L2C 码与 L2 载波数据质量分析

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摘　要：基于 IGS 的 L2C 信号跟踪站数据验证了具有 L2C 码的卫星的 L2 载波的信噪比高于没有 L2C 码的卫星的 L2 载波的信噪比，L2 载波恢复的数据质量更好。针对不同的接收机，对比分析了 C/A 码和 L2C 码多路径效应及观测噪声水平，发现对 TRIMBLE NETRS 接收机，L2C 码误差水平明显高于 C/A 码，与期望结果相反。

关键词：GPS 现代化；L2C 码；信噪比；多路径效应

中图分类号：P228.41　　**文献标志码**：B　　**文章编号**：1672-4623（2011）02-0075-03

GPS 现代化的一个主要措施是在 L2 频道上增加第二民用码，即 L2C 码，其应用意义主要有：①保证高精度用户可以直接获取 L2 信号而不是微弱的半波长跟踪技术，信号强度将得到大大提高[1]；②L2 载波上调制 L2C 码可以更好地消除电离层延迟误差，具有更强的信噪比以及更低的多路径效应影响[2]。目前，能发送 L2C 码信号的卫星达到 6 颗，IGS 也组织成立了 L2C 信号跟踪站网络。现已有国内外学者开展了 L2C 码方面的研究工作[3-5]。本文基于 IGS 的 L2C 信号跟踪站数据，对 L2C 码及 L2 载波数据质量进行了分析。

1　L2C 码观测数据采集

从 2005 年 9 月 26 日，第一颗现代化的 Block IIR-M 卫星（PRN 17）发射上天到现在，能发送 L2C 码信号的卫星达到 6 颗，分别是 7 号、12 号、15 号、17 号、29 号和 31 号。GPS 接收机生产商，比如 Trimble、NovAtel、Septentrio、Leica 以及 Topcon 等随之研发生产了不同型号可跟踪 L2C 信号的接收机。同时，IGS 也组织成立了 L2C 信号跟踪站网络。表 1 列出了部分主要跟踪站的站名及所用接收机型号[6]。

表 1　L2C 信号部分主要跟踪站的站名及接收机类型

站名	接收机类型
ALIC	LEICA GRX1200GG
UNAC	Trimble NETRS
XMIS	LEICA GRX1200GG
DAVR	Trimble NETR5
FAIC	Trimble NETRS
UNB3	Trimble NETR5
GANP	Trimble NETR5
MCMC	Trimble NETRS

2　比（SNR）试验分析

传统 L2 载波只调制了结构未公开的 Y 码，不能采用码相关法来恢复 L2 载波，而采用平方法，得到 L2 载波的信噪比较差。L2C 码主要优势是保证高精度用户可以直接获取 L2 信号而不是微弱的半波长跟踪技术，信号强度将得到大大提高。

以 2008 年随机选取的三天数据对比分析，很容易验证上述结论。以 UNAC 站 2008 年 8 月 15 日的观测数据为例，图 1 和图 2 分别为所有卫星 L1 和 L2 载波 SNR 值。很显然，各卫星 L1 载波 SNR 值整体优于 L2 载波，而图 2 中现代化卫星的 L2 载波信号强度（SV7、12、15、17、29、31）则高于其他卫星的 L2 载波信号强度。

