A Method of SLR Data Automatic Preprocessing

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Abstract

To get the range from observation station to satellite is the object of SLR. Data and its processing play an important role in SLR engineering. Data processing includes ephemeris prediction, producing tracking file, incepting initial data, preprocessing and producing result data, converting the format, and so on. And preprocessing is the most complex step in SLR data processing. The meaning of preprocessing is that noise is eliminated. How to realize automatic processing is the goal of this paper and it is also the object of next SLR generation. Reliability and efficiency are two necessary factors taken into account in automatic processing method.
Based on the reality of SLR engineering, a method of SLR data automatic preprocessing is introduced in this paper.

Introduction

Satellite Laser Ranging (SLR) observation data is used to satisfy the objectives of a wide range of scientific, engineering, and operational applications and experimentation. The basic observable is the precise time-of-flight of an ultrashort laser pulse to and from a satellite, corrected for atmospheric delays. These data sets are used by the ILRS to generate a number of fundamental data products, including:

- Centimeter accuracy satellite ephemerides
- Earth orientation parameters (polar motion and length of day)
- Three-dimensional coordinates and velocities of the ILRS tracking stations
- Time-varying geocenter coordinates
- Static and time-varying coefficients of the Earth's gravity field
- Fundamental physical constants (From http://ilrs.gsfc.nasa.gov)

But all these are based on SLR observation data sets of sufficient accuracy.
How to get high accuracy observation data is the first problem for SLR engineering and its application. In SLR engineering, the data flow includes satellite prediction, producing tracking file, incepting initial data, data preprocessing and building normal point (NP) observation data. Sites in the United States and Europe have been relatively stable over the past several years, with efforts continuing to improve overall performance or reducing the cost of SLR operations. The goal is to realize an automated SLR station. And the paper thinks that preprocessing is the most complex step in realizing automated SLR. To improve the ability of SLR station in preprocessing, we make great efforts that include SLR satellite ephemeris analysis, initial data distraction analysis, the indicator of standard built and automatic processing method proposed.

SLR data processing introduction

In this paper, the SLR data processing means that the work is done in SLR tracking station from satellite prediction to NP data built, and doesn't indicate that work done in ILRS data

centers, where they receive ranging data and create all kinds of scientific data products. So, the SLR data processing only includes satellite prediction (tracking file built), preprocessing (noise of initial observation data eliminated) and NP data built.
Satellite prediction is the foundation of SLR. Consolidated Prediction Format (CPF) is a new laser ranging prediction format.

