

利用社交媒体数据探测细粒度城市子区域

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摘 要: 对城市中人类活动子区域的精细探测, 能为城市资源合理配置和科学管理提供有效依据。提出了一种使用社交媒体数据细粒度分割城市空间区域的方法, 基于带有地理位置的社交媒体数据, 利用大量用户移动数据构建空间交互网络, 利用复杂网络的社区发现算法探测城市子区域。实验结果表明, 利用社交媒体数据能较好地探测出反映人们真实活动空间的细粒度城市区域, 为城市管理提供参考。

关键词: 社交媒体; 空间交互; 社区发现; 城市子区域

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随着城市发展进程的不断加快, 城市的科学化管理也面临着巨大挑战。城市的分区管理通常依据自上而下的行政区域划分, 但该方式并不能真正反映城市居民在空间上的活动规律, 不利于城市规划、高效资源配置的实施。对城市空间进行合理的子区域探测, 理解和掌握自组织演变下的城市空间结构, 有利于解决城市问题中的资源配置问题, 对建设智慧城市有重大意义^[1]。城市居民的移动规律潜在反映了城市空间结构信息, 因此可基于居民空间活动规律对城市区域进行划分。

得益于信息技术的发展, 获取大规模长时间序列的人类移动定位轨迹大数据得以实现, 为基于群体在空间上的移动规律, 自下而上地研究城市空间结构带来了新的契机^[2]。同时, 结合人类移动定位数据, 网络分析理论的发展也为研究城市空间结构提供了新的方法^[3-4]。Barthélemy M^[5] 等将复杂网络理论应用于移动定位数据, 从而进行空间网络分析。网络中的社区^[6]发现算法能将网络划分为内部联系紧密、外部联系稀疏的社区结构, 实现城市空间的区域划分。目前用于研究城市空间结构的人类移动定位大数据源主要包括手机数据、公共交通刷卡数据、出租车数据以及社交媒体数据等。基于这些数据, 结合网络分析方法, 学者们取得了较好的研究成果, 如 Sobolevsky S^[7] 等利用一系列全国范围内的手机数据构建了大规模的人类交互网络, 并结合网络社区发现算法揭示了与现有行政区相似的、有凝聚力的城市分区结构; ZHONG C^[8] 等利用不同时期的地铁智能卡数据构建了网络, 计算了网络节点属性并划分了网络社区结构, 分析了新加坡城市中心、枢纽以及社会经济分区的动态变化; GUO

DS^[9] 等利用出租车轨迹数据构建了空间网络, 并提出了一种在空间约束上进行优化的网络社区发现算法, 将网络划分为揭示空间移动的地理区域; YIN J J^[10] 等利用社交媒体数据, 结合 Infomap 网络社区发现算法探测了国家尺度和城市尺度下的城市区域边界。

本文提出了一种使用社交媒体数据细粒度分割城市空间区域的方法。通过带有地理位置的社交媒体数据构建空间交互网络, 结合复杂网络中社区发现算法划分空间网络, 进而揭示城市子区域结构。实验结果表明, 相比于单一出行数据, 社交媒体数据的用户活动类型更丰富, 能将城市空间划分为细粒度内部活动紧密的区域, 为城市资源配置优化和科学管理提供依据。

