



GPS 近景交会定位技术在海岛礁测绘上的运用

罗 亮

(广东省国土资源测绘院, 广东 广州 510500)

摘 要: 海岛礁测绘工程是国家测绘局“十一五”期间的5个重要项目之一, GPS 近景交会定位模块是卫星快速定位信息采集系统的一部分。该技术可完成对海岛礁特殊地形的测绘任务, 对困难海岸线的测绘提出新方法。

关键词: 海岛礁; 近景交会定位; 后方交会; 前方交会

中图分类号: P228.42

文献标志码: B

文章编号: 1672-4623 (2011) 02-0081-03

1 GPS 近景交会定位模块

GPS 近景交会定位模块是 GPS 卫星快速定位信息采集系统的一部分, 由 GPS 定位部分、三维数字罗盘、相机、电源等部分组成, 它是高精度卫星定位技术、近景大角度交会定位技术以及数字罗盘测角技术的集成与整合, 最终实现相片外方位元素的解算以及地物特征点量测。

影像的外方位元素包括摄站点的三维坐标和主光轴的姿态。主光轴的姿态由 2 种方式提供: 一种是三维数字罗盘直接测定, 精度约为 5‰; 另一种是利用 3 个影像控制点解算 (即单片后方交会)。摄站点坐标采用后处理差分动态定位技术获取, 定位精度 10 cm, 图 1 是其原理图。

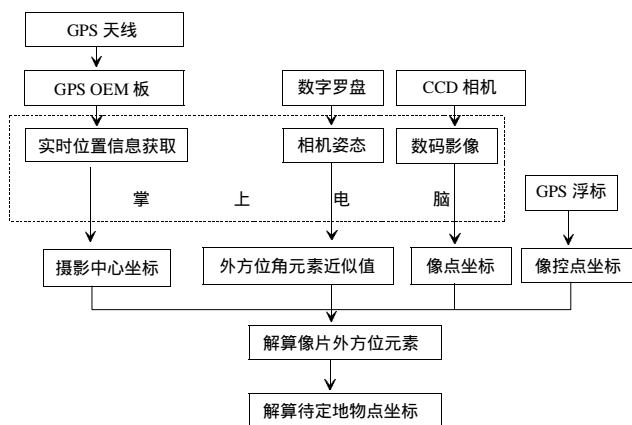


图 1 GPS 近景交会定位原理图

相片的 3 个角元素的初始值的确定在解算过程中很重要, 3 个角元素可由罗盘测得的数据经转换后确定; 但是 GPS 采集到的数据是以 WGS84 坐标系为地理约束框架的, 目前系统还未建立其与像空间坐标系的旋转关系, 罗盘的作用难以发挥。通过将 WGS84 坐标系转换为站心坐标系, 站心坐标系与像空间坐标系

之间的 3 个角元素的初始值可由罗盘测得的航向、俯仰和横滚转换后得到, 关系如图 2 所示。

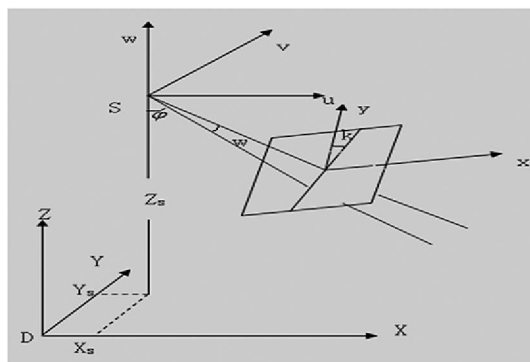


图 2 辅助空间坐标系与像空间坐标系的空间关系

采用 GPS 浮标结合地面控制点通过共线方程反解相机外方位元素 (即后方交会技术, 共线方程如下式所示):

$$\begin{cases} x-x_0+\Delta x = -f \frac{a_1(X-X_S)+b_1(Y-Y_S)+c_1(Z-Z_S)}{a_3(X-X_S)+b_3(Y-Y_S)+c_3(Z-Z_S)} \\ y-y_0+\Delta y = -f \frac{a_2(X-X_S)+b_2(Y-Y_S)+c_2(Z-Z_S)}{a_3(X-X_S)+b_3(Y-Y_S)+c_3(Z-Z_S)} \end{cases}$$

