

Specify rates or relative rates

		Adjusted Rates	Row Counts
Training Set	0.75	0.75	129
Validation Set	0.25	0.25	43
Test Set	0	0	0
Excluded Rows			2
Total Rows			172

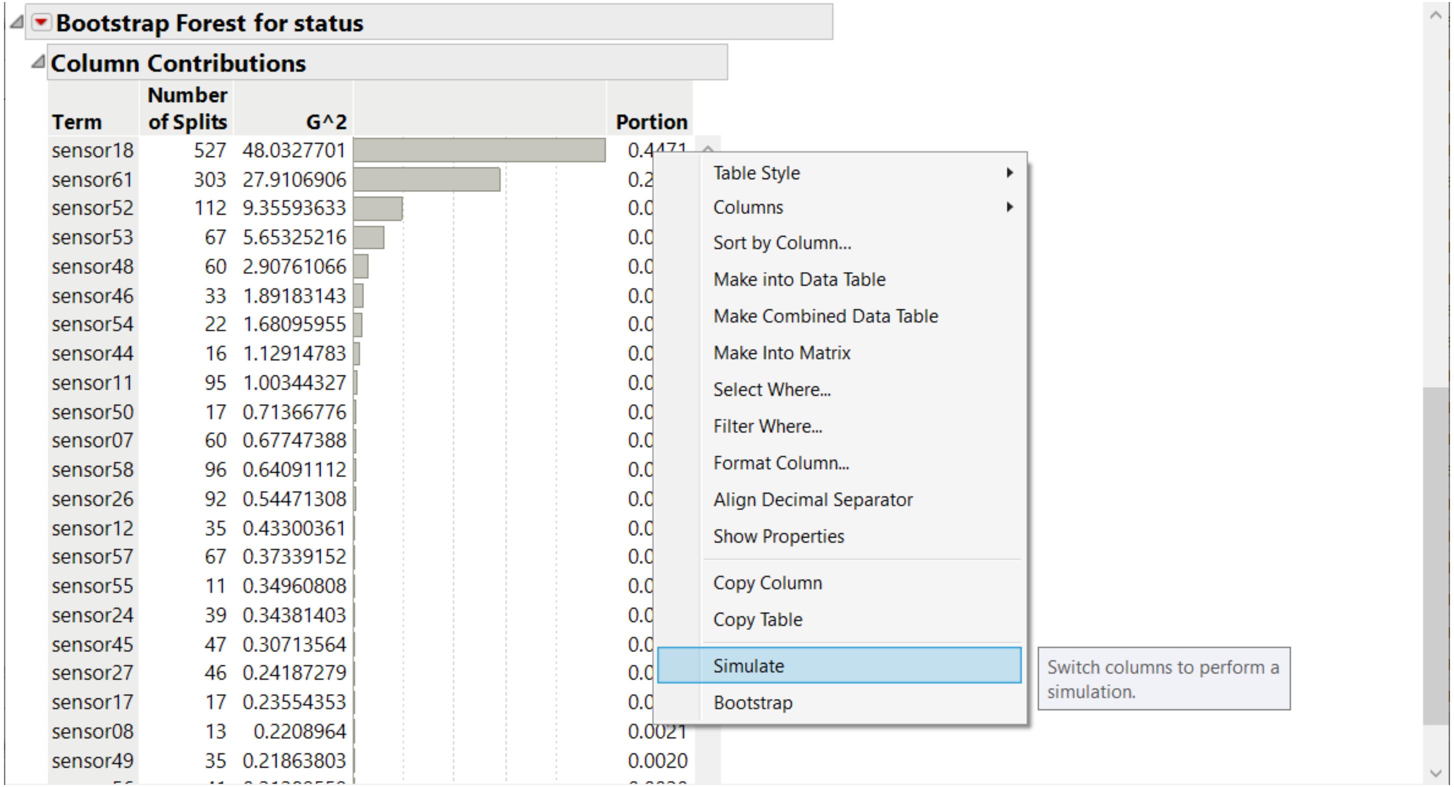
Options

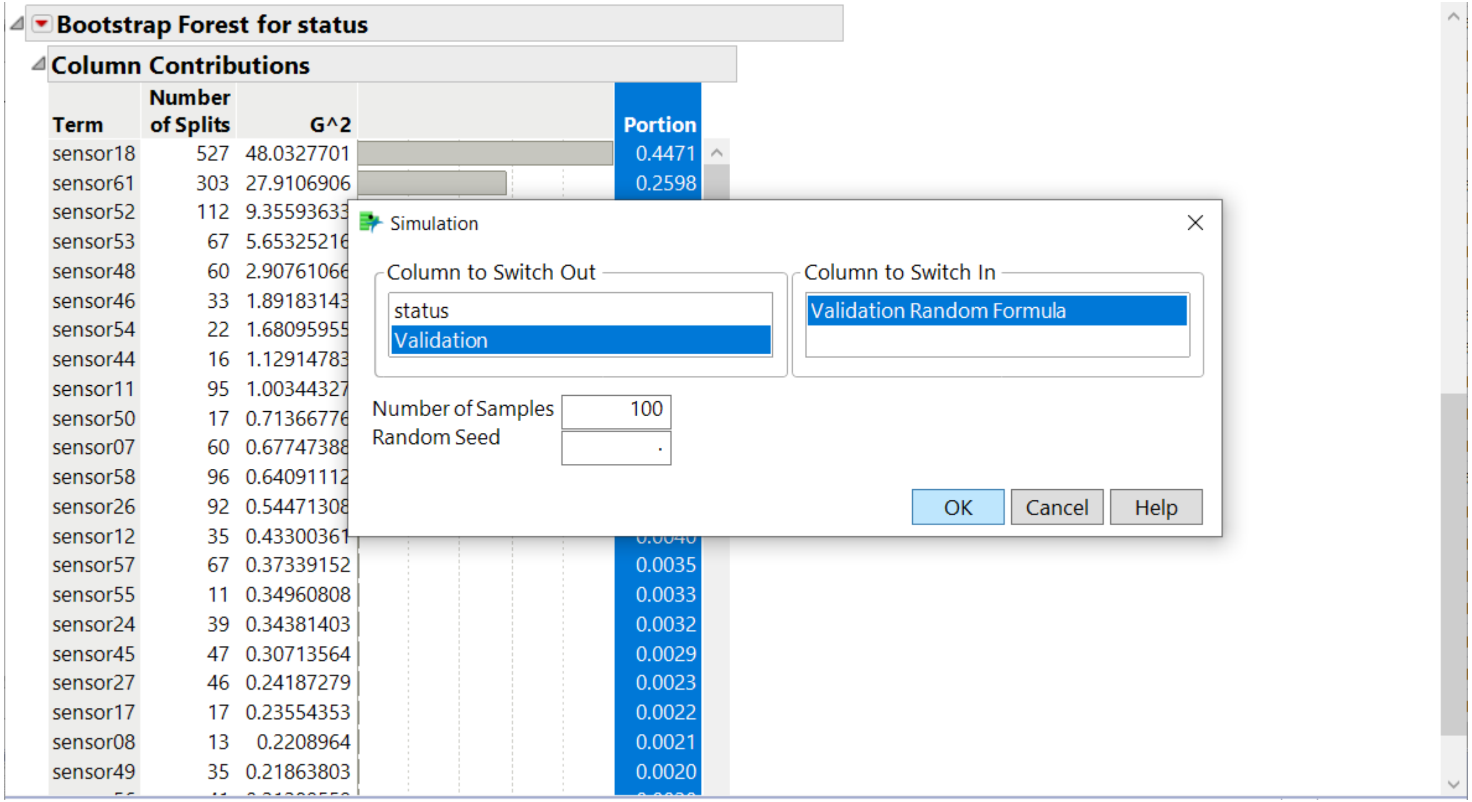
New Column Name: Validation

Validation Column Type: Formula

Go

Cancel Help


Bootstrap Forest for status
Column Contributions
Term
Number of Splits
G^2
Portion
sensor18 527 48.0327701 0.4471
sensor61 303 27.9106906
sensor52 112 9.35593633
sensor53 67 5.65325216
sensor48 60 2.90761066
sensor46 33 1.89183143
sensor54 22 1.68095955
sensor44 16 1.12914783
sensor11 95 1.00344327
sensor50 17 0.71366776
sensor07 60 0.67747388
sensor58 96 0.64091112
sensor26 92 0.54471308
sensor12 35 0.43300361
sensor57 67 0.37339152
sensor55 11 0.34960808
sensor24 39 0.34381403
sensor45 47 0.30713564
sensor27 46 0.24187279
sensor17 17 0.23554353
sensor08 13 0.2208964 0.0021
sensor49 35 0.21863803 0.0020
Table Style
Columns
Sort by Column...
Make into Data Table
Make Combined Data Table
Make Into Matrix
Select Where...
Filter Where...
Format Column...
Align Decimal Separator
Show Properties
Copy Column
Copy Table
Simulate
Bootstrap
Switch columns to perform a simulation.


Bootstrap Forest for status
Column Contributions
Term | Number of Splits | G^2 | Portion
sensor18 527 48.0327701 0.4471
sensor61 303 27.9106906 0.2598
sensor52 112 9.35593633
sensor53 67 5.65325216
sensor48 60 2.90761066
sensor46 33 1.89183143
sensor54 22 1.68095955
sensor44 16 1.12914783
sensor11 95 1.00344327
sensor50 17 0.71366776
sensor07 60 0.67747388
sensor58 96 0.64091112
sensor26 92 0.54471308
sensor12 35 0.43300361
sensor57 67 0.37339152 0.0035
sensor55 11 0.34960808 0.0033
sensor24 39 0.34381403 0.0032
sensor45 47 0.30713564 0.0029
sensor27 46 0.24187279 0.0023
sensor17 17 0.23554353 0.0022
sensor08 13 0.2208964 0.0021
sensor49 35 0.21863803 0.0020
Simulation
Column to Switch Out
status
Validation
Column to Switch In
Validation Random Formula
Number of Samples 100
Random Seed .
OK
Cancel
Help

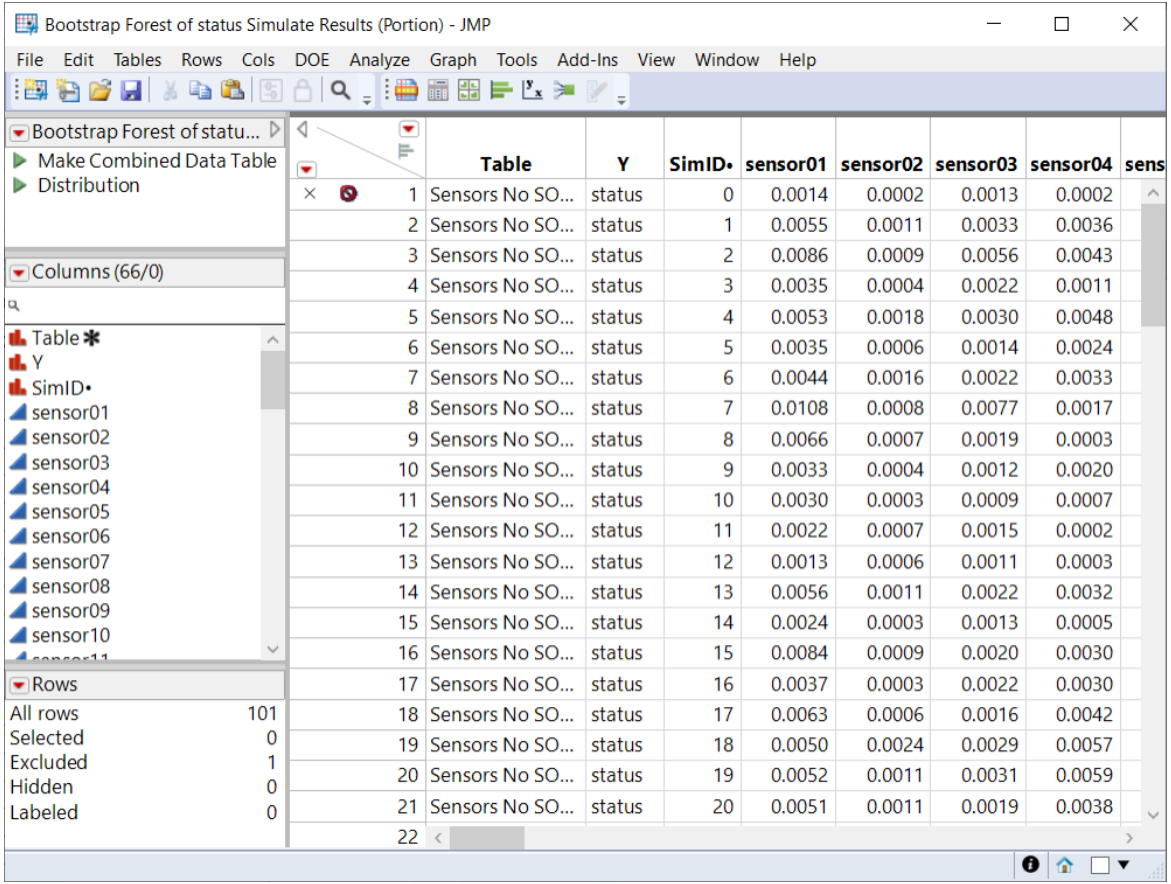
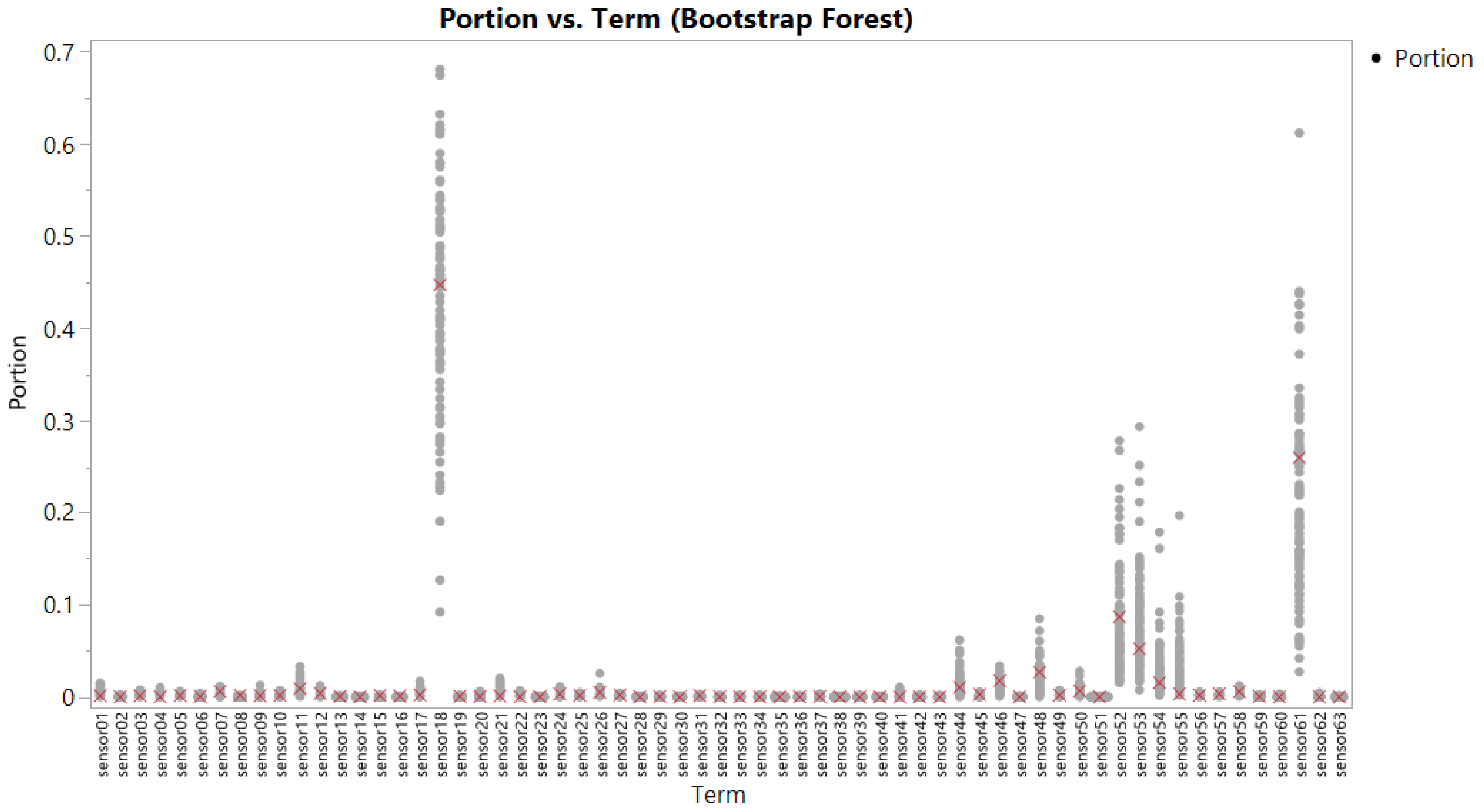


	Table	Y	SimID•	sensor01	sensor02	sensor03	sensor04	sens
1	Sensors No SO...	status	0	0.0014	0.0002	0.0013	0.0002	
2	Sensors No SO...	status	1	0.0055	0.0011	0.0033	0.0036	
3	Sensors No SO...	status	2	0.0086	0.0009	0.0056	0.0043	
4	Sensors No SO...	status	3	0.0035	0.0004	0.0022	0.0011	
5	Sensors No SO...	status	4	0.0053	0.0018	0.0030	0.0048	
6	Sensors No SO...	status	5	0.0035	0.0006	0.0014	0.0024	
7	Sensors No SO...	status	6	0.0044	0.0016	0.0022	0.0033	
8	Sensors No SO...	status	7	0.0108	0.0008	0.0077	0.0017	
9	Sensors No SO...	status	8	0.0066	0.0007	0.0019	0.0003	
10	Sensors No SO...	status	9	0.0033	0.0004	0.0012	0.0020	
11	Sensors No SO...	status	10	0.0030	0.0003	0.0009	0.0007	
12	Sensors No SO...	status	11	0.0022	0.0007	0.0015	0.0002	
13	Sensors No SO...	status	12	0.0013	0.0006	0.0011	0.0003	
14	Sensors No SO...	status	13	0.0056	0.0011	0.0022	0.0032	
15	Sensors No SO...	status	14	0.0024	0.0003	0.0013	0.0005	
16	Sensors No SO...	status	15	0.0084	0.0009	0.0020	0.0030	
17	Sensors No SO...	status	16	0.0037	0.0003	0.0022	0.0030	
18	Sensors No SO...	status	17	0.0063	0.0006	0.0016	0.0042	
19	Sensors No SO...	status	18	0.0050	0.0024	0.0029	0.0057	
20	Sensors No SO...	status	19	0.0052	0.0011	0.0031	0.0059	
21	Sensors No SO...	status	20	0.0051	0.0011	0.0019	0.0038	
22								

