

GPS Receiver Interface - Exercises

Keywords

NMEA 0183 standard, latitude, longitude, altitude, speed over ground, azimuth, elevation

Introduction

This section of exercises introduces the students to the NMEA 0183 standard usually used in the serial interfaces of navigation receivers. The following exercises use the data stored in file `ISTShuttle.nmea`. It contains NMEA messages from a navigation field trial conducted on board of the IST shuttle that connects the Alameda campus with the Tagus campus. The GPS used in the trial was a Qstarz BT-Q1300.

Use GNU Octave or Matlab® to open the file and do the following exercises (hint: check functions `fopen`, `fgetl`, `strtok`, `str2double`, `bitxor`, `hex2dec`).

All these exercises were taken from exams and work assignments from previous years.

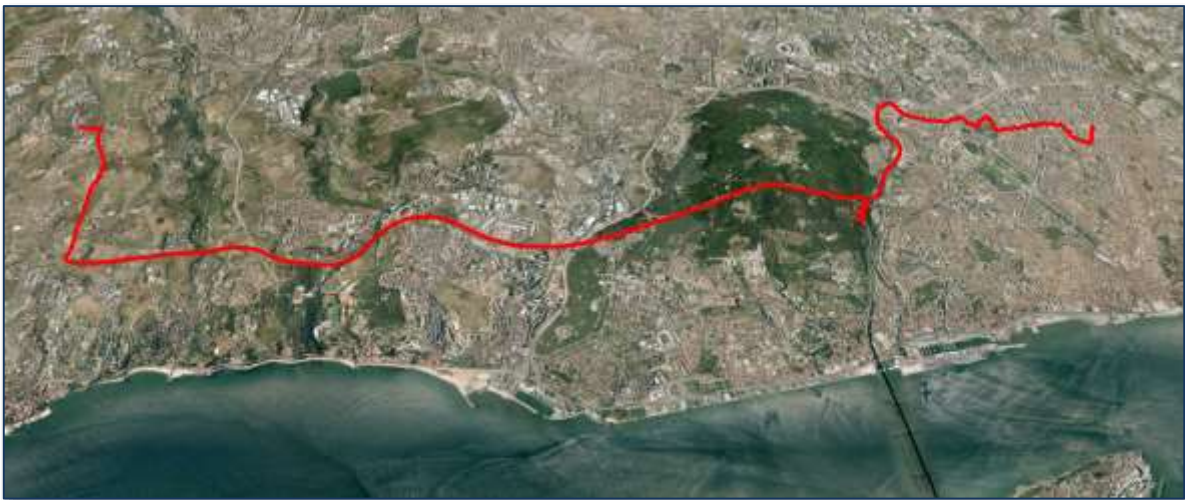


Fig. 1: IST shuttle between Alameda campus and Tagus campus.

Exercise 1 – NMEA Sentence Counter

Count the number of NMEA sentences in the log file.

Extra Exercises:

Count the number of GGA sentences, from GPS, in the log file.

Count the number of GLL sentences in the log file.

Exercise 2 – NMEA Sentences

Identify which NMEA sentences were logged.

Exercise 3 – Message Rate

Determine the message rate associated with each NMEA sentence.

Exercise 4 – Date and Time

Identify the date and time of the logging session (begin and end).

Extra Exercise

Show the GGA sentence associated with UTC 11:02:59.600.

Exercise 5 – Lat/Lon Box

Compute the latitude and longitude of the corners of the Lat/Lon box that contains all the position estimates.

Exercise 6 – Highest and Lowest Points

Identify the time/date and the coordinates of the highest and lowest points (altitude) on the track.

Exercise 7 – Cumulative Elevation Gain

Compute the cumulative elevation (altitude) gain on the track.

Extra Exercise

Compute the cumulative elevation (altitude) loss on the track.

Exercise 8 – Speed over Ground

Identify the highest speed over ground on the track.

Exercise 9 – Satellites in View

Identify the maximum number of satellites in view during the logging session.

Exercise 10 – Satellites Elevation

Identify the satellite with the highest elevation angle.

Exercise 11 – NMEA Checksum

Check the checksum of every message in the log.

Extra Exercise

Do the exercise again after changing the log file with a text editor (replace a few characters in a given sentence).

Solutions

1 Number of NMEA messages in `ISTShuttle.nmea`: 62966

2 NMEA sentences in `ISTShuttle.nmea`:

```
{GPZDA, GPGGA, GPGLL, GPGSA, GPRMC, GPVTG, GPGSV}
```

3 NMEA message rates (in `ISTShuttle.nmea`):

```
GPZDA - 5 Hz
GPGGA - 5 Hz
GPGLL - 5 Hz
GPGSA - 5 Hz
GPRMC - 5 Hz
GPVTG - 5 Hz
GPGSV - 1 Hz
```

4 Begin: 11:02:59.200 (UTC) 25/09/2013

```
$GPZDA,110259.200,25,09,2013,,*54
```

End: 11:33:58.600 (UTC) 25/09/2013

```
$GPRMC,113358.600,A,3844.2022,N,00918.1062,W,0.05,21.74,250913,,D*47
```

5 The track in `ISTShuttle.nmea` is contained in the Lat/Lon box with the following corner coordinates.

Upper left corner (NW corner)

