



机器学习方法用于汽车行人保护开发

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16 January 2023

行人保护测试与评价方法

目前，世界各国现行的行人保护法规以及NCAP行人保护测试评价程序，都采用了EEVC (European Enhanced Vehicle-Safety Committee) WG10工作组提出的人体模块撞击测试方法，具体包括：

头部冲击模块(分为成人与儿童)与发动机罩和风挡玻璃的撞击

大腿冲击模块与发动机罩前端撞击

小腿冲击模块与前保险杠撞击



(a) 头部保护测试



(b) 大腿保护测试



(c) 小腿保护测试

头部冲击模块有成人和儿童之分，两者结构基本一致，由半球形金属块覆盖橡胶“皮肤”构成，重量分别为4.5kg和3.5kg，直径均为165mm。球心位置安装加速度传感器，传感器输出头部X,Y,Z三个方向的加速度，通过合成加速度可以计算头部撞击时的HIC15伤害值，HIC15计算公式

$$HIC = \max \left\{ (t_2 - t_1) \left[\frac{\int_{t_1}^{t_2} a dt}{(t_2 - t_1)} \right]^{2.5} \right\}$$

行人保护测试与评价方法

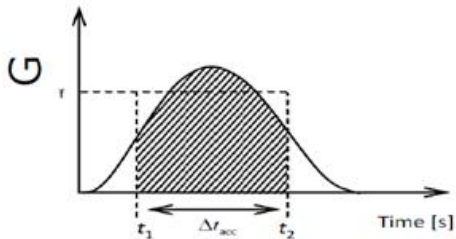
Head Injury Criterion

$$HIC = \left\{ \left(\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} G(t) dt \right)^{2.5} (t_2 - t_1) \right\}_{\max}$$

$t_2 - t_1 \leq 15 \text{ msec}$

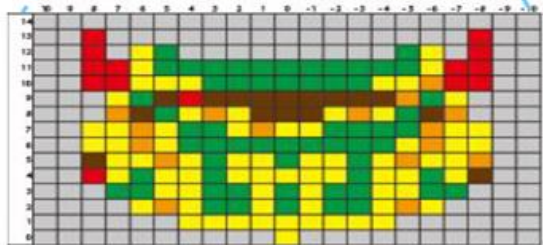
Skull fractures result from acceleration (G) and duration time (t)

A Review of Severity Index, SAE Technical Paper, 1971



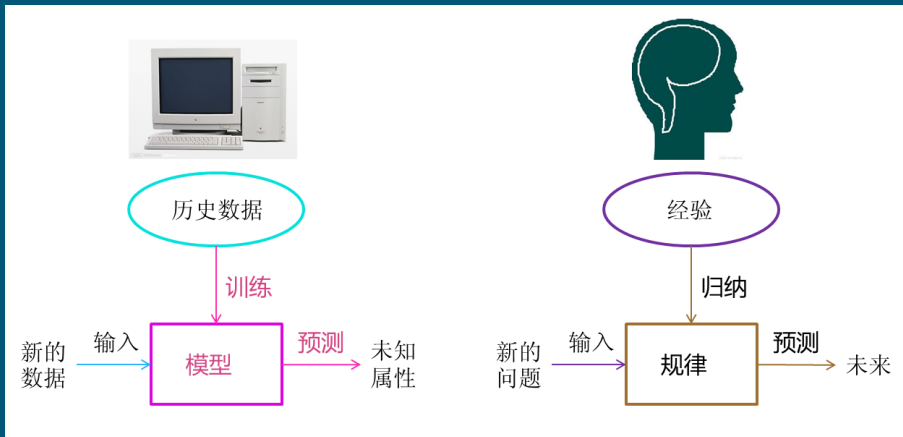
The HIC is calculated so that the waveform of “acceleration-time” is maximized within a maximum of 15 msec.

HIC increases if waveform keeps high acceleration



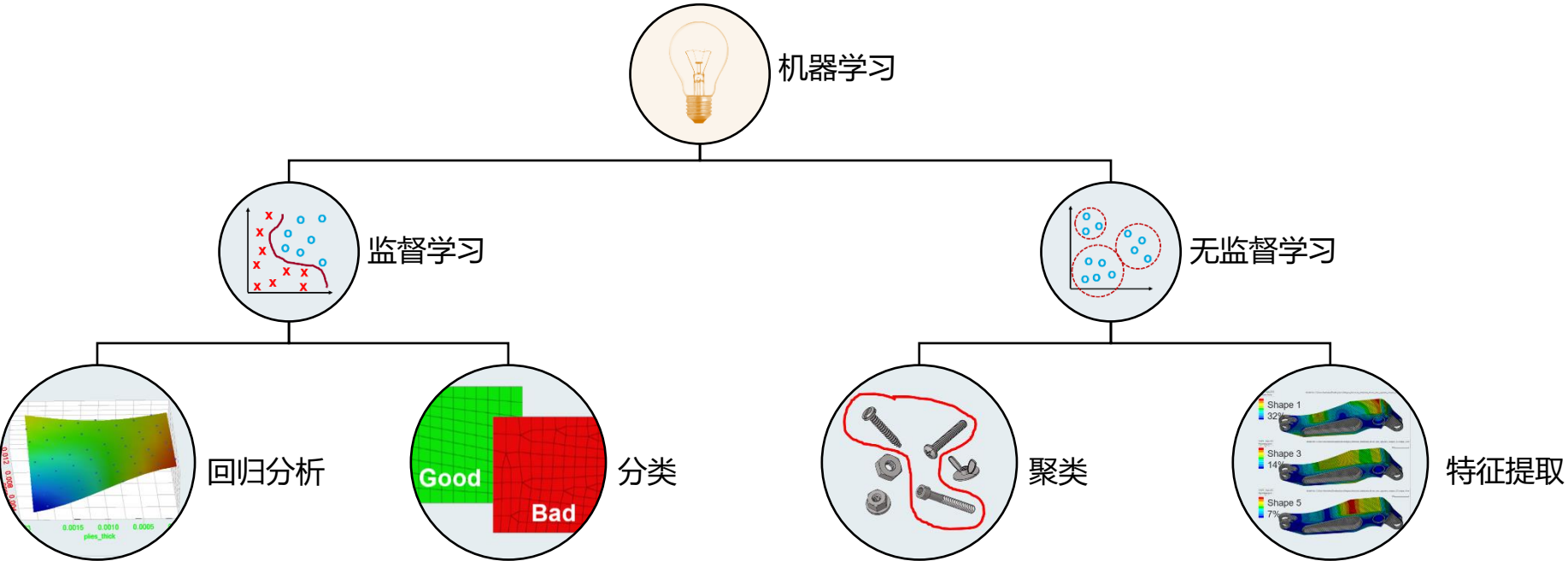
	Score	HIC
Green	1.00	HIC < 650
Yellow	0.75	650 ≤ HIC < 1000
Orange	0.50	1000 ≤ HIC < 1350
Brown	0.25	1350 ≤ HIC < 1700
Red	0.00	HIC ≥ 1700

机器学习



- 机器学习中的“训练”与“预测”过程可以对应到人类的“归纳”和“推测”过程。通过这样的对应，可以发现，机器学习的思想并不复杂，仅仅是对人类在生活中学习成长的一个模拟。
- 机器学习研究的是从数据中通过选取合适的算法，自动的归纳逻辑或规则，并根据这个归纳的模型（结果）对新数据来进行预测。
- 因此，机器学习不是基于编程形成的结果，而是通过归纳思想得出的相关性结论。

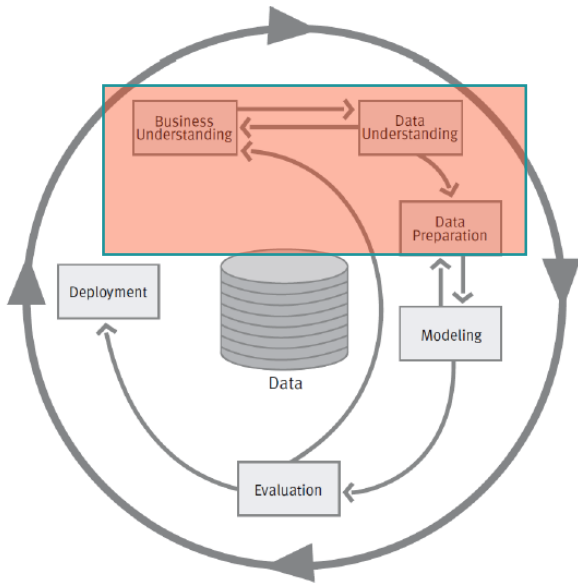
CAE中的机器学习技术



如何构建机器学习模型?

