The MathWorks™ MATLAB® & SIMULINK®

Solving Data Analysis Challenges Using MATLAB® and Statistics Products

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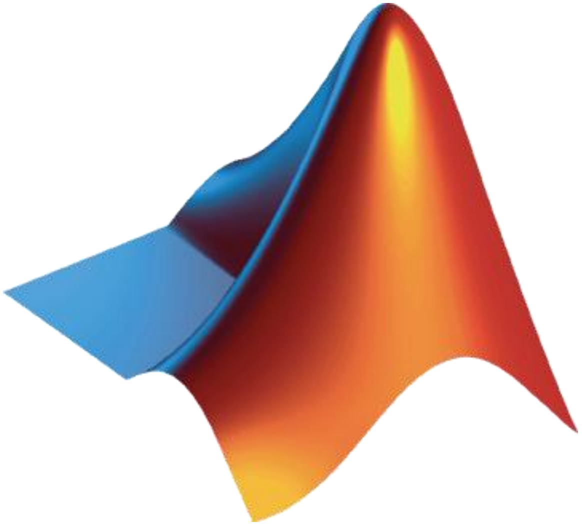
MathWorks Symposium

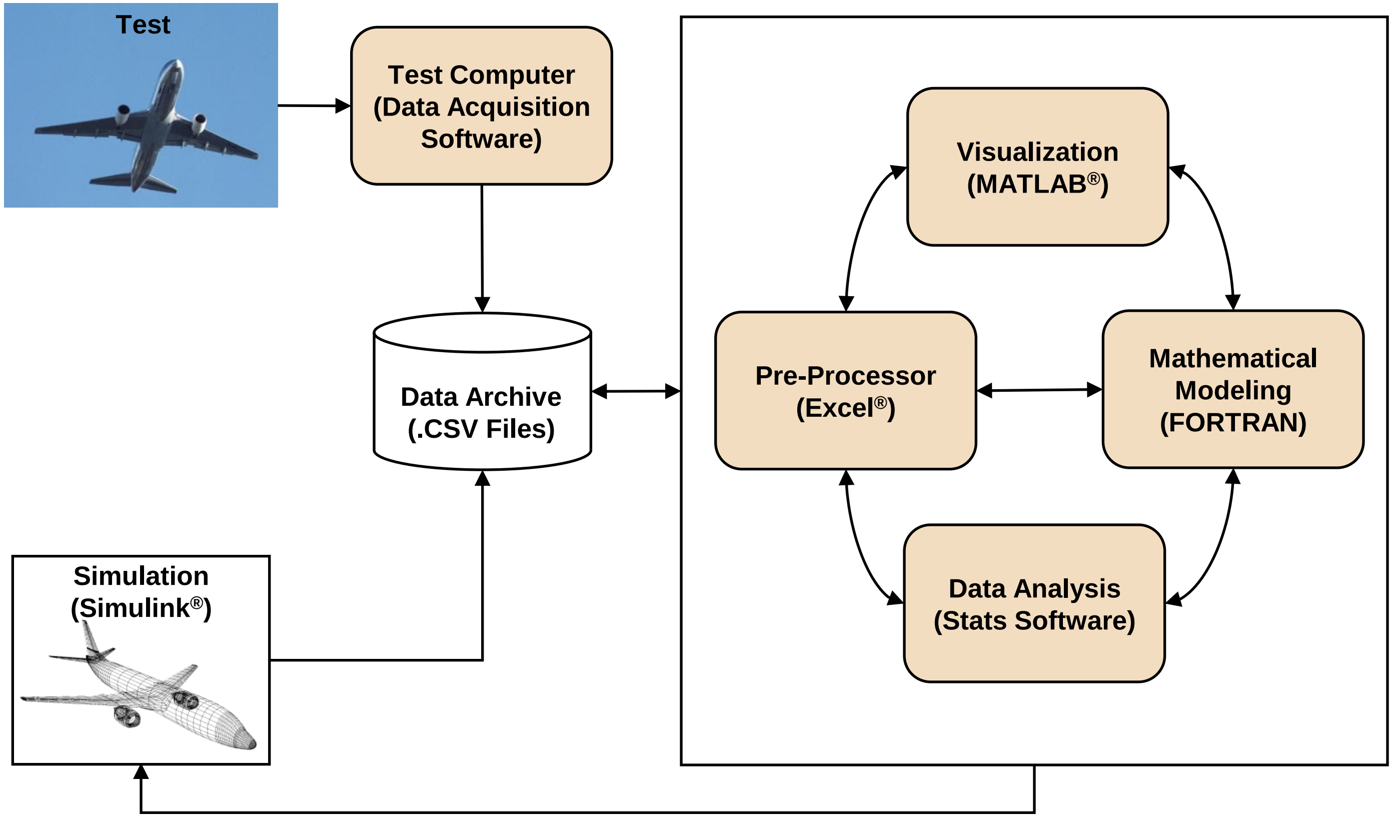
Adopting Model-Based Design within Aerospace and Defense

