

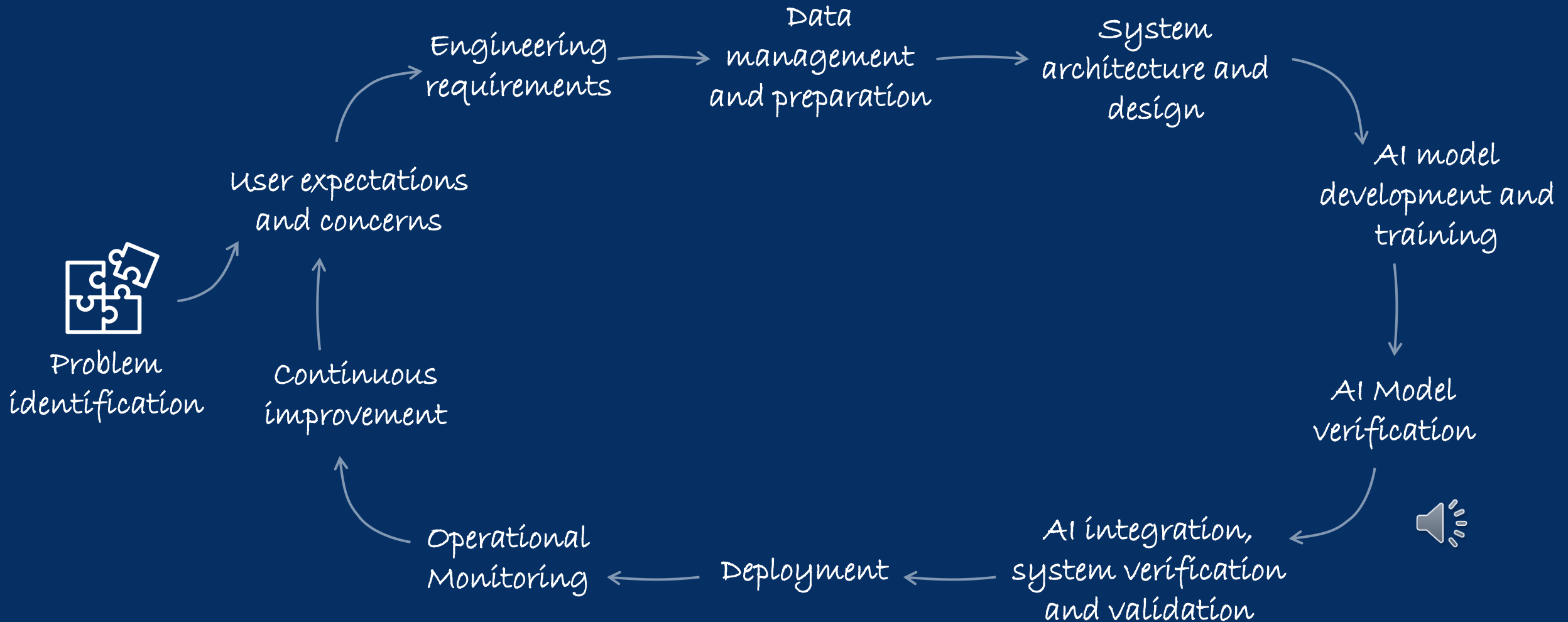
MathWorks  
**FINANCE**  
**CONFERENCE 2024**

