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Development of 2D and 3D WebGIS by Advanced CS/IT Technologies

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ABSTRACT: Continuous advances in Computer and Information technologies have directly or indirectly benefitted almost every field of life related to mankind. One of these fields is GIS (Geographic Information Systems). From the advent and gradual growth to the present times the GIS software technologies and related hardware has changed its appearance and organization. Paper presents the comparative analysis and reason for usage of certain software technologies in GIS by presenting a 2-D WebGIS and a 3-D WebGIS developed by the authors. Paper concludes by GIS future trends based on upcoming computer science technologies.

KEYWORDS: Cesium, CS (Computer Science), CSS3, Data Base, FPS (Frame per Second), GIS, HTML5, IT (Information Technology), KML (Key Hole Markup Language), MySQL, OpenLayers, PHP, WebGL.

I. INTRODUCTION

GIS is a formal computer system for working with geographic data and organizing, viewing, analyzing information in a geographic context. In this system geographic information is abstracted, synthesized, presented, manipulated visually and the geographic model deals with concepts like connectivity and adjacency. GIS is a unique integration of Database, Graphics, Algorithms, Data Structures and Computational Geometry that may be applied to fields like land use planning, forest management, military operations, disaster recovery, and transport facility [1].

Tomlinson is attributed with conceiving the earliest functional Geographic Information System, the computer program accountable for the astounding swing in the way spatial information is conceptualized today. Tomlinson and Pratt's team brought in IBM to develop programming software that could work on all the data that were collated. Meanwhile, Howard Fisher at Harvard developed a computer program to integrate mapped data for computer graphics and spatial analysis [4]. The earlier GIS technology has three evolutionary phases-Computer Mapping (70s), Spatial Database Management (80s) and Map Analysis/Modeling (90s). Today's GIS trend is towards Multimedia Mapping and Spatial Reasoning [5].

In next two sections two WebGIS namely GISoMAP (GIS openLayers MAP) and GLC3d (webGL Cesium 3d) developed successively by the authors are being presented in context of incorporating growing computer technologies in GIS. CS/IT technologies used in development of GISoMAP have been presented and advantage of the key ingredient OpenLayers with other available Web Map API's has been analyzed. GLC3d is an advanced version of GISoMAP where 3D capability with latest web technologies has been incorporated. The application was tested on web browsers and the results are presented. Final section discusses future trends in GIS with upcoming software technologies. The paper concludes by highlighting the close affect of CS/IT on enriching GIS technologies.

II. GISOMAP APPLICATION

GISoMAP is a web based GIS application developed using open source software/technologies to represent spatial and non spatial data on a 2-D map. This open source or open code application extracts miniature level urban information of geographical raster data reserved in an open source database [2]. Google Hybrid [6] and Bing Image layers [7] were employed to provide the raster data which were digitized to contrive vector data for the GIS followed by designing it for web with OpenLayers (an open source JavaScript API) [8].

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A. Computer Technologies in GISoMAP

There are diverse GIS applications available today like ArcGIS [9], CityGIS and AutoDesk-AutoCAD to name a few. The endeavor to develop a WebGIS using free and open source software together with latest computer technologies lead to the development of GISoMAP.

The software technologies DBMS, JavaScript, JQuery, PHP were used in realization of GISoMAP, a 2-D WebGIS application. Fig. 1 and Fig. 2 depict the detailed information of an arbitrary landmark present on GISoMAP. GISoMAP is equipped with prominent GIS functionalities.

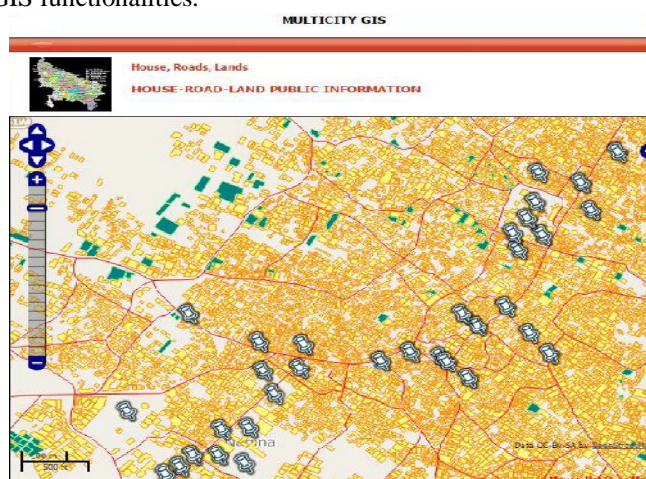


Fig. 1 WebGIS (GISoMAP)

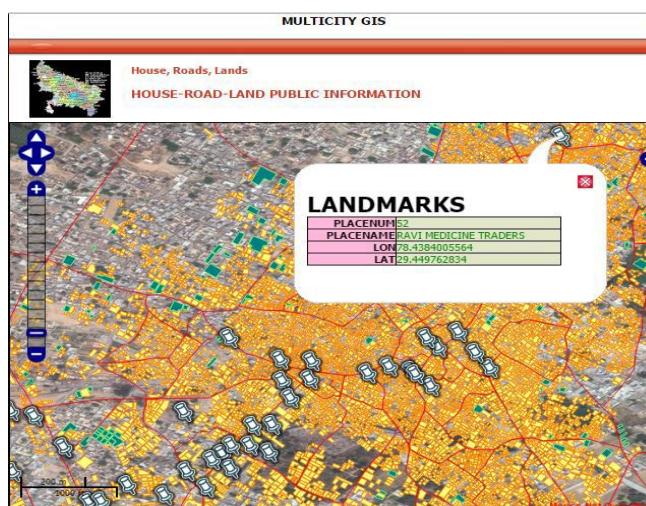


Fig. 2 GISoMAP (Individual Information)

There are three major contributors whose API's are available for development of web map and web GIS. The principal API of GISoMAP OpenLayers OpenLayers. OpenLayers API is compared with others in reference to the objects with their behavior and data[12]. Fig. 3 establishes OpenLayers as abundant and well-resourced API as compared to number of objects (methods and properties) of Google and ArcGIS.