Agenda

- Example data analysis workflow
- Demonstration: Analysis of aircraft wing stress
- Summary
- Question and answer



Example Data Analysis Workflow



Test

Test Computer (Data Acquisition Software)

Data Archive (.CSV Files)

Simulation (Simulink®)

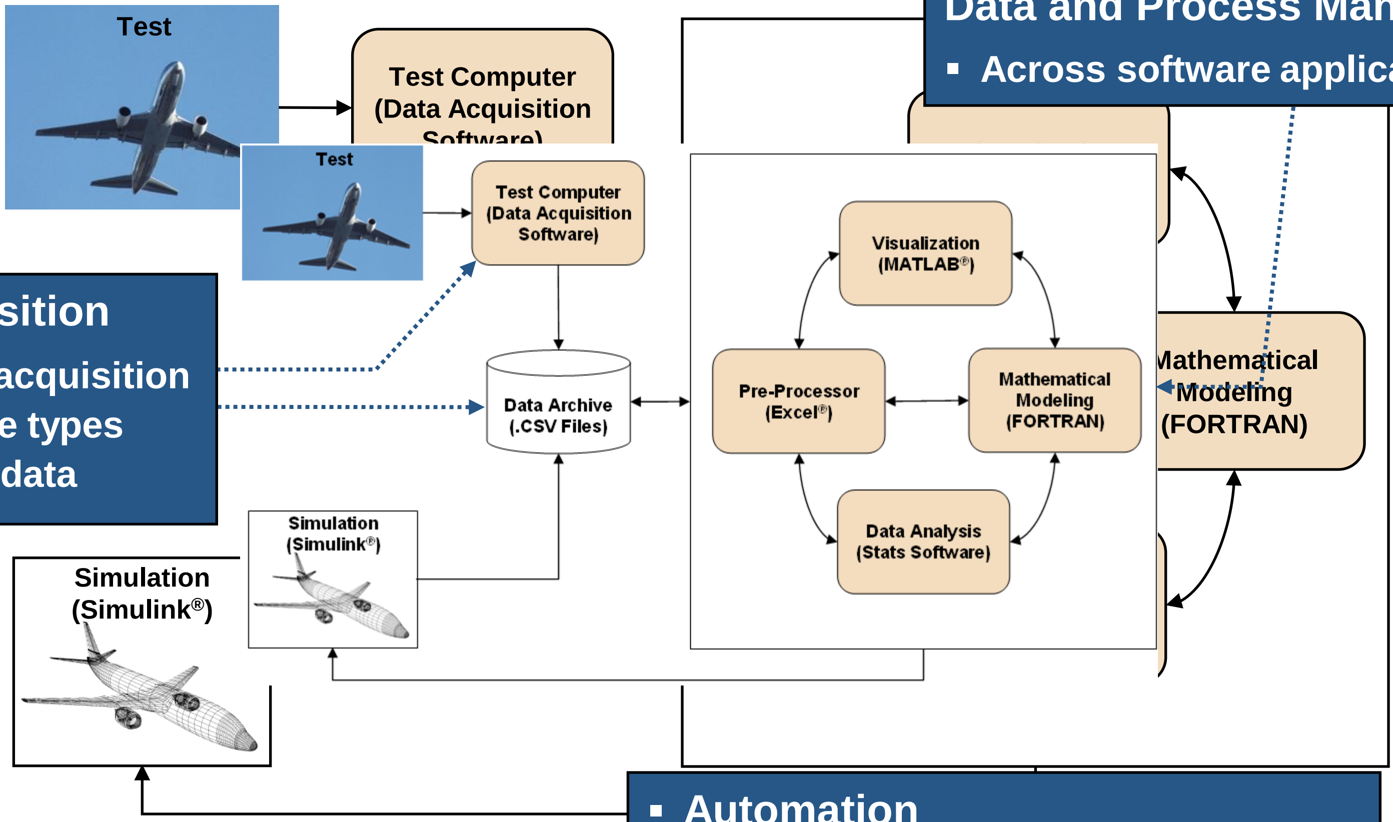
Visualization (MATLAB®)

