



KINEMATIC POSITION DETERMINATION USING GLOBAL POSITIONING SYSTEM

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ABSTRACT

The Global Positioning System (GPS) is a satellite-based navigation system that consists of 24 orbiting satellites; each satellite revolves around the Earth twice a day. With signals from four or more satellites, a GPS receiver can triangulate its location on the ground (i.e.,

longitude and latitude) to determine the accurate kinematic position of the user by using GPS satellites. The user's position is computed using Newton-Raphson method in the Matlab environment. The signal received from the faulty satellites that degrades the performance of the GPS is identified and those signals are isolated (Autonomous Fault Detection and Isolation).

KEYWORDS: Global positioning system, Accurate position, Newton Raphson method, Faulty Satellites, Space segment, Control segment, User segment, fault detection and isolation, ECEF coordinate system.

1 INTRODUCTION

Kinematics is the branch of classical mechanics which describes the motion of points, bodies (objects) and systems of bodies (groups of objects) without consideration of the causes of motion. The study of the kinematics, which defines the properties of the trajectory of a particle. The position of a particle is defined to be the coordinate vector from the origin of a coordinate frame to the particle.

Navigation is defined as the science of getting a craft or person from one place to another. Driving to work or walking to a store requires fundamental navigation skills. However, in some cases where a more accurate knowledge of our position, intended course, or transit time to a desired destination is required, navigation aids other than landmarks are used. These may be in the form of a simple clock to determine the velocity over a known distance or the odometer in our car to keep track of the distance travelled.

Global Positioning System

(GPS) is a space-based satellite navigation system developed and operated by US Department of Defence, which provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The different segments of the GPS are Space segment, Control segment and User segments.

The previous work is about Single point positioning, which is used in the determination of the coordinates of a receiver with respect to the earth's reference frame by intersection of the signals from four or more satellites (also referred to as absolute positioning or simply point positioning). In this paper, GPS single point positioning and velocity computation is carried out from RINEX file under MATLAB Environment. Velocity computation is first implemented and Detailed MATLAB codes are provided to perform more accurate results.

Factors that affect the accuracy of the computation, such as satellite selection, ionosphere correction, satellite clock error calculation and correction, troposphere correction, and Earth rotation correction, are all corresponding in order to obtain better position and velocity results.

In the proposed work, the accurate position of the receiver is determined by finding the faulty satellite and isolating those faulty satellites, so that the receiver can use the other satellite's signals. The accurate position is computed by using the "Newton-Raphson method" under the MATLAB environment.

2 SYSTEM ARCHITECTURE

The current GPS consists of three major segments. These are the space segment (SS), a control segment (CS), and a user segment (US). The U.S. Air Force develops, maintains and operates the space and control segments. GPS satellites broadcast signals from space and

each GPS receiver uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time. The Fig 1 represents the system architecture of the Global Positioning System.

The control segment is composed of a master control station (MCS), an alternate master control station, and a host of dedicated and shared ground antennas and monitor stations. The user segment is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial, and scientific users of the Standard Positioning Service. The space segments consist of space vehicles.

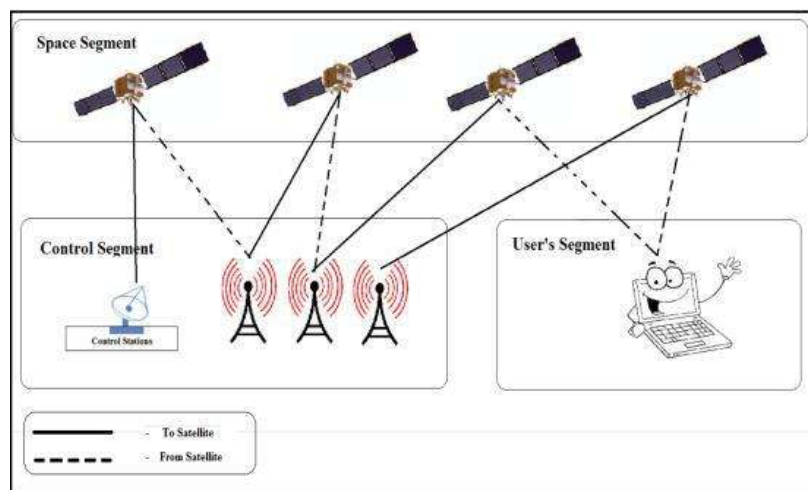


Fig 1: System architecture of the Global Positioning System.

2.1 Space Segment

The space segment consists of 24 satellites, each in its own orbit 11000 nautical miles (20,200 km) above the earth. The orbital period is one-half a sidereal day, i.e., 11 hours and 58 minutes so that the satellites pass over the same locations or almost the same locations every day. The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on Earth's surface. The space segment consists of solar panels, external components and internal components.

