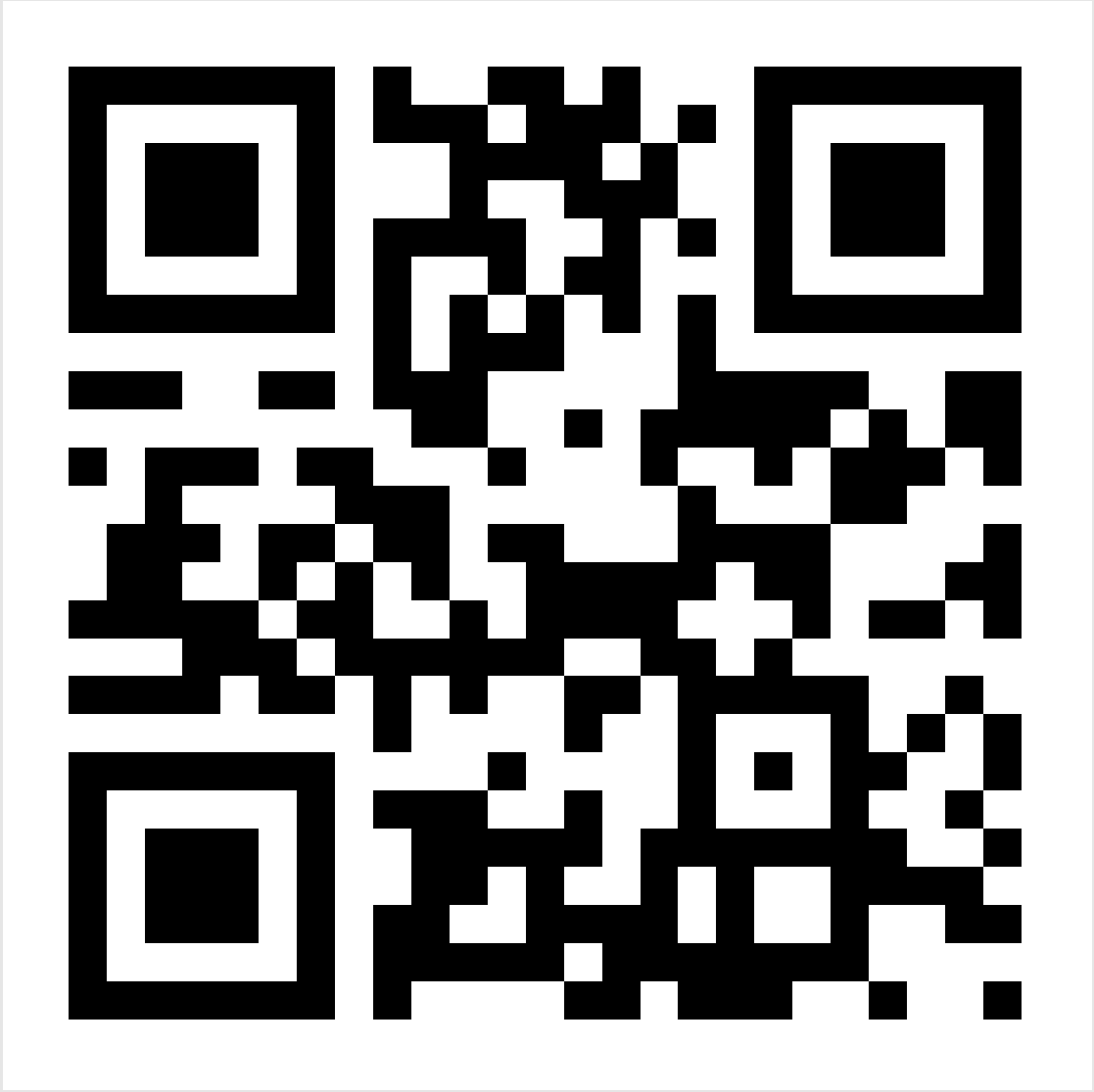
Leverage Power of Machine Learning with ONNX

