MATLAB EXPO

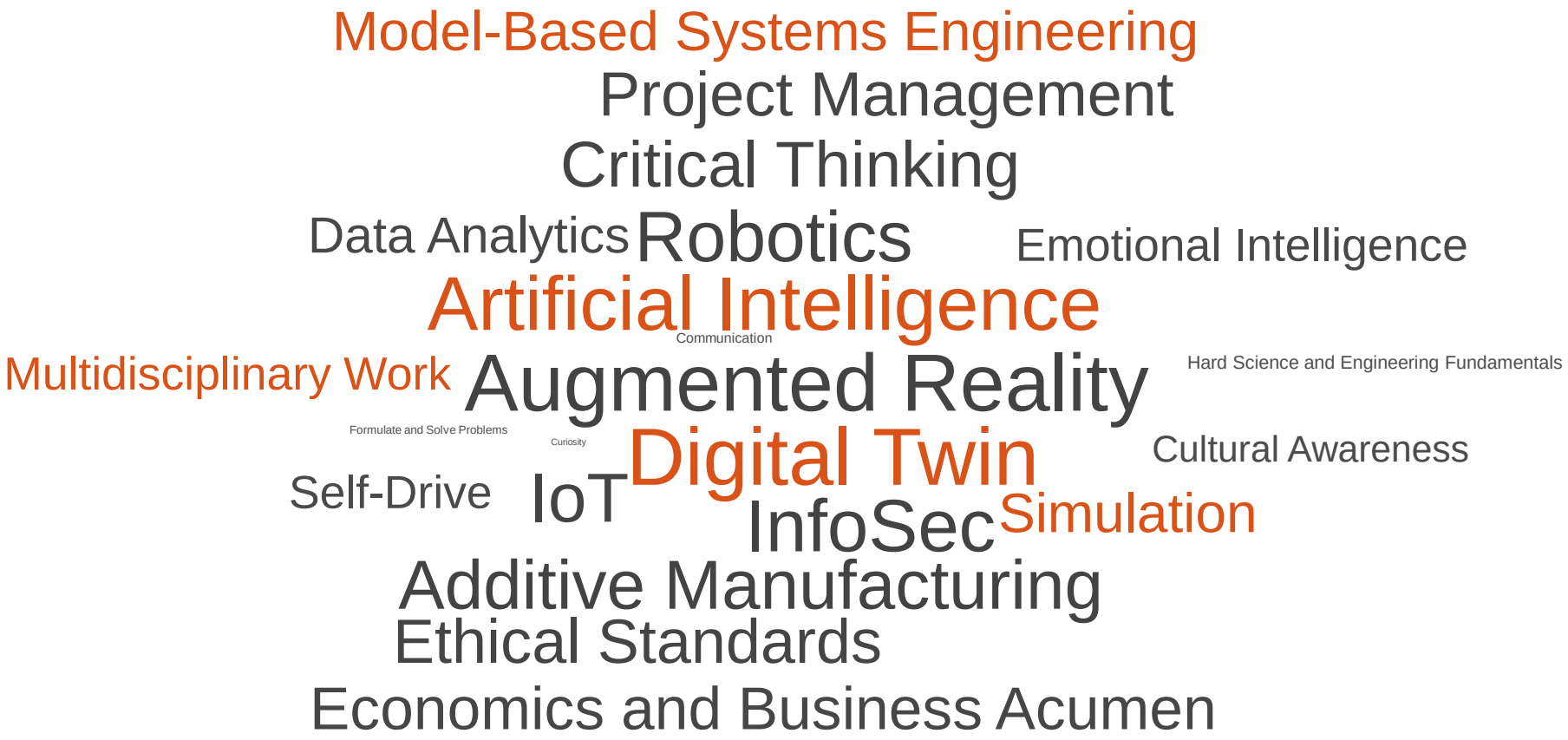
电气化、AI与工程教育的未来

阮卡佳
高校团队高级工程师

MathWorks®

2020 ASEE 工科毕业生的技能差距调查

系统思维 (80%)



https://monolith.asee.org/documents/cmc/2020-SURVEY-FOR-SKILLS-GAPS-IN-RECENT-ENGINEERING-GRADUATES.pdf

电气化技术革新

自主系统

工程教育与系统思维

电气化技术革新

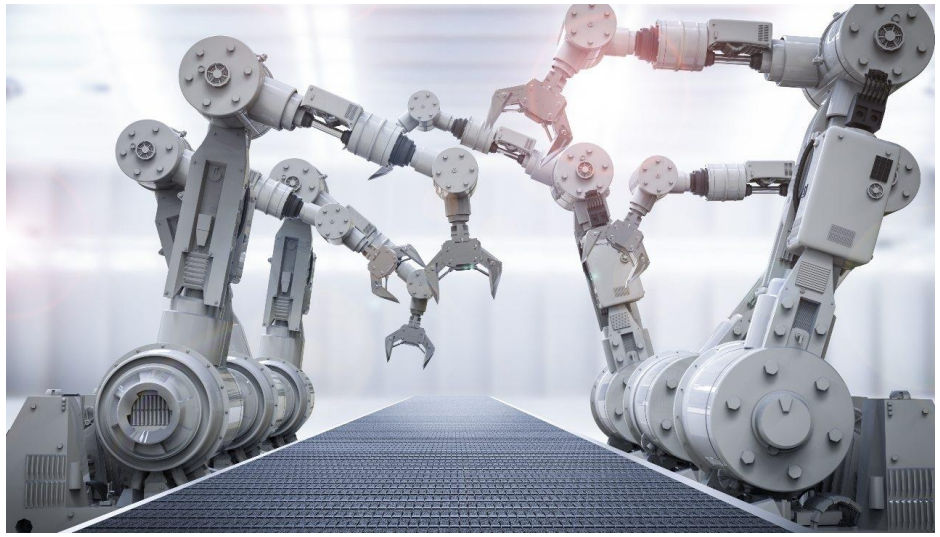
电气化技术革新

- 为什么正在发生？
- 工业界面临什么样的挑战？
- 工程师们是如何克服这些困难的？

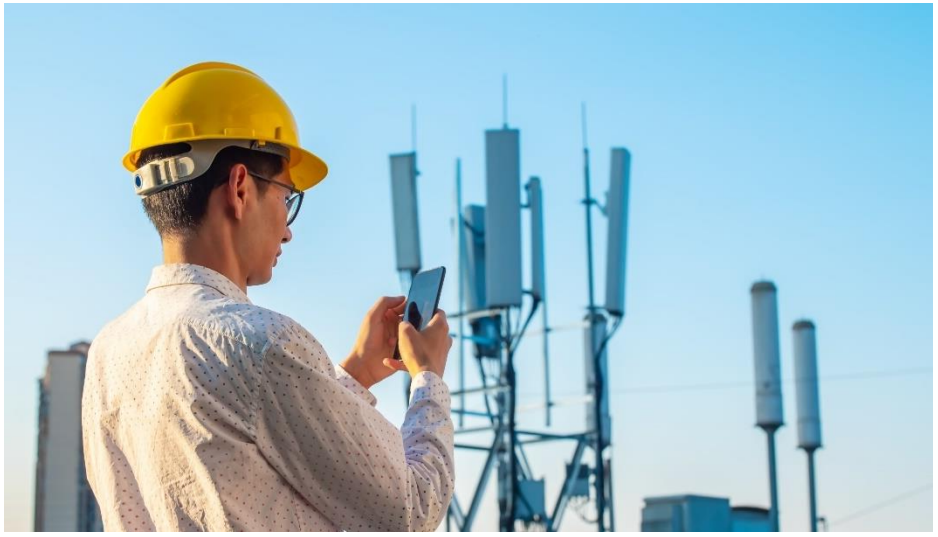
可再生能源

电动汽车

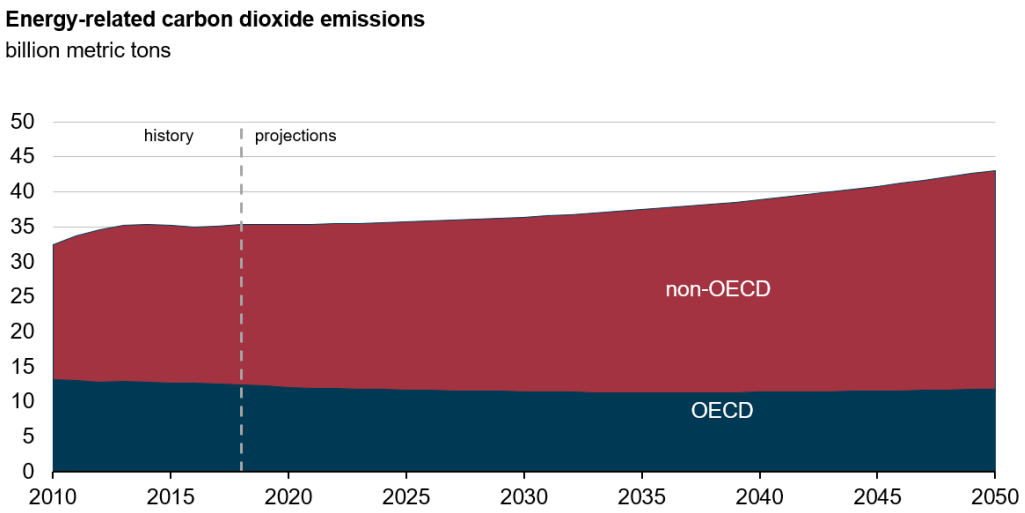
电机

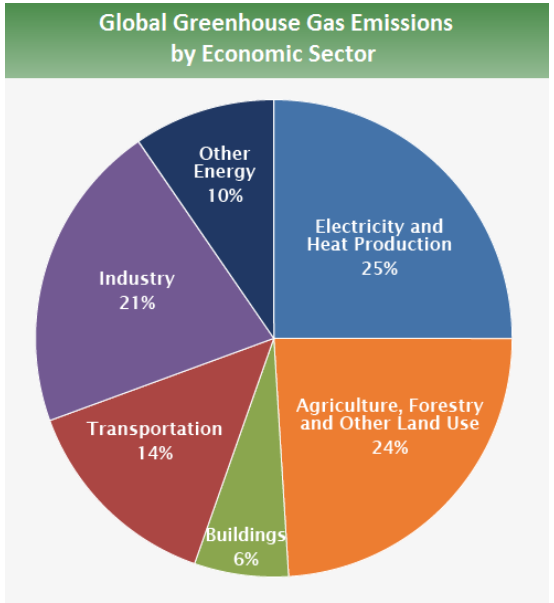


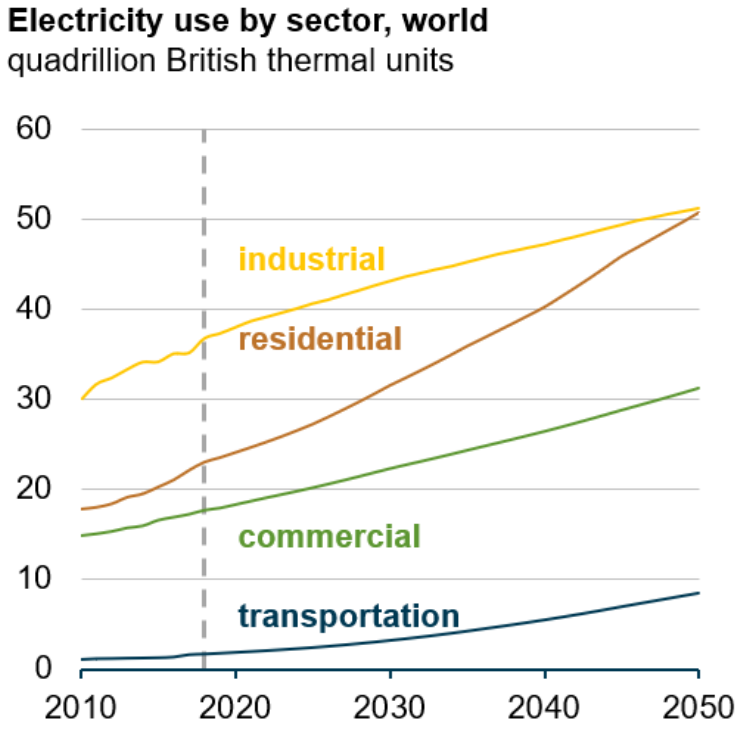
电子设备无处不在



气候变化与能源需求







OECD: [Organization for Economic Cooperation and Development]

International Energy Outlook 2019
https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf

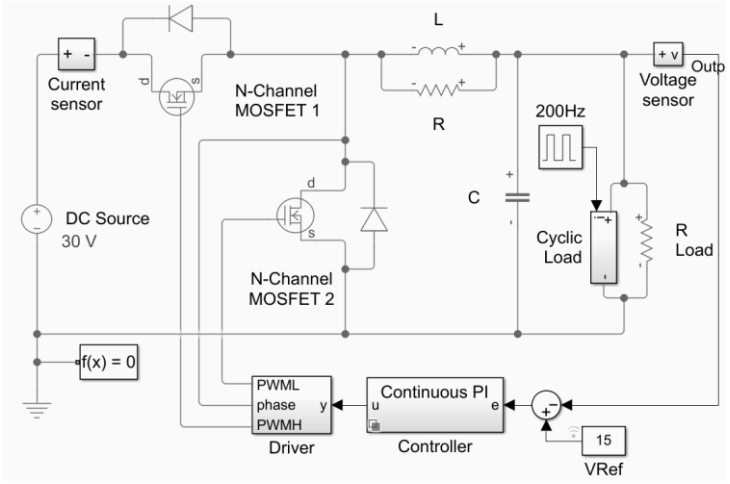
United States Environmental Protection Agency
https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Sector

International Energy Outlook 2019
https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf

电气化关键技术

电池

电力电子



电机控制

电气化的主要挑战

电池

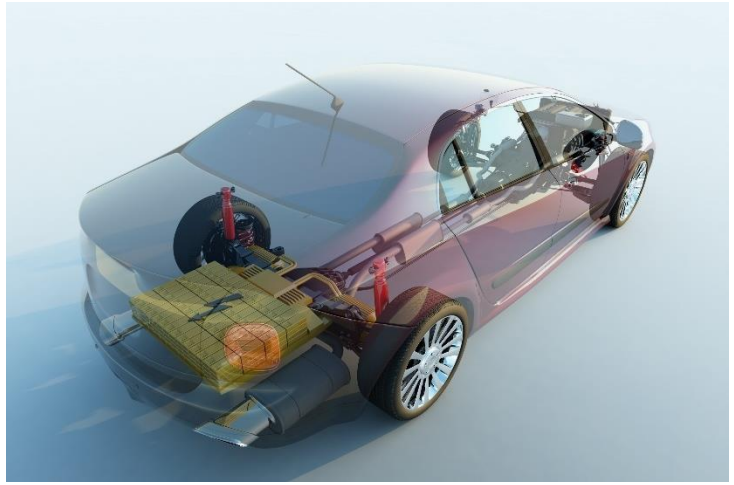
- 电池建模
- 安全操作
- 电池老化
- BMS开发

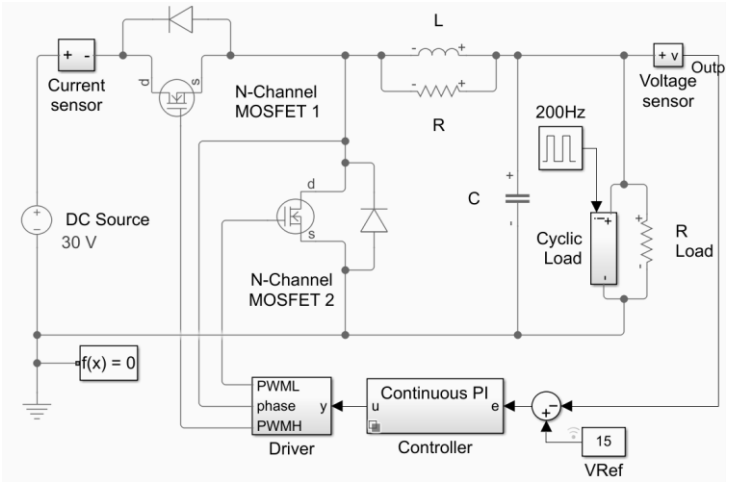
电力电子

- 动态仿真
- 数字控制
- 调度控制
- 快速原型

电机控制

- 传感器校准
- 参数估计
- 高效的算法
- 控制器调优



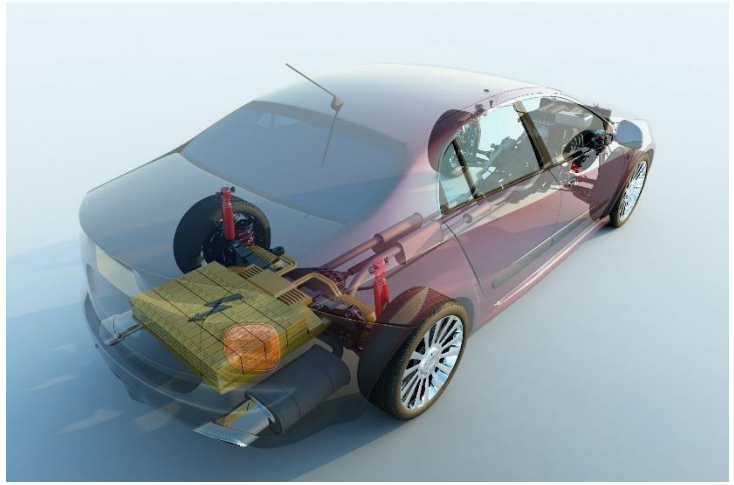



Lightyear One
世界上第一辆太阳能汽车
一次充电可行驶450英里
从学生竞赛到初创公司
LIGHTYEAR
NL 19-LYR-1

电气化的主要挑战

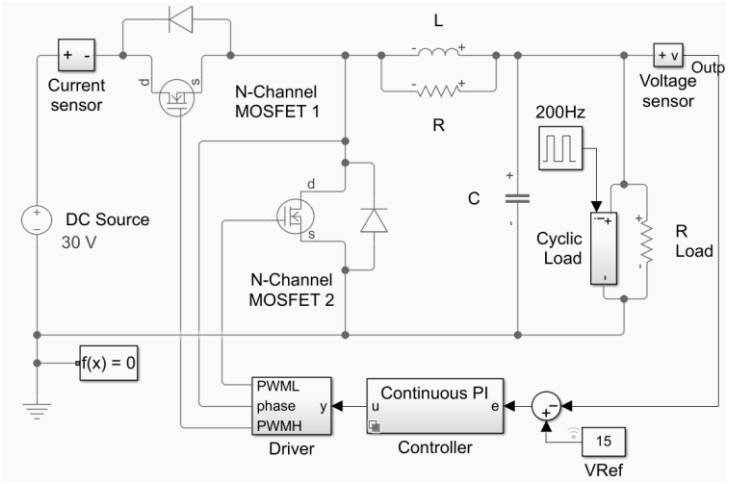
电池技术

- 电池建模
- 安全操作
- 电池老化
- BMS开发



电力电子技术

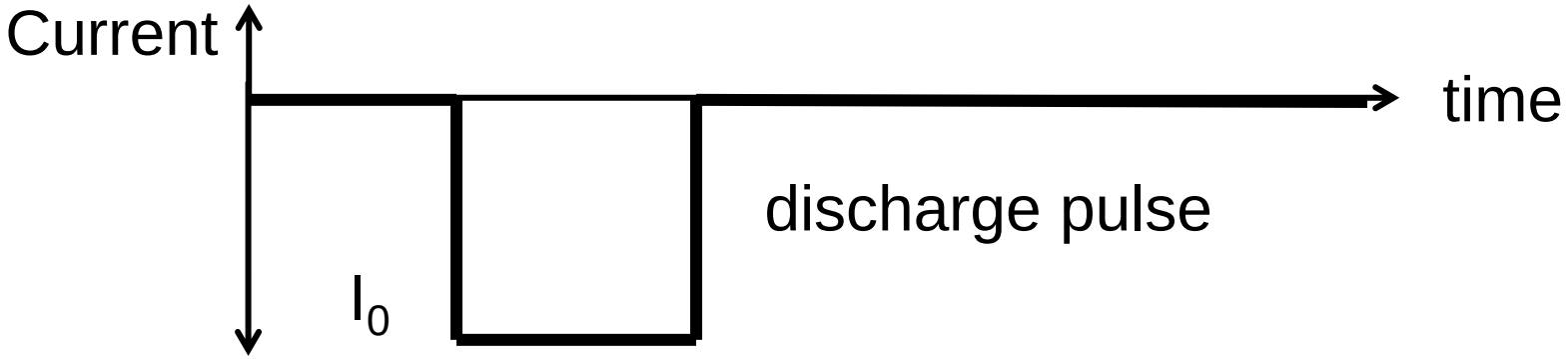
- 动态仿真
- 数字控制
- 调度控制
- 快速原型

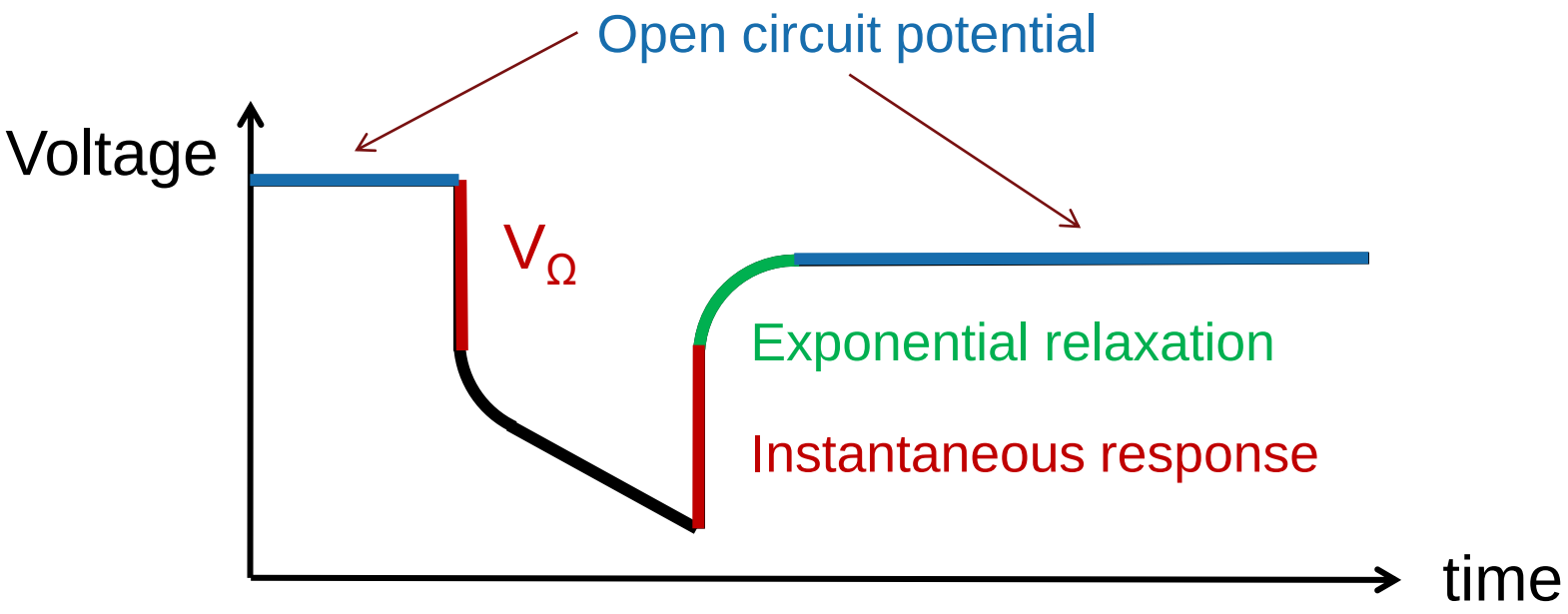


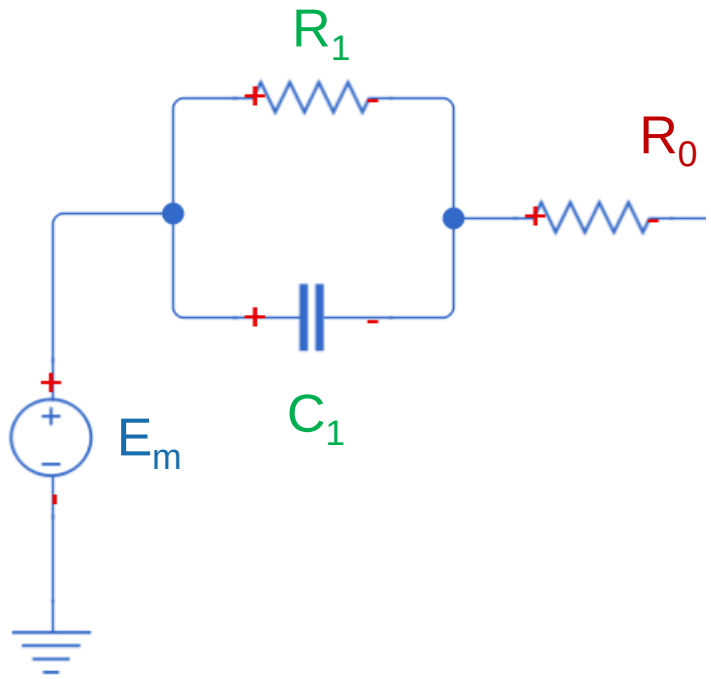
电机控制技术

- 传感器校准
- 参数估计
- 高效的算法
- 控制器调优

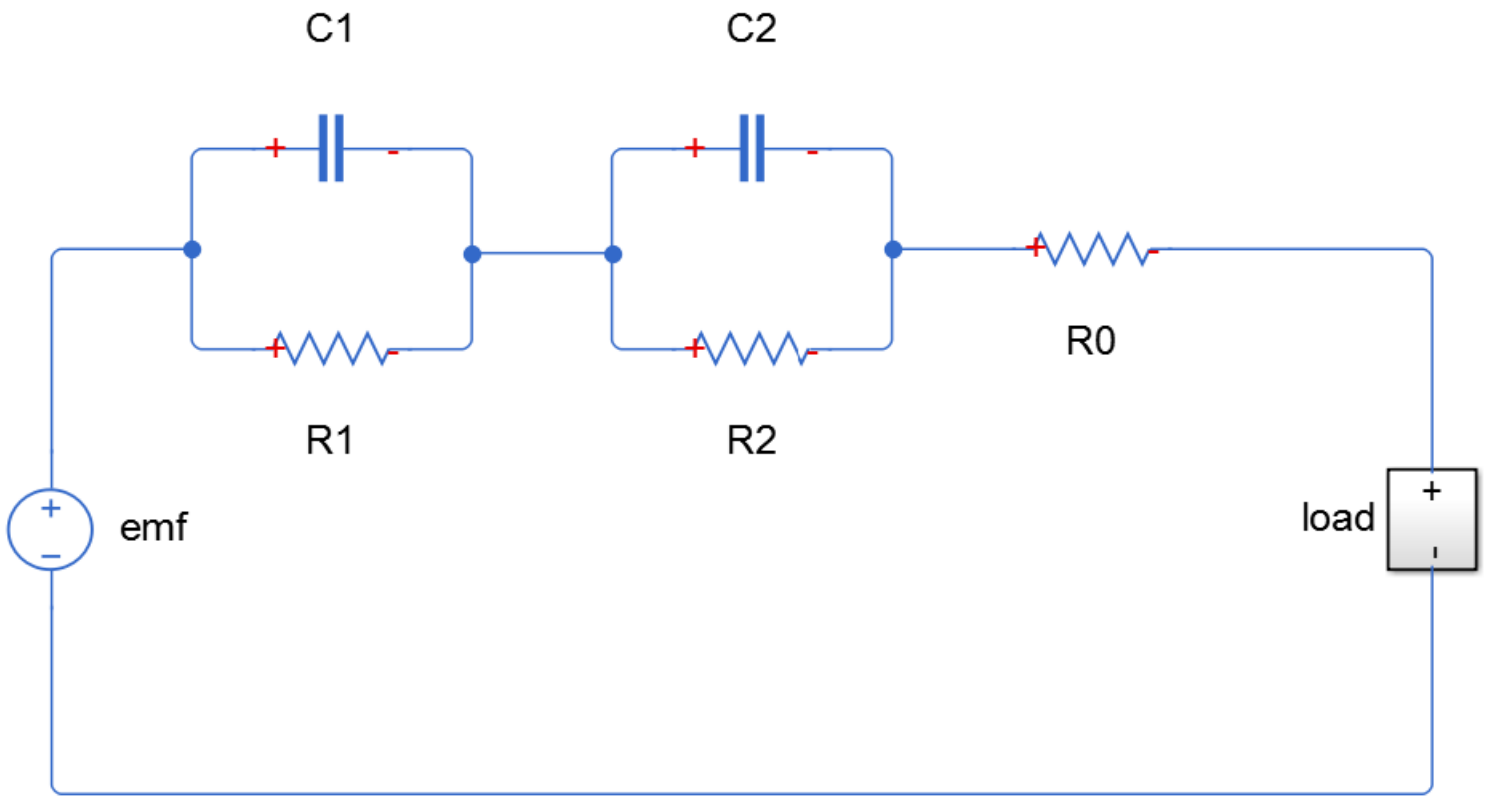
锂离子电池建模

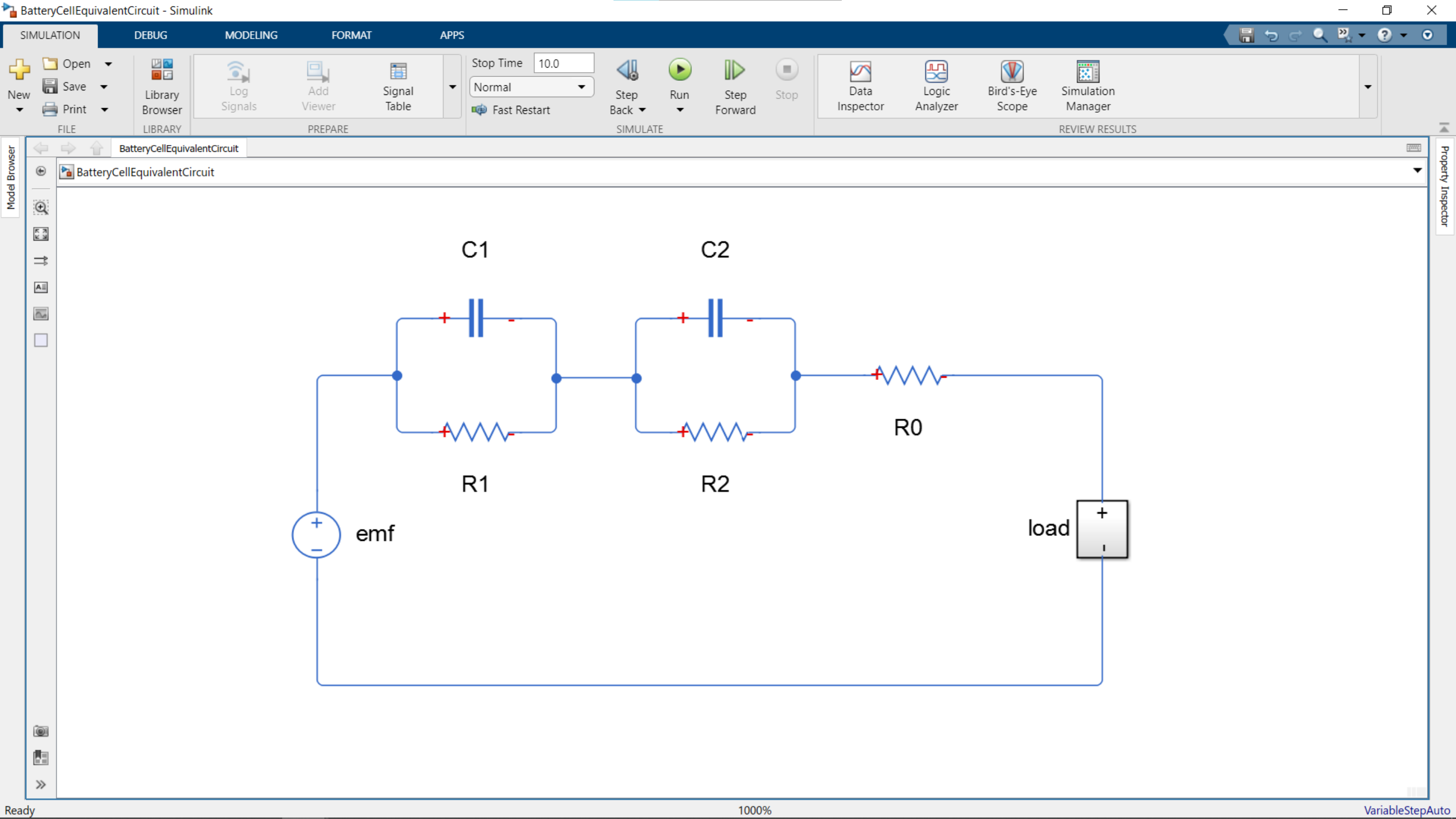

Current
time
discharge pulse
I_0

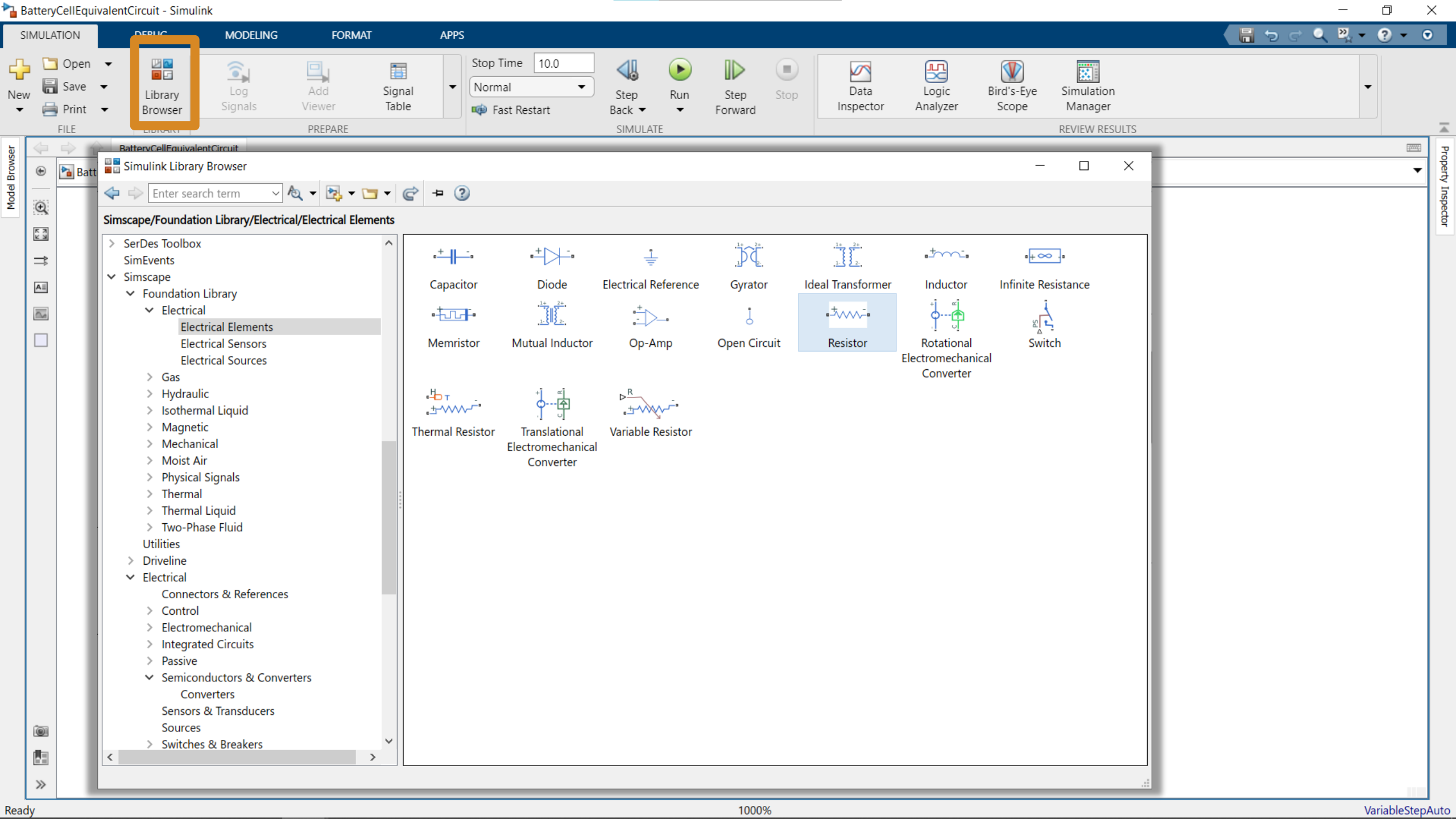

Open circuit potential
Voltage
V_Ω
Exponential relaxation
Instantaneous response
time

