Low-Code AI:

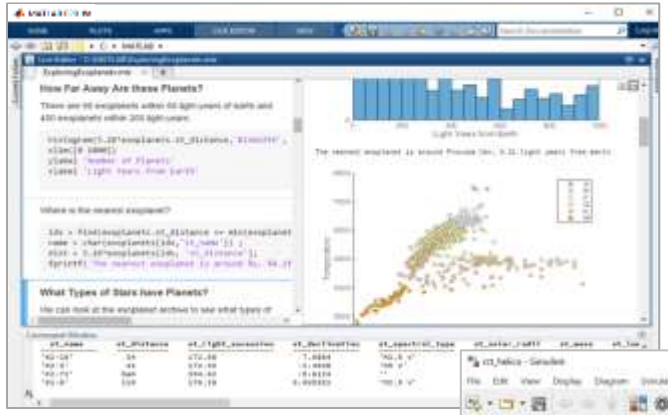
Making AI Accessible to Everyone

MathWorks

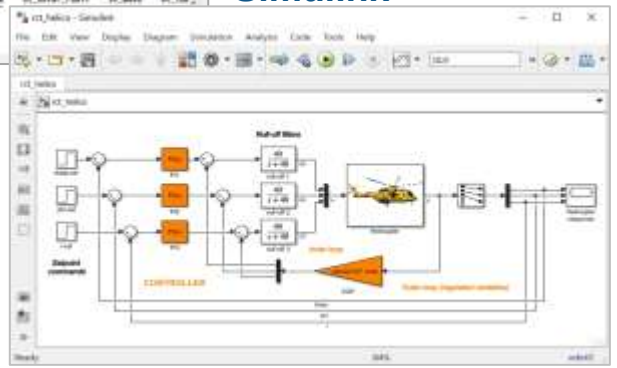
MATLAB® & SIMULINK®

- **MATLAB** – Create algorithms and AI models for biomedical data analysis
- **Simulink** – Simulate complex medical devices with sensors and software
- **Over 100 add-on products** for specialized R&D tasks

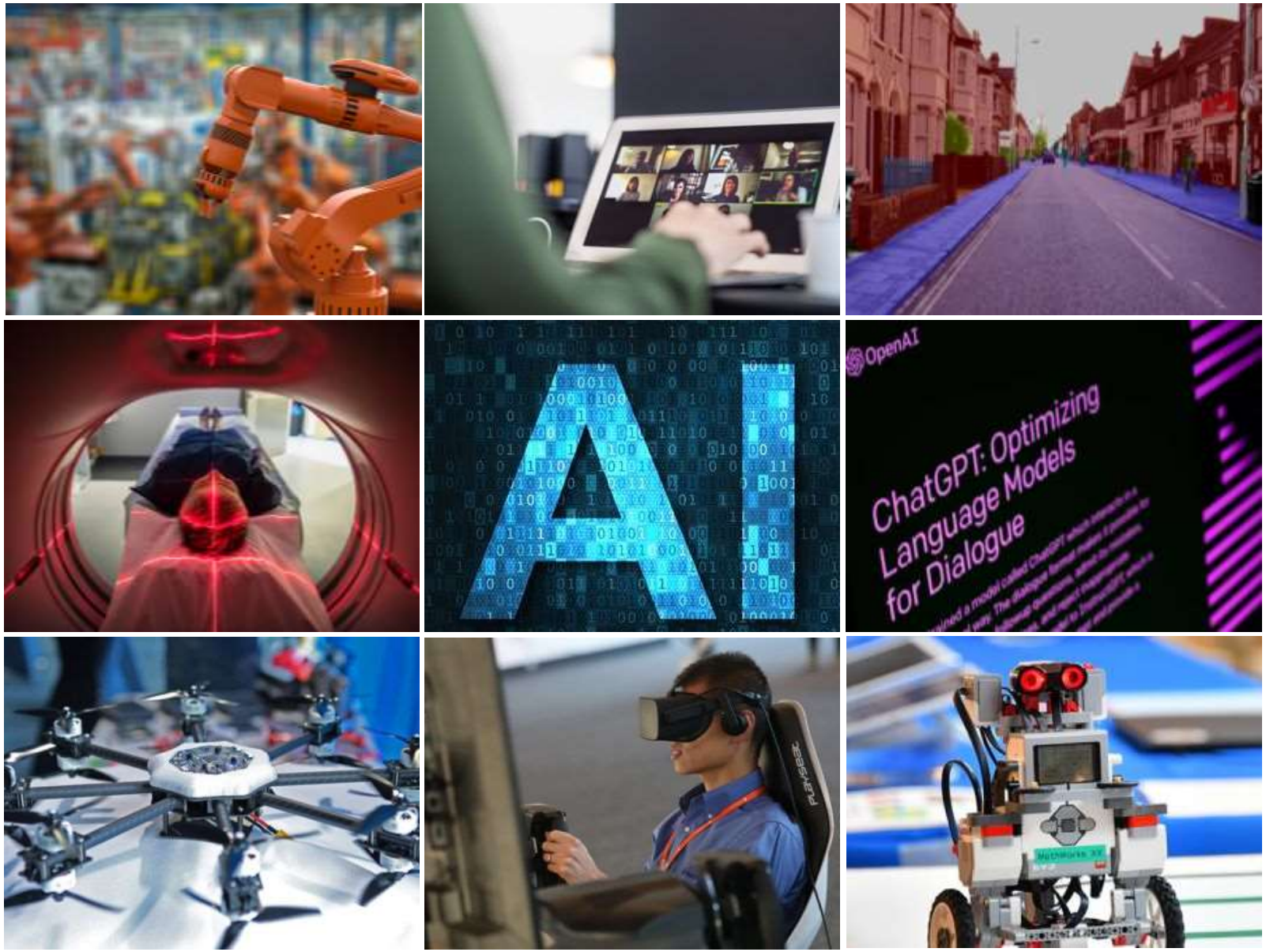
MATLAB



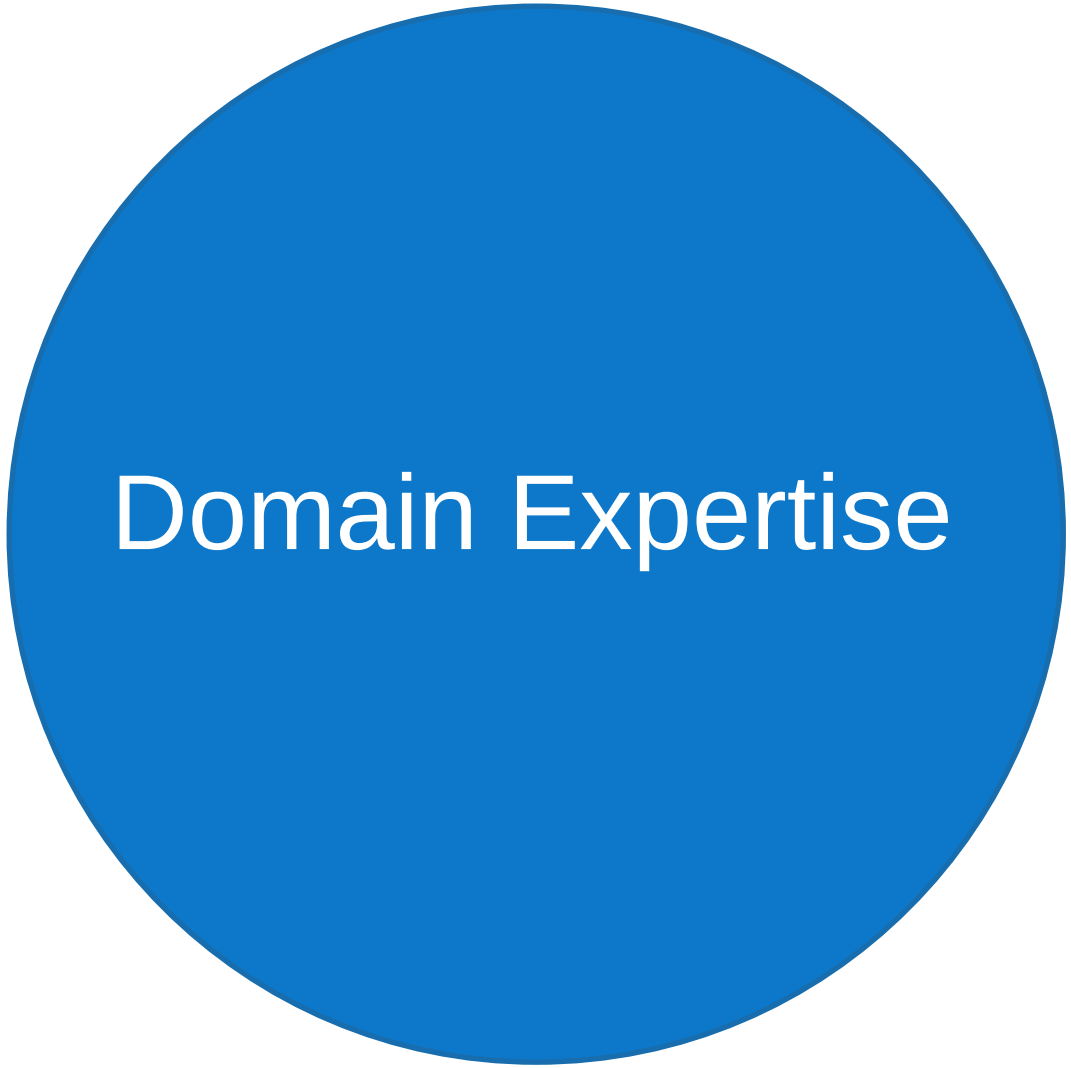
Simulink

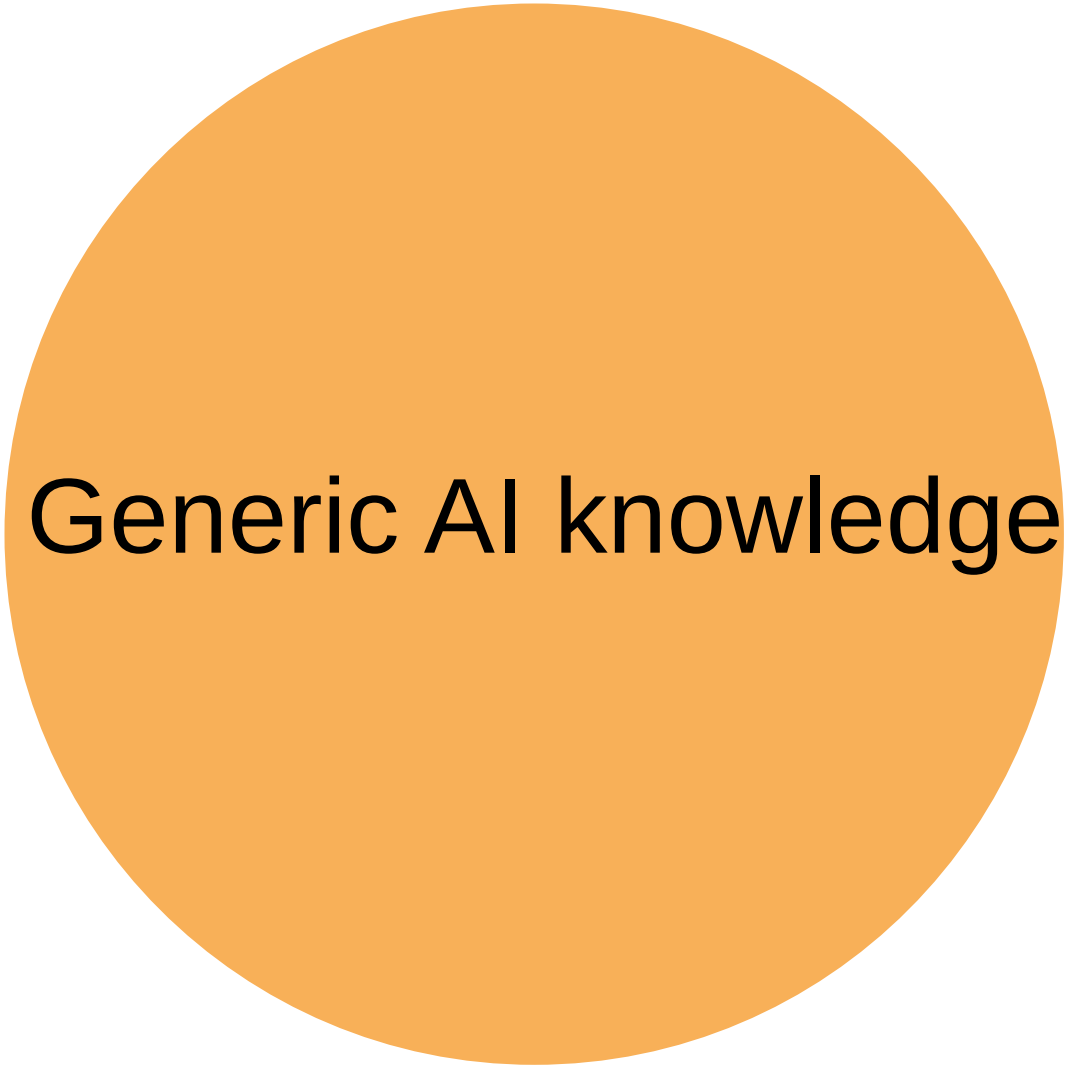


AI 无处不在


AI
OpenAI
ChatGPT: Optimizing Language Models for Dialogue

有哪些缺失？





需要什么？
将 AI 作为服务，用于特定于领域的应用程序

什么是“低代码”工具?

