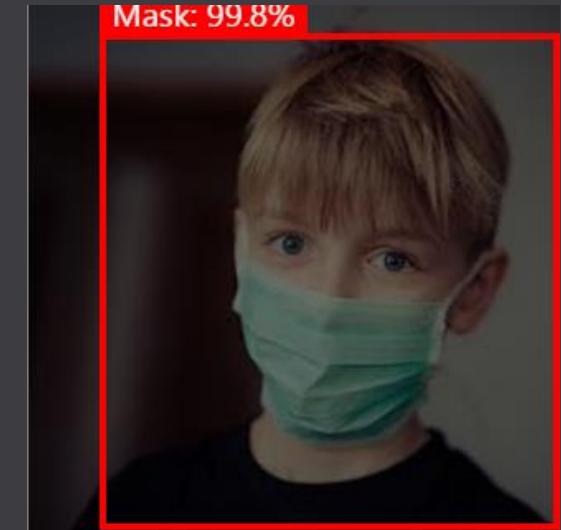
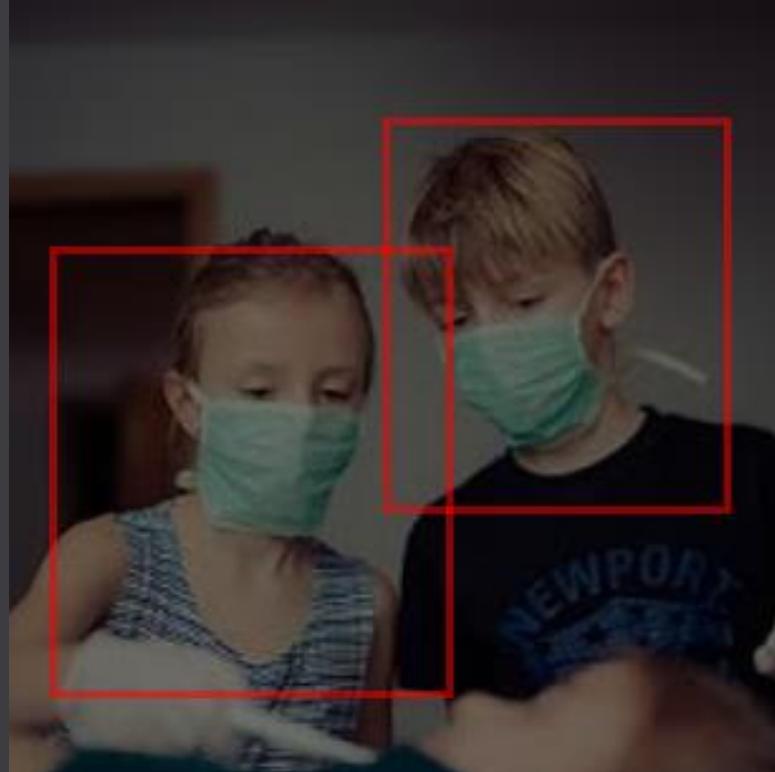


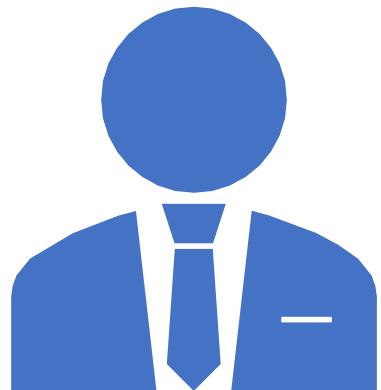
# Deploying AI with Azure IoT Edge

Mask Detection use case

22-April-2020



# Contact

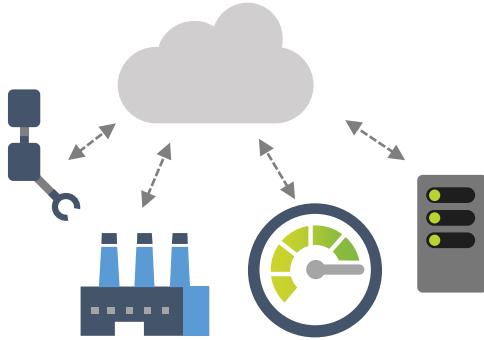


- Serge Retkowsky  
[serge.retkowsky@microsoft.com](mailto:serge.retkowsky@microsoft.com)

# Why Azure IoT Edge?

---

# IoT in the Cloud and on the Edge



## IoT in the Cloud

Remote monitoring and management

Merging remote data from multiple IoT devices

Infinite compute and storage to *train machine learning* and other advanced AI tools



## IoT on the Edge

Offline operations (short and long term)

Privacy of data and protection of IP

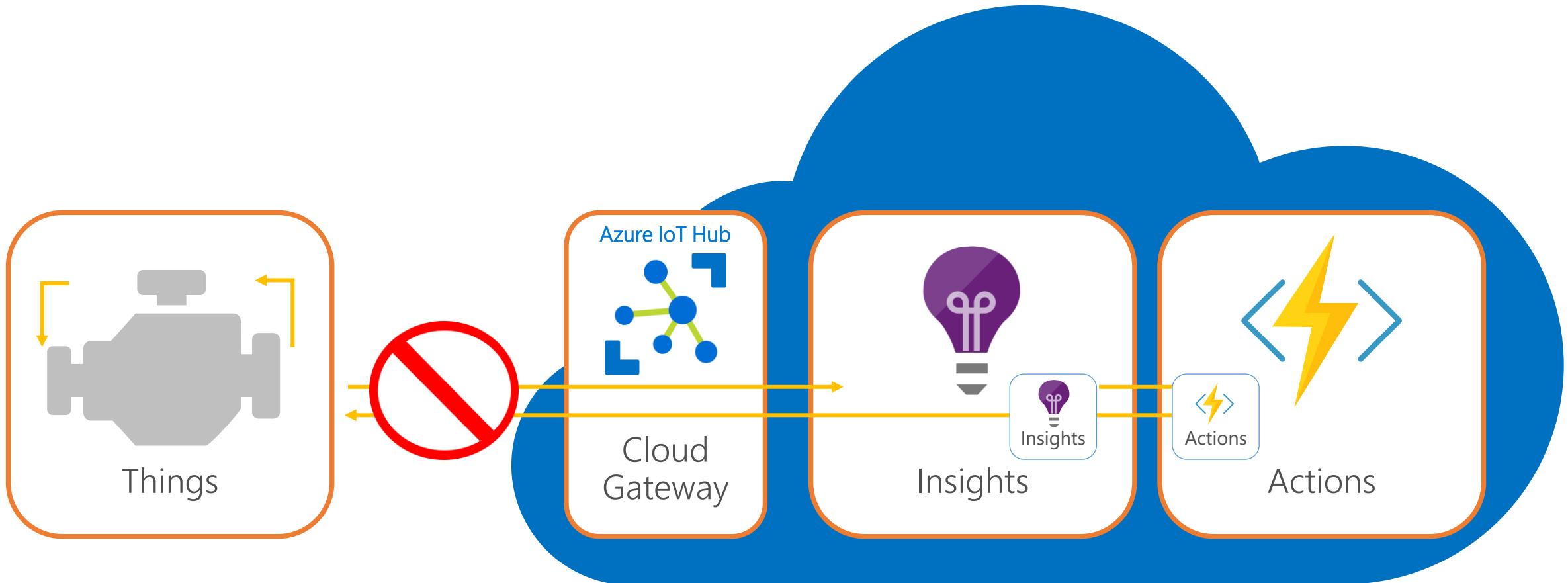
Pre-process data on prem – E.g. video streams

Low latency tight control loops require near real-time response

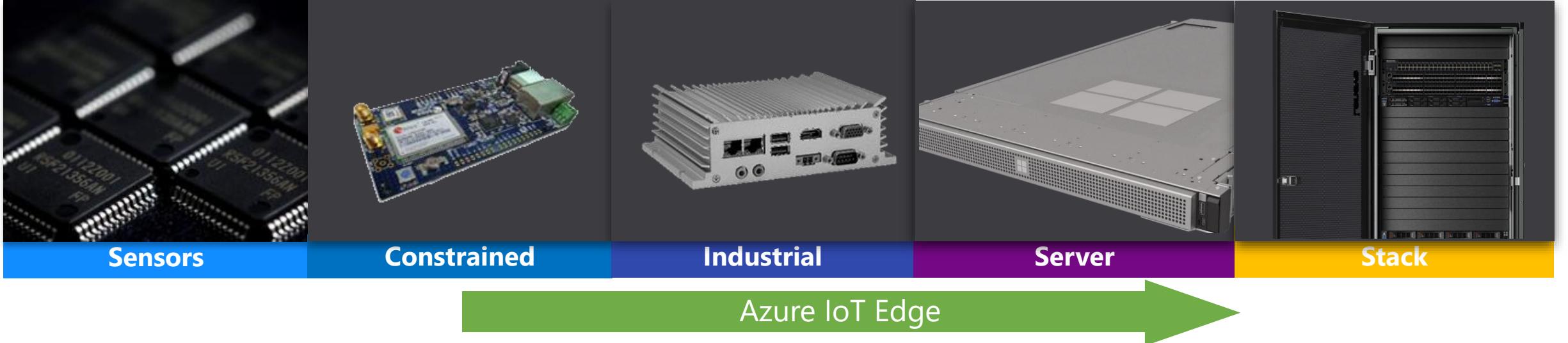
Protocol translation & data normalization