1 数据来源与研究方法

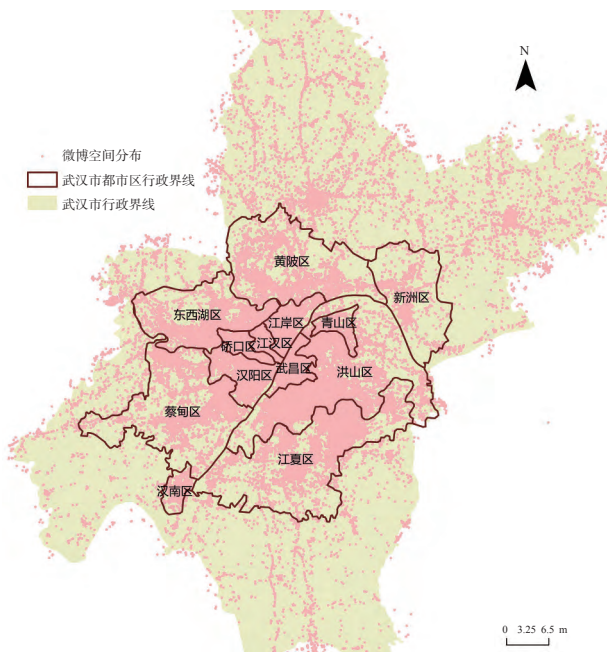
1.1 数据来源

本文将新浪微博社交媒体数据作为研究人类空间交互的载体, 实现对空间区域的划分。社交媒体数据主要通过新浪微博开放 API 接口获取, 包括微博的创建时间、空间位置、文本内容、用户信息、微博 ID 等。本文收集了武汉市 13 个月带有地理位置的微博数据, 共计 3 006 158 条记录, 来自 787 530 个微博用户, 时间为 2017 年 7 月—2018 年 8 月。微博数据的分布存在空间异质性, 市中心分布较多、郊区分布较少, 如图 1 所示, 因此本文将数据分布较多的武汉市都市区作为研究区域, 包括江岸、江汉、硚口、汉阳、武昌、青山、洪山 7 个城区以及江夏、黄陂、新洲、东西湖、蔡甸、汉南 6 个远城区的部分区域。

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此外, 本文还结合武汉市行政区划边界、主要道路干线、火车站、汽车站、机场、学校以及地铁线路等一些城市基本要素数据, 对区域划分结果进行了分析。

1.2 研究方法

基于大量人类移动定位数据可以挖掘出群体的空间交互模式^[11],进而挖掘城市空间结构信息。本文利用大量微博用户长时间序列在空间上的移动数据构建了空间交互网络,并采用复杂网络中的社区发现算法划分了城市区域。

1) 空间交互网络的构建。本文设计了一种利用带地理位置信息的社交媒体数据构建空间交互网络的方法:将城市划分为规则的格网,以空间格网为基本研究单元,即将格网作为网络中的节点;在微博移动数据中,时间相邻的两个记录可看作是一次移动,移动跨越两个格网则作为两个格网的一次交互,对应的两个网络节点之间存在一条有向边,若两次记录位置均位于同一个格网,则作为无效的移动流。本文设置规则格网的大小为 $400\text{ m} \times 400\text{ m}$,其主要原因在于:

- ①居民在 1 km 以内的出行方式大多为步行,若格网大小超过 1 km ,则社交媒体数据包含的该类出行可能被视为无效边处理掉,因此格网大小需小于 1 km ;
- ②为保证步行起始点位置落在不同的空间格网上构成有效的空间交互,格网大小选择 400 m 、 500 m 较为适宜;
- ③参考其他微博数据相关研究^[12]。

根据上述方法, 构建一个代表空间交互的加权有向网络 $G=\{V, E, W\}$, 将全部用户轨迹对应的所有格网集合作为网络节点集 $V=\{v_1, v_2, v_3, \dots, v_j\}$; 将格网间所有的有效交互作为网络的边集 $E=\{e_1, e_2, e_3, \dots,$

e_m }; 将同一条边包含的交互数量作为边的权重 $W=\{w_1, w_2, w_3, \dots, w_m\}$ 。以用户 i 为例, 其移动数据记录为 $U_i=\{(p_{i,1}, t_{i,1}), (p_{i,2}, t_{i,2}), (p_{i,3}, t_{i,3}), \dots, (p_{i,n}, t_{i,n})\}$, 其中 $(p_{i,n}, t_{i,n})$ 为用户 i 在 $t_{i,n}$ 时刻于 $p_{i,n}$ 位置上发布了其第 n 条微博, $t_{i,p} > t_{i,q} (1 \leq q < p \leq n)$, 可看作为用户 i 的移动轨迹; 再将移动记录映射到空间格网集 D , 则得到用户 i 移动轨迹的格网集 $D_i=\{d_{i,1}, d_{i,2}, d_{i,3}, \dots, d_{i,n}\}$, 其中 $(p_{i,1}, t_{i,1})$ 对应格网 $d_{i,1}$; 然后在用户 i 格网集合的基础上, 根据有效移动的定义得到其边集 $E_i=\{e_{i,1}, e_{i,2}, e_{i,3}, \dots, e_{i,n}\} \circ$