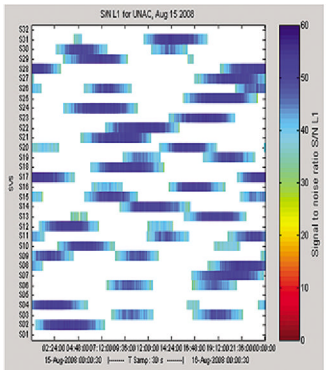

图 1　UNAC 站各卫星 L1 载波的 SNR 值

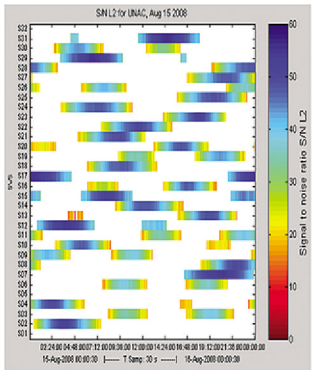

图 2　UNAC 站各卫星 L2 载波的 SNR 值

L1 载波的 SNR 值变化范围为 25.25 ～ 55.25dB-Hz，如表 2 所示，其中约 97%在 35 dB-Hz 以上。一般卫星的 L2 载波 SNR 值最高为 52 dB-Hz，最低只有 14 dB-Hz，而且仅一半观测值达到 35 dB-Hz 水平。现代化卫星 L2 载波的 SNR 值变化范围为 28.5 ～ 56dB-Hz，其各项水平还略高于 L1 载波。

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表 2 所有卫星的 L1、L2 载波 SNR 值统计表

	L1	L2	现代化 L2
≥30 dB-Hz	99.8%	64.4%	99.9%
≥35 dB-Hz	96.9%	49.0%	98.5%
≥40 dB-Hz	78.8%	33.9%	84.7%
≥45 dB-Hz	54.7%	19.7%	58.7%
≥50 dB-Hz	28.5%	1.2%	35.9%

3 L2C 码多路径效应及观测噪声误差分析

3.1 理论方法

电离层延迟、多路径效应、接收机噪声是影响数据质量的主要因素，其中多路径效应是最为复杂的。由文献[7]的理论推导，我们同样可以通过 L2C 码及 L1、L2 双频载波测量形成无几何相关、无电离层影响的线性组合方式得到L2C码的多路径效应及观测噪声误差，公式如下：

$$MP_1 = mp_{p_1} + noise_{p_1} = p_1 - 4.0915\Phi_1 + 3.0915\Phi_2 + [4.0915(\lambda_1 N_1 + mp_{\Phi_1} + noise_{\Phi_1}) - 3.0915(\lambda_2 N_2 + mp_{\Phi_2} + noise_{\Phi_2})] \quad (1)$$

$$MP_2 = mp_{p_2} + noise_{p_2} = p_2 - 5.0915\Phi_1 + 4.0915\Phi_2 + [5.0915(\lambda_1 N_1 + mp_{\Phi_1} + noise_{\Phi_1}) - 4.0915(\lambda_2 N_2 + mp_{\Phi_2} + noise_{\Phi_2})] \quad (2)$$

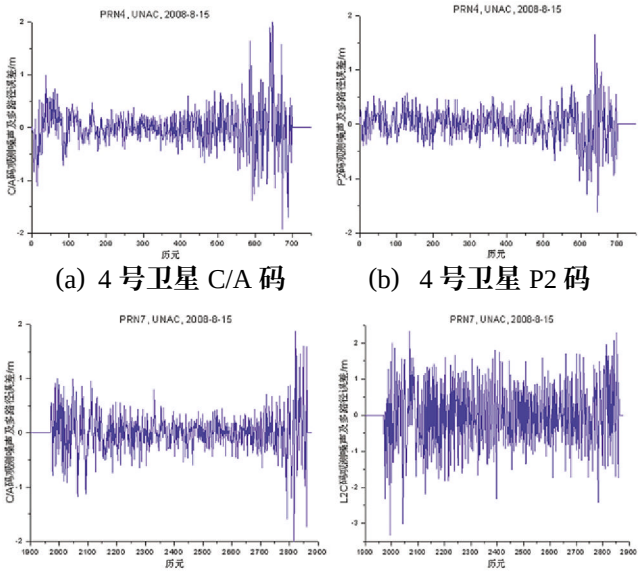
上两式中，λ_1、λ_2 为双频载波波长；p_1、p_2 为双频伪距观测值；Φ_1、Φ_2 为双频载波相位观测值；N_1、N_2 为整周模糊度；mp_p、mp_Φ分别为伪距和载波相位观测值的多路径效应；$noise_p$、$noise_\Phi$分别为伪距和载波相位观测值的观测噪声。