根据后方交会计算出的相机外方位元素, 结合同名像点解算地物特征点的地理坐标 (即前方交会技术), 原理如图 3 所示。

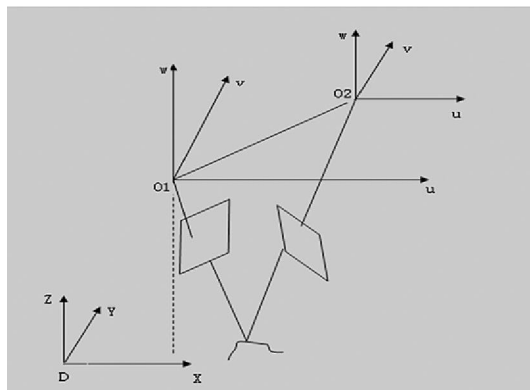


图 3 前方交会原理图

收稿日期: 2010-12-27

2 近景摄影测量方法

试验分别在陆地上和海面上进行，选择不同的摄站点，对准某段海岸线进行拍照。在 2 个摄站点对同一范围拍摄，通过 GPS 模块记录摄站点的坐标，罗盘模块测得相机的瞬时姿态参数。

影像的外方位元素包括摄站点的三维坐标和相片 3 个角元素。

摄站点坐标采用后处理差分动态定位技术，定位精度 10 cm；

相片 3 个角元素由 2 种方式提供：一种是三维数字罗盘经外标定模块改正并换算得到；另一种是利用 3 个影像控制点解算。

3 GPS 近景交会定位作业试验

3.1 陆地上相片拍摄

在陆地上分别选择摄站点 1、2、3，从 3 个不同的角度拍摄 3 组相片（命名为相片 1、相片 2、相片 3），相片两两组成像对。

在拍摄的相片中，应合理布设像控点，以使拍照时，像控点在照片上能均匀分布。每张相片的像控点个数为 8 个以上，像对上同名像点个数为 5 个以上，以便于解算结果与观测值比对。

利用卫星快速定位信息采集系统下的影像信息采集模块，通过掌上电脑控制相机拍照，读取并保存罗盘数据和 GPS 数据。

3.2 海上相片拍摄

在海面上离岸约 400 m 处，在 3 个摄站点（摄站固定安置在大船上）共拍摄了 3 组照片，第一组照片分为 6 个拍摄区域，第二、三组照片分为 6 个拍摄区域（分布示意图如图 4 所示）。

1) 在 1 号采集点，拍摄第一个区域。3 个 GPS 浮标按照图 1 所示在 1 号采集点第一个拍摄区域内安放好后，在 1 号采集点进行拍摄。两细实线之间代表相机的视场及拍摄范围，2 号及 3 号浮标的位置决定了拍摄范围，3 个实心三角形代表 GPS 浮标，实心正方形代表大船位置。

