

RL-Glue Lisp Codec 1.0 Manual

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1 Introduction

RL-Glue codecs provide TCP/IP connectivity to the RL-Glue reinforcement learning software library. This codec makes possible to create agent, environment and experiment programs in the Common Lisp programming language.

For general information and motivation about the *RL-Glue library*¹, please refer to the documentation provided with that project.

This software is licensed under the *Apache 2.0 license*². We are not lawyers, but our intention is that this codec should be used however it is useful. We would appreciate to hear what you are using it for, and to get credit if appropriate.

1.1 Software requirements

We highly recommend the usage of the *ASDF library*³, because the codec components are packaged this way.

The codec provides two (ASDF) packages, one of them (rl-glue-codec) is the codec itself which provides the connectivity with the RL-Glue component, the other (rl-glue-utilities) contains utilities which can be helpful during using the codec.

Required libraries for the codec.

usocket (<http://common-lisp.net/project/usocket/>)

1.2 Supported Lisp implementations

SBCL (<http://www.sbcl.org/>)

CMUCL (<http://www.cons.org/cmuc1/>)

Lispworks (<http://www.lispworks.com/>)

Allegro CL (<http://www.franz.com/products/allegrocl/>)

CLISP (<http://www.gnu.org/software/clisp/>)

Sciener (<http://www.sciener.com/scl/>)

CCL / OpenMCL (<http://www.closure.com/closurecl.html>)

¹<http://glue.rl-community.org/>

²<http://www.apache.org/licenses/LICENSE-2.0.html>

³<http://common-lisp.net/project/asdf/>

1.3 Getting the codec

The codec can be downloaded either as a tarball or can be checked out of the subversion repository.

The tarball distribution can be found here:

<http://code.google.com/p/rl-glue-ext/downloads/list>

To check the code out of subversion:

```
$ svn co http://rl-glue-ext.googlecode.com/svn/trunk/projects/codecs/Lisp Lisp-Codec
```

1.4 Installation

The codec can be installed by ASDF-Install or manually copying the files.

ASDF is designed so to use symbolic links for organizing the package directory structure. If the file system does not support it (e.g. *FAT*⁴, *NTFS*⁵), a few tricks have to be applied to get it work. More information can be found on <http://bc.tech.coop/blog/041113.html> or in the FAQ section of <http://www.cliki.net/asdf>. If you have this kind of system, just ignore the symbolic link descriptions of this manual and solve the problem described on these pages.

The following parts assume that the ASDF library has been installed previously. More information about this can be found on <http://common-lisp.net/project/asdf/>.

Optionally, if you want to put the compiled files user locally under your home instead of the ASDF source directory, you can use the ASDF-Binary-Locations library. More information about this can be found on <http://common-lisp.net/project/asdf-binary-locations/>.

Change to the Lisp-Codec directory.

```
$ cd Lisp-Codec
```

1.4.1 Installation by ASDF-Install

You need the ASDF-Install library for this. If you do not have this, the installation instructions can be found on <http://common-lisp.net/project/asdf-install/>.

On *Windows*⁶ ASDF-Install is only supported officially under *Cygwin*⁷, but it can be possible to use it without that (you have to test it on your own). A description can be found on <http://sean-ross.blogspot.com/2007/05/asdf-install-windows.html>.

Create the compressed ASDF packages.

```
$ tool/make-asdf-package.sh rl-glue-codec
```

```
$ tool/make-asdf-package.sh rl-glue-utils
```

⁴http://en.wikipedia.org/wiki/File_Allocation_Table

⁵<http://en.wikipedia.org/wiki/NTFS>

⁶http://en.wikipedia.org/wiki/Microsoft_Windows

⁷<http://www.cygwin.com/>

Start the Lisp interpreter.

```
$ lisp
*
```

Set up ASDF, ASDF-Install (optionally ASDF-Binary-Locations) according to their manual.

Install the packages.

```
* (asdf-install:install "./rl-glue-codec.tar.gz")
* (asdf-install:install "./rl-glue-utils.tar.gz")
```

1.4.2 Manual installation

This method assumes that you have installed the [library requirements](#) previously. The steps below are described for UNIX like systems, but the adaptation for other ones is straightforward.

If you downloaded the tarball, just copy the sources into the ASDF source directory.

```
$ cp -r src/rl-glue-codec asdf-source-directory
$ cp -r src/rl-glue-utils asdf-source-directory
```

If you checked out the SVN repository, you probably do not want to have the `.svn` directories under your `asdf-source-directory`. You can copy by skipping them with these commands.

```
$ cd src
$ find rl-glue-codec -name .svn -prune -o \( \! -name *~ -print0 \) |
  cpio -pmd0 asdf-source-directory
$ find rl-glue-utils -name .svn -prune -o \( \! -name *~ -print0 \) |
  cpio -pmd0 asdf-source-directory
$ cd ..
```

Create the symlinks (if your filesystem supports them).

```
$ cd asdf-system-directory
$ ln -s asdf-source-directory/rl-glue-codec/rl-glue-codec.asd rl-glue-codec.asd
$ ln -s asdf-source-directory/rl-glue-utils/rl-glue-utils.asd rl-glue-utils.asd
$ cd -
```

1.5 Uninstallation

The codec can be uninstalled by ASDF-Install or manually depending on how it was installed. If you do not need the dependent libraries installed for the codec, you have to uninstall them one by one.