# Innovations in the Delivery of AI- powered Financial Services

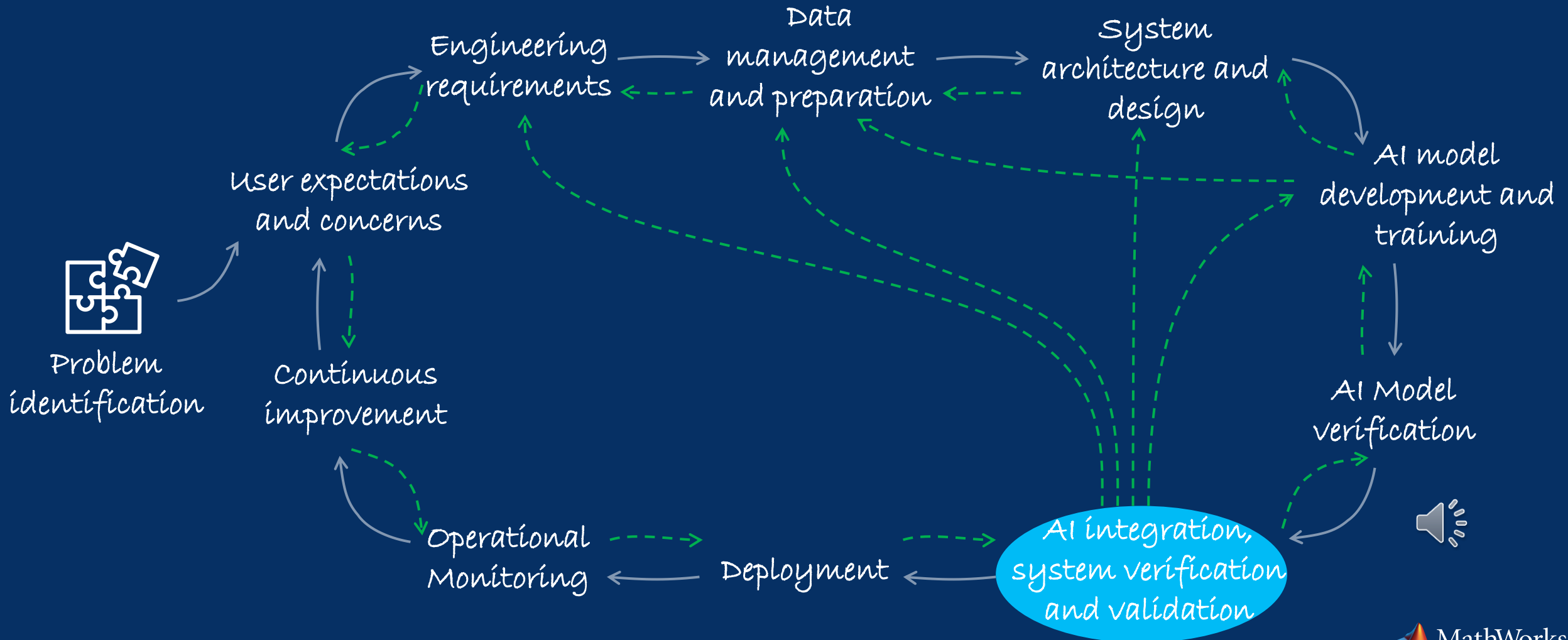
*Paul Peeling, MathWorks*



# A common AI Service Roadmap



# Build **confidence** in AI by incorporating continuous feedback



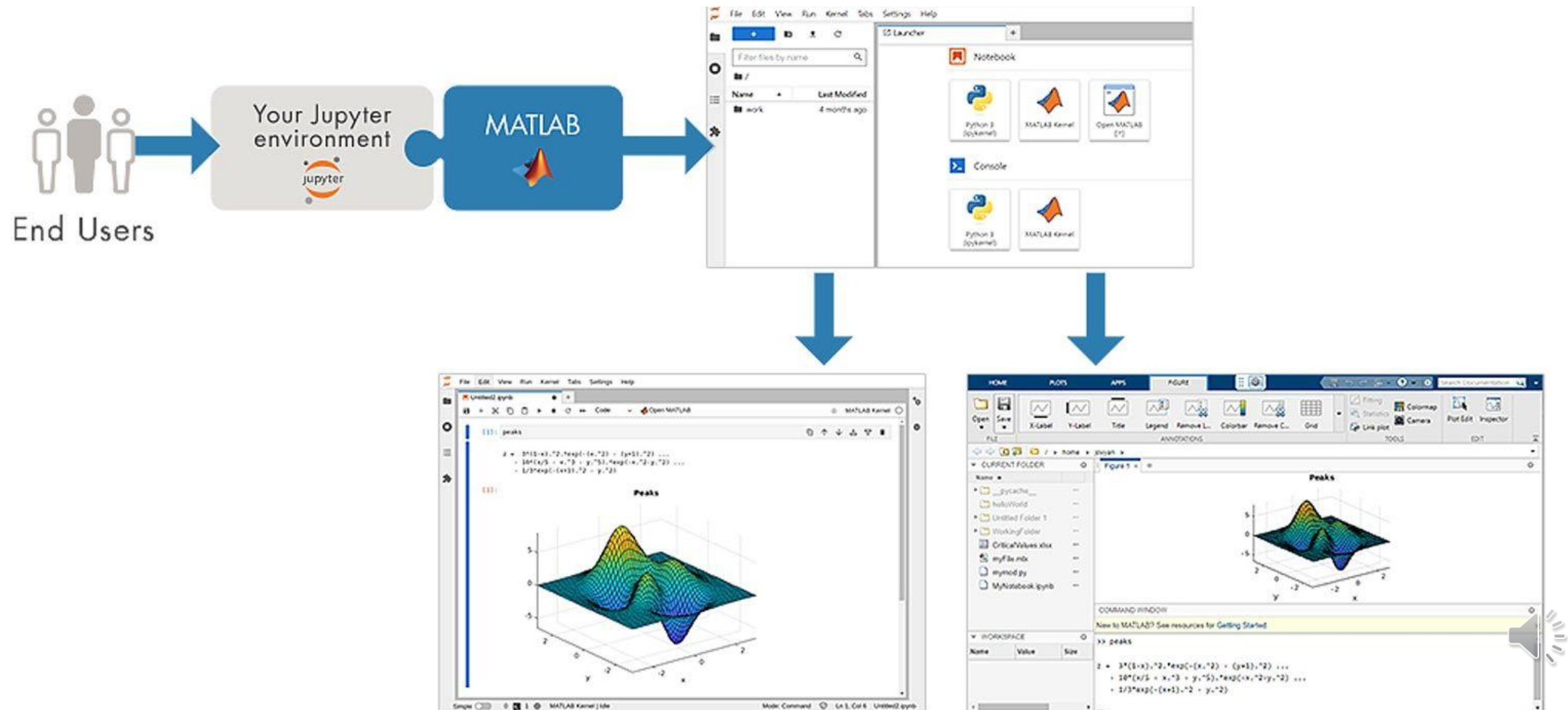


# Key areas for building confidence

- 1 Data**  
Automate data quality assurance processes
- 2 Leverage state-of-art in AI research**  
Leverage and extend pretrained models; use Generative AI for productivity
- 3 Explain and verify AI models**  
Adopt white box modeling and AI verification techniques
- 4 Deploy AI models into production**  
Utilize containerization and model monitoring
- 5 Regulation and Governance**  
Implement AI Governance to align with regulations



# Using MATLAB directly in a Jupyter environment



Filter files by name

/

Name	Last Modified
Documents	9 hours ago
matlab-apa...	9 hours ago
mlruns	7 hours ago
mrm	9 hours ago
work	last year
buildfile.m	12 hours ago
creditCard...	9 hours ago
spark-3.4.0...	last year

Launcher

### Notebook

Python 3 (ipykernel)

MATLAB Kernel

Open MATLAB [↗]

### Console

Python 3 (ipykernel)

MATLAB Kernel

### Other

Terminal

MATLAB File

Text File

Markdown File

Python File

Show Contextual Help

Filter files by name

/

Name	Last Modified
Documents	9 hours ago
matlab-apa...	9 hours ago
mlruns	7 hours ago
mrm	9 hours ago
work	last year
buildfile.m	12 hours ago
creditCard...	9 hours ago
spark-3.4.0...	last year
Untitled.ipynb	now

Untitled.ipynb

Code Open MATLAB git

```
[2]: data = readtable("creditCardData.csv");  
      histogram(data.CustIncome)
```

[2]:

Income Bin (x10 <sup>4</sup> )	Frequency
2.0 - 2.2	15
2.2 - 2.4	25
2.4 - 2.6	40
2.6 - 2.8	55
2.8 - 3.0	100
3.0 - 3.2	165
3.2 - 3.4	175
3.4 - 3.6	165
3.6 - 3.8	145
3.8 - 4.0	110
4.0 - 4.2	95
4.2 - 4.4	65
4.4 - 4.6	30
4.6 - 4.8	12
4.8 - 5.0	8

[ ]:



HOME PLOTS APPS

Search (Ctrl+Shift+Space)

New Script New Live Script New Open Find Files Go to File Import Data Save Workspace Clean Data New Variable Open Variable Clear Workspace Favorites Run and Time Clear Commands Layout Set Path Add-Ons Preferences Help Community Feedback Learn MATLAB

FILE VARIABLE CODE ENVIRONMENT RESOURCES

home > jovyan >

Files

- Documents
- matlab-apache-spark
- mlruns
- mrm
- work
- buildfile.m
- creditCardData.csv
- spark-3.4.0-bin-hadoop3:
- Untitled.ipynb

Workspace

Name	Value	Size	Class
data	1200x11 ta...	1200x11	table

Command Window

New to MATLAB? See resources for [Getting Started](#).

```
>> |
```





HOME



FILE

Import Open Save

CLEANING METHODS

Clean Missing Data Clean Outlier Data Normalize Data Smooth Data Retime Timetable Stack Table Variables Unstack Table ...

VIEW

Show Legend  Show Summary Statistics

EXPORT

Export

Variables

Name	Size	Class	Plot
data	1200x11	table	
Cus	1200x1	double	
Cus	1200x1	double	
Tm.	1200x1	double	
Res	1200x1	cell	
Em	1200x1	cell	
Cus	1200x1	double	
Tm'	1200x1	double	
Oth	1200x1	cell	
AM	1200x1	double	
Util	1200x1	double	
stat	1200x1	double	

data

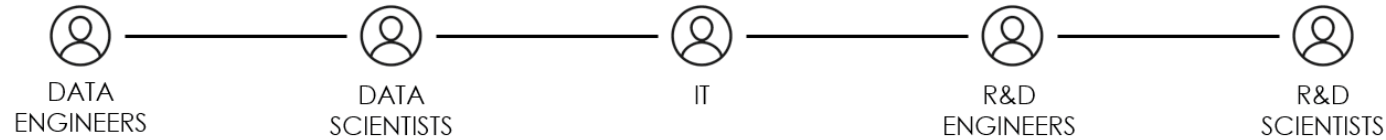
Data	Plot	Summary
	<p><b>CustID</b></p> <p>Min 1 Max 1200 Mean 600.5 Std Dev 346.5545 Missing 0 Class double</p>	<p><b>CustAge</b></p> <p>Min 21 Max 74 Mean 45.1094 Unique 54 Missing 30 Class double</p>
	<p><b>TmAtAddress</b></p> <p>Min 2 Max 207 Mean 41.9308 Std Dev 29.9028 Missing 0 Class double</p>	<p><b>ResStat</b></p> <p>Min Max Mean Std Dev Missing Class</p>
1	1	53
2	2	61
3	3	47
4	4	NaN
5	5	68
6	6	65
7	7	34
8	8	50
9	9	50
10	10	49
11	11	52
12	12	48
13	13	65

Cleaning Parameters

Cleaning Steps



# Connect to data and compute capabilities in the cloud.



Recording APPS LIVE EDITOR INSERT VIEW Search Documentation Arvind

File Edit View Tools Help

Current Folder: E:\work\databricks\Software\MATLAB\public\examples\DevDays\DatabricksDemo.mlx

# Databricks Dev Day Demo

## Cluster Management

It is possible to bring up a Databricks Cluster in a few lines of code:

```

1 cl = databricks.Cluster;
2 cl.cluster_name = 'AWS Databricks Dev Day Demo';
3 cl.enableMATLABRuntime();

```

Successfully closed the stream handle

Setting the scale of the spark cluster is equally easy.

```

4 cl.setNumWorkers( 10 );

```

Creating the cluster:

```

5 cl.create();

```

## Exploration using Databricks-Connect and Spark

MATLAB users can use databricks-connect to connect to the Spark cluster to explore datasets. The tooling allows users to slice / dice and query data by leveraging the distributed compute cluster that works with the storage to expose the datasets via a Spark API.

Command Window: fx >>

Clusters - Databricks

dbc-8c2a59a7-10f3.cloud.databricks.com/?o=1339781257718886#setting/clusters

# Clusters

Clusters Pools

+ Create Cluster

All Created by me Filter

### All-Purpose Clusters

2 clusters

Name	State	Nodes	Driver	Worker	Runtime
Databricks Demo	Running	3 (3 spot)	i3.xlarge	i3.xlarge	6.5 (includes ...)
AWS Databricks Dev Day Demo	Pending	0	i3.xlarge	i3.xlarge	6.5 (includes ...)

### Job Clusters

Name	State	Nodes	Driver	Worker	Runtime
job-1062-run-1	Error	-	i3.xlarge	i3.xlarge	6.5 (includes ...)
job-1056-run-1	Error	-	i3.xlarge	i3.xlarge	6.5 (includes ...)
job-1055-run-2	Error	-	i3.xlarge	i3.xlarge	6.5 (includes ...)
job-1055-run-1	Error	-	i3.xlarge	i3.xlarge	6.5 (includes ...)

