

# MATLAB EXPO

## 使用MATLAB加速信号处理和图像处理 算法开发

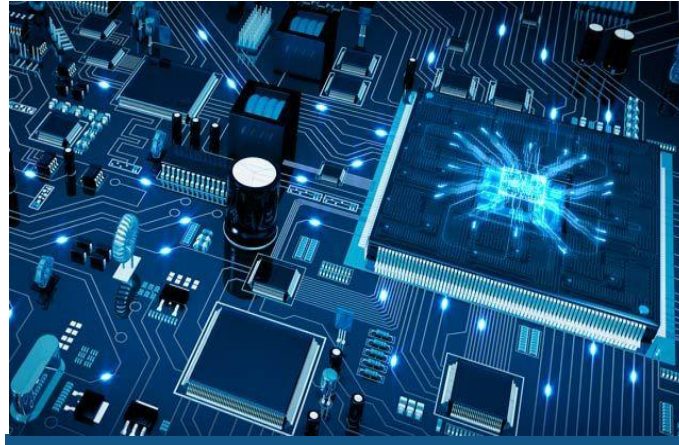
*Yixin Chen*



# 信号处理应用



Automated Driving



Communication



Consumer Electronics



Manufacturing

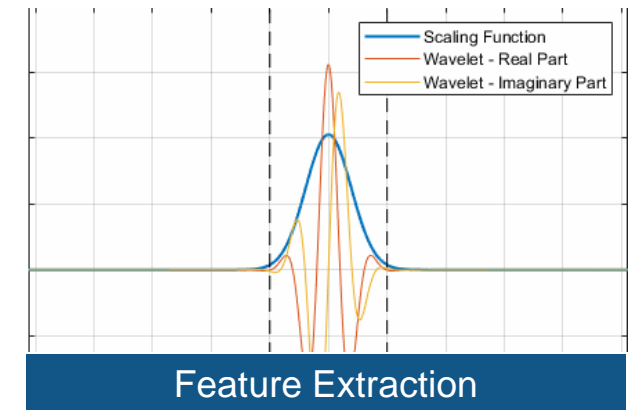
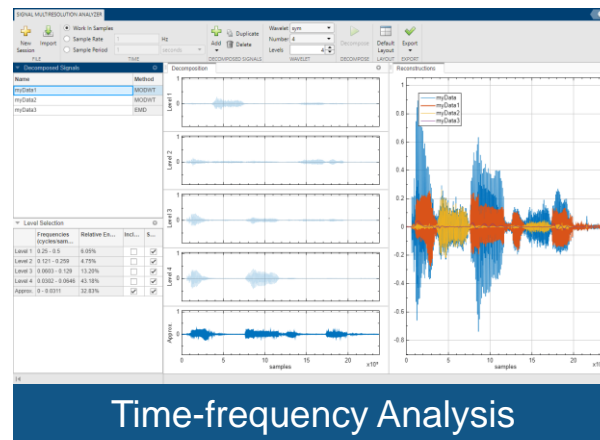
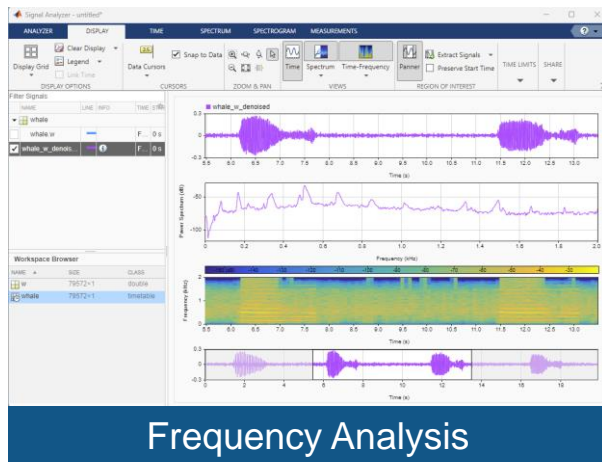
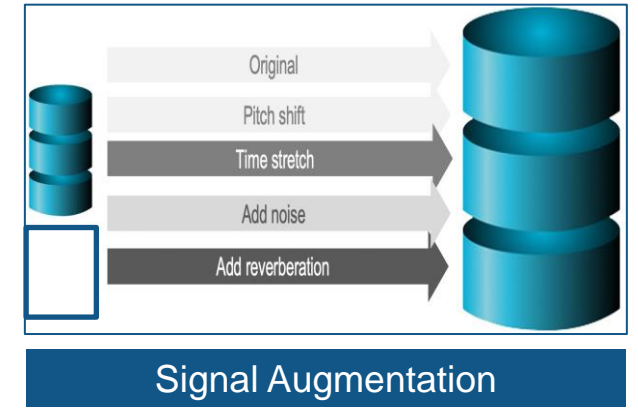
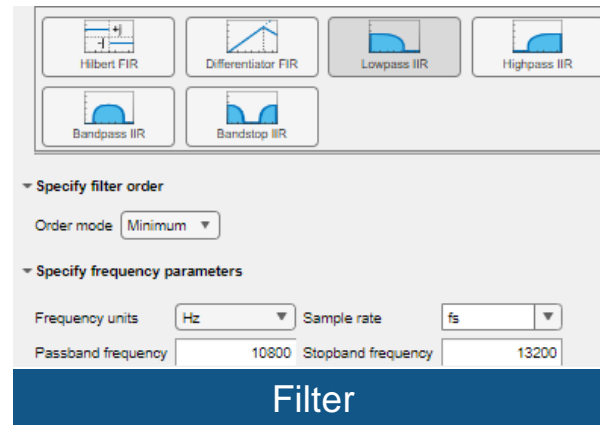
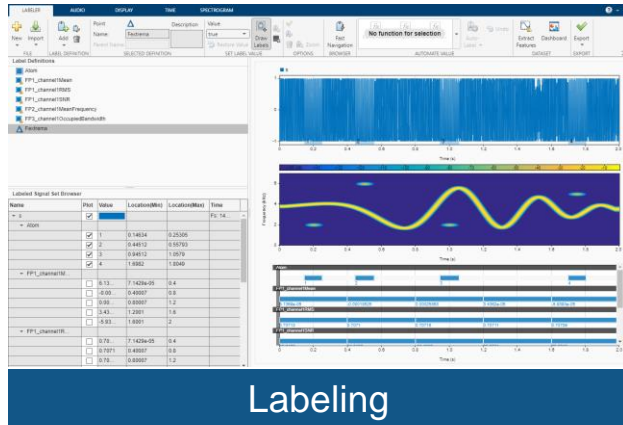


