AstroNavigation

A celestial navigation program for a Palm OS® computer

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Content

1. What you get

The pastroe.zip file includes the program AstroNav. It also includes a copy of MathLib.prc. Please move the programs to your Pilot. Clear an old version first. The program version is compiled for Palm OS® 2.0 and higher.

2. Something about your input

The data input for a program is always a problem if you have to input degrees, minutes, seconds or time. To make it easier the data are separeted by space (stroke),

```
 e.g. to enter 12 degrees 34.5 minutes do this    12<space>34.5
      for the time 12:45:56
                          12<space>45<space>56
```

All times are in UTC (universal time coordinated).

3. The menu

When you start your program you will see the following on your display:

```
┌─────────────────────────────────┐
│  Astronavigation          ⓘ     │
│ ┌──────┐ ┌────────┐ ┌────────┐  │
│ │ sun  │ │ sight  │ │ sights │  │
│ ├──────┤ ├────────┤ ├────────┤  │
│ │ moon │ │  fix   │ │ clear  │  │
│ ├──────┤ ├────────┤ ├────────┤  │
│ │ stars│ │  year  │ │ change │  │
│ ├──────┤ ├────────┤ └────────┘  │
│ │venus │ │  noon  │             │
│ ├──────┤ ├────────┤             │
│ │ mars │ │ course │             │
│ ├──────┤ ├────────────┐         │
│ │jupiter│ │destination│         │
│ ├──────┤ └────────────┘         │
│ │saturn│                        │
│ └──────┘                        │
│                                 │
│  year       2000                │
│  sights     0 (0)               │
└─────────────────────────────────┘
```
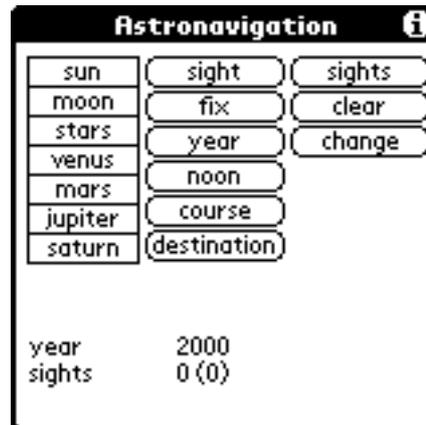
On the left are the celestial bodies the program can use while centre and left display the operations the program can perform.

3.1. Compute a position

The program uses its own internal year to allow you to work sample sight reductions. However, before commencing a reduction ensure that the correct date is set. The sample problems in this documentation all use the year 1990. Set the appropriate year by first selecting 'year' from the middle column.

To reduce a sight or calculate a fix choose a star (from the left column) and start the calculation of your first sight (select 'sight').

Example:

We will reduce two sights and calculate the fix using the following sample data. (Please set the year for the examples to 1990.)

```
D.R.        13  53' N
            44  39' W
1. sight    sun 16.12.1990  UTC 10:49:06
            down 19  18.6' no index error
            height 2 m
2. sight    sun 16.12.1990  UTC 14:37:10
            down 52  28.2' no index error
            height 2 m
            run distance course 270 , 19 nm
```

These are sun sights so select 'Sun' and then 'Sight' from the main menu.

Now you can input your data for the first sight. First input your D.R. (Dead Reckoning) position. Remember the input terms: first the degrees then a space followed by the minutes.

Then select north or south. North is the default.

Do the same with the longitude. Use the 'old' button to input an old fix or destination in these fields.

The date follows. Please input only month and day. The year is set in the main menu.

The time is the next data. Please remember the input terms.

Now input the sextant angle. If you work with the sun or the moon select the type of sight.

Input the correction now. The defaults are typical for sailors. If your index error is negative, you have to put an '-' in front of the minutes. The height of the eyes are in metres.

