

DEVELOPMENT OF 3D WEB GIS APPLICATION WITH OPEN SOURCE LIBRARY

Mete, M.O.,* Guler, D., Yomralioglu, T.

Istanbul Technical University, Civil Engineering Faculty, Department of Geomatics Engineering, 34469 Sariyer, Istanbul, Turkey - (metemu, gulerdo, tahsin@itu.edu.tr)

ABSTRACT:

Today, thanks to the internet connection, the borders are disappearing and accessing information is more comfortable. Instead of desktop applications, number of web-based applications which can be seen instant changes by all users are increasing day by day. The diversity of web-based applications that are currently used in presenting spatial information to users is also spreading. Using open source libraries, developers can develop web applications for their own purposes. Three dimensional (3D) visualization on the web is a commonly used approach in geographic information systems (GIS) applications. In this article, it is aimed to develop a 3D web application using open source library. Vector data layers containing attribute data on global, country and city levels are visualized on web application. The raster data layers produced in the most suitable site selection and mapping of land valuation process results are also visualized on the web application in three dimensional. It is pointed that the output products obtained from different studies can be accessed and visualized through the web browser without installing an additional program or add-ons on the users' computers.

KEY WORDS: GIS, geographic information systems, open source library, 3D, WebGL, Cesium

1. INTRODUCTION

Although Internet was developed for military purposes, it has globalized and evolved into many other areas like trade, academia, information sharing in public institutions (Yomralioglu, 2000). Widespread internet usage has led to sharing data and information easily all over the world. This technological development has made possible to visualize, create, store and share spatial data on web and has emerged Web GIS notion. Web GIS has many advantages when compared to desktop GIS. The applications that have been made for various purposes can be used easily without a GIS software over the internet. The users can access the current database 24 hours a day, 7 days a week at a low cost with a computer connected to the internet and a web browser. Moreover, users on different platforms can use the data concurrently. Spatial queries and analysis like nearest distance, optimum transportation route can be made easily on the web.

Third dimension on maps gives opportunity to have some details, increase the readability of the map and provide reality. We need 3D data to manage cities better. It is significant to create, visualize, store, analyze and share the 3D data for better decision making, planning or solving problems. Lately, the 3D representations of data on the web increasingly gain importance. Since it does not require any additional software or plugin to visualize and analyze the data, 3D Web GIS has become very popular and integral part of geospatial community. Several industries like real estate, tourism, geo-advertising, smart cities etc. take advantage of 3D web maps.

Javascript is a programming language that supported by many web browsers like Chrome, Firefox, Edge, Opera, Safari and can be operated on the web without using any plug-in. JavaScript APIs widely used for Web GIS applications. A new approach has seen for 3D Web GIS with the development of HTML5 and WebGL (Web Graphics Library). In order to render interactive 2D and 3D graphics within any web browser, WebGL JavaScript API can be used. WebGL allows GPU-accelerated usage of physics and image processing and it is integrated into all the web standards of the browser (Miao, Song & Zhu, 2017).

There are many map libraries for rendering 3D graphics on the web like Cesium JS, WebGL Earth JS API, ArcGIS API for JS, OSM Buildings GL, Vizicities, Tangram, Nasa Java World Wind, wrld3d. In this paper, Cesium JS 3D Map Library is used for creating 3D Web GIS application. Cesium was developed by an open-source community with the Cesium Consortium. Cesium JS uses WebGL for creating 3D globes and 2D maps in a web browser without using a plugin. Since it provides virtual globes with time dynamic 3D visualization of geospatial data, Cesium is functional 3D map library in terms of performance and features when compared with other libraries and frameworks (Chaturvedi, Yao & Kolbe, 2015). With the 3D Web GIS application, it is aimed to visualize different vector and raster data types in Cesium JS 3D globe.

2. MATERIAL AND METHODS

3D web mapping library Cesium is based on WebGL. Hence, it is independent of browsers and platforms. 2D, 3D, and 4D spatiotemporal data can be visualized efficiently by means of WebGL with Three.js framework implementation. WebGL can display many data points since it has direct access to the computing unit of the graphics card. Cameras, shaders, and lights to draw lines, spheres, particles, or a plane and some other tools for the representation of the data is provided for developers and many distinct features such as appearance, field of view for the scene, color, texture or size of objects can be easily managed with Three.js (Resch, Wohlfahrt & Wosniok, 2014).

