

MATLAB for Machine Learning

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- 1 Introductions to Machine Learning and MATLAB
- 2 MATLAB Toolboxes for Machine Learning
 - Statistics and Machine Learning Toolbox
 - Neural Network Toolbox
 - Deep Learning Toolbox
 - Reinforcement Learning Toolbox
- 3 Reference Materials



1 Introductions to Machine Learning and MATLAB

2 MATLAB Toolboxes for Machine Learning

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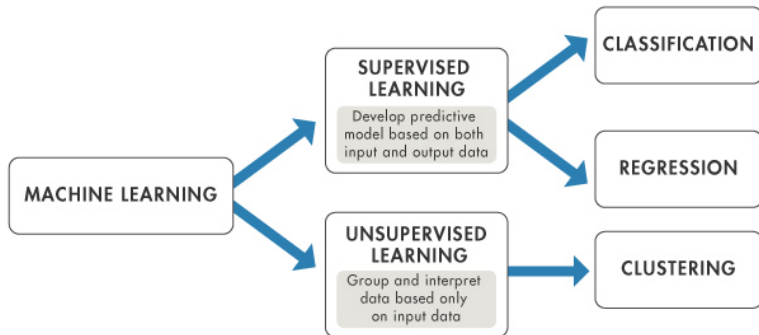
What Is Machine Learning?

- Machine learning teaches computers to do what comes naturally to humans: learn from **experience**.
- Machine learning algorithms use computational methods to “learn” information directly from **data**.
- The algorithms adaptively improve their performance as the number of **samples** available for learning **increases**.



Techniques of Machine Learning

- **Supervised learning:** train a model on known input and output data so that it can predict future outputs.
- **Unsupervised learning:** find hidden patterns or intrinsic structures in input data.



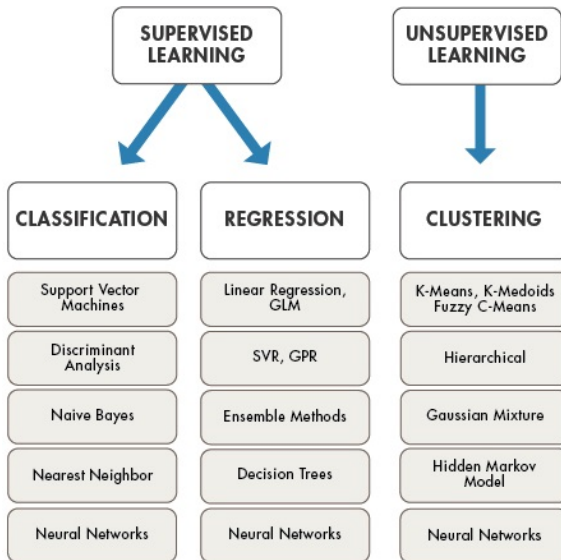
Regression vs classification

Andrew Ng:

- *Supervised learning problems are categorized into "regression" and "classification" problems.*
- *In a regression problem, we are trying to predict results within a continuous output, meaning that we are trying to map input variables to some continuous function.*
- *In a classification problem, we are instead trying to predict results in a discrete output. In other words, we are trying to map input variables into discrete categories.*



