Artificial Intelligence In MATLAB: From Research To Implementation And Production

Christoph Stockhammer

Senior Application Engineer

MathWorks

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Artificial Intelligence

The capability of a machine to imitate intelligent human behavior

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Artificial Intelligence

The capability of a machine to match or exceed intelligent human behavior

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Artificial Intelligence Today

The capability of a machine to match or exceed intelligent human behavior

by training a machine to learn the desired behavior

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There are two ways to get a computer to do what you want

Traditional Programming

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There are two ways to get a computer to do what you want

Machine Learning

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There are two ways to get a computer to do what you want

Machine Learning

Artificial Intelligence

Machine Learning

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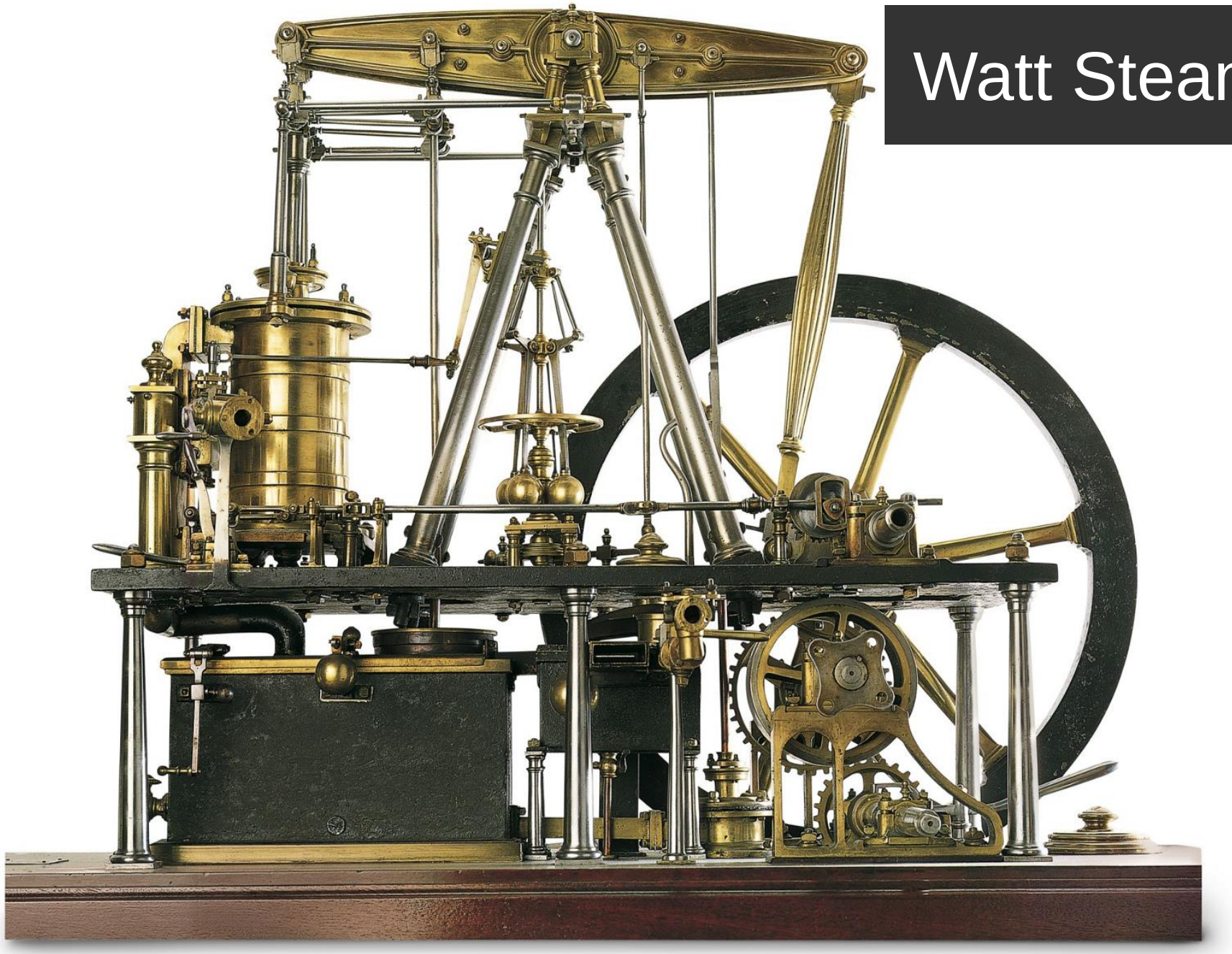
Watt Steam Engine



Artificial intelligence is a transformative technology

AI will create $13 trillion in value by 2030

based on McKinsey's latest AI forecast – September 2018

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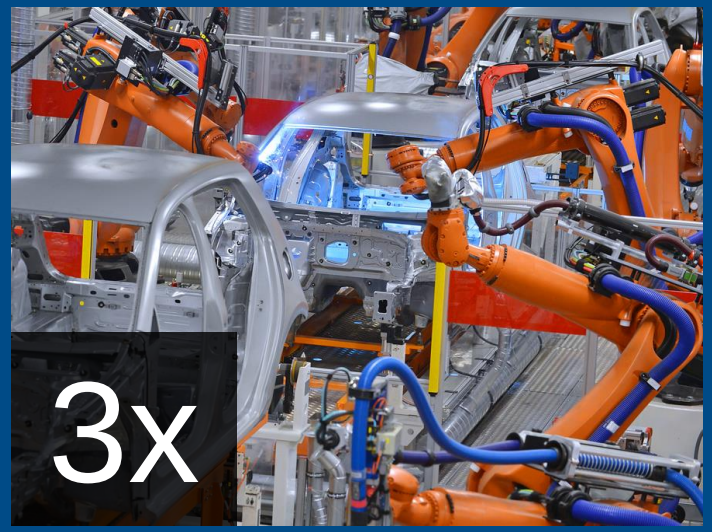
AI has tremendous potential to increase productivity

=



McKinsey Global Institute, September 2018

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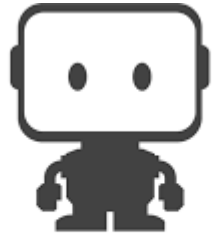
Yet AI is struggling

DigitalTonto
At the Crossroads of Media, Marketing and Technology...

Most AI Projects Fail. Here's How to Make Yours Successful.

July, 2018



DataRobot

Why Most AI Projects Fail

Oct, 2017

CMS WiRE

3 Common Reasons Artificial Intelligence Projects Fail

May, 2018

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There are many ways Artificial Intelligence can fail

No data scientists

Too much data

Poor ROI

Not enough data

Beyond the skill of the team

Incomplete tools

Problem is a poor fit for AI

Can’t interact with other systems

Problem is unsolvable

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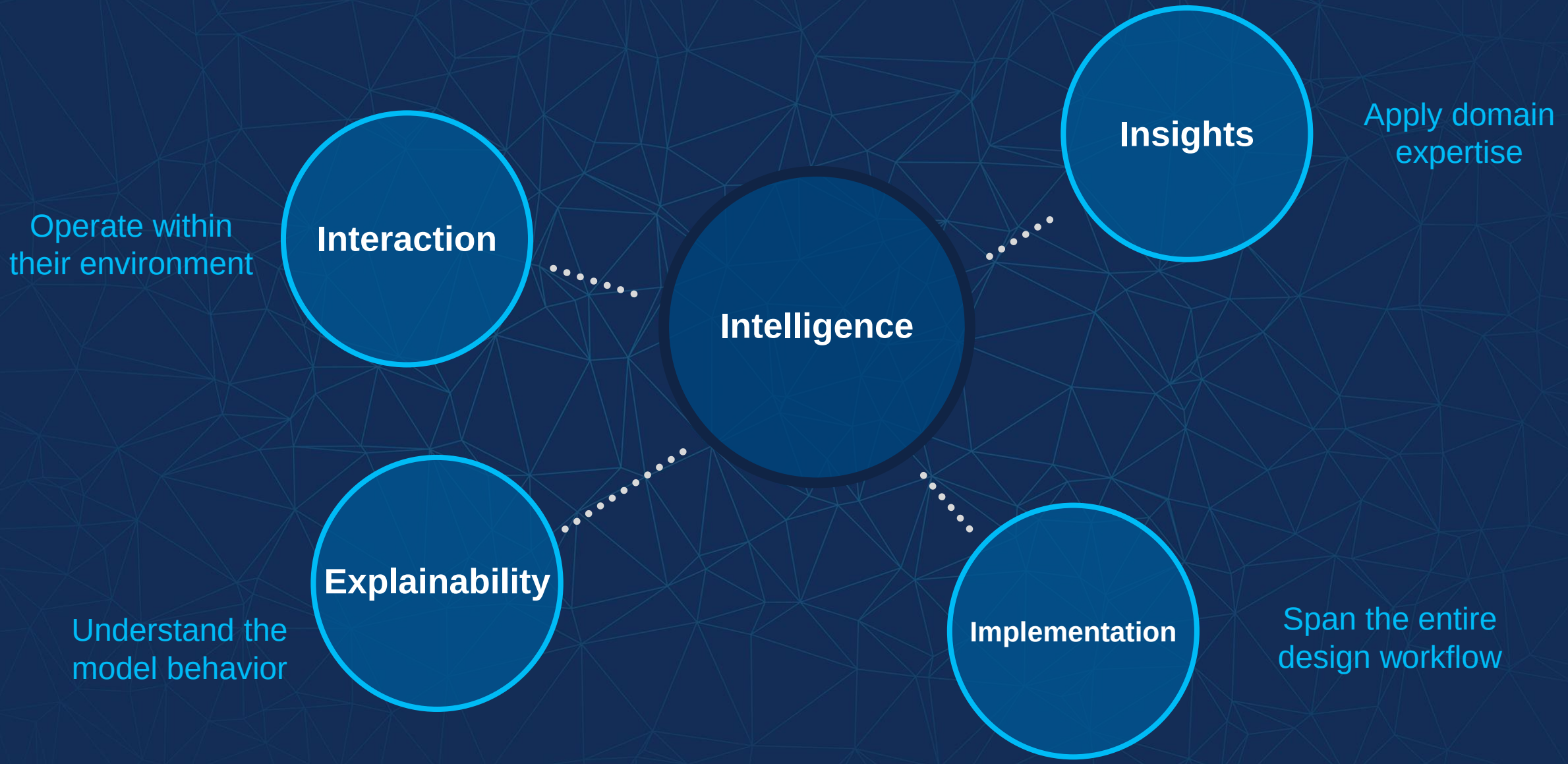
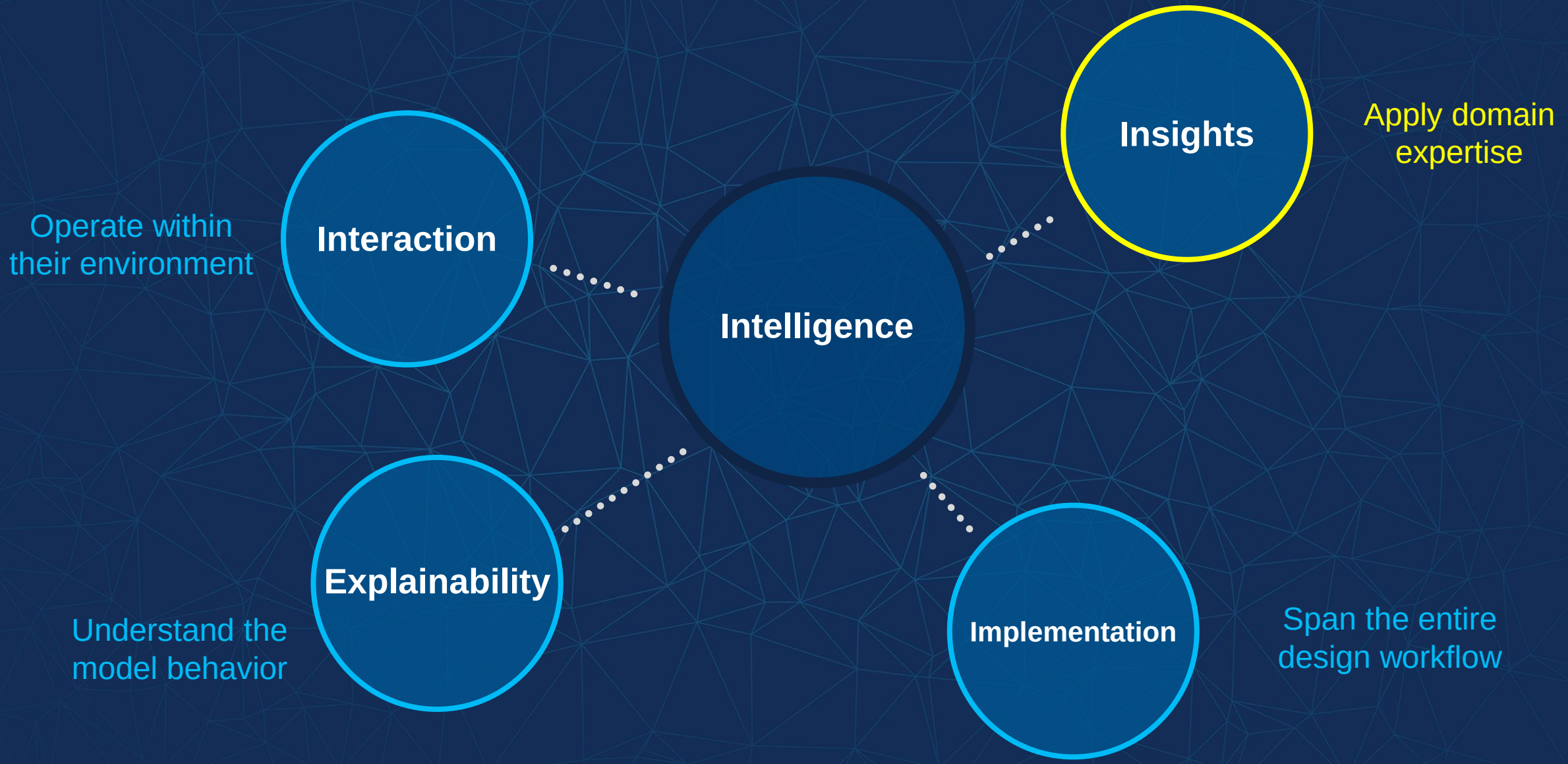
AI is more than just the intelligence of the algorithm



AI is more than just the intelligence of the algorithm



Bring human insights into AI

Select data

Make tradeoffs

Evaluate results

AI

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Bring human insights into AI

- We are the domain experts
- Shortage of data scientists
- We need the right tools

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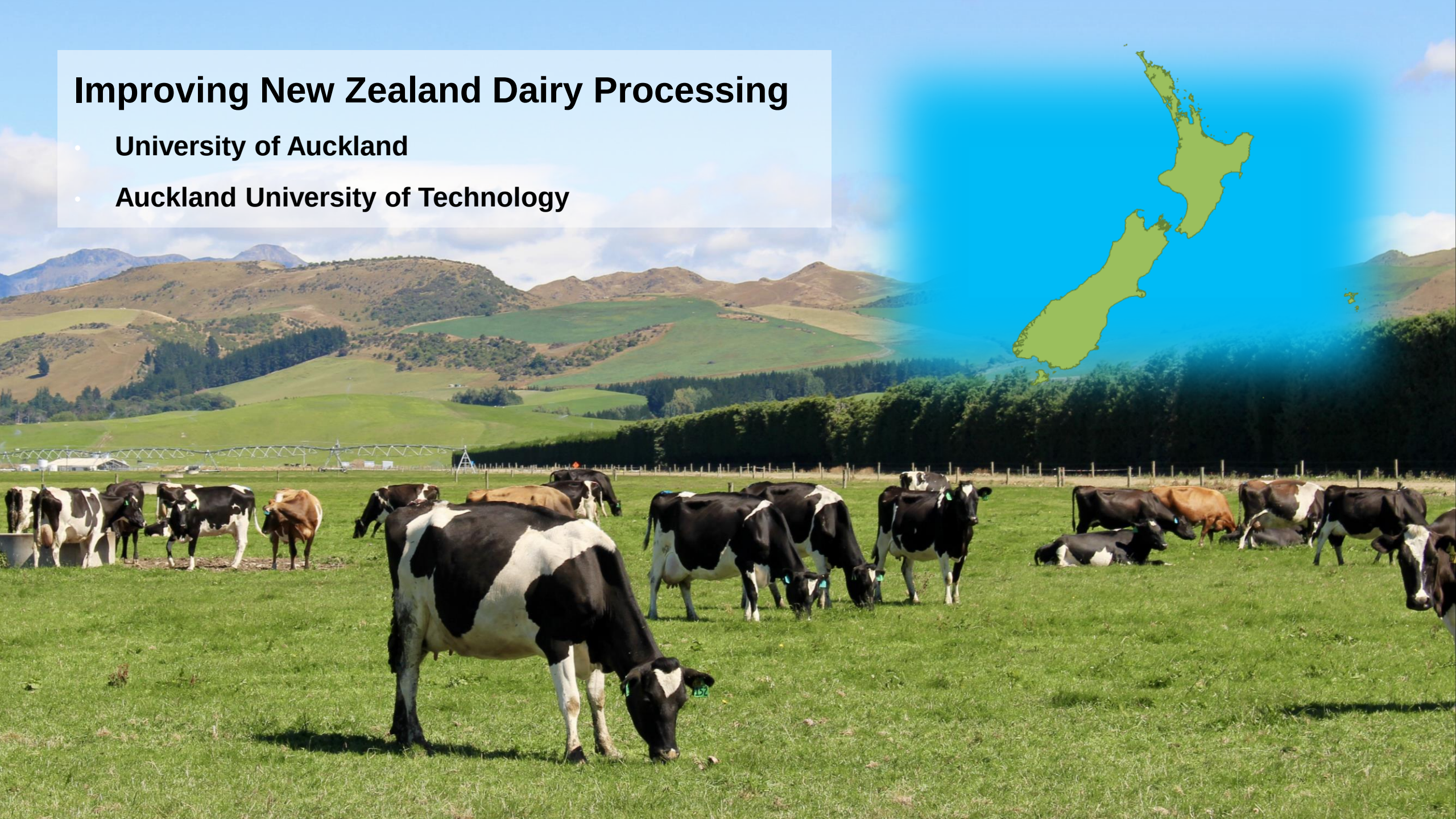
Improving New Zealand Dairy Processing

- University of Auckland
- Auckland University of Technology



Wanted to detect a bad product earlier

Raw Milk

Continuous Plant Process

Powdered Milk

Days later

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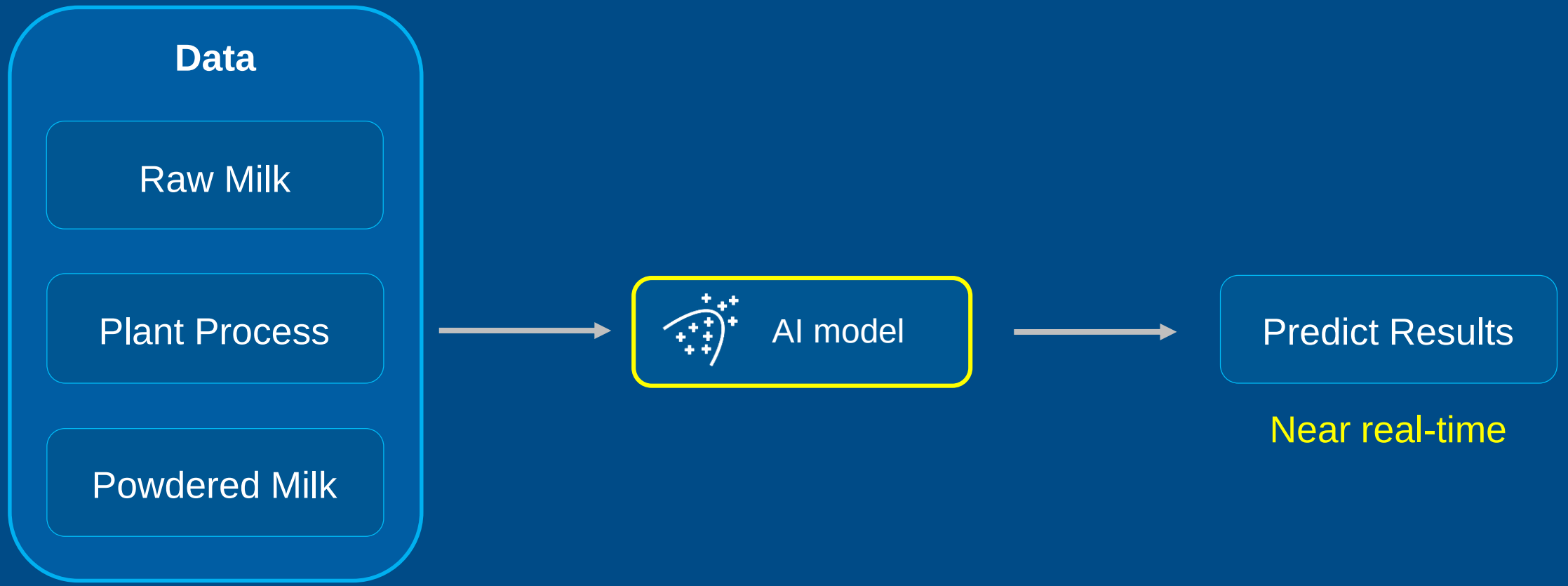
Wanted to detect a bad product earlier



