

# Predicting sports actions using Deep Learning at scale

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- Italian edition -

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Deltatre  
Innovation  
Lab



# Agenda



- The Goal: Automated Video Indexing
- Initial Steps: Ideas & Experimentation
- Using ML models in production
- Unsolved challenges
- Future Development

# The Goal: Automated Video Indexing

**Text/Graphics OCR**

**Faces/Logos detection and recognition**

**Content auto-tagging**  
objects, people, places, actions, etc.

**Camera detection**

**Emotion analysis**

**Automatic Highlights**

**Smart sub-clipping**

...



# SPORT CONTENT INDEXING



# Exploring existing solutions: Microsoft Video Indexer

The screenshot shows the Microsoft Video Indexer web interface. At the top, there's a navigation bar with the title "AMS Video Indexer", a "Create new account" button, and an "Account" dropdown. A "Trial" badge is visible in the top right. Below the header, a main search area features the text "Search inside your videos" and the sub-instruction "Find the exact moments you're looking for by text, by person, or even by object." There are four main search sections: "Find topics" (with a search bar for "Text, keywords, or visual content"), "Find people" (with a search bar for "people and celebrities"), "Find animated characters" (with a search bar for "character name"), and "Find in" (with dropdowns for "Entire video" and "Find by owner"). Below these are "Find by language" dropdowns for "All". A link "Show less filters ^" is located below the search sections. At the bottom of the interface, there are tabs for "Library" (which is selected), "Projects", and "Sample videos". On the far right, there are "Upload" and "Refresh" buttons. The "Library" section displays four video thumbnails: "Football" (NFL game), "Soccer" (soccer match), "Formula1" (Formula 1 race), and "Golf" (golf course). Each thumbnail includes a small preview image and the category name below it, followed by a truncated creator name.

<https://azure.microsoft.com/services/media-services/video-indexer/>

# Microsoft Video Indexer

AMS Video Indexer

Create new account Account Trial Insights Timeline



Search

30 People



Aaron Donald American Football Player Appears in 1.78% of video Show biography Find on Bing

Play previous Play next

5 Topics

Sport / Nfl teams / Dallas cowboys New orleans saints National football league nfl Sports +1 more topics