Aerospace



Digital Health

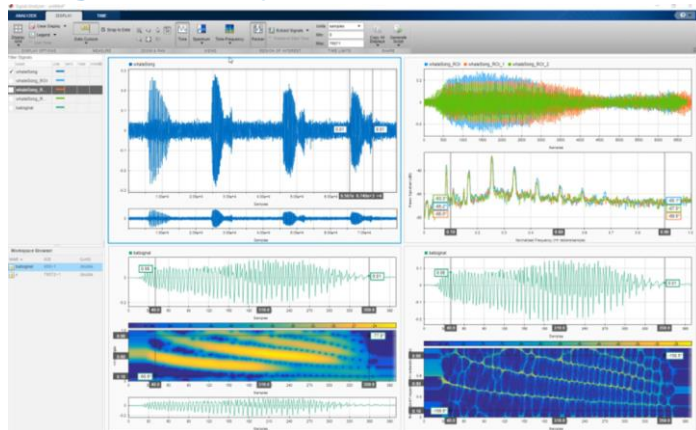
# 信号处理技术



# MATLAB信号处理 workflow



## Signal Analyzer App



## 示例

Deep Learning

Deep Learning

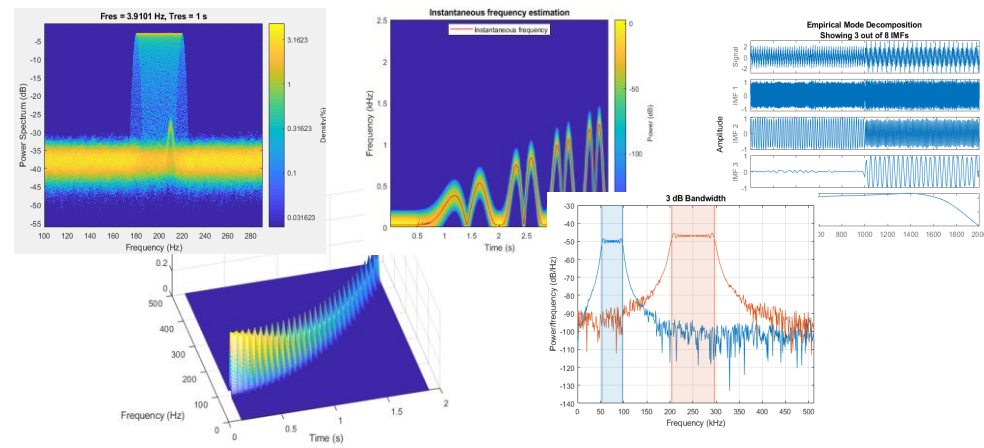
Deep Learning

Classify ECG Signals Using Long Short-Term Memory Networks

Classify heartbeat electrocardiogram (ECG) data from the PhysioNet 2017 Challenge using deep learning and signal

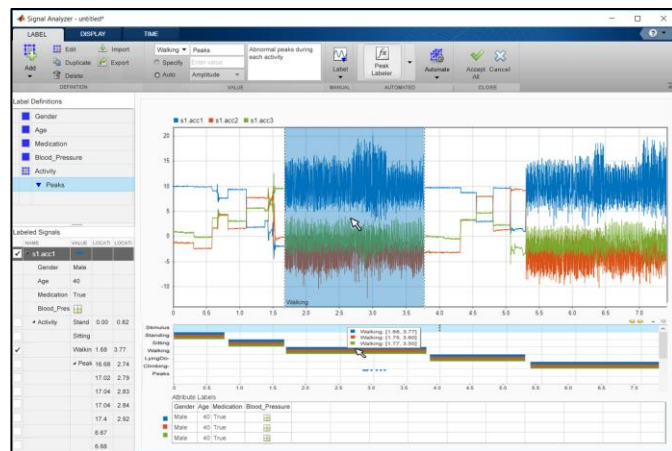
Open Live Script

## 特征提取



## 标注

## Signal Labeler App



## 数据管理

Datstores  
Label queries



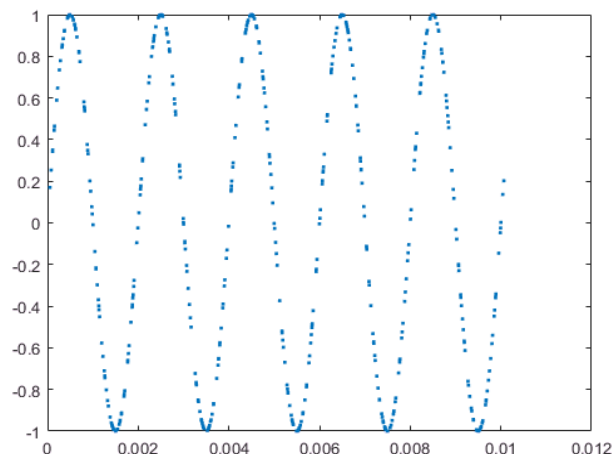
## Codegen



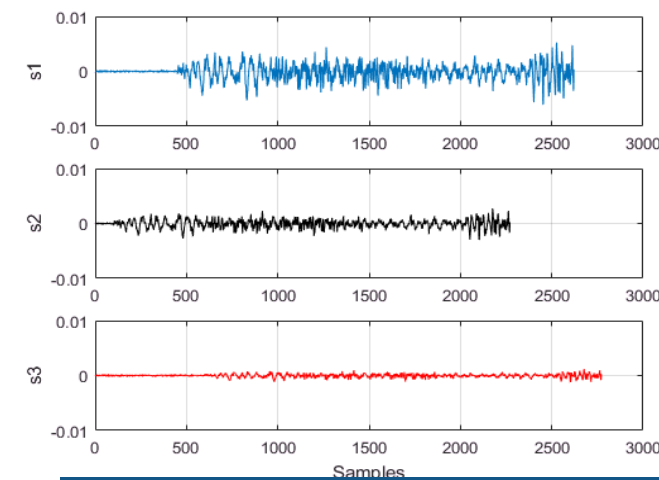
# 信号预处理

清洗脏数据:

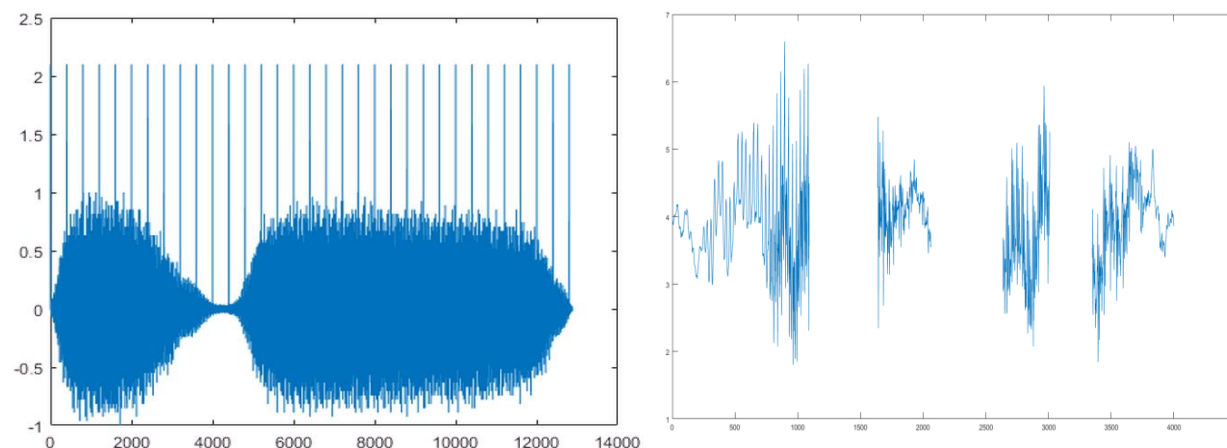
- 提高SNR
- 去除不需要的信号部分



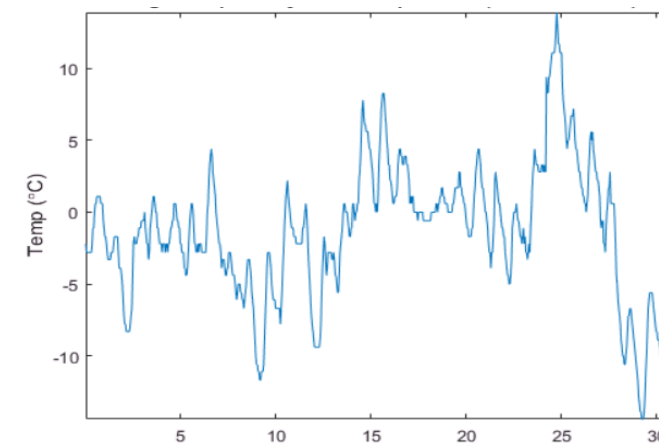
重采样信号



信号对齐



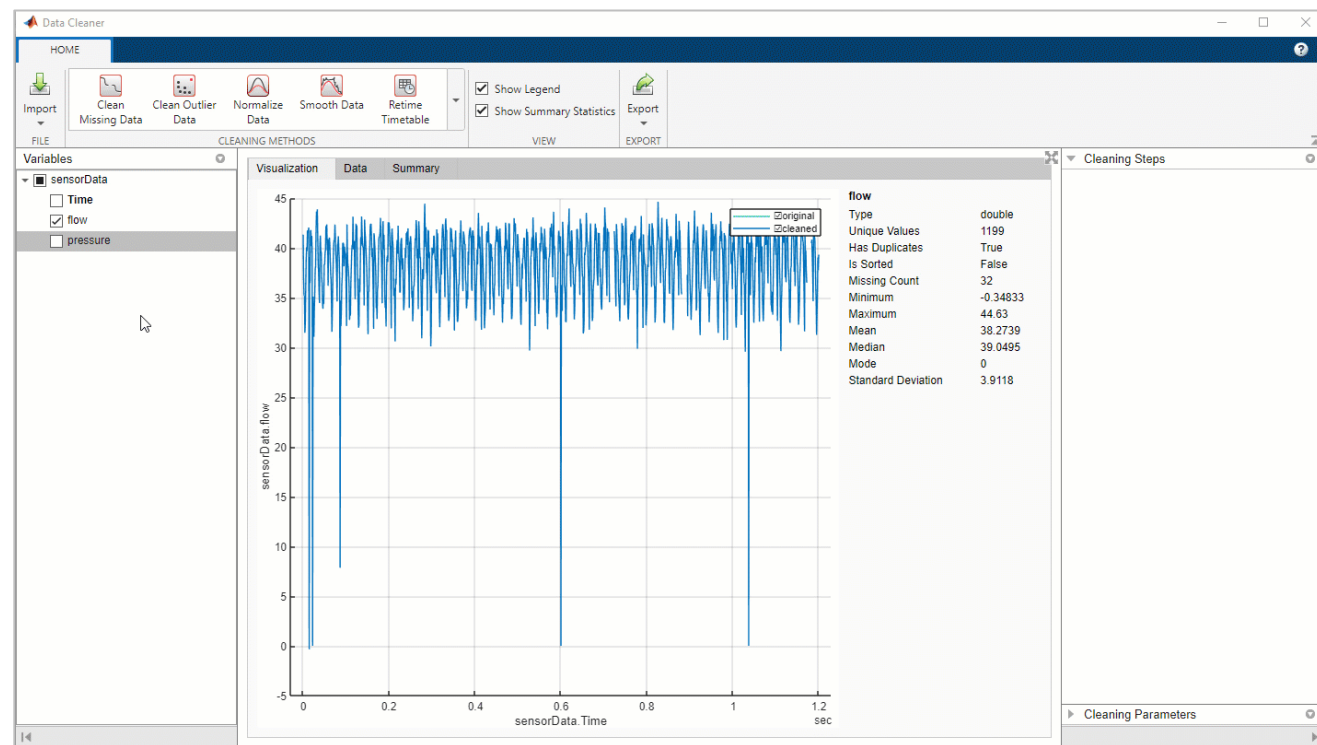
异常值 & 缺失数据



去除噪声或不需要的频率部分

# 交互式信号预处理

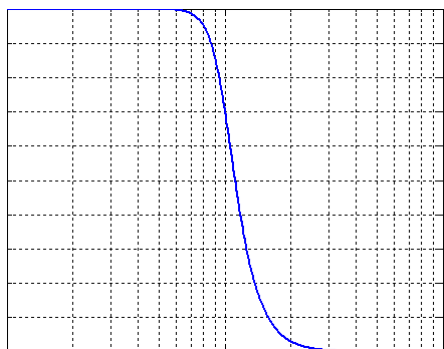
- 交互式清洗、验证和调整
- 导出到工作空间或生成MATLAB代码
- 处理timetable中的基于时间的信号
- 支持:
  - Missing data
  - Outlier data
  - Normalize and smoothing
  - Retiming
  - Stacking and unstacking