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They had lots of data

- Millions of data points
- 6 years
- 3 plants

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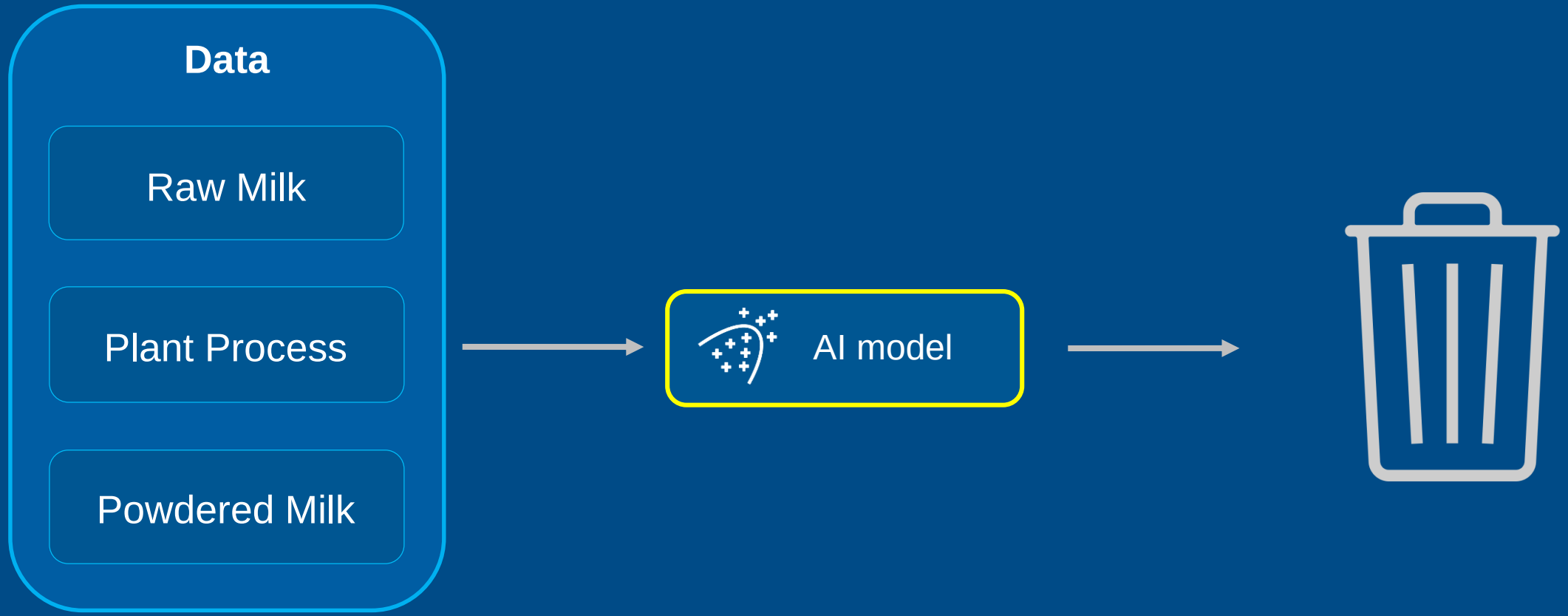
But…



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They made several key insights

1. Results were wrong

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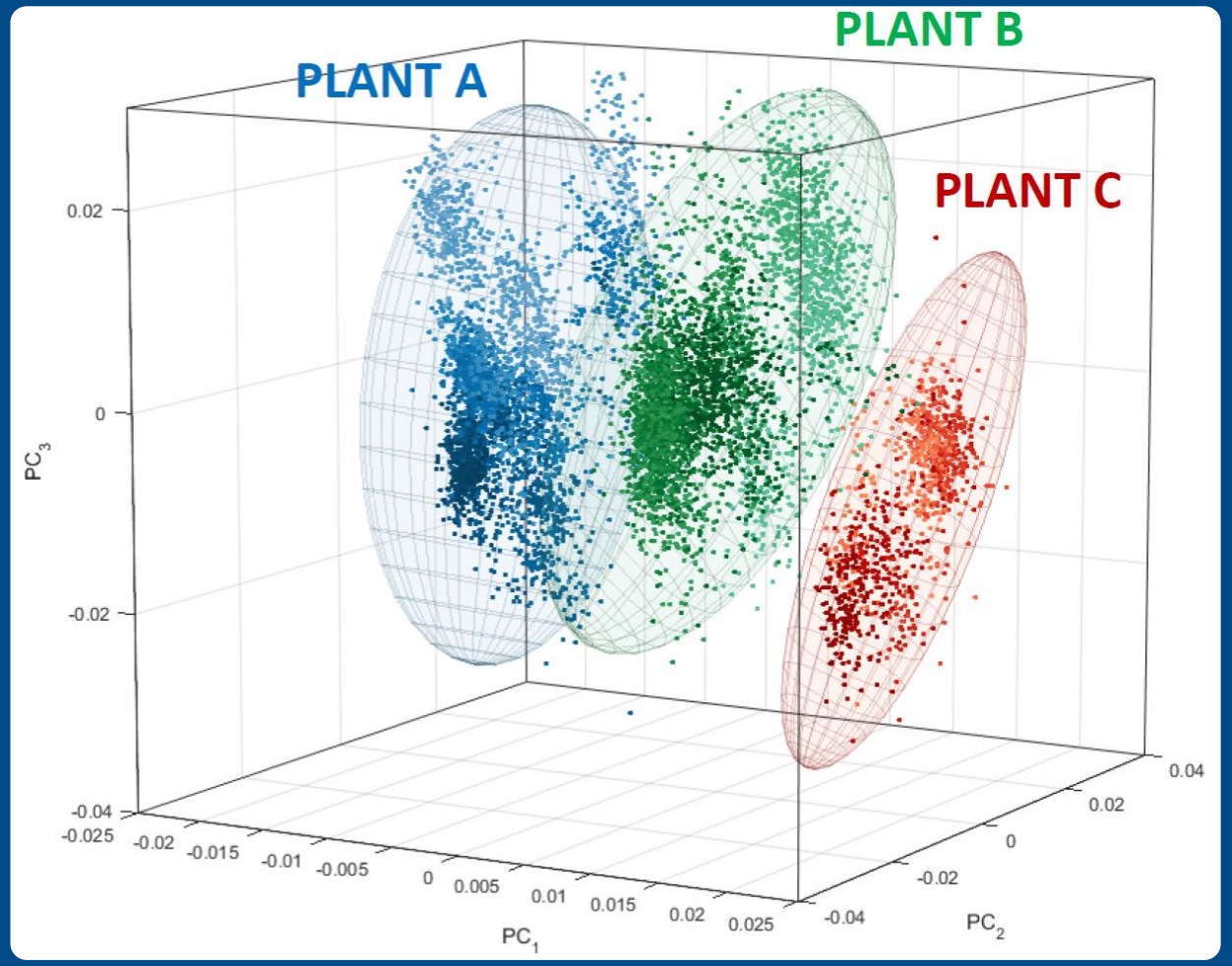
They made several key insights

1. Results were wrong

2. Need to build a separate model for each plant

Plants behaved differently from each another



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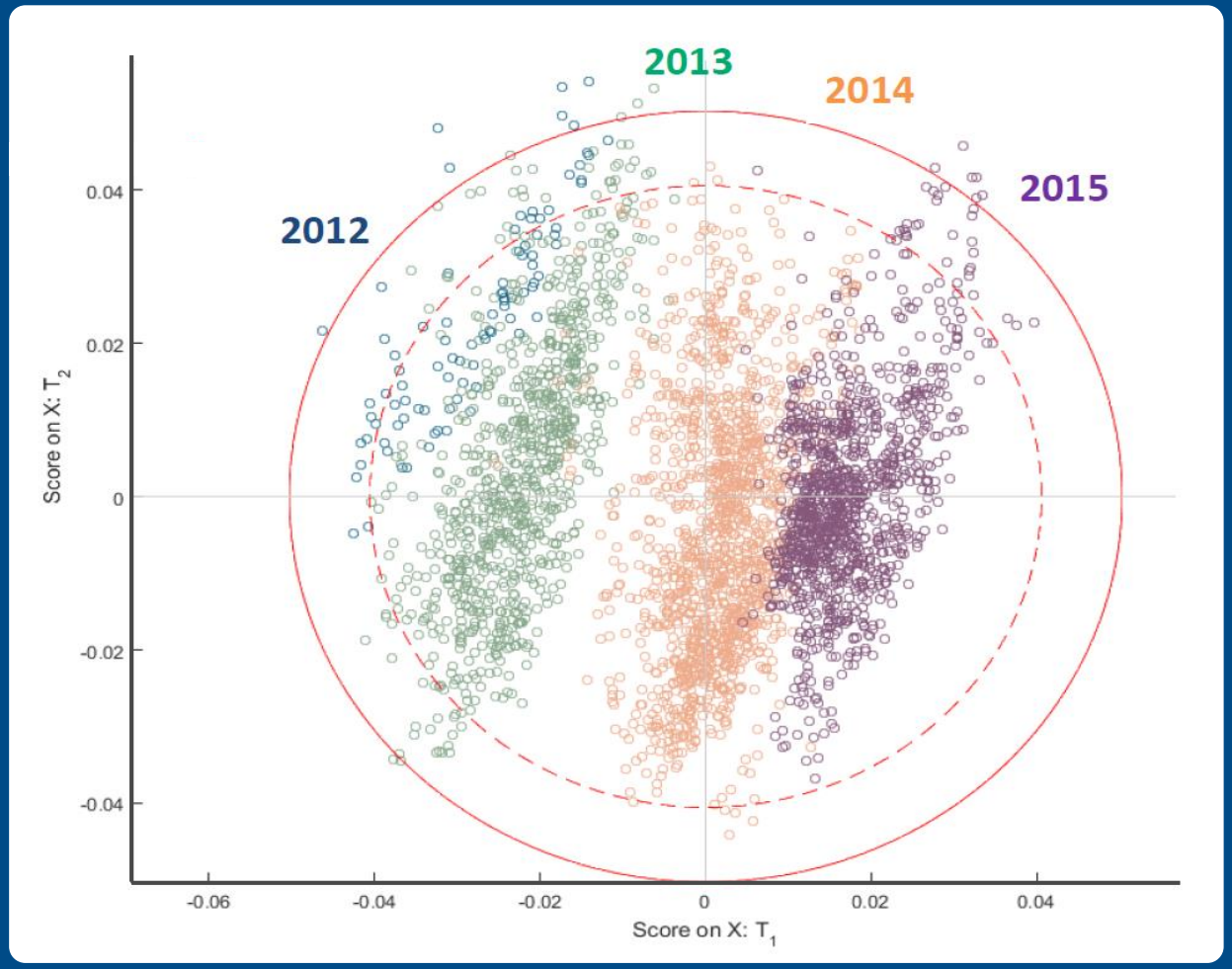
They made several key insights

1. Results were wrong
2. Need to build a separate model for each plant
3. Plant's operating state changes each year

Each year was like a completely different plant



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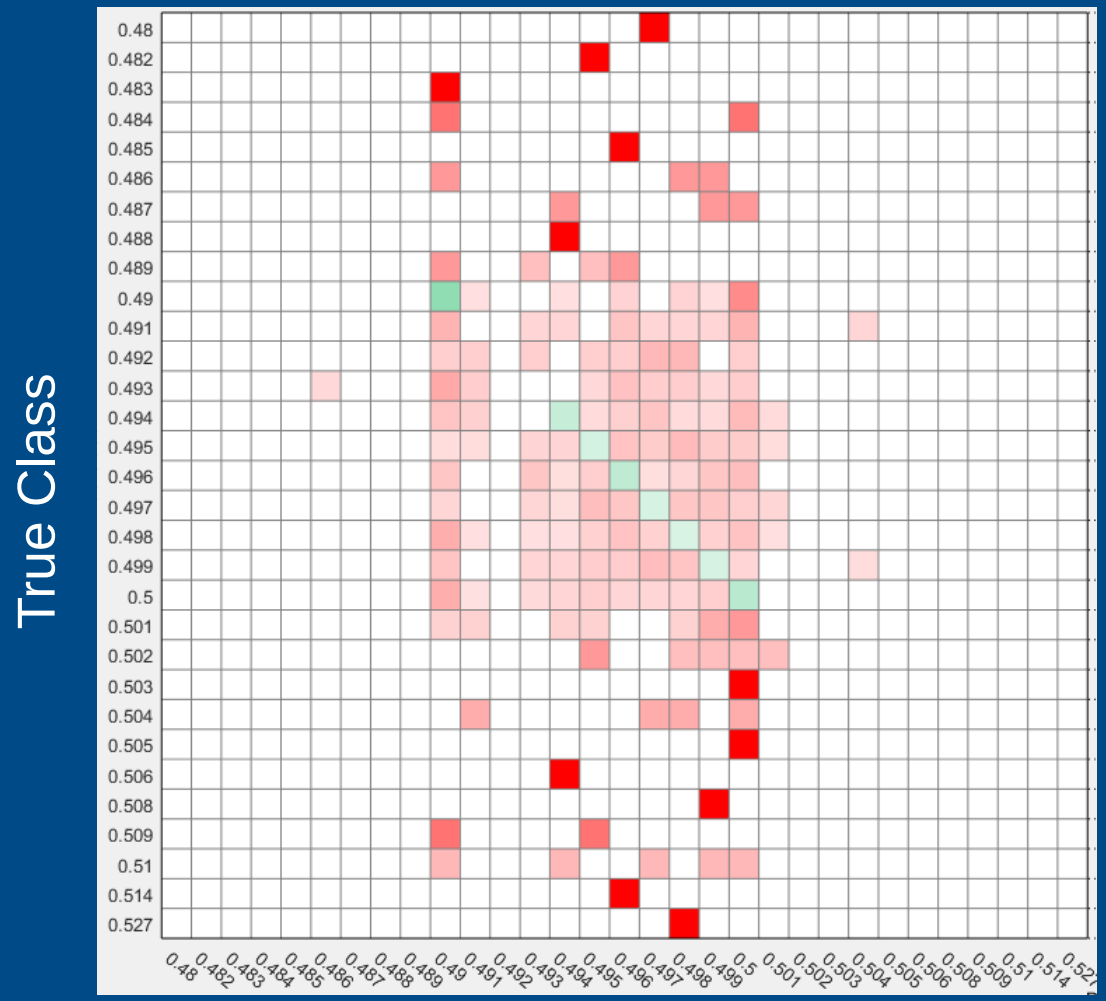
Bulk density prediction results were inaccurate

- Many false positives
- Unused classes



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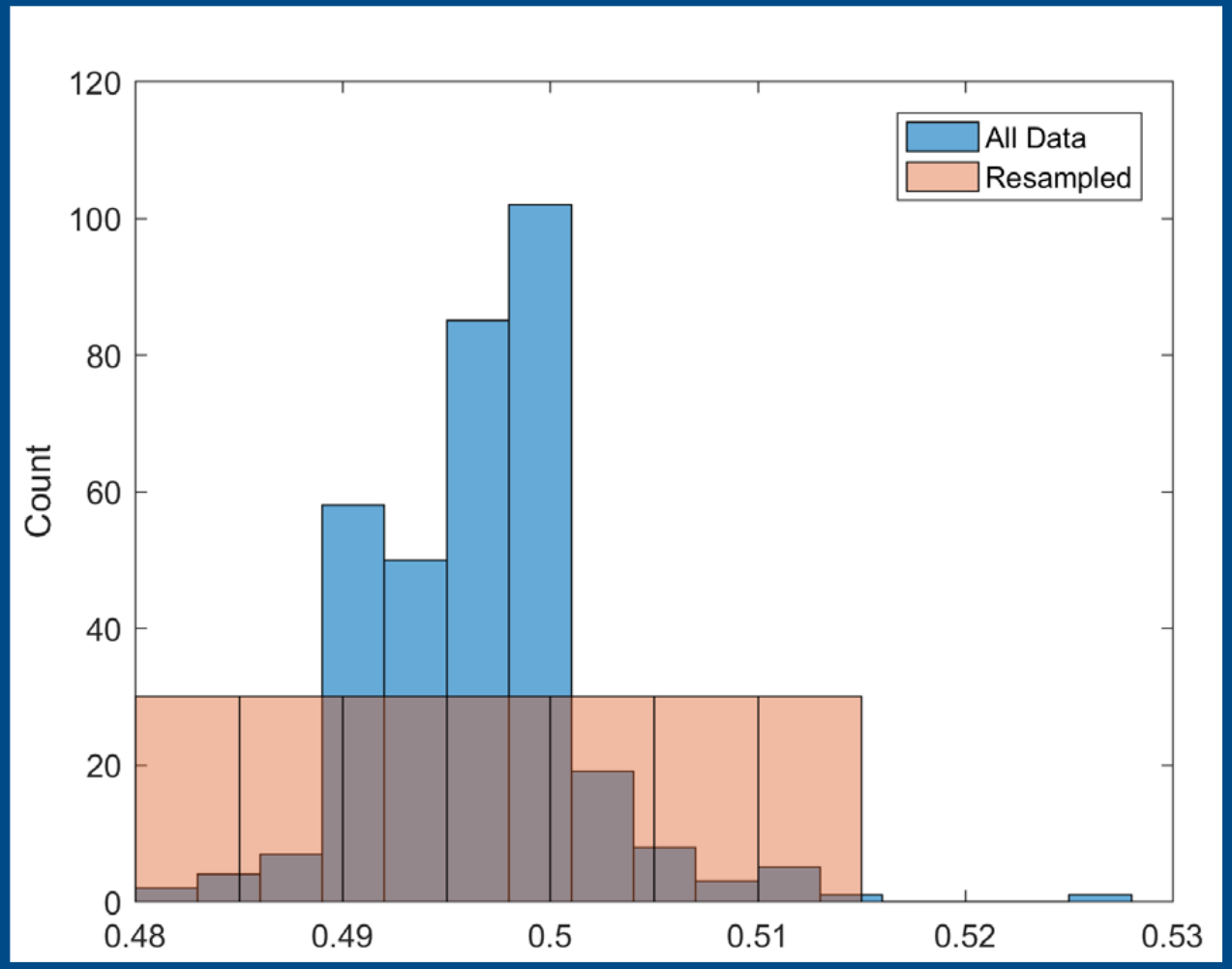
They made several key insights

1. Results were wrong
2. Need to build a separate model for each plant
3. Plant's operating state changes each year
4. Training data was biased



