
MatRTKLIB Manual

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Contents

1	Introduction	3
2	Requirement	3
3	Installation	3
4	Compile	4
5	Usage	4
5.1	Call RTKLIB functions	4
5.2	GT	4
5.3	Run examples	5
6	Appendix 1: Supported RTKLIB functions	6
6.1	Satellites, Systems, and Codes functions	6
6.2	Time and String functions	7
6.3	Coordinates transformation	8
6.4	Input and Output functions	10
6.5	Platform dependent functions	11
6.6	Positioning models	11
6.7	Atmosphere models	12
6.8	Antenna models	13
6.9	Earth tide models	14
6.10	Geoid models	14
6.11	Datum transformation	14
6.12	RINEX functions	14
6.13	Ephemeris and clock functions	15
6.14	RTCM functions	17
6.15	Solution functions	17
6.16	Google earth kml/gpx converter	18
6.17	SBAS functions	18
6.18	Options functions	18
6.19	Integer ambiguity resolution	19
6.20	Standard positioning	19
6.21	Precise positioning	19
6.22	Precise point positioning	20
7	Appendix 2: GT Classes	21

8 Appendix 3: Examples**22**

1 Introduction

MatRTKLIB provides a MATLAB wrapper for RTKLIB, an open source GNSS data processing library, and also provides various processes required for actual GNSS analysis and research in its own MATLAB classes.

The features of the developed MatRTKLIB are as follows.

1. **MatRTKLIB** uses the RTKLIB source code as a submodule and compiles each RTKLIB function as an MEX function in C to provide calls in MATLAB, improving processing speed and allowing for immediate reflection of any feature additions to RTKLIB (e.g., support for new satellites/signals and support for new RINEX/RTCM versions).
2. Single-input/output RTKLIB functions were adapted to the vector input/output to suit MATLAB's unique vector/matrix processing; this allows for batch processing of the GNSS data analysis without iterative processing, improving execution speed and code readability.
3. Providing a unique MATLAB class called **GT**, which not only ports RTKLIB but also provides useful tools related to GNSS data processing, such as allowing easy editing of GNSS observation data, and computing linear combinations commonly used in GNSS data processing. GT also provides methods for visualizing various GNSS-related data using the visualization capabilities of MATLAB.
4. The source code for various concrete examples of GNSS data processing is provided. Many sample implementations will facilitate understanding of GNSS data processing, such as step-by-step implementations of linear combination generation, residual evaluation, single-point positioning, and PPK using the double differences of the GNSS carrier phases.

2 Requirement

MatRTKLIB was tested and compiled on the following

- MATLAB 2024a
- OS: Windows 11, 64bit, Compiler: Microsoft Visual Studio 2022
- OS: Ubuntu 20.04, 64bit, Compiler: GCC

MatRTKLIB supports MATLAB 2023a and higher and does not require a special toolbox. The recompiled MEX files are provided, they do not need to be recompiled, except in special cases.

3 Installation

If you do not want to compile **MatRTKLIB** yourself, you can download a pre-compiled package:

```
git clone https://github.com/taroz/MatRTKLIB.git
```

To install **MatRTKLIB**, simply add its folder path to your MATLAB path list in MATLAB comand window:

```
addpath('/path/to/MatRTKLIB');
```

4 Compile

For 32-bit systems, you will need to recompile **MatRTKLIB** yourself. When compiling, clone including submodules.

```
git clone --recursive https://github.com/taroz/MatRTKLIB.git
```

Or, if you have already cloned

```
git submodule update --init --recursive
```

The compilation procedure is as follows. 1. In MATLAB, enter `mex -setup` to see if compiler is configured 2. Run `compile.m`

Note: If you are syncing directories via OneDrive or Dropbox, the compilation may fail. If this happens, please pause the synchronization.

5 Usage

5.1 Call RTKLIB functions

Use `rtklib.****` to call RTKLIB wrapper functions in MATLAB. Vector I/O is supported for many functions; see Appendix 1 for RTKLIB function support status and vector I/O support. You can also use the `doc rtklib.****` or `help rtklib.****` commands to get help on each function.

5.2 GT

To create a GT object in MATLAB, use `gt.****`. See Appendix 2 for more information on GT class types and methods. You can also use the `doc gt.****` or `help gt.****` commands to get help on each function.

