Frontiers in Computing and Intelligent Systems
ISSN: 2832-6024 | Vol. 2, No. 1, 2022

Research on the Fast Construction Method of Basic Geographic Framework of 3D Smart Community

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Abstract: In order to promote the reform and innovation of social governance system, create "community brain" and build digital twin community in digital space, the hierarchical and household-level three-dimensional basic geographic framework plays the role of data base. Based on the key technologies such as deep learning change monitoring, batch building and rendering of hierarchical household 3D models on the Web side, and multi-source address matching, this paper explores and realizes the technical route of quickly building hierarchical household-level 3D basic geographic framework of 3D smart communities. Through the technique of dynamic rendering monomer, a three-dimensional model visualization platform of oblique photography is built, which effectively integrates various government resources of people, houses, things and things, and realizes socialization, intelligence and specialization of social governance and convenience services.

Keywords: Smart community; Hierarchical household model; Dynamic rendering single; STANet; Address matching; Cesium.

1. Introduction

Based on computer technology, massive data storage, analysis and visualization technology, digital city uses 3S, unmanned aerial vehicle measurement and radar sensing, simulation-virtual technology, etc. to realize the three-dimensional description of the city with multi-dimension, multi-time and multi-data fusion. [1]. Urban three-dimensional integrated modeling is an important base for building smart cities. [2]. It is the "cell" of a community city, the basic unit of urban grid management, and the smallest unit to create a modern urban governance system.

On the three-dimensional model building, Zhai Jing [3] The traditional manual modeling method is used, and 3DMax, SketchUp and other modeling software are used to stretch, calculate and map the DWG graphic data to realize the building model. Li Zhirong [4] By calling geometric data processing functions provided by CityEngine, two-dimensional surveying and mapping data are used to realize the programmed building of building models. On the simplification of the 3D model of oblique photography, the methods can be summarized into four categories: the simplification of cutting objects (including cutting points and cutting triangles), the simplification of ID, the simplification of dynamic rendering, and other simplification methods (model reconstruction, dense point cloud of oblique images and semantic simplification).[5] The geographic framework construction in the intelligent community management platform is a dynamic monomer rendering of the building model by combining the three-dimensional model display based on oblique photography with the hierarchical household model applied to the management of people, houses, things and things. The problems to be studied and solved in this paper include: (1) It takes a lot of manpower and material resources to construct a three-dimensional model of oblique photography, and the recognition problem is partially updated in the application process according to its current requirements; (2) At present, the research focuses on the single building model, and in order to meet the needs and refinement of social management, it is necessary to explore the rapid construction method of hierarchical and household-level building models; (3) To meet the management requirements of "one household, one address" at the social level, integrate and match the addresses of multiple social management departments, and carry out three-dimensional address matching.

2. Research technical route

The three-dimensional basic geographic framework construction of three-dimensional smart communities at hierarchical and household levels mainly includes: collection of two-dimensional entity data of urban buildings, identification and update of changing areas based on dynamic monitoring of multi-temporal remote sensing images, collection of two-dimensional entity data of hierarchical and household buildings based on two-dimensional integrated mapping technology, building of batch hierarchical and household building models, matching of multi-source names and addresses, and building of dynamic rendering single platform. The technical route is shown in Figure 1.

Due to the problem of updating the 3D model of oblique photography in some areas (taking a certain area of Yantai as an example, the first round of global oblique photography flight will be completed in mid-2019), it is necessary to update the 3D model of oblique photography and the 2D entity data of corresponding buildings on this basis. The 3D model of urban oblique photography is used to build the 3D base of the real scene, and the large-scale DLG data and the registered floor plan of real estate (or multi-measurement results) are integrated to form the 2D entity data of buildings and the 2D hierarchical household results. Through the oblique photography real-life 3D model, the height and number of buildings are collected, the address information of the political and legal committee, the public security department and the planning department is integrated, and the address pre-coding is carried out through address matching, so as to construct the hierarchical household database of buildings. The collected SHP-format building 2D entity data (with building attributes) is converted into GeoJSON format, and batch 3D model rendering on the Web side is realized through Cesium.js, forming a 3D intelligent community geographic information database with one household and one yard. Finally, the integration of real scene displays and attribute management is realized through dynamic rendering technology on the 3D visualization platform.