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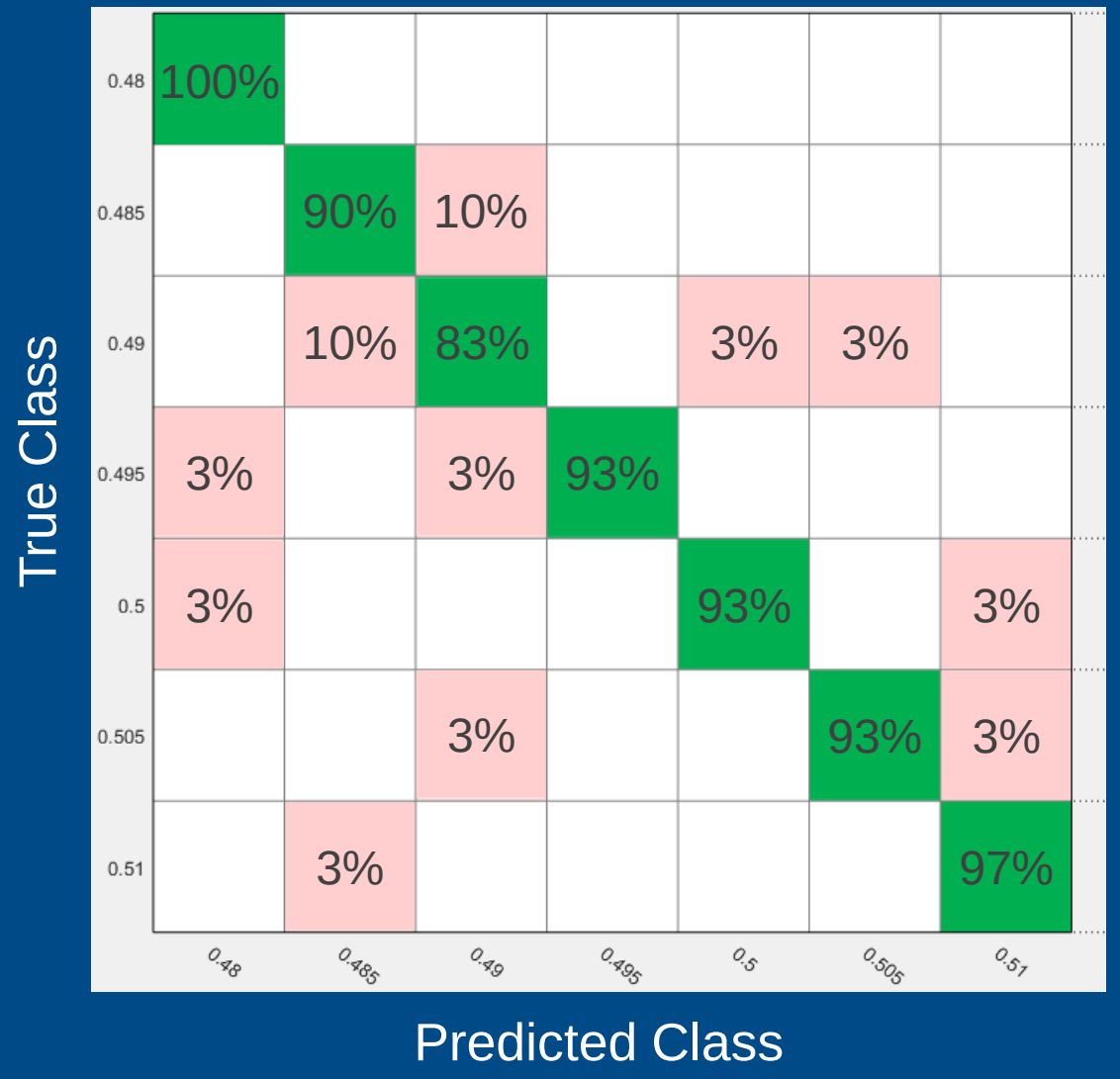
Resampling data resulted in higher predictive accuracy

- Resampled data
- Reduced the number of bins



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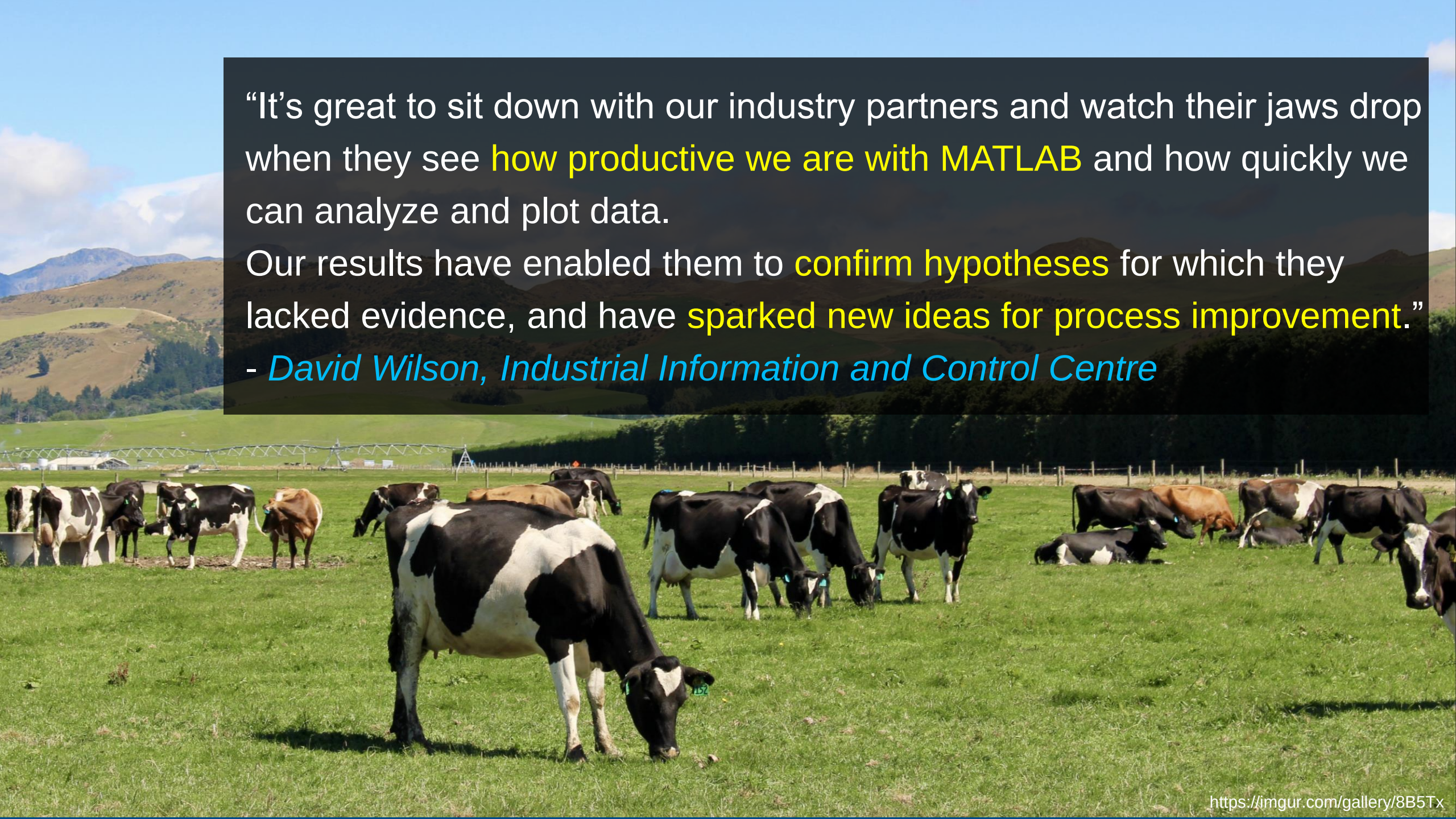
“It’s great to sit down with our industry partners and watch their jaws drop when they see how productive we are with MATLAB and how quickly we can analyze and plot data.
Our results have enabled them to confirm hypotheses for which they lacked evidence, and have sparked new ideas for process improvement.”
- David Wilson, Industrial Information and Control Centre
https://imgur.com/gallery/8B5Tx

To be successful with AI, we must …

Combine AI model building
with scientific and engineering insights

Along with tools that span
both the science and engineering and the data science

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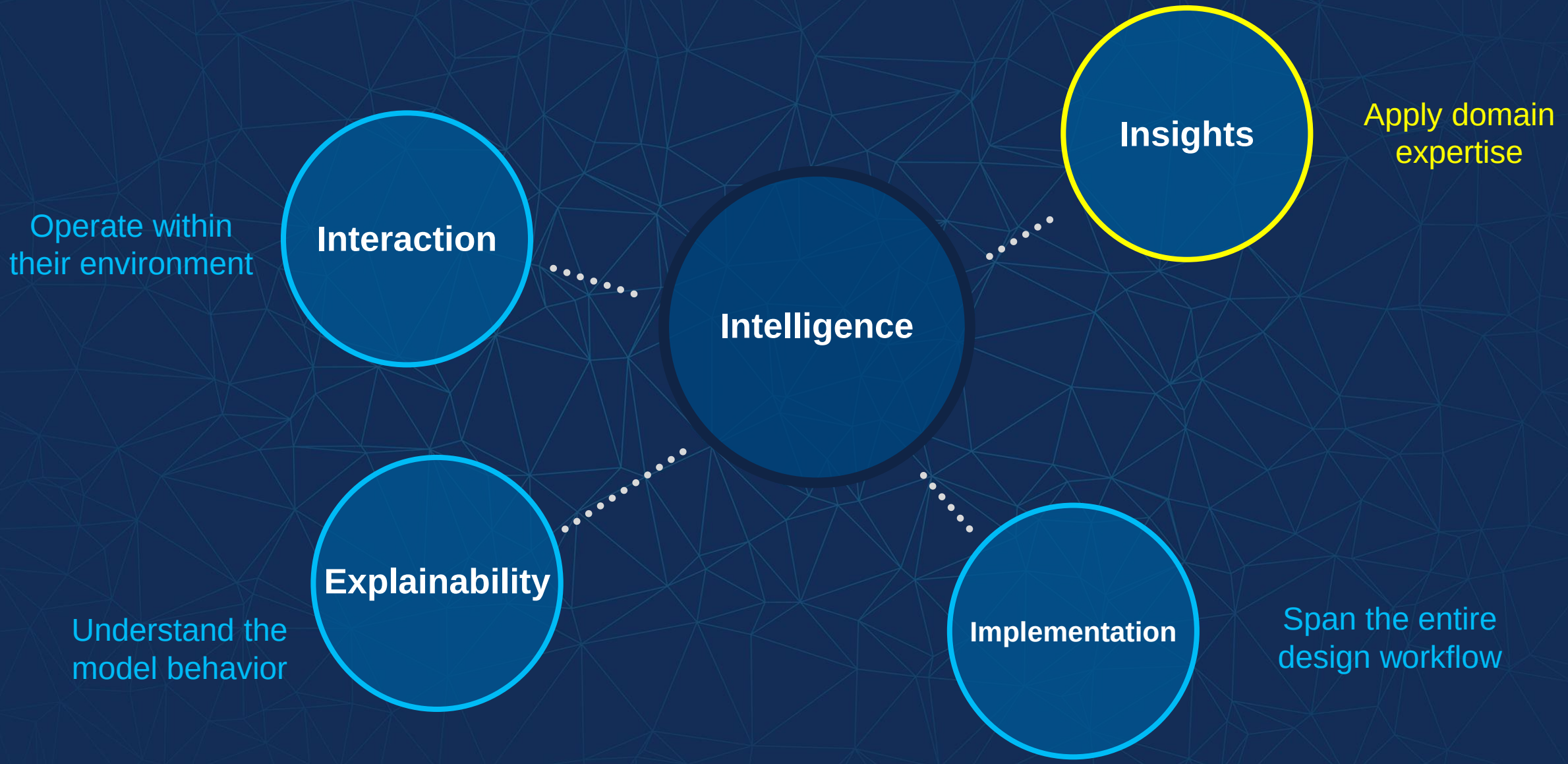
AI is more than just the intelligence of the algorithm



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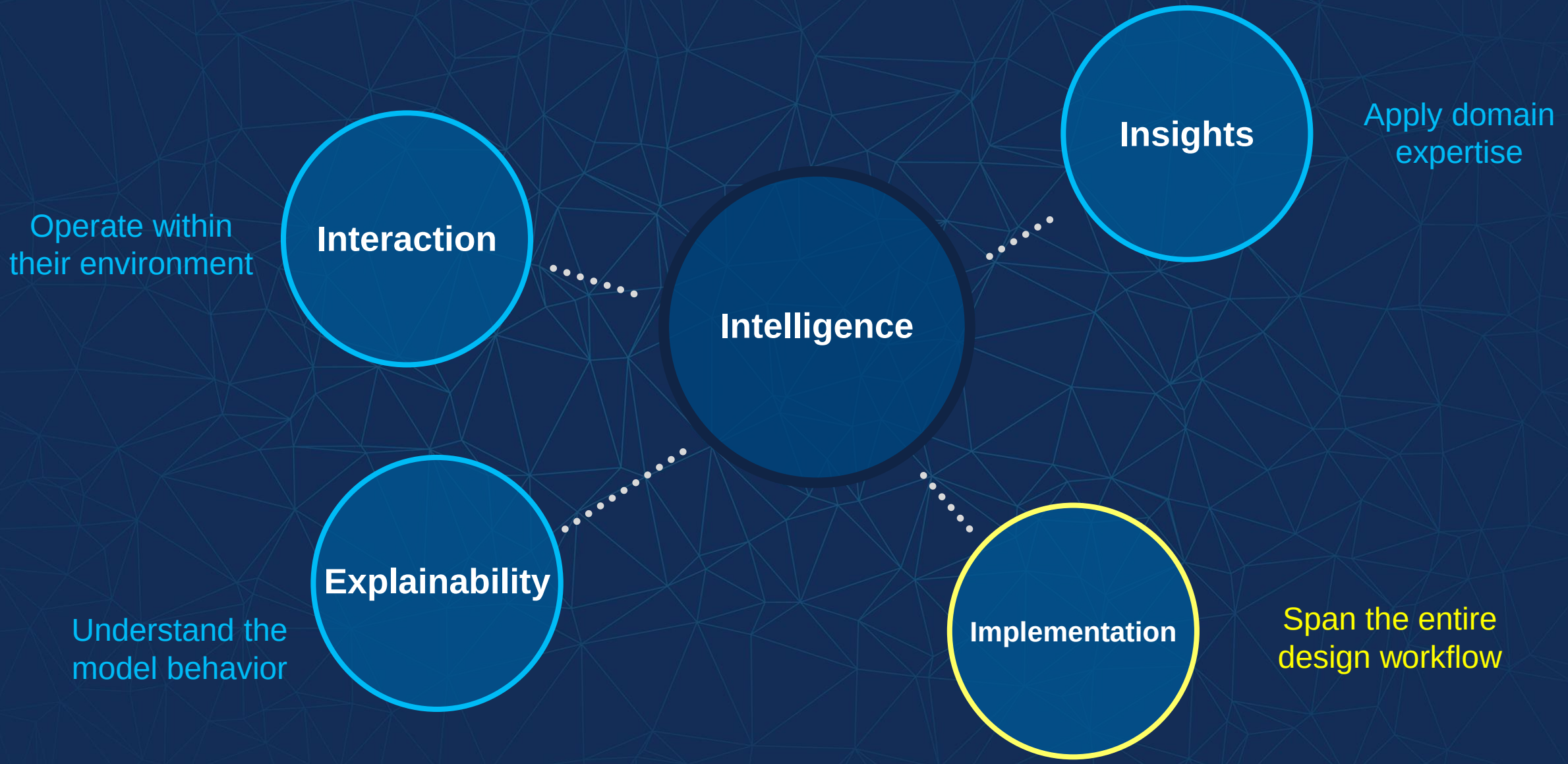

Implementation is about designing the solution

Research

Testing
Data analysis
Reporting

Manufacturing

Developing concept
Prototyping
Deployment

Autonomous System

Requirements building
Modeling and simulation
Verification and validation

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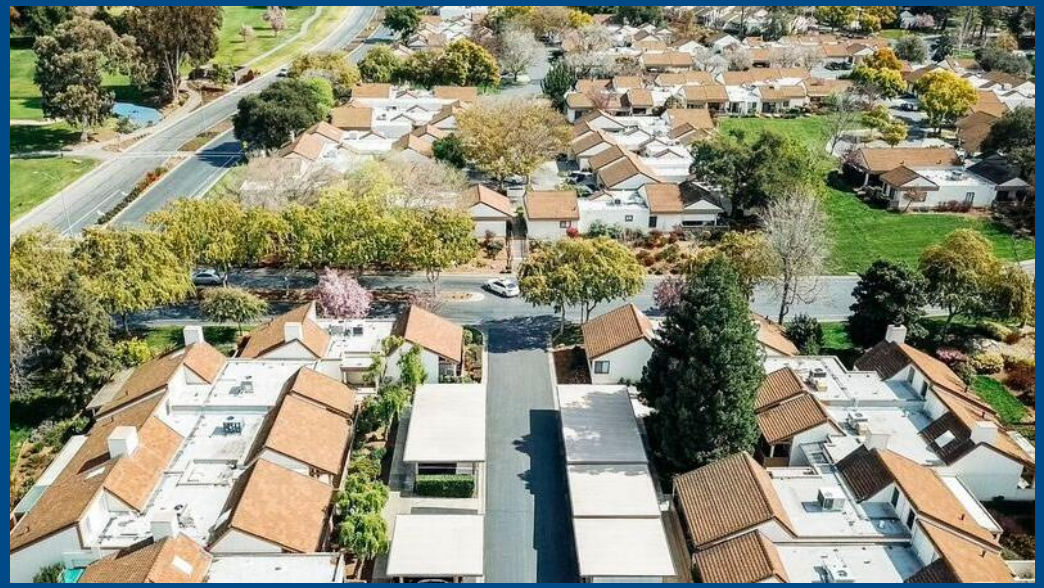
“Deliver on the promise of self-driving cars today.”
VOYAGE

Voyage's goal was to quickly get to market

1. Target retirement communities



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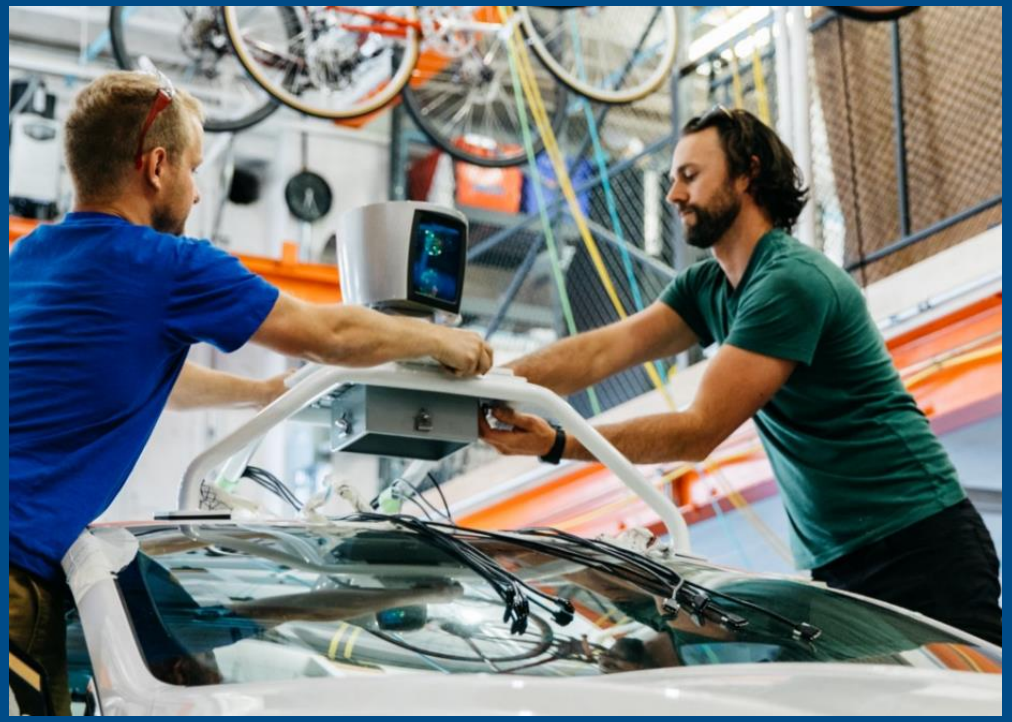
Voyage's goal was to quickly get to market

1. Target retirement communities

2. Use off-the-shelf components wherever possible



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Voyage's goal was to quickly get to market

1. Target retirement communities
2. Use off-the-shelf components wherever possible
3. Bring in the right software tools across the entire workflow

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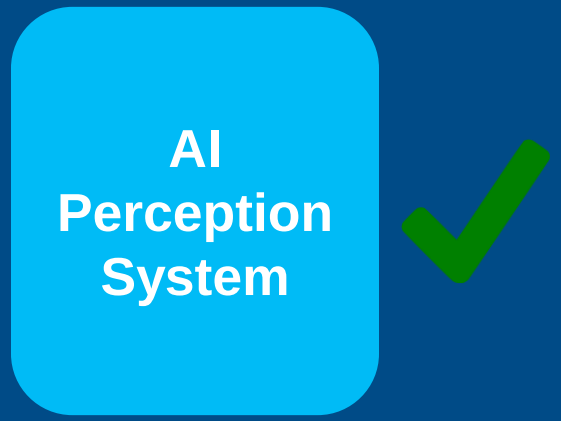
Voyage completed their AI system first