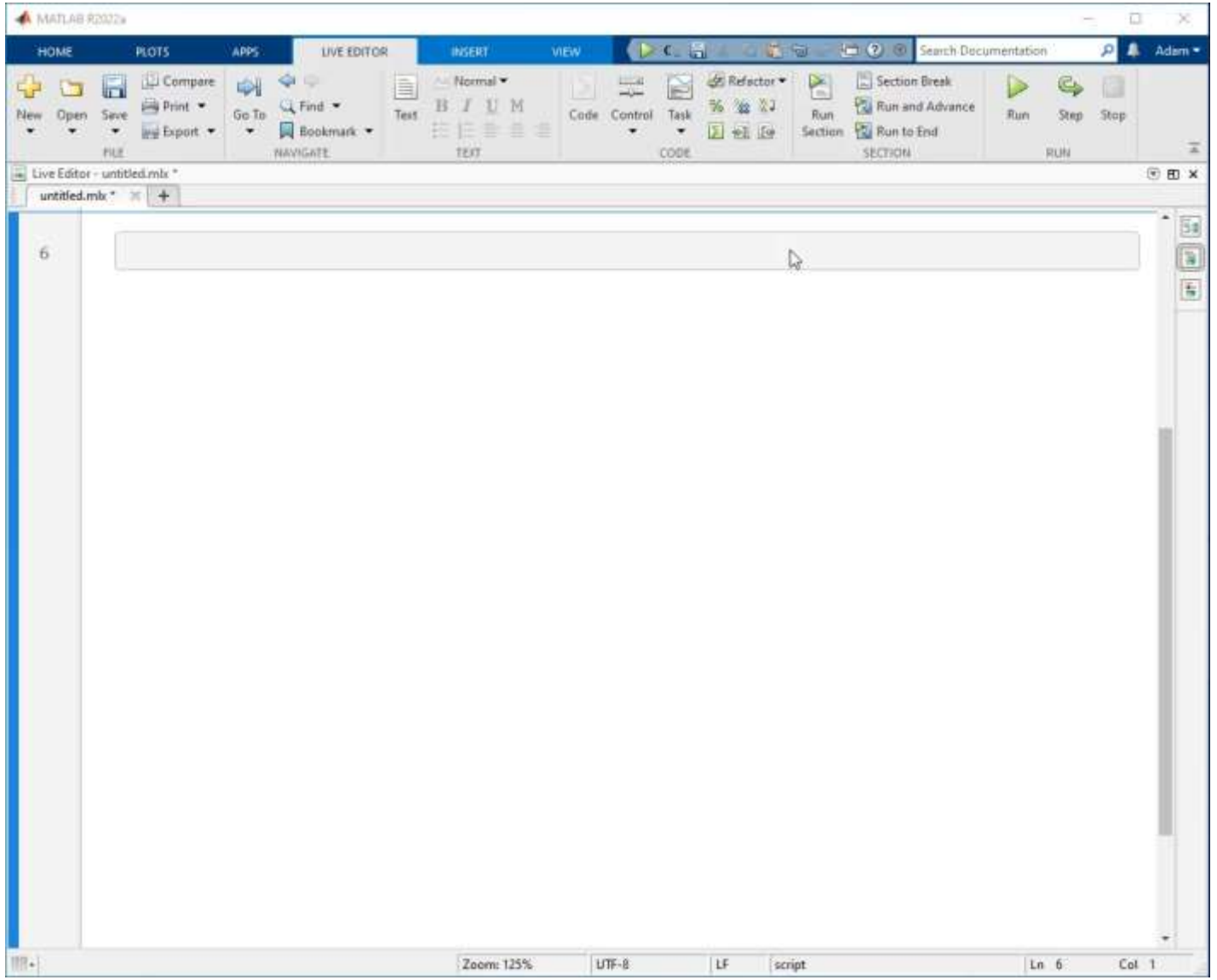
Low code tools enable:

- rapid software development
- minimal manual coding

Benefits of low code tools:

- Shallow learning curve
- Teach *how* to code
- Solve task first, code later

Not just for beginners



学习成果

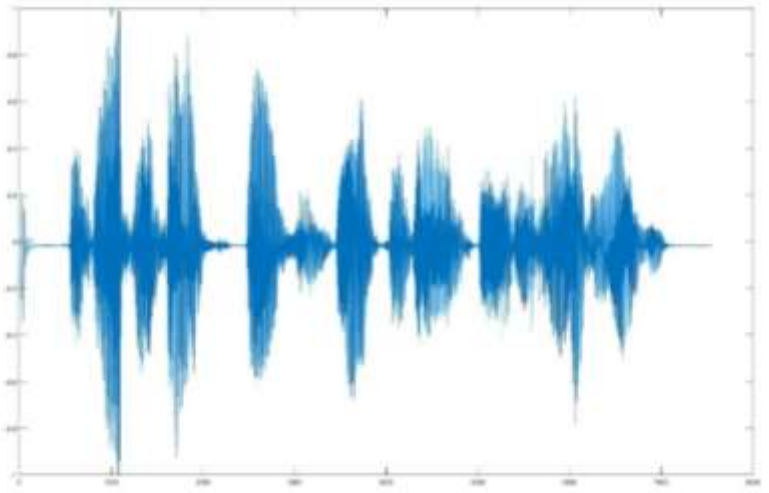
Fundamental knowledge of AI

Design and train AI models with interactive tools

Automatically generate code for reuse

数据类型

Image



Signal

Numeric

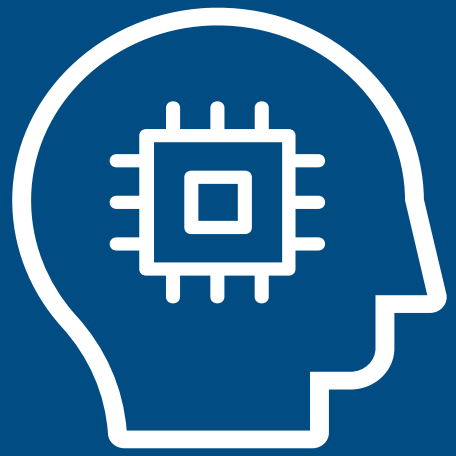
AgeCat	WeightQ	GroupCount	mean_BloodPressure	
Under 30	Q1	6	123.17	79.667
Under 30	Q2	3	120.33	79.667
Under 30	Q3	2	127.5	86.5
Under 30	Q4	4	122	78
30-39	Q1	12	121.75	81.75
30-39	Q2	9	119.56	82.556
30-39	Q3	9	121	83.222
30-39	Q4	11	125.55	87.273
Over 40	Q1	7	122.14	84.714
Over 40	Q2	13	123.38	79.385
Over 40	Q3	14	123.07	84.643
Over 40	Q4	10	124.6	85.1

Text

机器学习是推动人工智能大趋势的关键技术

ARTIFICIAL INTELLIGENCE

Any technique that enables machines to mimic human intelligence



MACHINE LEARNING

Statistical methods that enable machines to “learn” tasks from data without explicitly programming

UNSUPERVISED LEARNING

(No Labeled Data)

SUPERVISED LEARNING

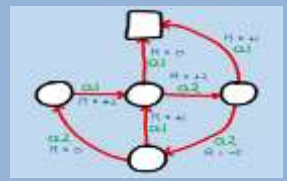
(Labeled Data)

DEEP LEARNING

(Neural networks with many layers)

REINFORCEMENT LEARNING

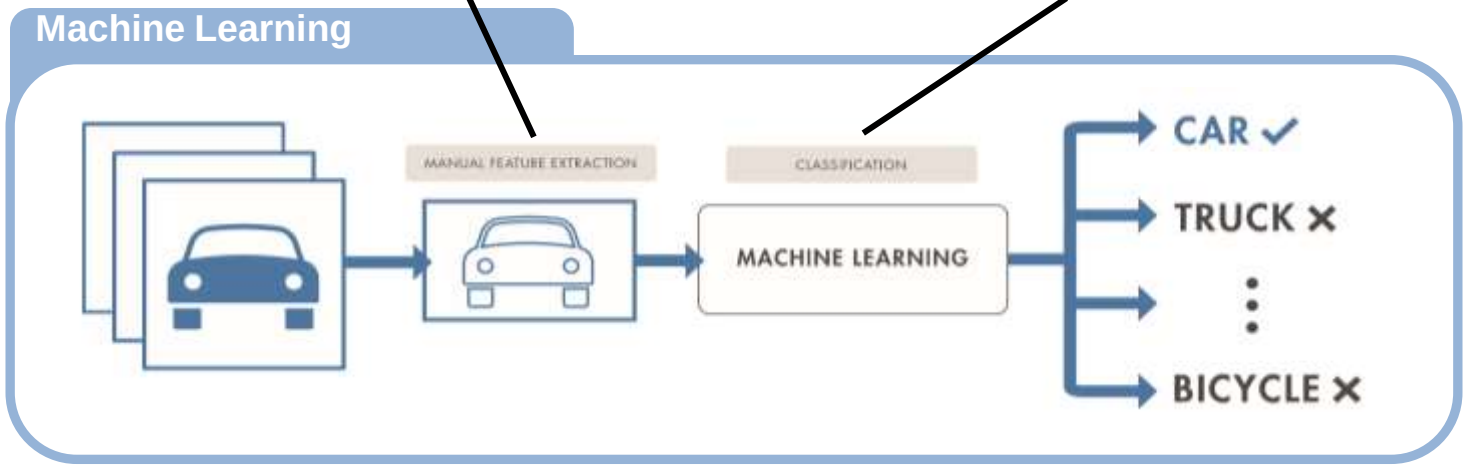
(Interaction Data)



机器学习与深度学习

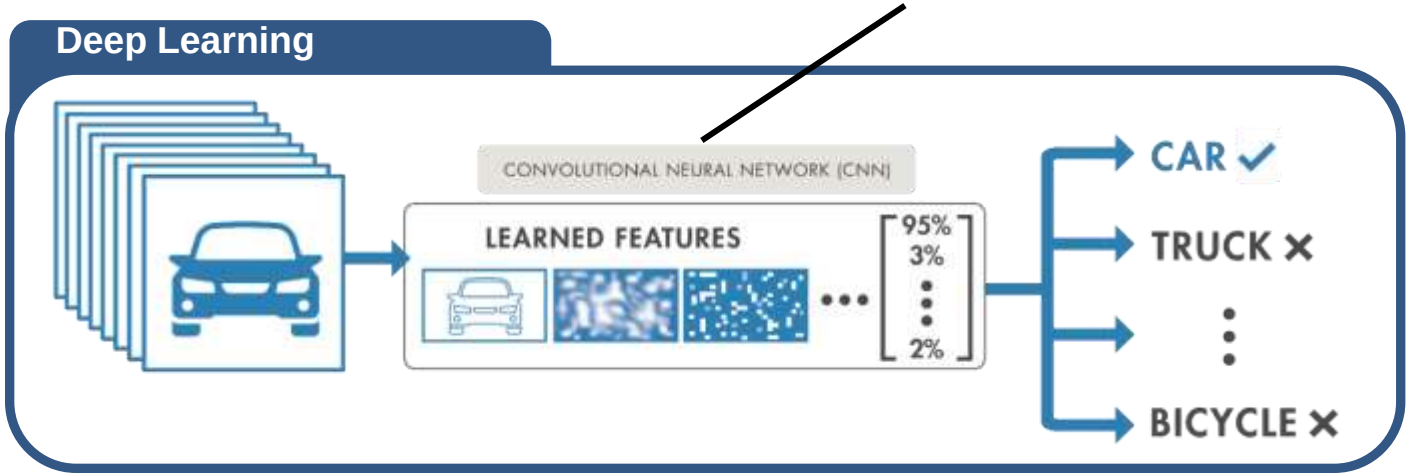
Decide on nature of the features …

…and the type of model.



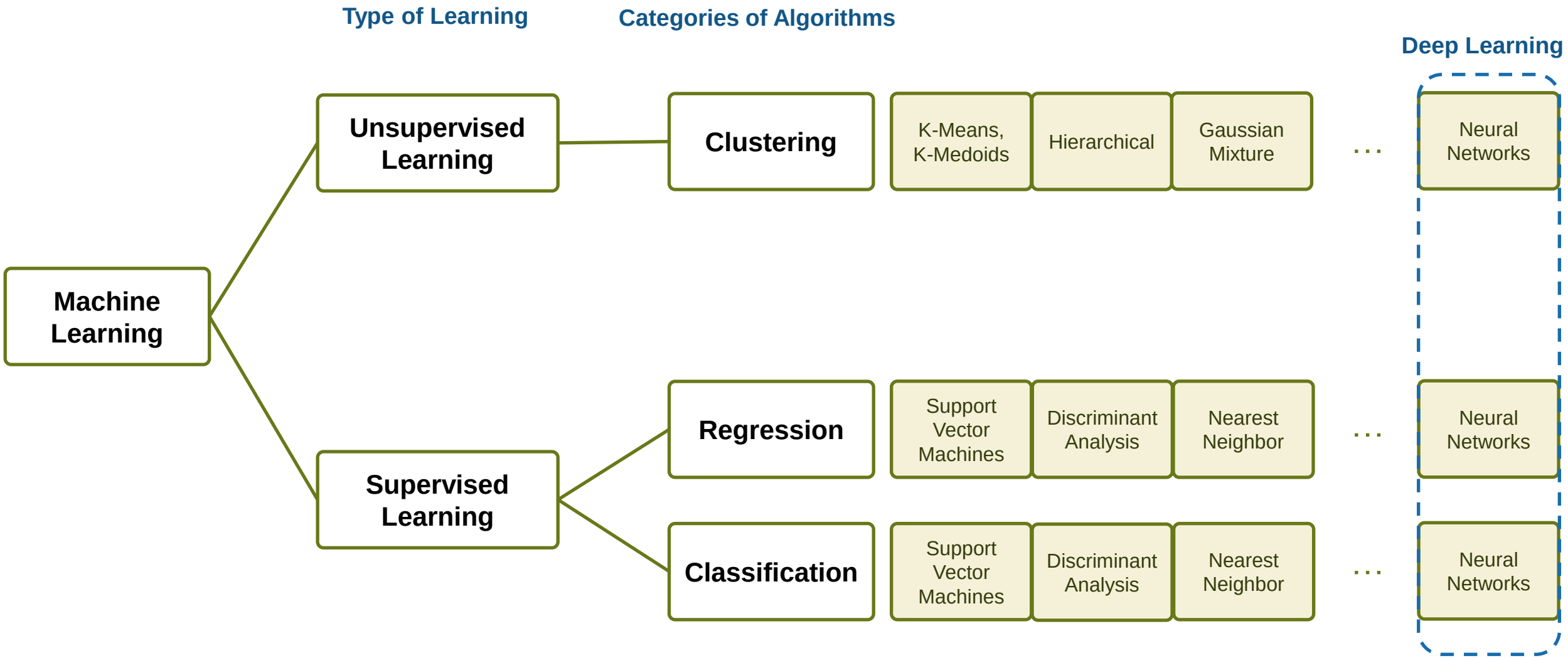
Domain knowledge required!!!