CRISP-DM

CROSS INDUSTRY STANDARD PROCESS FOR DATA MINING



如何描述/定义一个人?



性别	工作	偏好
年龄	学历	习惯
婚姻	收入	信用
家庭	资产	社交
...

机器学习最难之处:

- 8 如何把现实生产生活中的问题, 提炼成一个机器学习问题。这需要对问题本身的深刻理解。  ALTAIR

机器学习用于行人保护HIC预测

目标: Predict HIC value based on Historical Data Using Machine Learning Models.

Vehicle Parameters For Building Predictive Models:

- Impactor Parameters: Mass, Velocity
- Hood Parameters: Length, Width, Angle
- Hood Outer Thickness,
- Hood Inner Thickness
- Hood Outer Material Parameters: Yield Stress, Ultimate Stress, %Elongation
- Hood Inner Material Parameters: Yield Stress, Ultimate Stress, %Elongation
- **Clearance to Hood outer to hood inner for every impact point**
- **Clearance between Hood inner to hard point for that impact location.**
- Zonal Mass: Effective Hood stress wave circle radius:230 mm
- Cross Section Inertia Values Hood outer and Hood Inner(I_{xx} , I_{yy} , I_{xy})

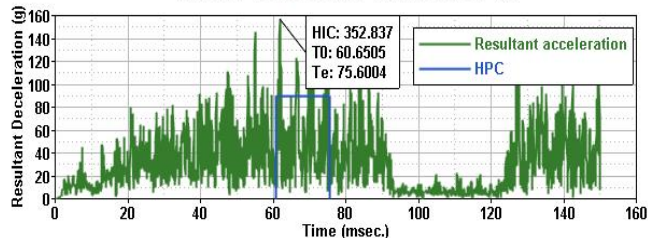
CAE Responses To Predict:

- 9• Head Injury Criteria (HIC) Value at each impact location

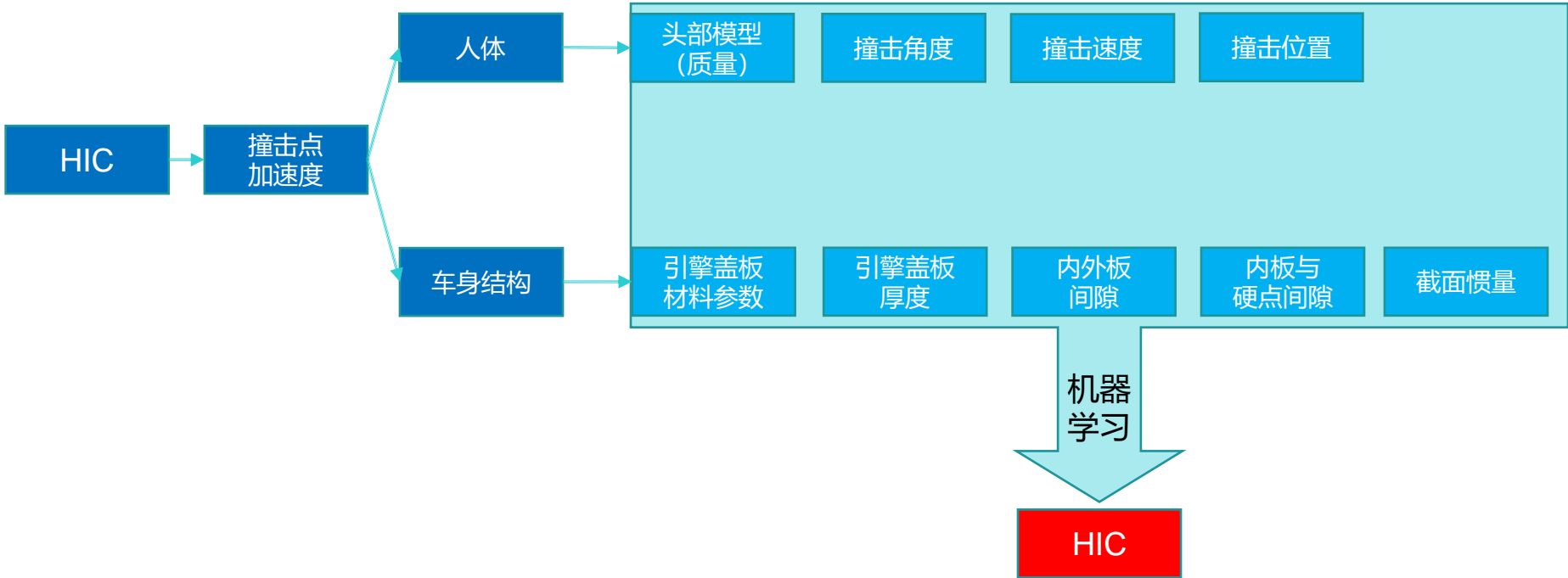
Pedestrian Impact



Head Performance Criteria (HPC)

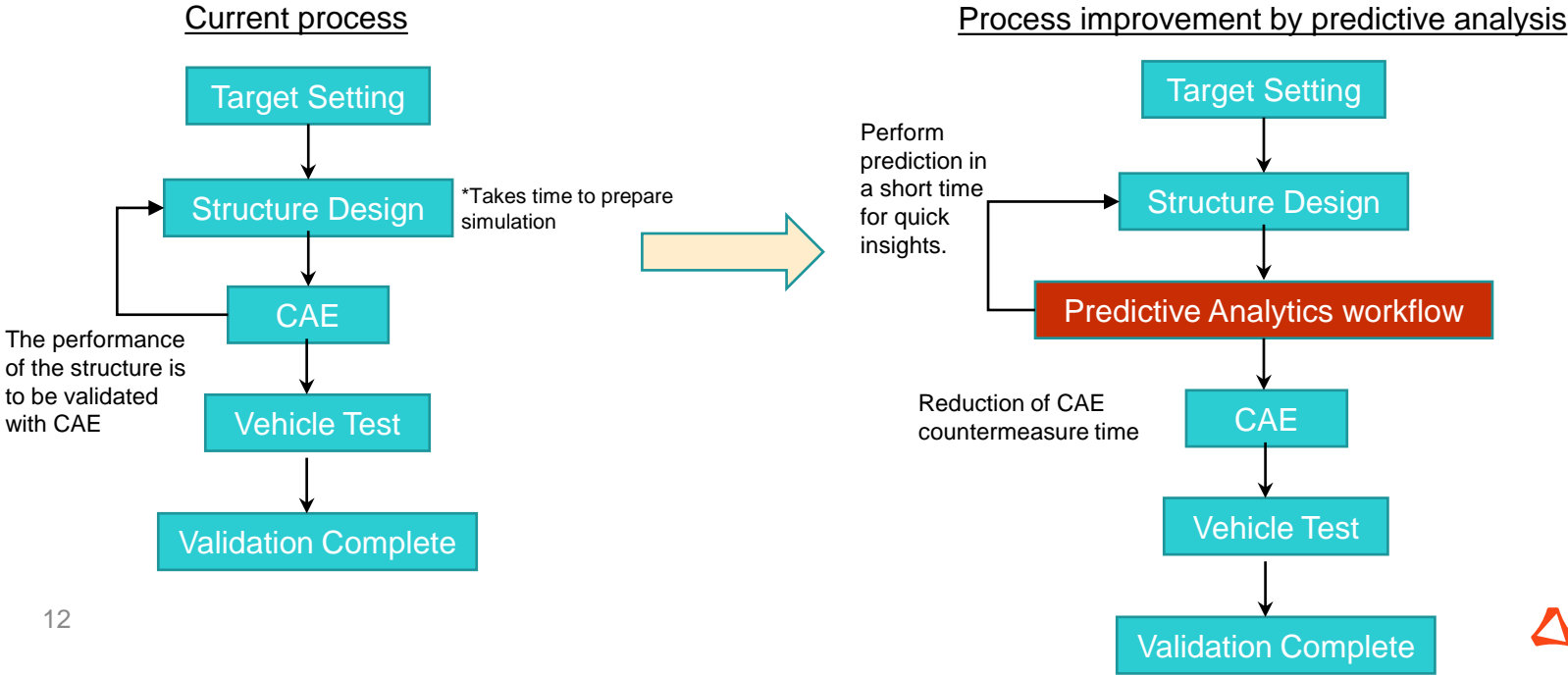


寻找问题的本质



开发流程

The goal of this solution is to reduce CAE safety process lead time by automating machine learning based predictive analytics workflow using HW and Knowledge Studio applications



HIC: Feature Extraction 特征提取



- Vehicle Parameters For Building Predictive Models**
- Impactor Parameters: Mass, Velocity
 - Hood Parameters: Length, Width, Angle
 - Hood Outer Thickness, Hood Inner Thickness
 - Hood Outer Material Parameters, Hood Inner Material Parameters:
 - Clearance to Hood outer to hood inner for every impact point
 - Clearance between Hood inner to hard point for that impact location.
 - Zonal Mass: Effective Hood stress wave circle radius 230 mm
 - Cross Section Inertia Values Hood outer and Hood Inner(I_{xx} , I_{yy} , I_{xy})
 - More....