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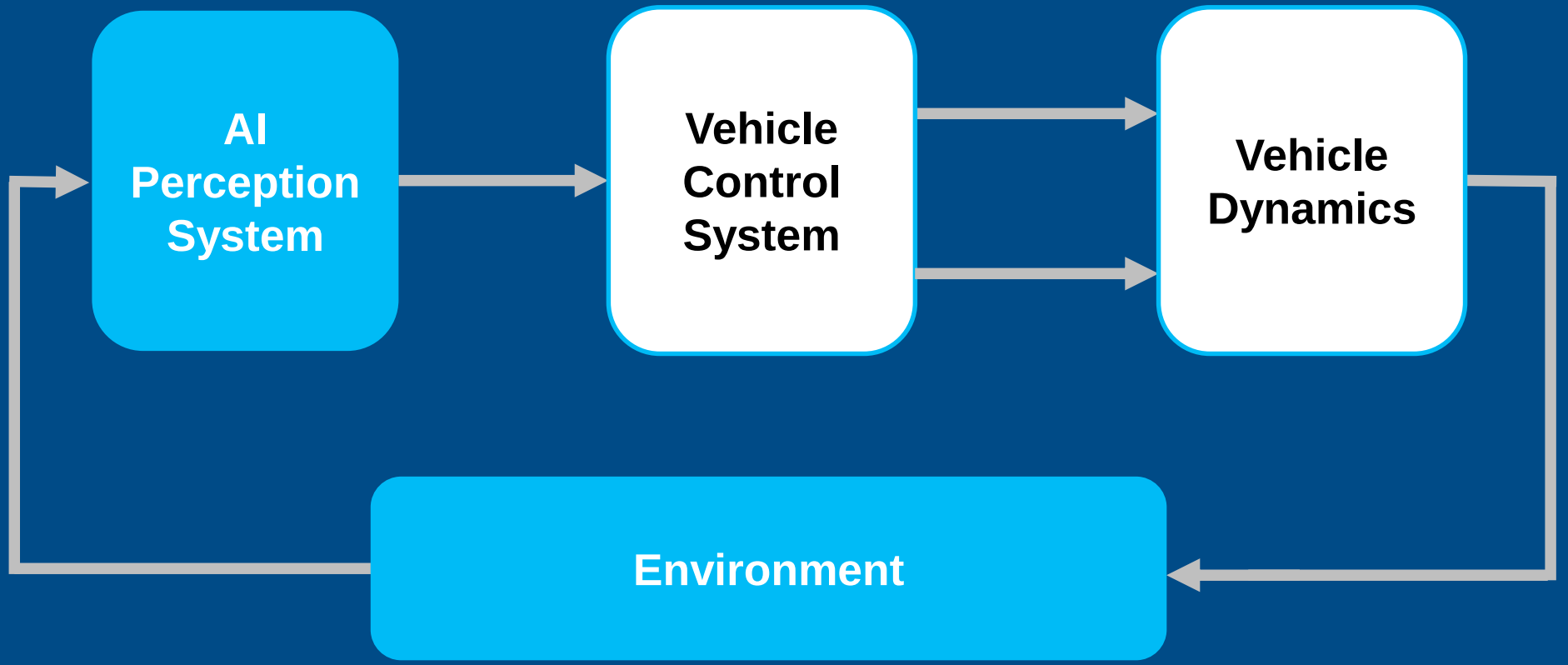
But they needed to connect the AI to the rest of the system



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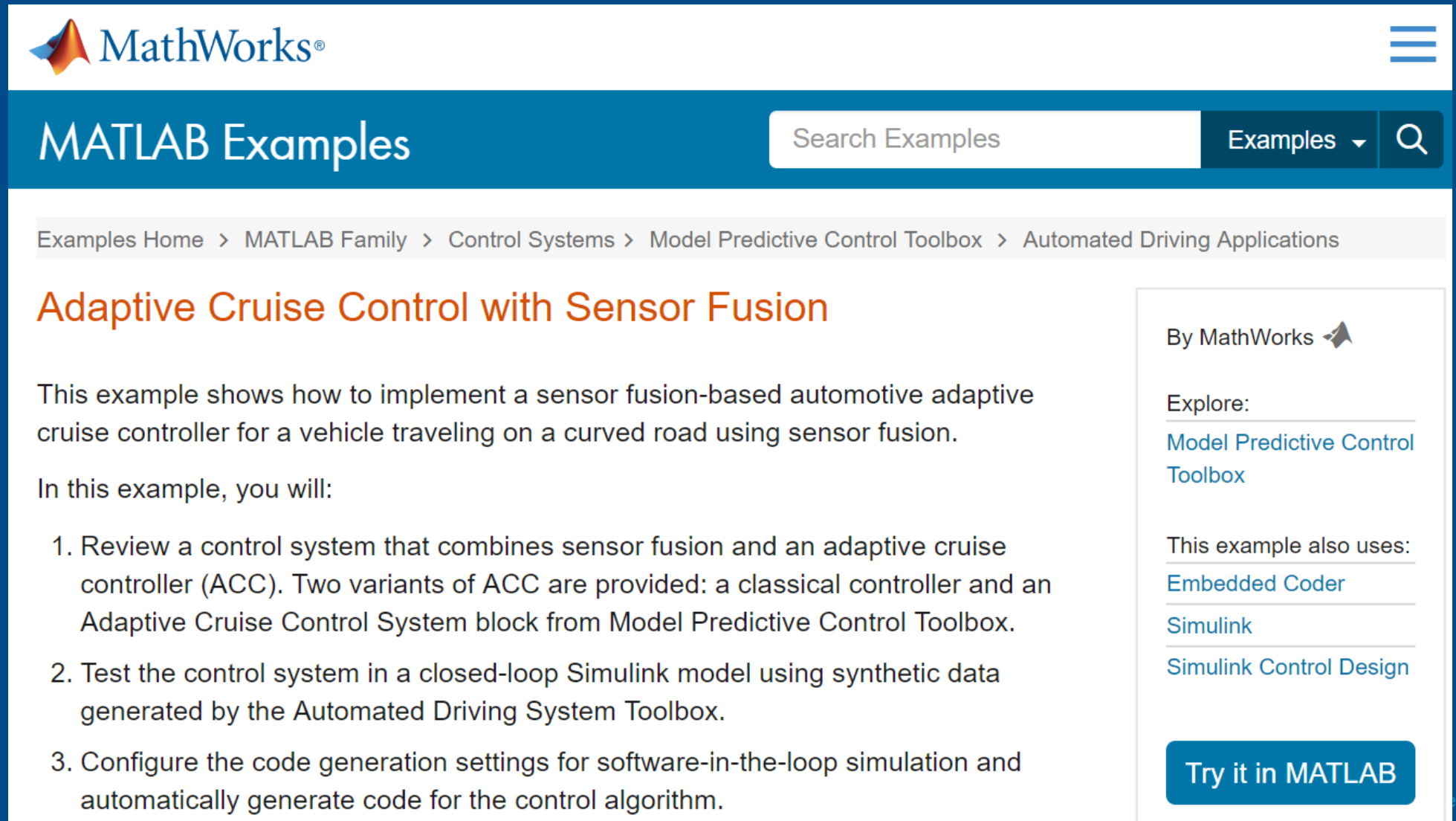
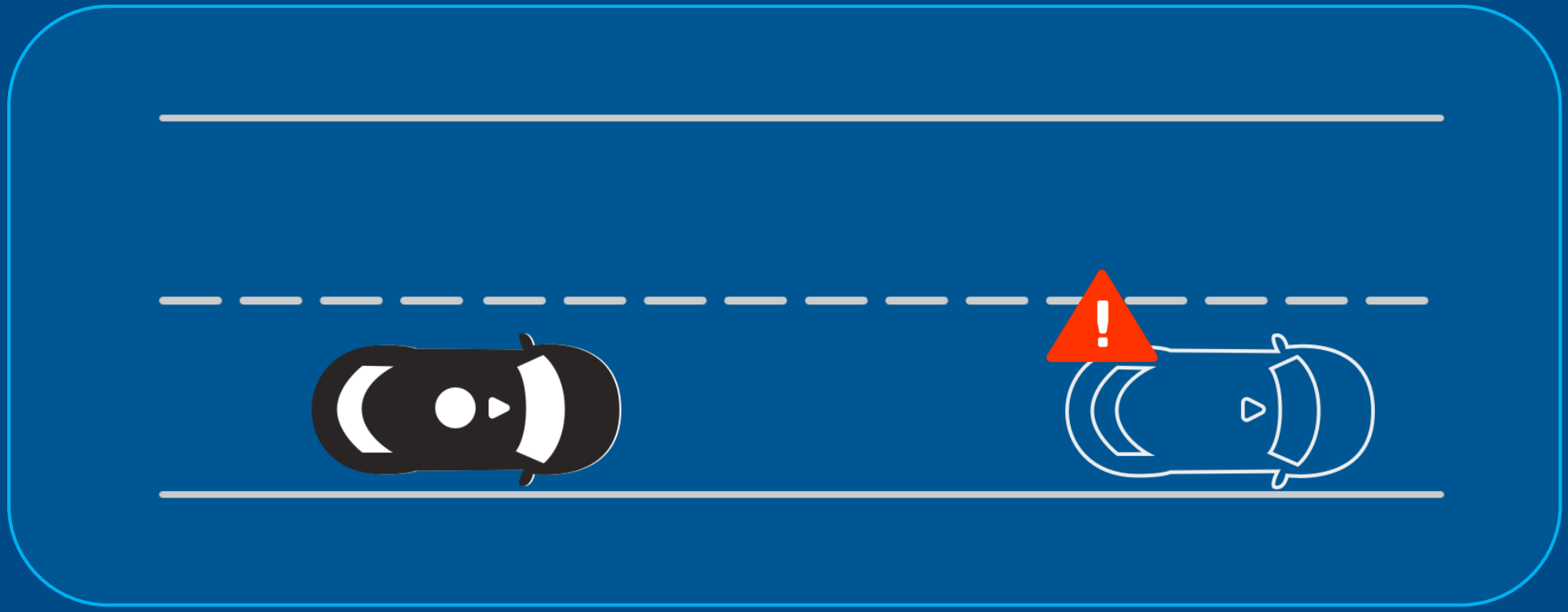
Started with Simulink example that they could build upon



Injected simulated vehicles to interact with while driving



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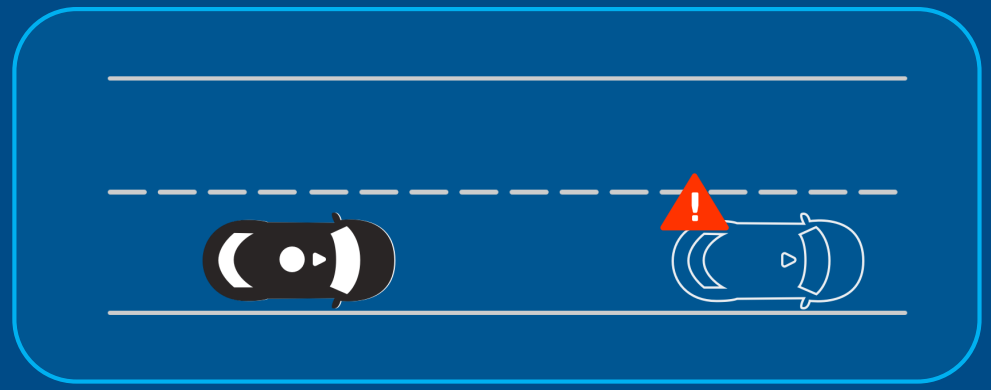
Deployed controller as ROS node and generated code



Robotics System Toolbox
Embedded Coder

ROS
Robot Operating System

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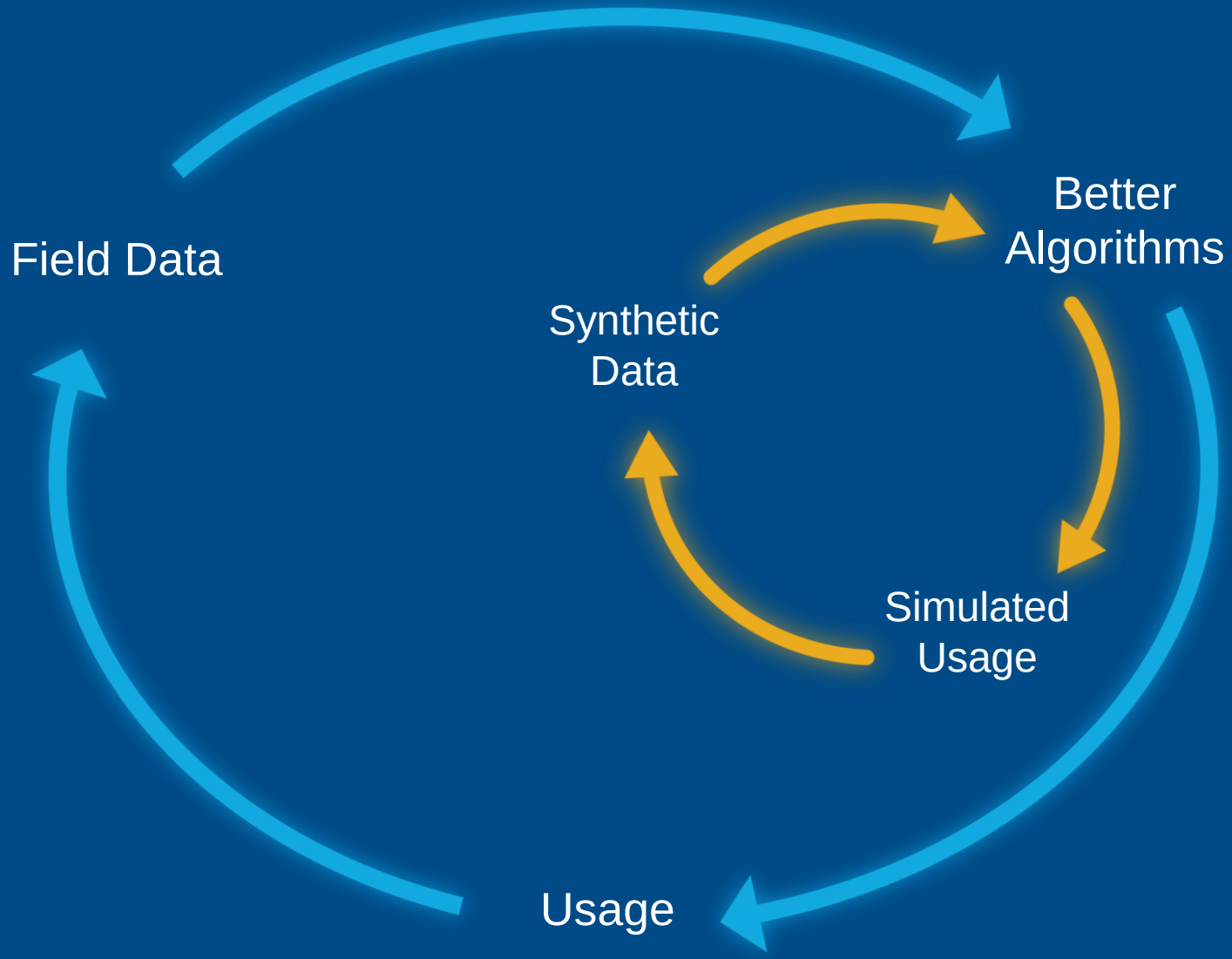
Train your AI faster with tight simulation loops



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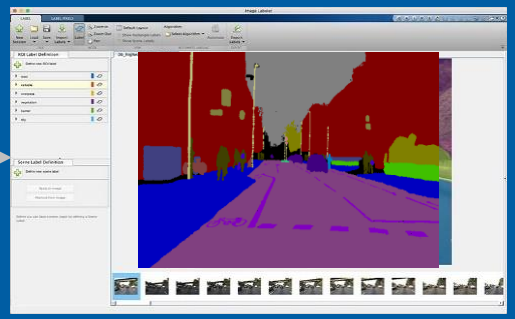
One example of leveraging simulation for data synthesis

Traditional deep learning workflow

Record



Label

AI model

Simulation-based workflow

Simulate

Auto-label

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"Simulink + ROS allowed us to deploy a Level 3 autonomous vehicle in less than 3 months."

– Alan Mond, Voyage

To be successful with AI, we must …

Use tool chains that span
the entire design workflow

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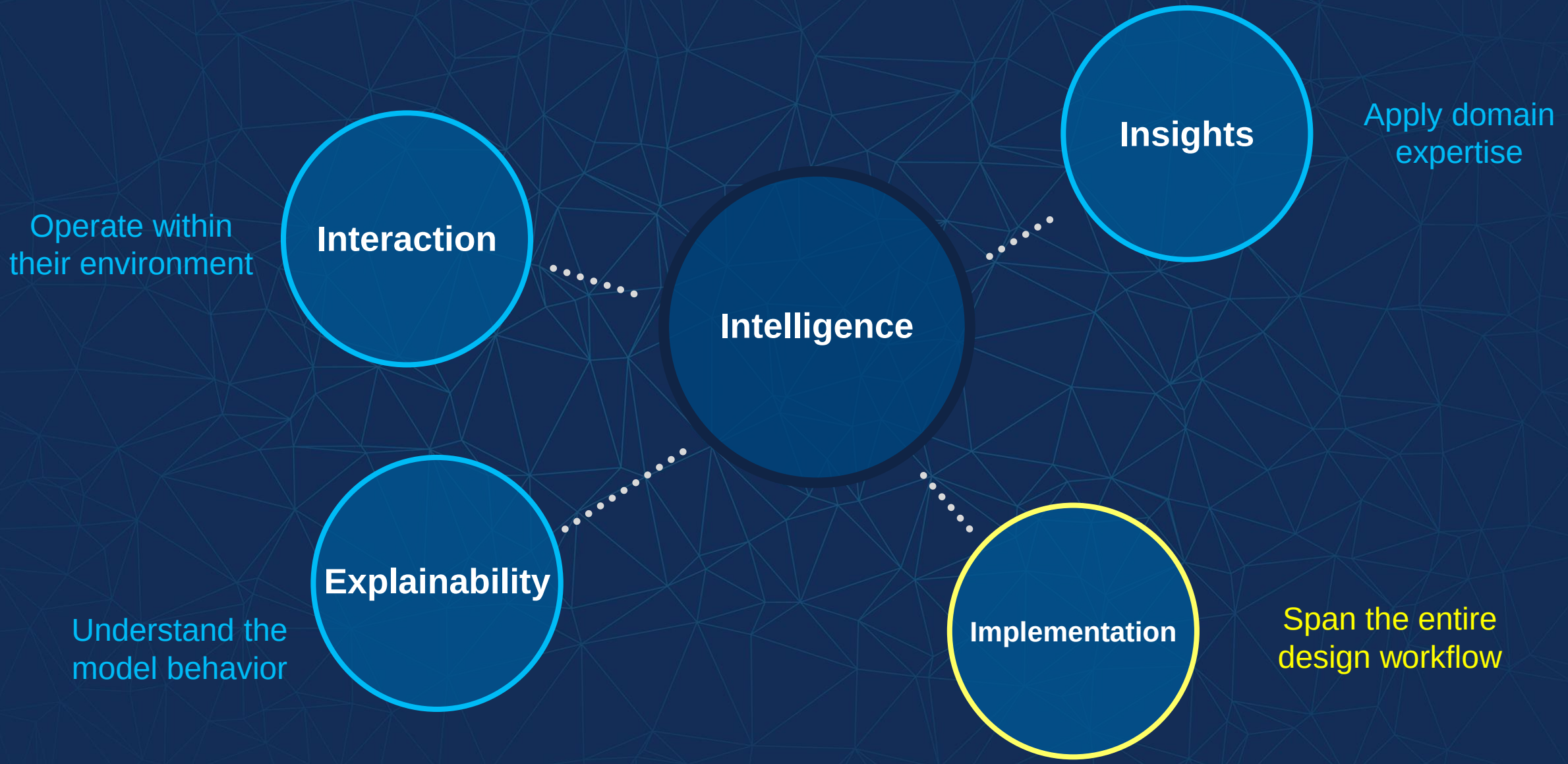
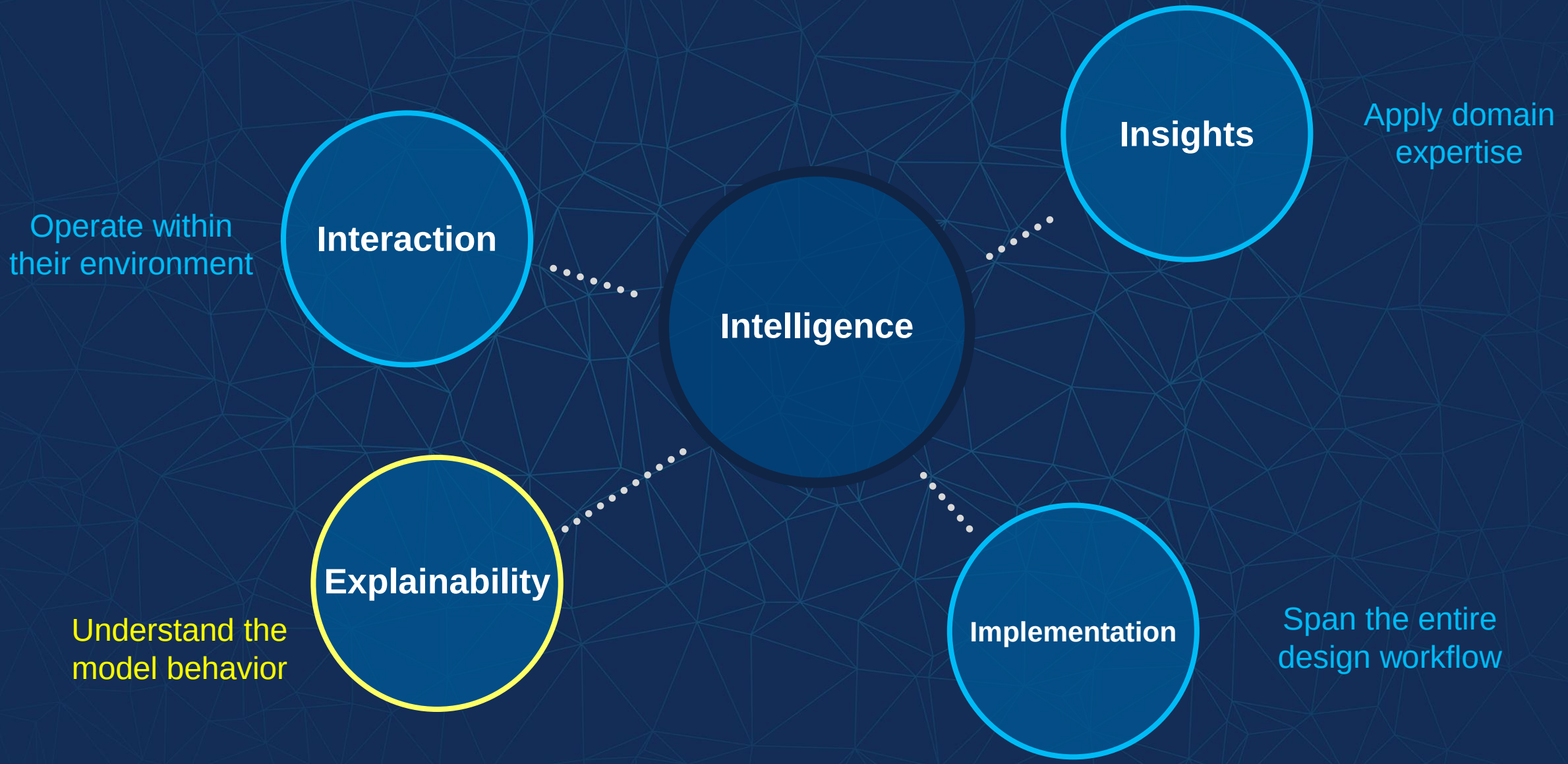
AI is more than just the intelligence of the algorithm