Play previous Play next

Football.mp4

Private Created one year ago by Gianni Rosa Gallina

Embed Download Open in editor

More videos with similar people and keywords

24 Labels

# Microsoft Azure Cognitive Services



Vision



Speech



Language

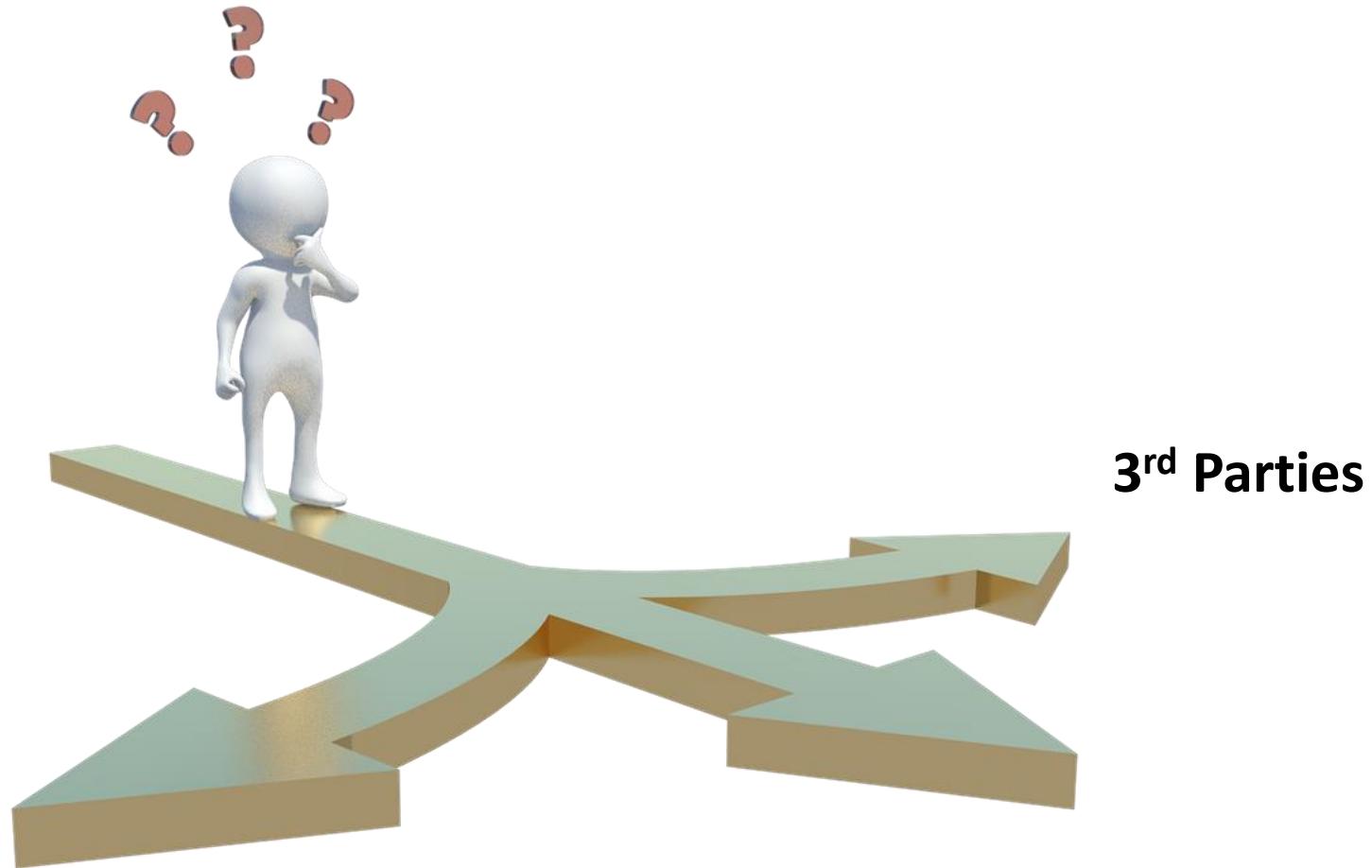


Decision



Web Search

<https://azure.microsoft.com/services/cognitive-services/>



**Custom Cognitive Services**

**Video Indexer Custom Models**

**Custom Video Indexer**

**3<sup>rd</sup> Parties**



The journey



# The Team



**Deltatre  
Innovation  
Lab**



 Microsoft  
Commercial  
Software  
Engineering



# TACKLING THE PROBLEM



**ACTION: SHOT ON GOAL**

# DATA PREPARATION, EXPLORATION, TOOLS



# Tools

Microsoft Azure DSVMs

