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点云数据与BIM技术对既有建筑改造的应用

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摘　要：随着时间的变化，现存的大量既有建筑中有相当一部分原有存档信息不能准确反映其真实情况。将利用三维激光扫描技术收集的具有高时效性的点云数据作为逆向工程的基础，通过采集现场实景照片、分析真实情况、参考原有图纸，在 Revit 软件中对点云数据进行逆向拟合，并赋予属性信息，将既有建筑以 BIM 模型的形式重现；对其进行精度分析，以验证模型的准确性。在满足分类统计工程量的基础上，结合 BIM 模型三维可视化的优势，将改造设计工作在模型中进行仿真模拟，以验证其可行性，并对以 BIM 技术为中心的逆向工程在既有建筑改造中的应用进行研究。

关键词：既有建筑；三维激光扫描技术；三维可视化；BIM 技术
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1　三维激光扫描技术

1.1　三维激光扫描技术概述

三维激光扫描技术作为一种新兴的空间信息获取方式，采用激光测距的方法，将激光扫描到的点所具有的三维坐标等信息采集下来，并能由点到面记录目标实体表面的真实情况[1]。三维激光扫描技术在实际应用中的特点为：①非接触式的数据采集方式；②受时间、空间的影响较小；③数据采集速率高、精度高；④数据兼容性和拓展性强[2]。

1.2　点云数据在既有建筑改造中的应用

既有建筑是工程施工前就已存在的建筑物与构筑物的统称。以古建筑为例，既有建筑往往因历史或人为因素，导致建筑图纸缺失。大量木质结构的使用，也使古建筑的安全性随着使用年限的增加而降低。

在对这类建筑进行测量时，相较于传统的测绘技术，三维激光扫描技术能节约大量的人力和时间成本。分阶段对既有建筑进行扫描，准确且高效的采集其点云数据，并对点云数据进行实时更新。一方面，可以对比不同时期的点云数据，得到既有建筑物沉降等真实情况，为结构的健康监测提供依据；另一方面，在改造过程中对既有建筑的实时点云数据进行三维建模，可模拟各施工阶段，作为既有建筑改造的设计依据[3]。

2　BIM技术

2.1　BIM 技术概述

BIM 技术是一种基于三维数字信息技术，涵盖了工程项目全生命周期，将各时期各类别的信息高度整合在统一的平台中，应用于工程项目的设计、建造、管理等阶段的数字化工具。相较于传统的二维图纸，BIM 技术在绘制过程中能将材质、用料、空间、结构等二维图纸难以表达的信息整合到模型中，生成更加直观便利的三维信息模型，并能对模型中各组成部分进行获取、查询、统计、修改等操作[4]。在项目设计过程中，对模型做出任何修改都会在平台中实时同步更新，降低了各学科各部门之间协调沟通的门槛，从而提高了设计质量和项目进度[5]。

2.2　三维激光扫描技术与 BIM 技术的结合

将三维激光扫描技术的即时数据采集与 BIM 技术在三维可视化方面的优势相结合，能为工程项目建设提供一种新的可能。在目前的工程实际中，这两种技术可视化的交互方式以及上下级平台的沟通方式，在以下方面有着重要的发展空间[6]：

1）资料存档。通过三维激光扫描技术实时采集施工现场的真实数据，特定构件或关键部位的信息采集应准确、客观、完整，并以电子文档形式加以保存。

2）质量检测。采集施工周期中各时期的点云数据，并与已建立的 BIM 模型进行参数对比。相较于传统全站仪等测量检测手段，该方法具有高效便捷、适用性广、得到的数据准确等特点。

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3）逆向建模。在图纸缺失或既有建筑的改扩建工程中，通过扫描既有建筑获得建筑各参数数据，再逆向建立BIM模型，常用于古建筑加固保护等领域。

