

GPS接收机的校准及校准结果的不确定度评估

贺浩, 方郢龙

(湖北省测绘产品质量监督检验站, 湖北 武汉 430071)



摘要: 根据实际校准GPS接收机的经验, 通过对GPS接收机的校准方法进行深入研究, 结合实例, 对校准过程中遇到的各种问题进行了分析探讨。

关键词: GPS接收机; 校准; 测量误差; 不确定度

中图分类号: P245

文献标志码: B

文章编号: 1672-4623 (2011) 03-0168-02

1 全球定位系统简介

全球定位系统(GPS)主要由三大部分组成,即空间星座部分、地面监控部分、用户设备部分-GPS信号接收机。空间星座部分和地面监控部分是用户应用该系统进行导航和定位的基础。用户只有通过用户设备(GPS接收机)才能实现应用GPS进行测量和导航、定位的目的。根据使用目的的不同,用户要求的GPS接收机也各有差异。目前GPS接收机按用途分为测地型、导航型和授时型。

2 GPS接收机校准方法

对GPS接收机进行计量校准,是测绘部门为经济建设提供可靠测绘保障不可缺少的一项重要工作。在GPS接收机校准过程中,主要按照《全球定位系统(GPS)接收机(测地型和导航型)校准规范》(以下简称《校准规范》)JJF1118-2004执行的。以下以徕卡4台套GS15测地型GPS接收机为案例,对如何校准静态测量GPS接收机进行技术探讨。

2.1 工作准备

按照《校准规范》要求,客户校准仪器必须携带有关电缆(数据传输线、天线电缆、手簿线)、软件及软件狗、电池、充电器等附件。内业检查时,首先要调整好每一台接收机的基座,充好电池,按规定设定好GPS接收机的卫星高度角、采样率等参数。

2.2 野外数据的采集

室内检查是基础,外业GPS数据采集就是整个仪器校准工作的关键,数据的精度就直接是衡量接收机精度的指标。因此,外业数据采集必须严格按《校准规范》要求执行。外业数据采集又分以下两步进行:天线相位中心一致性检定和短基线及中长基线测量误差

检定。

1) 天线相位中心一致性检定。天线相位中心(Antenna Phase Center)是指微波天线的电气中心,其理论设计应与天线几何中心一致。天线相位中心一致性的检测主要是在湖北庙岭测绘仪器检定场的微网场地进行,将一台接收机放在超短基线网中心J09号观测墩上,其余3台放在边上任意3个观测墩上。首先,将4台GPS接收机的天线全部指北,观测一个时段;然后,固定中间的W007,另外3台接收机依次旋转90°、180°、270°,观测3个时段;最后,将外面3个GPS接收机天线的指北标志指北,再依次旋转J09观测墩的天线指向东、南、西方向分别观测3个时段。整个过程观测7个时段,每个时段观测1个小时。每个天线在不同方位下测定同一基线的变化指标 d ,按规范要求 d 应小于GPS接收机标称的固定误差。在外业检定工作中,检定人员必须严格记录测站点的相关信息,如接收机的天线号码、天线高、观测点名称、观测时段的起止时间、以及参考天线等。

2) 短基线及中长基线测量误差测量误差检定。短基线及中长基线测量误差测量误差检定采用基线比较法进行。用强制对中连接杆将仪器架在观测墩上,整平仪器,天线指北,用量高尺量取天线高,记录天线编号和观测墩的编号,短基线同步观测1h,中长基线根据距离长短同步观测2.5h-4h。在GPS数据采集前,必须保证仪器天线指向标准指北;观测过程要观察仪器电池的使用情况;另外,禁止在接收机附近使用手机。外业检定计划中,尽可能地避免在中午12点到下午2点这一太阳活动高峰期进行中长基线观测,这对后面内业的基线解算很有帮助。

3) 内业数据处理。数据采集完成后,使用随机软件将数据传输到电脑,在随机软件平台上进行GPS数

收稿日期: 2010-03-24

据处理。通过剔除观测时间过短的卫星、剔除周跳多的卫星,截去周跳多的时间段、剔除受多路径影响严重的观测值等方式解算得到最佳基线解。

天线相位中心一致性检定结果如表1所示。被检测仪器的标称精度为 $3\text{mm}+0.5 \times 10^{-6}$,天线相位中心一致性检定结果的最大变化量 d 为 1.8mm ,小于接收机的固定误差,该项检定合格。