2) 细粒度城市子区域探测。利用社交媒体数据构建的空间交互网络隐藏着城市商业、社交、通勤、娱乐、政治活动等信息,反映在城市结构上形成空间联系紧密的簇^[10],通过社区发现算法划分网络结构,找到簇的边界,则可实现城市区域的精细探测。本文采用 Map Equation^[13]社区发现算法,其能较好地适用于加权有向网络。该算法从信息熵的角度出发,考虑流的方向,能发现网络中精细的社区结构,算法公式为:

$$\begin{aligned}\lg(M) &= H(P) + \sum_{i=1}^m P_i H(p)_i \\ &= -p \sum_{i=1}^m P_i \log P_i - \sum_{i=1}^m P_i \sum_{k=1}^{M_i} \frac{p_k}{P_i} \log \frac{p_k}{P_i} \\ P_i &= \sum_k p_k\end{aligned}$$

式中, $H(P)$ 为子区域之间的信息熵; $\sum_{i=1}^m P_i H(p)_i$ 为子区域加权信息熵; P_i 为用户访问子区域 m 的概率; p_k/P_i 为子区域 M_i 中的节点 k , 即空间单元 k 被访问的概率。 M_i 达到稳定的标准是信息熵达到最小。划分的网络社区结构具有社区内部节点联系紧密、社区之间节点联系稀疏的特点, 因此能直观地展示微博用户在区域内部和区域间的交互强弱情况, 更好地理解城市子区域划分结果。

3) 城市子区域探测结果优化。由于没有考虑地理空间因素的影响, 仅使用社交媒体用户移动的交互网络结构探测城市子区域将出现一些噪声点^[14], 因此需对结果进一步处理。城市子区域初步探测结果存在子区域边缘的离散格网点嵌入其他子区域内部的情况, 分析其原因可能是只考虑了网络节点中的流关系, 而实际情况中这些离散的格网可能受其邻近的格网影响更大, 因此本文将作为噪声处理。本文利用 DBSCAN 算法对探测的城市子区域进行去噪处理。DBSCAN 是一种基于密度相连的聚类算法, 能较好地识别噪声, 主要包括 EPS 邻域大小和 EPS 邻域内最小对象数量 MinPts 两个参数。根据研究区和节点格网

的空间尺度等具体情况，设置适宜的 EPS 邻域大小和 MinPts，从而达到较好的去噪效果，优化探测结果。

2 城市子区域探测实例

本文基于武汉市带有地理位置的微博数据，利用本文提出的方法探测城市子区域。实验前需先对数据进行预处理，包括去除数量过少、随机性强的用户数据、广告用户、重复记录等，最终采用的数据集包括 1 722 086 条微博，来自 168 676 个用户；构建的网络包括 11 400 个节点，535 884 条有效边，权重之和为 1 130 649。基于上述空间交互网络，本文划分了网络社区结构，并结合实际地理位置信息对探测结果进行了优化，得到城市子区域的划分结果。本文设置 DBSCAN 聚类 EPS 邻域大小为 400 m，MinPts 为 3。最终，得到了武汉市都市区的 193 个子区域，范围覆盖 7 051 个空间格网单元，如图 2 所示。局部放大如图 3 所示。

