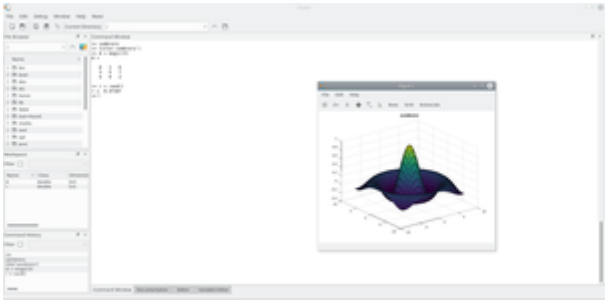
GNU Octave

GNU Octave is software featuring a high-level programming language, primarily intended for numerical computations. Octave helps in solving linear and nonlinear problems numerically, and for performing other numerical experiments using a language that is mostly compatible with MATLAB. It may also be used as a batch-oriented language. Since it is part of the GNU Project, it is free software under the terms of the GNU General Public License.

Other free alternatives to MATLAB include Scilab and FreeMat.[6][7][8][9] Octave is more compatible with MATLAB than Scilab is,[6][10][11] and FreeMat has not been updated since June 2013.[12]

Contents

GNU Octave



GNU Octave 4.3.0+ running on Linux

Developer(s)	John W. Eaton and many others[1]
Initial release	1988
Stable release	6.3.0[2] / 11 July 2021
Preview release	6.0.90a / 28 August 2020[3]
Repository	www.octave.org/hg/octave (https://www.octave.org/hg/octave)
Written in	C, C++, Fortran[4]
Operating system	Windows, macOS, Linux, BSD
Available in	17 languages[5]
Type	Scientific computing
License	GNU GPLv3
Website	gnu.org/software/octave/ (https://gnu.org/software/octave/)

History

The project was conceived around 1988.[13] At first it was intended to be a companion to a chemical reactor design course. Real development was started by John W. Eaton in 1992. The first alpha release dates back to 4 January 1993 and on 17 February 1994 version 1.0 was released. Version 4.0.0 was released on 29 May 2015.

The program is named after Octave Levenspiel, a former professor of the principal author. Levenspiel was known for his ability to perform quick back-of-the-envelope calculations.[14]

Development history

Time	Action
1988/1989	1st discussions (Book and Software)
February 1992	Begin of Development
January 1993	News in Web (Version 0.60)
February 1994	1st Publication (Version 1.0.0 to 1.1.1)[15]
December 1996	2nd Publication (Version 2.0.x) with Windows Port (Cygwin)[16]
March 1998	Version 2.1
November 2004	Version 2.9 (DEV Version of 3.0)[17]
December 2007	Publication of Version 3.0 (Milestone)[18]
June 2009	Publication of Version 3.2 (Milestone)[19]
8 February 2011	Version 3.4.0 (Milestone)[20]
22 February 2012	Publication of Octave 3.6.1 (Milestone)[21][22]
31 December 2013	Publication of Octave 3.8.0 (experimental GUI)[23][24][25]
29 May 2015	Version 4.0.0 (stable GUI and new Syntax for OOP)[26][27][28][29]
14 November 2016	Version 4.2.0 (gnuplot 4.4+)[30][31][32][33]
30 April 2018	Version 4.4.0 (new Goal for GUI QT Toolkit, the FLTK toolkit is not deprecated and there is no schedule for its removal - while no longer prioritized)[34][35][36]
1 March 2019	Publication of Octave 5.1.0 (QT5 preferred, Qt 4.8 minimum), hiDpi support[37]
31 January 2020	Publication of Octave 5.2.0 (QT5 preferred)[38]
26 November 2020	Publication of Octave 6.1.0 (QT5 preferred, Qt 4.x deprecated for remove in 7)[39]
20 February 2021	Publication of Octave 6.2.0 (QT5 preferred), Bugfix, improved matlab syntax support[40]

Developments

In addition to use on desktops for personal scientific computing, Octave is used in academia and industry. For example, Octave was used on a massive parallel computer at Pittsburgh Supercomputing Center to find vulnerabilities related to guessing social security numbers.[41]

Acceleration with OpenCL or CUDA is also possible with use of GPUs.[42]

Technical details

- Octave is written in C++ using the C++ standard library.
- Octave uses an interpreter to execute the Octave scripting language.
- Octave is extensible using dynamically loadable modules.
- Octave interpreter has an OpenGL-based graphics engine to create plots, graphs and charts and to save or print them. Alternatively, gnuplot can be used for the same purpose.
- Octave includes a Graphical User Interface (GUI) in addition to the traditional Command Line Interface (CLI); see #User interfaces for details.

