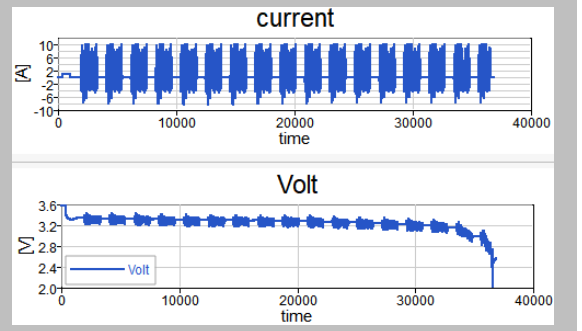
ALTAIR

Altair romAI工具降阶建模应用

romAI的目的 —— 生成降阶模型

数据

	A	B	C	D	E	F	G	H	I
1	time	Xref_mm	Yref_mm	X_mm	Y_mm	X_dot	Y_dot	TX_deg	TY_deg
2	0	0	0	0.1478	2.29719	0.002035	-5.00691	-0.13154	-0.75129
3	0.005	0	0	0.14781	2.272156	0.001635	-4.02188	-0.1229	-0.64688
4	0.01	0	0	0.147817	2.256972	0.000992	-2.43939	-0.11618	-0.66437
5	0.015	0	0	0.14782	2.247762	0.000601	-1.47957	-0.11099	-0.7383
6	0.02	0	0	0.147823	2.242176	0.000365	-0.8974	-0.107	-0.83284
7	0.025	0	0	0.147824	2.238788	0.000221	-0.5443	-0.10394	-0.92927
8	0.03	0	0	0.147825	2.236733	0.000134	-3.46057	-0.10162	-1.01857
9	0.035	0	0	0.147825	2.204182	6.809494	-9.0794	-0.09988	-0.74168
10	0.04	0	0	0.21592	2.145939	18.91092	-2.3765	-0.98042	-0.34267

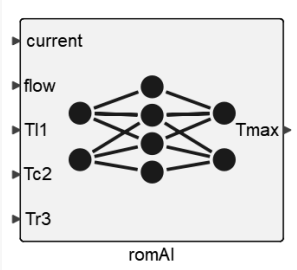


动态模型

$$u(t) \Rightarrow \begin{cases} \dot{x} = f(x(t), u(t), \theta) \\ y = g(x(t), u(t), \theta) \end{cases} \Rightarrow y(t)$$

数字孪生 · ROM · 监测

IoT　RT simulator　Control
Optimization



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SUPPORTED STD

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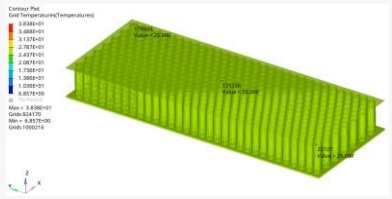
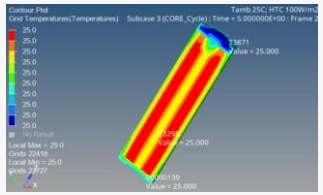
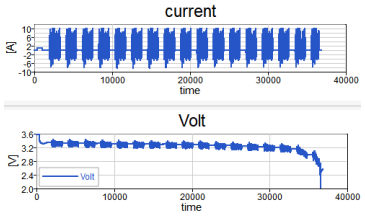
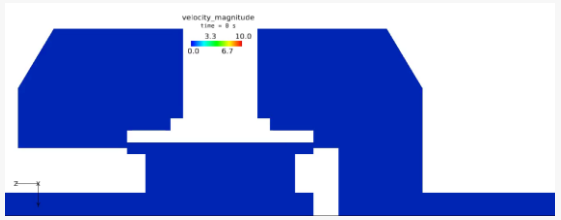
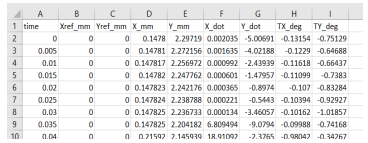
romAI工具应用

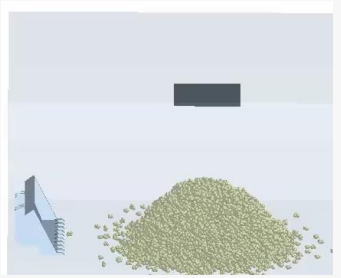




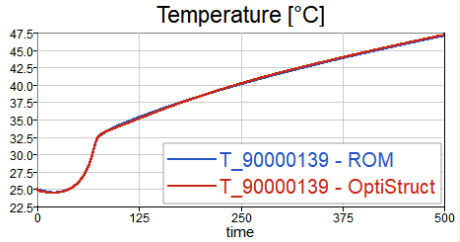


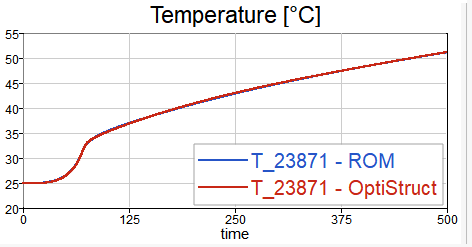




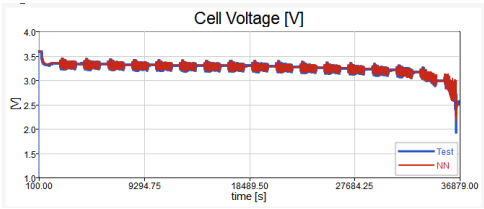


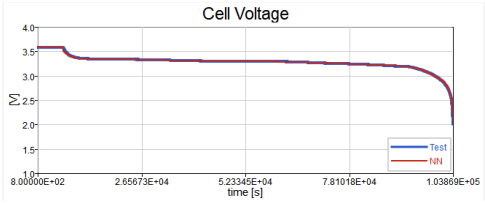
热



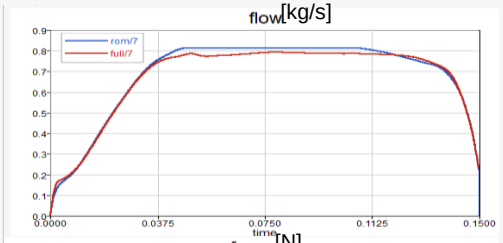


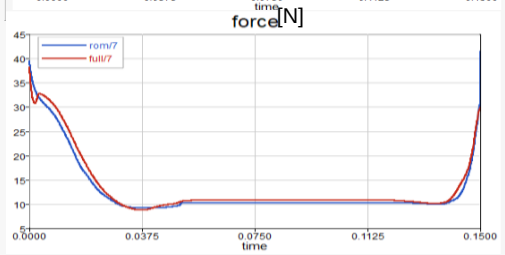
电气



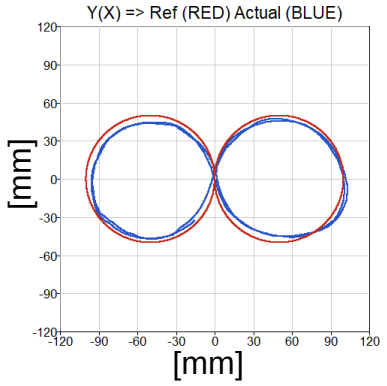


流体

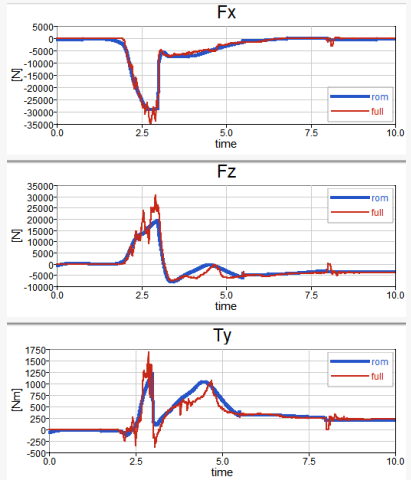




机械



离散元



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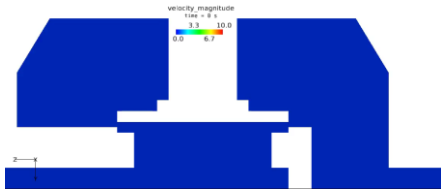
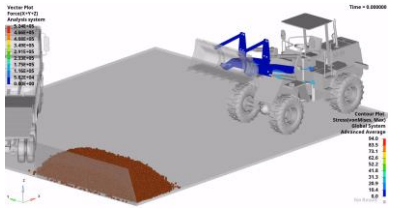
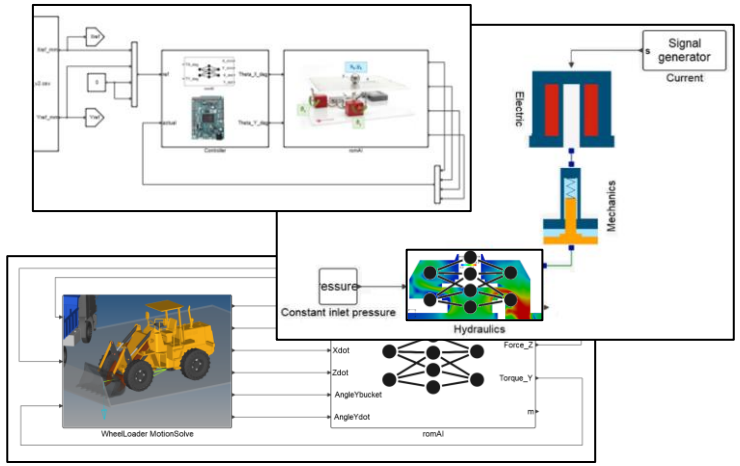
romAI 工具使用流程

