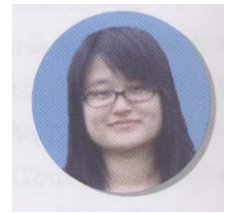


GNSS 差分协议校验方法的比较

申丽丽, 郭际明, 王磊, 向巍
(武汉大学 测绘学院, 湖北 武汉 430079)



摘要: 详细的比较了4种常见的差分协议所用到的校验方法的异同, 其中RTCM2.3采用的是奇偶校验的方法, RTCM3.0采用的是循环冗余检验方法, 而CMR和CMR+采用的则是数据块之和模256这样的方法。通过算例以及理论分析, 从校验方法的编码效率、容错率等方面对其进行比较分析。

关键词: RTCM; CMR; 奇偶校验; 循环冗余校验

中图分类号: P228.42

文献标志码: B

文章编号: 1672-4623 (2011) 01-0082-03

近年来, 随着城市的快速发展, 我国近20个省市相继建立了连续运行参考站系统(CORS系统)。CORS系统的数据处理中心在接收到基准站和流动站发送过来的数据之后, 生成RTCM/CMR的数据流, 并播发给用户。流动站与基准站以及控制中心之间的通讯数据链在系统中起着关键性作用, 因为数据链是否有效可靠决定了系统是否有效可靠, 而差分协议是数据链中很重要的一部分。决定数据传输效率、检错率的一个决定性因素就是数据传输协议中的校验方法, 一个好的校验方法能够在传输的过程中充分利用带宽传输数据, 并在数据出错的情况下检测出来, 并加以改正。本文正是针对目前常用的GNSS差分改正信息的数据传输协议的校验方法进行比较分析。

1 常见的差分电文格式校验方法

随着差分GPS的不断发展, 国际不同的组织制定了多种标准差分协议, 常用的差分协议主要包括RTCM差分协议和CMR差分协议。RTCM差分协议是由国际海运事业无线电技术委员会成立的SC-104委员会制定的, 目前经常应用的有RTCM2.3、RTCM3.0两个版本。RTCM2.3使用的校验方法是奇偶校验方法, 而RTCM3.0使用的是循环冗余校验方法。CMR差分协议是由Trimble公司制定的专门用于RTK的差分协议, 它适用于低带宽的通讯链的情况, 目前经常应用的有CMR和CMR+两个版本, 而它们的校验方法相同。

1.1 RTCM2.3 差分电文格式校验方法

RTCM2.3采用奇偶校验的方法, 但是它不是单纯的奇偶校验, 这与很多文章中提到的关于RTCM2.3的奇偶校验是普通的奇偶校验是不一样的, 它遵从(32, 26)汉明码检错准则, 汉明校验矩阵为H, 校验公式

为: $S6 \times 1 = H6 \times 24 \quad M24 \times 1$, 式中 $M24 \times 1$ 为电文中每个字码的前24位信息位, 如下所示^[1]。

$$\begin{aligned}
D1 &= d1 \quad D^*_{30} \\
D2 &= d2 \quad D^*_{30} \\
D3 &= d3 \quad D^*_{30} \\
&\dots \\
D24 &= d24 \quad D^*_{30} \\
D25 &= D^*_{29} \quad d1 \quad d2 \quad d3 \quad d5 \quad d6 \quad d10 \quad d11 \\
&\quad d12 \quad d13 \quad d14 \quad d17 \quad d18 \quad d20 \quad d23 \\
D26 &= D^*_{30} \quad d2 \quad d3 \quad d4 \quad d6 \quad d7 \quad d11 \quad d12 \\
&\quad d13 \quad d14 \quad d15 \quad d18 \quad d19 \quad d21 \quad d24 \\
D27 &= D^*_{29} \quad d1 \quad d3 \quad d4 \quad d5 \quad d7 \quad d8 \quad d12 \\
&\quad d13 \quad d14 \quad d15 \quad d16 \quad d19 \quad d20 \quad d22 \\
D28 &= D^*_{30} \quad d2 \quad d4 \quad d5 \quad d6 \quad d8 \quad d9 \quad d13 \\
&\quad d14 \quad d15 \quad d16 \quad d17 \quad d20 \quad d21 \quad d23 \\
D29 &= D^*_{30} \quad d1 \quad d3 \quad d5 \quad d6 \quad d7 \quad d9 \quad d10 \\
&\quad d14 \quad d15 \quad d16 \quad d17 \quad d18 \quad d21 \quad d22 \quad d24 \\
D30 &= D^*_{29} \quad d3 \quad d5 \quad d6 \quad d8 \quad d9 \quad d10 \quad d11 \\
&\quad d13 \quad d15 \quad d19 \quad d22 \quad d23 \quad d24
\end{aligned}$$

