Pontificia Universidad JAVERIANA Colombia

Tópicos Avanzados en Analítica

Maestría en Analítica para la Inteligencia de Negocios

Sergio Alberto Mora Pardo - H2 2024

Pontificia Universidad JAVERIANA Colombia

Tópicos Avanzados en Analítica

Estructura de la clase

- Machine Learning Operations
- Deep Learning
- Natural Language Processing
- Graph Machine Learning

Tópicos Avanzados en Analítica

Estructura de la clase

Machine Learning Operations

Deep Learning

Natural Lenguage Processing

Graph Machine Learning

Basic Methods in MLOps

Machine Learning as a Service - AIaaS

Model deployment

Rest API - microservicios

Machine Learning Observability

- Data Drift
- Target Drift
- Model Drift

Model Monitoring

Tópicos Avanzados en Analítica

Estructura de la clase

- Machine Learning Operations
- Deep Learning
- Natural Lenguage Processing
- Graph Machine Learning

Basic Methods in MLOps

scikit learn

Machine Learning as a Service - AIaaS

Flask
web development, one drop at a time

Machine Learning Observability

EVIDENTLY AI

DATADOG

Tópicos Avanzados en Analítica

Estructura de la clase

- Machine Learning Operations ✓
- Deep Learning
- Natural Language Processing
- Graph Machine Learning

Intro to Deep Learning

- Perceptron
- Multi-layer Perceptron
- Neural Networks
- Convolutional Neural Networks

Tópicos Avanzados en Analítica

Estructura de la clase

- Machine Learning Operations ✓
- Deep Learning ✓
- Natural Language Processing
- Graph Machine Learning

Natural Language Processing - NLP

- Introduction
- Text Representation
- NLP with Deep Learning

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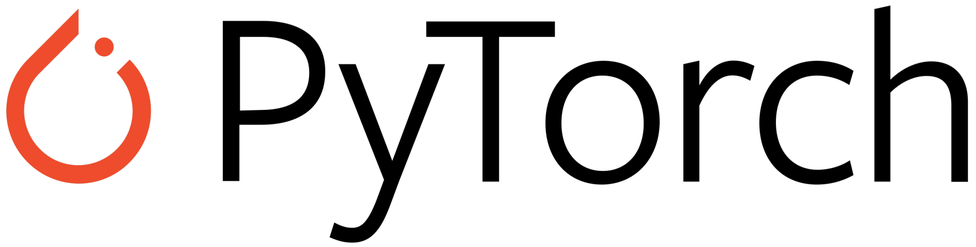
Estructura de la clase

- Machine Learning Operations ✓
- Deep Learning ✓
- Natural Language Processing ✓
- Graph Machine Learning

Geometric Deep Learning

- Graph Introduction
- Graph Representation Learning
- Graph Neural Network



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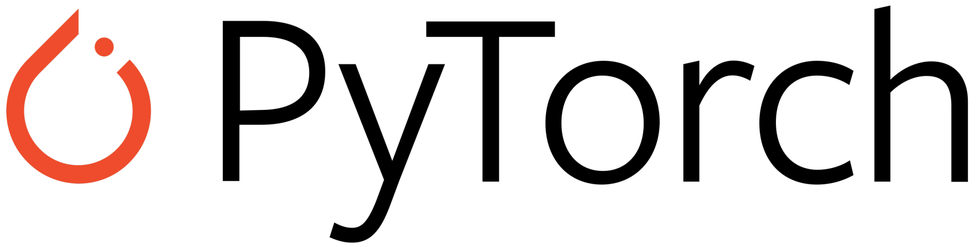

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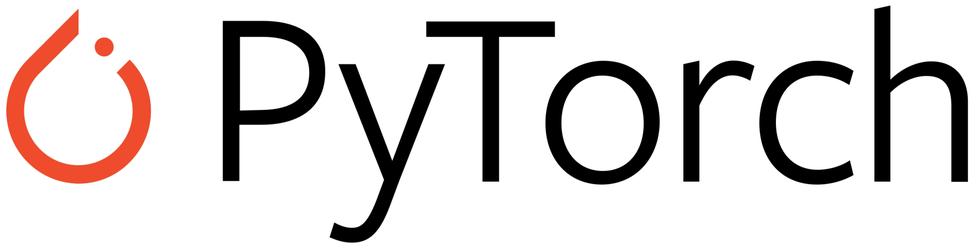

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Fechas de entrega

Session	Activity	Deadline	Comments
Deep Learning	• Exercises • Project	• September 6th	Expo September 7th
NLP	• Exercises • Project	• October 11th • October 4th	Expo October 5th
Graph Learning	• Exercises • Project	• November 9th	
Final grade	• project	• November 16th	

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Tópicos Avanzados en Analítica

Material de clase - canales de comunicación

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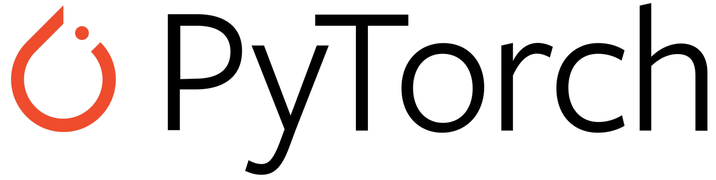
Tópicos Avanzados en Analítica