The buttons in the form 'sights' mean:
- down/up or normal = (lower/upper limb) natural horizon
- 0 = artificial horizon (the height is not used)
- 2 = artificial horizon with double angle (using lake as mirror)
- S = short horizon (dip short) includes down/up when needed, add the distance to horizon in nm

To change between date format (dd.mm./mm.dd.) or the height (m/ft) press the menu button and select your favorite.

Now push the 'compute' buttom.

Please wait for the computing. You will see the miles away or towards the star and the computered azimut. The miles should be very small. If the value seems too big there will be an input error or your sextant angle needs to be controlled. If everything is ok press the 'Ok' buttom. You are back to the main menu now.

For the second sight you can choose all stars again. The mask (inpout form) is like the first one but there is no position. You have to input the running values angle and distance.

The new sight is computed from the new position.

After two sights you can visit your position. Please press the 'fix' buttom in the main menu. The output looks like this:

```
              Astronavigation    ℹ

        sights 2 of 2
        12/16/1990
        14:37:10
        D.R.    13° 53.0' N
                44° 58.6' W
        fix     13° 42.5' N
                45° 5.0' W
        BV      210.7° 12.1 nm


        ( Ok )        (   save   )
```
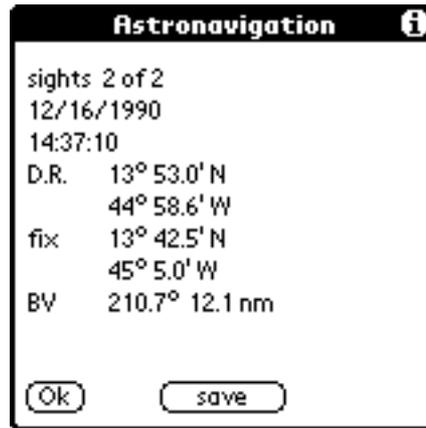
The D.R. is shown from your last postion. The correction is computed (BV) from here.

You may save your values to the memopad as a log file.

You can add now another sight or clean up everything. If you do nothing the sight will be saved so when you start the program again you still have this position. More examples are below in this document.

3.2. To find a star

In the twilight often you have the chance to take a sight of a star but you don't know which star it is. In this case you can select 'unknown' as the star name (default) and input the bearing of the star. The program will determine the star but it takes a little time since it must make the computation for all the candidate stars and planets. So please wait for the answer.

The other inputs are the same as for the sun.

For example:

```
 D.R.        13   55 N
             44   31 W
 1. sight    unknown star  16.12.1990  UTC 8:26:10
             bearing 80    sextant 44  36.4'
 2. sight    unknown star  16.12.1990  UTC 8:30:30
             bearing 350   sextant 42  4.4'
             no run distance
```

```
            Astronavigation     ⓘ
 stars      ▼ [unknown]
 lat      13.55    N S      ( old )
 long     44.31    W E
 date     12.16    1990 (mm.dd.)
 UTC      8.26.10  bearing 80
 sextant 44 36.4   normal 0 2 S
 indexerror 0.0    arcturus
 height  m 2.0     nm    9.5 away
                   azimut 76.6 °

 (Ok) (cancel) (?) (compute)
```
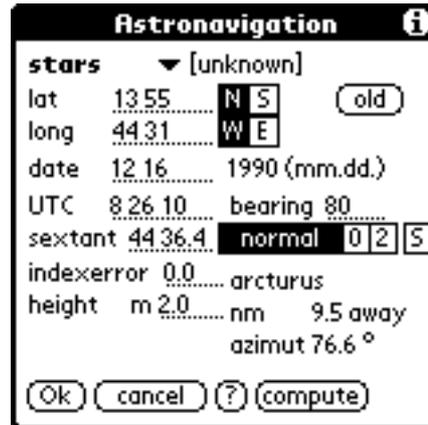
The program always computes all stars if unknown is selected. Selection is then made from the nearest of the 80 stars or planets but only you can determine if the output is correct or not.