Machine Learning Algorithms



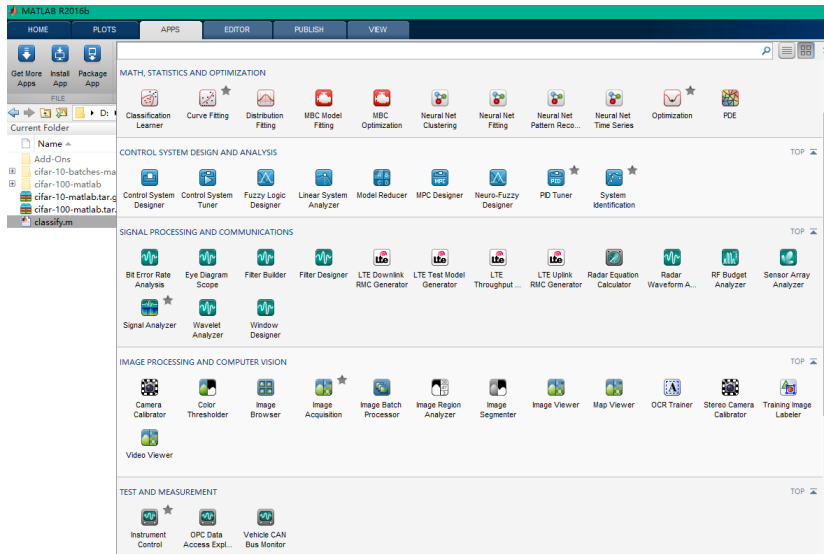
Features of MATLAB for Machine Learning

MATLAB makes the hard parts of machine learning easy with:

- 1 **Point-and-click apps** for training and comparing models
- 2 **Automatic** hyperparameter tuning and feature selection to optimize model performance
- 3 The ability to use the **same code** to scale processing to big data and clusters
- 4 Automated generation of **C/C++ code** for embedded and high-performance applications
- 5 Popular **classification, regression, and clustering** algorithms for supervised and unsupervised learning
- 6 **Faster** execution than open source on most statistical and machine learning computations



MATLAB apps and functions

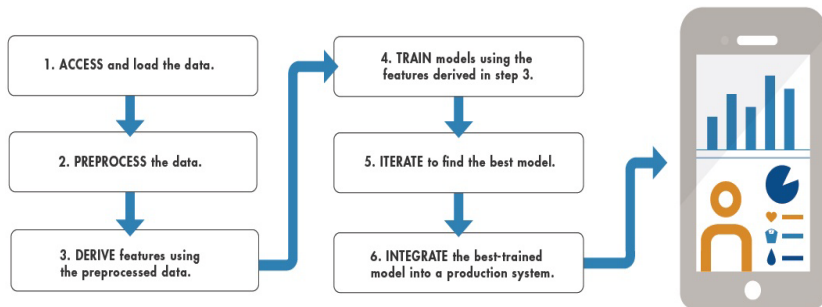


MATLAB apps and functions (cont'd)

Task	MATLAB Apps and Functions	Product
Classification to predict categorical responses	Use the Classification Learner app to automatically train a selection of models and help you choose the best. You can generate MATLAB code to work with scripts. For more options, you can use the command-line interface.	Statistics and Machine Learning Toolbox™
Regression to predict continuous responses	Use the Regression Learner app to automatically train a selection of models and help you choose the best. You can generate MATLAB code to work with scripts and other function options. For more options, you can use the command-line interface.	Statistics and Machine Learning Toolbox
Clustering	Use cluster analysis functions.	Statistics and Machine Learning Toolbox
Computational finance tasks such as credit scoring	Use tools for modeling credit risk analysis.	Financial Toolbox™ Risk Management Toolbox™
Deep learning with neural networks for classification and regression	Use pretrained networks and functions to train convolutional neural networks.	Deep Learning Toolbox™
Facial recognition, motion detection, and object detection	Use deep learning tools for image processing and computer vision.	Deep Learning Toolbox Computer Vision Toolbox™



The Entire Workflow in MATLAB



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- MATLAB toolboxes are collections of MATLAB **functions** solving particular classes of problems.
- MATLAB has specific toolboxes for processing machine learning problems:
 - **Statistics and Machine Learning Toolbox**
 - **Neural Network Toolbox**
 - ◇ Deep Learning Toolbox
 - ◇ Reinforcement Learning Toolbox

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Statistics and Machine Learning Toolbox

Statistics and Machine Learning Toolbox provides **functions** and **apps** to describe, analyze, and model data.

- **Multidimensional data analysis:** feature selection, stepwise regression, principal component analysis (PCA), regularization, and other dimensionality reduction methods.
- **Supervised and unsupervised machine learning algorithms:** support vector machines (SVMs), boosted and bagged decision trees, k-nearest neighbor, k-means, k-medoids, hierarchical clustering, Gaussian mixture models, and hidden Markov models.