仿真或测试

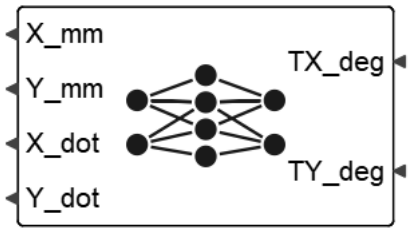






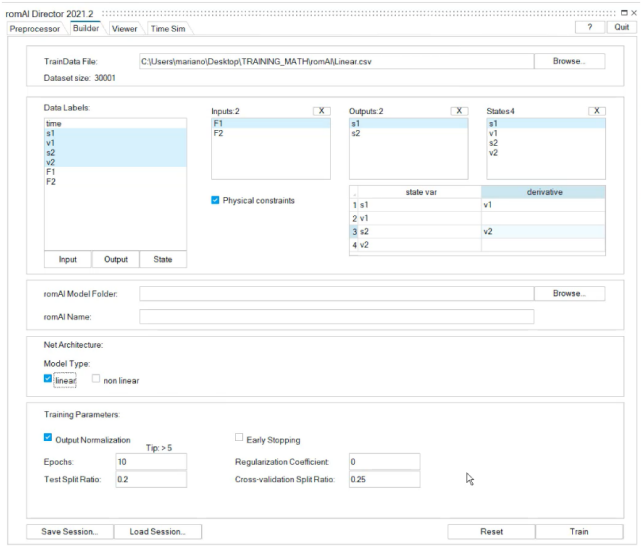
系统仿真应用

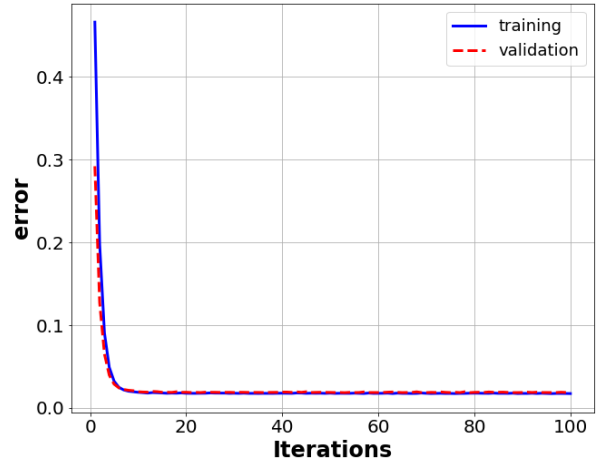
训练数据



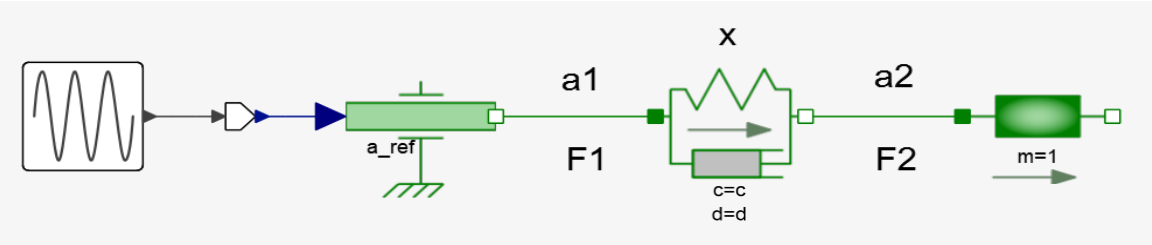
romAI

机器学习





单自由度弹簧系统理论模型（加速度加载）



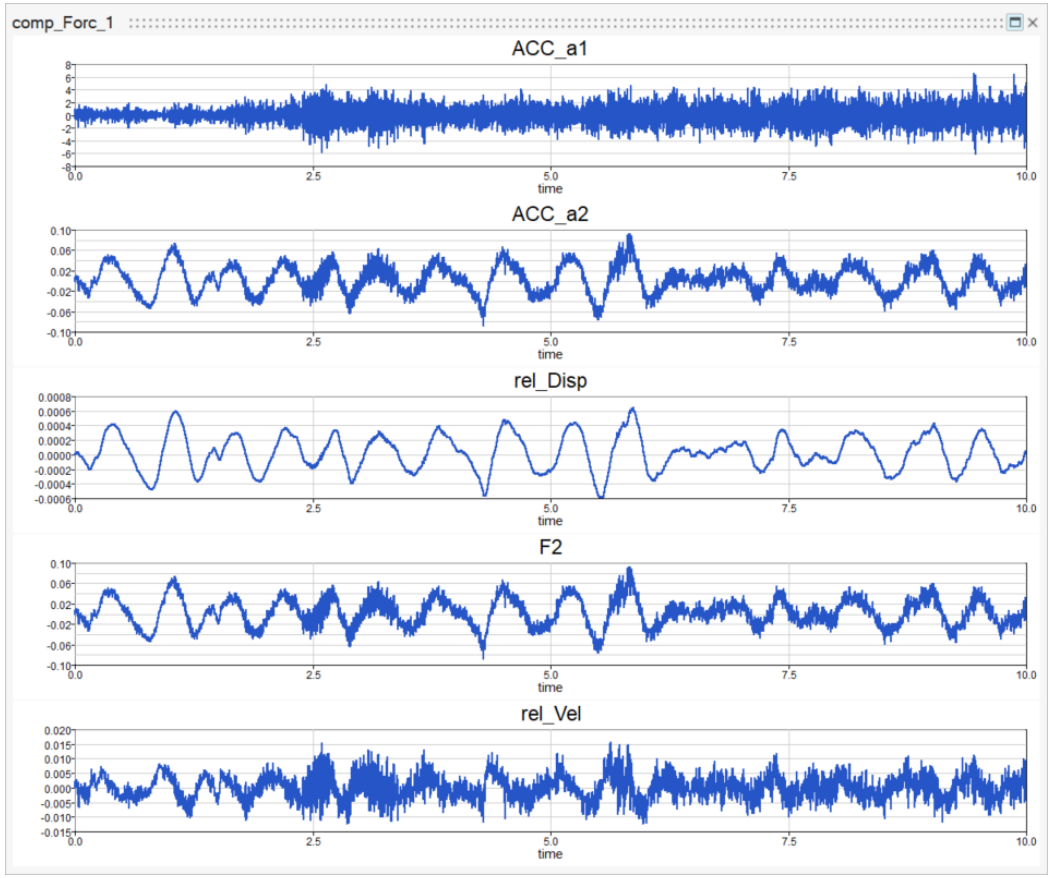
$$F_2 = ma_2$$

$$F_1 = F_2 = Kx + c\frac{dx}{dt}$$

$$a_1 = a_2 + \frac{d^2x}{dt^2}$$

$$\frac{d^2x}{dt^2} + \frac{c}{m}\frac{dx}{dt} + \frac{K}{m}x = a_1$$

$$\frac{d^2x}{dt^2} = a_1 - a_2$$



理论仿真结果

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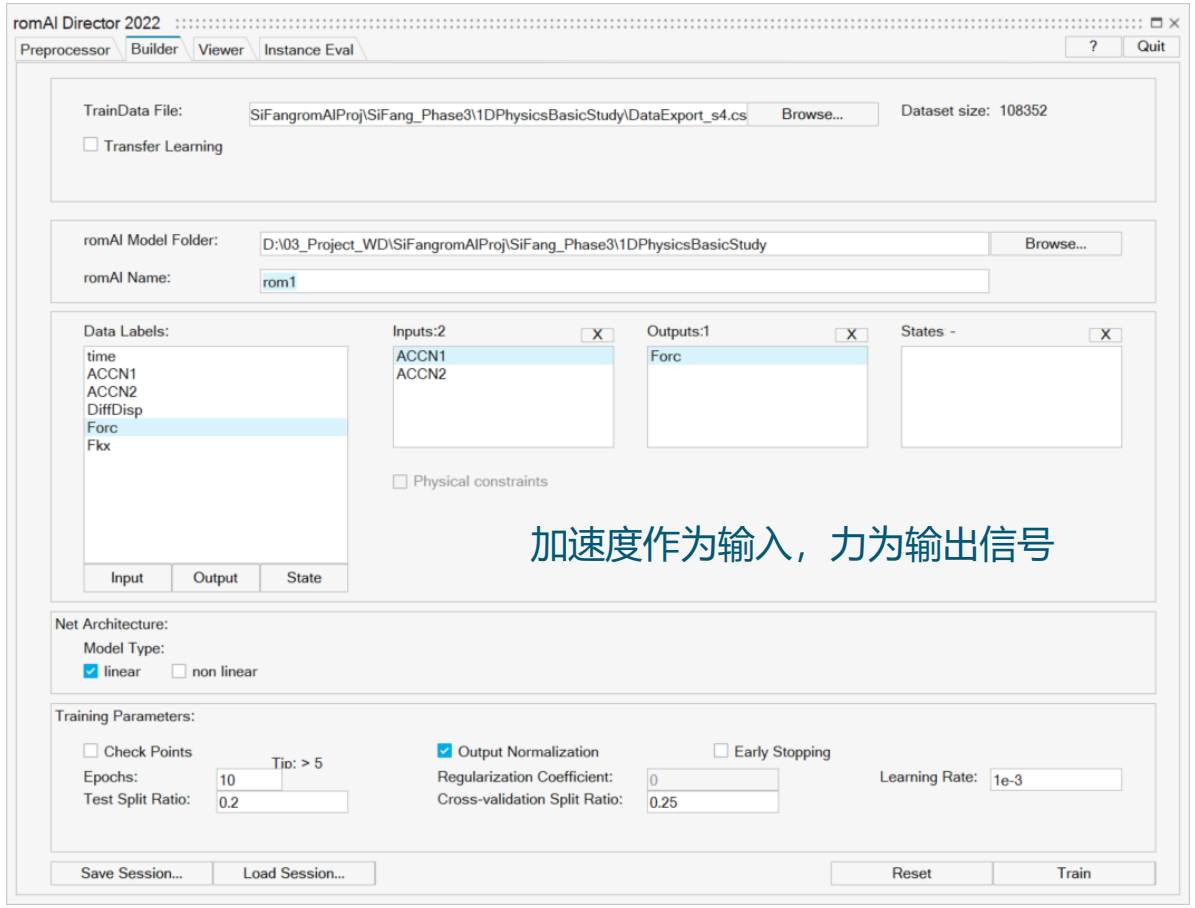
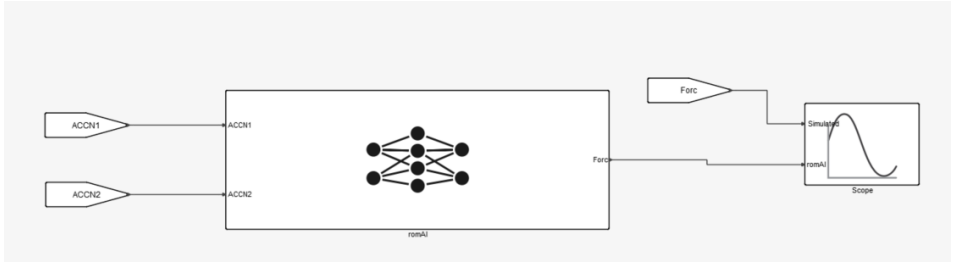
