tinyML® EMEA

Enabling Ultra-low Power Machine Learning at the Edge

June 26 - 28, 2023

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Change for the Better: Improving Predictions by Automating Drift Detection

Electric Bus Fleet Management Using ML

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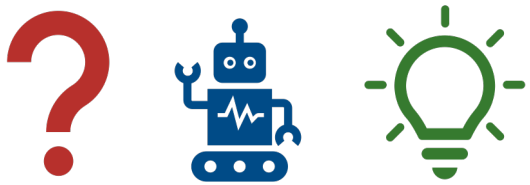
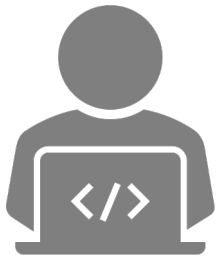
Technical Manager Application Engineering
MathWorks

June 27, 2023

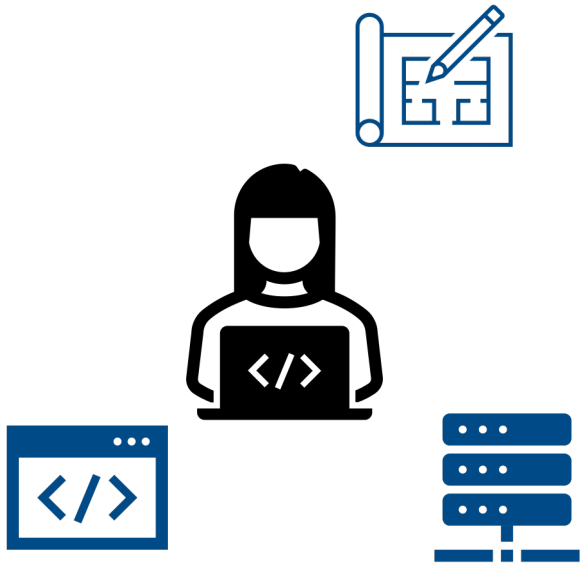
What you will learn today!

Automated ML



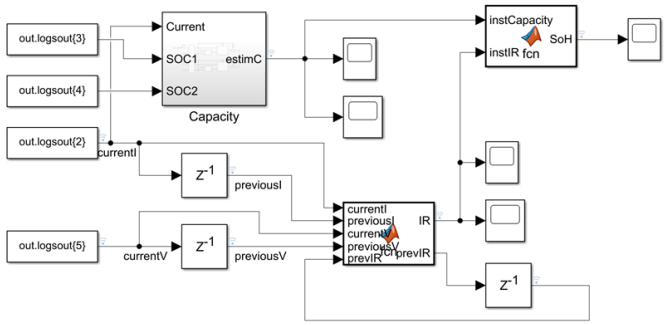


Production System

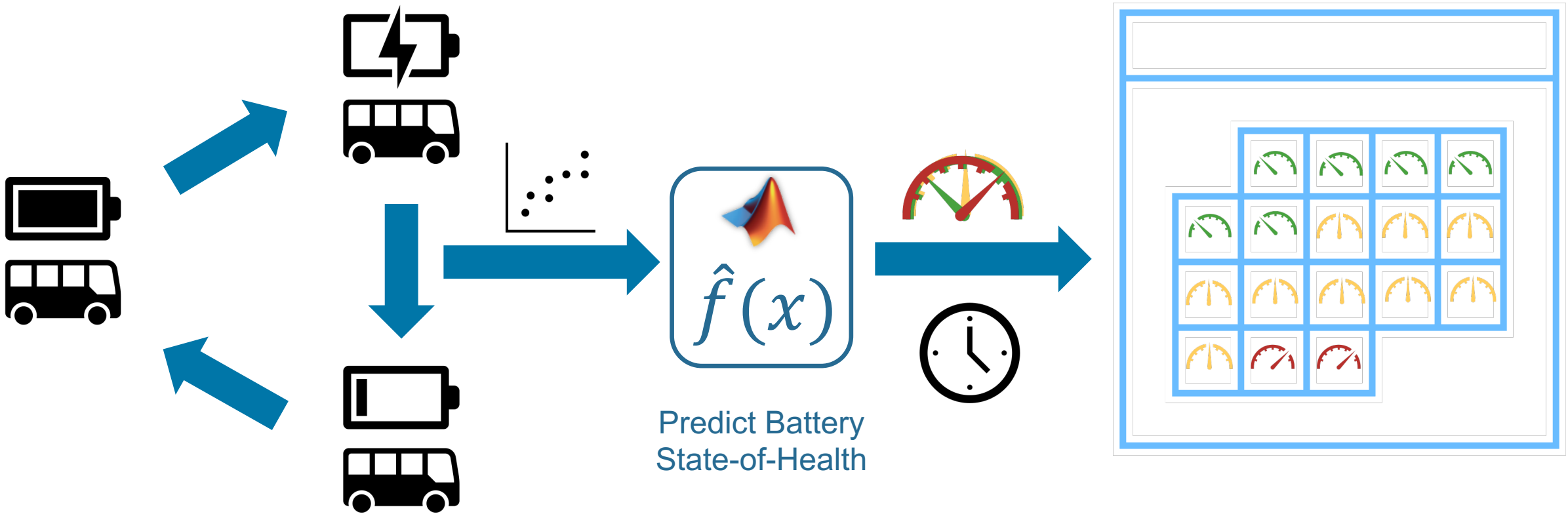


Key Technologies

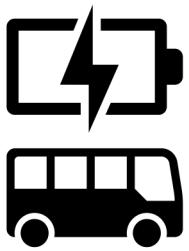
$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$