2.2 Control Segment

The control segment is composed of a master control station (MCS), an alternate master control station, and a host of dedicated and shared ground antennas and monitor stations. The master control station (MCS) performs the primary control segment functions, providing command and control of the GPS constellation. Monitor stations track the GPS satellites as

they pass overhead and channel their observations back to the master control station. Ground antennas are used to communicate with the GPS satellites for command and control purposes. These antennas support S-band communications links that send/transmit navigation data uploads and processor program loads and collect telemetry.

2.3 User Segment

The user segment is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service and tens of millions of civil, commercial, and scientific users of the Standard Positioning Service. The user segment consists of receivers, which you can hold in your hand or mounted in the vehicles. GPS receivers are composed of an antenna, pre-amplifier, radio, microprocessor, control and display unit, data recording unit and power supply.

3 IMPLEMENTATION

Computation of the receiver's ECEF position and velocity from its corresponding RINEX observation and navigation files applying pseudo range and Doppler observations are processed as shown in the Fig 2.

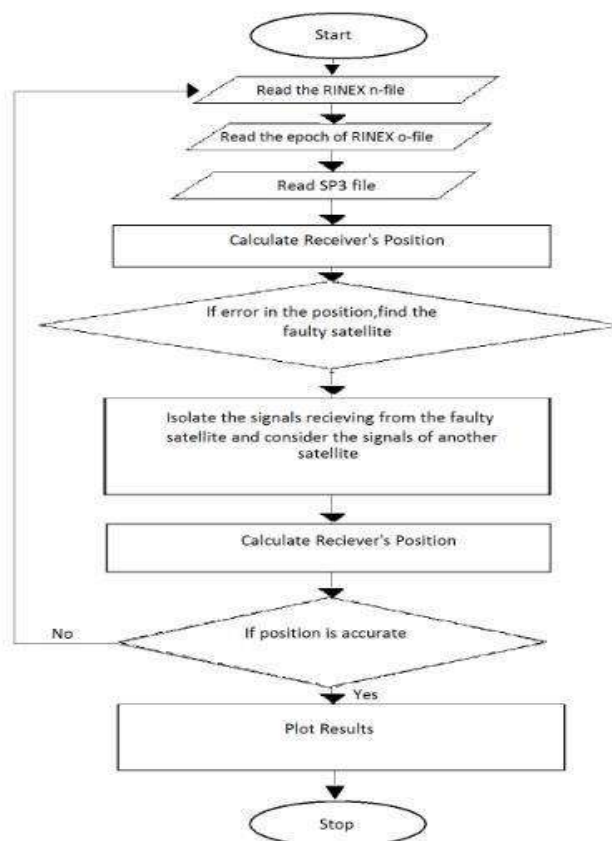


Fig 2: Flowchart for processing the data.

3.1 Navigation Message File

The Navigation Message provides all the necessary information to allow the user to perform the positioning service. It includes the Ephemeris parameters, needed to compute the satellite coordinates with enough accuracy, the Time parameters and Clock Corrections, to compute satellite clock offsets and time conversions, the Service Parameters with satellite health information (used to identify the navigation data set), Ionospheric parameters model needed for single frequency receivers, and the Almanacs. The ephemeris and clocks parameters are usually updated every two hours, while the almanac is updated at least every six days.

3.2 Observation Message

File

Each Observation file basically contains the data from one site and one session. RINEX also allows including observation data from more than one site subsequently occupied by a roving receiver in rapid static or kinematic applications. The observation file consists of messages that is sent to the receiver for every 30 seconds and which satellites are in line of sight at that point of time. The message consists of pseudo ranges, Doppler values of the satellites which are in the line of sight at that epoch of time.

3.3 Sp3 File Format

The format of the file is the satellite clock correction information which is computed simultaneously with the orbits. The basic format is a position and clock record; a second, optional, record contains velocities and clock rates-of-change. The Position Record Flag, P, in line one indicates that no velocities are included. The Velocity Record Flag (V), in line one indicates that at each epoch and for each satellite, a satellite velocity and clock rate-of-change has been computed. The SP3 format has been designed such that satellites other than GPS could be described as well.

3.4 Processing The Data Read

The algorithm by which, a GPS receiver computes the position of a satellite (x, y, z) in the ECEF coordinate system from the orbital elements. So the data read are processed using the equations of the ECEF coordinate system. Newton Raphson method, also called the Newton's method, is the fastest and simplest approach of all methods to find the real root of a nonlinear function. This method is used to improve the results obtained from other iterative approaches.

