2018
MathWorks
中国汽车年会

# 基于深度学习的感知

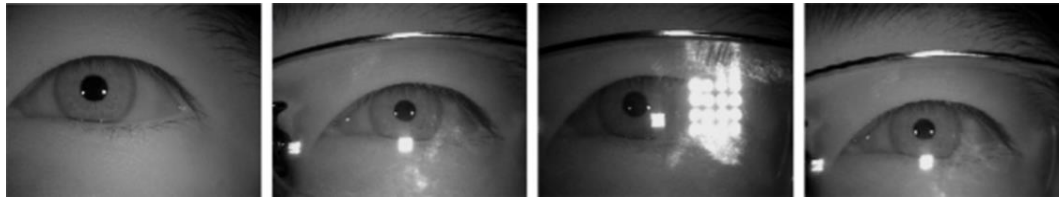
## —— 从算法开发到嵌入式实现

陈建平，MathWorks

# 深度学习多才多艺

*自动驾驶系统中的汽车和道路检测*

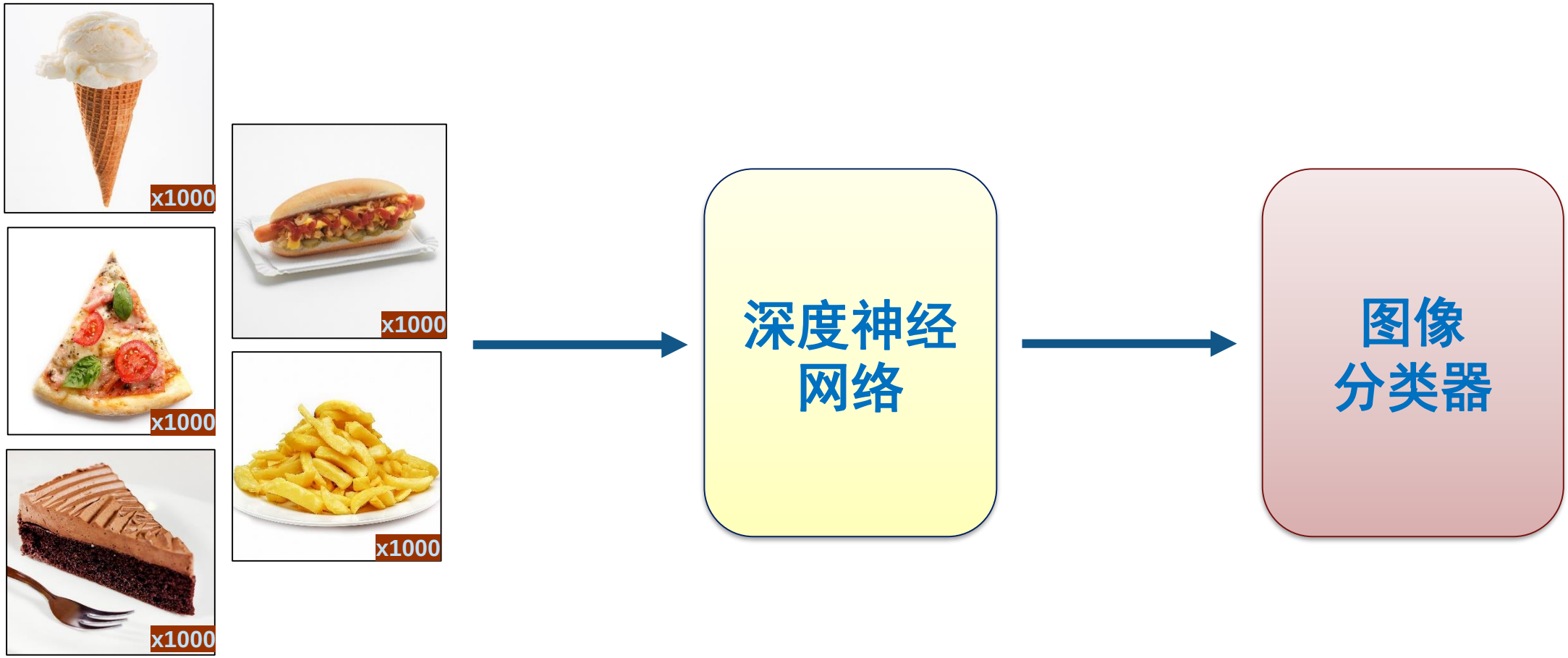
*雨水探测和清除*[1]



*虹膜识别 - 准确率达99.4 %*[2]

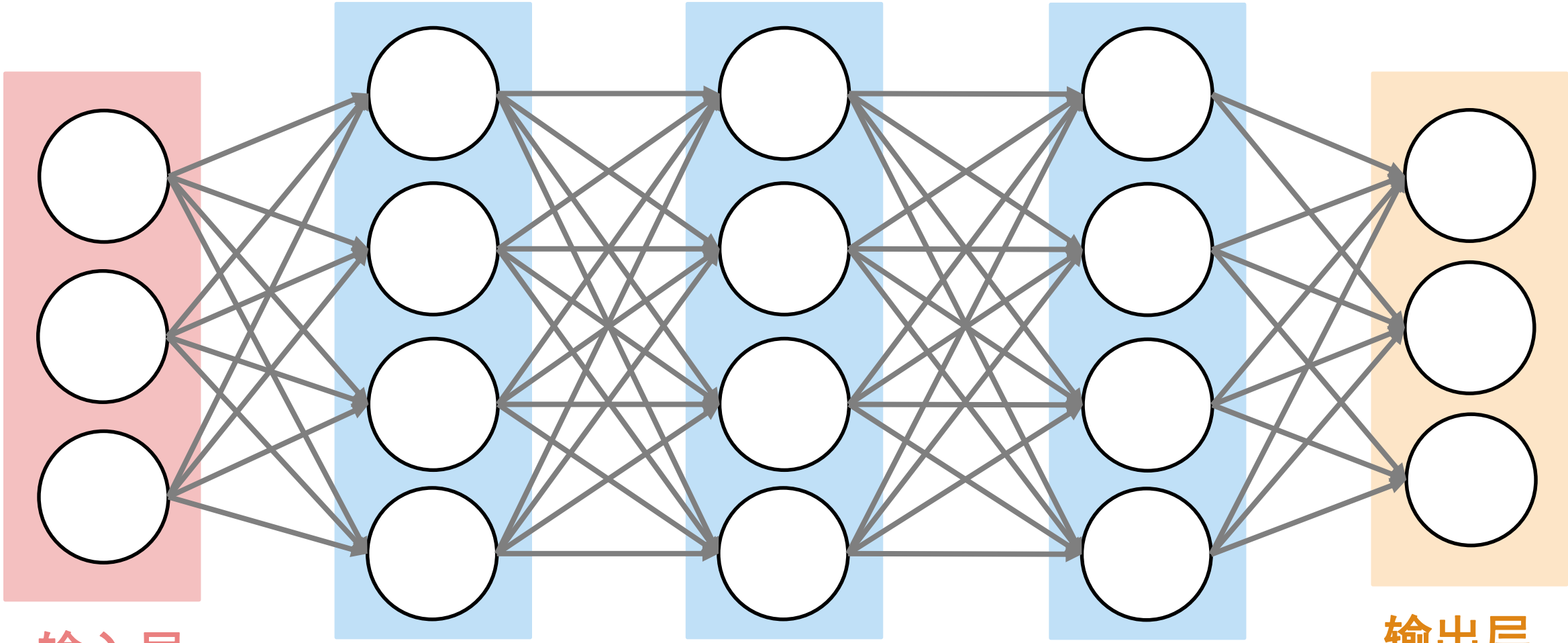
1. *Deep Joint Rain Detection and Removal from a Single Image" Wenhan Yang, Robby T. Tan, Jiashi Feng, Jiaying Liu, Zongming Guo, and Shuicheng Yan*
2. *Source: An experimental study of deep convolutional features for iris recognition Signal Processing in Medicine and Biology Symposium (SPMB), 2016 IEEE Shervin Minaee ; Amirali Abdolrashidiy ; Yao Wang; An experimental study of deep convolutional features for iris recognition*

