NASA WorldWind: virtual globe for an open smart city

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1. Abstract

In this paper, the open source framework NASA WorldWind is presented. NASA WorldWind comes with two versions. The Java version is well established in the market and has many customers. On the other side the new version, which is the Web version, Web WorldWind, is still at the dawn of development cycle, with many features implemented and already used in several applications, with a great future ahead. Moreover, some of the features available in the Web WorldWind are listed and a short comparison with Cesium library is provided. Additionally, an interesting application developed in the smart cities context with Web WorldWind is described.

2. Introduction

Considering the growth rate of world population and the shift of people from rural to urban areas, sustainability of cities must be addressed. In response to these challenges the concept of “smart city”, where a collective approach to identify the needs of a city through the involvement of citizens has emerged. A smart city is defined as follows by the report of the European Smart Cities: “A smart city is a city well performing in six characteristics, built on the ‘smart’ combination of endowments and activities of self-decisive, independent and aware citizens: mobility, environment, people, living, governance, economy”. A suite of transformational IT tools, called “OpenCitySmart” is aimed to be used to increase the sustainability and quality of urban life, in other words, to support smart cities. In the network of “OpenCitySmart”, technologies such as NASA WorldWind Java, Web WorldWind, QGIS, and PoliCrowd 2.0 exist. There are already projects serving the purpose of creating smart cities. The application presented here aims to take the existing projects further by selecting the tools that are more usable for citizens. The responsiveness and the ability to use the application with various devices is a key point to expand the usability. With this idea in mind NASA Web WorldWind, developed for JavaScript and HTML5 has been chosen.

3. Virtual Globes

Virtual globes started expanding around 2004 with the open source version of NASA WorldWind and later in 2005 with Google Earth. Being three-dimensional they offered a more realistic way to represent the world compared to two-dimensional maps. Virtual globes provided many ways to visualize and interact with geographic data and other kinds of data. However, as Declan Butler said: "Google Earth and other virtual globes are set to go beyond representing the world, and start changing it." (D. Butler, 2006). This escalation is supported by applications in numerous areas, such as smart cities, disaster response, crowdsourcing, and many more, in which the data can be shown on a three-dimensional map.

The virtual globes can be categorized into two groups: the first, running as an application in desktop devices and the second, running in web browsers, evolved in the last few years, thus the modern ones. Regarding the modern virtual globes, the two most outstanding examples are NASA Web WorldWind and Cesium. These two programs leverage the latest technologies for Web: JavaScript, WebGL and HTML5. They can be used by non-experts thanks to their API (Application Programming Interface) and customized conveniently to meet the needs of case studies. This means that almost any computer programmer without advanced programming skills can create their own virtual globe application easily and share it with everyone via Web. In other words, modern virtual globes increase the opportunity to create Web GIS tools and to let users interact with them. Moreover, they can run on any device (desktop or mobile) and major operating systems, without having to install any additional software, such as plugins or extensions. As a result of these factors, dealing with three-dimensional data and disseminating it has become much more manageable.

4. NASA WorldWind

NASA WorldWind was created in 2003 and released under the NASA Open Source Agreement license in 2004. Right from the creation it became an important point of reference for the GIS (Geographic Information System) community and thanks to the features of the globe it spread fast among different fields. By the release of NASA WorldWind, the approach to virtual globes changed as it expanded the user community who could interact with virtual globes and geographic data. Differently from other virtual globes, NASA WorldWind provided an SDK (Software Development Kit) based on Java programming language to create applications and customize the globe. The virtual globe created using Java SDK can run on any operating system on desktop devices as long as the JVM (Java Virtual Machine) is installed.