3.5 Computing The Receiver's Position

In order to determine user position in three dimensions (x, y, z) and the offset t , Pseudo range measurements are made to four satellites resulting in the system of equations. In order to determine user position in three dimensions (x, y, z) and the offset t , pseudo range measurements are made to four satellites resulting in the system of equations.

$$\rho_j = \sqrt{(x_j - x_u)^2 + (y_j - y_u)^2 + (z_j - z_u)^2} + ct_u$$

Where, x_j, y_j , and z_j denote the j^{th} satellite's position in three dimensions and $j = 1, 2, 3, 4$.

ρ represents the pseudoranges from the respective satellites

c represents the speed of light

t_u represents the clock bias

x_u, y_u, z_u is the initial user position.

4 SCREENSHOTS AND RESULTS

4.1 Snapshots Without Faulty Satellites

The Fig 3 shows the 3-D user positions calculated from broadcast and precise orbits are very close with each other, and it is hard to judge which one has better accuracy. The time range is from 2008/11/07 00:00:00 UTC to 2008/11/07 06:14:30 UTC, or GPS time of 432000 seconds to 454470 seconds at GPS week of 1504. The total time duration is 22500 seconds at 30 seconds time interval. The ranges of the y-axis in the plot, indicates the position of the satellite. The positive values in the y-axis indicates that the satellites is placed in front of the receiver and negative value indicates that the satellite is behind the receiver.

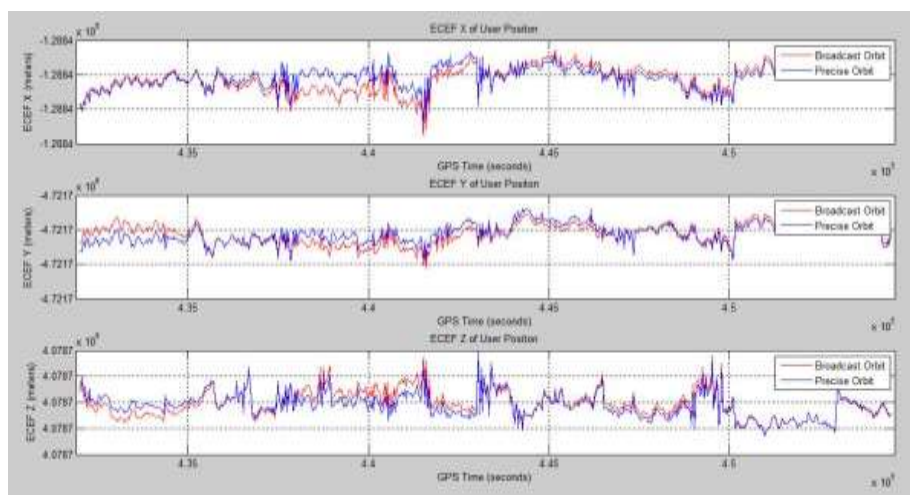


Fig 3: Estimated ECEF coordinates of user position based on broadcast and precise Orbits.

The Fig 4 is plotted by taking the approximate xyz position in the header of the observation file as the reference user position; the relative user position to the reference can be found and plotted. The x-axis which represents the GPS time from 43490seconds to 51890 seconds. The y-axis which indicates the position of the satellite, where the positive values, which corresponds to the receiver that is placed in front of the satellites and the negative values which corresponds to the receiver that is placed behind the receiver.

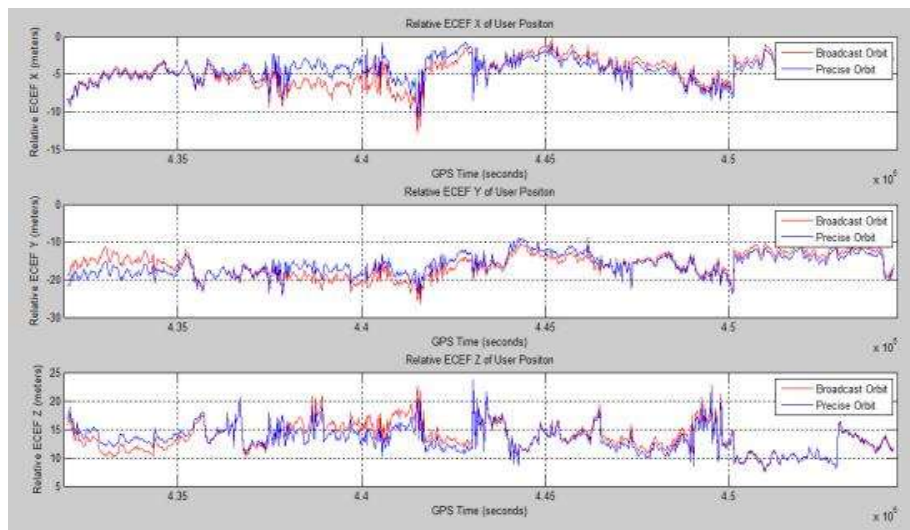


Fig 4: Relative user position to the reference position.