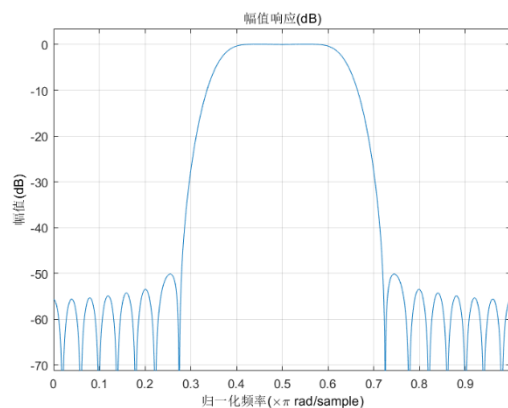
Data Cleaner

# 滤波器设计

## 标准响应

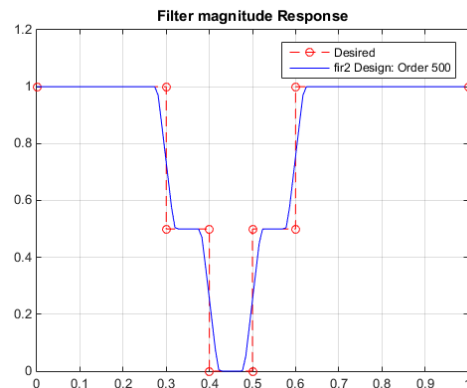


IIR Filter

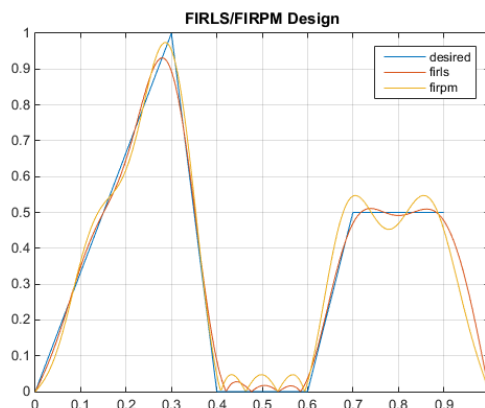


FIR Filter

## 指定响应

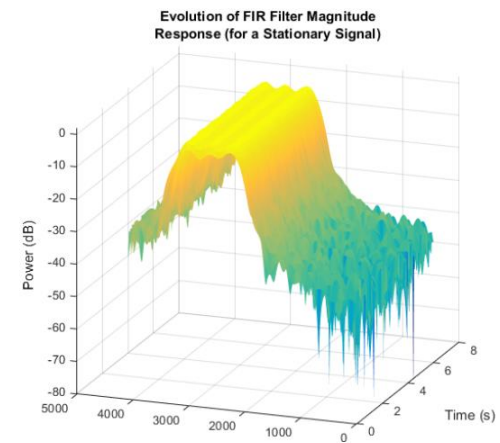


任意响应FIR

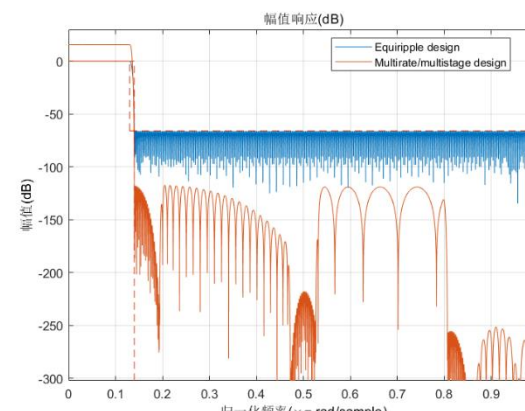


多带FIR

## 高级滤波器

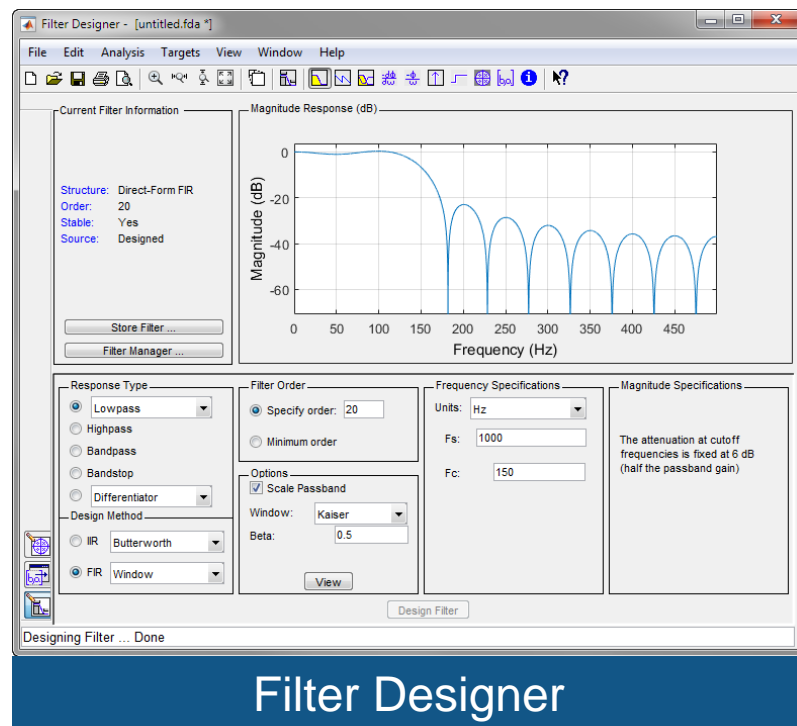


自适应滤波器

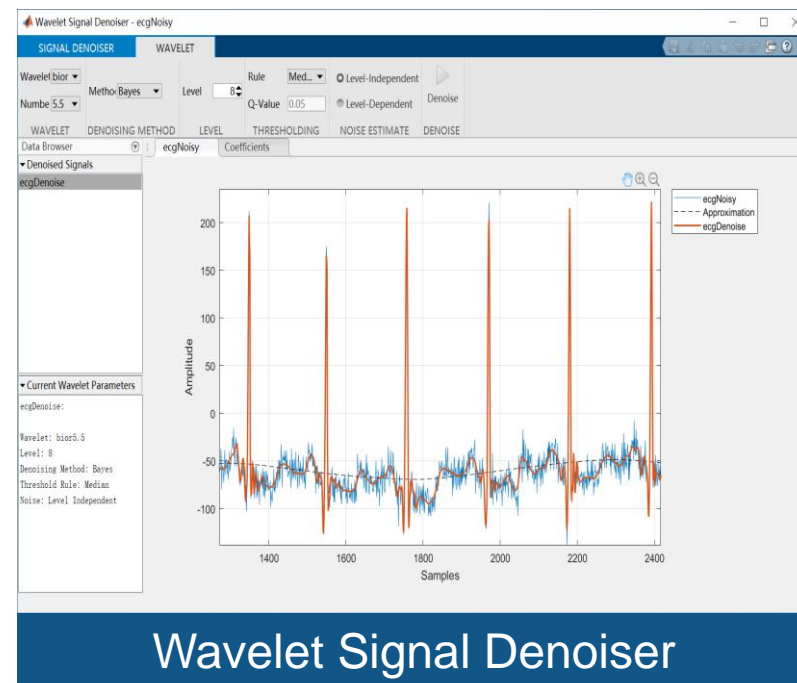


多级/多速率滤波器

# 滤波器设计



- 通过指定滤波器结构、响应类型、设计方法、阶数来设计滤波器
- 实时查看滤波器频率响应、相位响应等性能指标

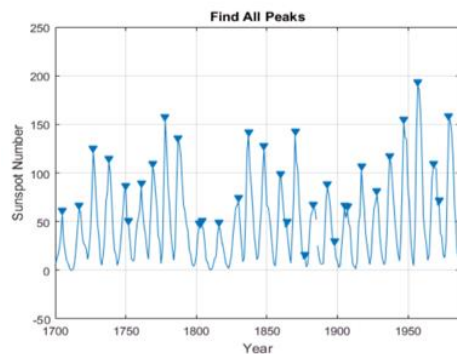


- 在保留清晰特征的同时进行降噪
- 自动选择去噪参数
- 支持多通道和时间表信号

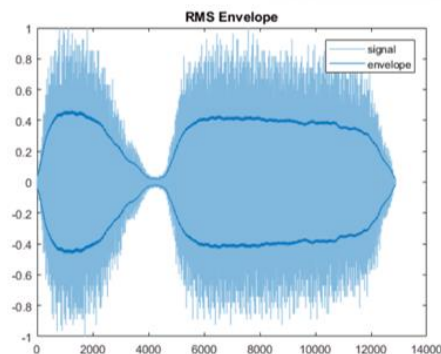


# 信号变换与分析

## 时域

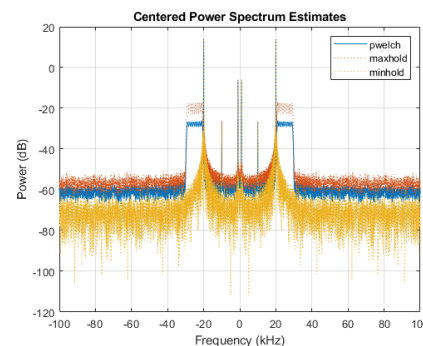


Find peaks

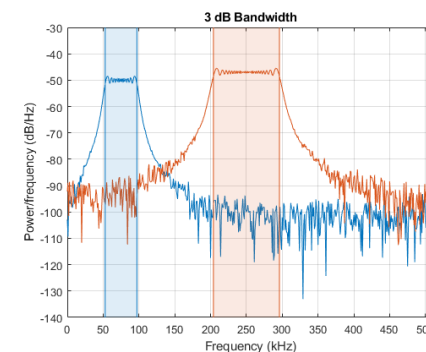


Find signal envelope

## 频域

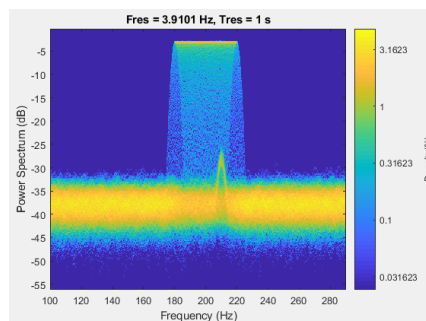


Welch periodogram

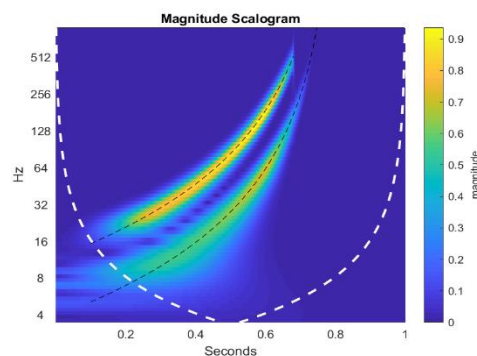


BW measurements

