Origins, Evolution, and Future Directions of MATLAB®

Loren Shure
Agenda

- Origins
- Evolution
- Tomorrow
Computational Finance Workflow

Access
- Files
- Databases
- Datafeeds

Research and Quantify
- Data Analysis & Visualization
- Financial Modeling

Automation

Share
- Reporting
- Applications
- Production

Automate

Files

Sharing

Accessing

Automation

Research & Quantification

Share

Computational Finance Workflow

Automation

Research & Quantification

Share

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Origins of MATLAB
1965 Birth of L-Shaped Membrane

Origin of MathWorks Corporate Logo

Cleve Moler’s Stanford Ph.D. Thesis

*Finite Difference Methods for Eigenvalues of Laplace’s Operator*

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Blog post
1965 Birth of L-Shaped Membrane

Evolution of MathWorks Corporate Logo

- vibes
- Vibrating L-shaped membrane
1967

1971

1976

1977

1979

1977 MATLAB Created

Cleve’s Work in Computational Mathematics

Handbook for
Automatic Computation
Edited by
F. L. Bauer · A. S. Householder · F. W. J. Olver
H. Rutishauser · K. Samelson · E. Stiefel

Volume II
J. H. Wilkinson · C. Reinsch

Linear Algebra
Chief editor
F. L. Bauer

Springer-Verlag Berlin Heidelberg New York 1971

Idea formed: Matrix Laboratory
FORTAN Program
Matrix as a Data Type
MATLAB Command Line Program Debuts as a Teaching Tool

MATLAB >
Version of 01/10/81

HELP is available

< > help

Type HELP followed by
INTRO  (to get started)
NEWS   (recent revisions)

ABS    ANS    ATAN   BASE   CHAR   CHOL   CHOP   CLEA   COND   CONV
DEG    DIAG   DIAR   DISP   EDIT   EIG    ELSE   END    EPS
EXP    EYE    FILE   FLOP   FLPS   FOR    FUN    HESS   HILB   IDEN
INV    KRON   LOAD   LOG    LONG   LU     MACR   MADR   MAX
ORTH   PINV   PLOT   POLY   PRIN   PROD   QR     RAND   RANK   REAL
REGR   RREF   ROOT   ROUN   SAVE   SCHU   SHOR   SED   SIVR   SORT
SQRT   STOP   SUM    SVD    TRIL   TRIU   USER   WHAT   WHOS
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1979 MATLAB 0.0

MATLAB Command Line Debuts as a Teaching Tool

Stanford: 1979-80 Winter Quarter
CS237 - Numerical Analysis

Math & CS Students
Not impressed

Engineering Students
Love MATLAB

Interactive text-based interpreter – No need to compile!
Evolution of MATLAB
1983-1984 Jack Little’s Vision

**MathWorks Founded to Commercialize MATLAB**

Jack Little left his job at the consulting company and bought a new COMPAQ portable computer at Sears. The machine had only 256KB of memory and no hard disc; Jack had to swap 3-1/4-inch floppies to compile programs. Jack and Steve took a year and a half to rewrite MATLAB in C, adding new features they had envisioned. Steve wrote the parser/interpreter, and Jack wrote the math libraries, including translations to C of about a dozen routines from LINPACK and MATLAB. Jack also wrote the first Control System Toolbox. Some of their original code is still used in MATLAB today.

In 1984, Jack, Steve, and I founded The MathWorks. The first mailing address was a rented A-frame cabin where Jack lived in the hills above Stanford University in Portola Valley, California.

Jack suggested making MATLAB a matrix-based programming language to which we could easily add new functions, organized into toolboxes. He wanted the system to be available on a wide range of machines, from PCs and workstations to mainframes. He also wanted it to take advantage of graphics where they were available. I readily agreed.

There was considerable concern about code size in the initial versions of MATLAB. On the PC, MATLAB had to share 256KB of memory with the DOS operating system and still leave room to store a few matrices. I designed a simple, single-shift, complex QZ algorithm that was not in EISPACK. It required little memory and could be used for most of the matrix eigenvalue problems. We even used it for polynomial zeros to save code.

The MathWorks released MATLAB 1.0, implemented in C for MS-DOS PCs. MATLAB made its commercial debut at the IEEE Conference on Design and Control in Las Vegas, Nevada.

**MATLAB becomes a language for Technical Computing**

**M-file scripts and functions**

**Toolboxes**
1987 Loren Shure Joins MathWorks as Hire #1

**MATLAB Developer**

[Image of an old computer screen running MATLAB]

```
>> a = 1:9
>> a
ans =
1   2   3   4   5   6   7   8   9
>> a(1 0 0 1 1 0 0 1)
ans =
1   2   5   6   9
```

[Image of a group of people posing in front of a building, labeled 1988/9]
MATLAB is more than a language:
- Library of mathematical functions
- Customizable by toolboxes
- M-file functions and scripts
- 2d/3d Graphics
- Matrix data type (2-d complex array)
1996 MATLAB 5.0
MATLAB Language Evolves Beyond the MATRIX Data Type

New Data Types, Structures, and Language Features
MATLAB 5 introduces new data types and language improvements. These new features make it easy to build much larger and more complex MATLAB applications.