Workspace Recents Data Clusters Jobs Models Search

Recording APPS LIVE EDITOR INSERT VIEW

Normal B I U M Task Control Refactor Run Section Run and Advance Run and End Pause Step Stop

FILE NAVIGATE TEXT CODE SECTION RUN

Current Folder: E:\work\databricks> Software\MATLAB\publicexamples\DevDays\DatabricksDemo.mlx

### Inspect dataset

Create a dataframe by pointing to all the data on the Data Lake (S3)

```
24 % Read the data from the datastorage (parquet) format
25 sparkDataSet = spark.read.format('parquet')...
26     .option('header','true')...
27     .option('inferSchema','true')...
28     .load(inputLocation);
```

### Use queries to identify data of interest

The Spark API allows us to slice/dice and query data using the Spark Cluster. As an example, let us inspect a single test from our dataset.

```
29 % Filter to a single trip of interest
30 testSet = sparkDataSet.filter("MachineType LIKE 'S750_L40_SugarcaneHarvester'");
```

MATLAB makes it easy to visualize data. For this given MachineType, a visualization of sensors logged during the drive cycle can be viewed interactively using:

```
31 testData = table(testSet.limit( 101  ));
32 plot(testData.TimeStamp, testData.SignalValue);
33 xlabel('Time');
34 ylabel('Sensor');
35 grid on;
```

### Develop the predictive model

To develop the predictive model, we can gather a slice of data from cloud storage and view the damage increment and accumulation to validate the model.

```
36 turboData = loadTurboData(spark);
```

Command Window: fx >>

DevDays (Folder) 1:46 / 3:29 1x CC

Recording PLUITS APPS LIVE EDITOR INSERT FIGURE VIEW

New Open Save Find Files Compare Go To Print Find

Normal Text Code Task Control Refactor Run Section Run and Advance Section Break Run to End Run Step Stop

Current Folder: E:\work\databricks\Software\MATLAB\public\examples\DevDays\DatabricksDemo.mlx

```
36 turboData = loadTurboData(spark);
```

### View the rainflow cycle

It is possible to inspect the data and view cycle information by leveraging the features of the Predictive Maintenance toolbox.

```
37 turboTable = table(days(turboData.TimestampRelative), turboData.m_TurboSpeedSensorReading);
```

turboData = 6188x4 table

	TimeStampRelative	mH_EngineSpeed_rpm	mM_DynoTorque_Nm	m_TurboSpeedSens
1	0.4000	1.1899e+03	1.1460e+03	
2	0.6000	1.1899e+03	1.1547e+03	
3	0.8000	1.1899e+03	1.1580e+03	
4	1.0000	1.1897e+03	1.1621e+03	
5	1.2000	1.1897e+03	1.1677e+03	
6	1.4000	1.1899e+03	1.1727e+03	
7	1.6000	1.1902e+03	1.1768e+03	
8	1.8000	1.1903e+03	1.1805e+03	
9	2.0000	1.1903e+03	1.1849e+03	
10	2.2000	1.1905e+03	1.1918e+03	

Command Window  
fx >>

DevDays (Folder) 2:47 / 3:29 1x CC

# Key Recommendations for building confidence

1

## Data

Automate data quality assurance processes

2

## Leverage state-of-art in AI research

Leverage and extend pretrained models; use Generative AI for productivity

3

## Explain and verify AI models

Adopt white box modeling and AI verification techniques

4

## Deploy AI models into production

Utilize containerization and model monitoring

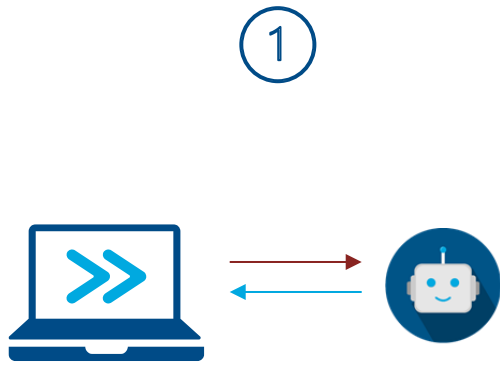
5

## Regulation and Governance

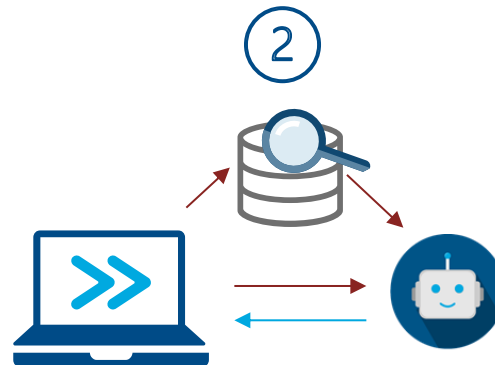
Implement AI Governance to align with regulations



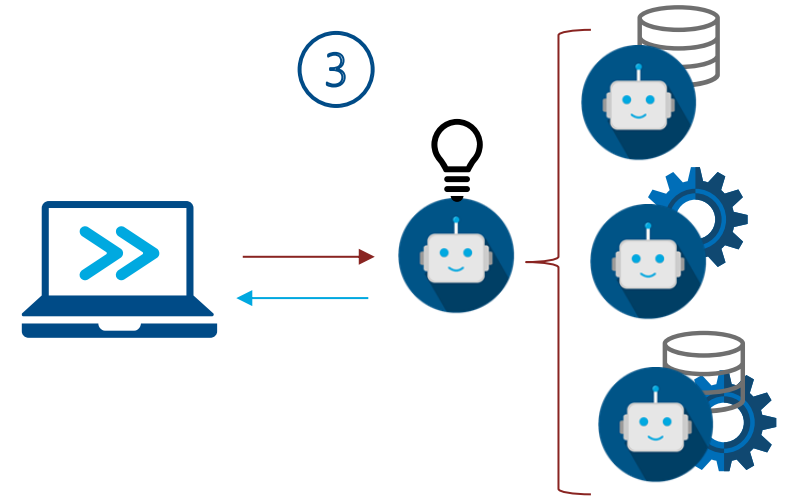
# Approaches for leveraging LLMs on data



Prompting



Retrieval-Augmented Generation



Fine-tuning



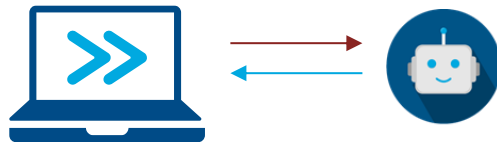


# Prompting: use the chat interface...



Generate MATLAB code to compute the sine of values between 1 and 30. The code should be optimized and use vectorization. Let's think step-by-step.

Prompt engineering is the process of crafting and refining inputs to an AI model to guide its output.



Sure! Here's the MATLAB code that computes the sine of values between 1 and 30 using vectorization:

matlab

Copy code

```
% Define the range of values
startValue = 1;
endValue = 30;

% Generate the values within the range
x = startValue:endValue;

% Compute the sine of the values using vectorization
y = sin(x);

% Display the results
disp(y);
```



# For data, you use ChatGPT programmatically



...



Summarize...

① Copy and paste each document individually into the chat interface.

② Ask ChatGPT for a summary

③ Copy and paste the result into another file



① Read each file inside MATLAB in a loop

② Request the ChatGPT API for a summary for each document

③ Automatically save each summary to a file



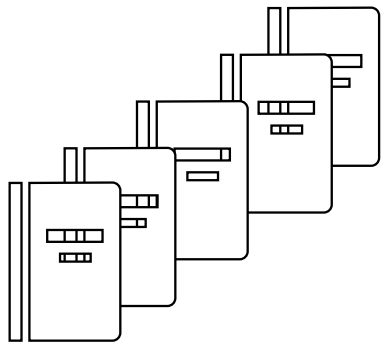
If there is repetition, there is potential for automation via MATLAB

Design notes

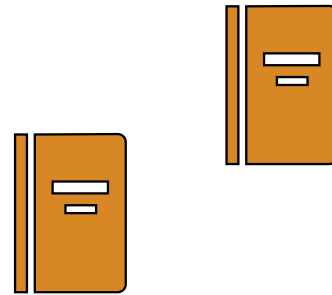
# Retrieval-Augmented Generation (RAG) to ask questions about your data

