



# Matlab Toolboxes

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# Introduction

- Toolboxes are add-ons that provide additional functionality to Matlab
- They are often maintained by third parties, or at least were originally developed by third parties, so pricing varies all over the map

# Which Do I have?

- Type **ver** to see which toolboxes are loaded
- Type **help** to see links to toolbox specific help

# Math

- Symbolic Math
- Extended Symbolic Math
- Optimization Toolbox
- Partial Differential Equation Toolbox
- Genetic Algorithm and Direct Search Toolbox

# Optimization

- Unconstrained and constrained nonlinear optimization solvers
- nonlinear least-squares, data fitting, and nonlinear equations
- quadratic and linear programming problems
- binary integer programming problems
- limited parallel computing support
- GUI and command line solvers

# GUI Solver

**Optimization Tool**

**Problem Setup and Results**

Solver: `fmincon` - Constrained nonlinear minimization  
Algorithm: Medium scale

Problem

Objective function: `@objfun`  
Derivatives: Approximated by solver  
Start point: `[0 1.625]`

Constraints:

Linear inequalities: A: [ ] b: [ ]  
Linear equalities: Aeq: [ ] beq: [ ]  
Bounds: Lower: [-3 -3] Upper: [3 3]  
Nonlinear constraint function: `@confun`  
Derivatives: Approximated by s...

Run solver and view results

Start [Pause] [Stop]

Current iteration: 13 [Clear Results]

Optimization running.  
Optimization terminated.  
Objective function value: -6.505181839971781  
Optimization terminated: first-order optimality measure less than maximum constraint violation is less than options.TolCo

Final point:

	1	2
	0.229	-1.569

**Options**

Stopping criteria

Function value check

User-supplied derivatives

Approximated derivatives

Algorithm settings

Multiobjective problem settings

Inner iteration stopping criteria

Plot functions

Current point  Function count  Function value  
 Norm of residuals  Max constraint  Current step  
 First order optimality  
 Custom function: [ ]

Output function

Custom function: `@PlotIterates`

Display to command window

Level of display: iterative

Node interval:  Use default  
 Specify: [ ]

Show diagnostics

**Quick Reference**

**fmincon Solver**  
Find a minimum of a constrained multivariable function.

Click to expand the section corresponding to your task.

**Problem Setup**

- [Solver and Algorithm](#)
- [Function to Minimize](#)

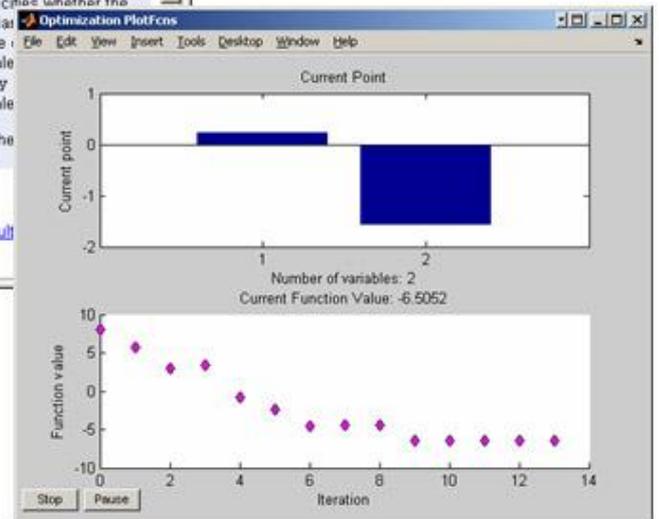
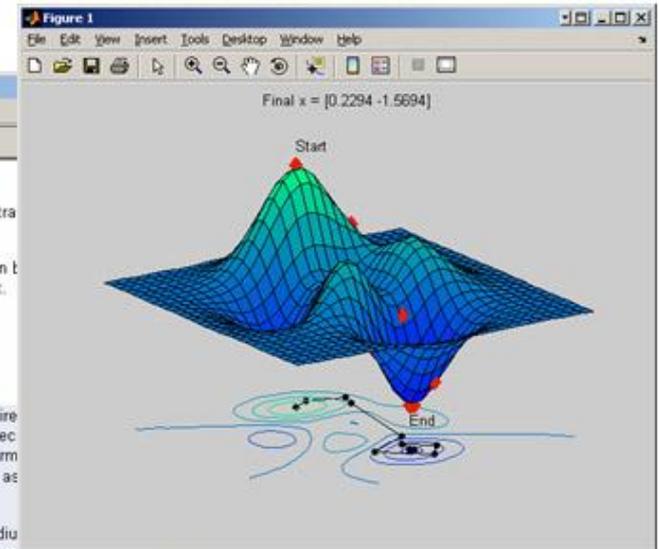
**Objective function** (require you want to minimize. Specify a function handle of the form `objfun.m` is an M-file or as function.