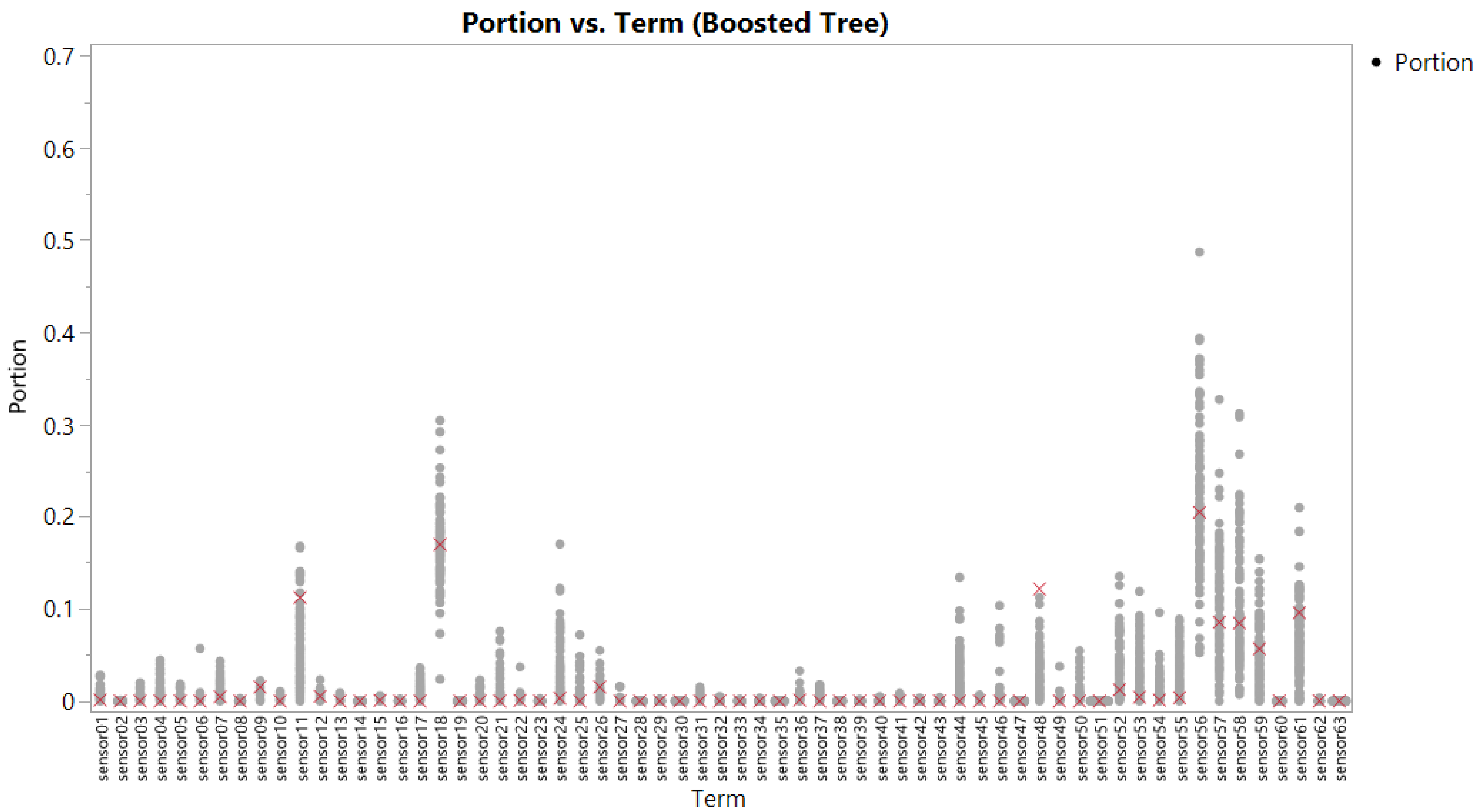
KPA Insights through analytics

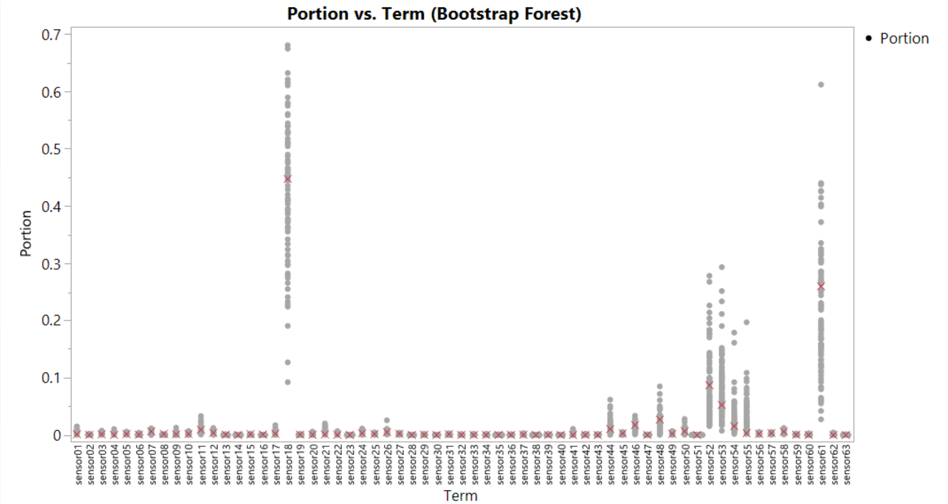
jmp STATISTICAL DISCOVERY

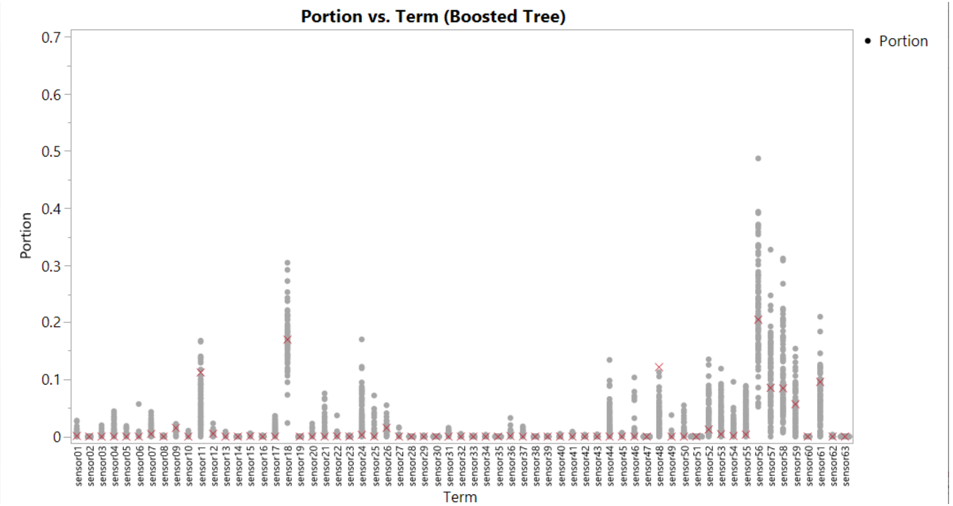


KPA
Insights through analytics

jmp STATISTICAL DISCOVERY

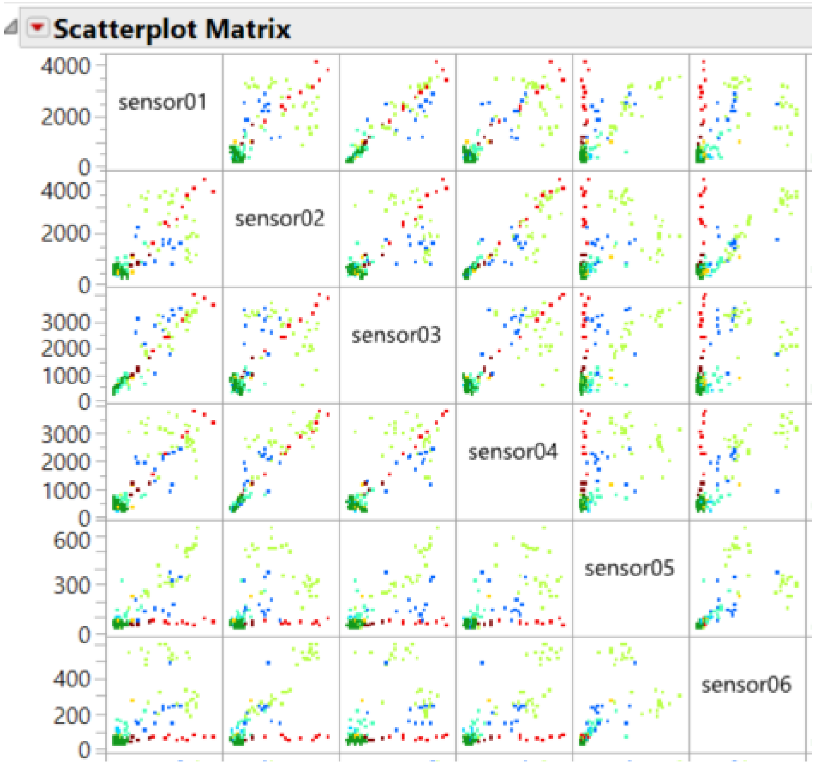

Portion vs. Term (Boosted Tree)
Portion
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Term
sensor01 … sensor63