表1 天线相位中心一致性检定结果表/mm

基线边	d
J09----W01	0.8
J09----W02	1.2
J09----W03	1.8
J09----W04	1.4
W01----J09	0.9

短基线($24\text{m} < D < 2000\text{m}$)及中长基线($2000\text{m} < D < 30000\text{m}$)测量误差检定结果如表2所示。中长基线各边的测量误差应满足:当基线长度 $D \leq 5\text{km}$ 时 $d \leq \sigma$;当基线长度 $D > 5\text{km}$ 时 $d \leq 2\sigma$;短基线边的测量误差应满足 $d \leq \sigma$, D 不足 500m 按 500m 计算。由表2可知此项目合格。

$$\sigma = \sqrt{a^2 + (bxD)^2}$$

式中, σ 为标准差,mm; a 为固定误差,mm; b 为比例误差,mm; D 为所测距离,km。

表2 中长基线误差表

基线边	D/km	di/mm	限差 σ /mm
J09----LJ19	11.975	1.9	$2\sigma=13.24$
J01----LJ19	11.751	2.2	$2\sigma=13.18$
J08----LJ19	10.266	-1.1	$2\sigma=11.90$
J01----J09	0.467	0.8	$\sigma=3.01$
J01----J08	1.104	1.3	$\sigma=3.05$
J08----J09	0.637	0.4	$\sigma=3.02$

校准结果不确定度的简略评定如下:

不确定度分量及计算:标准装置误差引入的不确定度分量 $u_1=1.0\text{mm}$;GPS接收机安置误差引入的不确定度分量 $u_2=0.06\text{mm}$;GPS接收机分辨率引入的不确定度分量 $u_3=0.29\text{mm}$ 测量误差引入的不确定度分量 u_4 。

u_4 的计算按测距误差 X_i 计算出算术平均值标准偏差

$$m = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (d_i - \bar{d})^2}$$

$$u_4 = m/2 = 0.60$$

式中, d_i 为各边的测量值与已知值之差; x_i 为测量误

差值的平均值; n 为测定边数。

合成标准不确定度

$$U_c = \sqrt{U_1^2 + U_2^2 + U_3^2 + U_4^2} = 1.2\text{mm}$$

$$\text{取 } t_p = t_{95}(\quad) = 1.96$$

$$U_{95} = t_{95}(\quad) \times U_c = 2.35\text{mm}$$

根据上面的公式最后算得本次校准结果的扩展不确定度为 2.35mm 。

4) 出具校准证书。仪器检定合格后,即可给用户出具校准证书。校准证书经批准人、校准员、核验员三人签字后盖上校准专用章即生效。

3 结 语

GPS接收机校准过程中,检定人员应注意如下关键问题:

1) 出野外采集数据前,一定要充好电或准备备用电池,检查机内数据和内存剩余量,同时检查要同步观测仪器的参数是否一致。

2) 严格记录开机时间,精确量取天线高,随时检查仪器工作状态,观测结束后要严格按照操作关机,每次观测完后应及时下载数据。

3) 内业数据处理时为保证基线解算结果的复现,要严格记录下使用的软件及版本、每个时段的起止时间以及处理中使用的参数以及其他人工干预信息。

4) 测量结果的质量(品质)是量度测量结果可信程度的最重要的依据。测量不确定度就是对测量结果质量的定量表征,测量结果的可用性很大程度上取决于其不确定度的大小。所以,测量结果表述必须同时包含赋予被测量的值及与该值相关的测量不确定度,才是完整并有意义的。

参考文献

[1] GB/T 18314-2001 全球定位系统(GPS)测量规范[S].
 [2] JJF 1118-2004 全球定位系统(GPS)接收机(测地型和导航型)校准规范[S].
 [3] JJF1059-1999 测量不确定度评定与表示[S].
 [4] 李文辉. 测量不确定度在工作中的应用[J]. 地理空间信息, 2007(5): 95-97
 [5] 胡景海. 测绘行业的质量管理[J]. 地理空间信息, 2007(5): 113-114

第一作者简介:贺浩,工程师,研究方向为测绘仪器检定测试。

Abstract Urgent monitoring of earthquake disasters need thematic maps of remote sensing. According to the distribution of the earthquake and the secondary disasters, classifications and coding of disaster information were analyzed. With the national basic scale topographic maps and thematic map symbols of the type, size, color etc separately defined at different scales, it was produced that thematic symbol library of the corresponding earthquake and secondary disasters. Meanwhile, standard for thematic maps of the disaster and the secondary disasters was formed. The templates met the cartography requirements of GIS applications, which can provide accurate disaster information and affected body quickly, and improved the mapping efficiency. It is useful to save time for the rescue and assure the earthquake relief work can be undertaken smoothly.

