Introduction to the off-line version of Yacas

by the YACAS team [1]

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This document gives a short introduction to Yacas. Included is a brief tutorial on the syntax and some commands to get you started using Yacas. There are also some examples.

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Contents

1 Getting started with Yacas off-line **2**
1.1 Introduction . . . 2
1.2 Installing YACAS . . . 2
1.3 Using the console mode . . . 2

2 Examples **4**
2.1 Using Yacas from the console . . . 4

3 Running Yacas off-line **7**
3.1 Interactive session commands . . . 7
`quit` — stop Yacas from running, from the command line . . . 7
`restart` — restart Yacas (to start with a clean slate) . . . 7
3.2 Command-line options . . . 7

4 Startup configuration **10**
`DefaultDirectory` — add directory to path for Yacas scripts . . . 10
`PrettyPrinter'Set` — set routine to use as pretty-printer . . . 10
`PrettyPrinter'Get` — get routine to use as pretty-printer . . . 10
`PrettyReader'Set` — set routine to use as pretty-reader . . . 10
`PrettyReader'Get` — get routine that is currently used as pretty-reader . . . 10
`MaxEvalDepth` — set depth of recursion stack . . . 11
`HistorySize` — set size of history file . . . 11

5 Platform-dependent packages **12**
`Version` — show version of Yacas . . . 12

6 GNU Free Documentation License **13**

Chapter 1

Getting started with Yacas off-line

1.1 Introduction

This section describes how to get started with YACAS locally by downloading and compiling the program. However, this is not strictly necessary. You can also go online to our web site and use YACAS in there inside your browser. The web page contains tutorials, example calculations and lots of documentation. This document is only useful if you plan to build and install YACAS yourself.

1.2 Installing Yacas

Read the file `INSTALL` for instructions on how to compile YACAS. YACAS is portable across most Unix-ish platforms and requires only a standard C++ compiler such as `g++`.

The base YACAS application accepts text as input and returns text as output. This makes it rather platform-independent. Apart from Unix-like systems, YACAS has been compiled on Windows and on EPOC32, aka Psion (which doesn't come with a standard C++ library!). The source code to compile YACAS for Windows can be found at the Sourceforge repository (Web URL: `http://sourceforge.net/projects/yacas/`).

For Unix, compilation basically amounts to the standard sequence

```
./configure
make
make install
```

This will install the binaries to `/usr/local/bin` and the library files to `/usr/local/share/yacas/`.

Additionally, LaTeX-formatted documentation in PostScript and PDF formats can be produced by the command

```
make texdocs
```

or, alternatively, by passing `--enable-ps-doc` or `--enable-pdf-doc` to `./configure` when building YACAS. In the latter case, the documentation will be automatically rebuilt every time the documentation changes (which is useful when maintaining the documentation).

In addition, there is also a Java version of the lower-level interpreter. The code for this Java version can be found in the directory "JavaYacas", and can be compiled with the make file "makefile.yacas", by typing in:

```
make -f makefile.yacas
```

The interpreter can then be invoked from the command line with:

```
java -jar yacas.jar
```

or alternatively it can be invoked as an applet, by opening yacasconsole.html.

The binary files that comprise the entire binary release for the Java version are:

1. yacas.jar - the Java class files in one jar file.
2. yacasconsole.html - the file that launches the applet.
3. hints.txt - the hints that are shown in the applet (the grey box with commands that match what you are typing in at that moment).

The Java version has almost all the features the C++ version has. In fact, there is no reason the Java version should not have all the same features. Not all command line arguments are available yet, and the command line prompt does not have the history yet.

1.3 Using the console mode

You can run YACAS in the console mode simply by typing `yacas`. The YACAS command prompt looks like this:

```
In>
```

and YACAS's answers appear after the prompt

```
Out>
```

A YACAS session may be terminated by typing `Exit()` or `quit`. Pressing `^C` will also quit YACAS; however, pressing `^C` while YACAS is busy with a calculation will stop just that calculation. A session can be restarted (forgetting all previous definitions and results) by typing

```
restart
```

Typically, you would enter one statement per line, for example

```
In> Sin(Pi/2);
Out> 1;
```

Statements should end with a semicolon (`;`) although this is not required in interactive sessions (YACAS will append a semicolon at end of line to finish the statement).

Type `Example();` to get some random examples of YACAS calculations.

The command line has a history list, so it should be easy to browse through the expressions you entered previously using the Up and Down arrow keys.