- Multi-dimensional arrays
- User-definable data structures
- Cell arrays: multi-type data arrays
- Character arrays: two bytes per character
- Single byte data type for images
- Object-oriented programming
- Variable-length argument lists
- Multifunction and private M-files
- Function and operator overloading
- switch/case statements

Faster, Better Graphics and Visualization
Graphics take another quantum leap with powerful new visualization techniques and significantly faster image display using the Z-buffer algorithm. Presentation graphics are also improved to give you more options and control over how you present your data.

- Visualization
1996 MATLAB 5.0

Financial Toolbox Launched
1998-1999 MATLAB 5.2 (R10) and 5.3 (R11)  
Desktop Evolves, Debugger, Enhanced 3D Graphics
2000-2003 MATLAB 6.0-6.5 (R12-R13)

New Dock-able Desktop, Command History, Function Handles

MATLAB JIT Introduced

fhandle = @humps;
x = fminbnd(fhandle, 0.3, 1)
x = 
0.6370
2000-2003 MATLAB 6.0-6.5 (R12-R13)
Start Menu, More GUI Tools (Apps), and More Finance Products

JAVA Interface
Anonymous functions:

\[
sqr = @(x) x.^2;
\]

Nested functions:

\[
\text{function } x = A(p1, p2) \\
\quad \ldots \\
\text{function } y = B(p3) \\
\quad \ldots \\
\text{end} \\
\quad \ldots \\
\text{end}
\]
2004 MATLAB 7 (R14)
And Publishing of Scripts

MATLAB scripts

→ Published Report
2006 MATLAB 7.2 (R2006a)

Move to Twice a Year Release, M-Lint Integrated into Editor
Statistics Toolbox (future MATLAB data types)
- Categorical variables
- Dataset variable
2008 MATLAB 7.8 (R2008a)
Econometrics Toolbox Launched, Performance Improvements

INV And Backslash
Speed-ups seen at R12, R14, and R2008a.

`perfchart(data, 'solving systems')`
set(gca, 'visible', 'off');
title('INV And Backslash');
ylabel('relative speed')
2008 MATLAB 7.8 (R2008a)

*Modernized Object-Oriented Programming*

<table>
<thead>
<tr>
<th></th>
<th>MATLAB 1997–2007</th>
<th>Release 2008a</th>
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<tbody>
<tr>
<td>Classes</td>
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<td>✓</td>
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<tr>
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<td>Methods</td>
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<tr>
<td>Properties</td>
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<td>✓</td>
</tr>
<tr>
<td>Events and listeners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overloaded operators</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Protected access</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Handle (reference) classes</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Destructors</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Classes defined in single files</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Static methods</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Help for properties</td>
<td></td>
<td>✓</td>
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</tbody>
</table>
2008 MATLAB 7.9 (R2008b)

New Symbolic Engine

Symbolic Notebook
2009 MATLAB 7.8/7.9 (R2009a/b)

Protected Code, .NET Interface
function vv = waveEqn(N,Nsteps)
% Initialization / Setup
vv = exp(-40*((xx-.4).^2 + yy.^2));

% Send data to GPU
   dt = gpuArray(dt);
   vv = gpuArray(vv);
   index1 = gpuArray(index1);

% Processing
   n=0;
   while n < Nsteps
       V = [vv(ii,:) vv(ii,N:-1:2)];
       U = real(fft(V.')).';
       W1test = (U.*W1T).';
       W1 = (real(ifft(W1test))).';

   % Gather vvg back from GPU memory when done
   vvg = gather(vv);

end

% Additional Code

2011 MATLAB 7.13/7.14 (R2011a/b)
Big .MAT Files – Partial Read/Write, 80+ Tools (aka Apps)
2012 MATLAB 7.13 (R2012b)
New Desktop Launched, Improved Discoverability, Apps
2012 MATLAB 7.13 (R2012b)

New Desktop Launched, Improved Discoverability, Apps
2012 MATLAB 7.13 (R2012b)

MATLAB Production Server Launched

![Diagram of MATLAB Production Server with connections to Web Server, Application Server, Database Server, and MATLAB Compiler. The server includes modules for Portfolio Optimization, Pricing, and Risk Analytics.]
2012 MATLAB 7.13 (R2012b)

**MATLAB Production Server Example: Web Asset Allocation**

http://54.208.30.187/mwa/
2012 MATLAB 7.13 (R2012b)
MATLAB Production Server Example: Predictive Modeling

http://is.gd/mwdfw
Unit Testing and Datasets become Tables in MATLAB

Unit tests for function priceOption

This script performs unit testing on the function priceOption

Contents
- Output correctness
- Put-Call Parity
- Error handling

Output correctness
Test an at-the-money call option price with varying interest rates

Average relative error 1.98e-07
Maximum relative error 3.99e-07

Test an at-the-money call option price with varying volatilities

Average relative error 3.52e-07
Maximum relative error 2.06e-06

Put-Call Parity
Verify that the option price results satisfy put-call parity relationships.