1.5.1 Uninstallation by ASDF-Install

You had to [install the codec by ASDF-Install](#) to use this method.

Start the Lisp interpreter.

```
$ lisp
*
```

Set up ASDF, ASDF-Install according to their manual.

Uninstall the packages.

```
* (asdf-install:uninstall :rl-glue-codec)
* (asdf-install:uninstall :rl-glue-utils)
```

1.5.2 Manual uninstallation

Delete the source files.

```
$ rm -r asdf-source-directory/rl-glue-codec
$ rm -r asdf-source-directory/rl-glue-utils
```

Delete the symlinks (if you have them).

```
$ rm -r asdf-system-directory/rl-glue-codec.asd
$ rm -r asdf-system-directory/rl-glue-utils.asd
```

If you use ASDF-Binary-Locations, do not forget to delete the compiled Lisp files from its directory.

1.6 Credits and acknowledgment

Gabor Balazs wrote the Lisp codec. Great!

1.6.1 Contributing

If you would like to become a member of this project and contribute updates/changes to the code, please send a message to rl-glue@googlegroups.com.

2 Using the codec

This section describes how the codec can be used to create agents, environments and experiments in Lisp, and how they can be glued into a running system.

2.1 Packages

The codec has an own (ASDF) package named `rl-glue-codec`.

```
* (asdf:oos 'asdf:load-op :rl-glue-codec)
```

One can use the proper package qualified symbol names, e.g.

```
* (defclass my-agent (rl-glue-codec:agent) ...)
* (defmethod rl-glue-codec:env-init ((env my-env)) ...)
```

Or one can import all the symbols into one's package by the `:use` directive, and use the codec symbols without any package qualification (the further examples will assume this case).

```
* (defpackage :my-package (:use :rl-glue ...) ...)
```

There are a few utilities for the codec which can be useful. These can be accessed in the `rl-glue-utils` (ASDF) package. More information about them can be found in [their section](#).

2.2 Types

There is an abstract data type, `rl-abstract-type`, which can contain integers, floating point numbers and a character string. Its slots can be accessed by the `int-array`, `float-array` and `char-string` functions. There are two macros for number array creation, `make-int-array` and `make-float-array`, which automatically set the type of the contained elements according to the codec requirements. The usage of them is strongly suggested.

| | |
|--------------------|------------------|
| observation | rl-abstract-type |
| action | rl-abstract-type |
| reward | double-float |
| terminal | boolean |
| task specification | string |
| state key | rl-abstract-type |
| random seed key | rl-abstract-type |

2.3 Agents

On writing an agent first, you have to create an own agent class, e.g.

```
* (defclass my-agent (agent) ...)
```

Second, implement the following methods for it.

```
* (defmethod agent-init ((agent my-agent) task-spec) ...)
* (defmethod agent-start ((agent my-agent) first-observation) ...)
* (defmethod agent-step ((agent my-agent) reward observation) ...)
* (defmethod agent-end ((agent my-agent) reward) ...)
* (defmethod agent-cleanup ((agent my-agent)) ...)
* (defmethod agent-message ((agent my-agent) input-message) ...)
```

A detailed description of the methods can be obtained this way.

```
* (documentation #'<method-name> 'function)
```

When your agent is ready, you can run it.

```
* (run-agent (make-instance 'my-agent)
             :host "192.168.1.1"
             :port 4096
             :retry-timeout 10)
```

It will try to connect your agent to an RL-Glue component listening on `192.168.1.1` and port `4096`, waiting 10 seconds between the trials. Its detailed description can be checked this way.

```
* (documentation #'run-agent 'function)
```

It will prompt something like this, where each dot denotes a connection trial.

```
RL-Glue Lisp Agent Codec Version 1.0, Build 414
Connecting to 192.168.1.1:4096 .... ok
```

2.4 Environments

On writing an environment, first you have to create an own environment class, e.g.

```
* (defclass my-env (environment) ...)
```

Second, implement the following methods for it.

```
* (defmethod env-init ((env my-env)) ...)
* (defmethod env-start ((env my-env)) ...)
* (defmethod env-step ((env my-env) action) ...)
* (defmethod env-cleanup ((env my-env)) ...)
* (defmethod env-message ((env my-env) input-message) ...)
```

A detailed description of the methods can be obtained this way.

```
* (documentation #'<method-name> 'function)
```

When your environment is ready, you can run it.

```
* (run-env (make-instance 'my-env)
           :host "192.168.1.1"
           :port 4096
           :retry-timeout 10)
```

It will try to connect your environment to an RL-Glue component listening on 192.168.1.1 and port 4096, waiting 10 seconds between the trials. Its detailed description is here.

```
* (documentation #'run-env 'function)
```