5.3 Run examples

MatRTKLIB contains over 30 examples, all of which exist as MATLAB script files in the `/examples` folder. You can learn how to use the GT class by running the examples. See Appendix 3 for a description of the types and contents of the examples.

6 Appendix 1: Supported RTKLIB functions

6.1 Satellites, Systems, and Codes functions

RTKLIB function name	Function	Ported	Vector input support	Note
satno	Convert satellite system+prn/slot number to satellite number	☑	☑	
satsys	Convert satellite number to satellite system	☑	☑	
satid2no	Convert satellite id to satellite number	☑	☑	
satno2id	Convert satellite number to satellite id	☑	☑	
obs2code	Convert obs code string to obs code	☑	☑	
code2obs	Convert obs code to obs code string	☑	☑	
code2freq	Convert system and obs code to carrier frequency	☑	☑	
sat2freq	Convert satellite and obs code to frequency	☑	☑	
code2idx	Convert system and obs code to frequency index	☑	☑	

6.2 Time and String functions

RTKLIB function name	Function	Ported	Vector input support	Note
tow2epoch	Convert GPS time of week to calendar day/time	☒	☒	Function change from gpst2time
epoch2tow	Convert calendar day/time to GPS time of week	☒	☒	Function change from time2gpst
gsttow2epoch	Convert Galileo time of week to calendar day/time	☒	☒	Function change from gst2time
epoch2gsttow	Convert calendar day/time to Galileo time of week	☒	☒	Function change from time2gst
bdttow2epoch	Convert BeiDou time of week to calendar day/time	☒	☒	Function change from bdt2time
epoch2bdttow	Convert calendar day/time to BeiDou time of week	☒	☒	Function change from time2bdt
gpst2utc	Convert GPST epoch to UTC epoch	☒	☒	
utc2gpst	Convert UTC epoch to GPST epoch	☒	☒	

RTKLIB function name	Function	Ported	Vector input support	Note
gpst2bdt	Convert GPST epoch to BDT epoch	☒	☒	
bdt2gpst	Convert BDT epoch to GPST epoch	☒	☒	
epoch2doy	Convert calendar day/time to day of year	☒	☒	Function change from time2doy
tow2doy	Convert GPS time of week to to day of year	☒	☒	Function change from time2doy
utc2gmst	Convert utc to GMST (Greenwich Mean Sidereal Time)	☒	☒	
adjgpsweek	Adjust GPS week number using cpu time	☒	☒	
reppath	Replace keywords in file path	☒		

6.3 Coordinates transformation

RTKLIB function name	Function	Ported	Vector input support	Note
xyz2llh	Transform ECEF position to geodetic position	☒	☒	Function change from ecef2pos

RTKLIB function name	Function	Ported	Vector input support	Note
llh2xyz	Transform geodetic position to ECEF position	☒	☒	Function change from pos2ecef
xyz2enu	Transform ECEF position to local ENU position	☒	☒	New development function
enu2xyz	Transform local ENU position to ECEF position	☒	☒	New development function
enu2llh	Transform local ENU position to geodetic position	☒	☒	New development function
llh2enu	Transform geodetic position to local ENU position	☒	☒	New development function
ecef2enu	Transform ECEF “vector” to local tangential coordinate	☒	☒	Function change from ecef2enu
enu2ecef	Transform ENU “vector” to ECEF coordinate	☒	☒	Function change from enu2ecef
covenu	Transform xyz-ECEF covariance to local ENU coordinate	☒	☒	

RTKLIB function name	Function	Ported	Vector input support	Note
covenusol	Transform xyz-ECEF covariance to local ENU coordinate	☒	☒	New development function
covecef	Transform local ENU covariance to xyz-ECEF coordinate	☒	☒	
covecefsol	Transform local ENU covariance to xyz-ECEF coordinate	☒	☒	New development function
eci2ecef	Compute ECI to ECEF transformation matrix	☒	☒	
deg2dms	Convert degree to degree-minute-second	☒	☒	
dms2deg	Convert degree-minute-second to degree	☒	☒	

6.4 Input and Output functions

RTKLIB function name	Function	Ported	Vector input support	Note
readpos	Read positions from station position file	☒	☒	

RTKLIB function name	Function	Ported	Vector input support	Note
readblq	Read BLQ ocean tide loading parameters	☒	☒	
readerp	Read earth rotation parameters	☒	☒	
geterp	Get earth rotation parameter values	☒	☒	

6.5 Platform dependent functions

RTKLIB function name	Function	Ported	Vector input support	Note
expath	Expand file path with wild-card (*) in file	☒		