The output for this example should be:

```
2 sights
16.12.1990
8:30:30
pos  lat:      13   55.0 N
     long:     44   31.0 W
fix  lat:      13   49.6 N
     long:     44   39.8 W
BV   237,5    10.1 nm
```

The stars in this case are Arcturus and Dubhe.

You can try an other sight (upto 20):

```
 3. sight    unkown star  16.12.1990  UTC 8:38:40
             bearing 270      sextant 57  19.2'
             no index error, height 2 m
             no run distance
```

The output is:

```
3 sights
16.12.1990
8:38:40
pos  lat:      13   55.0 N
     long:     44   31.0 W
fix  lat:      13   48.8 N
     long:     44   37.6 W
BV   225.9     8.8 nm
```

The unknown star was now the planet Jupiter.

There are no Greek characters for stars in the program I have used th following:

```
a alpha   e epsilon  i iota     n nu       r rho      v phi
b beta    f zeta     k kappa    q xi       s sigma    x chi
c gamma   g eta      l lambda   o omicron  t tau      y psi
```

```
d delta  h theta    m mu       p pi        u upsilon  z omega
```

3.3. (De)activate your sights

You can control which of your sights are used to compute the fix. If you want to have a sight not included on the fix, deselect that sight in the 'sights' screen and it will not be used for the fix. You can later reactivate this sight if desired.

```
┌─────────────────────────────────┐
│  Astronavigation          ℹ      │
├─────────────────────────────────┤
│ sight      3  jupiter            │
│ D.R.       13° 55.0' N           │
│            44° 31.0' W           │
│ date       12/16/1990            │
│            8:38:40               │
│ sextant    57° 19.2'             │
│ azimut     280.6°                │
│ nm         3.2 to                │
│            ☑ compute             │
│                                  │
│ ( Ok )                  (+)(−)   │
└─────────────────────────────────┘
```

If you do this with the above example and deactivate the third star then the fix must be the same as you got from the first two sights.

3.4. Rating the sights

It's very difficulty to estimate how accurate your 'Fix' is. Here are some error factors you must consider:

- Sextant calibration or accuracy
  A sextant is considered 'error free' when its index error is less then 20".

- Instability offshore
  You can generally estimate it around 2' but it depends to conditions off shore. When you are taking a sight always have a clear view of the horizon - avoid the wave troughs.

- Time
  The sun moves a quarter of a mile each second so it's nessessary to have the correct time. I got good experience with radio controlled clocks. Also less mistakes are made with digital clocks.

You can get a better assessment from a little plot of your sights which will indicate also an inaccurate sight. Remember: the cross point of your lines is not necessarily your correct position but it is approximate. Fix accuracy is very dpendant on the azimuths of your sights which require an angle between 60 and 120 degree for the good accuracy. In addition, each new sight gives you a better position and a smaller error in your fix.

3.5. Changing your recorded sights

The change of sights is the standard work for sailors. Example: you take a sun sight, then continue on course. You then take another sight and get a fix. With the button 'change' you can make your last sight available as the first sight of a new fix. The new computed fix will be based on your D.R. position from that last fix. You can start with a new series of sights from here and so on. Here is an example:

```
D.R.        15   30 N
            38   40 W
1. sight    sun down    13.12.1990   UTC 10:46:29
            sextant   23    6.6'
2. sight    sun down    13.12.1990   UTC 14:00:14
            sextant   51    0.8'
            no index error, height 2 m
            run distance   260    und 16 nm
```

Your fix should be

```
      14   50.7 N
      39   23.6 W
```

Press Change on the main menu. The 2nd sight is now the first sight in a new sequence with the fix becoming the D.R.position. The miles away or towards should be very short.

Here is the new sight:

```
      sun down    13.12.1990    18:08:24
      sextant   24   59.6'
      no index error, height 2 m
      run distance    260   und 24 nm
```

The fix is now:

```
      14   46.3 N
      39   48.0 W
```

3.6. Clearing your sights

The buttom 'clear' in the main menu will delete all your sights. There is no way to delete a single sight. However, you can deactive a sight through use the Sights button in the main menu and press +/- to select the required sight.