AI is more than just the intelligence of the algorithm

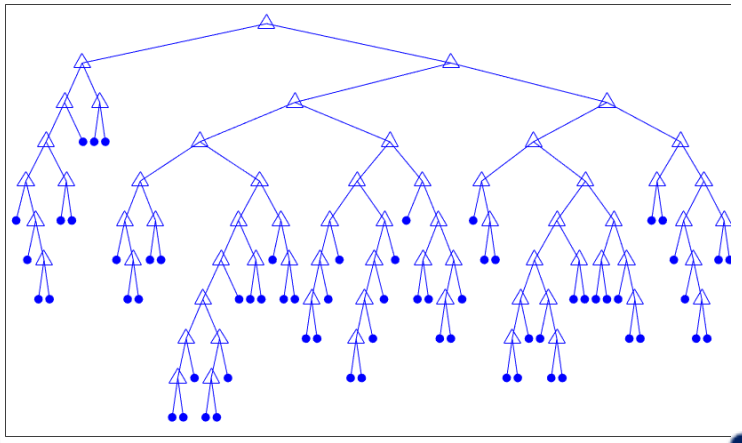


AI should be “explainable”

How did the model come the decision?

What do you want from me?

Why was my loan application denied?



Why did it fail?

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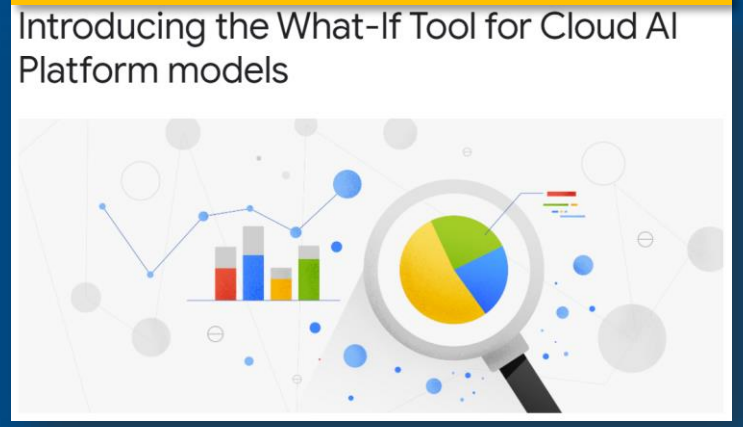
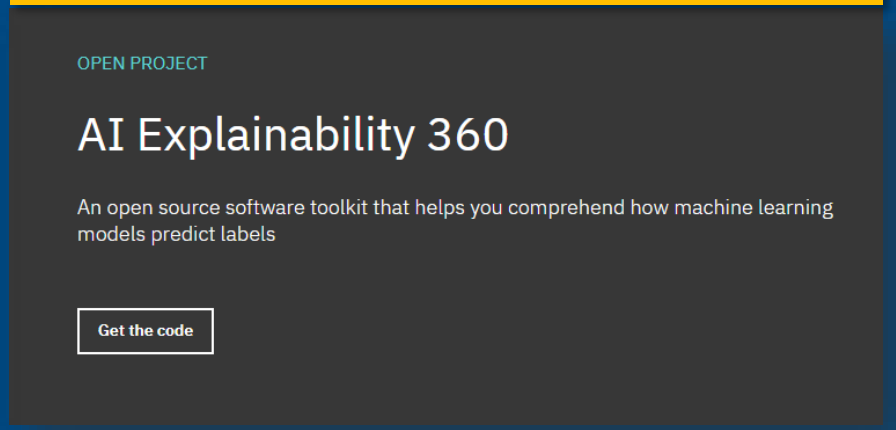
The community is realizing the importance of explainable AI

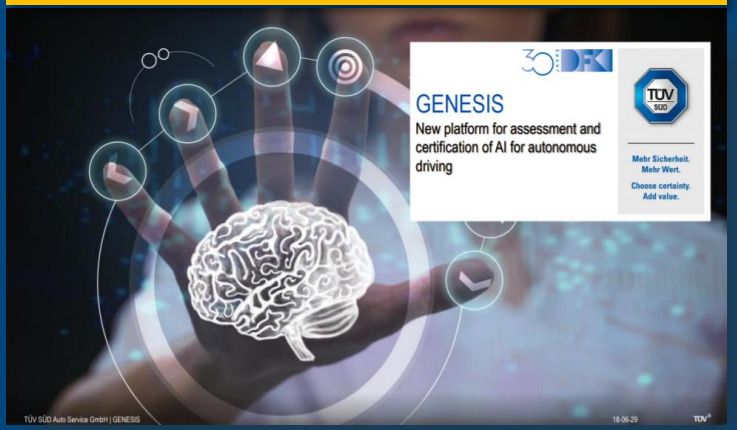
GOOGLE's What-If Tool (Link)



IBM Toolkit for Developing Explainable AI (Link)



GENESIS – Funded by German Govt. (Link)



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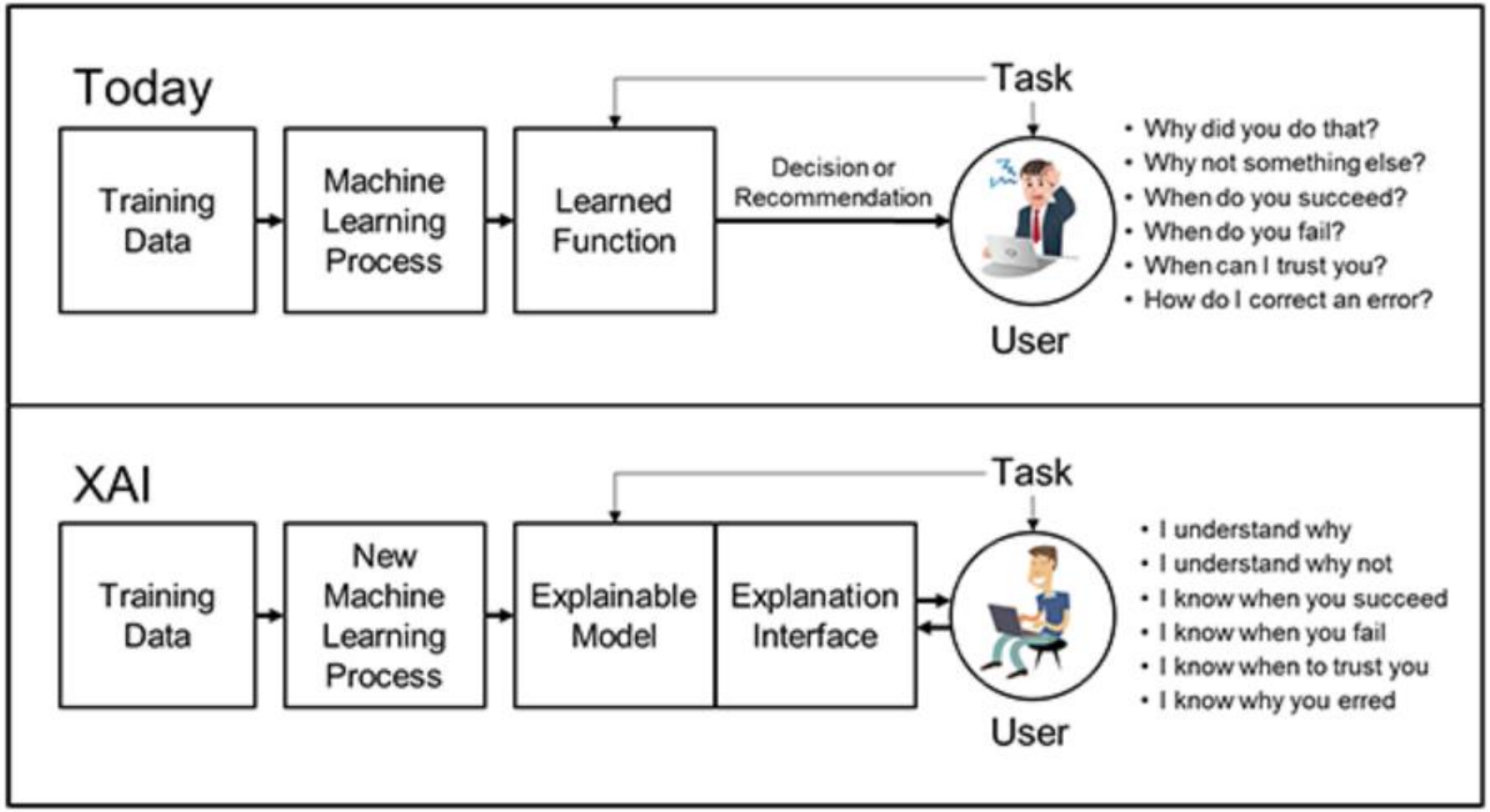
The community is realizing the importance of explainable AI

DARPA DEFENSE ADVANCED RESEARCH PROJECTS AGENCY



https://www.darpa.mil/program/explainable-artificial-intelligence

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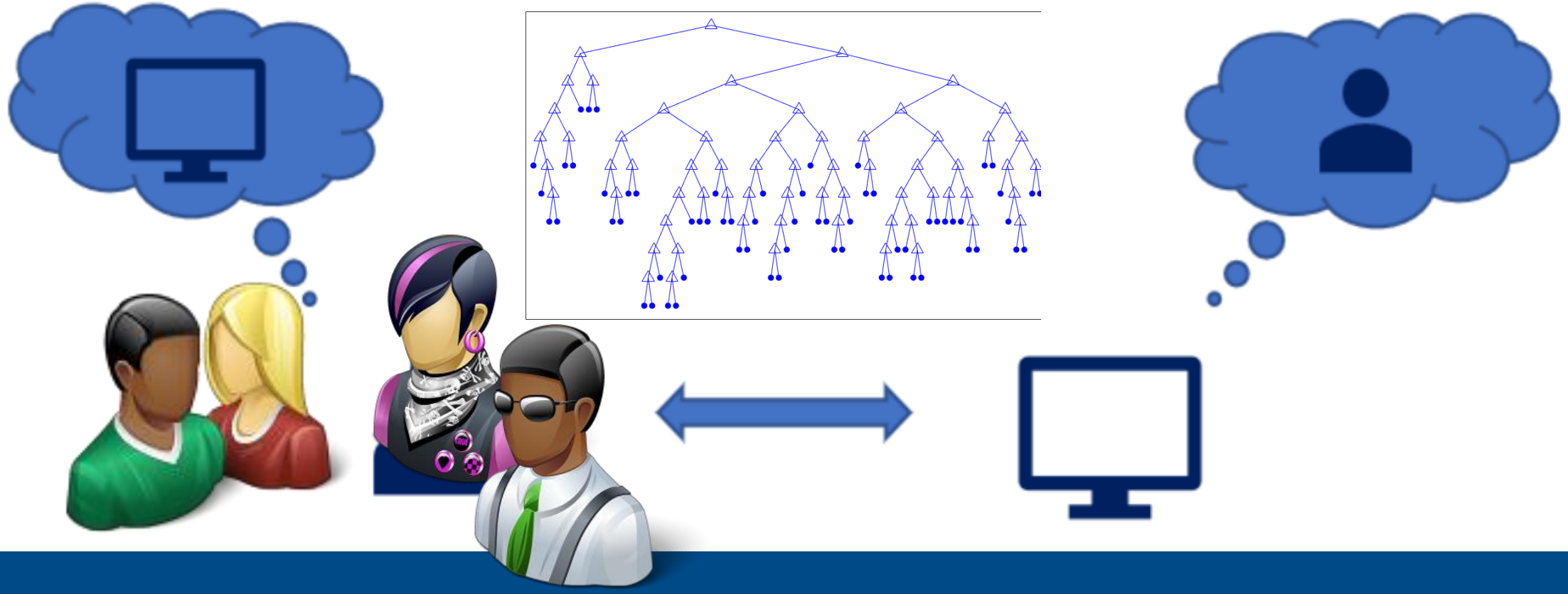
AI should be “explainable”

Explainable to everyone

Interpretable



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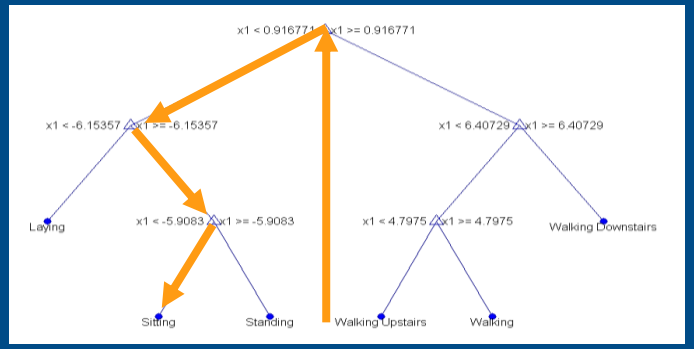
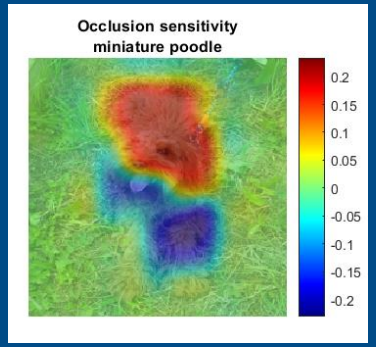
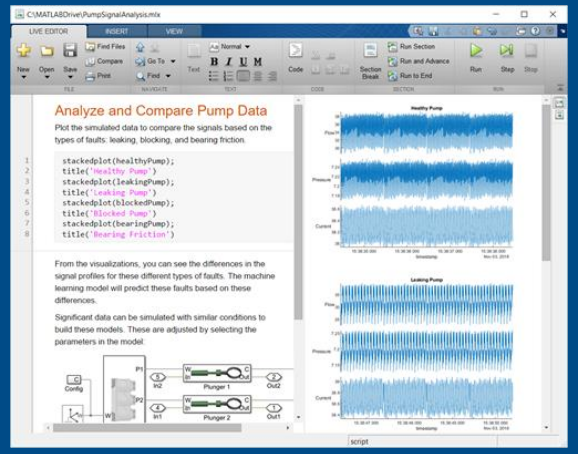
Model explainability can be improved



Simpler models

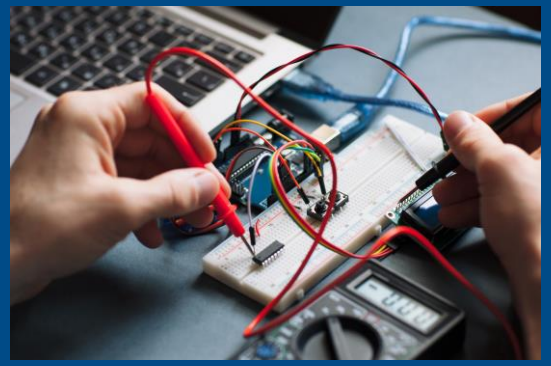


Visualizations



Documentation

Simulations



Rigorous testing

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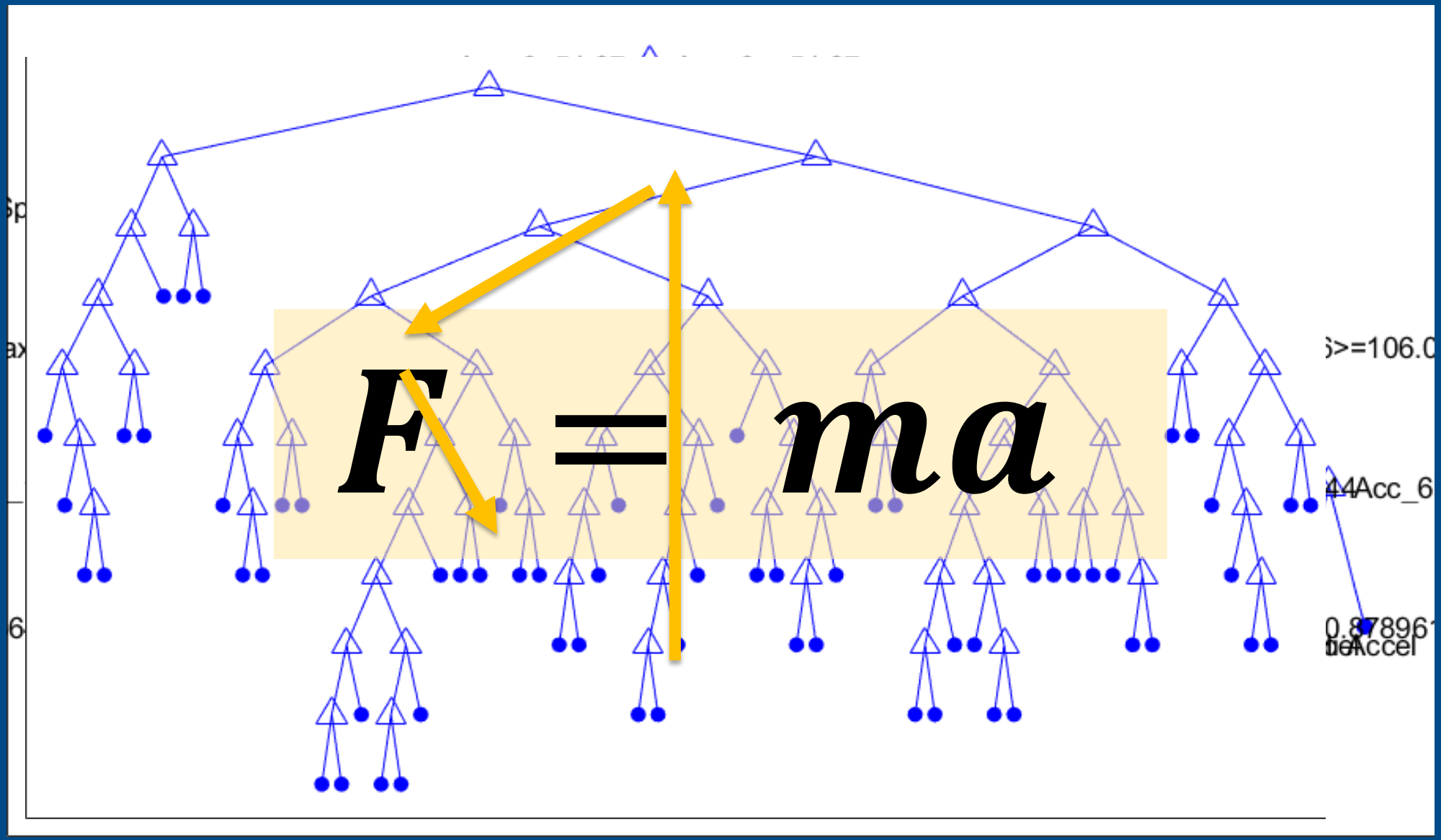
Use simpler, interpretable models