Text Analytics Toolbox

Documents  
financial reports



Retrieve relevant  
reports

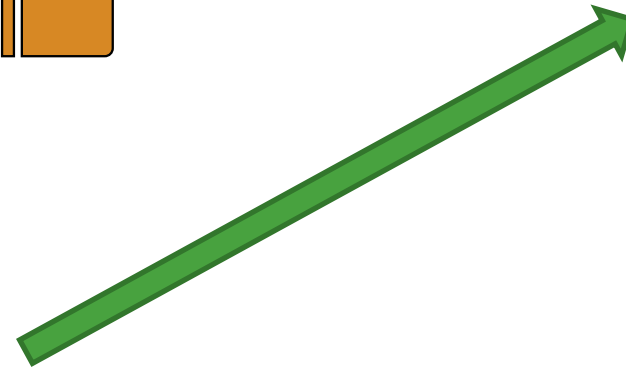


ChatGPT



Focused  
answer

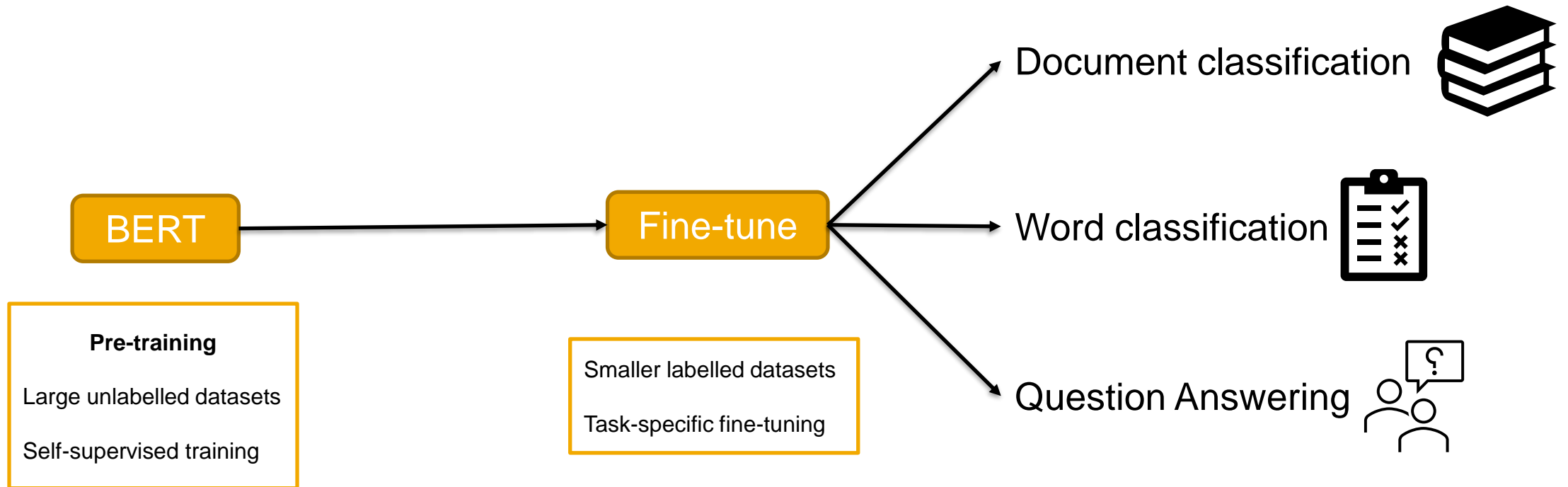
Query: Model XYZ has missing data,  
what should I do?



Use RAG when you  
want to tailor the  
model's output to  
your own data!

# Fine-tuning models

Models like BERT can be fine-tuned in low-resource settings



# Key Recommendations for building confidence

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Adopt white box modeling and AI verification techniques

4

## Deploy AI models into production

Utilize containerization and model monitoring

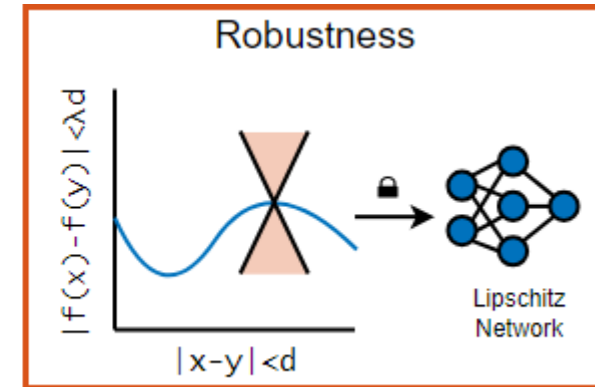
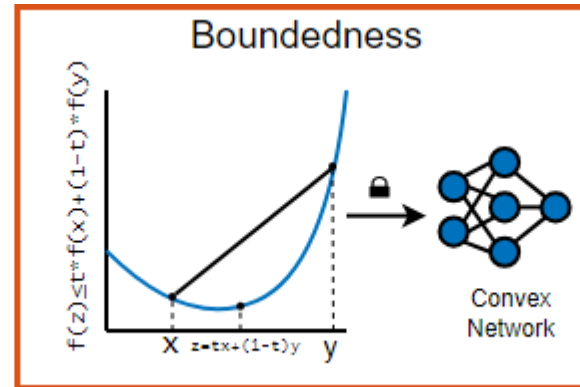
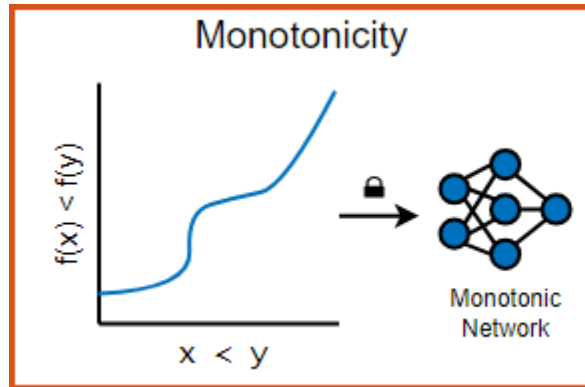
5

## Regulation and Governance

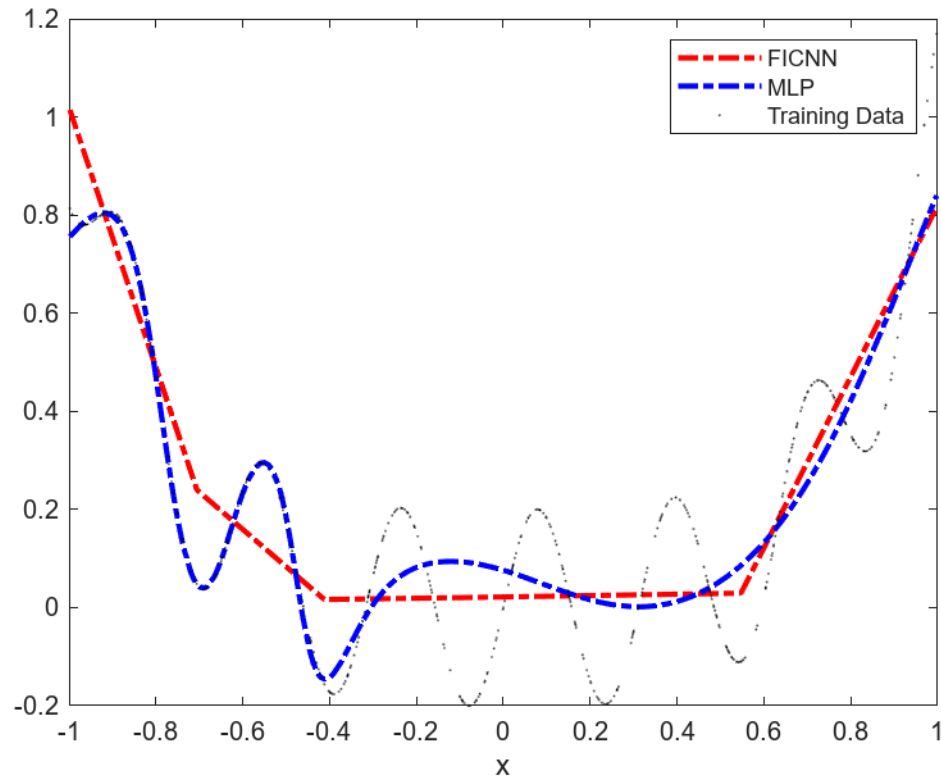
Implement AI Governance to align with regulations