4）施工模拟。在对钢结构等大型预制构件进行施工前，可采用构件数据建模的方式进行模拟施工，以辅助解决实际施工中存在的问题。

5）辅助施工量统计。BIM模型中各构件都可被赋予参数和属性，支持对模型各组成部分的分离和整合，常用于统计材料用量、建筑施工量等。

3　逆向建模

在既有建筑，特别是年代久远但现在仍具有使用价值或文物保护价值的建筑（如医院、图书馆、古寺等）中，或多或少都存在因图纸保存不善、部分缺失、已经过改造或位移等导致的现有图纸不能表达其准确数据信息的情况，需对其进行重新勘测，从而得到最新详尽的图纸信息[7]。

在实际操作中，逆向建模通过采集和拟合点云数据进而建立BIM模型，相较于GPS，无需考虑GPS信号的遮挡问题，适用性大大增强；与传统的全站仪相比，避免了测量过程中人为因素导致的误差累计，同时数据获取的速率也有显著提高。

3.1　点云数据处理

由于观测仪器设备的自身精度等内因以及在扫描过程中不可避免地会受自然风、振动等外因影响，扫描场地周围与目标建筑无关的物体也可能会被仪器采集，因此点云数据中必然存在噪声点、失真点和冗余数据。点云数据的预处理需过滤掉错误、冗余的点云，消除数据拼接中误差的积累，对后续模型建立具有重要的作用。点云数据的平滑处理，即对数据中可能存在的随机性误差进行平滑滤波处理；再利用去噪后的点云数据建立表面光滑且具有一定精度的三维模型。常用的去噪方法包括均值滤波、高斯滤波和中值滤波等。本文采用均值滤波和高斯滤波两种方法，其中均值滤波可通过统计各数据点的平均值来代替原点，处理后的数据从整体来看具有较平滑的状态；高斯滤波可滤除某指定区域内的高频信息，能较好地维持原数据的真貌。

由于点云数据由多个测站扫描采集，属于多视点云数据，且不同测站获取的点云数据的坐标系相互独立，因此两两相邻测站在扫描目标时需设定扫描的重叠部分，并在扫描重叠处选取标靶点（不少于3个），布设靶标作为拼接的依据。对多视点云数据进行坐标统一，可通过软件对处理过的点云数据进行多视对齐。其配准原理为：

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix} + \boldsymbol{R}_z(\alpha)\boldsymbol{R}_z(\beta)\boldsymbol{R}_z(\gamma) \begin{bmatrix} x \\ y \\ z \end{bmatrix} \tag{1}$$

$$\boldsymbol{R}_z(\alpha)\boldsymbol{R}_z(\beta)\boldsymbol{R}_z(\gamma) = \begin{bmatrix} \cos\alpha & -\sin\alpha & 0 \\ \sin\alpha & \cos\alpha & 0 \\ 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} \cos\beta & 0 & \sin\beta \\ 0 & 1 & 0 \\ -\sin\beta & 0 & \cos\beta \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\gamma & \sin\gamma \\ 0 & -\sin\gamma & \cos\gamma \end{bmatrix} \tag{2}$$

式中，(X, Y, Z)为点云配准处理后统一坐标系下的坐标；(x, y, z)为扫描获得的初始点云坐标；Δx、Δy、Δz分别为沿X、Y、Z轴平行正方向的平移量；α、β、γ分别为以X、Y、Z轴正方向为轴的旋转量[8]。

3.2　模型构建

在逆向建模前，需确定建模目标的轴网和标高，由于本次实验的对象是形状规则的建筑，因此可对其点云数据进行切片分层处理，将三维点云数据切片分层后可看作不同楼层平面的二维点云，再根据不同楼层平面的数据获取目标建筑墙、柱等结构物的位置信息[9]。