**Derivatives**, with the medium algorithm, specifies if the gradient is supplied in the objective function or if it should be approximated by the solver. With the large-scale algorithm, specifies whether the gradient or both the Hessian are supplied by the user in the objective function. Note that the medium-scale algorithm approximates the Hessian when approximated by selected, even if large scale derivatives are supplied.

**Start point** (required) is the initial (vector) for the algorithm.

- [Constraints](#)
- [Run solver and view result](#)

**Options**



To start:  
**optimtool**



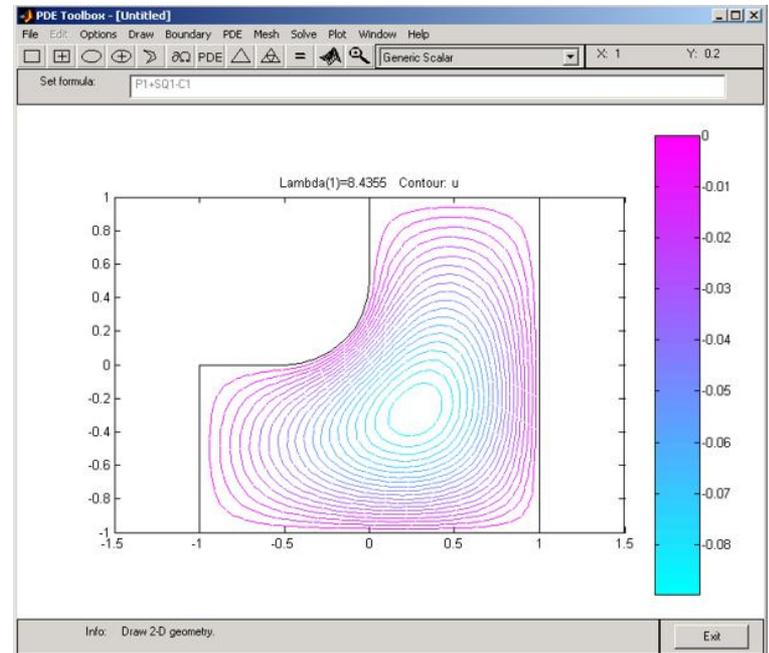
# Demo

# PDE Toolbox Functions

- Elliptic, parabolic, hyperbolic solvers
- Finite element solvers
- Adaptive mesh routines
- Eigenvalue solutions
- GUIs

To start:

**pdetool**





# Demo

# Statistics

- Statistics Toolbox
- Neural Network Toolbox
- Curve Fitting Toolbox
- Spline Toolbox
- Model-Based Calibration Toolbox

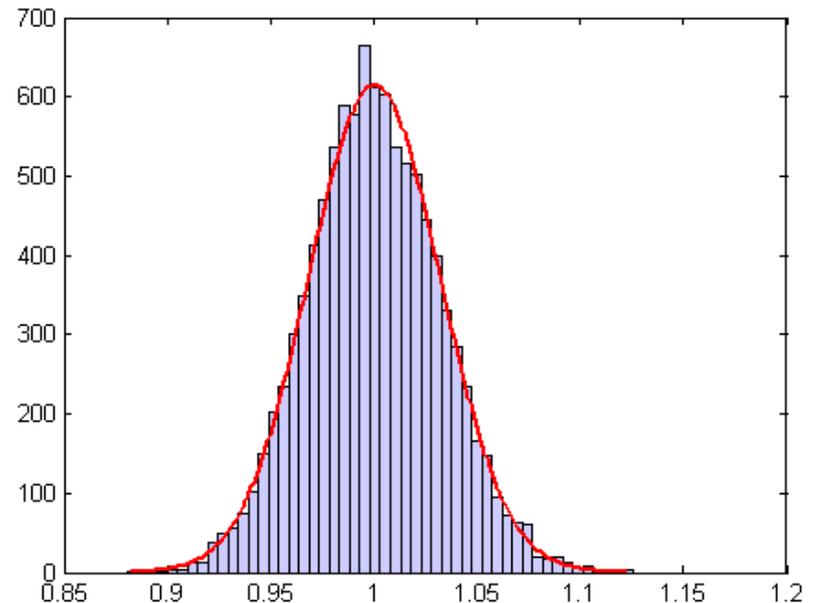
# Statistics Toolbox Functions

- Geomean, median, mode
- Moment, skewness, kurtosis
- Corr, corrcoef (correlation coefficients), cov (covariance)
- Cdfplot, dfittool (distribution fitting), errorbar, pareto

# PDFs (and corresponding CDFs)

- Beta
- Binomial
- chi-square
- Gamma
- lognormal
- Poisson
- Weibull
- Etc.