# Constrained deep learning



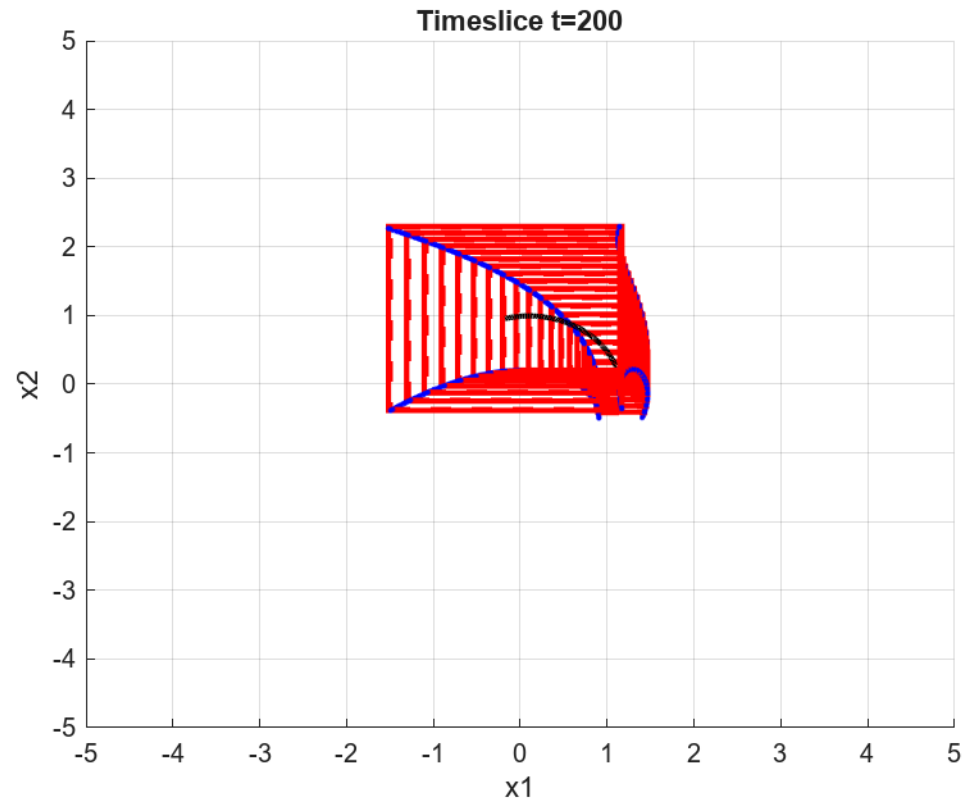
# Monotonicity



A convex output with respect to some of the model inputs is a desirable, and often required property of a model used in financial decision making.



# Boundedness

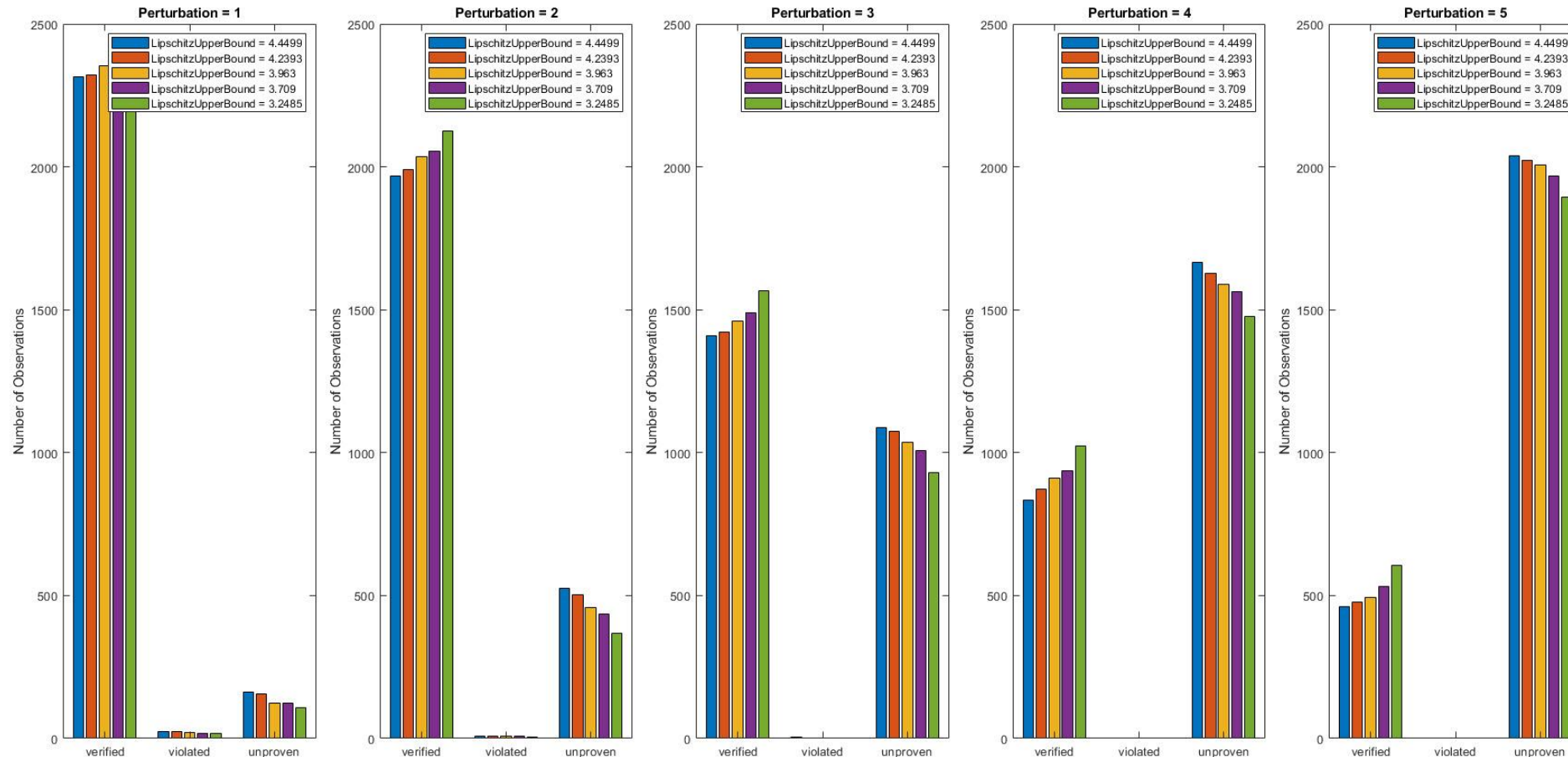


Models used in forecasting should produce outputs that remain within explainable bounds at any point in time.