Statistics and Machine Learning Toolbox
≈ clustering + classification + regression



Statistics and Machine Learning Toolbox

Clustering

Method	Basis of Algorithm	Input to Algorithm	Requires Specified Number of Clusters	Cluster Shapes Identified
Hierarchical Clustering	Distance between objects	Pairwise distances between observations	No	Arbitrarily shaped clusters, depending on the specified 'Linkage' algorithm
k-Means Clustering and k-Medoids Clustering	Distance between objects and centroids	Actual observations	Yes	Spheroidal clusters with equal diagonal covariance
Density-Based Spatial Clustering of Algorithms with Noise (DBSCAN)	Density of regions in the data	Actual observations or pairwise distances between observations	No	Arbitrarily shaped clusters
Gaussian Mixture Models	Mixture of Gaussian distributions	Actual observations	Yes	Spheroidal clusters with different covariance structures
Nearest Neighbors	Distance between objects	Actual observations	No	Arbitrarily shaped clusters
Spectral Clustering (Partition Data Using Spectral Clustering)	Graph representing connections between data points	Actual observations or similarity matrix	Yes, but the algorithm also provides a way to estimate the number of clusters	Arbitrarily shaped clusters

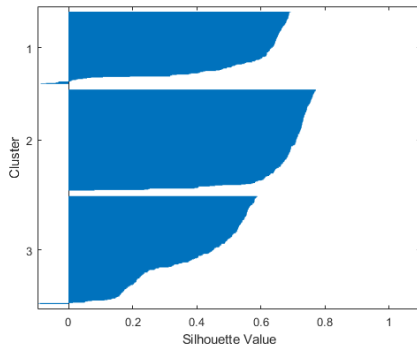


Statistics and Machine Learning Toolbox

k-means Clustering

```
[idx3,C,sumdist3] = kmeans(X,3,'Distance','cityblock','Display','final');
```

```
[silh3,h] = silhouette(X,idx3,'cityblock');  
xlabel('Silhouette Value')  
ylabel('Cluster')
```



A silhouette plot displays a measure of how close each point in one cluster is to points in the neighboring clusters.

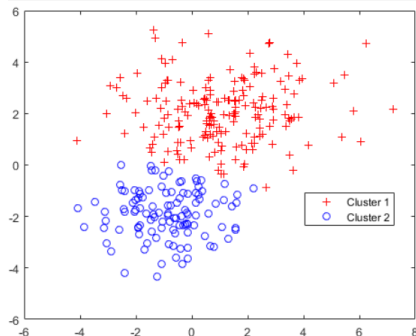
<https://ww2.mathworks.cn/help/stats/k-means-clustering.html>



Statistics and Machine Learning Toolbox

Clustering Using Gaussian Mixture Model

```
idx = cluster(gm,X);  
cluster1 = (idx == 1); % |1| for cluster 1 membership  
cluster2 = (idx == 2); % |2| for cluster 2 membership  
  
figure  
gscatter(X(:,1),X(:,2),idx,'rb','+o')  
legend('Cluster 1','Cluster 2','Location','best')
```



<https://ww2.mathworks.cn/help/stats/clustering-using-gaussian-mixture-models.html>



Statistics and Machine Learning Toolbox

1. Train Classification Models in Classification Learner App

Classification Learner app can train models to classify data using supervised machine learning.

