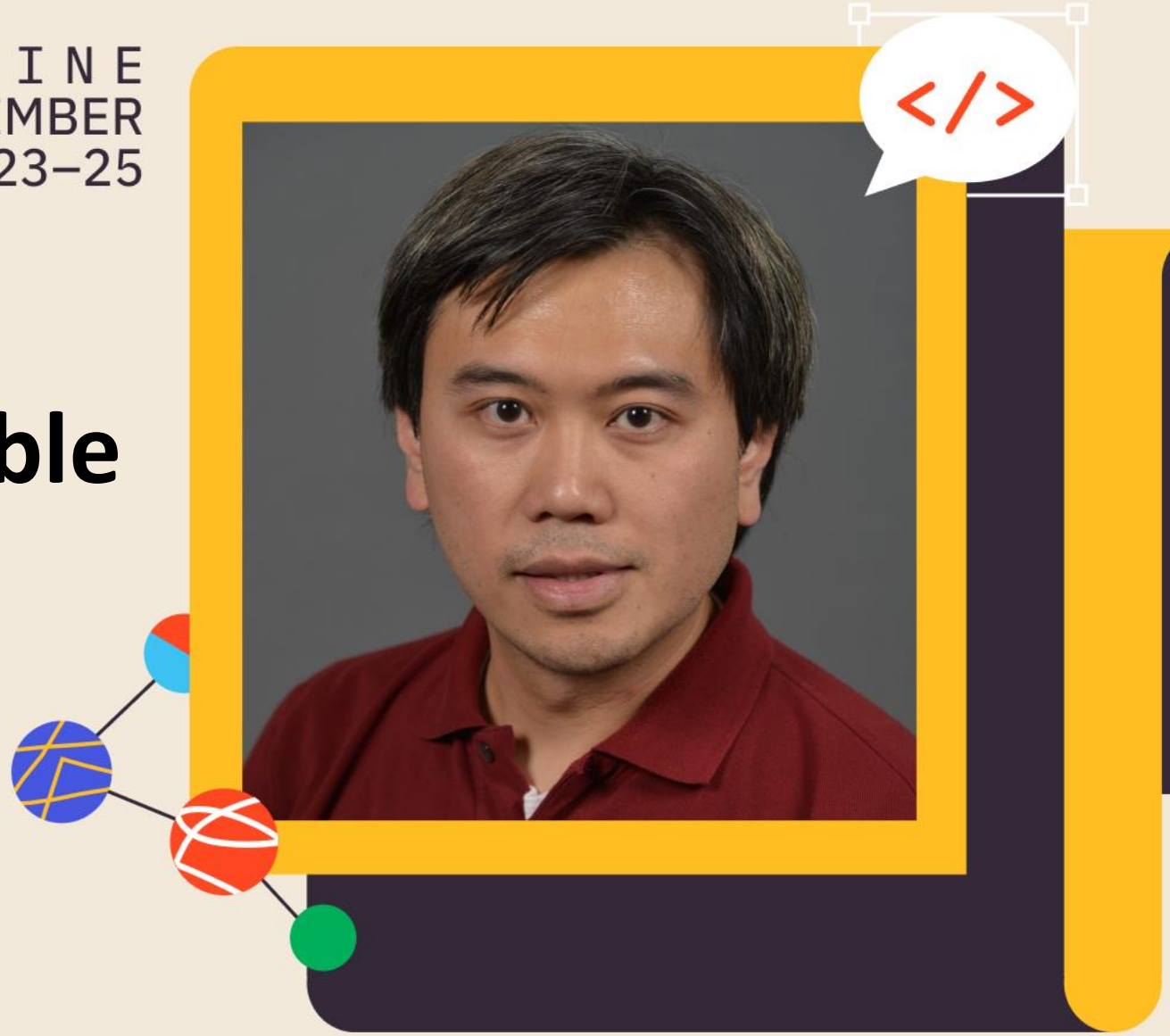
JavaScript Congress 2021

ONLINE
NOVEMBER
23–25

Making Neural Network Portable with ONNX



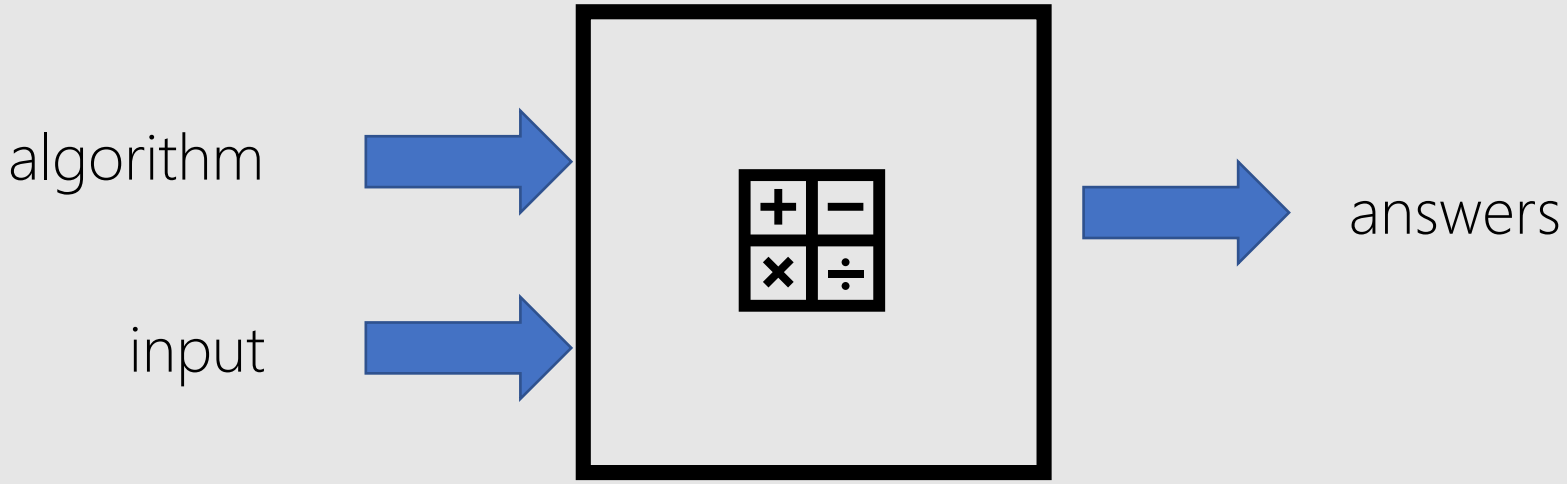
Ron Dagdag

Lead Software Engineer at Spacee and Microsoft MVP

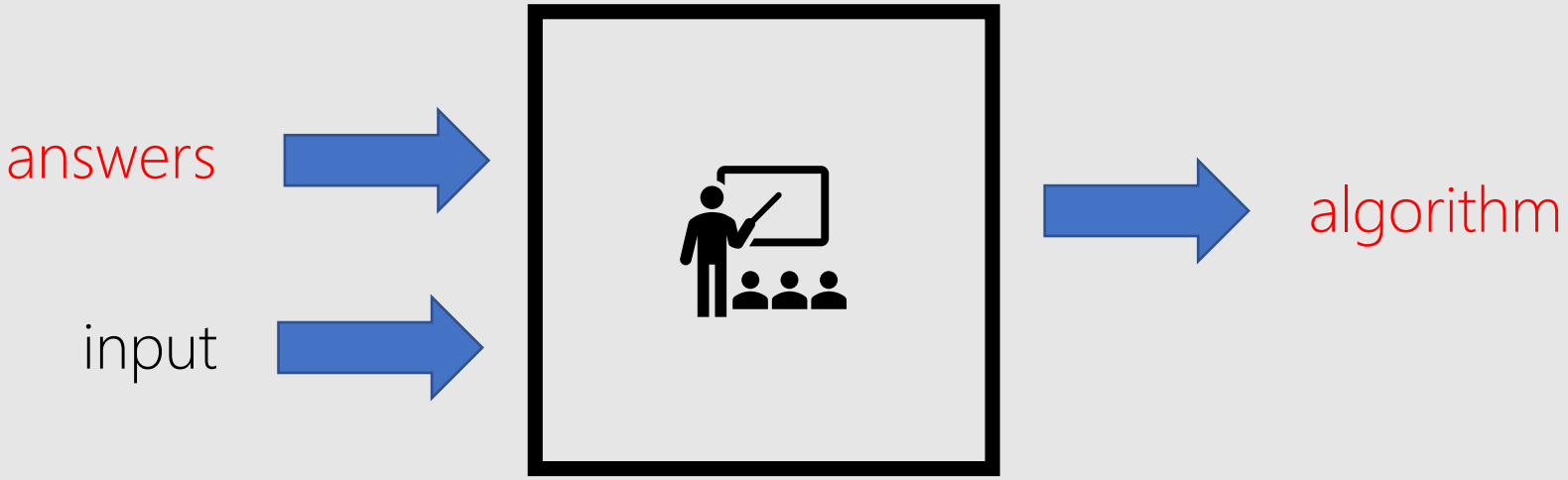
jscongress.com

ONNX
Not ONIX
Not ONYX

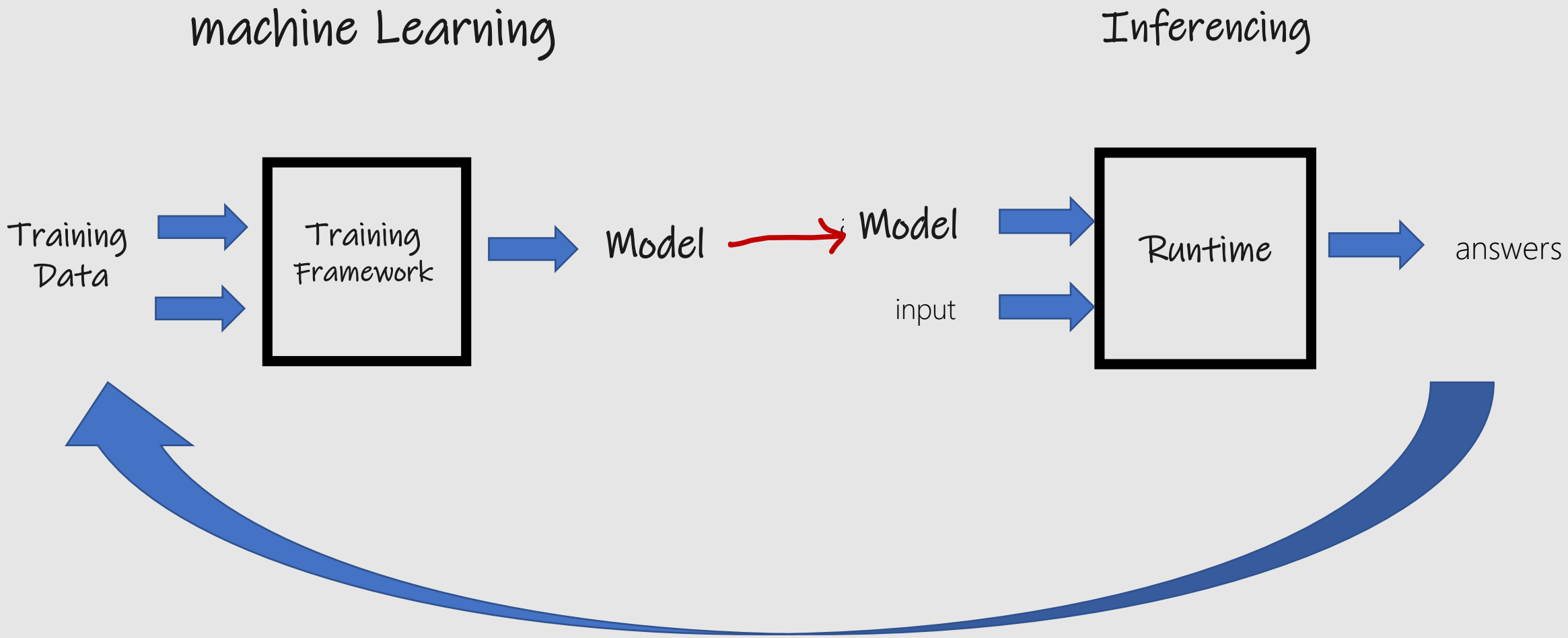
programming



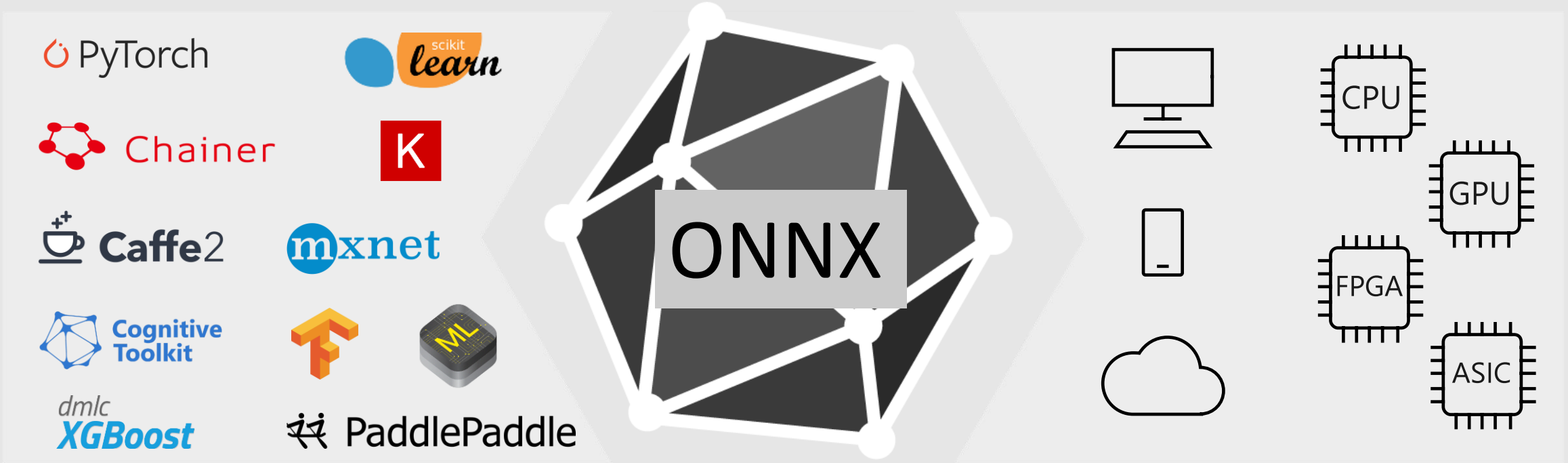
machine learning

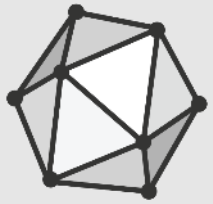


ML Primer


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

11.7k
Github Stars