Consistency

# Edge computing is required in latency and bandwidth constrained/sensitive environments



# Example of Vision-Capable Edge Devices



Example of Vision-Capable Edge Device



Vision AI Dev Kit



Intel Movidius



Nvidia Jetson



Nvidia Tesla



Databox Stack Edge  
(Intel FPGA)

Light Edge

Heavy Edge

# Vision AI Use-Cases

---

# In IoT Computer Vision is about converting Cameras into Sensors

## Retail



## Industrial



## Smart spaces



# Shell invests in safety with Azure, AI, and machine vision to better protect customers and service champions

In the energy industry, Shell manages everything from wells to retail gas stations—44,000 of them. The company works hard to ensure the safety of service champions and customers at its retail sites. Shell is piloting a new cloud-based, deep learning solution built on Microsoft Azure. The solution uses closed-circuit camera footage and Internet of Things technology to automatically identify safety hazards and alert service champions so they can quickly respond and eliminate potential problems.



## Products and Services

Microsoft Azure  
Azure Databricks  
Azure IoT Edge  
Azure IoT Hub

## Organization Size

86,000 employees

## Industry

Mining, Oil and Gas

## Country

The Netherlands



# Bühler's mission is to improve food quality and safety

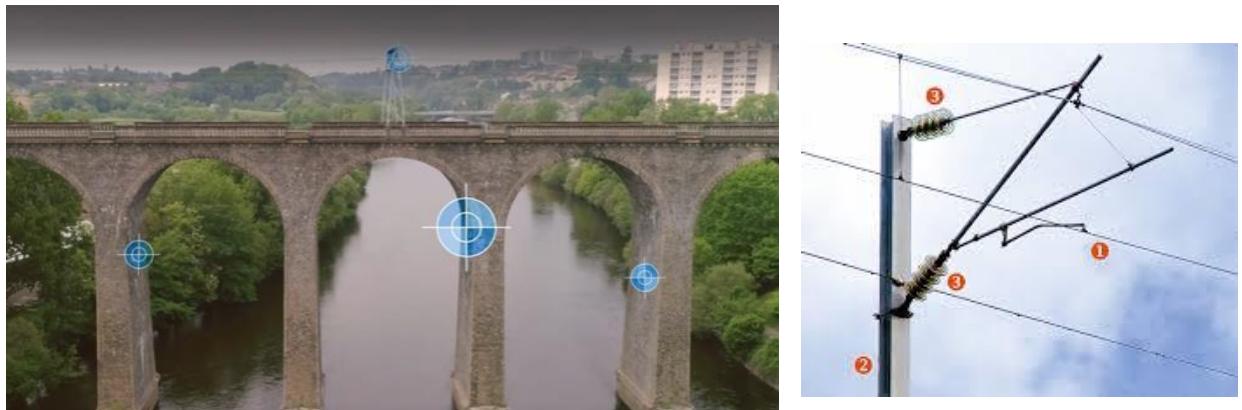
[Bühler's LumoVision solution](#) is a data-driven optical grain sorter that is connected to Azure for data analysis. It uses powerful cameras and ultraviolet lighting to hunt for hidden infections, sorting good corn from bad corn.



▷ [Watch](#)

# Rail company digitizes business

ALTAMETRIS est une société du Groupe SNCF Réseau spécialisée dans les services d'aide à la gestion des actifs industriels. Cette spin-off assure la collecte, le traitement et l'analyse de données pour faciliter la maintenance et l'ingénierie.



[Click to learn more](#)



## Products and Services

- Microsoft IoT Hub
- Microsoft IoT Edge
- Microsoft Power BI

## Organization Size

270,000 employees

## Industry

Travel & Transportation

## Country

France



réalise des relevés **topographiques** avec des **drones** et des **robots**.



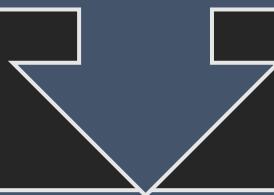
<https://customers.microsoft.com/fr-fr/story/altametris-viseo-azure-travel-transportation-france-fr>

# Mask Detection use case

---

# Mask Detection use case

We are going to build an AI custom vision model to support the lockdown exit and contain the spread.  
Our model will detect if a person is wearing or not a mask.



## Steps

1. Train a custom vision model

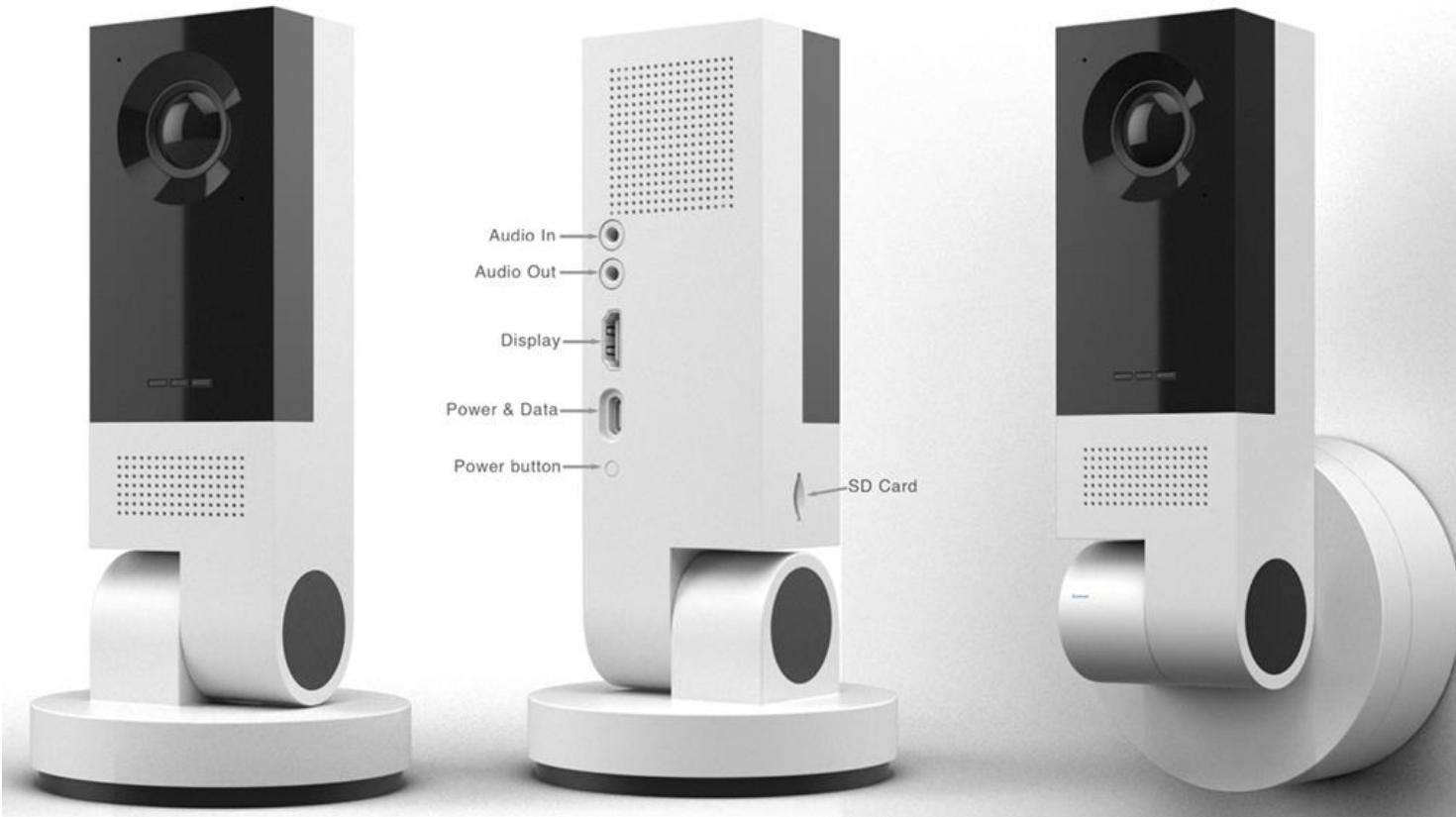
2. Evaluating the model

3. Deployment of the model directly on the Edge of a video camera device



# What is AI Dev Kit?

---



## AI Dev Kit

- This kit is based on [Qualcomm® Vision Intelligence Platform](#) powered by Qualcomm AI Engine with fully integrated support for **Azure ML and Azure IoT Edge**.
- This platform can run AI models locally on the device with support for hardware acceleration to enable real-time vision AI performance.
- Azure ML is responsible for AI model creation and monitoring, while device management and deployment are enabled by Azure IoT Edge.