# 深度学习



# MATLAB 如何构建深度学习网络?

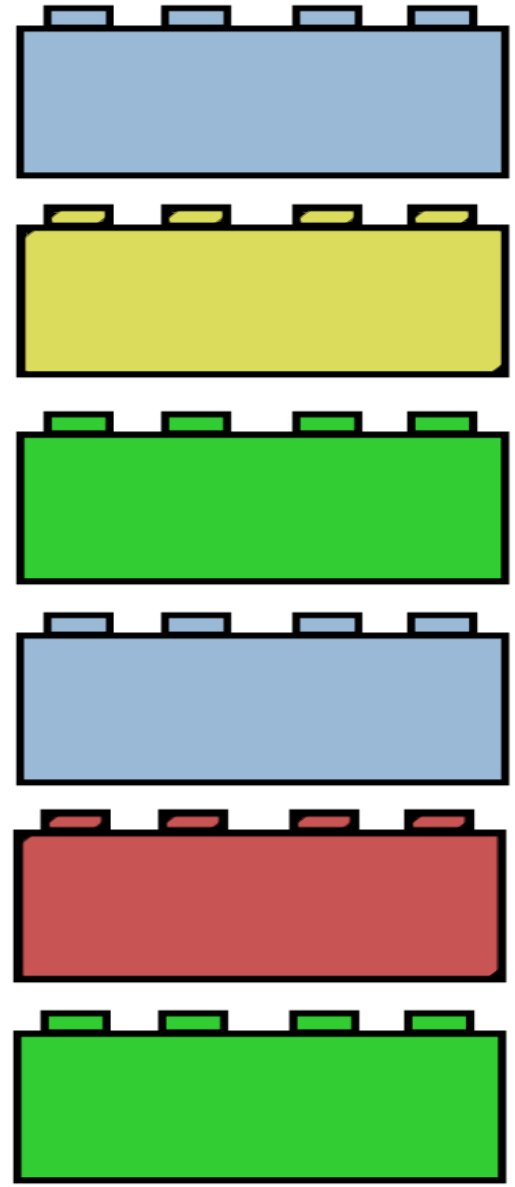
# 深度神经网络



# 神经网络的层次结构

- 层次就像积木
- 能堆叠起来
- 能替换层次

- 每个隐藏层处理上一层的信息

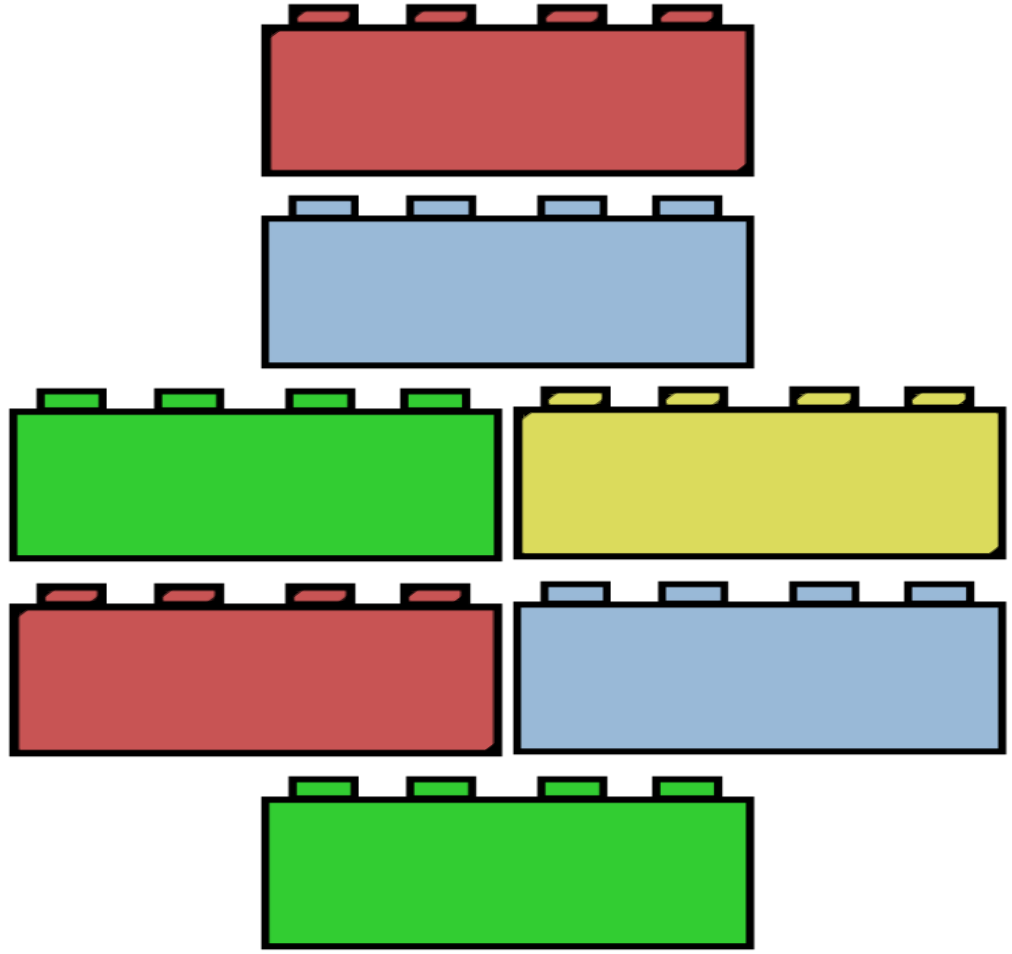


# 神经网络的层次结构

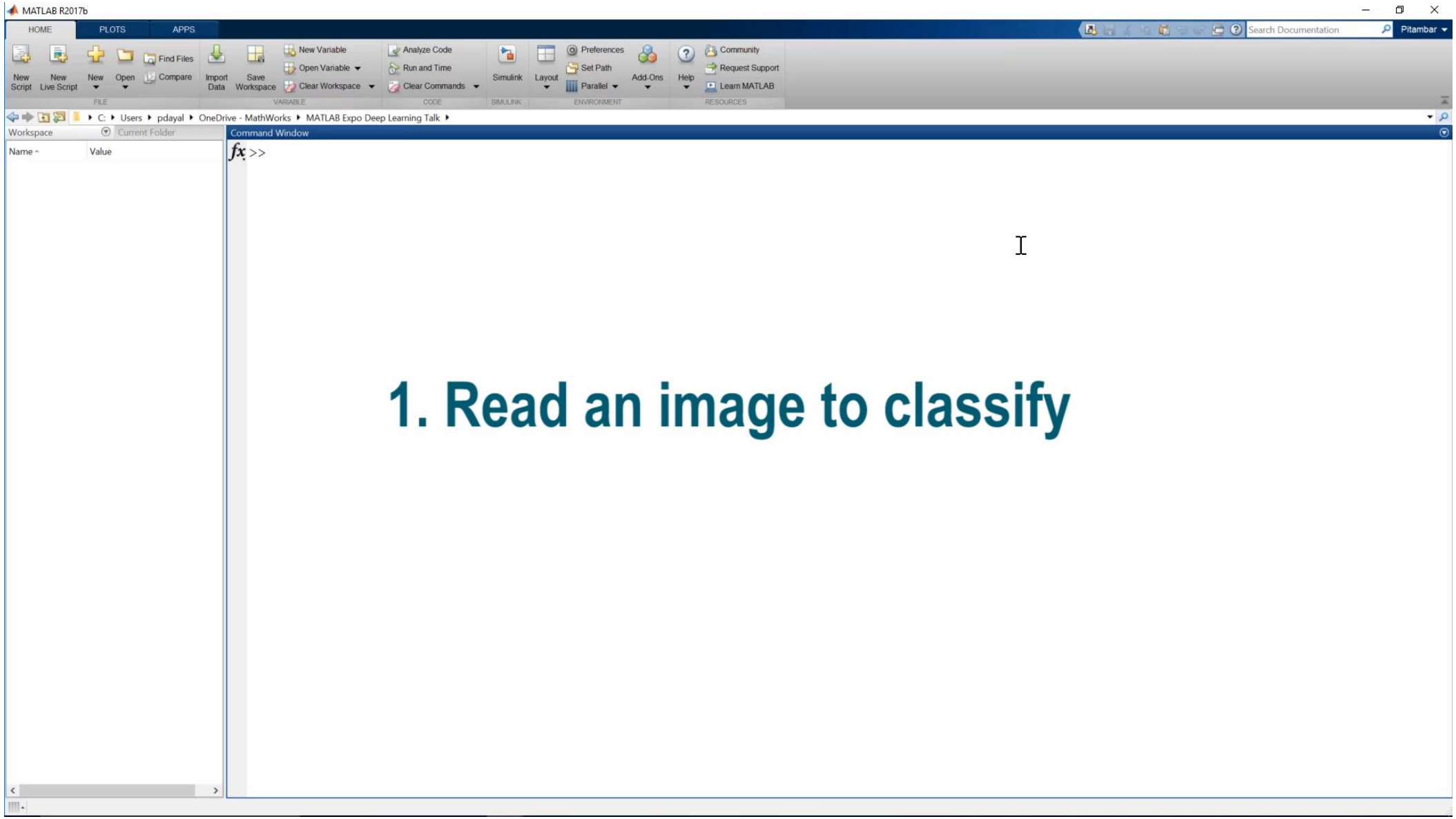
- 层次就像积木
- 能堆叠起来
- 能替换层次

- 每个隐藏层处理上一层的信息

- 可以用不同的方式排列层次



# 6 行 MATLAB 的深入学习应用



“我热爱标记和预处理数据！”