Visual Studio 2019

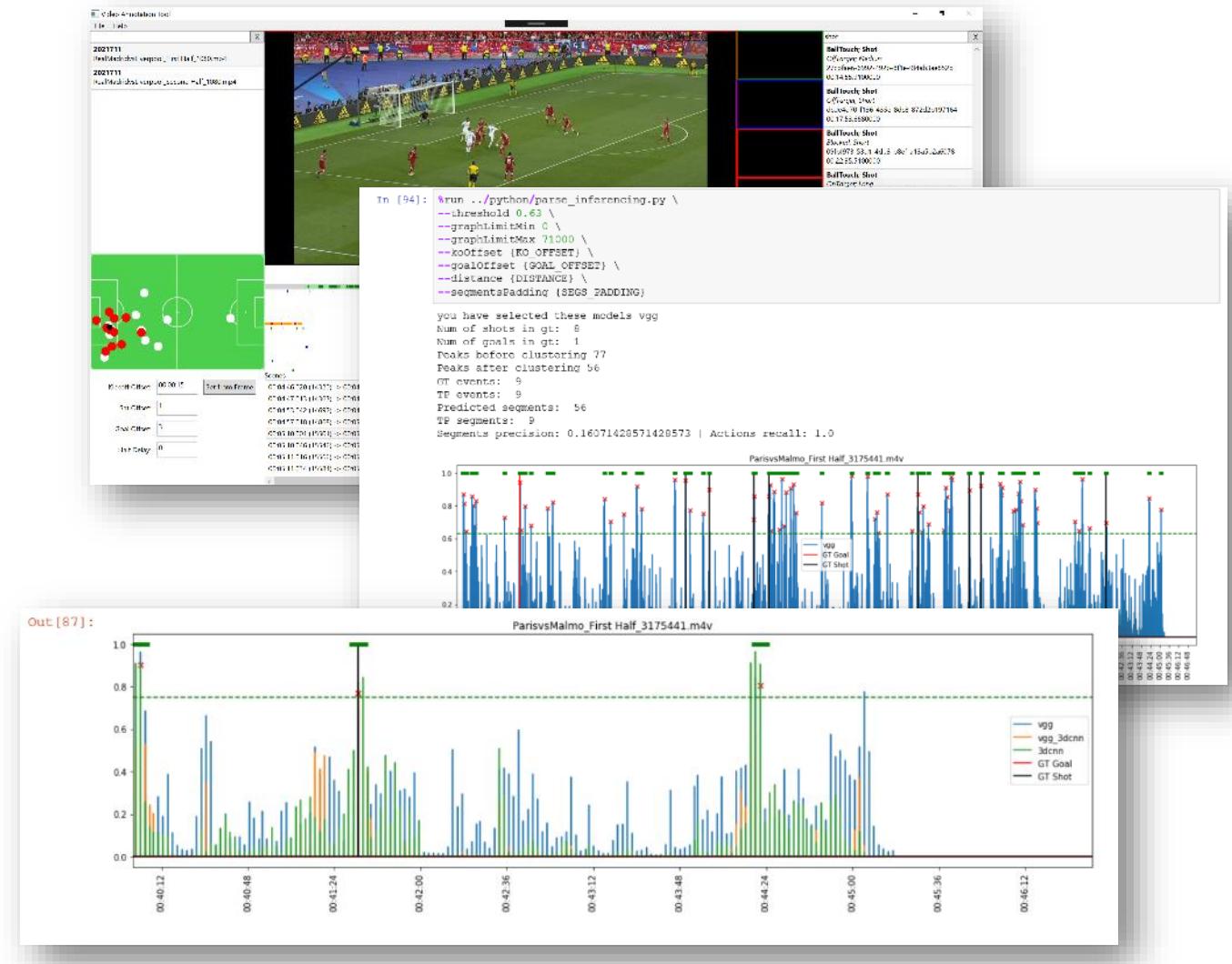
Visual Studio Code

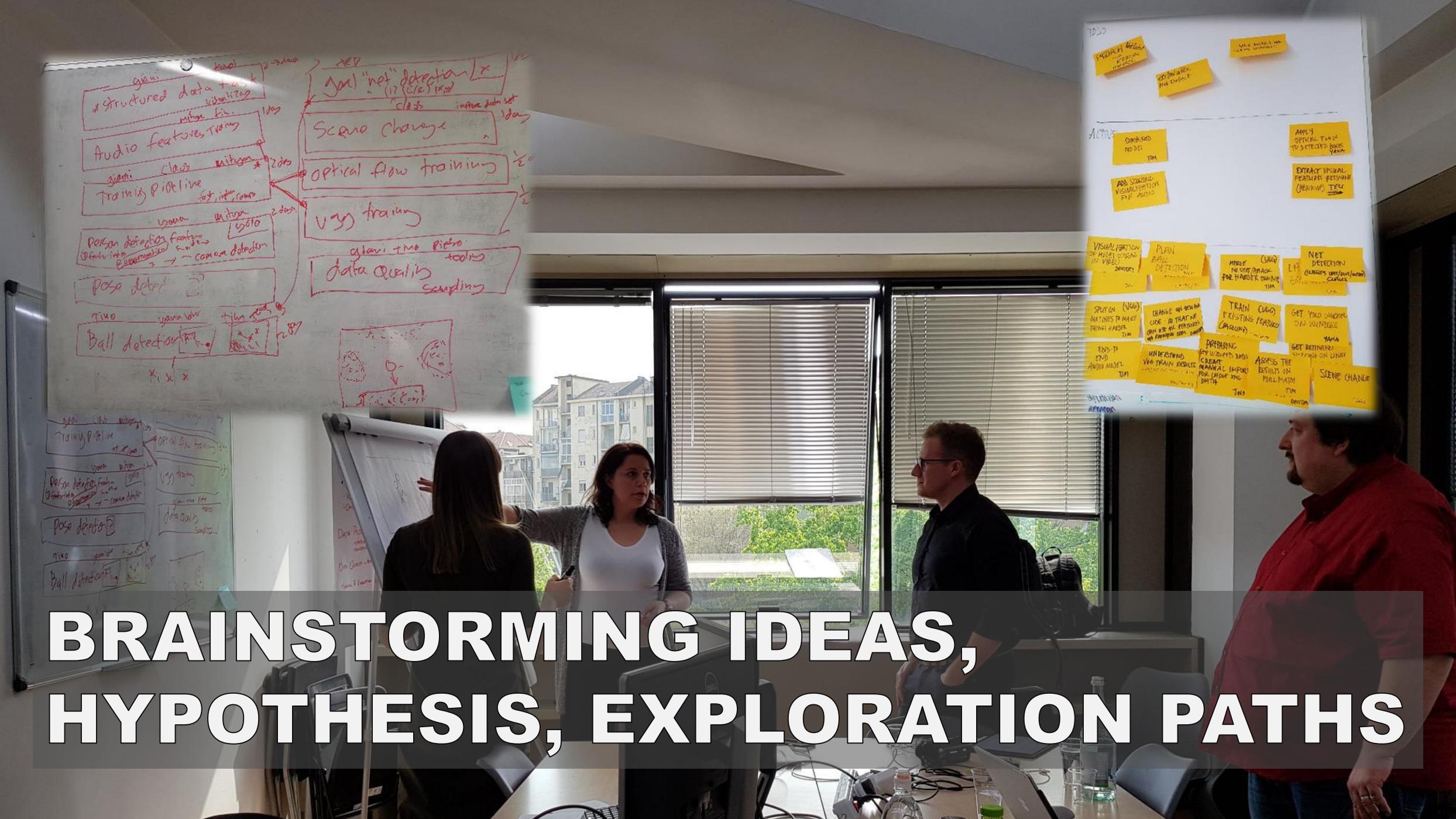
PyCharm

.NET ad-hoc tools

Python scripts

Jupyter notebooks





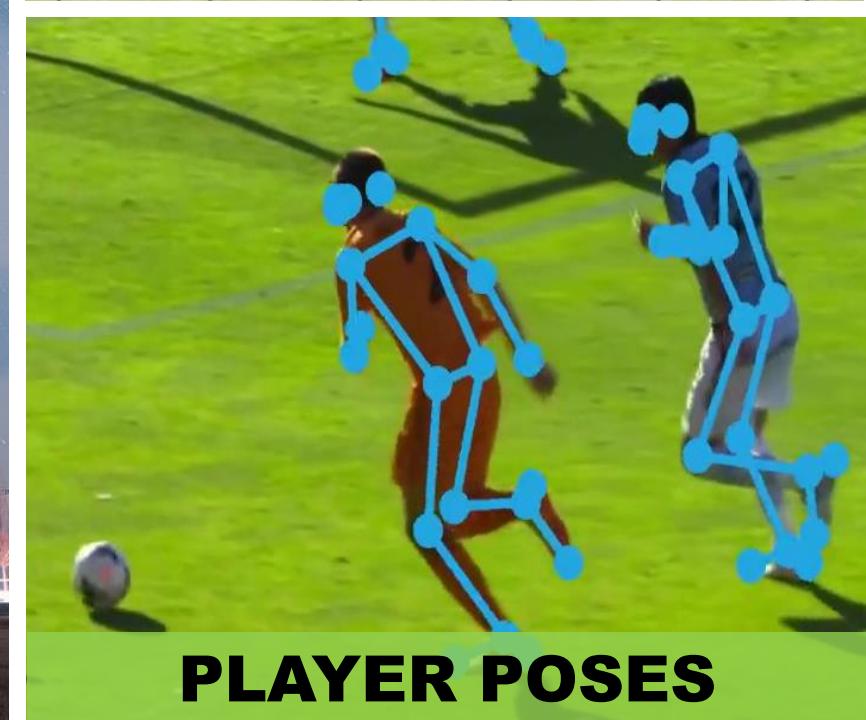
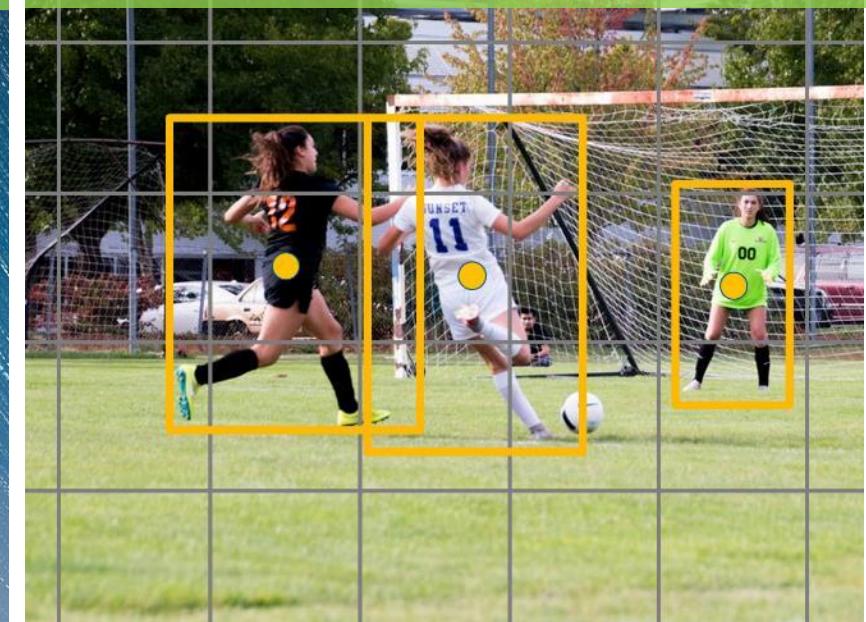
## AMBIENCE/CROWD



## SPEED/DIRECTION



## PLAYER DENSITY



## GOAL NET VISIBILITY



## PLAYER POSES

## SCENE CHANGES

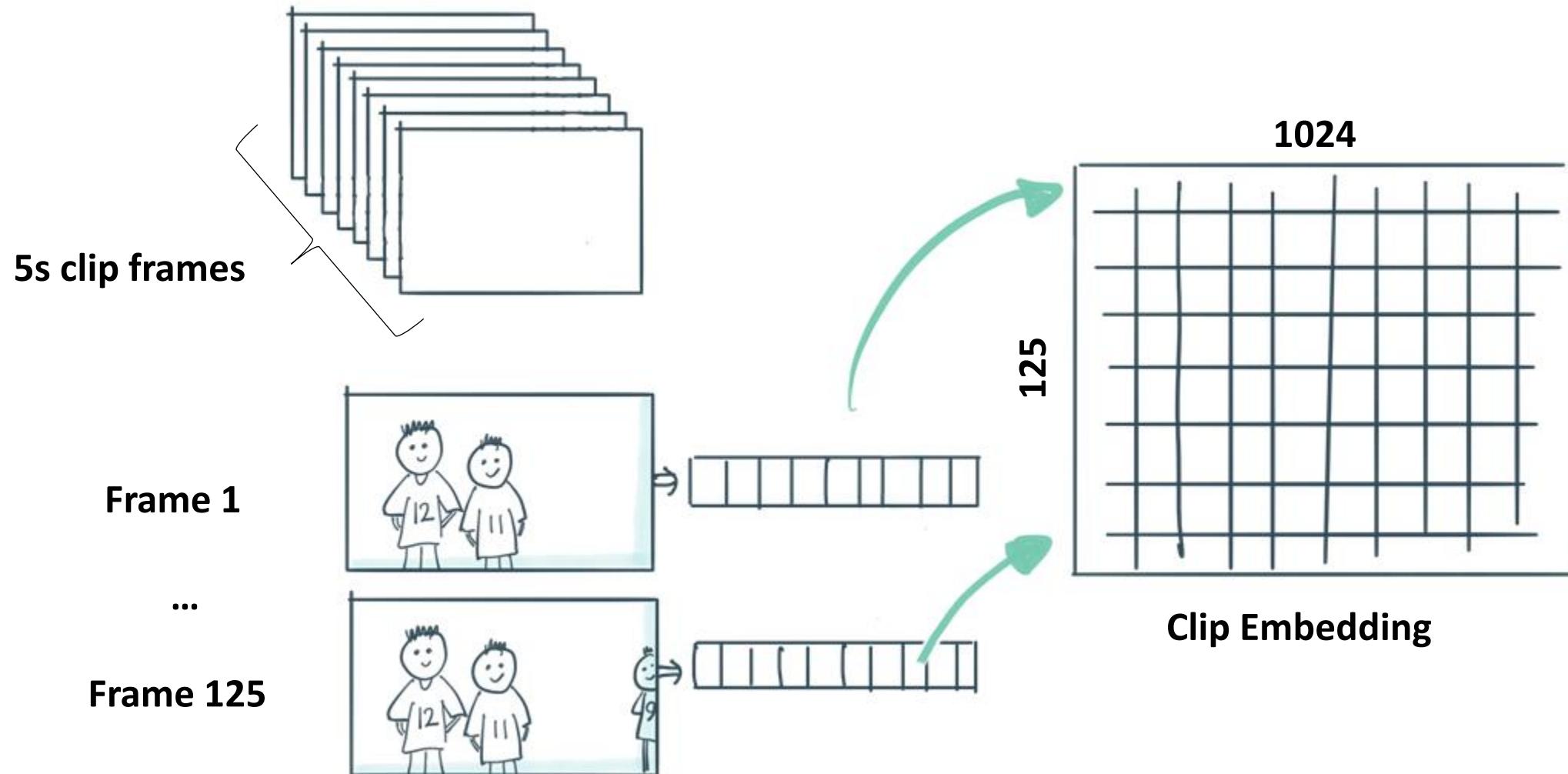


## GOAL NET VISIBILITY

## NEGATIVE SAMPLING



# Visual Features (VGG Embeddings)



Tensorflow+Keras, VGG16 pre-trained on ImageNet

**GRASS?**



**GOAL?**

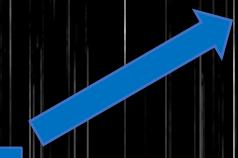


Image (1)