Pre-Processor (Excel®)

Mathematical Modeling (FORTRAN)

Data Analysis (Stats Software)

What are the challenges in this workflow?


Test
Test Computer (Data Acquisition Software)
Data Archive (.CSV Files)
Visualization (MATLAB®)
Pre-Processor (Excel®)
Mathematical Modeling (FORTRAN)
Data Analysis (Stats Software)
Simulation (Simulink®)

Data and Process Management

- Across software applications

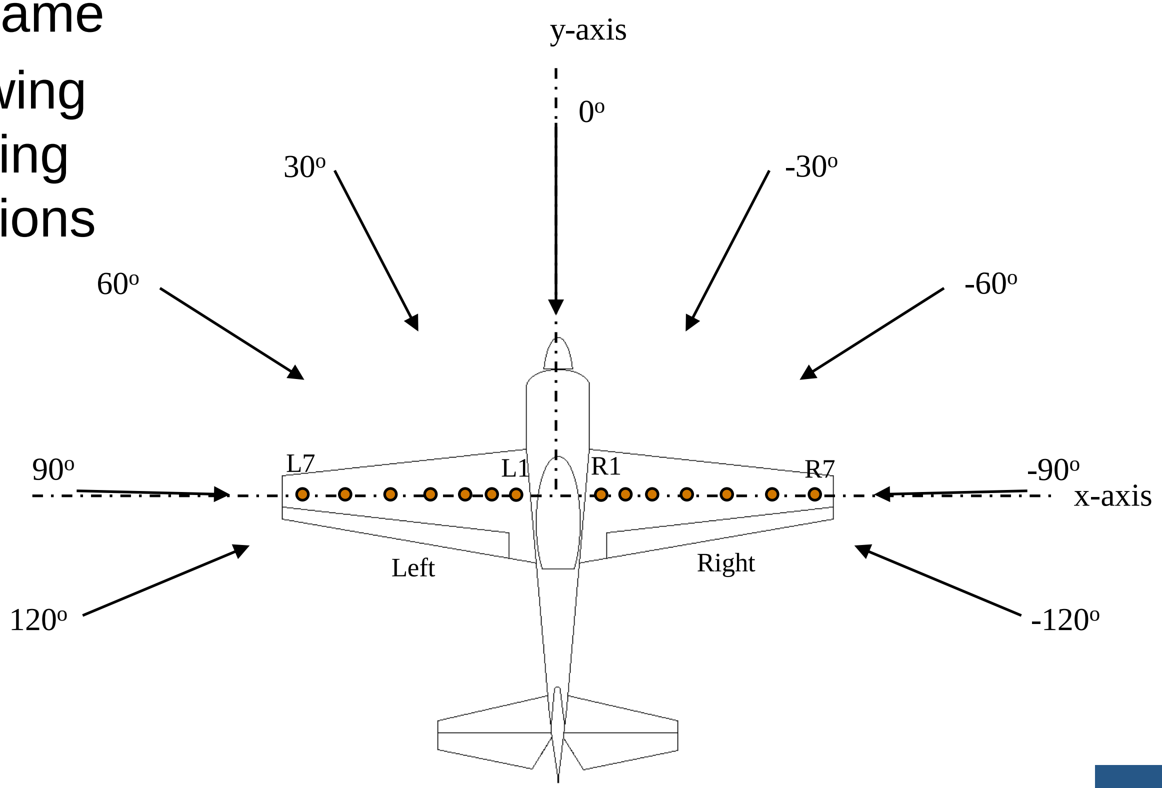
Data Acquisition

- Hardware acquisition
- Multiple file types
- Volume of data

- Automation
- Ability to share analysis routines
- Reporting

Demonstration: Wing Stress Analysis

- Determine if:
  - Stress levels on left and right wings are the same
  - Shear force on the wing exceeds 160 kN during extreme wind conditions


y-axis
0°
30°
-30°
60°
-60°
90°
-90°
x-axis
L7
L1
R1
R7
Left
Right
120°
-120°

Summary: Wing Stress Analysis

Products Used
- MATLAB®
- Curve Fitting Toolbox™
- Statistics Toolbox™

- Imported and visually inspected data
- Used statistics functionality to support the analysis
  - Hypothesis testing
  - Dataset and categorical arrays
  - Specialized visualizations and analysis techniques
- Used curve fitting analysis to estimate shear force