Cesium supports many open data formats for 3D rendering. To provide interoperability, Cesium visualize geospatial data through OGC standards (Prandi, Devigili, Soave, Di Staso & De Amicis, 2015). Using standard data formats like TopoJSON, GeoJSON and KML, Cesium provide building 3D map applications by supplying expressive tools. Besides, open-source community with support of Cesium Consortium developed data formats which they weren't available for 3D rendering like CZML, 3D Tiles, glTF and quantized-mesh. CZML is a JSON schema that provide temporal 3D scenes, such as of satellites and aircraft. 3D Tiles is a description for visualizing huge 3D geo-datasets like photogrammetry, CAD, and 3D building models. 3D Tiles describe a spatial data structure and a set of tile formats designed for 3D and optimized

* Corresponding author.

for streaming and rendering. glTF is an open standard 3D runtime asset format. It can be described as JPEG for 3D. Quantized-mesh provides efficient 3D terrain streaming and rendering. In this paper GeoJSON and glTF data formats used for 3D web map application. Gross Domestic Product (GDP) Per Capita and population statistics of countries have gathered for 2000, 2010 and 2017 years from World Bank Open Data to visualize on Cesium 3D globe. In figure 1, Turkey's GDP Per Capita in 2016 is shown.

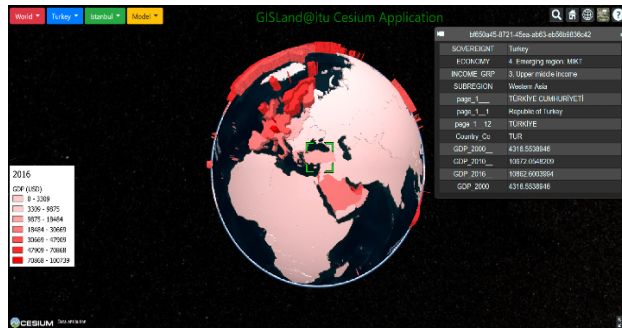


Figure 1. Turkey's Gross Domestic Product (GDP) Per Capita Besides, population of Turkey provinces and population of Istanbul districts visualized on 3D globe to test the data in different scales. In figure 3, population of Istanbul districts is shown.

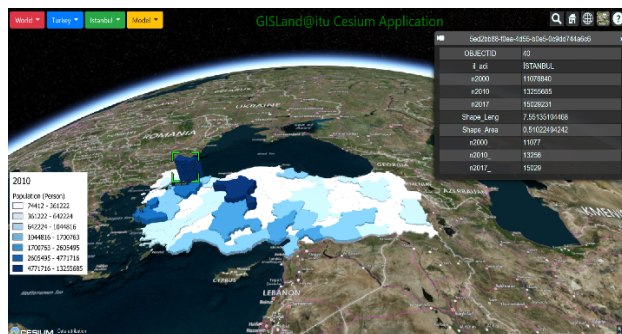


Figure 2. Population of Turkey provinces in 2010

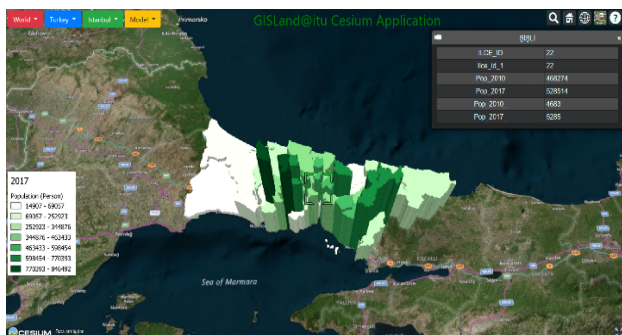


Figure 3. Population of Istanbul province in 2017

GDP Per Capita and Population data can be visualized according to different years using pop-up buttons at the top of the page. It is also possible to create CZML data for 4D temporal data to analyze the change in ten year periods for both statistics. Furthermore, nominal land values of Istanbul province visualized as 3D model in glTF data format on Cesium globe. In figure 4, nominal land values of Istanbul province are shown. In

order to convert raster data to glTF format, a three.js library, Qgis2Threejs is used. It is a python plugin which provides capability of exporting terrain data, map canvas images and vector data to the browsers that support WebGL (Evangelidis, Papadopoulos, Papatheodorou, Mastorokostas & Hilaris, 2018).

Since Cesium provides data interoperability, the projects which created with other platforms can be integrated easily. 3D Nominal Land Values of Istanbul City Project is visualized with Cesium JS. The model is created as pixel based raster data. In order to visualize it on 3D Cesium globe, raster data converted to glTF format using a three.js library, Qgis2Threejs. In figure 4, nominal land values of Istanbul districts is shown. The more valuable areas has shown as reddish color.



Figure 4. 3D Nominal Land Values of Istanbul province

It is possible to create aircraft and drone tour models, animations with Cesium JS. In order to scout sample geocache locations in New York, 3D city model is visualized in Cesium. The model has 1.1 million OSM buildings. In figure 5, New York 3D City Model tour is shown in drone view.