—— Nobody

# 卡特彼勒案例分析

- 世界领先的建筑和采矿设备制造商
- 这些项目之间的相似性？
  - 自主运输卡车
  - 行人检测
  - 设备分类
  - 地形映射

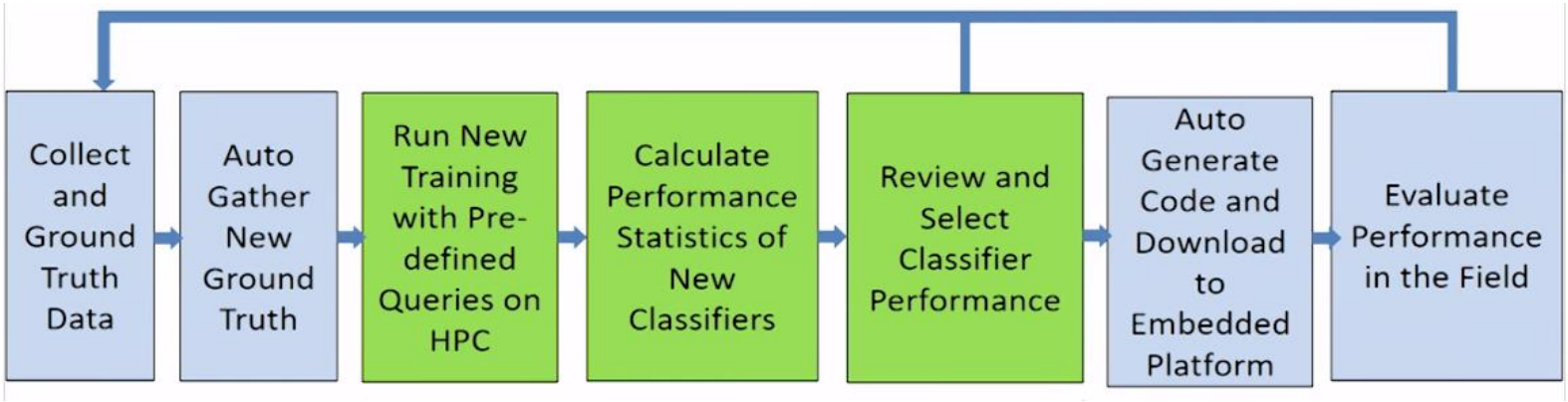
# 计算机必须从大量数据中学习

- “当构建自主系统,我们首先必须标记所有数据”。
- “我们之前花费太多时间标记来 ground-truth 数据”。

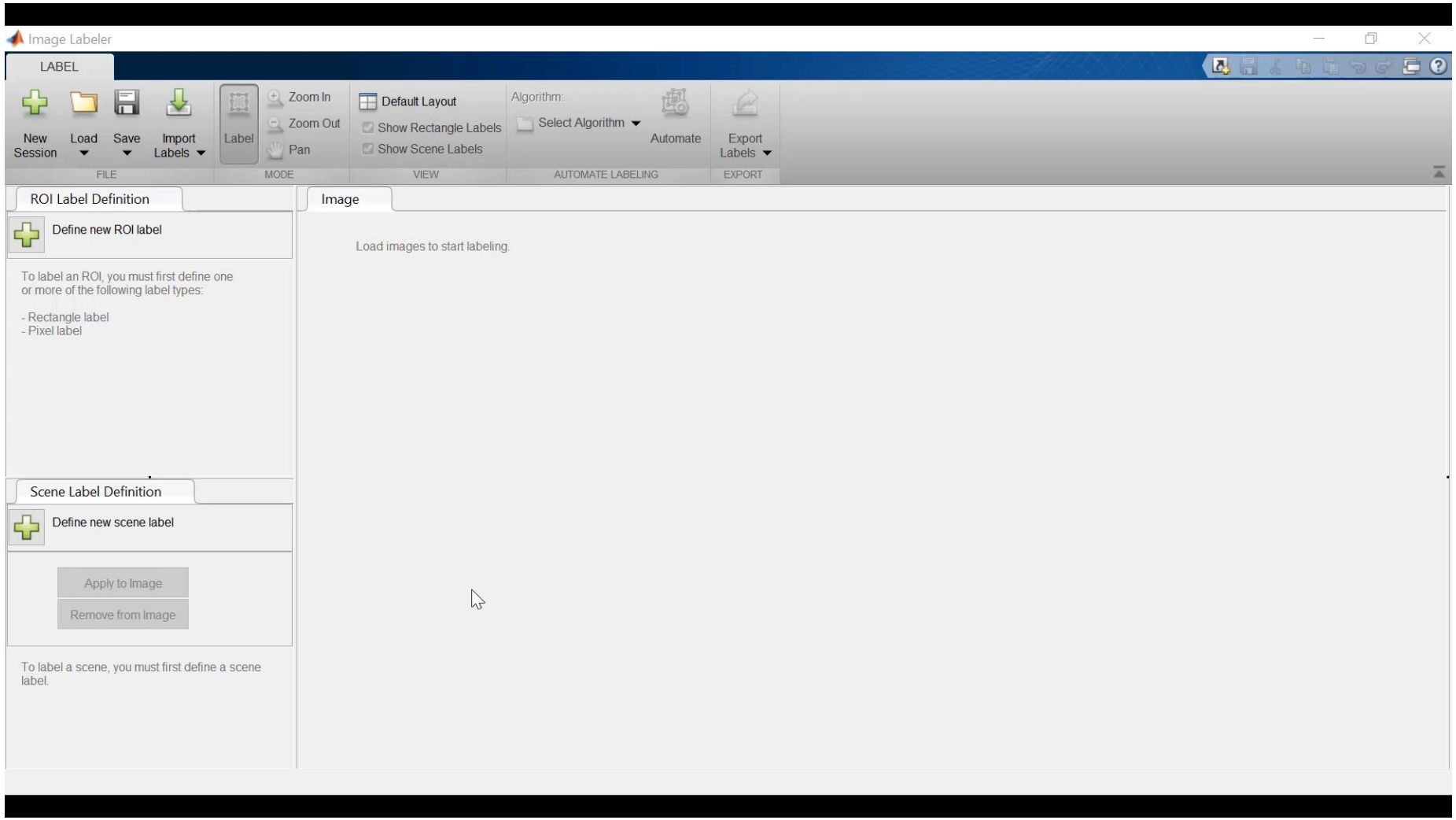
--Larry Mianzo, 卡特彼勒

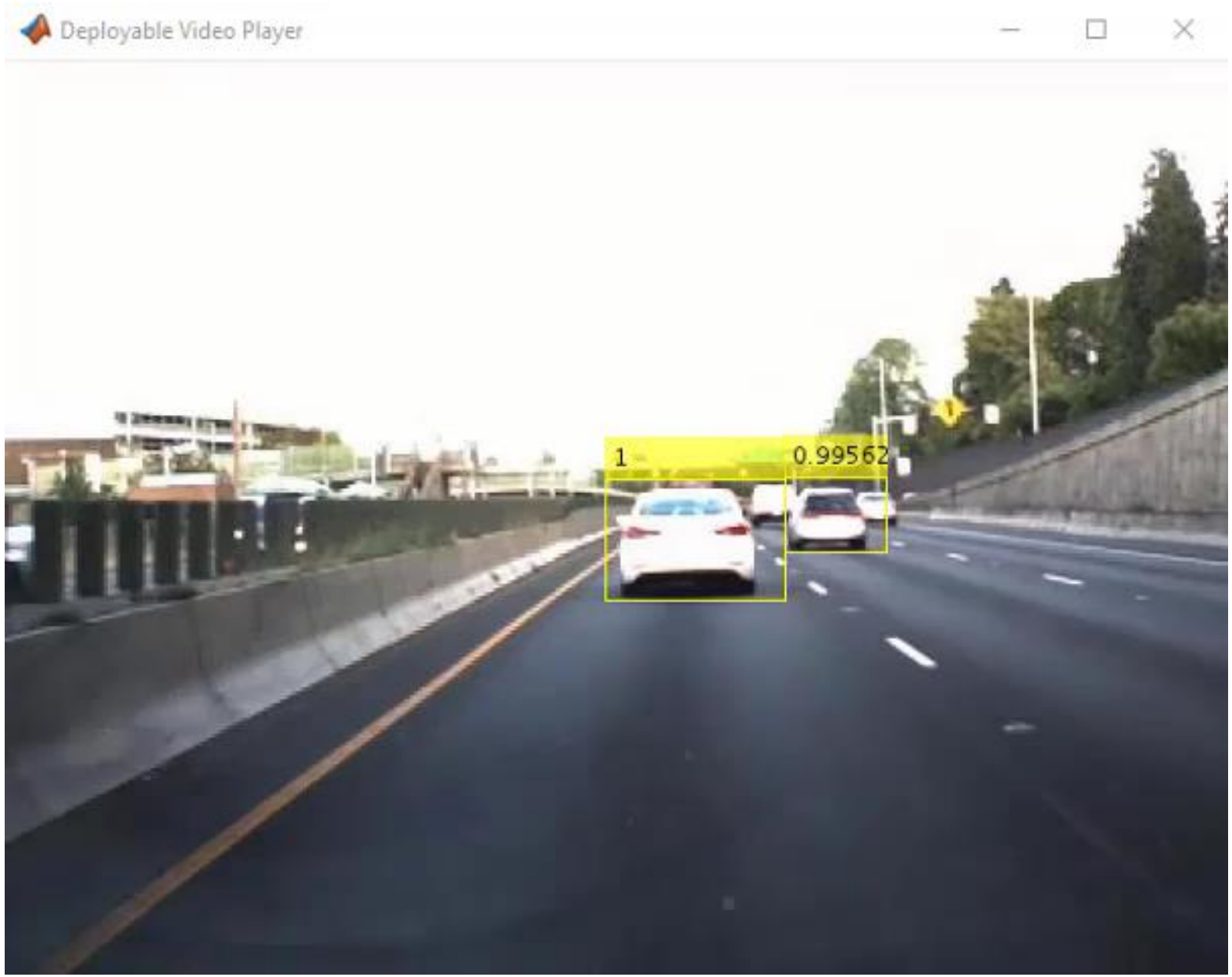
# 卡特彼勒如何使用 MATLAB?

- 半自动标记
  - *“我们从必须标记 100% 的数据到标记大约 80%到 90%的数据”*
- 在整个开发流程中只用 MATLAB
  - *“因为一切都在 MATLAB 中，所以开发时间很短”*



# 如何使用 MATLAB 标记数据？




Deployable Video Player
1
0.99562

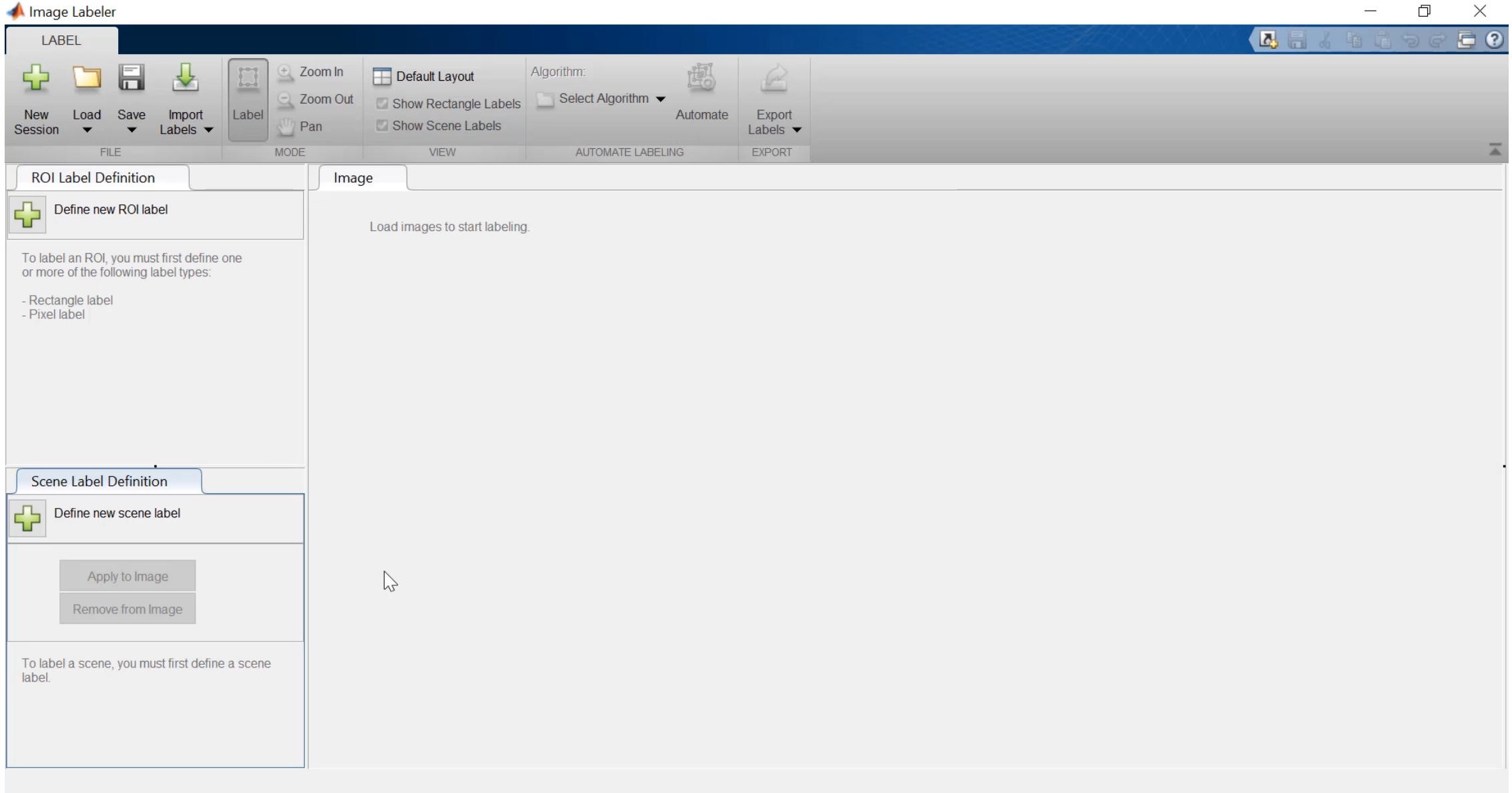


Image Labeler
LABEL
New Session
Load
Save
Import Labels
FILE
Label
Zoom In
Zoom Out
Pan
MODE
Default Layout
Show Rectangle Labels
Show Scene Labels
VIEW
Algorithm:
Select Algorithm
Automate
AUTOMATE LABELING
Export Labels
EXPORT
ROI Label Definition
Define new ROI label
To label an ROI, you must first define one or more of the following label types:
- Rectangle label
- Pixel label
Scene Label Definition
Define new scene label
Apply to Image
Remove from Image
To label a scene, you must first define a scene label.
Image
Load images to start labeling.