Octave, the language

The Octave language is an interpreted programming language. It is a structured programming language (similar to C) and supports many common C standard library functions, and also certain UNIX system calls and functions.[43] However, it does not support passing arguments by reference.[44]

Octave programs consist of a list of function calls or a script. The syntax is matrix-based and provides various functions for matrix operations. It supports various data structures and allows object-oriented programming.[45]

Its syntax is very similar to MATLAB, and careful programming of a script will allow it to run on both Octave and MATLAB.[46]

Because Octave is made available under the GNU General Public License, it may be freely changed, copied and used.[14] The program runs on Microsoft Windows and most Unix and Unix-like operating systems, including Linux, Android, and macOS.[47][48][49]

Notable features

Command and variable name completion

Typing a TAB character on the command line causes Octave to attempt to complete variable, function, and file names (similar to Bash's tab completion). Octave uses the text before the cursor as the initial portion of the name to complete.[50]

Command history

When running interactively, Octave saves the commands typed in an internal buffer so that they can be recalled and edited.

Data structures

Octave includes a limited amount of support for organizing data in structures. In this example, we see a structure "x" with elements "a", "b", and "c", (an integer, an array, and a string, respectively):

```
octave:1> x.a = 1; x.b = [1, 2; 3, 4]; x.c = "string";
octave:2> x.a
ans =  1
octave:3> x.b
ans =

   1   2
   3   4

octave:4> x.c
ans = string
octave:5> x
x =
{
  a =  1
  b =

     1   2
     3   4

  c = string
}
```

Short-circuit Boolean operators

Octave's && and || logical operators are evaluated in a short-circuit fashion (like the corresponding operators in the C language), in contrast to the element-by-element operators & and |.

Increment and decrement operators

Octave includes the C-like increment and decrement operators `++` and `--` in both their prefix and postfix forms. Octave also does augmented assignment, e.g. `x += 5`.

Unwind-protect

Octave supports a limited form of exception handling modelled after the `unwind_protect` (http://www.lispworks.com/documentation/HyperSpec/Body/s_unwind.htm) of Lisp. The general form of an unwind_protect block looks like this:

```
unwind_protect
   body
unwind_protect_cleanup
   cleanup
end_unwind_protect
```

As a general rule, GNU Octave recognizes as termination of a given *`block`* either the keyword `end` (which is compatible with the MATLAB language) or a more specific keyword `end_`*`block`*. As a consequence, an `unwind_protect` block can be terminated either with the keyword `end_unwind_protect` as in the example, or with the more portable keyword `end`.

The *cleanup* part of the block is always executed. In case an exception is raised by the *body* part, *cleanup* is executed immediately before propagating the exception outside the block `unwind_protect`.

GNU Octave also supports another form of exception handling (compatible with the MATLAB language):

```
try
   body
catch
   exception_handling
end
```

This latter form differs from an `unwind_protect` block in two ways. First, *exception_handling* is only executed when an exception is raised by *body*. Second, after the execution of *exception_handling* the exception is not propagated outside the block (unless a `rethrow( lasterror )` statement is explicitly inserted within the *exception_handling* code).

