HACETTEPE UNIVERSITY

GEOMATICS ENGINEERING DEPARTMENT

GMT312
GLOBAL NAVIGATION SATELLITE SYSTEMS

Assignment 2

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Spring
2024/25

1. INTRODUCTION

This study aims to calculate the three-dimensional position of GPS satellite PRN08 on April 1, 2025, through two approaches. The first is based on broadcast ephemeris data, which are frequently updated and well adapted to real-time positioning. These data are applied in most navigation systems but are less accurate compared to high-precision ephemeris data. Ephemeris data are broadcast by satellites and provide a coarse estimate of the position of the satellite, with inbuilt errors due to approximation in the orbital elements and limitations of update.

In contrast, the second technique employs precise ephemeris data, which are derived from actual GNSS observations and have much higher accuracy. Such data are commonly used within post-processing procedures and may be retrieved by way of services like the International GNSS Service (IGS). The precise ephemeris data updates more often and offers a wholly finer order of detail in representing satellite positions.

The primary objective of this work is to contrast positioning results derived from broadcast and precise ephemeris data. In light of the satellite position accuracy of either source, the study seeks to identify how the data source influences positioning precision.

2. METHODOLOGY

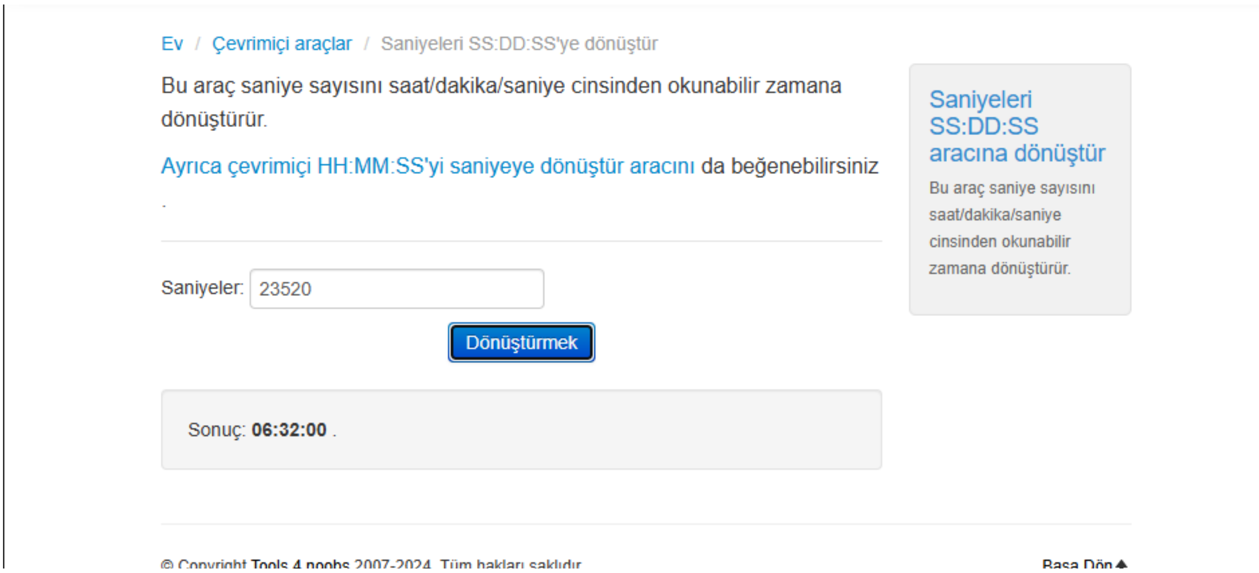
The process followed in this experiment began with determining the relevant satellite and epoch time based on the student ID number. After adding the last three digits of my student ID (0 + 6 + 2), the number 8 was obtained, and PRN08 GPS satellite was selected. Similarly, the sum of the last four digits (4 + 0 + 6 + 2 =) provided the value 12. This was multiply by 1960, which yielded a period of 23.520 seconds. This period was converted to hours, minutes, and seconds using an online converter, which provided 6 hours, 32 minutes, and 0 seconds.

As the first step, the broadcast navigation message for PRN08 was read from the file brdc0910.25n. The satellite's orbital parameters were selected from this message and stored in a 7 × 4 matrix as specified in the assignment instructions. This matrix contained the most fundamental Kepler orbital elements along with some of the correction coefficients. Using this data, the three-dimensional position of the satellite at the specific epoch was calculated using the function cal_brd.

In step two, precise orbital data was used for more accurate position prediction.
The file IGS0OPSFIN_20250910000_01D_15M_ORB was read, and ten PRN08 records were selected: five records before the 6-hour 32-minute cycle time and five records after the cycle time. The SP3 file contained only coordinate data but no time labels initially. However, the epoch times (seconds in the day) were manually inserted as the first column of the data sequence. The data array was now a 10×4 matrix with each row containing a timestamp followed by the respective X, Y, and Z coordinates.

The reason time labels were included after interpolation was that the time coordinate mapping had to be accurate for the interpolation to be accurate. If every position was not labeled with the corresponding time, the interpolation could not have made an accurate estimation of the satellite position at the epoch. With this format, the interpolation process could predict the satellite's position at the epoch perfectly.

Finally, the satellite positions were calculated with both datasets. The cal_brd function was used with the broadcast navigation message based on Kepler's equations, and the cal_sp3 function was used with the precise orbital data based on Lagrange interpolation. All calculations were conducted in Python, and their outputs were compared in the subsequent analysis.



3. RESULTS AND DISCUSSIONS

3.1. RESULTS

The satellite positions measured from the broadcast navigation message and the precise orbit data are listed in the following table:

METHOD	X(m)	Y(m)	Z(m)
Broadcast Ephemeris	-12,861,809.54	-15,934,718.99	18,096,515.10
Precise Ephemeris	-24,333,918.82	-6,028,522.77	-9,592,185.12

The results show that positions calculated from broadcast navigation messages are satisfactory for traditional GNSS uses but insufficient for high-precision use. In contrast, positions calculated from precise orbit data are considerably more precise, and the differences between the two are several kilometers. This clearly indicates that precision orbit data from spacecraft is a significant contribution to geodesy, surveying, and scientific research. In this way, the direct impact of the quality of the data source and the chosen method of computation on the acquired satellite position has been well established.

3.2. CONCLUSION

In this research, the three-dimensional location of the GPS satellite PRN08 at epoch time 6 hours and 32 minutes was determined using the student ID, both with broadcast navigation messages and precise orbit data.
The computation revealed that positions of the satellite derived from broadcast navigation messages were sufficient for usual navigation applications but not suitable for high-precision applications. Alternatively, accuracy in results derived by 9th-order Lagrange interpolation from reliable orbit data had much higher positional accuracy, approaching the level necessary for sensitive applications.

This research showcased the important role played by the quality of data as well as the mathematical methods employed in satellite positioning based on GNSS. Furthermore, the careful integration of the time tags within the data structure ensured the success and accuracy of the process of interpolation.

Therefore, selection of the data source and application of the proper mathematical techniques are shown to be crucial for achieving the desired accuracy in satellite positioning. The current work presents a practical engineering application for valuing the underlying principles of GNSS and comparison of other methods of calculating satellite positions

REFERENCES

- *IGS0OPSFIN_20250910000_01D_15M_ORB.SP3, International GNSS Service (IGS)*
- *brdc0910.25n, RINEX Navigation Message File*
- *Tools4Noobs GPS Time Converter*