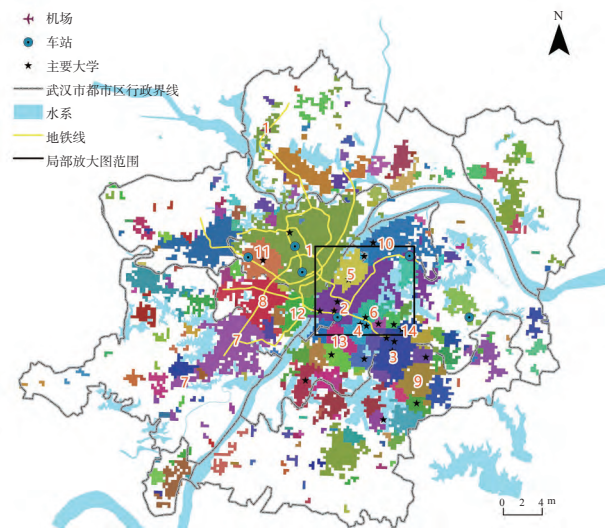


图 2 武汉市都市区子区域探测结果图

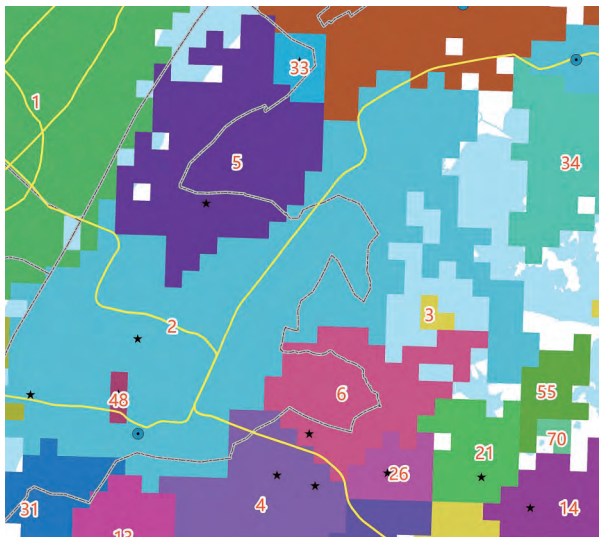


图 3 子区域探测结果局部放大图

本文结合武汉市行政区划边界、主要道路干线、火车站、汽车站、机场、学校以及地铁线路等城市基本要素信息，对武汉市区域划分结果进行分析，并分析了利用社交媒体数据划分细粒度城市子区域的可行性。由图 2、3 可知，本文方法从整体上实现了对武汉市较精细且符合真实人类活动情况的空间区域划分，子区域探测结果可分为两类。一类是面积较大、服务范围较广的区域，如面积最大的 1 号区域基本包括了江汉区和江岸区，且其区域边界与行政区划边界较吻合，其成因在于，整个 1 号区域（图 2）内部地铁线路发达、交通便利、居民活动范围较大，空间分布大体上沿着地铁线圈定区域向外延伸；探测出的 2 号区域（图 3）整体沿内部地铁线狭长分布，居民在空间活动上较便利，打破了行政区边界的约束；1 号、2 号、5 号等区域之间部分边界以长江为分界线，不存在区域打破水系约束的情况，说明水系等天然屏障在空间活动范围上对居民有巨大影响。另一类是面积较小、更加细粒度的城市子区域，如探测出的最细空间粒度范围为 3 个格网单元（图 3 中 48 号区域），覆盖了中南财经政法大学首义校区，在较大的 2 号区域内被当作独立区域划分出来；图 3 中的 6 号、26 号、21 号、14 号、4 号和 33 号等均为较精细的城市区域，主要为大学校区，分别为武汉大学、武汉体育学院、中国地质大学、华中科技大学、华中师范大学和武汉理工大学（余家头校区）。从结果分析整体来看，对于范围较大的区域，居民在空间上的交互更多体现的是行政区划、交通以及水系等天然屏障的影响；而对于细粒度的城市区域空间，更多体现的是人们日常生活形成的社区。

通过对武汉市区域划分结果的分析可知，基于社交媒体数据构建的网络，利用社区发现算法能根据区域内部和区域间交互性的强弱，实现对城市空间较为精细的子区域探测。在城市空间划分问题上，本文将社交媒体数据与其他数据进行了对比分析，采用出租车数据构建的空间网络（时间为 2013 年 12 月 31 日—2014 年 3 月 30 日，共 7 653 个节点、535 373 条有效边，与社交媒体网络数量较一致）划分的城市子区域结果如图 4 所示。对比社交媒体数据和出租车数据探测结果可以发现，二者差异显著，特别是图 4 中 2 号、5 号、8 号区域，利用社交媒体数据的空间交互能探测出较精细的区域结构，而在出租车数据结果中，则将其划分为粗粒度的子区域。分析其原因可能是相较于其他数据源，社交媒体数据涵盖的用户活动类型更丰富，在工作、购物、娱乐、锻炼等日常生活