Corresponding  
random number  
generators are  
also included



# Nonlinear Fits

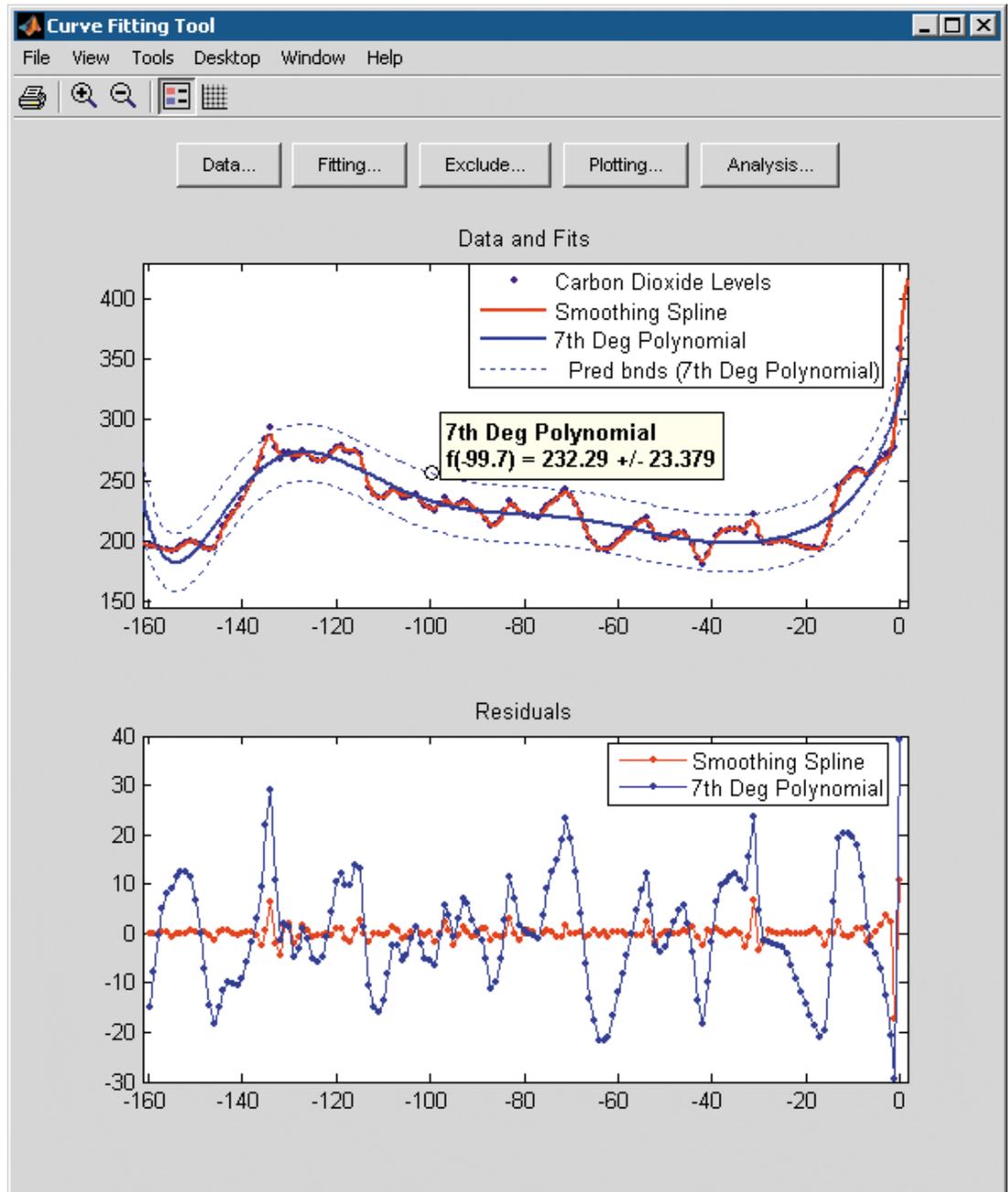
- **$b = \text{nlinfit}(x,y,\text{fun},b_0)$**
- **Returns set of coefficients providing best fit to data  $(x,y)$**