When a few characters have been typed, the command line will use the characters before the cursor as a filter into the history, and allow you to browse through all the commands in the history that start with these characters quickly, instead of browsing through the entire history.

Typing the first few characters of a previous expression and then hitting the TAB key makes YACAS recall the last expression in the history list that matches these first characters.

Commands spanning multiple lines can (and actually have to) be entered by using a trailing backslash
at end of each continued line. For example:

```
In> a:=2+3+
Error on line 1 in file [CommandLine]
Line error occurred on:
>>>
Error parsing expression
```

```
In> a:=2+3+ \
In> 1
Out> 6;
```

The error after our first attempt occurred because YACAS has appended a semicolon at end of the first line and `2+3+;` is not a valid YACAS expression.

Incidentally, any text YACAS prints without a prompt is either messages printed by functions as their side-effect, or error messages. Resulting values of expressions are always printed after an `Out>` prompt.

Chapter 2

Examples

This is a small tour of the capabilities YACAS currently offers. Note that this list of examples is far from complete. YACAS contains a few hundred commands, of which only a few are shown here.

Additional example calculations including the results can be found here:

- A selection of calculations from the *Wester benchmark*, in *Essays on Yacas, Chapter 2*.
- Some additional example calculations (Web URL: `mybench2.html`) that YACAS can currently perform.

2.1 Using Yacas from the console

Command-line options

The default operation of YACAS is to run in the interactive console mode. YACAS accepts several options that modify its operation. Here is a summary of options:

- *filename* ... (read and execute a file or several files)
- `-c` (omit line prompts)
- `-d` (print default directory)
- `-v` (print version information)
- `-f` (execute standard input as one statement)
- `-p` (do not use terminal capabilities)
- `-t` (enable extra history features)
- `--archive` *filename* (use a given library archive file)
- `--init` *filename* (use a given initial file)
- `--patchload` (use `PatchLoad` to load files)
- `--read-eval-print` *expression* (call this expression for the read-eval-print loop)
- `--rootdir` *directory* (specify default directory for scripts)
- `--server` *port* (start YACAS as a network server on given port)
- `--single-user-server` (If in server mode, start it in single-user mode)
- `--verbose-debug` (turn on showing some additional debugging information on screen)
- `--disable-compiled-plugins` (disable loading of compiled plugins, loading the script versions instead)
- `--stacksize` *size* (change size of stack arguments are stored on)
- `--execute` *expression* (run expression from the command line)

Options can be combined, for example

```
yacas -pc filename
```

will read and execute the file `filename` non-interactively without using terminal capabilities and without printing prompts.

Here is a more detailed description of the command-line options.

```
yacas -c
```

Inhibit printing of prompts `In>` and `Out>`. Useful for non-interactive sessions.

```
yacas -f
```

Reads standard input as one file, but executes only the first statement in it. (You may want to use a statement block to have several statements executed.)

```
yacas -p
```

Does not use terminal capabilities, no fancy editing on the command line and no escape sequences printed. Useful for non-interactive sessions.

```
yacas -t
```

Enable some extra history recall functionality in console mode: after executing a command from the history list, the next unmodified command from the history list will be automatically entered on the command line.

```
yacas [options] {filename}
```

Reads and executes commands in the filename and exits. Equivalent to `Load()`.

```
yacas -v
```

Prints version information and exits. (This is the same information as returned by `Version()`.)

```
yacas -d
```

Prints the path to the YACAS default library directory (this information is compiled into the YACAS executable) and exits.

```
yacas --patchload
```

Will load every file on the command line with the `PatchLoad` command instead of the normal `Load` command, This is useful for generating HTML pages for a web site using the YACAS scripting language, much like you can do with the PHP scripting language.

```
yacas --init [file]
```

Tells the system to load `file` as the initialization file. By default it loads the file `yacasinit.ys` from the scripts directory. Thus for customization one has two options: write a `~/.yacasrc` file with initialization code (as it is loaded after the initialization script is loaded), or write a custom initialization script that first uses `yacasinit.ys` and adds some extra custom code.

```
yacas --read-eval-print [expression]
```

Call `expression` for the read-eval-print loop. The default read-eval-print loop is implemented in the initialization script `yacasinit.ys` as the function `REP`. The default behavior is therefore equivalent to `--read-eval-print REP()`.

There is also a fallback read-eval-print loop in the kernel; it can be invoked by passing an empty string to this command line option, as `--read-eval-print ""`.

