The Journal of Open Source Software

PyMap3D: 3-D coordinate conversions for terrestrial and geospace environments

Michael Hirsch[1, 2]

1 Boston University ECE Dept. **2** SciVision, Inc.

DOI: 10.21105/joss.00580

Software

- Review
- Repository
- Archive

Submitted: 29 January 2018
Published: 12 March 2018

Summary

PyMap3D (Michael Hirsch 2018) is a pure Python coordinate transformation program that converts between geographic coordinate systems and local coordinate systems useful for airborne, space and remote sensing systems. Additional standalone coordinate conversions are provided for Matlab/GNU Octave and Fortran. A subset of PyMap3D functions using syntax compatible with the $1000 Matlab Mapping Toolbox is provided for Matlab and GNU Octave users in the `matlab/` directory. A modern Fortran 2018 implementation of many of the PyMap3D routines is provided in the `fortran/` directory.

The Fortran procedures are "elemental", so they may be used for massively parallel processing of arbitrarily shaped coordinate arrays. For Python, increased performance and accuracy is optionally available for certain functions with AstroPy. Numpy is optional to enable multi-dimensional array inputs, but most of the functions work with Python alone (without Numpy). Other functions that are iterative could possibly be sped up with modules such as Cython or Numba.

PyMap3D is targeted for users needing conversions between coordinate systems for observation platforms near Earth's surface, whether underwater, ground-based or space-based platforms. This includes rocket launches, orbiting spacecrafts, UAVs, cameras, radars and many more. By adding ellipsoid parameters, it could be readily be used for other planets as well. The coordinate systems included are: * ECEF (Earth centered, Earth fixed) * ENU (East, North, Up) * NED (North, East, Down) * ECI (Earth Centered Inertial) * Geodetic (Latitude, Longitude, Altitude) * Horizontal Celestial (Alt-Az or Az-El) * Equatorial Celestial (Right Ascension, Declination)

Additionally, Vincenty (Vincenty 1975, Veness (2016)) geodesic distances and direction are computed.

PyMap3D has already seen usage in projects including * EU ECSEL project 662107 SWARMs * Rafael Defense Systems DataHack 2017 * HERA radiotelescope * Mahali (NSF Grant: AGS-1343967) * Solar Eclipse network (NSF Grant: AGS-1743832) * High Speed Auroral Tomography (NSF Grant: AGS-1237376) (M. Hirsch et al. 2016)

Other Programs

Other Python geodesy programs include:

- PyGeodesy MIT license
- PyProj ISC license

These programs are targeted for geodesy experts, and require additional packages beyond Python that may not be readily accessible to users. Further, these programs do not include all the functions of PyMap3D, and do not have the straightforward function-based API of PyMap3D.

References

Hirsch, M., J. Semeter, M. Zettergren, H. Dahlgren, C. Goenka, and H. Akbari. 2016. "Reconstruction of Fine-Scale Auroral Dynamics." *IEEE Transactions on Geoscience and Remote Sensing* 54 (5):2780–91. https://doi.org/10.1109/TGRS.2015.2505686.

Hirsch, Michael. 2018. "PyMap3D: 3-d Coordinate Conversion Software for Python and Matlab." 2018. https://doi.org/https://doi.org/10.5281/zenodo.595430.

Veness, Chris. 2016. "Vincenty Solutions of Geodesics on the Ellipsoid." 2016. http://www.movable-type.co.uk/scripts/latlong-vincenty.html#direct.

Vincenty, T. 1975. "Direct and Inverse Solutions of Geodesics on the Ellipsoid with Application of Nested Equations." *Survey Review* 23 (176):88–93. https://www.ngs.noaa.gov/PUBS_LIB/inverse.pdf.