3.7. Computing a star's bearing

Take the first example for the following.

Most navigators like to prepare their sextant before taking a sight. To do this input

the data as usual. However you cannot input the sextant angle as you don't know it yet. Press the '?' to get the value. If you do this with a star you also will get a bearing.

3.8. Computing a course and distance

Select 'course'. Input your initial position and your target position and Astro will compute the course and the distance.

For example: You want to go from your last fix to St. Lucia. Choose the 'course' buttom in the main menu. As you have previously taken a fix you can select the fix data by pressing 'old'. Then you only have to put in your destination data.

```
pos:      lat:      14   46.3 N
          long:     39   48.0 W
target:   lat:      14    2.0 N
          long:     61    1.0 W
course    270.6
distance 1233.3 nm
```

If you ever used a target before your may recall it by pressing the 2nd 'old' button.

3.9. Computing a new position

This is the opposite of 'course'. Select 'destination'. Input your position, the course, and the distance and Astro will compute the new position. Use only distances less then 500 miles for this (due mid latitude computing).

Using the same example for this you sailed 30 miles with the course 260 degree.
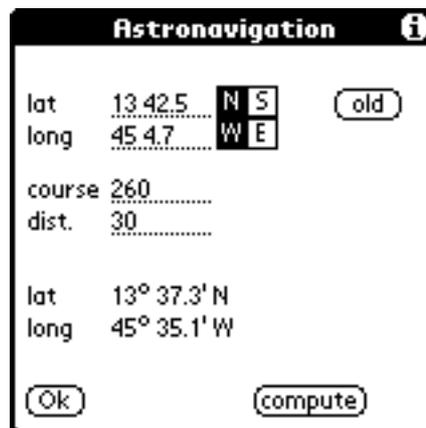
If you have calculated a fix before you may recall it now (press the 'old' button). The result also is saved and may by similarly recalled by the 'old' button. In this way you may continue computing destinations.

3.10. Noon

This computes some useful times of the day: local noon, sunrise, sunset, and the twilight times.
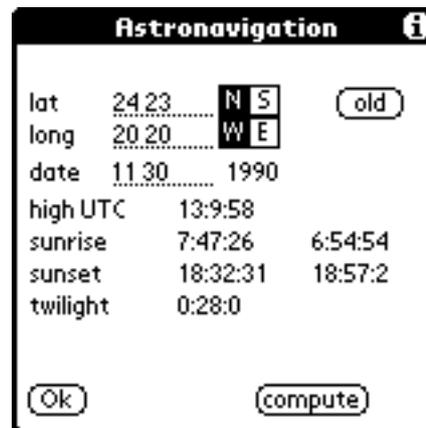
3.11. Change the year

Astro uses its own year for the sight calculations. You set Astro's year independently of the PDA's date. Select 'year' from the main screen.

4. High altitude sights

Get the time for local noon at your supposed position ('noon' at main menu) and take a sight at this time. Now reduce the sight. You will get the miles away or towards the sun (due South or due North). You only have to add the miles to your D.R. latitude (away = +, towards = -).

An example (clear all old sights first):

```
 D.R.       14  0.0 N
            56  0.0 W
            noon at 20.12.90   15:42:00
            sextant  52  30.2'
            Index 0.0'
            height 2 m
```

The miles are 9.1 towards.

```
            lat              14   0.0' N
            -                      9.1'
            --------------------------
            lat at noon      13  50.9' N
```

If you select 'Ok' this will be saved as a new sight.

5. The average of sights

Especially in the case of strong waves the accuracy of sights is going to be reduced. For this reason take additional sights. You don't have to average them, just put them into your program and let the computer do the work. For one sun series you don't have a correct fix but with another later series you can get a nice little fix.