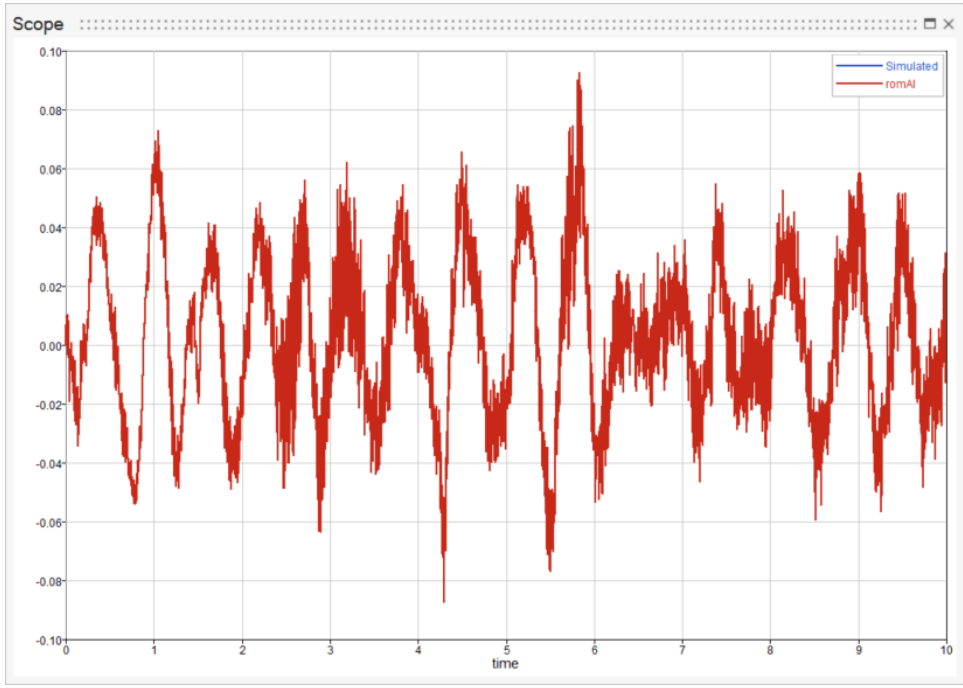
基于romAI的单弹簧系统降阶训练与验证



romAI模型训练





降阶模型验证测试

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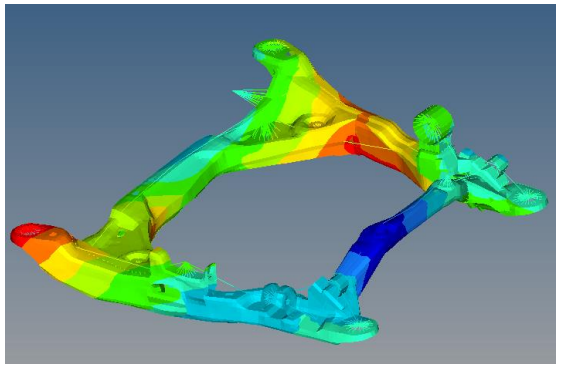
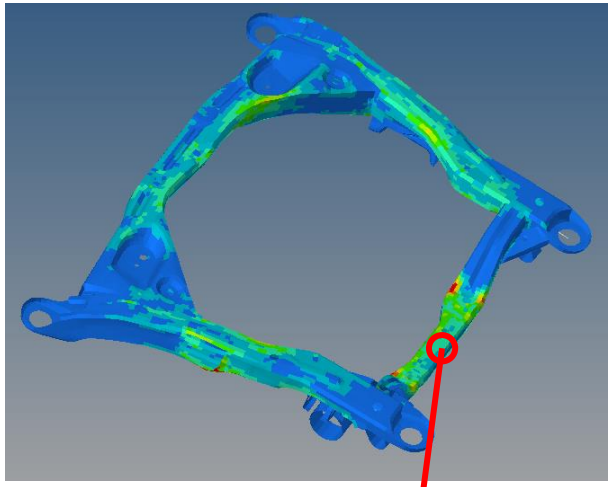
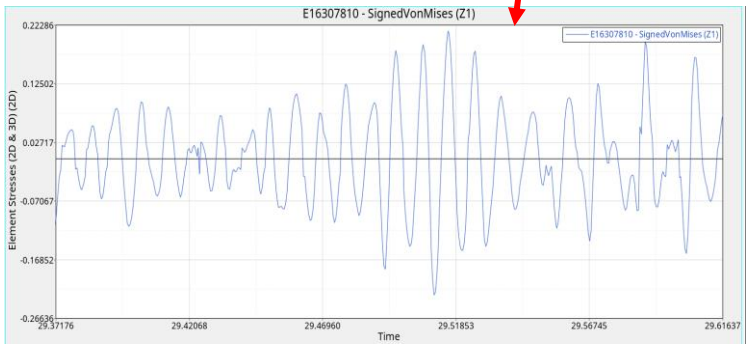
基于romAI的应力降阶模型生成与应用



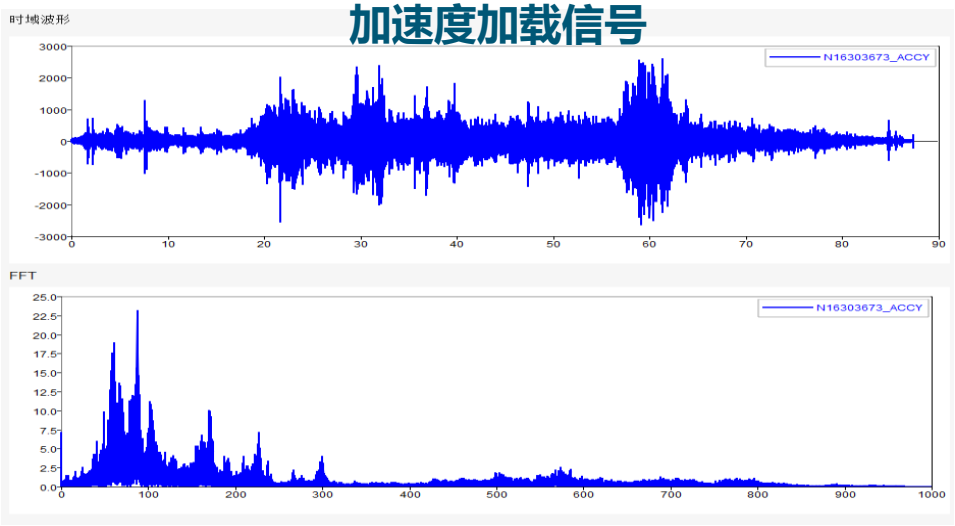


Mode 6 - F = 8.246306E+01
Mode 7 - F = 1.098576E+02
Mode 8 - F = 1.434572E+02
Mode 9 - F = 1.640329E+02
Mode 10 - F = 2.387948E+02
Mode 11 - F = 2.567569E+02
Mode 12 - F = 2.804139E+02
Mode 13 - F = 3.074962E+02
Mode 14 - F = 3.235824E+02
Mode 15 - F = 3.648698E+02