~2000
Pull
Requests

200+
Contributors

2.2k Github
Forks

40+ Model
Zoo

LF AI
GRADUATE
PROJECT

Agenda

- ✓ What is ONNX, When to use ONNX
- ❑ How to create ONNX models
- ❑ How to deploy ONNX models

When to use ONNX?

- Trained in Python - deploy into a C#/Java/Javascript app
- High Inferencing latency for production use
- Model to run resource on IoT/edge devices
- Model to run on different OS or Hardware
- Combine running models created from different frameworks
- Training takes too long (transformer models)

Create

Frameworks

Caffe2 · Chainer · Cognitive Toolkit

mxnet · PyTorch · PaddlePaddle

ML.NET · MathWorks · dmlc XGBoost

ML · scikit learn · TensorFlow · Keras

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 VM

Windows Devices

IoT/Edge Devices

Other Devices
(iOS, Android, etc)

Frameworks

Caffe2 Chainer Cognitive Toolkit

mxnet PyTorch PaddlePaddle

ML.NET MathWorks dmlc XGBoost

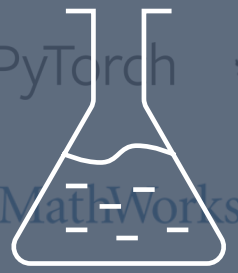
Services

Azure Custom Vision Service

Native support

Converters

Native support



Step 1: Create

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)