Knowledge Studio 2021.3.0
File Edit View Tools Window Help

File: E:\proj\2021\ANM_Crash_Team\HIC\HICPred\HICPred\dataset_HIC

Showing 93 out of 93 records.

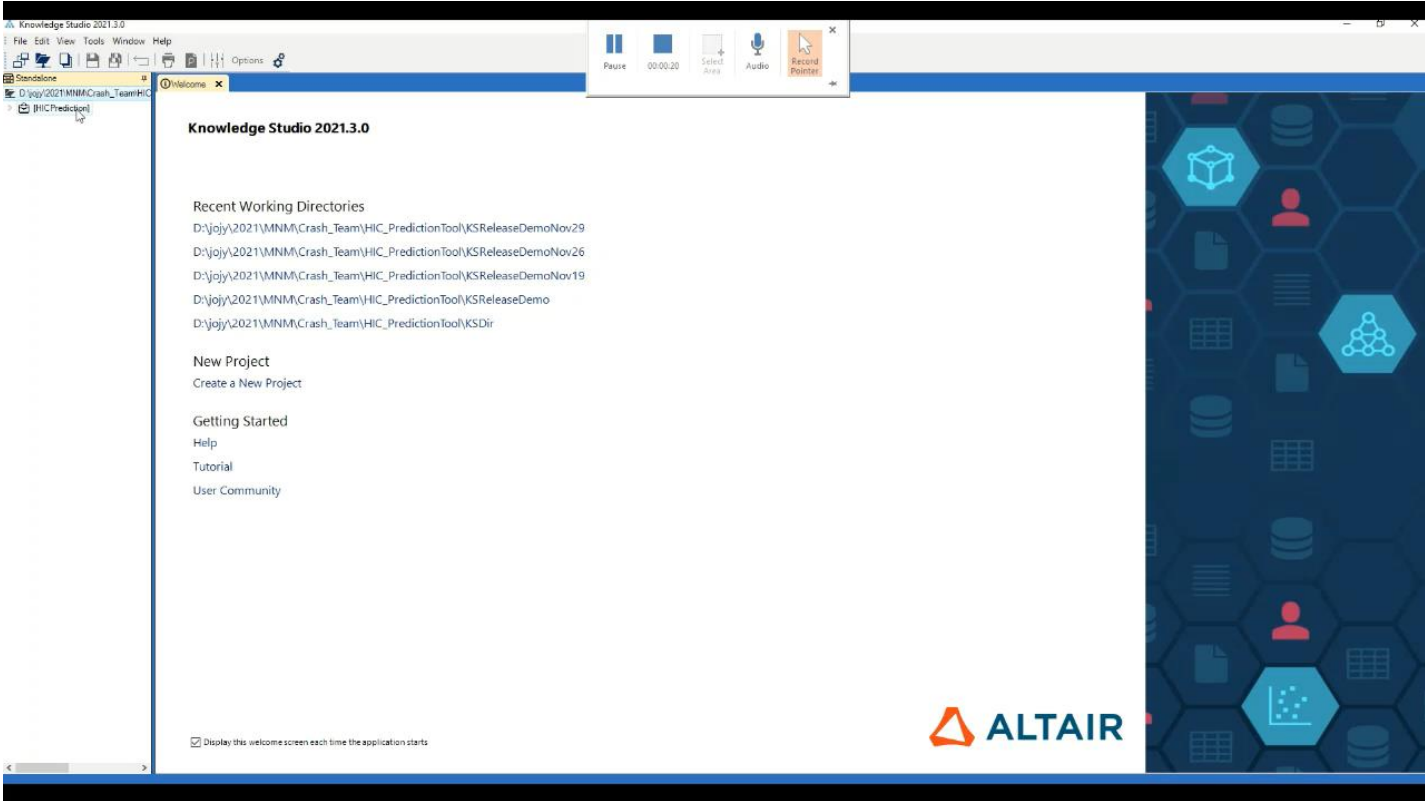
Impact Location	Impactor type	X	Y	Z	B1	B2	G1	G2	G3	W	L	HX	HZ	T1	T2	M1A	M1B	M1C	M2A	M2B
16 30125	cnhd	990	-500	1696	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
17 30127	cnhd	623.4	-593.2	1690	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
18 30129	cnhd	665.1	-475	1702	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
19 30301	cnhd	767.2	684.5	1719	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
20 30303	cnhd	721.6	602.5	1718	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
21 30305	cnhd	668.2	508.8	1715	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
22 30307	cnhd	666.1	409.8	1714	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
23 30309	cnhd	655.9	311.2	1714	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
24 30311	cnhd	636.6	212.2	1711	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
25 30313	cnhd	628	108.2	1715	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
26 30315	cnhd	628.6	0	1713	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
27 30317	cnhd	628	-109.2	1715	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
28 30319	cnhd	636.6	-212.2	1711	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
29 30321	cnhd	655.9	-311.2	1714	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
30 30323	cnhd	666.1	-409.8	1714	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
31 30325	cnhd	688.2	-508.8	1715	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
32 30327	cnhd	721.6	-602.5	1718	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
33 30329	cnhd	767.2	-684.5	1719	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
34 30501	cnhd	867.6	695.2	1734	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
35 30503	cnhd	821.2	605.4	1733	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
36 30505	cnhd	788.5	511.4	1730	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
37 30507	cnhd	768.8	412.4	1732	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
38 30509	cnhd	754.5	312.8	1731	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
39 30511	cnhd	737.8	211.8	1731	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
40 30513	cnhd	733	107.8	1732	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
41 30515	cnhd	732.5	0	1734	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
42 30517	cnhd	733	-107.8	1732	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
43 30519	cnhd	737.8	-211.8	1731	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
44 30521	cnhd	754.5	-312.8	1732	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
45 30523	cnhd	768.8	-412.4	1732	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
46 30525	cnhd	788.5	-511.4	1730	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
47 30527	cnhd	821.2	-605.4	1733	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
48 30529	cnhd	867.6	695.2	1734	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
49 30701	cnhd	694.2	699.4	1747	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
50 30703	cnhd	918.8	607.9	1747	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
51 30705	cnhd	887.7	513.8	1746	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
52 30707	cnhd	868.1	414.8	1749	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
53 30709	cnhd	853.6	313.2	1748	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
54 30711	cnhd	837.6	213.2	1748	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
55 30713	cnhd	826	108.2	1752	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5
56 30715	cnhd	831.6	0	1752	3.5	35	772.52	1575.23	5.99051622492023	1379.95825021608	601.119290204128	146.0341	97.06039999999999	0A	0A	1	2	3	4	5

Overview Report | Dataset Chart | Data | Segment Viewer | Cross Tabs | Characteristic Analysis | Correlations | Saved Charts