基于在Revit软件中链接处理后的点云数据，参照原图对目标建筑的梁、板、柱、墙体、门窗的位置进行绘制。预先设立族库，族作为BIM模型中的基本图元包含了丰富的信息，以墙体的族为例，墙体可按照其属性分为类型和功能两大类，分别包含墙体组成、厚度、功能等子项。在模型绘制前，通过创建不同种类的族，直接放置在对应的位置上。当属性结构不同时，可先修改族中结构物的尺寸材质组成等信息，再利用上述途径创建模型[10]。逆向建模流程如图1所示。

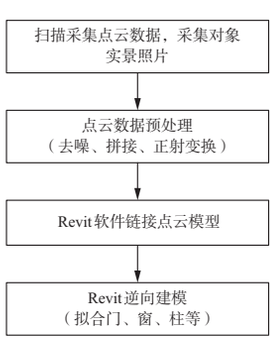

图1　逆向建模技术路线图

4　应用实例

本文以兰州理工大学兰工坪校区一号教学楼为例，探究了逆向建模辅助房屋改造的可行性。兰州理工大学兰工坪校区一号教学楼房屋位置较平坦，目标建筑前后分别为图书馆前的小广场和小花园，周围遮挡物较少通视良好；但建筑物内外装修和配套设备陈旧，为适应现代建筑功能和教学需要，需对其进行改建、装修。

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4.1　仪器与参数

本次扫描采用徕卡 RTC360 扫描仪，具体仪器参数如表 1 所示。徕卡 RTC360 扫描仪可结合配套的徕卡 Cyclone FIELD 360 外界操作 App 直接安装在 iPad 上，通过 WiFi 无线链接设备，实现远程操作、自动下载项目点云，能在现场对采集到的点云数据进行简单的检查和查询。

表 1　徕卡 RTC360 扫描仪参数

参数	指标
扫描范围	0.5～130 m
扫描速率	2 000 000 点/s
测角精度	18″
点位精度	1.9 mm@10 m 2.9 mm@20 m 5.3 mm@40 m
范围噪声	0.4 mm@10 m 0.5 mm@20 m

4.2　实验过程

实验期间一号教学楼处于正常使用状态，内部教室、办公室和自习室的使用情况颇为复杂，因此本文基于采集的一号教学楼外立面点云数据，结合教学楼原本的图纸来构建模型。由于一号教学楼的外形较简单，出于尽可能减少测站数量和两个测站间需有重叠部分的考虑，经过实地勘察，本文在目标建筑周围设立了 14 个测站进行扫描，并采集相应的点云数据。

外业结束后将扫描仪连接电脑，导出扫描后的原始数据；然后采用与仪器配套的 Cyclone 软件对原始数据进行去噪、正交变换，拼接等处理；最后得到完整且光滑的点云模型，如图 2 所示。将点云模型链接到 Revit 软件中，参照点云模型，在 Revit 软件中调整东、南、西、北 4 个立面视角，调整剖面角度，通过模型点云确定 BIM 模型在立面、水平面的标高、轴网，结合点云模型对外立面的墙体、窗户、雨棚、台阶、大门等结构物进行拟合，利用图纸和采集的现场照片调整模型构件的属性信息，使其真实反映一号教学楼的真实状态。点云数据拟合的 BIM 模型如图 3、4 所示。

图 2　一号教学楼点云模型

图 3　东立面门窗拟合逆向构建一号教学楼 BIM 模型

图 4　一号教学楼 BIM 模型效果图

4.3　实验结果

1）模型精度分析。在对点云模型进行拟合、逆向建立 BIM 模型后，需对已建立的模型精度进行分析。本文采用的精度分析方式为：在各测站点上架设全站仪，选取离测站最近的窗台上右侧拐点作为特征点，将测量测站与特征点之间的距离与从模型中提取的 14 组数据的相对距离进行分析比对，得到客观的精度评价。精度分析结果如表 2 所示，可以看出，最小的距离差值为 1 mm，最大的距离差值为 11 mm，通过计算得到特征点距离的中误差为 $\delta=\pm5.654$ mm，可见通过点云数据进行逆向建模建立的 BIM 模型具有不错的精度。