# Statistics

- Data organization and management
- Descriptive statistics
- Statistical plotting and data visualization
- Probability distributions (pdf, cdf, etc.)
- Analysis of variance (ANOVA)
- Linear and nonlinear modeling
- Multivariate statistics
- Design of Experiments (factorial design, response surf., etc.)
- Hypothesis testing (z-test, t-test, etc.)
- Statistical Process Control (SPC)

# Curve Fitting

- Interactive graphical user interface
- data scaling, sectioning, smoothing, and removal of outliers
- linear and nonlinear models
- least squares, weighted least squares, and robust fitting (all with or without bounds)
- Custom linear and nonlinear model development
- Nonparametric fitting using splines and interpolants
- Interpolation, extrapolation, differentiation, and integration of fits



To start:  
**cftool**

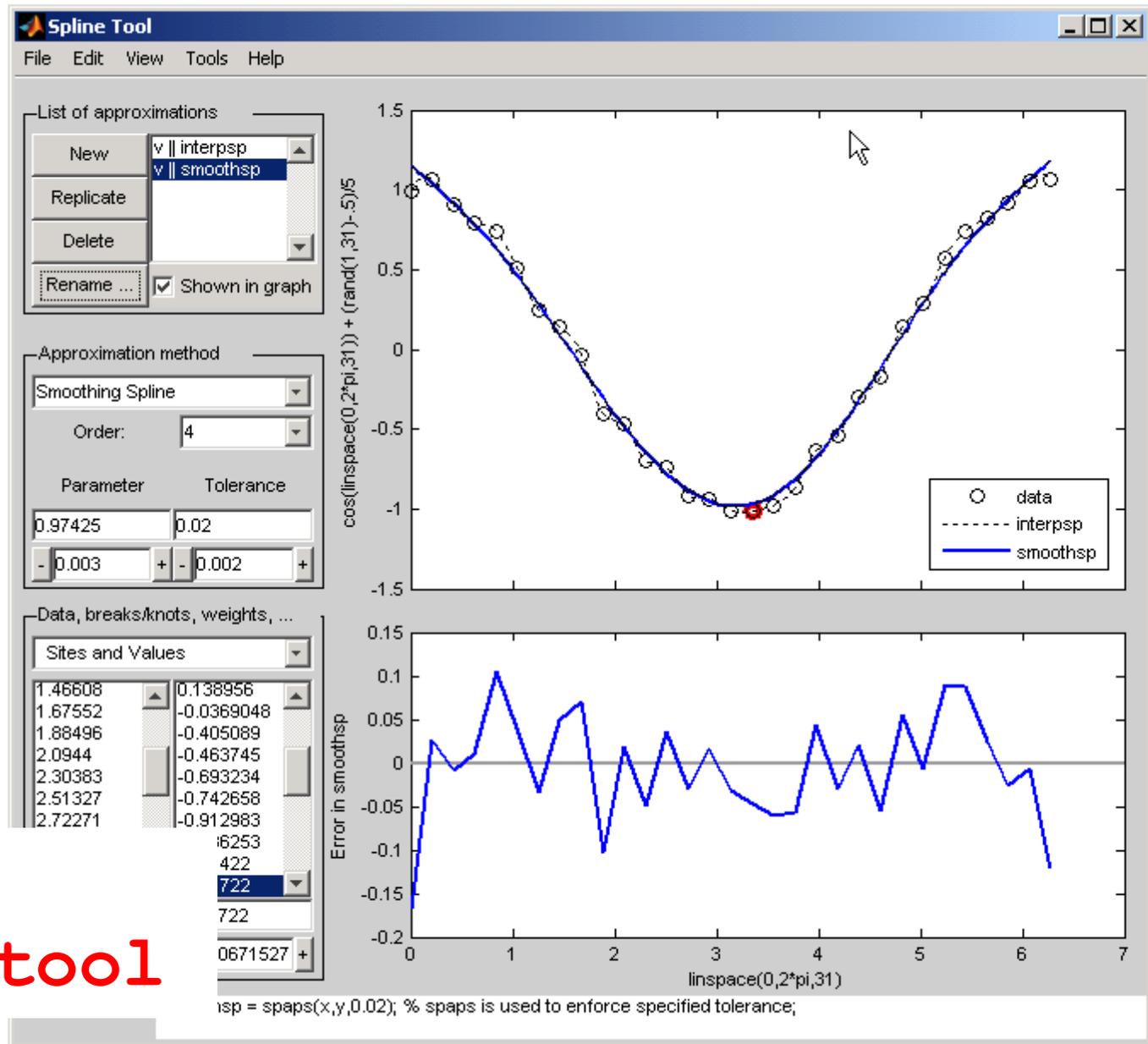
# Models

- Polynomial (to ninth degree)
- Exponential
- Rational (to degree 5/5)
- Peak (Gaussian)
- Distribution (Weibull)
- Fourier and power series
- Spline (cubic and smoothing)
- Interpolant