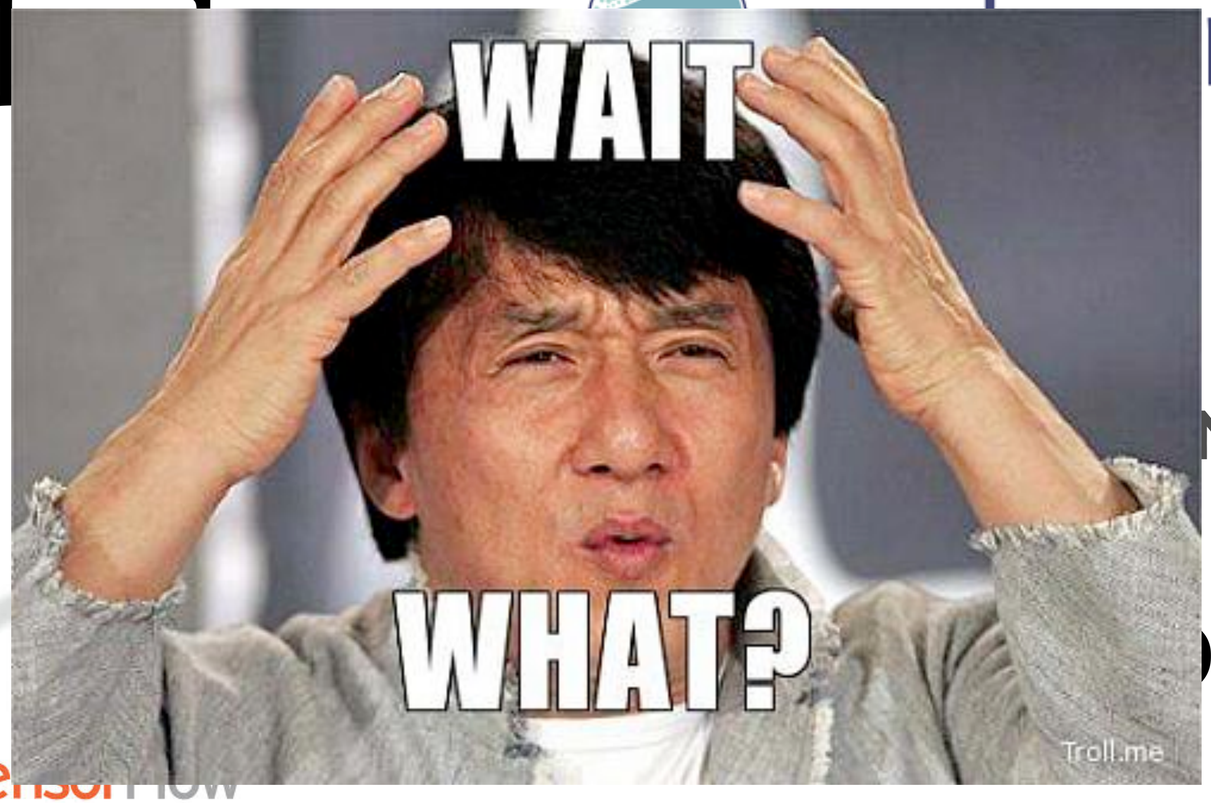
Toolkit - Frameworks - Packages

Hugging Face

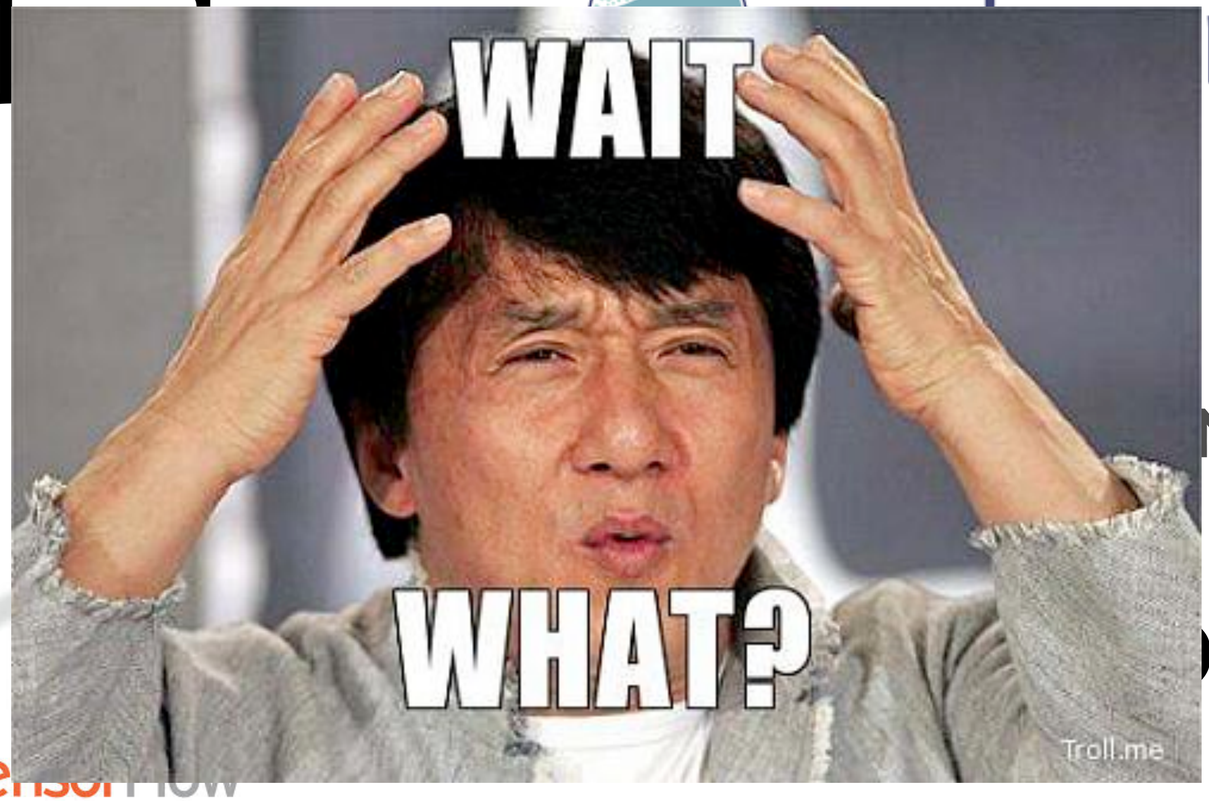


Tópicos Avanzados en Analítica

Toolkit - Frameworks - Packages



¡Estamos acá para aprender y equivocarnos!
Es un ambiente académico seguro donde se nos permite desconocer cosas y aprender...



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¿Nombre?
¿Profesión - pregrado?
¿En qué trabajas?
¿Cuál de estos framework conoces o haz trabajado alguno de estos temas?

Hugging Face

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Machine Learning Operations -MLOps-

Tópicos Avanzados en Analítica

Maestría en Analítica para la Inteligencia de Negocios

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Machine Learning Model Monitoring

- Data Drift
- Target Drift
- Model Drift

ML Monitoring

TL;DR

Model Quality in production

Model metrics:
- Precision, Accuracy, AUC...
- Data drift
- Prediction drift
- Data quality
- Model Bias
- Model fairness

- Model in Software != Health software

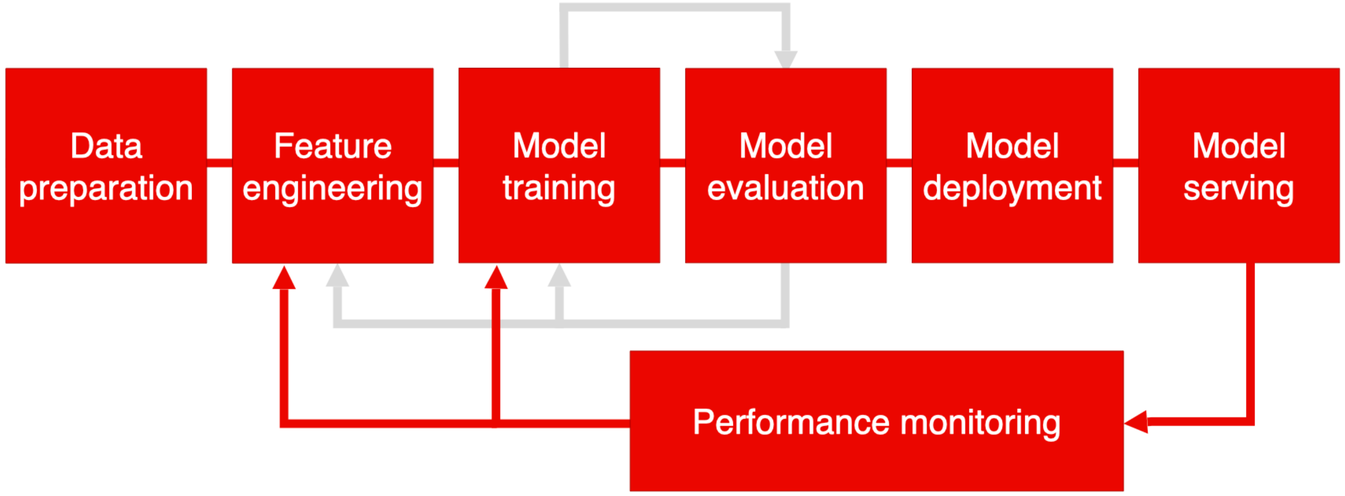
ML Monitoring

Why you need?

Model Quality in production

- Precision, Accuracy
- Data drift
- Prediction drift
- Data quality
- Model Bias
- Model fairness

Deploy in real world —> require continuous monitoring



ML Monitoring

Why you need?

Model Quality in production

↓

Gradual concept drift

Changes the relationships in the data over time

↙ variables

↘ Patterns

Ex.; SysRec over preference in last month, not today.

↑ Impact the quality model's suggestion

ML Monitoring

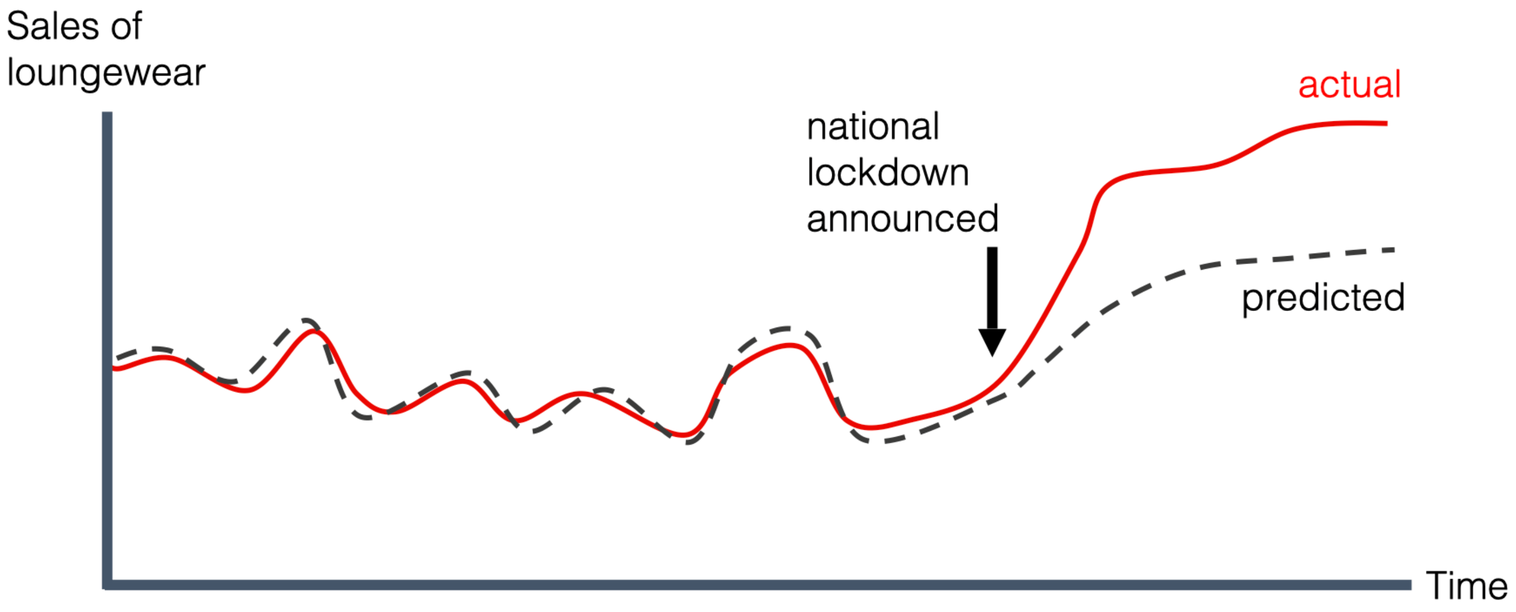
Why you need?

Model Quality in production

↓

Sudden concept drift

Unexpected changes in model environment



ML Monitoring

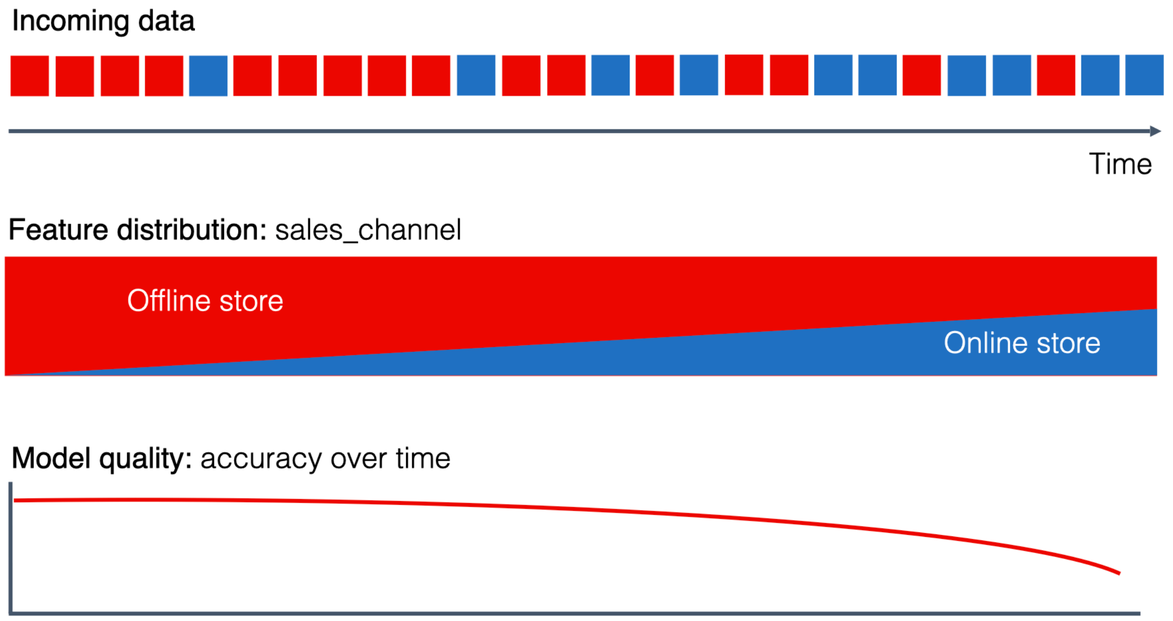
Why you need?