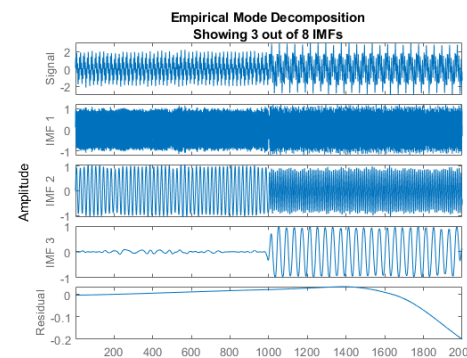
## 时频分析



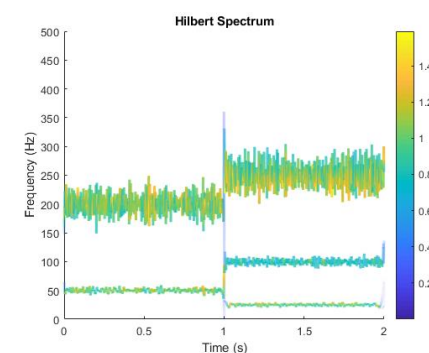
Persistent spectrum



Wavelet scalogram

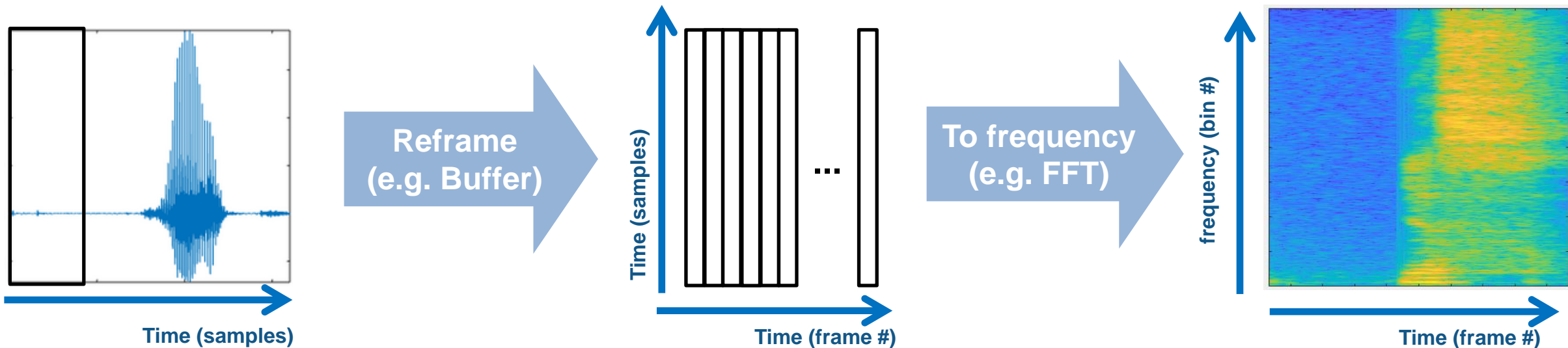


Empirical mode decomposition

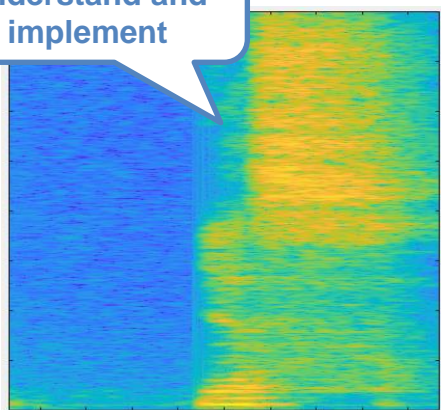


Hilbert-Huang transform

# 时频分析

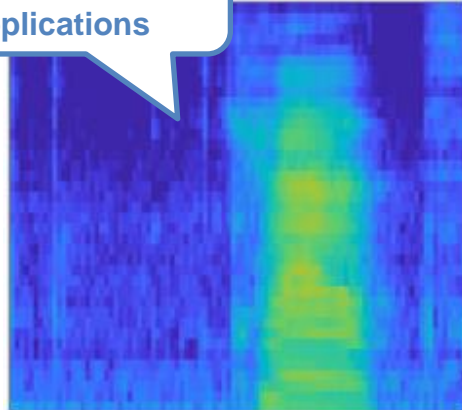


Easiest to understand and implement



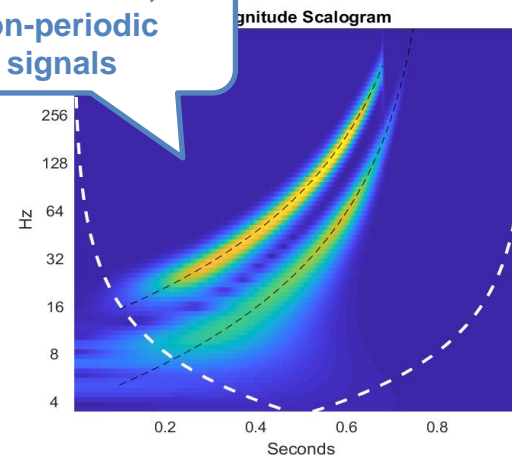
Basic spectrogram

More compact for speech & audio applications



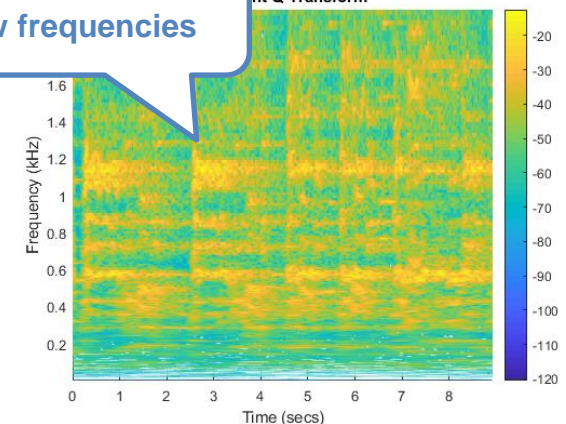
Perceptually-spaced Spectrogram

Best resolution, for non-periodic signals



Wavelet scalogram

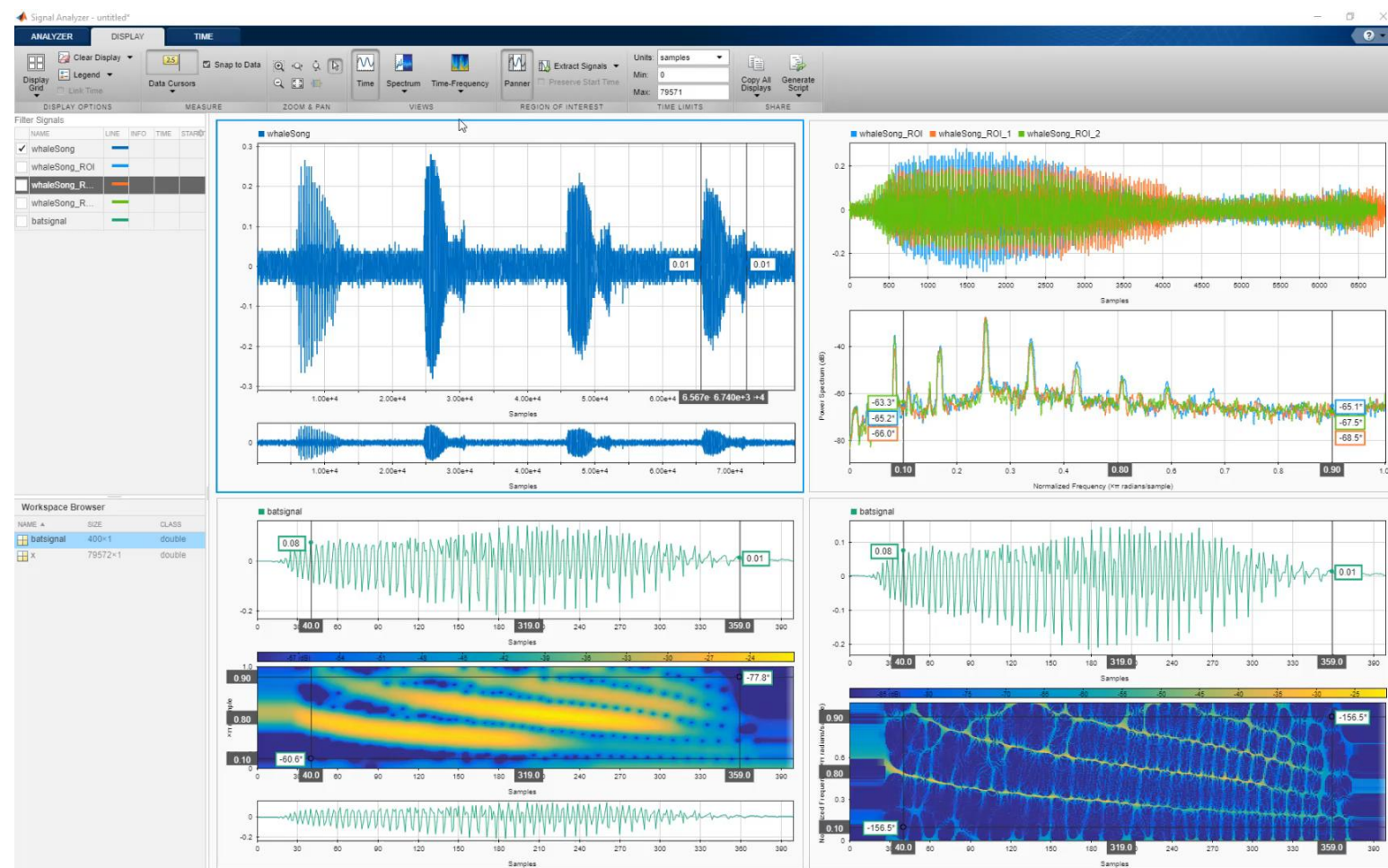
Better resolution at low frequencies



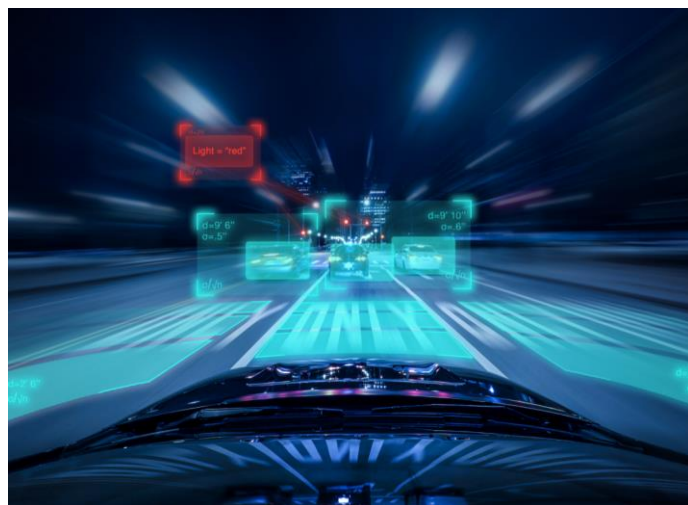
Constant Q transform

# 使用Signal Analyzer App探查信号

- 分析信号不同区域
- 滤波、重采样、去趋势、提取和重命名信号
- 比较信号的多个波形、频谱图和尺度图
- 自动化生成脚本