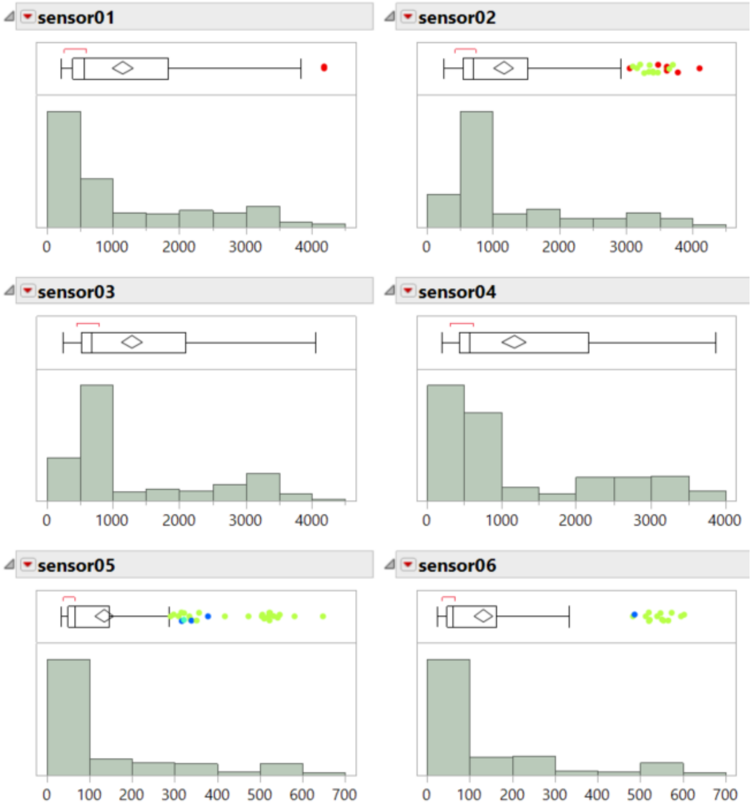




KPA
Insights through analytics

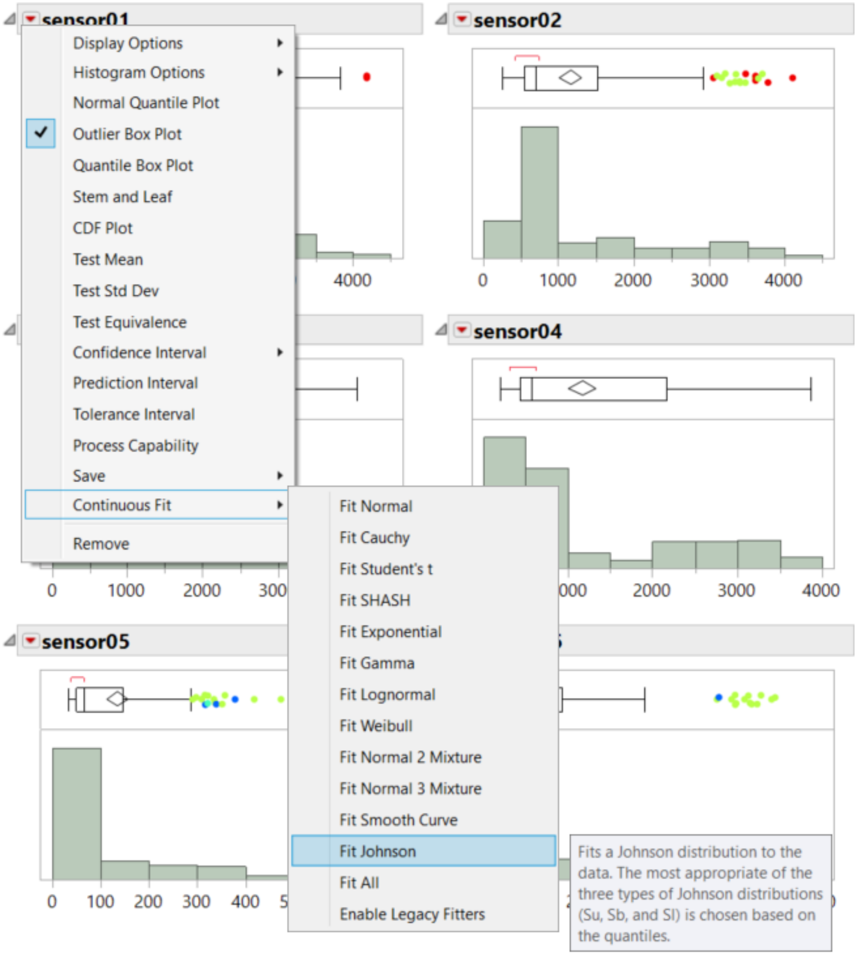
jmp STATISTICAL DISCOVERY



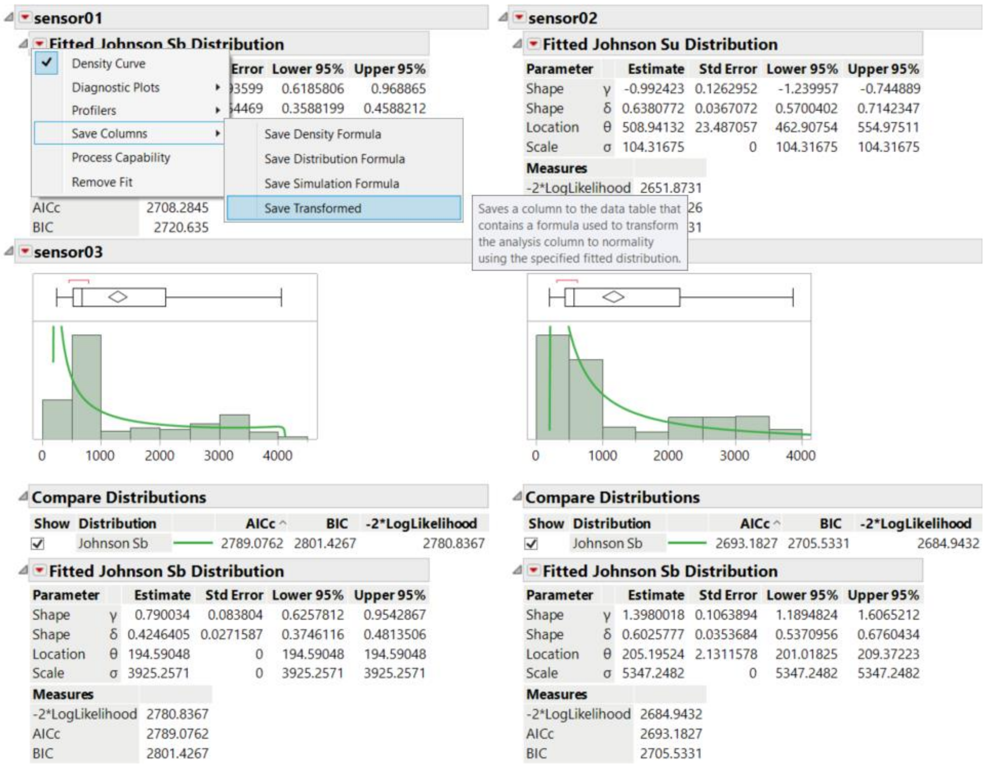


KPA
Insights through analytics

jmp STATISTICAL DISCOVERY

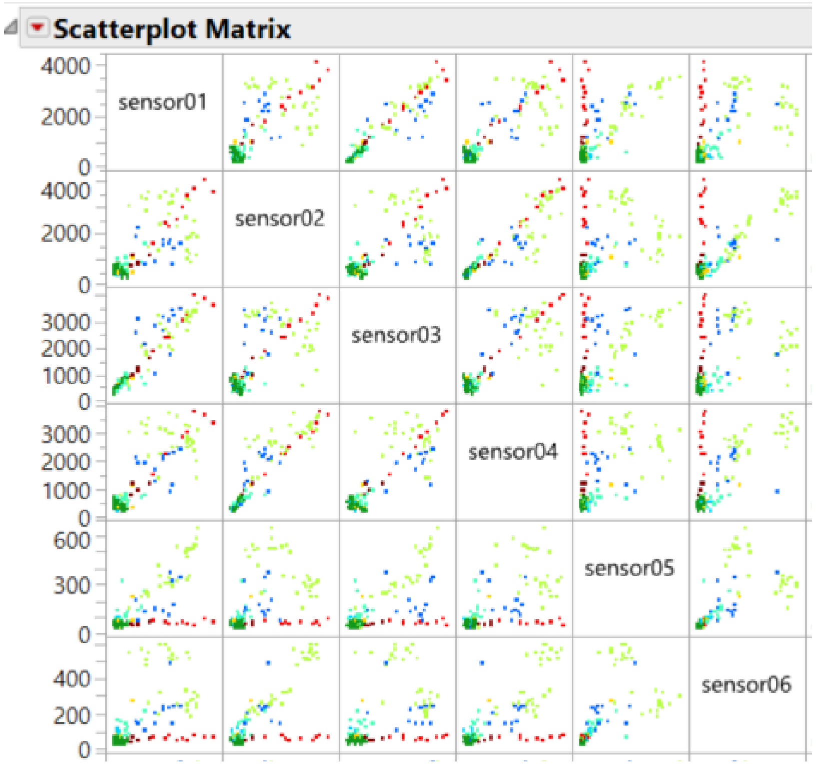


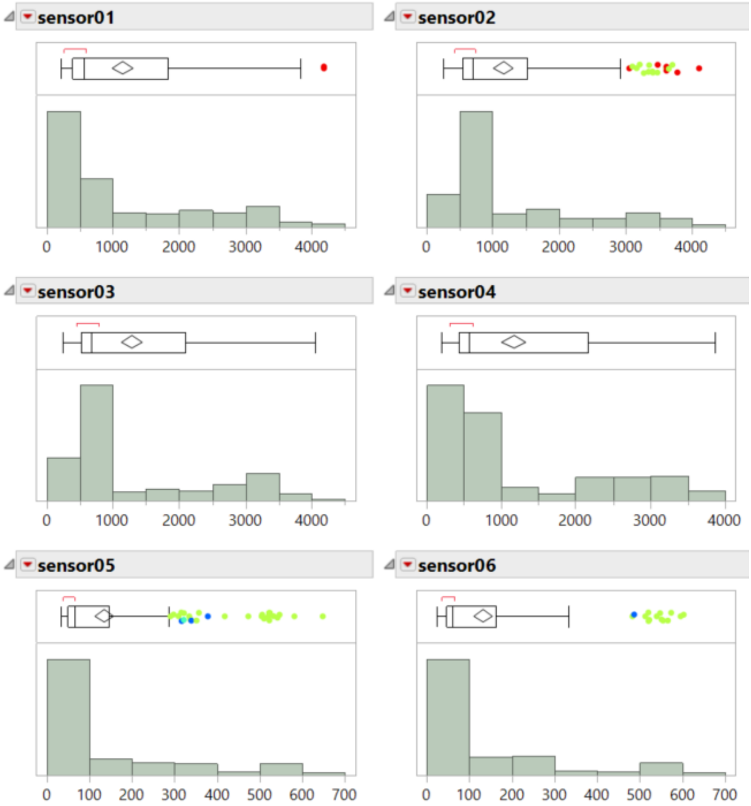
- Hold Alt + Click to broadcast to all columns

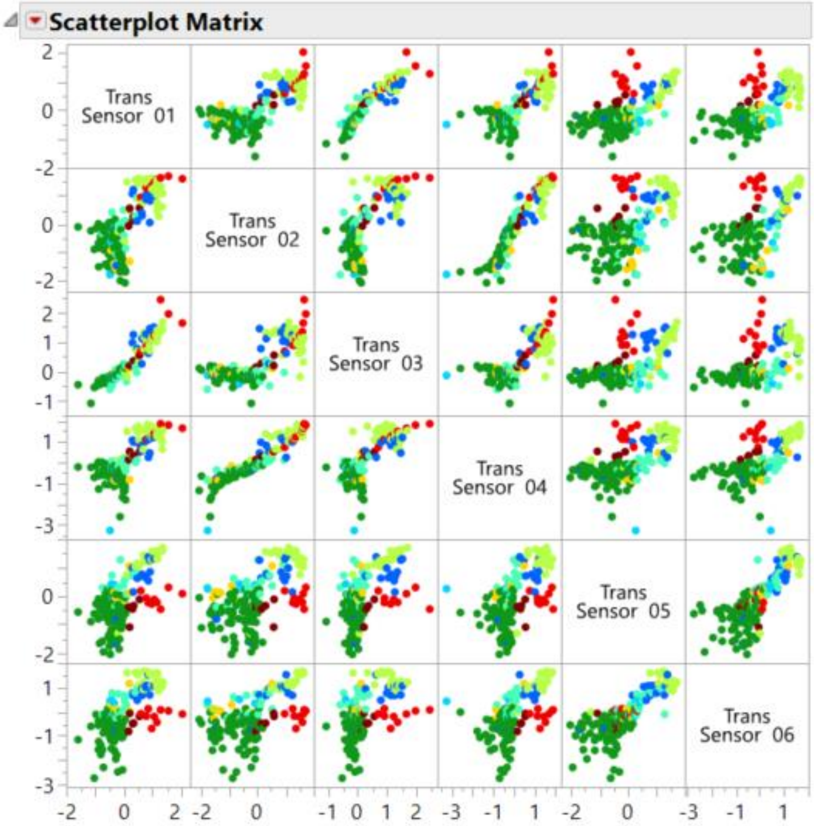


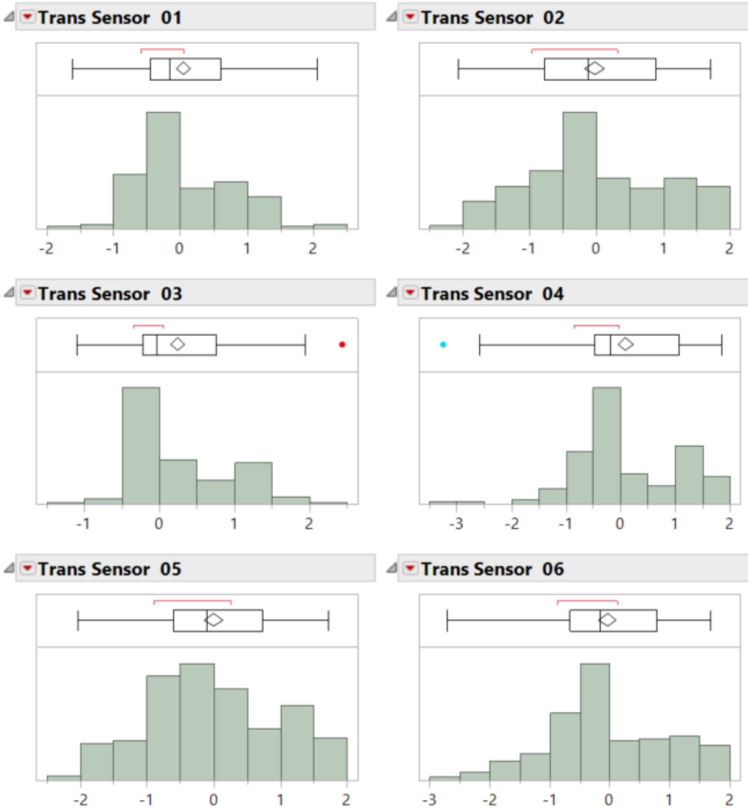
- Hold Alt + Click to broadcast to all columns

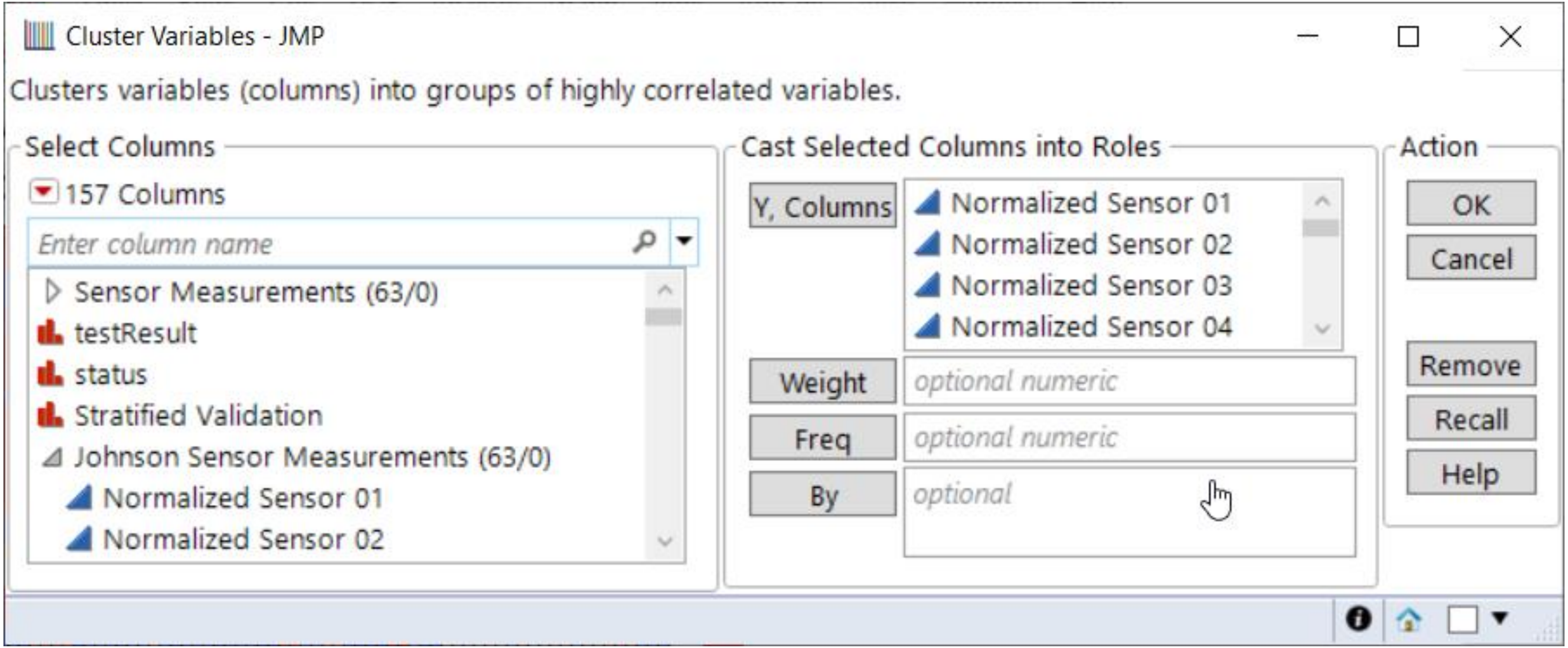
	status	Validation	Validation Random Formula	Johnson Sb Transform to Normal sensor01	Johnson Su Transform to Normal sensor02	Johnson Sb Transform to Normal sensor03	Johnson Sb Transform to Normal sensor04	Johnson Su Transform to Normal sensor05	Johnson Su Transform to Normal sensor06
1	Pass	Validation	Training	-0.429462541	-0.023164209	-0.180868093	-0.045175325	0.2103355703	-0.013999938
2	Pass	Validation	Training	-0.055300886	-1.63236901	0.0946350653	-1.649470993	-1.009090647	-1.042115859
3	Pass	Validation	Training	-0.111839132	-0.187981022	0.0190318601	-0.321027105	0.0413421482	-0.274633425
4	Pass	Training	Training	-0.545119593	-0.394709423	-0.250233244	-0.502509817	-0.35310491	-0.19353877
5	Pass	Validation	Training	-0.592368033	-0.381589246	-0.202267621	-0.067493582	-0.021463294	-0.083870644
6	Pass	Training	Training	0.0314637112	-2.059472445	0.0999572363	-1.329631387	-0.047036417	-0.310192693
7	Pass	Training	Training	-0.768441134	-0.068940672	-0.417092494	0.0214536018	-0.420836258	-0.424783097
8	Pass	Training	Training	-0.30113471	-0.3561646	-0.139427747	-0.229023302	-0.523040338	-0.000297651
9	Pass	Training	Training	-0.860416254	-0.790455797	-0.458553392	-0.622679123	-1.647412021	-0.44909209
10	Pass	Validation	Training	-0.516276499	-0.09857755	-0.194884031	-0.159489881	-1.334245723	-0.871892236
11	Pass	Training	Training	-0.447437398	-0.337014942	-0.285230865	-0.233164785	0.0729605379	-0.303294366
12	Pass	Training	Training	-0.247673385	-0.168014048	-0.027250896	-0.184571798	-1.529483355	-1.024703913


Scatterplot Matrix
sensor01
sensor02
sensor03
sensor04
sensor05
sensor06
4000
2000
0
4000
2000
0
3000
2000
1000
0
3000
2000
1000
0
600
300
0
400
200
0


sensor01
0
1000
2000
3000
4000
sensor02
0
1000
2000
3000
4000
sensor03
0
1000
2000
3000
4000
sensor04
0
1000
2000
3000
4000
sensor05
0
100
200
300
400
500
600
700
sensor06
0
100
200
300
400
500
600
700

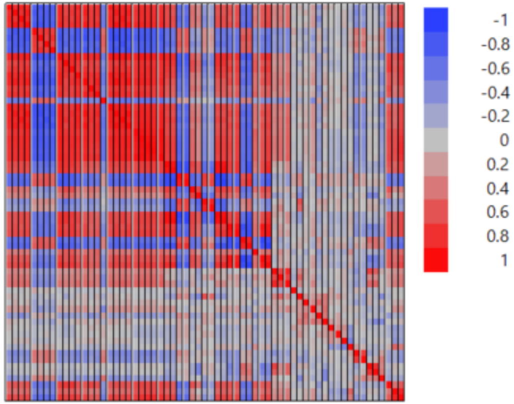

Scatterplot Matrix
Trans Sensor 01
Trans Sensor 02
Trans Sensor 03
Trans Sensor 04
Trans Sensor 05
Trans Sensor 06


Trans Sensor 01
Trans Sensor 02
Trans Sensor 03
Trans Sensor 04
Trans Sensor 05
Trans Sensor 06


Cluster Variables - JMP
Clusters variables (columns) into groups of highly correlated variables.
Select Columns
157 Columns
Enter column name
Sensor Measurements (63/0)
testResult
status
Stratified Validation
Johnson Sensor Measurements (63/0)
Normalized Sensor 01
Normalized Sensor 02
Cast Selected Columns into Roles
Y, Columns
Normalized Sensor 01
Normalized Sensor 02
Normalized Sensor 03
Normalized Sensor 04
Weight
optional numeric
Freq
optional numeric
By
optional
Action
OK
Cancel
Remove
Recall
Help

Variable Clustering

Color Map on Correlations



Cluster Summary

Cluster	Number of Members	Most Representative Variable	Cluster Proportion of Variation Explained	Total Proportion of Variation Explained
1	25	Trans Sensor 46	0.797	0.316
2	10	Trans Sensor 36	0.77	0.122
3	7	Trans Sensor 38	0.818	0.091
4	4	Trans Sensor 31	0.622	0.04
5	5	Trans Sensor 51	0.466	0.037
9	3	Trans Sensor 62	0.747	0.036
8	3	Trans Sensor 35	0.675	0.032
6	4	Trans Sensor 63	0.478	0.03
7	2	Trans Sensor 43	0.861	0.027

Proportion of variation explained by clustering: 0.731

Variable Clustering

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Trans Sensor 46	0.915	0.514	0.174
1	Trans Sensor 48	0.894	0.455	0.194
1	Trans Sensor 50	0.905	0.517	0.197
1	Trans Sensor 25	0.888	0.473	0.214
1	Trans Sensor 44	0.869	0.427	0.229
1	Trans Sensor 18	0.922	0.667	0.235
1	Trans Sensor 08	0.87	0.471	0.246
1	Trans Sensor 53	0.9	0.643	0.28
1	Trans Sensor 24	0.844	0.465	0.291
1	Trans Sensor 06	0.812	0.431	0.33
1	Trans Sensor 61	0.878	0.639	0.336
1	Trans Sensor 07	0.799	0.411	0.341
1	Trans Sensor 05	0.798	0.412	0.343
1	Trans Sensor 54	0.88	0.656	0.349
1	Trans Sensor 27	0.76	0.354	0.371
1	Trans Sensor 14	0.773	0.407	0.383
1	Trans Sensor 13	0.739	0.362	0.408
1	Trans Sensor 52	0.824	0.582	0.422
1	Trans Sensor 55	0.851	0.667	0.449
1	Trans Sensor 15	0.681	0.348	0.489
1	Trans Sensor 26	0.685	0.36	0.492
1	Trans Sensor 16	0.683	0.366	0.499
1	Trans Sensor 21	0.72	0.588	0.679
1	Trans Sensor 41	0.373	0.217	0.8
1	Trans Sensor 20	0.655	0.623	0.915
2	Trans Sensor 36	0.938	0.536	0.134
2	Trans Sensor 40	0.939	0.576	0.145
2	Trans Sensor 11	0.896	0.555	0.233
2	Trans Sensor 09	0.881	0.498	0.237
2	Trans Sensor 03	0.877	0.588	0.299
2	Trans Sensor 01	0.872	0.585	0.309
2	Trans Sensor 32	0.662	0.165	0.404
2	Trans Sensor 34	0.594	0.125	0.464
2	Trans Sensor 19	0.484	0.275	0.711
2	Trans Sensor 17	0.554	0.436	0.791
3	Trans Sensor 38	0.92	0.407	0.135

KPA Insights through analytics

jmp STATISTICAL DISCOVERY

Bootstrap Forest for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	579	54.9167342	0.5024
sensor61	198	18.7389273	0.1714
sensor52	145	13.1320295	0.1201
sensor53	[illegible]	[illegible]	0.0482
sensor44	33	[illegible]	0.0232
sensor48	42	2.45696551	0.0225
sensor46	31	2.08993095	0.0191
sensor11	114	1.34630042	0.0123
sensor54	12	1.01688952	0.0093
sensor58	111	0.73127415	0.0067
sensor07	61	0.68014104	0.0062
sensor26	89	0.5292647	0.0048
sensor12	40	0.51092374	0.0047
sensor50	8	0.41943383	0.0038
sensor57	75	0.3901658	0.0036
sensor01	44	0.35310066	0.0032
sensor05	47	0.3400086	0.0031
sensor21	8	0.30245908	0.0028