6.6 Positioning models

RTKLIB function name	Function	Ported	Vector input support	Note
satazel	Compute satellite azimuth/elevation angle	☒	☒	
geodist	Compute geometric distance and receiver-to-satellite unit vector	☒	☒	

RTKLIB function name	Function	Ported	Vector input support	Note
dops	Compute DOP (dilution of precision) from azimuth and elevation	☑	☑	

6.7 Atmosphere models

RTKLIB function name	Function	Ported	Vector input support	Note
ionmodel	Compute ionospheric delay by broadcast ionosphere model (klobuchar model)	☑	☑	
ionmapf	Compute ionospheric delay mapping function by single layer model	☑	☑	
ionppp	Compute ionospheric pierce point (ipp) position and slant factor	☑	☑	
tropmodel	Compute tropospheric delay by standard atmosphere and saastamoinen model	☑	☑	

RTKLIB function name	Function	Ported	Vector input support	Note
tropmapf	Compute tropospheric mapping function by NMF	☑	☑	
iontec		WIP		
readtec		WIP		
ionocorr	Compute ionospheric correction	☑	☑	
tropcorr	Compute tropospheric correction	☑	☑	

6.8 Antenna models

RTKLIB function name	Function	Ported	Vector input support	Note
readpcv	Read antenna parameters	☑		
searchpcv	Search antenna parameter	☑		
antmodel	Compute receiver antenna offset by antenna phase center parameters	☑	☑	
antmodel_s	Compute satellite antenna offset by antenna phase center parameters	☑	☑	

6.9 Earth tide models

RTKLIB function name	Function	Ported	Vector input support	Note
sunmoonpos	Get sun and moon position in ECEF	☑	☑	
tidedisp	Compute displacements by earth tides	☑	☑	

6.10 Geoid models

RTKLIB function name	Function	Ported	Vector input support	Note
geoidh	Get geoid height from geoid model	☑	☑	

6.11 Datum transformation

RTKLIB function name	Function	Ported	Vector input support	Note
tokyo2jgd	Transform position in Tokyo datum to JGD2000 datum	☑	☑	
jgd2tokyo	Transform position in JGD2000 datum to Tokyo datum	☑	☑	

6.12 RINEX functions

RTKLIB function name	Function	Ported	Vector input support	Note
readrnxobs	Read RINEX observation file	☒		Function change from readrnx
readrnxnav	Read RINEX navigation file	☒		Function change from readrnx
outrnxobs	Output RINEX observation file	☒		outrnxobsb+outrnxobsb
outrnxnav	Output RINEX navigation file		☒	
readrnxcl	Read RINEX clock files	☒		
convrnx		WIP		

6.13 Ephemeris and clock functions

RTKLIB function name	Function	Ported	Vector input support	Note
eph2clk	Compute satellite clock bias with broadcast ephemeris (GPS, GAL, QZS, BDS, IRN)	☒	☒	
geph2clk	Compute satellite clock bias with GLONASS ephemeris	☒	☒	
seph2clk		WIP		

RTKLIB function name	Function	Ported	Vector input support	Note
eph2pos	Compute satellite position and clock bias with broadcast ephemeris (GPS, GAL, QZS, BDS, IRN)	☑	☑	
geph2pos	Compute satellite position and clock bias with GLONASS ephemeris	☑	☑	
seph2pos		WIP		
peph2pos	Compute satellite position/clock with precise ephemeris/clock	☑	☑	
satantoff	Compute satellite antenna phase center offset in ECEF coordinate			
☑	☑			
satpos	Compute satellite position, velocity and clock	☑	☑	
satposs	Compute satellite position, velocity and clock	☑	☑	
readsp3	Read SP3 file	☑		
readsap	Read satellite antenna parameters	☑		

RTKLIB function name	Function	Ported	Vector input support	Note
readdcb	Read differential code bias (DCB) parameters	☒		
alm2pos		WIP		
tle_read		WIP		
tle_name_read		WIP		
tle_pos		WIP		

6.14 RTCM functions

RTKLIB function name	Function	Ported	Vector input support	Note
gen_rtc2		WIP		
gen_rtc3		WIP		

6.15 Solution functions

RTKLIB function name	Function	Ported	Vector input support	Note
readsol	Read rtklib solution file	☒		
readsolstat	Read rtklib solution status file	☒		
outsol	Output rtklib solution file	☒		
outsolex		WIP		
outnmea_rmc		WIP		