Ron Dagdag
@rondagdag

ONNX, Not ONIX

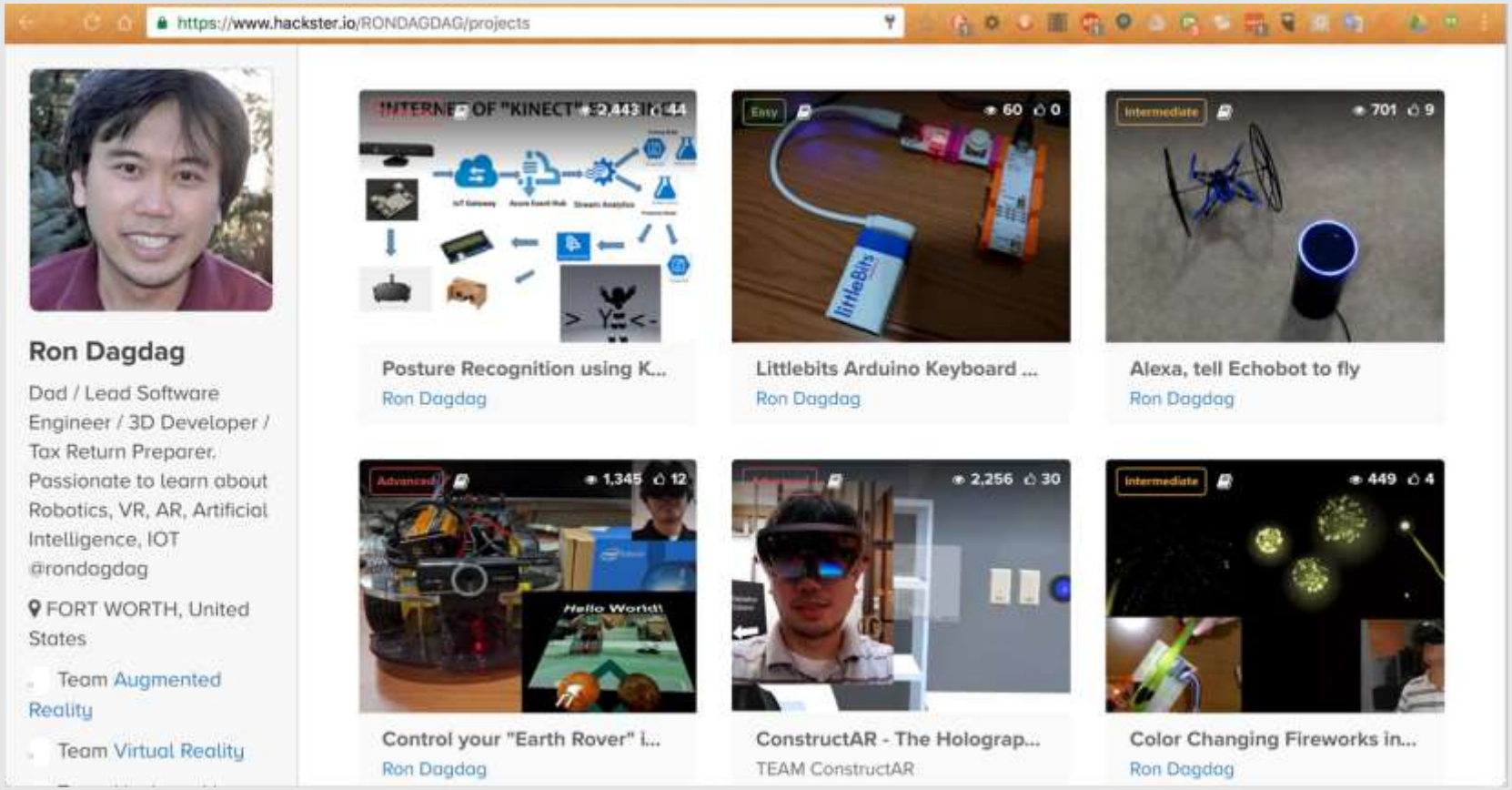


http://bit.ly/ml-onnx

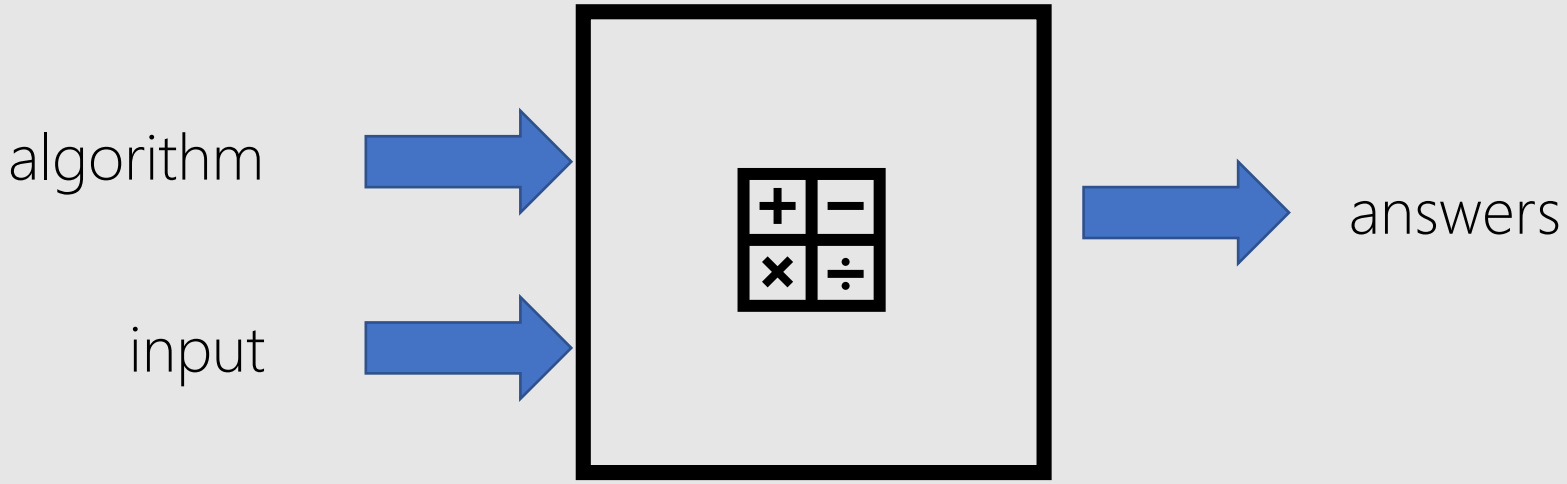
Hackster Portfolio

www.dagdag.net

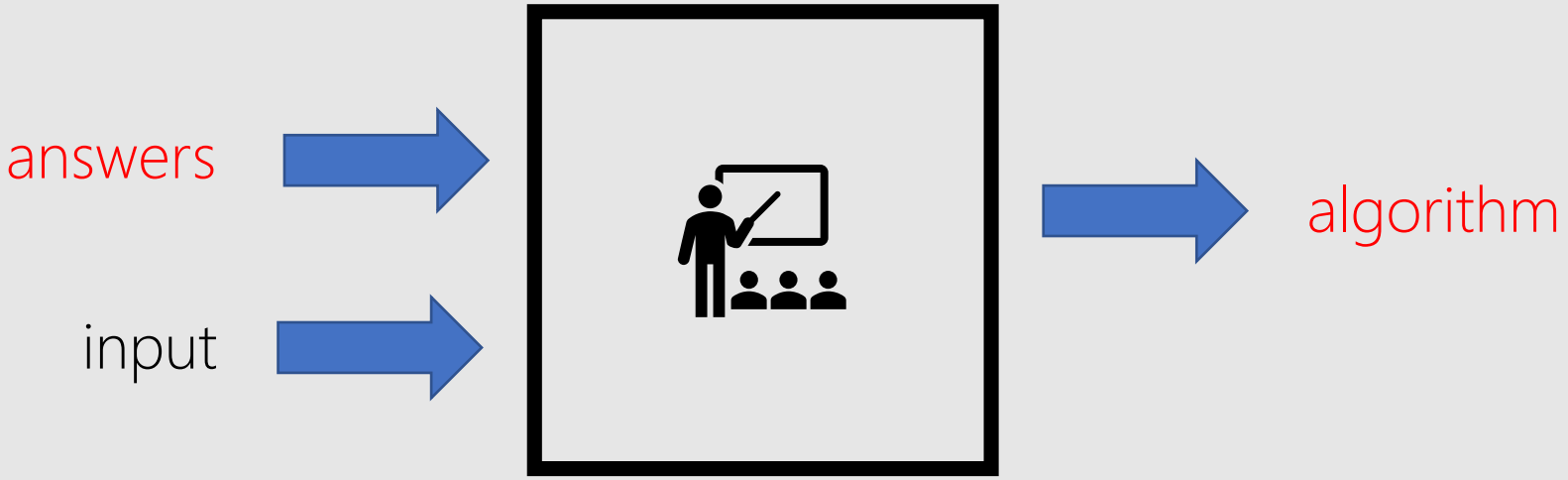
@rondagdag



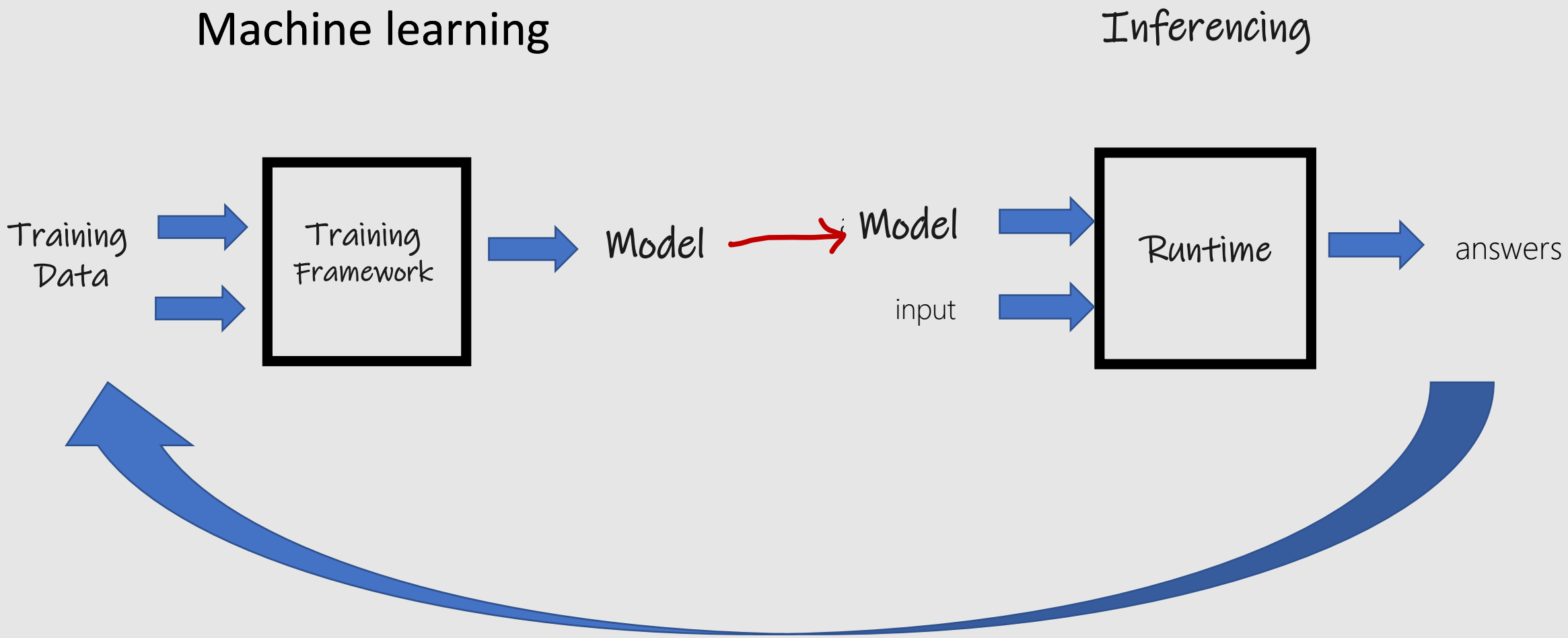
programming



machine learning



ML Primer


Machine learning
Inferencing
Training Data
Training Framework
Model
Model
input
Runtime
answers

Open and Interoperable AI

ONNX

Open Neural Network Exchange

Open format for ML models

github.com/onnx

onnx.ai/

ONNX Partners

Agenda

- ✓ What is ONNX
- ❑ How to create ONNX models
- ❑ How to deploy ONNX models

Create

Frameworks

Services

Azure Custom Vision Service

Native support

Converters

Native support

ONNX Model

Native support

Converters

Deploy

Cloud Services

- Azure Machine Learning services
- Ubuntu VM
- Windows Server 2019 VM

Windows Devices

IoT Edge Devices

Other Devices
(iOS, Android, etc)

Frameworks

Caffe2 Chainer Cognitive Toolkit

mxnet PyTorch PaddlePaddle

ML.NET MathWorks dmlc XGBoost

Services

Azure Custom Vision Service

Step 1: Create

Native support

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ONNX Model

Azure

Azure Machine Learning services

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Native support

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Step 2: Deploy

Converters

Other Devices (iOS, etc)

Secret Recipe

4 ways to get an ONNX model

ONNX Model Zoo

Azure Custom Vision Service

Convert existing models

Train models in Azure Machine Learning

Automated Machine Learning

ONNX Model Zoo: github.com/onnx/models

Image Classification

This collection of models take images as input, then classifies the major objects in the images into a set of predefined classes.