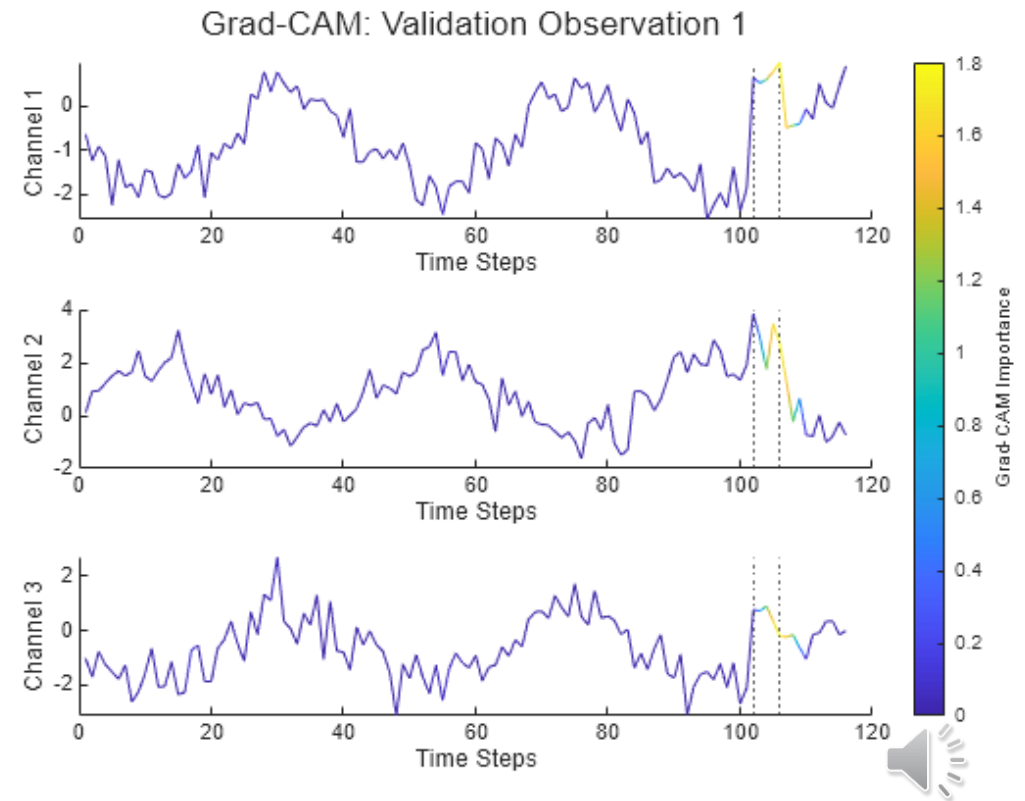
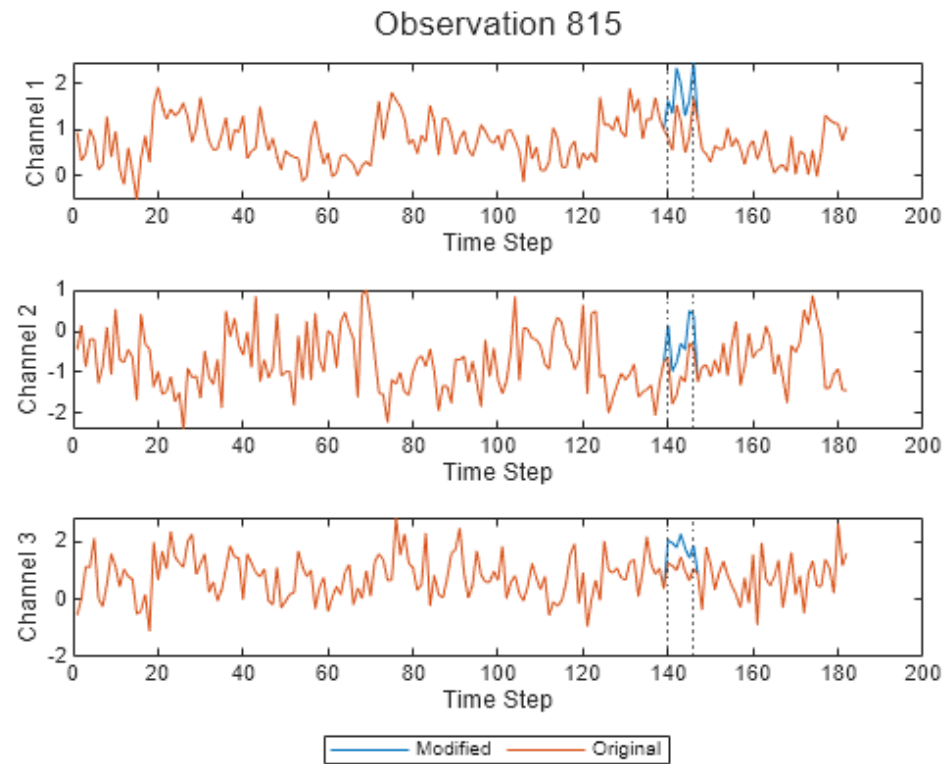
# Robustness



As sensitivity of the output to input perturbations decreases, the network is more stable and has more formally verifiable properties.



# Interpret Deep Learning Time-Series Classifications Using Grad-CAM



# Key Recommendations for building confidence

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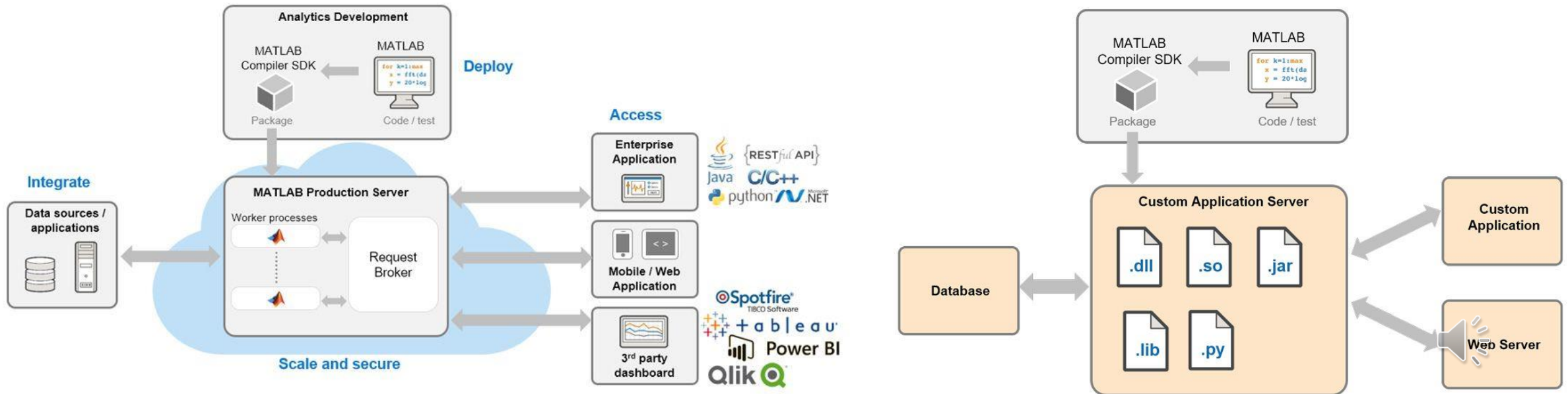
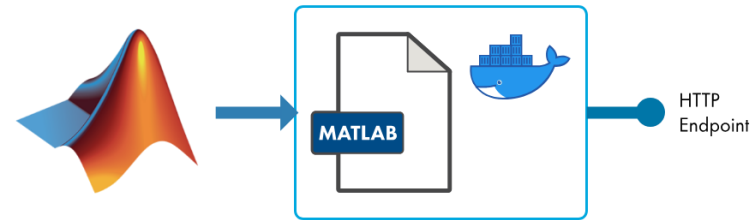
5

## Regulation and Governance

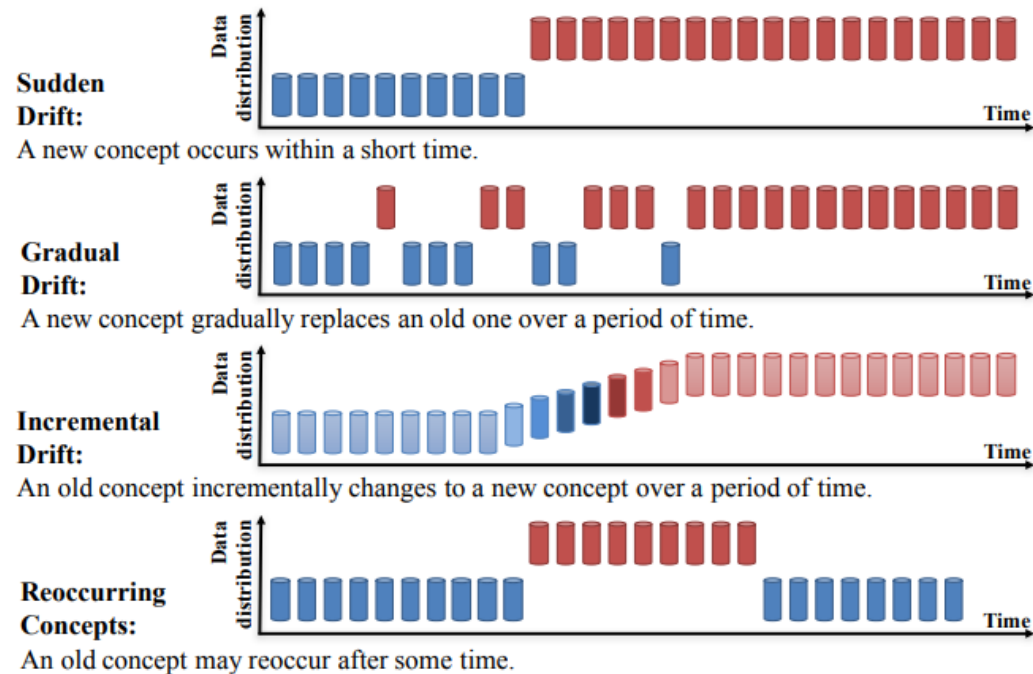
Implement AI Governance to align with regulations