RICE HOUSE

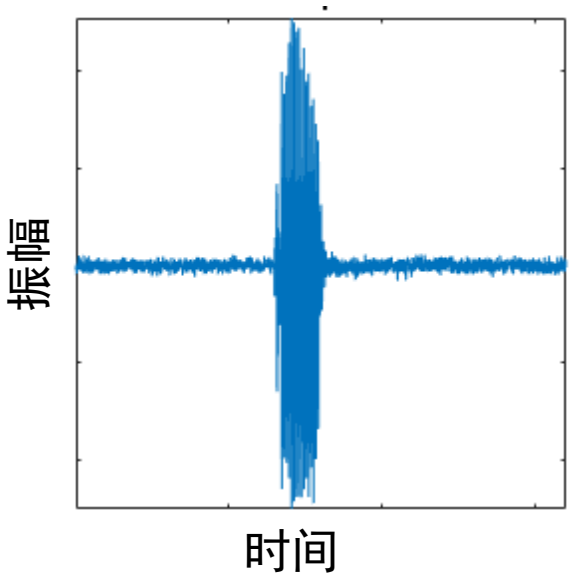
# MATLAB 是高效的

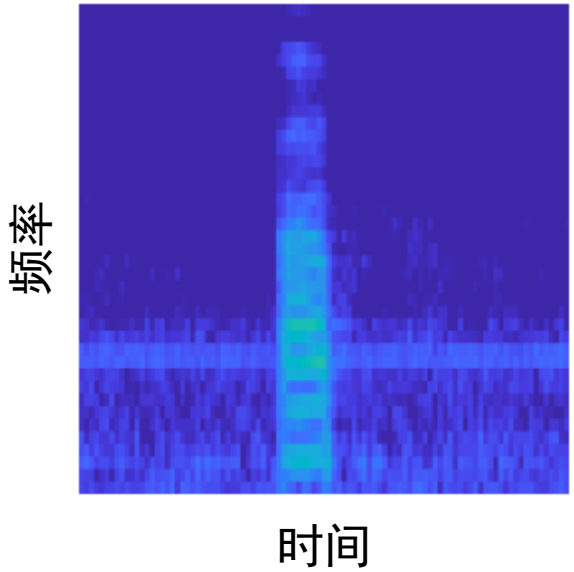
- Image Labeler App 半自动化标签流程
- Bootstrapping
  - 当您正确标记更多图像时，它会更新算法来改进自动标记精度
- 可以采用手工标记，也可直接导入导出元数据