若无周跳发生，则 $4.0915\lambda_1 N_1 - 3.0915\lambda_2 N_2$，$5.0915\lambda_1 N_1 - 4.0915\lambda_2 N_2$ 为常量，而 mp_Φ、$noise_\Phi$远小于 mp_p、$noise_p$。因此，Mp_1、Mp_2 主要是伪距的多路径效应和观测噪声的影响。实际应用中，每 50 个历元的计算结果求平均值作为上述中整周模糊度构成的常量，然后减去该常量则得到 Mp_1、Mp_2 的最终结果。

3.2 试验及结果分析

针对不同的接收机，本文选取 ALIC、UNAC、UNB3 三个站从 2008 年 8 月 15 日到 21 日的数据进行分析。每个站观测数据 24 h，采样率 30 s。3 个站点不同接收机的观测值类型均为：L1、L2、C1、C2、P2、S1 和 S2，其中 C2 即为 L2C 码观测值。由表 1 可知，ALIC、UNAC、UNB3 三个站的接收机类型分别为 LEICA GRX1200GG、TRIMBLE NETRS 和 TRIMBLE NETR5。

选取 4 号、14 号以及现代化 7 号、17 号卫星，分析其 C/A 码、P2 码或 L2C 码的观测噪声及多路径效应水平，如图 3 所示。各卫星 C/A 码、P2 码或 L2C 码的观测噪声及多路径效应水平的标准差列于表 3。



(a) 4 号卫星 C/A 码 (b) 4 号卫星 P2 码

(c) 7 号卫星 C/A 码 (d) 7 号卫星 L2C 码

图 3 4 号和 7 号卫星的 C/A 码、P2 码或 L2C 码观测噪声及多路径效应水平

表 3 各卫星 C/A 码、P2 码或 L2C 码的观测噪声及多路径效应水平的标准差

	PRN 4		PRN14		PRN7		PRN17	
	C/A	P2	C/A	P2	C/A	L2C	C/A	L2C
STD	0.402	0.310	0.493	0.347	0.370	0.822	0.390	0.814

由表 3 可以看出，7 号和 17 号卫星的 C/A 码观测噪声及多路径误差水平略小于 4 号和 14 号卫星，通过比较卫星高度角可以知道，这是因为前者卫星观测高度角略高于后者卫星。令人意外的是，7 号和 17 号卫星的L2C码观测噪声及多路径误差水平远高于C/A码，与期望中的两者水平基本差不多的结果相反。Liliána Sükeová 等人（2007）对 Trimble R7 接收机也指出了相似现象。出现这种结果的一种解释是与接收机硬件捕获 L2C 信号技术有关，为此，对 3 个测站上不同接收机分析 7 号、17 号和 29 号卫星的 C/A 码和 L2C 码的观测噪声及多路径效应水平，其标准差总结列于表 4。由表 4 可知，对LEICA GRX1200GG和TRIMBLE NETR5接收机，C/A 码和 L2C 码观测噪声及多路径误差的标准差大致相同，表明两者观测噪声和多路径影响水平基本一样，符合期望结果。而 TRIMBLE NETRS 接收机由于在捕获 L2C 信号时未采用 TRIMBLE 接收机的多路径缓解算法 Everest，另外也存在一些残留的捕获问题增加了L2C信号的观测噪声[8]，从而产生上述结果。

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表 4　不同接收机捕获 C/A 码和 L2C 码的观测噪声及多路径效应的标准差

站点名	接收机类型	PRN7		PRN17		PRN29	
		C/A	L2C	C/A	L2C	C/A	L2C
UNAC	TRIMBLE NETRS	0.370	0.822	0.390	0.814	0.374	0.812
ALIC	LEICA GRX1200GG	0.234	0.184	0.275	0.283	0.199	0.175
UNB3	TRIMBLE NETR5	0.372	0.396	0.245	0.336	0.368	0.378