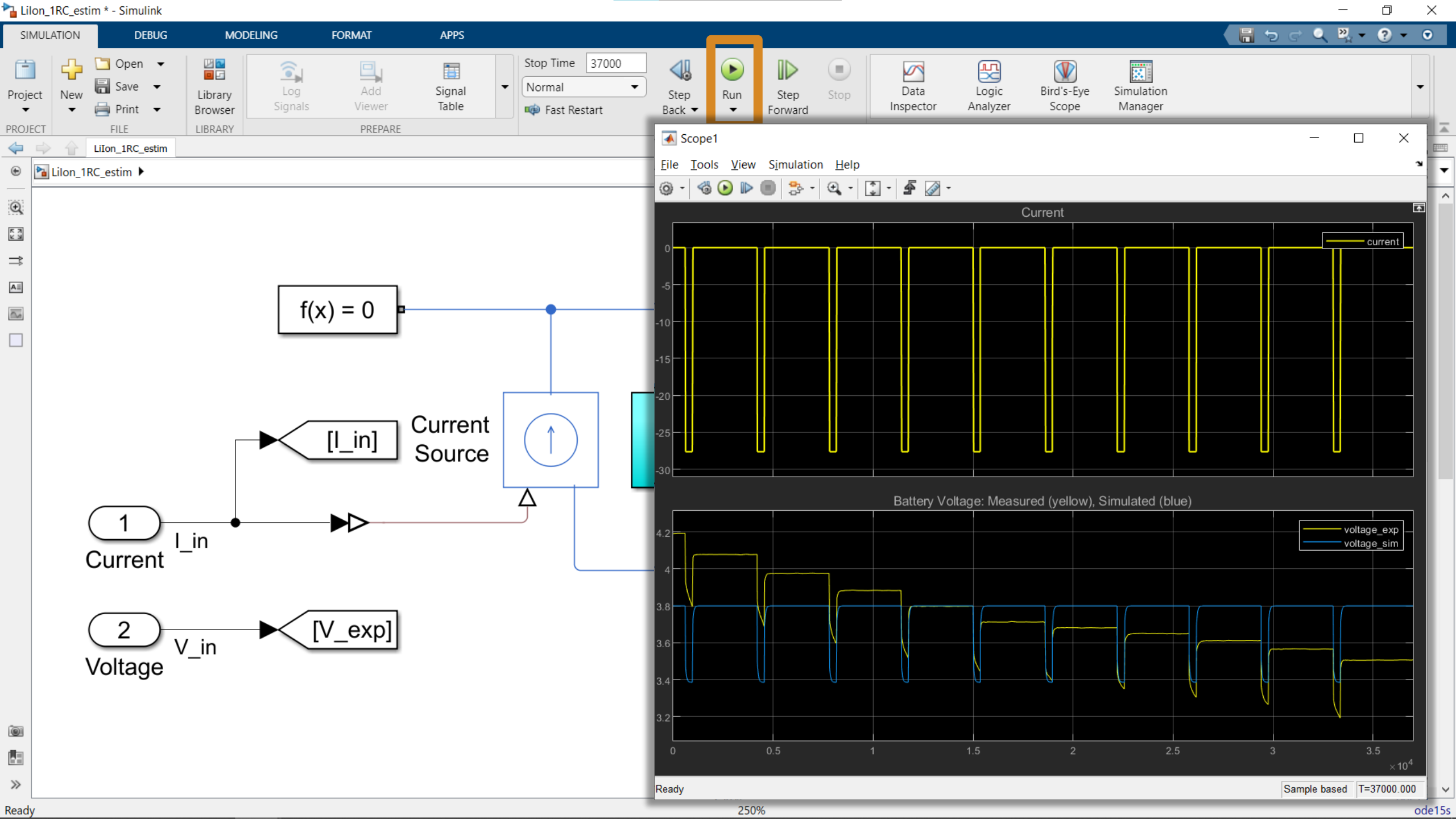

R_1
R_0
E_m
C_1

等效电路



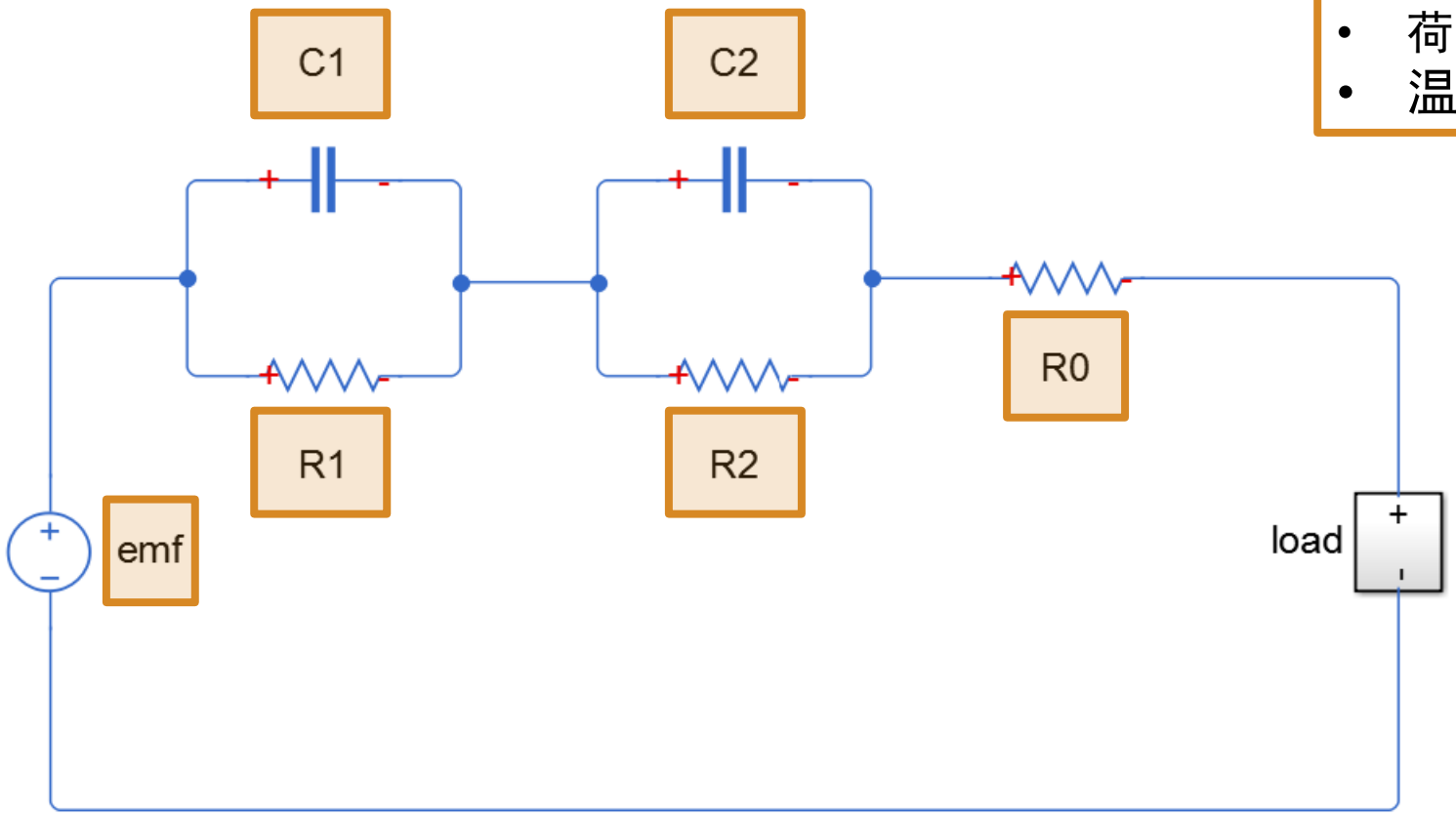

BatteryCellEquivalentCircuit - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
New
Open
Save
Print
FILE
Library Browser
LIBRARY
Log Signals
Add Viewer
Signal Table
PREPARE
Stop Time
10.0
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
REVIEW RESULTS
Model Browser
Property Inspector
BatteryCellEquivalentCircuit
C1
C2
R0
R1
R2
emf
load
Ready
1000%
VariableStepAuto

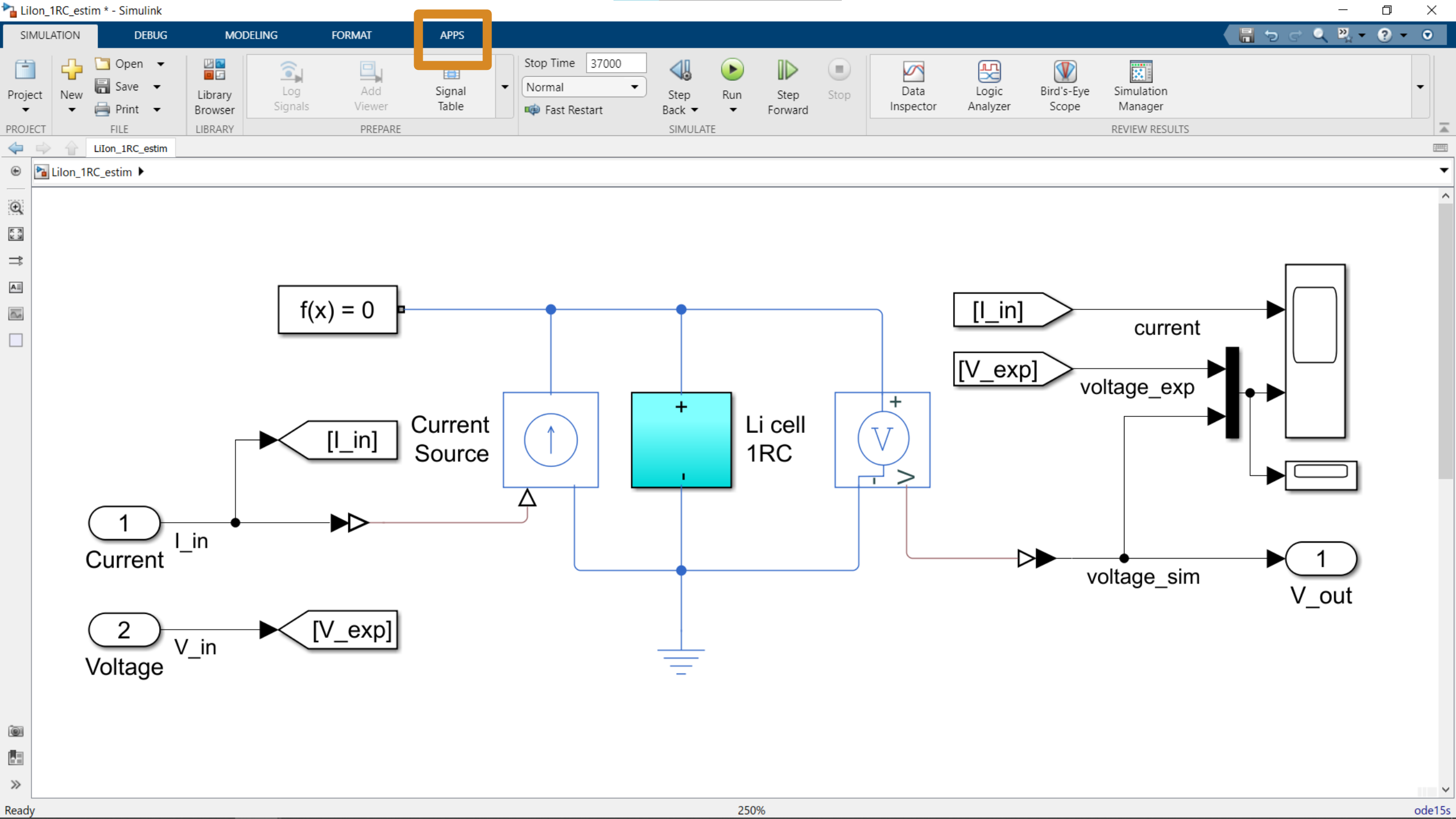

BatteryCellEquivalentCircuit - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
New
Open
Save
Print
FILE
Library Browser
LIBRARY
Log Signals
Add Viewer
Signal Table
PREPARE
Stop Time
10.0
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
REVIEW RESULTS
Model Browser
Property Inspector
Simulink Library Browser
Enter search term
Simscape/Foundation Library/Electrical/Electrical Elements
SerDes Toolbox
SimEvents
Simscape
Foundation Library
Electrical
Electrical Elements
Electrical Sensors
Electrical Sources
Gas
Hydraulic
Isothermal Liquid
Magnetic
Mechanical
Moist Air
Physical Signals
Thermal
Thermal Liquid
Two-Phase Fluid
Utilities
Driveline
Electrical
Connectors & References
Control
Electromechanical
Integrated Circuits
Passive
Semiconductors & Converters
Converters
Sensors & Transducers
Sources
Switches & Breakers
Capacitor
Diode
Electrical Reference
Gyrator
Ideal Transformer
Inductor
Infinite Resistance
Memristor
Mutual Inductor
Op-Amp
Open Circuit
Resistor
Rotational Electromechanical Converter
Switch
Thermal Resistor
Translational Electromechanical Converter
Variable Resistor
Ready
1000%
VariableStepAuto

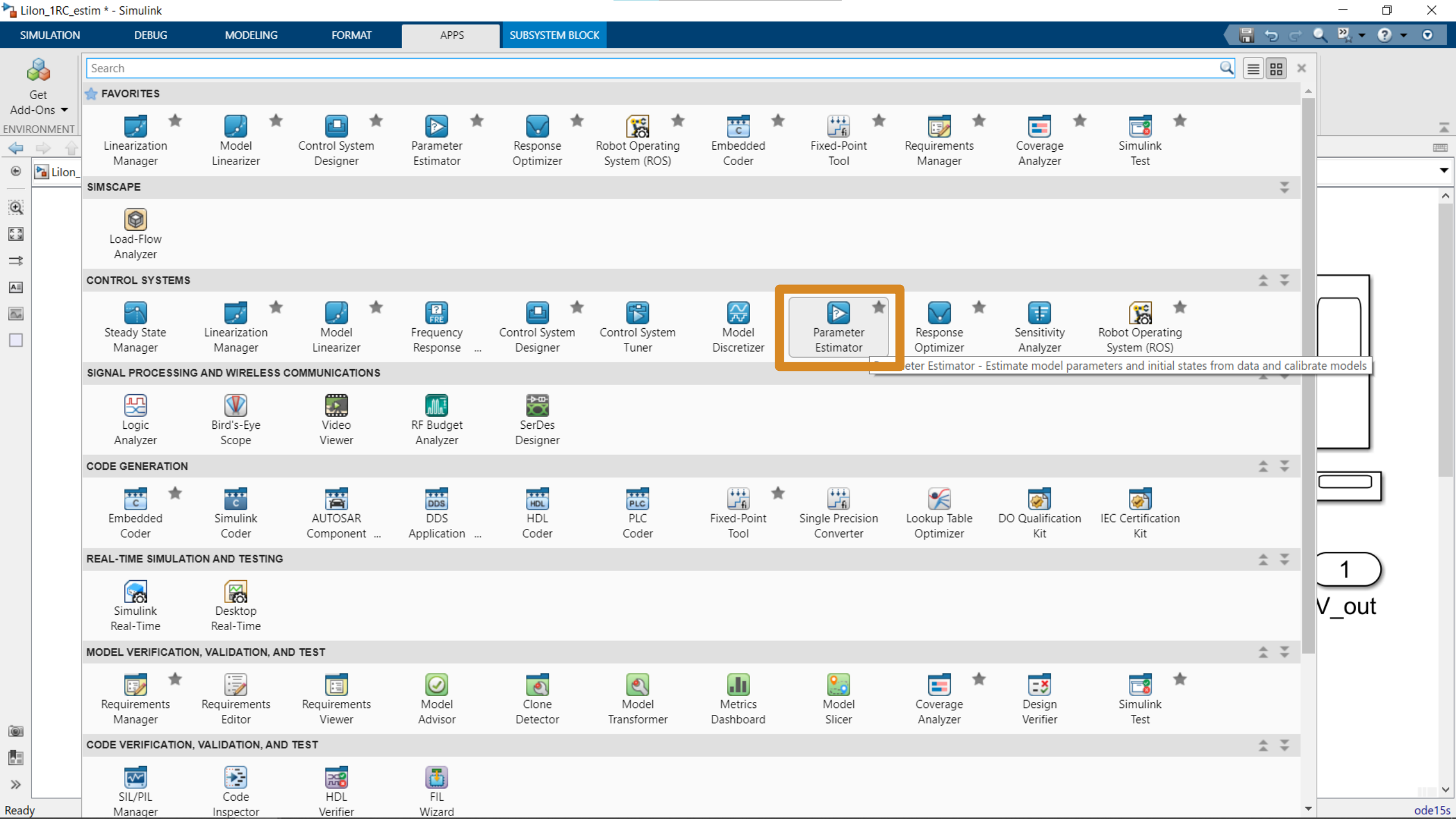

LiIon_1RC_estim * - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Project
New
Open
Save
Print
Library Browser
Log Signals
Add Viewer
Signal Table
Stop Time
37000
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
LiIon_1RC_estim
f(x) = 0
[I_in]
Current Source
1
I_in
Current
2
V_in
Voltage
[V_exp]
Scope1
File
Tools
View
Simulation
Help
Current
current
Battery Voltage: Measured (yellow), Simulated (blue)
voltage_exp
voltage_sim
Ready
Sample based
T=37000.000
Ready
250%
ode15s

等效电路参数

查找矩阵
- 荷电状态
- 温度




LiIon_1RC_estim * - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Project
New
Open
Save
Print
Library Browser
Log Signals
Add Viewer
Signal Table
Stop Time
37000
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
PROJECT
FILE
LIBRARY
PREPARE
SIMULATE
REVIEW RESULTS
LiIon_1RC_estim
Lilon_1RC_estim
f(x) = 0
[I_in]
Current Source
Li cell 1RC
1
Current
I_in
2
Voltage
V_in
[V_exp]
[I_in]
current
[V_exp]
voltage_exp
voltage_sim
1
V_out
Ready
250%
ode15s


LiIon_1RC_estim * - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
SUBSYSTEM BLOCK
Get Add-Ons
ENVIRONMENT
Search
FAVORITES
Linearization Manager
Model Linearizer
Control System Designer
Parameter Estimator
Response Optimizer
Robot Operating System (ROS)
Embedded Coder
Fixed-Point Tool
Requirements Manager
Coverage Analyzer
Simulink Test
SIMSCAPE
Load-Flow Analyzer
CONTROL SYSTEMS
Steady State Manager
Linearization Manager
Model Linearizer
Frequency Response ...
Control System Designer
Control System Tuner
Model Discretizer
Parameter Estimator
Response Optimizer
Sensitivity Analyzer
Robot Operating System (ROS)
eter Estimator - Estimate model parameters and initial states from data and calibrate models
SIGNAL PROCESSING AND WIRELESS COMMUNICATIONS
Logic Analyzer
Bird's-Eye Scope
Video Viewer
RF Budget Analyzer
SerDes Designer
CODE GENERATION
Embedded Coder
Simulink Coder
AUTOSAR Component ...
DDS Application ...
HDL Coder
PLC Coder
Fixed-Point Tool
Single Precision Converter
Lookup Table Optimizer
DO Qualification Kit
IEC Certification Kit
REAL-TIME SIMULATION AND TESTING
Simulink Real-Time
Desktop Real-Time
MODEL VERIFICATION, VALIDATION, AND TEST
Requirements Manager
Requirements Editor
Requirements Viewer
Model Advisor
Clone Detector
Model Transformer
Metrics Dashboard
Model Slicer
Coverage Analyzer
Design Verifier
Simulink Test
CODE VERIFICATION, VALIDATION, AND TEST
SIL/PIL Manager
Code Inspector
HDL Verifier
FIL Wizard
1
V_out
Ready
ode15s

Parameter Estimation - Lilon_1RC_T_estim - EstimatedParams

PARAMETER ESTIMATION | VALIDATION | ITERATION PLOT | VIEW

Open Session | Save Session | New Experiment | Select Experiments | Select Parameters | Sensitivity Analysis | Add Plot | Plot Model Response | Cost Function: Sum Squared Error | More Options | Stop Estimation

FILE | EXPERIMENTS | PARAMETERS | PLOTS | OPTIONS | ESTIMATE

Data Browser

Parameters

C1
Em
R0
R1

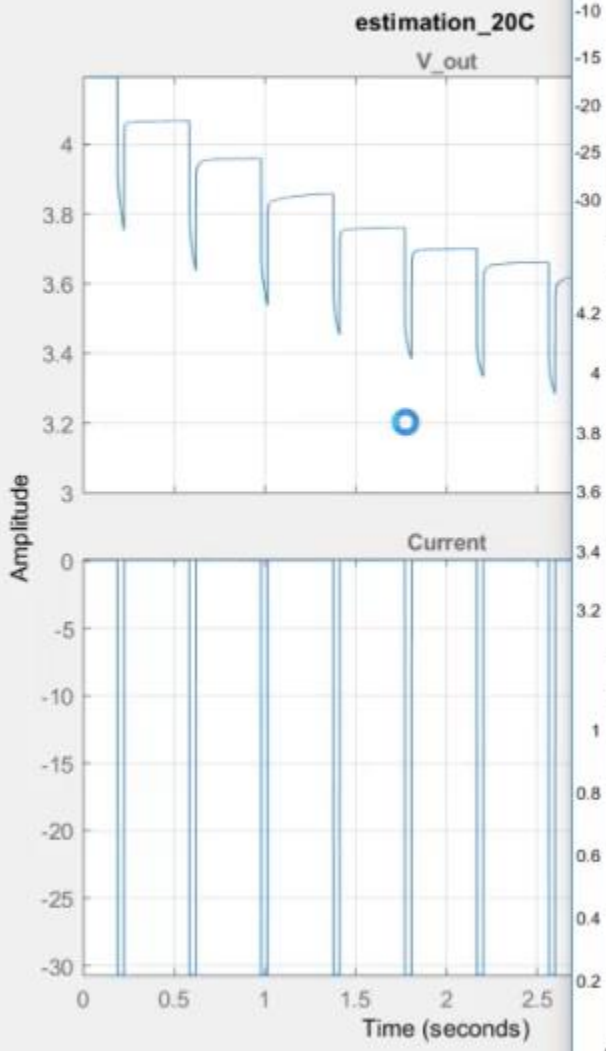
Experiments

estimation_20C
estimation_40C
estimation_5C
validation_20C

Results

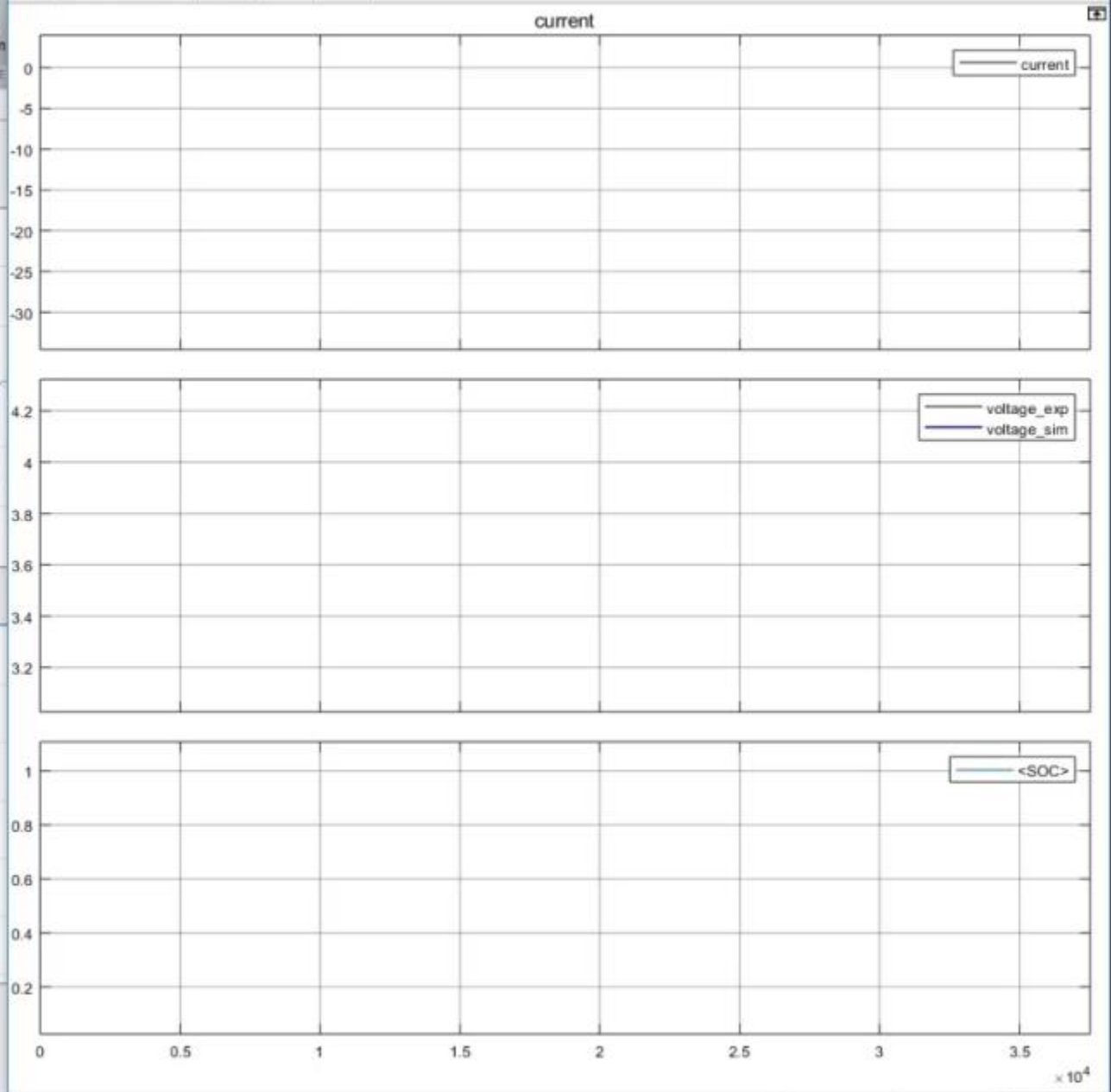
Preview

Experiment plot: estimation_20C



Scope

File Tools View Simulation Help



Running | Sample based | Offset=0 | T=37520.000

Parameter Estimation* - Lilon_1RC_T_estim - EstimatedParams

PARAMETER ESTIMATION | VALIDATION | ITERATION PLOT | VIEW

sandbox B battery C clean

Open Session | Save Session | New Experiment | Select Experiments | Select Parameters | Sensitivity Analysis | Add Plot | Plot Model Response | Cost Function: Sum Squared Error | More Options | Estimate

