# The accuracy decision for longitude and latitude of GPS receiver using fuzzy algorithm

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ABSTRACT : The Global Positioning System(GPS) is a satellite based precise positioning system avaliable worldwide. The GPS have many error sources. The earth's ionosphere and atmosphere cause delays in the GPS signal that translate into position errors.

Some errors can be factored out using mathematics and modeling. The configurati on of the satellites in the sky can magnify other errors. The problem of accuracy on GPS measurement data can be meaningful

In this study, we propose the method for GPS positioning accuracy improvement. The FUZZY set theory on PDOP(Position Dilution of Precision) and SNR(Signal to Noise Ratio) provide improved for measured positioning data. The accuracy of positioning has been improved by selecting data from original using the FUZZY set theory on PDOP and SNR.

## 1. Introduction

GPS is divided from it's service such as PPS for military service and SSP for private service. Especially, SSP uses L1 carrier wave and C/A code which SA, GPS coordination station's invention of navigation message to reduce accuracy and satellite clock handling, is included. The prime causes of GPS's error are splitted up geometrical error caused by satellite's position and signal measurement. In case of SPS service, it has signal measurement error such as ionospheric layer's error, troposphere delay and receiver noise. It has error range about 100 meter because of the error and SA. This paper shows that using receiver is better to get the result of position than using SNR or PDOP which uses FUZZY set from DOP about 3D's position independently.

## 2. The basic concept of GPS

GPS measures the distance between receiver and each satellite by reach-time from satellite. However, the accurate distance can not be measured because of the distortion of signal. For that reason, the distance between receiver and satellite expresses pseudo rangeconsidered time-error. For that reason, the distance between receiver and satellite expresses pseudo rangeconsidered time-error. pseudo-range to measure the distance between a receiver and a satellite in expression 2-1

$$pr_i = \rho_i + c\Delta T_b \quad \cdots\cdots\cdots\cdots\cdots\cdots (2\text{-}1)$$

The four satellites is observed in the upper air of a receiver considering spatial coordinates and $\Delta T_b$to measure the position of a receiver. Fig. 2-2 shows the navigation fomula to measure the position. To measure accurate position of a receiver, four values show exist and be seen four satellites in the upper air.

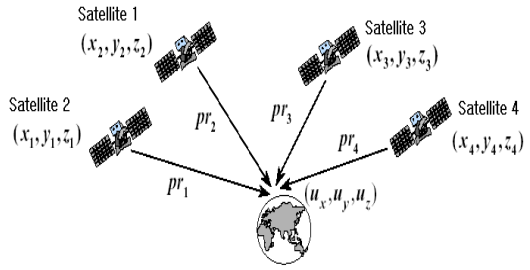


Fig. 2-1 Navigation diagram of GPS

$$pr_i = \sqrt{(u_x - x_i)^2 + (u_y - y_i)^2 + (u_z - z_i)^2} + c\Delta T_b$$
$$\cdots\cdots\cdots\cdots\cdots\cdots (2\text{-}2)$$

### 3. DOP and SNR

The prime factors of GPS's error are splitted up 3 parts. Firstly, structural causes such as an ionospheric layer's error, a troposphere delay, a receiver noise and Multipath. Secondly, a geometrical error caused by satellite's position and signal measurement. Thirdly, SA inpu intentionally. All of this factors make quiet big error result. It is called UERE(User Equvalent Range Error). Table. 2-1 shows the errors related to GPS

This study applied to DOP defined as error of geometrical configuration and SNR defined as the distortion of signal. DOP(Dilution of Precision) is the non-dimensional number expressing the error of relative satellite's geometrical position. Generally, the accuracy of

Table 3-1 GPS errors

| Source | 2σ | Remark |
|---|---|---|
| Orbit of a satellite | 20m | imprecision of satellite line estimate |
| Ionosphere delay | 30m | creat whensatellite signal pass ionosphere |
| Troposphere delay | 10m | Delay by pressure, vapor |
| Multipath | 10m | Error by environment of reciver |
| SA (Selective Availability) | 30m | Error |
| Sum | 100m | |

position is higher as the space between satellite is more. DOP changes as time goes because satellites move following the orbit. Fomula 2-3 shows the relationship between DOP and the accuracy of a position.

$$\sigma = DOP \bullet \sigma_0 \quad \cdots\cdots\cdots\cdots\cdots\cdots (2\text{-}3)$$

$\sigma_0$: measurement accuracy(standard deviation)

$\sigma$ : position accuracy

The signal measured in the receiver is called UERE unlike DOP indicating the accuracy of geometrical position. UERE is usually appliedto explaining the accuracy of measurement. This study used FUZZY set to decide the accuracy for the distortion of signal about relating to not relating to the error such as ionospheric layer's error, troposphere delay and receiver noise.

## 4. Structure of system

The system used a GPS receiver and communicated with PC by RS-232. After that PC processed values which was moved from GPS architecter.

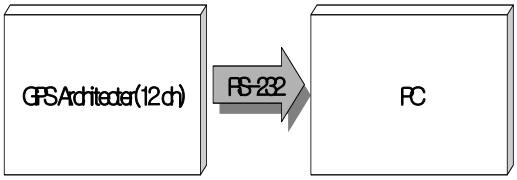


Fig. 4-1 The block diagram of experiment system

## 5. Declaration of Membership Function

PDOP had 3 member functions. SNR had 4 member functions. 4 member function for output was declared.