2) 在 1 号采集点，拍摄第二个区域。大船位置不动，将 1、2、3 号浮标移动到第二个拍摄区域，完成第二个区域的拍摄。

3) 依次类推，直到 1 号采集点完成第六个区域拍摄，保证 6 次拍摄覆盖整个目标区域。

在 1 号摄站点拍摄完成后，分别移动到 2、3 号摄站点按上述步骤进行拍摄完毕。

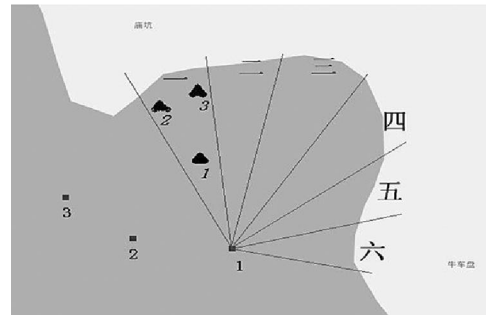


图 4 摄站点分布及 GPS 浮标布设位置图

3.3 检核点测量

根据获取的相片，选择一些明显的地物特征点（如房角等），作为检核点，用于解算值与观测值的比对。

4 近景摄影测量数据处理与分析

4.1 内业数据处理

1) GPS 数据精密处理。用 GPS 接收机测得的静态数据需经过其他软件处理，动态数据需经过 ROVER 等软件处理（如图 5 所示）。

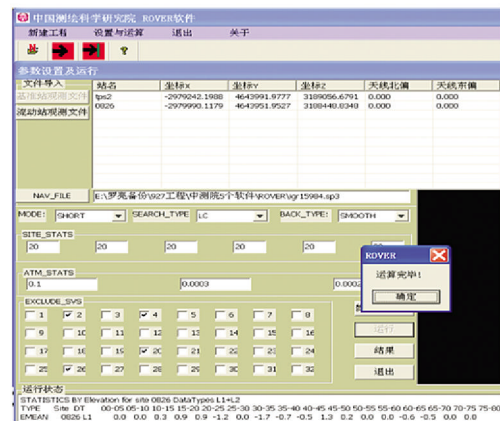


图 5 ROVER 软件处理示意图

2) GPS 及罗盘数据的提取。通过查找并判断 GPS、罗盘每条信息的时间与相机曝光时间来提取相机曝光时刻的 GPS、罗盘数据。

3) 天线归心及罗盘数据转换。将与相机固定在一起的天线的坐标归算出相机镜头中心的坐标；将罗盘的 3 个角度转换为相片的 3 个外方位角元素。

4) 进入“海岛礁卫星快速定位信息采集系统”的“后方交会子模块”，输入已知参数，计算外方位元素，并保存文件（见图 6）。

5) 进入“前方交会子模块”，打开后方交会的结果文件，输入已知参数，解算待定地物点的坐标。

4.2 陆地上试验精度统计

相片两两构成一个像对，后方交会用六参数解算，每张照片选用 3 点计算，将前方交会解算结果与实测的检核点进行比对统计（见表 1）。



图6 海岛礁卫星快速定位信息采集系统示意图

表1 解算结果与实测的检核点对比/m

点号	相片2与相片1			相片3与相片1			相片2与相片3		
	B	L	H	B	L	H	B	L	H
1	0.5	0.2	0.0	0.3	0.1	0.1	0.2	0.1	0.1
2	0.1	1.3	0.6	0.1	1.4	0.6	0.6	1.1	0.7
3	0.6	1.5	0.4	0.0	1.2	0.5	0.0	1.1	0.5
4	0.2	1.1	0.2	0.2	0.9	0.3	0.4	0.7	0.4
5	0.2	1.0	0.3	0.0	0.9	0.4	0.5	0.5	0.6
6	0.4	0.1	0.1	0.3	0.2	0.0	0.4	0.0	0.0
7	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.1
8	0.2	0.9	0.3	0.0	0.8	0.3	0.0	0.8	0.4
9	0.2	0.5	0.4	0.4	0.4	0.4	0.6	0.2	0.5
10	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0

4.3 海上试验精度统计分析

以第一拍摄区为例,第1、2、3摄站上对第一区摄影的相片分别命名为S11、S21和S31(其他拍摄区以此类推),将前方交会解算结果与实测的检核点分别进行比对,精度统计分别见表2、表3、表4。

1) 相片S11与S21上解算结果与实测的检核点对比统计(见表2)。

表2 解算结果与实测的检核点对比/m

点号	用第1、2、3个浮标			用第2、3个浮标		
	B	L	H	B	L	H
1	1.7	-1.3	-0.3	0.4	-0.6	0.0
5	1.4	-1.2	-0.4	0.2	-0.4	0.0
6	1.4	-0.6	-0.4	0.1	0.2	0.0
8	1.7	-1.1	-0.3	0.5	-0.5	0.0
15	1.8	-1.3	-0.9	0.3	-0.7	-0.3
16	2.0	-1.2	-0.9	0.6	-0.5	-0.2
17	2.2	-1.3	-1.0	0.9	-0.6	-0.2
18	1.9	-1.3	-1.0	0.5	-0.5	-0.3
22	2.9	-0.5	-1.8	1.0	0.1	-0.5
23	3.7	-0.5	-1.1	1.5	0.1	-0.1
24	1.4	-0.1	-0.9	0.3	0.2	0.0