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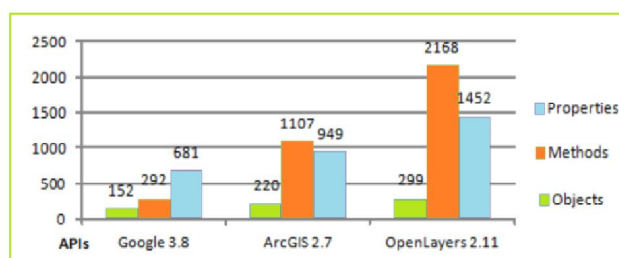


Fig. 3 API's Comparison[12]

III. GLC3D APPLICATION

GLC3d is a free and open source application designed to implement 2D and 3D view on a single WebGIS. This 3-D WebGIS application employs Cesium [10] and WebGL to develop an interactive 3D-Globe on a web browser. The developed 3-D globe presents the data/information to the most discrete level available on the GIS, incorporates the data/information of multiple cities, resulting into a multi-city GIS.

A. Computer Technologies in GLC3d

The software and web technologies that were used in realization of GLC3d are WebGL, Database, HTML5, CSS3, JavaScript, JQuery, PHP and Responsive design.

Fig. 4 illustrates the detailed features of an area represented on a 3-D Globe. Multiple layers including landmarks, buildings, land areas, roads, and water bodies can be simultaneously integrated onto the 3-D Globe providing a realistic perception for information extraction and decision making. Fig. 5 illustrates the 3-D exaggerated model of an area along with the detailed information of an arbitrary urban feature.



Fig. 4 Detailed Features Represented on 3-D Globe

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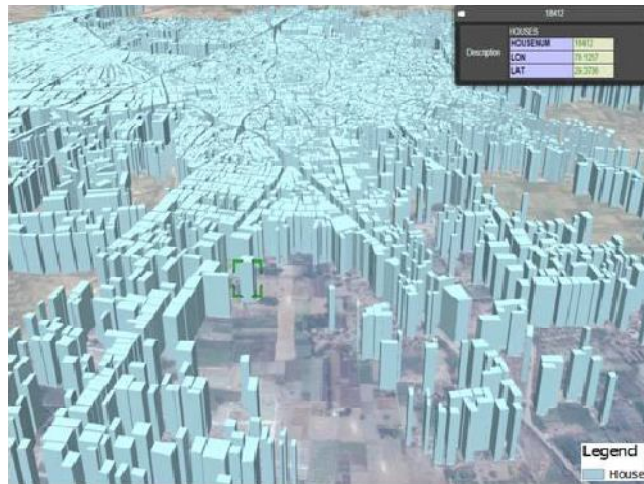


Fig. 5 3-D City Model with distinctive Information

GLC3d was tested in three major web browser on Windows-7 x64, Intel Xeon X5675 @ 3.07 GHz, 3.07 GHz 36 GB RAM, NVIDIA Quadro 5000. The FPS results of GLC3d (which is primarily developed using HTML5, CSS3 and WebGL) are shown in Table-I.

Table-I FPS Results of GLC3d

Device	Browser	Renderer	Frame Rate
Windows desktop	IE 11	webGL	59
Windows desktop	Chrome 31	webGL	60
Windows desktop	Firefox 38	webGL	59

These results confirm that HTML5 based applications Performance is good across a wide range of Browsers. WebGL support significantly improves performance and browsers are able to realize 3D experience on HTML5 and CSS3.

IV. FUTURE OF GIS

GIS is now an upward information system with countless applications. Integration of GIS with recently developed hardware and software technologies has resulted into the development of many incredible and revolutionary applications. Integration of 4-D technology within a GIS application can further extend its capabilities producing an effective and functional application. Current research on WebGIS technology focuses on developing user friendly and advanced GIS system which has application in fields like Disaster Management, CloudGIS, Advance Spatial Analysis/Reasoning, Weather Forecast and enhancement of the WebGIS tools to be easily accessed by visually impaired users [11]. Considering the growing importance of GIS in the everyday life and being a computer/software discipline, it has a promising future.



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V. CONCLUSION

Advancement in the field of computer and graphics technology has led to the development of 2D and 3D GIS applications. Introduction of viewing mode and technologies in modern GIS applications provides better user interactivity which is a huge improvement over previous GIS applications.

A 2-D WebGIS application GISoMAP has been developed using OpenLayers which is available for information extraction and decision making [3]. OpenLayers API was found to contain affluent set of methods for WebGIS development. Then as the software technology trended towards more interactive web based solutions, a 3-D WebGIS application was developed employing WebGL technology which runs on supporting web browser. The result of performance of GLC3d was presented and was found upright for major browsers. GLC3d is currently employed for urban information of multiple cities, and the incorporation of advanced software technologies allows for its usage in other GIS associated fields. These developed applications are step towards usage of recent software and hardware to strengthen the belief that people make more thoughtful decisions based on geographic reasoning.

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