Model Quality in production

↓

Data drift

Data distribution drift —> statistical properties of the input data change



ML Monitoring

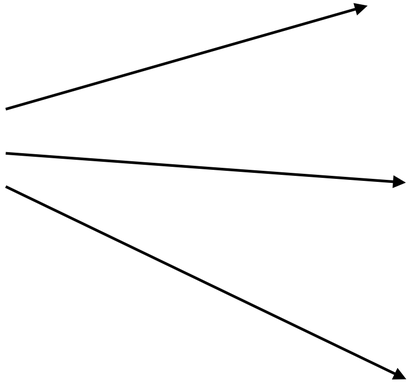
Why you need?

Model Quality in production

Data Quality Issues

Input data's accuracy

- Completness
- Reliability



Missing values

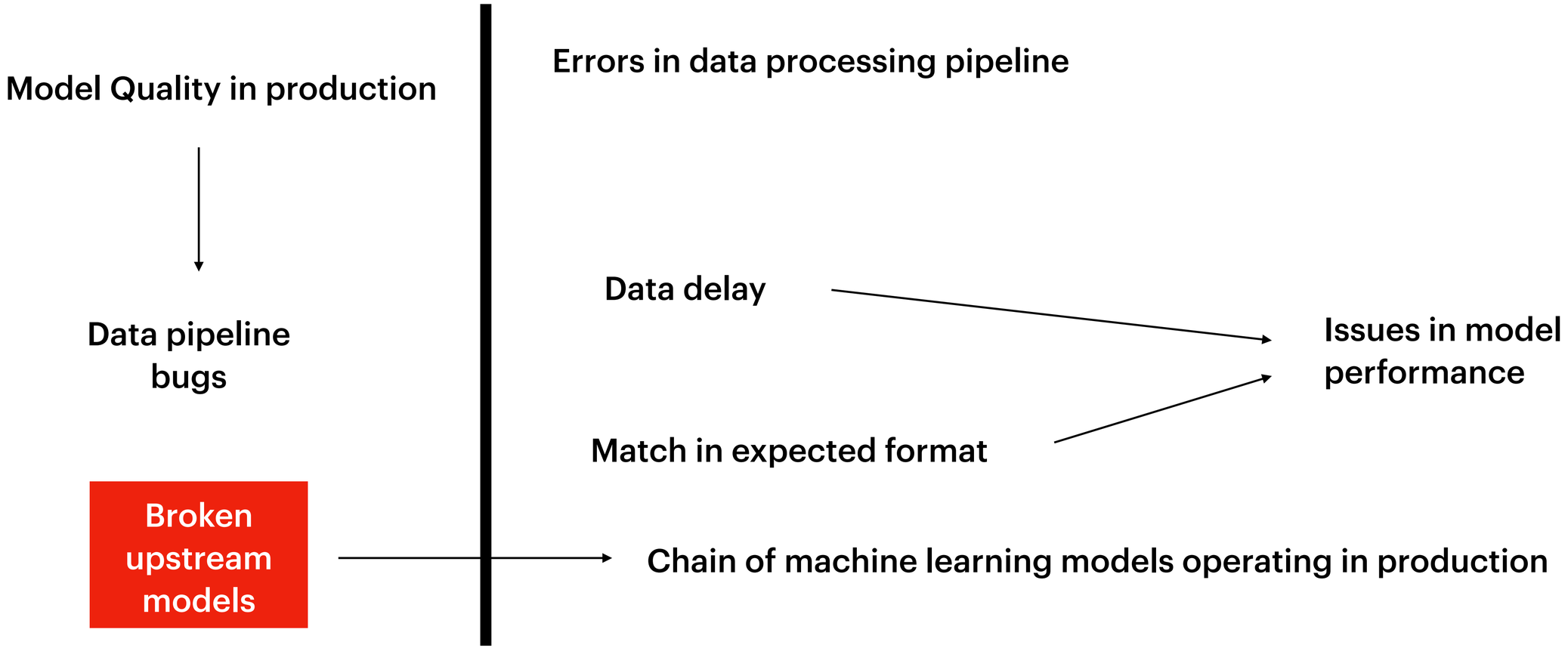
Duplicate records

Shift in feature range

- Seconds —> milliseconds

ML Monitoring

Why you need?



ML Monitoring

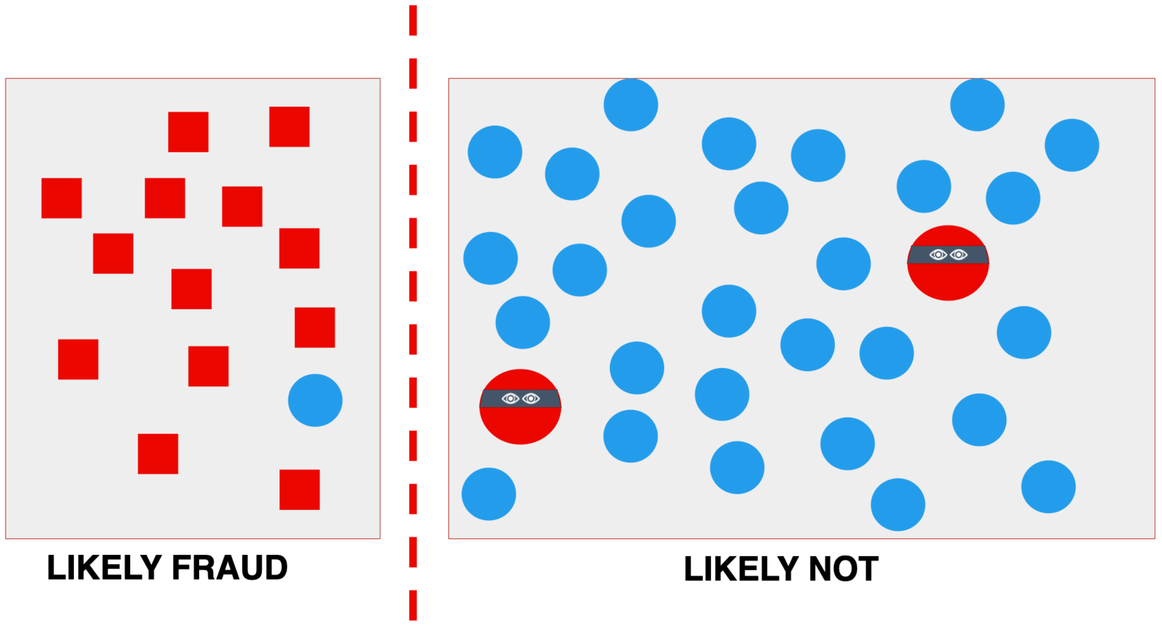
Why you need?

Model Quality in production

↓

Adversarial adaptation

Manipulate the model performance



Spammers adapt

↓

Spam detection filters

ML Monitoring

Model monitoring goals

Model Quality in production

what you can expect
from ML monitoring?

Model performance:

- Issue detection and alerting

- Root cause analysis

- ML model behavior analysis

- Action triggers

ML Monitoring

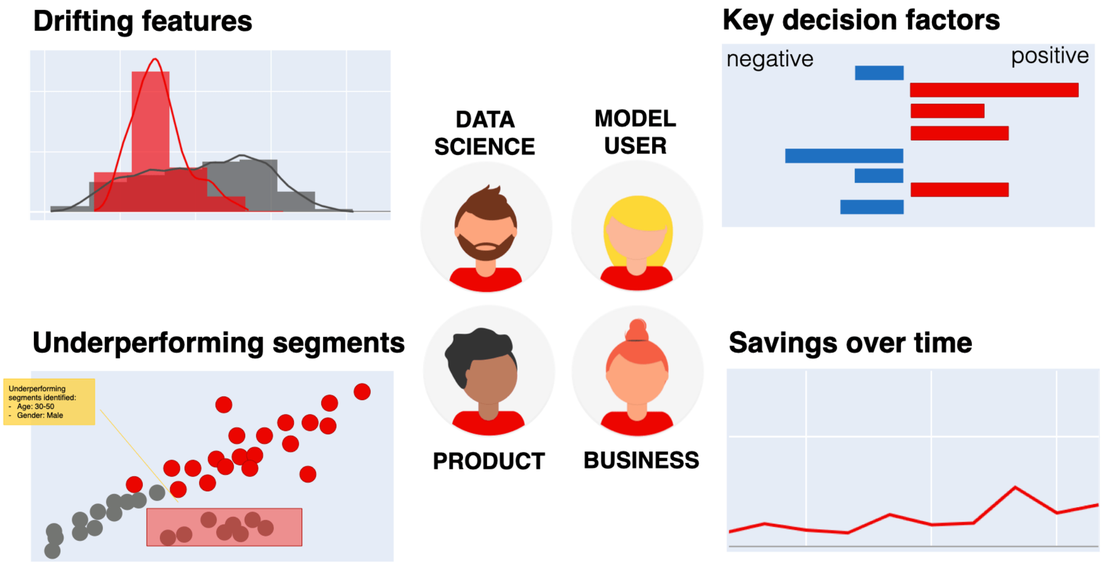
Model monitoring goals

Model Quality in production

↓

what you can expect from ML monitoring?

Performance visibility —> stakeholders:



ML Monitoring

Why is hard?

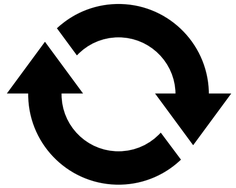
Model Quality in production

Established practice of tracking **software health** and **product performance**

- **how is ML model monitoring different?**
- **Is it possible to use the same methods?**

Silent failures.

