Apparent Place of a Star

This document describes a MATLAB function named `apstar1.m`, and a demonstration script, named `demo_astar1.m` that can be used to determine the apparent geocentric and topocentric coordinates of a star. The source ephemeris for this routine is a JPL binary ephemeris file. These applications use several functions ported to MATLAB from the Fortran version of the NOVAS (Naval Observatory Vector Astrometry Subroutines) source code developed at the United States Naval Observatory (www.usno.navy.mil/USNO/astronomical-applications/software-products/novas).

Several JPL binary ephemeris files for Windows compatible computers can be downloaded from www.cdeagle.com.

The `apstar1` MATLAB function includes the following types of coordinate corrections:

(1) precession

(2) nutation

(3) aberration

(4) gravitational deflection of light

(5) proper motion

(6) parallax

(7) radial velocity

Please note that this MATLAB function does not include a correction for atmospheric refraction. For extragalatic objects the proper motions, parallax and radial velocity should all be set to 0.

An excellent discussion about these corrections can be found in "Mean and Apparent Place Computations in the New IAU System. III. Apparent, Topocentric, and Astrometric Places of Planets and Stars", G.H. Kaplan, J.A. Hughes, P.K. Seidelmann, C.A. Smith and B.D. Yallop, *The Astronomical Journal*, Vol. 97, No. 4, pages 1197-1210, 1989.

The processing steps used in the `demo_astar1` MATLAB script are as follows:

(1) input a calendar date on the UT1 time scale

(2) compute the UT1 Julian date

(3) compute the TDT Julian date

(4) compute the TDB Julian date

(5) read the star's coordinates, proper motions, parallax and radial velocity

(6) define the type of coordinates

(7) calculate the apparent coordinates

The syntax and arguments for the MATLAB function that actually performs most of the calculations are as follows:

```
function [ra, dec] = apstar1 (tjd, ujd, n, topo, glon, glat, ht, ...
                              ram, decm, pmra, pmdec, parlax, radvel)

% this subroutine computes the geocentric or topocentric apparent place
% of a star, given its mean place, proper motion, parallax, and radial
% velocity for j2000.0.

% input

%  tjd    = tdt julian date for apparent place
%  ujd    = ut1 julian date for apparent topocentric place
%  n      = body identification number for the earth
%  topo   = type of apparent place calculation
%         = 0 ==> geocentric
%         = 1 ==> topocentric
%  ram    = mean right ascension j2000.0 (hours)
%  decm   = mean declination j2000.0 (degrees)
%  pmra   = proper motion in ra (seconds of time/julian century)
%  pmdec  = proper motion in dec (seconds of arc/julian century)
%  parlax = parallax (seconds of arc)
%  radvel = radial velocity (kilometers per second)

% output

%  ra  = apparent geocentric or topocentric right ascension,
%        referred to true equator and equinox of date (hours)
%  dec = apparent geocentric or topocentric declination,
%        referred to true equator and equinox of date (degrees)
```

The `demo_astar1` MATLAB script will prompt you for the calendar date, universal time, observer coordinates, the name of the star data file and the type of ephemeris (topocentric or geocentric).

The following is a typical star data file named `altair.dat`. Do not delete any lines of text or data as the software expects to find exactly 20 lines of information.