# Vision AI Dev Kit

A connected camera reference solution

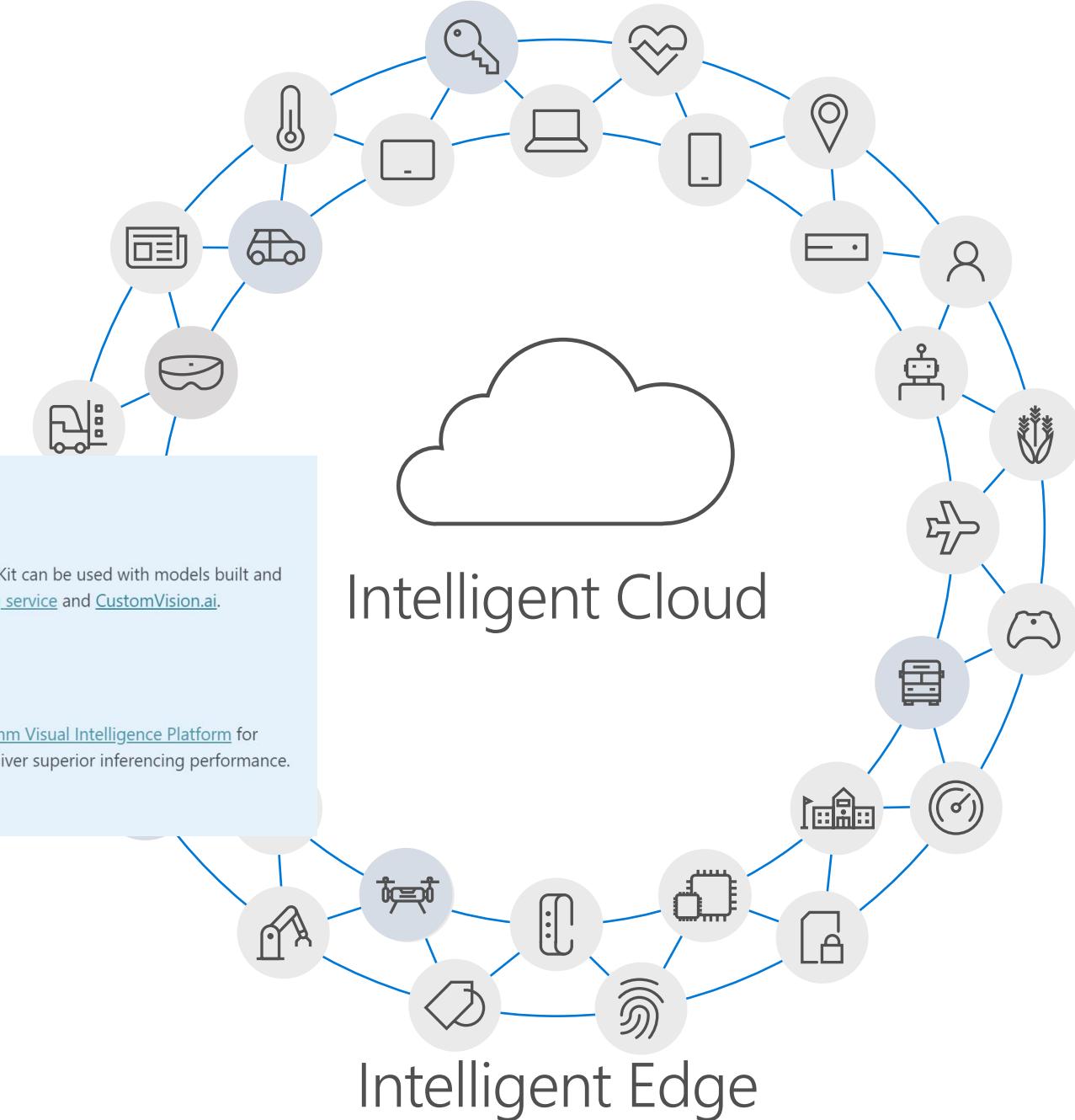


An Azure IoT starter kit, the Vision AI DevKit can be used with models built and trained using the [Azure Machine Learning service](#) and [CustomVision.ai](#).

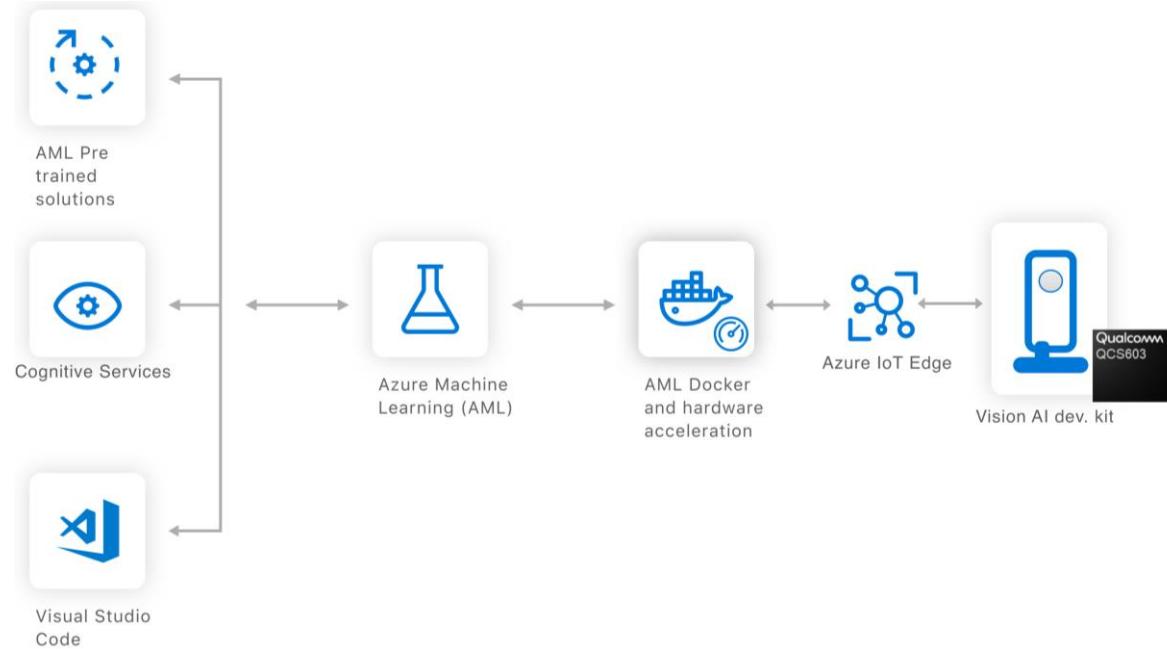
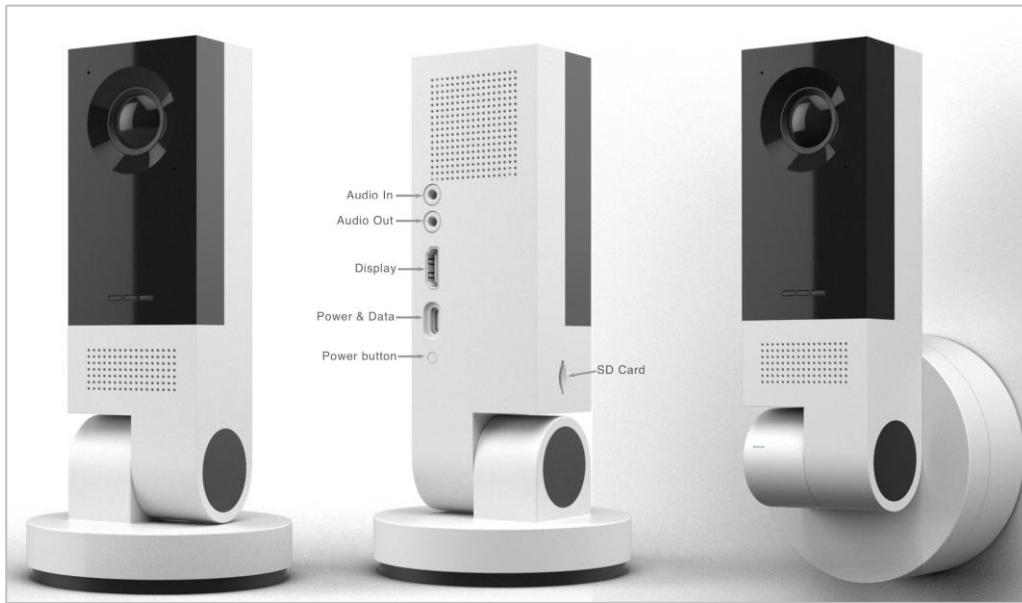


The Vision AI DevKit features the [Qualcomm Visual Intelligence Platform](#) for hardware acceleration of AI models to deliver superior inferencing performance.