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

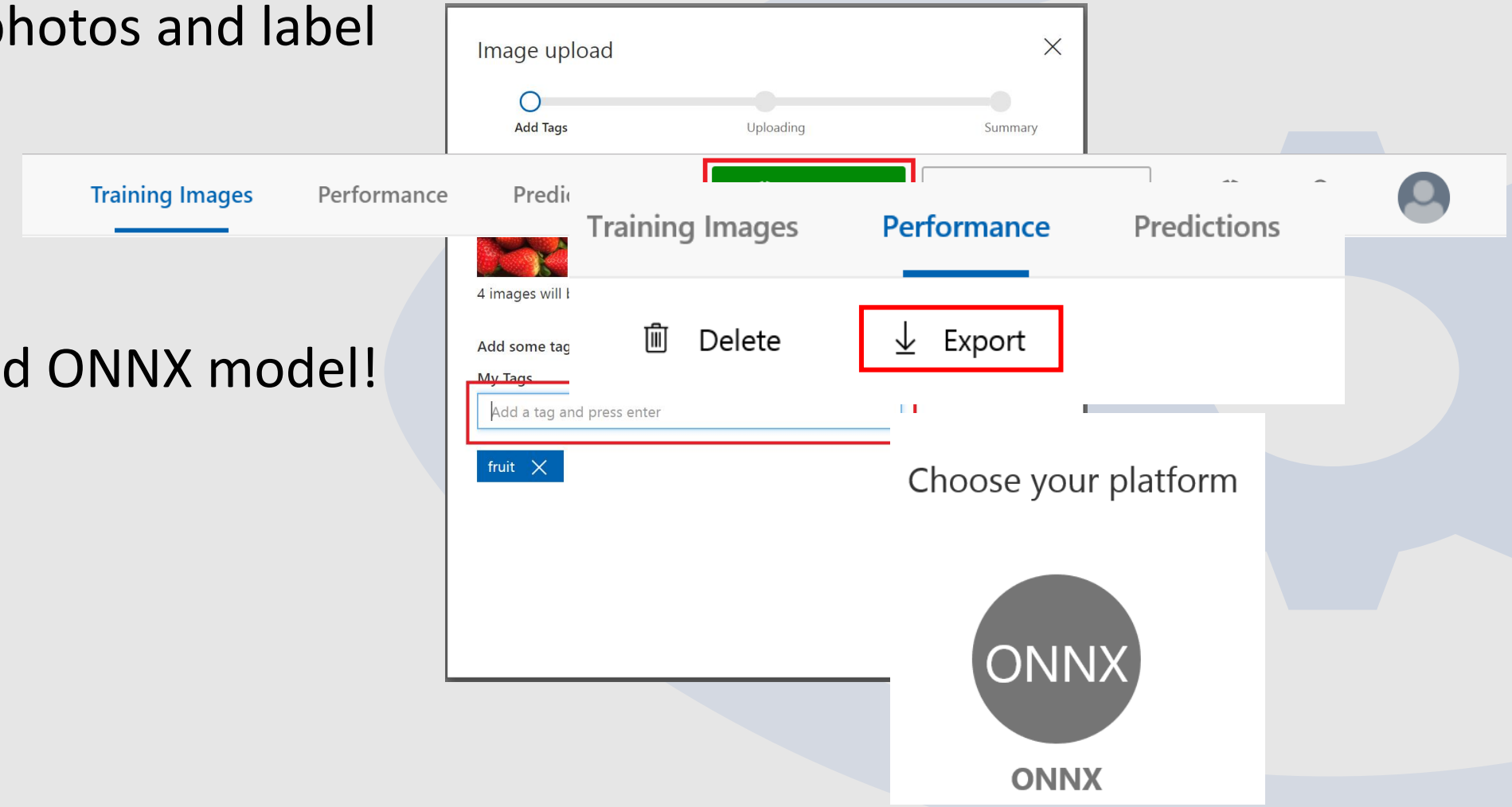
Model	Download	Checksum	Download (with sample test data)	ONNX version	Opset version	Top-1 accuracy (%)	Top-5 accuracy (%)
ResNet-18	44.6 MB	MD5	42.9 MB	1.2.1	7	69.70	89.49
ResNet-34	83.2 MB	MD5	78.6 MB	1.2.1	7	73.36	91.43
ResNet-50	97.7 MB	MD5	92.0 MB	1.2.1	7	75.81	92.82
ResNet-101	170.4 MB	MD5	159.4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

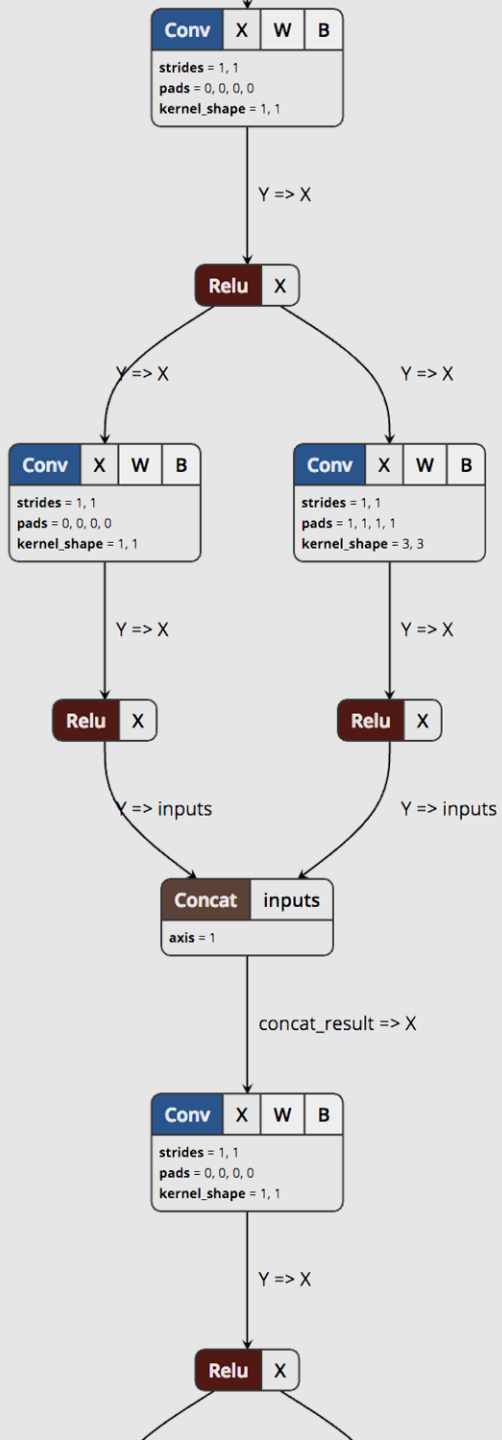
Convert models

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

https://github.com/onnx/tutorials

ONNX Models

Graph of operations



Netron

https://netron.app/

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

Convert models: PyTorch

```
import torch
import torch.onnx

model = torch.load(“model.pt”)

sample_input = torch.randn(1, 3, 224, 224)

torch.onnx.export(model, sample_input, “model.onnx")
```

Convert models: Keras

In [ ]:
```
import onnxmltools
from keras.models import load_model
```

In [ ]:
```
# Update the input name and path for your Keras model
input_keras_model = 'model.h5'

# Change this path to the output name and path for the ONNX model
output_onnx_model = 'model.onnx'
```

In [ ]:
```
# Load your Keras model
keras_model = load_model(input_keras_model)

# Convert the Keras model into ONNX
onnx_model = onnxmltools.convert_keras(keras_model)

# Save as protobuf
onnxmltools.utils.save_model(onnx_model, output_onnx_model)
```

Convert models:


```
> python -m tf2onnx.convert
            --saved-model tensorflow-model-path
            --output model.onnx
```

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

Convert models:

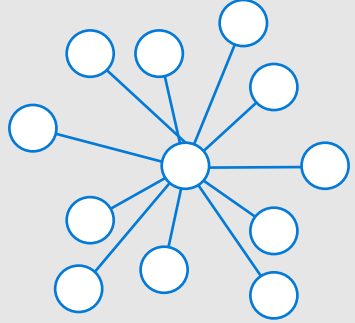

```
# Train a model.
from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
iris = load_iris()
X, y = iris.data, iris.target
X_train, X_test, y_train, y_test = train_test_split(X, y)
clr = RandomForestClassifier()
clr.fit(X_train, y_train)

# Convert into ONNX format
from skl2onnx import convert_sklearn
from skl2onnx.common.data_types import FloatTensorType
initial_type = [('float_input', FloatTensorType([None, 4]))]
onx = convert_sklearn(clr, initial_types=initial_type)
with open("rf_iris.onnx", "wb") as f:
    f.write(onx.SerializeToString())
```