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Normalized Sensor 46	0.915	0.514	0.174
1	Normalized Sensor 48	0.894	0.455	0.194
1	Normalized Sensor 50	0.905	0.517	0.197
1	Normalized Sensor 25	0.888	0.473	0.214
1	Normalized Sensor 44	0.869	0.427	0.229
1	Normalized Sensor 18	0.922	0.667	0.235
1	Normalized Sensor 08	0.87	0.471	0.246
1	Normalized Sensor 53	0.9	0.643	0.28
1	Normalized Sensor 24	0.844	0.465	0.291
1	Normalized Sensor 06	0.812	0.431	0.33
1	Normalized Sensor 61	0.878	0.639	0.336
1	Normalized Sensor 07	0.799	0.411	0.341
1	Normalized Sensor 05	0.798	0.412	0.343
1	Normalized Sensor 54	0.88	0.656	0.349
1	Normalized Sensor 27	0.76	0.354	0.371
1	Normalized Sensor 14	0.773	0.407	0.383
1	Normalized Sensor 13	0.739	0.362	0.408
1	Normalized Sensor 52	0.824	0.582	0.422
1	Normalized Sensor 55	0.851	0.667	0.449
1	Normalized Sensor 15	0.681	0.348	0.489
1	Normalized Sensor 26	0.685	0.36	0.492
1	Normalized Sensor 16	0.683	0.366	0.499
1	Normalized Sensor 21	0.72	0.588	0.679
1	Normalized Sensor 41	0.373	0.217	0.8
1	Normalized Sensor 20	0.655	0.623	0.915

KPA Insights through analytics

jmp STATISTICAL DISCOVERY

Variable Clustering

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Trans Sensor 46	0.915	0.514	0.174
1	Trans Sensor 48	0.894	0.455	0.194
1	Trans Sensor 50	0.905	0.517	0.197
1	Trans Sensor 25	0.888	0.473	0.214
1	Trans Sensor 44	0.869	0.427	0.229
1	Trans Sensor 18	0.922	0.667	0.235
1	Trans Sensor 08	0.87	0.471	0.246
1	Trans Sensor 53	0.9	0.643	0.28
1	Trans Sensor 24	0.844	0.465	0.291
1	Trans Sensor 06	0.812	0.431	0.33
1	Trans Sensor 61	0.878	0.639	0.336
1	Trans Sensor 07	0.799	0.411	0.341
1	Trans Sensor 05	0.798	0.412	0.343
1	Trans Sensor 54	0.88	0.656	0.349
1	Trans Sensor 27	0.76	0.354	0.371
1	Trans Sensor 14	0.773	0.407	0.383
1	Trans Sensor 13	0.739	0.362	0.408
1	Trans Sensor 52	0.824	0.582	0.422
1	Trans Sensor 55	0.851	0.667	0.449
1	Trans Sensor 15	0.681	0.348	0.489
1	Trans Sensor 26	0.685	0.36	0.492
1	Trans Sensor 16	0.683	0.366	0.499
1	Trans Sensor 21	0.72	0.588	0.679
1	Trans Sensor 41	0.373	0.217	0.8
1	Trans Sensor 20	0.655	0.623	0.915
2	Trans Sensor 36	0.938	0.536	0.134
2	Trans Sensor 40	0.939	0.576	0.145
2	Trans Sensor 11	0.896	0.555	0.233
2	Trans Sensor 09	0.881	0.498	0.237
2	Trans Sensor 03	0.877	0.588	0.299
2	Trans Sensor 01	0.872	0.585	0.309
2	Trans Sensor 32	0.662	0.165	0.404
2	Trans Sensor 34	0.594	0.125	0.464
2	Trans Sensor 19	0.484	0.275	0.711
2	Trans Sensor 17	0.554	0.436	0.791
3	Trans Sensor 38	0.92	0.407	0.135

Variable Clustering

Cluster Members

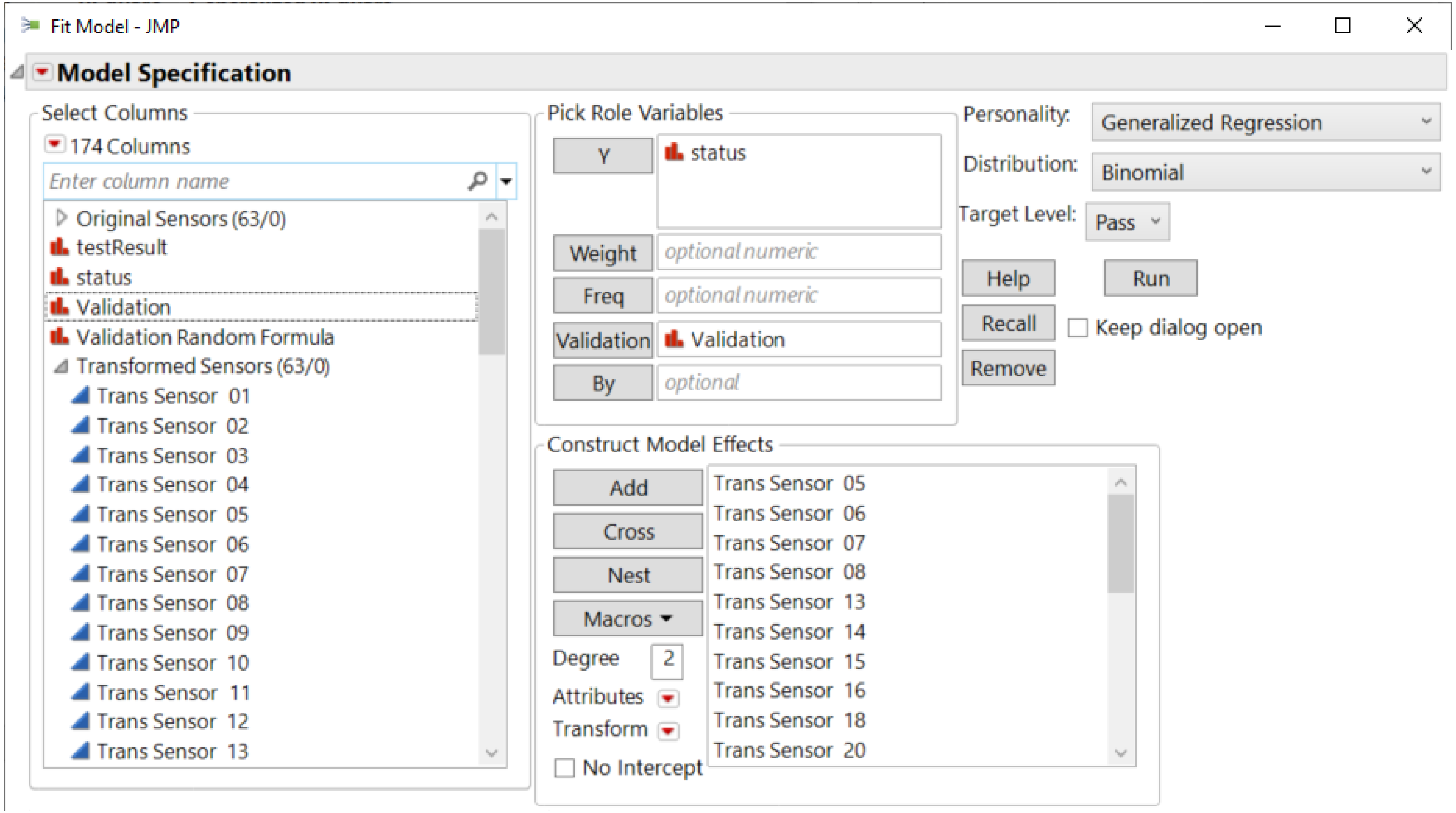
Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Trans Sensor 46	0.915	0.514	0.174
1	Trans Sensor 48	0.894	0.455	0.194
1	Trans Sensor 50	0.905	0.517	0.197
1	Trans Sensor 25	0.888	0.473	0.214
1	Trans Sensor 44	0.869	0.427	0.229
1	Trans Sensor 18	0.922	0.667	0.235
1	Trans Sensor 08	0.87	0.471	0.246
1	Trans Sensor 53	0.9	0.643	0.28
1	Trans Sensor 24	0.844	0.465	0.291
1	Trans Sensor 06	0.812	0.431	0.33
1	Trans Sensor 61	0.878	0.639	0.336
1	Trans Sensor 07	0.799	0.411	0.341
1	Trans Sensor 05	0.798	0.412	0.343
1	Trans Sensor 54	0.88	0.656	0.349
1	Trans Sensor 27	0.76	0.354	0.371
1	Trans Sensor 14	0.773	0.407	0.383
1	Trans Sensor 13	0.739	0.362	0.408
1	Trans Sensor 52	0.824	0.582	0.422
1	Trans Sensor 55	0.851	0.667	0.449
1	Trans Sensor 15	0.681	0.348	0.489
1	Trans Sensor 26	0.685	0.36	0.492
1	Trans Sensor 16	0.683	0.366	0.499
1	Trans Sensor 21	0.72	0.588	0.679
1	Trans Sensor 41	0.373	0.217	0.8
1	Trans Sensor 20	0.655	0.623	0.915
2	Trans Sensor 36	0.938	0.536	0.134
2	Trans Sensor 40	0.939	0.576	0.145
2	Trans Sensor 11	0.896	0.555	0.233
2	Trans Sensor 09	0.881	0.498	0.237
2	Trans Sensor 03	0.877	0.588	0.299
2	Trans Sensor 01	0.872	0.585	0.309
2	Trans Sensor 32	0.662	0.165	0.404
2	Trans Sensor 34	0.594	0.125	0.464
2	Trans Sensor 19	0.484	0.275	0.711
2	Trans Sensor 17	0.554	0.436	0.791
3	Trans Sensor 38	0.92	0.407	0.135

Variable Clustering

Cluster Members

Cluster	Members	RSquare with Own Cluster	RSquare with Next Closest	1-RSquare Ratio
1	Trans Sensor 46	0.915	0.514	0.174
1	Trans Sensor 48	0.894	0.455	0.194
1	Trans Sensor 50	0.905	0.517	0.197
1	Trans Sensor 25	0.888	0.473	0.214
1	Trans Sensor 44	0.869	0.427	0.229
1	Trans Sensor 18	0.922	0.667	0.235
1	Trans Sensor 08	0.87	0.471	0.246
1	Trans Sensor 53	0.9	0.643	0.28
1	Trans Sensor 24	0.844	0.465	0.291
1	Trans Sensor 06	0.812	0.431	0.33
1	Trans Sensor 61	0.878	0.639	0.336
1	Trans Sensor 07	0.799	0.411	0.341
1	Trans Sensor 05	0.798	0.412	0.343
1	Trans Sensor 54	0.88	0.656	0.349
1	Trans Sensor 27	0.76	0.354	0.371
1	Trans Sensor 14	0.773	0.407	0.383
1	Trans Sensor 13	0.739	0.362	0.408
1	Trans Sensor 52	0.824	0.582	0.422
1	Trans Sensor 55	0.851	0.667	0.449
1	Trans Sensor 15	0.681	0.348	0.489
1	Trans Sensor 26	0.685	0.36	0.492
1	Trans Sensor 16	0.683	0.366	0.499
1	Trans Sensor 21	0.72	0.588	0.679
1	Trans Sensor 41	0.373	0.217	0.8
1	Trans Sensor 20	0.655	0.623	0.915
2	Trans Sensor 36	0.938	0.536	0.134
2	Trans Sensor 40	0.939	0.576	0.145
2	Trans Sensor 11	0.896	0.555	0.233
2	Trans Sensor 09	0.881	0.498	0.237
2	Trans Sensor 03	0.877	0.588	0.299
2	Trans Sensor 01	0.872	0.585	0.309
2	Trans Sensor 32	0.662	0.165	0.404
2	Trans Sensor 34	0.594	0.125	0.464
2	Trans Sensor 19	0.484	0.275	0.711
2	Trans Sensor 17	0.554	0.436	0.791
3	Trans Sensor 38	0.92	0.407	0.135

Trans Sensor 01	Trans Sensor 02	Trans Sensor 03	Trans Sensor 04	Trans Sensor 05	Trans Sensor 06	Trans Sensor 07	Trans Sensor 08	Trans Sensor 09
-0.4294...	-0.0231...	-0.1808...	-0.0451...	0.2103...	-0.0139...	-0.1479...	-0.0003...	0.045...
-0.0553...	-1.6323...	0.0946...	-1.6494...	-1.0090...	-1.0421...	-1.1202...	-1.5259...	-0.07...
-0.1118...	-0.1879...	0.0190...	-0.3210...	0.0413...	-0.2746...	-0.2776...	-0.5321...	-0.00...
-0.5451...	-0.3947...	-0.2502...	-0.5025...	-0.3531...	-0.1935...	-0.0970...	-0.9698...	0.296...
-0.5923...	-0.3815...	-0.2022...	-0.0674...	-0.0214...	-0.0838...	-0.1310...	-0.0554...	0.205...
0.0314...	-2.0594...	0.0999...	-1.3296...	-0.0470...	-0.3101...	-0.1242...	-0.5256...	-0.20...
-0.7684...	-0.0689...	-0.4170...	0.0214...	-0.4208...	-0.4247...	-0.2626...	-0.7629...	0.208...
-0.3011...	-0.3561...	-0.1394...	-0.2290...	-0.5230...	-0.0002...	-0.0466...	0.1336...	-0.08...
-0.8604...	-0.7904...	-0.4585...	-0.6226...	-1.6474...	-0.4490...	-0.5911...	-0.6703...	0.279...
-0.5162...	-0.0985...	-0.1948...	-0.1594...	-1.3342...	-0.8718...	-0.8667...	-0.6355...	0.130...
-0.4474...	-0.3370...	-0.2852...	-0.2331...	0.0729...	-0.3032...	0.0418...	-0.9479...	0.145...
-0.2476...	-0.1680...	-0.0272...	-0.1845...	-1.5294...	-1.0247...	-1.2402...	-0.9938...	0.077...
-0.4825...	-0.9196...	-0.2014...	-0.7169...	-2.0343...	-0.5324...	-0.7525...	-0.6485...	0.105...



Fit Model - JMP
Model Specification
Select Columns
174 Columns
Enter column name
Original Sensors (63/0)
testResult
status
Validation
Validation Random Formula
Transformed Sensors (63/0)
Trans Sensor 01
Trans Sensor 02
Trans Sensor 03
Trans Sensor 04
Trans Sensor 05
Trans Sensor 06
Trans Sensor 07
Trans Sensor 08
Trans Sensor 09
Trans Sensor 10
Trans Sensor 11
Trans Sensor 12
Trans Sensor 13
Pick Role Variables
Y
status
Weight
optional numeric
Freq
optional numeric
Validation
Validation
By
optional
Personality:
Generalized Regression
Distribution:
Binomial
Target Level:
Pass
Help
Run
Recall
Keep dialog open
Remove
Construct Model Effects
Add
Cross
Nest
Macros
Degree
2
Attributes
Transform
No Intercept
Trans Sensor 05
Trans Sensor 06
Trans Sensor 07
Trans Sensor 08
Trans Sensor 13
Trans Sensor 14
Trans Sensor 15
Trans Sensor 16
Trans Sensor 18
Trans Sensor 20

Generalized Regression for status = Pass

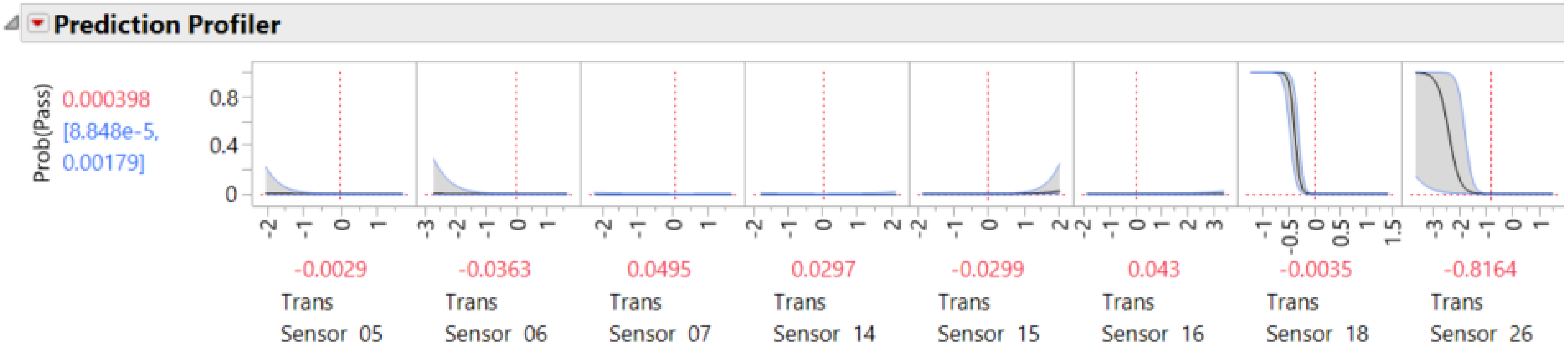
Model Comparison

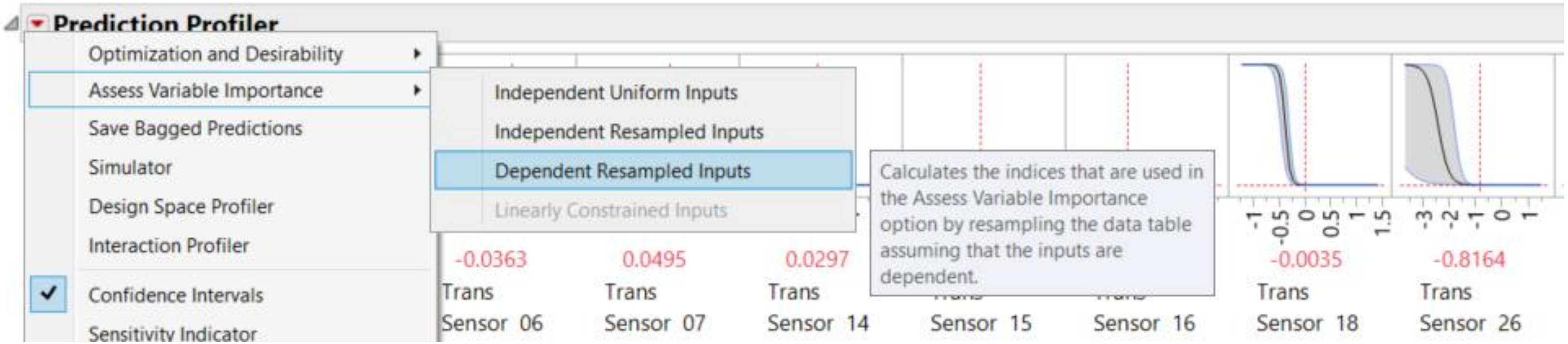
Show	Response Distribution	Estimation Method	Validation Method	Nonzero Parameters	AICc	BIC	Generalized RSquare	Validation Generalized RSquare
☑	Binomial	Logistic Regression	Validation Column	26	.	.	.	0.6234149
☑	Binomial	Lasso	Validation Column	13	30.775781	64.788125	0.9958038	0.906737
☑	Binomial	Elastic Net	Validation Column	17	43.746715	86.850012	0.9888577	0.8883607
☑	Binomial	Ridge	Validation Column	26	76.931684	137.5221	0.9697985	0.8336802