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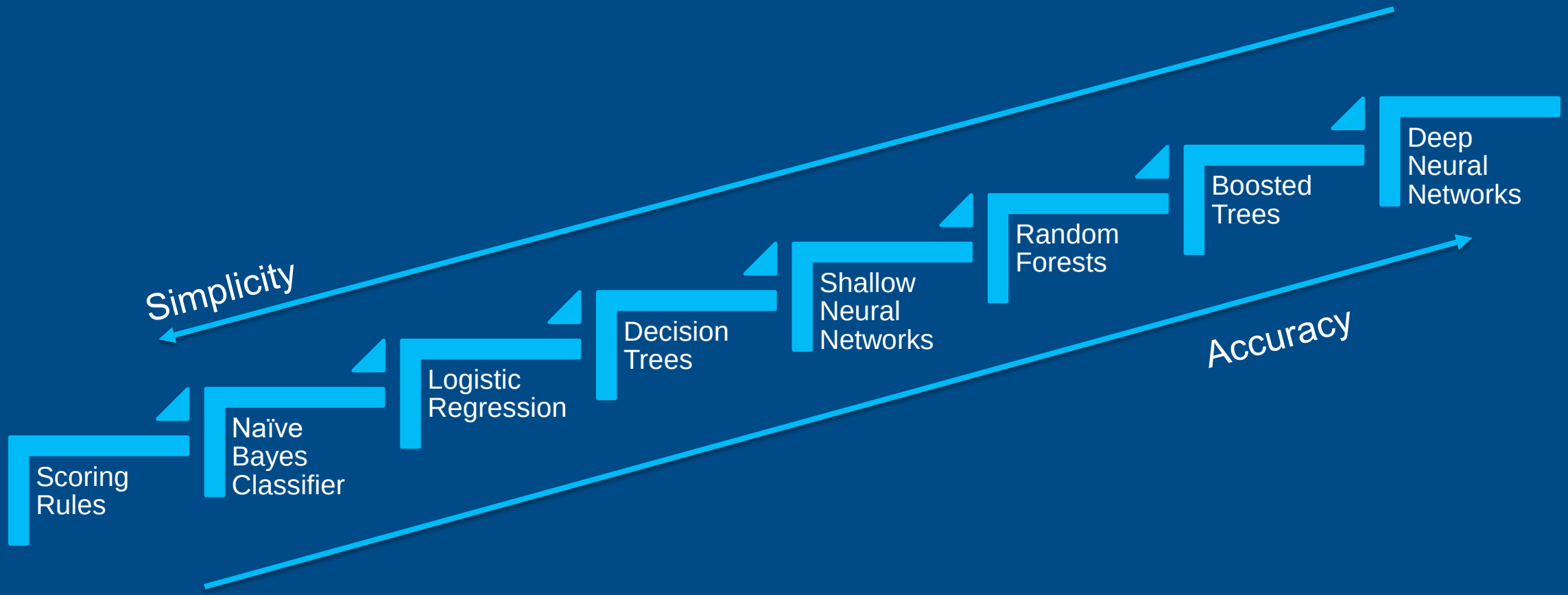
Use simpler, interpretable models



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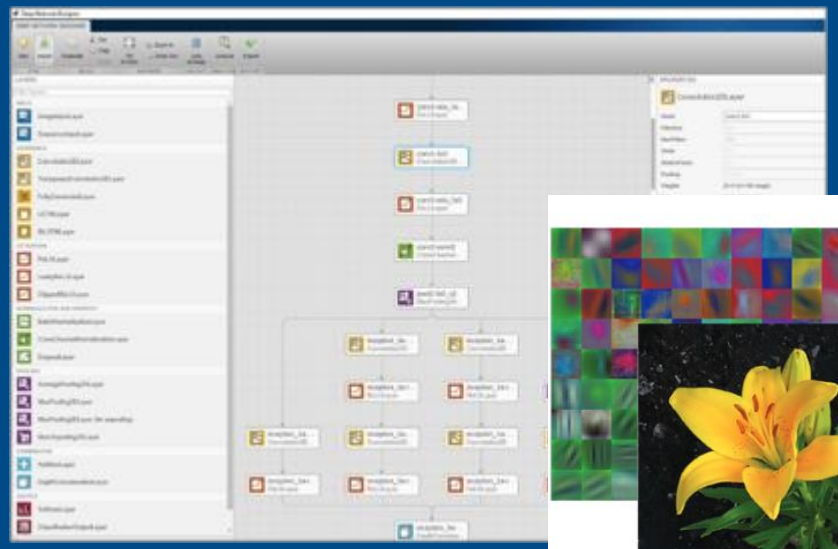
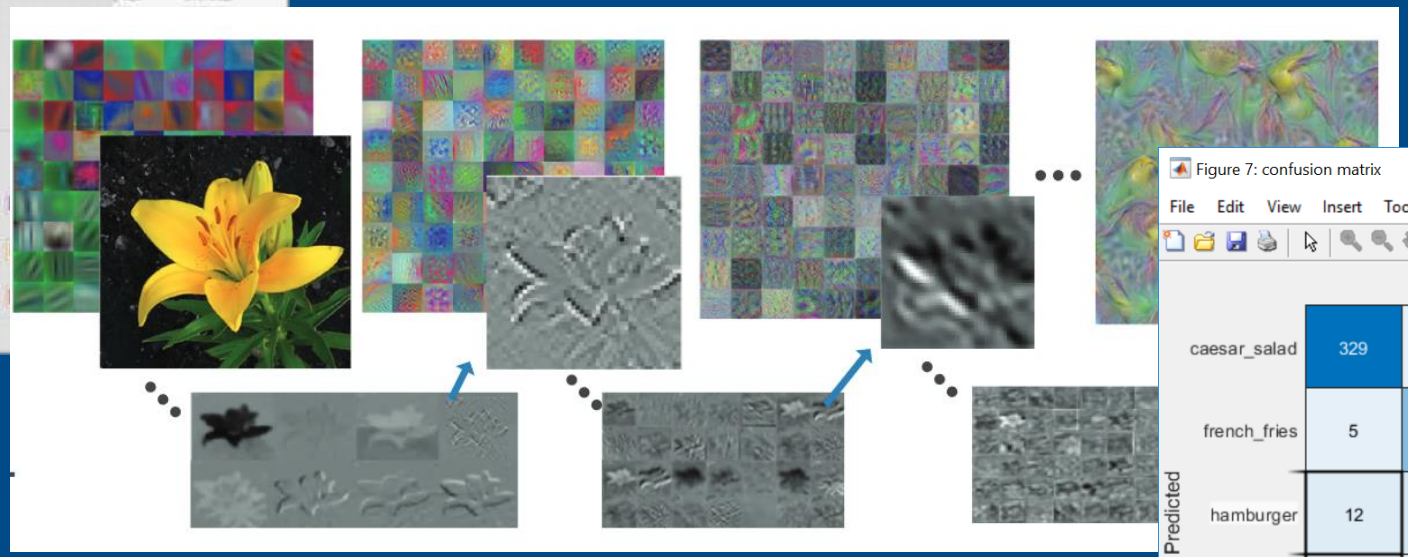
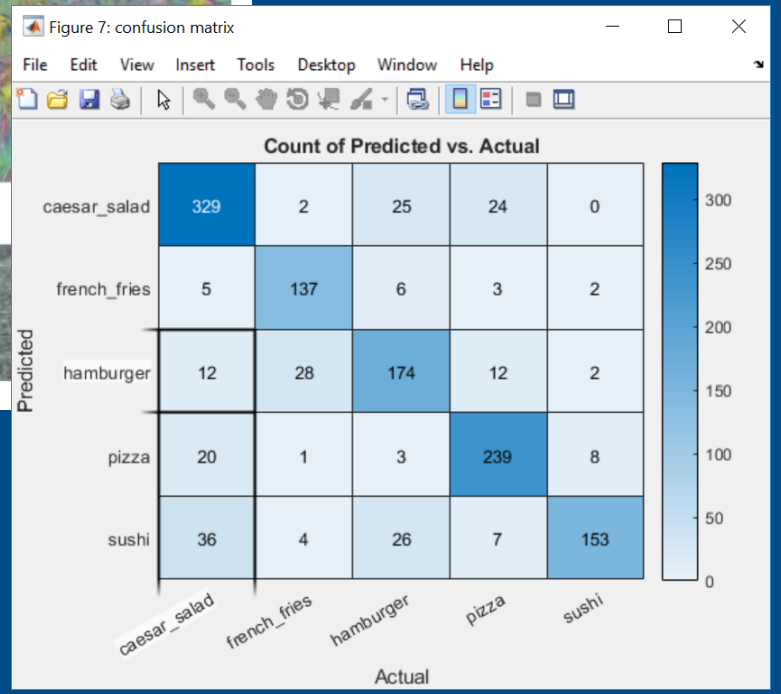
Visualize throughout the entire process







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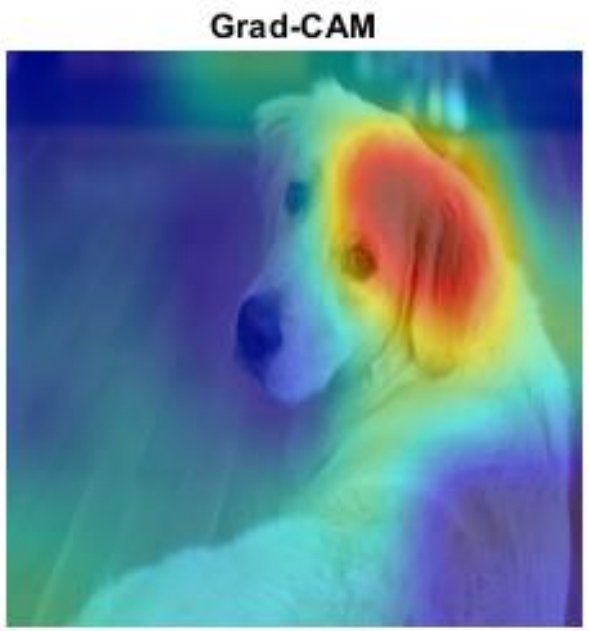
Use visualizations to understand predictions



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Visualize which parts of the image influence the classification

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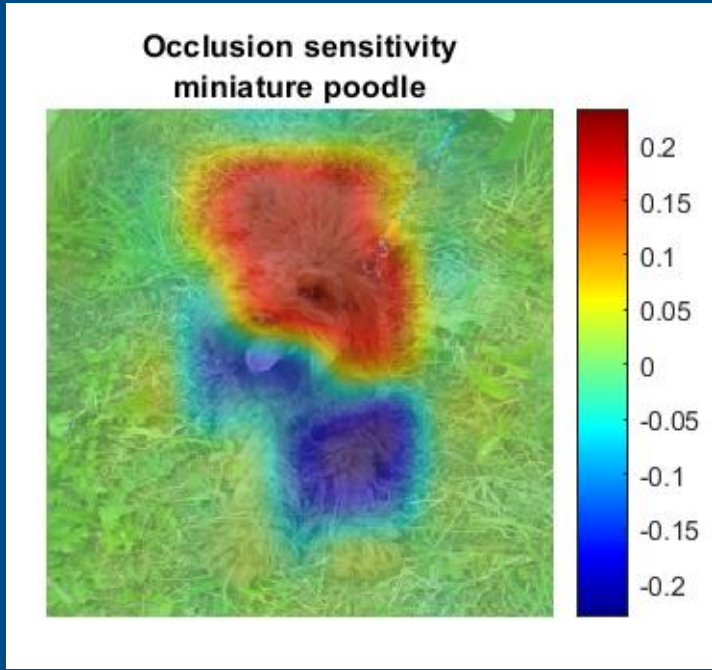
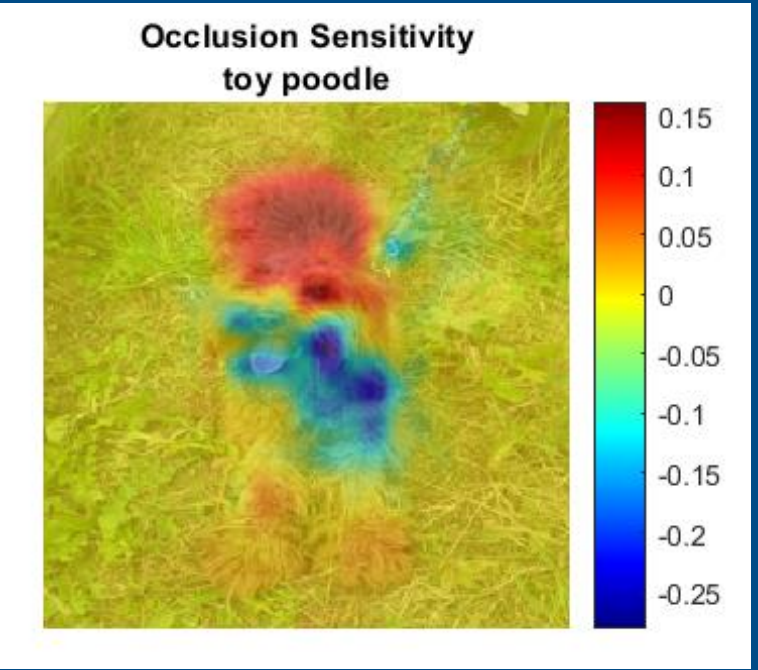
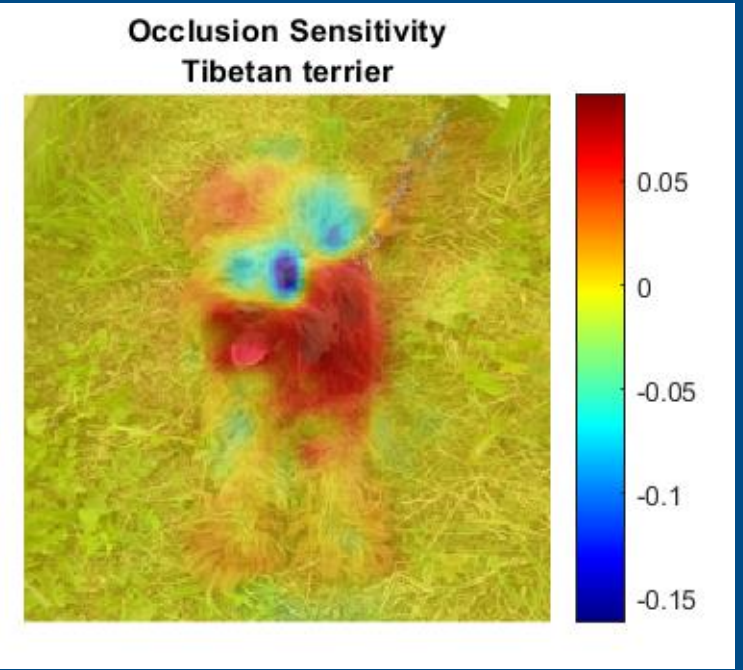
Visualize which parts of the image influence the classification







https://www.mathworks.com/help/deeplearning/ref/occlusionsensitivity.html

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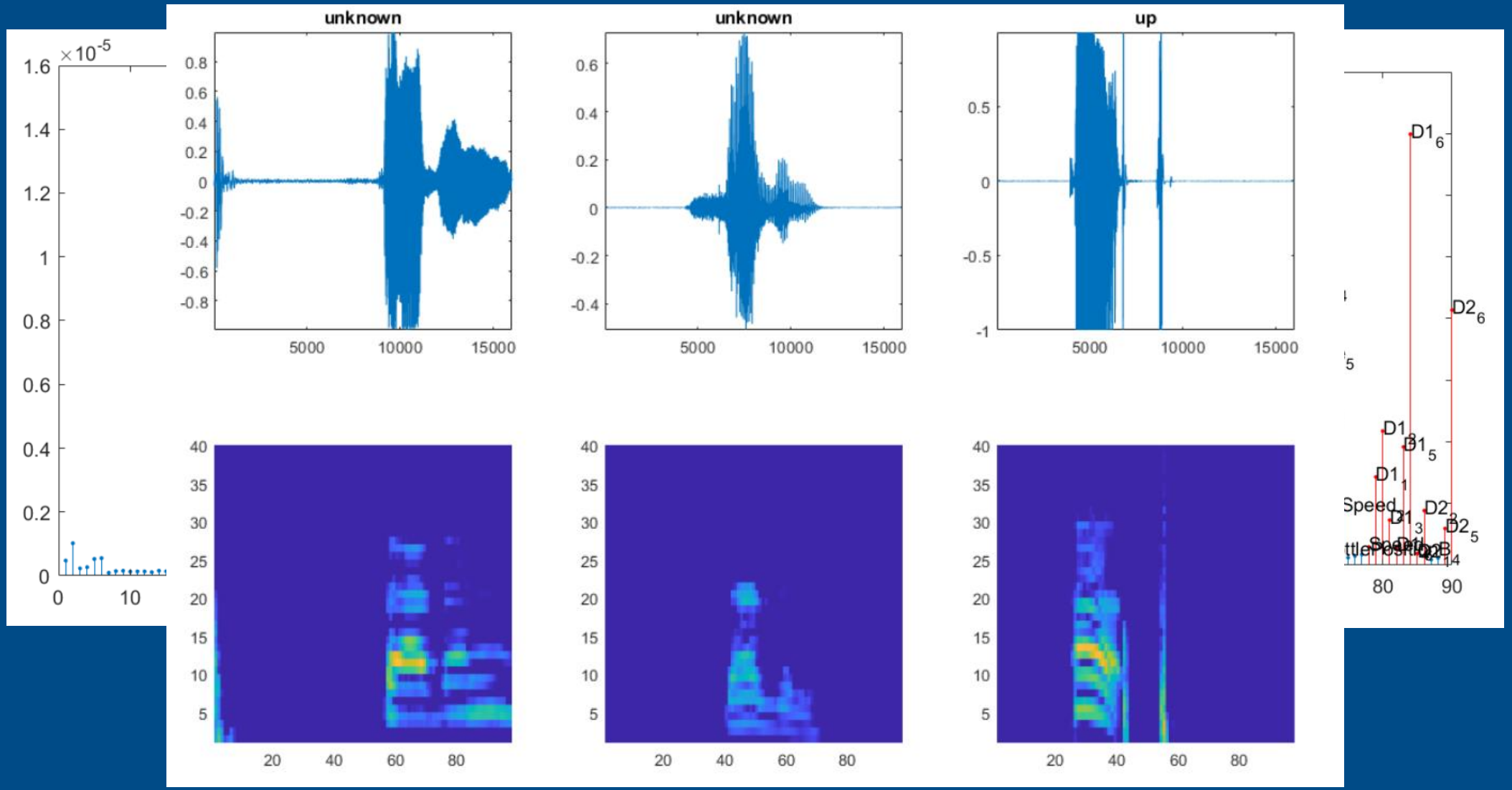
Visualize feature importance



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Document everything

MATLAB R2019b

HOME PLOTS APPS LIVE EDITOR INSERT VIEW

C: ▸ Users ▸ hgorr ▸ Demos ▸ HowsMyDrivingDemo ▸ 09_HowsMyDrivingModel

Live Editor - C:\Users\hgorr\Demos\HowsMyDrivingDemo\09_HowsMyDrivingModel\BuildDrivingModel.mlx *

BuildDrivingModel.mlx * | ImprovingTheModel.mlx | WorkWithImbalancedClasses.mlx | Untitled.mlx *

Develop Predictive Model

Table of Contents

Build Model

```
load('preprocessedTT.mat')
```

Create a table of predictor and response variables for classification. This is a table, so we will use a subset of data to train the model and test it with the remaining data.

```
results = timetable2table(tt);
rng(1234)
cv = cvpartition(results.Event,'Holdout',0.3);
trainData = results(cv.training,:);
```

C:\MATLABDrive\PumpSignalAnalysis.mlx

LIVE EDITOR INSERT VIEW

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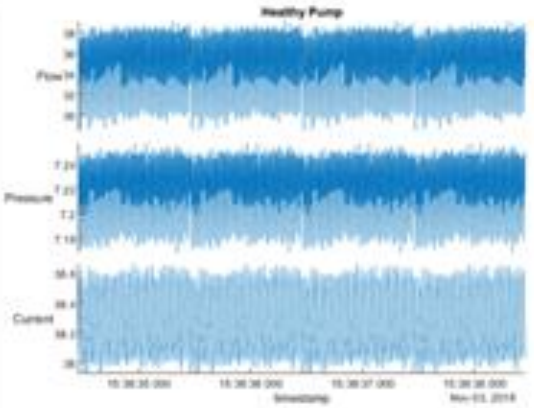
Analyze and Compare Pump Data

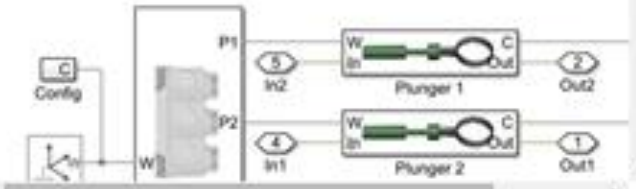
Plot the simulated data to compare the signals based on the types of faults: leaking, blocking, and bearing friction.