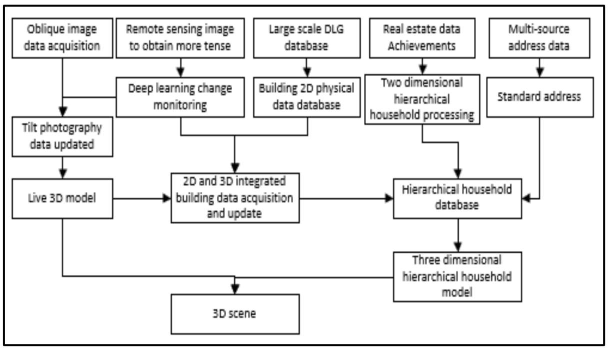

Figure 1. 3D smart community building hierarchical household 3D modeling technology roadmap

3. Key technologies

3.1. Remote sensing image change monitoring based on twin neural network and attention mechanism

3.1.1. STANet architecture and principle

STANet based on twin neural network architecture is a change monitoring network for remote sensing data proposed by Chen H in 2020.[6] Its network architecture is shown in Figure 2. The images before and after the change are taken as input respectively, and through the backbone network ResNet which deletes the global pool layer and the full connection layer. [7] Carry out feature extraction (take Res Net-34 as an example in Figure 2), and import the extracted feature map into the Spatio-temporal Self-Attention Mechanism Module (PAM). Based on the BAM (Bottleneck Attention Module) (architecture as shown in the figure), this module adopts pyramid mechanism, selects four scales of 1, 2, 4 and 8, imports the feature map of each scale into BAM, and splices the feature maps obtained by four branches. Finally, the Euclidean distance of Z (1) and Z (2) after bilinear difference is calculated, and the change graph is obtained by fixed threshold segmentation. To correct the gap between the changed sample and the unchanged sample, the loss function is defined as:

$$L(D,G) = \frac{1}{2}\frac{1}{n_c} \times \sum_{b,i,j} G_{b,i,j} \max(m - D_{b,i,j}, 0)^2 + \frac{1}{2}\frac{1}{n_u} \times \sum_{b,i,j} (1 - G_{b,i,j}) D_{b,i,j}^2 \quad (1)$$

Where nc and nu respectively represent the number of changed and unchanged pixel pairs; Gb,i,jand Db,i,jrespectively represent the distance values of the real label and network output of the pixel pairs in the first row and the second column of the data of the second pair. Gb,i,jcan be 0 or 1, representing the constant or changing pixels, and M represents the threshold value of lost distance.

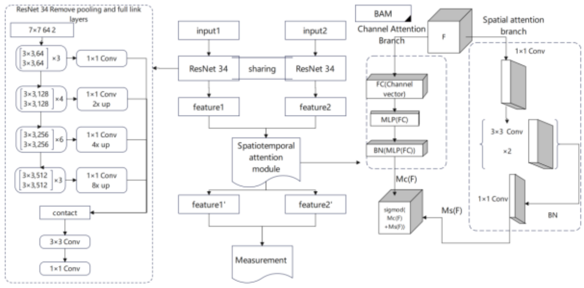

Figure 2. STANet neural network architecture

3.1.2. Deep Learning Method Based on ArcGIS Pro

The change monitoring module of ArcGIS deep learning is equipped with STANet deep learning framework, and runs the trained deep learning model to detect the change between two grids. The steps are divided into four steps: labeling samples, training data, model training and reasoning application.

2.1.2.1 annotation sample

Prepare the remote sensing images (0.5m) of the year (2018) and the year (2022) corresponding to the existing three-dimensional model of oblique photography in the region as the original data, refer to the architectural vector change results (2018~2020) in the relevant years, and mark the samples before and after the change by using image-classification tool-sample labeling in ArcGIS Pro. After marking, export the training set. The experimental area is 176 square kilometers and the sample size is 2,000.

Figure 3. Sample annotation example diagram

2.2.2.2 training data and model training

Select ArcGIS Pro Toolbox-Image Analysis-Training Deep Learning Model and use the tool of deep learning to monitor changes, import the sample set to start training, and select Res Net-34 as the backbone network of feature extraction. The model loss diagram is as follows, and examples of training results are shown in Figures 4 and 5. It has been verified that the accuracy rate of building change detection is 89.2%, and the detection results completely cover the changed residential quarters, meeting the project requirements.