Binomial Lasso with Validation Column

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Trans Sensor 18	-21.50633	1.983503	117.56198	<.0001*	-25.39392	-17.61874
Intercept	-16.15049	2.0322961	63.153519	<.0001*	-20.13372	-12.16726
Trans Sensor 27	7.6947349	1.5130301	25.863792	<.0001*	4.7292504	10.660219
Trans Sensor 26	-4.982007	1.4309036	12.12238	0.0005*	-7.786526	-2.177487
Trans Sensor 15	2.0136856	0.7221117	7.7763279	0.0053*	0.5983727	3.4289985
Trans Sensor 52	-6.155699	3.8026345	2.6205089	0.1055	-13.60873	1.2973273
Trans Sensor 05	-1.227494	0.9327291	1.7319197	0.1882	-3.05561	0.6006214
Trans Sensor 16	0.4251844	0.3580648	1.4100395	0.2350	-0.27661	1.1269786
Trans Sensor 53	-3.442666	3.6166922	0.9060802	0.3412	-10.53125	3.6459207
Trans Sensor 61	-2.92957	3.5324812	0.6877774	0.4069	-9.853105	3.9939665
Trans Sensor 06	-0.67685	0.8698959	0.6054114	0.4365	-2.381815	1.0281144
Trans Sensor 07	-0.165354	0.5695772	0.0842799	0.7716	-1.281705	0.9509968
Trans Sensor 14	0.1156922	0.816768	0.0200637	0.8874	-1.485144	1.7165282
Trans Sensor 08	0	0	0	1.0000	0	0
Trans Sensor 13	0	0	0	1.0000	0	0
Trans Sensor 20	0	0	0	1.0000	0	0


Prediction Profiler
Prob(Pass)
0.000398
[8.848e-5,
0.00179]
0.8
0.4
0
-0.0029
Trans
Sensor 05
-0.0363
Trans
Sensor 06
0.0495
Trans
Sensor 07
0.0297
Trans
Sensor 14
-0.0299
Trans
Sensor 15
0.043
Trans
Sensor 16
-0.0035
Trans
Sensor 18
-0.8164
Trans
Sensor 26


Prediction Profiler
Optimization and Desirability
Assess Variable Importance
Save Bagged Predictions
Simulator
Design Space Profiler
Interaction Profiler
Confidence Intervals
Sensitivity Indicator
Independent Uniform Inputs
Independent Resampled Inputs
Dependent Resampled Inputs
Linearly Constrained Inputs
Calculates the indices that are used in the Assess Variable Importance option by resampling the data table assuming that the inputs are dependent.
-0.0363
0.0495
0.0297
-0.0035
-0.8164
Trans Sensor 06
Trans Sensor 07
Trans Sensor 14
Sensor 15
Sensor 16
Trans Sensor 18
Trans Sensor 26

Binomial Lasso with Validation Column

Prediction Profiler

Variable Importance: Dependent Resampled Inputs

Summary Report

Column	Main Effect	Total Effect	.2 .4 .6 .8
Trans Sensor 18	0.053	0.175	
Trans Sensor 27	0.035	0.077	
Trans Sensor 52	0.051	0.051	
Trans Sensor 61	0.051	0.051	
Trans Sensor 53	0.05	0.05	
Trans Sensor 26	0.041	0.041	
Trans Sensor 06	0.038	0.038	
Trans Sensor 07	0.037	0.037	
Trans Sensor 05	0.036	0.036	
Trans Sensor 14	0.034	0.034	
Trans Sensor 16	0.03	0.03	
Trans Sensor 15	0.029	0.029	

Rsq=.9

Rsq=.8

Binomial Lasso with Validation Column

Prediction Profiler

Variable Importance: Dependent Resampled Inputs

Summary Report

Column	Main Effect	Total Effect
Trans Sensor 18	0.053	0.175
Trans Sensor 27	0.035	0.077
Trans Sensor 52	0.051	0.051
Trans Sensor 61	0.051	0.051
Trans Sensor 53	0.05	0.05
Trans Sensor 26	0.041	0.041
Trans Sensor 06	0.038	0.038
Trans Sensor 07	0.037	0.037
Trans Sensor 05	0.036	0.036
Trans Sensor 14	0.034	0.034
Trans Sensor 16	0.03	0.03
Trans Sensor 15	0.029	0.029

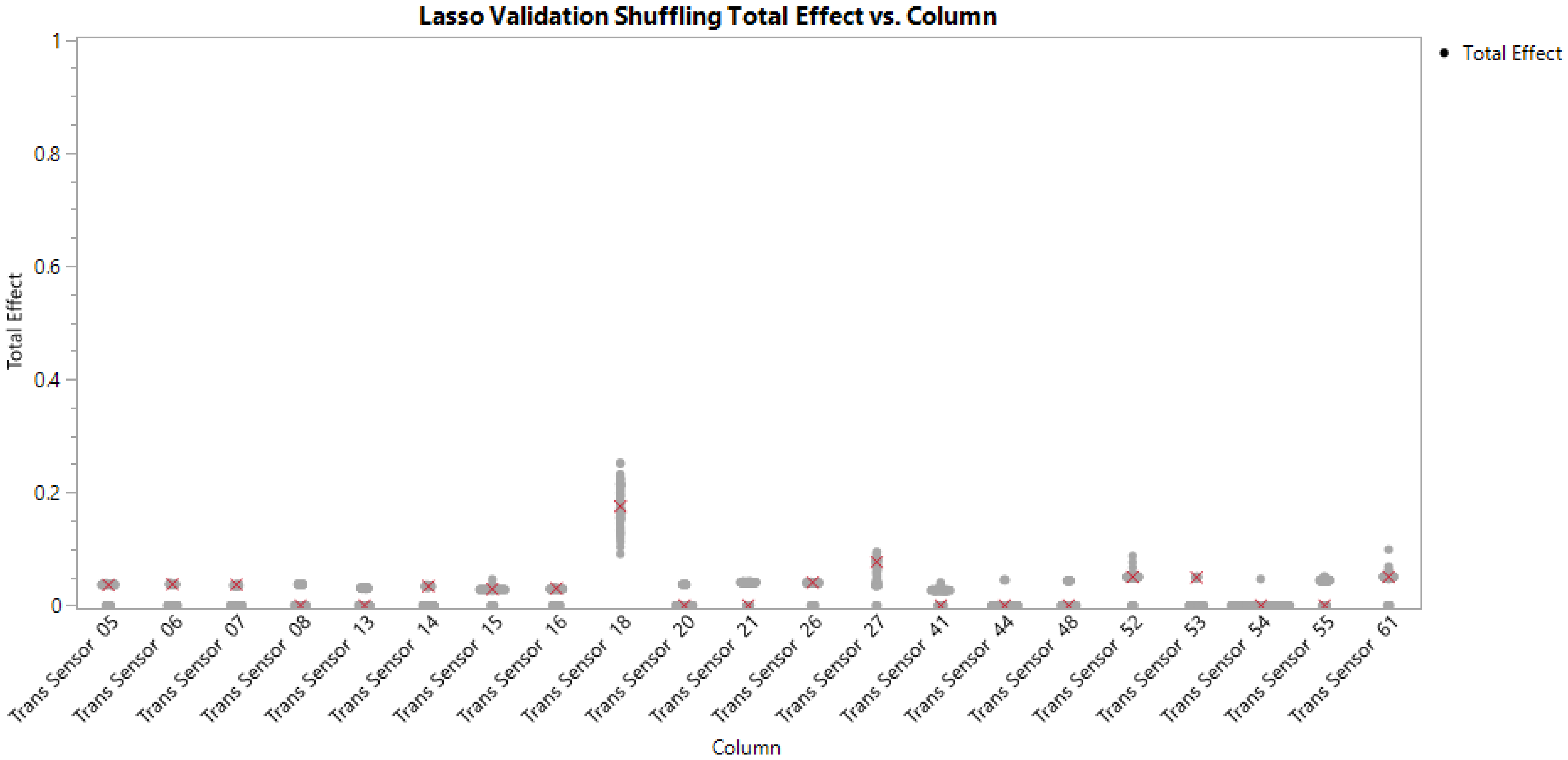
Bootstrap Forest for status

Column Contributions

Term	Number of Splits	G^2	Portion
sensor18	579	54.9167342	0.5024
sensor61	198	18.7389273	0.1714
sensor52	145	13.1320295	0.1201
sensor53	56	5.26374221	0.0482
sensor44	33	2.53070023	0.0232
sensor48	42	2.45696551	0.0225
sensor46	31	2.08993095	0.0191
sensor11	114	1.34630042	0.0123
sensor54	12	1.01688952	0.0093
sensor58	111	0.73127415	0.0067
sensor07	61	0.68014104	0.0062
sensor26	89	0.5292647	0.0048
sensor12	40	0.51092374	0.0047
sensor50	8	0.41943383	0.0038
sensor57	75	0.3901658	0.0036
sensor01	44	0.35310066	0.0032
sensor05	47	0.3400086	0.0031
sensor21	8	0.30245908	0.0028

Rsq=.9

Rsq=.8



KPA Insights through analytics

jmp STATISTICAL DISCOVERY

“*How important are the inputs to a predictive model*”

Column Contributions

- What predictors explain the most ***response*** variation on the ***training data***?
- Partition-based models only
- Based on equivalent Least Sq model
- Includes residual error
- Robust and stable (random forests)
- Results will not change if columns monotonically transformed
- Good early step in modeling process

Variable Importance

- What predictors explain the most variation in *predictive model on the data or a region*?
- General: applies to all supervised models
- Based on Sobol (1990) sensitivity analysis
- Model variation based, not residual error
- Very sensitive to model over/under fit
- Results change unpredictably if columns are transformed
- Descriptive tool at the end of the modeling process

KPA
Insights through analytics

jmp STATISTICAL DISCOVERY

“What are the groups of related columns?”

“How representative are each column to its group?”

Variable Clustering

- Unsupervised method
- Based on recursive partitioning of columns guided by PCA/Factor Analysis of groups
- Reference: PROC VARCLUS documentation
- Only seeks linear relationships among columns
- Sensitive to outliers
- Useful in the early stages of data exploration

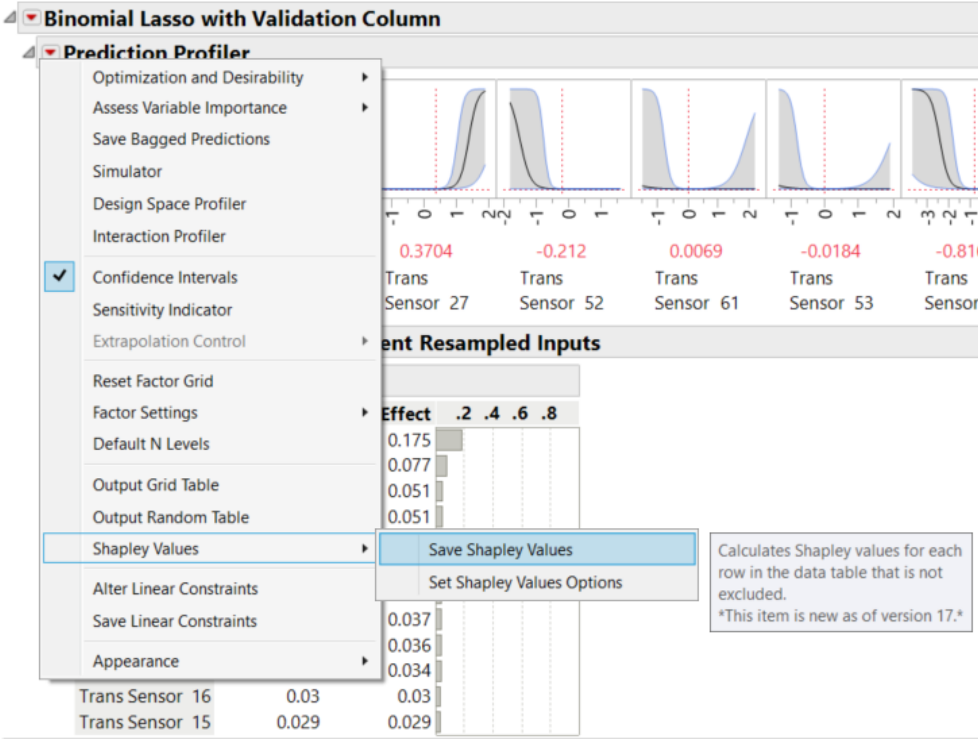
KPA Insights through analytics

jmp STATISTICAL DISCOVERY

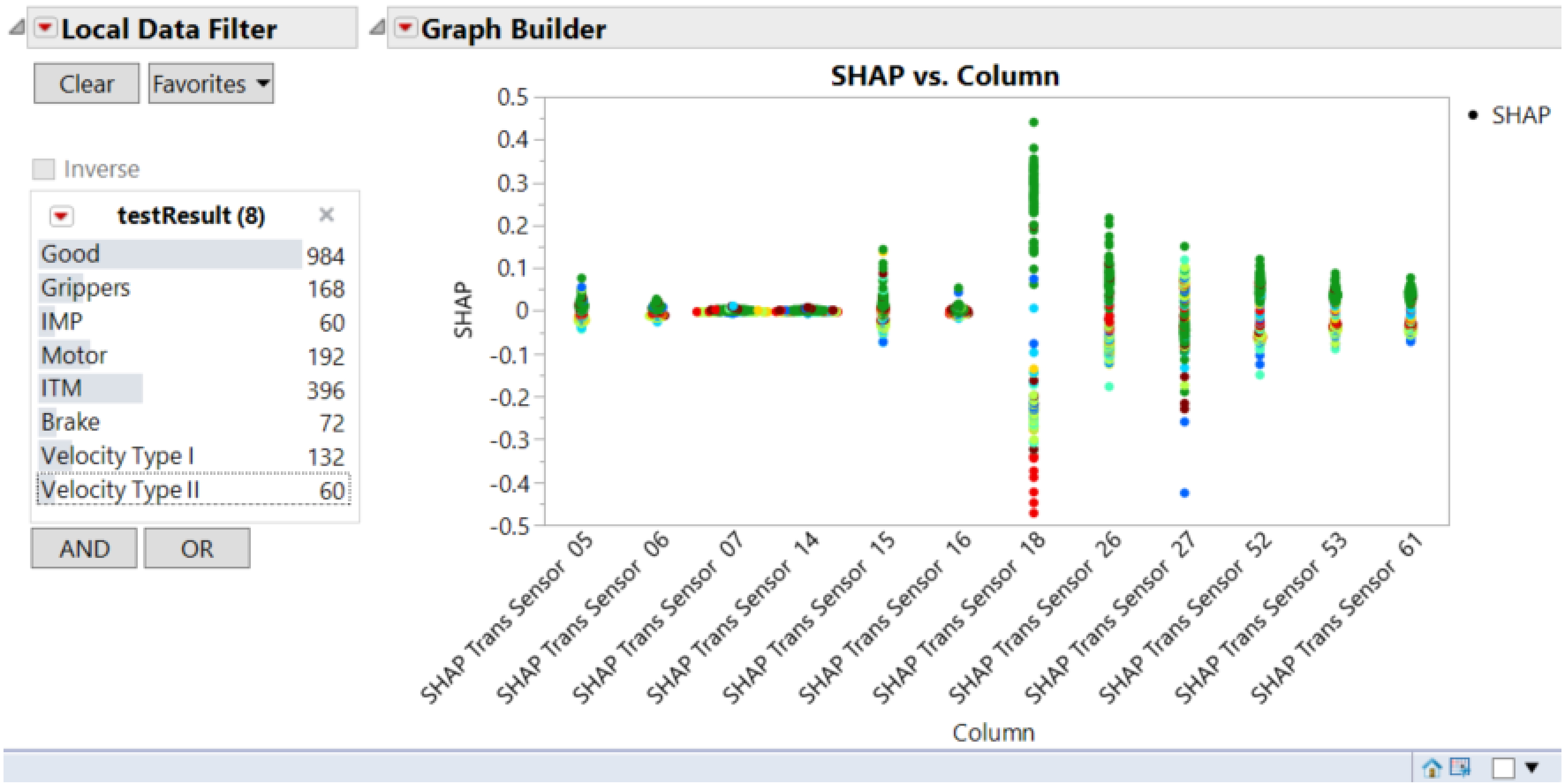
“How did each input column contribute to this model’s prediction at a particular value of X?”