Lack of ground truth



Complex data testing

Relative definition of quality

ML Monitoring

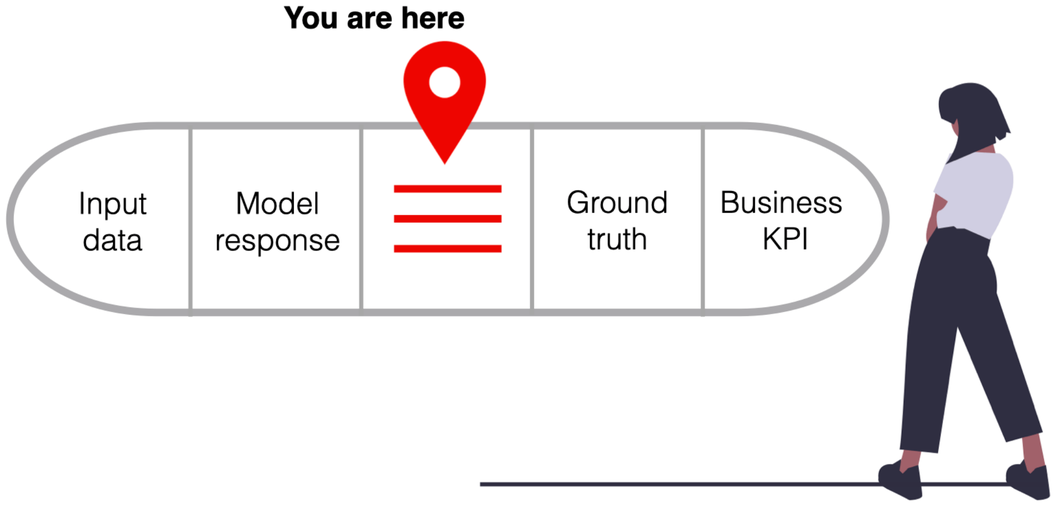
Why is hard?

Model Quality in production

↓

Established practice of tracking **software health** and **product performance**

Lack of ground truth



ML Monitoring

Why is hard?

Model Quality in production

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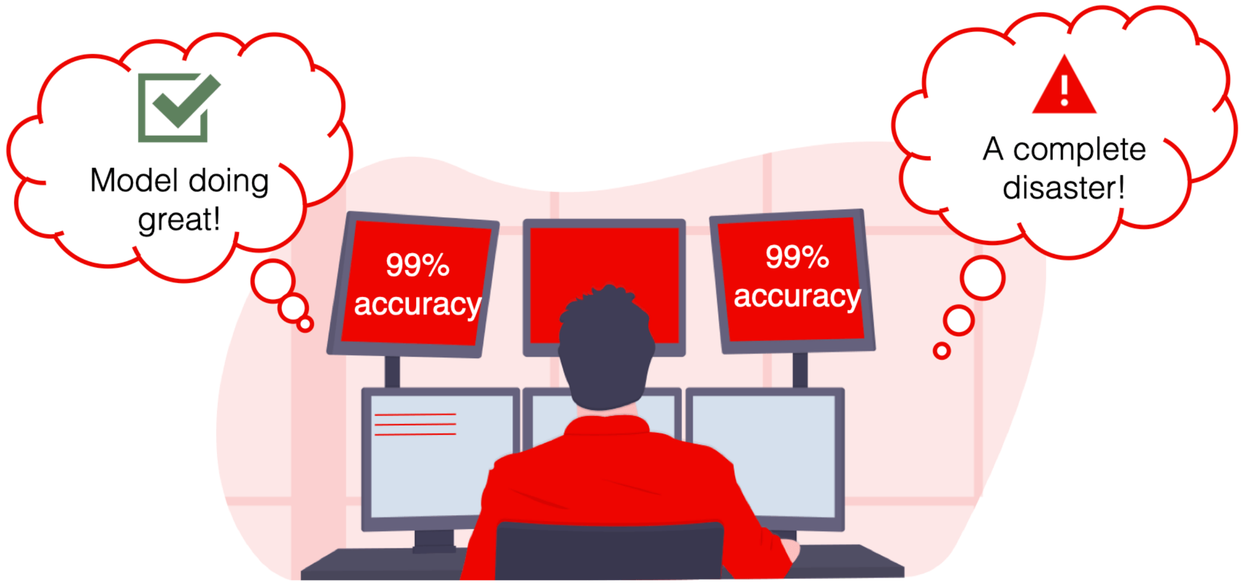
Established practice of tracking **software health** and **product performance**

Relative definition of quality



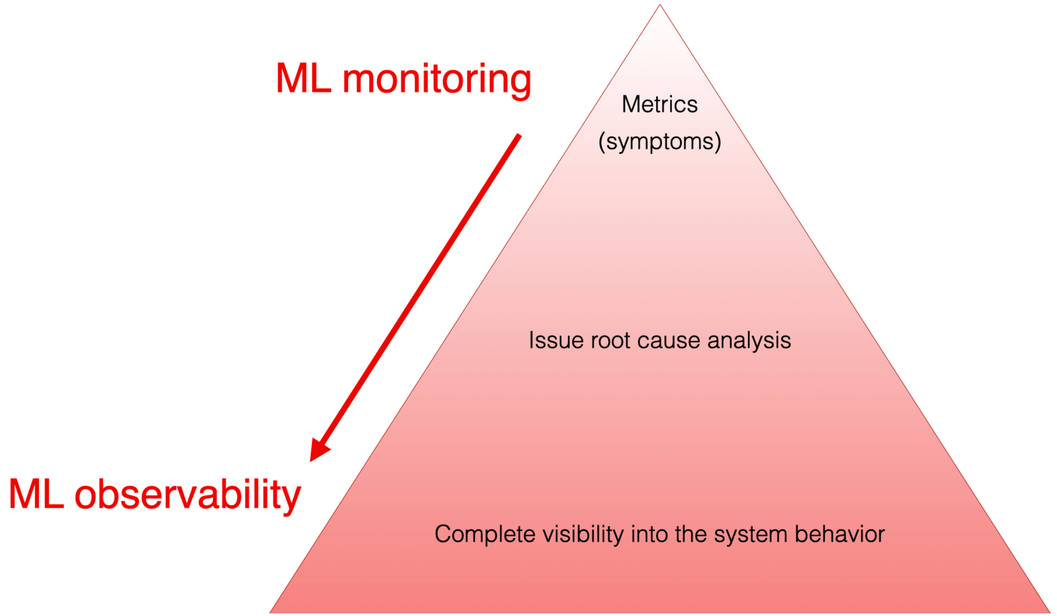
ML Monitoring

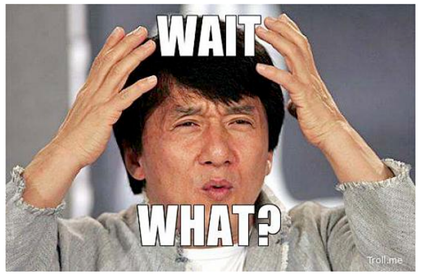
vs. others

Model Quality in production

Established practice of tracking **software health** and **product performance**

Model observability





- Unknown unknowns

- Why did it happen?
- Where exactly did it wrong?