<https://visionaidevkit.com>



# The vision AI Developer Kit



- Qualcomm® Technologies, Inc. and Microsoft collaboration
- Run AI models on the edge without additional computers or web connection or leverage the cloud
- Create, deploy and manage all your models in the cloud and the edge with Azure ML and Azure IoT Edge
- <http://www.visionaidevkit.com>

# Camera Specifications



## Model: EIC MS Vision 500

SoC	Memory
Qualcomm QCS603	4GB LPDDR4x
OS	Built-In Storage
Yocto Linux	16GB eMMC
Battery	Microphone
1550 mAh	4 separate
Camera	Wi-Fi
8 MP/ 4K UHD	Qualcomm WCN3980 (1x1) 802.11b/g/n 2.4 + 5GHz



# The Video camera

# Android Debug Bridge (ABD) Command Line Utility



- ADB :
  - ✓ For checking camera status
  - ✓ for upgrading the firmware
  - ✓ for checking the release of the firmware
  - ✓ for checking the % of the battery
  - ✓ for rebooting the device

[https://azure.github.io/Vision-AI-DevKit-Pages/docs/platform\\_tools/](https://azure.github.io/Vision-AI-DevKit-Pages/docs/platform_tools/)

# Android Debug Bridge (ABD) Command Line Utility

Check if the device is connected to the laptop:

```
PS C:\Users\seretkow> adb devices
List of devices attached
f6dfe161        device
```

Version of the firmware:

```
PS C:\Users\seretkow> adb shell cat /etc/version
v0.5370_Perf
PS C:\Users\seretkow>
```

# Configuration of the device

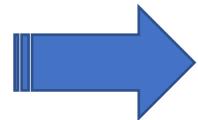


Microsoft Vision AI Developer kit



Microsoft Vision AI Developer kit

Let's get started



Your camera is ONLINE! ( connected to Samsung S7 Serge )

You will need an Azure IoT Edge connection string to connect your camera to Microsoft Azure.

Go to <https://aka.ms/setup-ai-camera> to set one up and have it available before you continue.

Previous

Next

Next

<http://setupaicamera.ms>

# Azure IoT Hub

Microsoft Azure (Preview) [Report a bug](#)  ≡ grid refresh bell gear ? smile seretkow@microsoft.com MICROSOFT

Home > IoT Hub

## IoT Hub

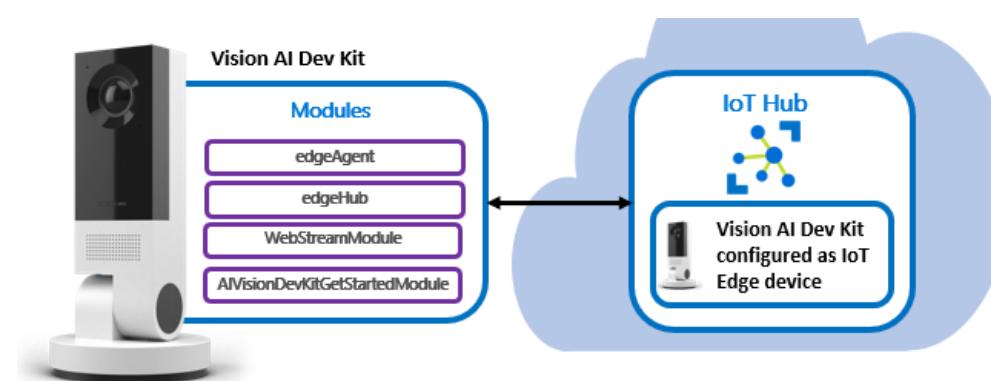
Microsoft

+ Add Manage view Refresh Export to CSV Assign tags Feedback Leave preview

Filter by name... Subscription == Microsoft Azure Internal Consumption Resource group == all Location == all + Add filter

Showing 1 to 1 of 1 records.

Name ↑↓	Type ↑↓	Resource group ↑↓	Location ↑↓	Subscription ↑↓	Kind ↑↓	Resource ID ↑↓	Resource type ↑↓
<input type="checkbox"/> aidevkitserge	IoT Hub	AldevKit-rg	West Europe	Microsoft Azure Internal ...		/subscriptions/70b8f39e-... microsoft.devices/iothubs ...	



# Azure IoT Edge device

aidekitserge | IoT Edge

IoT Hub

Search (Ctrl+ /) Add an IoT Edge device Create Deployment Create Layered Deployment Refresh Delete

Shared access policies Pricing and scale IP Filter Certificates Built-in endpoints Failover Properties Locks Export template

Explorers Query explorer IoT devices

Automatic Device Management IoT Edge IoT device configuration

Deploy Azure services and solution-specific code to on-premises devices. Use IoT Edge devices to perform compute and analytics tasks on data before it's sent to the cloud.

IoT Edge devices IoT Edge deployments

IoT Edge devices

Field Operator Value + X Add new clause

Query devices Switch to query editor

<input type="checkbox"/> Device ID	Runtime Response	IoT Edge Module Count	Connected Client Count	Deployment Count
<input type="checkbox"/> CameraSerge	OK	4	1	0

# Azure IoT Edge device

Home > IoT Hub > aidevkitserge | IoT Edge > CameraSerge

**CameraSerge**  
aidevkitserge

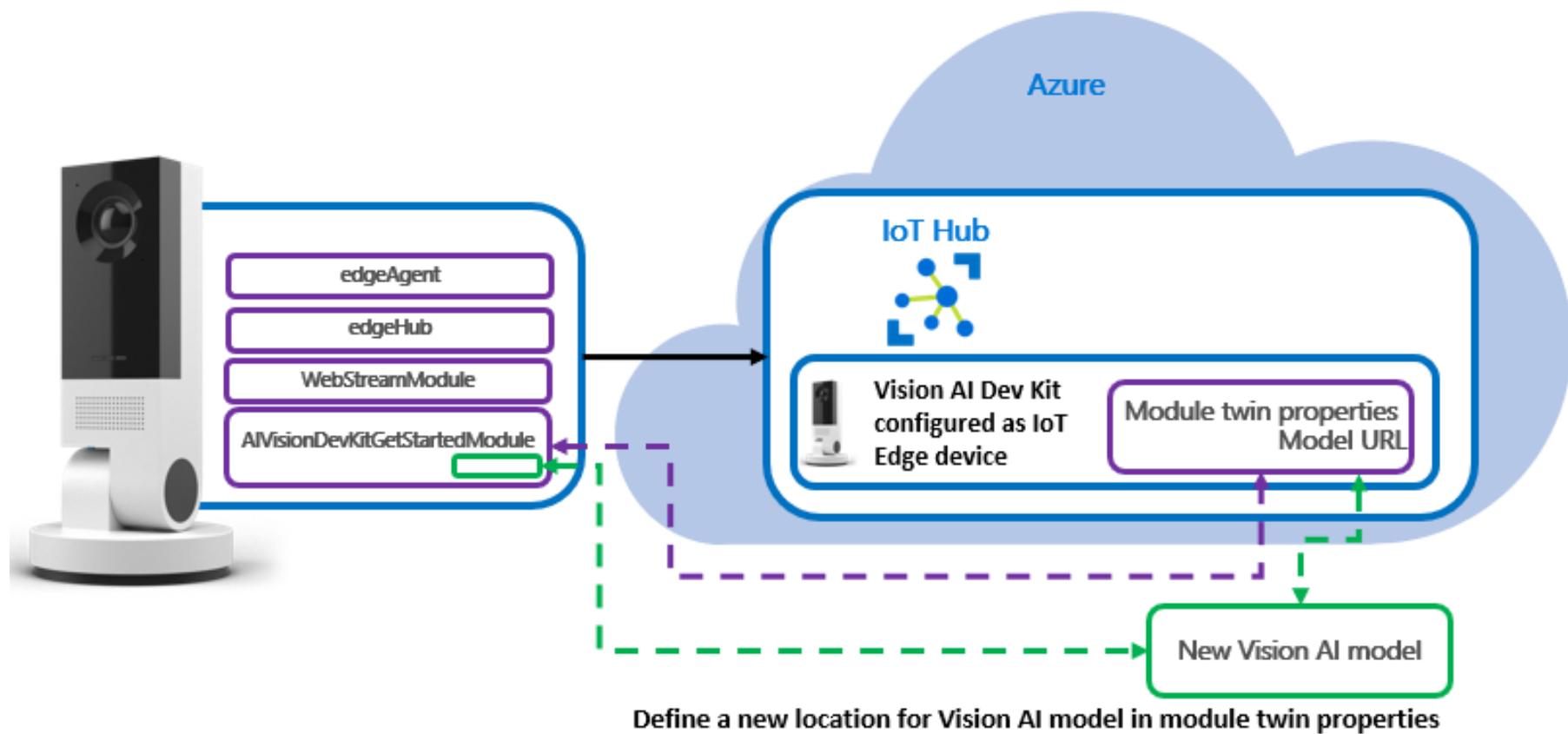
Save Set Modules Manage Child Devices Device Twin Manage keys Refresh