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/1.3.1/tutorials/onnx/fine_tuning_gluon.html

https://github.com/onnx/tutorials

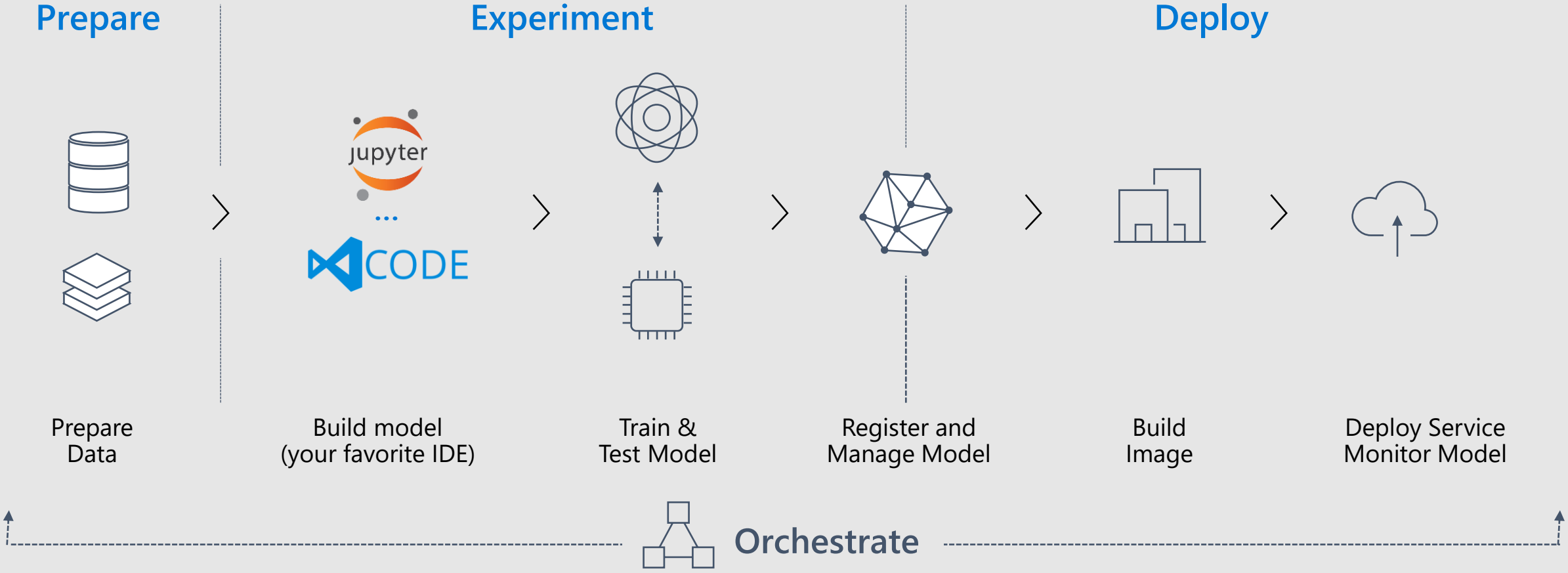
Train models in the Cloud



- 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



Frameworks

Caffe2 Chainer Cognitive Toolkit

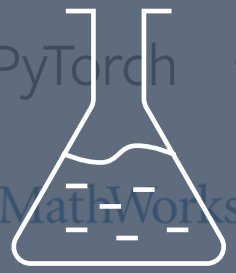
mxnet PyTorch PaddlePaddle

ML.NET MathWorks dmlc XGBoost

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

Azure Custom Vision Service

Native support

Converters

Native support

ONNX Model

Native support

Converters

Deploy

Azure

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

Windows/Linux Devices

IoT Edge Devices

Other Devices
(iOS, etc)