Latitude: 38° 44.5002'N

```
$GPGGA,111937.800,3844.5002,N,00910.1222,W,2,8,1.23,63.6,M,50.7,M,0000,0000*77
```

```
$GPGLL,3844.5002,N,00910.1222,W,111937.800,A,D*4D
```

Longitude: 9° 18.1252'W

```
$GPGGA,113325.600,3844.1802,N,00918.1252,W,2,8,0.98,148.9,M,50.7,M,0000,0000*47
```

```
$GPGLL,3844.1802,N,00918.1252,W,113325.600,A,D*4B
```

Lower right corner (SE corner)

Latitude: 38° 42.8104'N

```
$GPGGA,113024.800,3842.8104,N,00917.5400,W,2,10,0.94,86.5,M,50.7,M,0000,0000*4B
```

```
$GPGLL,3842.8104,N,00917.5400,W,113024.800,A,D*4D
```

Longitude: 9° 08.1854'W

```
$GPGGA,110301.800,3844.2188,N,00908.1854,W,1,3,3.71,99.5,M,50.7,M,,*74
```

```
$GPGLL,3844.2188,N,00908.1854,W,110301.800,A,A*40
```

Use only GGA sentences with the GPS Quality Indicator field different from 0, 6, 7, and 8, or GLL sentences with the Status field equal to 'A'.

Use only sentences with a valid checksum (in this case all the sentences in the file have a valid checksum).

6 Highest altitude: 163.8m

Time: 11:33:49.400 (UTC)

Date: 25/09/2013

Latitude: 38°44.1929'N

Longitude: 9°18.1046'W

```
$GPGGA,113349.400,3844.1929,N,00918.1046,W,2,8,1.04,163.8,M,50.7,M,0000,0000*4C
```

Note that in

```
$GPGGA,110532.000,3844.2030,N,00908.3045,W,0,2,,165.4,M,50.7,M,,*5A
```

the GPS quality indicator is 0 (fix not available or invalid).

Lowest altitude: 28.5m

Time: 11:28:10.400 (UTC)

Date: 25/09/2013

Latitude: 38°42.8175'N

Longitude: 9°15.4120'W

\$GPGGA,112810.400,3842.8175,N,00915.4120,W,2,9,0.93,28.5,M,50.7,M,0000,0000*70

Use only GGA sentences with the GPS Quality Indicator field different from 0, 6, 7, and 8 and a valid checksum (in this case all the sentences in the file have a valid checksum).

7 Cumulative elevation gain: 575.6m

In the computation of the cumulative elevation gain, only GGA sentences with the GPS Quality Indicator field different from 0, 6, 7, and 8 and a valid checksum (in this case all the sentences in the file have a valid checksum) were considered.

8 Maximum speed over ground: 106.7km/h

\$GPVTG,238.03,T,,M,57.58,N,106.70,K,D*0D

Use only VTG sentences with the Mode Indicator field equal to 'A' or 'D', and a valid checksum (in this case all the sentences in the file have a valid checksum).

9 According to message GPGGA the maximum number of satellites in use was 10.

\$GPGGA,111451.600,3844.3061,N,00909.4236,W,1,10,1.01,79.1,M,50.7,M,,*49

According to message GPGSV the maximum number of satellites in view was 14.

\$GPGSV,4,1,14,21,64,090,31,16,48,316,34,33,44,190,,06,43,272,21*76

\$GPGSV,4,2,14,31,41,189,20,27,33,264,29,03,20,267,25,29,18,060,19*78

\$GPGSV,4,3,14,18,13,125,,25,07,117,,23,05,290,,13,04,317,*7D

\$GPGSV,4,4,14,19,03,250,,22,02,157,*71

In NMEA messages, GPS satellites are identified by their PRN (Pseudo Random Noise code), which range from 1 to 32. The numbers 33-64 are reserved to SBAS (Satellite Based Augmentation System) satellites. SBAS systems include WAAS (Wide Area Augmentation System), EGNOS (European Geostationary Navigation Overlay Service) and MTSAT (Multi-Functional Transport Satellite). The SBAS system PRN numbers are 120 to 138. The offset from NMEA satellite ID number to SBAS PRN number is 87.

The following table show some SBAS satellite PRN numbers and corresponding NMEA satellite ID numbers.

Table I: SBAS Satellites

SBAS Satellite	SBAS PRN	NMEA SV ID	Location	Notes
WAAS POR (Pacific Ocean Region)	134	47	178°E	deactivated
WAAS AORW (Atlantic Ocean Region - West)	122	35	142°W	deactivated
WAAS Inmarsat 4-F3	133	46	98°W	
WAAS Galaxy 15	135	48	133°W	
WAAS Anik F1R	138	51	107.3°W	
EGNOS Inmarsat 3-F2 (Atlantic Ocean Region - East)	120	33	15.5°W	
EGNOS ARTEMIS	124	37	21.5°E	
EGNOS Inmarsat 4-F2 (Europe Middle East Africa)	126	39	25°E	
EGNOS Inmarsat 3-F1 (Indian Ocean Region)	131	44	64.5°E	
MTSAT-1R	129	42		
MTSAT-2	137	50		

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10 The satellite with the highest elevation angle, during the track, was PRN 21, with an elevation angle of 64°.

```
$GPGSV,4,1,13,21,64,093,33,16,47,315,22,06,42,271,17,31,42,189,21*73
```

11 There are no checksum errors. All messages Ok.