It will prompt something like this, where each dot denotes a connection trial.

```
RL-Glue Lisp Environment Codec Version 1.0, Build 414
Connecting to 192.168.1.1:4096 .... ok
```

2.5 Experiments

On writing an experiment, first you have to create an own experiment class, e.g.

```
* (defclass my-exp (experiment) ...)
```

Second, implement your experiment. For this the codec provides client functions which hides the necessary buffer handling and network operation. These are the following.

```
rl-init, rl-start, rl-step, rl-cleanup, rl-close, rl-return, rl-num-steps,
rl-num-episodes, rl-episode, rl-agent-message, rl-env-message.
```

A detailed description of these functions can be obtained this way.

```
* (documentation #'<function name> 'function)
```

Do not forget to call the `rl-close` function at the end of your experiment, because it closes the network connection and so terminates the RL-Glue session.

2.6 Running

After you have an agent, an environment and an experiment, which could be written on any of the supported languages, you can connect them by RL-Glue.

First start the server.

```
$ rl_glue
```

You should see this kind of output on the server side.

```
RL-Glue Version 3.0, Build 909
```

```
RL-Glue is listening for connections on port=4096
```

```
    RL-Glue :: Agent connected.
```

```
    RL-Glue :: Environment connected.
```

```
    RL-Glue :: Experiment connected.
```

Then start the agent, the environment and the experiment.

The output of the Lisp agent.

```
RL-Glue Lisp Agent Codec Version 1.0, Build 414
```

```
    Connecting to 127.0.0.1:4096 . ok
```

The output of the Lisp environment.

```
RL-Glue Lisp Environment Codec Version 1.0, Build 414
```

```
    Connecting to 127.0.0.1:4096 . ok
```

The output of the Lisp experiment.

```
RL-Glue Lisp Experiment Codec Version 1.0, Build 414
```

```
    Connecting to 127.0.0.1:4096 . ok
```

2.7 Utilities

The utilities has an own (ASDF) package named `rl-glue-utils`.

```
* (asdf:oos 'asdf:load-op :rl-glue-utils)
```

2.7.1 Task specification parser

This is a parser for the *task specification language*⁸. Only the RL-Glue version 3.0 specification type is supported.

The parser can return a `task-spec` object from a specification string, e.g.

```
* (parse-task-spec
  "VERSION RL-Glue-3.0 PROBLEMTYPE episodic DISCOUNTFACTOR 1
  OBSERVATIONS INTS (3 0 1) ACTIONS DOUBLES (3.2 6.5) CHARCOUNT 50
  REWARDS (-1.0 1.0) EXTRA extra specification")
#<TASK-SPEC>
```

⁸<http://glue.rl-community.org/Home/rl-glue/task-spec-language>

The `task-spec` object has the following slots.

```
version, problem-type, discount-factor,  
int-observations, float-observations, char-observations,  
int-actions, float-actions, char-actions,  
rewards, extra-spec
```

Their names are appropriately show their functionalities according to the task specification documentation. The `int-` and `float-` observation and action slot values contain `int-range` and `float-range` objects appropriately. These have the `repeat-count`, `min-value` and `max-value` slots. For the latter two there are three special symbols which are `'-inf`, `'+inf` and `'unspec`. They are used to represent the `NEGINF`, `POSINF` and `UNSPEC` specification keywords.

The `task-spec` type supports the `to-string` generic function with which it can be converted to a string. There are also two other helper functions, namely `across-ranges` and `ranges-dimension`, which can be useful for range vector handling. Their documentation can be checked by the `documentation` function.

```
* (documentation 'rl-glue-utils:across-ranges 'function)  
* (documentation 'rl-glue-utils:ranges-dimension 'function)
```

2.8 Examples

There is an (ASDF) package named `rl-glue-examples` located in the `example` directory.

```
* (push #P"/path/to/Lisp-Codec/example/" asdf:*central-registry*)  
* (asdf:oos 'asdf:load-op :rl-glue-examples)
```

2.8.1 The mines-sarsa example

The `mines-sarsa` example has an episodic environment. At the beginning of each episode the agents is put somewhere onto the mine field. Its goal is to find the exit point without stepping to a mine. The rewards are -1 for each intermediate step, -100 for stepping to a mine and $+10$ for reaching the exit. The example contains a simple sarsa agent with epsilon greedy action selection policy and a simple lookup table to store the action values. A few basic functionalities like turning learning or exploration on/off, saving the value function and setting the starting position are implemented by the message system of RL-Glue.

To run the example one has to do the following.

Running the RL-Glue core.

```
$ rl_glue
```

Starting the agent (in the first lisp thread).

```
* (rl-glue-mines-sarsa:start-agent)
```

Starting the environment (in the second lisp thread).

```
* (rl-glue-mines-sarsa:start-environment)
```

Starting the experiment (in the third lisp thread).

```
* (rl-glue-mines-sarsa:start-experiment)
```