Cloud
or
Edge

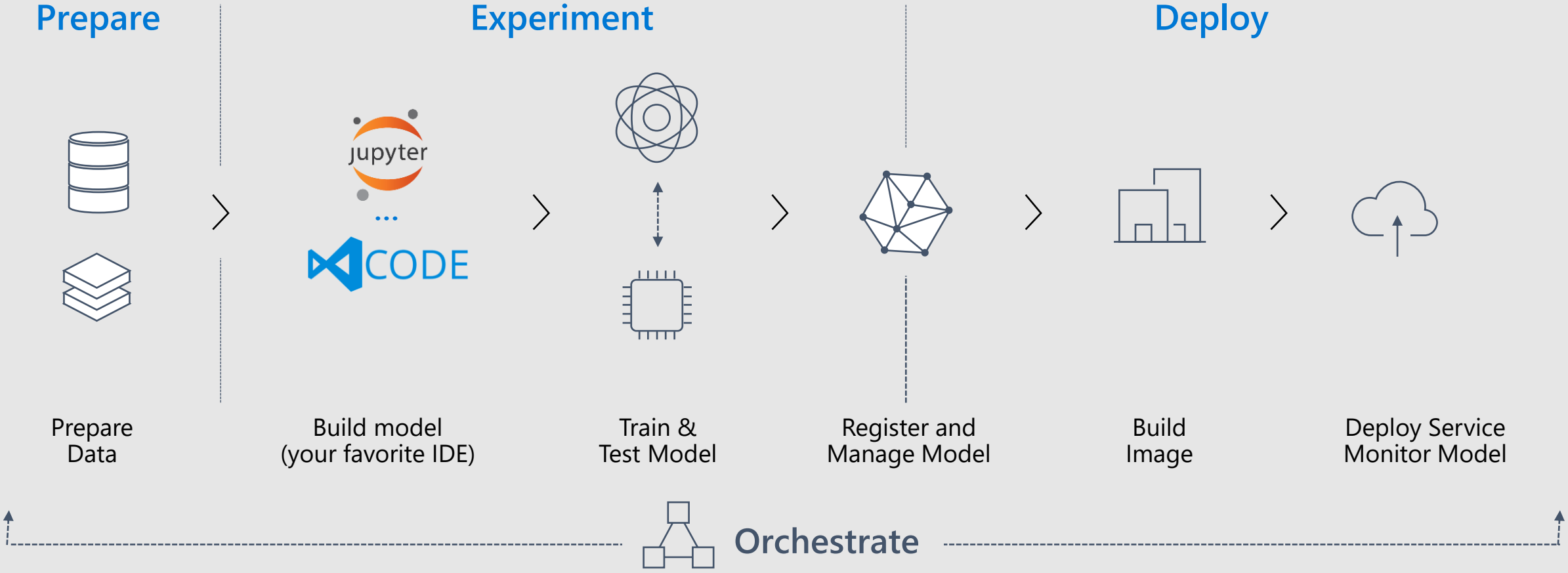
Deploy in Cloud

- Model management services
- Deploy as web service
- Capture model telemetry

Azure
Machine Learning

Machine Learning

Typical E2E Process



ONNX Docker Image

ONNX

onnx-base: Use published ONNX package from PyPi with minimal dependencies.

onnx-dev: Build ONNX from source with minimal dependencies.

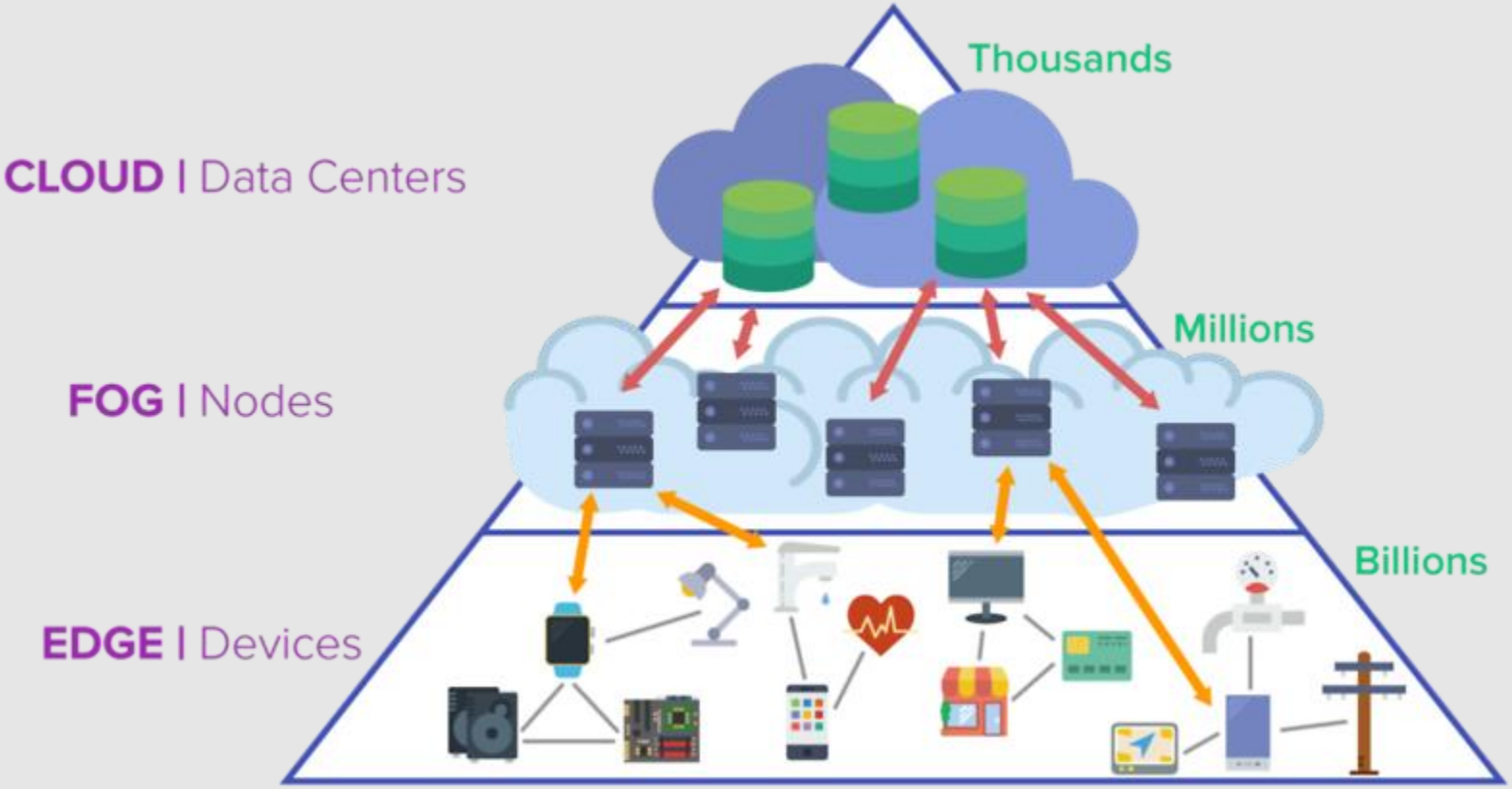
onnx-ecosystem: Jupyter notebook environment

- getting started quickly with ONNX models
- ONNX converters
- inference using ONNX Runtime.

Caffe2/PyTorch Docker

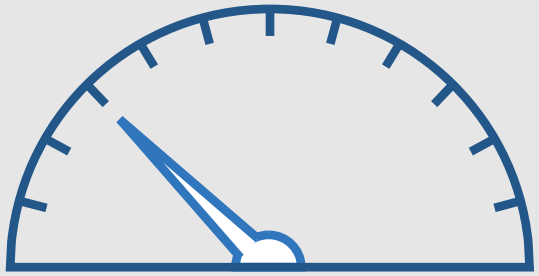
```
docker run -it --rm onnx/onnx-docker:cpu /bin/bash
```

What is the Edge?