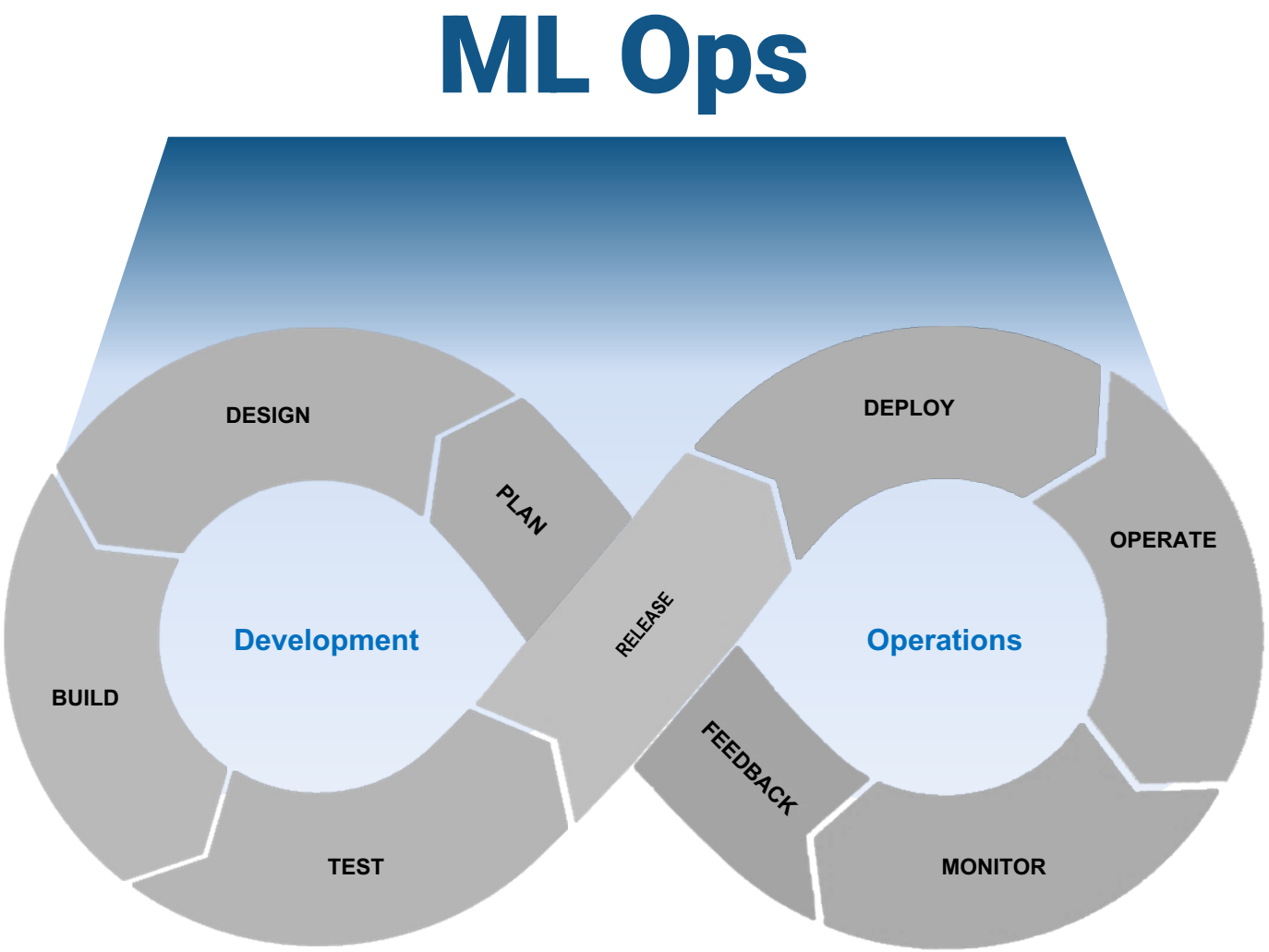


Predictive maintenance enables downtime to be scheduled rather than disruptive.



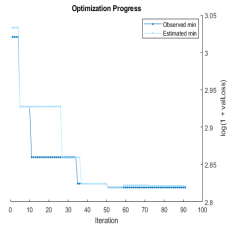
Development Operations principles reduce complexity.

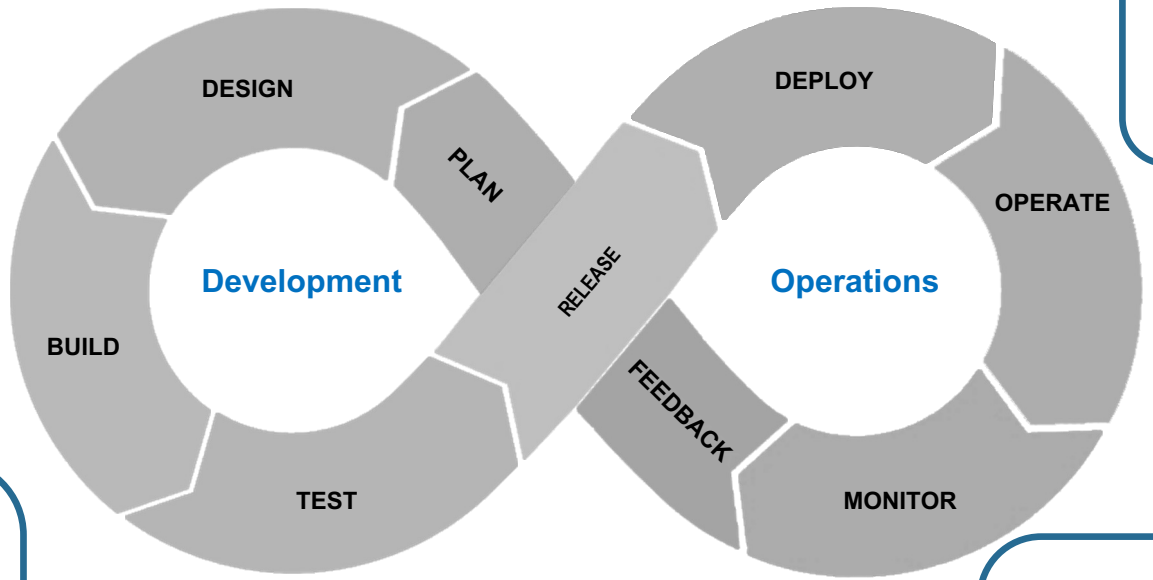




Development Operations principles reduce complexity.

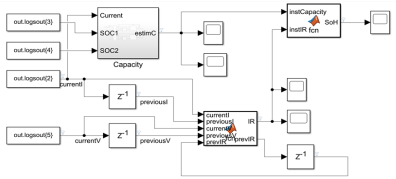
"AutoML"