4　结　语

通过 IGS 的 L2C 信号跟踪站数据的试验与分析，可以得到以下结论：

1）具有 L2C 码的卫星的 L2 载波的信噪比高于没有 L2C 码的卫星的 L2 载波的信噪比，L2 载波恢复的数据质量更好。

2）针对不同的接收机，对比分析了 C/A 码和 L2C 码多路径效应及观测噪声水平发现：对 LEICA GRX1200GG 和 TRIMBLE NETR5 接收机，C/A 码和 L2C 码观测噪声和多路径影响水平基本一样，符合期望结果；而 TRIMBLE NETRS 接收机由于在捕获 L2C 信号时未采用 TRIMBLE 接收机的多路径缓解算法 Everest，另外也存在一些残留的捕获问题增加了 L2C 信号的观测噪声，使得 L2C 码多路径效应及观测噪声水平明显高于 C/A 码。

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Abstract This paper introduced the concept of common height system in the measurement process, GPS elevation fitting method and scope of application. It analyzed and discussed the method of rapid change in the height anomaly area to meet the GPS Fitting Height with 1: 10 000 precision control requirements.
Key words height system, GPS, aerial photogrmmetry, adjustment, error (Page:35)

Research of CORS Station Stability Monitor Based on Gamit by ZHANG Xudong

Abstract CORS has founded and been maintaining the regional control survey frame and benchmark with multi-station,whose stability are very important to the system.Because of the distances between stations are larger than 40km,common GPS data processing software can not process the data with high precision.Taking Ningbo CORS as example,this paper studied on monitoring the CORS stations'stability with Gamit data processing.
Key words GAMIT, CORS station, stability,monitoring (Page:38)

Construction of TIN and Generation of Contour Line on AutoCAD by DAI Li

Abstract The generation of TIN was being analysed. According to algorithm of triangle generation, construct the TIN while based on discrete point in AutoCAD,and generated contour line of arbitrary height the same.
Keywords Digital Elevation Model, Triangular Irregular Network, Delaunay triangular network, contour line (Page:40)

Application Research of Geographic Information Platform for Public Emergency Services in Hubei Province by NIE Xiaobo

Abstract Summary of the provincial emergency response system, the basic geographic information platform needs, explained how digital space-based information infrastructure, used of the network geographic information system technology (WebGIS) to integrate basic geographic information resources and the resources of public emergency project to build provincial Public Emergency Services Geographic Information Platform's overall design and technical implementation.
Key words emergency platform, public emergency incident, WebGIS, public safety (Page:43)

Application of AutoCAD and Surfer to the Contour Drawing by ZHAO Fang

Abstract This paper described the significance of contour and the principle of Surfer drawing. Details of the use of Surfer and AutoCAD combined contour drawing methods and procedures. Because of its accuracy and rapidity, it improved the graphics quality and efficiency.
Key words Surfer, AutoCAD, contour, coal mine, Map (Page:46)

Design and Application of Decision Support System for Negotiation and Delimitation of National Boundaries by LIU Hehui

Abstract The negotiation and delimitation of national boundaries is an important and complicated problem. This paper discussed and introduced the design of functional modules and the system data design based on the spatial analysis technology of GIS, after analyzing the business process of the negotiation and delimitation of national boundaries. And this system could effectively manage data, and provided the tools for auxiliary delimitation and resources evaluation.These provide effectual support for the negotiation and delimitation.
Key words negotiations and demarcation of national boundaries, ArcGIS Engine, documents directory tree, auxiliary demarcation, document database (Page:49)

Design of Drawing Documents Information Management System Based on ArcIMS by WANG Xianpu

Abstract This paper researched desing and development of drawing documents information management system, introduced ArcIMS and this system framework, functional design, database design,especially introduced attribute table design.
Key words drawing documents sharing, ArcIMS, database design (Page:52)