其中, $d1, d2, d3, \dots, d24$ 是原始的数据信息; D^*_{29}, D^*_{30} 是前一个字的最后两位; $D25, \dots, D30$ 是计算的奇偶校验位; $D1, D2, \dots, D29, D30$ 是最终发送的信息。表示模2和, 或者异或运算。

为了满足信息位(24 bit)的要求, 将(32, 26)汉明码缩短, 去掉两位信息位构成(30, 24)缩短码。这种缩短码的纠错能力和最小距离与原码相同。这种校验方法的原理是在一组代码中采用几位校验位, 使每一位信息都参加几组不同成员的奇偶校验。若某一位信息出错, 则会引起有关的几组奇偶校验结果都出错。于是, 根据哪些组出错, 就可以确定出错信息的

位置,从而进行自动纠正。RTCM2.3 电文中,每 30 bits 最后 6 bits 都是奇偶校验位,后面的 6 位是根据前面的 24 位以及上一个字的最后两位得到的。首先获得上一电文中的最后两位 D_{29}^* , D_{30}^* , 然后如果 D_{30}^* 为 1 则 1-24 位取补码,为 0 则不变,根据得到的 24 位数据以及 D_{29}^* , D_{30}^* 代入到表 1 中进行计算,如果计算的结果与数据中的校验码相同,则通过校验,否则,校验没有通过,数据出错。校验流程如图 1 所示。

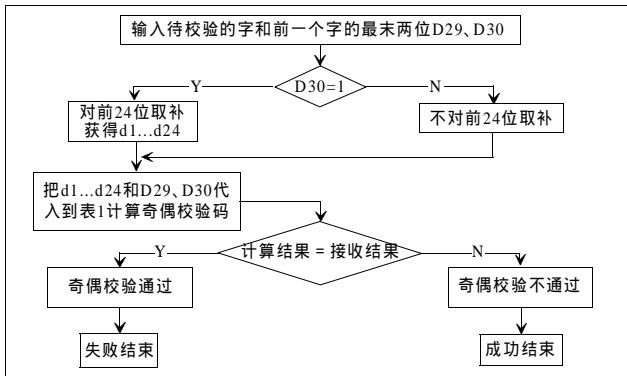


图 1 奇偶校验流程图

1.2 RTCM3.0 差分电文格式校验方法

迫于 Trimble 公司已经制定了 CMR 这一压缩格式的压力,RTCM SC-104 委员会制定了 RTCM3.0 版本的数据协议。RTCM3.0 采用的是 24 位循环冗余校验(CRC)规则,是数据通信领域中最常用的一种差错校验码,它与之前的奇偶校验有很大不同。它是利用线性编码理论,在发送端根据要传送的 k 位信息码,以一定的规则产生一个 24 位的校验码,并附在信息码后面作为校验码一个发送出去。而在接收端则根据信息码和校验码之间的规则进行校验,以确定得到的是否是所需要的信息码。在代数编码理论中,将一个码序列表示成一个多项式的形式,码序列中各码元当作多项式的系数。例如 110010 表示为 $1gx^5 + 1gx^4 + 0gx^3 + 0gx^2 + 1gx^1 + 1gx^0$

$$\text{即 } x^5 + x^4 + x + 1$$

CRC 校验的信息字段是从导言开始到可变长度信息字段结束,标准给定的生成多项式为

$$g(x) = (1+x)p(x)$$

$p(x)$ 是简单不可约分的多项式

$$p(x) = x^{23} + x^{17} + x^{13} + x^{12} + x^{11} + x^9 + x^8 + x^7 + x^5 + x^3 + 1$$

设 $m(x)$ 为 k 位信息字段所组成的二进多项式, $m(x)$ 的最高幂次为 $k-1$ 。发送方以 $g(x)$ 去除 $m(x)x^{24}$ (即对应的信息码序列左移 24 位),得到余式 $r(x)$,把此余式的系数作为 CRC 校验码附加到信息码后面,就得到了一个能被 $g(x)$ 整除的码多项式 $C(x)$ 。即

$$C(x) = m(x)x^{24} + r(x) = q(x)g(x)$$

式中, $q(x)$ 为商式。解码时,将 $C(x)$ 除以 $g(x)$,余数为 0 则证明这段信息有效,否则为无效。

1.3 CMR、CMR+电文格式校验方法

CMR、CMR+差分协议是 Trimble 公司制定的专门为网络 RTK 服务的协议标准。主要是针对 RTCM 格式的码发送率必须高于 4 800 b/s 这一不足之处而制定的,CMR、CMR+的码发送率只有 RTCM 的一半,即 2 400 b/s。