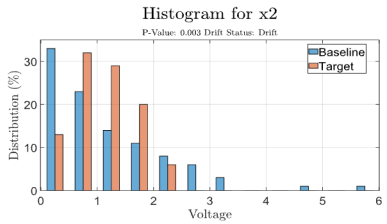


$\hat{f}(x)$

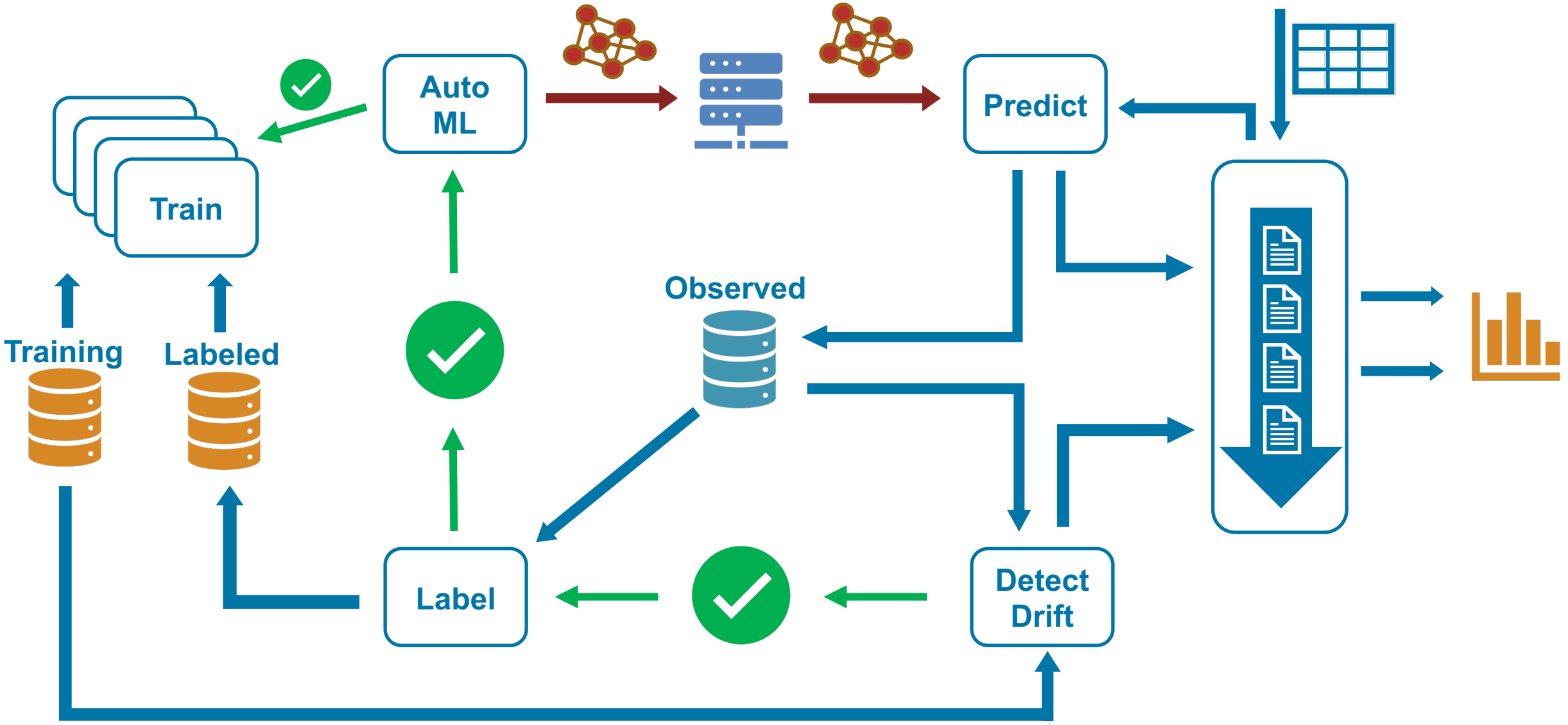
Model-based labeling



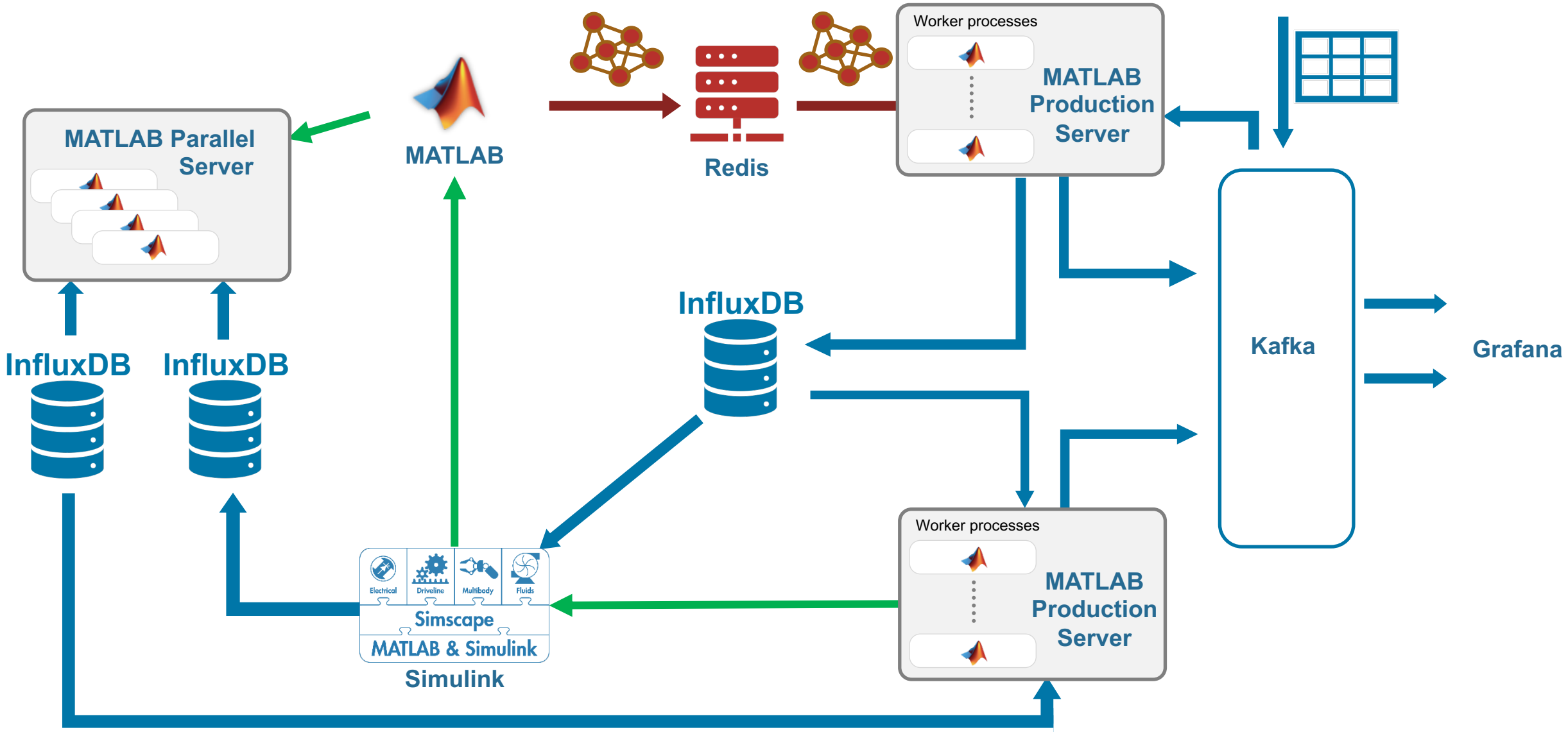
Drift Detection

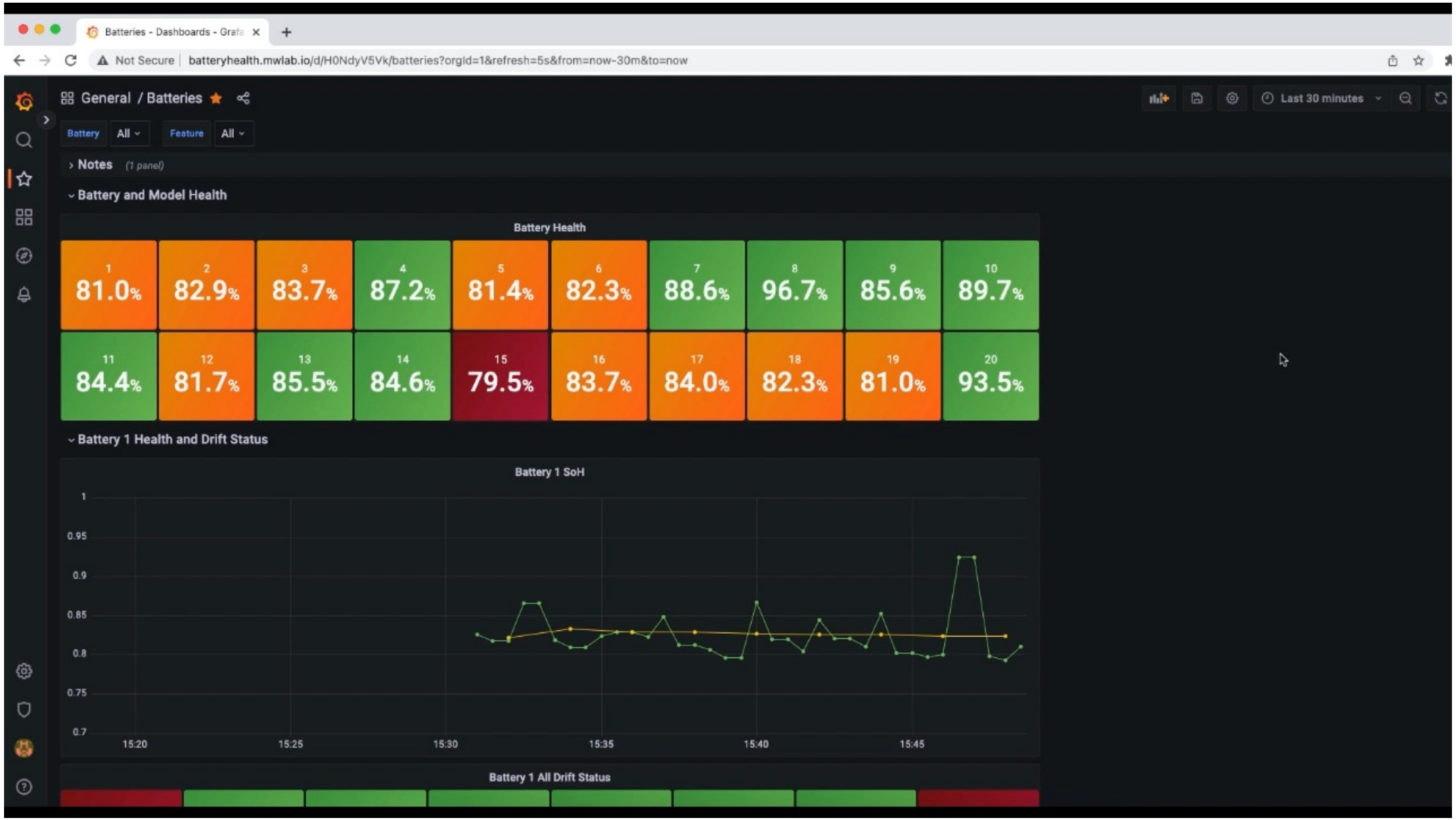


Production system architecture mirrors the stages of the ML Ops cycle.