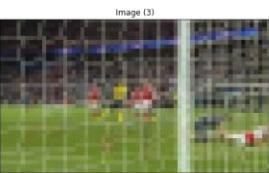
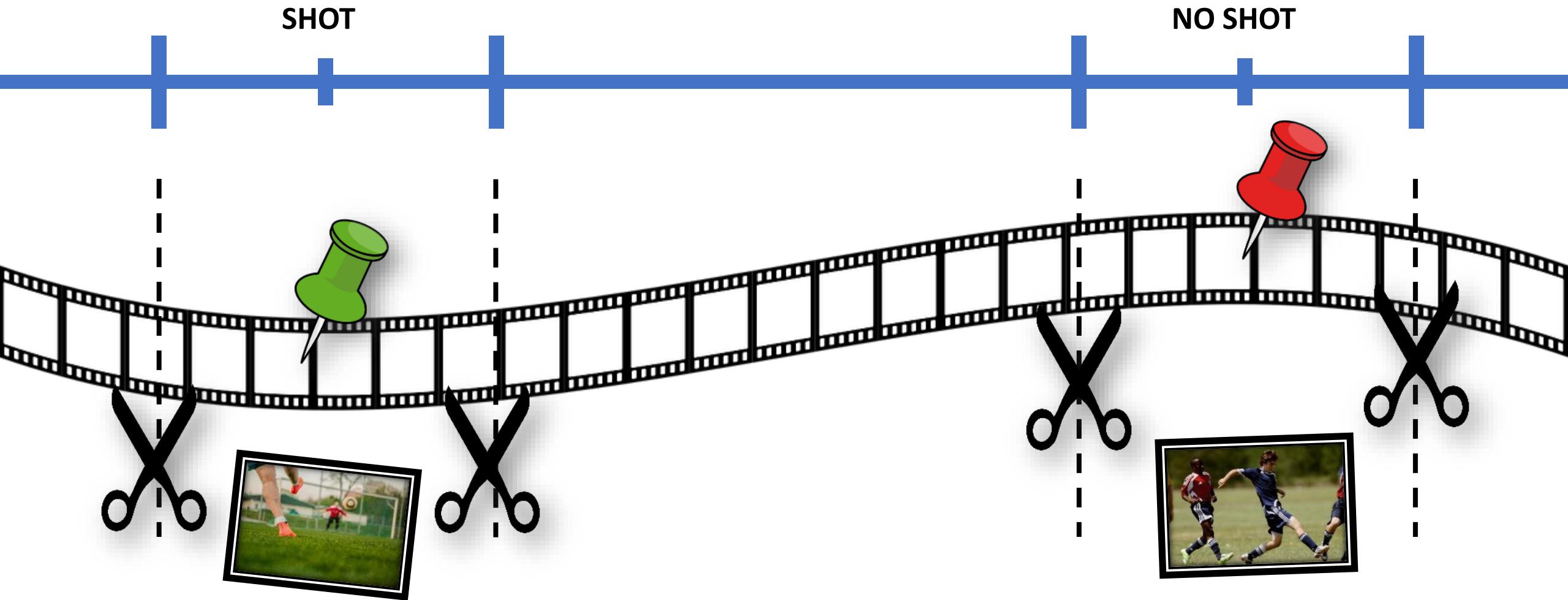


Image (4)

Image (5)

**SCENE CHANGE**





**BINARY CLASSIFIER:**  
**CLIPS WITH/WITHOUT AN ACTION**

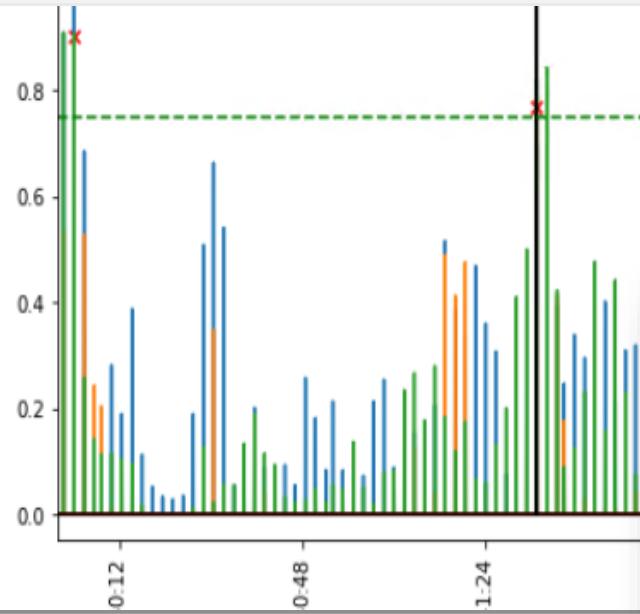


**LEFT/RIGHT GOAL NET CLASSIFIER**

# PoC Demo



- Scoring a full video, with multiple custom models
- Detecting “interesting” action clips, produce an EDL



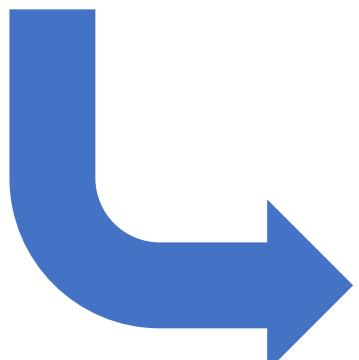
test\_ed\_2.edl

```

1 TITLE: test_sequence_id
2 FCM: NON-DROP FRAME
3
4 000001 BL V C 00:00:00:00 00:00:01:00 00:00:00:00 00:00:01:00
5
6 000002 AX V C 00:02:06:00 00:02:14:00 00:00:01:00 00:00:09:00
7 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v
8
9 000003 AX AA C 00:02:06:00 00:02:14:00 00:00:01:00 00:00:09:00
10 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v
11
12 000004 AX NONE C 00:02:06:00 00:02:14:00 00:00:01:00 00:00:09:00
13 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v
14 AUD 3 4
15
16 000005 BL V C 00:00:00:00 00:00:01:00 00:00:09:00 00:00:10:00
17
18 000006 AX V C 00:03:35:00 00:03:41:00 00:00:10:00 00:00:16:00
19 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v
20
21 000007 AX AA C 00:03:35:00 00:03:41:00 00:00:10:00 00:00:16:00
22 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v
23
24 000008 AX NONE C 00:03:35:00 00:03:41:00 00:00:10:00 00:00:16:00
25 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v
26 AUD 3 4
27
28 000009 BL V C 00:00:00:00 00:00:01:00 00:00:16:00 00:00:17:00
29
30 000010 AX V C 00:05:35:00 00:05:41:00 00:00:17:00 00:00:23:00
31 * FROM CLIP NAME: CelticvsParis_First Half_3707723.m4v

```

Goal  
Shot



# Going to production



- MLOps & available frameworks
- From experimentation to implementation
  - Applying MLOps to the Machine Learning Workflow
- Challenges
  - Engineering (Unit test, logging, monitoring)
  - Dataset size (videos, TBs)
  - Overall performance
- Requirements
  - Language preference (C# vs Python)
  - Cloud vs On-prem vs Hybrid
- Pain Points

# MLOps → DevOps on Machine Learning components

## **Model reproducibility & versioning**

Track, snapshot & manage assets used to create the model  
Enable collaboration and sharing of ML pipelines

## **Model auditability & explainability**

Maintain asset integrity & persist access control logs  
Certify model behavior meets regulatory & adversarial standards

## **Model packaging & validation**

Support model portability across a variety of platforms  
Certify model performance meets functional and latency requirements

## **Model deployment & monitoring**

Release models with confidence  
Monitor & know when to retrain by analyzing signals such as data drift

# MLOps Frameworks

<https://mlflow.org/>

MLFlow: an Open Source Machine Learning Platform

<https://azure.microsoft.com/services/machine-learning/>

Azure Machine Learning

<https://www.kubeflow.org>

Management and deployment of ML workflows on Kubernetes

<https://dvc.org/>

Git + DVC - Model/dataset tracking and pipeline definition/execution

# Azure Machine Learning



## ML for all skills

Productivity for all skill levels, with code-first and drag-and-drop designer, and automated machine learning.



## End-to-end MLOps

Robust MLOps capabilities that integrate with existing DevOps processes and help manage the complete ML lifecycle.



## State-of-the-art Responsible ML

Responsible ML capabilities – understand models with interpretability and fairness, protect data with differential privacy and confidential computing, and control the ML lifecycle with audit trials and datasheets.