FILE | EXPERIMENTS | PARAMETERS | PLOTS | OPTIONS | ESTIMATE

Data Browser

Parameters

C1
Em
R0
R1

Experiments

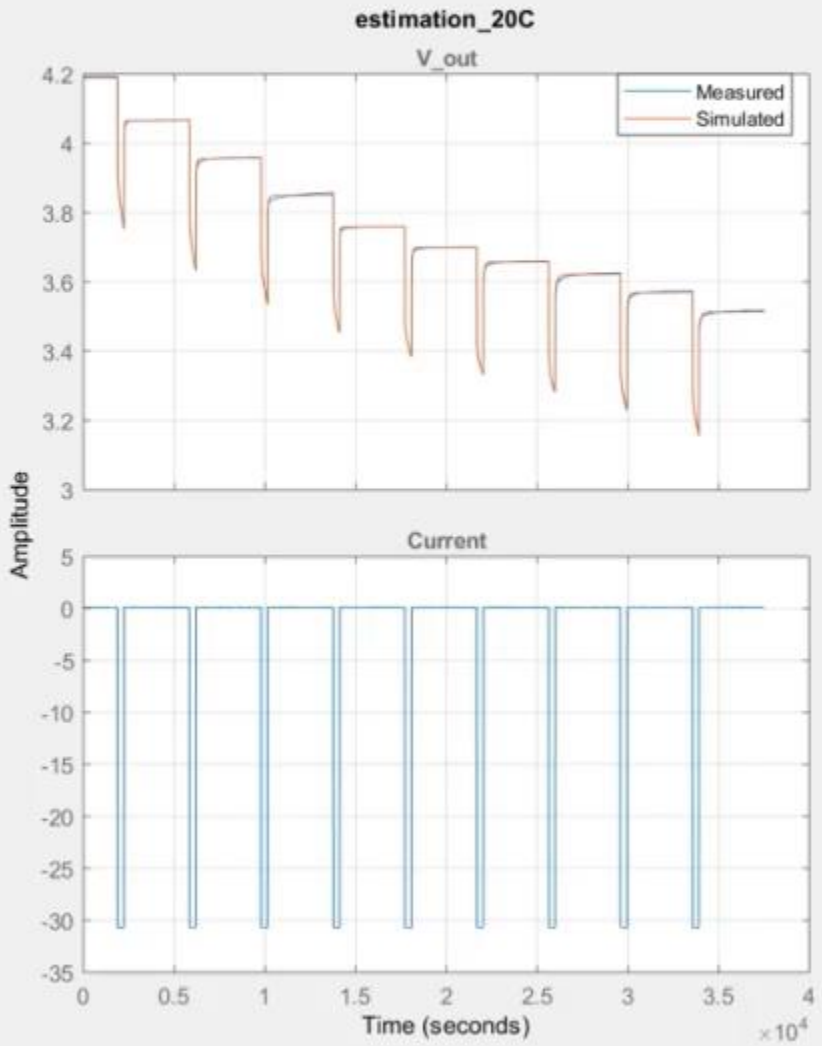
estimation_20C
estimation_40C
estimation_5C
validation_20C

Results

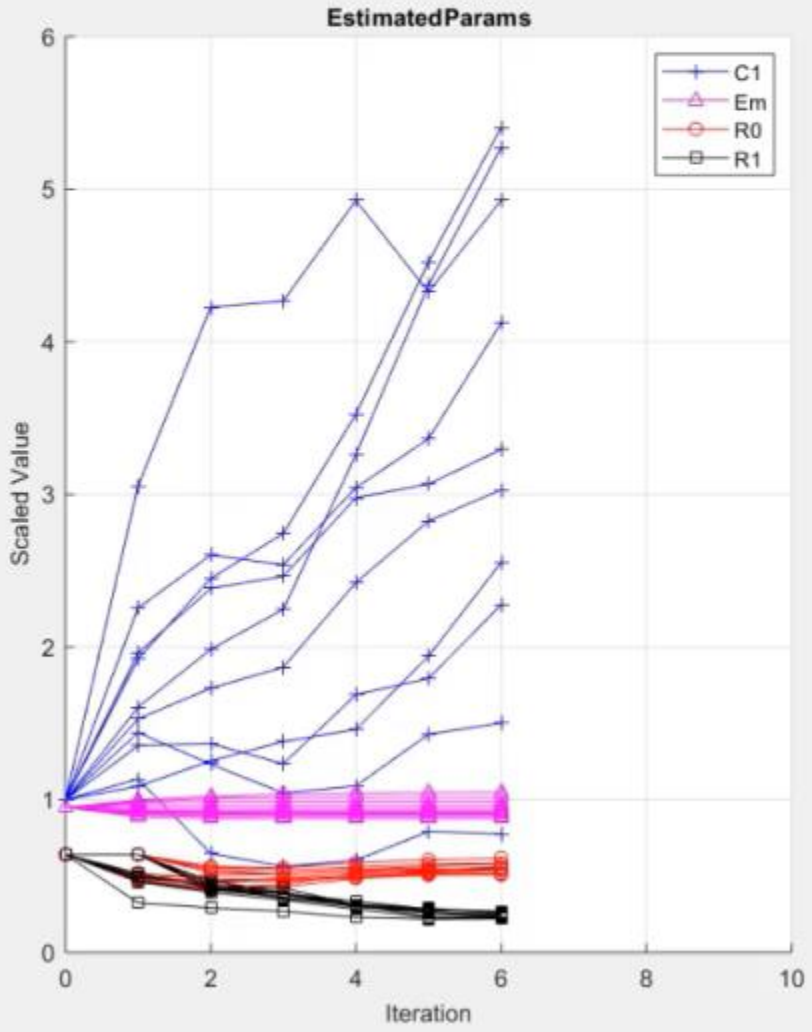
EstimatedParams

Preview

Experiment plot: estimation_20C



EstimatedParams



ssc_battery_charge_balance_3RC/Battery * - Simulink

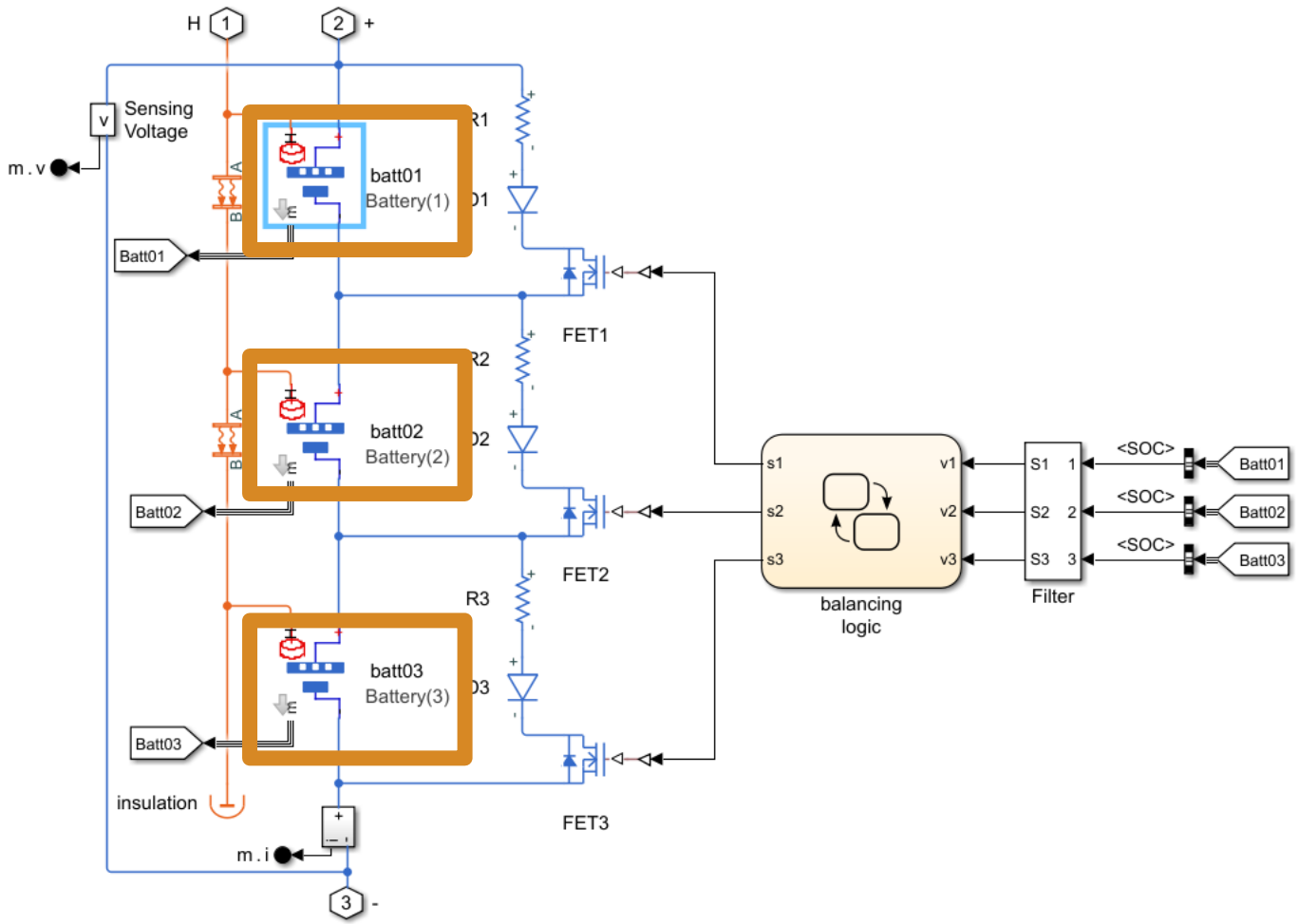
SIMULATION DEBUG MODELING FORMAT APPS BLOCK

Project New Open Save Print Library Browser Log Signals Log Events Add Viewer Stop Time 3600 * 4 Normal Fast Restart Step Back Run Step Forward Stop Data Inspector Sequence Viewer Logic Analyzer Bird's-Eye Scope Simulation Manager Simscape Results ...

PROJECT FILE LIBRARY PREPARE SIMULATE REVIEW RESULTS

Battery

ssc_battery_charge_balance_3RC ▸ Battery ▸



Ready 101% ode23t

ssc_battery_charge_balance_3RC/Battery * - Simulink

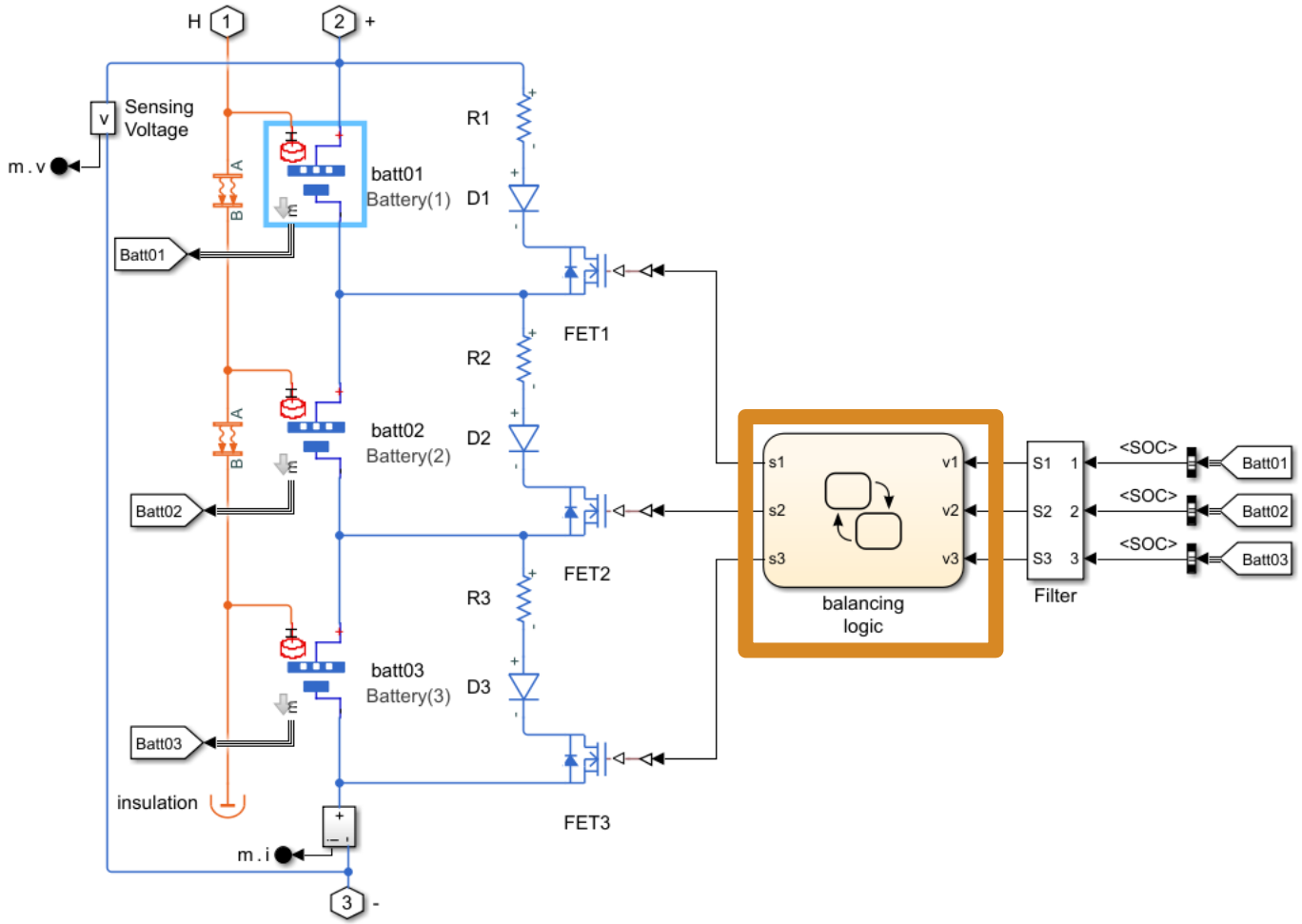
SIMULATION DEBUG MODELING FORMAT APPS BLOCK

Project New Open Save Print Library Browser Log Signals Log Events Add Viewer Stop Time 3600 * 4 Normal Fast Restart Step Back Run Step Forward Stop Data Inspector Sequence Viewer Logic Analyzer Bird's-Eye Scope Simulation Manager Simscape Results ...