Variable-length argument lists

Octave has a mechanism for handling functions that take an unspecified number of arguments without explicit upper limit. To specify a list of zero or more arguments, use the special argument `varargin` as the last (or only) argument in the list.

```
function s = plus (varargin)
   if (nargin==0)
      s = 0;
   else
      s = varargin{1} + plus (varargin{2:nargin});
   end
end
```

Variable-length return lists

A function can be set up to return any number of values by using the special return value `varargout`. For example:

```
function varargout = multiassign (data)
   for k=1:nargout
      varargout{k} = data(:,k);
   end
end
```

C++ integration

It is also possible to execute Octave code directly in a C++ program. For example, here is a code snippet for calling `rand([10,1])`:

```
#include <octave/oct.h>
...
ColumnVector NumRands(2);
NumRands(0) = 10;
NumRands(1) = 1;
octave_value_list f_arg, f_ret;
f_arg(0) = octave_value(NumRands);
f_ret = feval("rand", f_arg, 1);
Matrix unis(f_ret(0).matrix_value());
```

C and C++ code can be integrated into GNU Octave by creating oct files, or using the MATLAB compatible MEX files.

MATLAB compatibility

Octave has been built with MATLAB compatibility in mind, and shares many features with MATLAB:

1. Matrices as fundamental data type.
2. Built-in support for complex numbers.
3. Powerful built-in math functions and extensive function libraries.
4. Extensibility in the form of user-defined functions.

Octave treats incompatibility with MATLAB as a bug; therefore, it could be considered a software clone, which does not infringe software copyright as per *Lotus v. Borland* court case.

MATLAB scripts from the MathWorks' FileExchange repository in principle are compatible with Octave. However, while they are often provided and uploaded by users under an Octave compatible and proper open source BSD license, the FileExchange Terms of use prohibit any usage beside MathWorks' proprietary MATLAB.[51][52][53]

Syntax compatibility

There are a few purposeful, albeit minor, syntax additions (http://octave.org/wiki/index.php?title=FAQ#Porting_programs_from_Matlab_to_Octave):

1. Comment lines can be prefixed with the # character as well as the % character;
2. Various C-based operators ++, --, +=, *=, /= are supported;
3. Elements can be referenced without creating a new variable by cascaded indexing, e.g. [1:10](3);
4. Strings can be defined with the double-quote " character as well as the single-quote ' character;
5. When the variable type is single (a single-precision floating-point number), Octave calculates the "mean" in the single-domain (MATLAB in double-domain) which is faster but gives less accurate results;
6. Blocks can also be terminated with more specific Control structure keywords, i.e., endif, endfor, endwhile, etc.;
7. Functions can be defined within scripts and at the Octave prompt;
8. Presence of a do-until loop (similar to do-while in C).

Function compatibility

Many, but not all, of the numerous MATLAB functions are available in GNU Octave, some of them accessible through packages in Octave Forge (https://octave.sourceforge.io). The functions available as part of either core Octave or Forge packages are listed online (https://octave.sourceforge.io/list_functions.php?q=&sort=alphabetic).

A list of unavailable functions is included in the Octave function `__unimplemented.m__` (http://hg.savannah.gnu.org/hgweb/octave/file/tip/scripts/help/__unimplemented__.m). Unimplemented functions are also listed under many Octave Forge packages in the Octave Wiki (https://wiki.octave.org/Category:Octave_Forge).

When an unimplemented function is called the following error message is shown:

```
  octave:1> guide
  warning: the 'guide' function is not yet implemented in Octave

  Please read <http://www.octave.org/missing.html> to learn how you can contribute missing
functionality.
  error: 'guide' undefined near line 1 column 1
```

User interfaces

Octave comes with an official graphical user interface (GUI) and an integrated development environment (IDE) based on Qt. It has been available since Octave 3.8,[54] and has become the default interface (over the command line interface) with the release of Octave 4.0.[55] It was well-received by EDN contributor, who said "[Octave] now has a very workable GUI."[56]

Several 3rd-party graphical front-ends have also been developed, like ToolboX for coding education.