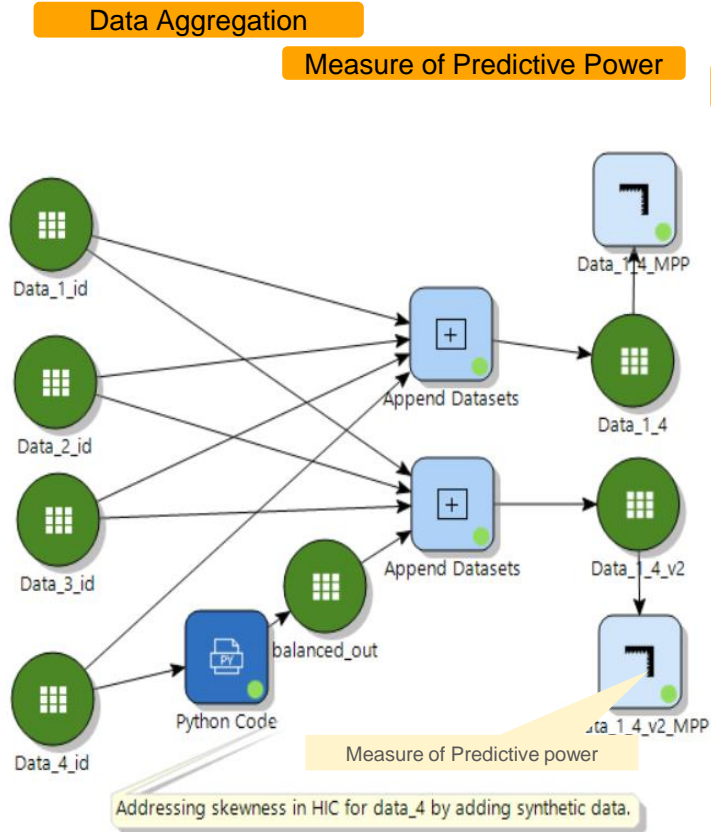
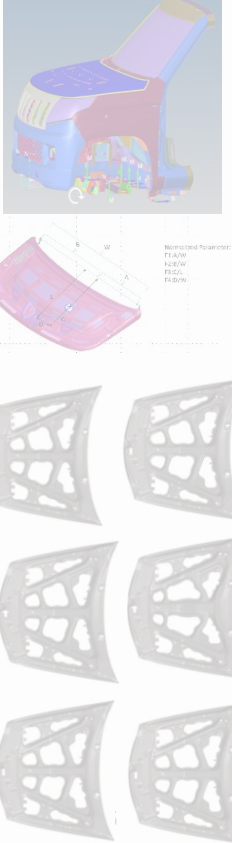
HyperWorks®

- Data Prep**
- FE model data
 - Automated data query

HIC Data Extraction Demo



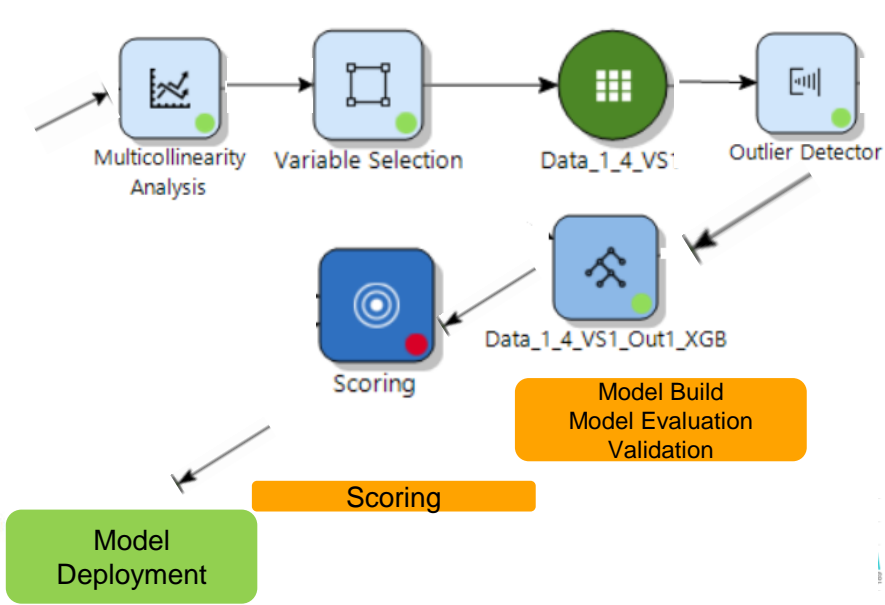
Feature Extraction → Data Exploration → Data Modelling → Deployment



Multicollinearity

Variable Selection

Outlier



Deployment | Consuming the Knowledge Studio ML model

The screenshot shows a workflow in Knowledge Studio. On the left, there are five 'Data Import' nodes, each connected to an 'ML Model' node. The 'ML Model' nodes are all connected to a single 'Scoring' node. The 'Scoring' node is connected to a 'Target Dataset' node. The 'Target Dataset' node is connected to a 'Data Import' node. The 'Data Import' node is connected to a 'Data Import' node. The 'Data Import' node is connected to a 'Data Import' node. The 'Data Import' node is connected to a 'Data Import' node. The 'Data Import' node is connected to a 'Data Import' node.

The screenshot shows a 3D CAD model of a car seat in HyperWorks software. The model is blue and purple. The software interface includes a menu bar, a toolbar, and a central 3D view area. The 3D view area shows the car seat model with various features and dimensions. The software interface also includes a 'Data Prep' panel on the left and a 'Properties' panel on the right.

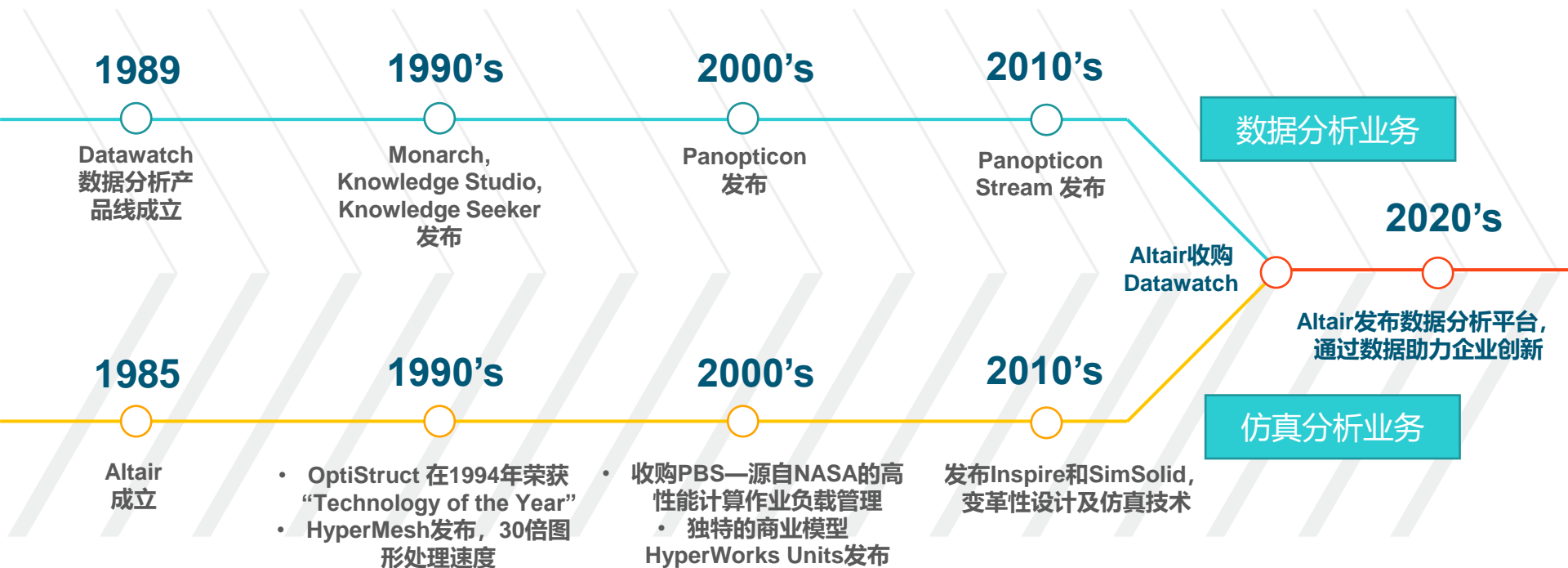
The screenshot shows the Auto Py to Exe tool interface. It includes a 'Script Location' field, an 'Onefile' checkbox, a 'Console Window' checkbox, an 'Icon' field, and an 'Additional Files' section. There are also checkboxes for 'Advanced' and 'Settings'. The interface is in English and has a 'Language' dropdown menu.