# Splines

- GUIs that let you create, view, and manipulate splines and compare spline approximations
- differentiation, integration, etc. of splines
- piecewise polynomial form (ppform) and basis form (B-form) splines
- tensor-product splines and rational splines (including NURBS)

# Spline GUI



To start:  
**splinetool**

# Controls

- Control System Toolbox
- System Identification Toolbox
- Fuzzy Logic Toolbox
- Robust Control Toolbox
- Model Predictive Control Toolbox
- Aerospace Toolbox

# Control Systems

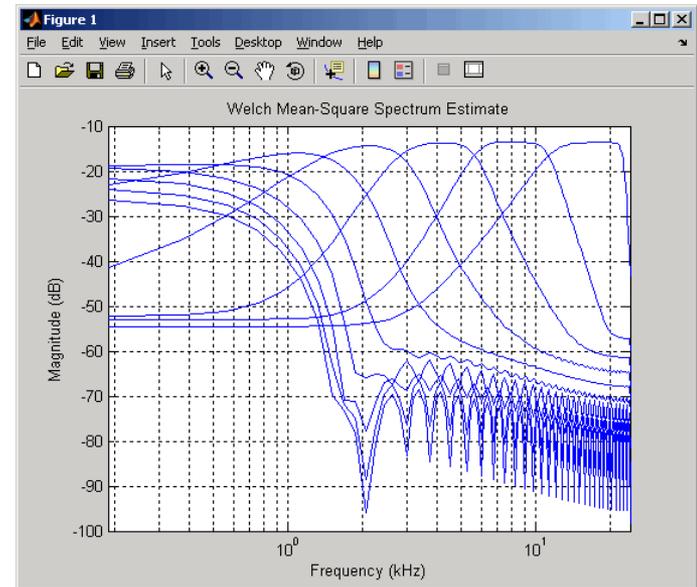
- Single-loop and multi-loop control systems using a variety of classical and state-space techniques
- Lets you analyze system responses and performance using a GUI or command-line functions
- Optimizes control system performance to meet time- and frequency-based requirements
- Represents and manipulates linear models as transfer-function, state-space, zero-pole-gain, and frequency-response data objects
- Converts between model representations, discretizes continuous-time models, and computes low-order approximations of high-order systems
- Uses state-of-the-art algorithms built on the LAPACK and SLICOT libraries for optimal performance and accuracy