Model Class	Reference	Description
MobileNet	Sandler et al.	Efficient CNN model for mobile and embedded vision applications. Top-5 error from paper - ~10%
ResNet	He et al., He et al.	Very deep CNN model (up to 152 layers), won the ImageNet Challenge in 2015. Top-5
SqueezeNet	Iandola et al.	A ligh fewer Top-5
VGG	Simonyan et al.	Deep Challe Top-5

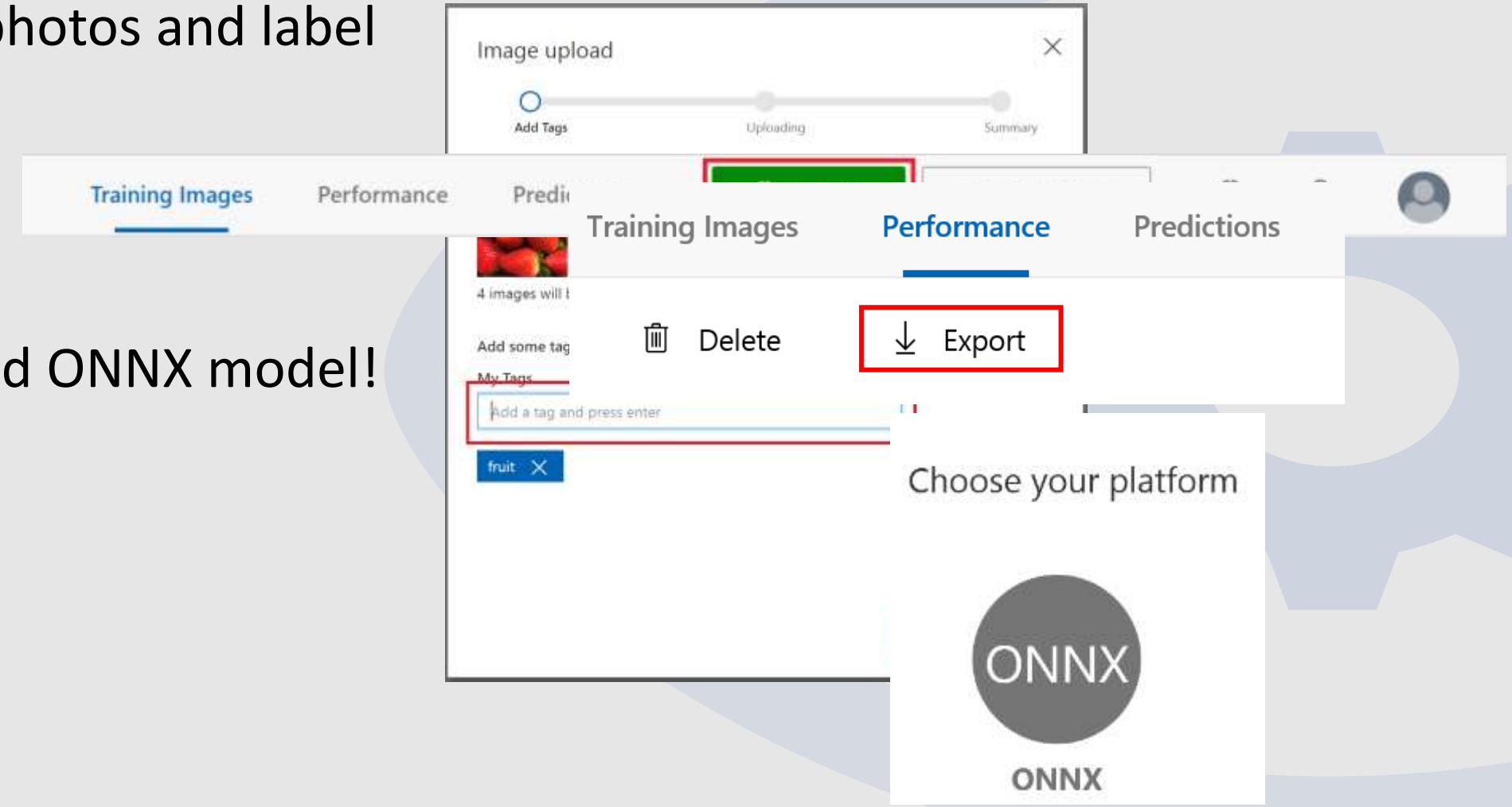
Model	Download	Checksum	Download (with sample test data)	ONNX version	Opset version	Top-1 accuracy (%)	Top-5 accuracy (%)
ResNet-18	44.6 MB	MD5	42.9 MB	1.2.1	7	69.70	89.49
ResNet-34	83.2 MB	MD5	78.6 MB	1.2.1	7	73.36	91.43
ResNet-50	97.7 MB	MD5	92.0 MB	1.2.1	7	75.81	92.82
ResNet-101	170.4 MB	MD5	159.4 MB	1.2.1	7	77.42	93.61
ResNet-152	230.3 MB	MD5	216.0 MB	1.2.1	7	78.20	94.21