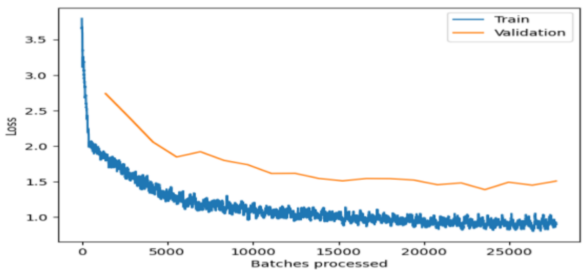

Figure 4. Deep learning loss diagram

Figure 5. Example diagram of change monitoring results

3.2. 2Batch hierarchical household model generation

In the desktop GIS processing software, the building floor is extracted from the large-scale topographic map as the two-dimensional entity data base of the building, and the two-dimensional hierarchical household data results are formed by referring to the hierarchical household map of the real estate. At the same time, the floor and household information are obtained, and the attributes such as floor height and floor data are given according to the three-dimensional model of oblique photography, and the building number of the real estate unit number is pre-coded. Finally, FME (Feature Manipulate Engine) is used to convert it into GeoJSON data format.

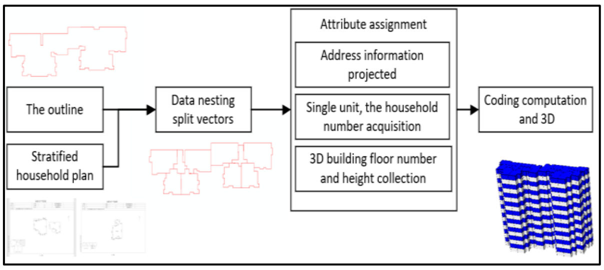

Figure 6. Process of building hierarchical household model

CesiumJS is an open source three-dimensional large scene earth model framework developed based on WebGL image engine [8] Through traversing the three-dimensional entity defined in GeoJSON, it is created and added to the Cesium scene view, so as to realize the rapid batch construction of the hierarchical household model on the Web side.

3.3. Address information matching

Political and Legal Committee, public security, planning and other departments all have their own address databases. Multi-source address data are diverse in organization, chaotic in management, and lack of authority, which is not conducive to address sharing services at the smart city level. In this paper, rules and dictionaries are used for address matching. The public security address is taken as the standard address, and it is segmented and labeled according to the standard address model. Tags are combined according to the set query rules, and matched with reference address dictionaries. After that, the address geographic space is roughly matched through the grid of the Political and Legal Committee, and finally distributed to the grid staff to check the specific accuracy. The technical route of address information matching is shown in Figure 7.

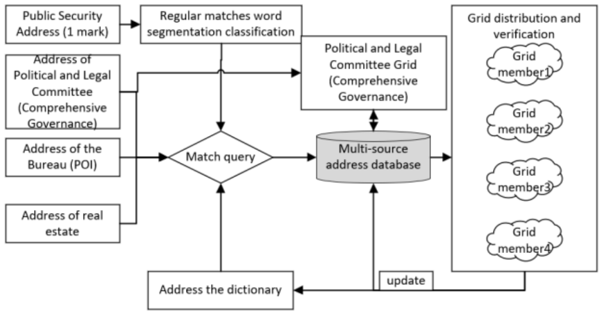

Figure 7. Technical route of address matching

2.3.1 Build a standard address model.

The standard address model refers to the Specification for Place Name Address Data of Geographic Information Public Service Platform (DB37/T 4361-2021), and is specified according to the actual application needs. The standard address is composed of three major elements: administrative area name, basic area qualifier name and local point location description, and is described in the following way: < standard address >: = < administrative area name > [basic area qualifier name] [local point location description].

Table 1 Standard Address Level Model

Level coding	Level name	type	Level content
1	Prefecture-level		City-level/region
2	District and	Admini strative area	Districts/counties/county-level cities
3	Township level		Streets/towns/townships
4	Administrative		Community/Administrative Village
5	streets and lanes		Street/Lane/Highway
6	number		number plate
7	Residential area	Basic area qualifier	Residents/Natural Villages/ | POI
8	Functional area		Commercial areas, industrial parks, science and technology parks, industrial parks, scenic spots, parks, universities and large hospitals
9	Ban	Local point position	Door (building) address | building name | village
10	other		Unit | Building | Floor | Room

2.3.2 address segmentation and classification

Design regular matching rules of elements at all levels, refer to Yu Yuanjian.[8] The idea of matching is that, taking into account the characteristics of residential buildings at the level of smart communities, the first matching interception is carried out with "Digital+Building" (Grade 9), because the address of residential buildings will be divided into two sections, and the first section will be intercepted with "Digital+Number" (Grade 6) for the second time, and the final words will be regularly judged to determine whether it is a road (Grade 5) or a community (village) [9] and mark the level of address elements. The accuracy of segmentation and marking of residential quarters by this method is about 84%.