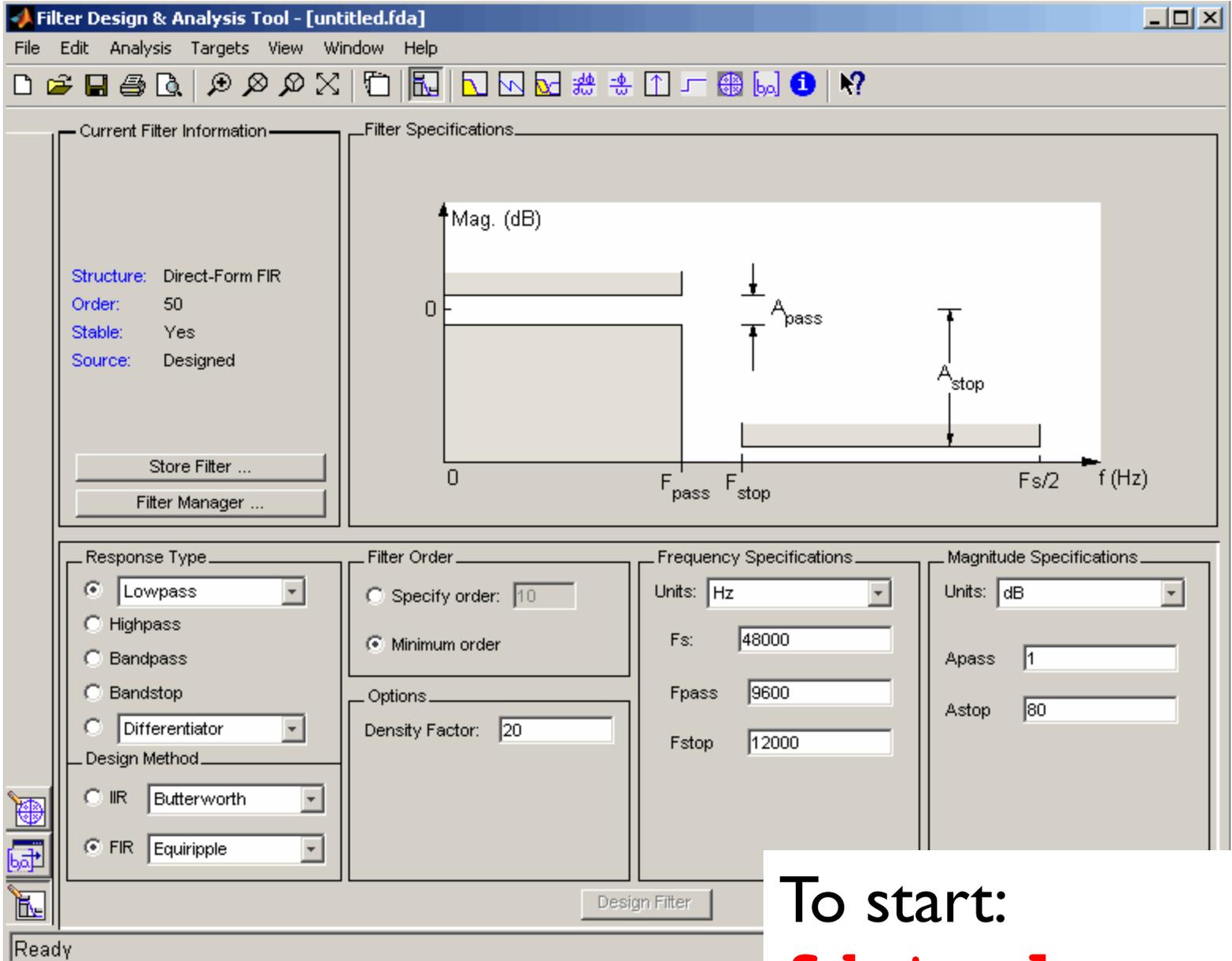
# Signal Processing

- Signal Processing Toolbox
- Communications Toolbox
- Filter Design Toolbox
- Filter Design HDL Coder
- Wavelet Toolbox
- Fixed-Point Toolbox
- RF Toolbox

# Signal Processing Functions

- FIR filter design
- Digital filter design
- Characterization/Analysis
- Implementation (convolution, etc.)
- Analog filters
- Waveform generators
- Some GUI tools





To start:  
**fdatool**



# Demo

# Signal Processing

- Comprehensive set of signal and linear system models
- Finite impulse response (FIR) and infinite impulse response (IIR) digital filter design, analysis, and implementation
- Analog filter design
- Fourier and discrete cosine transforms
- Spectral analysis and statistical signal processing
- Parametric time-series modeling
- Waveform generation, including a Gaussian pulse generator, a periodic sinc generator, and a pulse train generator
- Graphical user interfaces for designing, analyzing, and visualizing signals, filters, and windows