Prescriptive Analytics

Optimization

- KS-HST Integration
- Global/Local Optimization
- Single/Multi Obj

Altair时间线及里程碑



Altair数据分析解决方案：面向终端用户



首席数据官，
决策层，管理层



数据科学家



数据分析师



IT/数据管理员



数据工程师，
设计师

数据准备
Monarch

数据科学
Knowledge Studio & WPS

数据可视化
Panopticon

数据治理

数据转换

机器学习

数据质量

数据信任

预测分析

数据资产

数据安全

实时分析

数据层



数据流



数据湖



IoT 数据



云



流数据

Altair 数据分析产品简介

Monarch

桌面级，自助式
数据准备



市场领先的，多种数据结构的
访问与获取



面向每一位企业员工的
数据市场

WPS Analytics

机器学习
(支持SAS语言)



便捷、灵活的部署方式



超过14,000客户的信任

Knowledge Studio

预测分析，机器学习
数据科学



众多的企业应用案例



现代，企业级的软件框架与
解决方案

Panopticon

实时，流数据可视化



数据治理与管控



真正的实时数据可视化

Altair® Knowledge Studio & WPS

机器学习和数据科学平台



数据连接

- 支持连接到任何数据源，如TXT、XLS、Hadoop
- 内置数据准备操作，方便用户对数据进行前处理



可视化建模

- 全流程可视化建模：数据探索，模型构建、模型评估
- 行业领先的交互式决策树
- 建模过程不需要编程
- 模型可生成代码，方便客户部署



大数据支持

- 可通过Spark集群进行模型运算
- 支持大数据运算：千万级数据规模

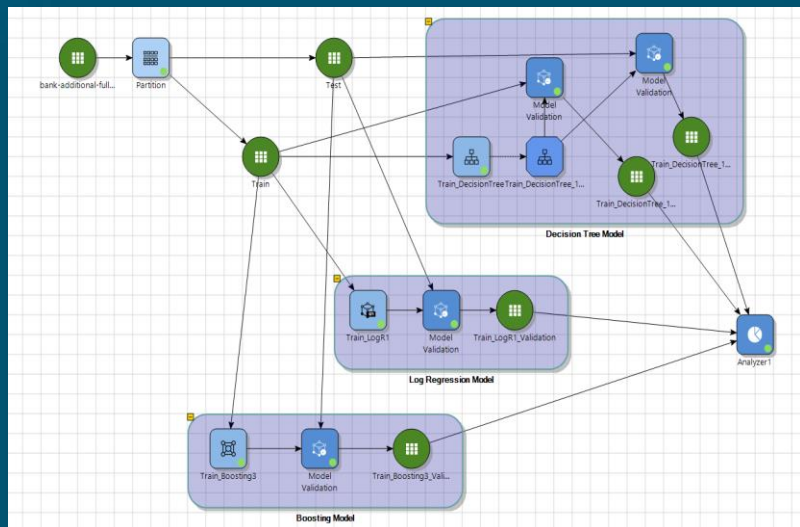


开放式部署

- 模型支持生成多种代码语言，如：Python、SAS、R、Java等
- 代码可部署在客户自有系统

直观可视化拖拉拽建模方式

可视化建模



流程可视化、功能模块化、结果可信度高

代码建模

K-Nearest Neighbors (Python)

```
>>> from sklearn.neighbors import NearestNeighbors
>>> import numpy as np
>>> X = np.array([[1, -2], [-2, -2], [-3, -5], [1, 1], [2, 2], [4, 4]])
>>> model = NearestNeighbors(n_neighbors=2, algorithm='ball_tree').fit(X)
>>> distances, indices = model.kneighbors([[0,0]])
>>> distances
array([[ 1.41421356,  2.23606798]])
>>> indices
array([[3, 0]], dtype=int64)
```

Logistic Regression

```
>>> from sklearn.linear_model import LogisticRegression
>>> model = LogisticRegression(penalty="l2")
>>> model.fit([[-2,-3],[1,0],[1,1]],[1,0,1])
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
penalty='l2', random_state=None, solver='liblinear', tol=0.0001,
verbose=0, warm_start=False)
>>> print(model.coef_)
[[-0.36284928 -0.89783526]]
>>> print(model.intercept_)
[ 0.28802799]
>>> model.predict([[3,3]])
array([0])
```

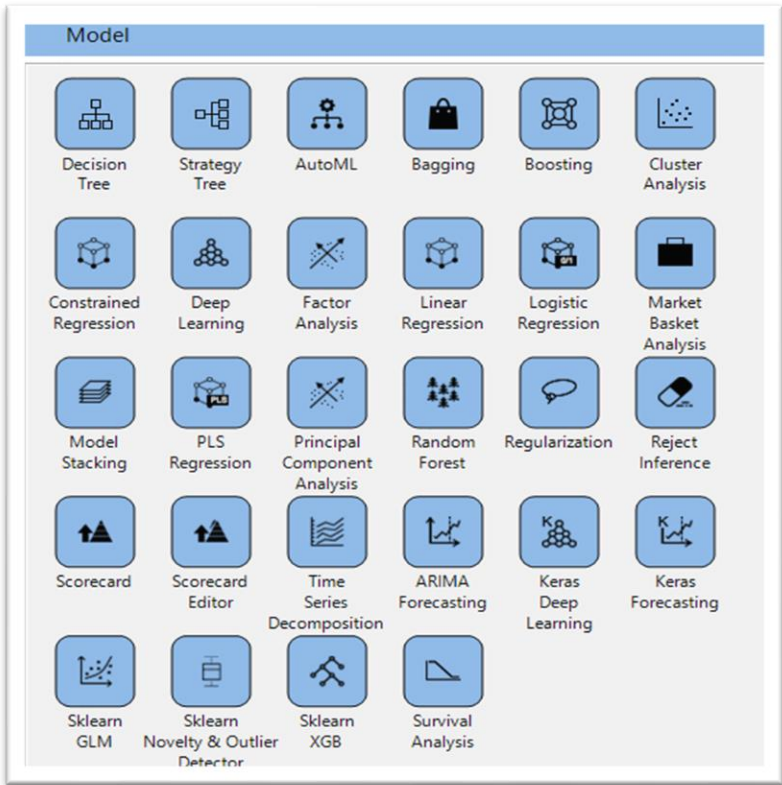
SVM

```
>>> from sklearn.svm import SVC
>>> import numpy as np
>>> X = np.array([[-1, -2], [-4, -5], [3, 4], [4, 5]])
>>> y = np.array([1, 1, 2, 2])
>>> model = SVC()
>>> model.fit(X,y)
SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
decision_function_shape=None, degree=3, gamma='auto', kernel='rbf',
max_iter=1, probability=False, random_state=None, shrinking=True,
tol=0.001, verbose=False)
>>> print(model.predict([[0,0]]))
[1]
```

学习成本高、耗时、交接效率低

VS

多种算法集成



- 内置28种常用算法模型，开箱即用
- 主流算法
 - 决策树
 - 评分卡
 - 线性回归
 - 逻辑回归
 - 随机森林
 - Bagging装袋
 - Boosting
 - 深度学习
 -

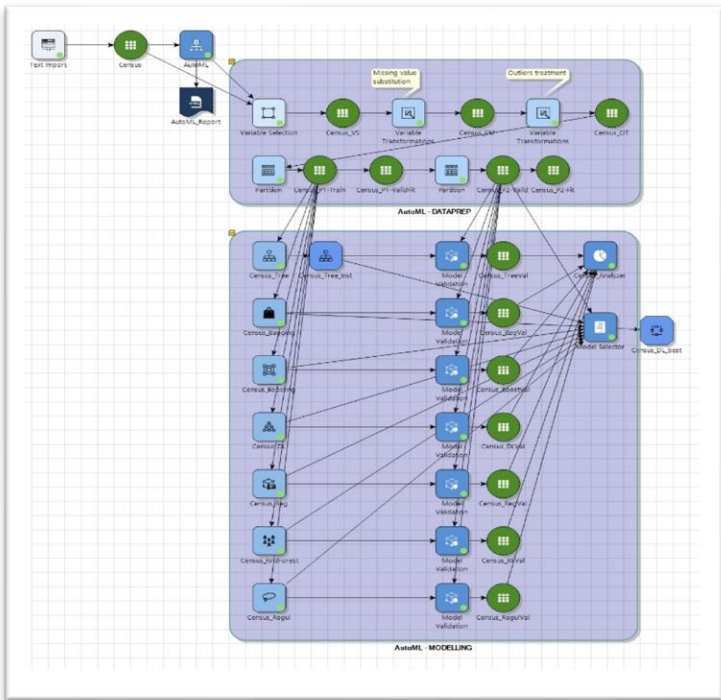
自动机器学习 (AutoML)