中均会产生数据，这对刻画城市空间子区域非常有利；而地铁、出租车等交通出行数据，只能反映单方面居民交通出行在空间交互上的情况，采用单一出行数据，对城市空间划分的粒度较粗^[14]，不能区分细粒度下的空间差异。因此，在利用单一数据源研究城市子区域划分时，选用能涵盖多方面信息的社交媒体数据在精细空间尺度上表现较好，进而能为城市管理提供合理的参考。

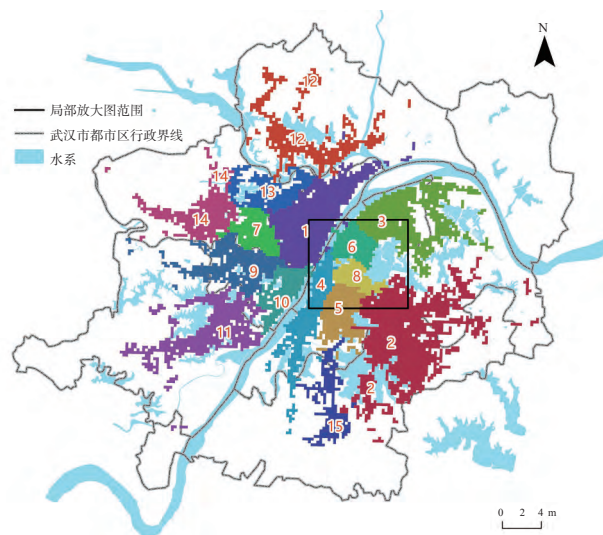


图4 出租车数据划分城市子区域结果图

3 结 语

带有地理位置的社交媒体数据能记录用户在空间上的移动轨迹，进而能通过这种移动定位大数据探测出城市群移动规律中蕴含的城市结构信息。本文通过获取大量社交媒体用户长时间序列的移动数据构建了用户在城市空间上的交互网络，再利用复杂网络中的社区发现算法得到区域内部交互紧密、区域间交互稀疏的城市子区域结构。区域探测结果表明，大学校区及其周边等内部一致性强、交互关系相对周边更紧密的细粒度区域能被正确划分出来；地铁等发达交通使得居民在城市空间上的移动更便利，因此也存在空间上居民活动聚集范围较大的区域；得到的子区域边界部分与行政区边界以及水系边界吻合，说明居民的空间移动在一定程度上受行政区划、水系等天然屏障的影响；城市子区域边界也有跨越行政边界的部分，这可能是由于交通等方面原因，使居民在空间移动上能打破行政划分的约束。综上所述，社交媒体数据能

综合城市空间交互上多方面的因素影响，能对城市进行较精细的区域划分，进而为城市资源合理配置和科学管理提供参考。

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data checking and database building system, can acquire and feedback the field investigation data fast and efficiently, inspect the quality of field investigation results quickly, and realize the automatic warehousing of results and the output of customize chart, which provides data support for government decision-making, and has good social benefits.

Key words land change investigation, UAV, Android, data check (Page: 87)

Research on the Relationship Between Urban Impervious Surface and Surface Thermal Environment

by YANG Junjun
Abstract Taking Xi'an City as the study area, based on Landsat8 OLI/TIRS images, we used support vector machine(SVM) method to extract the urban impervious surface information at first. And then, we inverted the urban surface temperature by mono-window algorithm. Finally, we carried out a random sampling regression analysis between the urban impervious surface and surface temperature. The results show that there is a significant correlation between the urban impervious surface and surface temperature, and the spatial pattern is highly consistent, namely when the impervious surface increased then the local surface temperature will increase, and vice versa. With a rapid increase of urban impervious surface, in order to form an ecological, green, healthy and sustainable urban ecological environment, we should carry out reasonable planning and layout of urban greening at the same time.

