Research on the Construction of standardized WebGL 3D scene Service for Power Grid Service

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Abstract. With the increasing maturity of WebGL technology as well as the development and construction of the 3D geographic information system, 3D geographic information sharing service has become the trend of future development. There are numerous three-dimensional data sources of the power grid and many applications across departments and systems, but the three-dimensional geographic information service based on unified standards is still rarely seen. The paper studies and discusses the selection of 3D service standards and the implementation technology of 3D geographic information service for the power grid.

Keywords: WebGL,3DTiles, I3S, S3M, 3D Geographic Information Service.

1. Introduction

The construction of unified standard service for power grid 3D scene based on WebGL is the focus of power grid 3D data sharing and application, and it is necessary to ensure the integrity and reusability of power grid 3D data. Currently, the current power grid 3D data unified standard service is still rarely seen, and 3D platforms using their proprietary 3D data services to achieve 3D scene visualization, cannot achieve the cross-platform application of 3D data. Given the situation, the study focuses on the issue of 3D geographic information sharing based on the unified standard service of WebGL power grid 3D scene, so as to provide support for power grid 3D geographic information sharing and achieve cross-platform online access, lightweight browsing, professional applications, and other requirements.

Currently, such widely used geographic information platforms as Esri and hypermap could provide support for 3D geographic information. These platforms boast their 3D data standards respectively. In addition to the 3D data standards of some software manufacturers[1], there are also 3D Tiles 3D
standard services that are open sources and accepted by OGC organizations. There are three main 3D service standards: (1) 3D service based on the Esri-I3S standard; (2) 3D service based on the hypergraph S3M standard; (3) 3D service based on the 3D Tiles standard.

Based on the above comprehensive analysis, it can be summarized that the main shortcomings of the current 3D geographic information sharing services based on these three standards include: (1) each service standard is supported by different platforms; (2) sharing can only be carried out among platforms of the same manufacturer. The services of different platforms cannot be integrated.

2. The implementation principle of Three-Dimensional standard service for power grid service
The realization of 3D scene service for power grid business needs to start from the following three aspects: (1) unifying the standard of service interface definition; (2) developing data processing tools; and (3) performance optimization. The technical route of implementation is shown in figure 1:
The development of data processing tools requires the use of multi-core parallel computing technology to improve the efficiency of data processing. The main functions of the data processing tool are to transform the point cloud data, artificial model data, and tilt model data, and to generate the results according to the standard of 3D Tiles.

3. Performance optimization and service releasing

The main work of the data processing tool includes two aspects: (1) according to the 3D Tiles standard, the manual modeling model, point cloud, and tilt photography model are processed into standard data files; (2) the manual modeling 3D model data is optimized, and the main work is to simplify the model by LOD[2], which includes the combination of LOD and texture of the model geometric features. Besides, for the repeated model combined with Instance technology to reduce the amount of data. After performance optimization, it is convenient for 3D customers based on 3DTiles standard to improve the efficiency of rendering.

The idea of geometric LOD algorithm: based on the analysis of the data characteristics, multi-component aggregation characteristics, and some unique geometric features of the 3D building model, the paper proposes a simplified method that is suitable for non-manifold 3D building model. The whole simplification process is divided into two levels, namely: geometric component-level simplification and component-by-component-preserving geometric feature-preserving QEM weighted simplification[3].

![Model geometric feature simplification](image)

**Fig. 2 Model geometric feature simplification**

The specific steps of implementing the QEM simplification algorithm are as follows:

1) The main contents are as follows: read the triangulation model structure and construct the data structures such as the vertex table, surface table, and point-surface topology table.

2) Quadratic error Q is calculated for each triangular patch, and the quadratic error Qi, of each vertex v, is the sum of the quadratic errors of all associated triangular patches of the vertex.

   For example, it is known that the three vertices that make up a triangular patch are v1 and v3, respectively, and let the triangular patch. The plane equation is \( ax + by + cz + d = 0 \), where \( a \sim 2 + b \sim 2 + c \sim 2 = 1 \sim n = [a, b, c] \). The quadratic error Q of the triangular patch is defined as \( Q = (A, b, c) = (nnT, dn, D2) \). Can be described as a matrix of the following \( 4 \times 4 \).