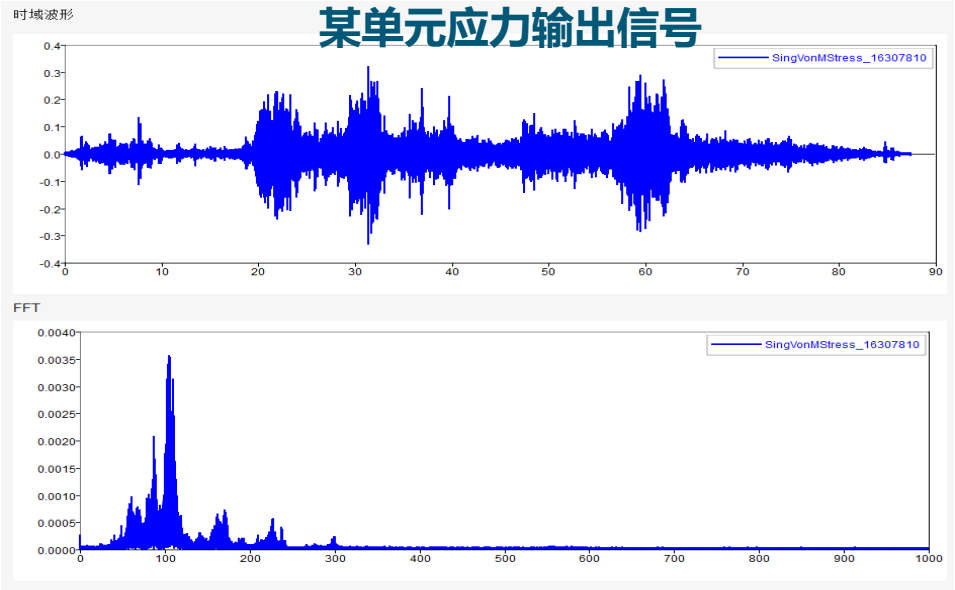


基于OptiStruct瞬态计算

加速度加载信号



某单元应力输出信号



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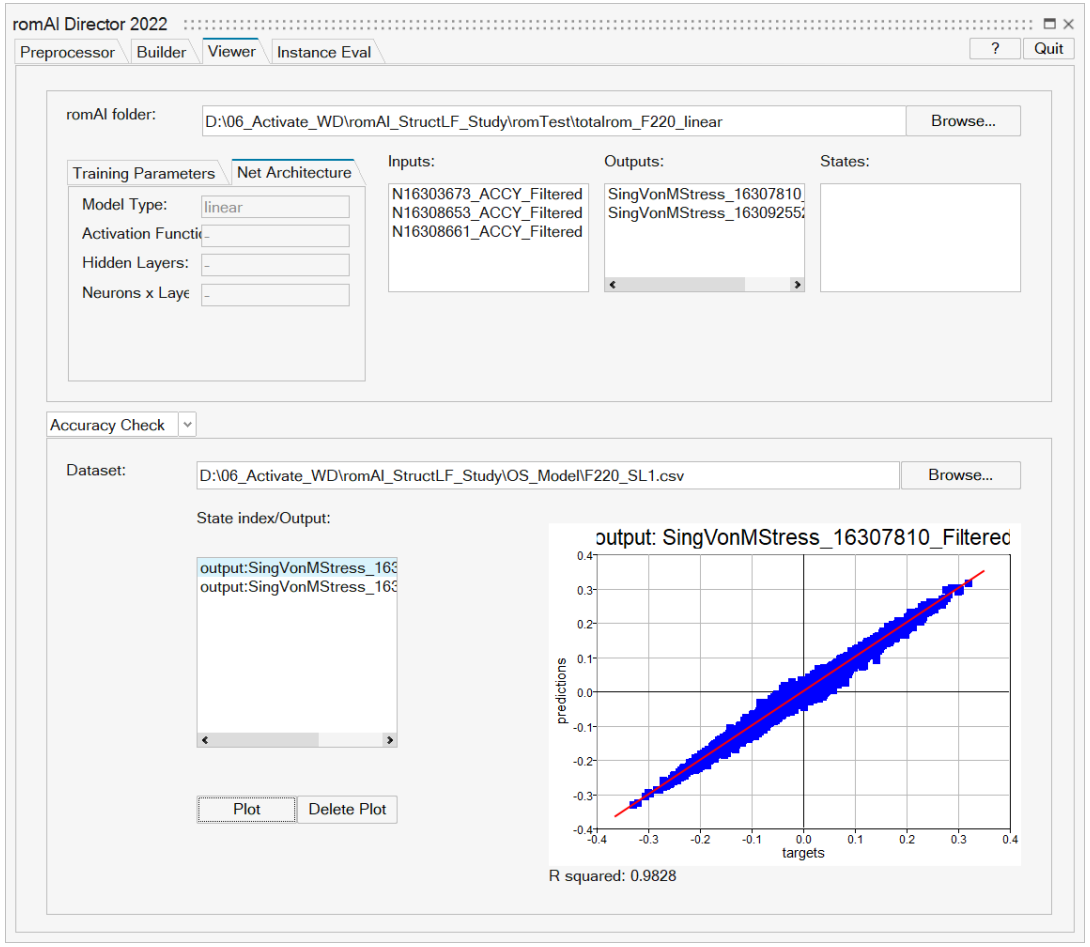
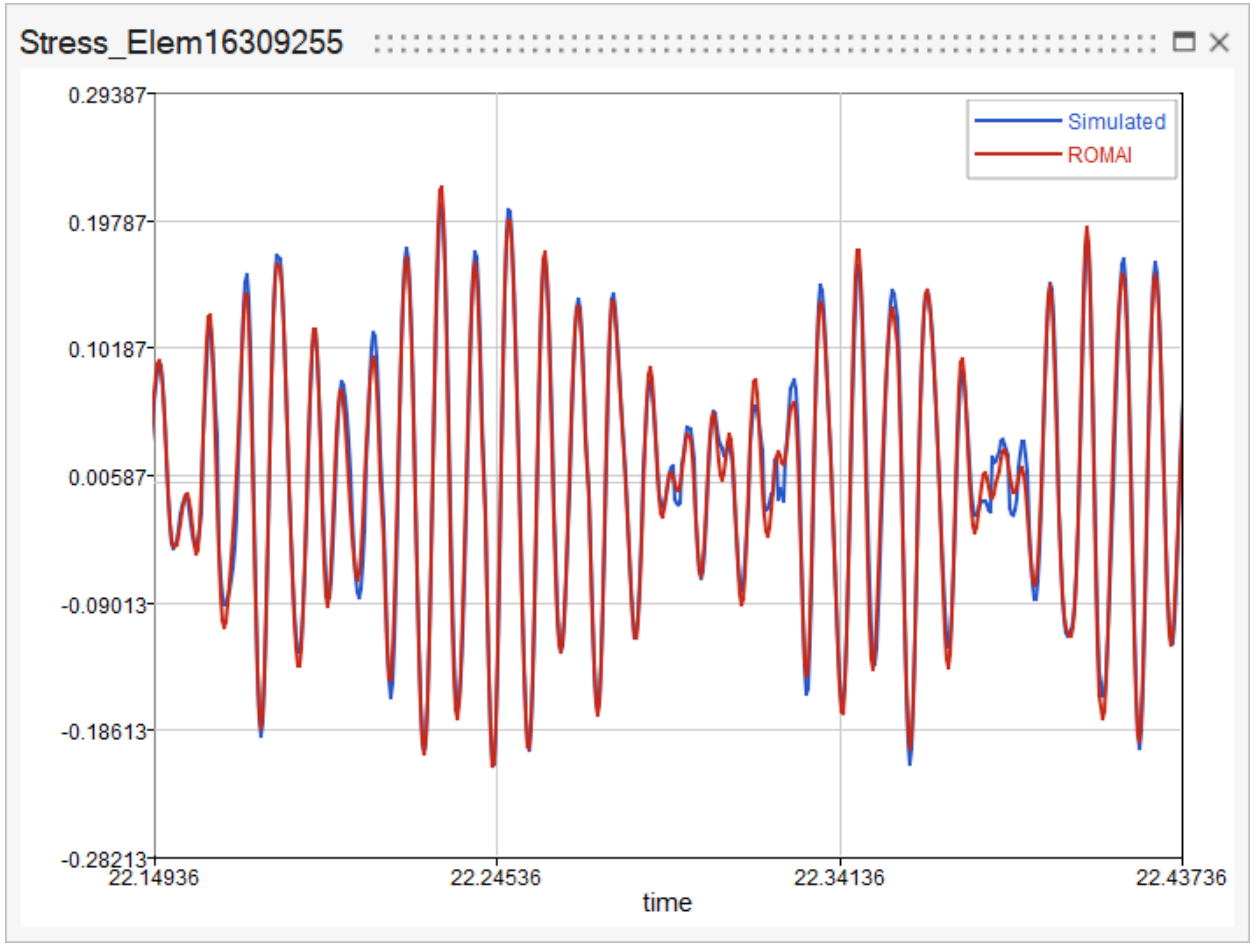
基于romAI的应力降阶模型生成