Key words impervious surface, surface temperature, Xi'an City, SVM, mono-window algorithm (Page: 89)

Low-cost RTK Device Based on RTKLIB and Raspberry Pi

by YANG Shenglian
Abstract In this paper, we operated the open source RTK software package RTKLIB on Raspberry Pi 3, and combining with u-blox NEO-M8T, made a low-cost RTK device. The actual test results show that the low-cost RTK device can reach dm level, and the accuracy is in the cm level after reaching the fixed solution of RTK in a better environment. This device can be widely used in geology, geophysical exploration and some surveying and mapping fields.

Key words Raspberry Pi, RTKLIB, low-cost RTK device (Page: 91)

Application of Low-altitude Oblique Photography in Unlicensed Mining Survey of Mine

by PENG Yanpeng
Abstract In this paper, we introduced a method of low-altitude oblique photography technique to conduct unlicensed mining survey of mine. Through UAV oblique photography and high precision 3D modeling of unlicensed mining areas in mines, we calculated the differences in surface changes before and after mining to obtain the amount of mineral resource of unlicensed mining. Then, we used the lithology identification and density test of the rock samples in the mining area to calculate the mineral resource reserves of the unlicensed mining of mines, and assessed the mining behavior and surface damage. The result shows that the work efficiency can be significantly improved. This study can provide certain operability and reference significance for the implementation of the unlicensed mining survey of mine.

Key words oblique photography, high precision 3D modeling, mine survey (Page: 93)

Hyperspectral Image Classification Combining Random Subspace and SSAE-LR

by CHENG Yuan'e
Abstract Aiming at the limitation problems of classification accuracy caused by high-dimensional hyperspectral data and the limited sample size, we proposed a new hyperspectral image classification method combining random subspace and SSAE-LR in this paper. Firstly, we carried out the spatial feature extraction of pixel neighborhood structure information based on the pixel neighborhood window, and serial spliced with spectral information. And then, we used the random subspace method to randomly select some feature subsets of the same size from the obtained global feature space. Finally, we used the method of SSAE-LR to train the base classifier on these feature subsets, and integrated the output of all the base classifiers to obtain the classification results. The experimental results of two sets of hyperspectral image data show that this method can effectively improve the classification effect compared with the traditional method.

Key words hyperspectral image classification, SSAE-LR, feature extraction, random subspace method (Page: 96)

Dynamic Simulation of Land Use in Dongjiang Basin Based on CA-Markov Model

by YE Jiao
Abstract In this paper, based on multi-period MSS and TM images, we analyzed and summarized the land use change rules of Dongjiang basin from 1980 to 2000. The results showed that the Dong basin was dominated by forest land before 1980, accounted for 61.56% of the area, and the cultivated land area accounted for 26.42%. The conversion intensity of land use structure was large and complex from 1980 to 2000, and the cultivated land, construction land, grassland and garden land had increased by 1 395.5 km², 1 118.85 km², 113 km² and 241.3 km² respectively. Using the CA-Markov model to simulate the spatial distribution pattern of land use in the Dongjiang basin, the experimental result shows that by 2020, the growth rate of forest land in the Dongjiang basin is 4.63%, and the growth rate of construction land is 35.31%. The cultivated land, grassland, garden land and unused land are reduced. The rates are -15.76%, -12.96%, -18.91%, and -4.98% respectively.

Key words Dongjiang basin, CA-Markov model, land use (Page: 102)

Primary Investigation of Surface Deformation in the Yellow River Delta Based on InSAR Technology

by DI Guishuan
Abstract With the geological reasons such as crustal movement, soil consolidation and human economic activities such as resource exploitation, urban construction, the surface deformation appeared in the Yellow River Delta, which was as a potential hazard for urban infrastructure and the safety of personnel, and the rate of somewhere reached -100 mm/a. In order to track the surface conditions, we

used the permanent scatterer interferometry (PS-InSAR) technique to process the Sentinel-1 images from May 2015 to August 2017, and verified the result's precision. And then, we analyzed the spatial distribution characteristics and genetic mechanism of the deformation funnel based on geological data and underground mineral resource development and utilization data.