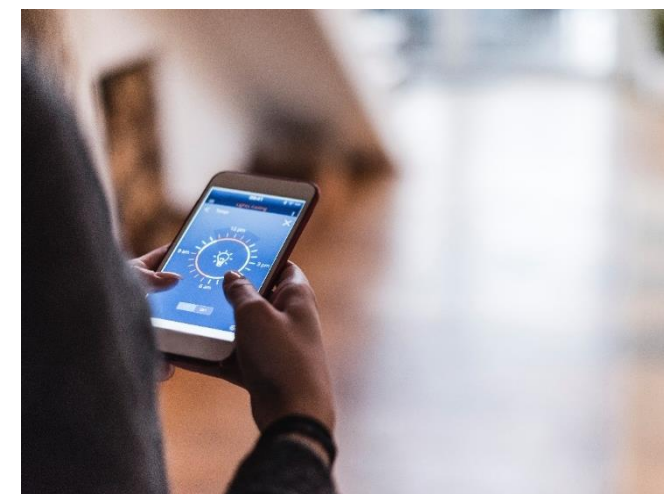
# 图像处理和计算机视觉应用



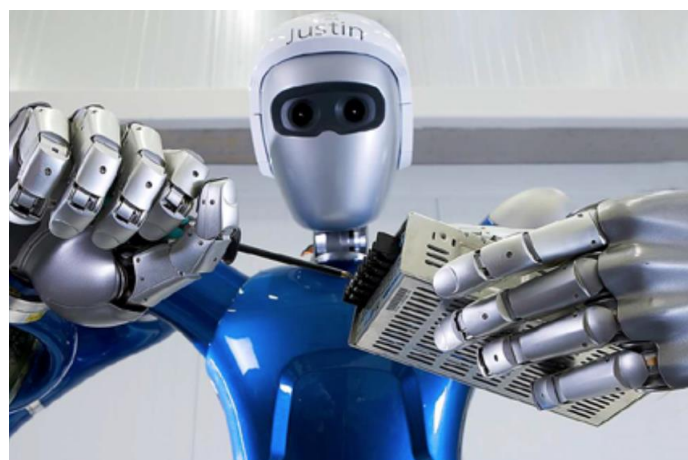
**Automated Driving**



**Satellite Imagery**



**Consumer Electronics**



**Robotics**

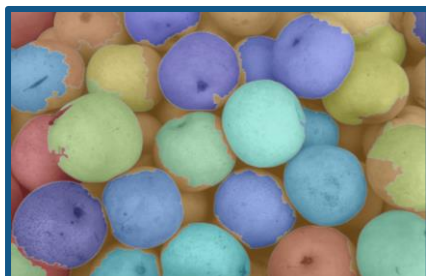


**Machine Vision**



**Medical Imaging**

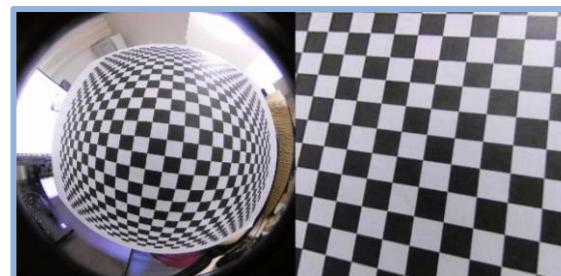
# 图像处理和计算机视觉技术



Segmentation



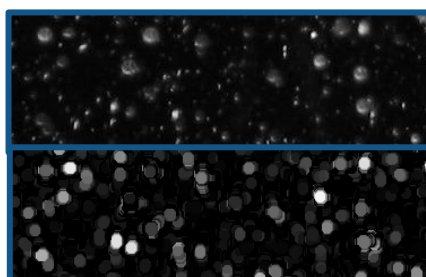
Edge Detection



Camera Calibration



Labeling



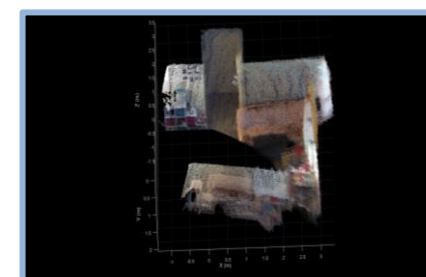
Morphology



3D Image Processing



Feature Detection



Point Cloud Processing

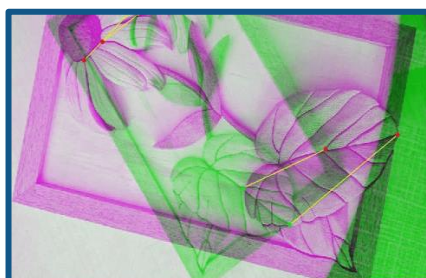
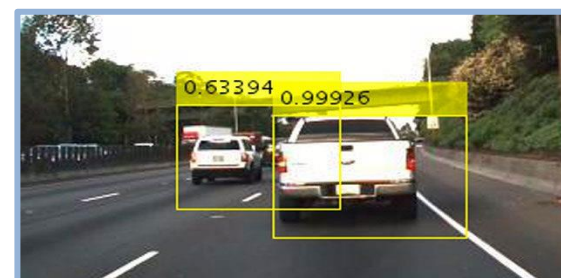


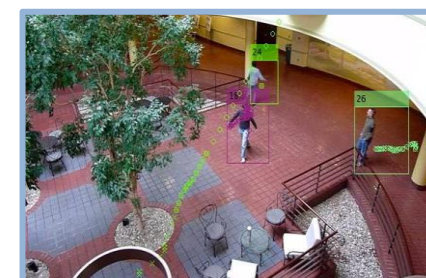
Image Registration



Image Enhancement



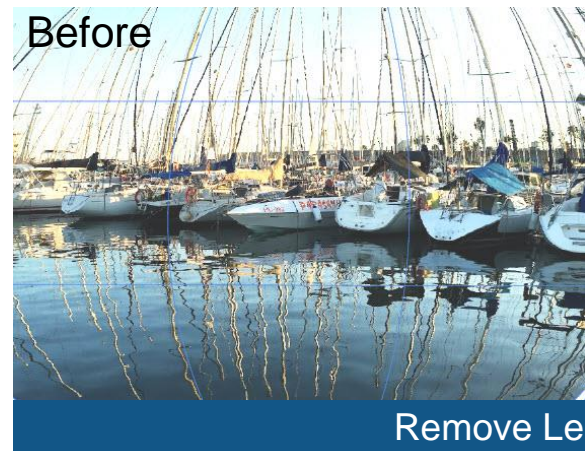
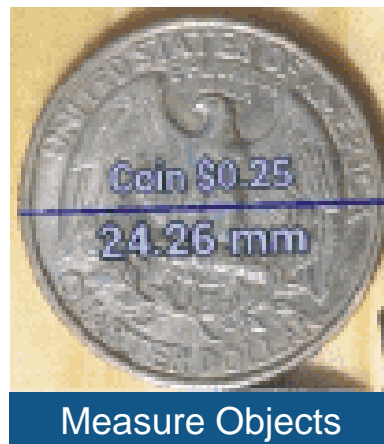
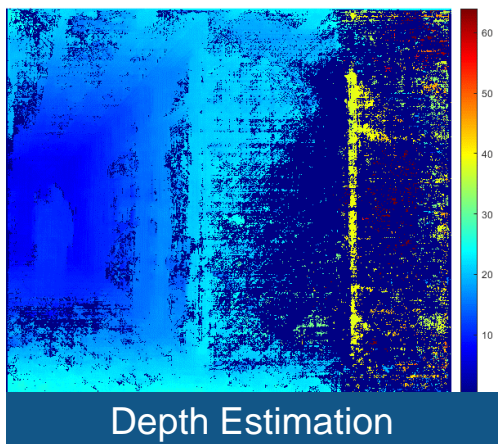
Object Detection