An alternative way to replace the default read-eval-print loop is to write a custom initialization script that implements the read-eval-print loop function `REP()` instead of `yacasinit.ys`.

Care has to be taken with this option because a Yacas session may become unusable if the read-eval-print expression doesn't function correctly.

```
yacas --server <port>
```

On some platforms server mode can be enabled at build time by passing the flag `--enable-server` to the `./configure` script. YACAS then allows you to pass the flag `--server` with a port number behind it, and the YACAS executable will listen to the socket behind that port instead of waiting for user input on the console.

Commands can be sent to the server by sending a text line as one block of data, and the server will respond back with another text block.

One can test this function by using `telnet`. First, set up the server by calling

```
yacas --server 9734
```

and then invoke `telnet` in another window, for example:

```
telnet 127.0.0.1 9734
```

Then type a line of Yacas input and hit Enter. The result will be one line that you will get back from the Yacas server.

Some security measures and resource management measures have been taken. No more than 10 connections can be alive at any time, a calculation cannot take more than 30 seconds, and YACAS operates in the *secure* mode, much like calling an expression by passing it as an argument to the `Secure` function. This means that no system calls are allowed, and no writing to local files, amongst other things. Something that has not been taken care of yet is memory use. A calculation could take up all memory, but not for longer than 30 seconds.

The server is single-threaded, but has persistent sessions for at most 10 users at a time, from which it can service requests in a sequential order. To make the service multi-threaded, a solution might be to have a proxy in front of the service listening to the port, redirecting it to different processes which get started up for users (this has not been tried yet).

The flag –single-user-server can be passed on to instruct `yacas` to start in single-user mode. In this mode, unsecure operations can be performed (like reading from and writing to files), and the calculation may take more than 30 seconds. The `yacas` process will automatically be shut down when the last session is closed or when "Exit();" is sent.

```
yacas --rootdir [directory]
```

Tells the system where to find the library scripts. Here, `directory` is a path that is passed to `DefaultDirectory`. It is also possible to give a list of directories, separated by a colon, e.g. `yacas --rootdir scripts/:morescripts/`. Note that it is not necessary to append a trailing slash to the directory names.

```
yacas --archive [file]
```

Use a compressed archive instead of the script library.

YACAS has an experimental system where files can be compressed into one file, and accessed through this command line option. The advantages are:

1. Smaller disk/memory use (useful if YACAS is used on small hand-held computers).
2. No problems with directory path separators: "`path/file`" will always resolve to the right file, no matter what platform (read: Windows) it runs on.
3. The start-up time of the program might improve a little, since a smaller file is loaded from disk (disk access being slow), and then decompressed in memory, which might be a lot faster than loading from disk.

An additional savings is due to the fact that the script files are stripped from white spaces and comments, making them smaller and faster loading.

To prepare the compressed library archive, run `./configure` with the command line option `--enable-archive`.

The result should be the archive file `scripts.dat`. Then launch YACAS with the command line option `--archive scripts.dat`, with the file `scripts.dat` in the current directory.

The reason that the `scripts.dat` file is not built automatically is that it is not tested, at this time, that the build process works on all platforms. (Right now it works on Unix, MacOSX, and Win32.)

Alternatively, configure Yacas with

```
./configure --enable-archive
```

and the archive file `scripts.dat` will be created in the `ramscripts/` subdirectory.

When an archive is present, Yacas will try to load it before it looks for scripts from the library directories. Typing

```
make archivetest -f makefile.compressor
```

in the `ramscripts/` directory runs all the test scripts using the archived files.

The currently supported compression schemes are uncompressed and compressed with `minilzo`. Script file stripping (removing whitespace and comments) may be disabled by editing `compressor.cpp` (variable `strip_script`).

```
yacas --disable-compiled-plugins
```

Disable loading of compiled scripts, in favor of scripts themselves. This is useful when developing the scripts that need to be compiled in the end, or when the scripts have not been compiled yet.

```
yacas --stacksize <size>
```

Yacas maintains an internal stack for arguments. For nested function calls, all arguments currently used are on this stack. The size of this stack is 50000 be default.

For a function that would take 4 arguments and has one return value, there would be 5 places reserved on this stack, and the function could call itself recursively 10000 steps deep.