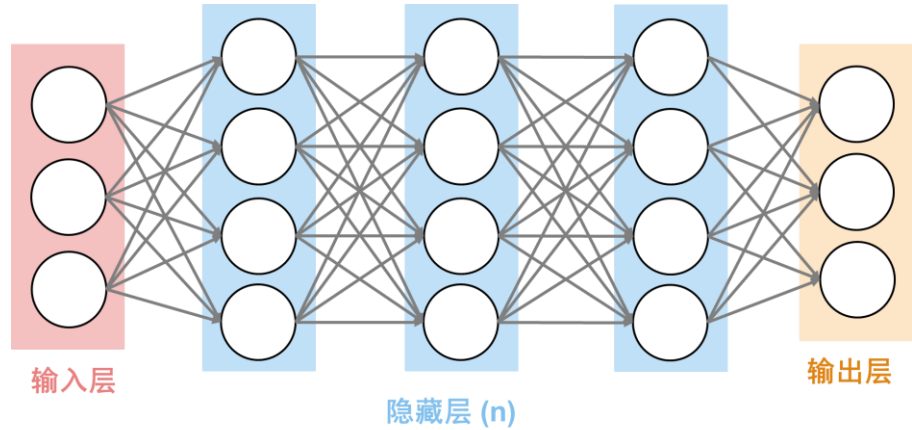
# MATLAB 如何训练深度网络？

# 语音识别示例

音频信号 → 频谱图 → 图像分类算法

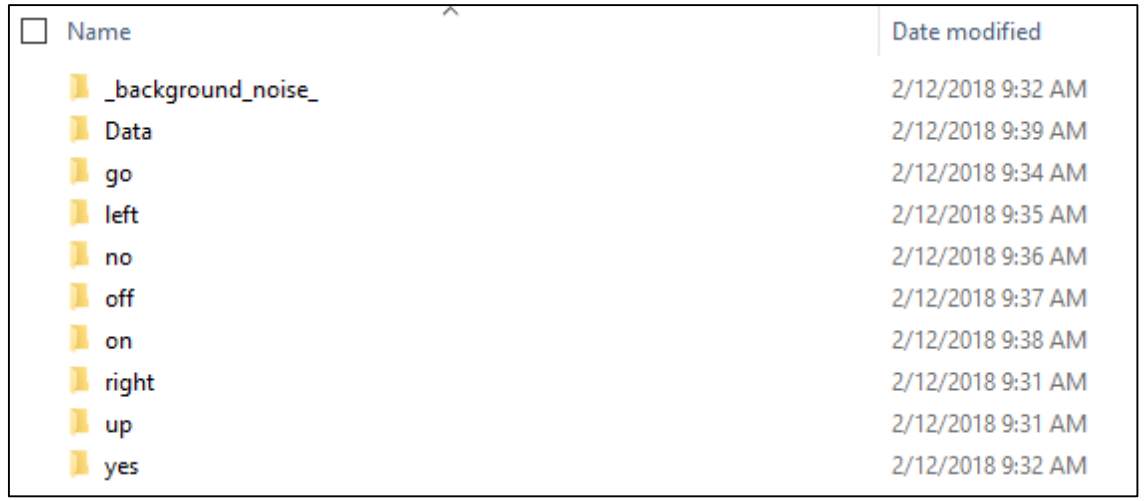


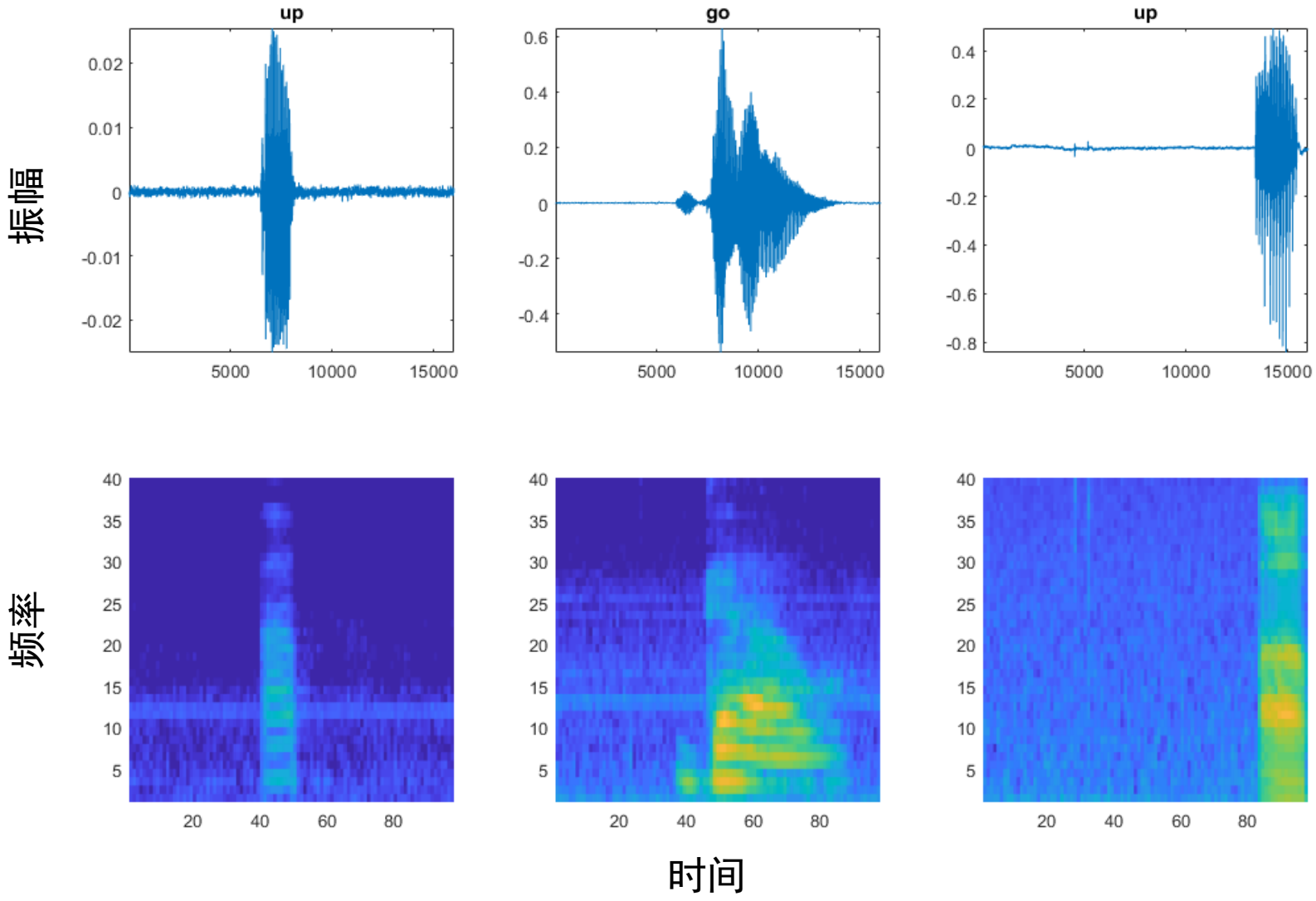
# 1. 创建数据存储

- 创建数据存储 datastore
  - 对磁盘数据的引用
  - 不会一次性加载
- 支持不同的数据来源
- 可以指定预处理算法




```
datafolder = fullfile(tempdir,'speech_commands_v0.01');

addpath(fullfile(matlabroot,'toolbox','audio','audiodemos'))
ads = audioexample.Datastore(datafolder, ...
    'IncludeSubfolders',true, ...
    'FileExtensions','.wav', ...
    'LabelSource','foldernames', ...
    'ReadMethod','File')
```

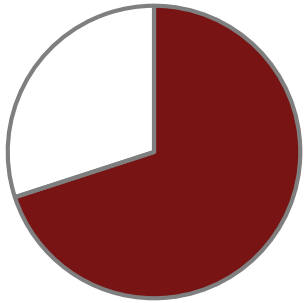
# 2. 计算语音信号的频谱图



# 3. 拆分数据存储

## 训练

70%



- 训练神经网络
- 计算机从这些数据中“学习”模型

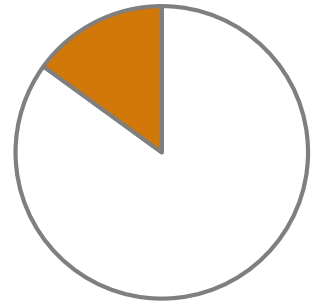
## 验证

15%

- 在训练期间检查神经网络的准确性

## 测试

15%



- 测试神经网络的准确性
- 在验证准确性达到标准之后使用

# 4. 定义网络结构和参数

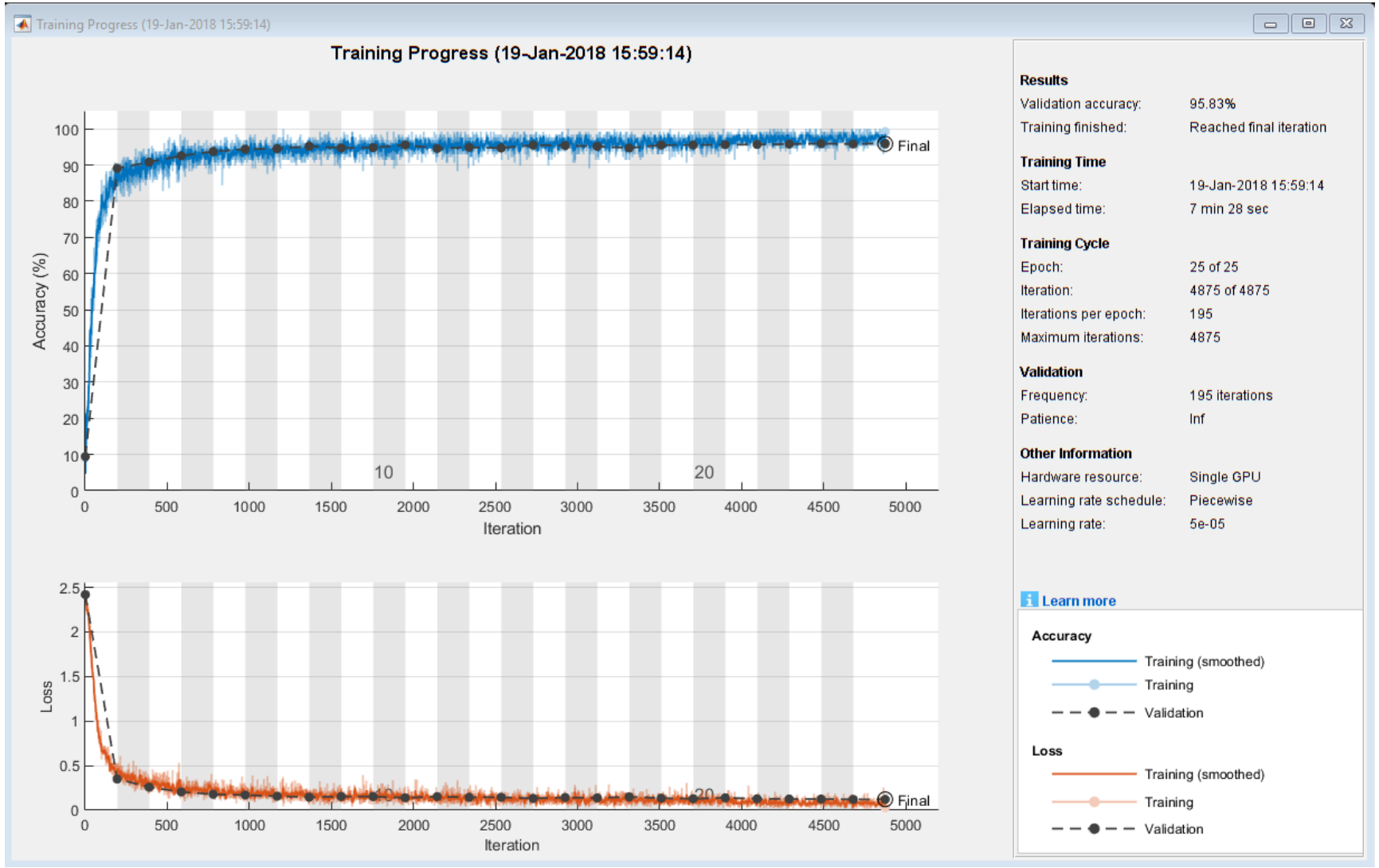
```
layers = [
    imageInputLayer(imageSize)

    convolution2dLayer(3,16,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2)

    convolution2dLayer(3,32,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2,'Padding',[0,1])

    dropoutLayer(dropoutProb)
    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    dropoutLayer(dropoutProb)
    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer(2,'Stride',2,'Padding',[0,1])

    dropoutLayer(dropoutProb)
    convolution2dLayer(3,64,'Padding','same')
    batchNormalizationLayer
    reluLayer

    maxPooling2dLayer([1 13])

    fullyConnectedLayer(numClasses)
    softmaxLayer
    weightedCrossEntropyLayer(classNames,classWeights)];
```

神经网络结构

```
miniBatchSize = 128;
validationFrequency = floor(numel(YTrain)/miniBatchSize);
options = trainingOptions('adam', ...
    'InitialLearnRate',5e-4, ...
    'MaxEpochs',25, ...
    'MiniBatchSize',miniBatchSize, ...
    'Shuffle','every-epoch', ...
    'Plots','training-progress', ...
    'Verbose',false, ...
    'ValidationData',{XValidation,YValidation}, ...
    'ValidationFrequency',validationFrequency, ...
    'ValidationPatience',Inf, ...
    'LearnRateSchedule','piecewise', ...
    'LearnRateDropFactor',0.1, ...
    'LearnRateDropPeriod',20);
```

训练参数

# 5. 训练神经网络

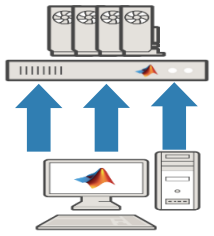

Training Progress (19-Jan-2018 15:59:14)
Training Progress (19-Jan-2018 15:59:14)
Accuracy (%)
Iteration
Final
10
20
Loss
Iteration
Final
20
Results
Validation accuracy: 95.83%
Training finished: Reached final iteration
Training Time
Start time: 19-Jan-2018 15:59:14
Elapsed time: 7 min 28 sec
Training Cycle
Epoch: 25 of 25
Iteration: 4875 of 4875
Iterations per epoch: 195
Maximum iterations: 4875
Validation
Frequency: 195 iterations
Patience: Inf
Other Information
Hardware resource: Single GPU
Learning rate schedule: Piecewise
Learning rate: 5e-05
Learn more
Accuracy
Training (smoothed)
Training
Validation
Loss
Training (smoothed)
Training
Validation