表 2　BIM 模型精度对比分析表

特征点	全站仪测距（s_1）/m	三维测距（s_2）/m	$\Delta s=s_1-s_2$ /mm
A1-A2	8.279	8.287	−8
B1-B2	4.715	4.718	−3
C1-C2	6.280	6.291	−11
D1-D2	4.981	4.975	6
E1-E2	5.186	5.188	−2
F1-F2	8.673	8.670	3
G1-G2	3.992	3.986	6
H1-H2	5.489	5.494	5
I1-I2	8.002	7.998	4
J1-J2	6.674	6.673	1
K1-K2	5.103	5.107	−4
L1-L2	8.097	8.095	2
M1-M2	9.860	9.863	−3
N1-N2	4.664	4.654	10

2）工程量统计。本文以一号教学楼改造范围内涉及的外立面墙体上的木框窗户为例，基于 BIM 技术在 BIM 模型中对需要改造的木制窗户进行工程量计算。由于安装时间较长，木制窗框本体发生了变形，窗户的密封性变差且部分窗户已无法正常开闭，影响到楼体本身保温和采光等问题，打算将其换成强度更高、密封性更好的 PVC 塑料窗户，因此需对外立面窗户的数量、尺寸大小进行工程量的统计，用于施工预算的计量。利用 Revit 软件的明细表功能，能在完成数量尺寸统计的同时，呈现窗户在不同楼层的分布情况，如表 3 所示。

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表3　楼体外立面窗明细表

标高	样式	宽度	高低	数量
F1	单层固定窗	1 300	1 900	1
F1	单层固定窗	1 300	2 000	2
F1	单层固定窗	1 500	2 000	2
F1	单层固定窗	1 700	2 000	1
F1	单层固定窗	1 300	2 300	23
F1	单层固定窗	1 000	2 400	11
F1	单层固定窗	1 500	2 400	24
F2	单层固定窗	1 300	1 900	24
F2	单层固定窗	1 000	2 000	9
F2	单层固定窗	1 300	2 000	2
F2	单层固定窗	1 300	2 000	2
F2	单层固定窗	1 500	2 000	28
F2	单层固定窗	1 700	2 000	1
F2	单层固定窗	1 700	2 000	1
F3	单层固定窗	1 300	1 900	18
F3	单层固定窗	1 000	2 000	10
F3	单层固定窗	1 300	2 000	2
F3	单层固定窗	1 500	2 000	26
F3	单层固定窗	1 700	2 000	1
F3	单层固定窗	1 300	3 500	2
F3	单层固定窗	1 500	3 500	2
F3	单层固定窗	1 700	3 500	1
F4	单层固定窗	1 000	2 000	10
F4	单层固定窗	1 300	2 000	2
F4	单层固定窗	1 500	2 000	26
F4	单层固定窗	1 700	2 000	1

3）三维可视化展示。三维可视化作为BIM模型区别于传统建筑图纸的巨大突破，将图纸中的建筑以三维模型的形式鲜活地呈现在设计、施工人员的眼前。在既有建筑的改造中，可利用其可视化的优点，在模型中对房屋内部的照明设备、管网的排布等进行布置；对原有设计进行改动前，可在BIM模型中进行仿真模拟，直观准确地将修改后的效果表现出来；在维修改建影响结构完整的构件时，可在模型中对改动部位进行碰撞测试来验证改动设计的可行性。相较于传统设计中施工方发现问题先向设计方反映、沟通后再对现场进行考察修改的方式，该方法更加便捷直观。

本文以一号教学楼一层东侧教室的照明设计为例，可在模型中对该位置上的教室进行三维可视化模拟。选取合适的位置放置“相机”功能，得到该位置上某一教室的三维剖切图；再结合该教学楼所处地区日照情况，对该教室内灯光布置进行粗略检查；最后根据仿真的情况选择合适的排布方式。教室内照明设备三维可视化效果如图5所示。