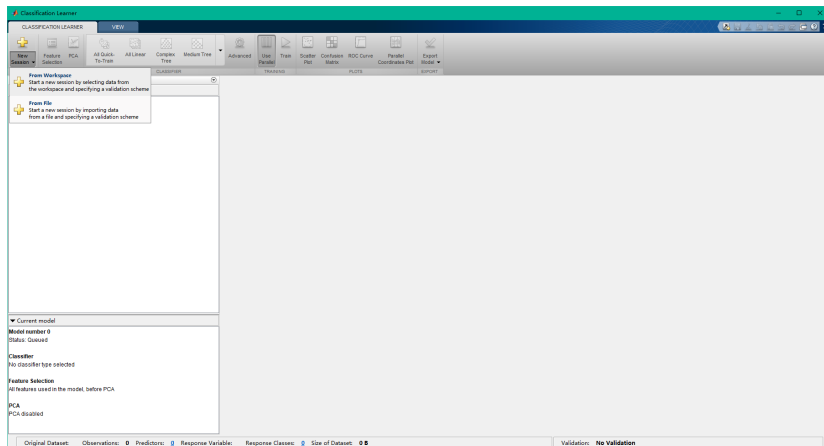
- Classifiers: **decision trees**, discriminant analysis, support vector machines, logistic regression, nearest neighbors, **naive Bayes**, and ensemble classification.
- Explore data, specify validation schemes, select features, and visualize results.
- Export models to make predictions with new data.
- Generate MATLAB code for further analysis.



Statistics and Machine Learning Toolbox

1. Train Classification Models in Classification Learner App

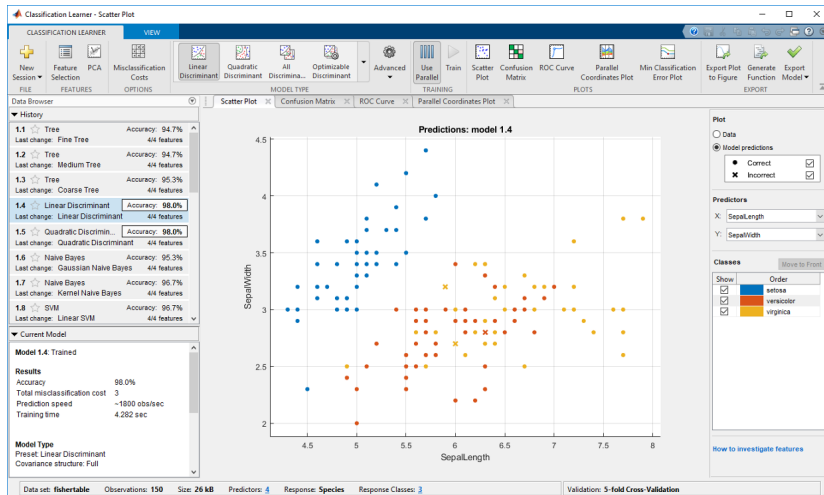
Load Data



Statistics and Machine Learning Toolbox

1. Train Classification Models in Classification Learner App (cont'd)

Results



<https://ww2.mathworks.cn/help/stats/train-decision-trees-in-classification-learner-app.html>

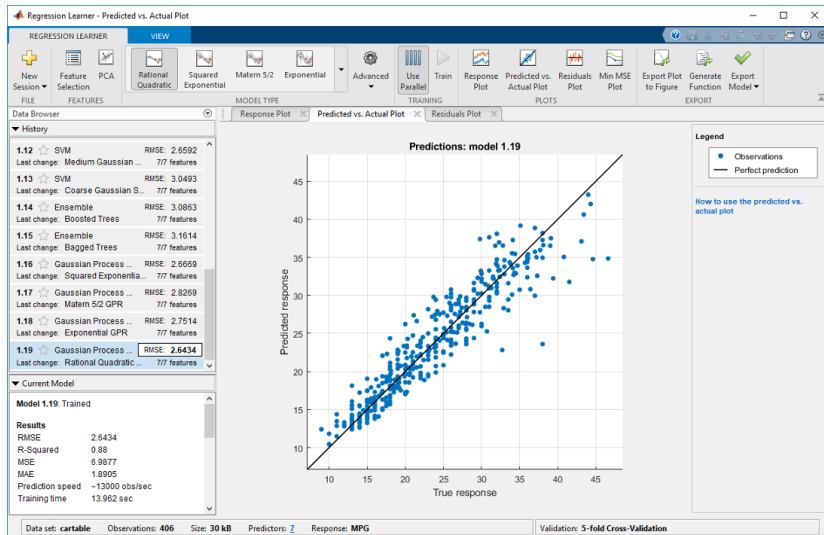
Regression Learner app can train models to predict continuous data using supervised machine learning.