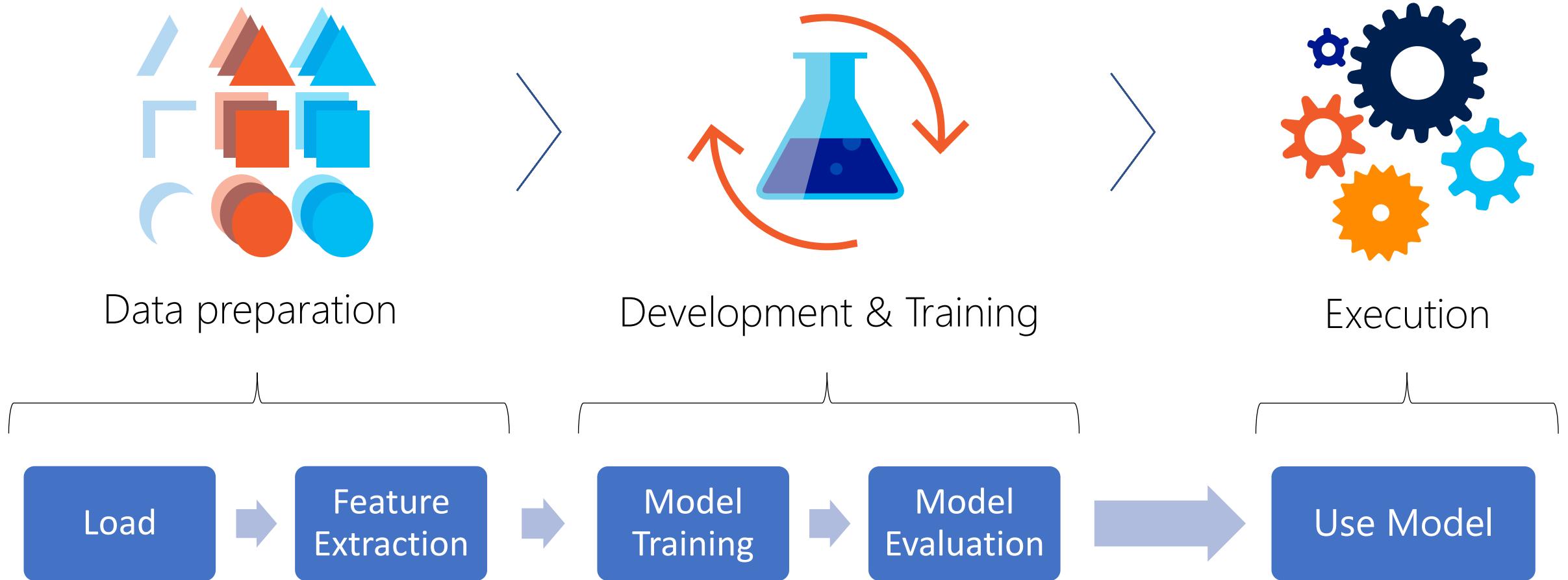
## Open and Interoperable

Best-in-class support for open-source frameworks and languages including MLflow, Kubeflow, ONNX, PyTorch, TensorFlow, Python, and R.

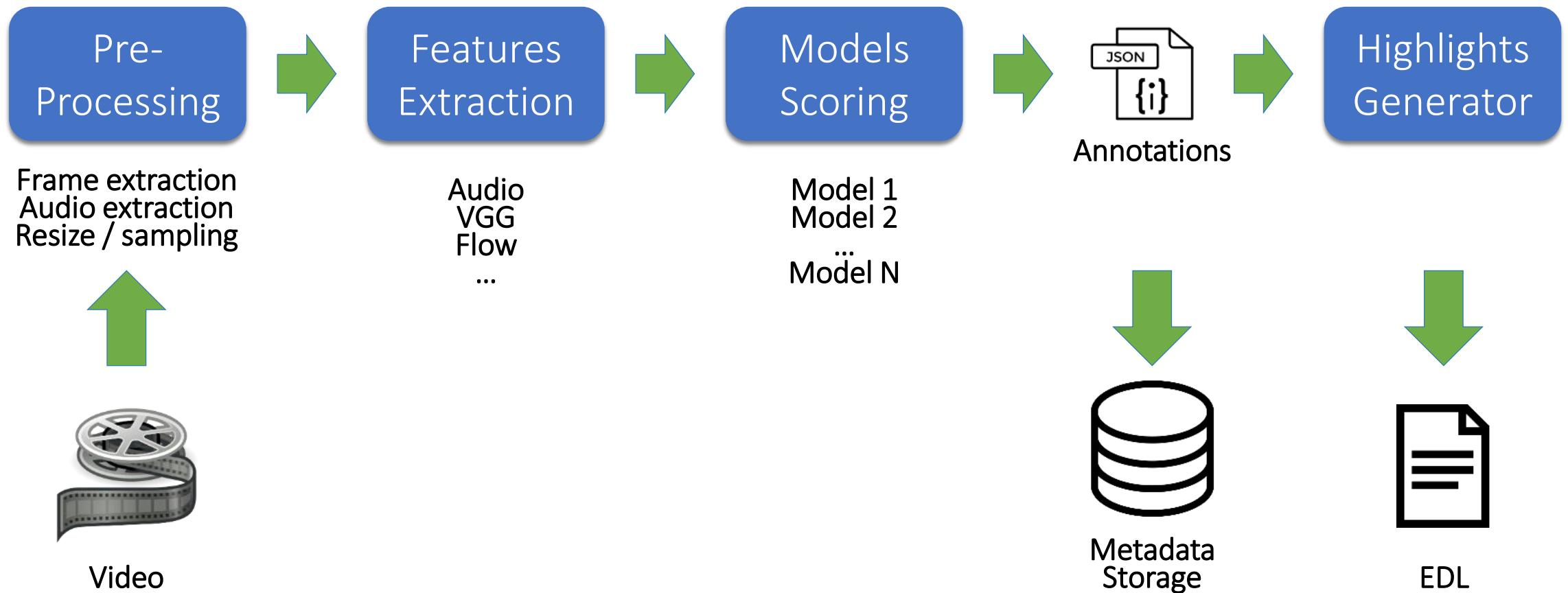
# Azure Machine Learning + Azure DevOps

The image shows two overlapping screenshots of Microsoft Azure services. The top screenshot is the Azure Machine Learning studio, showing the 'emptypipeline-ws' workspace. It features a sidebar with options like 'New', 'Home', 'Notebooks', 'Automated ML', 'Designer', 'Datasets', 'Experiments', 'Pipelines', 'Models', 'Endpoints', 'Compute', 'Datastores', and 'Data Labeling'. The main area has sections for 'Create new', 'Notebooks', 'Automated ML', and 'Designer', each with a 'Start now' button. Below this is a 'My recent resources' section titled 'Runs', listing several runs with details like Run ID, Experiment, Status, Submitted time, Submitted by, and Run type. The bottom screenshot is the Azure DevOps Boards interface, specifically the 'MLOps-for-Sports' board for the 'MLOps-for-Sports Team'. It displays a Kanban board with columns for 'New', 'Active', 'Resolved', and 'Closed'. Work items are represented as cards with titles like '443 Implement a simplified control API (v1)', '672 optimize the way our AML pipelines handles blob storage', '493 Refine ML Pipelines', etc. Each card includes a 'State' indicator (e.g., New, Active, Resolved) and a progress bar.