Decide on the architecture.



A LOT of data is required!!!

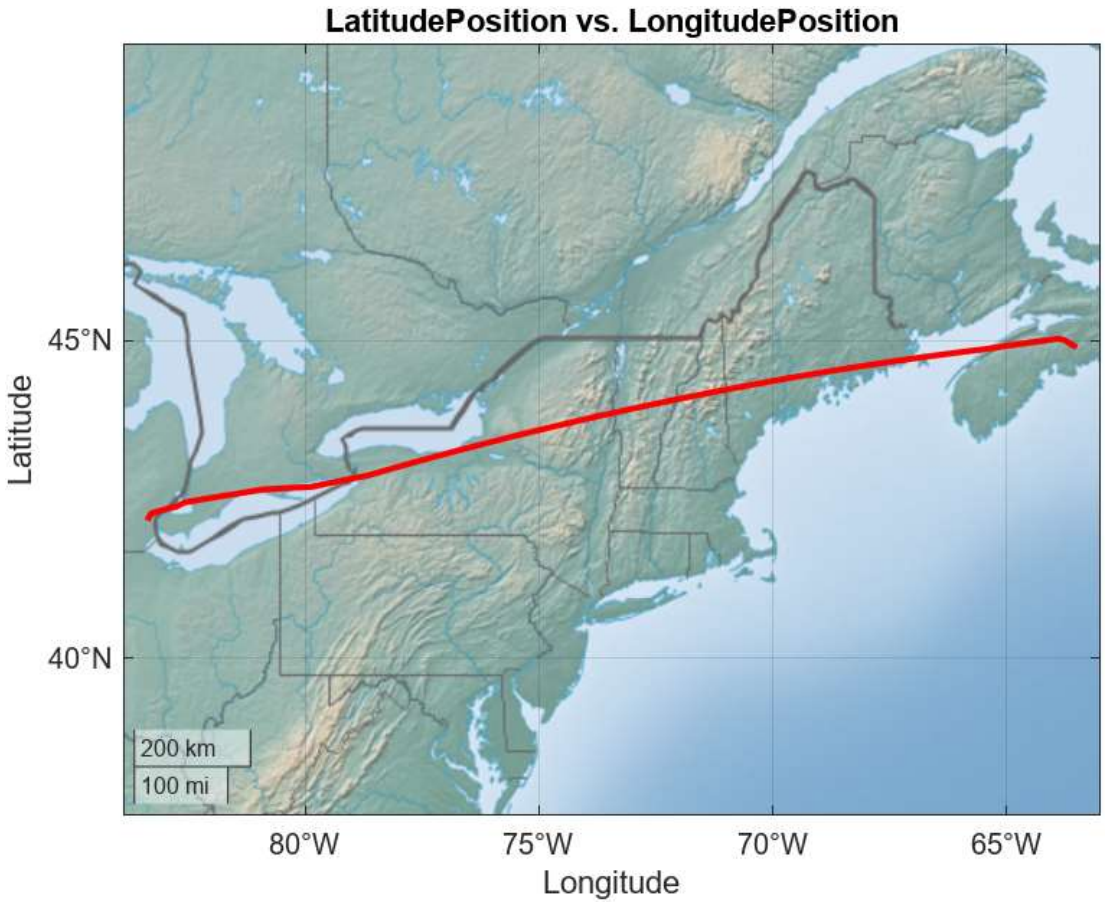
机器学习的类型


Type of Learning
Categories of Algorithms
Deep Learning
Machine Learning
Unsupervised Learning
Supervised Learning
Clustering
Regression
Classification
K-Means, K-Medoids
Hierarchical
Gaussian Mixture
Support Vector Machines
Discriminant Analysis
Nearest Neighbor
Support Vector Machines
Discriminant Analysis
Nearest Neighbor
Neural Networks
Neural Networks
Neural Networks

机器学习

示例：飞行传感器数据建模

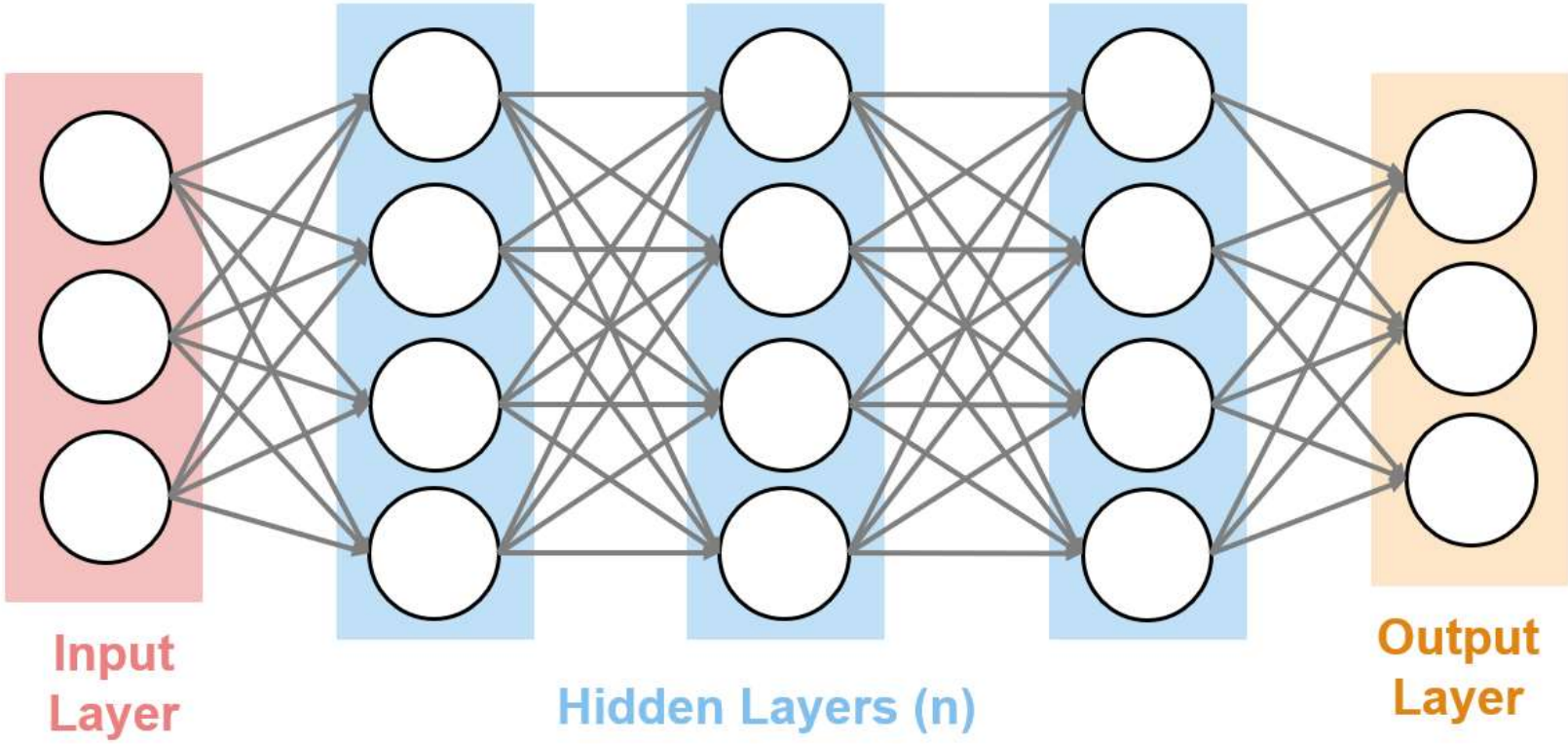
- **Objective:**
  - Create a virtual sensor model for non-observable or costly-to-observe states
- **Inputs:**
  - Excel file with 13 sensors from 1 flight
- **Approach:**
  - Visualize and explore data
  - Clean sensor anomalies
  - Train regression model to predict state
  - Share results in a report



深度学习

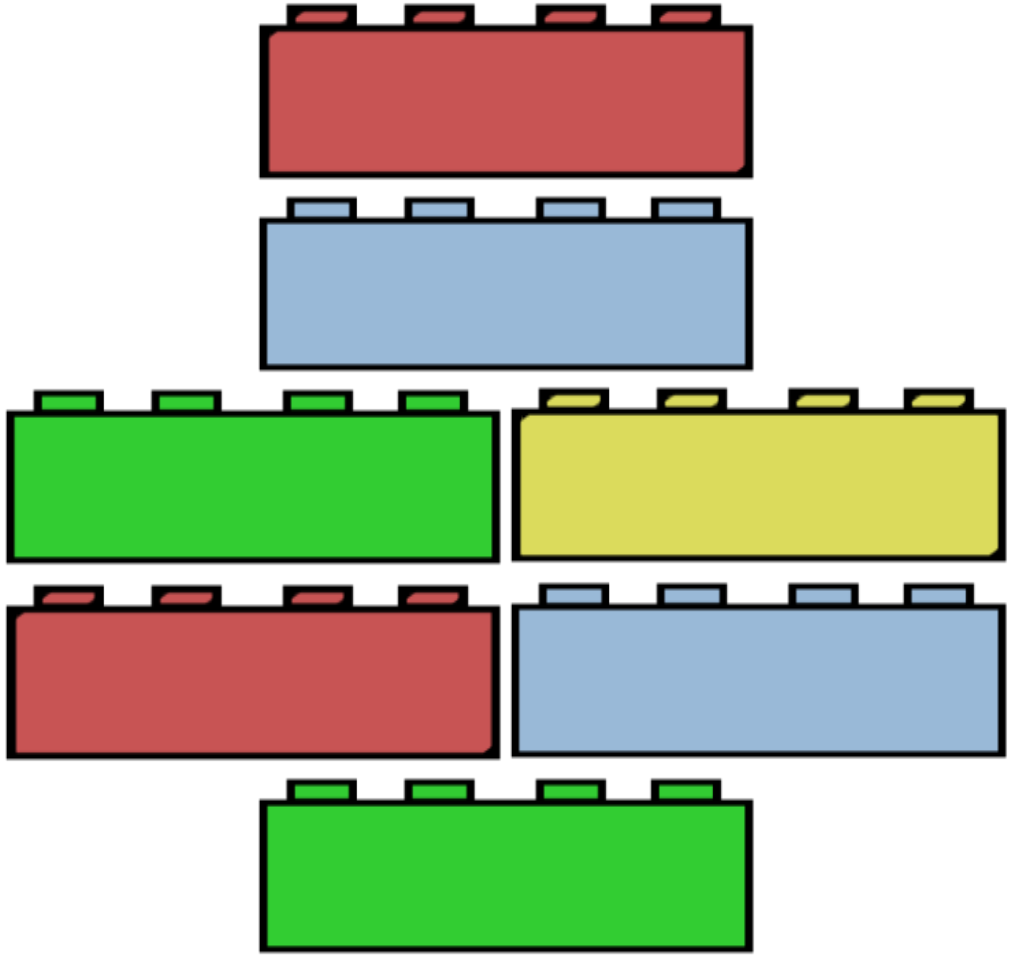
深度学习模型是神经网络

- Deep neural networks have many layers
- Data is passed through the network, and the layer parameters are updated (training)



层次

- Layers are like blocks
  - Stack on top of each other
  - Replace one block with a different one
- Each hidden layer processes the information from the previous layer
- Layers can be ordered in different ways



我们如何知道使用哪一层?

Feature Extraction - Images

- 2D and 3D convolution
- Transposed convolution (…)

Activation Functions

- ReLU
- Tanh (…)

Sequence Data

Signal, Text, Numeric

- LSTM
- BiLSTM
- Word Embedding (…)

Normalization

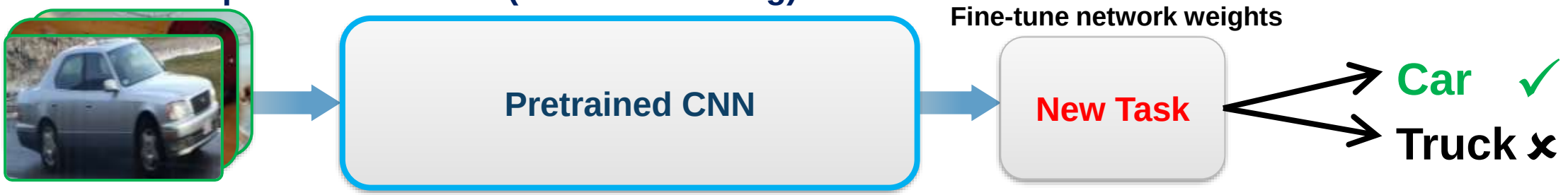
- Dropout
- Batch normalization
- (…)

Research papers and doc examples can provide guidelines for creating architecture.