5　结　语

在经济高速腾飞的现代社会，对既有建筑进行改造升级顺应了时代的发展要求。以BIM技术为中心，结合三维激光扫描技术的逆向工程的应用，避免了传统测量方式的繁琐和不确定性的影响，为信息采集、模型构建和实时管理提供了一个高效、便捷的新方法。本文通过实验验证了逆向工程中三维激光扫描技术信息采集的准确性，同时逆向建立的BIM模型中的各组成构件都被赋予了属性信息和三维可视化的优势，为改建过程中的设计、施工提供了大量帮助（如优化设计、工程量统计、监督施工质量等）。作为一种新兴的辅助工程建设方式，其在既有房屋改建中具有广阔的应用前景，值得在今后的工程实际中推广。

图5　一号教学楼东侧教室照明设备三维可视效果图

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Influence Analysis of DEM on the Orthorectification of SuperView-1 Satellite Images by *LI Junjie*
Abstract The high-precision orthorectification of image needs appropriate control points and DEM, but the high-resolution DEM is often difficult to obtain. In this paper, we used four kinds of DEM with different scales to generate the orthoimages of SuperView-1 satellite, and evaluated and compared their accuracy, so as to provide a reference for choosing which scale of DEM for the practical application of orthorectification. The results show that the open-source DEM in the hilly area can make the RMSE of the plane position accuracy of orthoimages better than 3 m, and the DEM with 5 m grid spacing can improve its accuracy to 1.5 m.
Key words scale, DEM, SuperView-1, orthorectification (Page: 50)

Research on Population Spatialization Based on Luojia-1 Nighttime Light Data by *WANG Meiling*
Abstract The nighttime light data are increasingly used in the research of population spatialization. The Luojia-1 nighttime light data are the newest. In order to explore the application value and potential of Luojia-1 nighttime light image in the population spatialization, taking the Luojia-1 nighttime light data and land use data as the source data, we constructed a progressive regression model with a partition way at the township (street) scale, and obtained the population spatialization results of Beijing City. Then, we compared these results with the NPP/VIIR results. The results show that the fitting degree and accuracy of regression results of Luojia-1 nighttime light data are superior to those of NPP/VIIRS regression results, and especially, in the regions with a low population density. Moreover, the population spatialization results based on Luojia-1 nighttime light data can clearly present the spatial distribution difference of population in the city, which has a practical significance in urban resource and environmental management.
Key words Luojia-1 nighttime light data, NPP/VIIRS nighttime light data, land use data, progressive regression model, population spatialization (Page: 53)

Evaluation of Territorial Spatial Development Suitability at County Scale Based on GIS Spatial Analysis by *LI Juan*
Abstract It is of great significance to evaluate the suitability of territorial spatial development based on industrial-living-ecological space for rational layout and orderly development of land space, and the realization of regional coordination and sustainable development. In this paper, taking Linze County for example, taking the grid size of 5 m×5 m as the basic unit, we used GIS technology and "Puff Pastry" model to carry out the evaluation of territorial spatial development suitability based on industrial-living-ecological space, which could reveal the territorial spatial development suitability of Linze quantitatively from multi-scale. This method can provide decision-making reference and data support for the optimal allocation and orderly development of the county unit's territorial spatial planning schemes.
Key words industrial-living-ecological space, county, territorial space, development suitability, Linze (Page: 57)