Device ID	CameraSerge
Primary Key	.....
Secondary Key	.....
Primary Connection String	.....
Secondary Connection String	.....
IoT Edge Runtime Response	200 -- OK
Enable connection to IoT Hub	<input checked="" type="radio"/> Enable <input type="radio"/> Disable

**Modules** [IoT Edge Hub connections](#) [Deployments](#)

NAME	TYPE	SPECIFIED IN DEPLOYMENT	REPORTED BY DEVICE	RUNTIME STATUS	EXIT CODE
\$edgeAgent	IoT Edge System Module	✓ Yes	✓ Yes	running	0
\$edgeHub	IoT Edge System Module	✓ Yes	✓ Yes	running	0
AIVisionDevKitGetStartedModule	IoT Edge Custom Module	✓ Yes	✓ Yes	running	0
WebStreamModule	IoT Edge Custom Module	✓ Yes	✓ Yes	running	0

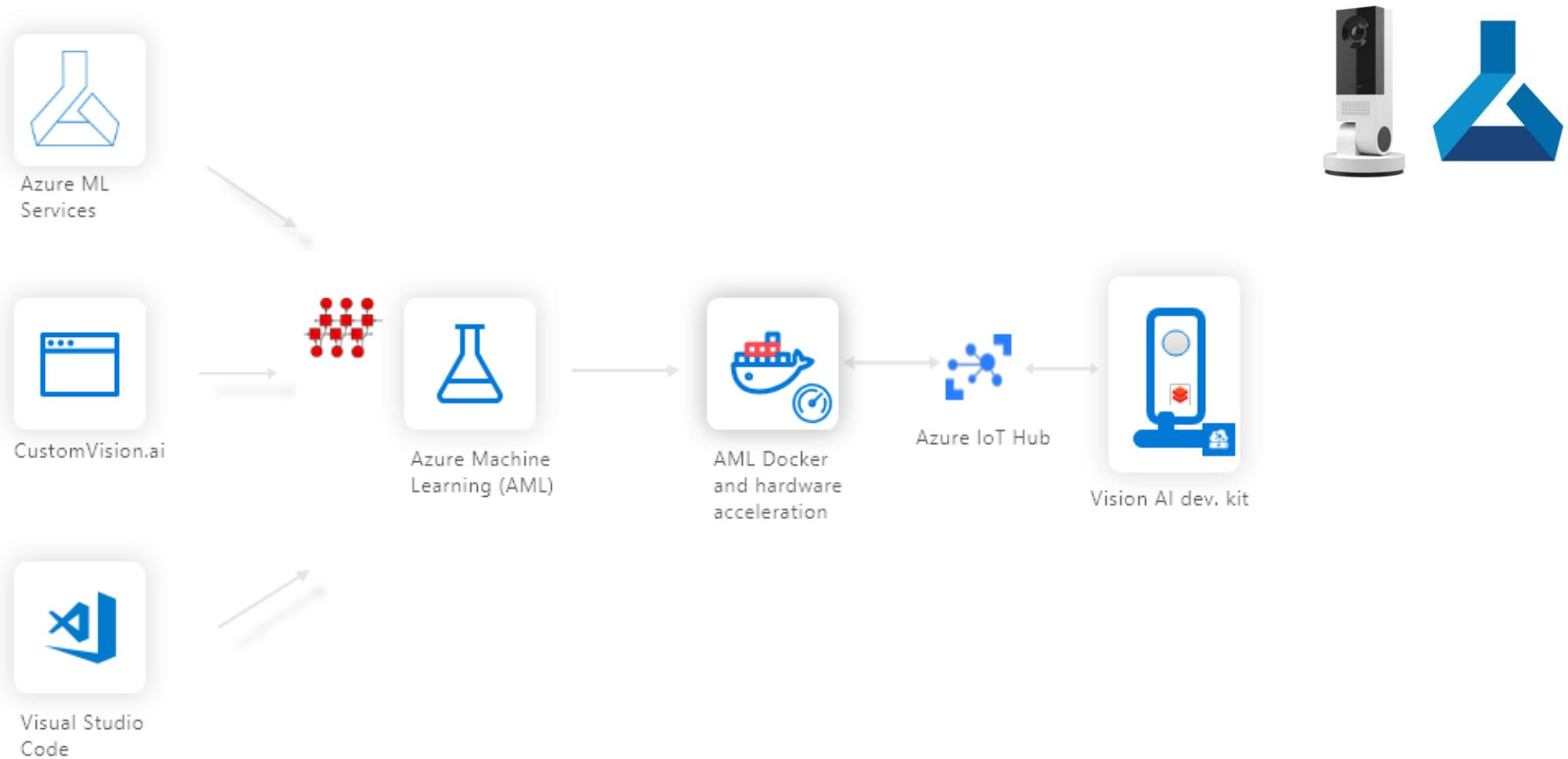
# Azure IoT Hub - AI Model reference link



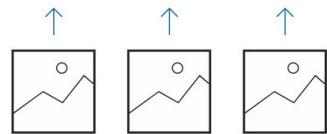
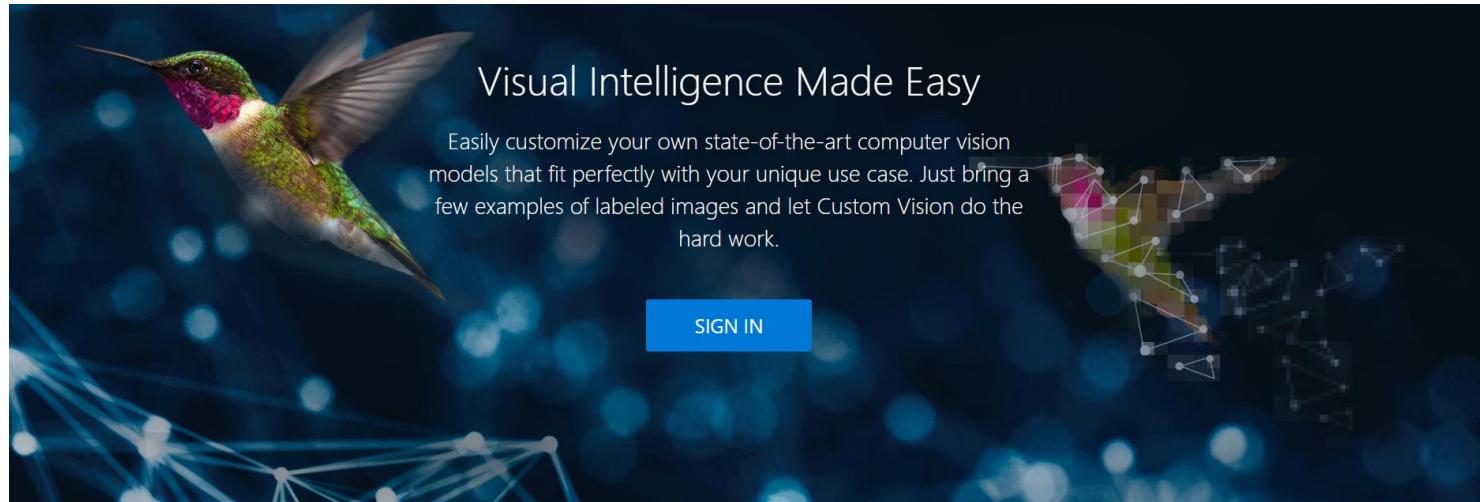
# Let's create a custom vision model

---

# Building a new AI model



# Azure Custom Vision – No Code approach



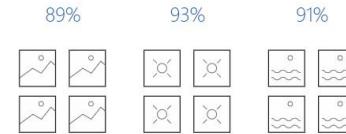
## Upload Images

Bring your own labeled images, or use Custom Vision to quickly add tags to any unlabeled images.



## Train

Use your labeled images to teach Custom Vision the concepts you care about.



## Evaluate

Use simple REST API calls to quickly tag images with your new custom computer vision model.