Accuracy of Real-time Range Assessment for CORS by LI Bo

Abstract An assessment method for the accuracy of near real-time range was proposed based on the pseudo range observation equation and the character of the CORS stations, and then the key problems of that were expounded in detail. In addition, the performance and adaptively were demonstrated base on real GPS data and the result gave the confidences that the assessment could be used in practical successfully.
Key words CNSS, CORS, accuracy (Page:55)

Establishment Website Dedicated on Government Administration GIS Platform by WANG Yiqin

Abstract Taking the Subject of Geographic Information System (GIS) on fundamental realities of Yunnan under the program of "Public Access Spatial Information Platform on South Asian Association for Regional Cooperation (SAARC) in South East Asia regional cooperating China (Yunnan)-EASAN Free Trade Zone as a case, this paper introduced methodologies on home page development of GIS platform, including page layout, information structuring, map service call up. Methods for web page items control as well as its application prospect were discussed in detail, which hopefully is of reference value for the development and application of similar function for government administration GIS platform.
Key words government administration GIS, web page control, digital information tree, map service (Page:57)

Transformation Program and Precision Analysis between Geodetic Coordinate and Gauss Plane Coordinate by XU Lei

Abstract The paper gained formula that adopted computer computation based analyzing transformation formula between geodetic coordinate and Gauss plane coordinate. It adopted method that programs many subprogram and realized transformation between geodetic coordinate and Gauss plane coordinate, programs to realize transformation Beijing 54 coordinate ,Xi'an 1980 coordinate, 30 band Gauss plane coordinate and 60 band Gauss plane coordinate. The paper analyzed precision about transformation results, drew a conclusion that it can meet ordinary production use adapting the transformation program, but there was a little error.
Key words Geodetic coordinates, Gaussian Cartesian coordinates, coordinate transformation, precision analysis (Page:60)

Application of Several Models to Plane Coordinate Transformation by YAO Chaolong

Abstract Aiming at the coordinate transformation between two 2D coordinate systems, diffrient accuracies from diffrient models will be achieved.This paper utilized the program to compare the accuracy of four-parameter model, six-parameter model and second-degree polynomial model.Results from testing showed when reasonable choose transforming points, the accuracy of second-degree polynomial model is better than the accuracies of four-parameter model and six-parameter model in 2D coordinate transformation.
Key words plane coordinate systems,coordinate transformation,conversion model, transformation accuracy (Page:64)

Change Detection Based on Aviation Remote Sensing Image by XV Xiaoqin

Abstract In this paper, the change detection methode of utilizing aviation images' grey level difference and ratio was mainly studied.In order to analyse this two kinds of methods, a group of aviation images taking farmland as main landscape of the whole view was measured.According to the result of experiments presented by the form of black-and-white pictures, while relatively choosing different threshold value, these two kinds of methods were compared, especially in the use of detecting the result through the change of this specific goal of farmland, and the combination of the two methods was applied as a final result.
Key words grey level difference, grey level ratio, change detection, aviation image (Page:67)

Research on Space Road Network of Kaifeng Based on the Model of Space Syntax by XU Chong

Abstract The model of space syntax analysis is an objective method of analyzing road network. This paper analyzed the accessibility and the spatial distribution of accessibility regional of Kaifeng with the analysis functions of Arcview and ArcGIS. And then discussed the problem of Kaifeng road network and give some improvement measures.
Key words space syntax, space road network, Kaifeng (Page:69)

Quality Evaluation Methods of Large Scale Digital Map Before Import into Database by LI Xuanrui

Abstract Firstly, the importance of quality evaluation of large scale digital map before import into database were introduced. Then the mathematical model and the steps of fuzzy mathematics judgement applied in quality evaluation were given. Lastly, an engineering example was given to verify the feasibility of the method, this method can ensure the quality of large scale digital map before import into database.
Key words large scale digital map, quality evaluation, fuzzy mathematics judgement (Page:73)