# Container and Server Integrations



# Data Drift Has Many Forms and Causes

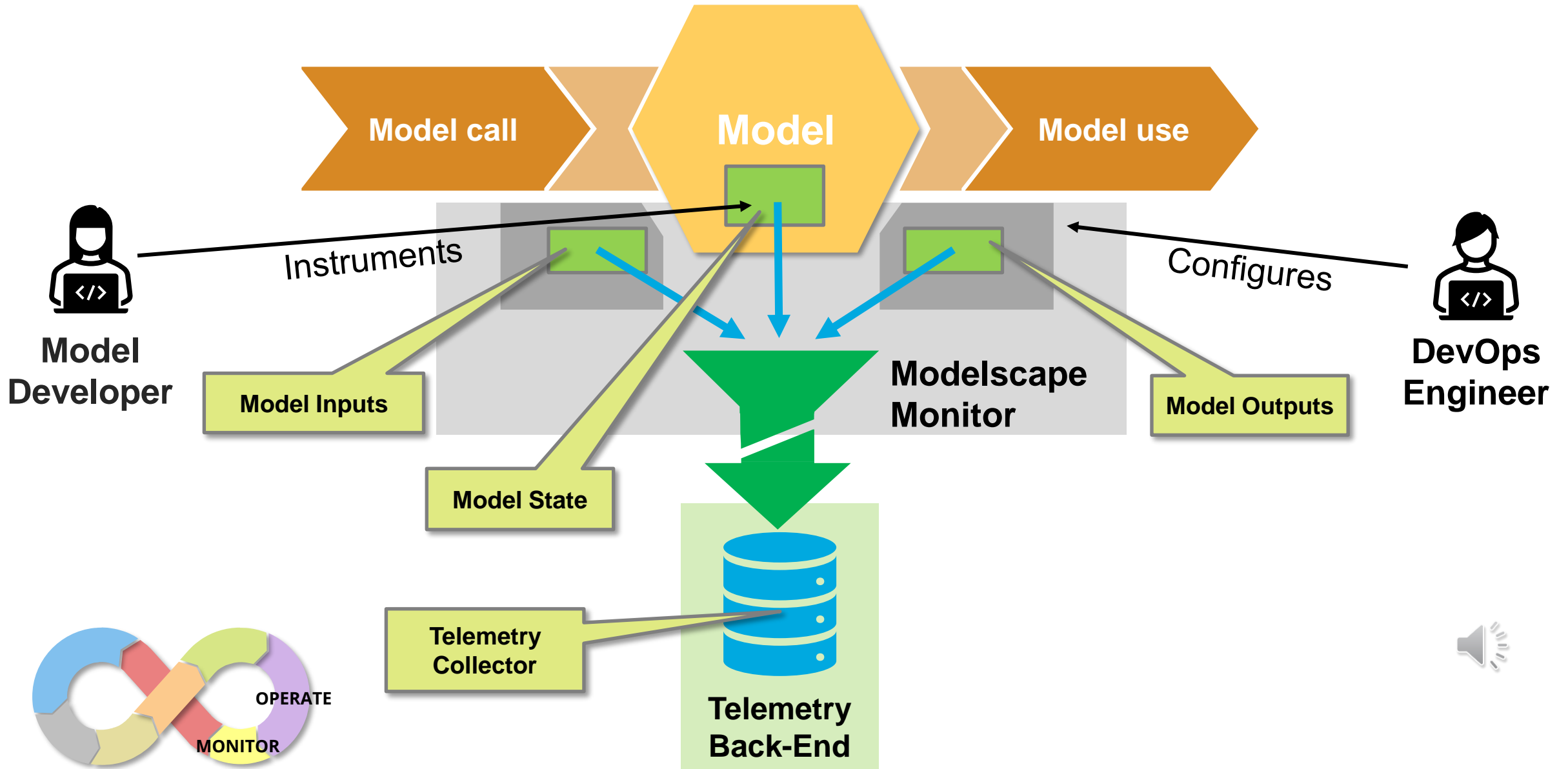


- Low-negative-normal interest rate regimes – Can your vol model handle this?
- LLM hitting token limits – Are people happy to chat or are they not getting the answers they need?

**Source:** <https://arxiv.org/pdf/2004.05785.pdf>



# Modelscope Monitor – Custom Instrumentation for Model Internals



# Modelscope Provides Visibility of Model Health

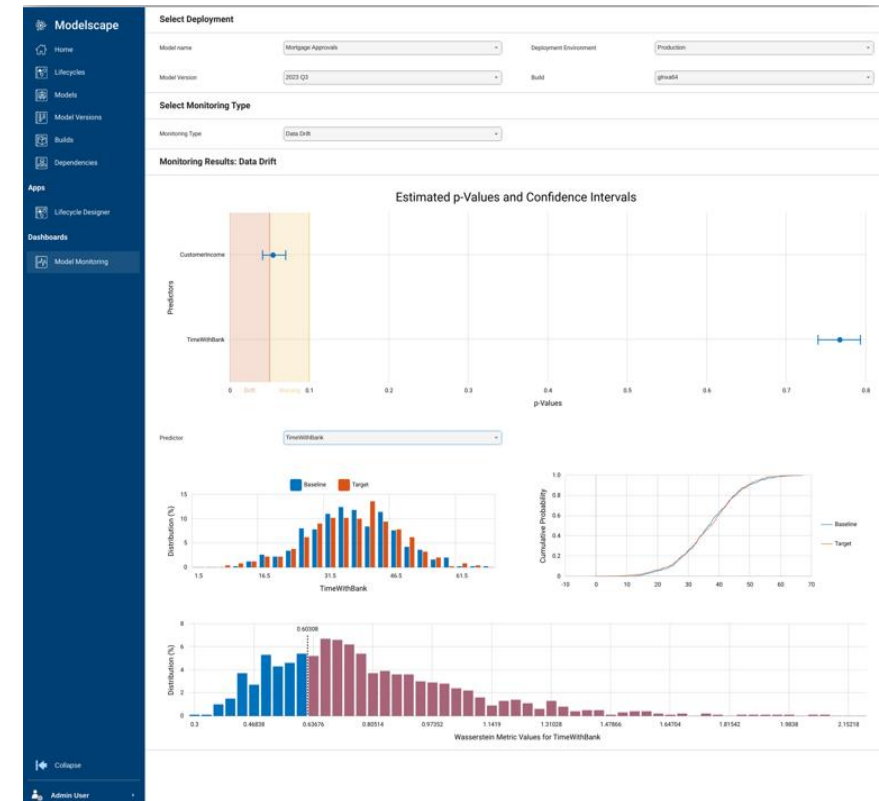
Modelscope displays diagnostics of monitoring status.

**Monitoring Status (4)**

DEPLOYMENT ENVIRONMENT

Prod - EMEA (3)    Prod - Asia ex-Japan (1)

ACTIONS	DEPLOYMENT ENVIRONMENT	BUILD	MONITORING TYPE	LAST UPDATED	VALUE	STATUS
<a href="#">View Details</a>	Prod - EMEA	Simple Model v 2.0.0	Data Drift	15/08/2024 23:59	Warning	<b>Under Investigation</b>
<a href="#">View Details</a>	Prod - EMEA	Simple Model v 2.0.0	Fairness - SPD	30/06/2024 14:30	0.0163	<b>OK</b>
<a href="#">View Details</a>	Prod - EMEA	Simple Model v 2.0.0	Failure Rate	16/08/2024 10:55	0.29385	<b>Alert</b>
<a href="#">View Details</a>	Prod - Asia ex-Japan	Simple Model v 2.0.0	Data Drift	15/08/2024 23:59	Stable	<b>OK</b>



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**Modelscope**

- Search
- Create
- Show all models
- Show all non-models
- Submissions
- Document Library
- Planning
- Model Risk Appetite Metrics

**Admin**

- Lifecycle Designer
- Inventory Browser
- Version 0.4.3

**Paul**

# Modelscope Governance SS1/23 Compliance

## Quick Access

**Principle 1.1**

Model Identification.

**Lifecycle Designer**

Use the Lifecycle Designer app to create new lifecycles and edit existing lifecycles in Modelscope.

**Inventory Browser**

Use the Inventory Browser app to create Modelscope models and add dependencies between models.