Research on Spatio-temporal Characteristics of Urban Landscape Pattern Based on Impervious Surface by *YANG Junjun*
Abstract Land use/cover change (LUCC) is the most direct process of human influence on global environmental change, and cities as the products of human civilization are the most violent areas in this process. Objective, accurate and timely development dynamic assessment can help us better understand the development status and existing problems of urban construction. In this study, taking the Sentinel images as the data source, taking Xixian New Area as the research area, we used quantitative analysis methods of transfer matrix and dynamic indexes to study the spatio-temporal characteristics of dynamic landscape pattern in the research area from 2016 to 2019. The main conclusions show that ①in 2019, the coverage area of each land use type in the new area is vegetation, impervious surface, bare land and water body in order from large to small. With the deepening of urbanization, the vegetation area is decreasing, while the impervious surface area is increasing. The area proportions of the two are 47.5% and 42.6% respectively in 2019. ②Based on the concept of "Green Development", the regional characteristics and location environment of each new town, the transfer of land use types in each new city has its own characteristics and significant differences. The land use type transfer of 2017 is the most dramatic. Among them, the impervious surface area shows a significant increase trend at the whole picture, but the increase of Fengdong New Town is not significant. The vegetation area of each new town decreases to different degrees, among which Qinhan New Town has the most significant reduction but the largest area of vegetation. ③ From 2016 to 2019, the single dynamic index of impervious surface in Xixian New Area is 13.9%, and there is a significantly expanded, among which Jing River New Town and Airport New Town are the most prominent, 26.9% and 37.2%, respectively. During the study period, the integrated dynamic index of Xixian New Area is 4.4%, with frequent land transfer and high comprehensive utilization, indicating that Xixian New Area is under systematic and all-round construction in the study period. The rapid construction of Xixian New Area will become a growth point of economic and social development in Shaanxi Province, provide impetus for talents introduction, economic construction and social progress in the region, and make important contributions to the construction and influence of the Silk Road in Shaanxi Province.
Key words impervious surface, landscape pattern, spatio-temporal dynamic, Sentinel image, Xixian New Area (Page: 61)

Research on Dynamic Changes of Vegetation Cover in Liangcheng County Based on RS and GIS by *YIN Duoduo*
Abstract Taking Liangcheng County as the study area, taking the remote sensing images of Landsat TM/OLI in two different times as the study data, using the models of dynamic degree and transfer matrix of land use, we studied the dynamic changes of vegetation cover in Liangcheng County from two aspects, such as quantitative change and spatial change based on the techniques of RS and GIS. The results show that ①the area of vegetation cover in Liangcheng County has decreased from 2006 to 2016. Annual mean change rate of -2.04% presents reduction trend. Spatial change degree of 6.52% shows relatively significant differences in spatial changes. ② The large areas of vegetation cover in Liangcheng County are mainly composed of two mountains and several hills. Some lost vegetation cover area converted into other land, which mainly happened in the sunny slopes of Manhan Mountain, Matou Mountain and eastern hills. The others converted into construction land, and it is obvious especially in Daihai basin because of the project of "Ten Complete Coverage" in the Inner Mongolia Autonomous Region since 2014. There are three main driving factors for the dynamic change of vegetation cover, which is climatic factor, topographic factor and human factor.
Key words RS, GIS, land use/cover change, vegetation cover, Liangcheng County (Page: 67)

Land Cover Change Monitoring Based on Google Earth Engine and Multi-source Remote Sensing Images by *XIONG Yuankang*
Abstract Rapid and accurate acquisition of land cover change information in a region, can provide important support for the socio-economic development, eco-environment construction and territorial space planning of the region. In this study, taking Guangdong Province as the study area, supported by Google Earth Engine (GEE) cloud platform, taking Sentinel-1/2 and Landsat 7/8 data as remote sensing data sources, combining multi-source temporal images with DSM images, we used machine learning algorithm to carry out land cover type monitoring.
Key words land cover type, land cover change, GEE, machine learning, multi-source data (Page: 73)