全自动化的机器学习流程, 支持8种模型算法

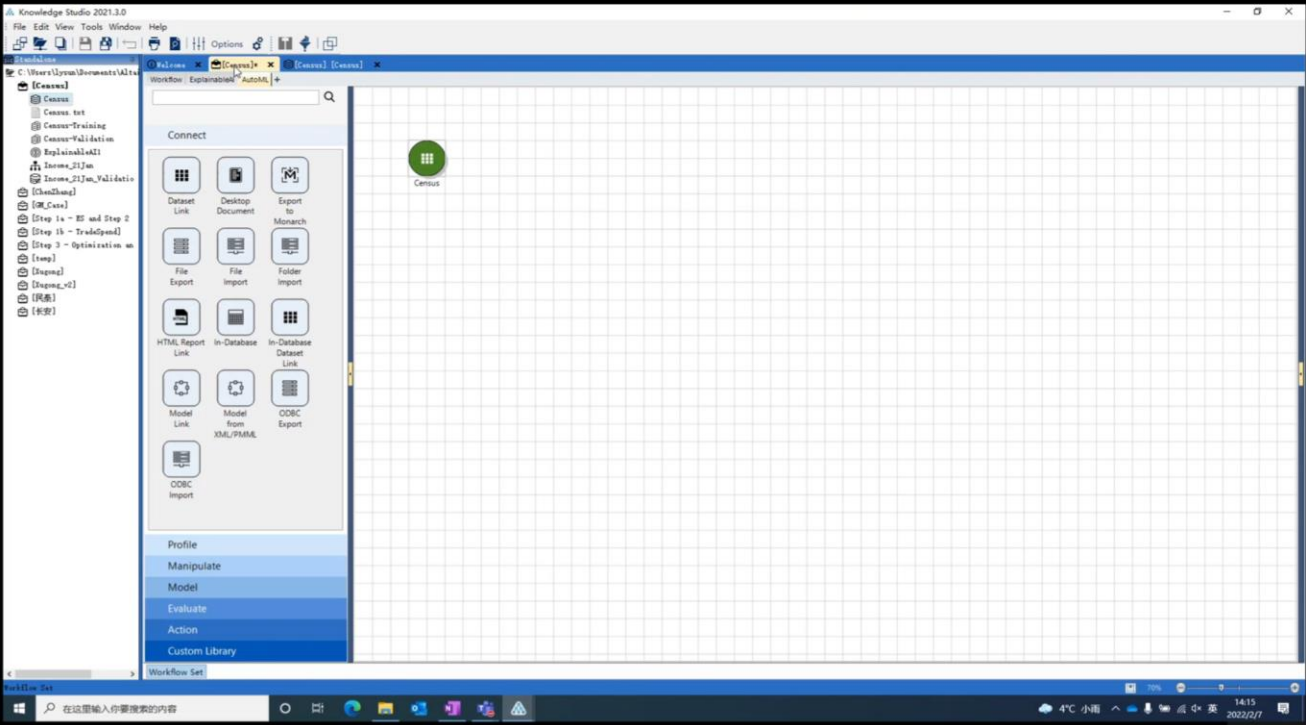
支持数据处理, 模型验证, 模型分析, 模型选择自动化

Settings

Variable Selection	Data Preprocessing	Feature Engineering	Modelling
<input checked="" type="checkbox"/> Decision Tree	<input checked="" type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input checked="" type="checkbox"/> Bagging	<input checked="" type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input checked="" type="checkbox"/> Boosting	<input checked="" type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input checked="" type="checkbox"/> Deep Learning	<input checked="" type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input type="checkbox"/> Regression	<input type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input checked="" type="checkbox"/> Random Forest	<input checked="" type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input type="checkbox"/> Regularization	<input type="radio"/> Advanced	<input type="radio"/> Grid Search	
<input type="checkbox"/> Model Stacking			

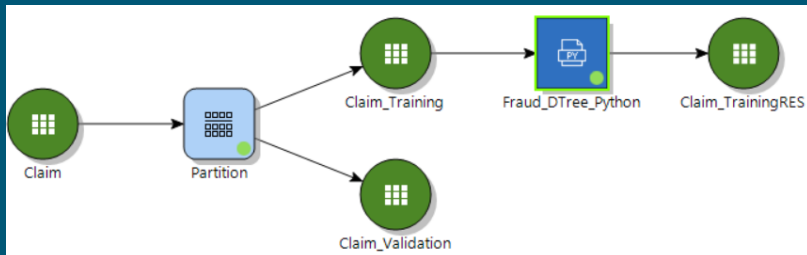
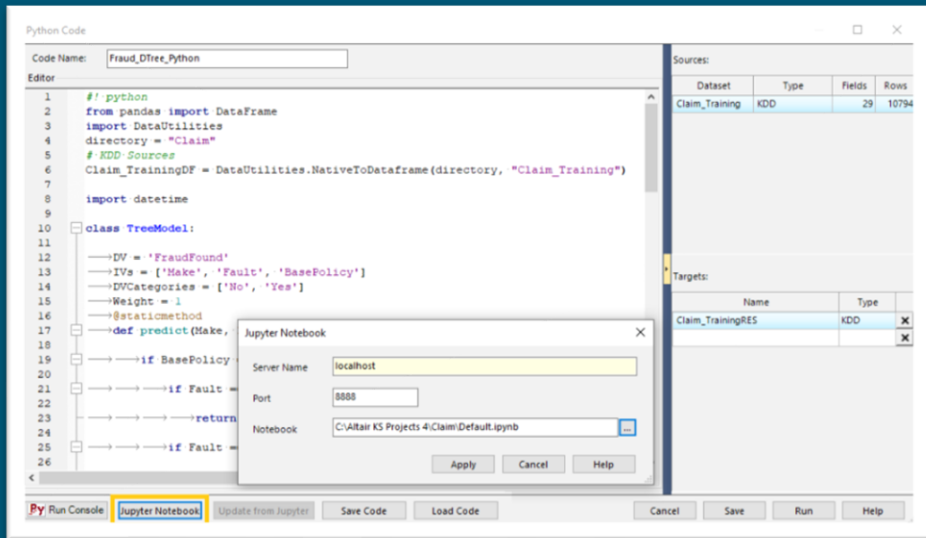


自动机器学习 (AutoML)



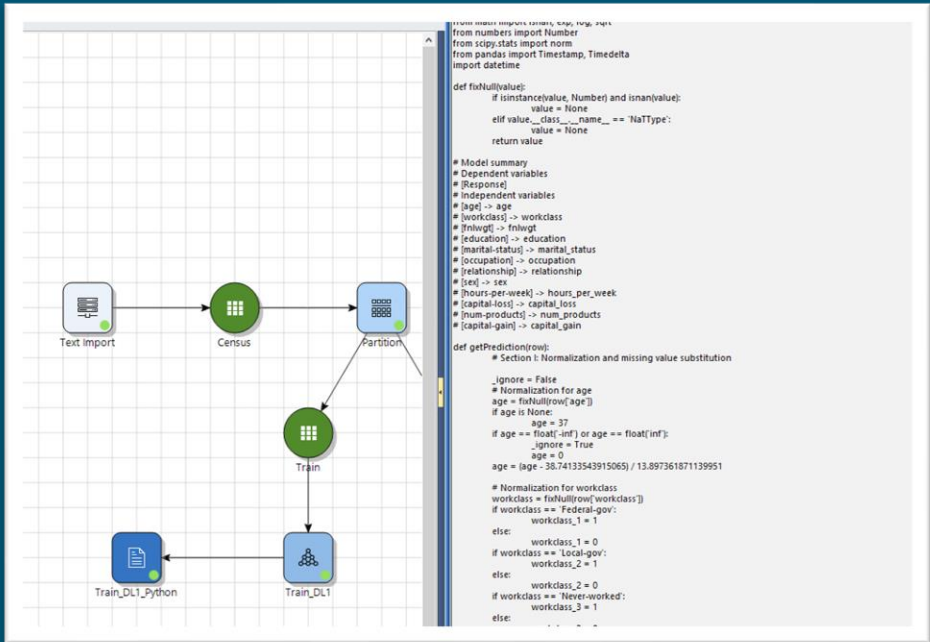
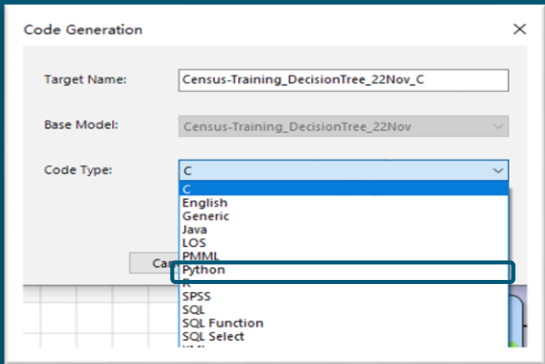
支持Python代码嵌入