RTKLIB function name	Function	Ported	Vector input support	Note
outnmea_gga		WIP		
outnmea_gsv		WIP		

6.16 Google earth kml/gpx converter

RTKLIB function name	Function	Ported	Vector input support	Note
convkml	Convert from solution files to Google Earth KML files	☒		
convgpx	Convert from solution files to GPX files	☒		

6.17 SBAS functions

RTKLIB function name	Function	Ported	Vector input support	Note
sbsreadmsg		WIP		
sbssatcorr		WIP		
sbsioncorr		WIP		
sbstropcorr		WIP		

6.18 Options functions

RTKLIB function name	Function	Ported	Vector input support	Note
loadopts	Load option struct	☒		
saveopts	Save option struct	☒		

6.19 Integer ambiguity resolution

RTKLIB function name	Function	Ported	Vector input support	Note
lambda	Integer least-square estimation	☒	WIP	

6.20 Standard positioning

RTKLIB function name	Function	Ported	Vector input support	Note
pntpos	Compute receiver position, velocity, clock bias by single-point positioning	☒	☒	

6.21 Precise positioning

RTKLIB function name	Function	Ported	Vector input support	Note
rtkinit	Initialize RTK control struct	☒		

RTKLIB function name	Function	Ported	Vector input support	Note
rtkpos	Compute rover position by precise positioning	☑	☑	

6.22 Precise point positioning

RTKLIB function name	Function	Ported	Vector input support	Note
pppos		WIP		

7 Appendix 2: GT Classes

Class name	Function
Gobs	GNSS observation: read/edit/write/visualization
Gnav	GNSS navigation: read/edit/write/visualization
Gtime	GPS time: time system conversion
Gpos	Geodetic position: coordinate system conversion
Gvel	Velocity: coordinate system conversion
Gcov	Covariance: coordinate system conversion
Gsat	Satellite-related data: edit/visualization
Gsol	Position solution: read/edit/write/visualization
Gstat	Position status: read/edit/write/visualization
Grtk	RTK control class
Gopt	Process option: read/edit/write
Gfun	Wrapper for positioning function
C	Define constants

8 Appendix 3: Examples

File	Description
compute_double_difference.m	Compute double-differenced GNSS observation
compute_fixrate.m	Compute ambiguity fixed rate from RTK-GNSS solution
compute_float_ambiguity.m	Compute double-differenced float carrier phase ambiguity
compute_geoid.m	Compute Geoid hight
compute_mean_position.m	Compute mean position from solution file
compute_residuals_doppler.m	Compute Doppler residuals
compute_residuals_pseudorange.m	Compute pseudorange residuals
convert_coordinate.m	Convert LLH, ECEF and ENU position to each other
convert_solution_to_kml.m	Convert positioning solution to Google Earth KML file
convert_time.m	Convert GPS time, calender time and UTC time to each other
edit_rinex_observation1.m	Read and write RINEX observation
edit_rinex_observation2.m	Trim RINEX observation using time span
edit_rinex_observation3.m	Modify RINEX observation interval
edit_rinex_observation4.m	Exclude satellites from RINEX observation
edit_solution.m	Read position solution file and trim solution
estimate_position_rtk.m	RTK-GNSS positioning using RTKLIB
estimate_position_rtk_step_by_step.m	Step by step example of RTK-GNSS positioning
estimate_position_spp.m	Single point positioning using RTKLIB
estimate_position_spp1_step_by_step.m	Step by step example of single point positioning
estimate_position_spp2_step_by_step.m	Step by step example of single point positioning
estimate_velocity_doppler_step_by_step.m	Step by step example of velocity estimation by Doppler

File	Description
estimate_velocity_tdcg_step_by_step.m	Step by step example of velocity estimation by TDCP
evaluate_position_error.m	Evaluate positioning accuracy and plot error
evaluate_velocity_error.m	Evaluate velocity accuracy and plot error
generate_configuration_file.m	Generate RTKLIB configuration file
generate_solution_file.m	Generate RTKLIB solution file
plot_observation1.m	Show observation status and number of satellite
plot_observation2.m	Show raw GNSS measurements
plot_position.m	Show position on map
plot_satellite_constellation1.m	Show satellite constellation
plot_satellite_constellation2.m	Show satellite elevation and azimuth angles
plot_solution.m	Show RTK position solutions