This differs from the MaxEvalDepth mechanism. The MaxEvalDepth mechanism allows one to specify the number of separate stack frames (number of calls, nested), instead of the number of arguments pushed on the stack. MaxEvalDepth was introduced to protect the normal `C++` stack.

```
yacas --execute <expression>
```

This instructs Yacas to run a certain expression, passed in over the command line, before dropping to the read-eval-print loop. This can be used to load a file before dropping to the command line without exiting (if there are files to run specified on the command line, Yacas will exit after running these scripts). Alternatively, the expression can exit the interpreter immediately by calling `Exit();`. When used in combination with `-pc`, the Yacas interpreter can be used to calculate something and print the result to standard output. Example:

```
user% ./yacas -pc --execute '[Echo("answer ",D(x)Sin(x));Exit();]'
answer Cos(x)
user%
```

Chapter 3

Running Yacas off-line

3.1 Interactive session commands

This section describes the special commands for the Yacas interactive sessions (for example, to restart or to exit the interpreter). These commands are not functions but special directives that only apply while running Yacas interactively. They should not be used in scripts.

`quit` — stop Yacas from running, from the command line

`restart` — restart Yacas (to start with a clean slate)

(YACAS internal)

Calling format:

```
quit
restart
```

Description:

Type `quit` or `restart` at the Yacas prompt to exit or to restart the interpreter.

The directives `quit` and `restart` are *not* reserved words or variable names. They take effect only when typed as first characters at a prompt.

Pressing `Ctrl-C` will stop the currently running calculation. If there is no currently running calculation, `Ctrl-C` will quit the interpreter.

When the interpreter quits, it saves the command history (so quitting by `Ctrl-C` does not mean a "crash").

Examples:

To be effective, the directive must be typed immediately after the prompt:

```
In> quit
Quitting...
```

We can use variables named `quit`:

```
In> 1+quit
Out> quit+1;
```

There is no effect if we type some spaces first:

```
In>       restart
Out> restart;
```

See also: `Exit`

3.2 Command-line options

The default operation of YACAS is to run in the interactive console mode. YACAS accepts several options that modify its operation. Here is a summary of options:

- *filename* ... (read and execute a file or several files)
- `-c` (omit line prompts)
- `-d` (print default directory)
- `-v` (print version information)
- `-f` (execute standard input as one statement)
- `-p` (do not use terminal capabilities)
- `-t` (enable extra history features)
- `--archive` *filename* (use a given library archive file)
- `--init` *filename* (use a given initial file)
- `--patchload` (use `PatchLoad` to load files)
- `--read-eval-print` *expression* (call this expression for the read-eval-print loop)
- `--rootdir` *directory* (specify default directory for scripts)
- `--server` *port* (start YACAS as a network server on given port)
- `--single-user-server` (If in server mode, start it in single-user mode)
- `--verbose-debug` (turn on showing some additional debugging information on screen)
- `--disable-compiled-plugins` (disable loading of compiled plugins, loading the script versions instead)
- `--stacksize` *size* (change size of stack arguments are stored on)
- `--execute` *expression* (run expression from the command line)

Options can be combined, for example

```
yacas -pc filename
```

will read and execute the file `filename` non-interactively without using terminal capabilities and without printing prompts.

Here is a more detailed description of the command-line options.

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yacas -c
```

Inhibit printing of prompts `In>` and `Out>`. Useful for non-interactive sessions.

```
yacas -f
```

Reads standard input as one file, but executes only the first statement in it. (You may want to use a statement block to have several statements executed.)

```
yacas -p
```

Does not use terminal capabilities, no fancy editing on the command line and no escape sequences printed. Useful for non-interactive sessions.

```
yacas -t
```

Enable some extra history recall functionality in console mode: after executing a command from the history list, the next unmodified command from the history list will be automatically entered on the command line.

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yacas [options] {filename}
```

Reads and executes commands in the filename and exits. Equivalent to `Load()`.

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yacas -v
```

Prints version information and exits. (This is the same information as returned by `Version()`.)

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Prints the path to the YACAS default library directory (this information is compiled into the YACAS executable) and exits.

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Will load every file on the command line with the `PatchLoad` command instead of the normal `Load` command, This is useful for generating HTML pages for a web site using the YACAS scripting language, much like you can do with the PHP scripting language.

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Tells the system to load `file` as the initialization file. By default it loads the file `yacasinit.ys` from the scripts directory. Thus for customization one has two options: write a `~/.yacasrc` file with initialization code (as it is loaded after the initialization script is loaded), or write a custom initialization script that first uses `yacasinit.ys` and adds some extra custom code.