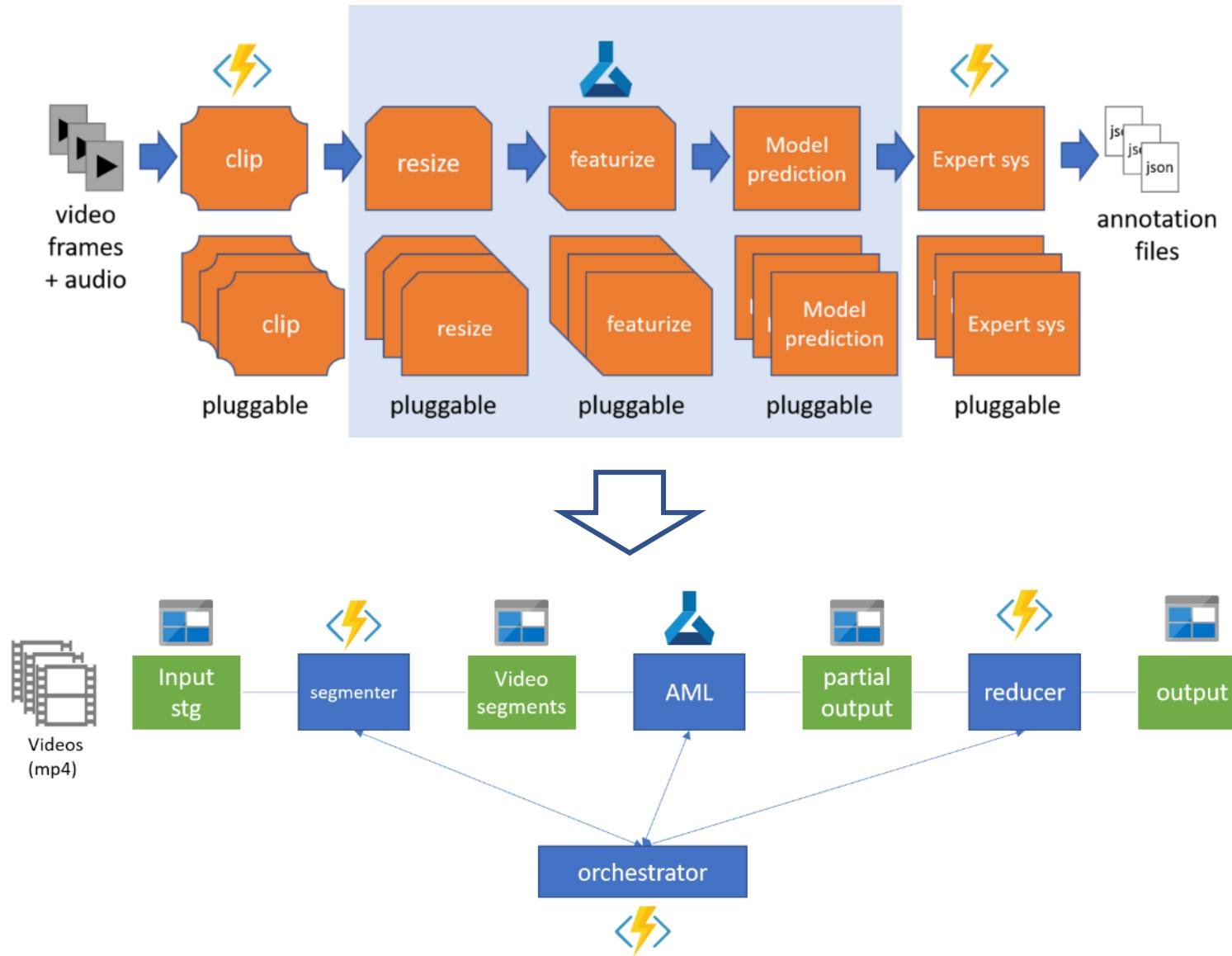
# Applying MLOps to the Machine Learning Workflow