Tracking

# 相机标定

Camera calibration estimates the parameters of lens and image sensor



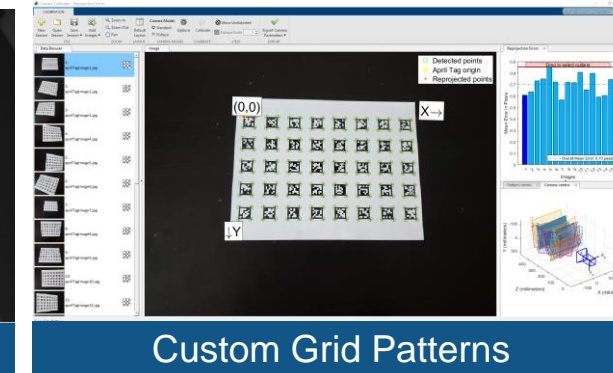
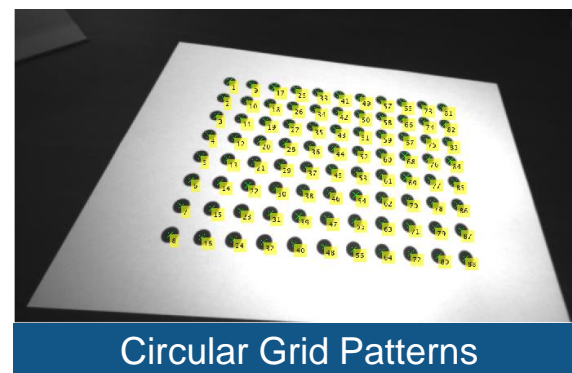
Camera Calibrator - Reprojection Errors

Camera Model: Standard, Fisheye, Options, Calibrate, Show Undistorted, Export Fisheye Parameters

Reprojection Errors: Mean Error in Pixels vs Images (Overall Mean Error: 0.54 pixels)

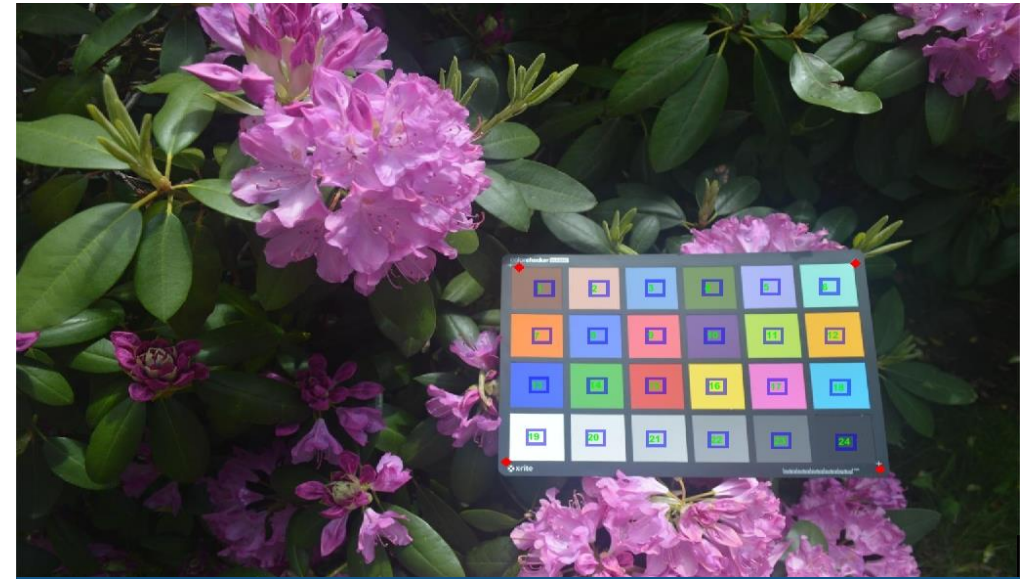
Pattern-centric / Camera-centric

Camera Calibrator App



# 相机管线

- Camera pipeline covers the various parts of the camera design workflow which include:
  - RAW to RGB camera pipeline
  - Test Chart Measurements
  - Illuminant and Color Estimation
  - Conversion between color spaces
  - Image Enhancement
- Example Applications:
  - Use test charts to:
    - Adjust color balance and brightness
    - Measure noise, sharpness and color differences
  - Optimize image processing pipeline parameters
  - Evaluate image quality when no references are available



Calculate CIE94 Color Difference of Colors on Test Chart




Quantify Image Quality Using Neural Image Assessment

# 图像预处理

## ■ 图像增强

Original Image and Enhanced Images using imadjust, histeq, and adapthist




**Contrast Enhancement Techniques**

Adjust the contrast of grayscale and color images using three techniques: intensity value mapping, histogram equalization, and contrast-limited

[Open Live Script](#)

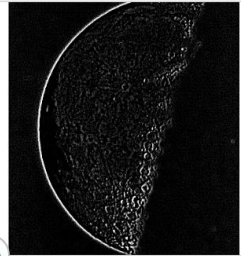
Lowlight Image      Elimination Map



**Low-Light Image Enhancement**

Use haze removal techniques to enhance the dynamic range of low-light images.

[Open Live Script](#)



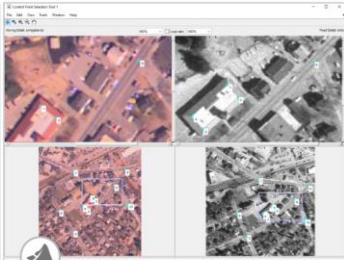
**Filter Images Using Predefined Filter**

Create a type of special filter called an unsharp masking filter, which makes edges and detail in an image appear sharper.

[Open Live Script](#)

- Image Filtering/Denoising
- Contrast Adjustment
- Morphological Operation
- Deblurring

## ■ 图像配准

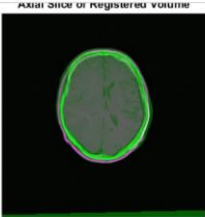


**Register Images with Projection Distortion Using Control Points**

Register two images by selecting control points common to both images and inferring a geometric transformation that aligns the control

[Open Live Script](#)

AXIAL SLICE OF REGISTERED VOLUME



**Register Multimodal 3-D Medical Images**

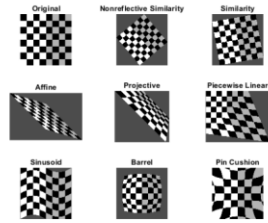
Align two volumetric images using automatic intensity-based image registration.

[Open Live Script](#)

Original      Nonreflective Similarity      Similarity

Affine      Projective      Piecewise Linear

Sinucoid      Barrel      Pin Cushion



**Create a Gallery of Transformed Images**

Warp a test image using built-in and custom geometric transformations, including affine, projective, polynomial, piecewise linear,

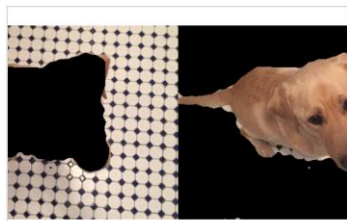
[Open Live Script](#)

- Spatial Transformation
- Phase Correlation
- Feature Detection, Extraction & Matching



# 图像预处理

## ■ 图像分割



### Texture Segmentation Using Gabor Filters

Use texture segmentation to identify regions based on their texture.