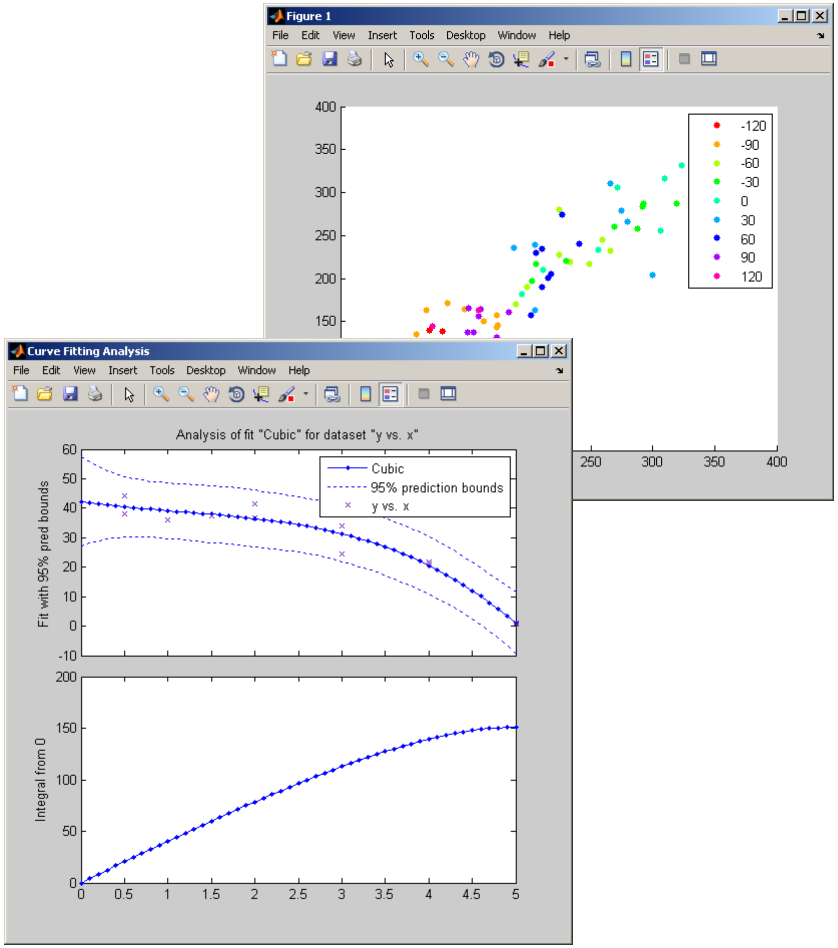