基于romAI的降阶模型训练



降阶模型精度验证

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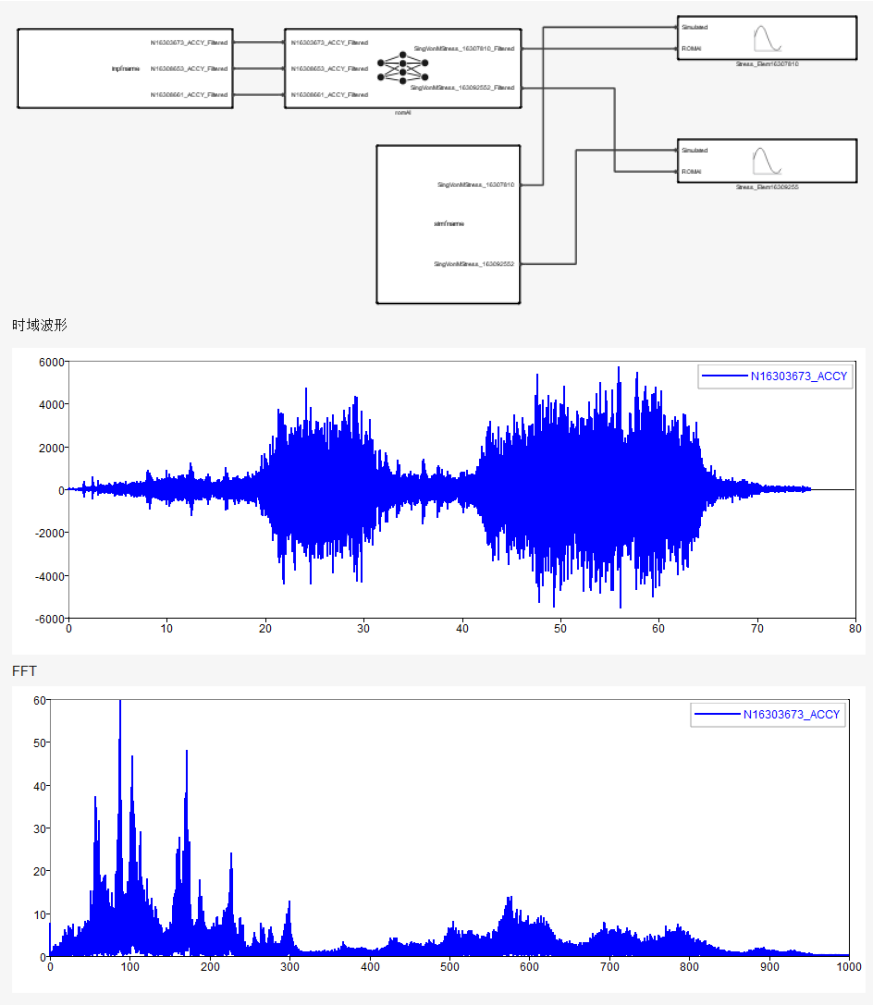
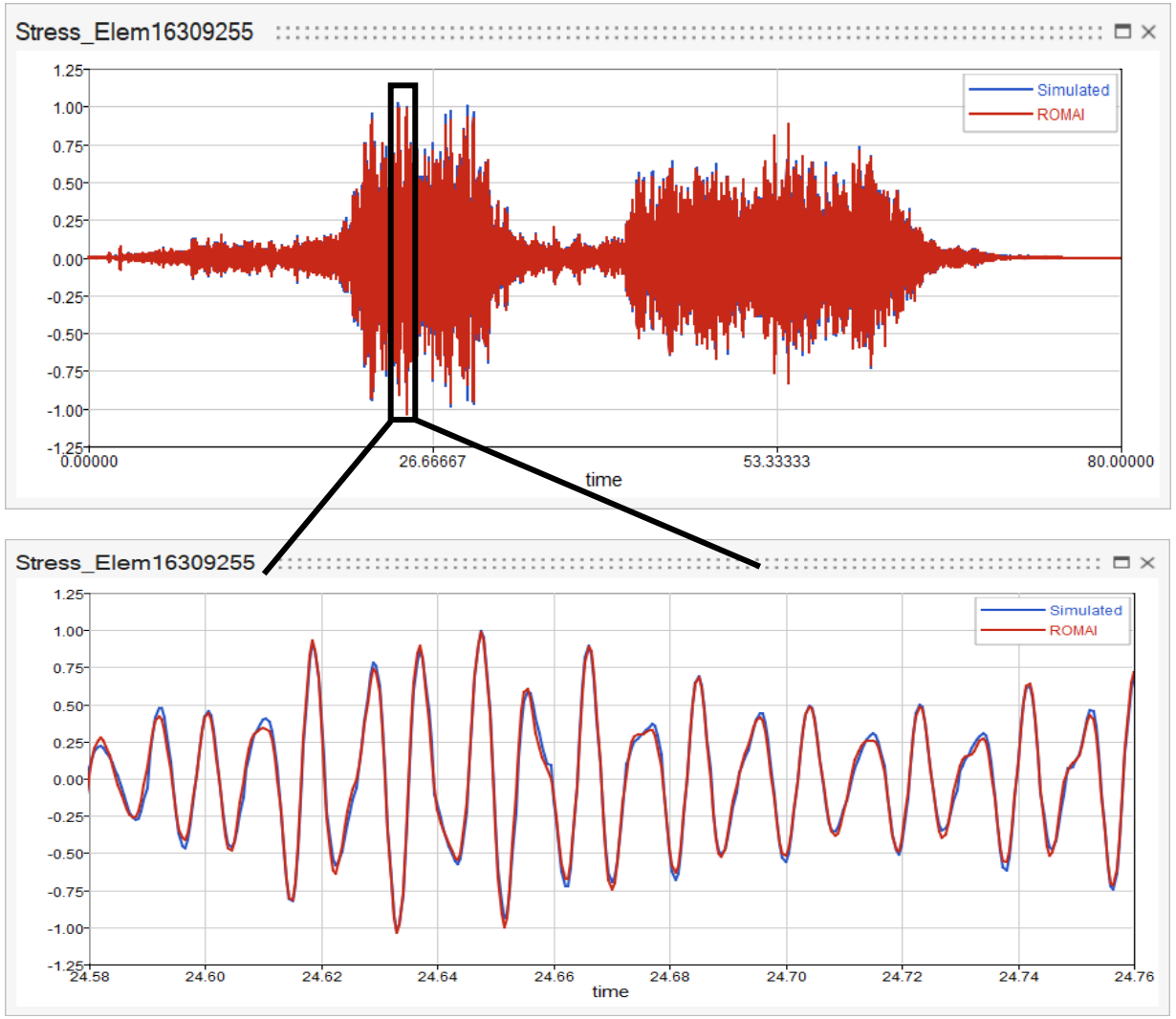
基于romAI的应力降阶模型应用