Shapley (SHAP) Values

- Additive decomposition of a single predicted value that can be anywhere (not just data used for fitting the model)
- $\hat{f}(x_1 x_2 \dots) = SHAP_{Intercept} + SHAP_{\hat{f},1}(x_{1,}) + SHAP_{\hat{f},1}(x_2) + \cdots$
- General: applies to all supervised models
- Based on Shapley (1951) – resulted in 2012 Nobel
- Model variation based, not residual error
- Very sensitive to model over/under fit
- Results change unpredictably if columns are transformed
- Descriptive tool at the end of the modeling process


Binomial Lasso with Validation Column
Prediction Profiler
Optimization and Desirability
Assess Variable Importance
Save Bagged Predictions
Simulator
Design Space Profiler
Interaction Profiler
Confidence Intervals
Sensitivity Indicator
Extrapolation Control
Reset Factor Grid
Factor Settings
Default N Levels
Output Grid Table
Output Random Table
Shapley Values
Alter Linear Constraints
Save Linear Constraints
Appearance
Save Shapley Values
Set Shapley Values Options
Calculates Shapley values for each row in the data table that is not excluded.
This item is new as of version 17.
0.3704
Trans Sensor 27
-0.212
Trans Sensor 52
0.0069
Trans Sensor 61
-0.0184
Trans Sensor 53
-0.8164
Trans Sensor 26
ent Resampled Inputs
Effect
.2 .4 .6 .8
0.175
0.077
0.051
0.051
0.037
0.036
0.034
Trans Sensor 16
0.03
0.03
Trans Sensor 15
0.029
0.029

SHAP Trans Sensor 05	SHAP Trans Sensor 06	SHAP Trans Sensor 07	SHAP Trans Sensor 14	SHAP Trans Sensor 15	SHAP Trans Sensor 16	SHAP Trans Sensor 18	SHAP Trans Sensor 26	SHAP Trans Sensor 27	SHAP Trans Sensor 52	SHAP Trans Sensor 53	SHAP Trans Sensor 61	SHAP Intercept	SHAP Trans Sensor 05+SHAP Trans Sensor 06+SHAP T...ns Sensor 53+SHAP Trans Sensor 61+SHAP Intercept	Probability(status=Pass)
-0.01...	-0.00...	0.000...	0.000...	0.073...	-0.00...	0.138...	0.038...	0.019...	0.103...	0.078...	0.050...	0.480...	0.9646941837	0.9646941837
0.016...	0.007...	0.001...	0.002...	0.019...	0.006...	0.333...	0.052...	-0.05...	0.060...	0.037...	0.037...	0.480...	0.999999949	0.999999949
0.001...	0.006...	0.001...	0.002...	-0.01...	-0.00...	0.255...	0.104...	-0.08...	0.082...	0.068...	0.060...	0.480...	0.9669140606	0.9669140606


Local Data Filter
Clear
Favorites
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column

Local Data Filter

Clear | Favorites

984 matching rows

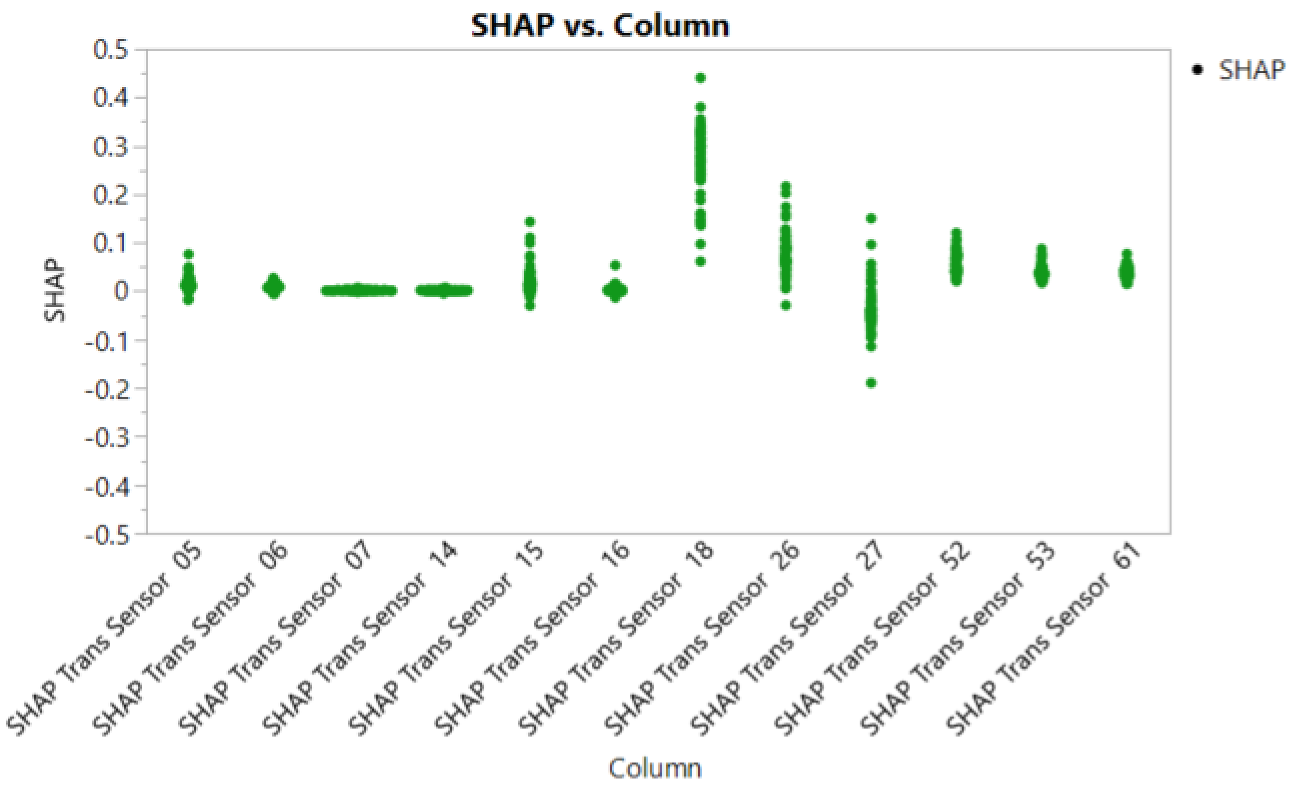
☐ Inverse

testResult (8)

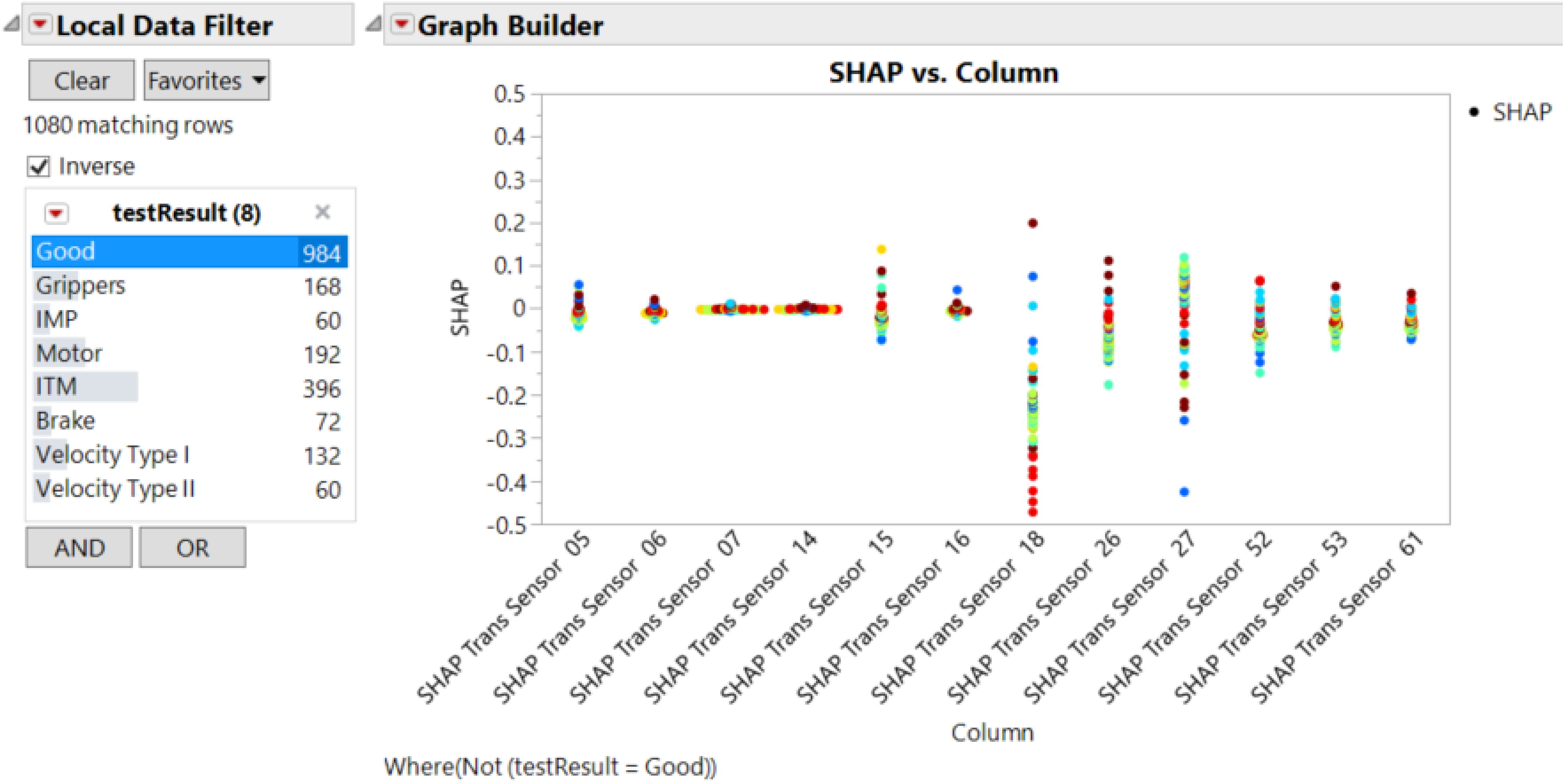
Good	984
Grippers	168
IMP	60
Motor	192
ITM	396
Brake	72
Velocity Type I	132
Velocity Type II	60