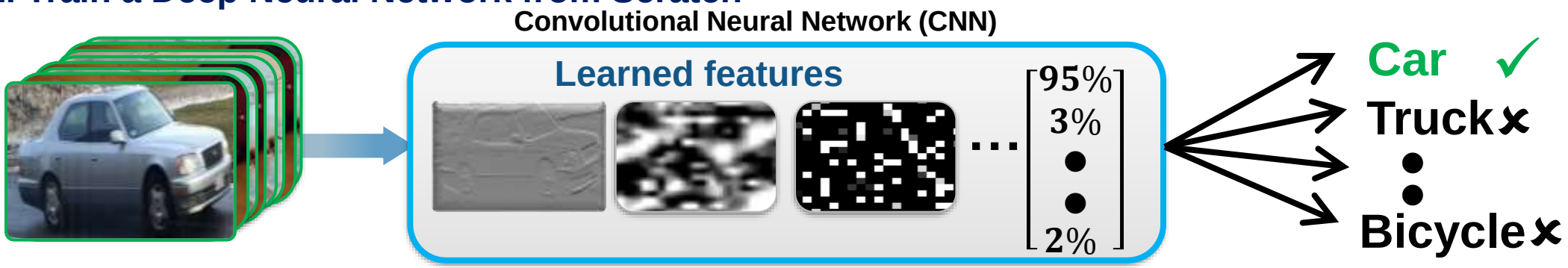
Documentation on Network Layers

使用迁移学习 vs 从零开始搭建网络

1. Fine-tune a pretrained model (transfer learning)

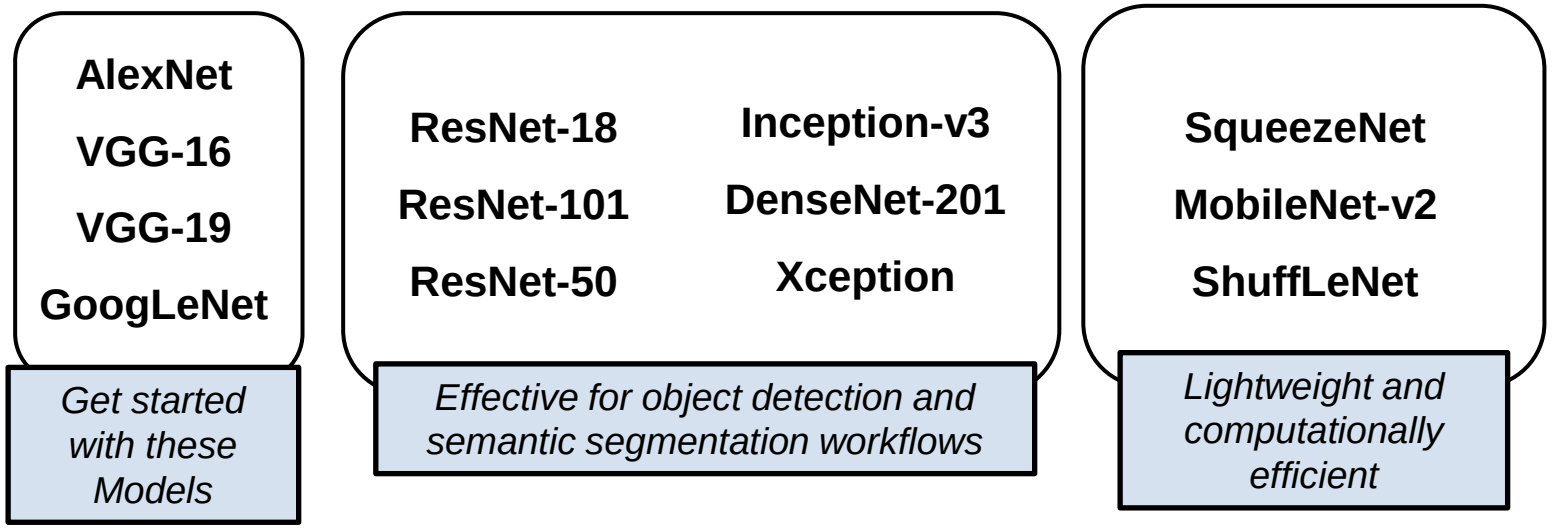


2. Train a Deep Neural Network from Scratch



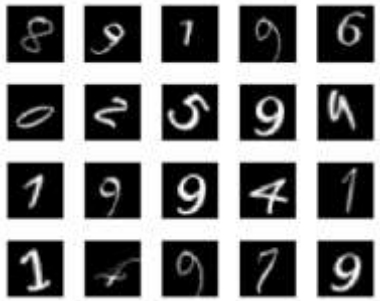
使用预训练模型构建网络

- Pretrained models have predefined layer orders and parameter values
- Can be used directly for inference (AlexNet Example)



Full list of models available HERE

使用 MATLAB 练网络



训练参数定义

```
options = trainingOptions('sgdm', ...
    'MaxEpochs',4, ...
    'ValidationData',imdsValidation, ...
    'ValidationFrequency',30, ...
    'Verbose',false, ...
    'Plots','training-progress');
```

训练网络

```
net = trainNetwork(imdsTrain,layers,options);
```

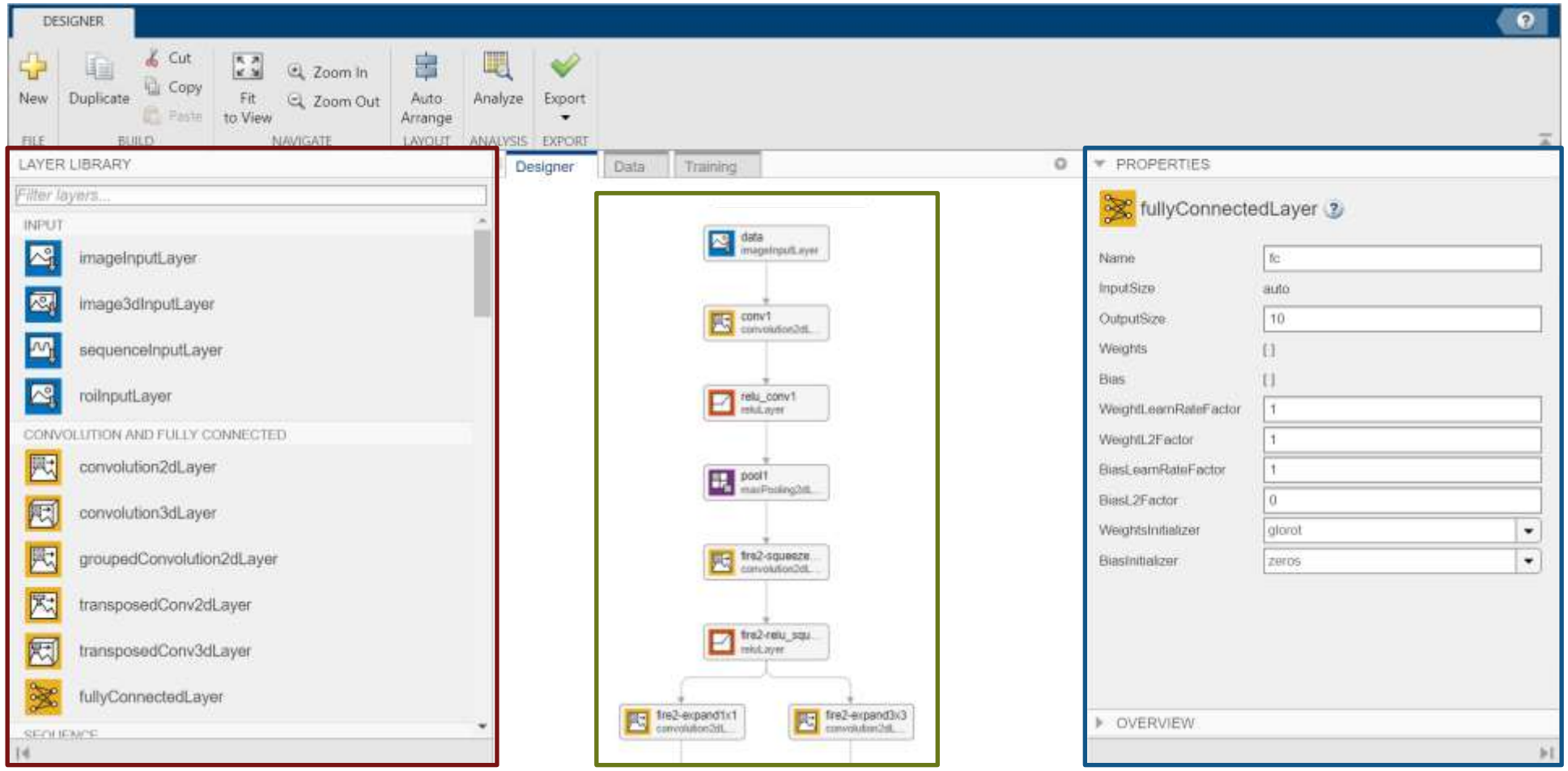
内置网络层

```
layers = [
    imageInputLayer([28 28 1])

    convolution2dLayer(3,8,'Padding',1)
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2)
```

使用“深度网络设计器”修改或构建网络



Select layers from layer library

Drag and connect layers on canvas

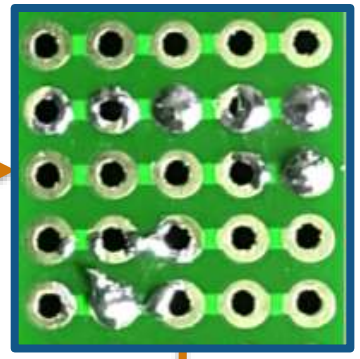
Edit parameters of individual layers

计算机视觉工作流

Photos / Video Captured

- Technician
- Inspection Camera

Environment Containing Objects of Interest



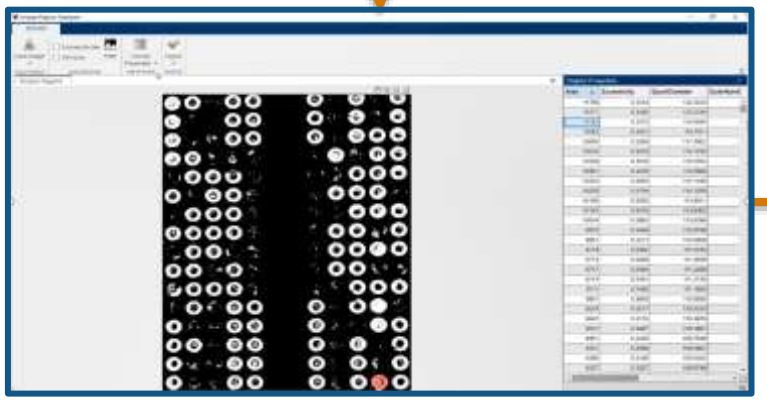
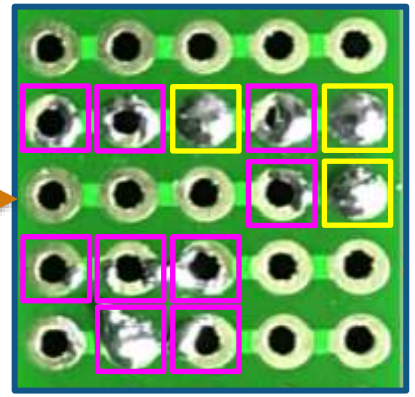


Image Analysis

anomaly detection, defect classification, object localization, etc.

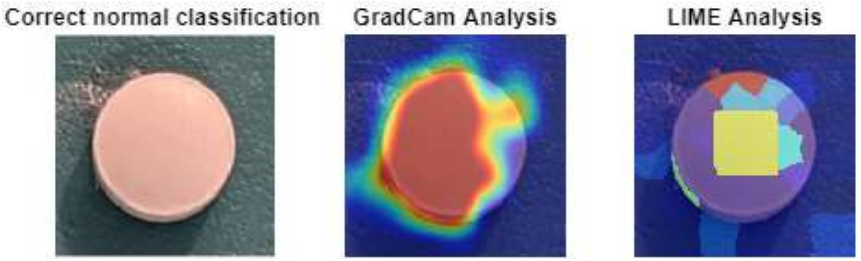


Output Results

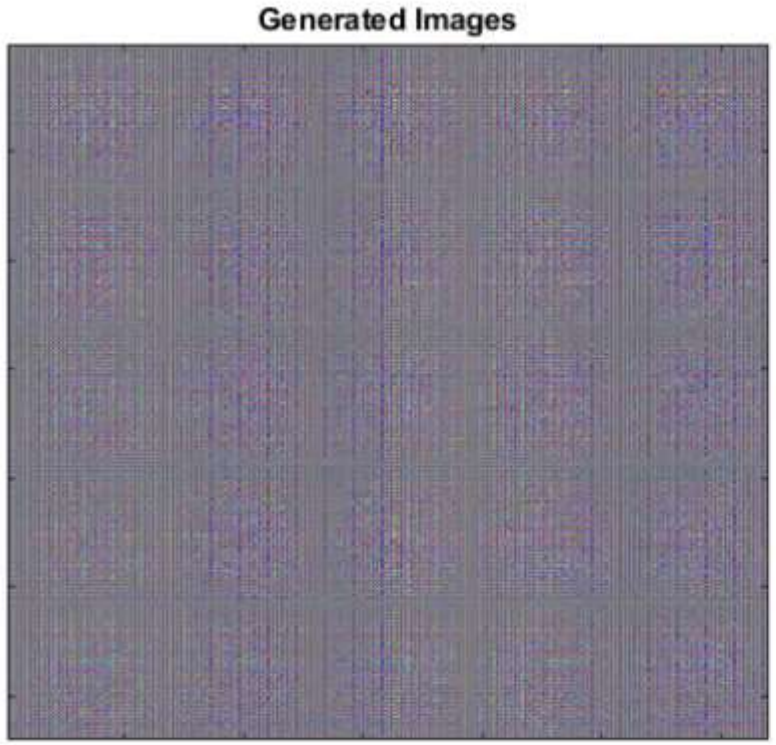
示例 1:通过迁移学习进行图像分类

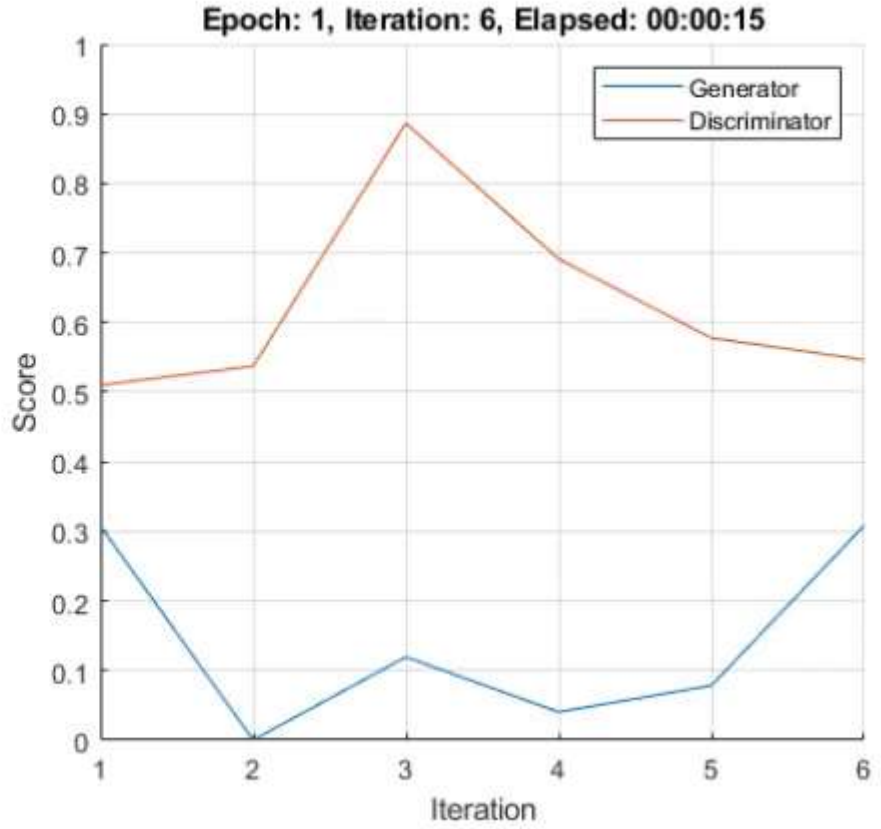
- Use transfer learning to visually inspect pills and classify them based on the type of defect