romAI降阶模型用于新加速度分析应用



应力结果及与OptiStruct仿真结果对比

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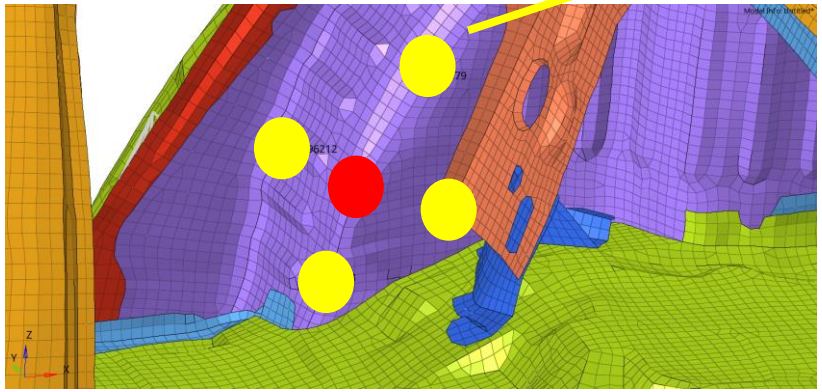
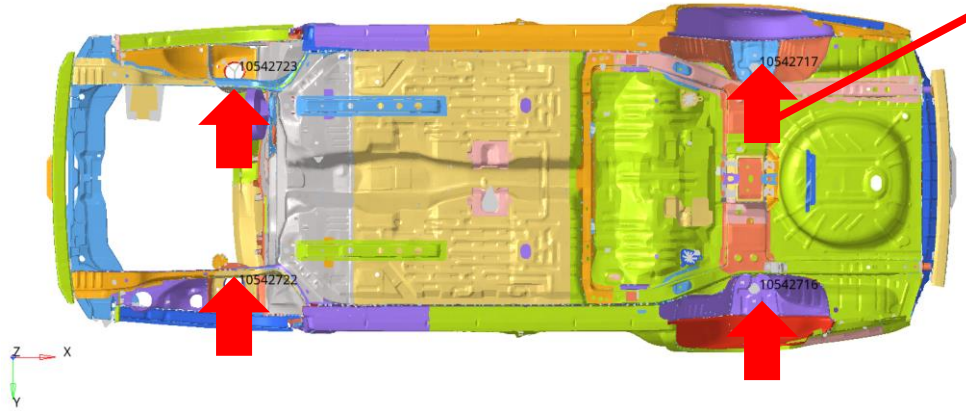
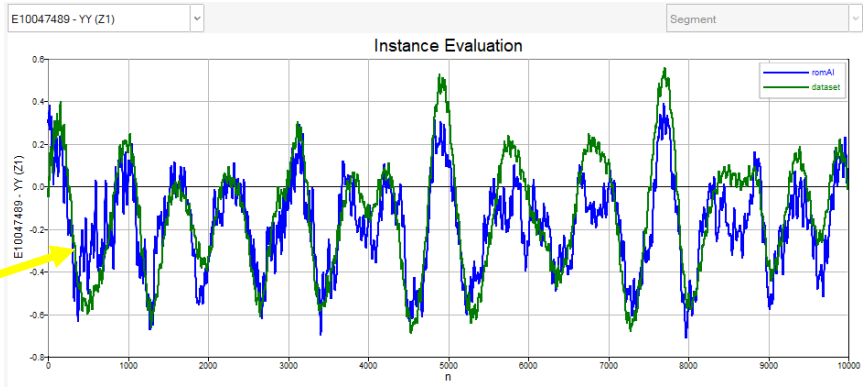
基于romAI的应力降阶建模

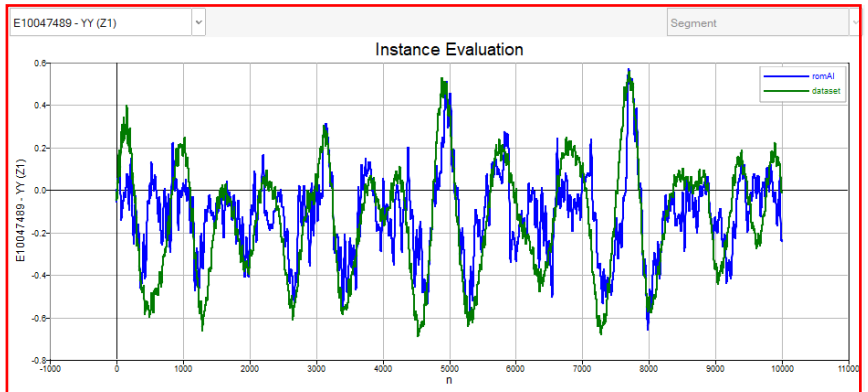
在车身四个减振塔加载xyz三方向实测加速度，通过romAI 获得车身后轮毂包附近局部应力，如右侧曲线所示无论是关注位置附近还是四个加载点加速度都可以比较好的预测局部应力。



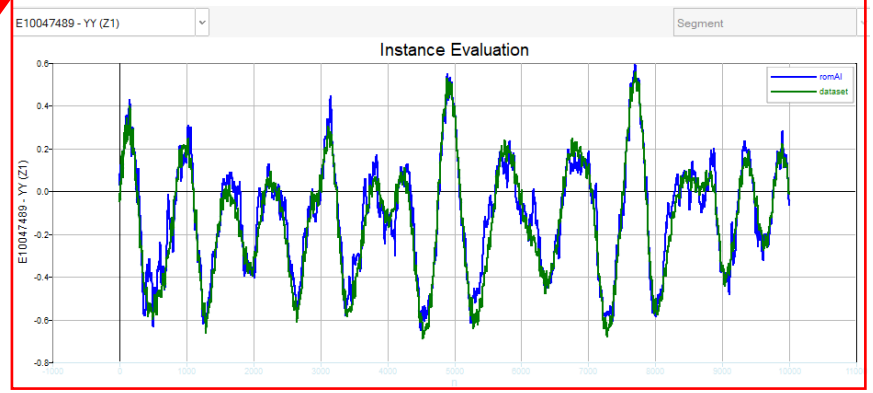




关注单元附近节点加速度



四个减振塔Z向加速度



四个减振塔xyz向加速度

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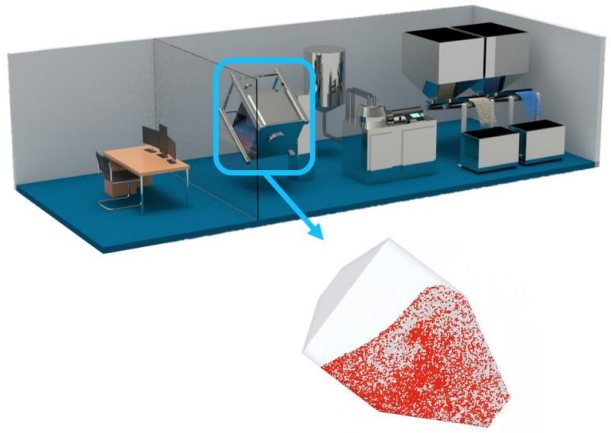
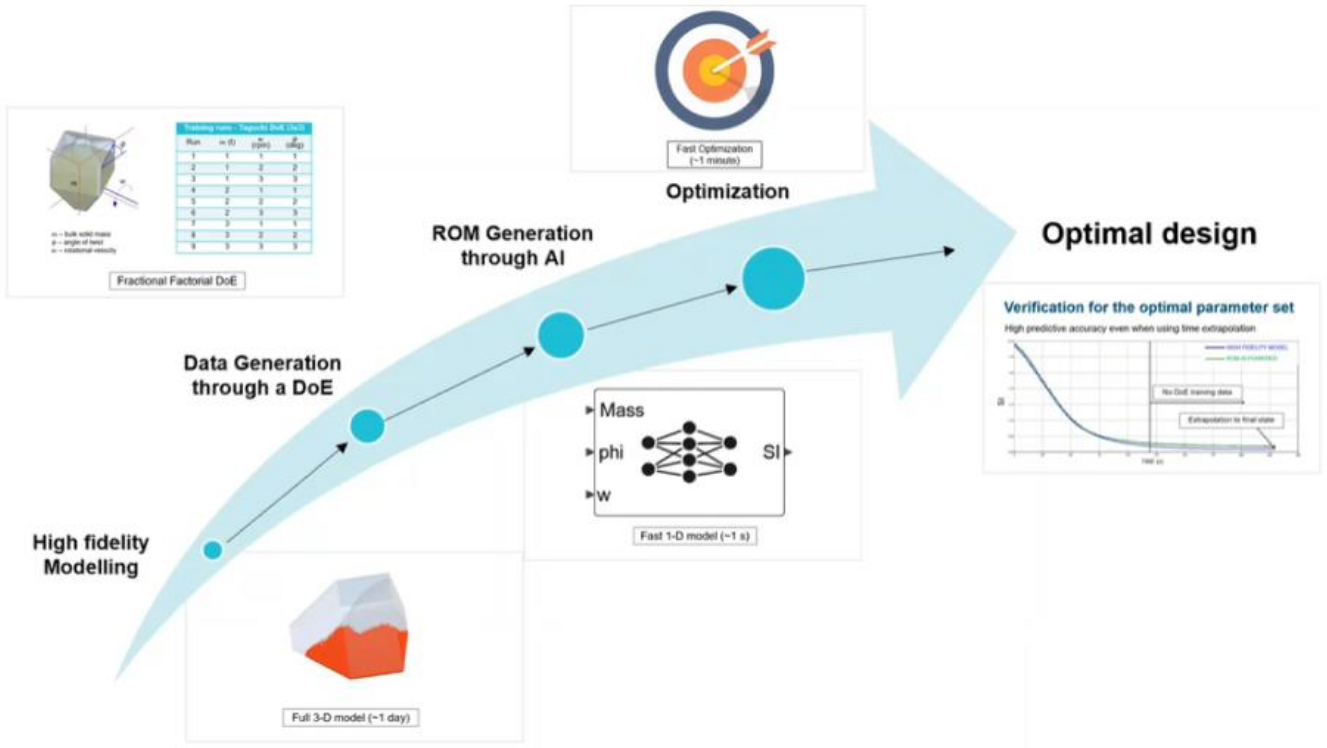
机器学习与CAE融合应用：基于romAI降阶建模加速优化设计