CMR+是对 CMR 的改进,CMR、CMR+的校验方法相同。CMR 和 CMR+的校验非常简单,它只负责一部分校验,在数据链层会提供足够的差错检验来保证信息的正确性。这部分的校验只是把 Status、Type、Length 以及 Data Block 部分每个字节的和模 256,如果结果为 0 则通过检验,否则不通过。

2 GNSS 差分信息电文格式校验方法算例验证

笔者编程实现了对 RTCM2.3、RTCM3.0 以及 CMR+的编码以及解码,用来比较各种校验方法的区别。笔者通过实验分别获取了采用 3 种差分数据格式传输的数据,如下所示:

RTCM2.3: 66 41 7F 7F 72 76 67 57 7B 63 5F 6A 43 50 73 67 60 73 65 6E 45 48 75 45 5E 4D 51 45 52 49 66 59 56 7E 4A 75 4D 4D 7D 63 62 6B 4F 45 76 6F 59 76 7E 4A 72 4D 4D 64 63

RTCM3.0: D3 00 13 3E D7 D3 02 02 98 0E DE EF 34 B4 BD 62 AC 09 41 98 6F 33 36 0B 98^[3]

CMR+: 02 00 94 0a 0d 01 08 15 10 99 f8 c6 00 00 30 03 02 00 94 0a 0d 02 08 b7 b7 ef 44 40 00 3b d1 03 02 00 94 0a 0d 03 08 3d 69 2e 00 00 0b 03 98 03

以上 3 段电文传递的信息是相同的,即同一个虚拟参考站在地心地固坐标系下的坐标 X, Y, Z。

RTCM2.3 采用 Type3 和 Type22 这两帧数据传递这一个坐标,在 RTCM2.3 中 Type3 表示的是虚拟参考站的地心地固坐标,精确到小数点后厘米,而 Type22 则是表示坐标的厘米以后的尾数,精确到 1/256 cm。RTCM3.0 仅用了一个字段,即 1005 字段来传递,它用 38 bits 来表示一个坐标,精确到 0.1 mm。CMR+采用三个子页,即 1,2,3 子页来表示,用 34 bits 来表示一个坐标,精确到 1 mm。

在上述的数据例子中,RTCM2.3 完整的表示 VRS 的坐标共需要 55 字节,前 30 个字节为 Type3,后 25 字节为 Type22,每四个字节校验一次,即第 5,10,15,20,25,30,35,40,45,50,55 字节用于校验,校验位占 11 字节;RTCM3.0 表示 VRS 坐标共需要 25 字节,

固定的校验码长度为 24 bits，跟随在信息位之后，本例中第 23,24,25 字节用于校验，校验位仅占了 3 字节；而 CMR+表示同样的信息需要 48 字节，每 16 字节为一个子页，每页的倒数第二个字节为校验位，即第 15,31,47 字节用于校验，校验位总长度为 3 字节。

3 GNSS 差分信息电文格式校验方法的比较

根据编码原则， $k+r=n$ ， k 为信息码， r 为校验码， n 为发送的码组，信道的传输效率即编码效率 $R=k/n$ ，则 RTCM2.3 的编码效率 R_1 为 80%，RTCM3.0 的 1005 字段的编码效率 R_2 为 88%，而 CMR+的编码效率为 R_3 为 93.75%。所以从编码效率上看， $R_3>R_2>R_1$ ，即 CMR+的编码效率最高，RTCM3.0 次之，RTCM2.3 最低。

RTCM2.3 采用的校验方法符合汉明码检错准则，它的各个校验位并不是独立存在的，但是当特定信息位同时改变时，此时校验可能会通过，而数据却是错误的，比如用自编程序验证当信息位第 5、10、15、24 位同时改变时，奇偶校验通过。但是出现这样错误的概率为百万分之一，所以奇偶检验还是可以满足应用的要求。