- 可以在python节点中编写代码，支持Jupyter notebook
- Python节点可内嵌入工作流中
- 支持从Python节点代码重用



支持模型代码导出

语言支持：Python, PMML, R, LOS, Java等



剩余使用寿命

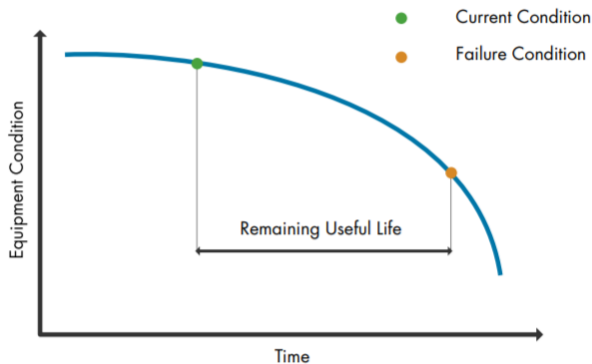
- 相似性模型, 降阶模型, 生存模型

目标/问题陈述: 预测在故障排除之前剩余的运行周期数发动机将继续正常运行的最后一个循环后的工作循环数。

剩余使用寿命 (RUL) 是一台机器在需要维修或更换之前可能要运行的时间。

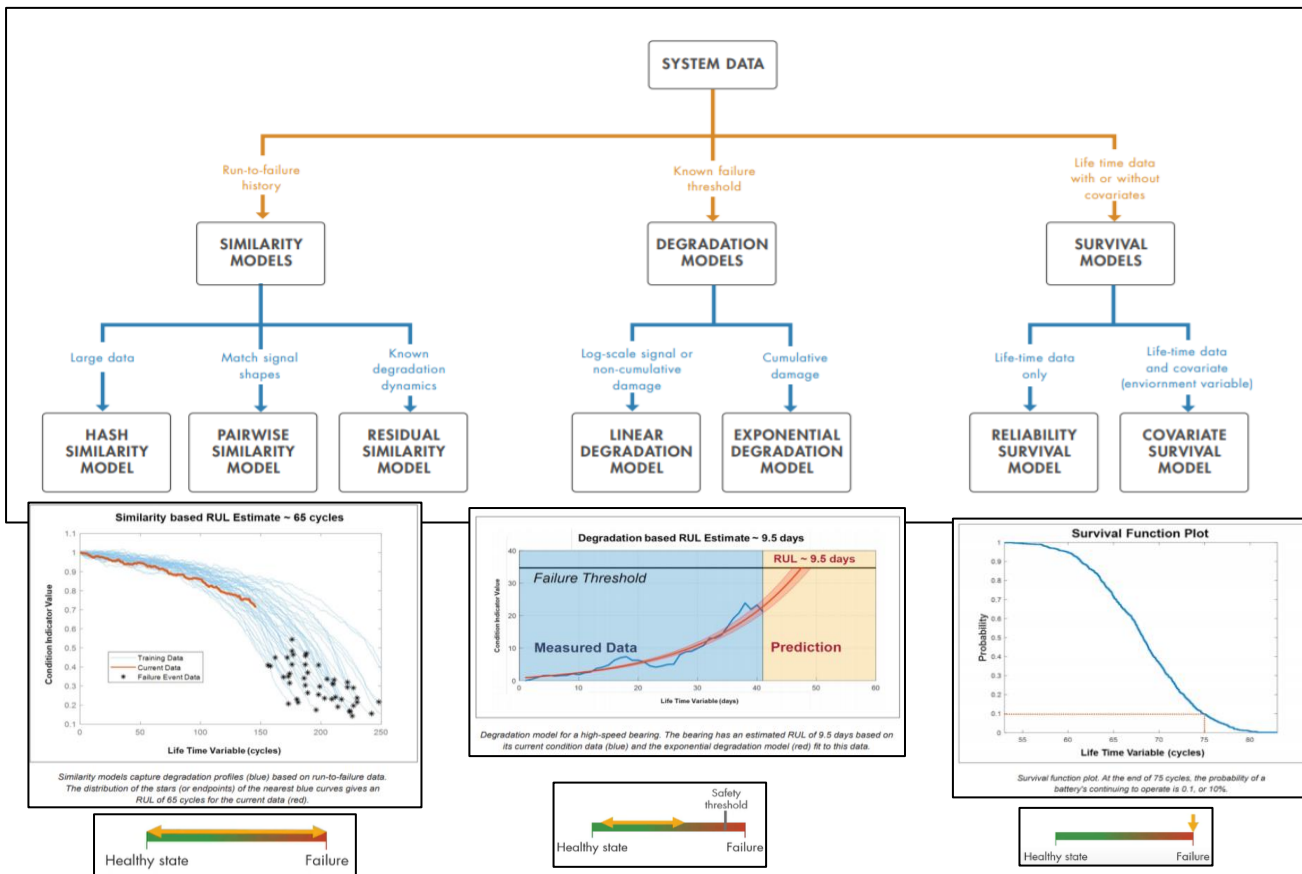
从飞机上的传感器收集的数据可提供有关各个零件状况的信息。

Equipment Deterioration Profile



剩余使用寿命

相似性模型, 降阶模型, 生存模型

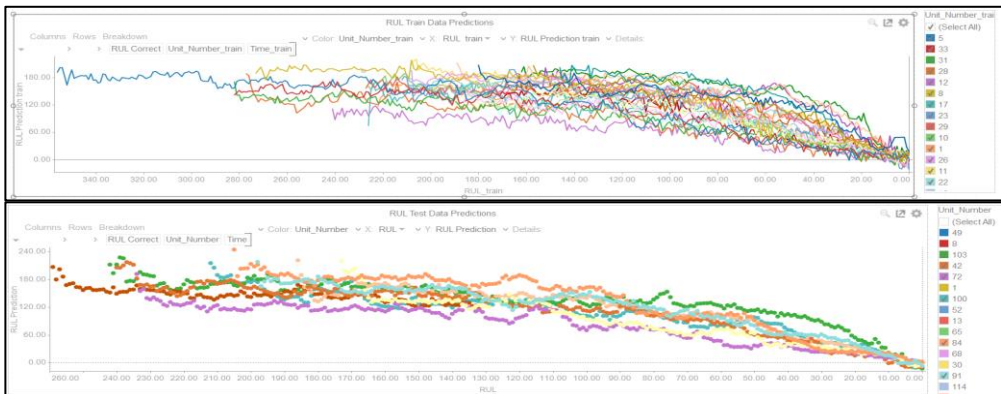


剩余使用寿命

相似性模型

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预计的RUL随时间的进展

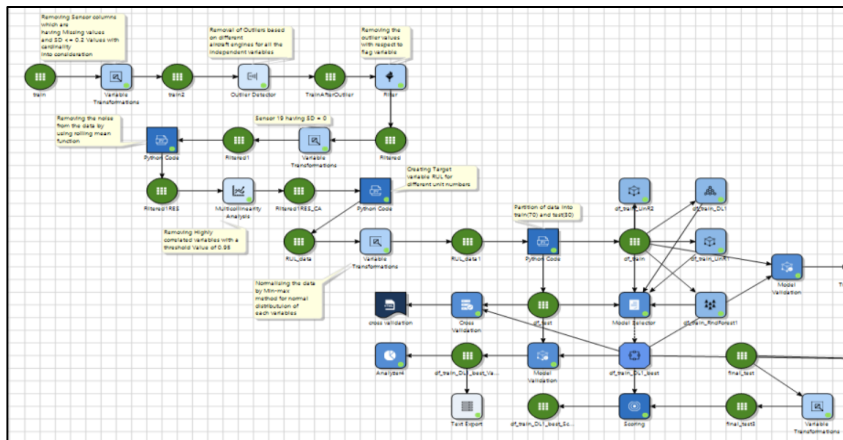


Prediction summary on Test Data

Engine No.	Current Cycle	Actual RUL (cycles)	Predicted RUL (cycles)
3	119	30	33
6	58	163	166
21	38	166	161
135	120	65	74
216	53	136	136