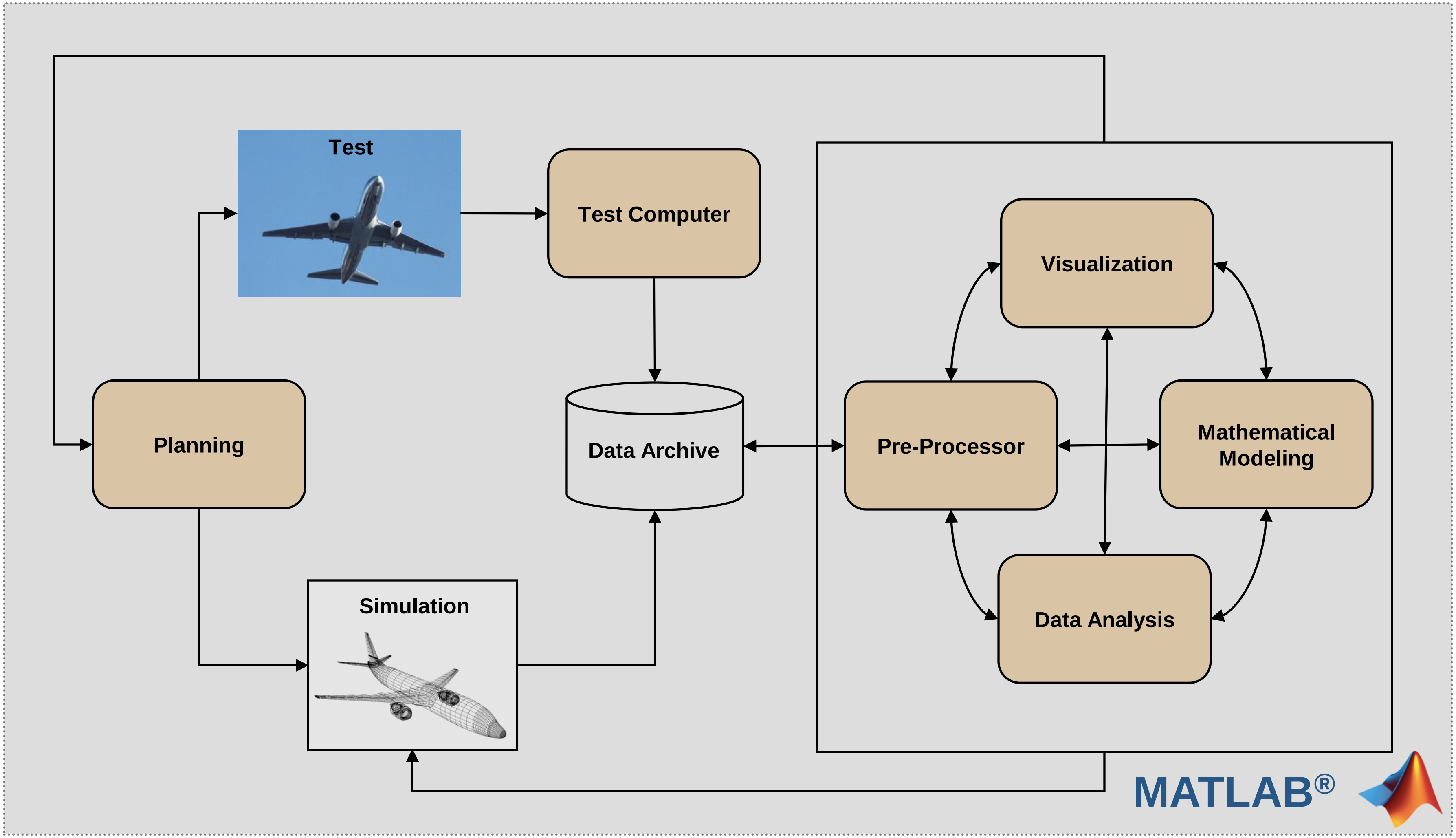