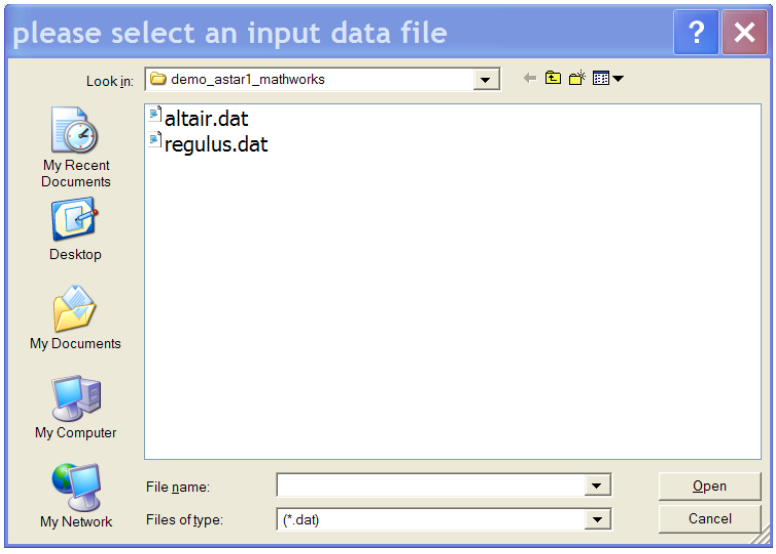
```
star name
ALTAIR

J2000 right ascension (hours)
19.8463894440

J2000 declination (degrees)
8.8683416670

J2000 proper motion in right ascension (seconds/Julian century)
3.6290

J2000 proper motion in declination (arcseconds/Julian century)
38.6300

parallax (arcseconds)
0.1981
```

```
radial velocity (kilometers/second)
-26.30
```

The following is the syntax of the MATLAB function that reads this data file. The input and output arguments are defined within the function annotation text. Please note the proper units for each item.

```
function [fid, sname, ram, decm, pmra, pmdec, parlax, radvel] =
                                                    readstar(filename)

% read star data file

% required by star*.m

% input

%  filename = name of star data file

% output

%  sname  = star name
%  ram    = J2000 right ascension (hours)
%  decm   = J2000 declination (degrees)
%  pmra   = J2000 proper motion in right ascension
%           (seconds/Julian century)
%  pmdec  = J2000 proper motion in declination
%           (arcseconds/Julian century)
%  parlax = parallax (arcseconds)
%  radvel = radial velocity (kilometers/second)
%  fid    = file id
```

The software will prompt you for the name of the star data file with a screen display similar to



The file type defaults to names with a `*.dat` filename extension. However, you can select any `demo_astar1.m` compatible ASCII data file by selecting the Files of type: field or by typing the name of the file directly in the File name: field.

The following is a typical user interaction with the `demo_astar1` script. It illustrates the calculation of the topocentric coordinates of Altair relative to an observer located at the Chamberlin Observatory in Denver, Colorado on December 2, 2012 at 0 hours UTC.

```
demo_astar1 - apparent coordinates - jpl ephemeris


please input a UTC calendar date

please input the calendar date
(1 <= month <= 12, 1 <= day <= 31, year = all digits!)
? 12,2,2012

please input the universal time
(0 <= hours <= 24, 0 <= minutes <= 60, 0 <= seconds <= 60)
? 0,0,0

coordinate type menu

 <1> geocentric

 <2> topocentric

please select coordinate type
? 2

please input the geographic latitude of the observer
(-90 <= degrees <= +90, 0 <= minutes <= 60, 0 <= seconds <= 60)
(north latitude is positive, south latitude is negative)
? 39,40,36

please input the geographic longitude of the observer
(0 <= degrees <= 360, 0 <= minutes <= 60, 0 <= seconds <= 60)
(east longitude is positive, west longitude is negative)
? -104,57,12

please input the altitude of the observer (meters)
(positive above sea level, negative below sea level)
? 1644

apparent topocentric coordinates

ALTAIR

UTC calendar date        02-Dec-2012

UTC time                 00:00:00.000

UTC julian date          2456263.5000

observer latitude        +39d 40m 36.00s

observer east longitude  -104d 57m 12.00s

observer altitude           1644.0000 meters

right ascension          +19h 51m 28.0635s
```

```
declination              +08d 54m 16.66s
```

The following are the results for this same epoch and object using the Multiyear Interactive Computer Almanac (MICA) published by the United States Naval Observatory.

```
                                Altair

                    Apparent Topocentric Positions
                   True Equator and Equinox of Date

                         Chamberlin Obs., Denver
              Location:  W104°57'12.0", N39°40'36.0",  1644m
                (Longitude referred to Greenwich meridian)

   Date         Time           Right Ascension          Declination
        (UT1)
              h  m   s              h                        °
2012 Dec 02 00:00:00.0          19.8568462             +  8.906685
```