L2C Signal and L2 Carrier Data Quality Analysis by LI Weijun

Abstract Based on the IGS tracking station data, the signal-to-noise ratio (SNR) of L2 carrier phase resumed by L2C code was improved obviously, almost close to the SNR of L1 carrier. For different receivers, this paper followed with a study on the multipath and noise levels of C/A and L2C code pseudorange, pointing out for TRIMBLE

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NETRS receiver, multipath and noise levels of L2C code was significantly higher than C/A code, contrary to expectations.
Key words GPS modernization, L2C code, SNR, multipath effect (Page:75)

Landscape Pattern Analysis Based on High-resolution Remote Sensing Image by CHEN Zhiyun
Abstract On the basis of landscape ecology theory, using high resolution remote sensing data as sources, using RS and GIS techniques, the planning area of Meizhou City was divided into 9 land use types, including cultivated land, forest, grassland, urban land and highway land, lake, river, bare land and beaches. The basic structure of the landscape, the fragmentation and diversity of landscape-level and the spatial pattern characteristics of different landscape patches were studied and analyzed. At last, some recommendations were proposed to rational planning land development and utilization of the study area.
Key words high-resolution remote sensing image, landscape pattern, landscape indexes, planning area of Meizhou City (Page:78)

Application of GPS Close-range Photogrammetry Crossing Location Technique in Surveying and Mapping on Island and Reef by LUO Liang
Abstract Surveying and mapping engineering on island and reef is one of five important items during 11th five-year planning in State Bureau of Surveying and Mapping. GPS close-range photogrammetry crossing location module is part of the quickly positioning information collection system. This technology can be completed on island and reef of the special terrain mapping mission. Particularly it can provide a new method to map difficulties coastline.
Key words island and reef, close-range photogrammetry crossing location, resection, forward intersection (Page:81)

Design and Realization of Query System of Geographic Information Based on ArcIMS by YANG Guofei
Abstract WebGIS, based on the Internet and the Web, is the main trend of the development of GIS currently. And one of the most popular platform for realizing it is ArcIMS.We summarized the characteristics and the system structure of the ArcIMS, then described the idea of designing and developing the query system of geographic information by using ArcIMS. At last we made geographic information released online and queried in multiple forms, managed and shared in network by users.
Key words Query of geographic information, ArcIMS, WebGIS (Page:84)

Design and Implementation of Campus Information Service Platform Based on Object by MAO Yanqing
Abstract Open and flexible campus services platform is the key to promoting campus information technology, the difficulty is the descripting ,organizating and sharing of information and data. This article investigated the object-oriented spatial data model on the basis of proposing object-oriented method and process of information organization on campus , as well as the ways of designing the services platform. Focus on object-based information organization on campus and campus information management platform framework. To achieve a set of "people", "capital equipment", "geospatial information" resource management platform for the integration of campus information services, information service system for the construction of the campus and campus information sharing to provide new methods and ideas.
Key words GIS, object-oriented, campus information, service platform (Page:87)

Design of Provincial Land Resource Electronic Government Information System Based on ArcGIS by PENG Jianbin
Abstract This article researched on the design of the provincial land resource E-Government system, proposed the overall goals and framework of the system, particularly described the function modules of the system based on the soft platform of ArcGIS, finally discussed the key techniques and system features related with the system, formed a unified technical framework, operating environment and normative standards, achieved the integration management of land resource information.
Key Words land and resource, E-government, ArcGIS (Page:90)

Study of Land Quality Assessment Based on GIS by ZHOU Dan
Abstract The authors established the system of land quality assessment and evaluated the land quality of Shuangqiao in Dongxing district of Neijiang city based on the Analytical Hierarchy Process and graphic overlay methods, made the evaluation results map of the region, the region was divided into five types, the excellent or better quality land area was 699.45 km2, in possession of 72.87% of the whole region; the moderate quality land area was 184.43km2, which was in possession of 19.2% ; the land of lower or poor quality area was 76.4km2, in possession of 7.96%,according to the location and the modes of fanning of the region , the whole land quality of Shuangqiao in Dongxing district of Neijiang city was in good condition.
Key words GIS, land quality assessment, Neijiang (Page:93)