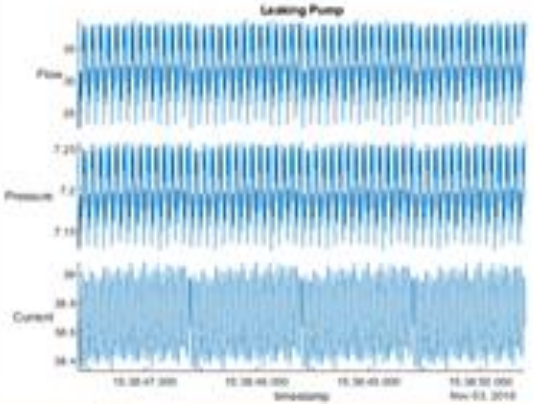
```
stackedplot(healthyPump);
title('Healthy Pump')
stackedplot(leakingPump);
title('Leaking Pump')
stackedplot(blockedPump);
title('Blocked Pump')
stackedplot(bearingPump);
title('Bearing Friction')
```



From the visualizations, you can see the differences in the signal profiles for these different types of faults. The machine learning model will predict these faults based on these differences.

Significant data can be simulated with similar conditions to build these models. These are adjusted by selecting the parameters in the model.





script

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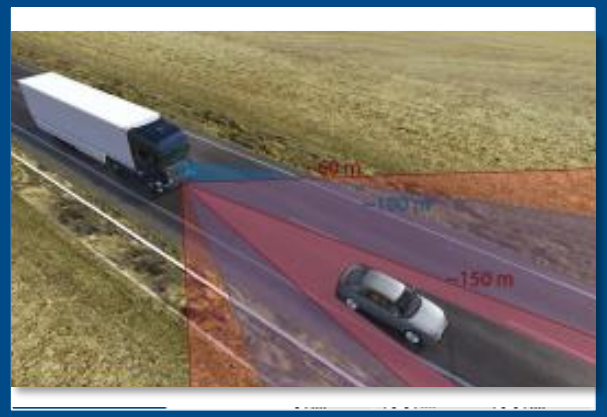
Simulate real data

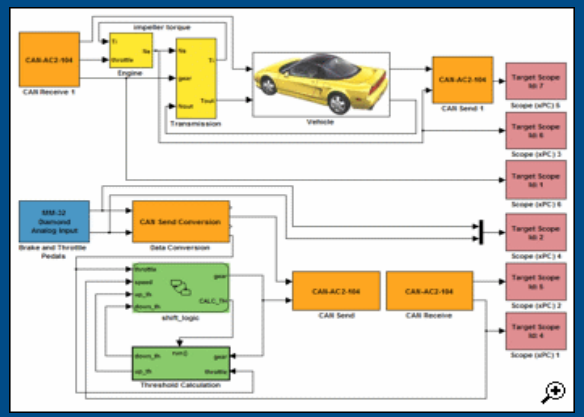
"Need **11** billion miles of testing
to demonstrate with **95%** confidence
that failure rate is **20%** better than human drivers"

Source: RAND

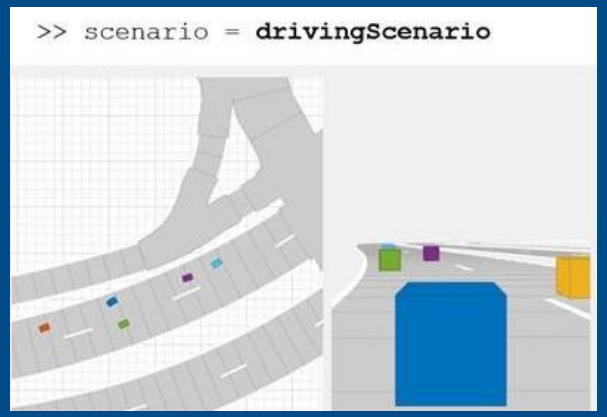
X 1,000,000's



Model Confidence



Components, Systems



Test Scenarios

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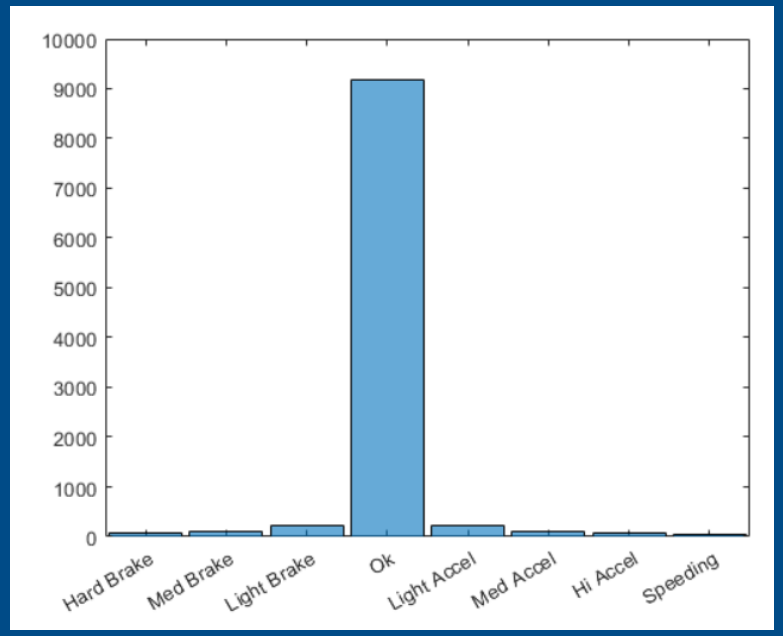
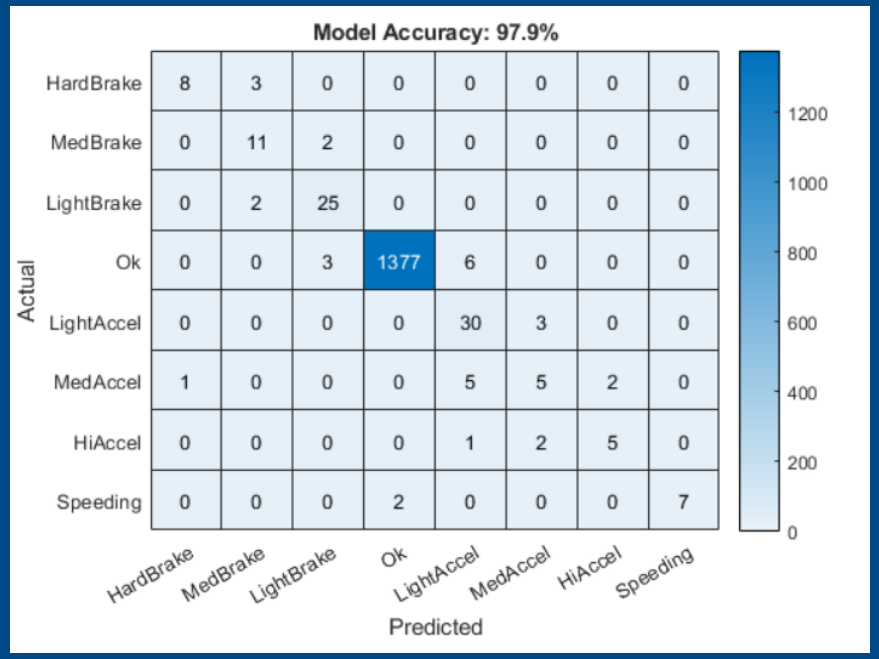
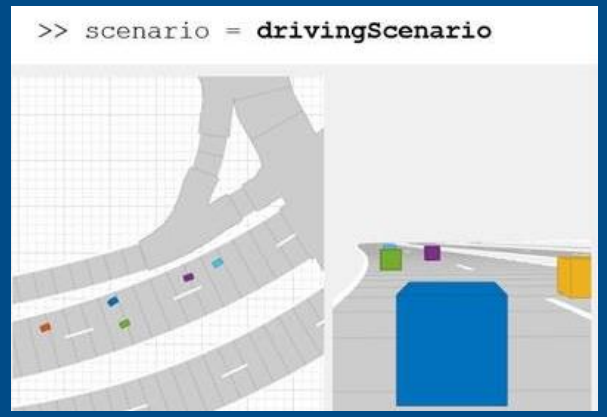
Simulate data for more confidence

Model





System



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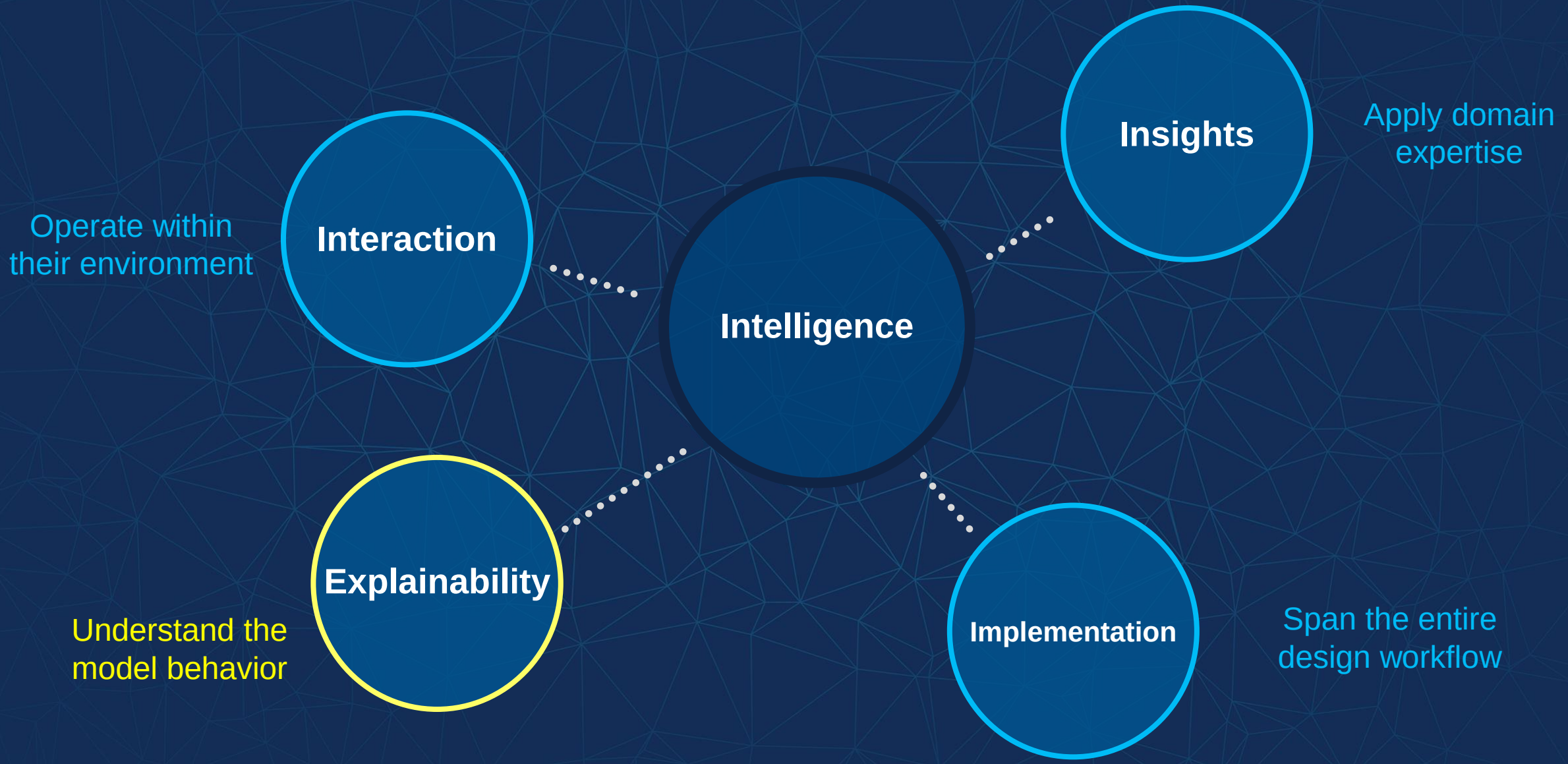
AI is more than just the intelligence of the algorithm



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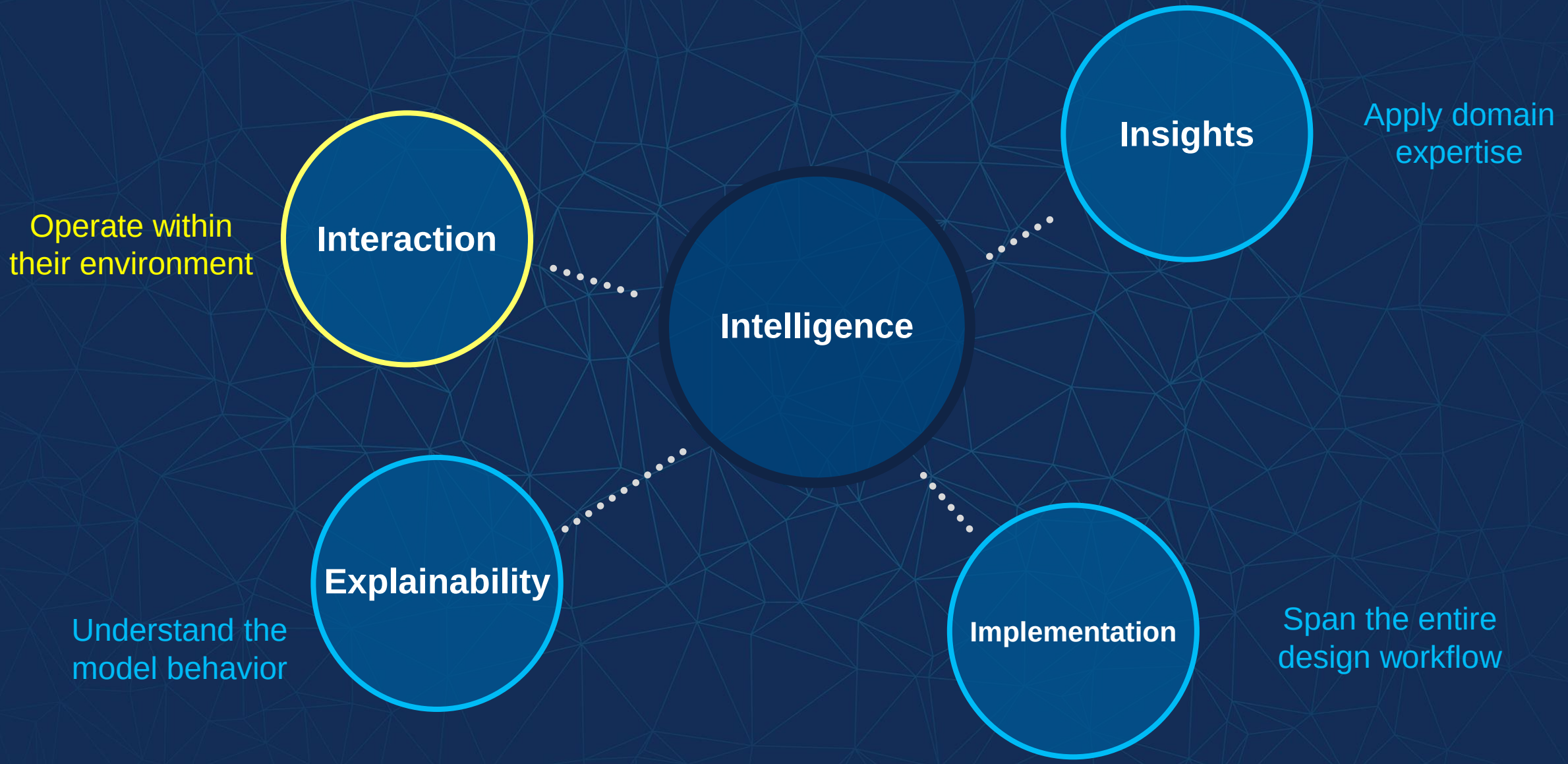
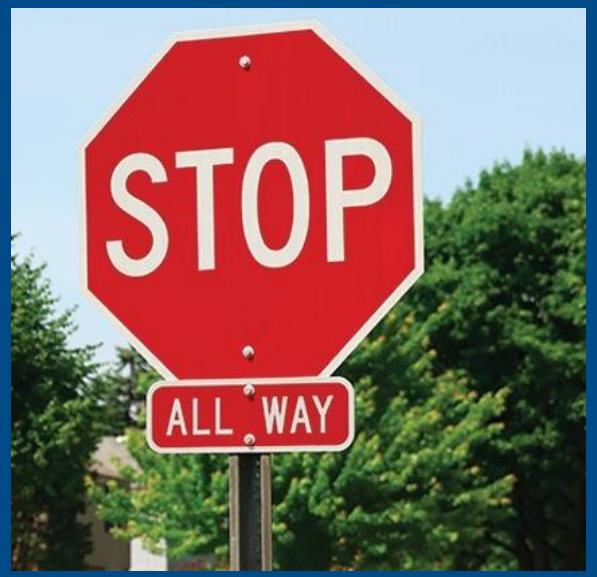


Interaction within complex environments

What was the larger system the vehicle had to operate in?