# 5. 训练神经网络

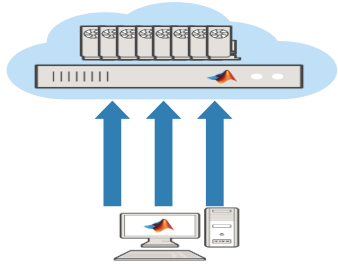
单CPU

单CPU
单GPU

单CPU, 多GPU



带GPU的内部服务器



GPU云
(AWS)

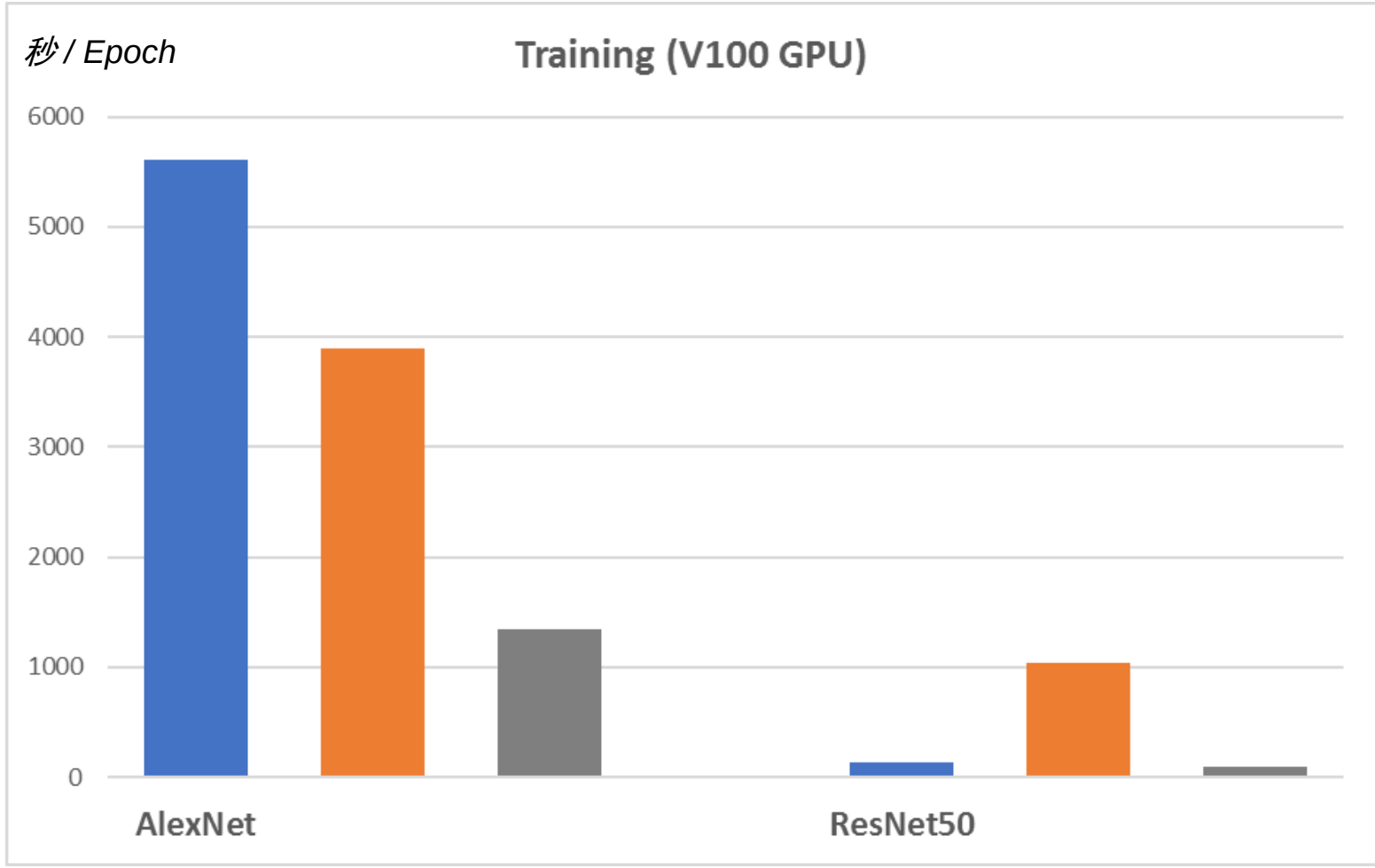
## 训练参数

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'auto' );
```

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'multi-gpu' );
```

```
opts = trainingOptions('sgdm', ...
    'MaxEpochs', 100, ...
    'MiniBatchSize', 250, ...
    'InitialLearnRate', 0.00005, ...
'ExecutionEnvironment', 'parallel' );
```

# 训练的计算性能




TensorFlow

MATLAB

MXNet

*批量 32*

# 训练是一个迭代过程

```
miniBatchSize = 128;
validationFrequency = floor(numel(YTrain)/miniBatchSize);
options = trainingOptions('adam', ...
    'InitialLearnRate',5e-4, ...
    'MaxEpochs',25, ...
    'MiniBatchSize',miniBatchSize, ...
    'Shuffle','every-epoch', ...
    'Plots','training-progress', ...
    'Verbose',false, ...
    'ValidationData',{XValidation,YValidation}, ...
    'ValidationFrequency',validationFrequency, ...
    'ValidationPatience',Inf, ...
    'LearnRateSchedule','piecewise', ...
    'LearnRateDropFactor',0.1, ...
    'LearnRateDropPeriod',20);
```