Delay Model and Accuracy Analysis of EGNOS Tropospheric by LIU Jingye
Abstract Tropospheric delay in GPS positioning is a major source of error ,in the handling of the main methods of tropospheric delay correction through model,difference method, etc, weakening or elimination of tropospheric delay error. When the distance is short baseline, baseline ends meteorological conditions are basically the same ,difference method can be very good correction troposphere delay error, when the baseline, due to the long distance between the meteorological data at baseline large , difference method can't eliminate the troposphere error well, but model can be a very good method to eliminate the troposphere error. In this paper, EGNOS model was introduced in detail, and through MATLAB programming. IGS tracking station data used to calculate statistical analysis, results showed that the EGNOS tropospheric correction model in elevation on the Saastamoinen model and the Hopfield model range, between the x, y direction precision.
Key words GPS , tropspheric model ,EGNOS , accuracy analysis (Page:96)

Measuring Method of Unified Annual Output Value Standard of Land Expropriation Based on GIS Technology by FU Weijia
Abstract Reasonable measuring method of unified annual output value standard of land expropriation is the basis and guarantee to improve the land expropriation compensation mechanism and protect farmers' rights of land. In this paper, revision and related measurements had been optimized with selecting the representative revision factors and building GIS spatial clustering model. At the same time, it used data organization method which integrated maps, data and database based on GIS. Finally, it achieved the measuring method of unified annual output value standard of land expropriation. Measuring results not only to present the spatial distribution of land expropriation compensation and the difference rule, but also to provide a new way to measure.
Key words Unified Annual Output Value Standard of Land Expropriation, GIS, Gongcheng County, revision, spatial clustering, compensation standard (Page:99)

Building and Application of Remote Sensing Image Interpretation Signs of Eco-environmental in Four Rivers Valley of Tibet by GUAN Lei
Abstract In fully grasp the characters of natural geography and with the region of the TM images and related data contrast, we builded remote sensing image interpretation signs of Eco-environmental by using the classification system in Four Rivers Valley of Tibet. This work provided basis for Eco-environment or land resource remote sensing survey in south-east Tibet.
Key words remote sensing, interpretation signs , Four Rivers Valley , Tibet (Page:103)

Rendering Method Over 3D Vector Data in EV-Globe by WANG Haitao
Abstract The paper, which based on the3D plat roof of EV-Globe,annlysed advantages and disadvantages of 3D vector-data, raster-data and mixsed modals,realized symbolization and LOD display of vector data in 3D GIS.The method satidtied the rendering resquest of vector data in 3D GIS.
Key words 3D vector data modal, 3D vector data modal, modal based on feature, symbolization, LOD (Page:106)

Gray Model and Intelligent Algorithm Combined Model in Deformation Prediction by ZHANG Yutang
Abstract Because of various parameters have great uncertainty, deformation monitor project is a complicated integrated system. At present deformation prediction and analysis using a single forecasting methods, but each method has their own application scope.Sometimes a single forecasting method made it difficult to determine the nature of projects. This paper introduced the idea of combination forecasting, based on the gray GM (1,1) model, Construction of the gray + GA + BP neural networks combination models, explored the time series of data processing and prediction problems. Calculation and analysis by example, proved that the combined model met the engineering needs and had a certain value.
Key words deformation monitor, combination model, gray prediction model, genetic algorithm , BP network (Page:109)

Control Surveying of the Combined Highway and Railway Yangtze Bridge of Tongling by ZHOU Ruixiang
Abstract This article brought forward and expatiate a method using GPS, electronic level and techniques of river-crossing leveling to fulfill the precision measurement task. The results not only verified the accuracy of this method, as well as provided references for other similar projects.
Key words bridge engineering ,construction control network, GPS ,river-crossing leveling (Page:112)

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