4.2 Snapshots With Faulty Satellites

Fig 5 is similar to the Fig 3. This Fig shows, how the position is varied when the satellite has an error of 100 meters.

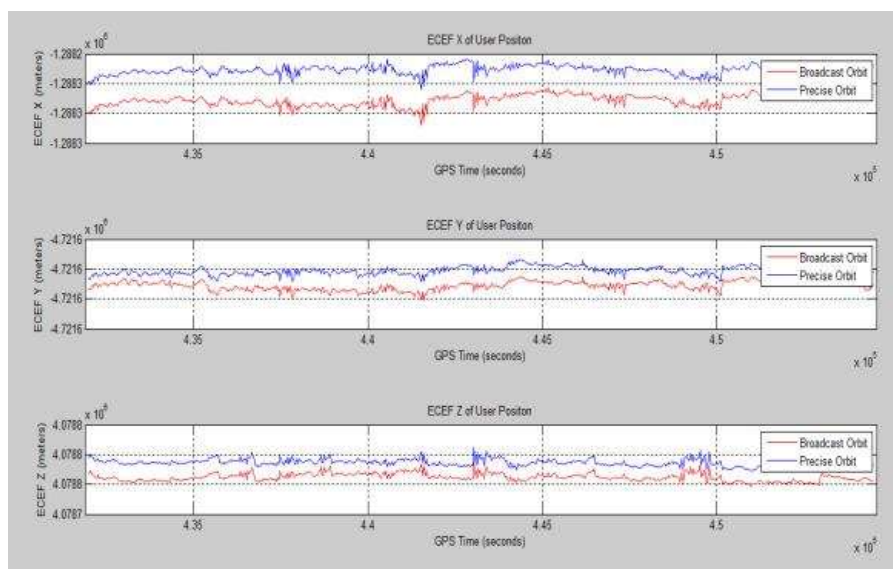


Fig 5: Estimated ECEF coordinates of user position with an error of 100 meters.

The Fig 6 is similar to the Fig 4. This Fig shows how the position is varied when the satellite has an error of 100 meters.

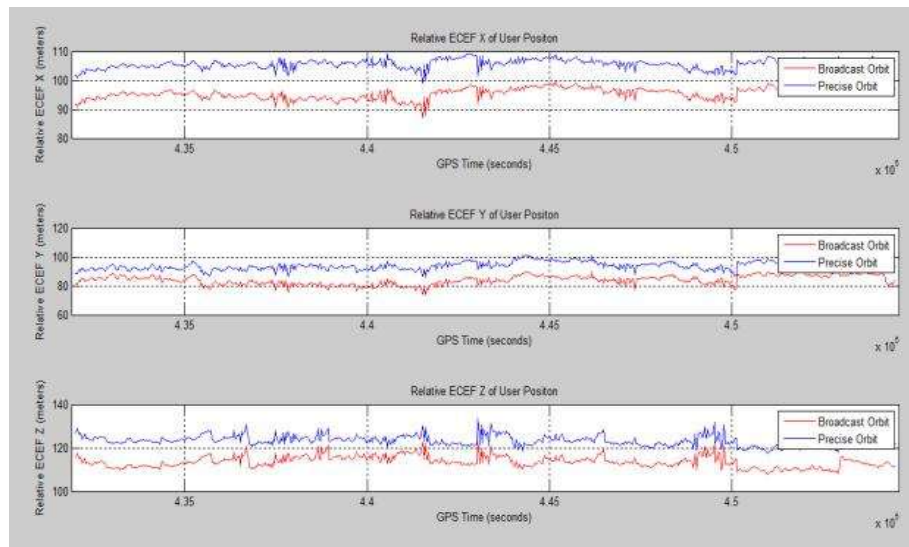


Fig 6: Relative user position to the reference position with an error of 100 meters.

6 CONCLUSION AND FUTURE ENHANCEMENT

The technology of the Global Positioning System is used for computing the accurate position of the receiver by detecting the faulty satellites and isolating those faulty satellites under the MATLAB environment using “NEWTON RAPHSON’S METHOD”.

The project is developed to find the accurate position of the receiver and detecting the faulty satellite and isolating those satellites. The future enhancement of this project can be implemented on the Automation of GPS satellites which can also be enhanced by finding the atmospheric delays which causes the deterioration of the receiver’s position. The goal is for each update to occur automatically

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