CelestLab

The *Scilab* Space Mechanics Toolbox

CNES – DCT/SB

Overview of CelestLab

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Introduction to CelestLab

CelestLab is a library of space mechanics functions for Scilab. It has been developed by CNES-DCT/SB (Centre National d'Etudes Spatiales - French Space Agency) for mission analysis purposes.

CelestLab can be used for trajectory analysis and orbit design for various types of space missions. It allows engineers to perform tasks such as: orbit propagation, attitude computation, elementary manoeuvre computation, change of reference frame, change of coordinate systems, ...

The functions are arranged into several categories:

- **Coordinates and frames**: Definition of reference frames, time scales, types of coordinate systems,...
- **Geometry and events**: Computation of orbital geometry and orbital events (ground station visibility, ...)
- **Interplanetary**: Interplanetary and 3-body problem
- **Math**: Mathematical functions
- **Models**: Models for atmospheric density, Sun and Moon position,...
- **Orbit Properties**: Orbit properties (Sun synchronicity, repeating ground tracks, frozen orbits, drift of orbital elements, ...)
- **Relative motion**: Relative trajectory analysis using Clohessy Whiltshire formalism
- **Trajectory and maneuvers**: Orbit propagation and maneuver computation
- **Utilities**: Miscellaneous and multi-purpose functions

Installing and loading CelestLab

CelestLab can be installed in two different (and equivalent) ways:

- **by using ATOMS**:
  Simply execute the command:
  `atomsInstall("celestlab");`

- **manually**:
  1) Unzip/copy the celestLab directory to a location of your choice. Let's call *`CelestLabRoot`* the new CelestLab path.
  If the distribution only contains source files, create the library by executing the command:
  `exec(fullfile(`*`CelestLabRoot`*`, "builder.sce"));`
  2) Load CelestLab by executing the command:
  `exec(fullfile(`*`CelestLabRoot`*`, "loader.sce"));`
  (For convenience, you can add this latter line in the `scilab.ini` file.)

Loading CelestLab makes one (global) variable appear: %CL__PRIV. It is intended for CelestLab internal use only (and consequently, should not be used).

Using CelestLab

All CelestLab functions are directly useable after CelestLab has been loaded; no special action is required. You can browse the help files (in particular the "Introduction" section), and run some of the examples. You can also type "`help` *`function`*" (e.g. "`help` *`CL_dat_convert`*") if you know what you're looking for (this is not specific to CelestLab).

Another good way to start is to try the demos. Select "demos" in the CelestLab menu, then select one "topic" and one "application". Each demo corresponds to one single script that can be used as an example (although some of them are not that simple).

It is also possible to bring some useful (local) variables into existence (commonly used quantities or conversion factors, values of optional arguments) by just typing `CL_init()`.

Note:

- `CL_init` is only a convenience function. CelestLab is fully functional even if `CL_init` has not been called.
- A call to `CL_init` can be added to the `scilab.ini` file in order to make the variables exist each time celestLab is loaded.

More about CelestLab...

- To get the latest version of CelestLab or post comments, go to: http://atoms.scilab.

org/toolboxes/celestlab .

- For any question or suggestion, you may also use the CelestLab mailing list.
  => Send emails to: `celestlab@lists.scilab.org`
  => To subscribe to the list, send a message to: `celestlab-subscribe@lists.scilab.org`

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Configuration

Configuration of CelestLab

Configuration overview

A few configuration parameters exist in CelestLab. They are used to set global properties such as how warning messages are handled or how the ECI frame is defined.

The configuration values are initially loaded from the`config.txt` file located in the CelestLab home directory. The values can then be retrieved and modified (See CL_configGet and CL_configSet).

If necessary it is possible to modify the`config.txt` file (select "Edit configuration file" in CelestLab's menu).

Configuration parameters

The configuration options are the following:

- **display_menu** (not changeable*) :
  - yes: The CelestLab menu is displayed (if Scilab is launched in 'standard' mode).
  - no: The CelestLab menu is not displayed.