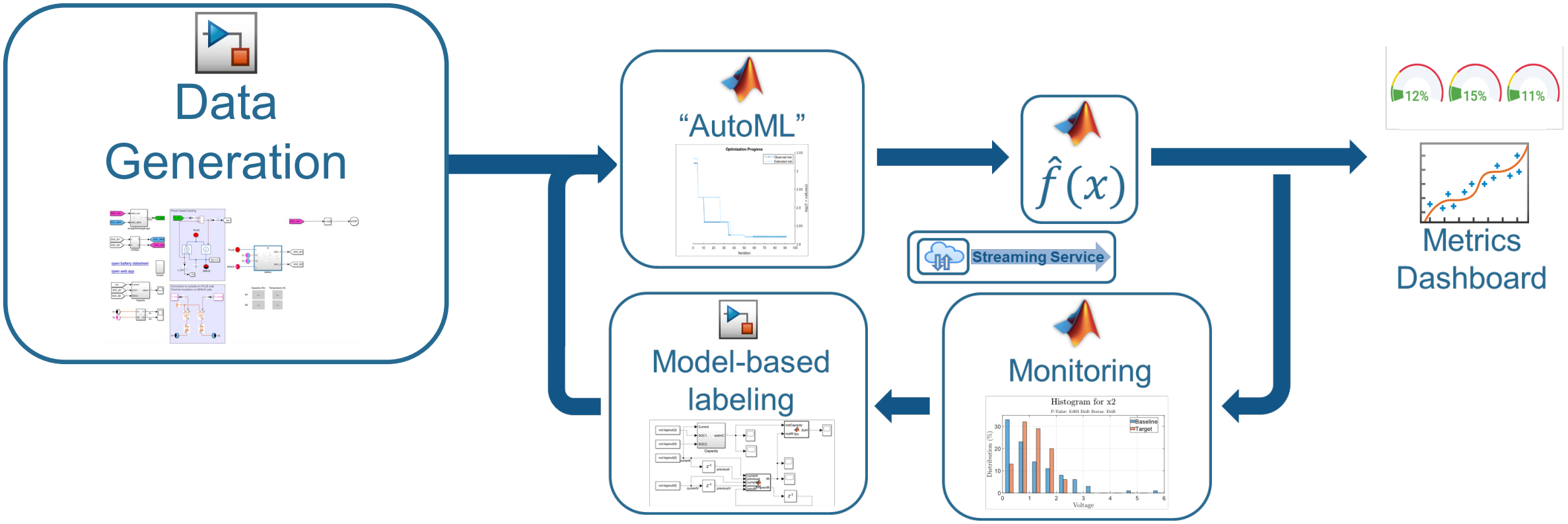


Off the shelf components minimize development effort.

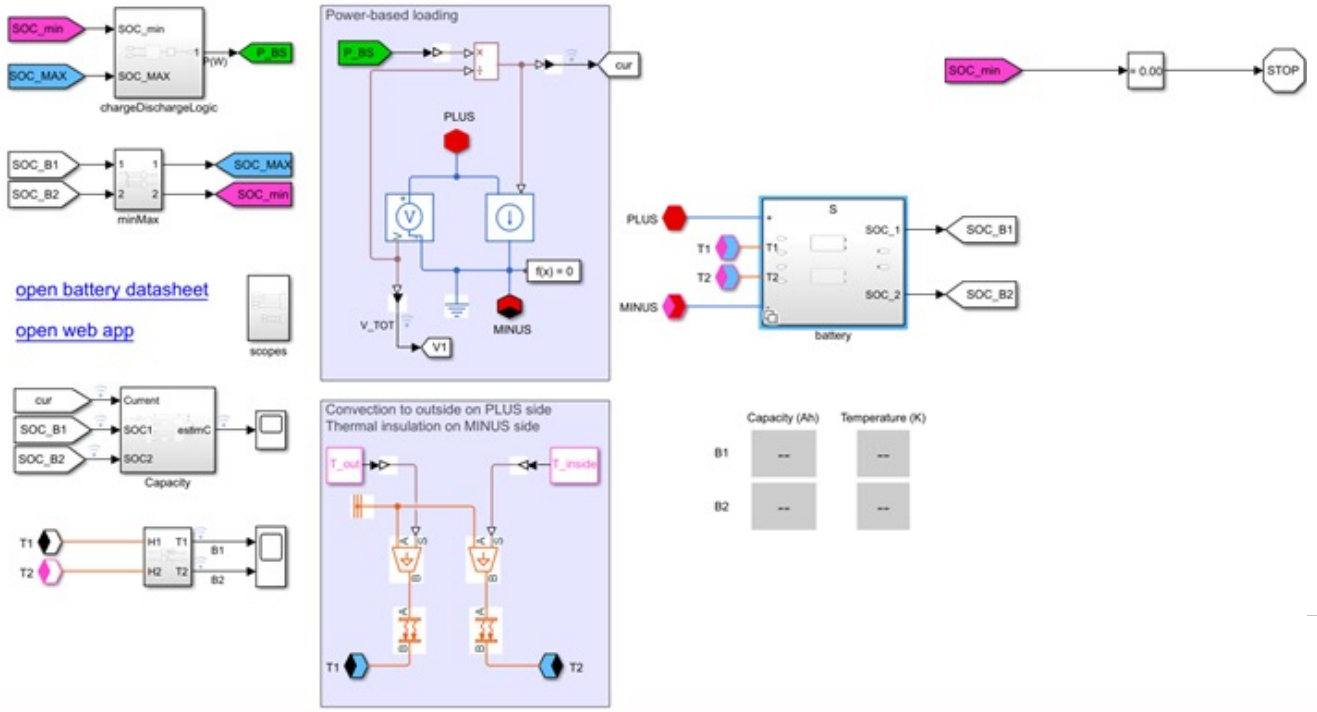


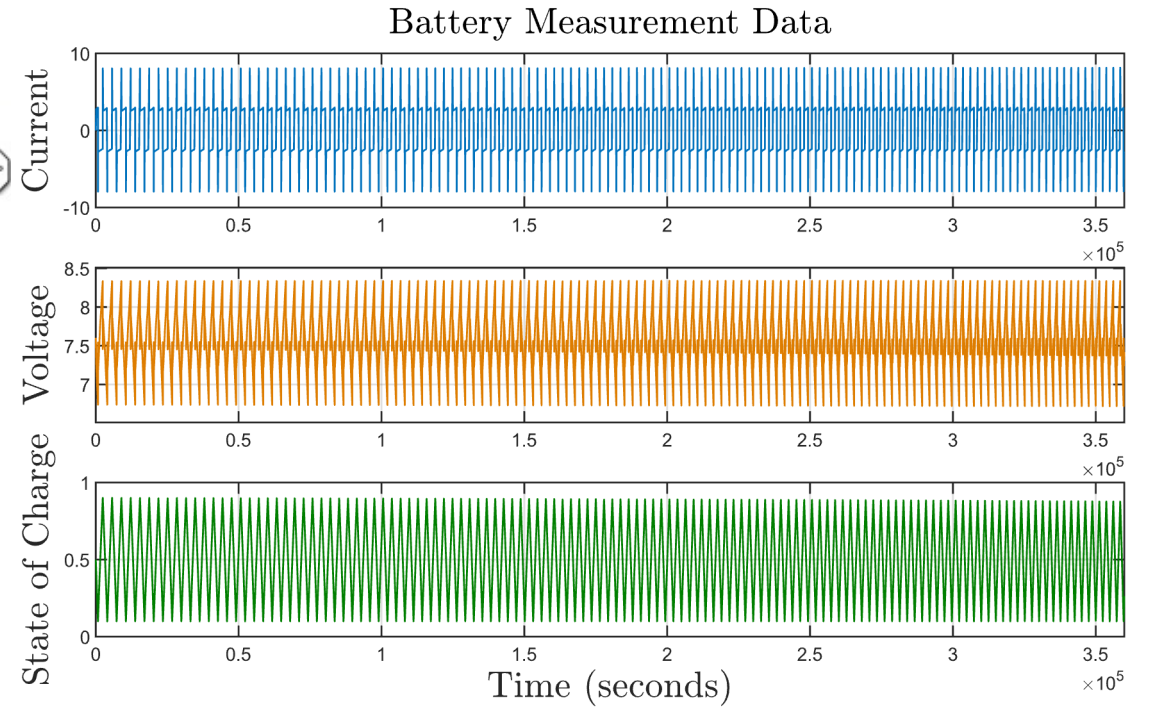


Physics-based simulation allows realistic data generation.