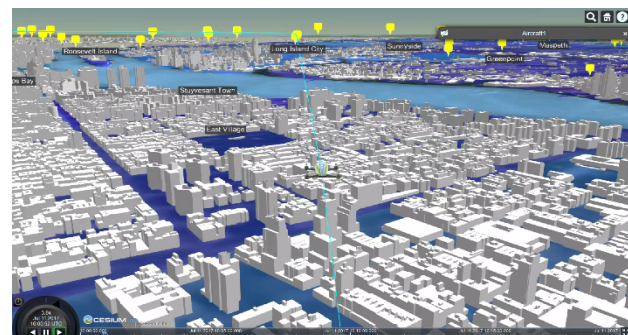


Figure 5. 3D Model of New York City in Drone View

3. RESULTS AND DISCUSSION

Visualization 3D data on the web has become very popular nowadays. There are many libraries and frameworks provide 3D data visualization on the web. Cesium JS is an Open Source JavaScript package supporting WebGL which is an extension of HTML5. Cesium provide effective and coherent 3D data visualization without any plugin. It is possible to visualize point clouds, photogrammetry models, CAD/BIM models, KML + COLLADA, CityGML, OpenStreetMap, shapefiles data on Cesium. Cesium is one of the most used 3D web mapping library. It has manual, code examples, help forum and wide user community. Cesium suffer from Javascript limitations and performance issues. Performance of Cesium can vary on different browsers because of different Javascript engines implementation. Therefore, it can fail to render big 3D city

models. However, it shows good performance in GeoJSON data visualization. Since it is open source, it does not require additional software or plugin, it has wide community, active help forum and clear manual, Cesium JS is good alternative for 3D data visualization on the web.

4. CONCLUSIONS

Third dimensional data is widely used in many areas such as smart cities, real estate, tourism, planning etc. It is beneficial to visualize it on the web without any additional software or plugin. Thanks to WebGL, 3D geospatial data can be visualized on the web using javascript mapping libraries. Cesium supports many open formats to visualize 2D, 3D and 4D data. In this paper, in order to test GeoJSON and glTF data formats, GDP Per Capita of countries, population and nominal land value model data are used for 3D visualization on Cesium globe. Further, Cesium JS library provide efficient 4D temporal data, creating animations and mobile 3D scenes. To conclude, Cesium is consistent 3d javascript web mapping library. Using WebGL, it makes possible to visualize 3D data on globe on a browser without any plugin.

REFERENCES

- ArcGIS API for JS. Available online: <https://developers.arcgis.com/javascript/> (accessed on 14 September 2018).
- Cesium.js. Available online: <https://cesiumjs.org> (accessed on 14 September 2018).
- Chaturvedi, K.; Yao, Z.; Kolbe, T.H. Web-based Exploration of and Interaction with Large and Deeply Structured Semantic 3D City Models using HTML5 and WebGL. In *Bridging Scales-Skalenübergreifende Nah-und Fernerkundungsmethoden*; 35. Wissenschaftlich-Technische Jahrestagung der DGPF; Deutsche Gesellschaft für Photogrammetrie, Fernerkundung und Geoinformation (DGPF) e.V: Köln, Germany, 2015.
- Evangelidis, K.; Papadopoulos, T.; Papatheodorou, K.; Mastorokostas, P.; Hilar, C. 3D geospatial visualizations: Animation and motion effects on spatial objects. *Comput. Geosci.* **2018**, *111*, 200–212.
- HTML5. Available online: <https://www.w3.org/TR/html5/> (accessed on 14 September 2018).
- Nasa Java World Wind. Available online: <http://worldwind.arc.nasa.gov/java/> (accessed on 14 September 2018).
- Miao, R., Song, J., & Zhu, Y. (2017, August). 3D geographic scenes visualization based on WebGL. In *Agro-Geoinformatics, 2017 6th International Conference on* (pp. 1-6). IEEE.
- WebGL Overview. Available online: <https://www.khronos.org/webgl/> (accessed on 14 September 2018).
- OSM Buildings GL. Available online: <https://osmbuildings.org/developer/> (accessed on 14 September 2018).
- Prandi, F., Devigili, F., Soave, M., Di Staso, U., & De Amicis, R. (2015). 3D web visualization of huge CityGML models. *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*, 40.
- Resch, B.; Wohlfahrt, R.; Wosniok, C. Web-based 4D visualization of marine geo-data using WebGL. *Cartogr. Geogr. Inf. Sci.* **2014**, *41*, 235–247.
- Tangram. Available online: <https://tangrams.github.io/tangram> (accessed on 14 September 2018).
- Three.js. Available online: <https://threejs.org/> (accessed on 14 September 2018).
- Vizicities. Available online: <http://www.vizicities.com/> (accessed on 14 September 2018).
- WebGLEarth. Available online: <https://www.webglearth.com> (accessed on 14 September 2018).
- wrld3d. Available online: <https://www.wrld3d.com/> (accessed on 14 September 2018).
- Yomralıoğlu, T. (2000). Geographical information systems, basic concepts and applications. *Istanbul (In Turkish)*.