- You will learn how to:
  - Modify an existing deep learning network
  - Train a deep learning network to classify images
  - Analyze the behavior of the deep learning network



示例2：训练生成对抗网络（Generative Adversarial Networks，GANs)

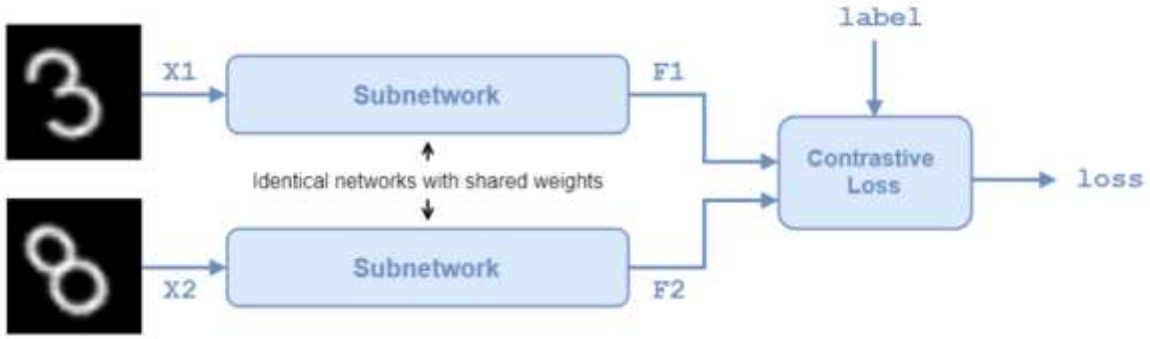




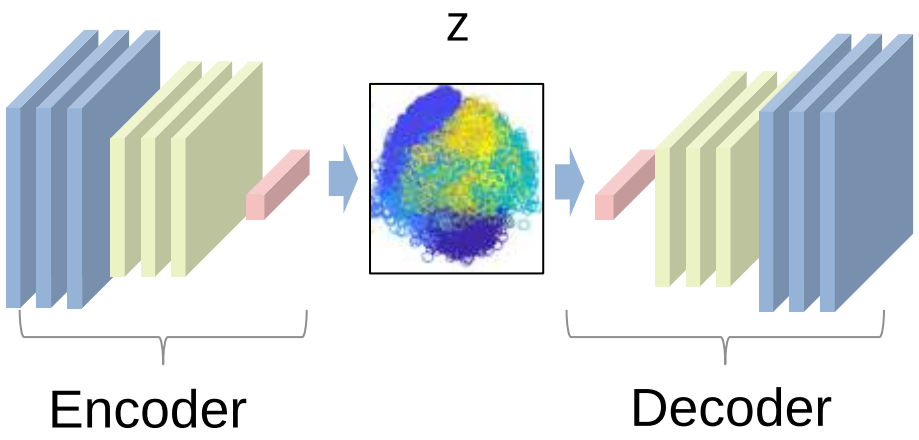
高级的神经网络

生成对抗网络（GAN）

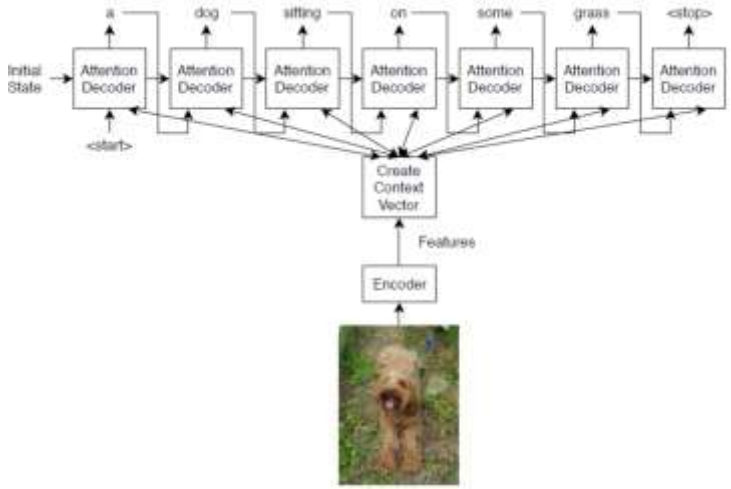
孪生网络
(Siamese networks）



变分自编码器（VAE）



注意力机制
（attention mechanism）

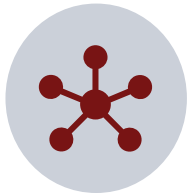


38

扩展的深度学习框架增加了以下内容:

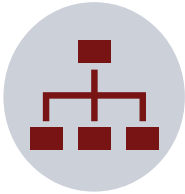
- 无监督式深度学习（生成模型）
- 多输入多输出（MIMO）神经网络
- 神经网络中的任意函数编程
- 完全定制的神经网络训练循环

关键技术



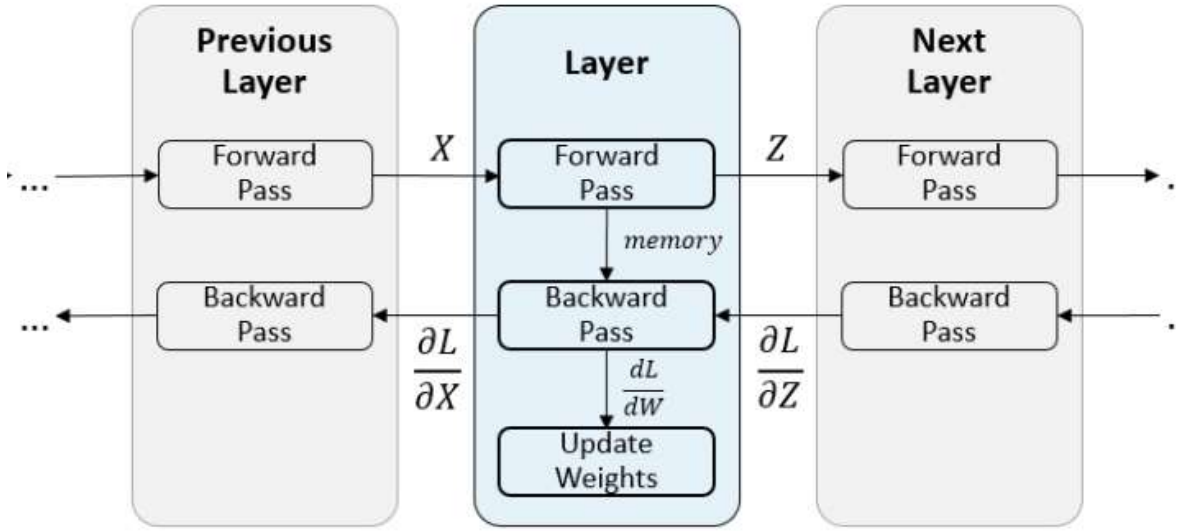
共享的权重

自动微分



灵活的训练结构

定义自定义深度学习层




```
classdef myLayer < nnet.layer.Layer % & nnet.layer.Formattable (Optional)

    properties (Learnable)
    % (Optional) Layer learnable parameters.
     % Layer learnable parameters go here.
    end

    methods
        function layer = myLayer()
        % (Optional) Create a myLayer.
        end

        function [Z1, …, Zm] = predict(layer, X1, …, Xn)
        % Forward input data through the layer at prediction time and
        % output the result.
        end

        function [Z1, …, Zm, memory] = forward(layer, X1, …, Xn)
        % (Optional) Forward input data through the layer at training
        % time and output the result and a memory value.
        end

        function [dLdX1, …, dLdXn, dLdW1, …, dLdWk] = ...
        backward(layer, X1, …, Xn, Z1, …, Zm, dLdZ1, …, dLdZm, memory)
        % (Optional) Backward propagate the derivative of the loss
        % function through the layer.
        end
    end
end
```