ML Monitoring

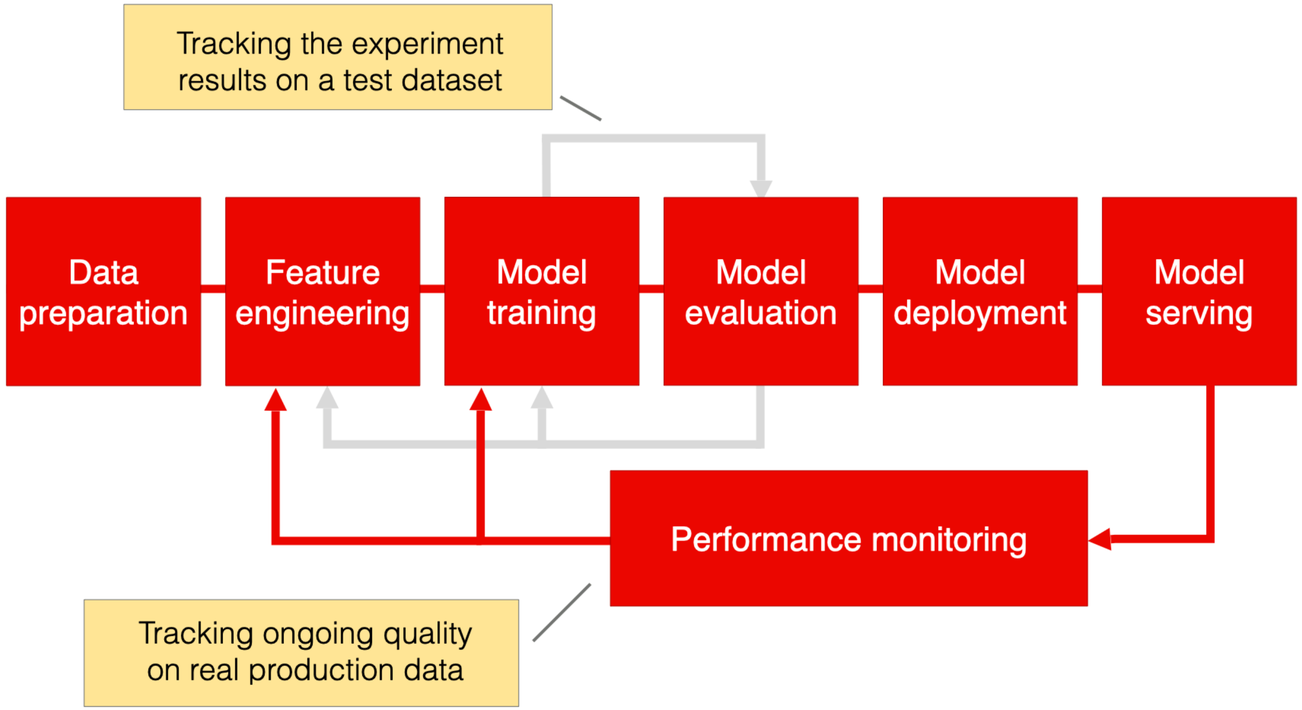
vs. others

Model Quality in production

↓

Established practice of tracking **software health** and **product performance**

Experiment tracking



ML Monitoring

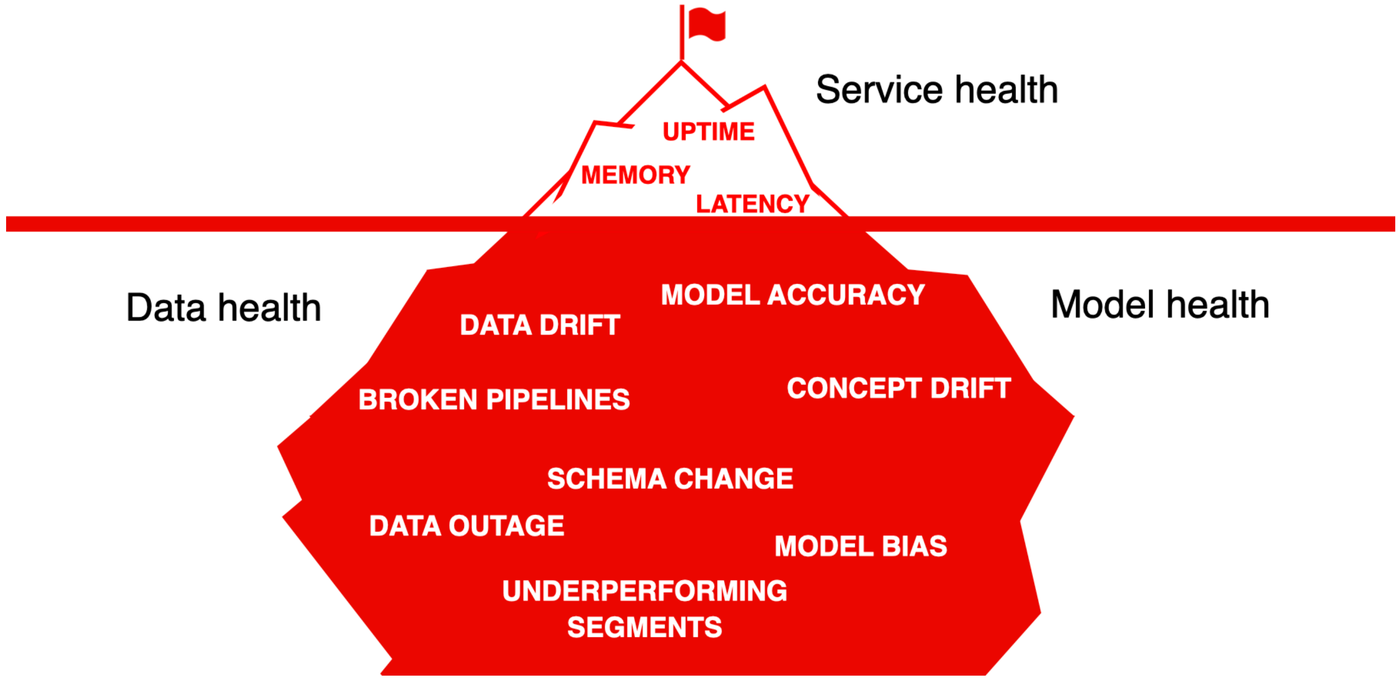
vs. others

Model Quality in production

↓

Established practice of tracking **software health** and **product performance**

Software monitoring



ML Monitoring

vs. others

Model Quality in production

Established practice of tracking **software health** and **product performance**

Data monitoring

Data monitoring tracks the **overall health of data** assets. Model monitoring tracks the **quality of individual ML models**, which may involve checking their input data quality.

Integrity —> Quality —> Security —> Overall health

ML Monitoring

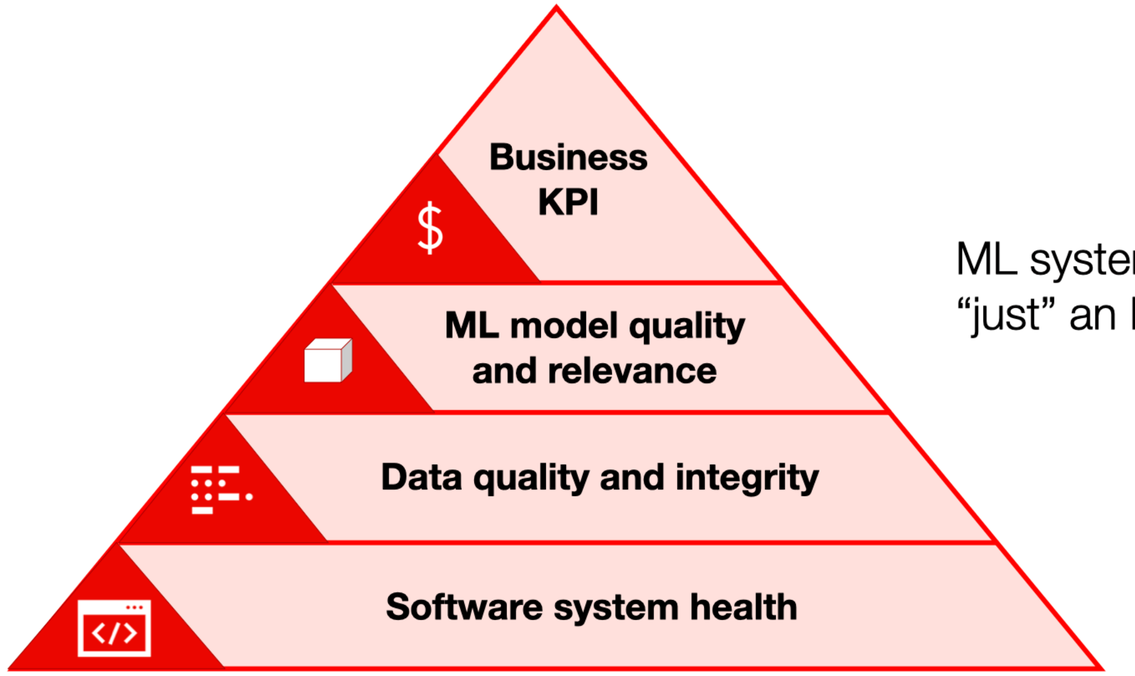
Metric overview

Model Quality in production

↓

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

Group of metrics:



ML system is more than “just” an ML model

ML Monitoring

Metric overview

Model Quality in production

↓

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

Business Key Performance Indicators (KPIs)

Great ML model quality

… but the product metrics are down

ML Monitoring

Model quality metrics

Model Quality in production

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

Direct model quality metrics

Classification

- accuracy
- Precision
- Recall
- F1-score.

Regression

- mean absolute error (MAE)
- mean squared error (MSE)
- mean absolute percentage error (MAPE)

Ranking and recommendations

- normalized discounted cumulative gain (NDCG)
- precision at K
- mean average precision (MAP)

ML Monitoring

Model quality metrics

Model Quality in production

↓

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

Data and prediction drift:

Data drift

↓

Input

Target Drift

↓

Output

ML Monitoring

Model quality metrics

Model Quality in production

↓

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

Data and prediction drift:

- **Summary statistics** → mean, median, variance
- **Statistical tests** → Kolmogorov-Smirnov, Chi-square, p-value
- **Distance-based methods** → Wasserstein distance or Jensen-Shannon
- **Rule-based checks** → “new categorical values appear”

ML Monitoring

Data quality metrics

Model Quality in production

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

makes predictions based on high-quality features:

Missing data

Monitoring feature statistics

Feature range and list constraints

Data schema checks

Outlier detection

ML Monitoring

Bias and fairness

Model Quality in production

↓

Monitoring **data and model quality** are typically the primary concern of **ML model monitoring**

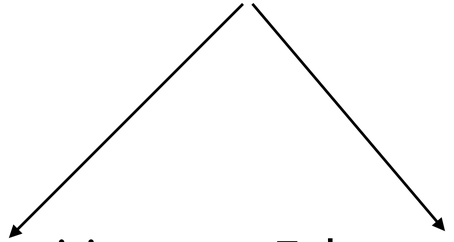
ML models don't discriminate against specific groups or individuals

Predictive parity.

↓

True positive rates

Equalized odds.



False positives False negatives

race, gender, or age.

ML Monitoring

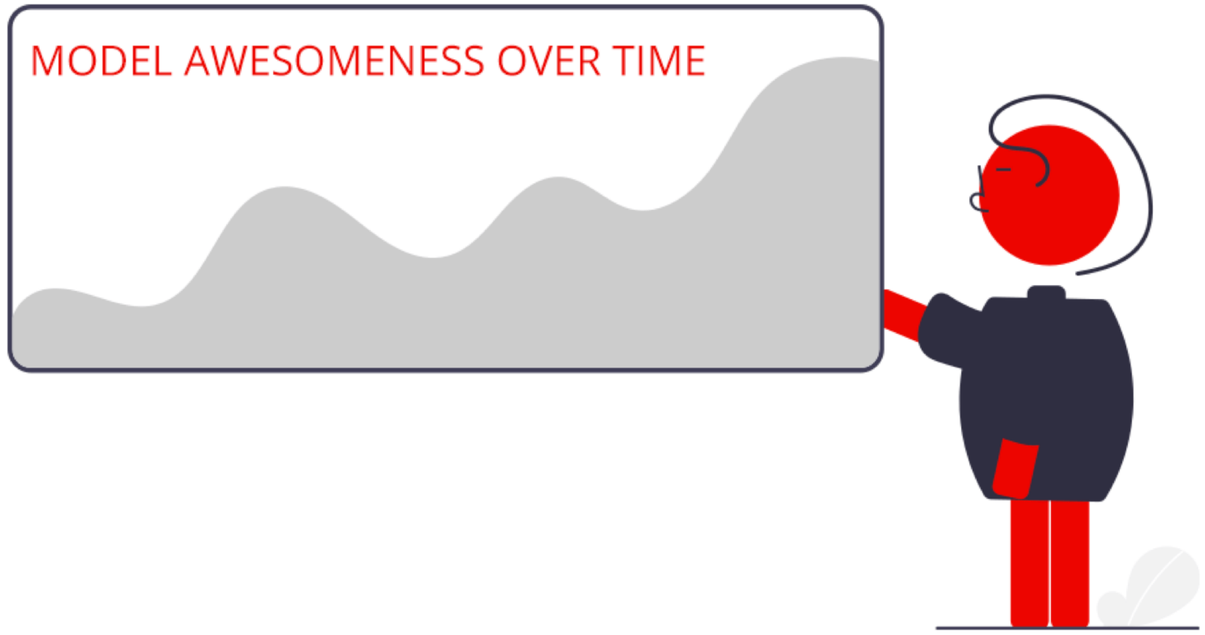
Model monitoring strategy

Model Quality in production

↓

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

What affects the monitoring strategy?