```
yacas --read-eval-print [expression]
```

Call `expression` for the read-eval-print loop. The default read-eval-print loop is implemented in the initialization script `yacasinit.ys` as the function `REP`. The default behavior is therefore equivalent to `--read-eval-print REP()`.

There is also a fallback read-eval-print loop in the kernel; it can be invoked by passing an empty string to this command line option, as `--read-eval-print ""`.

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```
yacas --rootdir [directory]
```

Tells the system where to find the library scripts. Here, `directory` is a path that is passed to `DefaultDirectory`. It is also possible to give a list of directories, separated by a colon, e.g. `yacas --rootdir scripts/:morescripts/`. Note that it is not necessary to append a trailing slash to the directory names.

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yacas --archive [file]
```

Use a compressed archive instead of the script library.

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2. No problems with directory path separators: "`path/file`" will always resolve to the right file, no matter what platform (read: Windows) it runs on.
3. The start-up time of the program might improve a little, since a smaller file is loaded from disk (disk access being slow), and then decompressed in memory, which might be a lot faster than loading from disk.

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The result should be the archive file `scripts.dat`. Then launch YACAS with the command line option `--archive scripts.dat`, with the file `scripts.dat` in the current directory.

The reason that the `scripts.dat` file is not built automatically is that it is not tested, at this time, that the build process works on all platforms. (Right now it works on Unix, MacOSX, and Win32.)

Alternatively, configure Yacas with

```
./configure --enable-archive
```

and the archive file `scripts.dat` will be created in the `ramscripts/` subdirectory.

When an archive is present, Yacas will try to load it before it looks for scripts from the library directories. Typing

```
make archivetest -f makefile.compressor
```

in the `ramscripts/` directory runs all the test scripts using the archived files.

The currently supported compression schemes are uncompressed and compressed with `minilzo`. Script file stripping (removing whitespace and comments) may be disabled by editing `compressor.cpp` (variable `strip_script`).

```
yacas --disable-compiled-plugins
```

Disable loading of compiled scripts, in favor of scripts themselves. This is useful when developing the scripts that need to be compiled in the end, or when the scripts have not been compiled yet.

```
yacas --stacksize <size>
```

Yacas maintains an internal stack for arguments. For nested function calls, all arguments currently used are on this stack. The size of this stack is 50000 be default.

For a function that would take 4 arguments and has one return value, there would be 5 places reserved on this stack, and the function could call itself recursively 10000 steps deep.

This differs from the MaxEvalDepth mechanism. The MaxEvalDepth mechanism allows one to specify the number of separate stack frames (number of calls, nested), instead of the number of arguments pushed on the stack. MaxEvalDepth was introduced to protect the normal `C++` stack.

```
yacas --execute <expression>
```

This instructs Yacas to run a certain expression, passed in over the command line, before dropping to the read-eval-print loop. This can be used to load a file before dropping to the command line without exiting (if there are files to run specified on the command line, Yacas will exit after running these scripts). Alternatively, the expression can exit the interpreter immediately by calling `Exit();`. When used in combination with `-pc`, the Yacas interpreter can be used to calculate something and print the result to standard output. Example:

```
user% ./yacas -pc --execute '[Echo("answer ",D(x)Sin(x));Exit();]'
answer Cos(x)
user%
```

Chapter 4

Startup configuration

Yacas allows you to configure a few things at startup. The file `~.yacasrc` is written in the Yacas language and will be executed when Yacas is run. The following functions can be useful in the `~.yacasrc` file.

DefaultDirectory — add directory to path for Yacas scripts

(YACAS internal)

Calling format:

```
DefaultDirectory(path)
```

Parameters:

`path` – a string containing a full path where yacas script files reside

Description:

When loading files, yacas is also allowed to look in the folder "path". `path` will be prepended to the file name before trying to load the file. This means that "path" should end with a forward slash (under Unix-like operating systems).

Yacas first tries to load a file from the current directory, and otherwise it tries to load from directories defined with this function, in the order they are defined. Note there will be at least one directory specified at start-up time, defined during compilation. This is the directory Yacas searches for the initialization scripts and standard scripts.

Examples:

```
In> DefaultDirectory("/home/user/myscripts/");
Out> True;
```

See also: `Load`, `Use`, `DefLoad`, `FindFile`

PrettyPrinter'Set — set routine to use as pretty-printer

PrettyPrinter'Get — get routine to use as pretty-printer

(standard library)

Calling format:

```
PrettyPrinter'Set(printer)
PrettyPrinter'Set()
PrettyPrinter'Get()
```

Parameters:

`printer` – a string containing the name of a function that can "pretty-print" an expression.

Description:

This function sets up the function printer to print out the results on the command line. This can be reset to the internal printer with `PrettyPrinter'Set()` (when no argument is given, the system returns to the default).

Currently implemented prettyprinters are: `PrettyForm`, `TeXForm`, `Print`, `OMForm`, `CForm` and `DefaultPrint`.

`PrettyPrinter'Get()` returns the current pretty printer, or it returns an empty string if the default pretty printer is used.

Examples:

```
In> Taylor(x,0,5)Sin(x)
Out> x-x^3/6+x^5/120;
In> PrettyPrinter'Set("PrettyForm");

True

In> Taylor(x,0,5)Sin(x)

     3    5
    x    x
x - -- + ---
    6    120

In> PrettyPrinter'Set();
Out> True;
In> Taylor(x,0,5)Sin(x)
Out> x-x^3/6+x^5/120;
```

See also: `PrettyForm`, `Write`, `TeXForm`, `CForm`, `OMForm`, `PrettyReader'Set`, `PrettyReader'Get`

PrettyReader'Set — set routine to use as pretty-reader

PrettyReader'Get — get routine that is currently used as pretty-reader

(standard library)

Calling format:

```
PrettyReader'Set(reader)
PrettyReader'Set()
PrettyReader'Get()
```

Parameters:

`reader` – a string containing the name of a function that can read an expression from current input.

Description:

This function sets up the function reader to read in the input on the command line. This can be reset to the internal reader with `PrettyReader'Set()` (when no argument is given, the system returns to the default).

Currently implemented PrettyReaders are: `LispRead`, `OMRead`.

`PrettyReader'Get()` returns the current reader, or it returns an empty string if the default pretty printer is used.

Examples:

```
In> Taylor(x,0,5)Sin(x)
Out> x-x^3/6+x^5/120
In> PrettyReader'Set("LispRead")
Out> True
In> (Taylor x 0 5 (Sin x))
Out> x-x^3/6+x^5/120
```

See also: `Read`, `LispRead`, `OMRead`, `PrettyPrinter'Set`, `PrettyPrinter'Get`

`MaxEvalDepth` — set depth of recursion stack

(YACAS internal)

Calling format:

```
MaxEvalDepth(n)
```

Parameters:

`n` – integer

Description:

Sets the maximum depth of recursive function call. An error message is printed when too many recursive calls are executed, and this function can be used to increase or decrease the limit as necessary.

`HistorySize` — set size of history file

(YACAS internal)

Calling format:

```
HistorySize(n)
```

Parameters:

`n` – number of lines to store in history file

Description:

When exiting, yacas saves the command line history to a file `~/.yacas_history`. By default it will save the last 1024 lines. The default can be overridden with this function. Passing -1 tells the system to save *all* lines.

Examples:

```
In> HistorySize(200)
Out> True;
In> quit
```

See also: `quit`

Chapter 5

Platform-dependent packages

Certain facilities have been developed for use on Unix-like platforms, which is currently the main development target for Yacas. Other facilities have limited support on the Windows platform as well. These functions are described in this chapter.

`Version` — show version of Yacas

(YACAS internal)

Calling format:

```
Version()
```

Description:

The function `Version()` returns a string representing the version of the currently running Yacas interpreter.

Examples:

```
In> Version()
Out> "1.0.48rev3";
In> LessThan(Version(), "1.0.47")
Out> False;
In> GreaterThan(Version(), "1.0.47")
Out> True;
```

The last two calls show that the `LessThan` and `GreaterThan` functions can be used for comparing version numbers. This method is only guaranteed, however, if the version is always expressed in the form `d.d.dd` as above.

See also: `LessThan`, `GreaterThan`

Chapter 6

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Index

`^C`, 2

command history, 2
command-line options, 4, 7
    summary, 4, 7

`DefaultDirectory`, 10

`Example`, 2
executing script files, 4, 8
`Exit`, 2

getting printed manuals, 2

`HistorySize`, 11

`MaxEvalDepth`, 11
multi-line commands, 3

options, 7

`PrettyPrinter'Get`, 10
`PrettyPrinter'Set`, 10
`PrettyReader'Get`, 10
`PrettyReader'Set`, 10

`quit`, 2
`quit`, 7

`restart`, 2
`restart`, 7

TAB completion, 2

using compressed libraries, 5, 8

`Version`, 12