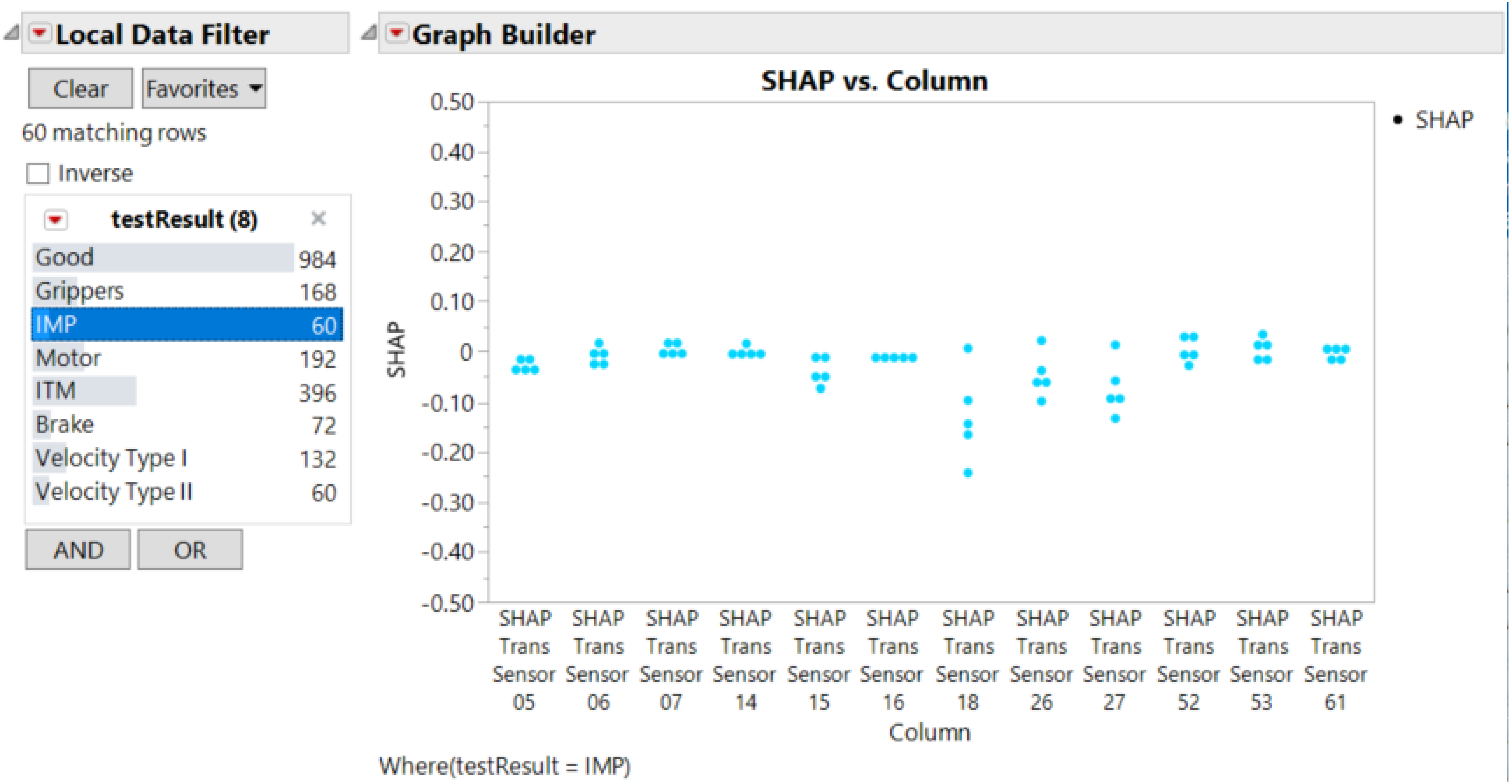
AND | OR

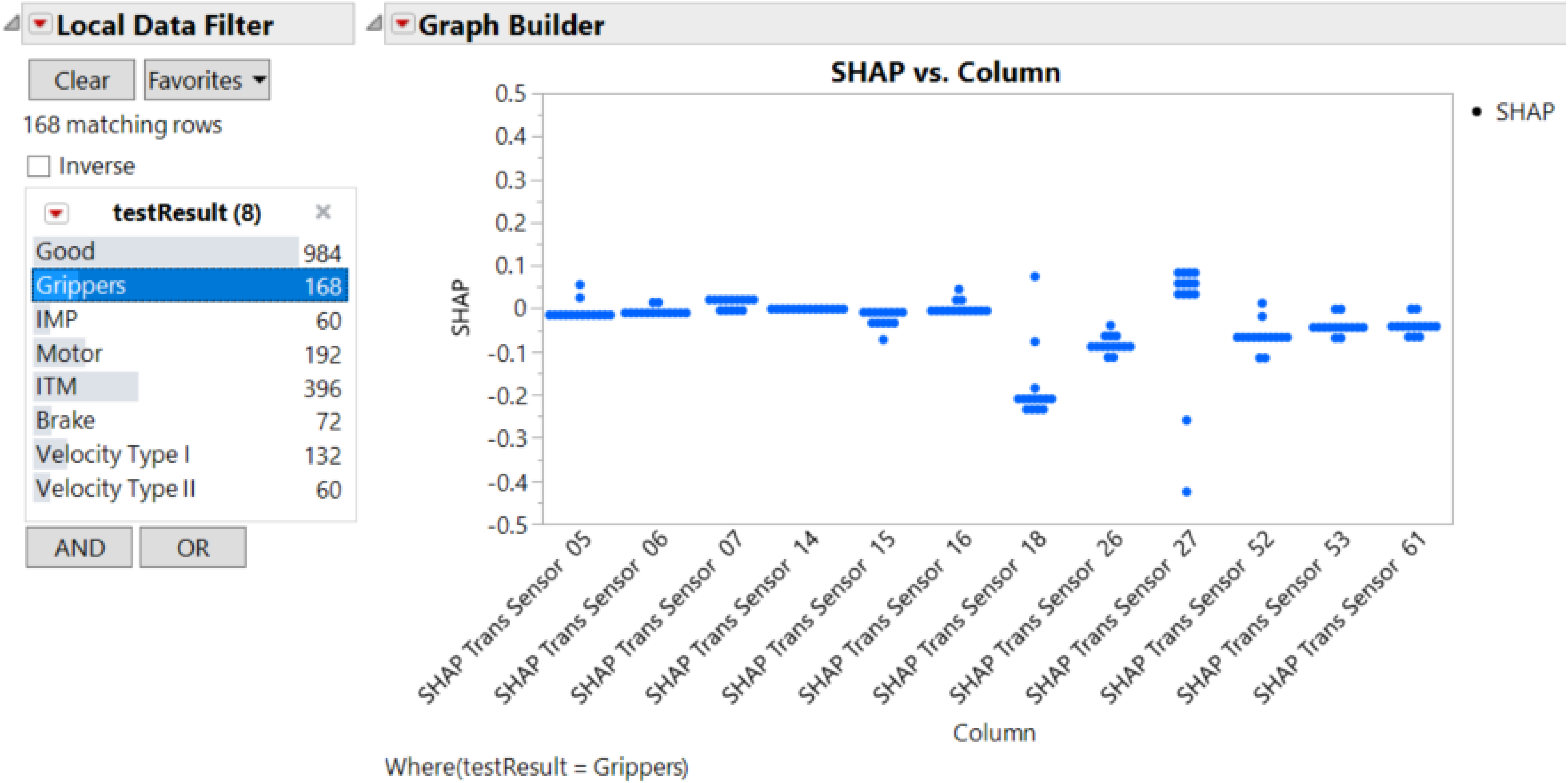
Graph Builder

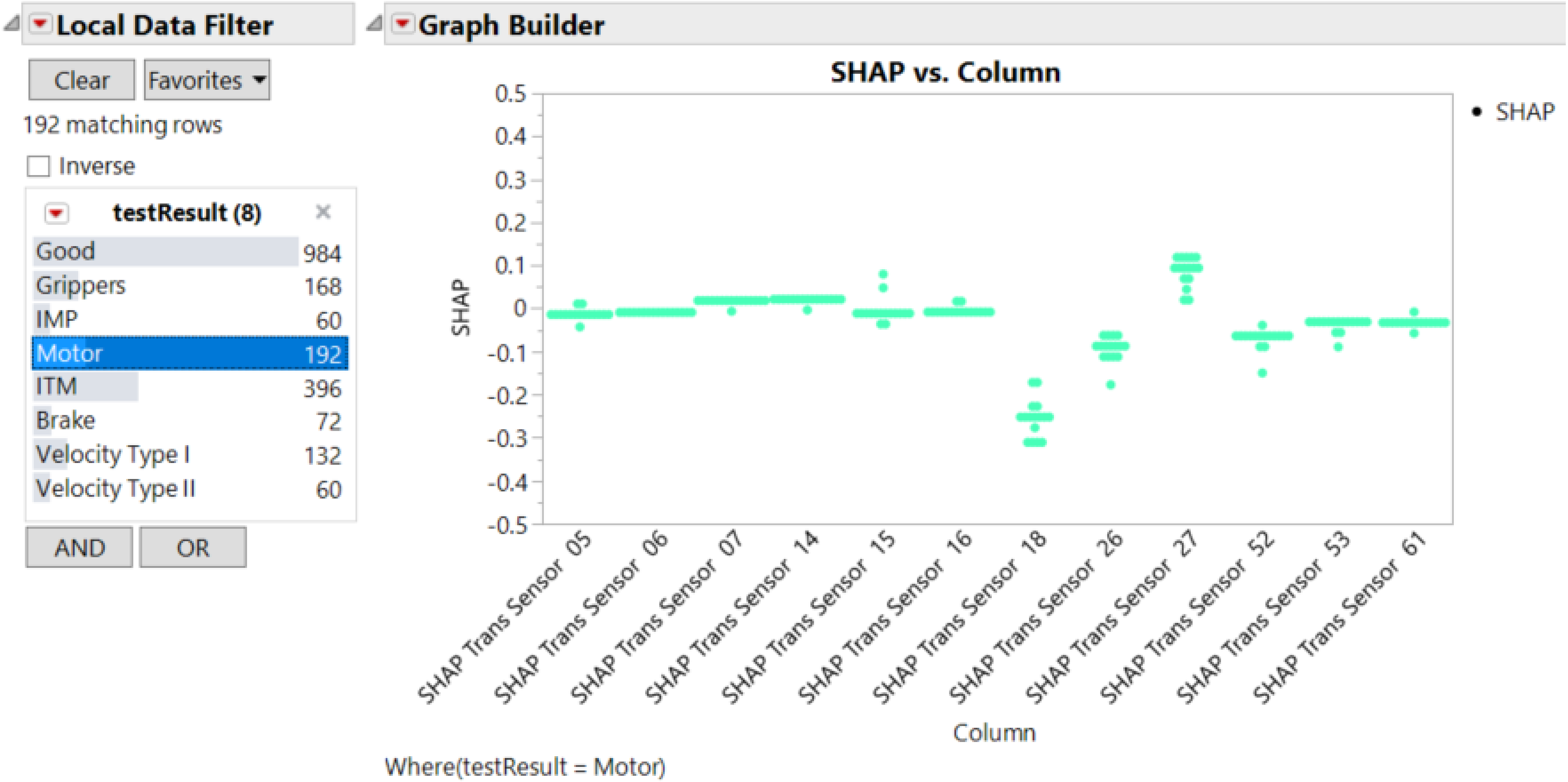


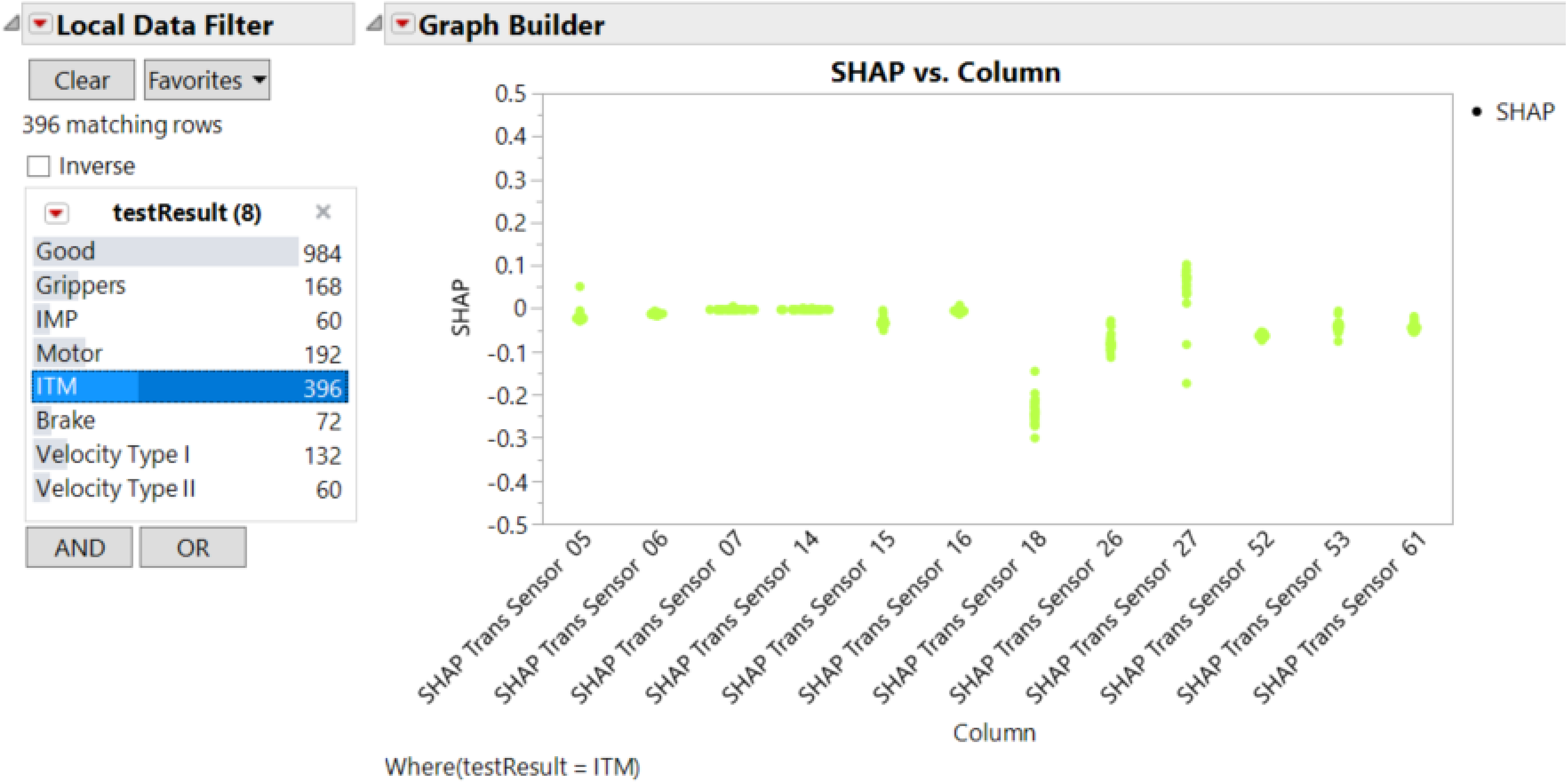
Where(testResult = Good)

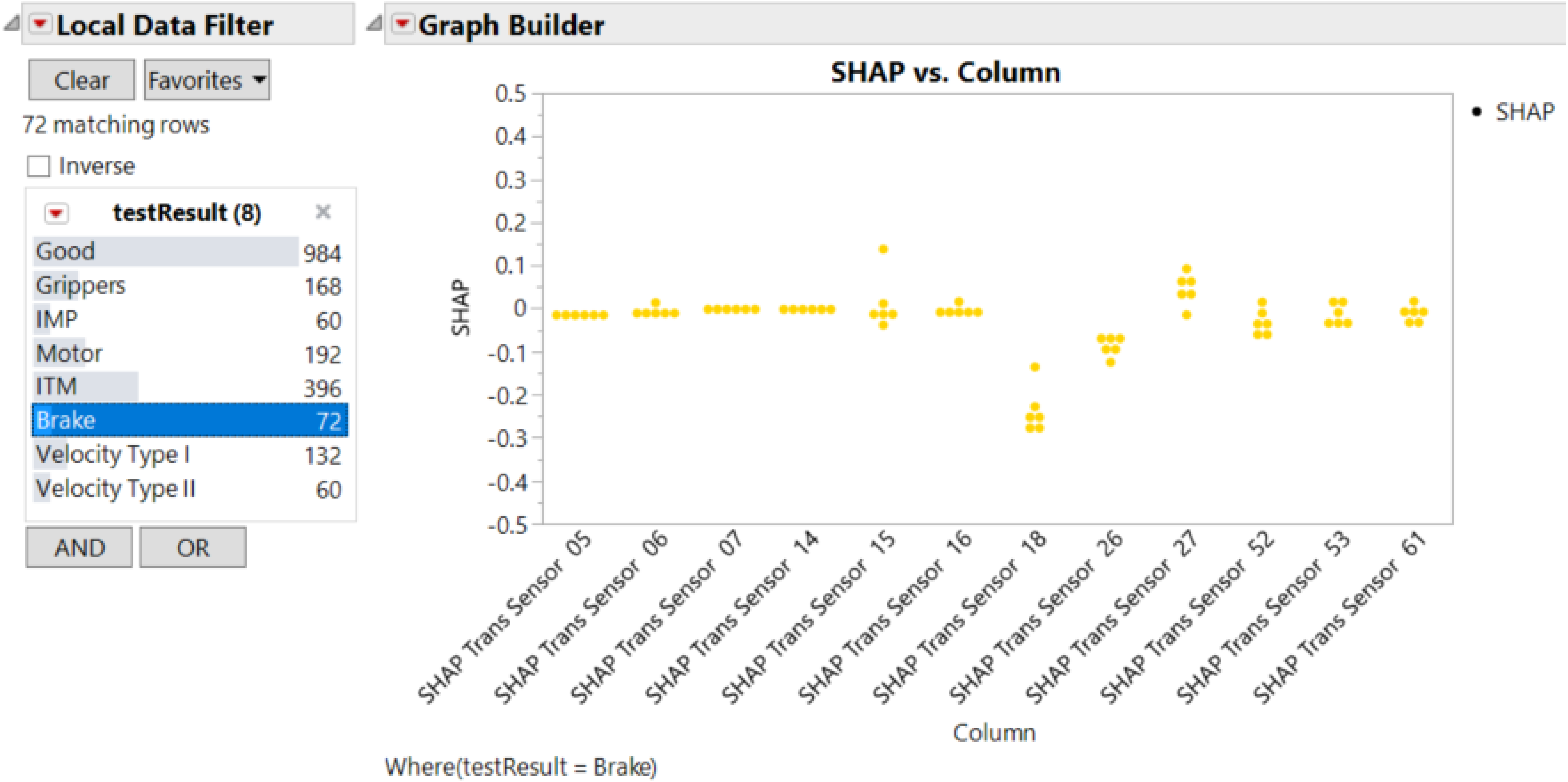

Local Data Filter
Clear
Favorites
1080 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(Not (testResult = Good))


Local Data Filter
Clear
Favorites
60 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.50
0.40
0.30
0.20
0.10
0
-0.10
-0.20
-0.30
-0.40
-0.50
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(testResult = IMP)


Local Data Filter
Clear
Favorites
168 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(testResult = Grippers)


Local Data Filter
Clear
Favorites
192 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(testResult = Motor)


Local Data Filter
Clear
Favorites
396 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(testResult = ITM)


Local Data Filter
Clear
Favorites
72 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(testResult = Brake)

Local Data Filter

Clear | Favorites

132 matching rows

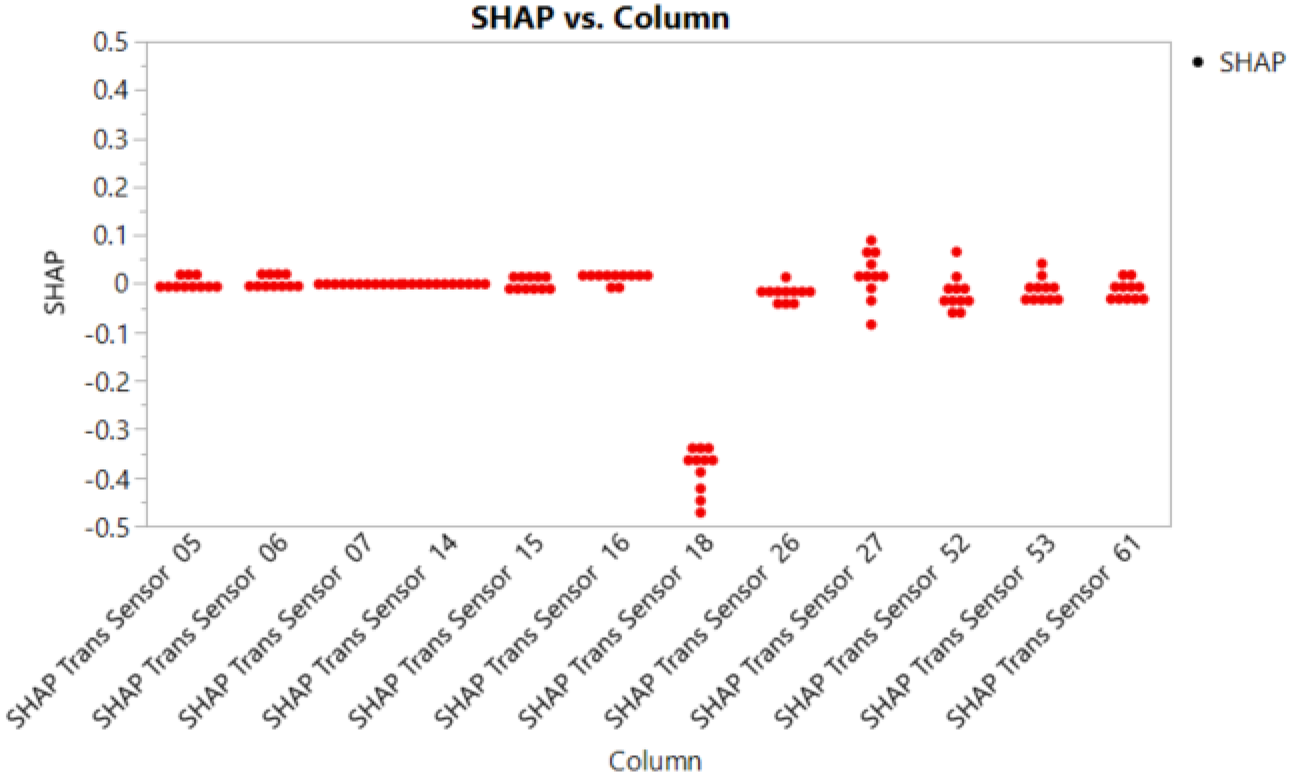
☐ Inverse

testResult (8)

Good	984
Grippers	168
IMP	60
Motor	192
ITM	396
Brake	72
Velocity Type I	132
Velocity Type II	60

AND | OR

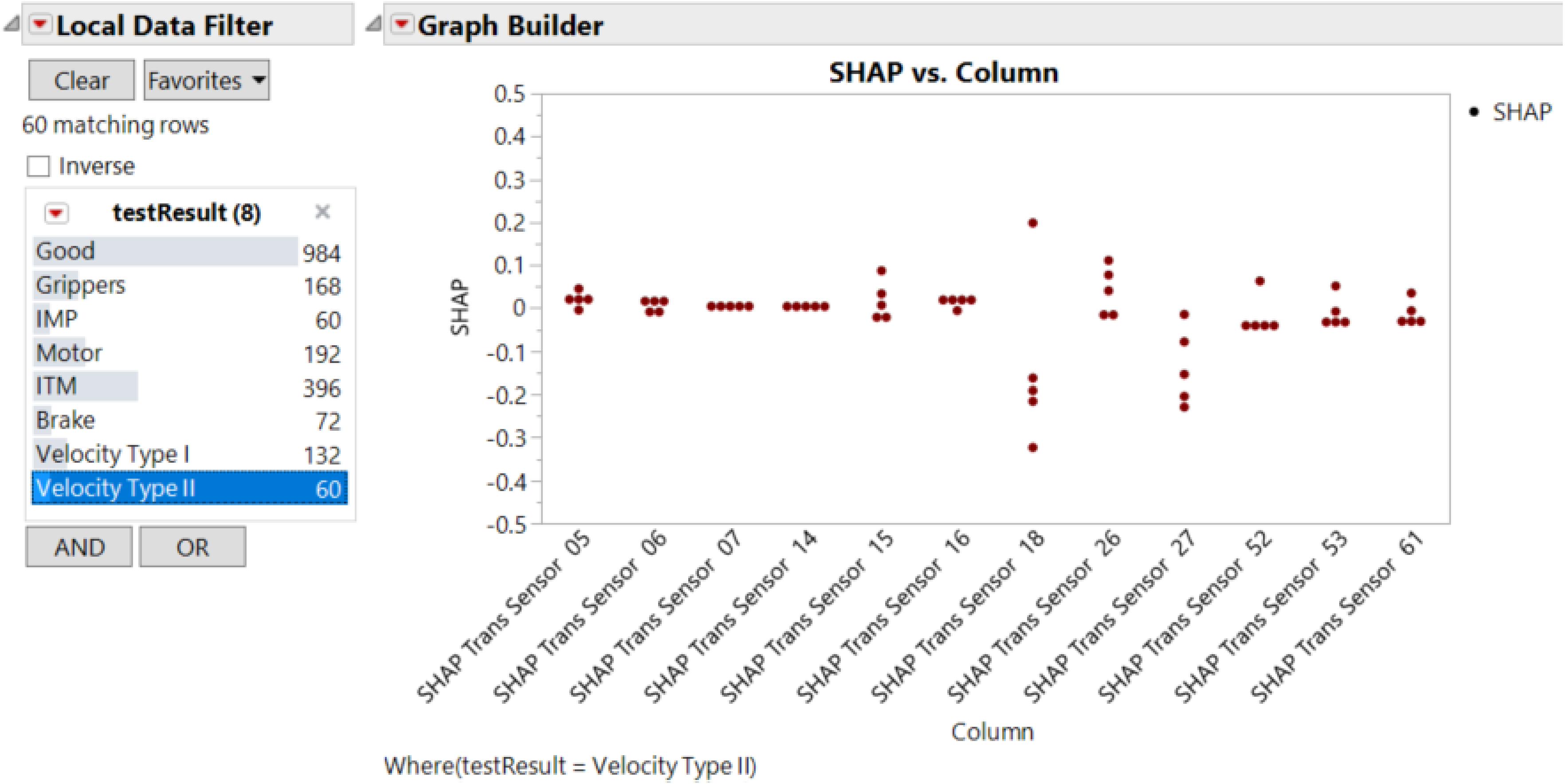
Graph Builder



Where(testResult = Velocity Type I)