Custom Vision Service: customvision.ai

1. Upload photos and label

2. Train

3. Download ONNX model!



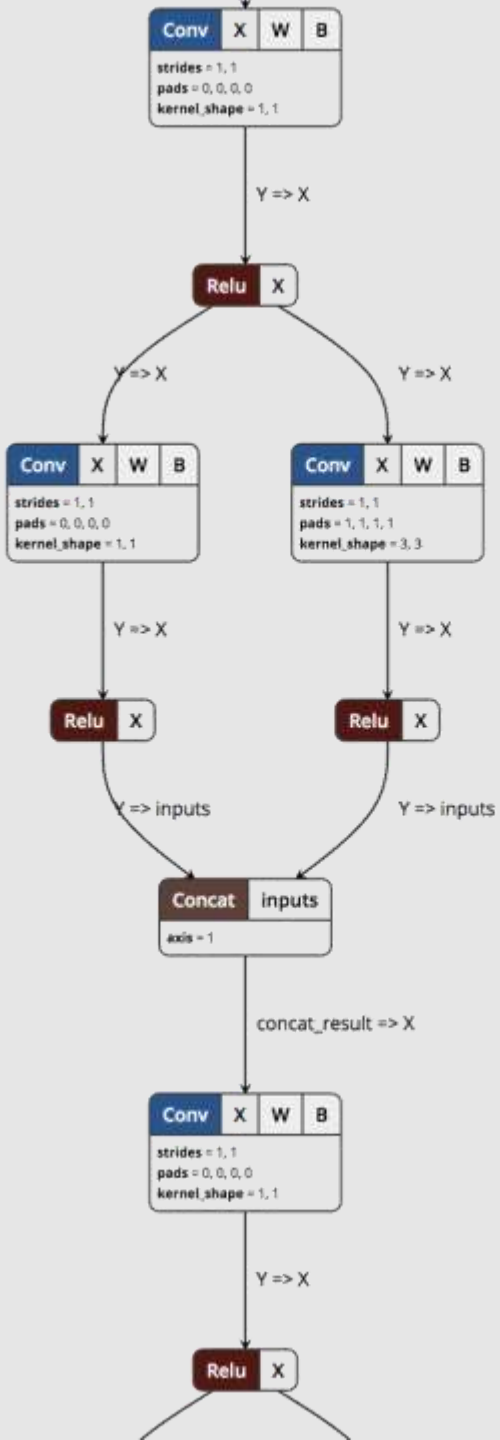
Convert models

Convert models

1. Load existing model
2. (Convert to ONNX)
3. Save ONNX model

ONNX Models

Graph of operations



Netron

https://lutzroeder.github.io/netron/

Convert models: Keras

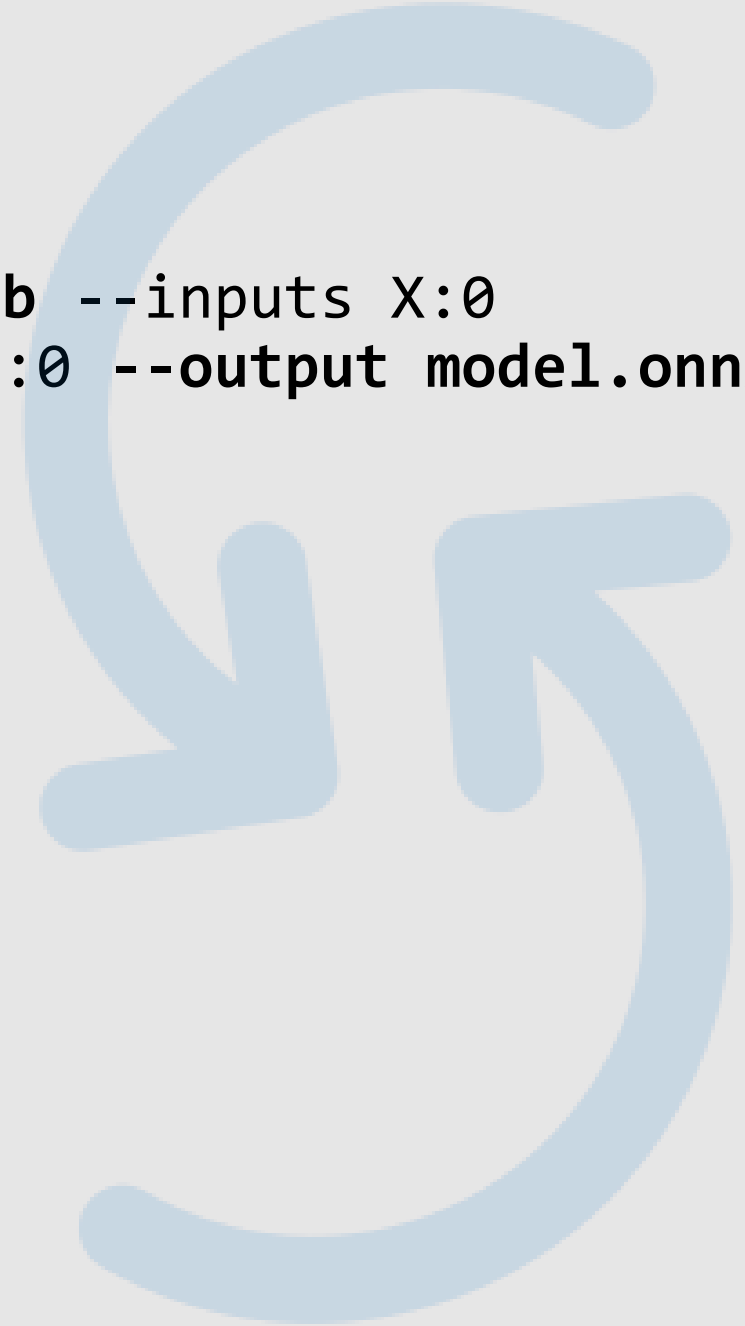
```
import numpy as np
from keras.preprocessing import image
from keras.applications.resnet50 import preprocess_input
import keras2onnx
import onnxruntime

# load keras model
from keras.applications.resnet50 import ResNet50
model = ResNet50(include_top=True, weights='imagenet')

# convert to onnx model
onnx_model = keras2onnx.convert_keras(model, model.name)
```

Convert models: Pytorch

```
import torch
import torchvision

dummy_input = torch.randn(10, 3, 224, 224, device='cuda')
model = torchvision.models.alexnet(pretrained=True).cuda()

input_names = [ "actual_input_1" ] + [ "learned_%d" % i for i in range(16) ]
output_names = [ "output1" ]

torch.onnx.export(model, dummy_input, "alexnet.onnx", verbose=True,
input_names=input_names, output_names=output_names)
```

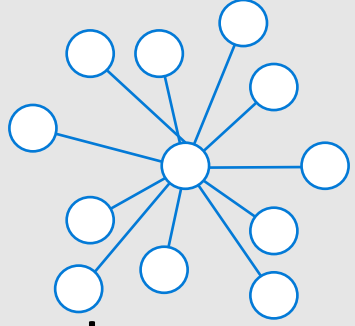
Convert models: TensorFlow

```
python -m tf2onnx.convert --input frozen.pb --inputs X:0
                          --outputs output:0 --output model.onnx
```



https://github.com/onnx/tensorflow-onnx

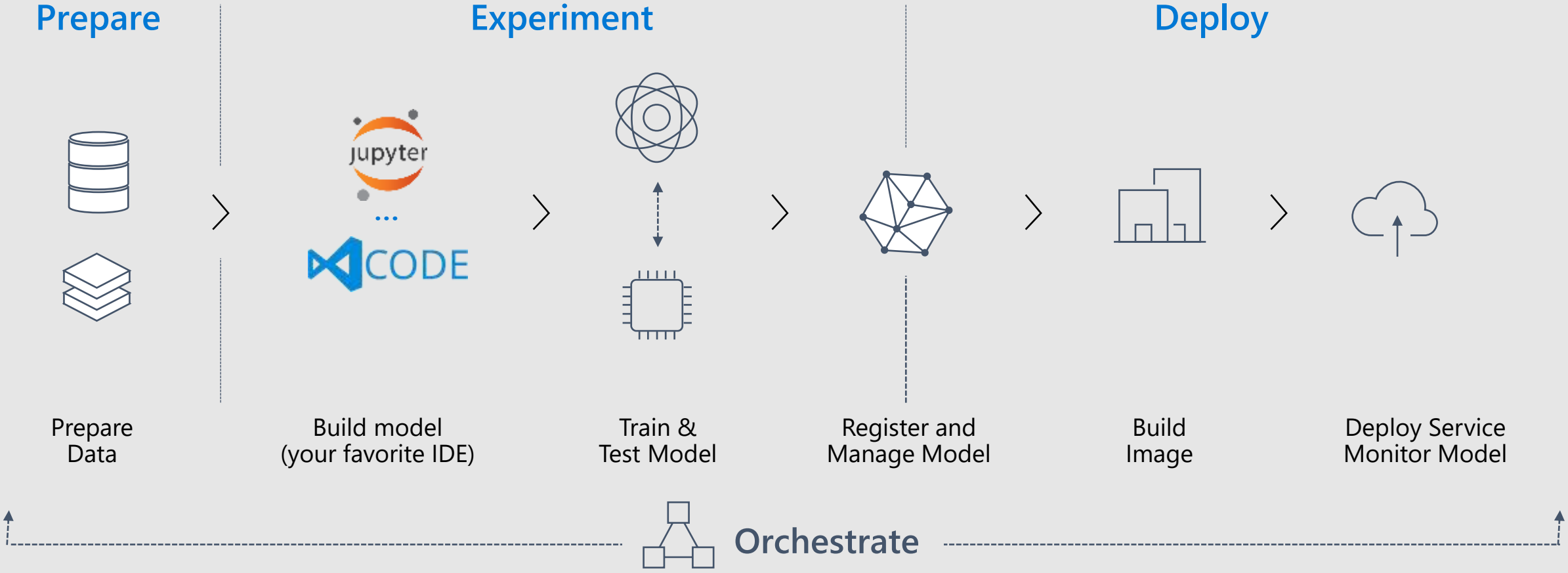
Train models in Azure Machine Learning



- Experiment locally then quickly scale with GPU clusters in the cloud
- Use automated machine learning and hyper-parameter tuning.
- Keeping Track of experiments, manage models, and easily deploy with integrated CI/CD tooling

Machine Learning

Typical E2E Process



high dimensional matrices

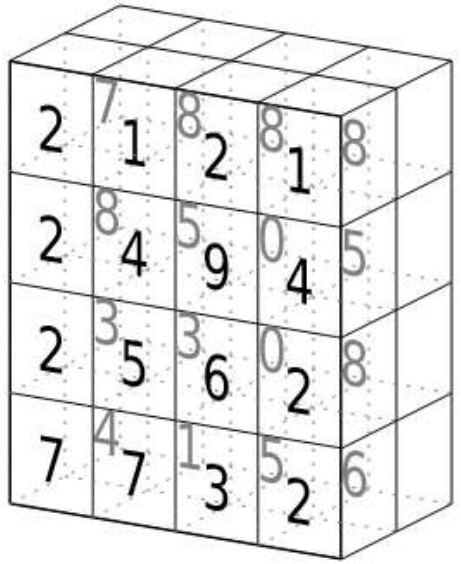
tensor

't'
'e'
'n'
's'
'o'
'r'

tensor of dimensions [6]
(vector of dimension 6)