GUI applications

With Octave code, the user can create GUI applications [1] (https://www.gnu.org/software/octave/doc/interpreter/GUI-Development.html). Below are some examples:

Button, edit control, checkbox

```
# create figure and panel on it
f = figure;
# create a button (default style)
b1 = uicontrol (f, "string", "A Button", "position",[10 10 150 40]);
# create an edit control
e1 = uicontrol (f, "style", "edit", "string", "editable text", "position",[10 60 300 40]);
# create a checkbox
c1 = uicontrol (f, "style", "checkbox", "string", "a checkbox", "position",[10 120 150 40]);
```

Textbox

```
prompt = {"Width", "Height", "Depth"};
defaults = {"1.10", "2.20", "3.30"};
rowscols = [1,10; 2,20; 3,30];
dims = inputdlg (prompt, "Enter Box Dimensions", rowscols, defaults);
```

Listbox with message boxes.

```
my_options = {"An item", "another", "yet another"};
[sel, ok] = listdlg ("ListString", my_options, "SelectionMode", "Multiple");
if (ok == 1)
  msgbox ("You selected:");
  for i = 1:numel (sel)
    msgbox (sprintf ("\t%s", my_options{sel(i)}));
  endfor
else
  msgbox ("You cancelled.");
endif
```

Radiobuttons

```
# create figure and panel on it
f = figure;
```

```
# create a button group
gp = uibuttongroup (f, "Position", [ 0 0.5 1 1])
# create a buttons in the group
b1 = uicontrol (gp, "style", "radiobutton", "string", "Choice 1", "Position", [ 10 150 100 50
]);
b2 = uicontrol (gp, "style", "radiobutton", "string", "Choice 2", "Position", [ 10 50 100 30
]);
# create a button not in the group
b3 = uicontrol (f, "style", "radiobutton","string", "Not in the group","Position", [ 10 50
100 50 ]);
```

Packages

Octave also has packages available for free. Those packages are located at Octave-Forge [2] (https://octave.sourceforge.io/packages.php). Available packages are:

- **bim** - Package for solving Diffusion Advection Reaction (DAR) Partial Differential Equations
- **bsltl** - The BSLTL package is a free collection of OCTAVE/MATLAB routines for working with the biospeckle laser technique
- **cgi** - Common Gateway Interface for Octave
- **communications** - Digital Communications, Error Correcting Codes (Channel Code), Source Code functions, Modulation and Galois Fields
- **control** - Computer-Aided Control System Design (CACSD) Tools for GNU Octave, based on the proven SLICOT Library
- **data-smoothing** - Algorithms for smoothing noisy data
- **database** - Interface to SQL databases, currently only postgresql using libpq
- **dataframe** - Data manipulation toolbox similar to R data
- **dicom** - Digital communications in medicine (DICOM) file io
- **divand** - divand performs an n-dimensional variational analysis (interpolation) of arbitrarily located observations
- **doctest** - The Octave-Forge Doctest package finds specially-formatted blocks of example code within documentation files
- **econometrics** - Econometrics functions including MLE and GMM based techniques
- **fem-fenics** - pkg for the resolution of partial differential equations based on fenics
- **financial** - Monte Carlo simulation, options pricing routines, financial manipulation, plotting functions and additional date manipulation tools
- **fits** - The Octave-FITS package provides functions for reading, and writing FITS (Flexible Image Transport System) files
- **fpl** - Collection of routines to export data produced by Finite Elements or Finite Volume Simulations in formats used by some visualization programs
- **fuzzy-logic toolkit** - A mostly MATLAB-compatible fuzzy logic toolkit for Octave (fails to install due to long-standing bug[57])
- **ga** - Genetic optimization code
- **general** - General tools for Octave
- **generate_html** - This package provides functions for generating HTML pages that contain the help texts for a set of functions
- **geometry** - Library for geometric computing extending MatGeom functions
- **gsl** - Octave bindings to the GNU Scientific Library
- **image** - The Octave-forge Image package provides functions for processing images
- **image-acquisition** - The Octave-forge Image Acquisition package provides functions to capture images from connected devices