<https://www.customvision.ai>

1. Let's  
create a  
project



# Let's create a new custom vision project

Create new project X

**Name\***

**Description**

**Resource** [create new](#)  
 ▼  
[Manage Resource Permissions](#)

**Project Types** (i)  
 Classification  
 Object Detection

**Domains:**  
 General  
 Logo  
 Products on Shelves  
 General (compact)  
 General (compact) [S1]

Pick the domain closest to your scenario. Compact domains are lightweight models that can be exported to iOS/Android and other platforms. [Learn More](#)

**Export Capabilities:** (i)  
 Basic platforms (Tensorflow, CoreML, ONNX, ...)  
 Vision AI Dev Kit

Cancel Create project

# Let's create a new custom vision project

Projet Mask Detection

Training Images   Performance   Predictions   Train   Quick Test   ?   User profile

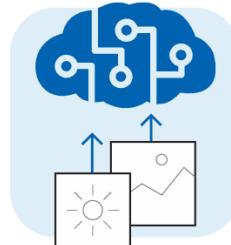
Filter   Add images   Delete   Select all

Iteration   Workspace

Tags   +  
Tagged   Untagged

Showing: all tagged images

Search For Tags:



Looks like you don't have any images here!

Go ahead and browse for images to upload to your project, tag them, and they will be ready to be trained.

Add images

JPG, .PNG, .BMP format, up to 6 MB per image

Get started

## 2. Importing the images files



# Loading the images files into customvision.ai

Mask Detection Projct

Training Images   Performance   Predictions   Train   Quick Test   ?

Add images   Delete   Select all

Filter

Iteration: Workspace

Tags: Tagged   Untagged

Showing: all tagged images

Search For Tags:

Mask 83   ...  
 No\_Mask 84   ...

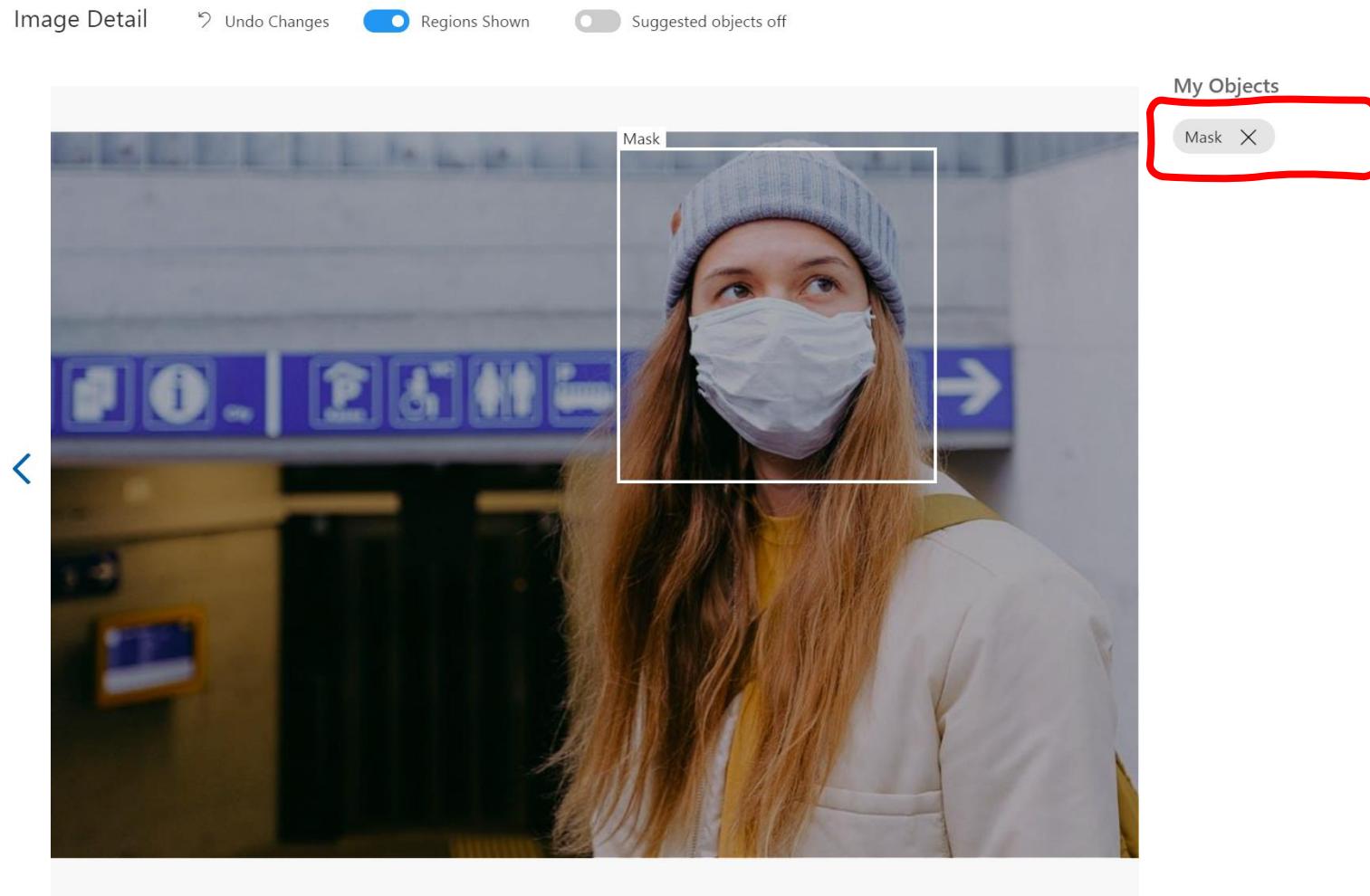
Training Images

1 2 3 >

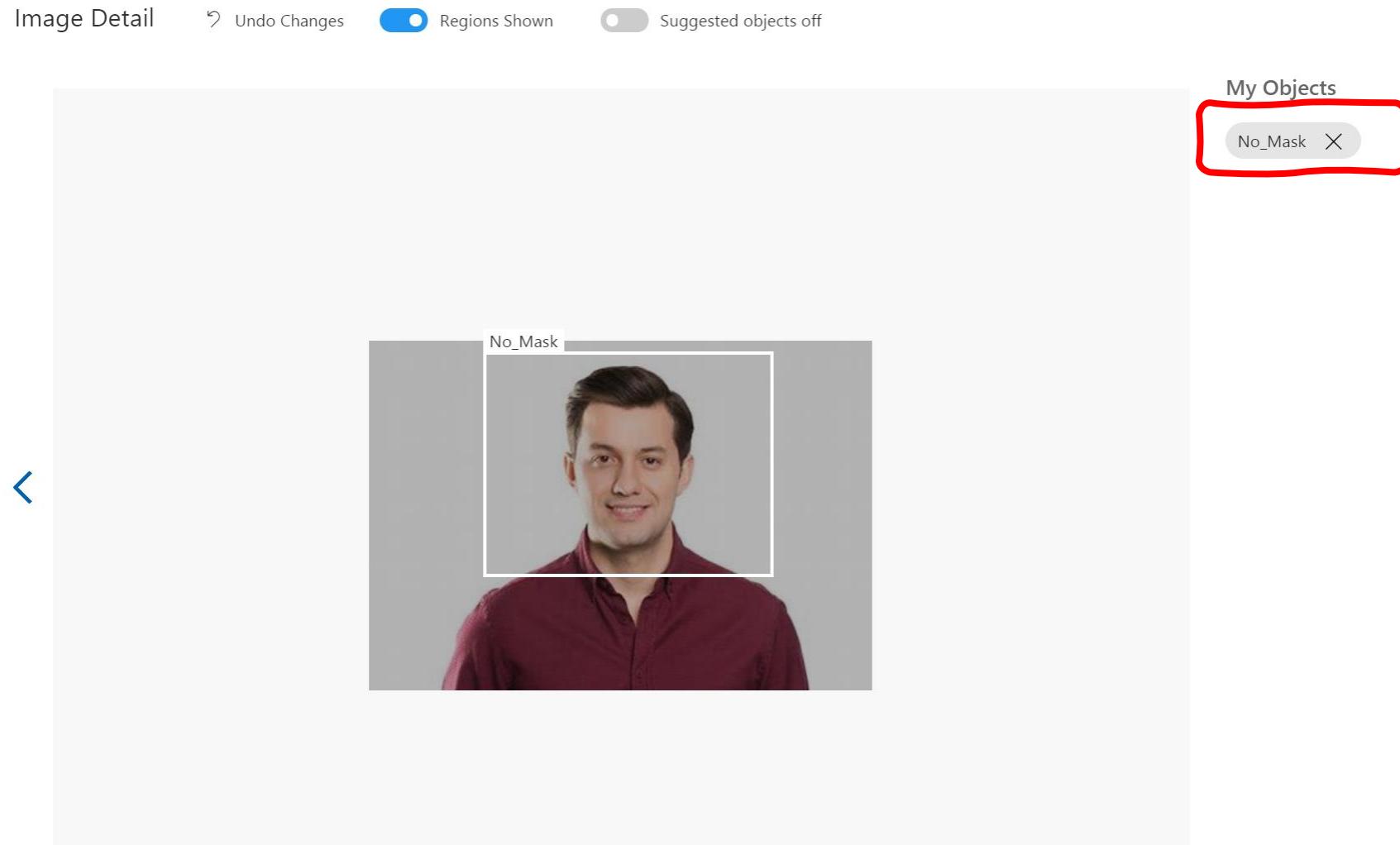
### 3. Tagging the training images



# Let's create the tag to detect (« Mask » vs « No Mask »)



# Let's create the tag to detect (« Mask » vs « No Mask »)



# Mask Detection Project

Mask Detection Projct

Training Images

Add images Delete Select all

Filter

Iteration

Workspace

Tags

Tagged Untagged

Showing: all tagged images

Search For Tags:

Mask 83

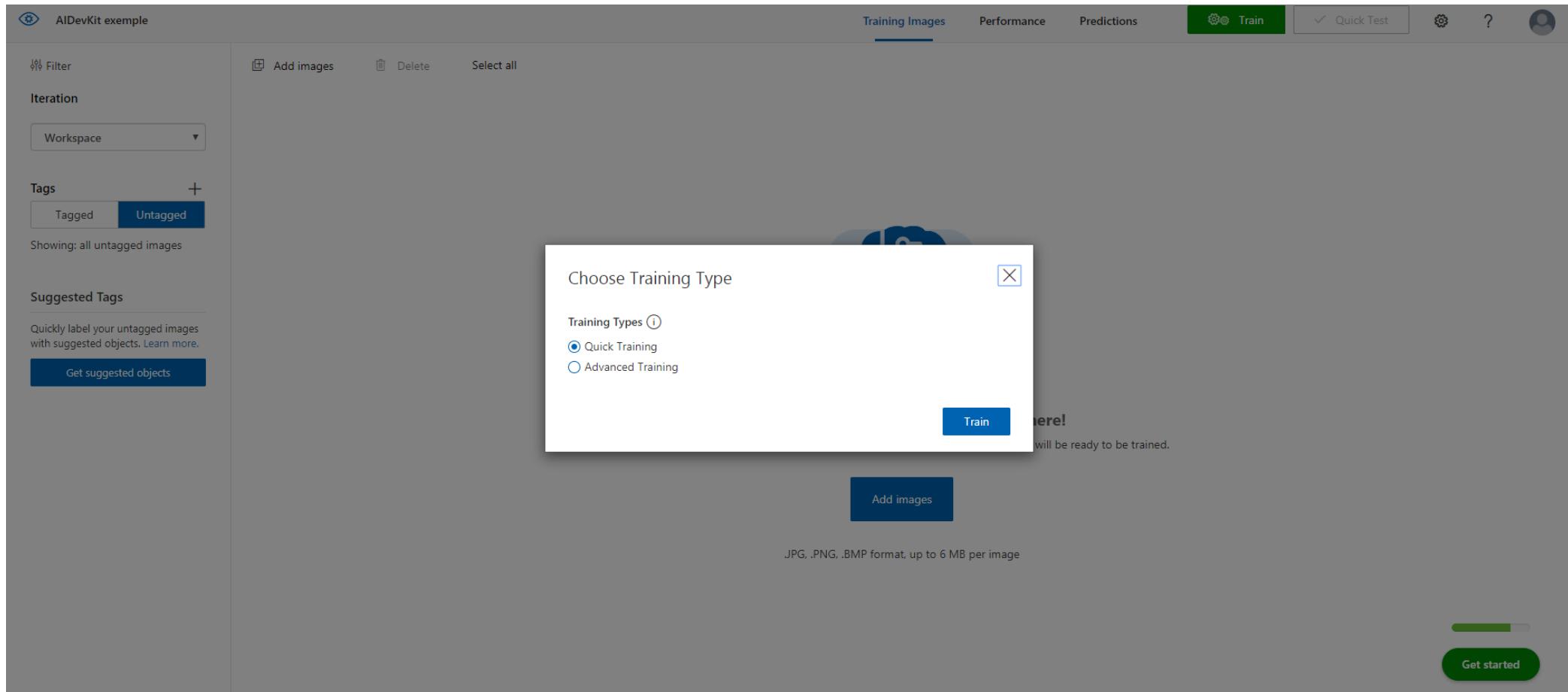
No\_Mask 84

Training Images

4. Let's  
build the  
model



# Building the model



# Performance of the model

Mask Detection Projet

Iterations

Probability Threshold: 50% ⓘ

Overlap Threshold: 30% ⓘ

Iteration 7 PUBLISHED

Trained : 1 days ago with General (compact) domain

Iteration 6

Trained : 1 days ago with General (compact) domain

Iteration 5

Advanced Trained : 1 days ago with General (compact) domain, Training Budget: 1 hour

Iteration 4

Trained : 1 days ago with General (compact) domain

Iteration 3

Trained : 1 days ago with General (compact) domain

Iteration 2

X Unpublish ⏪ Prediction URL Delete ⏴ Export

Training Images Perfo

### Iteration 7

Finished training on 20/04/2020 à 13:52:36 using General (compact) domain  
Iteration id: 2f88d71e-0993-4677-a7ce-c5ec6bb3ad72  
Published as: Iteration7

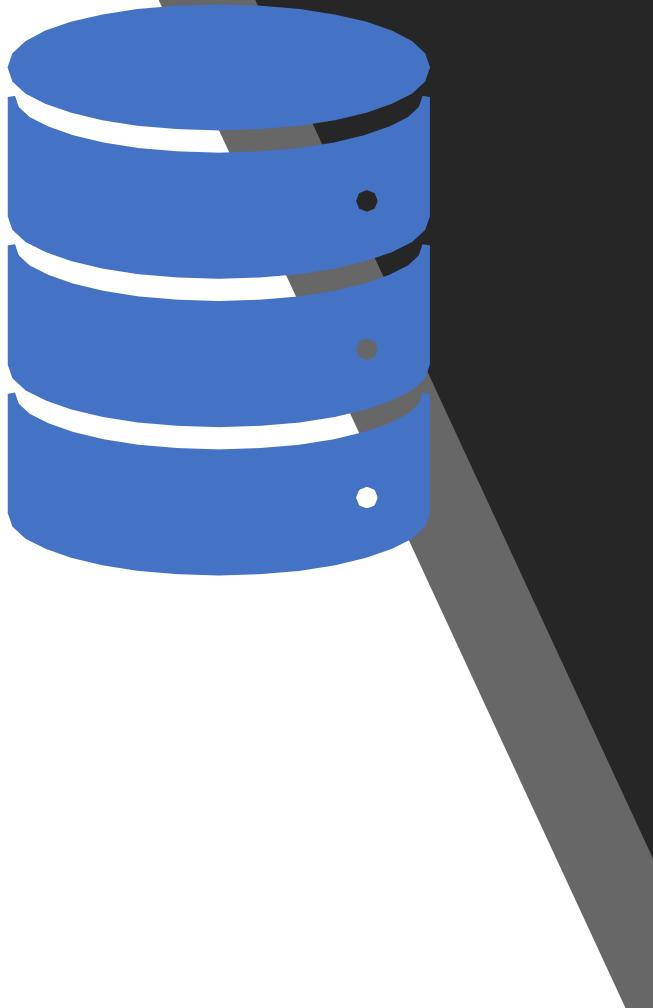
Precision ⓘ 86.5%

Recall ⓘ 66.7%

mAP ⓘ 76.6%

### Performance Per Tag

Tag	Precision	Recall	A.P.	Image count
No_Mask	87.0%	76.9%	78.8%	85 
Mask	85.7%	54.5%	74.5%	83 



# Indicators definition

- **Precision** indicates the fraction of identified classifications that were correct. For example, if the model identified 100 images as "Mask", and 90 of them were actually of "Mask", then the precision would be 90%.
- **Recall** indicates the fraction of actual classifications that were correctly identified. For example, if there were actually 100 images of "Mask", and the model identified 85 as "Mask", the recall would be 85%.
- **mAP** is Mean Average Precision. Its use is different in the field of Information Retrieval Multi-Class classification (Object Detection) settings. To calculate it for Object Detection, you calculate the average precision for each class in your data based on your model predictions. Average precision is related to the area under the precision-recall curve for a class. Then Taking the mean of these average individual-class-precision gives you the Mean Average Precision.

## 5. Testing the model



# Testing the model from customvision.ai

Mask Detection Project

Training Images Performance Predictions Train Quick Test Filter Delete Iteration 7  ?

Tags  
Showing: all predicted images  
Search For Tags:   
 Mask  No\_Mask

Sort  
 Suggested  Newest  Oldest



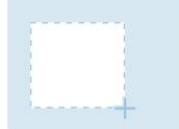
The screenshot shows the 'Predictions' tab of the Custom Vision interface. On the left, there are filters for 'Iteration' (set to 'Iteration 7') and 'Tags' (showing all predicted images). Below these are checkboxes for 'Mask' and 'No\_Mask'. On the right, there are five thumbnail images of people wearing face masks. The 'Predictions' tab is highlighted with a red box.