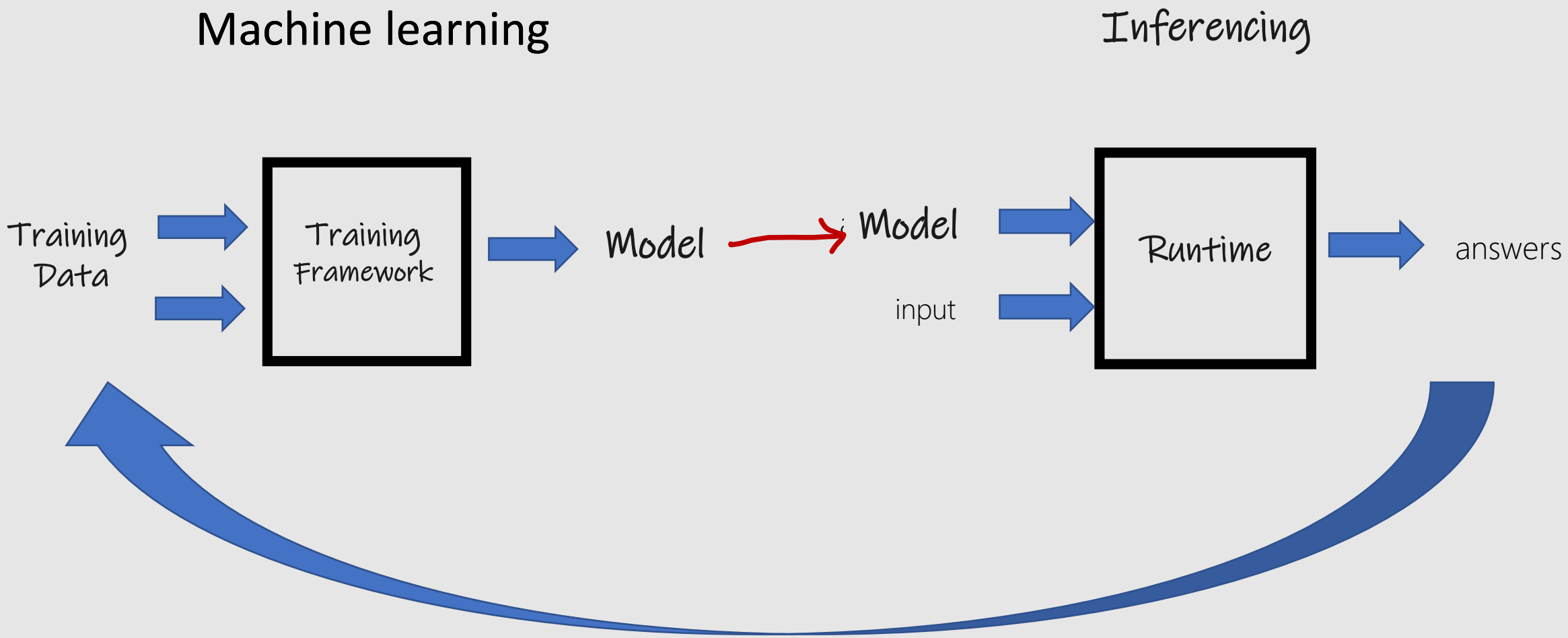
3	1	4	1
5	9	2	6
5	3	5	8
9	7	9	3
2	3	8	4
6	2	6	4

tensor of dimensions [6,4]
(matrix 6 by 4)



tensor of dimensions [4,4,2]

ML Primer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Native support

Converters

Native support

Step 1: Create

Services

Azure Custom Vision Service

ONNX Model

Azure

Azure Machine Learning services

Ubuntu VM

Windows Server 2019 VM

Native support

Windows Devices

Step 2: Deploy

Converters

Other Devices (iOS, etc)


Baker
vs
Starting a Bakery

Create

Frameworks

Caffe2 · Chainer · Cognitive Toolkit

mxnet · PyTorch · PaddlePaddle

ML.NET · MathWorks · dmlc XGBoost

ML · scikit-learn · TensorFlow · Keras

Services

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Native support

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Deploy

Azure

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Windows Devices

IoT Edge Devices

Other Devices
(iOS, etc)


Cloud
or
Edge

Cloud or Edge

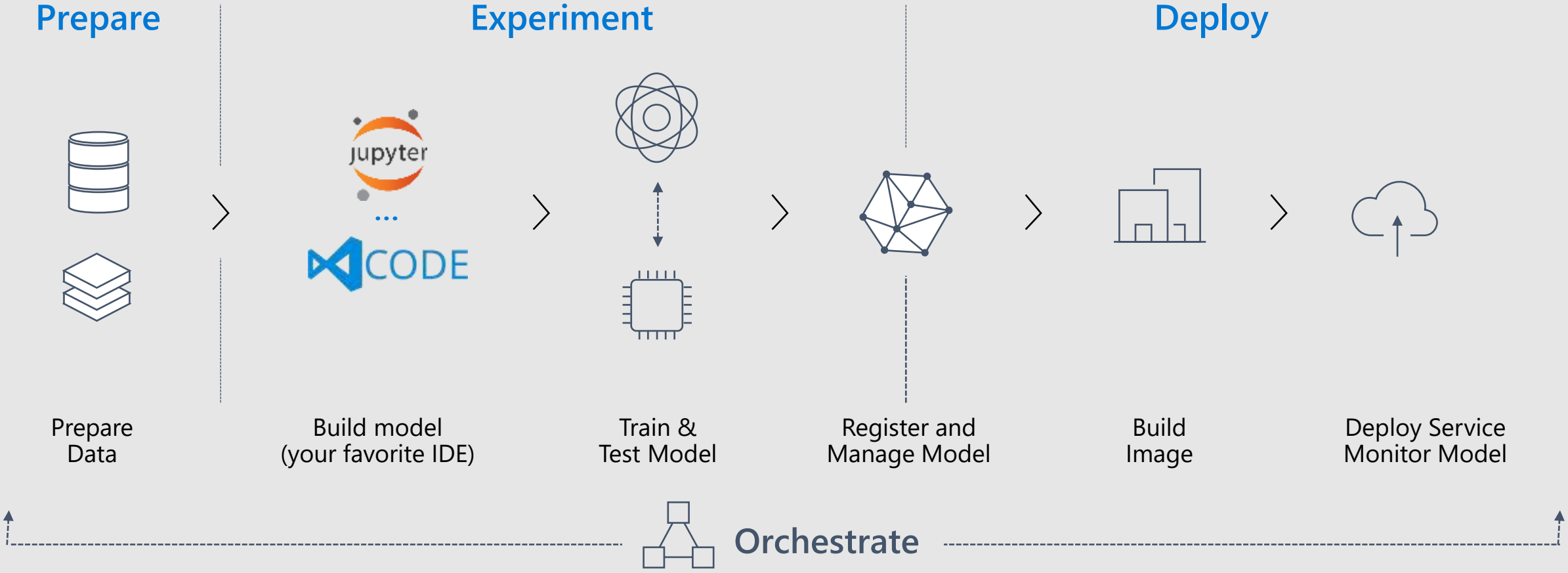
Deploy with Azure Machine Learning

- Model management services
- Deploy as web service to ACI or AKS
- Capture model telemetry