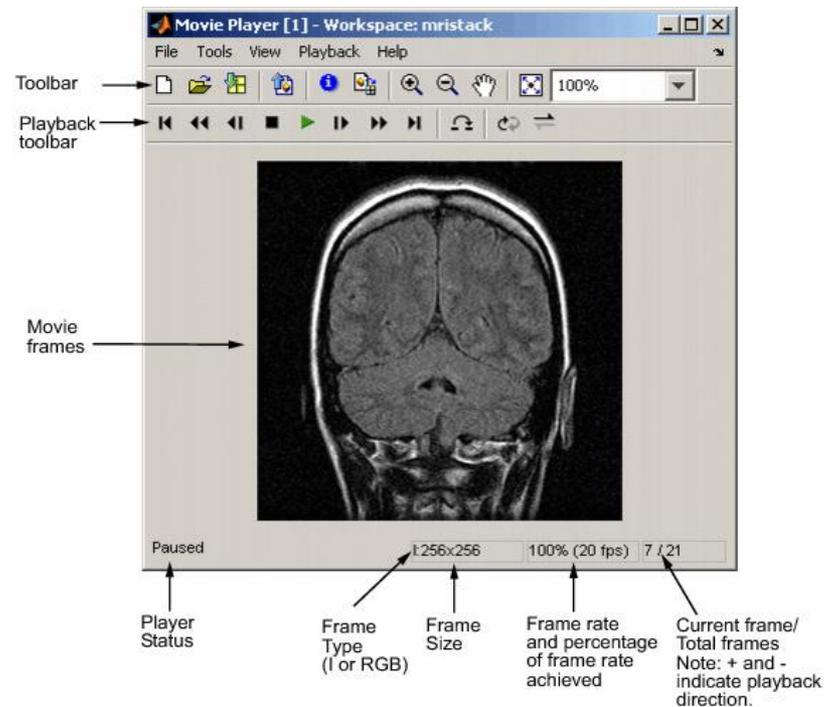
# Image Processing

- Image Processing Toolbox
- Image Acquisition Toolbox
- Mapping Toolbox

To start GUIs:

**implay**

**imtool**



# Image Processing

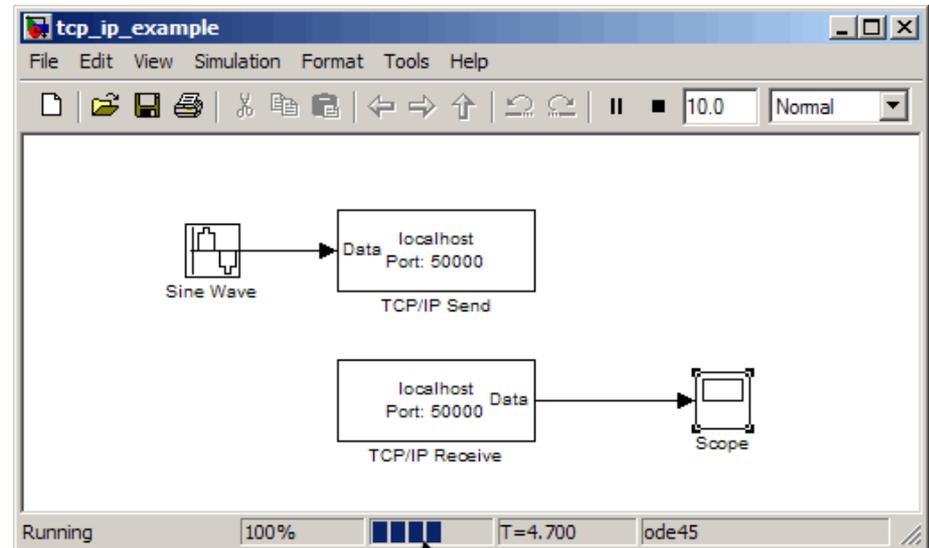
- Image enhancement, including filtering, filter design, deblurring, and contrast enhancement
- Image analysis, including feature detection, morphology, segmentation, and measurement
- Spatial transformations and image registration
- Image transforms, including FFT, DCT, Radon, and fan-beam projection
- Modular interactive tools, including ROI selections, histograms, and distance measurements
- Interactive image and video display
- DICOM import and export



# Demo

# Measurement

- Data Acquisition Toolbox
- Instrument Control Toolbox
- Image Acquisition Toolbox
- SystemTest
- OPC Toolbox



Simulation Status

# Development and Deployment

- MATLAB Compiler
- Spreadsheet Link
- MATLAB Builder (for Excel, .NET, or Java)

# Compiler

- Packages MATLAB® applications as executables and shared libraries
- Lets you distribute standalone executables and software components royalty-free
- Lets you incorporate MATLAB based algorithms into applications developed using other languages and technologies
- Encrypts MATLAB code so that it cannot be viewed or modified

# Approaches

- Standalone applications
- C or C++ libraries (DLLs in Windows®, shared libraries in Linux® and UNIX®)
- Software components, such as Java classes, .NET assemblies, or Excel add-ins for use within other applications (with MATLAB builder products)

# High Perf. Computation

- Parallel Computing
- Distributed Computing

# Others

- Biology
- Financial Modeling
- Database Connectivity
- Fixed Point Modeling

# Simulink

- Simulink
- Simulink Report Generator
- Simulink Fixed Point
- Stateflow
- SimEvents
- Simscape
- SimMechanics
- SimPowerSystems
- SimDriveline
- SimHydraulics
- SimElectronics

To start:

**simulink**

- ◆ Virtual Reality Toolbox
- ◆ Gauges Blockset
- ◆ Control System Design and Analysis
- ◆ Simulink Control Design
- ◆ Simulink Response Optimization
- ◆ Simulink Parameter Estimation
- ◆ Aerospace Blockset