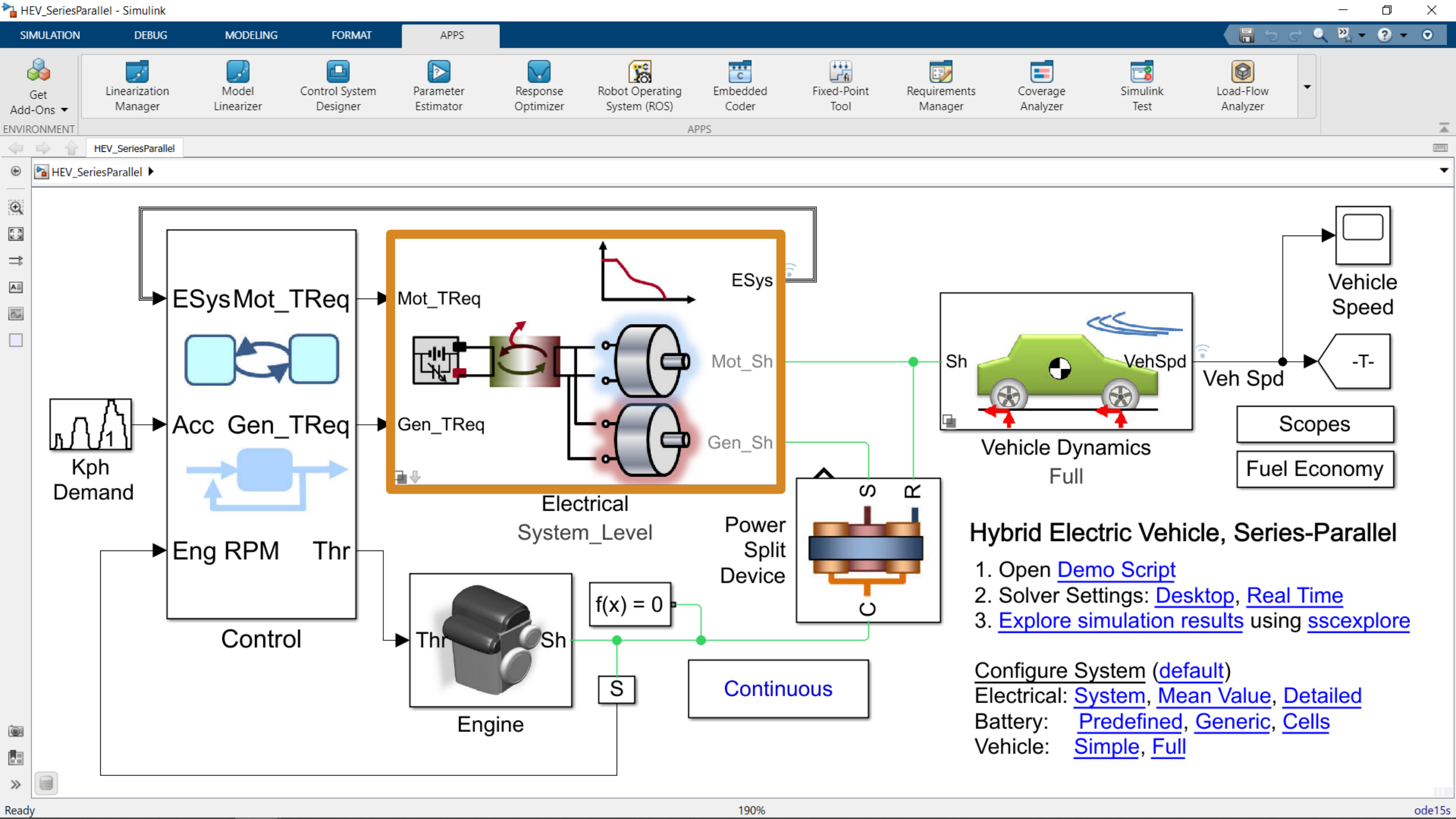
PROJECT FILE LIBRARY PREPARE SIMULATE REVIEW RESULTS

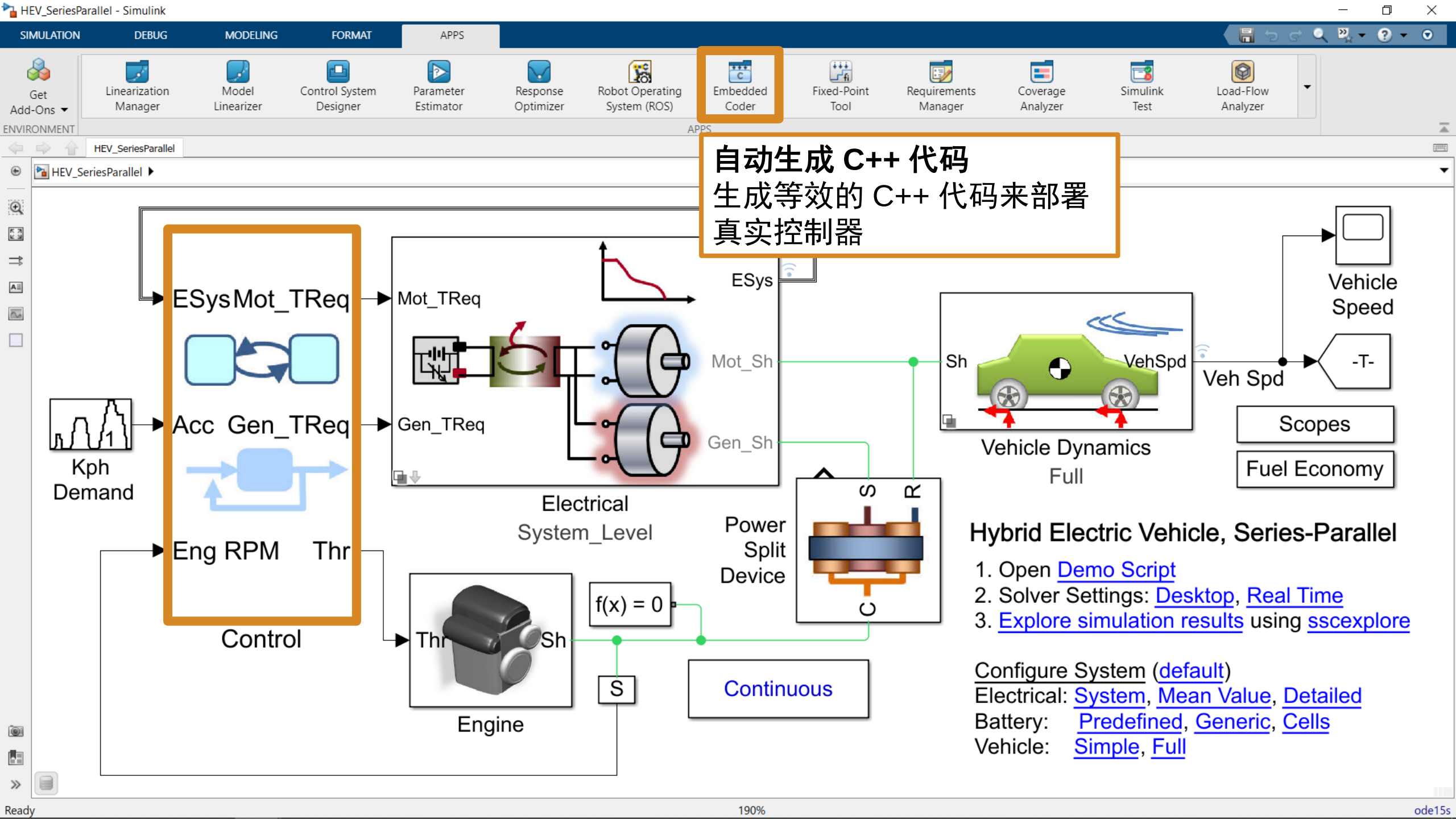
Battery

ssc_battery_charge_balance_3RC ▸ Battery ▸

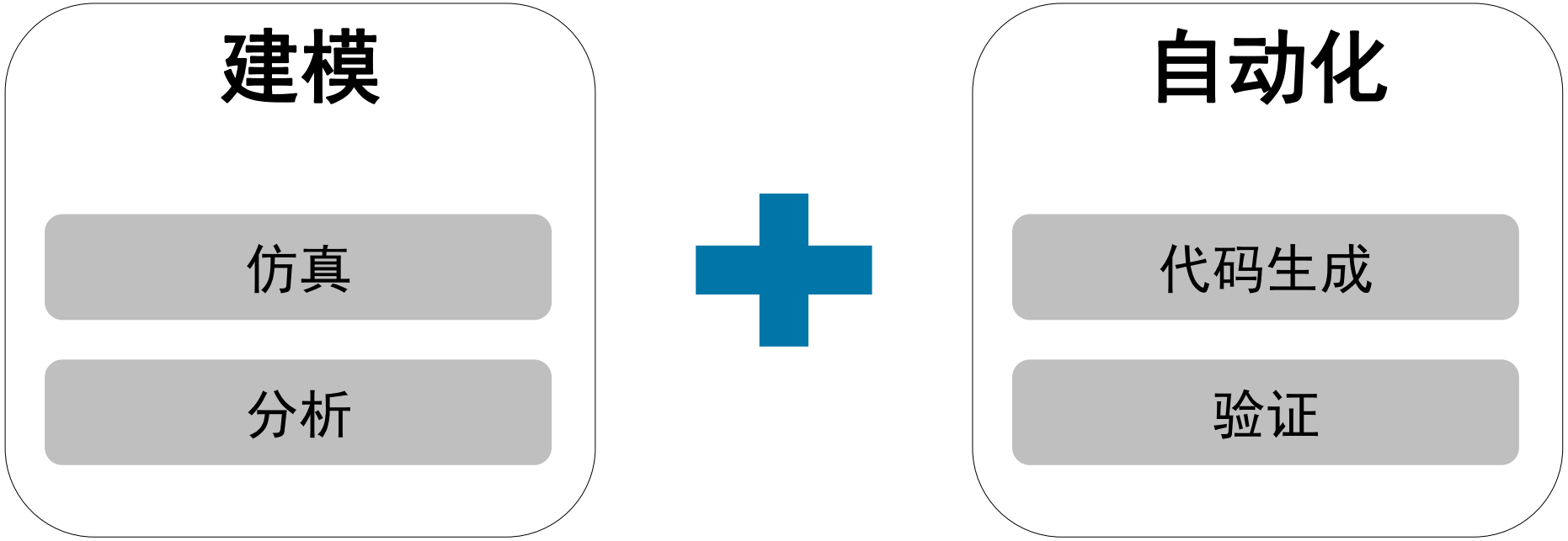


Ready 101% ode23t


HEV_SeriesParallel - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Get Add-Ons
ENVIRONMENT
Linearization Manager
Model Linearizer
Control System Designer
Parameter Estimator
Response Optimizer
Robot Operating System (ROS)
Embedded Coder
Fixed-Point Tool
Requirements Manager
Coverage Analyzer
Simulink Test
Load-Flow Analyzer
APPS
HEV_SeriesParallel
ESys Mot_TReq
Acc Gen_TReq
Eng RPM Thr
Control
Kph Demand
Mot_TReq
Gen_TReq
ESys
Mot_Sh
Gen_Sh
Electrical System_Level
Power Split Device
S
R
C
Thr
Sh
Engine
f(x) = 0
S
Continuous
Sh
VehSpd
Vehicle Dynamics Full
Vehicle Speed
Veh Spd
-T-
Scopes
Fuel Economy
Hybrid Electric Vehicle, Series-Parallel
1. Open Demo Script
2. Solver Settings: Desktop, Real Time
3. Explore simulation results using sscexplore
Configure System (default)
Electrical: System, Mean Value, Detailed
Battery: Predefined, Generic, Cells
Vehicle: Simple, Full
Ready
190%
ode15s


HEV_SeriesParallel - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Get Add-Ons
ENVIRONMENT
Linearization Manager
Model Linearizer
Control System Designer
Parameter Estimator
Response Optimizer
Robot Operating System (ROS)
Embedded Coder
Fixed-Point Tool
Requirements Manager
Coverage Analyzer
Simulink Test
Load-Flow Analyzer
APPS
自动生成 C++ 代码
生成等效的 C++ 代码来部署
真实控制器
HEV_SeriesParallel
ESys Mot_TReq
Acc Gen_TReq
Eng RPM Thr
Control
Kph Demand
Mot_TReq
Gen_TReq
ESys
Mot_Sh
Gen_Sh
Electrical
System_Level
Power Split Device
S
R
C
Thr
Sh
Engine
f(x) = 0
S
Continuous
Sh
VehSpd
Vehicle Dynamics
Full
Vehicle Speed
Veh Spd
-T-
Scopes
Fuel Economy
Hybrid Electric Vehicle, Series-Parallel
1. Open Demo Script
2. Solver Settings: Desktop, Real Time
3. Explore simulation results using sscexplore
Configure System (default)
Electrical: System, Mean Value, Detailed
Battery: Predefined, Generic, Cells
Vehicle: Simple, Full
Ready
190%
ode15s

基于模型设计



尝试**创新**想法，快速**重复**测试

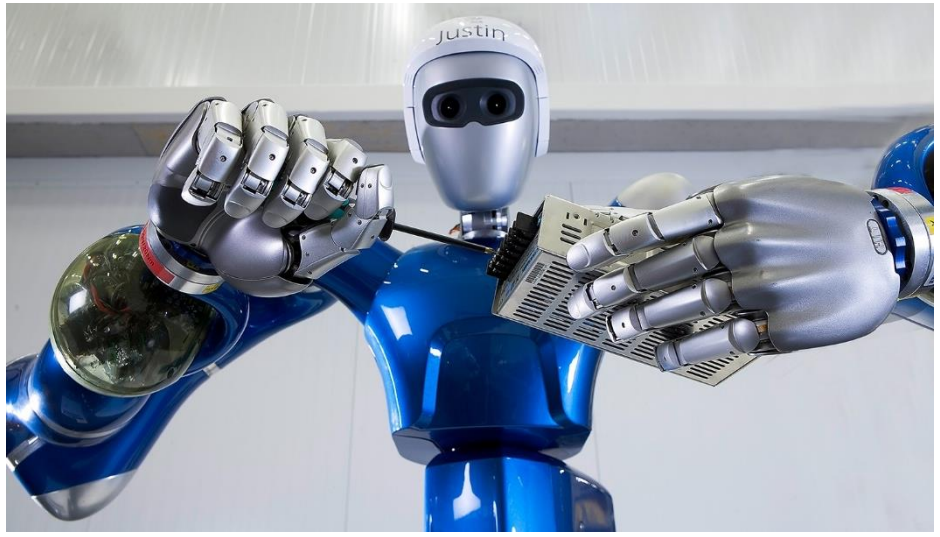
消除**手工**步骤，减少**人为**错误

自主系统

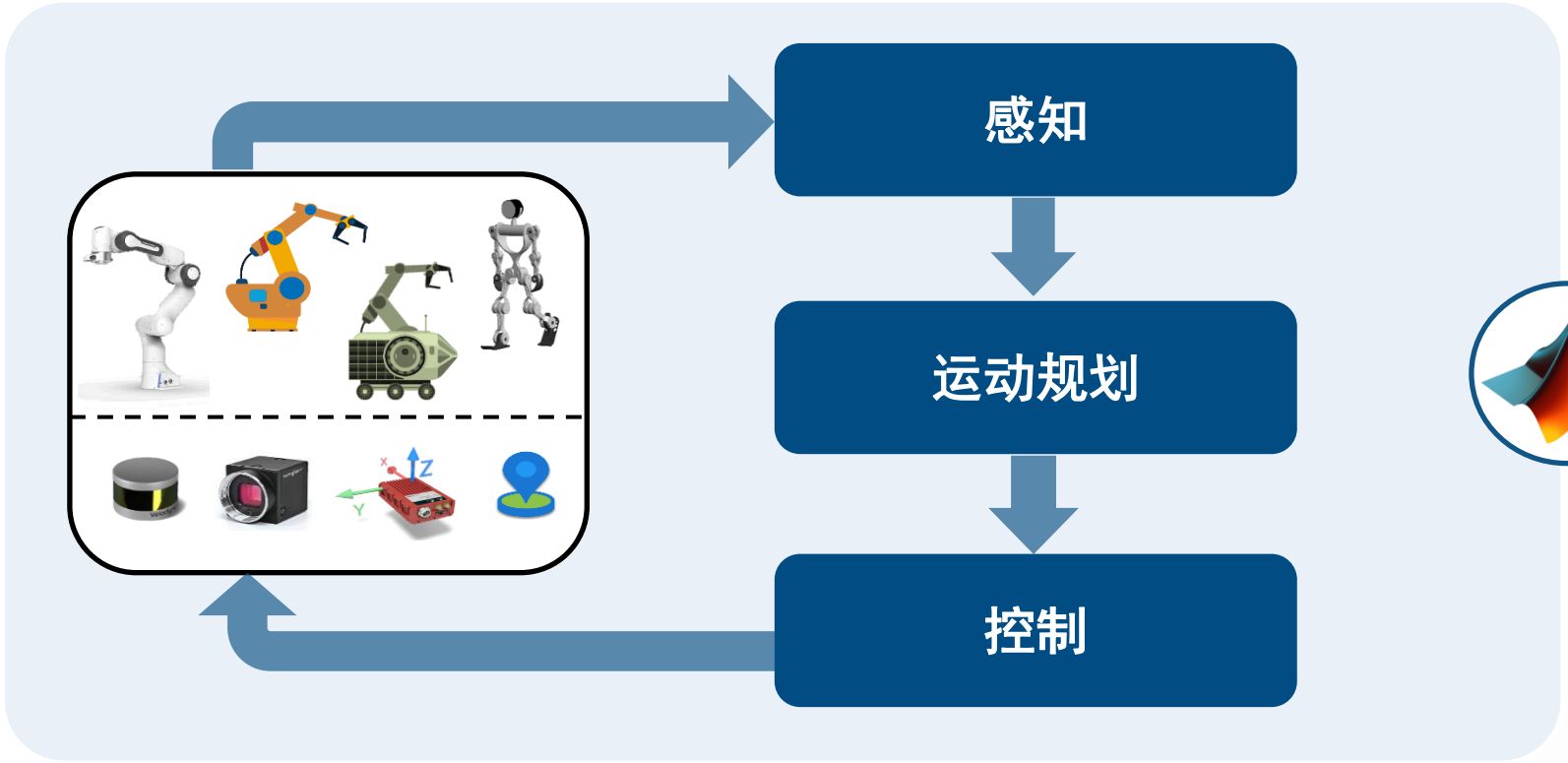
自主系统

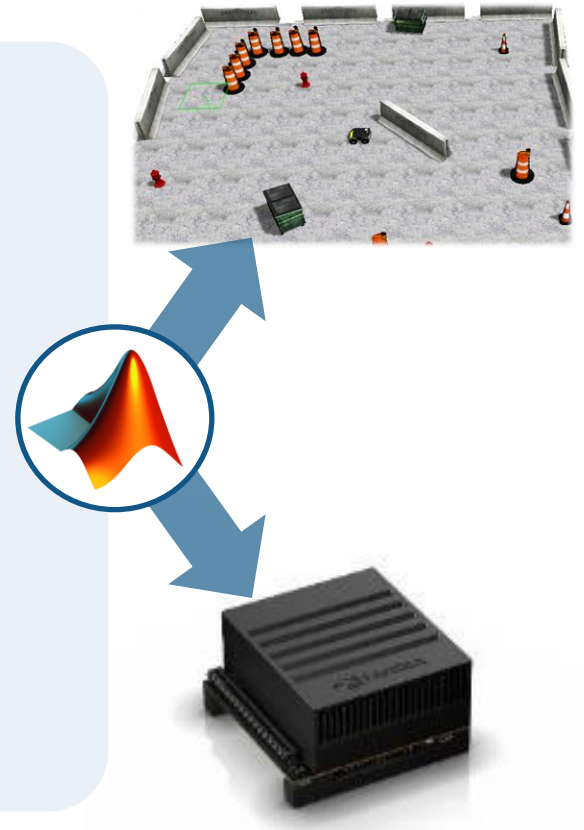
- 为什么正在发生？
- 工业界面临什么样的挑战？
- 工程师们是如何克服这些困难的

自主系统



机器人和自主系统设计常见挑战



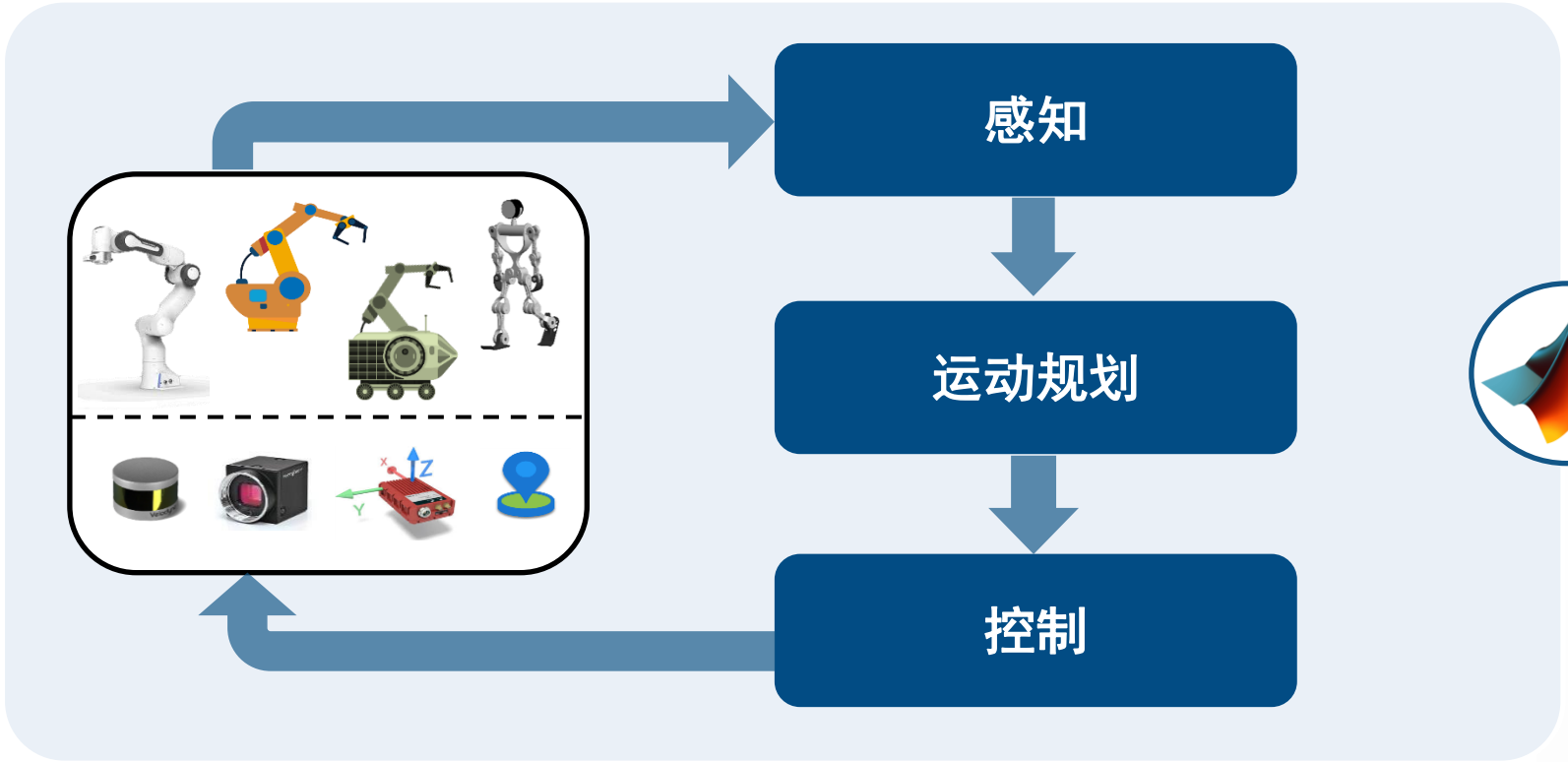


如何为机器人和传感器建模仿真?

如何发现和设计自主算法?

如何测试和部署自主系统应用程序?