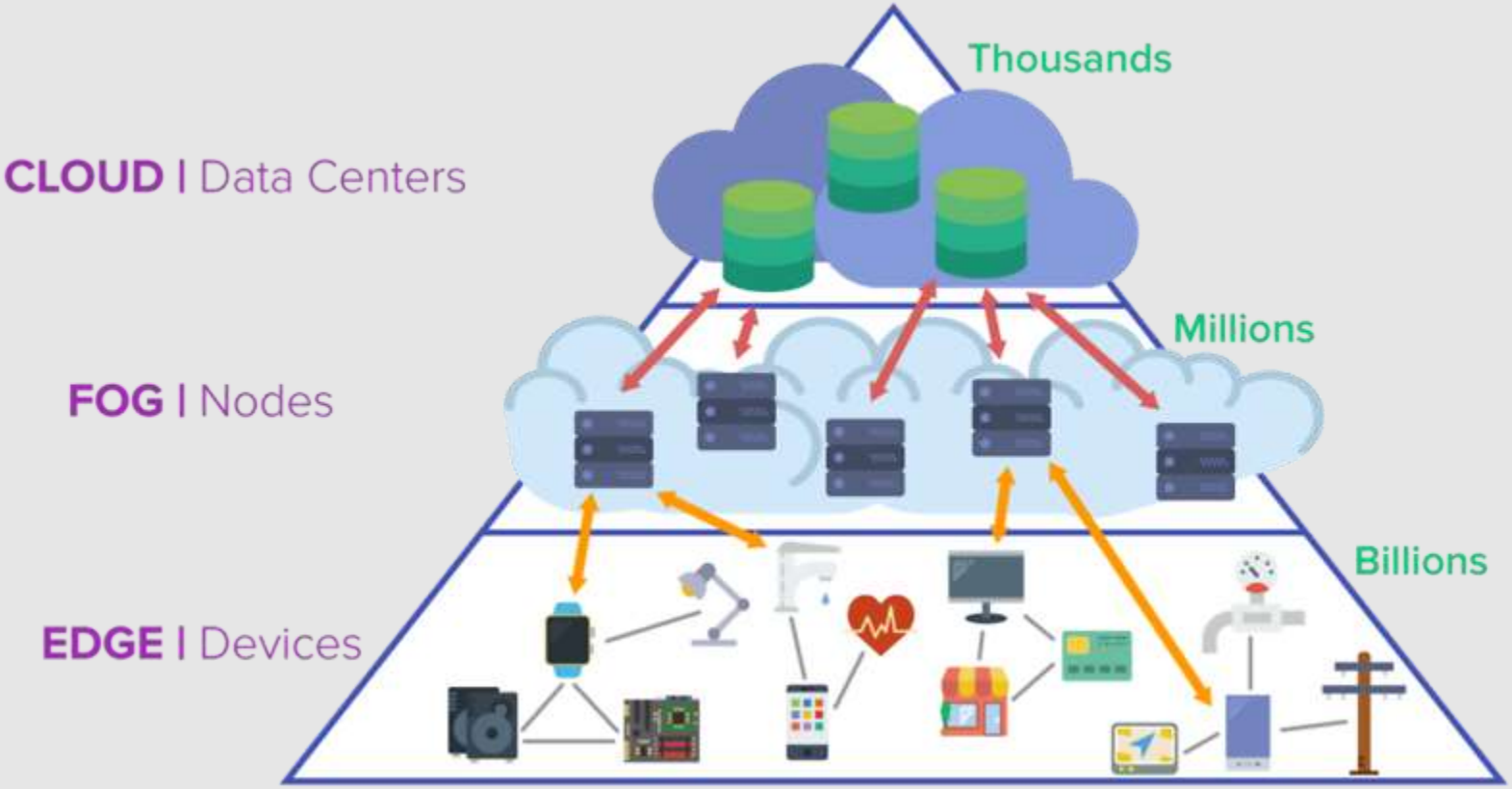
Azure
Machine Learning

Machine Learning

Typical E2E Process

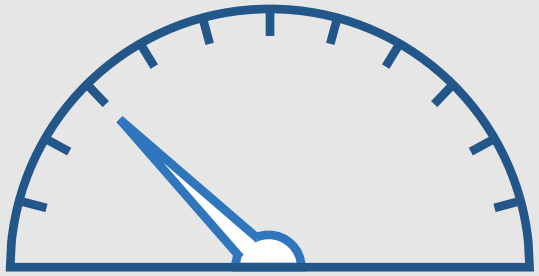


What is the Edge?

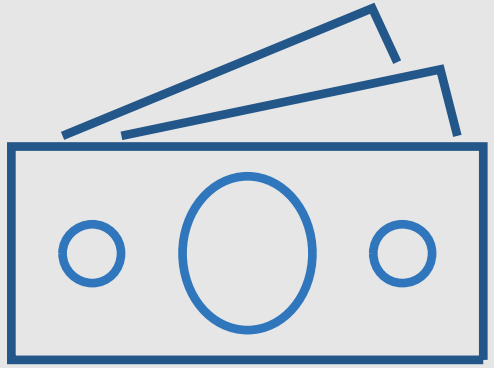


Imagimob AB

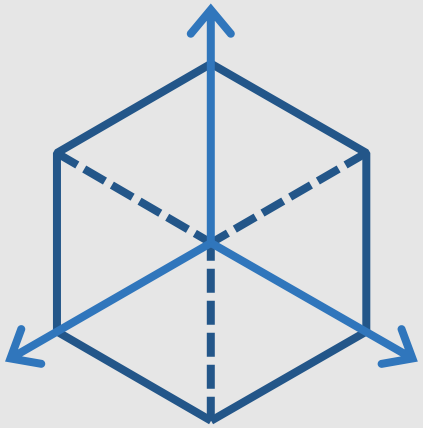
AI on the edge



Low latency



Scalability



Flexibility

ONNX as an intermediary format

- **Convert to Tensorflow for Android**
  - Convert a PyTorch model to Tensorflow using ONNX
- **Convert to CoreML for iOS**
  - https://github.com/onnx/onnx-coreml
- **Fine-tuning an ONNX model with MXNet/Gluon**
  - https://mxnet.apache.org/versions/master/tutorials/onnx/fine_tuning_gluon.html

ONNX Runtime

- High performance runtime for ONNX models
- Supports full ONNX-ML spec (currently v1.2+)
- Extensible architecture to plug-in hardware accelerators
- Simple Python API

ONNX

ONNX Runtime

ONNX

Get Started Easily

Select your requirements and use the resources provided to get started quickly

OS	Windows	**Linux**	Mac		
Language	Python (3.5-3.7)	C++	**C#**	C	Java
Architecture	**X64**	X86	ARM64	ARM32	
Hardware Acceleration	Default CPU	**CUDA**	TensorRT	DirectML	MKL-DNN
	MKL-ML	nGraph	NUPHAR	OpenVINO	
Installation Instructions	Install Nuget package Microsoft.ML.OnnxRuntime.Gpu				

Demo

https://github.com/rondagdag/LeverageONNX

ONNX Docker Image

ONNX

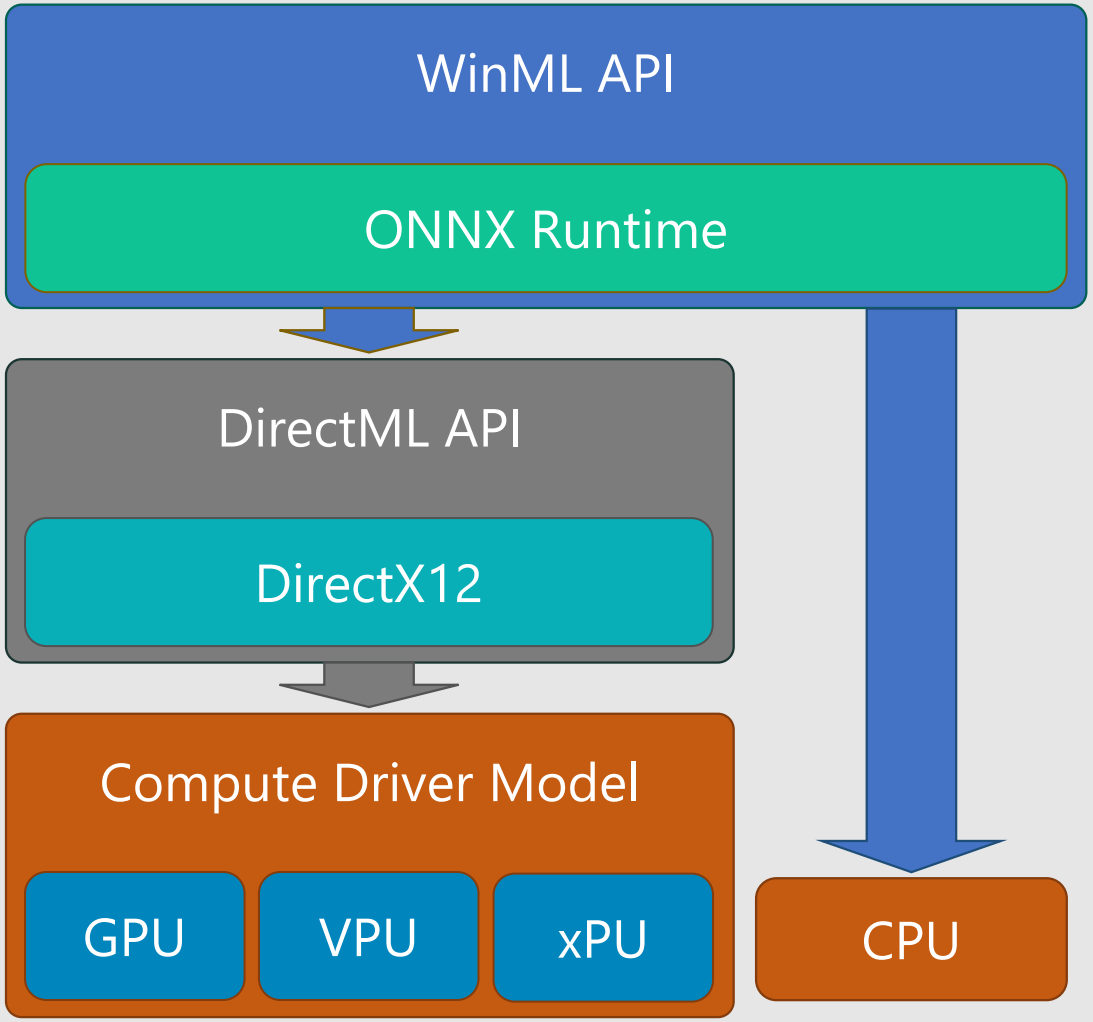
- onnx-base: Use published ONNX package from PyPi with minimal dependencies.
- onnx-dev: Build ONNX from source with minimal dependencies.
- onnx-ecosystem: Jupyter notebook environment for getting started quickly with ONNX models, ONNX converters, and inference using ONNX Runtime.