Link：定义自定义深度学习层模板

生成对抗网络（GANs）

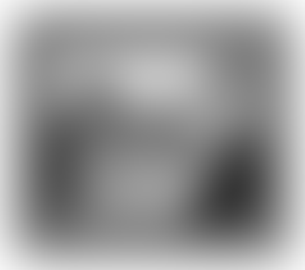
很多种 GAN

训练集

可以是图片、视频或者声音

❑真
❑假

输入



随机向量

生成器

许多类型和不同数量的生成器

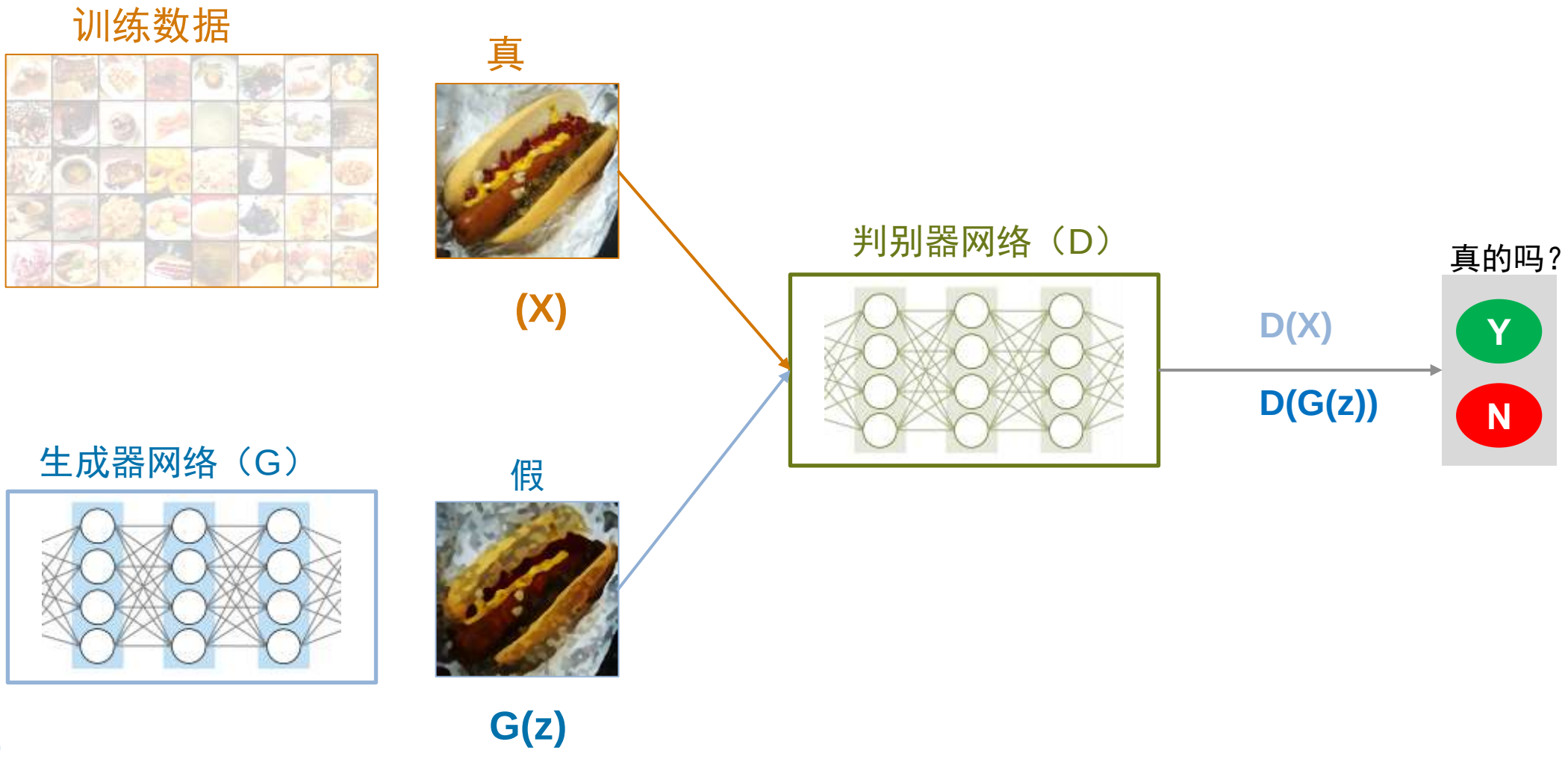
生成的图片

不同的分辨率

判别器

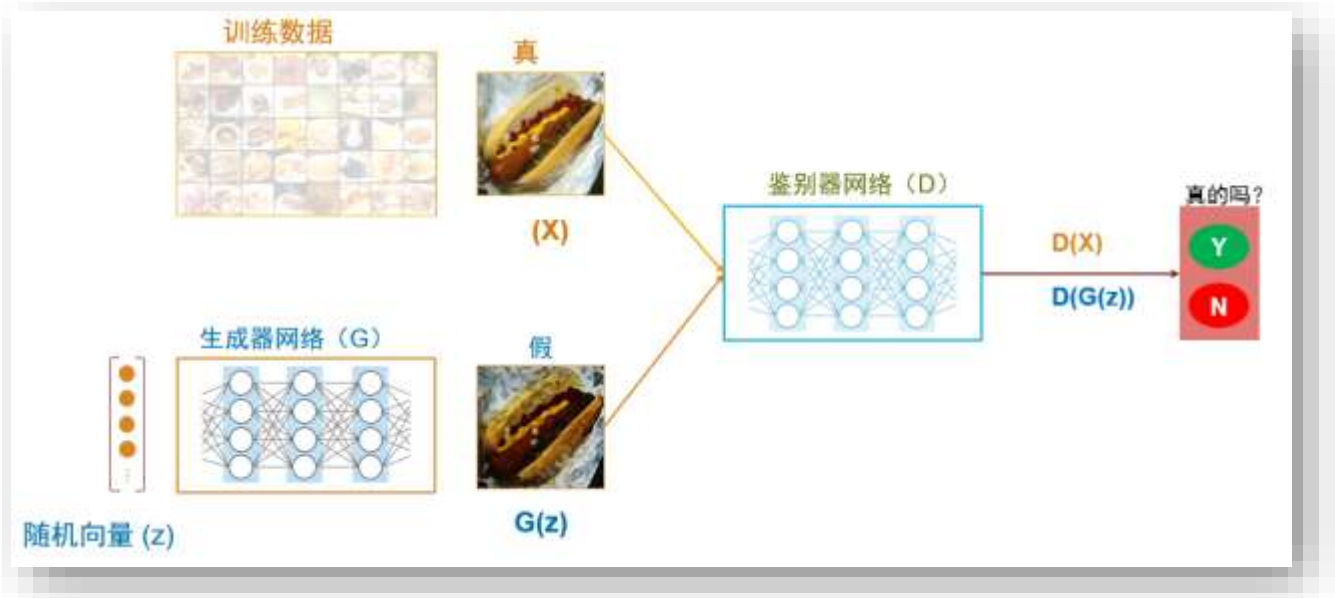
许多类型和不同数量的判别器

GAN 的可视化



Example

GAN 具有竞争性的损失函数



GAN 输出 —— 介于 0 和 1 之间的值

- **D(X) – 真 -→ 1**
- **D(G(z)) – 假 -→0**

生成器的损失函数

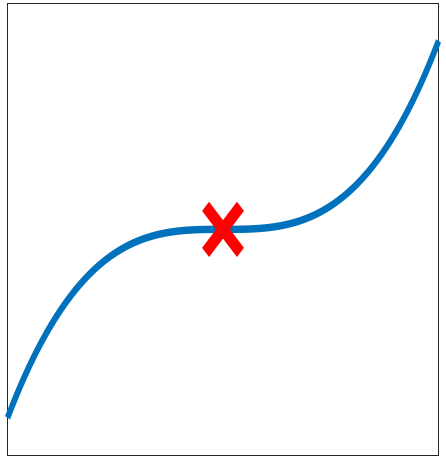
- $(-1) * mean\left(log\left(\boldsymbol{D}\left(\boldsymbol{G}(\boldsymbol{z})\right)\right)\right)$
- 当 **D(G(z))** 接近1时，函数最小化

判别器的损失函数

- $(-1) * mean\left(log\left(\boldsymbol{D}(\boldsymbol{X})\right)\right)$ + $(-1) * mean\left(log\left(1 - \boldsymbol{D}\left(\boldsymbol{G}(\boldsymbol{z})\right)\right)\right)$

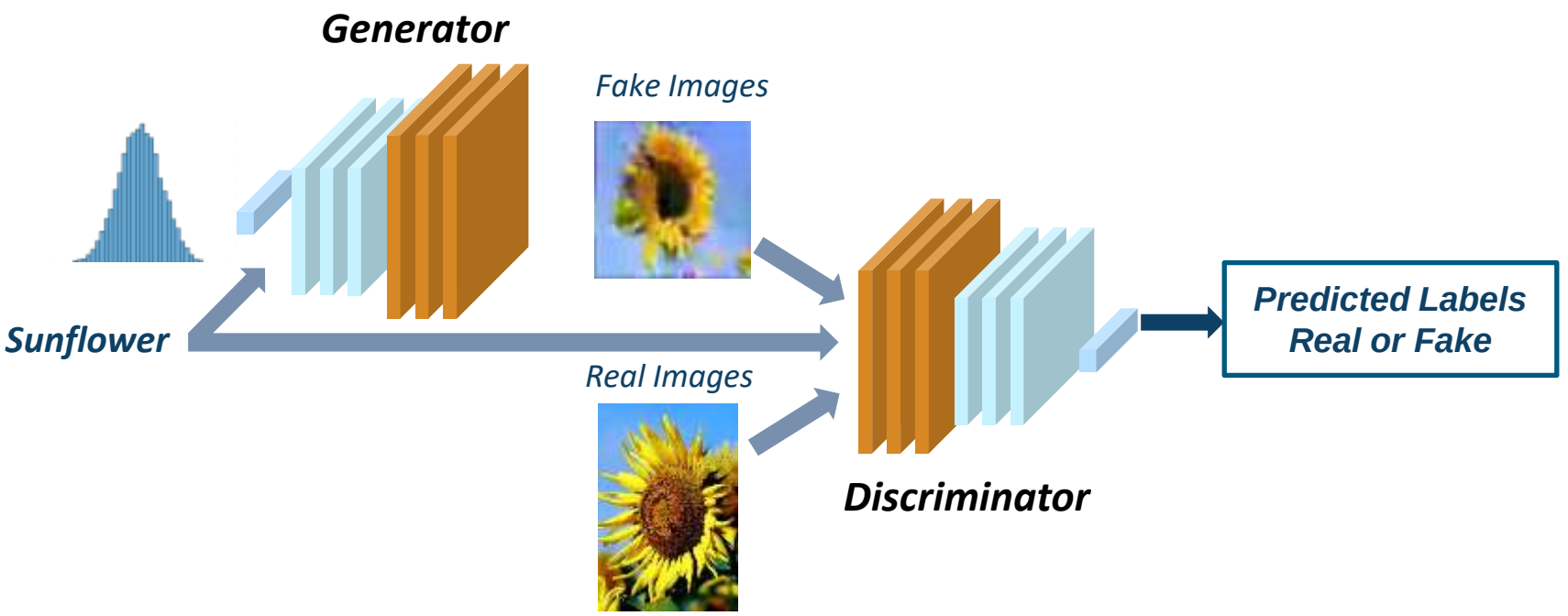
判断真的图片为真

判断假的图片为假



示例：扩展的 GANs

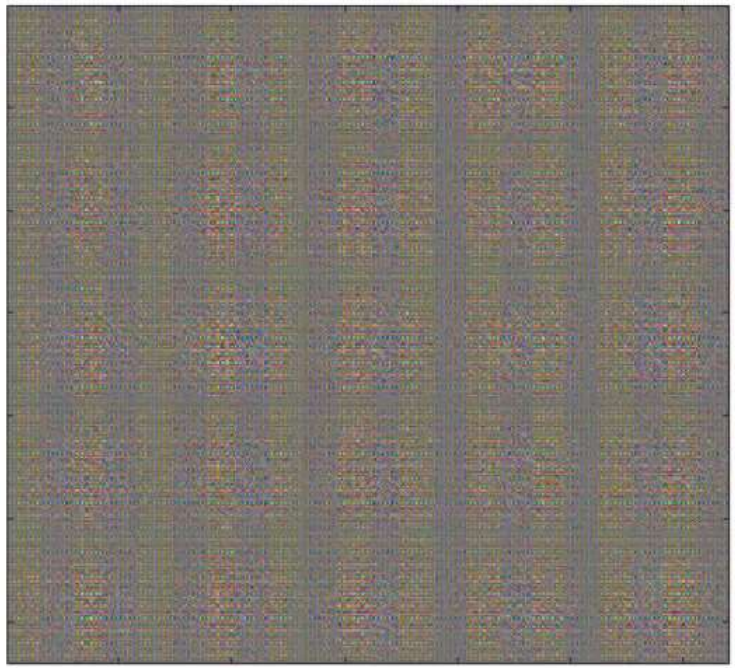
- C-GAN
  - 条件生成对抗网络是GAN的一种类型，它在训练过程中也利用了标签

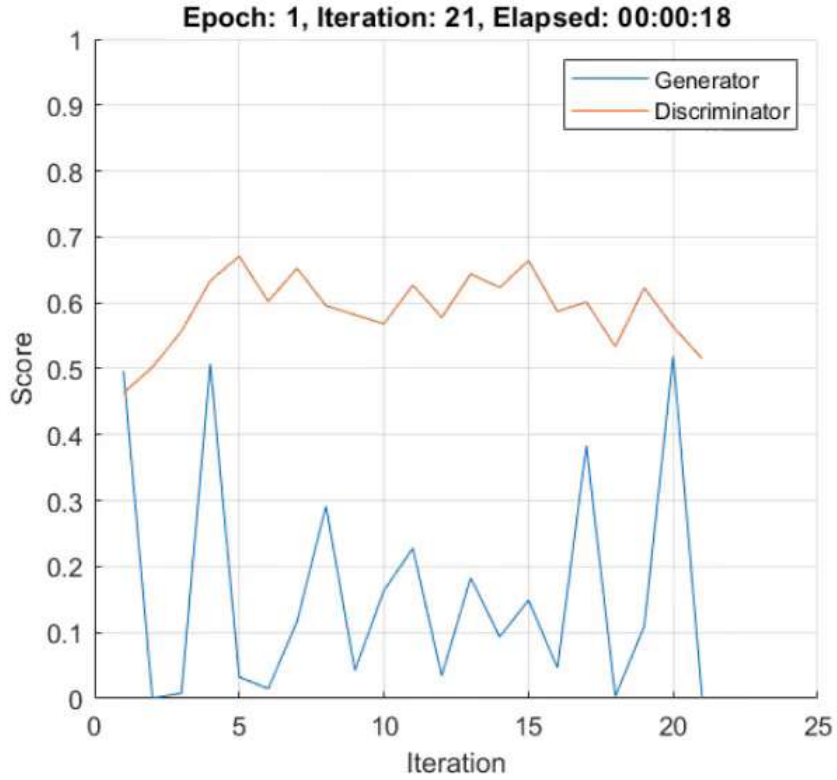


Generate Daisy flower!

Full code available

44





此时，判别器已学会在生成的图像中识别真实图像的强特征表示。顺带，生成器已学会类似的强特征表示，能够生成类似于训练数据的一类图像。

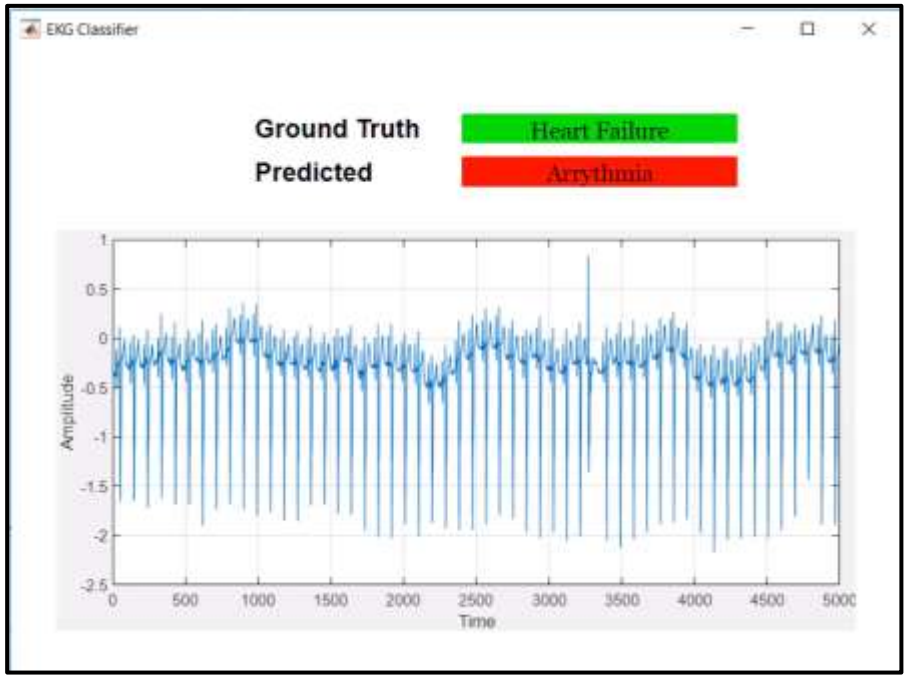
训练图显示生成器和判别器网络的分数。要了解有关如何解释网络分数的详细信息，请参阅Monitor GAN Training Progress and Identify Common Failure Modes。

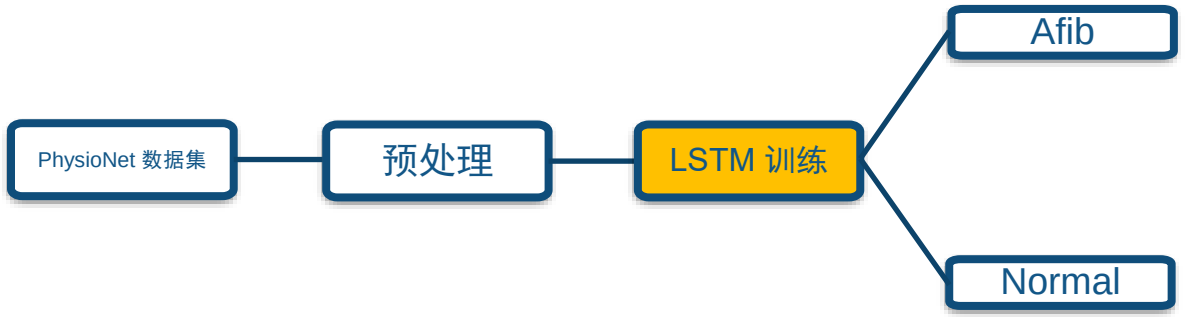
生成新图像

示例 3：心电图信号分类：房颤心律（Afib）检查

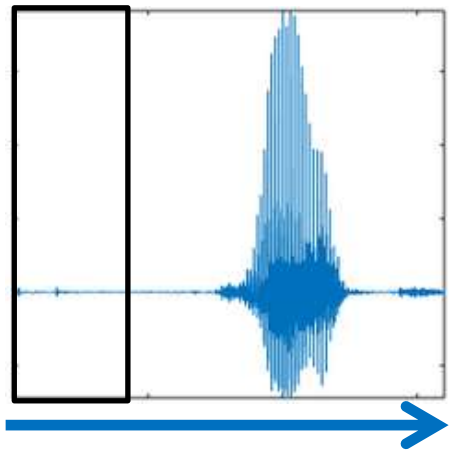
完整代码

- **动机**
  - 房颤（Afib）是一种不规则的心跳
  - 创建并训练一个 LSTM 二分类网络
- **目的**
  - 开发心电图的分类器
- **数据**
  - 来源：PhysioNet
  - 下载地址：https://archive.physionet.org/challenge/2017/training2017.zip
  - 训练数据: 8876 个信号
  - 验证数据：980 个信号
  - 每个信号：记录长短不一，类别不平衡
  - 标签：房颤心律（Afib）和正常心律（Normal）