31

KS Workflow Similarity models

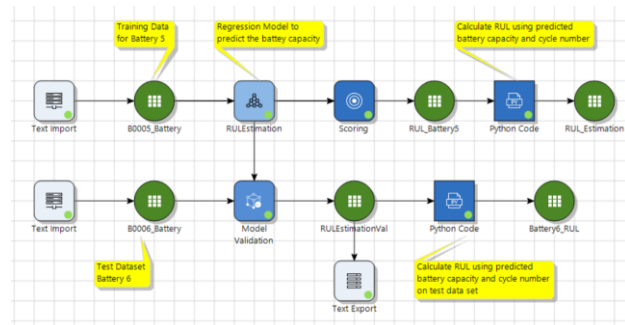
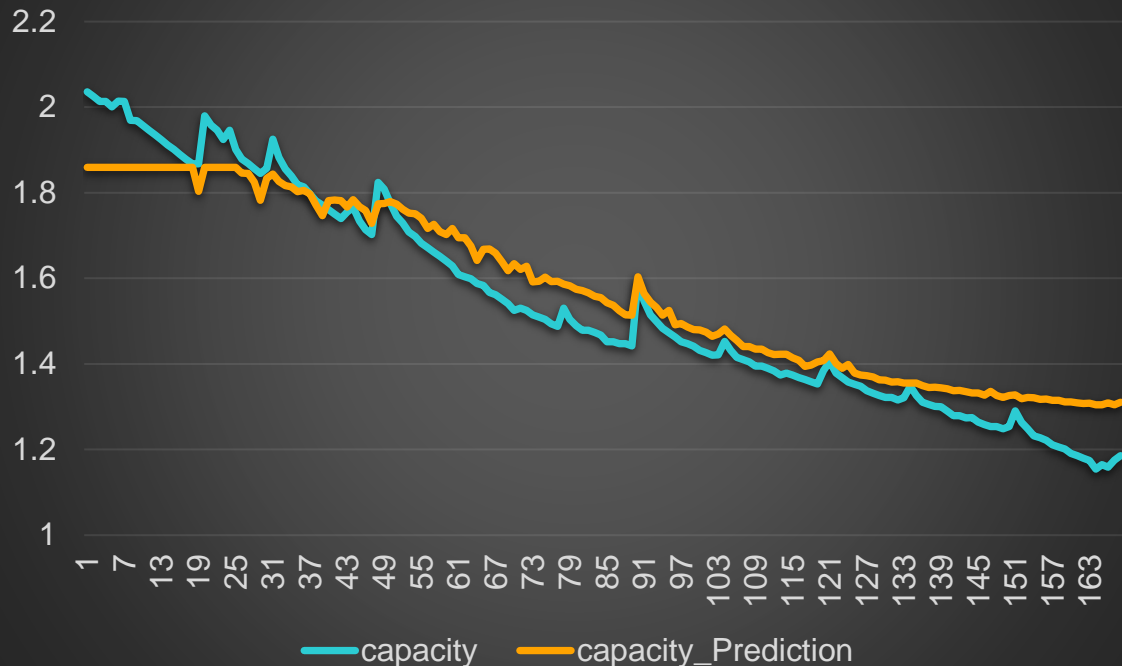


剩余使用寿命

降阶模型

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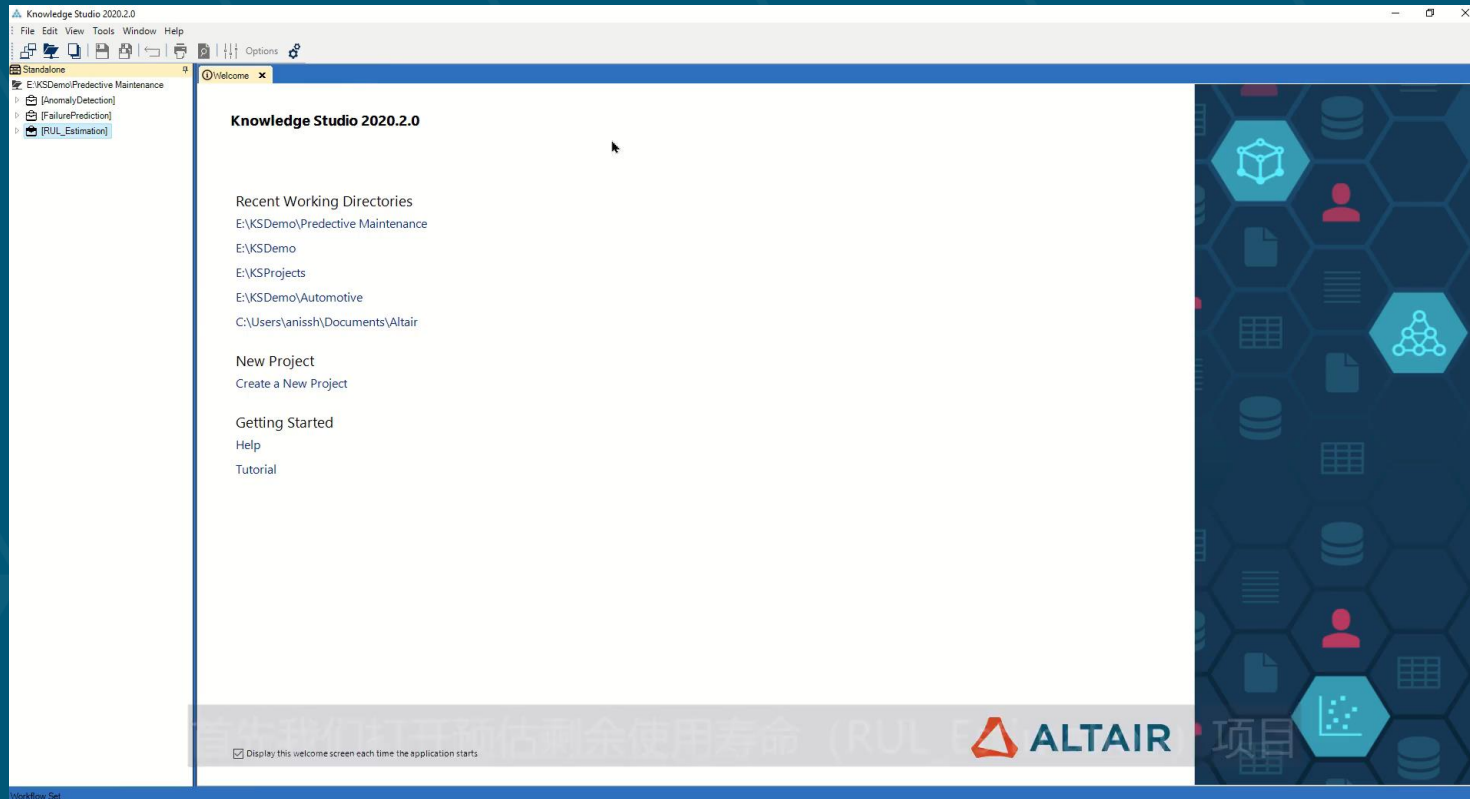
预测能力vs. 实际能力



Threshold Value = 1.35

Parameter	Values
Actual RUL	43
Prediction RUL	33
RUL error	10

剩余寿命预测





THANK YOU

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