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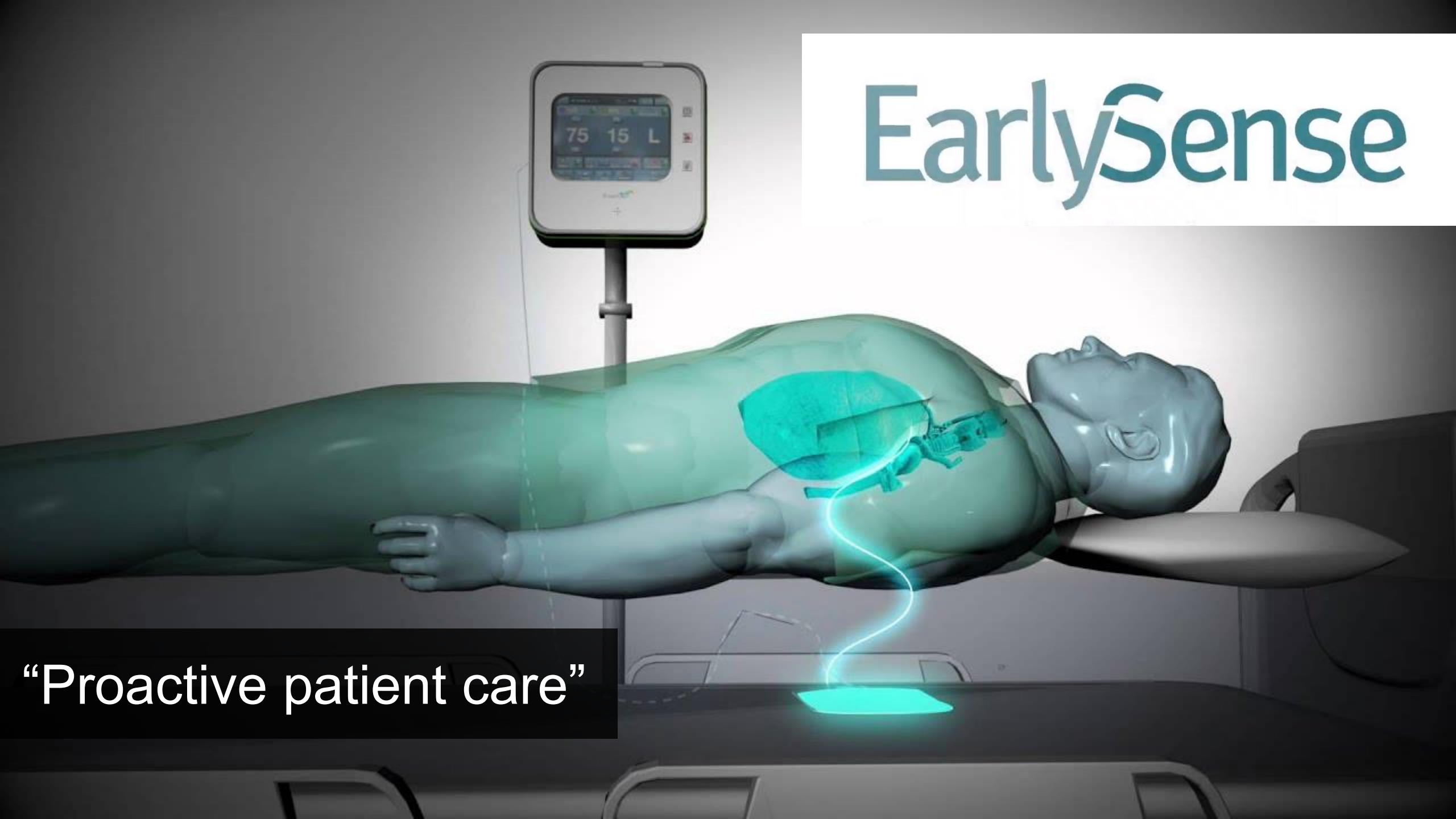
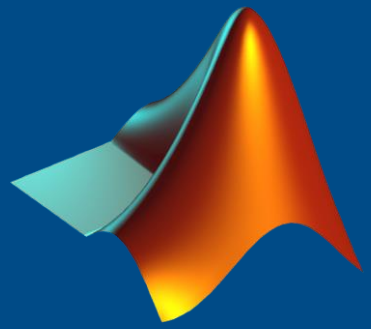
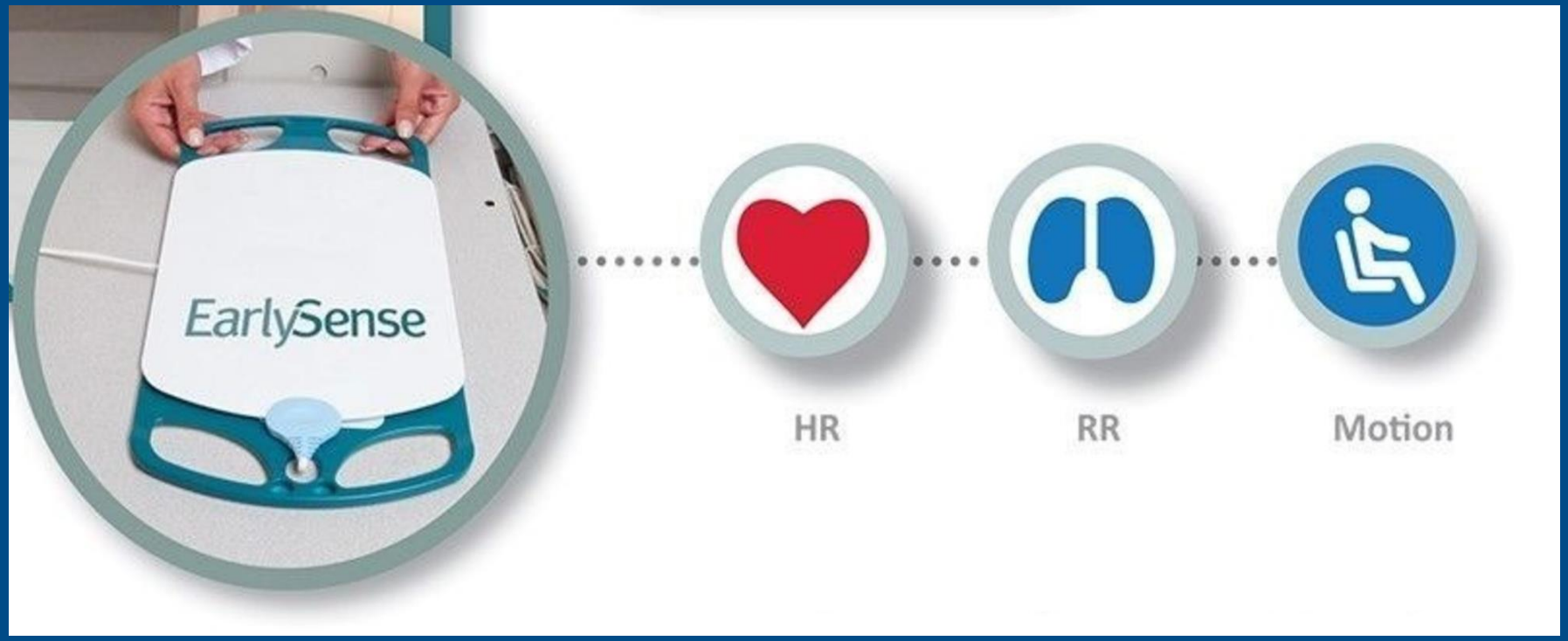

EarlySense
75 15 L
“Proactive patient care”



Statistics and Machine Learning Toolbox
Signal Processing Toolbox
MATLAB Coder
Embedded Coder



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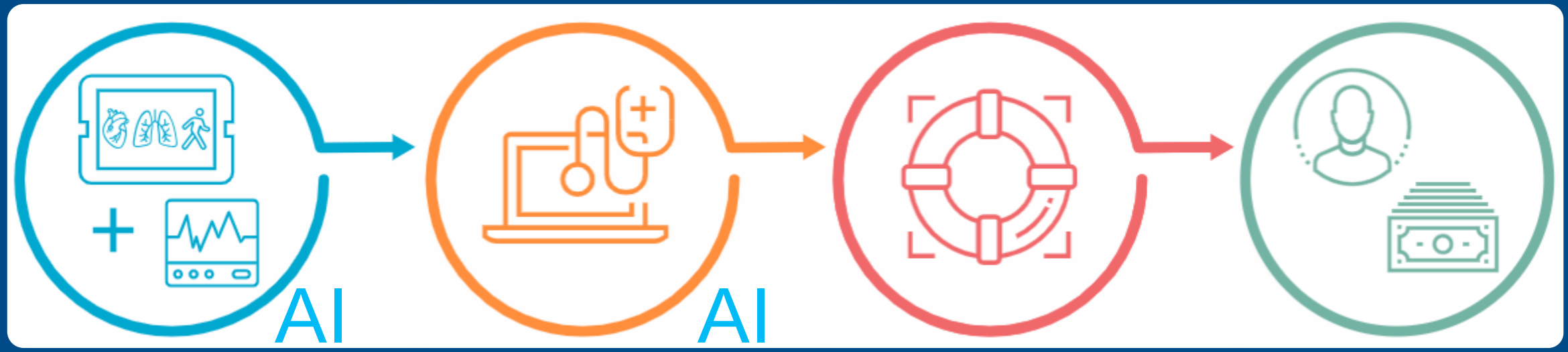
EarlySense's AI can predict critical events before they happen



Continuous Monitoring

Early Detection

Early Intervention

Better Outcomes

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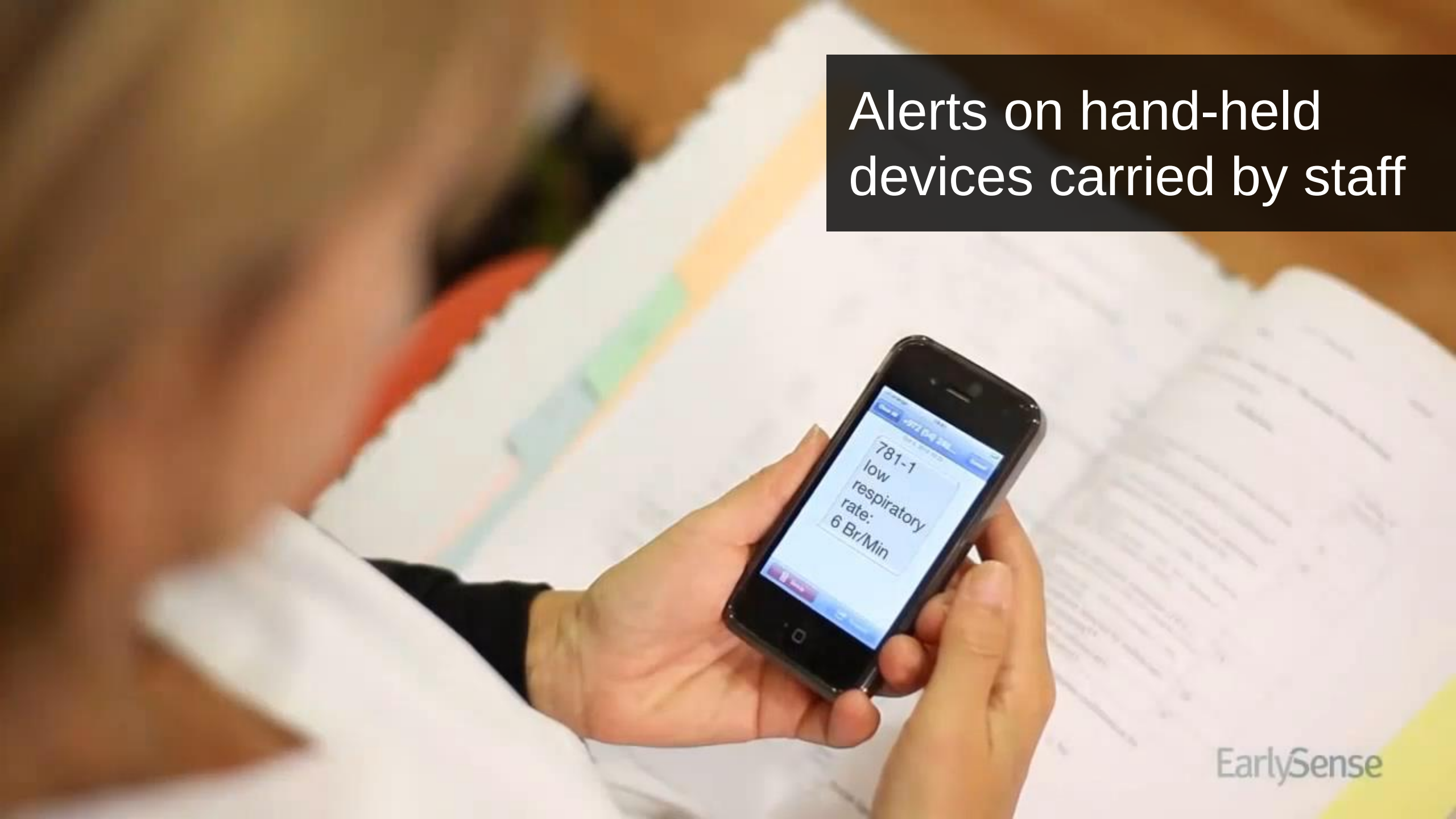
Dashboards at nurses’ stations and on hallway monitors



Alerts on hand-held devices carried by staff

EarlySense


Address problems before they become emergencies

To be successful with AI, we must …

Design how our systems will integrate
and interact within their environment

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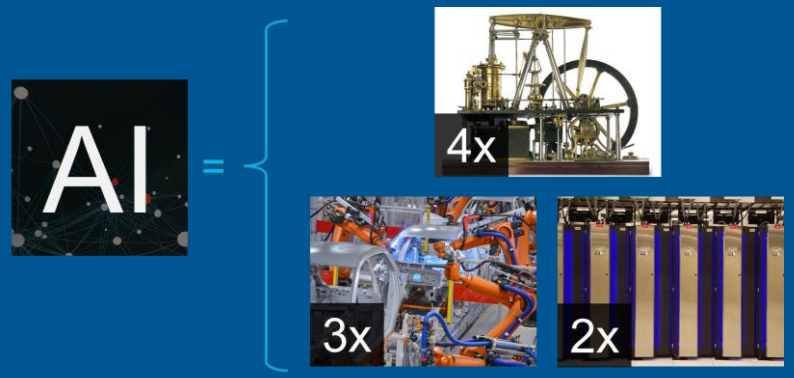
Success requires more than just intelligence

AI is a transformative technology



But AI projects can and do fail

DigitalTonto
At the Crossroads of Media, Marketing and Technology...

Most AI Projects Fail. Here's How to Make Yours Successful.

July, 2018

CMS WiRE

3 Common Reasons Artificial Intelligence Projects Fail

May, 2018

DataRobot

Why Most AI Projects Fail

Oct, 2017

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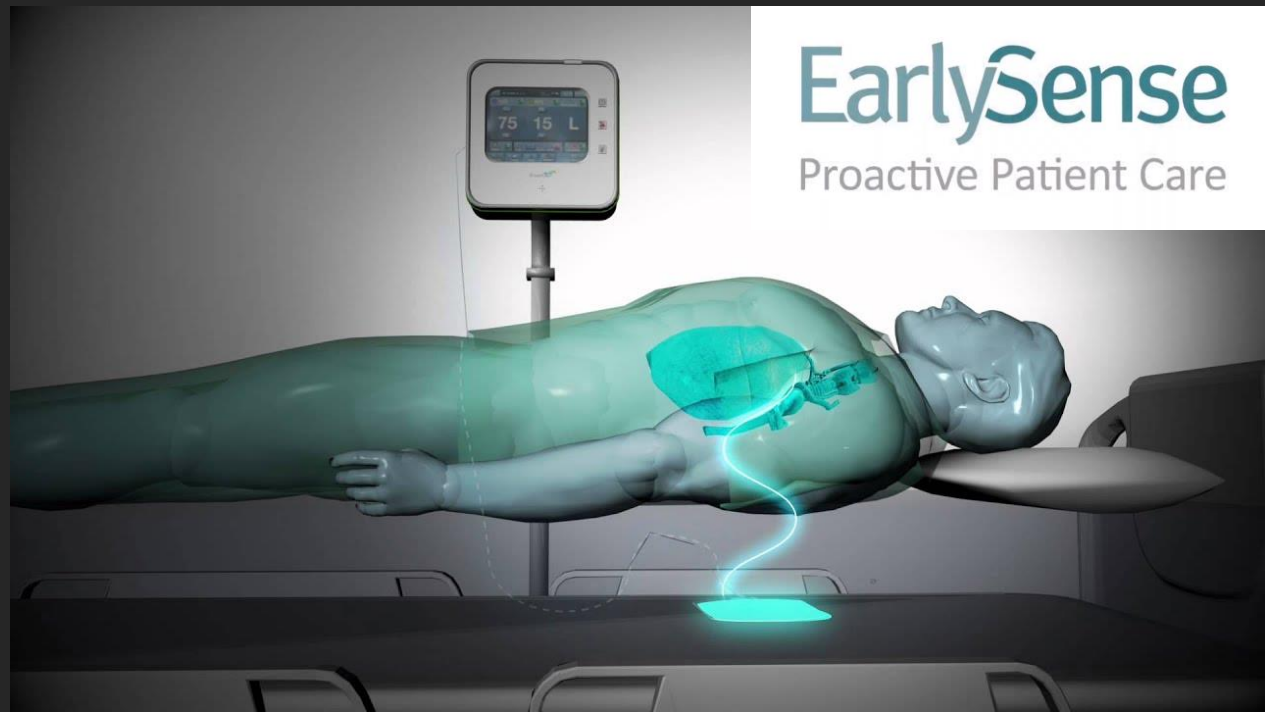
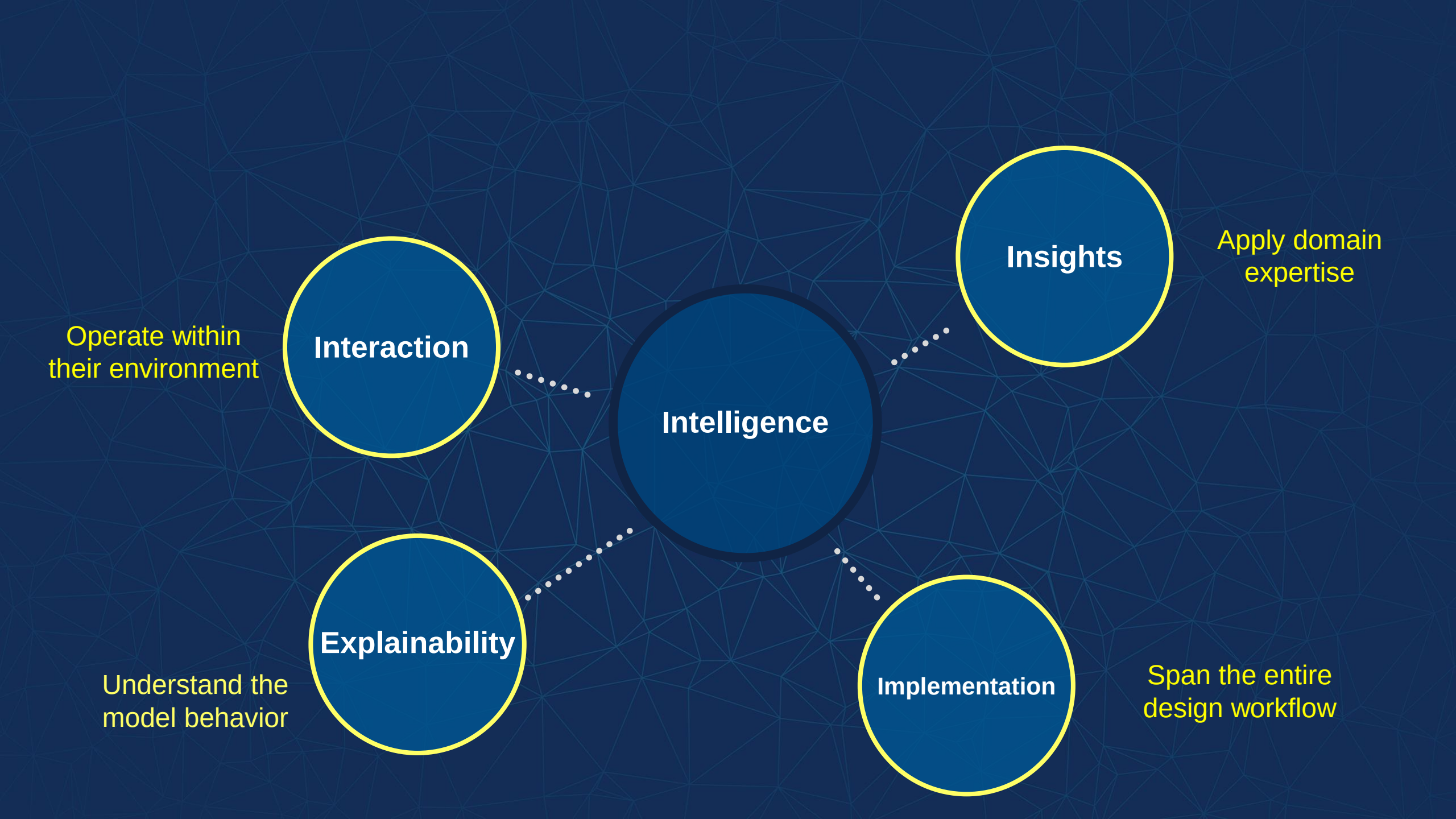
VOYAGE


EarlySense
Proactive Patient Care


Intelligence
Interaction
Operate within their environment
Insights
Apply domain expertise
Explainability
Understand the model behavior
Implementation
Span the entire design workflow

How will you apply AI to your projects?