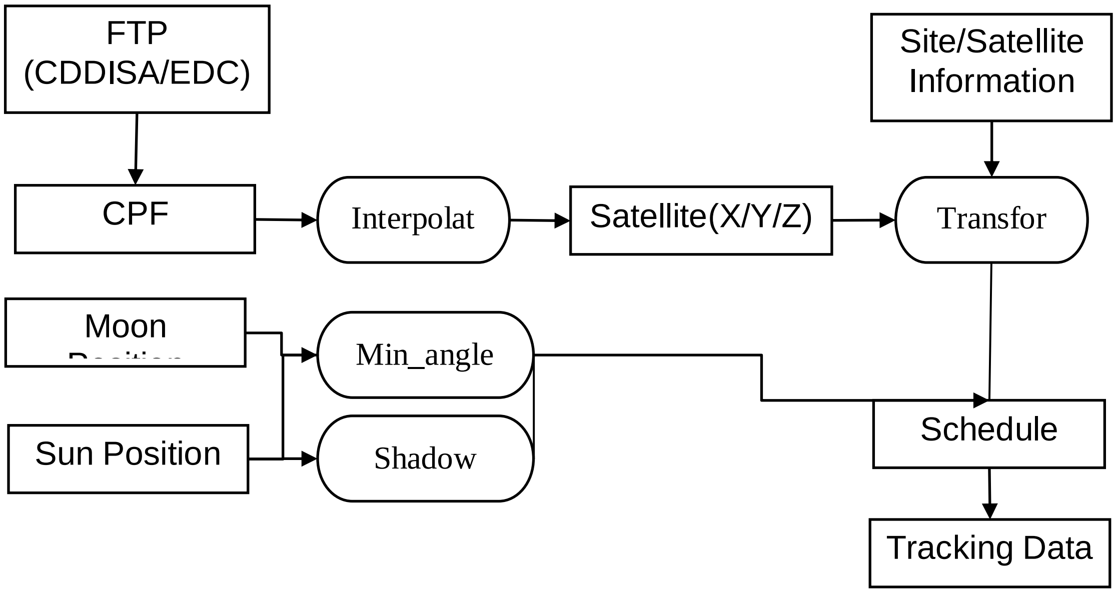


Figure 1. The data processing flow of before tracking

The data processing before tracking is the first step of data processing and is also the foundation in SLR engineering, which includes satellite prediction interpolation, Moon and Sun position computation, coordinate transforming and so on (see Fig.1). This object is to get tracking data to prepare the telescope to carry out ranging. Automation has been realized for this step, for every computation is well known. The second step is to eliminate noise from raw data and to form NP data. How to realize this step as automatic processing is the main goal of this paper.

Automatic preprocessing method

1. Main idea

SLR work is based on satellite predictions in either IRV or CPF format, so the quality of CPF is one determining factor in data preprocessing. And precision of the satellite prediction orbit should be in determinate range, so we can eliminate big noise from raw data if we know the precision range of satellite prediction orbit. For example, we compare the CPF to IGS(SP3) of GPS satellite prediction orbit to evaluate the precision of CPF satellite orbit based on IGS accuracy satellite ephemeris(to see Fig.2). The standard deviation seen in table 1.

Table 1. The compare of CPT to IGS of GPS satellite

Period	dX(CM)	dY(CM)	dZ(CM)
Pro-two days	±2.36	±6.30	±5.58
All five days	±14.21	±12.37	±8.09

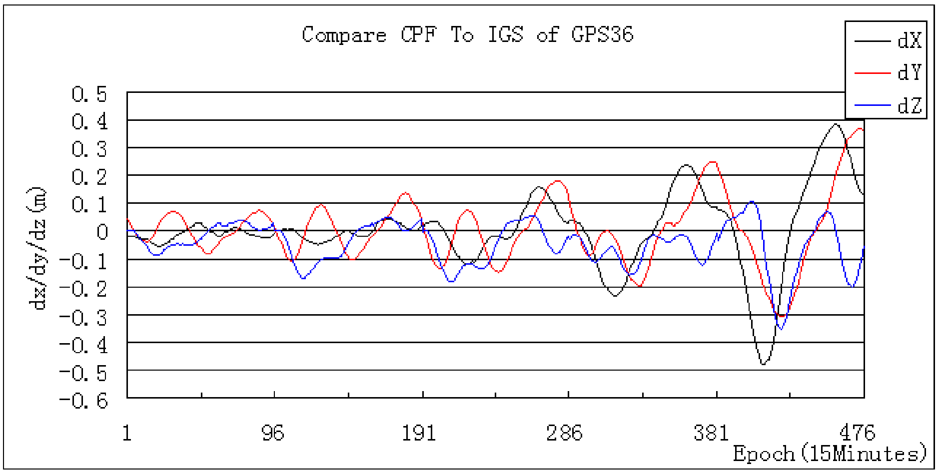


Figure 2 The compare of CPT to IGS of GPS satellite

In theory, satellite orbit is sequential, so the range of SLR observation and its change should be continuous. This is first very important information. The other important fact is that noise and true data is mutually exclusive, so a point is either noise or data. The true data must be in a line, and the noise is not. So we propose a spatial distribution comparison method to eliminate noise. First, setting the raw data based on prediction and its precision range, we can draw remaining data of O-C on time series. Second, cutting the O-C in scale, as formula (2-1).

$$\frac{Max(o-c)-Min(o-c)}{100}=\Delta R$$
$$Num(i)\geq All/100, i=1,2,\ldots,k_1$$
$$Num(j)\leq All/100, j=100,99,\ldots,k_2 \qquad (2\text{-}1)$$

Then we obtain the new remaining range of O-C on $R_{\max New}$ and $R_{\max New}$.