KPA Insights through analytics

jmp STATISTICAL DISCOVERY



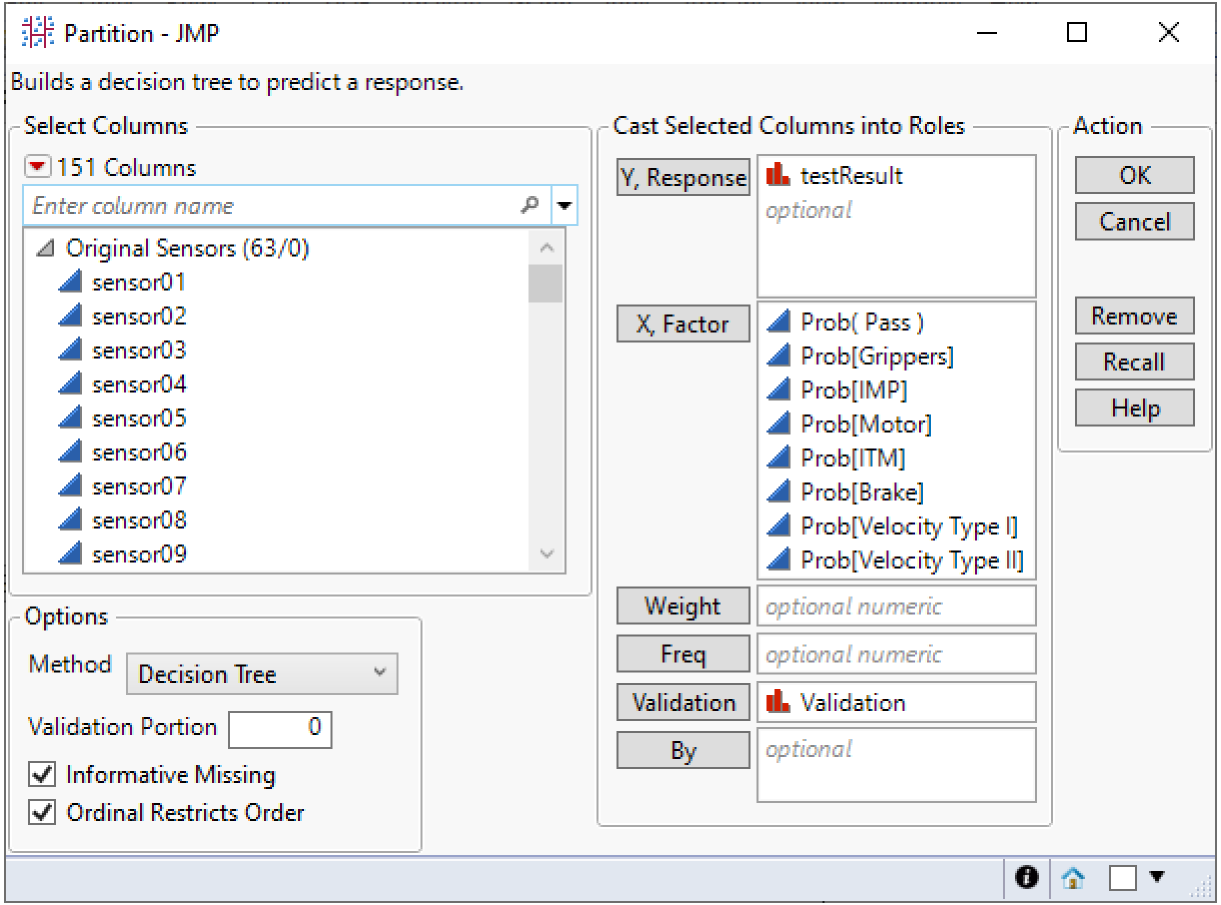
Local Data Filter
Clear
Favorites
60 matching rows
Inverse
testResult (8)
Good 984
Grippers 168
IMP 60
Motor 192
ITM 396
Brake 72
Velocity Type I 132
Velocity Type II 60
AND
OR
Graph Builder
SHAP vs. Column
SHAP
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
SHAP Trans Sensor 05
SHAP Trans Sensor 06
SHAP Trans Sensor 07
SHAP Trans Sensor 14
SHAP Trans Sensor 15
SHAP Trans Sensor 16
SHAP Trans Sensor 18
SHAP Trans Sensor 26
SHAP Trans Sensor 27
SHAP Trans Sensor 52
SHAP Trans Sensor 53
SHAP Trans Sensor 61
Column
Where(testResult = Velocity Type II)

Generalized Regression for testResult

Model Comparison

Show	Response Distribution	Estimation Method	Validation Method	Nonzero Parameters	AICc	BIC	Generalized RSquare	Validation Generalized RSquare
☑	Multinomial	Maximum Likelihood	Validation Column	156	.	655.93721	0.999997	-43.17824
☑	Multinomial	Lasso	Validation Column	60	1346.9128	259.19431	0.995714	0.9396993
☑	Multinomial	Elastic Net	Validation Column	64	4304.7032	285.80357	0.988835	0.9282288
☑	Multinomial	Ridge	Validation Column	156	.	682.86499	0.9804884	0.8778949

- Exclude all the “Pass” rows to focus on the failures
- Same Cluster 1 columns used in the Pass model

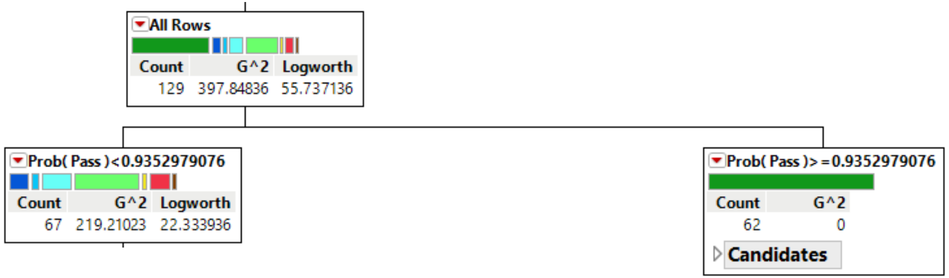

Partition - JMP
Builds a decision tree to predict a response.
Select Columns
151 Columns
Enter column name
Original Sensors (63/0)
sensor01
sensor02
sensor03
sensor04
sensor05
sensor06
sensor07
sensor08
sensor09
Cast Selected Columns into Roles
Y, Response
testResult
optional
X, Factor
Prob(Pass)
Prob[Grippers]
Prob[IMP]
Prob[Motor]
Prob[ITM]
Prob[Brake]
Prob[Velocity Type I]
Prob[Velocity Type II]
Weight
optional numeric
Freq
optional numeric
Validation
Validation
By
optional
Action
OK
Cancel
Remove
Recall
Help
Options
Method
Decision Tree
Validation Portion
0
Informative Missing
Ordinal Restricts Order

All Rows

Count	G^2	Logworth
129	397.84836	55.737136

testResult

- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II

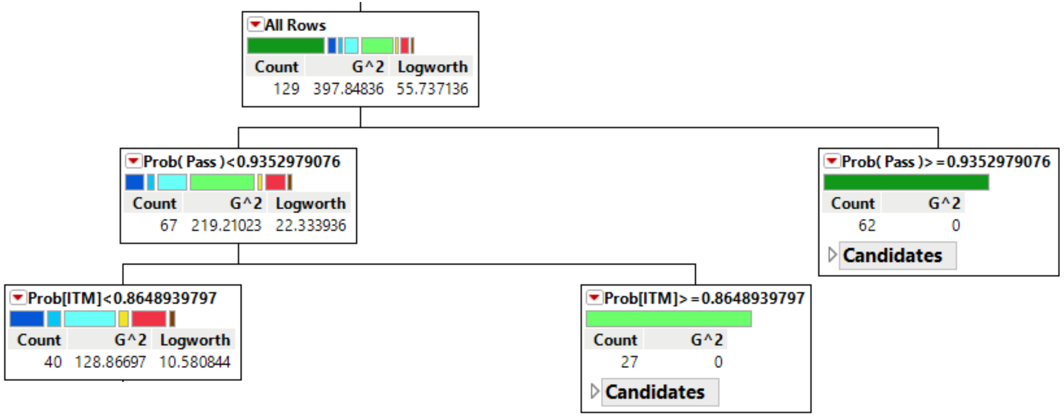


testResult

- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II

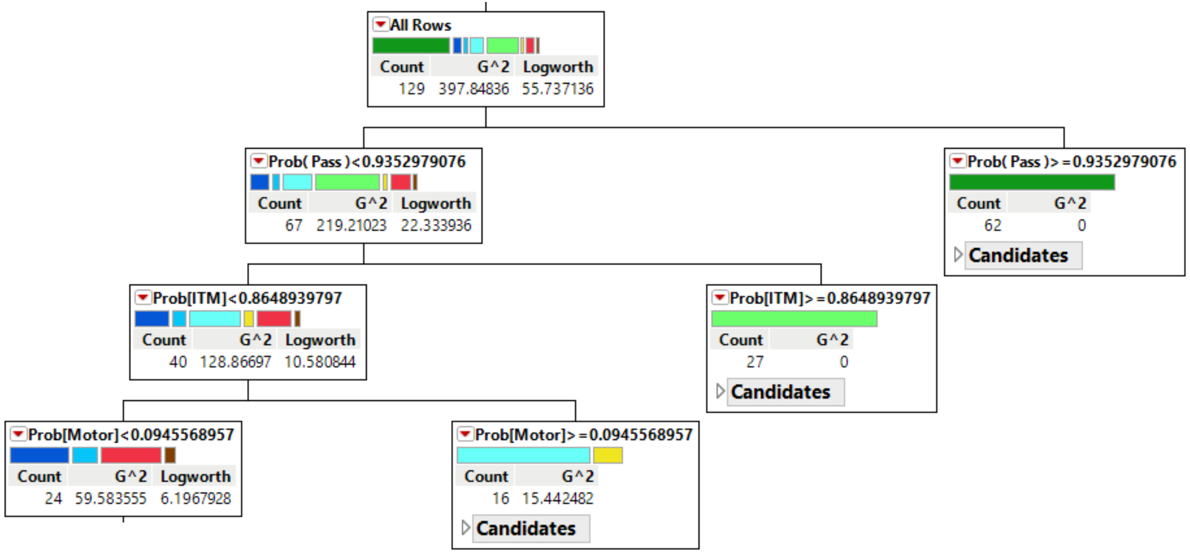
testResult

- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II



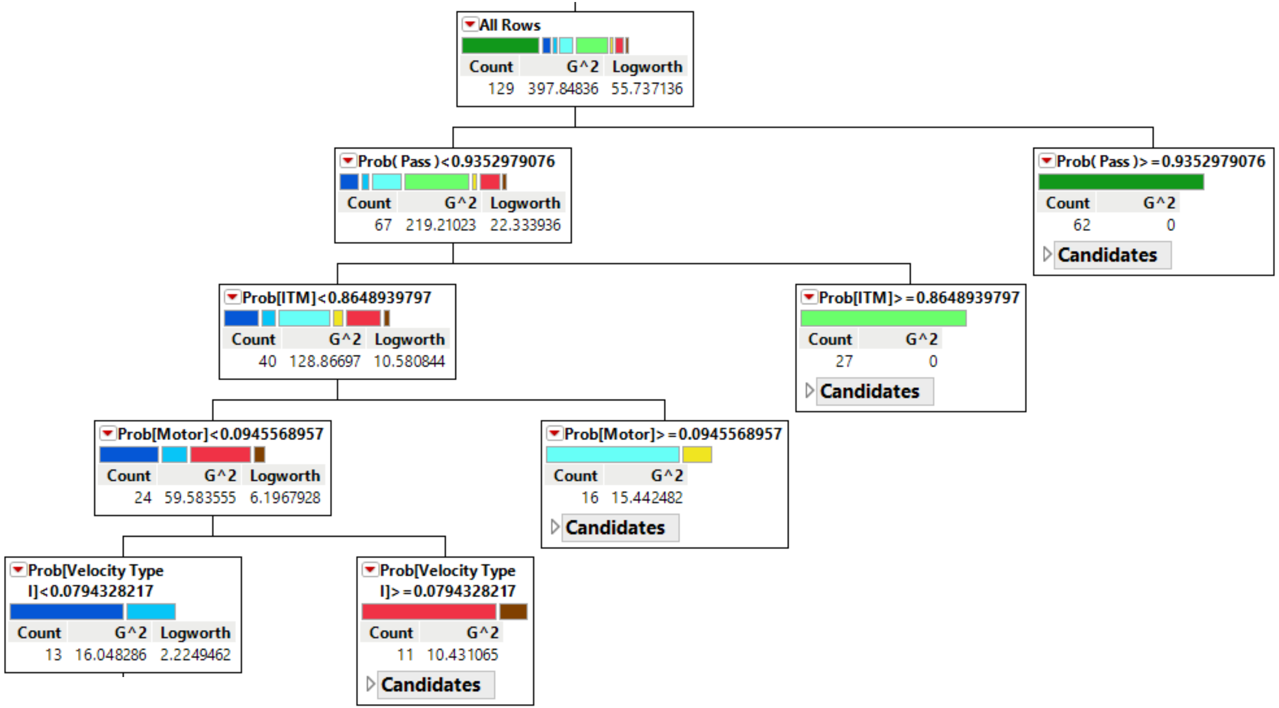
testResult

- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II



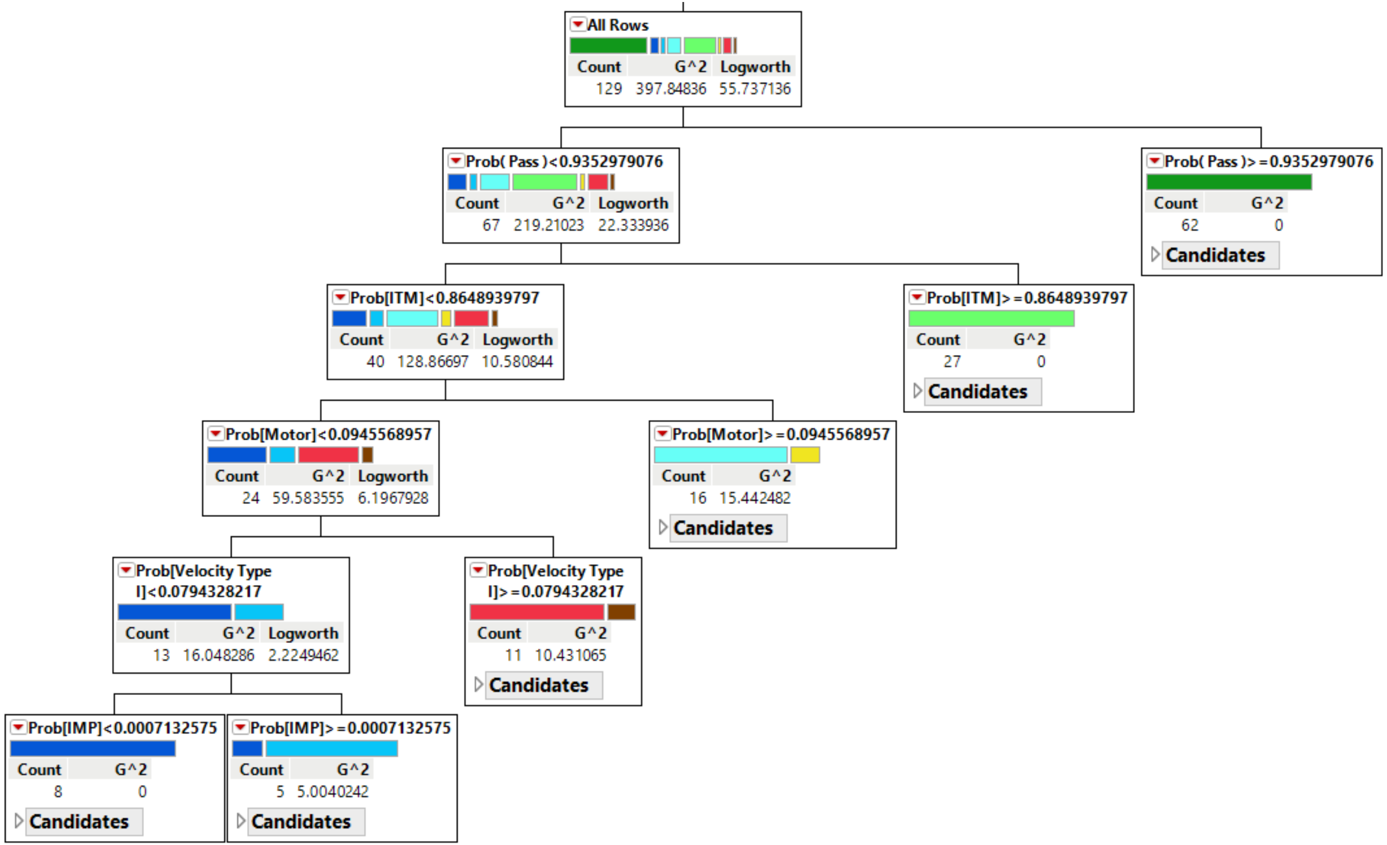
testResult

- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II



testResult

- Good
- Grippers
- IMP
- Motor
- ITM
- Brake
- SOS
- Velocity Type I
- Velocity Type II



Actual By Predicted Category on Training

testResult

Leaf Label Formula / Count	Good	Grippers	IMP	Motor	ITM	Brake	Velocity Type I	Velocity Type II
Predict Good	62	0	0	0	0	0	0	0
Predict Grippers or IMP	0	9	4	0	0	0	0	0
Predict ITM	0	0	0	0	27	0	0	0
Predict Motor or Brake	0	0	0	13	0	3	0	0
Predict Velocity Type I or II	0	0	0	0	0	0	9	2

Actual By Predicted Category on Validation

testResult

Leaf Label Formula / Count	Good	Grippers	IMP	Motor	ITM	Brake	Velocity Type I	Velocity Type II
Predict Good	18	0	0	0	0	0	0	1
Predict Grippers or IMP	2	5	1	0	0	1	0	2
Predict ITM	0	0	0	0	6	0	0	0
Predict Motor or Brake	0	0	0	3	0	2	0	0
Predict Velocity Type I or II	0	0	0	0	0	0	2	0

Thank you for your attention

KPA
Insights through analytics

jmp STATISTICAL DISCOVERY