2) 相片S21与S31上解算结果与实测的检核点对比统计(详见表3)。

表3 解算结果与实测的检核点对比/m

点号	用第1、2、3个浮标			用第2、3个浮标		
	B	L	H	B	L	H
16	2.0	1.2	0.4	0.4	-0.7	0.0
17	2.1	1.4	0.4	0.4	-0.9	0.0
22	3.1	0.4	0.8	0.7	-0.1	-0.3
23	4.1	0.3	0.2	1.2	0.0	0.1
24	1.5	0.3	0.2	0.0	0.2	0.2
58	4.0	0.1	0.6	0.6	-0.3	-0.1
59	3.5	0.3	0.7	0.4	0.0	-0.3
60	3.5	0.4	0.7	1.6	0.2	-0.2
61	3.6	0.4	0.6	0.5	0.0	-0.3
62	5.2	1.3	0.6	1.2	0.4	-0.4
64	3.7	1.0	0.8	0.8	0.3	-0.3

3) 相片S11与S31上解算结果与实测的检核点对比统计(见表4)。

表4 解算结果与实测的检核点对比/m

点号	用第2、3个浮标			陆地的三个静态点		
	B	L	H	B	L	H
74	0.7	0.7	-0.1	0.2	0.1	-0.1
75	0.6	0.4	0.2	0.3	0.5	0.1
43	0.6	1.2	0.0	0.0	-0.1	-0.1
44	-0.4	0.1	-0.4	-0.8	-1.7	-0.6
45	0.0	0.6	-0.2	0.0	-0.4	-0.1
46	0.0	1.4	-0.3	-0.1	-0.4	-0.4
47	-0.1	2.0	-0.2	0.1	0.1	-0.2
48	0.0	4.6	-0.3	0.0	0.7	-0.6

通过像对S11-S21、S21-S31的解算结果的分析,离相机镜头近的“第1浮标”,对解算结果影响很大;离镜头近时,控制点目标在相片上显示较大,其中心位置不易判断,在相片上刺点时,容易偏离控制点的实际位置,导致解算结果精度下降。

通过对像对S11-S31的解算结果的分析,用岛上的静态测量点作为控制点进行近景交会定位点坐标的解算要比用海上的动态测量点作为控制点进点坐标解算的结果要好;说明GPS接收机采样率或动态GPS数据处理得到的瞬时坐标精度对近景交会定位的坐标解算影响很大。

5 结 语

近景交会定位解算未知点绝对精度基本优于1m。用海上的GPS浮标作为控制点,控制点精度与GPS数据的后处理精度相关,近景交会定位解算未知点绝对精度可达到1m。

地物点的三维定位采用像对前方交会实现,定位精度指标通过实地卫星定位比对确定。(下转第86页)

4.2.1 GIS 地图基本操作功能

它包括地图的放大、缩小、漫游、全幅显示、刷新功能以及在地图上单击鼠标右键显示上下文菜单,使用常用功能。其他有关 GIS 地图操作的常用功能如放大镜、鹰眼、比例尺等。

4.2.2 “图层可视性管理”控制图层的可见性

“地图提示”对地图中某图层(点图层)的地物具体信息进行表现。当鼠标悬浮在某地物上,出现小提示。单击后,弹出更大窗口显示该地物的具体信息,包括相关图片、链接等内容。

4.2.3 查询功能

1) 简单量算查询。“经纬度查询”可查看地图上的任一地点的经度和纬度。“距离量算”在地图上画多段线,悬浮窗口将显示总长度和最近一次画的线段部分长度。同时可选择要显示的长度单位,如 m、km 等,距离数值将随之相应变化。“周长和面积量算”测算出用户在地图上任意画多边形的实地周长及其所表示的实地面积大小。同时可选择要显示的长度单位,以及面积单位,数值将随之相应变化。

2) 图查属性与定位。在地图上选择一个或多个地图要素后,客户端浏览器弹出悬浮窗口,在窗口中以 TOC 控件显示要素详细的属性信息。在某个要素名上单击鼠标右键选择“放大到”、“漫游到”、“删除”等上下文菜单命令,完成相应的功能。例如“放大到”是放大并定位到地图要素,并进行高亮显示。