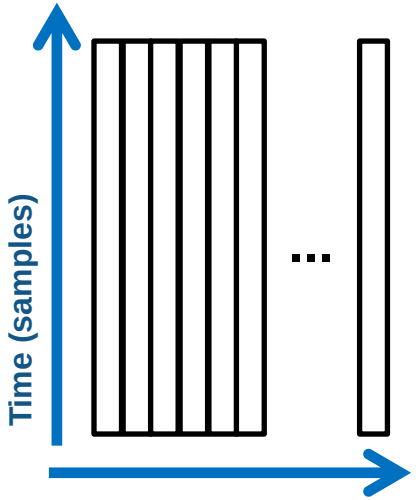




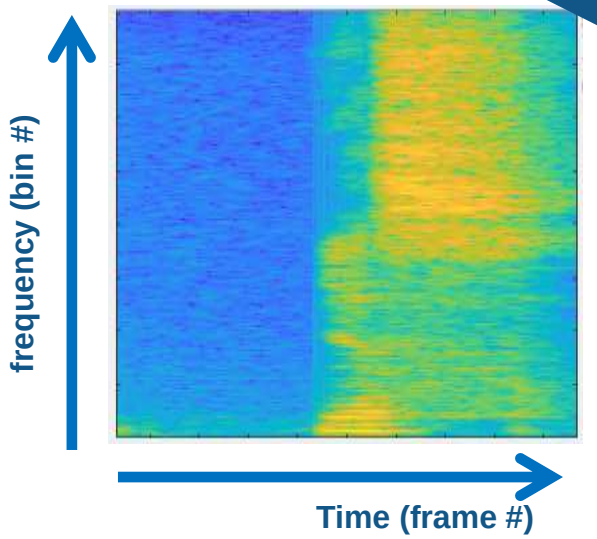
时频转换



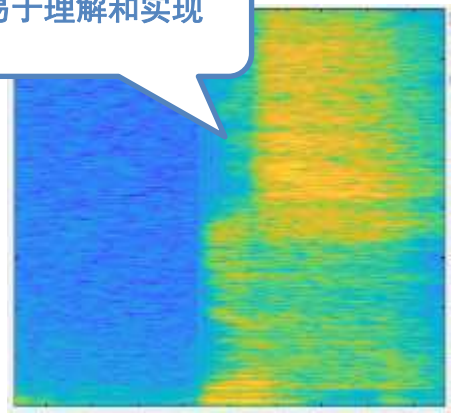
Reframe
(e.g. Buffer)



To frequency
(e.g. FFT)

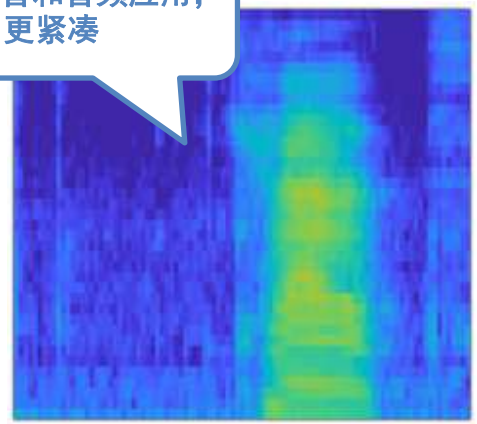


易于理解和实现



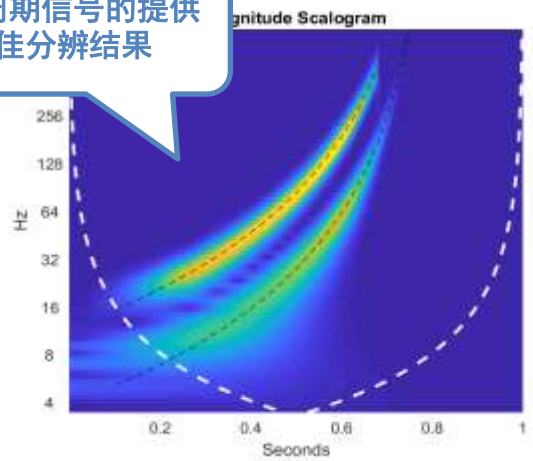
时频图

适合语音和音频应用，
更紧凑



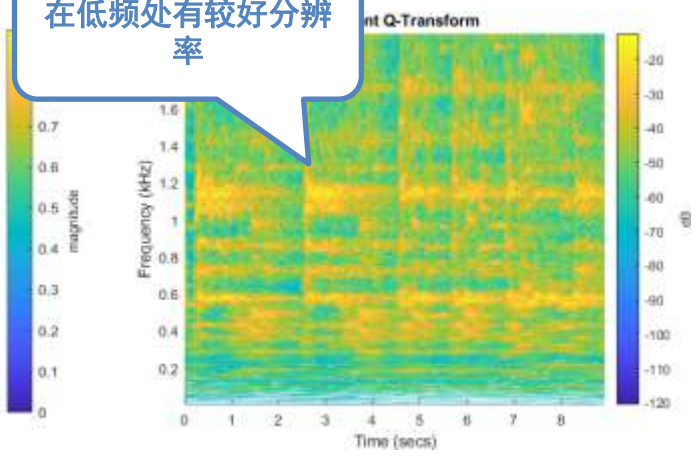
Perceptually-spaced (e.g. Mel, Bark) 时频图

为非周期信号的提供
最佳分辨结果



小波时频尺度图

在低频处有较好分辨
率



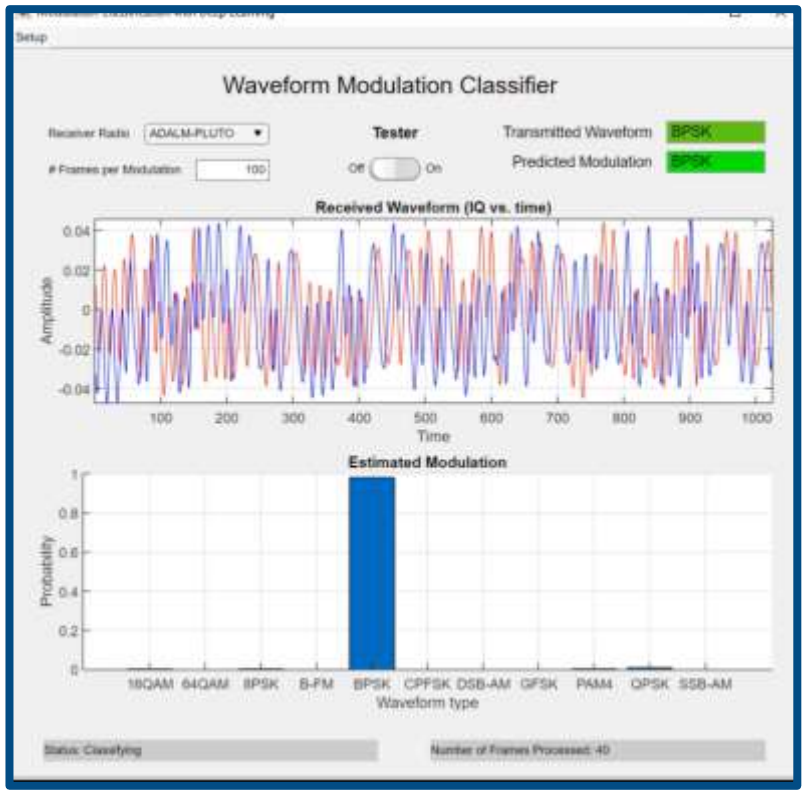
常数Q变换

示例 4：基于深度学习的信号调制识别

目标：开发分类器并部署为 App

训练数据:

- 由 MATLAB 合成的11类传输损伤调制信号
- 训练、测试与验证数据：88000 v.s 11000 v.s 11000 帧
- 标签: BPSK, QPSK, 8PSK, 16QAM, 64QAM, PAM4, GFSK, CPFSK, B-FM, DSB-AM, SSB-AM
- 每帧 1024 个采样



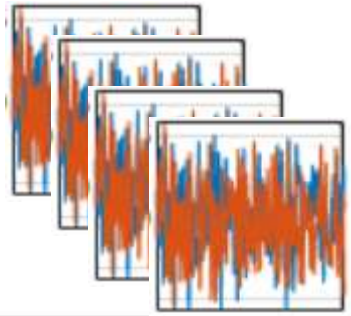
真实信号分类:

- 使用 Adalm Pluto SDR 硬件发送和采集信号

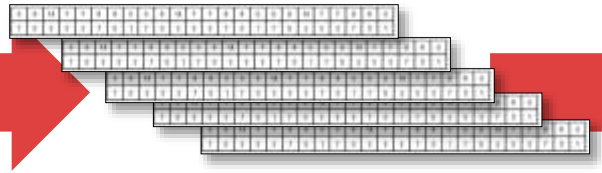
[完整示例]


Predict Modulation Type Using CNN
ADALM-PLUTO
ADALM-PLUTO
ThinkPad

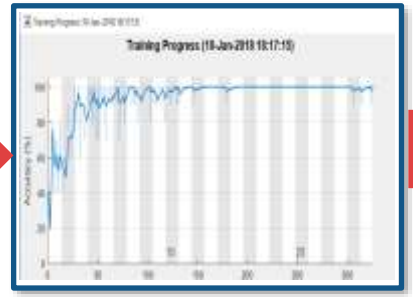
深度神经网络训练



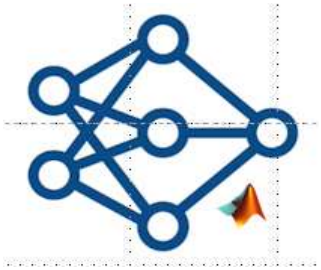
合成的信号



信号预处理



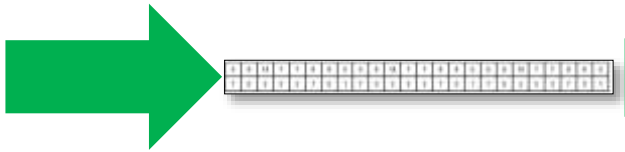
开发和训练 CNN 网络



训练好的模型

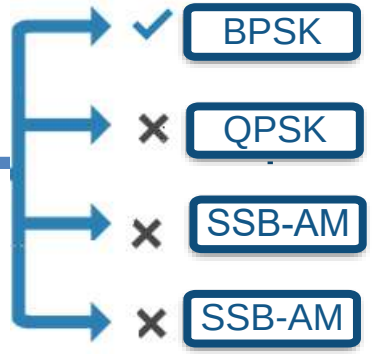
信号识别

无线信号采集

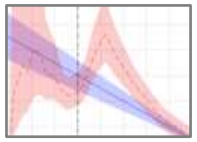


信号与处理

预测



为什么使用MATLAB进行深度学习？



Predictive Maintenance
- Bearing Prognosis
- Pump Fault Diagnosis

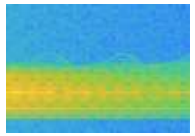
Predictive Maintenance Toolbox™

Land-Use Classification
- Semantic Segmentation for Multispectral Images

Image Processing Toolbox™

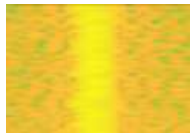
Lidar
- Lidar Point Cloud Semantic Segmentation
- 3-D Object Detection Using PointPillars

Lidar Toolbox™



Radar
- Radar Waveform Classification
- Pedestrian and Bicyclist Classification

Phased Array System Toolbox™

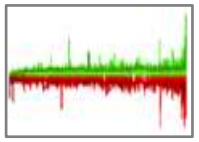


Wireless Communications
- Modulation Classification
- Detect WLAN Router Impersonation

Communications Toolbox™

Reinforcement Learning
- Train Biped Robot to Walk
- PMSM Motor Control

Reinforcement Learning Toolbox™



Computational Finance
- Machine Learning for Statistical Arbitrage

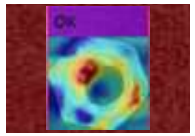
Financial Toolbox™

Robotics
- Avoid Obstacles using Reinforcement Learning

Robotics System Toolbox™

Automated Driving
- Deep Learning Vehicle Detector
- Occupancy Grid with Semantic Segmentation

Automated Driving Toolbox™

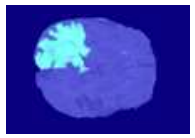


Visual Inspection
- Manufacturing Defect Detection
- Anomaly Detection for Cloth Manufacturing

Image Processing Toolbox™

Audio
- Speech Command Recognition
- Cocktail Party Source Separation

Audio Toolbox™



Medical Imaging
- 3-D Brain Tumor Segmentation
- Breast Cancer Tumor Classification