- Models: linear regression models, regression trees, Gaussian process regression models, support vector machines, and ensembles of regression trees.
- Explore data, specify validation schemes, select features, and visualize results.
- Export models to make predictions with new data.
- Generate MATLAB code for further analysis.



Statistics and Machine Learning Toolbox

2. Train Regression Models in Regression Learner App (cont'd)



<https://ww2.mathworks.cn/help/stats/train-regression-models-in-regression-learner-app.html>

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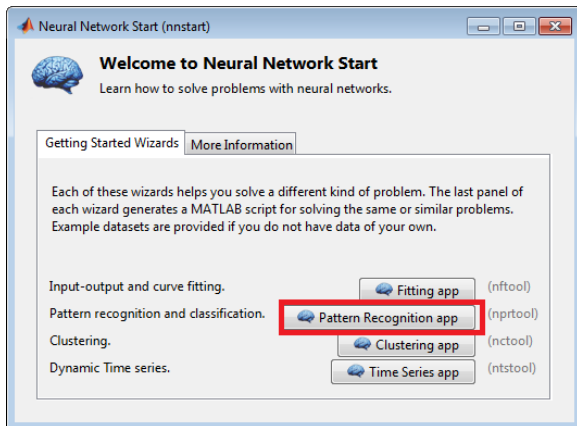
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Neural Network Toolbox

Classify Patterns with a Shallow Neural Network

1. Open the **Neural Network Start GUI** with command:
nnstart



Neural Network Toolbox

Classify Patterns with a Shallow Neural Network

2. Click **Pattern Recognition app** to open the **Neural Network Pattern Recognition app**. (or the command `nprtool`.)
3. Open the **Select Data window**.
4. Continue to the **Validation and Test Data window**.
5. Set the **number of hidden neurons** in the hidden layer.
6. **Train** the network.
7. **Evaluate** the network.

<https://ww2.mathworks.cn/help/deeplearning/gs/classify-patterns-with-a-neural-network.html>



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- Use **convolutional neural networks** (CNNs) and **long short-term memory** (LSTM) networks to perform classification and regression on image, time-series, and text data.
- Build advanced network architectures such as **generative adversarial networks** (GANs).
- Apps and plots can visualize **activations**, edit and analyze **network architectures**, and monitor **training progress**.
- Import models from **TensorFlow-Keras** and **Caffe**.
- Supports **transfer learning**.



Deep Learning Toolbox

Create Simple Image Classification Network

1. Load Data

```
digitDatasetPath = fullfile(matlabroot,'toolbox','nnet','nndemos', ...  
    'nndatasets','DigitDataset');
```

```
imds = imageDatastore(digitDatasetPath, ...  
    'IncludeSubfolders',true, ...  
    'LabelSource','foldernames');
```

```
numTrainFiles = 750;    750 images
```

```
[imdsTrain,imdsValidation] = splitEachLabel(imds,numTrainFiles,'randomize'); training set and validation set
```

2. Define Network Architecture

```
inputSize = [28 28 1];    Each image is 28-by-28 pixels  
numClasses = 10;
```

```
layers = [  
    imageInputLayer(inputSize)  
    convolution2dLayer(5,20)  
    batchNormalizationLayer  
    reluLayer  
    fullyConnectedLayer(numClasses)  
    softmaxLayer  
    classificationLayer];
```

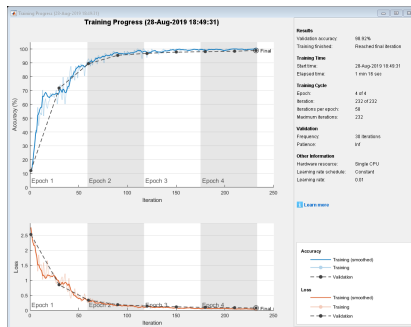


Deep Learning Toolbox

Create Simple Image Classification Network (cont'd)