ML Monitoring

Model monitoring strategy

Model Quality in production

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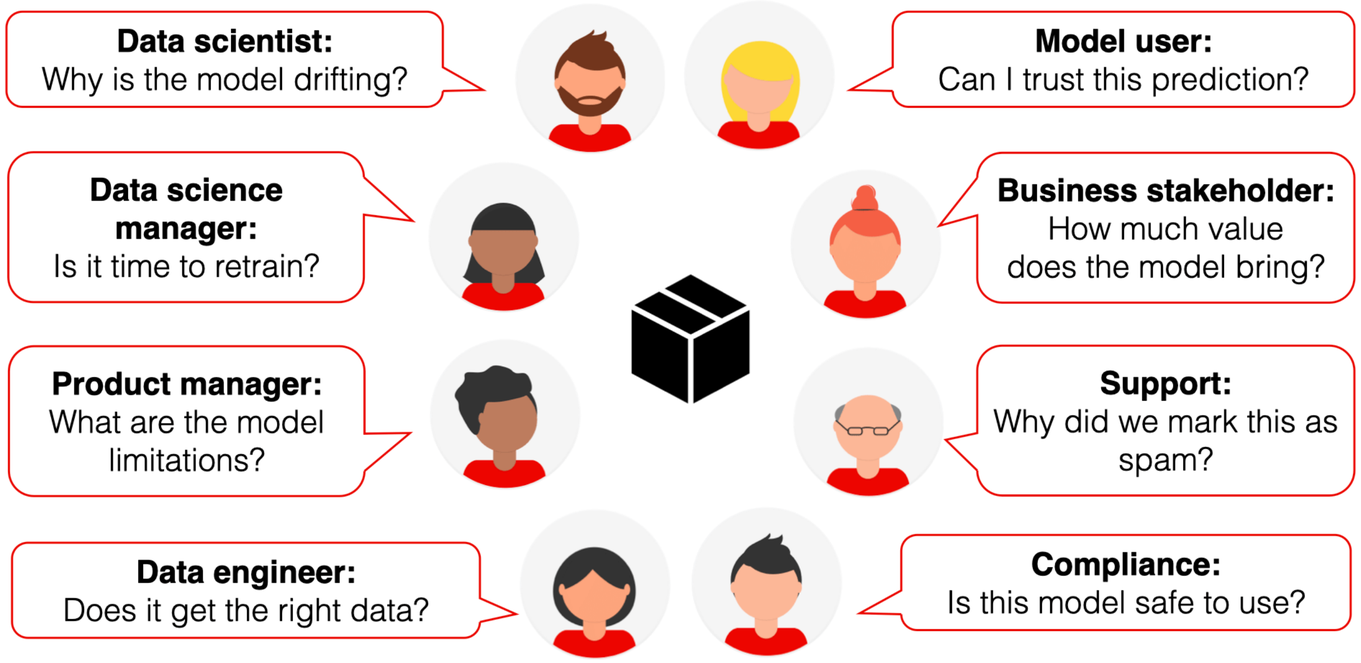
What affects the monitoring strategy? —> The goals of monitoring



ML Monitoring

Model monitoring strategy

Model Quality in production

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

What affects the monitoring strategy? —> The goals of monitoring

The data and model types	→	Monitoring metrics
Label availability	→	Feedback loops affectation
Model criticality and importance	→	financial decisions, medical diagnosis
Model deployment architecture	→	Batch jobs or real-time?
Speed of environmental changes	→	Rapidly shifting environments

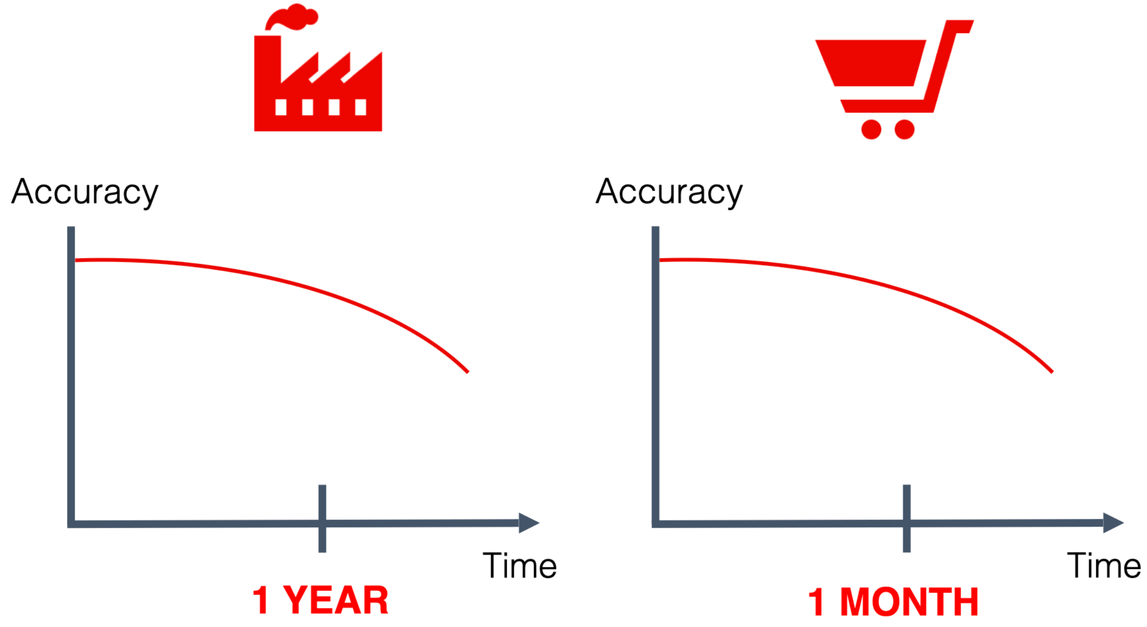
ML Monitoring

Model monitoring strategy

Model Quality in production

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Speed of environmental changes



ML Monitoring

Establishing the monitoring strategy

Model Quality in production

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Effective model monitoring strategy

Step 1. Define objectives

Step 2. Choose the visualization layer.

Step 3. Select relevant metrics.

Step 4. Choose the reference dataset.

Step 5. Define the monitoring architecture.

Step 6. Alerting design.

ML Monitoring

Establishing the monitoring strategy

Model Quality in production

↓

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Effective model monitoring strategy

Step 1. Define objectives

- Do you want to help data engineers detect missing data?
- Is it for data scientists to evaluate the changes in the key features?
- Is it to provide insight for product managers?
- Will you use the monitoring signals to trigger retraining?

ML Monitoring

Establishing the monitoring strategy

Model Quality in production

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Effective model monitoring strategy

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ML Monitoring

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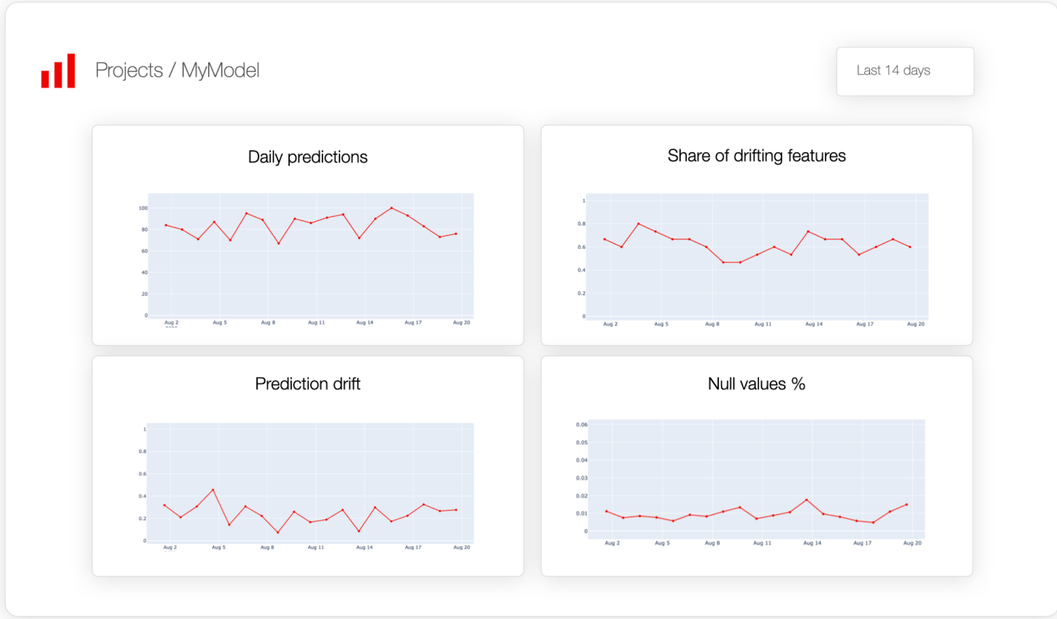

ML Monitoring

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ML Monitoring

Establishing the monitoring strategy

Model Quality in production

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Effective model monitoring strategy

Step 3. Select relevant metrics.