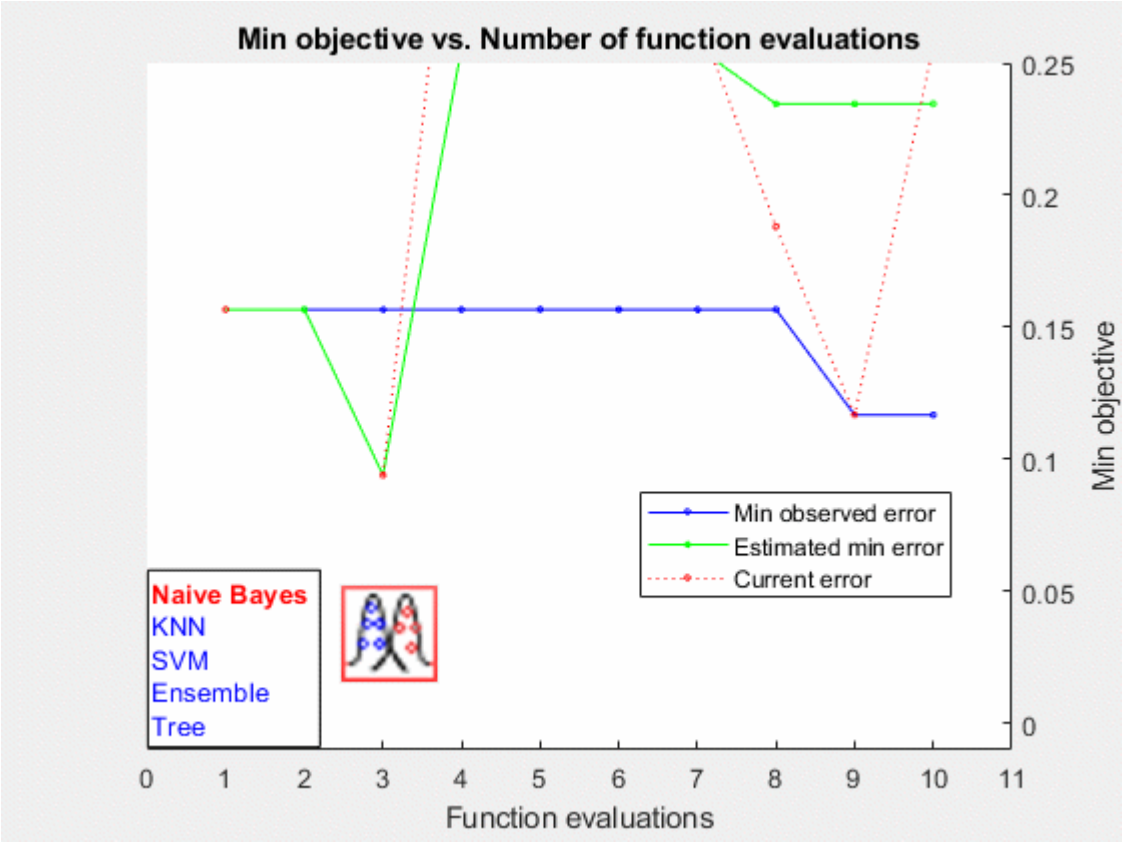
Domain-specific capabilities allow you to create a State-of-Health prediction function.

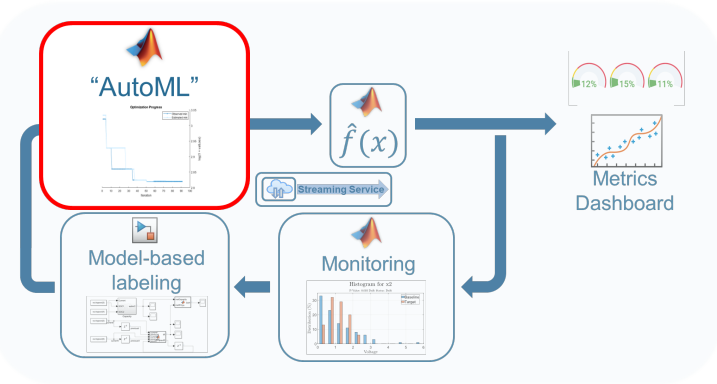




Member No.	Signal (3 frames, 20% overlap)	Mean
1	Frame 1, Frame 2, Frame 3	0.22 0.3 0.48

AutoML “automagically” finds the right model.





fitrauto

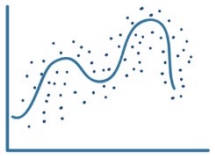
Automatically select regression model with optimized hyperparameters

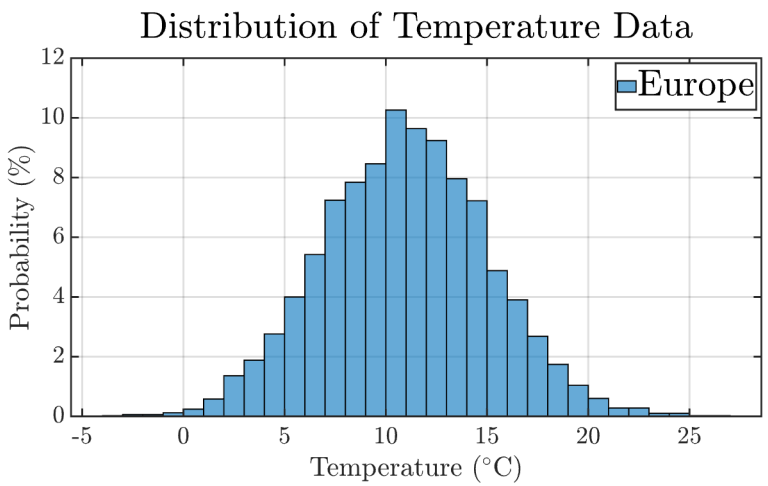
Since R2020b

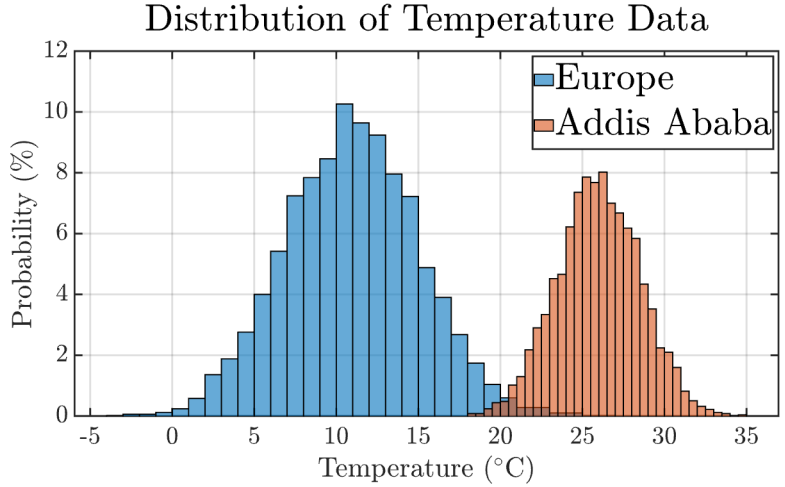
Syntax

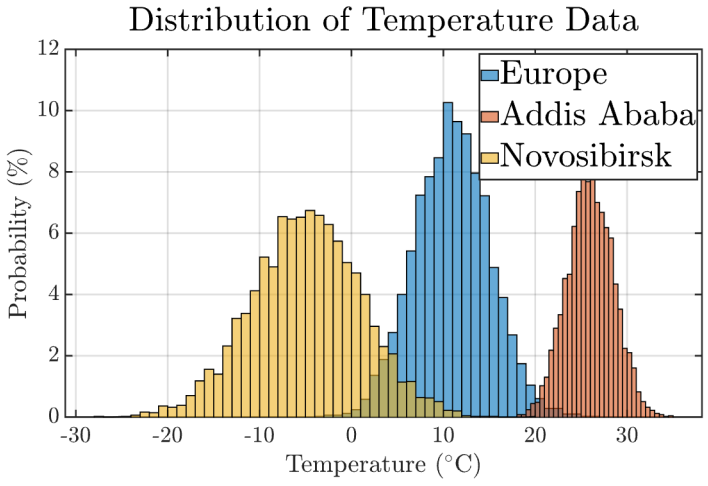
```
Mdl = fitrauto(Tbl,ResponseVarName)
```

Static data assumption rarely holds in the real world.