# Testing the model directly from customvision.ai

Image Detail    Undo Changes     Regions Shown    X



My Objects



To create an object, hover and select the region in the image

Predictions

Predictions are shown in red

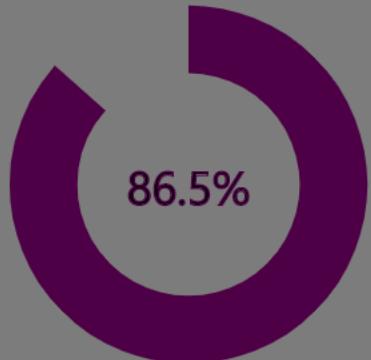
Tag	Probability
Mask	99.6%

# Deploying the model into an API

Iteration 7

Finished training on 20/04/2020 à 13:52:36 using General (compact) domain  
Iteration id: 2f88d71e-0993-4677-a7ce-c5e  
Published as: Iteration7

Precision ⓘ



86.5%

Performance Per Tag

How to use the Prediction API X

If you have an image URL:

```
https://westeurope.api.cognitive.microsoft.com/customvision/v3.0/Prediction/9aaf1!
```

Set `Prediction-Key` Header to : `e027df6c5b5d4e7c889a132b25be3ad1`  
Set `Content-Type` Header to : `application/json`  
Set Body to : `{"Url": "https://example.com/image.png"}`

If you have an image file:

```
https://westeurope.api.cognitive.microsoft.com/customvision/v3.0/Prediction/9aaf1!
```

Set `Prediction-Key` Header to : `e027df6c5b5d4e7c889a132b25be3ad1`  
Set `Content-Type` Header to : `application/octet-stream`  
Set Body to : <image file>

Got it!

# Testing the model using PostMan

▶ Mask Detection (Mask)

POST https://westeurope.api.cognitive.microsoft.com/customvision/v3.0/Prediction/9aaf1937-9cab-48b9-9fe6-05482aca6dce/detect/iterations/Iteration7/url

Params Authorization Headers (11) **Body** Pre-request Script Tests Settings

none form-data x-www-form-urlencoded raw binary GraphQL JSON

```
1 [{}]
2   "url": "https://github.com/retkowsky/CustomVision_Datasets/blob/master/Test%20Mask%20(1).jpg?raw=true"
3 }
```

Body Cookies Headers (7) Test Results Status: 200 OK Time:

Pretty Raw Preview Visualize JSON

```
1 [
2   {
3     "id": "5757a6df-f7bd-4553-9db4-414a25919d21",
4     "project": "9aaf1937-9cab-48b9-9fe6-05482aca6dce",
5     "iteration": "2f88d71e-0993-4677-a7ce-c5ec6bb3ad72",
6     "created": "2020-04-21T14:26:18.356Z",
7     "predictions": [
8       {
9         "probability": 0.996311247,
10        "tagId": "96b39a84-f4a8-4302-9d68-bfa08671b607",
11        "tagName": "Mask",
12        "boundingBox": {
13          "left": -0.008913398,
14          "top": 0.005661458,
15          "width": 1.010312,
16          "height": 0.9983281
17        }
18      }
19    ]
20  ]
21 ]
```

## 6. Exporting the model



# Exporting the model

Choose your platform



**CoreML** ⓘ

iOS 11



**TensorFlow** ⓘ

Android



**ONNX** ⓘ

Windows ML



**Dockerfile** ⓘ

Azure IoT Edge, Azure Functions,  
AzureML



**Vision AI Dev Kit**

# Storing the model into an Azure blob storage

Home > customvisionstorage | Containers > customvision

**customvision**  
Container

Search (Ctrl+/  
Upload Change access level Refresh Delete Change tier Acquire lease Break lease View snapshots Create snapshot

Overview Authentication method: Access key (Switch to Azure AD User Account)  
Location: customvision

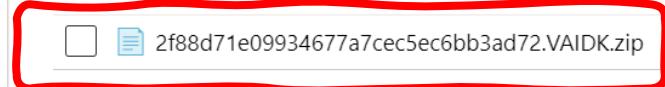
Access Control (IAM)

Search blobs by prefix (case-sensitive) Show deleted blobs

Settings

Access policy Properties Metadata Editor (preview)

Name	Modified	Access tier	Blob type	Size	Lease state
<input type="checkbox"/> 2f88d71e09934677a7cec5ec6bb3ad72.VALIDK.zip	20/04/2020 à 16:35:56	Hot (Inferred)	Block blob	10.55 MiB	Available



# Location of the model in the Edge configuration

Home > IoT Hub > aidevkitserge | IoT Edge > CameraSerge > IoT Edge Module Details > Module Identity Twin

 **Module Identity Twin**  
AIVisionDevKitGetStartedModule

 Save

 The module twin for 'AVisionDevKitGetStartedModule' is shown below. You can add tags and desired properties to your module twin here. To remove a tag or desired property, set the value of the item to be removed to 'null'.

```
1  {
2    "deviceId": "CameraSerge",
3    "moduleId": "AVisionDevKitGetStartedModule",
4    "etag": "AAAAAAAAAAAM=",
5    "deviceEtag": "Njc4Njg5NTM0",
6    "status": "enabled",
7    "statusUpdateTime": "2001-01-01T00:00:00Z",
8    "connectionState": "Disconnected",
9    "lastActivityTime": "2020-04-20T13:19:33.3043363Z",
10   "cloudToDeviceMessageCount": 0,
11   "authenticationType": "sas",
12   "x509Thumbprint": {
13     "primaryThumbprint": null,
14     "secondaryThumbprint": null
15   },
16   "version": 11,
17   "properties": {
18     "desired": {
19       "ModelZipUrl": "https://customvisionstockage.blob.core.windows.net/customvision/2f88d71e09934677a7cec5ec6bb3ad72.VAIDK.zip",
20       "TimeBetweenMessagesInSeconds": 12,
21       "ObjectsOfInterest": "",
22       "ShowVideoOverlay": "true",
23       "Bitrate": "1.5Mbps",
24       "Resolution": "1080P",
25       "VideoOverlayConfig": "inference",
26       "FrameRate": 30,
27       "HdmiDisplayActive": "true",
28       "VideoAnalyticsEnabled": "true",
29       "ShowVideoPreview": "true",
30       "Codec": "AVC/H.264",
31     }
32   }
33 }
```

A red box highlights the line "ModelZipUrl": "<https://customvisionstockage.blob.core.windows.net/customvision/2f88d71e09934677a7cec5ec6bb3ad72.VAIDK.zip>", indicating its location in the Edge configuration.

7. Let's test  
the deployed  
model on the  
edge



# Checking the deployed model on the Edge

Vision AI models which run on the Vision AI DevKit consists of three files:

1. .DLC file - containing the model
2. .TXT file - containing a list of the objects recognized by the model
3. .json file - containing the VAM engine configuration

```
PS C:\Users\seretkow> adb shell ls -ls /data/misc/camera
>>
total 22552
10800 -rw-r--r--. 1 root root 11059113 Apr 20 11:56 2f88d71e09934677a7cec5ec6bb3ad72.VAIDK.zip
    4 -rw-r--r--. 1 root root      1165 Apr 20 11:56 LICENSE
    4 -rw-r--r--. 1 root root       54 Apr 20 22:17 aecWarmStartCamera_0.txt
    4 -rw-r--r--. 1 root root     378 Apr 20 11:56 cvexport.manifest
    4 -rw-r--r--. 1 root root      51 Apr 20 11:56 labels.txt
11732 -rw-r--r--. 1 root root 12009474 Apr 20 11:56 model.dlc
    4 -rw-r--r--. 1 root root     384 Apr 20 11:56 va-snpe-engine-library_config.json
```

# Checking the deployed model on the Edge

```
PS C:\Users\seretkow> adb shell cat /data/misc/camera/labels.txt  
14aac23b-818b-4095-b749-c9b00e4t0t96  
Mask  
No_Mask  
PS C:\Users\seretkow> adb shell cat /data/misc/camera/va-snpe-engine-library_config.json  
{  
    "FrameworkType":0,  
    "Engine":3,  
    "NetworkIO":0,  
    "ScaleWidth":300,  
    "ScaleHeight":300,  
    "PixelNorm":0,  
    "BlueMean":0,  
    "GreenMean":0,  
    "RedMean":0,  
    "TargetFPS":30,  
    "ConfThreshold":0.7,  
    "DLC_NAME":"model.dlc",  
    "LABELS_NAME":"labels.txt",  
    "InputLayers":"data",  
    "OutputLayers":["model_output"],  
    "ResultLayers":["model_output"],  
    "Runtime":1  
}
```

Let's use the video camera with the Mask Detection model on the Edge



# Documentation

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# Vision AI Dev Kit

## A connected camera reference solution

<https://www.customvision.ai>

<https://visionaidevkit.com>

<https://azure.microsoft.com/en-us/services/iot-edge/>

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

<https://www.youtube.com/watch?v=Db3EX0e76qc>



Microsoft