   Where \( A = nnT \) is a \( 3 \times 3 \) symmetric matrix, \( b = dn \) is a \( 3 \times 1 \) vector, \( c = D2 \) is scalar.

   The square formula of the distance from vertex v to the triangular patch can be expressed in the form of quadratic error: \( Q (v) = vT Av + 2bT v + c Qi (v) + Qj (v) = (Qi + Qj) (v) \). The addition operation of quadratic error is defined as: \( Qi (v) + Qj (v) = (Qi + Qj) (v) \). Where \( Qi + Qj = (Ai + Aj, bi + bj, ci + cj) \).

3) Build vertex pairs \((vi, vj)\), for example:
① (vi, vj) is the edge on the mesh: ② (vi, vj) is not an edge on the mesh, but the distance between vi and vj < m:

![Fig. 3 Vertex optimization graph](image)

(4) For any pair of vertices:
① Calculate $Q = Q_i + Q_j = (A, b, c)$; ② Use the above Q to calculate the new location
If An is reversible, $V_{vector} = A - 1b$, Folding cost of $V_{vector}: Q(V_{vector}) = -bTA-1b + c$
If An is irreversible, find the best point on the vi and VJ segments, and currently take the midpoint
of the vi and VJ segments.
③ Put vertex pairs on the stack at the cost of Q ($V_{vector}$)
④ Compare the stack, and the stack as shown below:

![Fig. 4 Vertex reduction graph](image)

The hardware environment of the test is as follows: CPU: Intel Core i7, Video card: Nvidia GTX 1080. The comparison table before and after optimization is as follows:

|                      | Before optimization | After optimization |
|----------------------|---------------------|--------------------|
| Amount of data       | 11G                 | 4G                 |
| Render frame rate    | 10                  | 30                 |

Tab.1 Comparison table of data volume and rendering frame rate after using model optimization.

After the data processing is completed, 3D services can be published through Web servers such as IIS and Tomcat. What you need to pay attention to when publishing in IIS is to configure the MIME header of IIS and add the corresponding file type. The cross-domain problem needs to be solved when Tomcat publishes 3D Tiles files.

|                      | Number of vertices | Number of triangles | Triangle simplified rate |
|----------------------|--------------------|---------------------|--------------------------|
| Before simplified    | 1578               | 2543                | 0%                       |
| Widget removed       | 689                | 963                 | 62.1%                    |
| QEM weight simplified| 135                | 212                 | 91.6%                    |

Tab.2 Comparison table before and after geometric vertex optimization.

4. Conclusion
Based on the analysis of common 3D geographic information service standards, the paper discusses the selection basis of 3D geographic information service standards for power grid business and puts forward the idea of 3D service implementation based on 3D Tiles, which provides a reference scheme for the implementation of service-based 3D geographic information sharing. With the continuous development of WebGL technology and 3D geographic information service, the demand for 3D geographic information sharing based on the 3D Tiles standard will be further highlighted. The paper, a preliminary study of the above issues, can provide support for the construction of a 3D geographic information service platform for power grid business, and has important practical
significance for promoting the wide application of 3D power grid data and promoting the co-construction and sharing of 3D geographic information resources.

References
[1] Hanqing J and Bosheng W 2015 High quality texture Mapping for complex 3D scene J. Chinese Journal of Computers 12 pp 2349-2360
[2] Xiaofen H and Shuai X 2016 A method of 3D scene Reconstruction for Sequential Images J. Science of Surveying and Mapping 2 pp162-129
[3] Wei W, Wei G and Zhanyi H 2014 Dense 3D scene Reconstruction based on semantic constraints and Graph Cuts J. Scientia Sinica(Informationis) 6 pp 774-792
[4] Ruosi H and Chuanrong L 2014 Research on 3D rendering Technology of WebGL Vector data based on Geometry 2019 J. Remote Sensing Technology and Application 3 pp 463-468
[5] Xingjie W and Shoulin W Research and implementation of 3D GIS Space algorithm based on WebGL J. Computer Applications and Software. 4 pp 63-68
[6] Cunxiang C and Xu M 2019 Research on Vector Tile rendering Optimization method based on WebGL J. Journal of Hebei GEO University. 2 pp 38-41