RTCM3.0 采用的 CRC 校验固定了校验码的长度为 24 位，它既能检测出每个字的 1 位误码，也能检测出 2 位误码，还可以 100%的检测出所有奇数个随机错误和长度小于等于 24 位的突发错误，当突发错误的长度 b 大于 24 时，未能检测率为 2^{-24} ($b>25$ bits) 或者为 2^{-23} ($b=25$ bits)。RTCM3.0 比 RTCM2.3 节省带宽，编码效率至少高了 8%，而且校验方法的容错率明显高于 RTCM2.3，所以 RTCM3.0 比 RTCM2.3 更能满足应用要求。

CMR、CMR+采用的校验方法相对简单，只要 Data Block 位改变之后每个字节之和是 256 的整数倍，那么校验就可以通过。它可以检测出 1 位误码，检错率不高，所以需要数据链提供额外的、足够的数据差错检验机制，以确保接收到的信息内容是有效的。

用户在实际应用时，可以根据不同的要求采用不同的数据传输协议，总体来说，RTCM3.0 与 RTCM2.3 相比，无论从数据传输效率、编码效率以及容错率方面都要好，而 CMR、CMR+在数据传输效率上比 RTCM 高，但是它们的容错率没有 RTCM 好，所以可以根据带宽以及数据质量的好坏决定使用哪种数据传输协议。

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第一作者简介：申丽丽，硕士，研究方向为大地测量学与测量工程。



(上接第 81 页) 程度了实现了空间要素批量融合的智能化处理，改进了现有的其他要素融合方法，弥补了目前商业软件针对此类问题处理的不足。特别是批量要素融合时，使用此方法优势更为明显。

该方法的不足之处在于，对于跨越多幅图的同一地理要素，如江河、公路等，经过多次融合后，导致构成该面的点集合过大，在判断位置接边时，增加了算法的计算次数，影响了整体效率。如何提高跨多幅图要素的融合速度，是今后主要努力方向。

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第一作者简介：吕志勇，硕士，助理工程师，主要从事研究空间数据处理、GIS 软件工程、GIS 理论与算法分析及应用系统开发。

Comparison of Parity Algorithms for Differential GNSS Data Transmission Standards

by Shen Lili

Abstract This paper compared the differences in the 4 common standard's parity algorithm. RTCM2.3 took the Parity Check as parity algorithm, and RTCM3.0 took the Qualcomm CRC algorithm as parity algorithm, while CMR and CMRPlus used the sum of data blocks to mode 256 as parity algorithm. The author analyzed parity algorithms from coding efficiency and fault-tolerance efficiency by examples and theory analysis.

Key words RTCM, CMR, parity check, qualcomm CRC algorithm

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Key Technologies of 3D Large-Scale Urban Architecture in GIS

by Zhou Jingfei

Abstract The paper presented the cost-effective methods of building 3D modeling based on geographic information systems through analyzing and concluding the characteristics of GIS technology and 3D modeling. That was using Google SketchUp for building 3D modeling, and the modeling will be implanted in ArcGIS system by using ArcGIS software interface, to construct 3D application modules of large-scale of the urban architecture, which can achieve 3D application and view; also focused on the structured approach of the establishment of 3D application modules, 3D file organization and management, as well as the details of 3D data efficiently handle cache technology.

Key words 3D, ArcGIS, Sketchup, optimization model, data cache

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Design and Implementation of the Fundamental Geographic Information System Based on ArcEngine

by Zhu Zhenhua

Abstract This paper described features of ArcEngine technology for developing fundamental GIS softwares which focused on the realizations of some specific functions, including query, buffer analysis and annotation varying with the zoom of the map.

Key words comGIS, fundamental geographic information system, the third control ArcEngine, .NET

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Research on the Fire Evacuation in a Three-dimensional Dormitory Built in the STEPS

by Tang Tao

Abstract A three-dimensional model was established in the software STEPS. In this model, we should find the hithermost emergency exit to simulate the population evacuation and keep the number of people at every period of time and the total time recorded at the same time. Then, on that basis, we could study how the firing floor, the location and number of the spare exits, the reaction time consistency of the students and that whether the evacuating population bear precious goods and briefcases or not have a influence on the final evacuation time.

Key words STEPS, Fruin distribution, time of evacuation, normal distribution

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Simplified 4-Intersection-Difference Model of Topological Relations in GIS

by Xie Junping

Abstract The description of topological relations, which is in line with cognition concepts of human, is one of the main contents in the special relations and plays important roles in spatial data inquiry and mining. First, we reviewed the current existing models. Subsequently, we analyzed 4-intersection-difference model and set up a simplified 4-intersection-difference model. In addition, we made detailed analysis on the rationality of simplified 4-intersection-difference model. At last, we prospected related research work on simplified 4-intersection-difference model.