Key words earthquake, the secondary disasters, symbol database, mapping templates (Page:153)

Preliminary Understanding and Simple Analysis of Numerical Calculation Errors by LIU Ping

Abstract This paper introduced the classification of numerical calculation errors, and used math expressions as examples to illustrate truncation error. According to IEEE754 criterion, this paper used math expressions to explain rounding error. Then this paper simply analyzed the truncation error and rounding error. At last, this paper pointed out attentions in the numerical calculation.

Key words numerical calculation, calculation errors, preliminary understanding, simple analysis (Page:156)

Application of the Second Land Investigation's Result to Daily Land and Resources Management by XU Yong

Abstract This paper introduced the basal informations, technical route, investigating methodology and investigation's result of the WUHAN Second Time Land Investigation, and discussed the applying of the Second Time Land Investigation's result based on the daily Land and Resources Management's requirement.

Key words land investigation, land management, cadastral management (Page:159)

Method for Prediction of Landslide by Phase Space Reconstruction by XIONG Tianan

Abstract In view of the nonlinear characteristics of landslide displacement time sequence, this paper introduced the prediction method based on phase space reconstruction and least squares support vector machine (LSSVM). Used Cao's method to determine the embedding dimension, according to mutual information method to compute the best delay time; Then in the phase space, used least squares support vector machine (LSSVM) to establish the forecast model to compared with LSSVM and the neural network predicting mode. The test result show that the model has the high precision, is scientific and feasible.

Key words predictable mode; landslide prediction; phase space reconstruction; least squares; neural network (Page:162)

Application of SET 1X Total Station Device to Tunnel Through Survey by CHEN Sansheng

Abstracts Combined with the application in Pusagang tunnel through survey of Yalu Highway of SET 1X total station device, elaborated the adoptive ways and technical measurements of tunnel through survey so as to make sure the accurate perforation of the tunnel.

Key words total station device, Pusagang tunnel, perforation survey, control survey (Page:165)

Evaluation of Uncertainty of GPS Receiver Calibration and Calibration Results by HE Hao

Abstract Based on the actual calibration GPS receiver's experience, through the GPS receiver calibration method of in-depth research, with

practical examples, the calibration process problems encountered were analyzed and investigated

Key words GPS receiver, Calibration, measuring error, uncertainty (Page:168)

Establishment of Monitoring Data Processing and Analysis System with Excel VBA Programming by ZHU Xingang

Abstract Excel is popular office software which we often use at work. Excel itself provides a strong secondary development function, VBA, which has powerful programming capabilities. This article described how to use Excel VBA to create a complete deformation monitoring system to realize simple, rapid, accurate and automated monitoring job.

Key words Excel, VBA, deformation monitoring data processing and analysis system (Page:170)

Application of Robotic Total Station in Volume of Vertical Metal Cans by ZHU Lianghua

Abstract The application of robotic total station in volume surveying of vertical metal cans was introduced in this paper. The surveying preparation work, fieldwork, data processing and key technology were discussed detailed combining an example.

Key words total station, vertical metal cans, volume surveying (Page:173)

Matlab and Visual C++ Mixing Programming to Process the Data of the South Total Station by HU Jiaying

Abstract During the indoor work data checking, we often compared the point's field work coordinate with its indoor work coordinate. So we could find if there be some points were artificial, or some points had been moved. At the same time, the processed data could direct provide the three dimension coordinate, it was helpful for the next measure work. This article took the South total station instrument for example, based on matlab and Visual C++ mixing programming to generate the directly executable file, which could separate from the MTALAB environment, then gave the code and the images of the result.

Key words MTALAB, hybrid programming, data processing (Page:175)

Research of Teaching Content in Digital Surveying & Mapping by MENG Fanchao

Abstract Based on the production units of the engineering survey mapping and technical personnel needs, and for "Digital Mapping" characteristics of the course to a topographic mapping of the main line to explore the teaching content and practice, through the constant adjustment and reform to improve Higher engineering professional teaching quality measurement techniques, enhanced their ability and employability and competitiveness.

Key words Digital Surveying & Mapping, teaching, research (Page:178)

Strengthening the teaching of surveying error theory for GIS by ZHAO Dongbao

Abstract Surveying error analysis and treatment is the basic theory which lay a solid foundation for students majored in GIS studying surveying courses, and is also the key to understand surveying principle of various surveying courses. Aiming at the problem that many colleges lacked the uniform plan for surveying error theory course teaching for GIS major students, teaching contents of surveying error theory course for GIS major students were discussed, and teaching schedule was arranged based on characteristic of surveying error theory teaching, and teaching methods of surveying error theory course for GIS major students were listed according to related teaching experience.

Key words GIS major, surveying error theory, teaching contents, teaching method (Page:180)