Deploy to Windows Devices

Windows ML

- Available across Windows family of devices
- Hardware abstraction via DirectML
- Unified API for Win32 and WinRT
- Optimized for performance
- Virtualization ready

Windows AI platform



- WinML
  - **Practical**, simple model-based API for ML inferencing on Windows
- DirectML
  - **Realtime, high control** ML operator API; part of DirectX family
- Compute Driver Model
  - Robust **hardware reach**/abstraction layer for compute and graphics silicon

ONNX Runtime

- Microsoft services have seen an **average 2x performance gain on CPU**
- Office team saw a **14.6x reduction in latency** for a grammar checking model (thousands of queries per minute)
- Azure Cognitive Services saw a **3.5x reduction in latency** for an optical character recognition (OCR) model
- Bing QnA saw a **2.8x reduction in latency** for a model that generates answers to questions
- Bing Visual Search saw a **2x reduction in latency** for a model that helps identify similar images

https://cloudblogs.microsoft.com/opensource/2019/05/22/onnx-runtime-machine-learning-inferencing-0-4-release/

ONNX Runtime - Python API

```
import onnxruntime

session = onnxruntime.InferenceSession("mymodel.onnx")

results = session.run([], {"input": input_data})
```

ONNX

Reference implementation to use ONNX Runtime with Azure IoT Edge

- https://github.com/Azure-Samples/onnxruntime-iot-edge

ONNX

ONNX.js

- ONNX.js is a JavaScript library for running ONNX models on browsers and on Node.js.
- ONNX.js has adopted Web Assembly and WebGL technologies
- optimized ONNX model inference runtime for both CPUs and GPUs.

https://github.com/microsoft/onnxjs

ONNX

ONNX.js

Compatibility

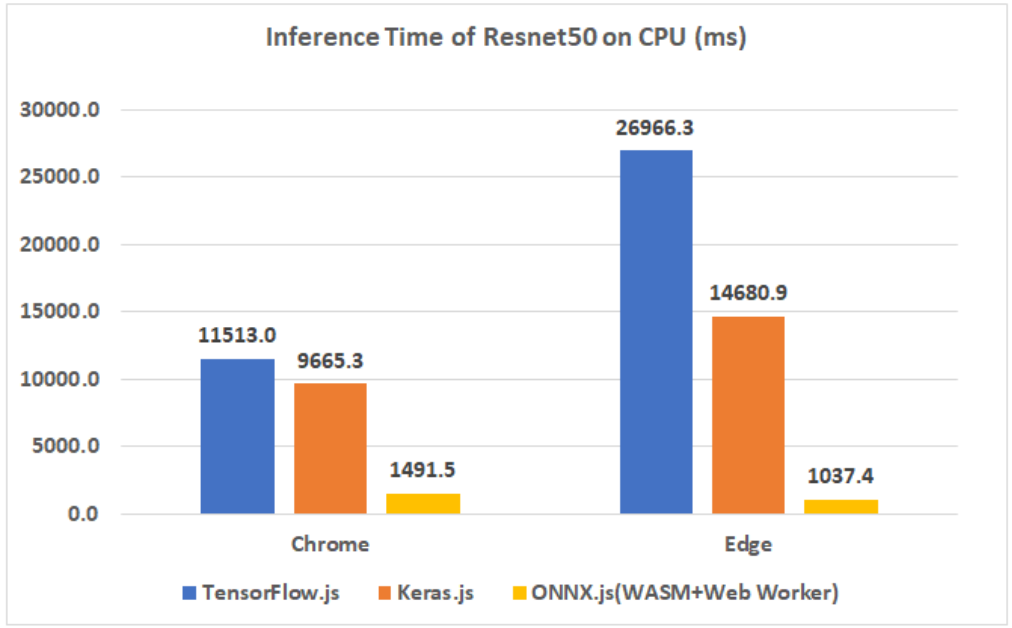
Desktop Platforms

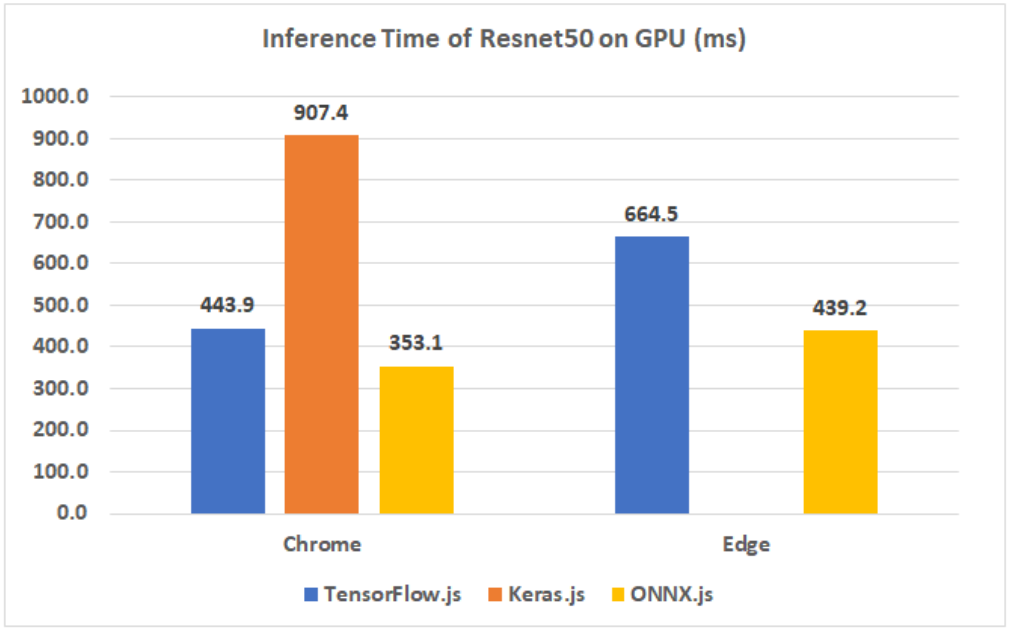
OS/Browser	Chrome	Edge	FireFox	Safari	Opera	Electron	Node.js
Windows 10	✓	✓	✓	-	✓	✓	✓
macOS	✓	-	✓	✓	✓	✓	✓
Ubuntu LTS 18.04	✓	-	✓	-	✓	✓	✓

Mobile Platforms

OS/Browser	Chrome	Edge	FireFox	Safari	Opera
iOS	✓	✓	✓	✓	✓
Android	✓	✓	Coming soon	-	✓