3. Train Network

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



4. Test Network

```
YPred = classify(net,imdsValidation);  
YValidation = imdsValidation.Labels;  
accuracy = mean(YPred == YValidation)
```

[https:](https://ww2.mathworks.cn/help/deeplearning/gs/create-simple-deep-learning-classification-network.html)

[//ww2.mathworks.cn/help/deeplearning/gs/create-simple-deep-learning-classification-network.html](https://ww2.mathworks.cn/help/deeplearning/gs/create-simple-deep-learning-classification-network.html)

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- Functions for training policies using reinforcement learning algorithms including DQN, A2C, and DDPG.
- Train policies by enabling them to interact with environments represented by MATLAB or Simulink models.
- Evaluate algorithms, experiment with hyperparameter settings, and monitor training progress.
- Existing policies can be imported from deep learning frameworks such as TensorFlow, Keras and PyTorch.

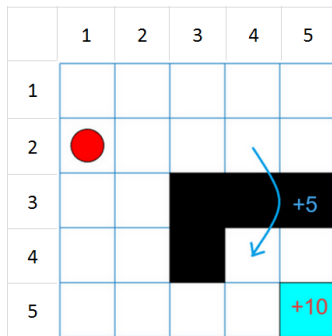


Reinforcement Learning Toolbox

Train Reinforcement Learning Agent in Basic Grid World

1. Create Grid World Environment

```
env = rlPredefinedEnv("BasicGridWorld");
```



- starts at [2,1], ends at [5,5].
- 4 possible actions (North, South, East and West).
- blocked by black cells.
- a special jump from cell [2,4] to cell [4,4] with +5 reward.
- all other actions result in -1 reward.

<https://ww2.mathworks.cn/help/reinforcement-learning/ug/train-q-learning-agent-to-solve-basic-grid-world.html>



Reinforcement Learning Toolbox

Train Reinforcement Learning Agent in Basic Grid World



2. Create Q-Learning Agent

```
qTable = rlTable(getObservationInfo(env),getActionInfo(env)); creata Q table  
tableRep = rlRepresentation(qTable);  
tableRep.Options.LearnRate = 1; Set the learn rate of the representation to 1
```

3. Train Q-Learning Agent

```
agentOpts = rlQAgentOptions;  
agentOpts.EpsilonGreedyExploration.Epsilon = .04; configure the epsilon-greedy exploration  
qAgent = rlQAgent(tableRep,agentOpts); create a Q-learning agent
```

4. Train Q-Learning Agent

```
trainOpts = rlTrainingOptions;  
trainOpts.MaxStepsPerEpisode = 50;  
trainOpts.MaxEpisodes= 200;  
trainOpts.StopTrainingCriteria = "AverageReward";  
trainOpts.StopTrainingValue = 11;  
trainOpts.ScoreAveragingWindowLength = 30;
```

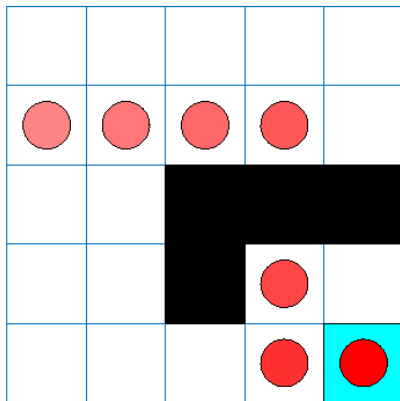


Reinforcement Learning Toolbox

Train Reinforcement Learning Agent in Basic Grid World

5. Validate Q-Learning Results

```
plot(env)  
env.Model.Viewer.ShowTrace = true;  
env.Model.Viewer.clearTrace;  
  
sim(qAgent,env) · Simulate
```



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★ ★ ★ https://ww2.mathworks.cn/help/index.html?s_tid=CRUX_lftnav

[//ww2.mathworks.cn/help/index.html?s_tid=CRUX_lftnav](https://ww2.mathworks.cn/help/index.html?s_tid=CRUX_lftnav)