3) 专题信息精确查询与定位。根据用户要查询的地图要素名或者要素名称的部分内容,“查找”出所有

符合要求的内容,并在悬浮窗口以 TOC 控件的形式显示要素的详细属性或含有输入内容的所有要素的详细信息。在查出的要素上单击鼠标右键,可选择上下文菜单命令,进行定位、移动到、删除等操作。

4) 专题信息模糊查询与定位。根据用户输入的内容且选择相关约束条件,“查找”出用户感兴趣的所有内容,并在悬浮窗口以 TOC 控件的形式显示所有符合条件的要素的详细属性信息。在查出的要素上单击鼠标右键,可选择上下文菜单命令,进行定位、移动到、删除等操作。

5) 属性选择性查询。结合 SQL 语句进行的选择性条件查询。例如对城镇人口、街道信息进行感兴趣的多条件相结合的选择性查询。

参考文献

- [1] 黄丙湖, 阎国年, 张亦含, 等. 基于 ArcIMS 的环保 WebGIS 的设计与实现[J]. 南京师范大学学报:工程技术版, 2004, 4 (2): 59-61
- [2] 杨扬. 基于 ArcIMS 的 WebGIS 设计 [J]. 电脑知识与技术, 2008,3(27):1979-1981
- [3] 马林兵, 张新长, 伍少坤. WebGIS 原理与方法教程[M]. 北京: 科学出版社, 2006
- [4] 颜辉武, 吴涛, 王方雄. 网络地理信息系统[M]. 北京: 测绘出版社, 2007
- [5] 侯国祥, 黄凯辉, 李洪斌, 等. 基于 WebGIS 的汉江水环境管理信息系统[J]. 华中科技大学学报:自然科学版, 2006, 34 (10):67-69

第一作者简介:杨国飞, 硕士, 研究方向为地学三维认知模型与可视化。



(上接第 83 页)

拍摄用于前方交会计算的照片时,遵循的几个原则:

- 1) 摄站点距控制点的平均距离大约为两摄站点间基线距离 1.5 ~ 3 倍。
- 2) 拍摄像对时,两位置上相机视准轴的夹角为 15 ° ~ 75 °, 可通过数字罗盘的航向读数判断。
- 3) 像控点在相片上要分布均匀, 尽量避免像控点分布在相片的边缘。
- 4) 海面 3 个 GPS 浮标天线高差不小于 3 m, 浮标三角形夹角不小于 30 °。

用于后方交会的控制点在相片上分布均匀, 避免在一条直线上; 用于后方交会计算的控制点精度越高越好; 拍摄像对时的交会角尽量大一些。当摄站点坐标精度高时, 可作为已知值, 后方交会时只解算外方位角元素; 当摄站点坐标精度低时, 可作为初始值, 后

方交会时解算 6 个外方位元素。

利用 GPS 近景交会定位方法, 可应用于海岛礁岸线测量。用于岸线测量时, 需考虑海面上船只的遮挡情况、光线强度及方向、拍摄距离等因素, 使获得的像片上岸线清晰。

参考文献

- [1] 朱肇光, 孙护, 崔炳光. 摄影测量学[M]. 北京: 测绘出版社, 1995
- [2] 李征航, 黄劲松. GPS 测量与数据处理[M]. 武汉: 武汉大学出版社, 2005
- [3] 冯文灏. 近景摄影测量[M]. 武汉: 武汉大学出版社, 2002
- [4] 邵卫东, 焦明连. GPS 动态后处理技术及精度研究[J]. 中国科技博览, 2008, 24: 247-247
- [5] 方书山. GPS 动态数据处理软件 ROVER1.0 用户手册[M/CD]. 中国测绘科学研究院, 2010

作者简介:罗亮, 工程师, 主要从事工程测量、摄影测量和海洋测绘工作。

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 describing ,organizing 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 , tropospheric 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 the 3D plat roof of EV-Globe, analysed advantages and disadvantages of 3D vector-data, raster-data and mixed modals, realized symbolization and LOD display of vector data in 3D GIS. The method satisfied the rendering request 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 expatiated 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)