Spatial Characteristics Analysis of Soil Erosion Risk in Typical Black Soil Area by *CHEN Xiaoning*
Abstract Soil erosion risk is used to evaluate and predict the severity of soil erosion and land resource destruction. Taking Zhangkoutun small watershed in Baiquan County of Heilongjiang Province for example, we used the slope erosion data in 2005 to estimate the anti-erosion annually of black soil layer. Then we used GIS to conduct spatial superposition statistical analysis of erosion risk and geographical environment factors, and discussed the relationship between soil erosion and land use, soil type and slope. The results show that the anti-erosion annually of black soil with broken skin and clay bottom is the shortest, and the average anti-erosion annually of thick clay bottom black soil is the longest. At the same time, with the increase of slope, the anti-erosion annually gradually decreases. According to the land use type, the anti-erosion annually of woodland and grassland are significantly longer than that of cultivated land, urban and rural industrial and mining residential land and bare land.
Key words GIS, anti-erosion annually, soil type, slope, land use (Page: 79)

Research on Application of Point Cloud Data and BIM Technology in Existing Building Reconstruction by *YU Hao*
Abstract With the change of time, a lot of the original information can not accurately reflect the real situation of the existing buildings. In this article, we used 3D laser scanning technology to collect high-timeliness point cloud data at first. And then, we collected live photos and analyzed the real situation. After referring to the original drawing, we performed a reverse fitting of the point cloud data in Revit software, and established a BIM model. Finally, we verified the accuracy of the model by precision analysis. BIM model can count and classify engineering quantities in software. At the same time, BIM model has the characteristics of 3D visualization. We simulated the reconstruction design in the model to verify the feasibility, and studied the application of point cloud data and BIM technology in existing building reconstruction.
Key words existing building, 3D laser scanning technology, 3D visualization, BIM technology (Page: 83)

Application and Analysis of Trimle DiNi03 Level in Foundation Monitoring by *CUI Mingjun*
Abstract In this article, we introduced the principle and characteristics of Trimle DiNi03 level at first. And then, combining with practical work experience, we analyzed the problems that should be paid attention to in the application of Trimle DiNi03 level in detail. Finally, we proposed the precautions in the instrument operation and the methods to deal with the problems occurred during observation, which could increase the observation precision and the working efficiency effectively.
Key words electronic level principle, characteristic, foundation monitoring, application and analysis (Page: 87)

Establishment of Second-class Gravity Network Based on CORS Reference Stations by *LI Yanlong*
Abstract Qinghai Province continuously operating reference station(QHCORS) as second-class gravity point, the selected point conforms to the requirements of the current national standards. Taking 2000 national gravity basic network, national gravity basic network supplementary and encrypted gravity measurement project, and 1606 engineering gravity basic network as the starting points, we used two CG-5 relative gravimeters to carry out second-class gravimetry at the QHCORS, and established a second-class gravity network in Qinghai. The average error of the accuracy of point gravity results after adjustment is 18.00×10^{-8} ms^{-2}, which can meet specification requirements.
Key words second-class gravity, CORS, CG-5 (Page: 90)

Experimental Research on the Effects of Different GNSS Sessions in Vehicle-borne Laser Scanning by *CHEN Hui*
Abstract Through the vehicle-borne laser scanning data in different GNSS sessions on the same day for the same environment, we analyzed and studied the effects of different GNSS sessions in vehicle-borne laser scanning. The result shows that the effects of different GNSS sessions need to be considered if in a poor GNSS signal area blocked by trees and buildings, while the effects of different GNSS sessions don't need to be considered if in an area with good GNSS signal. We can predict the GNSS signal quality in different sessions of an area in advance to plan the scanning operation time and improve data reliability through satellite ephemeris prediction software or platform. It is of great reference significance and worth promoting for vehicle-borne laser scanning.
Key words GNSS session, vehicle-borne laser scanning, integrated navigation, reliability (Page: 94)

Research on the Extraction Technologies of Proof Map Spots and Restoration Attributes in the Third National Land Survey by *WANG Chuanxian*
Abstract The extraction technologies of proof map spots and restoration attributes is extracting field work map spots and screening restoration attribute map spots after overlay analysis of existing data by ArcGIS software. It plays an important role in the accuracy of extraction and restoration attribute extraction. It can effectively

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