机器人和自主系统常见问题

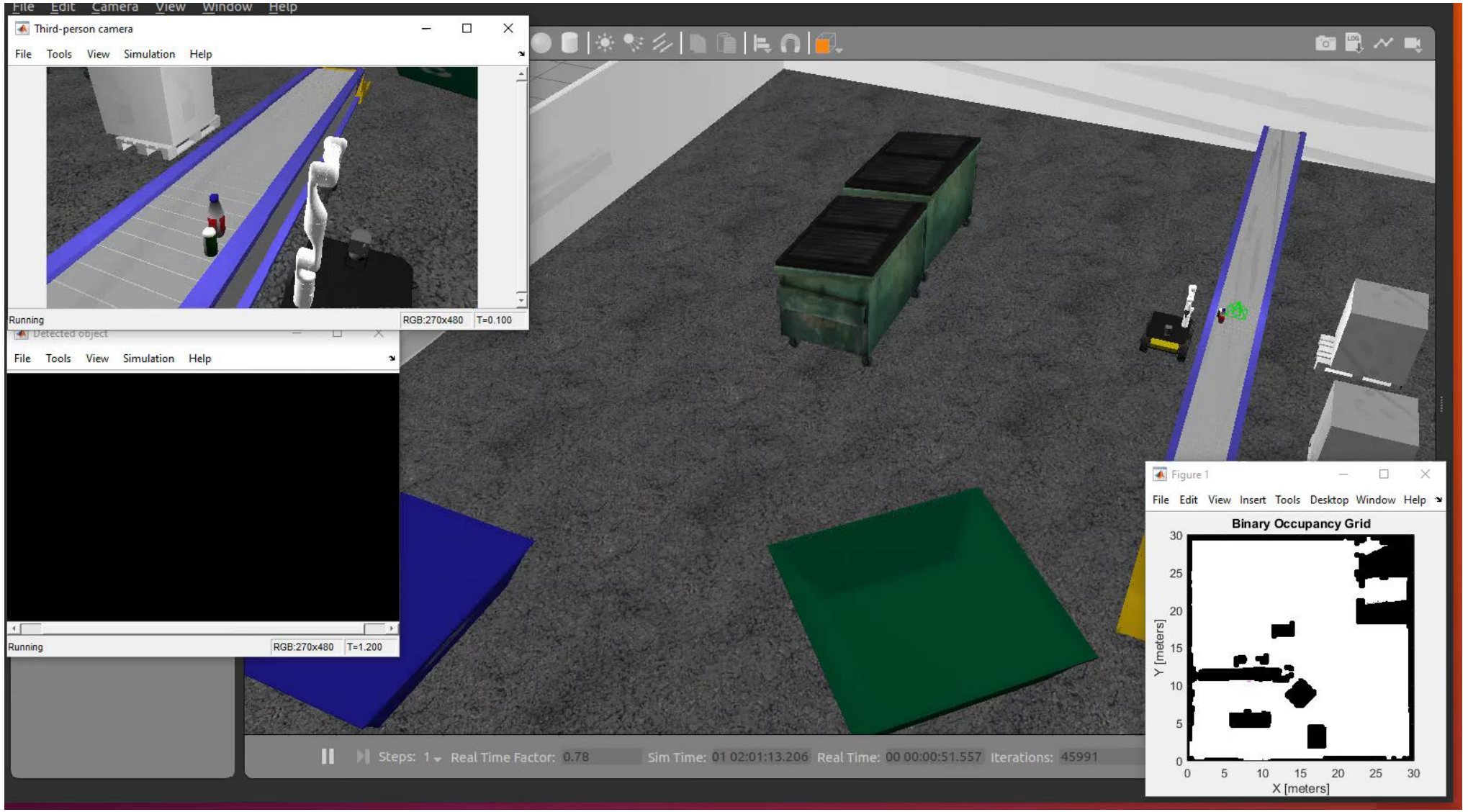


MATLAB

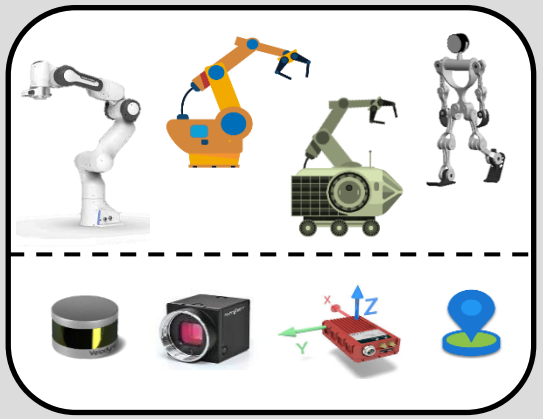
开发环境

Simulink

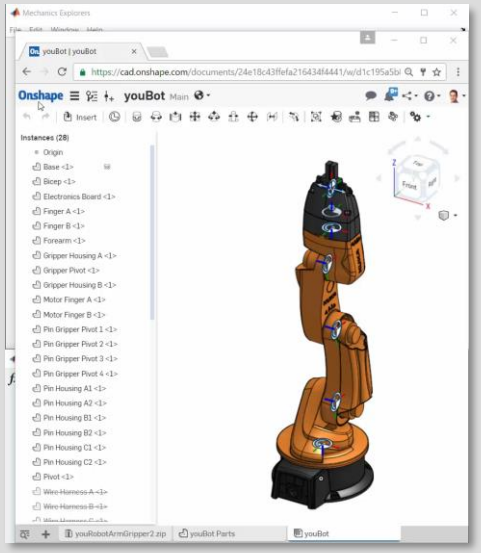
设计并仿真从感知到运动的复杂工作流



不同保真度的机器人模型



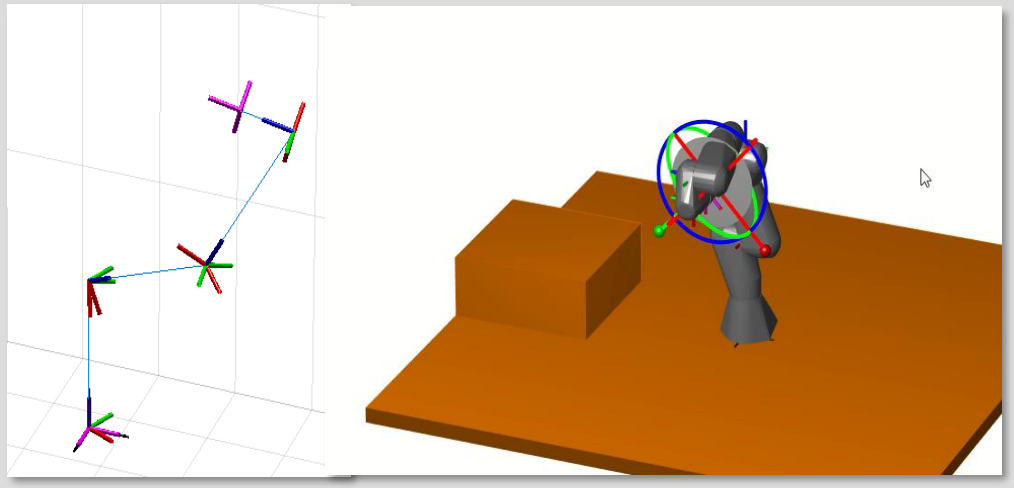
物理模型



[Import Onshape CAD Assembly to Simscape Multibody]

Simscape Multibody™

运动学模型



[Interact with Rigid Body Tree models]

Robotics System Toolbox™

开发环境

MATLAB

Simulink

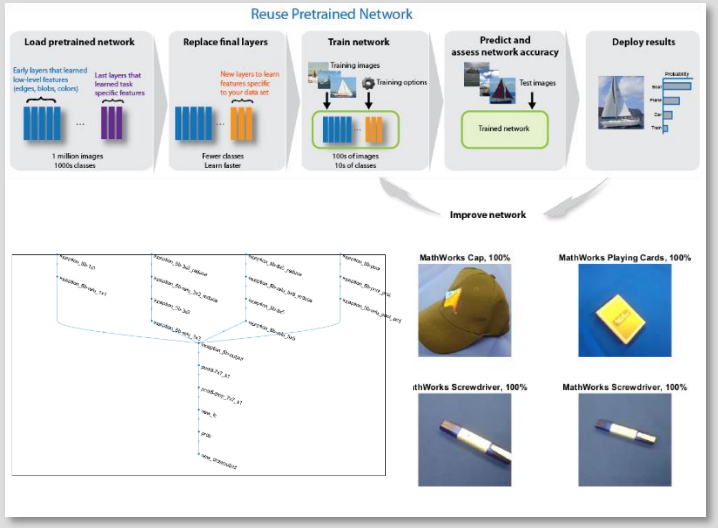
开发自主算法

感知

运动规划

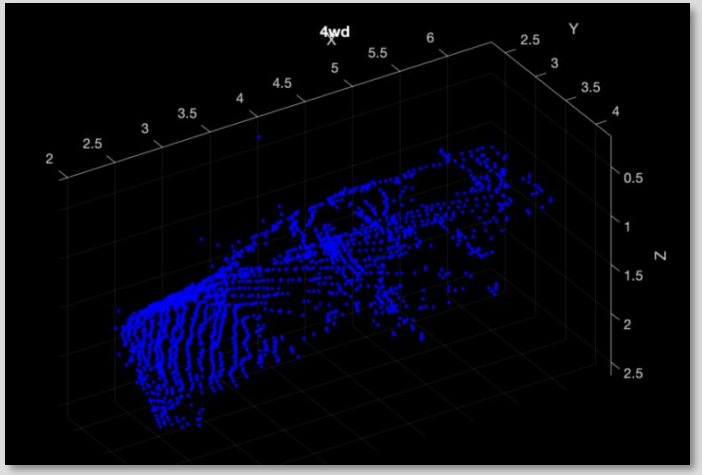
控制

深度学习图像分类



Train Deep Learning Network to Classify New Images

深度学习点云分类



Point Cloud Classification Using PointNet Deep Learning

Computer Vision Toolbox™ ***Deep Learning Toolbox™*** ***Lidar Toolbox™***

开发环境

MATLAB

Simulink

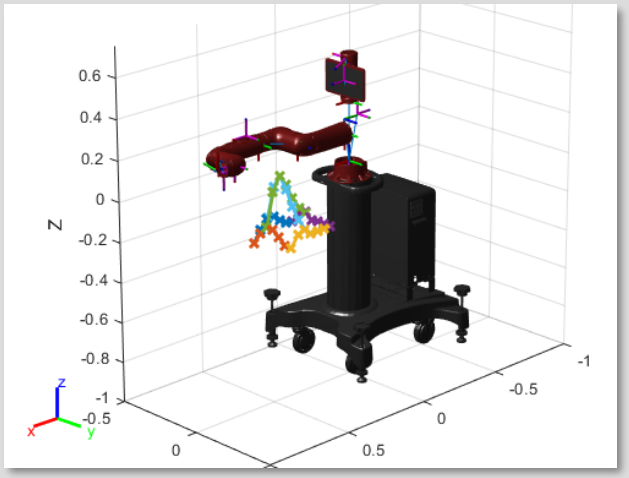
开发自主算法

感知

运动规划

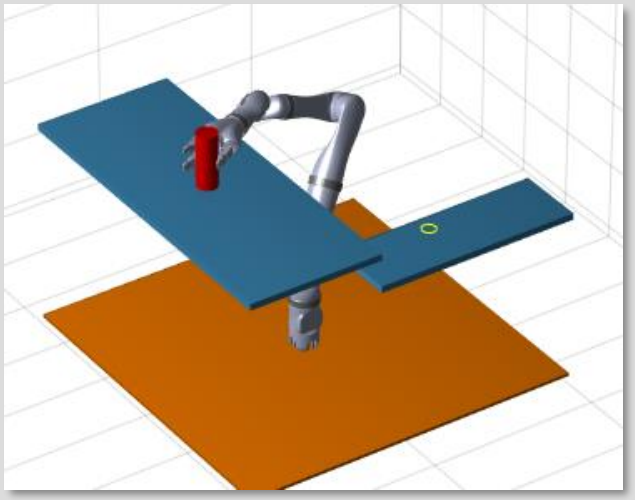
控制

正/反向运动学与动力学



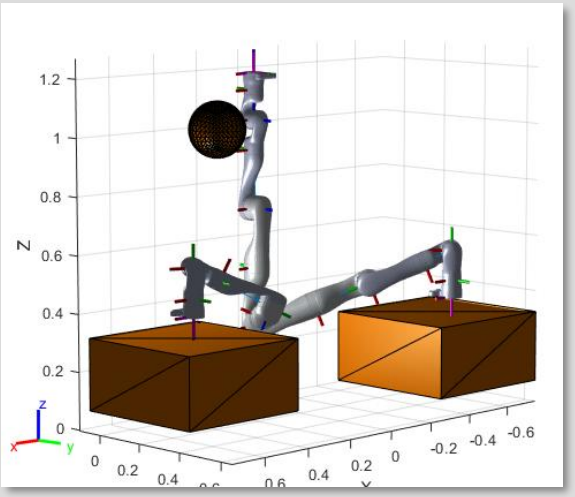
[Manipulator Shape Tracing in MATLAB and Simulink]

运动规划



[Motion Planning with RRT for a Robot Manipulator]

碰撞检查/检测



[Check for Environmental Collisions with Manipulators]

Robotics System Toolbox™ ***Navigation Toolbox™***

开发环境

MATLAB

Simulink

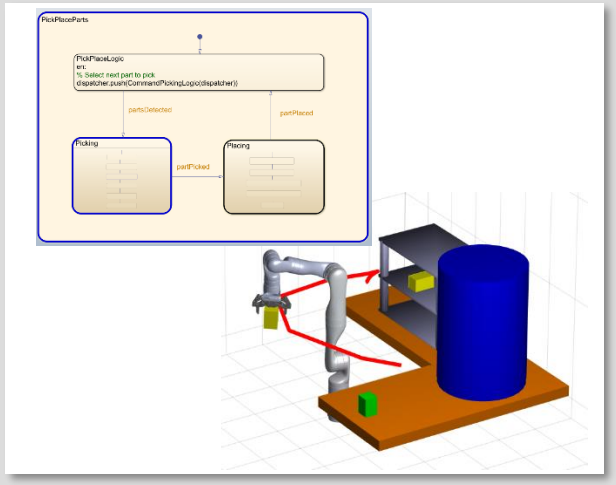
开发自主算法

感知

运动规划

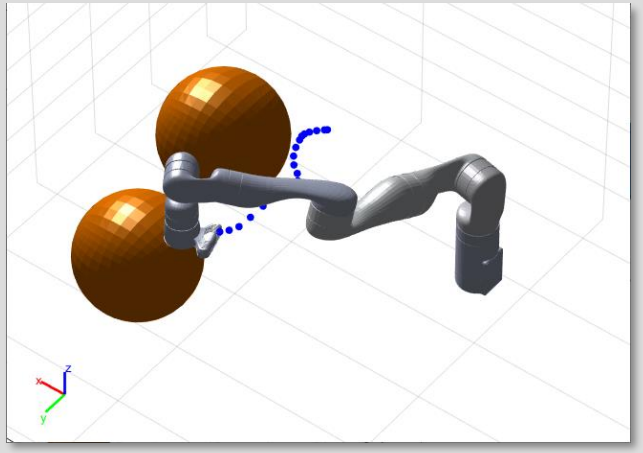
控制

任务调度



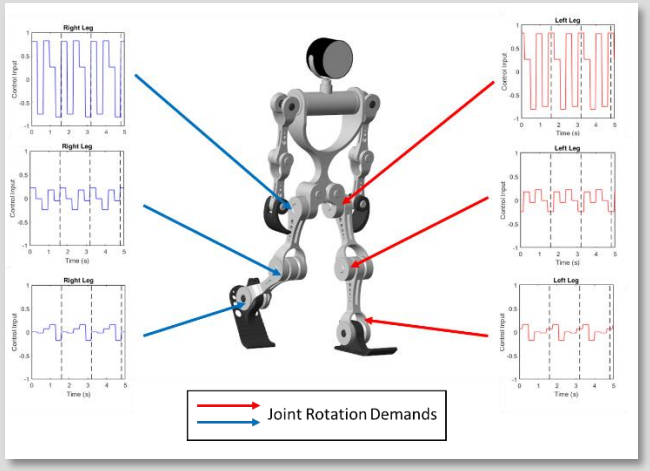
Pick-and-Place Workflow using Stateflow for MATLAB

避障
模型机器人



Collision-Free Trajectories using KINOVA Gen3 Manipulator

强化学习
人形机器人



Train a Humanoid Walker

Stateflow®

Model Predictive Control Toolbox™

Robotics System Toolbox™

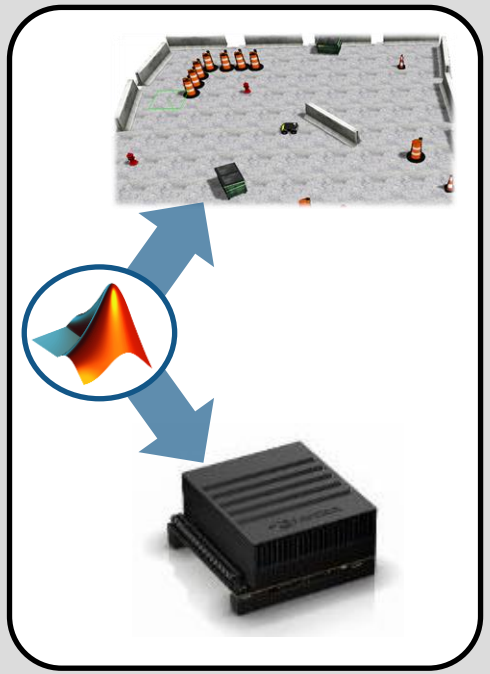
Reinforcement Learning Toolbox™

开发环境

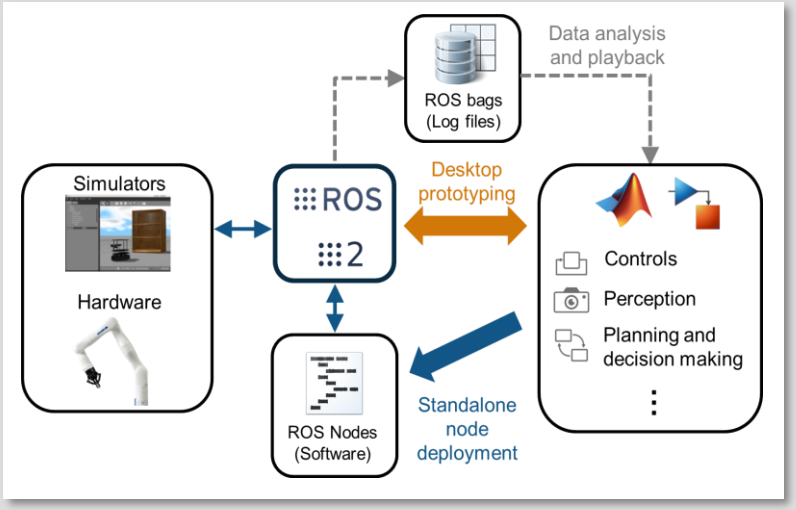
MATLAB

Simulink

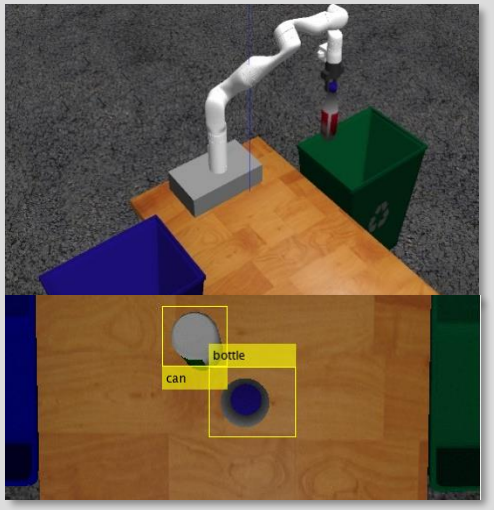
虚拟测试和硬件部署



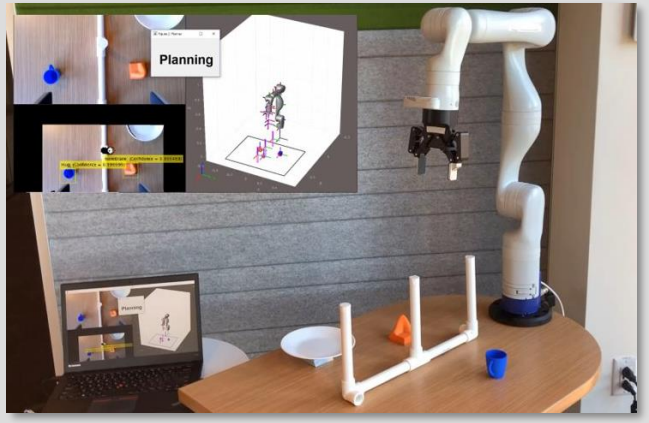
ROS 工作流



Gazebo联合仿真



硬件测试



[Pick-and-Place Workflow in Gazebo using ROS]