Figure 1
File Edit View Insert Tools Desktop Window Help
400
350
300
250
200
150
-120
-90
-60
-30
0
30
60
90
120
250
300
350
400
Curve Fitting Analysis
File Edit View Insert Tools Desktop Window Help
Analysis of fit "Cubic" for dataset "y vs. x"
Fit with 95% pred bounds
60
50
40
30
20
10
0
-10
Cubic
95% prediction bounds
y vs. x
Integral from 0
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Summary


Test
Test Computer
Planning
Data Archive
Simulation
Visualization
Pre-Processor
Mathematical Modeling
Data Analysis
MATLAB®

Questions?

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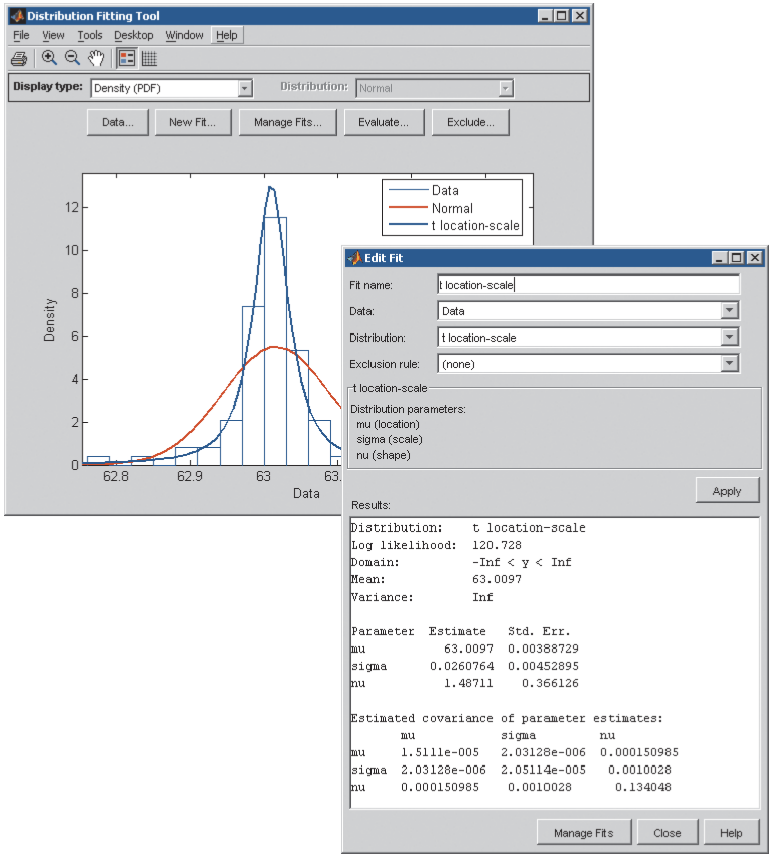
Statistics Toolbox™

Statistics Toolbox™ provides interactive and command line tools for:

- Data collection and management
- Descriptive statistics
- Multivariate statistics
- Probability distribution fitting and modeling
- Hypothesis testing
- Analysis of variance/covariance
- Linear and nonlinear modeling
- Visualization
- Statistical Process Control


