# 大比例尺地形图入库前质量评价方法

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**摘　要**：介绍了大比例尺地形图入库前质量评价的重要性，给出了模糊数学评价法应用于大比例尺地形图入库前质量评价的数学模型和方法，并结合工程实例数据来验证方法的可行性，为大比例尺地形图入库提供了质量保障的依据。

**关键词**：大比例尺地形图；质量评价；模糊数学评价法
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目前，我国很多城市已经或正在建立本市的城市基础地理信息数据库，而建立城市基础地理信息数据库的重要数据源就是现有大比例尺数字地形图。高质量的数据源才能构成高质量的数据库，从而为实现对地形图的专题信息提取、数据挖掘等应用提供更精准的服务。所以在地形图入库前，为了了解地形图的数据是否合格，质量是否满足 GIS 的要求，需要进行质量评价。地形图传统的质量评价法通常是采用缺陷扣分法：以“幅”为单位，将满分设为 100 分，根据产品质量缺陷程度进行扣分，再将各缺陷扣分值累加，最后用满分值减去累加的扣分值，得到的最后分值即为该幅产品的评判值，以此判断它的质量等级。缺陷扣分法虽然操作简便，易于量化和分等定级，但该方法只能在缺陷和非缺陷之间以及缺陷的程度上进行评定，是一种基于刚性的质量观，其对缺陷的认定过于绝对。然而，数字地形图质量评价中所采用的“优秀”、“良好”、“及格”、“不及格”等质量指标都是模糊概念，所以运用上述方法会导致评价结果比较粗糙。为此，本文将模糊数学评价法应用于数字地形图入库前的质量评价中。该方法特点是在于改善了传统方法刚性评价，充分尊重数据的模糊性，提高了质量评价的精度，更具有科学性、严密性和统一性，为数字地形图评价提供了一种比较好的数学工具。

## 1　模糊数学评价地形图质量方法

利用模糊数学评价地形图质量是根据模糊数学原理，首先建立因素集和评价集，将模糊概念用模糊集合来描述，再对影响地形图质量的因素一一评定，建立质量综合评定的模糊矩阵，最后确定各影响因素的隶属度，依“隶属度最大及聚类分析原则”确定质量等级。

建立因素集和评价集是模糊数学评价地形图质量首要工作。影响地形图的质量取决于多种因素，这些因素构成一个集合，称为“因素集”，用 U 代表因素集，即 U=［几何精度，图形质量，属性精度，逻辑一致性，完整性］。对其中的每个因素做出评价组成的集合，叫做“评价集”，用 V 代表评价集，选择 4 个评价级组成一个评价集，即 V=［优级品，良级品，合格品，不合格品］。而大比例尺数字地形图入库质量取决于下面 5 个因素：

1）几何精度：除了少数需要更改的要素外，整理后的要素应与原图中对应的要素在几何位置上完全一致；相邻图幅要素的几何位置应接边；

2）图形质量：整理后的地形图数据的图形表示应正确并符合新版图式的规定；整理后的地形图中，图形应正确、完整、美观，无遗漏、无添加、无重复、无明显变形；不允许存在不合理的悬挂线、回头线、伪节点、冗余节点、碎线、面积为零的多边形、空注记等；

3）属性精度：地形要素的分类编码应正确无误；地形要素的属性信息应完整、正确；相邻图幅同一要素的属性信息应一致；

4）逻辑一致性：面状区域应闭合，属性应一致；相关要素处理应正确；要素几何类型应正确，具有唯一性；

5）完整性：地形要素应与原图保持一致，无遗漏；地形要素的几何描述应完整；数据的分层与组织应正确，不得有重复或遗漏；数据说明的内容应正确、完整；注记应完整、正确，字体应一致。

考虑到各种因素对地形图质量的影响程度各有不同，所以正确地给因素赋予权重对质量评价有很重要

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的意义。建立相应的权重集 A=[$a_1$ $a_2$…$a_n$]，确定权重可采用层次分析法和特尔菲测定法等方法。本文根据工程实际情况，采用特尔菲测定法，确定的权重矩阵为 A=[0.2 0.25 0.3 0.1 0.15]。

评价地形图质量这一模糊概念为何等级时，需要确定其隶属度。根据各因素数据的分布特征，本文采取“降半梯形”分布公式，公式如下:

$$U_{\mathrm{I}}(x)=\begin{cases}0 & x\le 90\\ (X-90)/10 & 90<x\le 100\end{cases} \quad (1)$$

$$U_{\mathrm{II}}(x)=\begin{cases}0 & x<75\\ (X-75)/15 & 75\le x\le 90\\ (100-X)/10 & 90<x\le 100\end{cases} \quad (2)$$

$$U_{\mathrm{III}}(x)=\begin{cases}0 & x<60,\ x>90\\ (X-60)/15 & 60\le x\le 75\\ (90-X)/15 & 75<x\le 90\end{cases} \quad (3)$$

$$U_{\mathrm{IV}}(x)=\begin{cases}0 & x>75\\ (75-X)/15 & 60\le x\le 75\\ 1 & x<600\end{cases} \quad (4)$$