- The right metrics, tests, and statistics to track
- A good rule of thumb is to monitor direct model performance metrics first

Reference: Model Quality With Macro-average Metrics

Accuracy	Precision	Recall	F1	ROC AUC	LogLoss
0.993	0.992	0.993	0.993	1.0	0.052

Production: Model Quality With Macro-average Metrics

Accuracy	Precision	Recall	F1	ROC AUC	LogLoss
1.0	1.0	1.0	1.0	1.0	0.052

ML Monitoring

Establishing the monitoring strategy

Model Quality in production

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systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Effective model monitoring strategy

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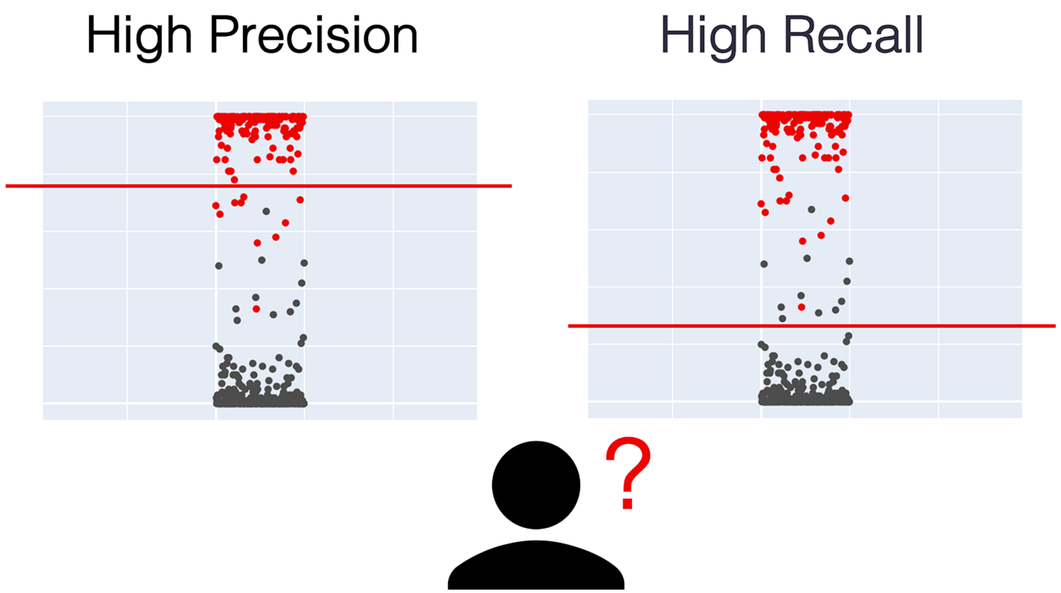

ML Monitoring

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Effective model monitoring strategy

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ML Monitoring

Establishing the monitoring strategy

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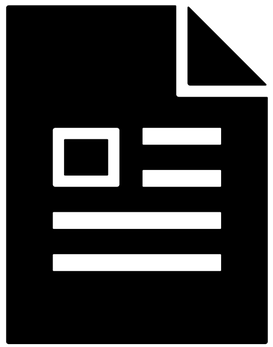
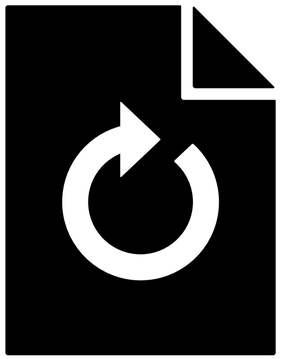
Effective model monitoring strategy

Step 4. Choose the reference dataset.



Reference dataset



Current dataset

ML Monitoring

Establishing the monitoring strategy

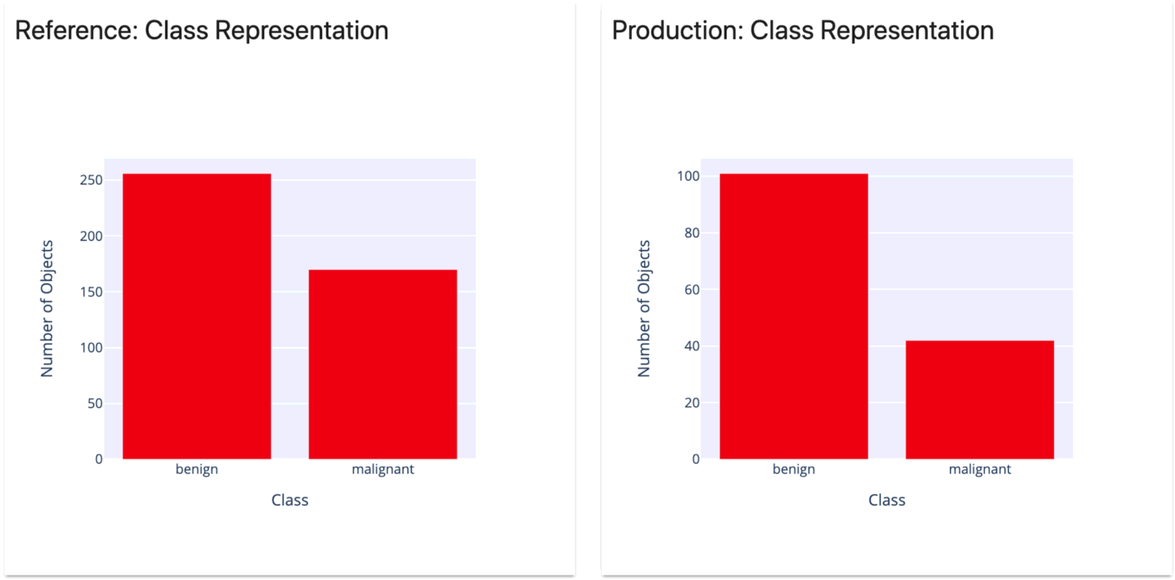
Model Quality in production

↓

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

Effective model monitoring strategy

Step 4. Choose the reference dataset.



ML Monitoring

Establishing the monitoring strategy

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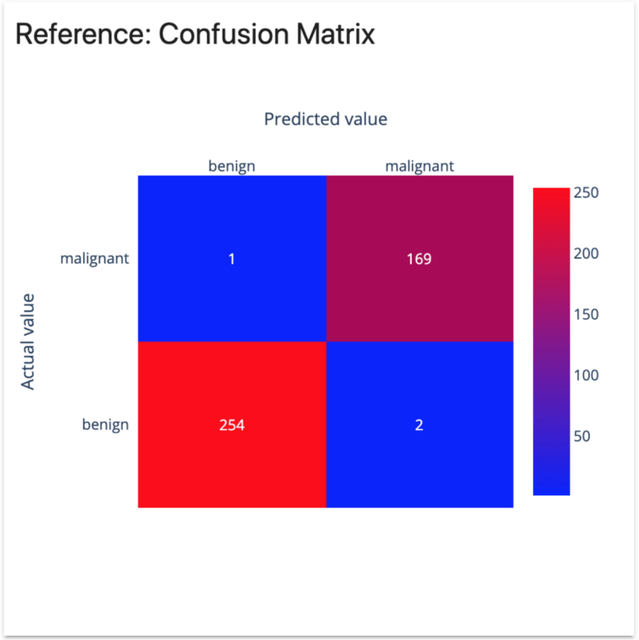

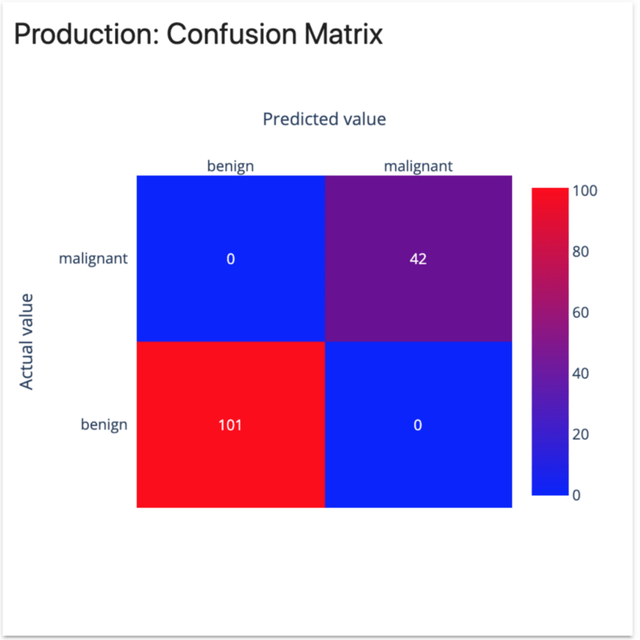

ML Monitoring

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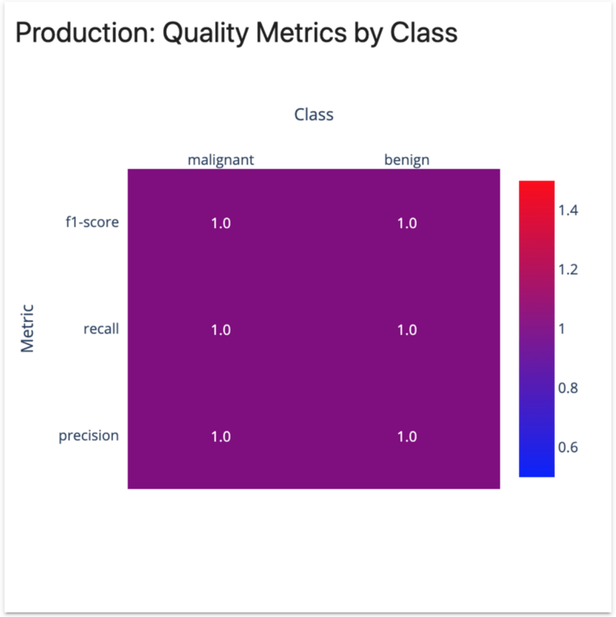
Effective model monitoring strategy

Step 4. Choose the reference dataset.