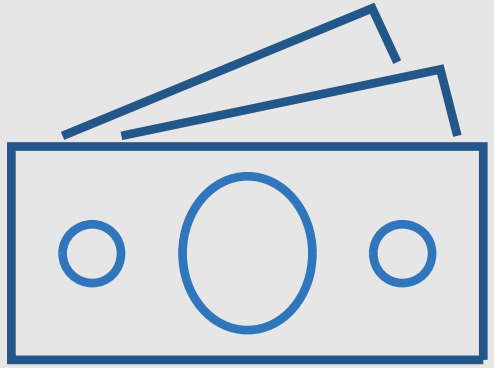


Imagimob AB

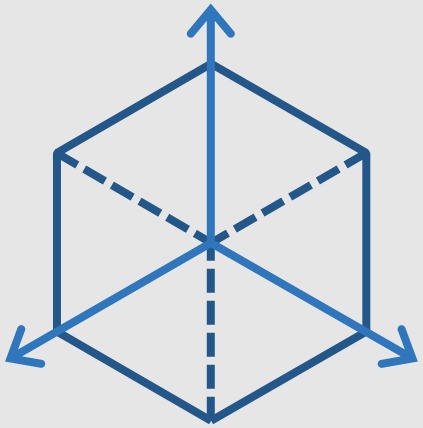
AI on the edge



Low latency



Scalability



Flexibility

ONNX Runtime

- High performance inference engine for ONNX models
- Founded and Open Sourced by Microsoft under MIT License
- Supports full ONNX-ML spec
- Extensible architecture to plug-in hardware accelerators
- Ships with Windows 10 as WinML
- onnxruntime.ai

ONNX

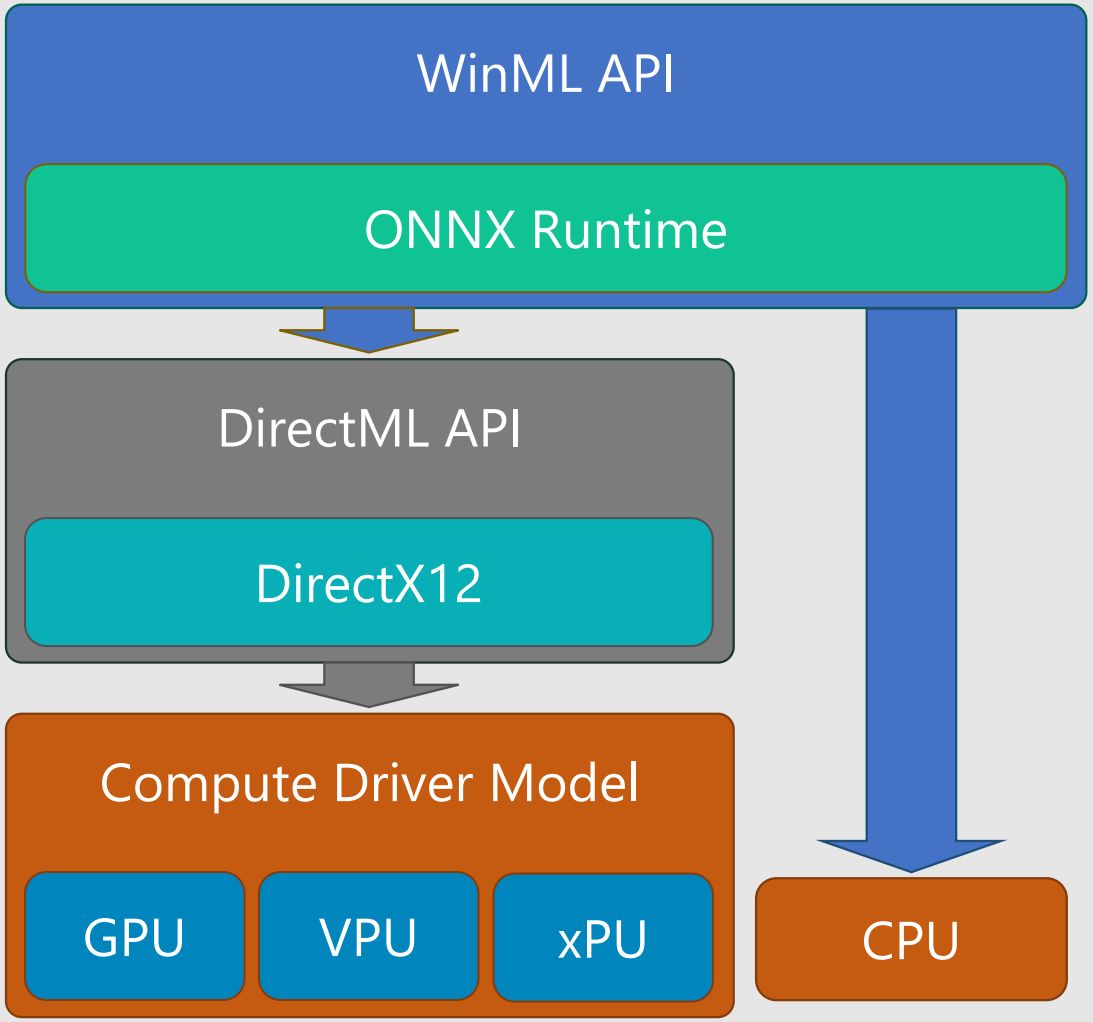
ONNX Runtime

Get Started Easily

Optimize Inferencing | Optimize Training

Platform	Windows	**Linux**	Mac	Android	iOS	Web Browser (Preview)	
API	Python	C++	**C#**	C	Java	JS	Obj-C	WinRT
Architecture	**X64**	X86	ARM64	ARM32	IBM Power		
Hardware Acceleration	Default CPU	**CUDA**	DirectML	oneDNN	OpenVINO		
	TensorRT	NNAPI	ACL (Preview)	ArmNN (Preview)	CoreML (Preview)		
	MIGraphX (Preview)	NUPHAR (Preview)	Rockchip NPU (Preview)	Vitis AI (Preview)			
Installation Instructions	Install Nuget package **Microsoft.ML.OnnxRuntime.Gpu** Refer to **docs** for requirements.						