- **warning_mode** :
  - standard: Warning messages are printed in the console.
  - silent: Warning messages are not printed.
  - error: Warning messages are turned into error messages.
- **verbose_mode** :
  - standard: Additional messages are printed in the console.
  - silent: Additional messages are not printed.
- **warn_deprecated** :
  - yes: Deprecated functions warning messages are printed (once) in the console.
  - no: Deprecated functions warning messages are not printed.
- **ECI_frame** (not changeable*) :
  - CIRS: The ECI frame is CIRS, the ECF frame is TIRS.
  - Veis: The ECI frame is Veis, the ECF frame is PEF.

*: not changeable byCL_configSet function.

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CelestLab data

Overview of data available in CelestLab

Basic data

These data consist of physical quantities and other constants.

They are defined in 4 files in the**CL_home()/data** directory.

The contents of the files can be accessed by: "CelestLab" menu -> "Data files (predefined variables)"

Each file is self-documented and contains a description and references.

- *physical_data.scd* :
  General physical data such as data related to Earth gravity, rotation rate of the Earth, speed of light, astronomical unit, etc ...

- *solar_system_data.scd* :
  equatorial radius, oblateness and gravitational constants of solar system bodies.

- *time_data.scd* :
  offsets between various time scales (including the leap seconds between TAI and UTC).

- *constants.scd* :
  miscellaneous data that should not be modifed.

These data can be retrieved by the functionCL_dataGet.

It is also possible to bring some useful (local) variables into existence (commonly used quantities or conversion factors, values of optional arguments). See `CL_init`.

Earth gravity potential data

Earth gravity potential data are available in the**CL_home()/data/potential** directory.

There is only one file available: EGM96s potential.

The file is a ".scd" file (Scilab syntax); the original data come from: http://icgem.gfz-potsdam.de/ICGEM

Ephemerides data

Ephemerides data are available in the**CL_home()/data/ephem** directory.

- *de405* directory:
  contains DE405 ephemerides files. These files are in binary format and are specific to CelestLab.
  They have been built from ASCII files, available at the following URL:
  ftp://ssd.jpl.nasa.gov/pub/eph/planets/ascii
  Period covered in default CelestLab installation: [2000-2200].
  These data are used by the functionCL_eph_de405 .

- *VSOP87_series* directory:
  contains VSOP87 series data. These files are in binary format and are specific to CelestLab.
  They have been built from ASCII files, available at the following URL:
  ftp://ftp.imcce.fr/pub/ephem/planets/vsop87
  These data are used by the functionCL_eph_planet .

- *elp_mpp02.dat* :
  contains ELP/MPP02 series data. These files are in a binary format and are specific to CelestLab.
  They have been built from ASCII files, available at the following URL:
  ftp://syrte.obspm.fr/pub/polac/2_lunar_solutions/2_elpmpp02/
  These data are used by the functionCL_eph_moon .

Geographical data

Geographical data are available in the**CL_home()/data/earthMap** directory.

- *earthMap_xxx.dat* files:
  contains Earth maps (outlines of continents, islands and lakes) in various coordinates and resolutions.
  These data are used by the functionCL_plot_earthMap .

- *info_land_ratio.dat* :
  contains data associated to Earth locations. The data represent the percentage of land in a 0.25 deg^2 area around the location.
  They are used by the functionCL_locationInfo .

Frame conversion data

These data are available in the**CL_home()/data/frame** directory. They are used by the frame conversion functionsCL_fr_convert andCL_fr_convertMat.

- *IERS series*:
  Series for X, Y, s+XY/2 (for the CIP and CIO coordinates), psi (nutation in longitude) and eps (nutation in obliquity).
  The file format is CelestLab specific (binary format).
  The original data come from:http://www.iers.org .

- *Precomputed data* :
  Data (X,Y,s) used for the GCRS to CIRS frame transformation to

speed-up the process. The data are sampled with a time step of 0.5 day and can be interpolated. The preferred degree for the interpolating polynomials is 5.
The files cover the period [2000-2100].

Environment data

These data are available in the **CL_home()/data/environment** directory. They are used by various physical models.

- *igrf11.dat*:
  Data for the computation of the magnetic field (IGRF11 model).
  The file format is CelestLab specific (binary format).
  The original data come from:
  http://www.ngdc.noaa.gov/IAGA/vmod/igrf.html.
  These data are used by the function CL_mod_geomagField .