ROS Toolbox

Robotics System Toolbox

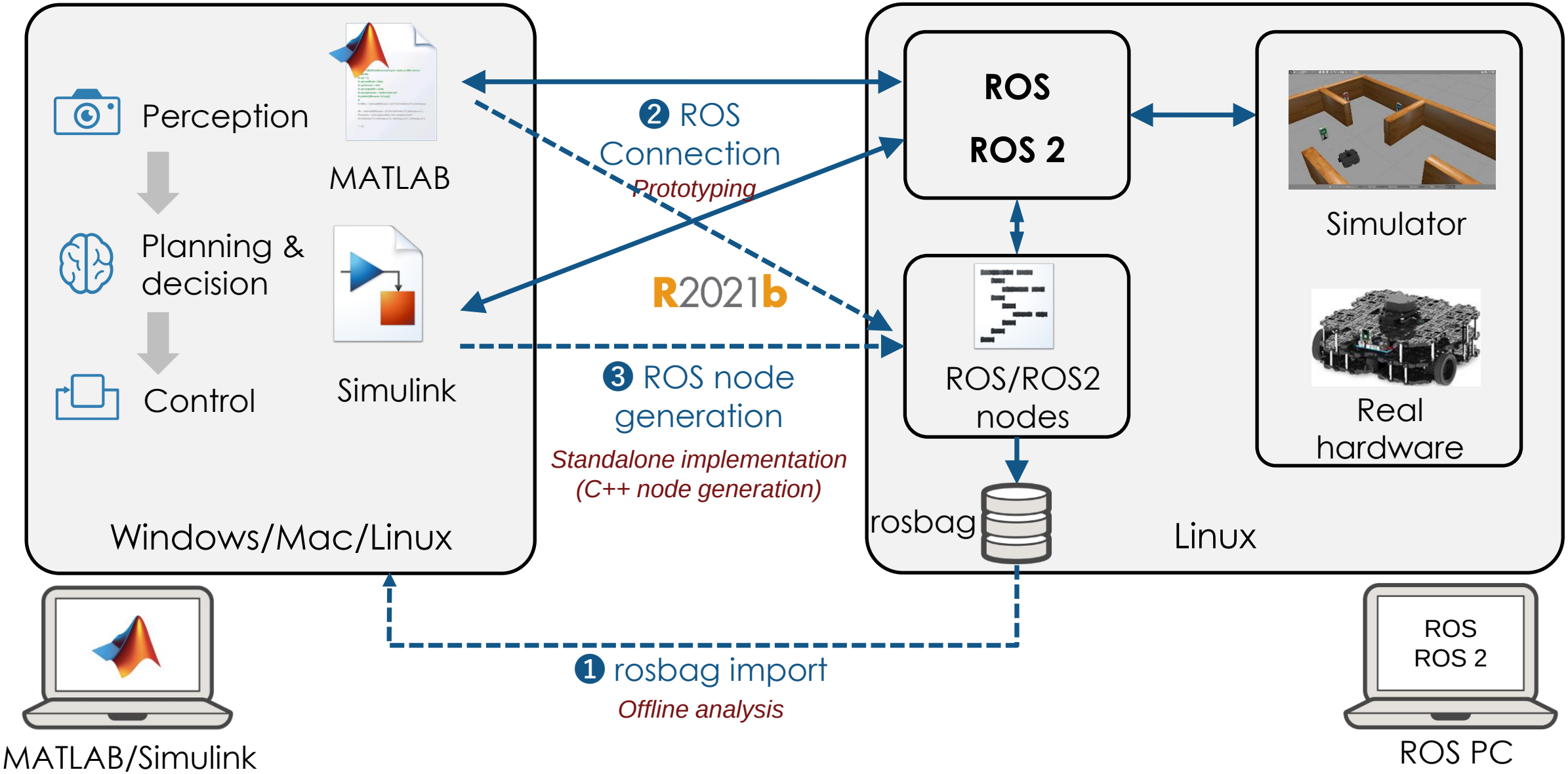
Simulink Coder™
Embedded Coder™
GPU Coder™

开发环境

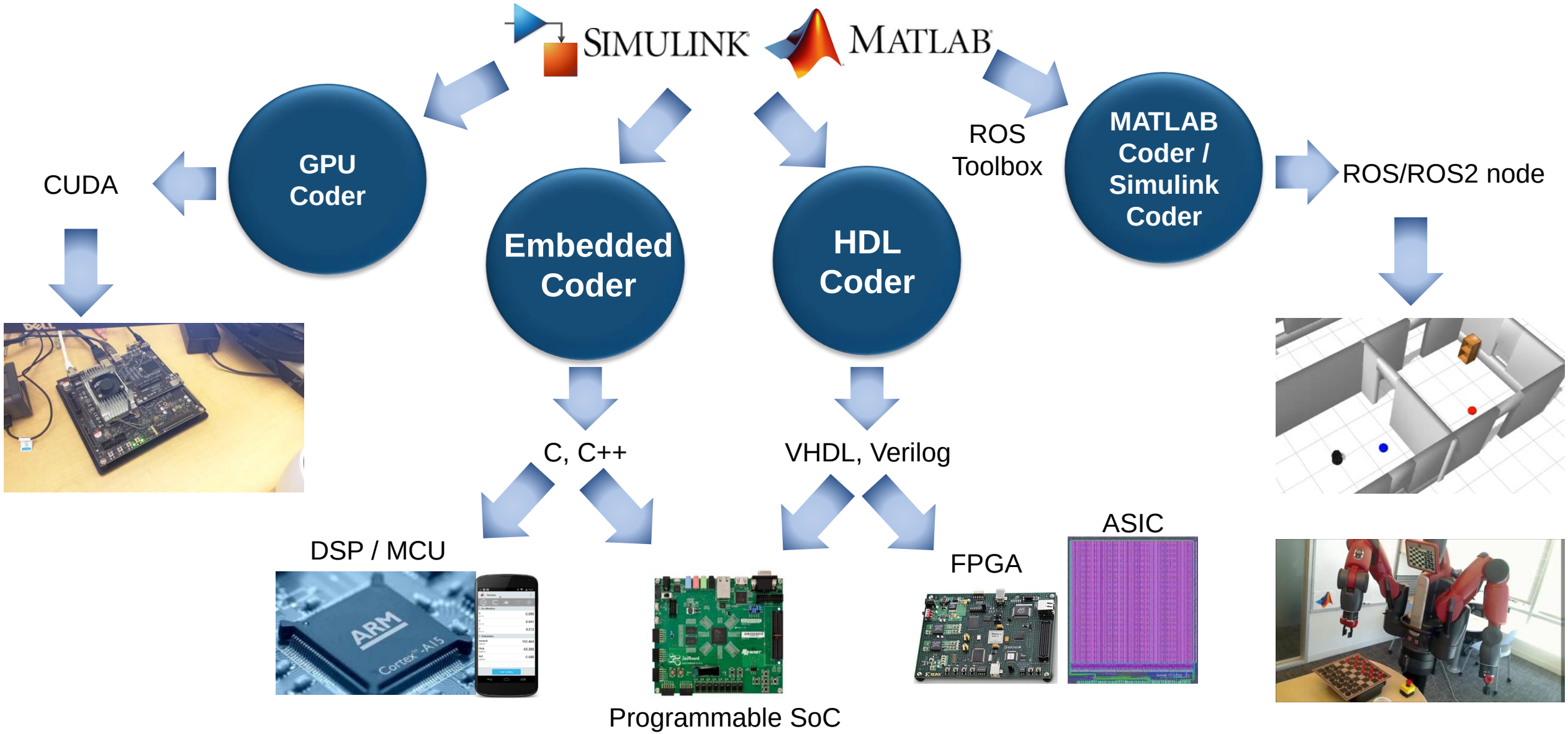
MATLAB

Simulink

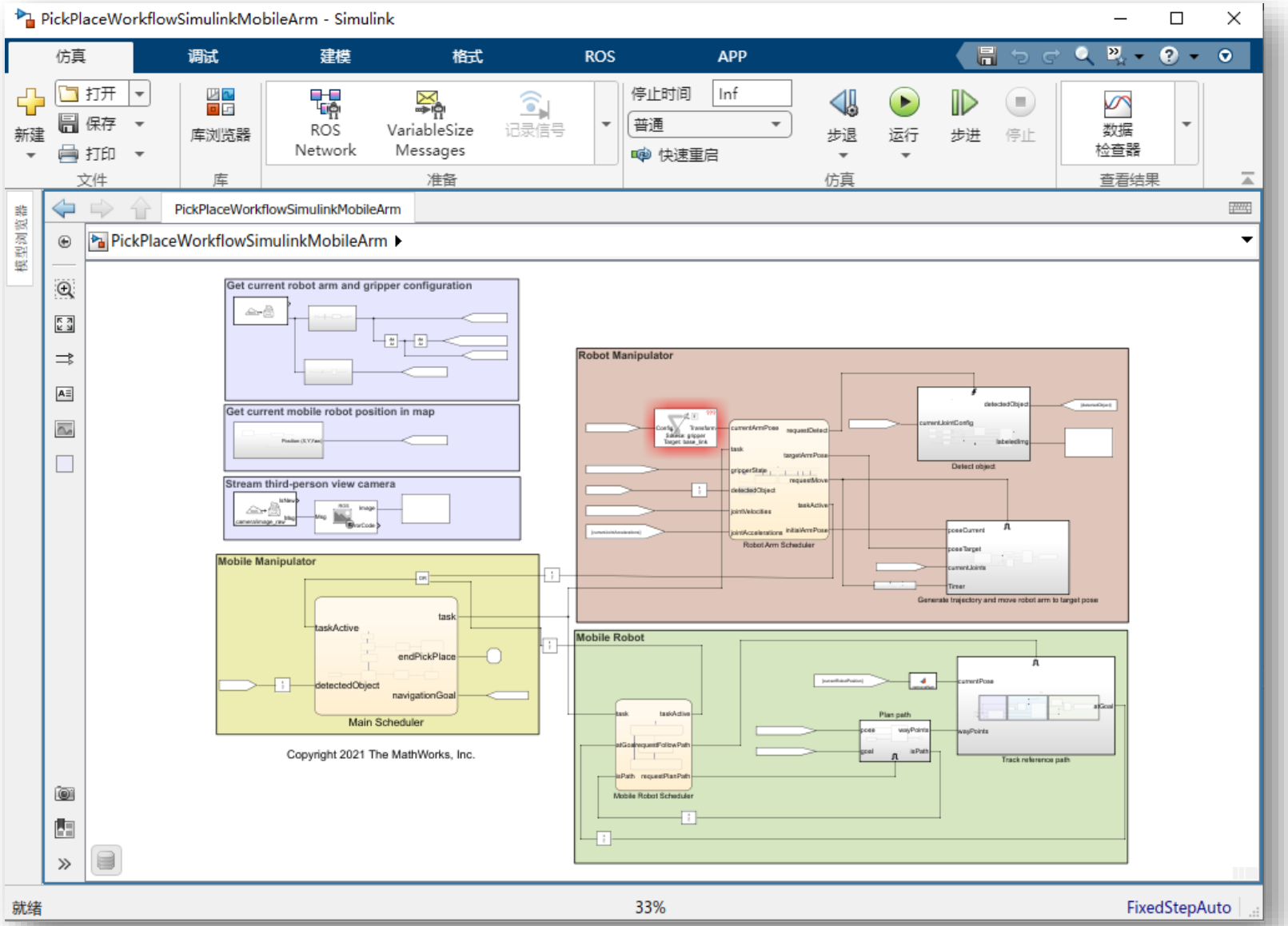
使用 MATLAB/Simulink 与 ROS/ROS2 进行通信



在硬件上实现和原型化算法



系统仿真


PickPlaceWorkflowSimulinkMobileArm - Simulink
仿真
调试
建模
格式
ROS
APP
新建
打开
保存
打印
文件
库浏览器
库
ROS Network
VariableSize Messages
记录信号
准备
停止时间
Inf
普通
快速重启
步退
运行
步进
停止
仿真
数据检查器
查看结果
模型浏览器
PickPlaceWorkflowSimulinkMobileArm
Get current robot arm and gripper configuration
Get current mobile robot position in map
Stream third-person view camera
Mobile Manipulator
task
taskActive
endPickPlace
detectedObject
navigationGoal
Main Scheduler
Robot Manipulator
Detect object
Robot Arm Scheduler
Generate trajectory and move robot arm to target pose
Mobile Robot
Plan path
Track reference path
Mobile Robot Scheduler
Copyright 2021 The MathWorks, Inc.
就绪
33%
FixedStepAuto

基于模型设计

建模

- 仿真
- 分析

自动化

- 代码生成
- 验证

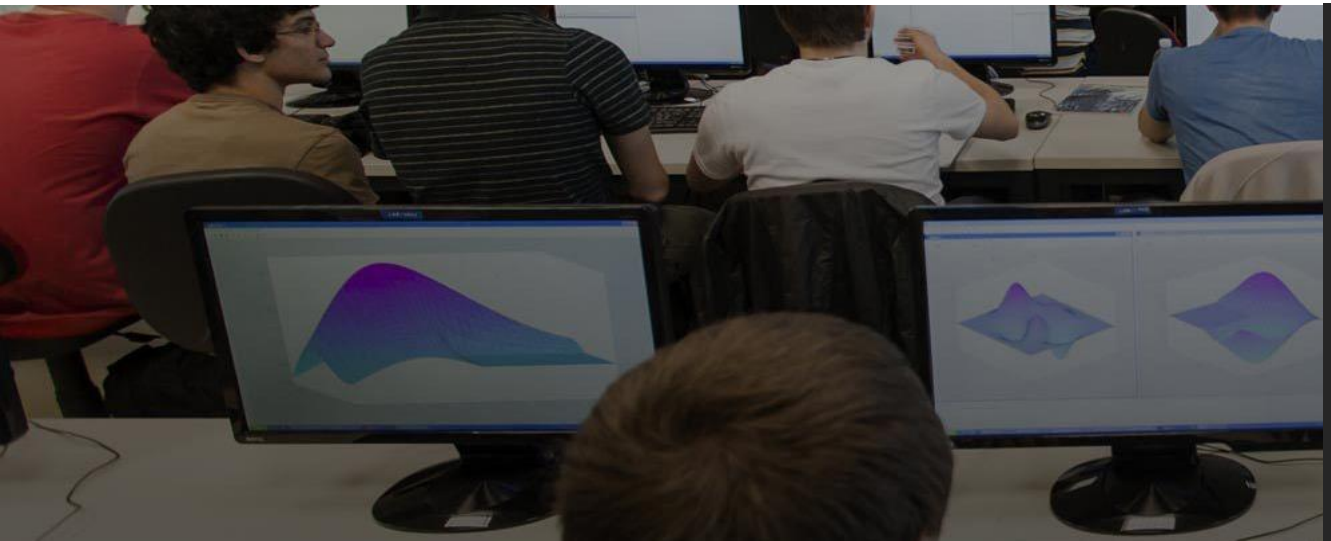
尝试**创新**想法，快速**重复**测试

消除**手工**步骤，减少**人为**错误

工程教育与系统思维

为什么系统化如此重要？

算法 → 模型设计 → 系统仿真 → 实物运行

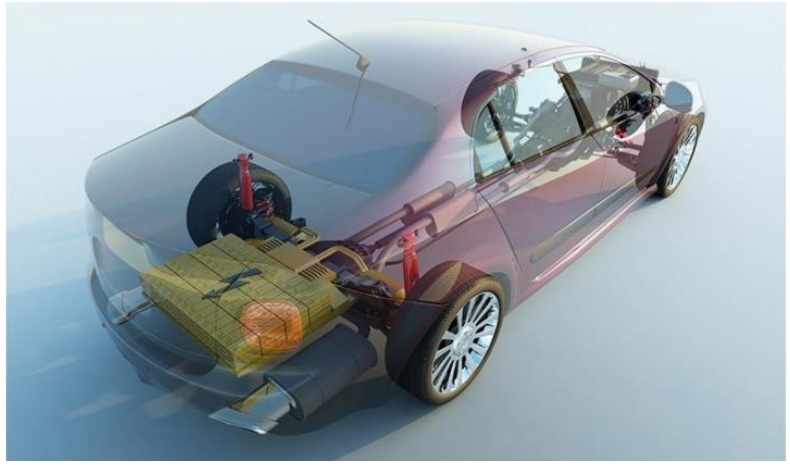


建模 仿真 部署

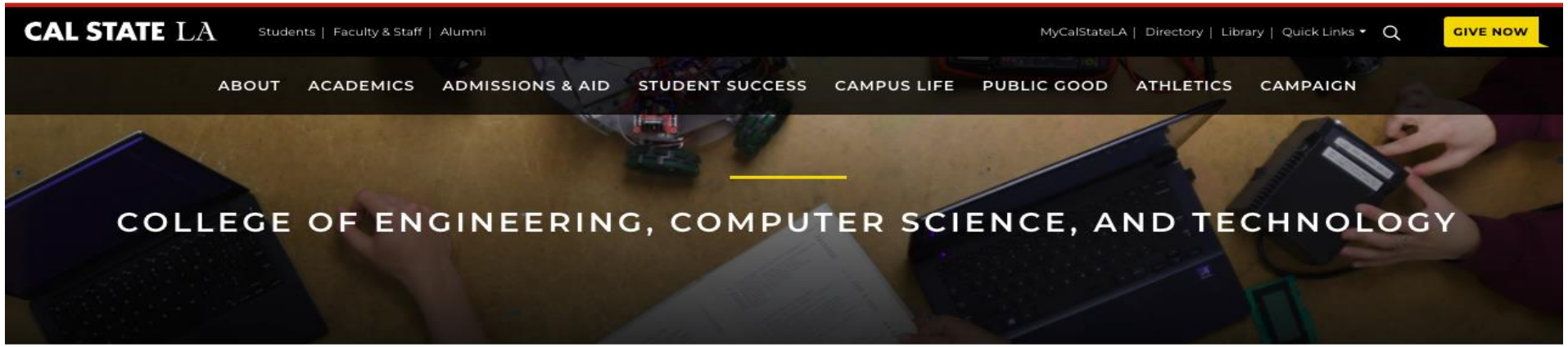
在迁移到硬件之前，在 Simulink 中设计和仿真复杂系统，
仿真是连接理论知识与物理世界的桥梁

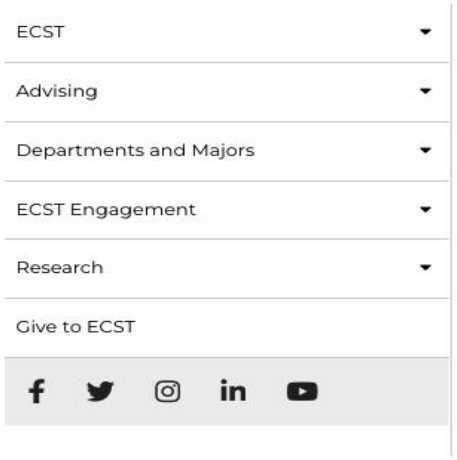
MATLAB 与 Simulink 适用于工程教学

- Simulink 适合 MATLAB 用户，业界广泛使用
- 基于模型的设计为**复杂系统**的开发提供了一种数学性的、形象化的方法探索广阔的设计空间
- 通过**多域建模**和仿真**快速评估**多种设计思路
- 为多领域研究与教学，提供了一种通用语言，支持和推动了**跨学科**交流