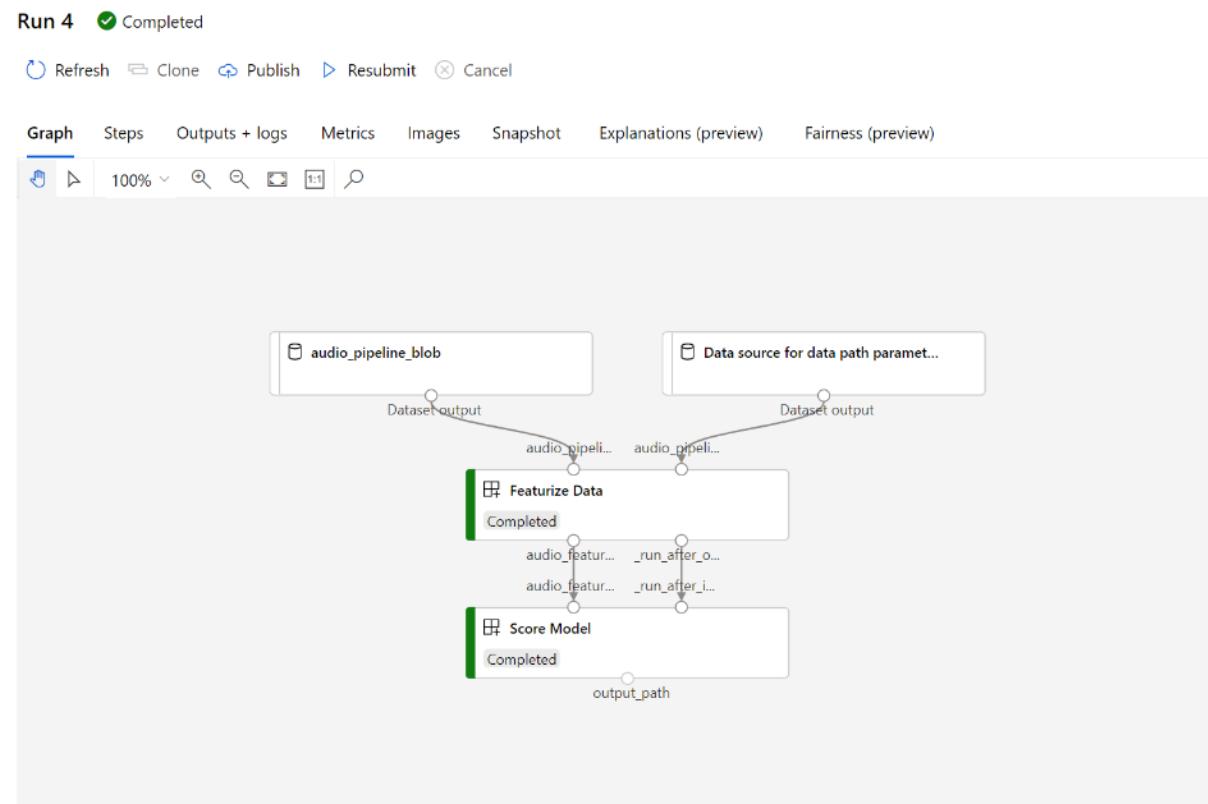
# Inference Pipeline



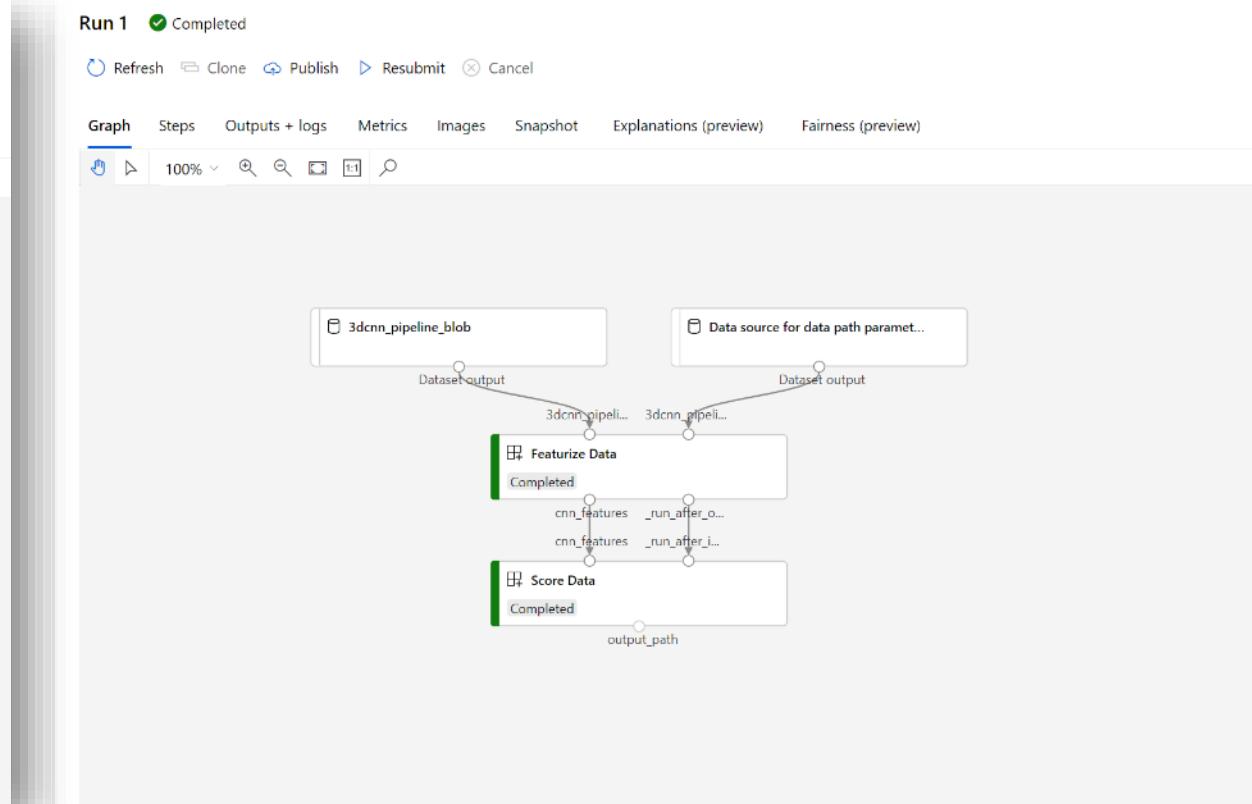
# From conceptual design to implementation



# The resulting Azure ML pipelines



## Audio Model



## 3DCNN Model

# Challenges: Dev Environment

- Mixed Environments
  - Python + .NET
- Team collaboration and HW requirements
  - VSCode DevContainers  
<https://github.com/polatengin/project-standards/blob/master/DevContainers.md>

# Challenges: production grade code

- Making Python Notebooks become production code
- How to (unit) test Machine Learning models and pipelines
- From C# to Python – by **Tess Ferrandez**  
<https://www.youtube.com/watch?v=LDVVvwoVtLY>



# Challenges: Dataset size



- Dataset size and management
  - 750 videos, 45' per video  $\sim 800\text{MB} \Rightarrow$  video set  $\sim 600\text{GB}$
  - Additional metadata per video is 10MB  $\Rightarrow \sim 8\text{GB}$
  - Extracted frames and audio per video is  $\sim 2\text{GB} \Rightarrow \sim 1.5\text{ TB}$
  - Overall Data size  $\sim 2\text{TB+}$
- Azure Functions
  - Great scalability (parallel execution of video segments extraction)
  - Support REST calls
  - Durable Functions patterns  
<https://docs.microsoft.com/azure/azure-functions/durable/durable-functions-overview?#application-patterns>

# Unsolved challenges



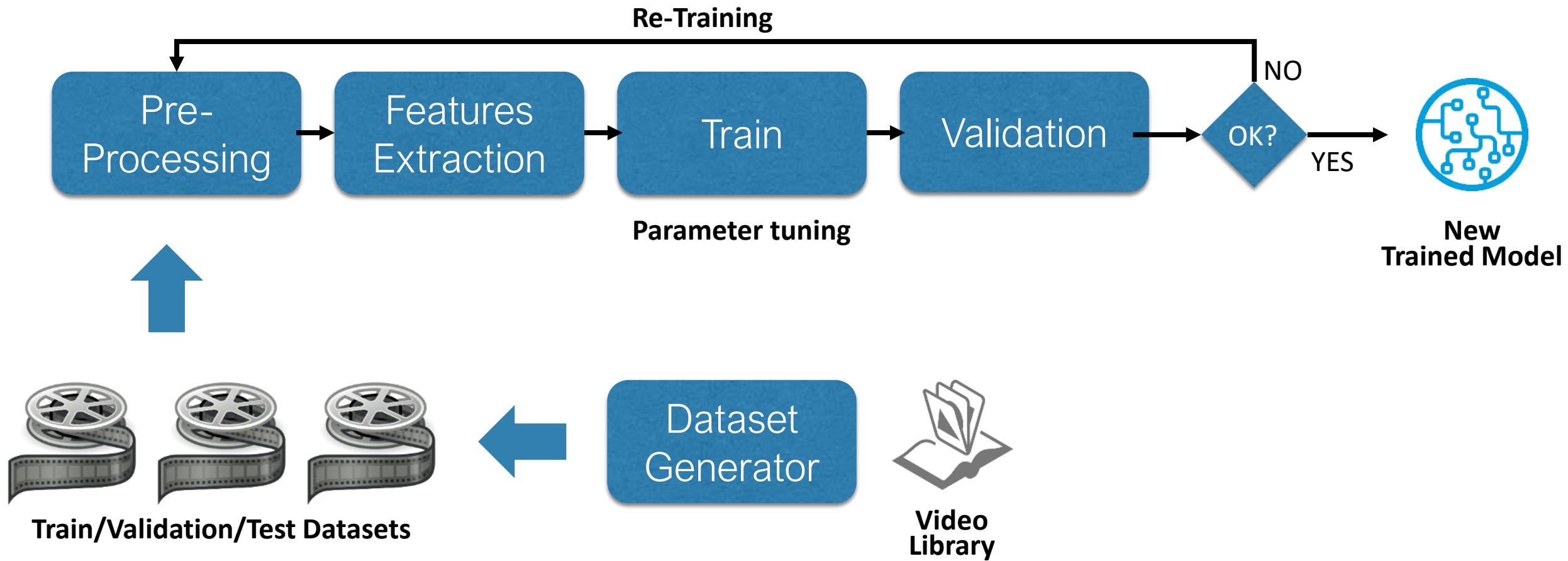
- Compute choice for inferencing
  - Azure ML vs AKS
- Hybrid deployment for inferencing
  - On-Prem + Cloud
    - Azure Functions in Kubernetes (KEDA)  
<https://docs.microsoft.com/azure/azure-functions/functions-kubernetes-keda>
    - AKS + Azure Arc for Kubernetes (Preview)  
<https://docs.microsoft.com/azure/azure-arc/kubernetes/overview>