*参数根据性能进行调整*

# 从算法到实现？

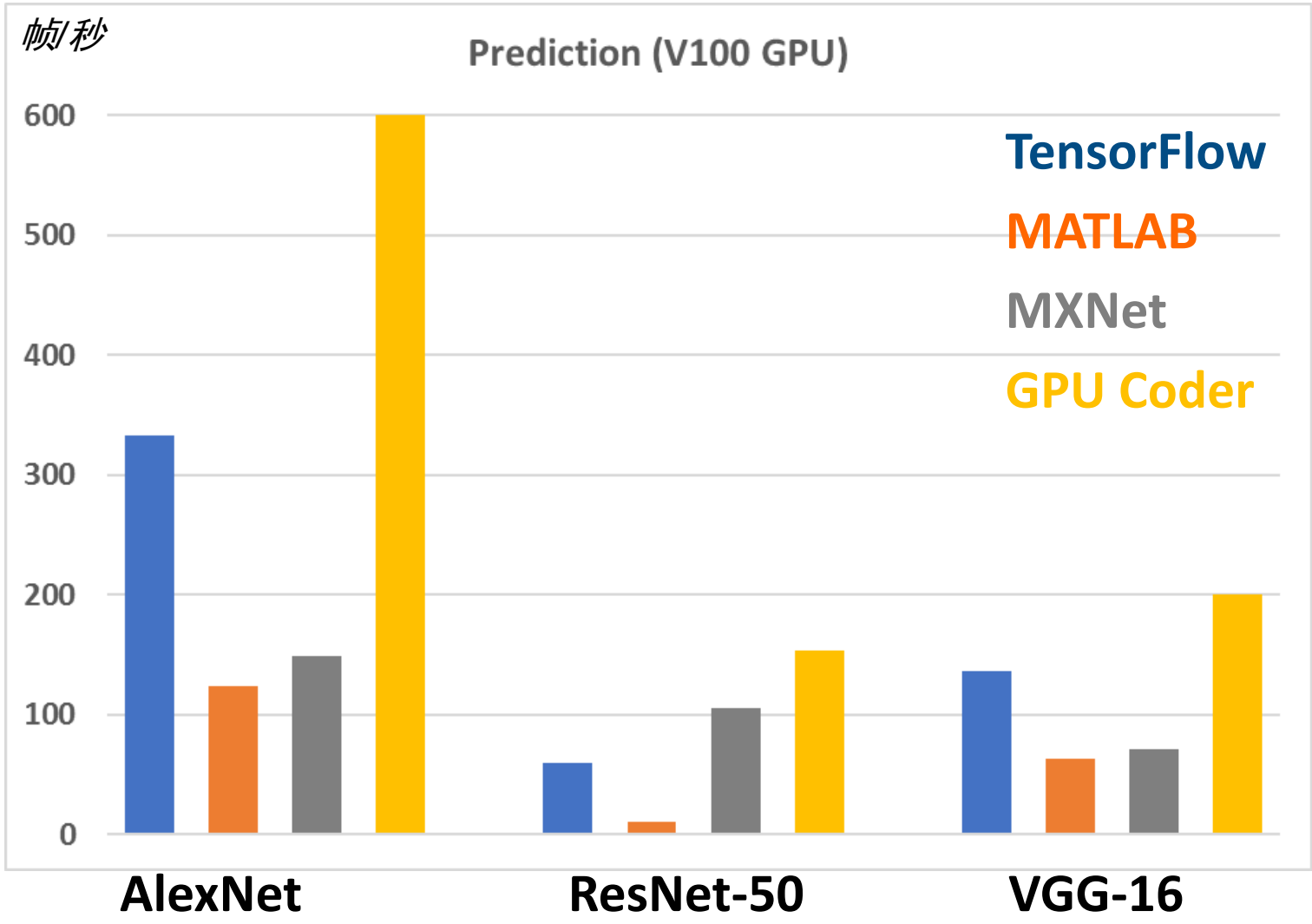
# GPU Coder

- 从MATLAB代码自动生成 **CUDA** 代码
  - 可在NVIDIA GPU上跑

- CUDA 将 C / C ++ 代码扩展为并行结构

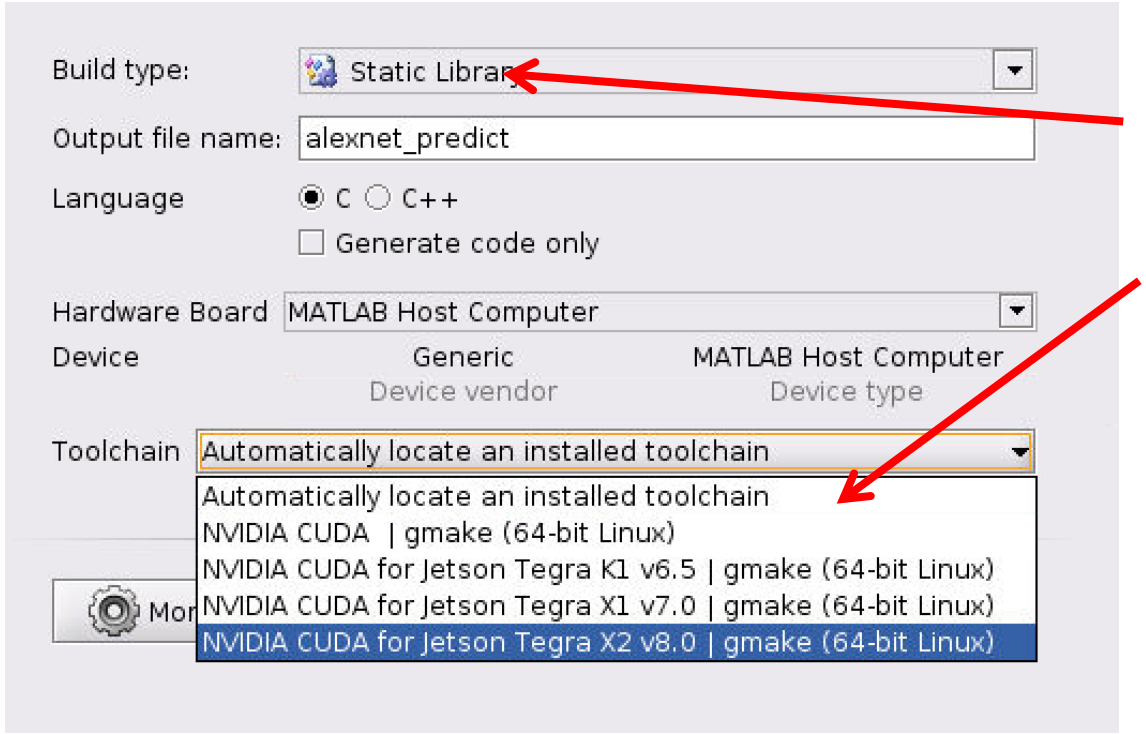
# GPU Coder 的性能

# GPU Coder 支持深度学习模型的推断



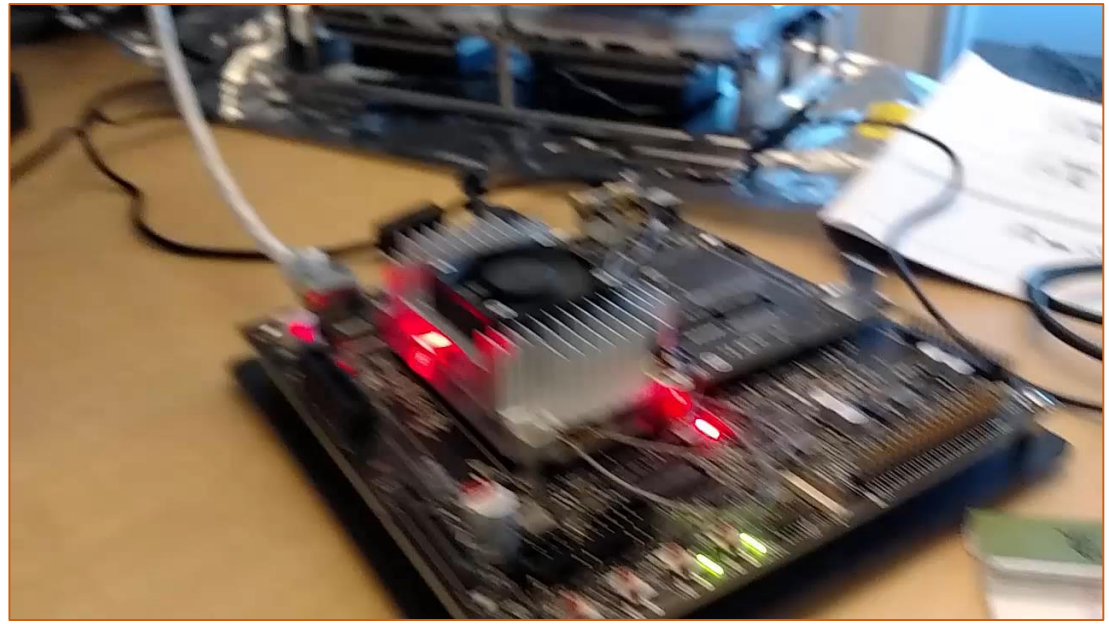

- 分析和优化网络结构
- MathWorks 有 20 年代码生成的产品经验

# Alexnet部署到Tegra：交叉编译




两个小变化

1. 将build-type更改为'lib'
2. 选择交叉编译工具链



# MATLAB 如何和开源交互？

# MATLAB 与开源软件的交互

- Caffe和MATLAB一起使用
- 比专门设计的降雨模型取得更好的效果

- 使用MATLAB，让您的工作流程更轻松！

1. *Deep Joint Rain Detection and Removal from a Single Image" Wenhan Yang, Robby T. Tan, Jiashi Feng, Jiaying Liu, Zongming Guo, and Shuicheng Yan*

# MATLAB 与开源软件的交互

- 使用 add-on 获得许多预先训练好的神经网络
  - 无需转换直接使用

- 直接从 Tensorflow 或 Caffe 导入神经网络
  - 提高与其他用户的协作

KERAS IMPORTER

Importer for TensorFlow-Keras Models

Caffe

MODELS

# 深度学习： 从算法设计到嵌入式实现

MATLAB 算法
(功能参考)

GPU Coder

Build type

MATLAB调用
CUDA代码

.mex

手编C++ main()调
用CUDA代码

.lib

手编C++ main()调用CUDA代
码。使用Linaro工具链交叉编
译主机

交叉编译
.lib

桌面
GPU

Tesla
GPU

Tegra GPU

C++

C++

1 功能测试

2 部署单元测试

3 部署集成测试

4 实时测试

（在主机上的MATLAB测试）

（在主机+ GPU上测试
MATLAB生成的代码）

（在主机+ GPU上测试C/C++应
用程序中的生成代码）

（在Tegra目标上的C/C++应用
程序中测试生成的代码）

# MATLAB 深度学习

## 从算法到嵌入式实现

- 图像标记
- 数据预处理
- 快速训练
- 代码生成
- 一键式嵌入式部署