## Quick Search

Filter: All 6 Models 3 Versions 3 Lifecycles 0  Show my items only

Results per page: 10

< Results 1 - 6 of 6 >

ACTIONS	NAME	TYPE	CREATED BY	MODIFIED ON
<a href="#">View Details</a>	Market Risk for Clear IRS	Model	@serviceUser	26 Sept 2023
<a href="#">View Details</a>	Market Risk for TRS - 15.0.0	Model Version	@mwa0000030344018	26 Sept 2023
<a href="#">View Details</a>	Market Risk for Equity Swap	Model	@serviceUser	26 Sept 2023
<a href="#">View Details</a>	Market Risk for Equity Swap - 7.0.0	Model Version	@tituse	22 Sept 2023



- Search
- Create
- Show Active
- Show Change History
- Show Retired/Inactive
- Show All Submissions



### Submission S.1.1

<b>SUBMISSION ID</b> S.1.1	<b>MODEL NAME</b> Equity Options	<b>SUBMISSION TYPE</b> Initial Validation	<b>SUBMISSION STATE</b> Rejected
<b>MODEL OWNER</b> Yang	<b>MODEL DEVELOPER</b> Yang	<b>MODEL ATTESTER</b> Yang	<b>CURRENT REVALIDATION DUE DATE</b> 1 Sept 2024
<b>HEAD OF MODEL VALIDATION</b> MV Head	<b>MODEL VALIDATION CONTACT</b> Frank	<b>ADD. MODEL VALIDATION CONTACT</b> N/A	

[Edit Stakeholder Info](#)

### MGC WG Meeting Minutes

<b>MGC WG DATE</b> <input type="text" value="m/d/yyyy"/>	<b>COMMENTS</b> <input type="text"/>
---	---

### MGC Approval/MV Signoff Evidence

<b>MGC APPROVAL/MV SIGNOFF DATE</b> <input type="text" value="m/d/yyyy"/>	<b>COMMENTS</b> <input type="text"/>
--	---

### MGC Approval/MV Signoff/Meeting Minutes Documents

NAME	LINK	AUTHOR	DESCRIPTION	TYPE	UPLOAD DATE	ACTION
------	------	--------	-------------	------	-------------	--------

# Modelscope – The Complete Workflow for AI Models

## Modelscope Monitor™

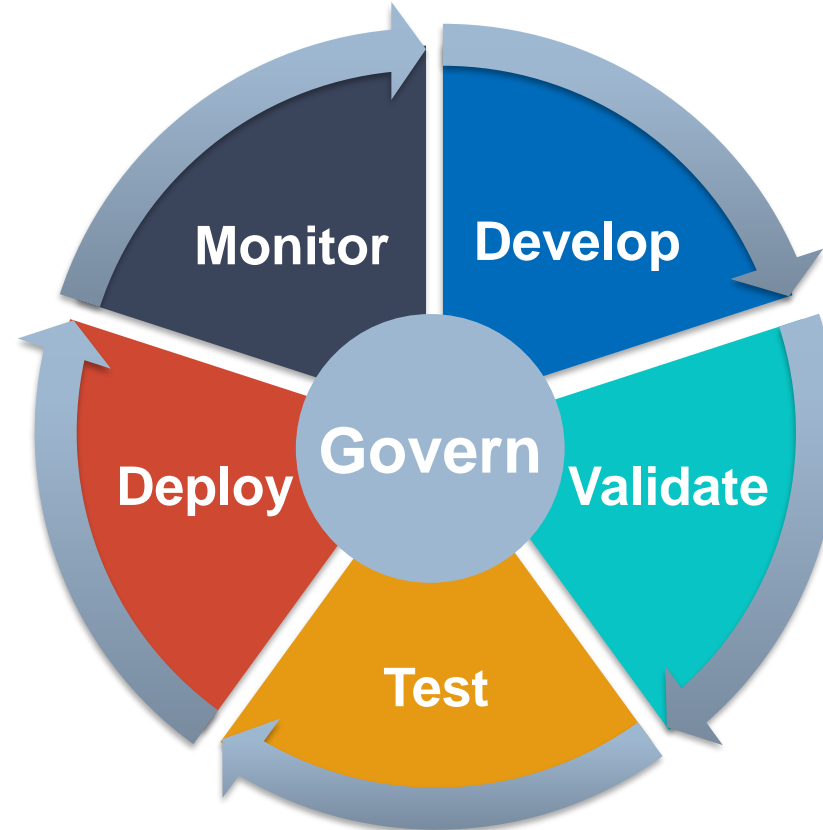
- Configure performance thresholds and alerts for breaches and generate reports
- Summarize model execution results using a customizable web dashboard
- Analyze the model usage to determine candidate models for retirement

## Modelscope Deploy™

- Deploy models in production environment without recoding
- Integrate with existing technology infrastructures
- Host production models and scale to end users in a secure controlled environment “on-prem” or “cloud”

## Modelscope Governance™

- Centralized access to models, dependencies, meta-data, lineage, audit trail, risk scoring, and model risk reporting



## Modelscope Test™

- Automatically run unit tests and generate test reports
- Perform preproduction testing and validation for approved models
- Compare tests of preproduction model with a production model

## Modelscope Develop™

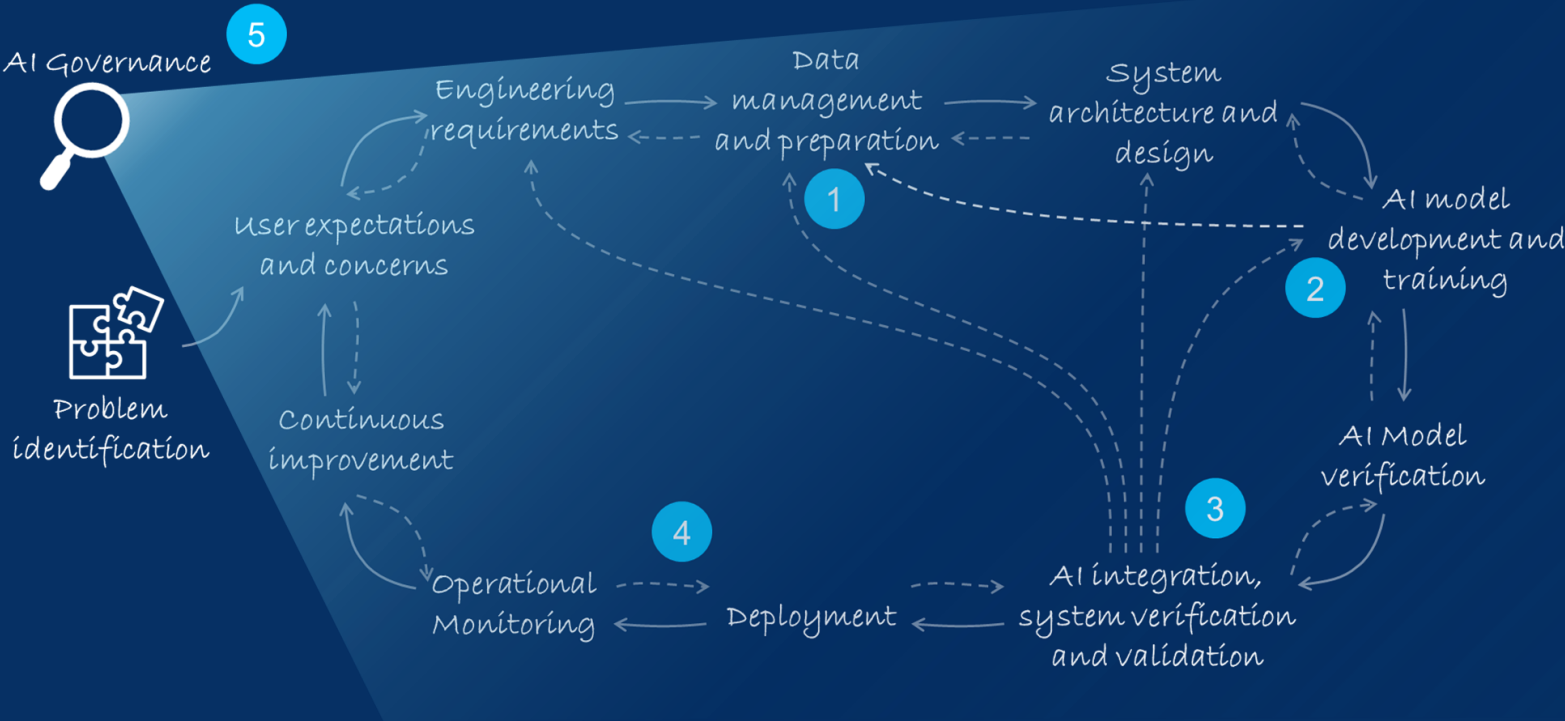
- Explore, develop, back-test, and document models and methodologies
- Improve transparency and reproducibility of model development process
- Create reusable model templates
- Auto-generate model documentation

## Modelscope Validate™

- Perform independent model reviews
- Perform interactive what-if and sensitivity analysis on model parameters
- Comment and flag various aspects for response and resolution



# Building confidence in AI powered financial services



- 1 **Data**
- 2 **Leverage state-of-art in AI research**
- 3 **Explain and verify AI models**
- 4 **Deploy AI models into production**
- 5 **Regulation and Governance**



## GitHub and MathWorks links

- [MATLAB Integration for Jupyter](#)
- [MATLAB Interface for Databricks](#)
- [LLMs with MATLAB](#)
- [AI Verification: Constrained Deep Learning](#)
- [Deep Learning Toolbox Verification Library](#)
- [MATLAB Interface to OpenTelemetry](#)
- [Modelscape for MATLAB](#)



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**Thank you**

