A MATLAB Script for Predicting Lunar Occultations

This document describes a MATLAB script named `loccult.m` that can be used to predict the local circumstances of lunar occultations of a planet or star. The source ephemeris for this routine is a JPL binary ephemeris file. This application uses 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). JPL binary ephemeris files for Windows compatible computers can be downloaded at www.cdeagle.com.

This script uses a combination of one-dimensional minimization and root-finding to solve this problem. The objective function used in these calculations is the topocentric separation angle between the center of the Moon and the object being occulted. This function is given by the following expression:

$$f\left(t\right) = \cos^{-1}\left(\hat{\mathbf{u}}_m \bullet \hat{\mathbf{u}}_b\right) - \left(s_m + s_b\right)$$

where

$\hat{\mathbf{u}}_m$ = topocentric unit position vector of the Moon
$\hat{\mathbf{u}}_b$ = topocentric unit position vector of the object
s_m = semidiameter of the Moon
s_b = semidiameter of the object

The semidiameter of the Moon is given by

$$s_m = \sin^{-1}\left(\frac{r_m}{d_m}\right)$$

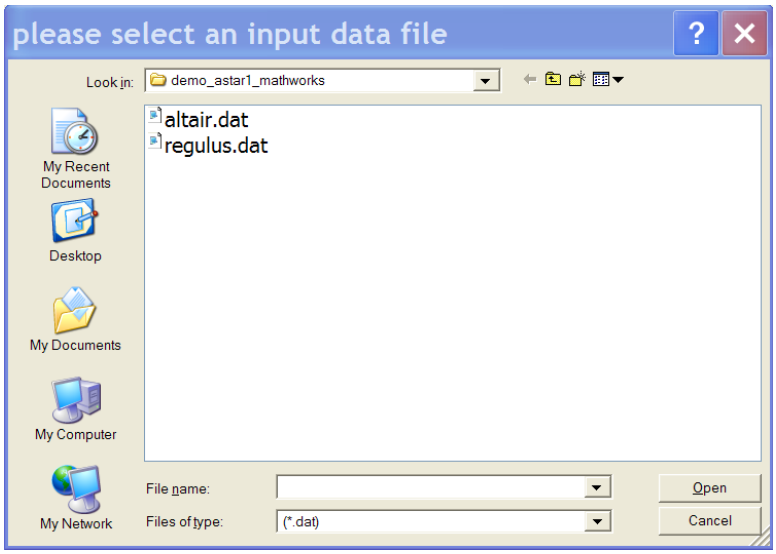
where r_m is the radius of the Moon (1738 kilometers) and d_m is the topocentric distance of the Moon.

The semidiameter of a star is zero and the semidiameter of a planet is

$$s_p = \frac{s_{p_0}}{r_p}$$

where s_{p_0} is the semidiameter of the planet at a distance of one astronomical unit and r_p is the topocentric distance of the planet.

If the target body is a star, 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 `loccult` 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 star data file named `spica.dat`. Do not delete any lines of text or data as the software expects to find exactly 20 lines of information. Please note the proper units.

```
star name
SPICA

J2000 right ascension (hours)
13.4198852780

J2000 declination (degrees)
-11.1613083330

J2000 proper motion in right ascension (seconds/Julian century)
-0.2780

J2000 proper motion in declination (arcseconds/Julian century)
-2.8300

parallax (arcseconds)
0.0210

radial velocity (kilometers/second)
1.0
```

The following is a typical user interaction with this MATLAB script. It illustrates a lunar occultation of the star Spica relative to an observer located in Denver, Colorado.

```
local circumstances of lunar occultations
==========================================

please input an initial UTC calendar date

please input the calendar date
(1 <= month <= 12, 1 <= day <= 31, year = all digits!)
? 2,1,1987
```

```
please input the search duration (days)
? 30

    target body menu

  <1> Mercury
  <2> Venus
  <3> Mars
  <4> Jupiter
  <5> Saturn
  <6> Uranus
  <7> Neptune
  <8> Pluto
  <9> Star

please select the target body
? 9

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)
? 40,0,0

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)
? -105,0,0

please input the altitude of the observer (meters)
(positive above sea level, negative below sea level)
? 0

begin lunar occultation
-----------------------

calendar date             18-Feb-1987

universal time            12:26:26.300

UTC Julian date           2446845.0184

lunar azimuth angle        +213d 46m 13.25s

lunar elevation angle      +32d 44m 24.80s

end lunar occultation
---------------------

calendar date             18-Feb-1987

universal time            13:17:31.899

UTC Julian date           2446845.0538

lunar azimuth angle        +225d 54m 29.72s

lunar elevation angle      +26d 25m 12.26s


event duration             +00h 51m 5.5985s
```