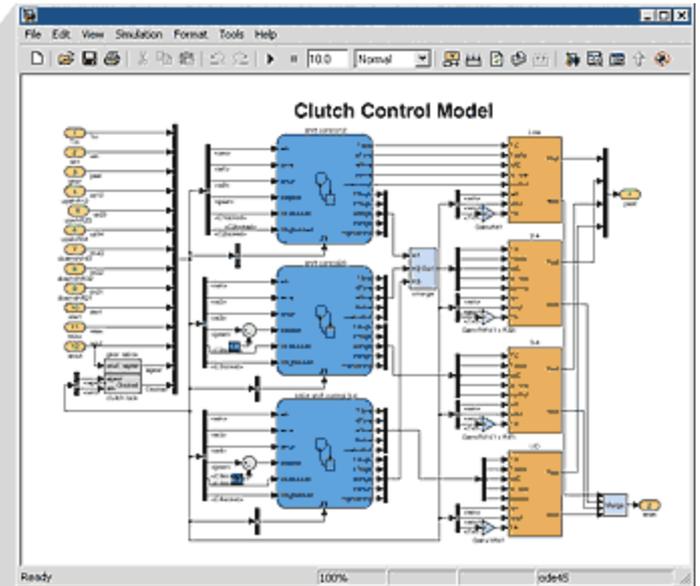
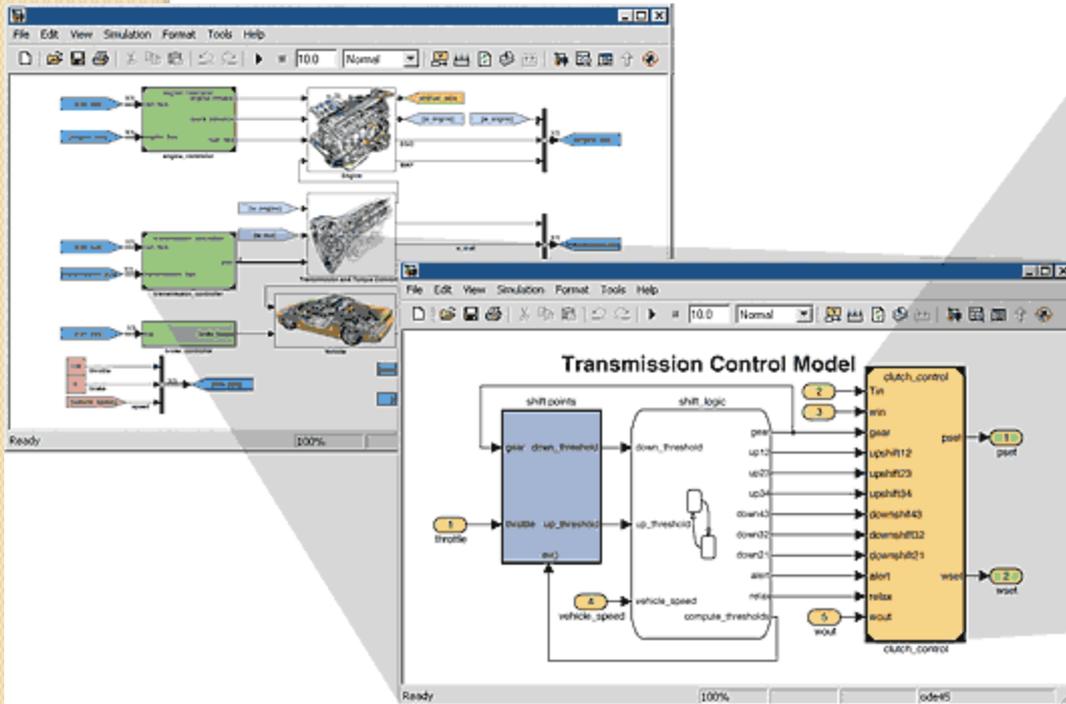
# Simulink

- Environment for multidomain simulation and Model-Based Design for dynamic and embedded systems
- Provides an interactive graphical environment and a customizable set of block libraries
  - Design
  - Simulate
  - Implement
  - test

# Simulink Features

- Libraries of predefined blocks
- Graphical editor for assembling block diagrams
- Segment models into hierarchies of design components
- Model Explorer
- APIs let you connect with other simulation programs
- Embedded MATLAB Function blocks for bringing in MATLAB algorithms
- Normal, Accelerator, and Rapid Accelerator simulation modes
- Graphical debugger and profiler
- Full access to MATLAB for postprocessing
- Model analysis and diagnostics tools

# Typical Models





# Simulink Demo



**Questions?**