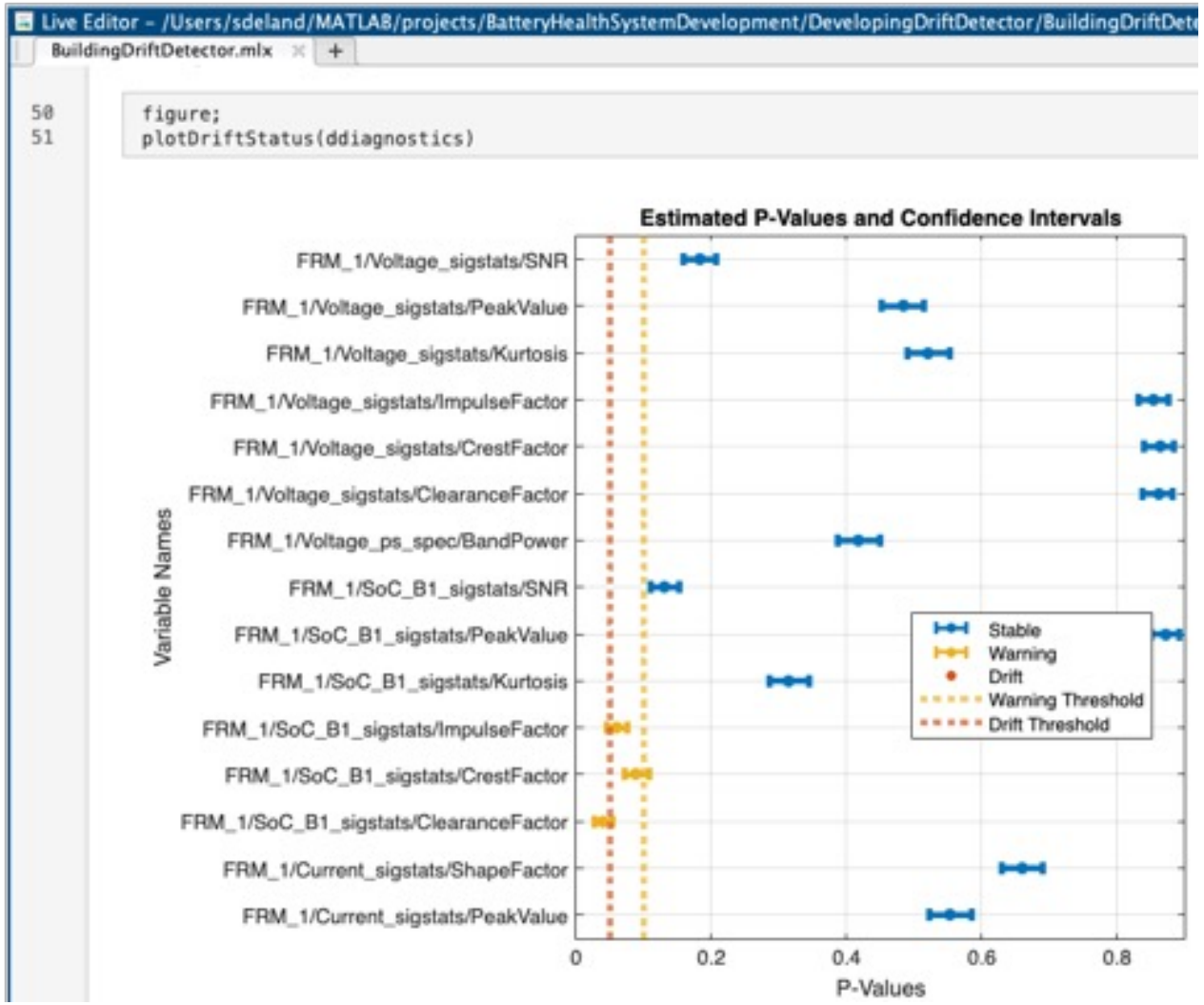








Data drift can be visualized, interpreted and assessed.