DIGITAL TWIN FOR DESIGN
OPTIMIZATION OF
BULK HANDLING PROCESSES



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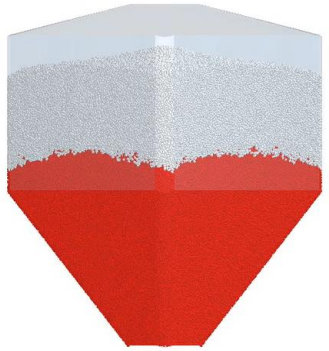
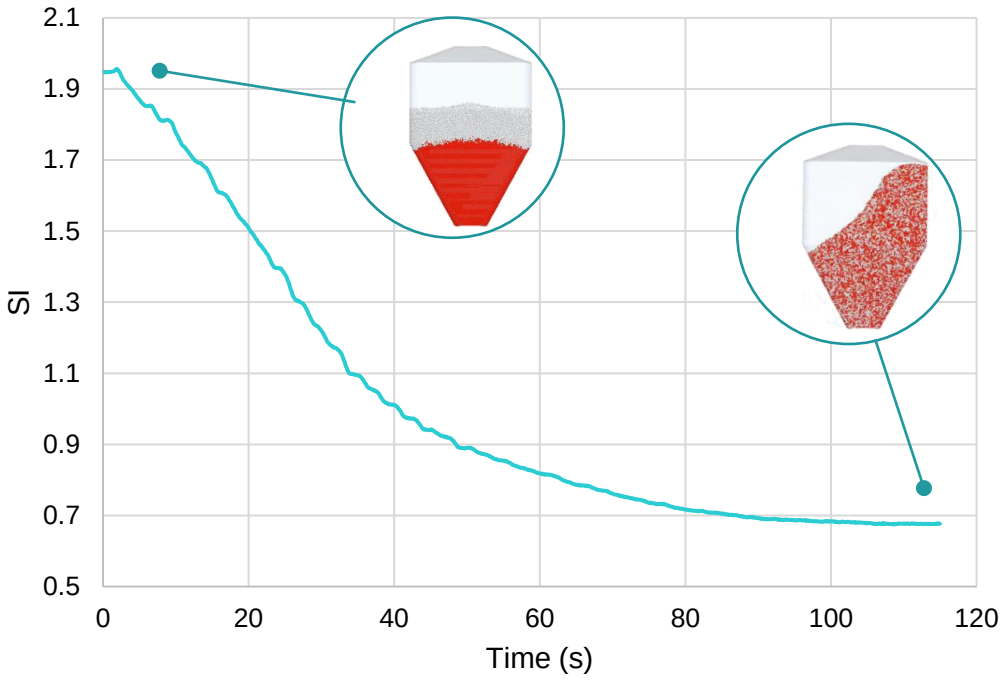
机器学习与CAE融合应用：基于romAI降阶建模加速优化设计

高精度CAE模型



高精度EDEM模型

→ 计算时间：1天



隔离指数（SI）：量化混合均匀度

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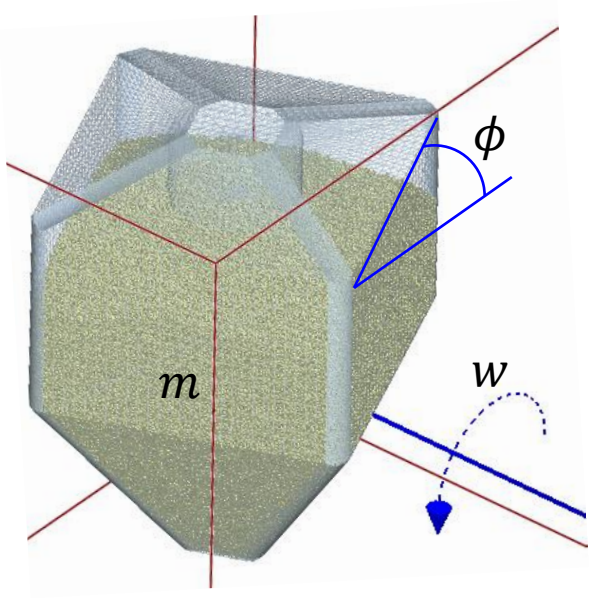
机器学习与CAE融合应用：基于romAI降阶建模加速优化设计

通过DOE生成数据

运行参数



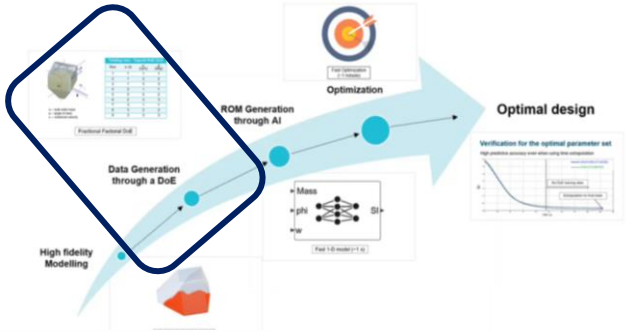
m – *颗粒质量*

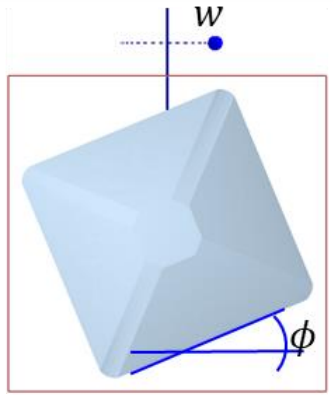
ϕ – *扭转角*

w – *旋转速度*

使用3 x 3 Taguchi DoE–仅占全因子设计的33%

Training runs - Taguchi DoE (3x3)			
Run	m (t)	w (rpm)	ϕ (deg)
1	1.6	8	0
2	1.6	12	22.5
3	1.6	16	45
4	2	8	0
5	2	12	22.5
6	2	16	45
7	2.4	8	0
8	2.4	12	22.5
9	2.4	16	45
Testing run – Random values			
Run	m (t)	w (rpm)	ϕ (deg)
10	2.24	14.7	34.4





$\phi = 22.5° \mid m = 2\ t$

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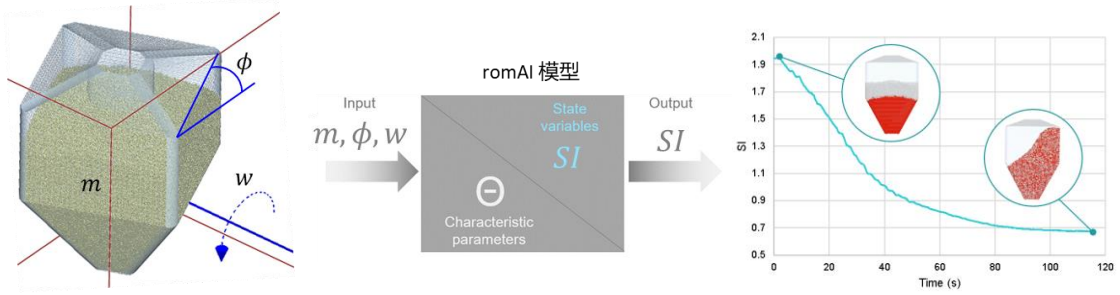
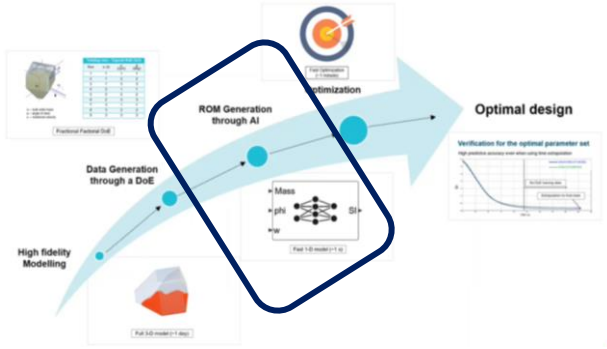
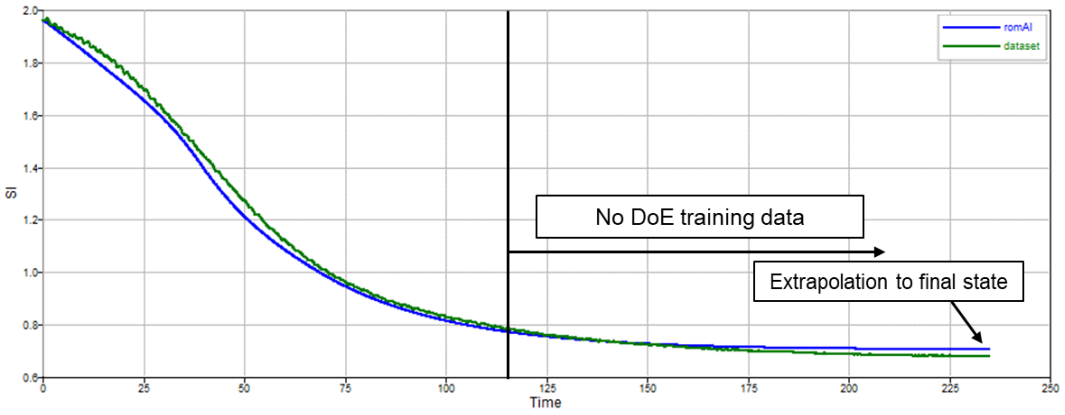
机器学习与CAE融合应用：基于romAI降阶建模加速优化设计