An example (remember to clear the old data first):

```
D.R.         16  45.0' N
             34  23.0' W
1. sight     sun down   11.12.90     10:21:32
             sextant  21   8.2
2. sight     sun down   11.12.90     10:23:17
             sextant  21  29.3
3. sight     sun down   11.12.90     10:25:38
             sextant  21  55.0
4. sight     sun down   11.12.90     10:27:50
             sextant  22  30.0
5. sight     sun down   11.12.90     10:30:07
             sextant  22  51.1
run distance  course     250
              nm          15
Some more sights:
6. sight     sun down   11.12.90     13:30:18
             sextant  49   2.0
7. sight     sun down   11.12.90     13:34:02
             sextant  49  19.0
8. sight     sun down   11.12.90     13:37:13
             sextant  49  31.4
9. sight     sun down   11.12.90     13:40:32
             sextant  49  41.2
10. sight    sun down   11.12.90     13:44:24
             sextant  49  54.6
```

>From 10 sights you get this fix:

```
           16  19.9 N
           34  50.7 W
```

Now select 'lines' in the fix page and examine distance values. We will now deactivate the sights with the largest offsets. When you deactivate the sight 4 (5.7 nm) you will get a better standard deviation. Going on with the 6. sight (4.7 nm) the deviation is further reduced.

```
           16  18.2 N
           34  53.6 W
```

Please be careful. The angle between the two azimuths is very low. It's better to have an azimuth value of more then 40 degrees.

Appendix

Some examples

Use the year 1990 for all.

```
for all use      index error = 0.0'
                 height   = 2 metres
1.  D.R.         25  18 N
                 18   6 W
    1. sight   sun down 28.11.90  UTC 16.53.02
                 sextant 16   40.4
    2. sight   moon up  28.11.90  UTC 16.56.18
                 sextant 22   35
    no run distance
    new pos.   25  23.3 N
                 18  15.1 W
2.  D.R.         24  23 N
                 20  20 W
    1. sight   unknown star 30.11.90  UTC 7.05.42
                 bearing 120    sextant 32   41.4
    2. sight   unknown star 30.11.90  UTC 7.12.14
                 bearing 230    sextant 22   29.8
    position   24   5.9 N    the star are spica and
                 20  32.1 W    sirius.
3.  D.R.         13  43 N
                 44  31 W
    1. sight   mars     16.12.90  UTC 21.33.30
                 sextant 39   29.4
    2. sight   achernar 16.12.90  UTC 21.38.18
                 sextant 16   23.2
    position   14  38.3 N
                 44  55.5 W  (very bad)
4.  D.R.         14  15 N
                 56   7 W
    1. sight   venus    25.12.90  UTC 21.56.20
                 sextant  4  54.2
    2. sight   vega     25.12.90  UTC 22.01.54
                 sextant  9  23.8
    position   14  4.9 N
                 56  7.1 W
5.  Examples for a running fix
    D.R.         39  40 N
                 15  20 E
    1. sight   sun down    14.07.1990  UTC  5:20:16
                 sextant  16  20.6
    run distance  336   8 nm
    2. sight   sun down    14.07.1990  UTC  7:26:53
                 sextant  40  30.0
    fix        39  26.0 N          please notice the
                 15  16.8 E          very short time between
                                      the sights
    Now change the 2nd sight to become the first position
    new sight
    run distance  323   9.4 nm
    sight      sun down    14.07.1990  UTC  9:44:23
```

```
            sextant  64   54.3
new fix      39   40.7 N
             15   10.3 E
Now change the 2nd sight to become the first position again
new sight
run distance  323    7.4 nm
sight        sun down    14.07.1990  UTC 11:10:22
             sextant  71   39.6
new fix      39   46.6 N
             15    4.4 E
```

Addenda

I tested his program offshore for one year. For the reference I used various nautical almanacs, a GPS receiver and the logs of some friends. I believe that the compiled positions are relatively error free. But I can't give you any 100% guarantee that your positions are correct. Be careful with the output and, like all good navigators, use common sense and always cross-check your fixes an position by other methods and systems.

Acknowledgements