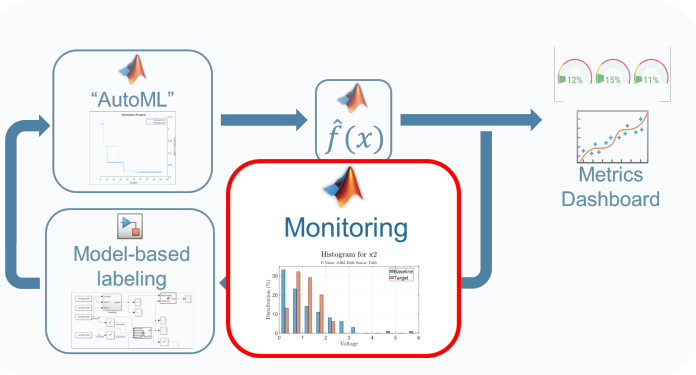
detectdrift

Update drift detector states and drift status with new data

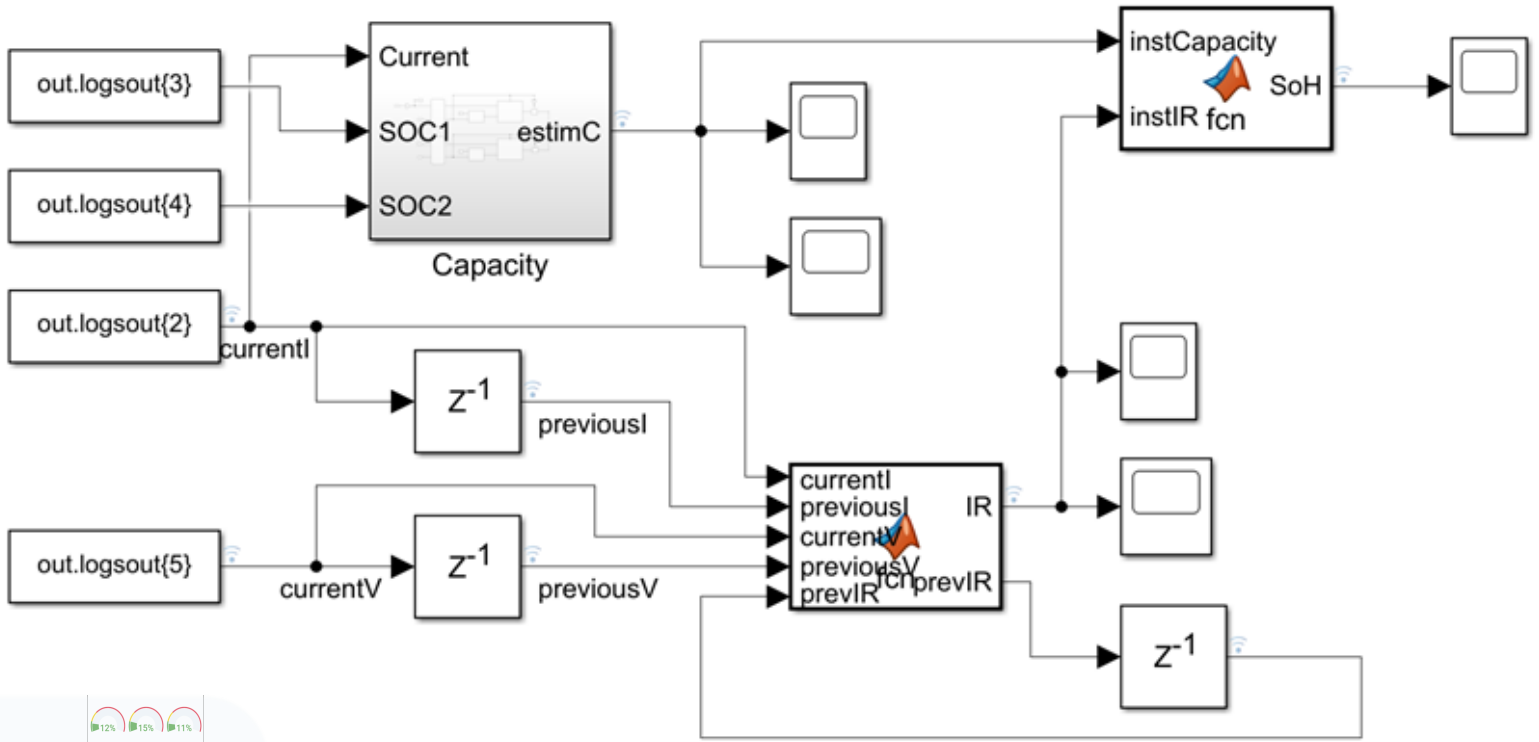
Since R2022a

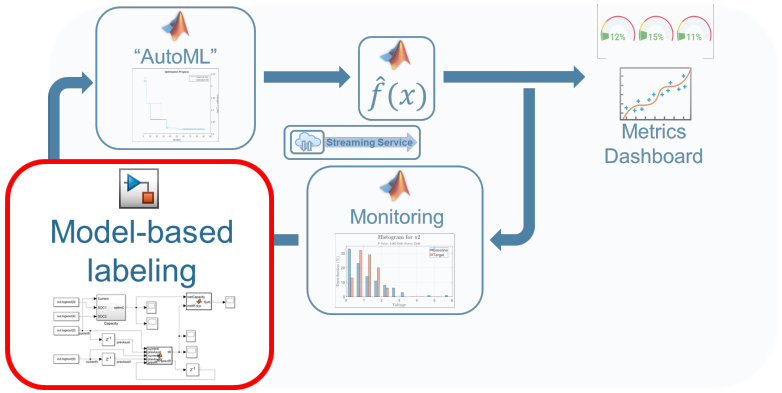
Syntax

```
IncCDDetector = detectdrift(IncCDDetector,X)
```

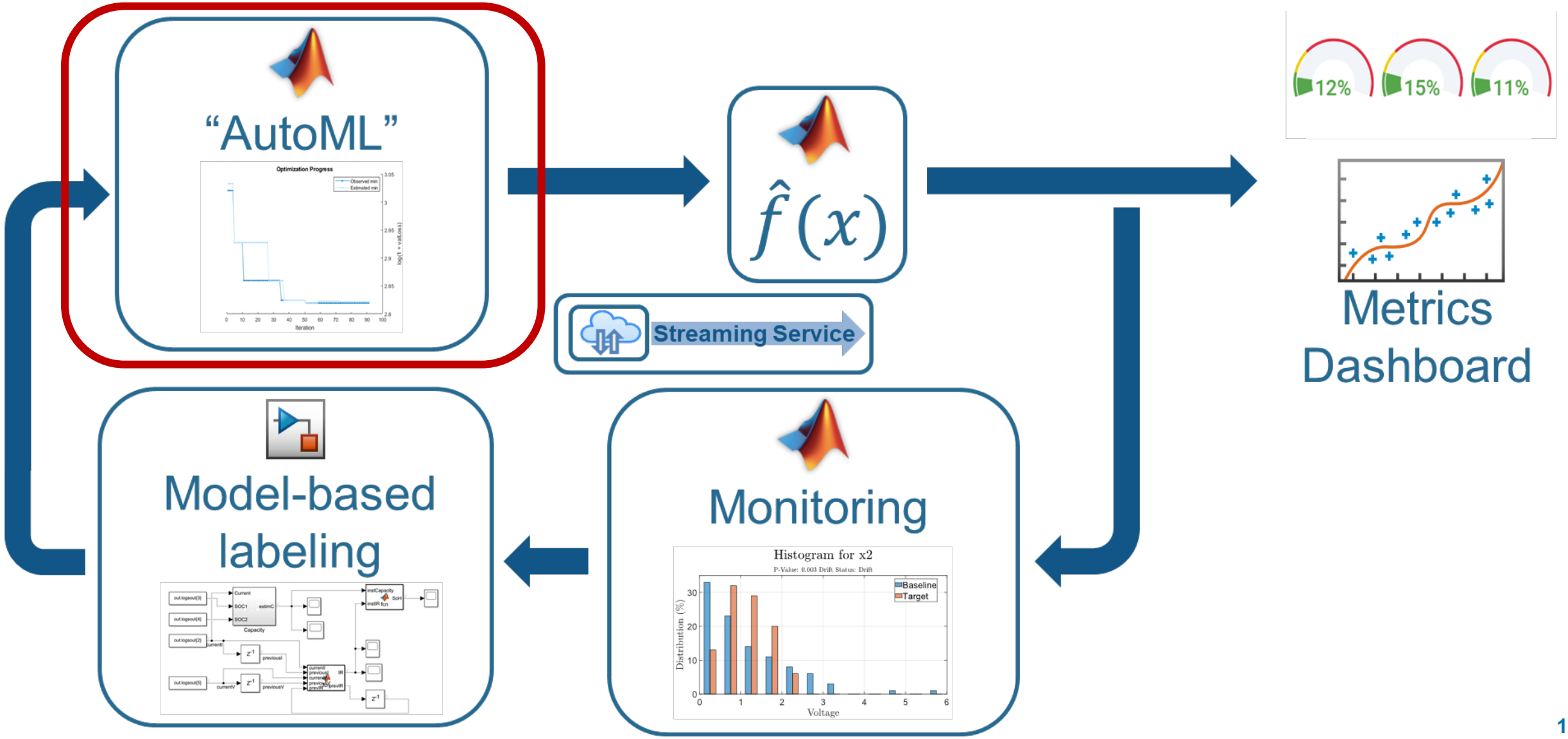


Model-based labeling system is high fidelity.





The train-deploy-monitor-label cycle automatically works on its own.



MATLAB R2023a

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Workspace

Name ▲	Value

Current Folder

Name ▲	Git
DevelopingBatterySoHPredictor	·
DevelopingDriftDetector	·
LabelNewDataAndTrain	■
matlab_influxdb_http_client	·
connectToInfluxDB.m	●
InfluxDBParams.env	●
LabelNewDataAndTrain.m	●
LabelNewDataAndTrain.mlx	■
readDataFromInfluxDB.m	●
sohEstimator.slx	●
log	·
resources	·
slprj	·
TrainingData	·
BatteryHealthSystemDevelopme...	●
README.md	●
sohEstimator.slxc	○

Details

Live Editor – LabelNewDataAndTrain.mlx | Command Window | Project – BatteryHealthSystemDevelopment

LabelNewDataAndTrain.mlx

Label New Data and Train Next Model

Connect to database and read new battery telemetry data

```
loadenv("InfluxDBParams.env");
idb = connectToInfluxDB();

startTime = datetime(2021,11,3);
endTime = datetime(2021,11,5,4,0,1);
batteryID = 1;
data = readDataFromInfluxDB(idb,batteryID,"battery","Production",startTime,endTime)
```

Label new data using a physics-based digital twin

Assign variables that are used as inputs to the simulation

```
simInData = data;
simInData.Time = simInData.Time-simInData.Time(1); % Start at 00:00:00
soc1 = simInData(:,'SoC_B1');
soc2 = simInData(:,'SoC_B2');
Current = simInData(:,'Current');
Voltage = simInData(:,'Voltage');
```