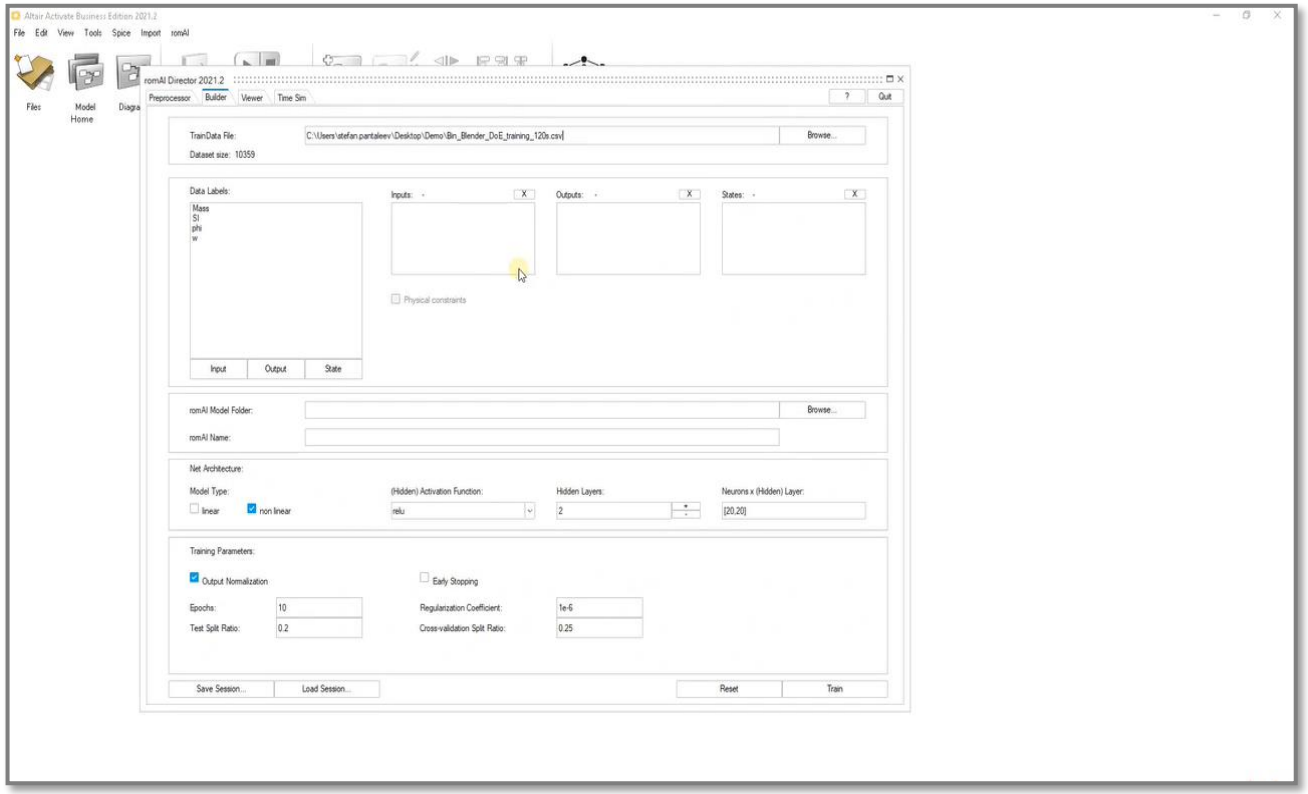
生成降阶模型





Testing run – Random values			
Run	m (kg)	w (rpm)	ϕ (deg)
10	2240	14.7	34.4





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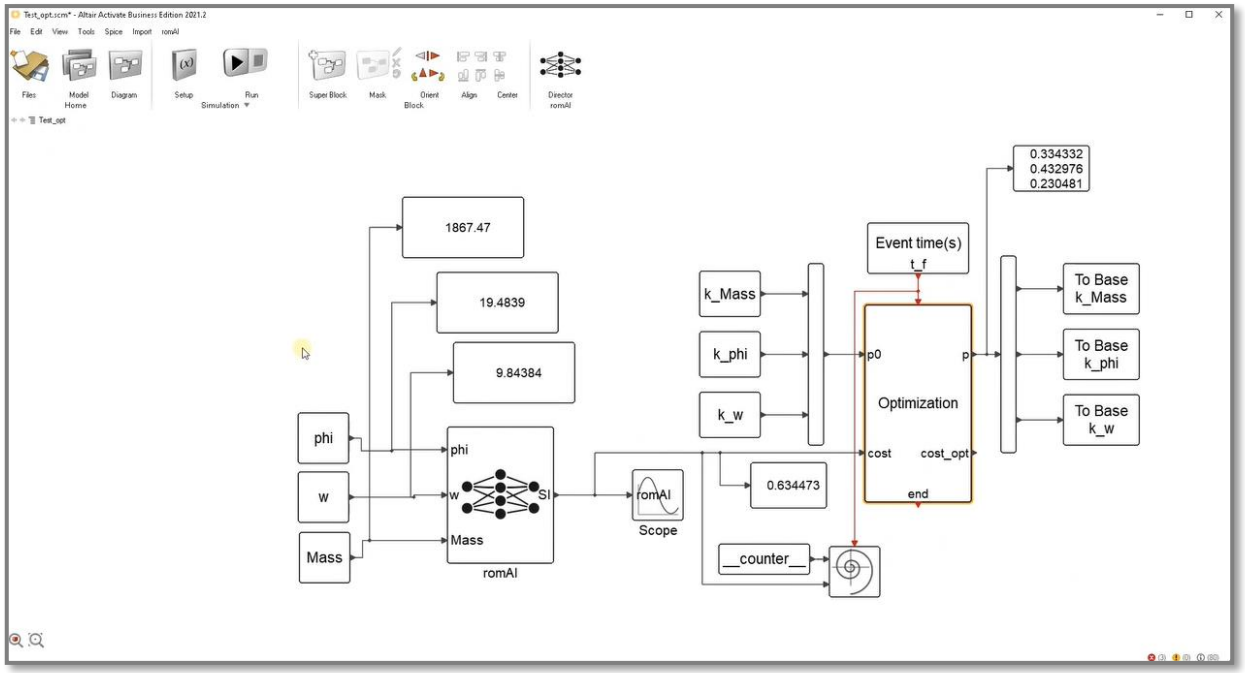
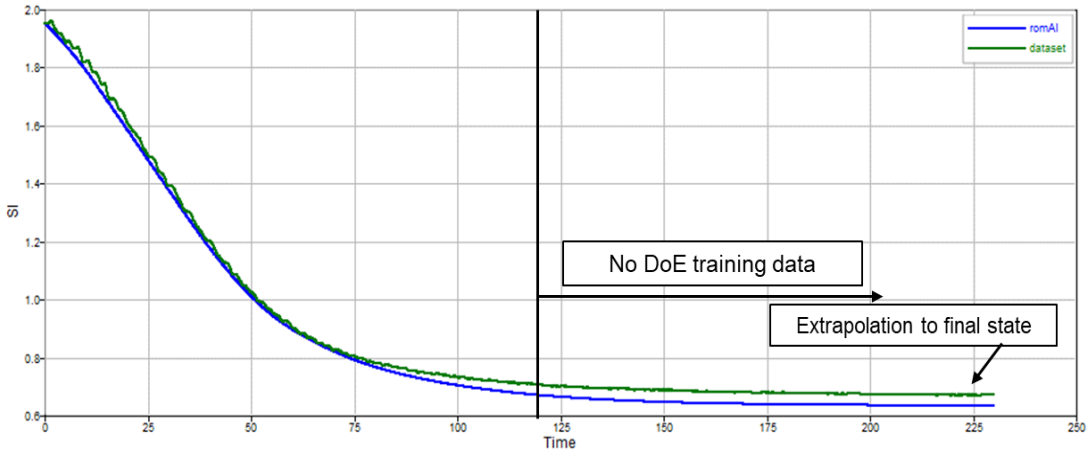
降阶模型用于优化分析

在几秒钟内（相比几个月）评估50种工况下的最终SI参数





基于降阶模型的优化参数精度验证

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THANK YOU

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