洛杉矶加州州立大学 —— 无人机项目





CAL STATE LA SUPPORTS USING THE TOOLS PROFESSIONALS USE IN ENGINEERING EDUCATION

Photo: Jocylene Arevalo

USING THE TOOLS PROFESSIONALS USE GIVES ECST STUDENTS A LEG UP

系统思维融入：技术方面

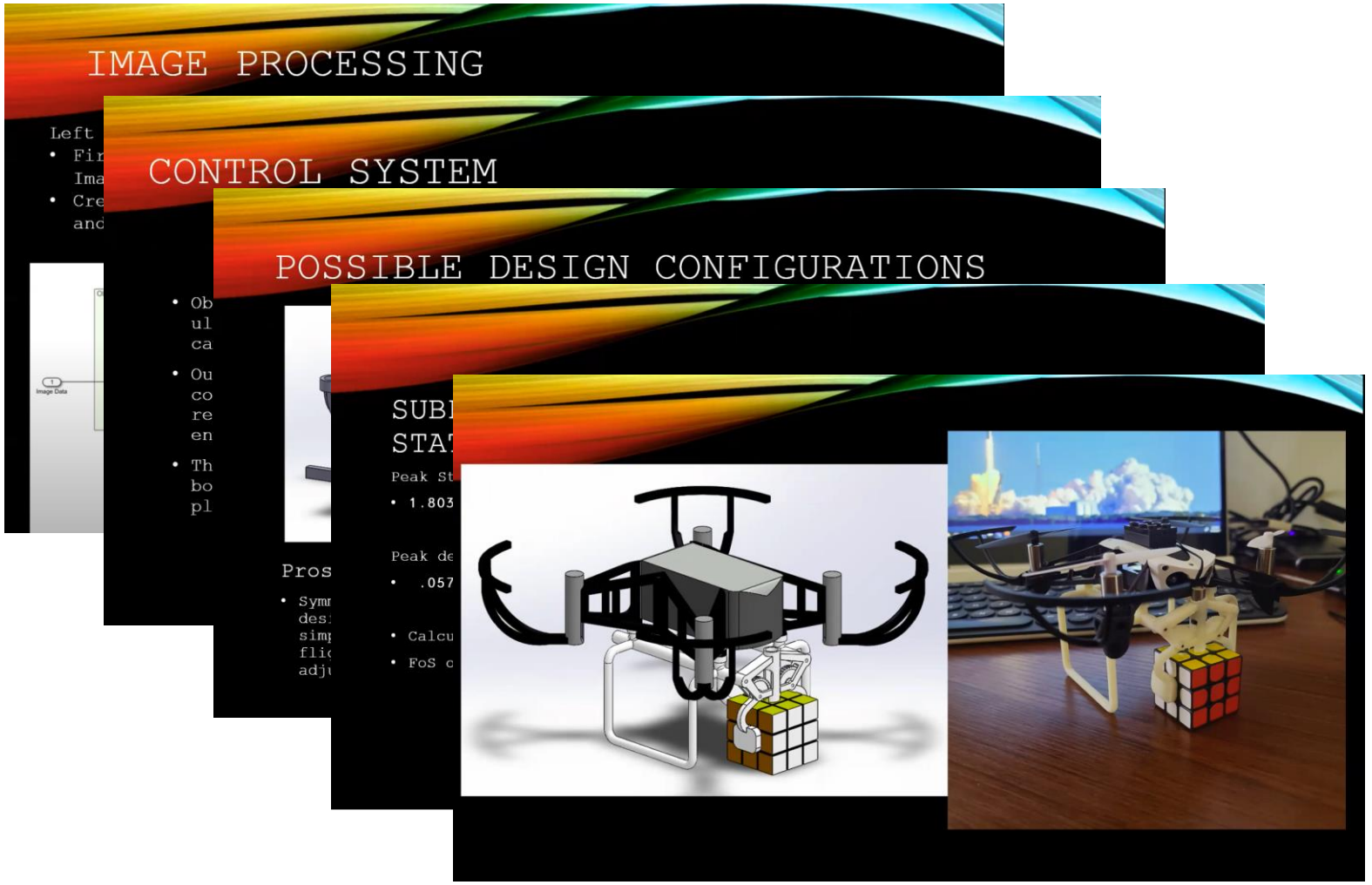
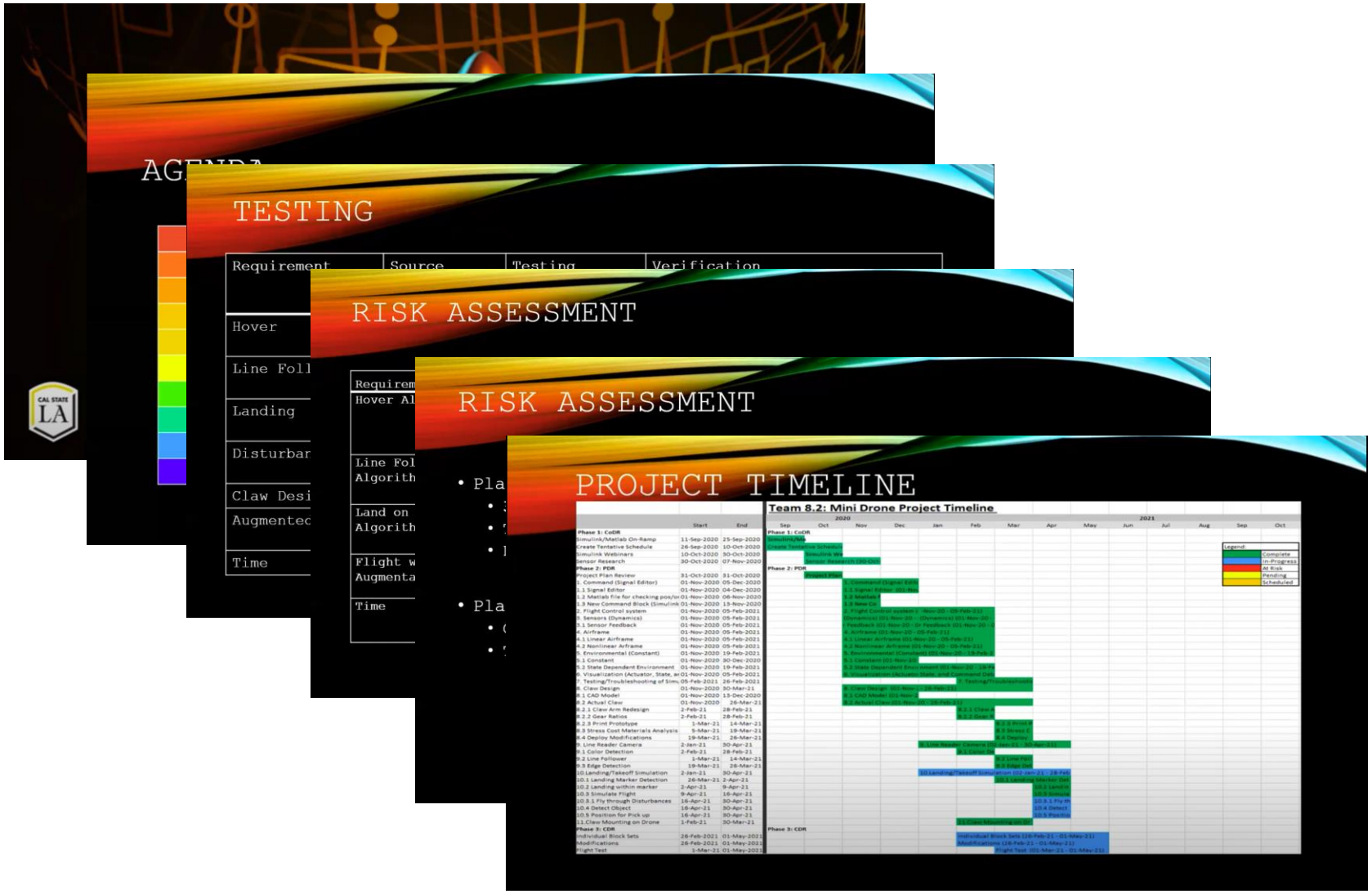


IMAGE PROCESSING
CONTROL SYSTEM
POSSIBLE DESIGN CONFIGURATIONS

系统思维融入：非技术方面

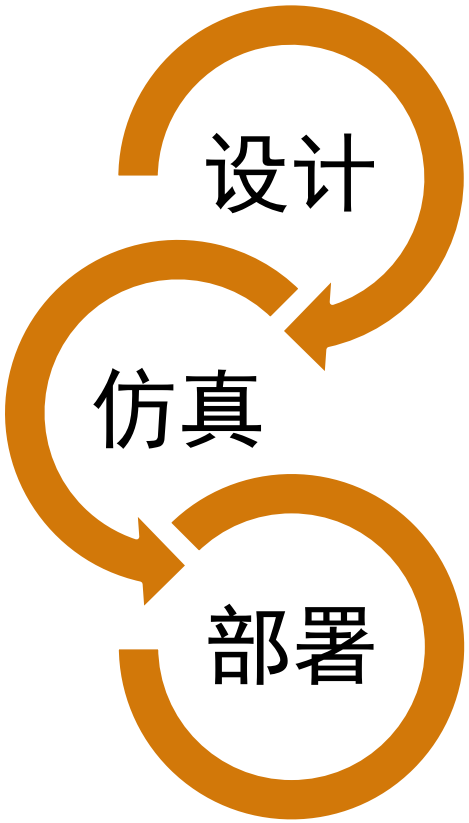


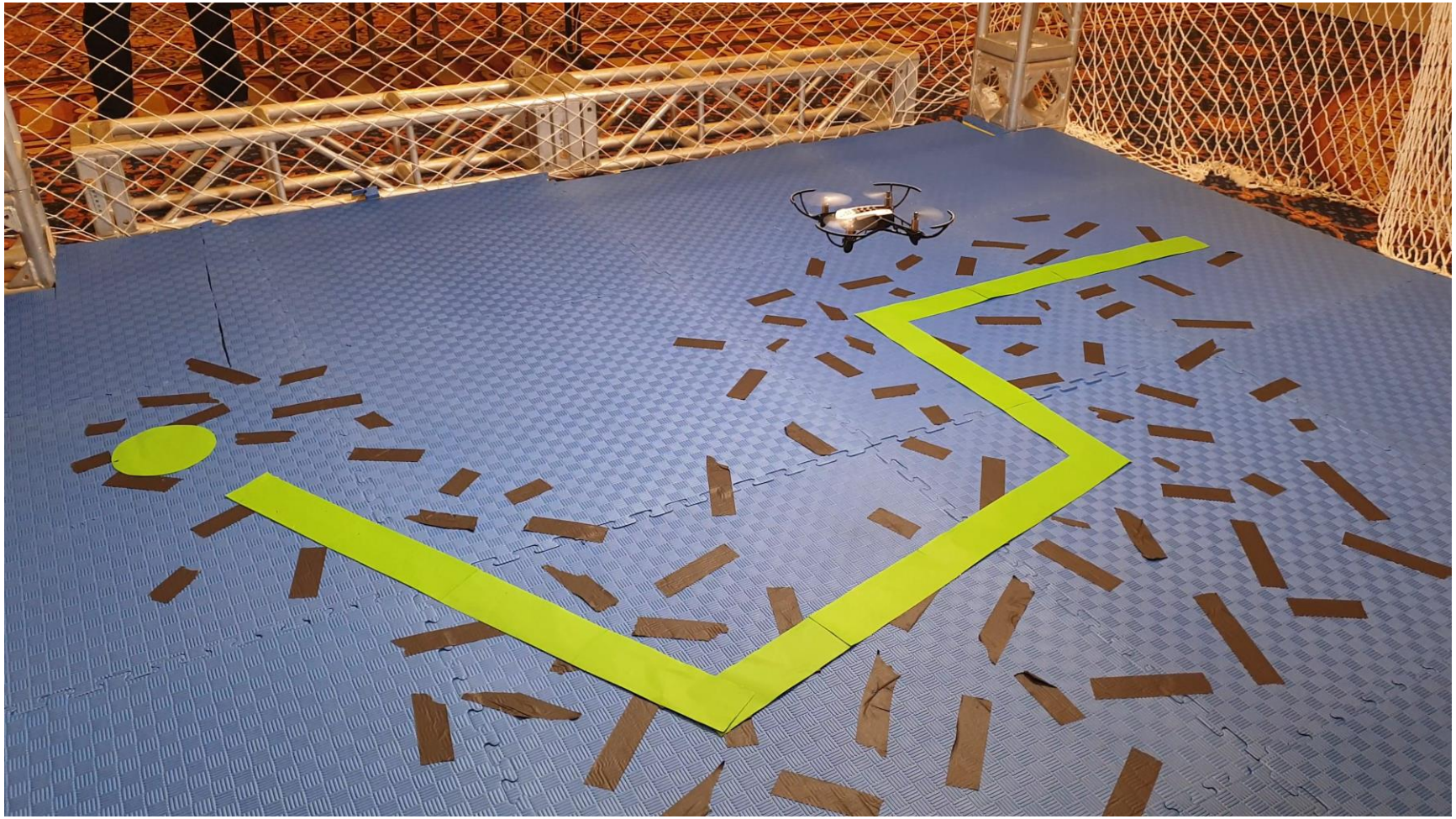
MathWorks 无人机大赛

建立与行业相关的技能

使用 Simulink + Parrot Mambo 小型无人机开展基于模型的设计，使用 Simulink 设计线路的线路算法。决赛队伍：

- 将算法部署到 Parrot，或者
- 展示他们的作品（线上）

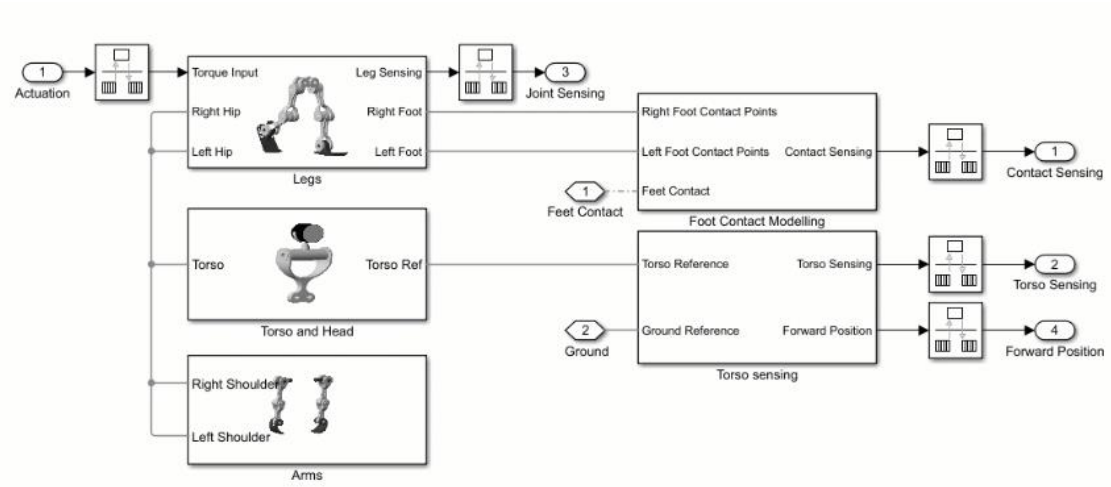

设计
仿真
部署



MATHWORKS

EXCELLENCE IN INNOVATION

通过解决重点行业挑战，为工程和科学的进步贡献力量！



项目创意涵盖了所有热门技术趋势：

- 人工智能
- 自主汽车
- 无人机
- 可再生能源
- 机器人

MathWorks

虚拟硬件与实验室

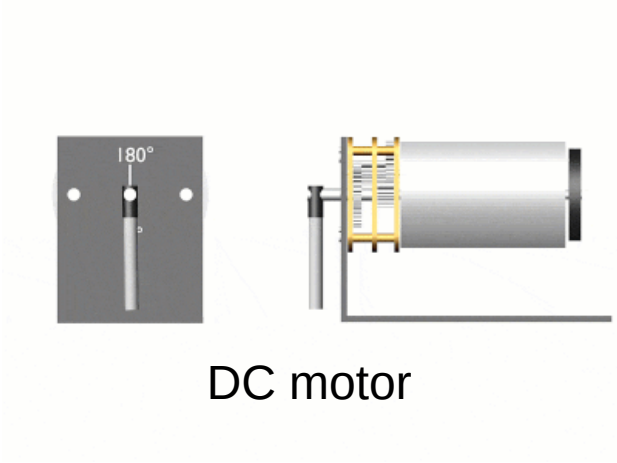
包含：

MATLAB 代码

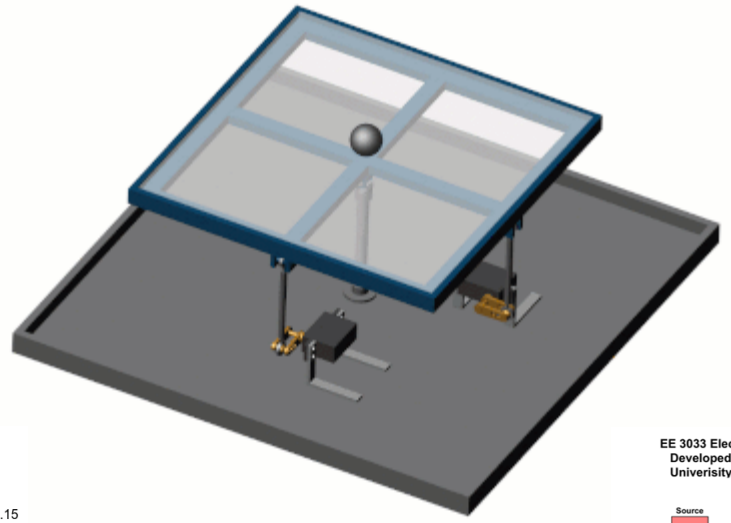
Simulink 模型

交互式 App

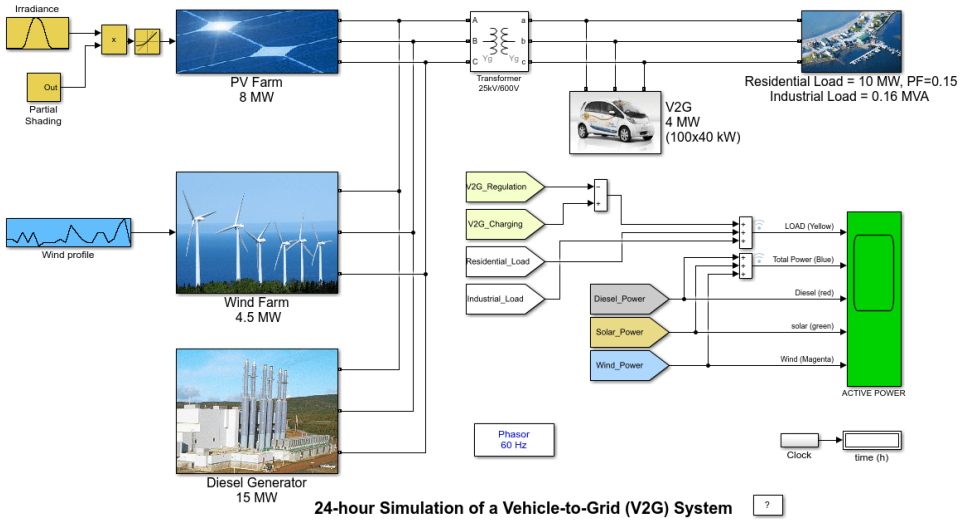
课程作业



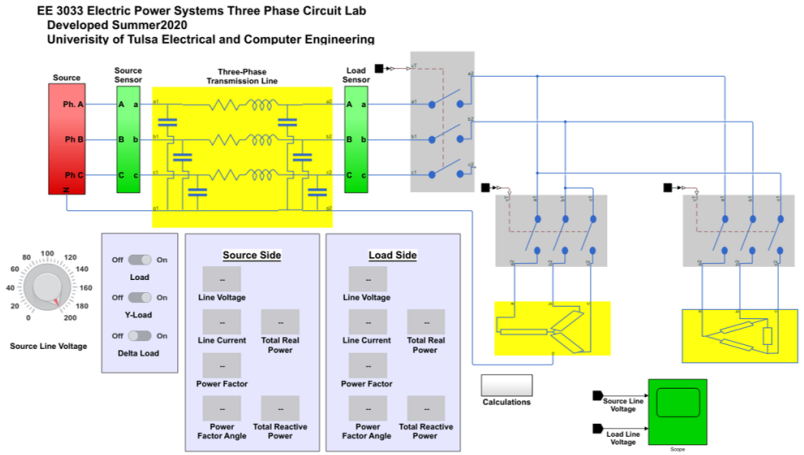
DC motor



Ball and plate



Vehicle-to-Grid (V2G) System



Virtual Electric Machine & Power Labs

MATLAB 与 Simulink 之于工程教学

学生竞赛

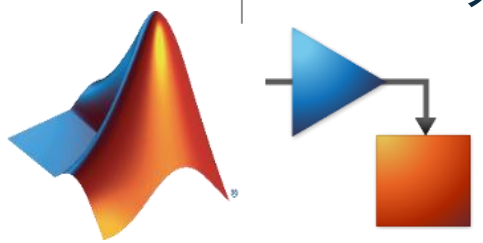
毕设

数字化
教学平台

实践、实验教学

通识与专业课程教学

大一 大二 大三 大四



构建系统思维 培养工程人才

MATLAB EXPO

谢谢