Table 2 element characteristic correspondence table

Element level	Element name	Feature word set of corresponding elements
5	way	Road, Street, Avenue, Lane, Lane, Lane, Hutong, Lane
6	number plate	Number+sign
7	residential community	District, Garden, Village, Fang, Zhuang, Residence, Residence, Garden, Villa, Residential District, Mansion, Apartment
8	Functional area	Industrial parks, science parks, schools, colleges and universities
9	Ban	Building, building, block, building, row, #, number, etc.
10	other	Unit, ladder, floor, room, room, etc.
11	POI	Hotels, squares, buildings, department stores, companies, factories, halls, bureaus, markets, centers, guest houses, etc.

2.3.3 Address matching

The established standard address model can't be suitable for all complex and diverse Chinese address matching situations. By establishing an appropriate rule base, the problem of incomplete and fuzzy address expression can be effectively solved, and the search efficiency can be improved [10]. At the same time, according to the naming rules of different departments, it is necessary to establish a matching dictionary of addresses. At the community level, it is generally the community name corresponding to road+house number. Through the most effective address elements [11] Set the matching rules: POI (unique), road+house number, road+building number, community+house number, community+building number, road+community, road+road, community. According to the set rules.

3.4. Spatial matching

According to the grid data in the address of the Political and Legal Committee and the address matching result, the information is forwarded to all grid members for verification through the unified address verification system. After verification, the grid members feedback the information to form a correct address information base.

4. Web-side 3D visualization smart community platform construction

The problem of "monomer" of the tilted real-life 3D model is the basis for its divisibility and query. This project needs not only to divide a building, but also to "monomer" the building model by layers and households. The dynamic rendering monomer method is to dynamically attach transparent or semitransparent film on the 3D model of the real scene matching with it, so as to realize the monomer of the 3D model of the oblique photography real scene on the rendering level. [12], which can be dynamically rendered by 3D GIS engines such as cesium. 3D Tiles is developed and formulated by Cesium team. It is a data specification based on LOD technology, which is established on the basis of GLTF model definition, and realizes the loading of massive 3D spatial data on the Web.

Firstly, tilt photography is converted into 3DTiles format by CesiumLib software to load tilt photography data on the Web side, and at the same time, the layered household building model generated by GeoJSON is loaded. According to the layered household building model ID, the unique address and personnel information are linked, and the B/S-side 3D visual intelligent community platform is built.

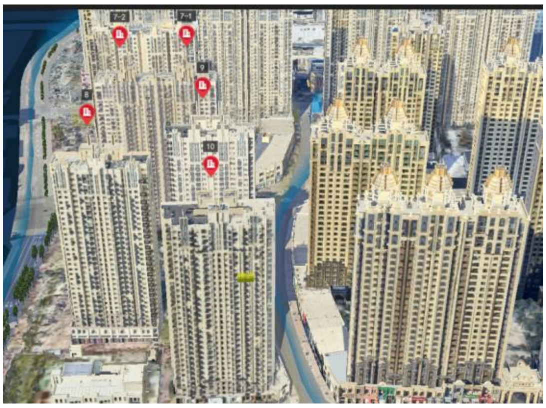

Figure 8. 3D Visualization Smart Community Platform

5. Conclusion

In this paper, the key technologies of community management based on the three-dimensional model of oblique photography are discussed and practiced, and the Web-side visualization platform is built, which provides a technical route for the rapid construction of the basic geographic framework at the level of smart community. Firstly, the change area is identified by deep learning change monitoring technology, so as to update the 3D model of oblique photography and the 2D entity data of buildings. Then, combined with the hierarchical household map of real estate (or multi-measurement) and the results of three-dimensional model of oblique photography, the two-dimensional entity data of buildings are processed by hierarchical household, and the building model is built and rendered directly on the Web. After that, the spatial uniqueness of the hierarchical household building model is matched with the address data of multiple departments, and one household with one address is realized. Finally, the results are displayed by building a three-dimensional visualization platform, creating an intelligent "community brain" and forming a modern community governance model based on information and intelligent social management and services.

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