Load the simulation and run it

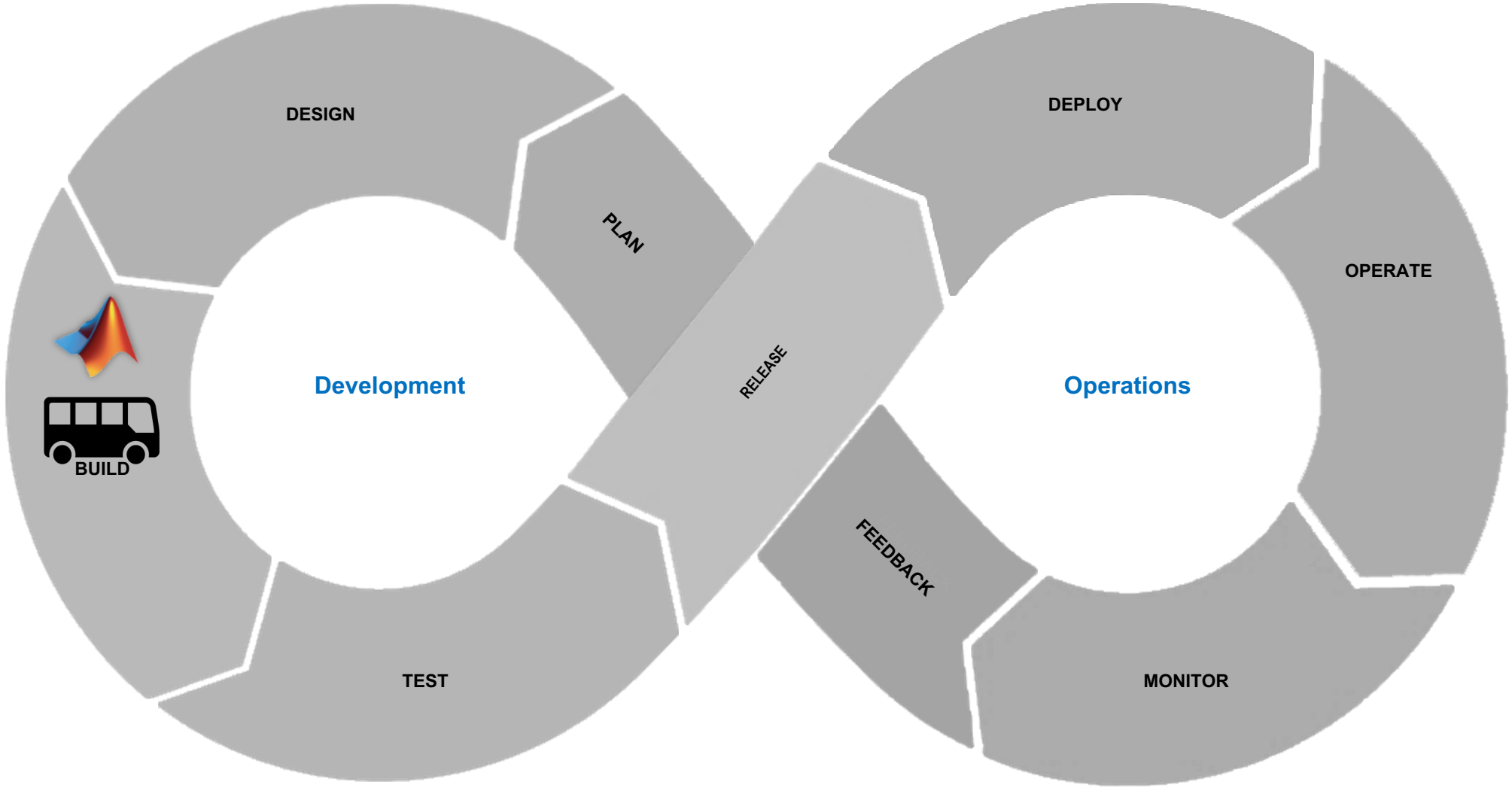
```
simTime = seconds(simInData.Time(end));
mdl = "sohEstimator.slx";
open_system(mdl);
groundTruth = sim(mdl,StopTime=string(simTime));
close_system(mdl,false);
```

Post-process simluation results to extract the SoH values

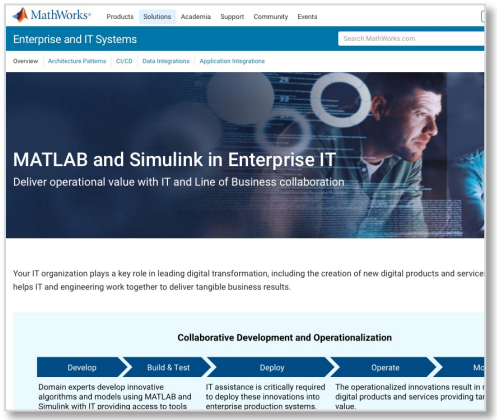
```
groundTruthSoH = groundTruth.logsout.extractTimetable;
```

Zoom: 125% | UTF-8 | LF | script | Ln 1 | Col 31

Automate the entire ML Ops cycle and your machine learning models can change for the better, by themselves.

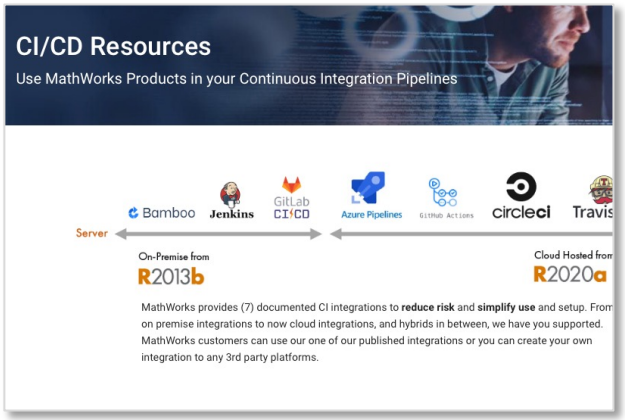


Resources to learn more



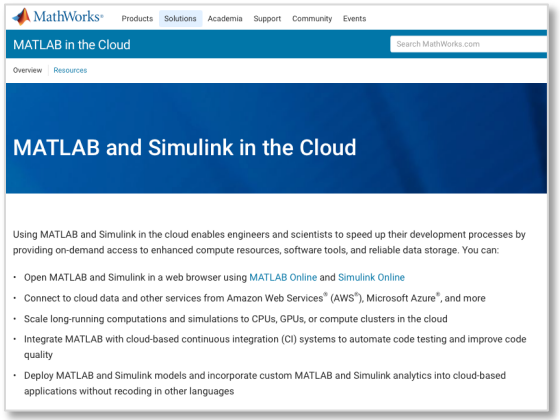
How MATLAB and Simulink are used with Enterprise IT

https://www.mathworks.com/solutions/enterprise-it-systems.html



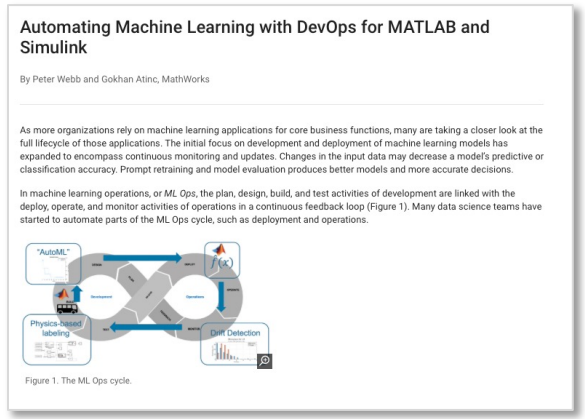
CI/CD Resources

https://www.mathworks.com/solutions/enterprise-it-systems/ci-cd.html



MATLAB and Simulink in the Cloud

https://www.mathworks.com/solutions/cloud.html



Automating Machine Learning with DevOps for MATLAB and Simulink

https://www.mathworks.com/company/newsletters/articles/automating-machine-learning-with-devops-for-matlab-and-simulink.html

https://www.mathworks.com/learn/training.html

Thank you!

Let's connect and collaborate

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MathWorks

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