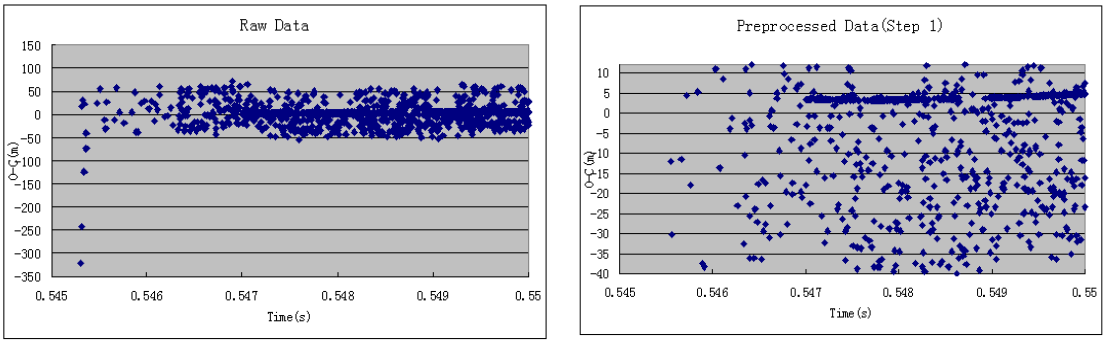
$$R_{\max New}=Max(0-c)-k_1\times\Delta R$$
$$R_{\min New}=Min(0-c)+(100-k_2)\times\Delta R \qquad (2\text{-}2)$$

The same method is used to cut on time series in scale. We can obtain the new time range. $T_{\max New}$ and $T_{\max New}$. At last, we obtain the new data range. In this range, the rate of signal to noise is very high, which is the prime indicator to realize automatic processing.

2. Application

In this part, we use the method in real data processing based on Beijing SLR station. Given a pass of BeaconC satellite as example.

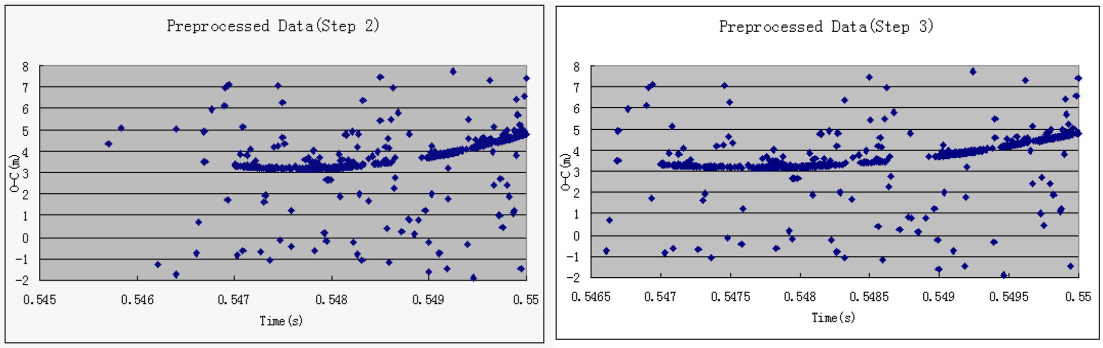
(1) Using CPF precision scope to eliminate large noise



(a) Raw data (b) After first step processing

Figure 3. First step processing based on ephemeris precision scope

(2) Filtering on O-C range and Time serial



(a) After filtering on Range (b) After filtering on Time

Figure 4. After second and third processing step

Conclusion

To improve the automation in SLR tracking work and data processing is the aim in the future. Data preprocessing is a necessary part in SLR station. How to realize its automation is a quite complex problem, for there are lots of differences in every pass of observation data. So it is difficult to find a simple and unified method for all data. We make lots of experiments on this problem and draw a conclusion that rate of signal-to-noise is the prime indicator during data preprocessing. And the method mentioned in this paper purposes an approach in data automatic preprocessing and can perform the function to a certain extent. In fact, we only process observation data if the rate of signal-to-noise is very low. So we must make deep scientific researchers on this problem and wish to find reliable and effective method.