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 JavaScript

Node.js binding

Web

React Native

ONNX Runtime Node.js

- Node.js binding
- ONNX model inferencing
- Electron
- Uses web assembly

Install

```
# install latest release version
npm install onnxruntime-node
```

Import

```
// use ES6 style import syntax (recommended)
import * as ort from 'onnxruntime-node';
```

```
// or use CommonJS style import syntax
const ort = require('onnxruntime-node');
```

ONNX Runtime Web (ORT-Web)

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

Install

```
# install latest release version
npm install onnxruntime-web


# install nightly build dev version
npm install onnxruntime-web@dev
```

Import

```
// use ES6 style import syntax (recommended)
import * as ort from 'onnxruntime-web';
```

```
// or use CommonJS style import syntax
const ort = require('onnxruntime-web');
```

Why inference in the browser

It’s faster

It’s safer and helps with privacy

It works offline

It’s cheaper

Why not in the browser?

THE MODEL IS TOO LARGE AND REQUIRES HIGHER HARDWARE SPECS.

DOWNLOADED ONTO THE DEVICE

React Native

- score pre-trained ONNX models
- ONNX Runtime Mobile
- light-weight inference solution
- Android and iOS

Install

```
# install latest release version
npm install onnxruntime-react-native
```

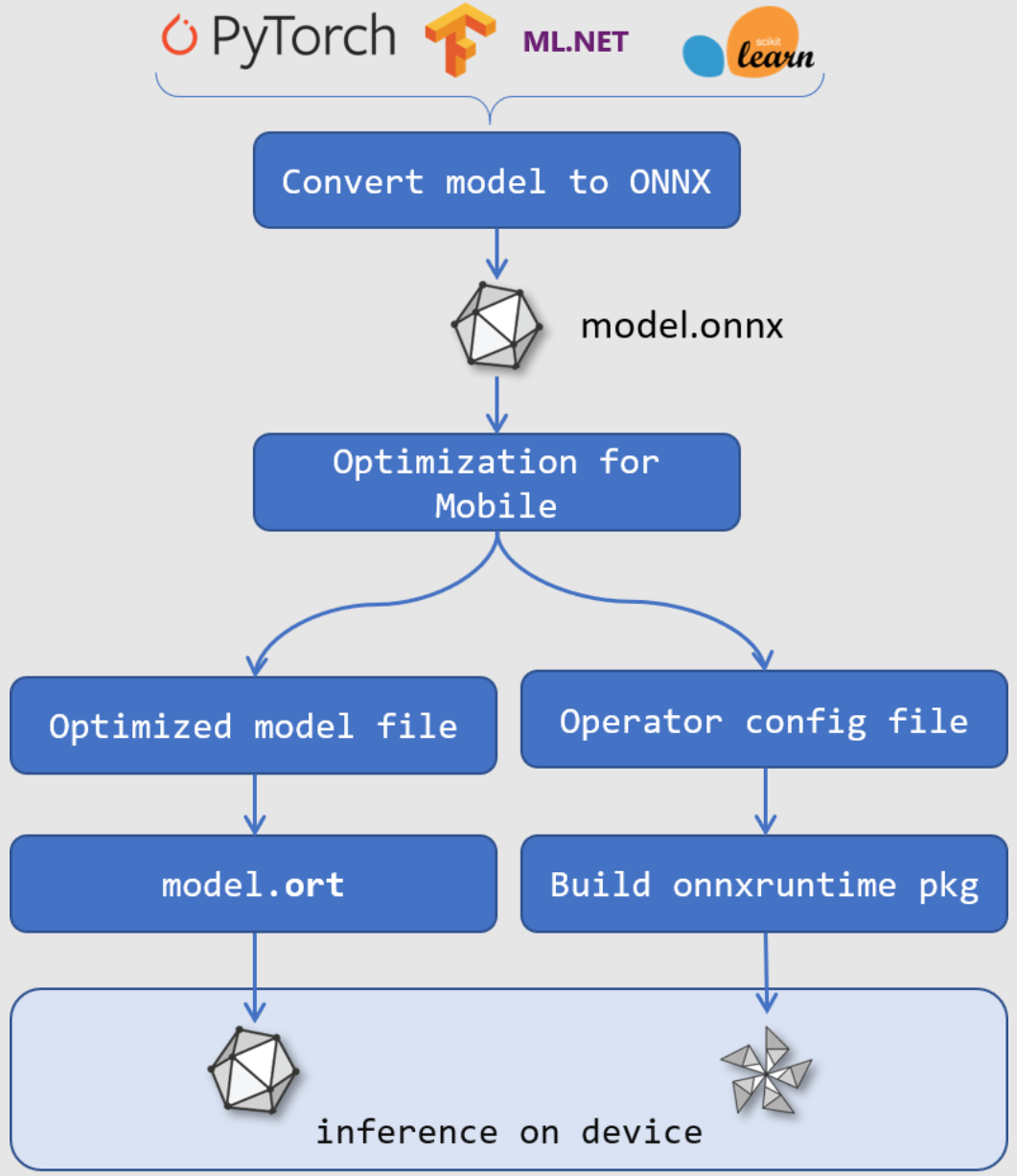
Import

```
// use ES6 style import syntax (recommended)
import * as ort from 'onnxruntime-react-native';
```

```
// or use CommonJS style import syntax
const ort = require('onnxruntime-react-native');
```

ONNX Runtime Mobile

- minimizes the binary size
- pre-optimized ONNX model to an internal format (‘ORT format model’)



Compatibility Chart

Compatibility

OS/Browser	Chrome	Edge	Safari	Electron	Node.js
Windows 10	wasm, webgl	wasm, webgl	-	wasm, webgl	wasm
macOS	wasm, webgl	wasm, webgl	wasm, webgl	wasm, webgl	wasm
Ubuntu LTS 18.04	wasm, webgl	wasm, webgl	-	wasm, webgl	wasm
iOS	wasm, webgl	wasm, webgl	wasm, webgl	-	-
Android	wasm, webgl	wasm, webgl	-	-	-

https://bit.ly/onnxportable

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 Node, Web Browser, React Mobile using high performance ONNX Runtime

About Me

Ron Dagdag

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- Lead Software Engineer at Spacee
- 5th year Microsoft MVP awardee
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  Twitter @rondagdag
- Connect me via Linked In
  www.linkedin.com/in/rondagdag/
- Thanks for geeking out with me about ONNX

Hackster Portfolio

www.dagdag.net

@rondagdag