Key words topological relations, line objects, area objects, 4-intersection-difference model, simplified 4-intersection-difference model

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Application of Mobile GIS to Urban Planning

by Huo Junwei

Abstract At present, there is a series of question in urban planning actuality data acquisition. For example, inaccuracy, no standard, long acquisition cycle and so on. I had designed one from map downloading, the data acquisition to the data updating actuality data acquisition flow and developed the actuality data acquisition system. It realized map downloading, data acquisition, spatial inquiry, spatial analysis and so on by interacting with server. It also simplified the actuality data acquisition flow and raised the data acquisition efficiency.

Key words urban planning, Mobile GIS, information acquisition

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Application of GIS to Converting Cultivated Land to Forest in Gongshan, Nujiang

by Song Qiaoying

Abstract Reforest the cultivated land is one of the essential project for protecting the ecological environment as well as soil and water conservation. At the

same time, it's an important way to improve ecological environment and promote sustainable economic development in the region. The states social and economic development was restricted by the remote terrain, natural and man-made factors and eco-environmental degradation of the. By using GIS technology, combined with the principle of converting cultivated land to forest and with the research method of spatial analysis, this paper did overlay analysis for data, such as land use, slope, river and so on. It resulted in acquiring the areas of converting cultivated land to forest and investigating its timing and Forest distribution. At last determine the key area of converting cultivated land to forest. An investigation showed that need the areas of 2184.78 hm² for converting cultivated land to forest above 25 of slope in Gongshan, and the scope of the key area of Converting Cultivated Land To Forest is 479.31hm².

Key words GIS, Gongshan County Nujiang, converting cultivated land to forest

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Characteristics Analysis of the Relationship between the Landuse Pattern and the Terrain in Guangxi North-west Based on DEM

by Zhao Ling

Abstract The thesis took the duan town as the example, based on DEM data, land use map and other materials from field survey, the study analyzed the spatial pattern of land use and the relationship between land use and topography in the research zone by creating DEM, geomorphologic zoning and altitude classification. The results showed that, spatial distribution of land use types was characterized by strong area differentiation. Even though it was the same land use type, the spatial distribution was diversified in different geomorphologic sub-area and altitude sub-zone. With the rise of altitude, the area of residence land decreased, but the area of woodland and drought land increased before and then decreased after, the bare land also the main type of land utilization.

Key words Digital Elevation Model, geomorphologic zoning, landuse characteristics

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Application of LINQ to Soil and Water Conservation Management System

by Luo Wanbo

Abstract The paper introduced framework and principles of .NET Language Integrated Query, and used it to achieve multiple types of data query statistics of the Soil and water conservation management system. It showed that LINQ technology provides simple and effective data access methods for developers by analysis of and using of the examples.

Key words GIS, LINQ, soil conservation management system, .NET3.5

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Remote Sensing Image Classification Utilizing K-means and SOM

by Zhang Tao

Abstract A method of multispectral remote sensing image classification was discussed in the paper, which utilized K-means and SOM neural network. The comparison experiments with K-means, ISODATA and SOM verify the validity of the method.

Key words remote sensing image classification, neural network, self organizing map, K-means

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Analyzing Expansion of Urban Land Area Based on RS and GIS

by Dai Liang

Abstract Based on the SPOT image of Cixi city in 2006 and the data of land alter-surveying in 1990, spatial patterns and temporal variation of land use change were analyzed. Some analytical indexes such as the land-use dynamic degree model, transfer matrix, growth intensity index were introduced to describe the spatial differentiation of urban land expansion. The research showed that there was a rapid growth of urban land use while significant differences in land use among regions. The urban construction land was increasingly expanding by massively occupying arable land. Centers of growth are concentrated on the central city as well as regions adjacent to the city.

Key words remote sensing, GIS, urban land use, extended analysis, Cixi city

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Research on Application of LIDAR Technology in Vehicles Detection and Intelligent Traffic Signal Controlling

by Hu Zhaohui

Abstract The urban traffic intersections are usually the focus and nodus of the traffic management. As the advantage of the simple installation and access to the rich-information and easy maintenance, the traditional traffic flow information detection system based on image processing and Pattern Recognition has been the main trends of the traffic detection. However, there are many shortcomings in practice. This paper proposed a new vehicle detection to detect the traffic flow by the LiDAR to get the point cloud data of the vehicles flow, which could help the traffic signal control system adapt to the different traffic flow and