Key words Yellow River Delta, PS-InSAR, surface deformation, formation analysis (Page: 106)

Prediction and Analysis of Building Settlement Based on GM(1,1) and Verhulst Model

by YAN Xiaohui
Abstract In this paper, we used GM(1,1) and Verhulst models to predict and analyze the settlement of buildings. The results show that the two models have different pros and cons. When the settlement prediction is carried out before the building load is stable, the GM(1,1) model is better for settlement prediction. While, when the settlement prediction is carried out after the building load is stable, the Verhulst model is better for settlement prediction. The final settlement shall be determined by field observations in conjunction with the final predictions of the Verhulst model. In the whole process prediction analysis of building settlement, it is recommended to use both models for prediction and comparative analysis.

Key words GM(1,1) model, gray Verhulst model, prediction of building settlement (Page: 110)

Urban Land Surface Settlement Monitoring Based on PS-InSAR Technology

by WANG Shengyan
Abstract With theoretical analysis and experimental comparison, we evaluated two methods for PS identification, such as correlation coefficient threshold method and amplitude dispersion index threshold method in this paper. Based on the traditional method, we combined with two methods to extract some reliable PS points. Taking the Shengli oil field in Shandong Province as the research area, we used PS-InSAR technology to extract the reliable PS points, and used 28 scene ALOS images to obtain the land surface settlement rate, and extract the settlement time series in the study area. The experimental results showed that from 2007 to 2011, a certain degree of settlement occurred in the study area, and the average settlement rate of this area exceeded 14 mm/a.

Key words PS-InSAR technology, PS point, land surface settlement (Page: 113)

New Method of Obtaining CGCS2000 Coordinate in Land Right Confirmation Registration of Land Contractual Rights

by SU Qiangqiang
Abstract In the process of land right confirmation registration of rural land contractual management rights, the parcel survey is involved. The parcel survey's coordinate system adopts the CGCS2000 national geodetic coordinate system. On the basis of this, we used GAMIT/GLOBK software to solve static observation stations to obtain high-precision ITRF frame coordinates, and then proceeded the coordinate frame conversion to obtain CGCS2000 coordinates. The result shows that the difference between the velocity field calculation coordinates obtained by the grid average method and the CORS measured coordinates is about 1 cm, which can fully meet the limit requirements.

Key words land right confirmation, GAMIT/GLOBK, coordinate transformation, velocity field, CGCS2000 (Page: 116)

Research on the Status and Development of Basic Surveying and Mapping in Jiangsu Province

by ZHANG Kai
Abstract Based on the construction status of basic surveying and mapping in Jiangsu Province, combining with the transformation needs, we analyzed the problems and shortcomings in the development of basic surveying and mapping, and put forward suggestions in the development direction and system composition research, which could provide a reference for the construction of new basic surveying and mapping system in Jiangsu Province.

Key words basic surveying and mapping, transformation and upgrade, system composition, new basic surveying and mapping system construction (Page: 119)

Detecting Fine-grained Urban Sub-region Using Social Media Data

by WU Shanmei
Abstract The fine detection of human activity sub-region of the city is an effective basis for realizing the appropriate city resource allocation and scientific management. In this paper, we proposed a method of finely dividing the urban area using social media data. Firstly, we built a spatial interactive network based on a large amount of user movement data obtained from geo-tagged social media data. Then, we used the community discovery algorithm in complex networks to detect the community structure. Finally, we revealed the urban sub-regions. The experimental results show that compared with single travel data, social media data cover a wider range of user activity types, which can divide urban space into fine-grained sub-regions reflecting people's real activity space with closer interaction. Compared with other top-down urban structures, such as administrative divisions, the fine-grained urban sub-region structure detected in this paper can provide a more detailed basis for urban management.

Key words social media, spatial interaction, community detection, urban sub-region (Page: 122)

Standardized Database Construction Method of Planning Results Based on FME and ArcGIS Pro

by JIANG Wei
Abstract Through the establishment of the database construction standard about planning results, we used FME and ArcGIS Pro software to realize the inspection, extraction, conversion and database construction of planning results, which realized the standardized database construction of planning results.

Key words FME, ArcGIS Pro, urban planning, standardized database construction (Page: 126)