ML Monitoring

Establishing the monitoring strategy

Model Quality in production

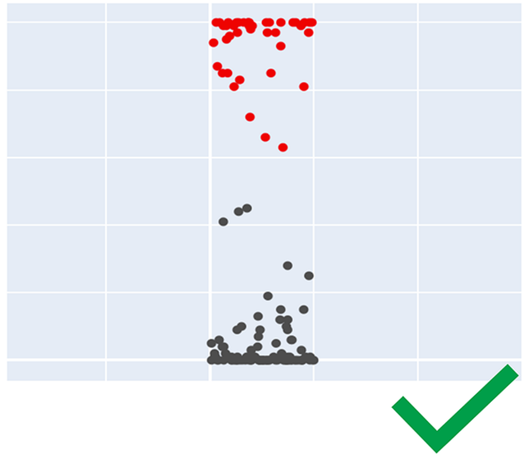
↓

systematic plan that outlines how you will **track, assess, and maintain** the **performance** of your ML models

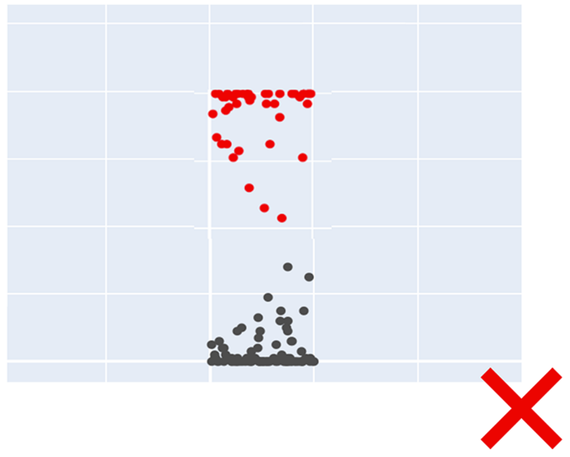
Effective model monitoring strategy

Step 4. Choose the reference dataset.

Well-calibrated probabilities



Model needs recalibration:



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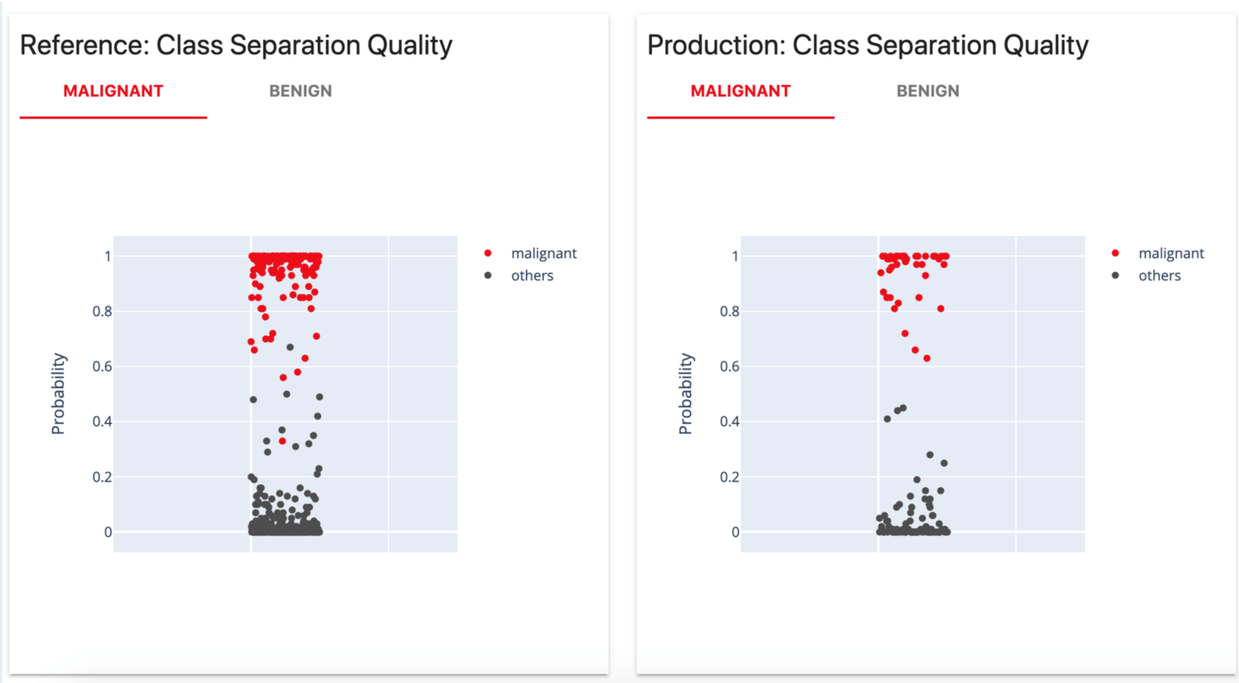

ML Monitoring

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Effective model monitoring strategy

Step 1. Define objectives ✓

Step 2. Choose the visualization layer. ✓

Step 3. Select relevant metrics. ✓

Step 4. Choose the reference dataset. ✓

Step 5. Define the monitoring architecture.

Step 6. Alerting design.

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Effective model monitoring strategy

Step 5. Define the monitoring architecture.

Batch jobs
OR
real-time (streaming) model monitoring

ML Monitoring

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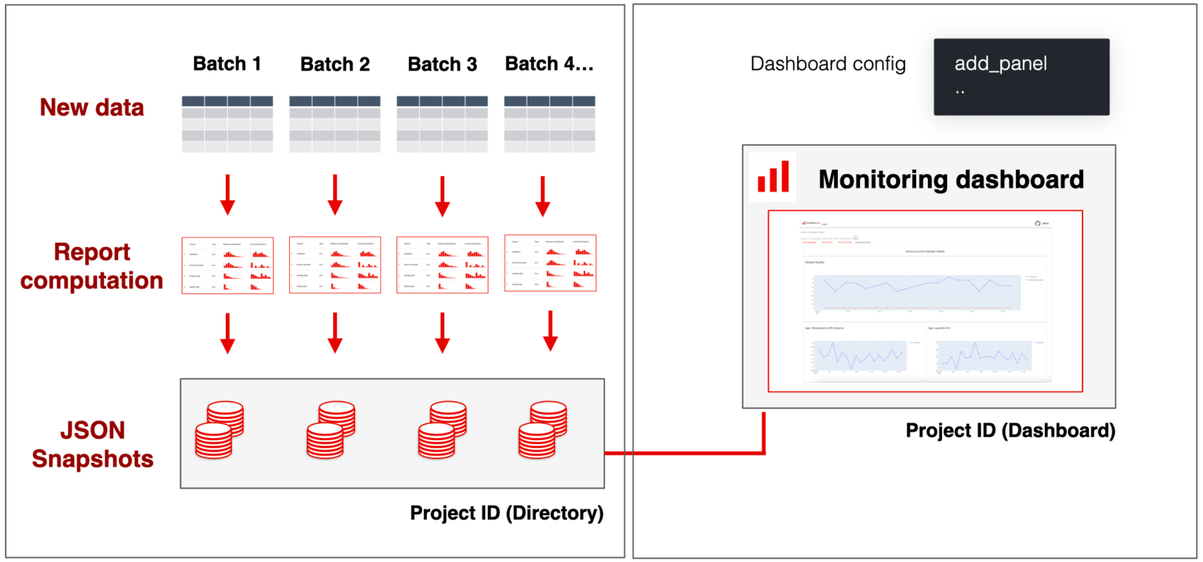
Effective model monitoring strategy

Step 5. Define the monitoring architecture.



Backend: Run data monitoring jobs and log snapshots

Frontend: Configure monitoring panels and run the UI

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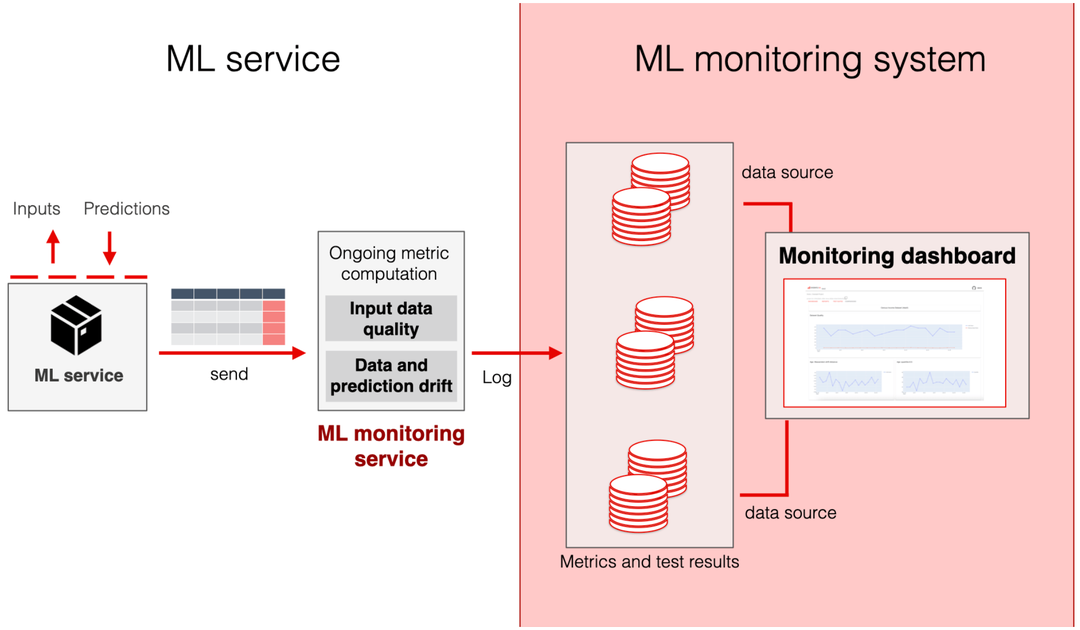
Effective model monitoring strategy

Step 5. Define the monitoring architecture.



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Effective model monitoring strategy

Step 6. Alerting design.

You can typically choose a small number of key performance metrics to alert on so that you know when the model behavior significantly deviates from expected values.

ML Monitoring

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Effective model monitoring strategy

Step 1. Define objectives ✓

Step 2. Choose the visualization layer. ✓

Step 3. Select relevant metrics. ✓

Step 4. Choose the reference dataset. ✓

Step 5. Define the monitoring architecture. ✓

Step 6. Alerting design. ✓

Machine Learning Model Deployment

Model Deployment

API stands for application programming interfaces.

API Design

An API is the tool that makes a website's data digestible for a computer.