- **instrument-control** - Low level I/O functions for serial, i2c, parallel, tcp, gpib, vxi11, udp and usbtmc interfaces
- **interval** - The interval package for real-valued interval arithmetic allows one to evaluate functions over subsets of their domain
- **io** - Input/Output in external formats e.g. Excel
- **level-set** - Routines for calculating the time-evolution of the level-set equation and extracting geometric information from the level-set function
- **linear-algebra** - Additional linear algebra code, including general SVD and matrix functions
- **lssa** - A package implementing tools to compute spectral decompositions of irregularly-spaced time series
- **ltfat** - The Large Time/Frequency Analysis Toolbox (LTFAT) is a MATLAB/Octave toolbox for working with time-frequency analysis, wavelets and signal processing
- **mapping** - Simple mapping and GIS .shp and raster file functions
- **mataveid** - System identification package for both MATLAB and GNU Octave
- **matavecontrol** - Control toolbox for both MATLAB and GNU Octave
- **miscellaneous** - Miscellaneous tools that would fit nowhere else
- **mpi** - Octave bindings for basic Message Passing Interface (MPI) functions for parallel computing
- **msh** - Create and manage triangular and tetrahedral meshes for Finite Element or Finite Volume PDE solvers
- **mvn** - Multivariate normal distribution clustering and utility functions
- **nan** - A statistics and machine learning toolbox for data with and w/o missing values
- **ncarray** - Access a single or a collection of NetCDF files as a multi-dimensional array
- **netcdf** - A MATLAB compatible NetCDF interface for Octave
- **nurbs** - Collection of routines for the creation, and manipulation of Non-Uniform Rational B-Splines (NURBS), based on the NURBS toolbox by Mark Spink
- **ocs** - Package for solving DC and transient electrical circuit equations
- **octclip** - This package allows users to do boolean operations with polygons using the Greiner-Hormann algorithm
- **octproj** - This package allows users to call functions of PROJ
- **optics** - Functions covering various aspects of optics
- **optim** - Non-linear optimization toolkit
- **optiminterp** - An optimal interpolation toolbox for octave
- **parallel** - Parallel execution package
- **quaternion** - Quaternion package for GNU Octave, includes a quaternion class with overloaded operators
- **queueing** - The queueing package provides functions for queueing networks and Markov chains analysis
- **secs1d** - A Drift-Diffusion simulator for 1d semiconductor devices
- **secs2d** - A Drift-Diffusion simulator for 2d semiconductor devices
- **secs3d** - A Drift-Diffusion simulator for 3d semiconductor devices
- **signal** - Signal processing tools, including filtering, windowing and display functions
- **sockets** - Socket functions for networking from within octave
- **sparsersb** - Interface to the librsb package implementing the RSB sparse matrix format for fast shared-memory sparse matrix computations
- **splines** - Additional spline functions
- **statistics** - Additional statistics functions for Octave

- **stk** - The STK is a (not so) Small Toolbox for Kriging
- **strings** - Additional functions for manipulation and analysis of strings
- **struct** - Additional structure manipulation functions
- **symbolic** - The Octave-Forge Symbolic package adds symbolic calculation features to GNU Octave
- **tisean** - Port of TISEAN 3
- **tsa** - Stochastic concepts and maximum entropy methods for time series analysis
- **vibes** - The VIBes API allows one to easily display results (boxes, pavings) from interval methods
- **video** - A wrapper for ffmpeg's libavformat and libavcodec, implementing addframe, avifile, aviinfo and aviread
- **vrml** - 3D graphics using VRML
- **windows** - Provides COM interface and additional functionality on Windows
- **zeromq** - ZeroMQ bindings for GNU Octave

See also

- List of numerical analysis software
- Comparison of numerical analysis software
- List of statistical packages
- List of numerical libraries

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55. "Summary of important user-visible changes for version 4.0" (https://www.gnu.org/software/octave/NEWS-4.0.html).
56. GNU Octave hits a high note – Steve Hageman, 7 February 2014 (http://www.edn.com/electronics-blogs/the-practicing-instrumentation-engineer/4428091/GNU-Octave-hits-a-high-note)
57. https://savannah.gnu.org/search/?words=fuzzy-logic-toolkit&type_of_search=bugs&Search=Search&exact=1#options

Further reading

- Hansen, Jesper Schmidt (June 2011). *GNU Octave. Beginner's Guide* (http://www.packtpub.com/gnu-octave-beginners-guide/book). Packt Publishing. ISBN 978-1-849-51332-6.

External links

- Official website (https://gnu.org/software/octave/)