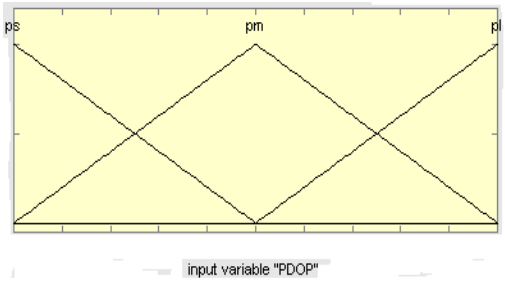


Fig. 5-1 Membership function of "PDOP"

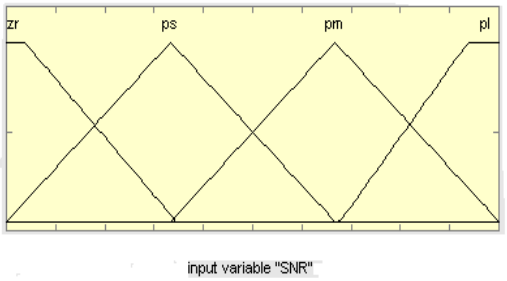


Fig. 5-2 Membership function of "SNR"

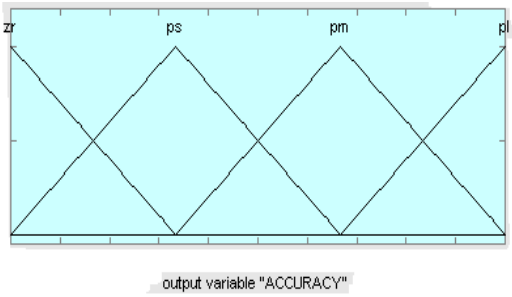


Fig. 5-3 Membership function of "ACCURACY"

## 6. Rule declaration

Declared rules according to member functions ware declared following

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IF PDOP IS PL AND SNR IS ZR THEN ACCURACY IS ZR
IF PDOP IS PL AND SNR IS PS THEN ACCURACY IS ZR
IF PDOP IS PL AND SNR IS PM THEN ACCURACY IS ZR
IF PDOP IS PL AND SNR IS PL THEN ACCURACY IS PS
IF PDOP IS PM AND SNR IS ZR THEN ACCURACY IS ZR
IF PDOP IS PM AND SNR IS PS THEN ACCURACY IS ZR
IF PDOP IS PM AND SNR IS PM THEN ACCURACY IS PS
IF PDOP IS PM AND SNR IS PL THEN ACCURACY IS PM
IF PDOP IS PS AND SNR IS ZR THEN ACCURACY IS ZR
IF PDOP IS PS AND SNR IS PS THEN ACCURACY IS PS
IF PDOP IS PS AND SNR IS PM THEN ACCURACY IS PM
IF PDOP IS PS AND SNR IS PL THEN ACCURACY IS PL
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Fig. 6-1 Rule base

## 7. The result of experiment.

The experimental data was processed from GPS receive after saving the computer per 1 second for 40 minutes.

The base point is 35.1799075 latitude and 126.9088861 longitude. The data from only receive, the data based accuracy, the data based SNR and the data from FUZZY are shown in the experimental data. We can observe that the method of FUZZY can accept much more data than PDOP and SNR and much less distance error. However, It ignores lots of data from origin data. This is because of the change like the signal of satellite and the geometrical position between each satellite by the movement of satellite rounding the orbit.

Table 7-1 Result of experiment

| Criteria / classification | Receiver alone | SNR | PDOP | FUZZY |
|---|---|---|---|---|
| latitude gap | 0.0014 3230 | 0.0006 9573 | 0.0007 3875 | 0.0010 7543 |
| longitude gap | 0.0002 4607 | 0.0001 9361 | 0.0001 6636 | 0.0002 3758 |
| distance gap | 162.7 | 79.5 | 84.1 | 122.4 |
| data | 2177 | 201 | 198 | 81 |
| criterion value | | 0.44 | 4 | 40 |

Table 7-2 Accuracy on varying criteria in FUZZY

| Criteria / classification | 0.4 | 0.43 | 0.45 | 0.46 |
|---|---|---|---|---|
| Average latitude gap | 0.00121 0357 | 0.00086 5402 | 0.00045 30859 | 0.00012 9606 |
| Average longitude gap | 0.00031 75273 | 0.00023 72586 | 0.00011 01732 | 0.00002 78545 |
| Average distance gap | 138.1 | 98.85 | 51.65 | 14.75 |
| data | 312 | 244 | 115 | 25 |

## 8. Conclusion

The adaptation about PDOP and SNR is shown that there is improvement that it can make a decision more efficiently than using PDOP and SNR independently . However, There are some problem that origin data doesn't have accuracy though it is accurate andthe number of data and error can change. Consequently, we are going to widen the study such as the definition of default value which can accept valid value having accuracy between other error's relationship and the method of being able to increase the valid value.

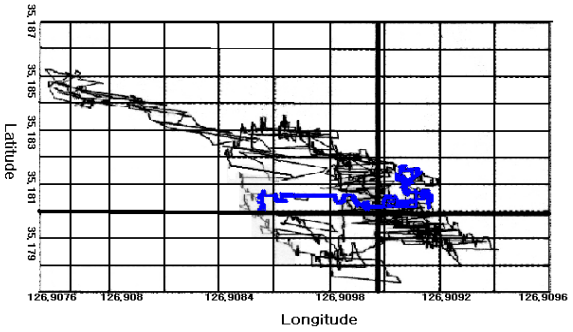


Fig. 8-1 Position data(The Fuzzy data in Origin data) Receiver position: Lat:35.1799075 Lon:126.9088861

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