# Next Steps

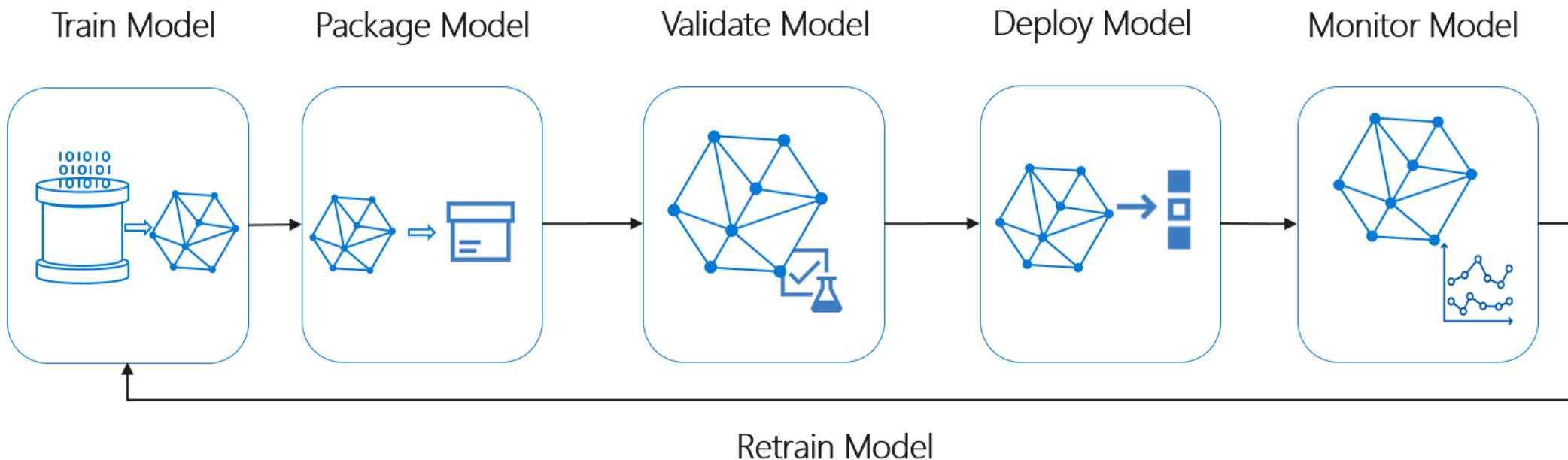


- Training and Dataset Pipelines
- End-to-end MLops

# Training and Dataset Pipelines

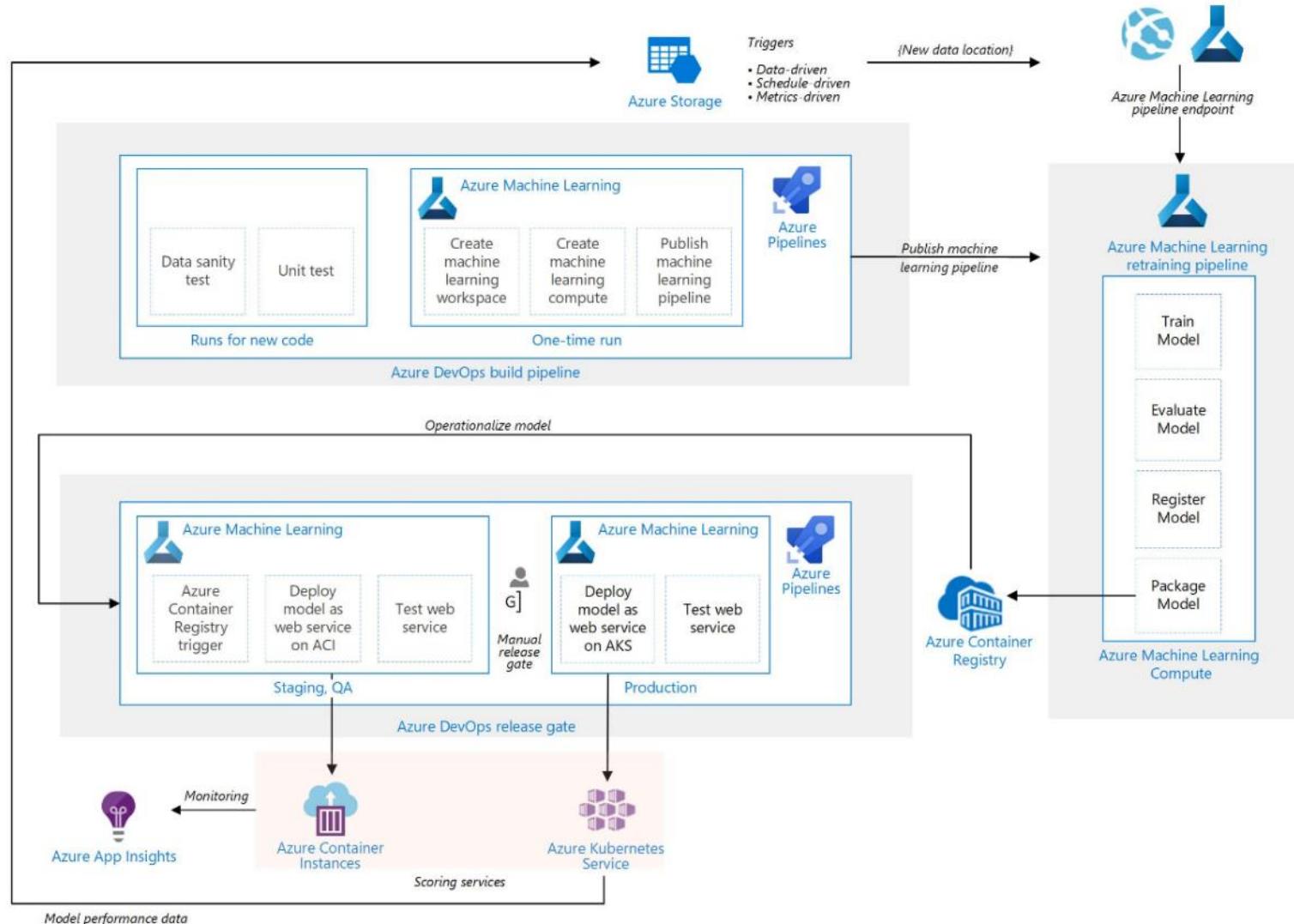


# End-to-End Mlops



<https://github.com/microsoft/MLOps>

# End-to-End Mlops



# GitHub Repository

<https://github.com/deltatrelabs/deltatre-microsoft-ai-soccer-action-recognition>

Exploration Notebooks

PoC Python Scripts

Pre-trained Models



# Thank You!

ευχαριστώ Salamat Po متشكرم شكرًا Grazie

благодаря ありがとうございます Kiitos Teşekkürler 谢谢

ឧបបញ្ជូរ ឥឡូវ Obrigado شكريه Terima Kasih Dziękuję

Hvala Köszönöm Tak Dank u wel ДЯКУЮ Tack

Mulțumesc спасибо Danke Cám ơn Gracias

多謝晒 Ďakujem הודה දෙකුඩී Děkuji 감사합니다

# References (1/3)

## Tools / IDE

<https://www.python.org/>

<https://jupyter.org/>

<https://code.visualstudio.com/>

<https://visualstudio.microsoft.com/vs/>

<https://www.jetbrains.com/pycharm/>

## ML/Deep Learning Frameworks

<https://www.tensorflow.org/>

<https://keras.io/>

<https://pytorch.org/>

<https://fast.ai/>

# References (2/3)

## Pre-processing libraries, helpers and models

<https://github.com/fizyr/keras-retinanet>

<https://github.com/Breakthrough/PySceneDetect/>

<https://github.com/tyiannak/pyAudioAnalysis>

<https://pypi.org/project/mPyPI/>

## MLOps

<https://mlflow.org/>

<https://www.kubeflow.org>

<https://dvc.org/>

<https://github.com/microsoft/MLOps>

<https://docs.microsoft.com/azure/machine-learning/team-data-science-process>

<https://docs.microsoft.com/azure/architecture/reference-architectures/#ai-and-machine-learning>

# References (3/3)

## Python

<https://github.com/polatengin/project-standards/blob/master/DevContainers.md>  
<https://www.youtube.com/watch?v=LDVVvwoVtLY>

## VSCode DevContainers

<https://github.com/polatengin/project-standards/blob/master/DevContainers.md>  
<https://code.visualstudio.com/docs/remote/containers>

## Azure Functions

<https://docs.microsoft.com/azure/azure-functions/durable/>  
<https://docs.microsoft.com/azure/azure-functions/durable/durable-functions-overview>  
<https://docs.microsoft.com/azure/azure-functions/functions-best-practices>

Questions?



# About us



Ing. Gianni ROSA GALLINA  
R&D Senior Software Engineer @ **Deltatre**



- AI, Machine Learning, Deep Learning on multimedia content
- Virtual/Augmented/Mixed Reality
- Immersive video streaming & 3D graphics for sport events
- Cloud solutions, web backends, serverless, video workflows
- Mobile apps dev (Windows / Android / Xamarin)
- End-to-end solutions with Microsoft Azure



<https://gianni.rosagallina.com>



# About us



Elena Terenzi

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Strong Cloud expertise

Artificial Intelligence and Machine Learning enthusiast

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