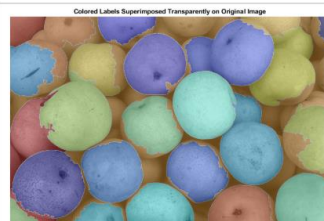
[Open Live Script](#)



### Color-Based Segmentation Using the L\*a\*b\* Color Space

Identify different colors in fabric by analyzing the L\*a\*b\* color space.

[Open Live Script](#)



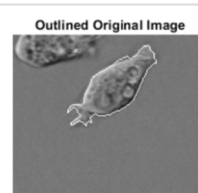
### Marker-Controlled Watershed Segmentation

Use watershed segmentation to separate touching objects in an image.

[Open Live Script](#)

- Thresholding
- Watershed Segmentation
- Color-based Segmentation

## ■ 图像分析



### Detect Cell Using Edge Detection and Morphology

Detect an object against the background using edge detection and basic morphology

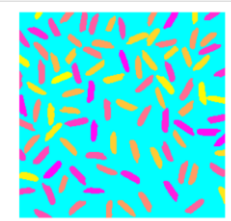
[Open Live Script](#)



### Detect and Measure Circular Objects in an Image

Automatically detect circular objects in an image and visualize the detected circles.

[Open Live Script](#)



### Correct Nonuniform Illumination and Analyze Foreground Objects

Perform image preprocessing such as morphological opening and contrast adjustment. Then, create a binary image and compute statistics

[Open Live Script](#)

- Object Analysis: Edge/Line/Circle Detection
- Region and Image Properties
- Image Quality

# 基于 App 的工作流

*Apps provide interactive tools for tweaking parameters and visualizing results*

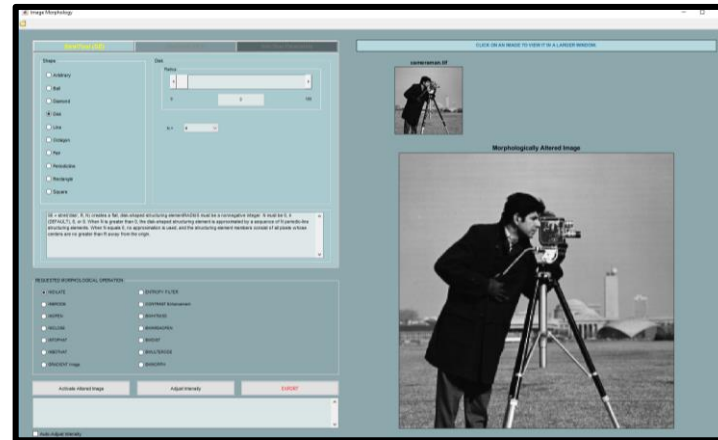
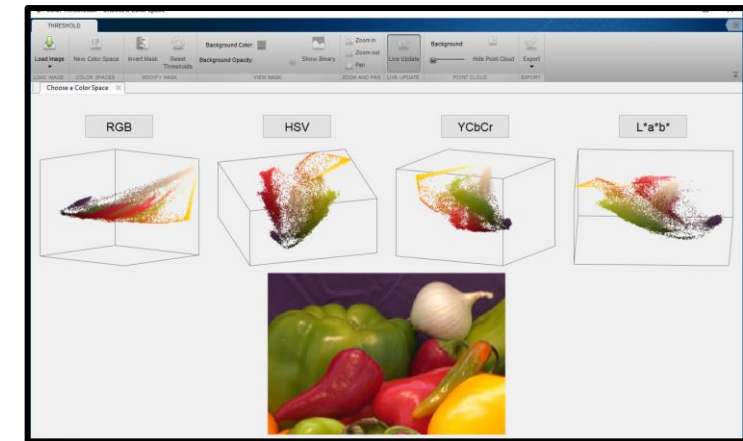


Image Morphology



Color Thresholder

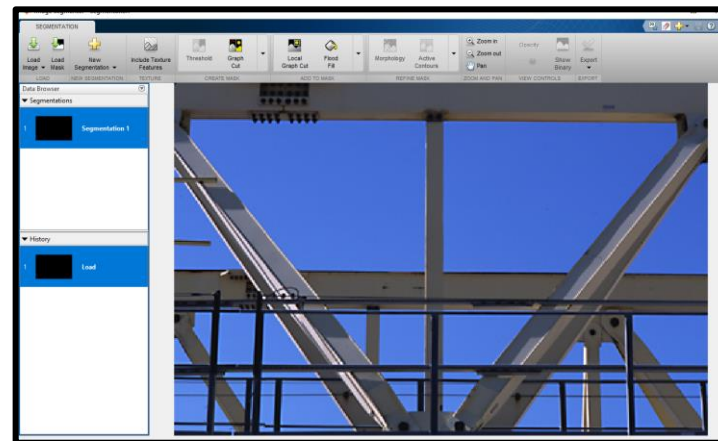


Image Segmenter

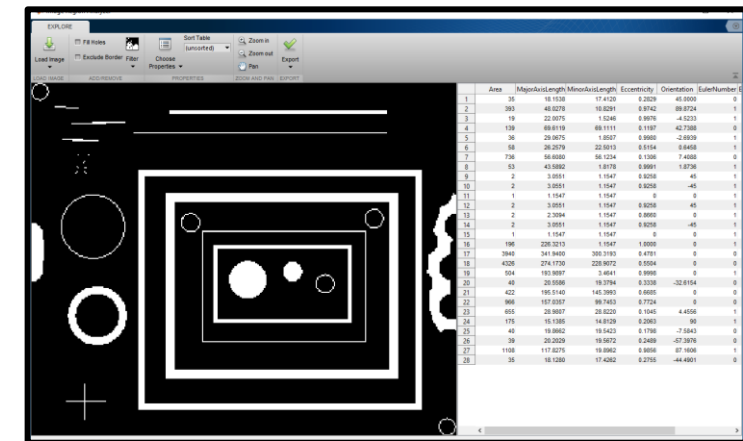
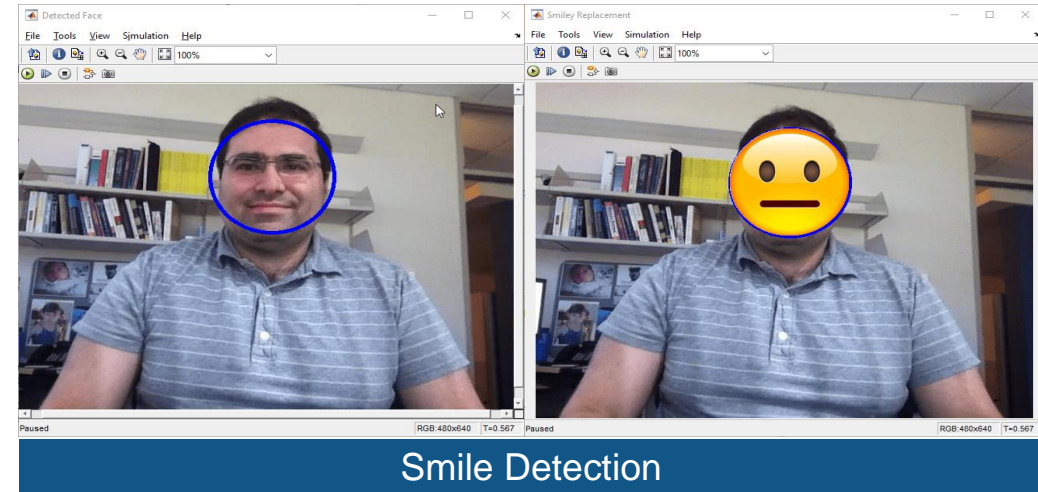


Image Region Analyzer

# OpenCV 集成

- Import OpenCV code into Simulink and MATLAB
- Export code to OpenCV-based projects using code generation
- Call openCV functions from MATLAB
- Benefits:
  - Algorithm development
  - Testing and debugging
  - Collaborative development
  - Embedded deployment



Shadow Detection



Vehicle Pedestrian Detection

# MATLAB EXPO

Thank you



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