式中，U 为隶属度函数；x 为某影响因素依据评价集给定的分值。

利用缺陷扣分法对每个影响因素打分，所得的分值构成如下形式的模糊判断矩阵 R。

$$R=(r_{ij})_{n\times n}=\begin{bmatrix} r_{11} & \cdots & r_{1n}\\ \vdots & \ddots & \vdots\\ r_{n1} & \cdots & r_{nn}\end{bmatrix} \quad (5)$$

所以，模糊数学评判的基本形式为：

$$B=A\cdot R \quad (6)$$

式中，A 为权重矩阵；R 为隶属度矩阵；B 为评判结果向量，表示被批评事物等级程度，与评判集 V 对应，B 向量中数值最大的隶属于评判集 V 中等级程度。

## 2 工程应用分析

笔者将以上模糊数学评价方法运用于某市的大比例尺数字地形图入库前质量评价。该批大比例尺地形图共有 286 幅，参与大比例尺地形图入库前整理工作的人员共 8 名，费时 2 个月，在入库前对地形图进行质量评价，结果优级品占大多数，共有 191 幅，良级品 89 幅，合格品 2 幅，不合格品 4 幅。针对不合格品，根据实际缺陷情况选择返工或者重新获取地形数据。

限于篇幅，这里只给出了一幅地形图模糊质量评级情况。表 1 列出了一幅地形图质量特性计分情况；将得分带入隶属度函数得模糊判断矩阵 R 如下：

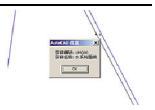
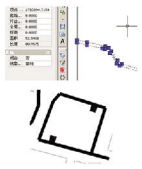
$$R=\begin{bmatrix}0 & 1 & 0 & 0\\ 0 & 0.6 & 0.4 & 0\\ 0 & 0 & 0.67 & 0.33\\ 0 & 0.47 & 0.53 & 0\\ 0.4 & 0.6 & 0 & 0\end{bmatrix}$$

则评判结果向量 B=A · R=[0.2 0.25 0.3 0.1 0.15]

$$\begin{bmatrix}0 & 1 & 0 & 0\\ 0 & 0.6 & 0.4 & 0\\ 0 & 0 & 0.67 & 0.33\\ 0 & 0.47 & 0.53 & 0\\ 0.4 & 0.6 & 0 & 0\end{bmatrix}=[0.06\ 0.487\ 0.353\ 0.1]$$

根据最大隶属度原则，该幅地形图质量评价为良级品。

表 1 质量特性计分表

| 质量特性 | 得分 | 缺陷详查内容 | 缺陷例图 |
|---|---|---|---|
| 几何精度 | 90 | 与原要素几何位置上不完全一致属于重缺陷，两处计为 1 个，即每错一个扣 4 分。 |  |
| 图形质量 | 84 | 重要要素或其属性数据错漏属于重缺陷，一处计为 1 个，即每错一个扣 6 分。<br>多余节点属于轻缺陷，两处计为 1 个，即每错一个扣 1 分。本图中有 21 处，扣 10 分。 |  |
| 属性精度 | 70 | 地形要素的属性信息不完整属于重缺陷，两处计为 1 个，即每错一个扣 6 分。本图共有 6 处，扣 18 分。<br>数据有冗余现象属于重缺陷，三处计为 1 个，即每错一个扣 4 分。本图共有 8 处，扣 12 分。 |  |
| 逻辑一致性 | 82 | 要素面状要素未封闭，属于重缺陷，两处计为 1 个，即每错一个扣 6 分。本图共有 5 处，扣 15 分。<br>线相交或点线矛盾为轻缺陷，1 处为 1 个，即每错一个扣 1 分。本图共有 3 处，扣 3 分。 |  |
| 完整性 | 94 | 地物要素越过图廓属于轻缺陷，一个扣 1 分。本图共有 1 个，扣 1 分。<br>一般要素放错层属于轻缺陷，一个扣 1 分。本图共有 5 个，扣 5 分。 |  |

## 3 结 语

尽管模糊评价法和传统的缺陷扣分法有相似的操作步骤，但由于其最后的评定结果的算法完全不同，所以意义也不同。模糊评价法采用严谨的数学算法经过了严格的逻辑推理，利用各评价因子对不同质量等级的隶属度来反映其质量信息，考虑到了其模糊属性，利用的信息更充分，得出的结果也就更为客观和公正。但其也有需要改进的地方：对于影响地形图质量的各质量特性的权重如何确定，仍然需要寻找一种更科学严谨的方法。 （下转第 77 页）

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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第一作者简介：李宣锐，硕士，研究方向为地理信息系统研究与应用。

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