Average relative error 2.95e-16
Maximum relative error 2.01e-15
Future Directions of MATLAB

2014 - onwards
MATLAB – The Financial Development Platform
MATLAB – The Financial Development Platform
Cloud as a New Platform

BILLIONS of users 3rd PLATFORM MILLIONS of apps

Cloud – mobile, browser, social, big data

HUNDREDS OF MILLIONS of users 2nd PLATFORM 10,000s of applications

PC - LAN, Internet

MILLIONS of users 1st PLATFORM 1,000s of applications

Terminal - mainframe, mini

Source: IDC, 2013
MATLAB Mobile
Support for iPhone, iPad, and Android
Cloud Enhancing Your MATLAB Desktop

MATLAB Distributed Computing Server on Amazon EC2
The 4 V’s of Big Data

Volume

Velocity

Variety

Veracity
Big Data Capabilities in MATLAB

Memory and Data Access
- 64-bit processors
- Memory Mapped Variables
- Disk Variables
- Databases
- Datastores

Programming Constructs
- Streaming
- Block Processing
- Parallel-for loops
- GPU Arrays
- SPMD and Distributed Arrays
- MapReduce

Platforms
- Desktop (Multicore, GPU)
- Clusters
- Cloud Computing (MDCS on EC2)
- Hadoop
New Big Data Capabilities in MATLAB

Memory and Data Access
- 64-bit processors
- Memory Mapped Variables
- Disk Variables
- Databases
- Datastores

Programming Constructs
- Streaming
- Block Processing
- Parallel-for loops
- GPU Arrays
- SPMD and Distributed Arrays
- MapReduce

Platforms
- Desktop (Multicore, GPU)
- Clusters
- Cloud Computing (MDCS on EC2)
- Hadoop
Analyze Big Data

mapreduce

- Use the powerful MapReduce programming technique to analyze big data
  - Multiple items (keys) to organize and process
  - Intermediate results do not fit in memory

- On the desktop
  - Analyze big database tables (Database Toolbox)
  - Increase compute capacity (Parallel Computing Toolbox)
  - Access data on HDFS to develop algorithms for use on Hadoop

- With Hadoop
  - Run on Hadoop using MATLAB Distributed Computing Server
  - Deploy applications and libraries for Hadoop using MATLAB Compiler
## Mapreduce

### Data Store

<table>
<thead>
<tr>
<th>Muni_ID</th>
<th>Airline_ID</th>
<th>Distance</th>
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<tbody>
<tr>
<td>1503</td>
<td>UA</td>
<td>LAX</td>
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<tr>
<td>540</td>
<td>PS</td>
<td>BUR</td>
</tr>
<tr>
<td>1920</td>
<td>DL</td>
<td>BOS</td>
</tr>
<tr>
<td>1840</td>
<td>DL</td>
<td>SFO</td>
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<td>272</td>
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<td>BWI</td>
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<td>784</td>
<td>PS</td>
<td>SEA</td>
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<td>UA</td>
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<td>SJC</td>
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<td>EWR</td>
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<tr>
<td>2134</td>
<td>DL</td>
<td>DFW</td>
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</tbody>
</table>

### Map

#### UA
- 2356

#### PS
- 186
- 359

#### DL
- 1876

### Reduce

#### UA
- 2356
- 1867

#### PS
- 237

#### DL
- 1876
Statistics and Machine Learning

What’s New

Classification Learner

- New app to train models and classify data using supervised machine learning

Features

- Import and interactively explore data
- Choose kfold or holdout validation
- Train SVM, kNN, bagged trees and other algorithms
- Assess results using classification accuracy, ROC curves and Confusion Matrices
- Export models to the MATLAB or generate MATLAB code
Statistics and Machine Learning

What’s New?

New:
- Classification Learner app
- Multiclass SVM
- Statistical tests for comparing classifiers
- Kmediods Clustering (robust to outliers)
- C Code Generation for PCA

Enhancements:
- Speedup of the kmeans and gmdistribution using the kmeans++
- Performance enhancements for decision trees and performance curves
MATLAB Distributed Computing Server

with Hadoop
MATLAB Compiler with Hadoop

MATLAB runtime

Datastore

HDFS

Node
Data

Map
Reduce

Node
Data

Map
Reduce

Node
Data

Map
Reduce

Hadoop

MATLAB MapReduce Code

.exe

MATLAB runtime

Datastore

HDFS

Node
Data

Map
Reduce

Node
Data

Map
Reduce

Node
Data

Map
Reduce

.exe

MATLAB MapReduce Code
...and much more to come
MATLAB – The Financial Development Platform