MathWorks 产品 解决方案 学术 支持 社区 活动

文档 所有 类别 信息 论坛 App 搜索 R2019b 文档 文档中心

目录 关闭

类别

- MATLAB
- Simulink
- 5G Toolbox
- Aerospace Blockset
- Aerospace Toolbox
- Antenna Toolbox
- Audio Toolbox
- Automated Driving Toolbox
- AUTOSAR Blockset
- Bioinformatics Toolbox
- Communications Toolbox
- Computer Vision Toolbox
- Control System Toolbox
- Curve Fitting Toolbox
- Data Acquisition Toolbox
- Database Toolbox
- Datafeed Toolbox
- Deep Learning Toolbox
- DO Qualification Kit (for DO-178)
- DSP System Toolbox
- Econometrics Toolbox
- Embedded Coder
- Filter Design HDL Coder
- Financial Instruments Toolbox
- Financial Toolbox
- Fixed-Point Designer
- Fuzzy Logic Toolbox

我们将持续提供翻译文档，以便您尽早看到更新的内容。
请参阅“其他版本”获取以前版本的翻译文档。
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- > 机器人和自主系统
- > 控制系统
- > 实时仿真和测试
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- > 代码生成
- > 并行计算
- > 验证、确认和测试
- > 测试和测量
- > 数据库访问和报告
- > 计算金融
- > 仿真图形和报告



Reference Materials (cont'd)

★ https://blog.csdn.net/devil_bye/article/details/80536006

 **Coursera吴恩达机器学习笔记及代码练习(Matlab版)**

置顶 2018-06-01 12:20:31 不晓得X 阅读数 13144 ☆ 收藏 更多

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本文链接：https://blog.csdn.net/devil_bye/article/details/80536006

coursera课程主页

<https://www.coursera.org/learn/machine-learning>

之前寒假其实已经在B站上看过Andrew的这门机器学习了，先在这里给出链接，基本上都是中文字幕的，喜欢弹幕的小伙伴可以看这个。

<https://www.bilibili.com/video/av9912938>

网易云课堂也上线了这门课，因为是官方翻译肯定比B站的好，缺点也是没有配套练习。

<https://study.163.com/course/introduction/1004570029.htm>

但是因为时间长了，有所遗忘，而且还是觉得配合Coursera上原本的练习和学习资源比较好，所以在最近又开始重看一遍，顺便做下练习。看网上很少能搜到代码练习的答案，所以在这里分享出来。老师推荐使用MATLAB或者octave，因为MATLAB可以在线使用，我就选择了使用MATLAB。之后可能还会用python再实现一遍，加深印象。

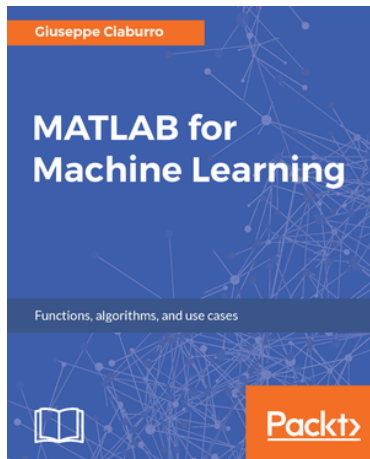
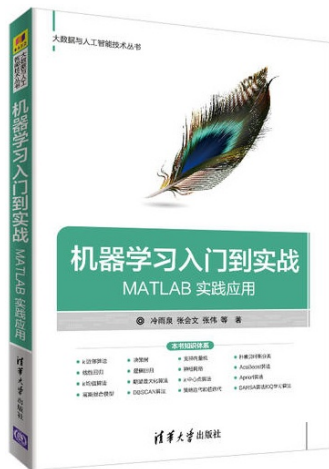
matlab版的代码实现已全部完成

github地址：<https://github.com/xjwhhh/AndrewNgMachineLearning>

欢迎follow和star



Reference Materials (cont'd)



The End