Image Processing Toolbox™

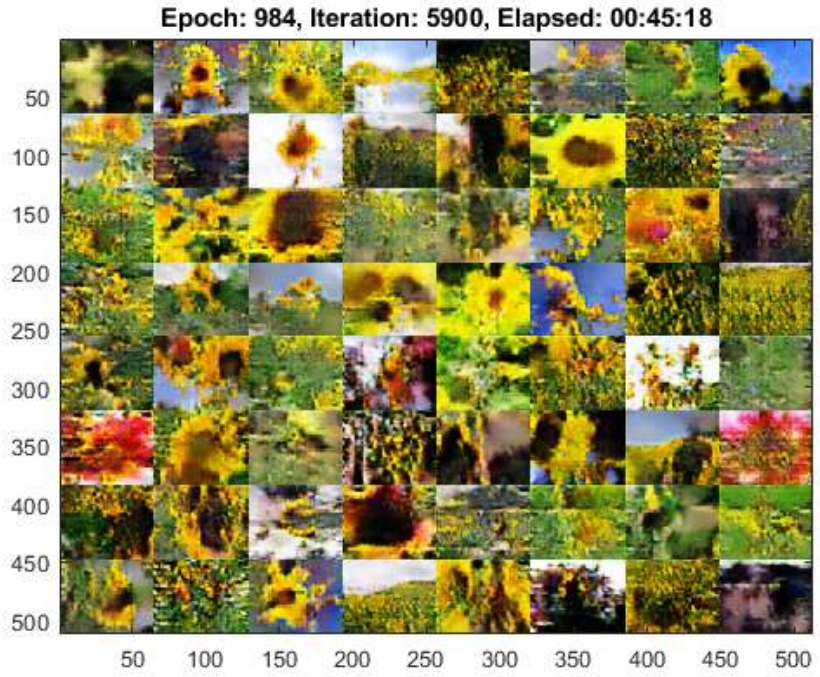
Low-Code AI

开发你自己的自定义网络

创建你自己的自定义网络，或者重建最新研究发布的网络

Custom training loops, Custom loss functions	R2019b
Automatic Differentiation, Shared Weights	
3-D layers, MIMO	R2020a
Code generation support	R2020b
Higher Order Derivatives, 1-D Convolution	R2021a
Short-time Fourier transform layer *Signal Processing Toolbox*	R2021b

GANs, Siamese Networks	R2019b
CGANs	R2020a
Graph Convolutional Networks	R2021a

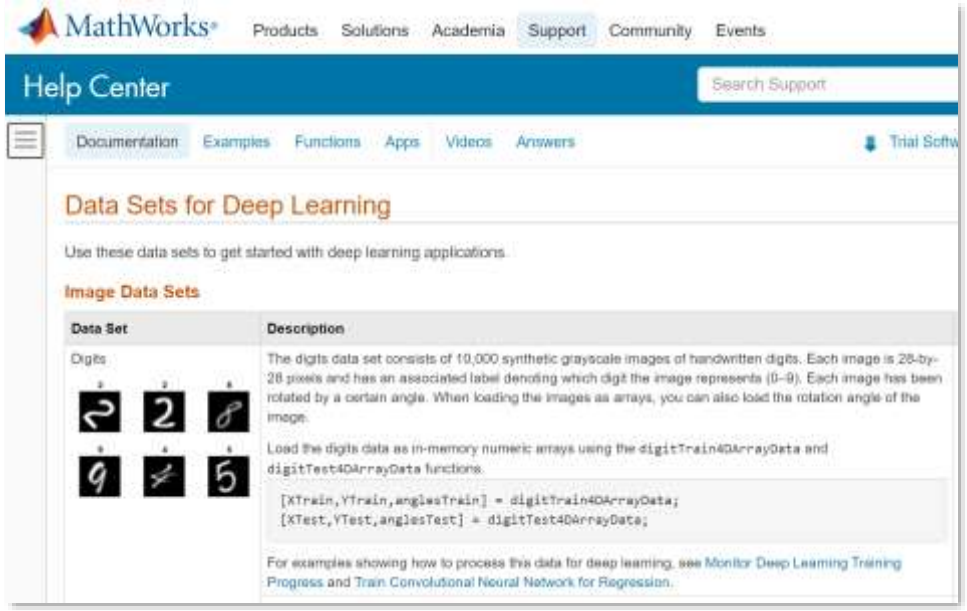


53

为 AI 找到有用的数据集

为训练模型节省搜索适当数据集的时间:

- 图片
- 视频
- 信号
- 时间序列
- 文本
- 音频
- 表格数据



[Data Sets for Deep Learning](#) 帮助文档

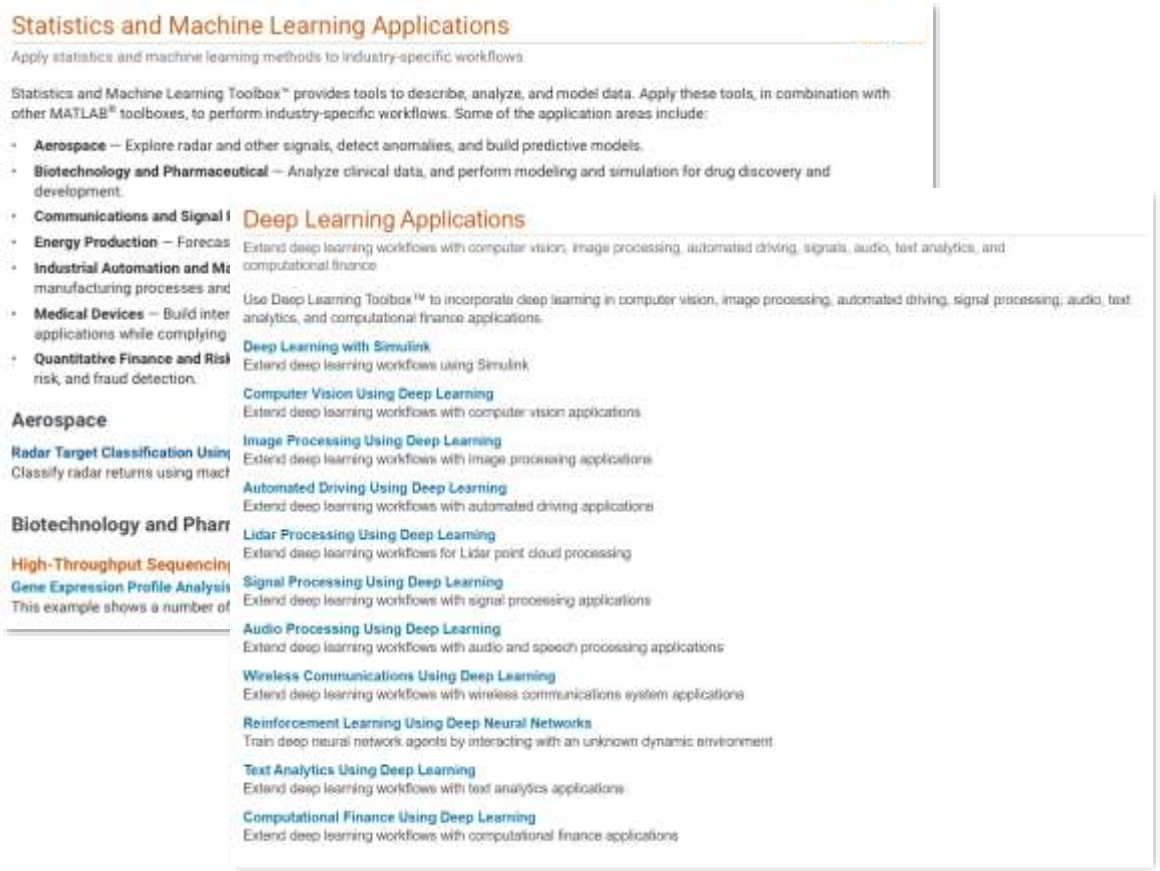
[Data Sets for Machine Learning and Statistics](#) 帮助文档

54

从领域特定的例子开始

例如，工程师和科学家如何学习应用人工智能构建
深度学习应用 和 机器学习应用

- 计算机视觉(图像与视频)
- 信号处理
- 文本
- 音频
- 控制(强化学习)
- 通信系统设计(Simulink)
- 无线生物技术与医药
- 金融
- 能源
- 生产制造业
- **超过 500+ 完整示例！**



55

从领域特定的例子开始

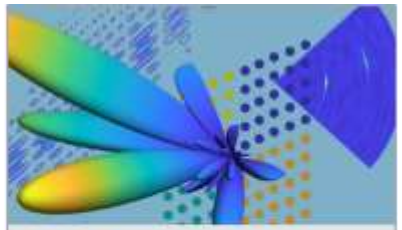
AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

Predictive Maintenance
Anomaly Detection and Condition Monitoring

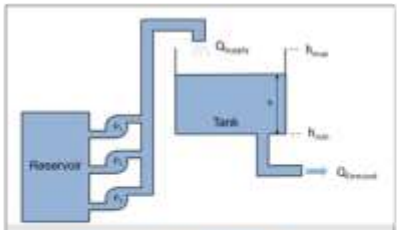
Geospatial Analysis
Hyperspectral Image Classification

Lidar
3-D Point Cloud Object Detection



Radar
Waveform Classification

Wireless Comms
Data Synthesis for 5G Channel Estimation

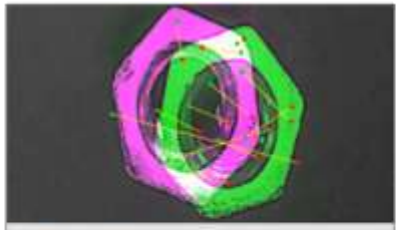


Controls Systems
PID Tuning & System Scheduling

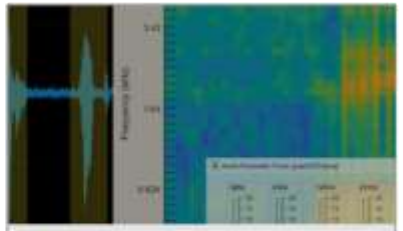
Computational Finance
Trading & Risk Management

Automated Driving
Pedestrian & Vehicle Detection

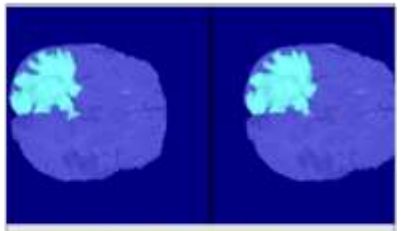
Robotics
Path Planning & Process Optimization



Visual Inspection
Defect Detection



Audio
Speech Recognition



Medical Imaging
Tumor Detection

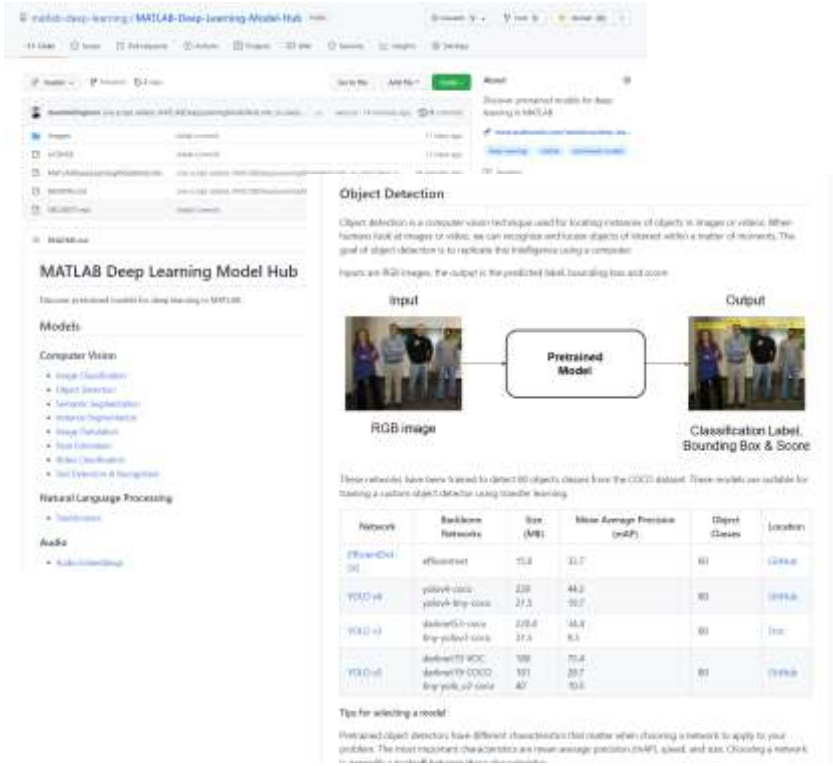
56

在GitHub上找到最新的预训练模型

R2022a

MATLAB 深度学习模型中心

- 快速参考超过 50 个预训练模型：
  - 计算机视觉
  - 自然语言处理
  - 语音
  - 激光雷达
  - * 每月增加新模型



https://github.com/matlab-deep-learning/MATLAB-Deep-Learning-Model-Hub

在 MATLAB 中免费开始使用 AI

无需下载，无需安装，只需您的浏览器和您…

机器学习入门之旅

初步了解面向分类问题的机器学习实用方法。

详细信息与启动

深度学习入门之旅

快速入门，运用深度学习方法执行图像识别。

详细信息与启动

强化学习入门之旅

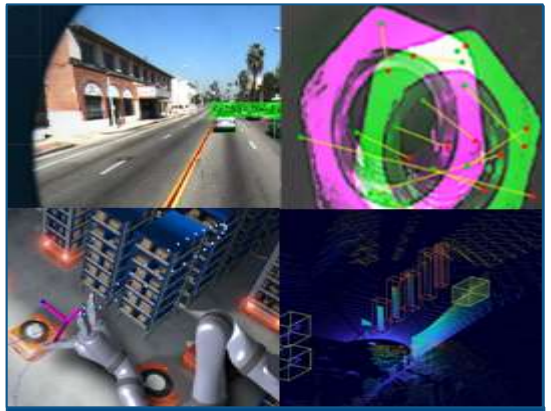
交互式入门教程，介绍了面向控制问题的强化学习方法。

详细信息与启动

https://matlabacademy.mathworks.com/cn

支持领域专家做最好的工作

建立更好的数据集



利用专业领域示例

在系统内模拟 AI

部署到任何设备

59

Key takeaways

Ease-of-use through interactive tools

AI accessible to everyone

Interactive tools can enhance programming skills

Thank you