Distribution Fitting Tool
File
View
Tools
Desktop
Window
Help
Distribution:
Normal
Data...
New Fit...
Manage Fits...
Evaluate...
Exclude...
Density
0
2
4
6
8
10
12
62.8
62.9
63
63.
Data
Data
Normal
t location-scale
Edit Fit
t location-scale
Apply
Manage Fits
Close
Help

Display type: Density (PDF)

Fit name: t location-scale

Data: Data

Distribution: t location-scale

Exclusion rule: (none)

Distribution parameters:
mu (location)
sigma (scale)
nu (shape)

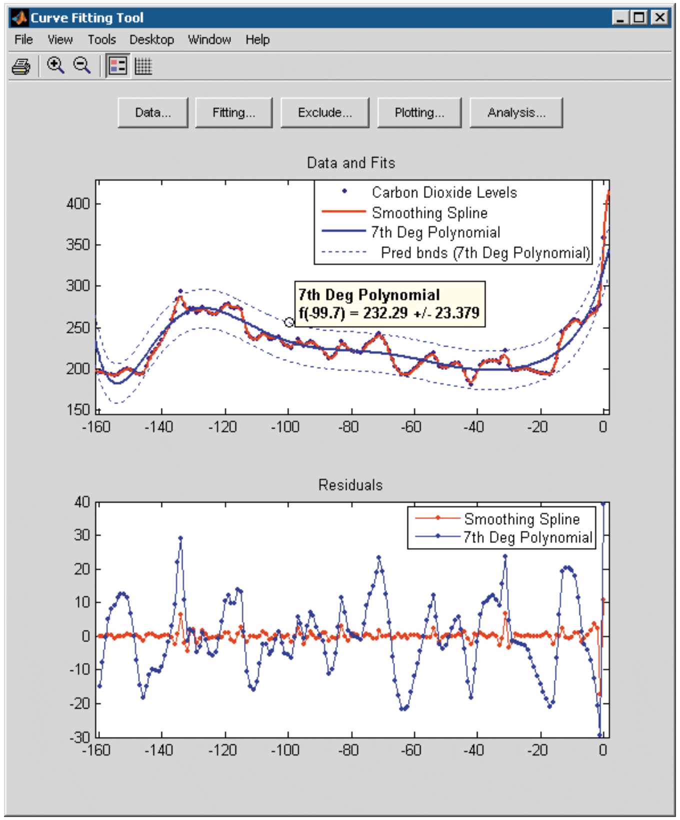
Results:

```
Distribution:     t location-scale
Log likelihood:   120.728
Domain:           -Inf < y < Inf
Mean:             63.0097
Variance:         Inf

Parameter  Estimate   Std. Err.
mu           63.0097  0.00388729
sigma      0.0260764  0.00452895
nu           1.48711    0.366126

Estimated covariance of parameter estimates:
       mu            sigma         nu
mu     1.5111e-005   2.03128e-006  0.000150985
sigma  2.03128e-006  2.05114e-005   0.0010028
nu     0.000150985    0.0010028      0.134048
```

Curve Fitting Toolbox™

Graphical user interface and command line functions for:

- Previewing and preprocessing data
- Developing, comparing, and managing models
- Extensive library of linear, nonlinear, and nonparametric models
- Customizable model fitting
- Interpolation, extrapolation, differentiation, and integration


Curve Fitting Tool
File View Tools Desktop Window Help
Data... Fitting... Exclude... Plotting... Analysis...
Data and Fits
Carbon Dioxide Levels
Smoothing Spline
7th Deg Polynomial
Pred bnds (7th Deg Polynomial)
7th Deg Polynomial
f(-99.7) = 232.29 +/- 23.379
400
350
300
250
200
150
-160 -140 -120 -100 -80 -60 -40 -20 0
Residuals
Smoothing Spline
7th Deg Polynomial
40
30
20
10
0
-10
-20
-30
-160 -140 -120 -100 -80 -60 -40 -20 0