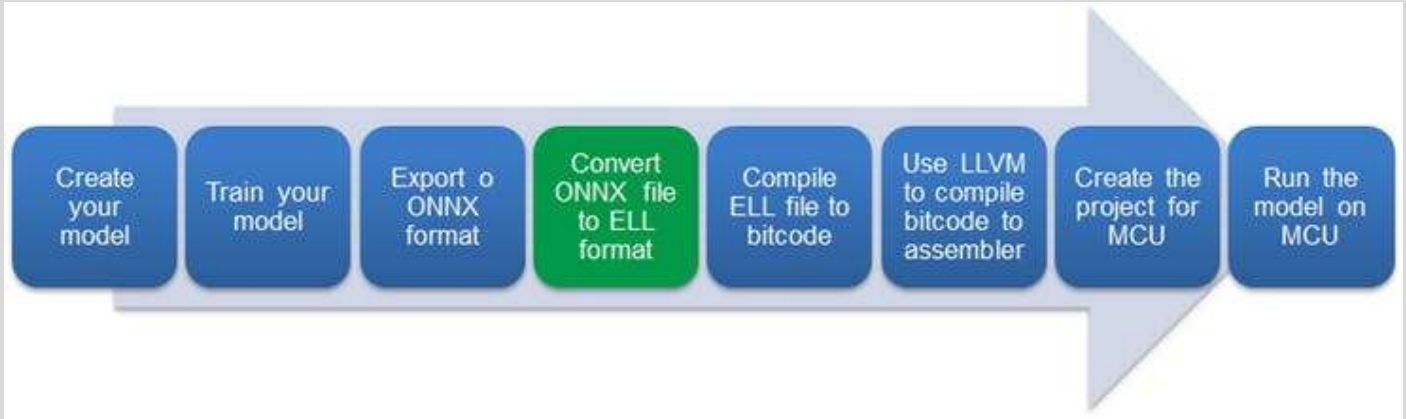
ONNX.js

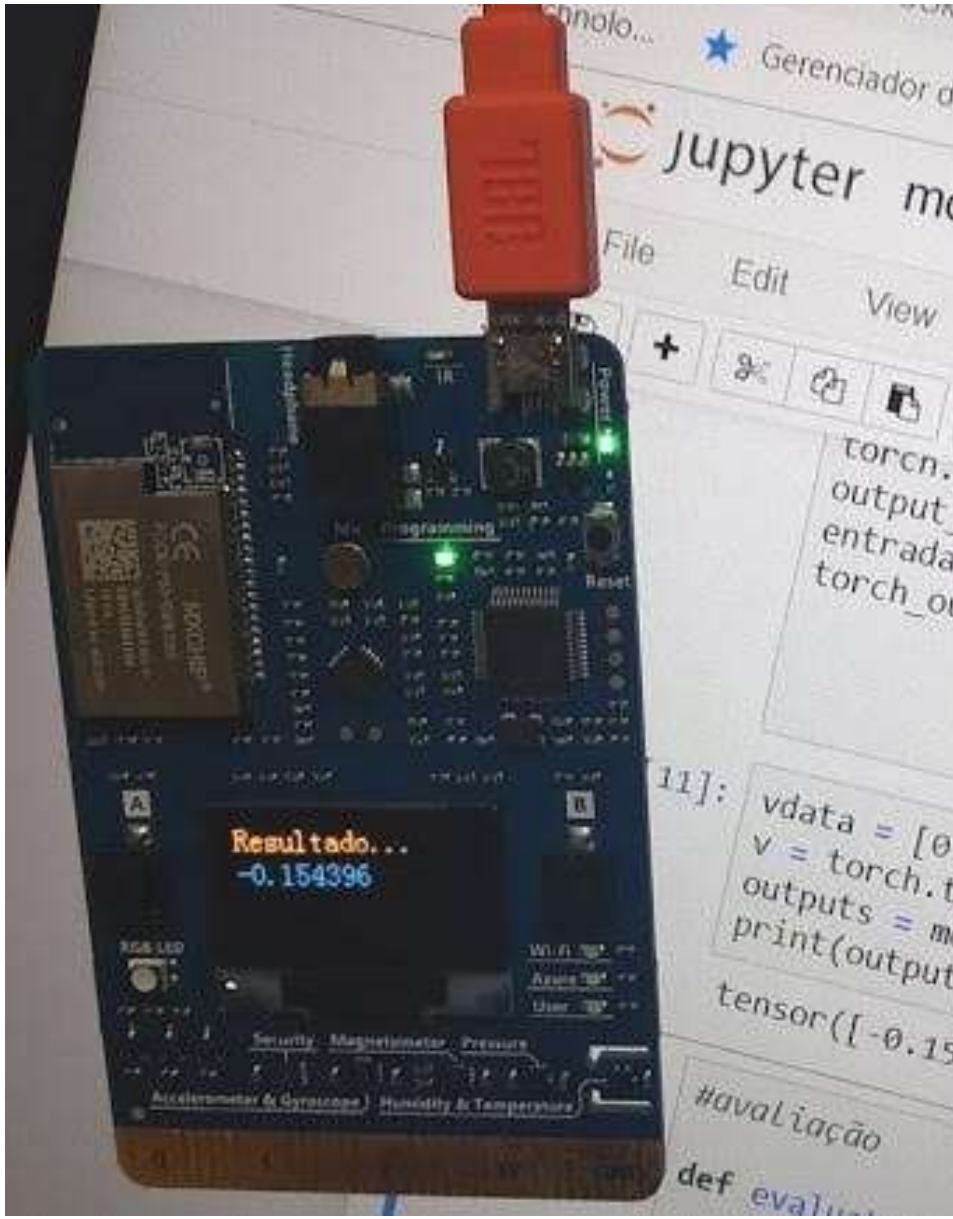

Inference Time of Resnet50 on CPU (ms)
30000.0
25000.0
20000.0
15000.0
10000.0
5000.0
0.0
11513.0
9665.3
1491.5
26966.3
14680.9
1037.4
Chrome
Edge
TensorFlow.js
Keras.js
ONNX.js(WASM+Web Worker)


Inference Time of Resnet50 on GPU (ms)
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
443.9
907.4
353.1
664.5
439.2
Chrome
Edge
TensorFlow.js
Keras.js
ONNX.js

Wait… there's more

- Embedded Learning Library
  - https://github.com/microsoft/ELL
- Machine Learning Model Running on Azure IoT Starter Kit
  - https://www.hackster.io/waltercoan/machine-learning-model-running-on-azure-iot-starter-kit-f9608b





Recap

- ✓ What is ONNX

  ONNX is an open standard so you can use the right tools for the job and be confident your models will run efficiently on your target platforms

- ✓ How to create ONNX models

  ONNX models can be created from many frameworks

- ✓ How to deploy ONNX models

  ONNX models can be deployed with Windows ML, .NET/Javascript/Python and to the cloud with Azure ML and the high performance ONNX Runtime

Try it for yourself!

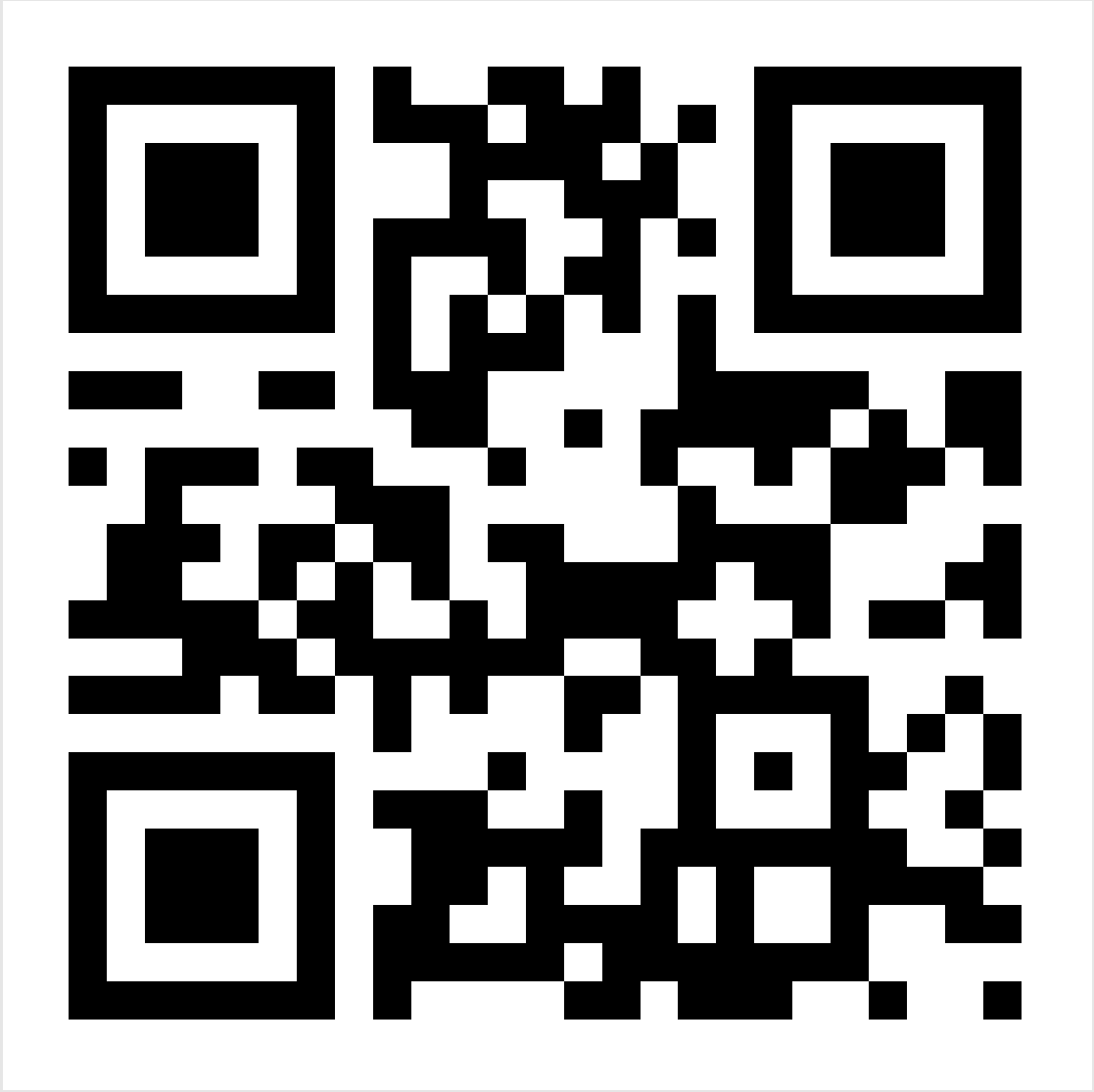
ONNX Runtime is available now!

```
pip install onnxruntime
pip install onnxruntime-gpu
```

Documentation and samples at aka.ms/onnxruntime

Source for Demo:

https://github.com/rondagdag/onnx-pected



http://bit.ly/ml-onnx

About Me

Ron Dagdag

- Sr. Software Developer/AI Edge Engineer at Spacee
- Microsoft MVP award – Windows Development
- Personal Projects
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- Feedback appreciated, help improve my presentation skills