Following WorldWind Java, the new Web WorldWind has been released, based on Web technologies such as JavaScript, WebGL and HTML5. It can run in web browsers on any device and major operating systems, provided that WebGL is supported and enabled. It provides many features that any programmer can implement quickly following the examples on the reference website (https://webworldwind.org/). Among the features, there are graphical capabilities such as the display of placemarks, text, polygons, shapefiles, and imagery (JPEG, PNG and GeoTIFF) on the virtual globe. Besides the graphical capabilities many OGC standards are implemented as WMS, WMTS, KML and Collada. Since it is an open source project, it is available on GitHub (https://github.com/NASAWorldWind/WebWorldWind/) and many programmers are involved in implementing new functionalities in the framework. Web WorldWind can be customized without too much effort and extended easily by programmers. Thanks to this, many organizations are using it in several applications in the context of smart cities, urban planning, terrain visualizations and more.

5. Modern Virtual Globes

As stated before, two notable examples of modern virtual globes are NASA Web WorldWind and Cesium. Their APIs offer feasible ways to display and interact with a wide range of data. The differences between these two virtual globes are listed below in depth:

1. Both frameworks are designed to display data available via Web standards, but Web WorldWind is focusing more on supporting formats used by the United States Department of Defense.
2. Web WorldWind uses a geographic interface for configuring the objects in the virtual globe, while Cesium's primary interface is 3D-centric. Apart from the primary interface, a second interface using geographic coordinates is available.
3. Web WorldWind offers support for different elevation data, using WCS (Web Coverage Service) and DTED data sources. In the client, at run time, different data sources are used together and combined in the globe. Instead, Cesium supports proprietary data and allows using ESRI ArcGIS elevation data sources.
4. Web WorldWind is designed to enable users to extend its functionalities by adding new components written in JavaScript and WebGL. On the other hand, Cesium is made of two interfaces, a high level one to interact with JavaScript and another one to interact with WebGL.
5. Cesium offers some functionalities, which are available only in the "Cesium Pro" version, which is a proprietary commercial version. Web WorldWind offers all functionalities free of charge and does not have a "Pro" version.

While Cesium is focusing towards supporting computer graphics features, Web WorldWind targets to maintain practical features to work with the standard geospatial data formats. Thus, Cesium can be considered mainly a graphical tool to visualize 3D data rather than being a geospatial visualization tool. Thanks to the geospatial approach used in the Web WorldWind framework, any user with some experience in JavaScript can create components for it while the extensibility of Cesium requires a broad knowledge of WebGL.

6. Web WorldWind Sample Application

One interesting application developed with NASA Web WorldWind aims to visualize information collected by citizens on a virtual globe. The architecture of the application can be seen in Figure 1. The information that is visualized on the virtual globe is reported using either ODK (OpenDataKit) platform or a cross-platform application called Via Regina, which are explained below. Both of the applications are developed within the framework of Via Regina project (http://www.viaregina.eu/), which is an INTERREG project (Cross-border Cooperation Operational Programme Italy – Switzerland, 2007 - 2013) developed thanks to the cooperation between Italy and Switzerland. The project aims at promoting, rediscovering and enhancing the naturalistic, artistic and cultural heritage along Via Regina, overlooking the West coast of Lake Como in the northernmost part of Italy (Antonovic et al., 2015).

ODK platform allows users to report Points of Interest (POIs) using Android mobile devices and is composed of three modules: ODK Build, ODK Aggregate and ODK Collect. ODK Build is used to design the survey form, where the information to be asked is set. ODK Aggregate is used to provide blank forms to ODK Collect, accept compiled forms from it, store the reported data and administer the users. ODK Collect is used to fill the blank forms and send it to ODK Aggregate. On the other hand, Via Regina is a cross-platform application developed using Cordova mobile application development framework and it is available as an application for Android and iOS operating systems and also on web browsers (http://viaregina3.como.polimi.it/app/). The map is built using mobile-friendly Leaflet library. Users are required to register and after registration they can insert a POI by answering some

questions and then submitting the answers. The inserted POI is immediately available on the map as a marker and upon clicking the inserted data is shown inside a popup. In both applications the questions asked are stored in their database as the attributes of the POI and these attributes are decided in a way to fit the requirements of the Via Regina project.

The platform developed using the API of NASA Web WorldWind displays the data collected using the above mentioned two applications as markers and shows the information inside a small window upon clicking as shown in Figure 2.

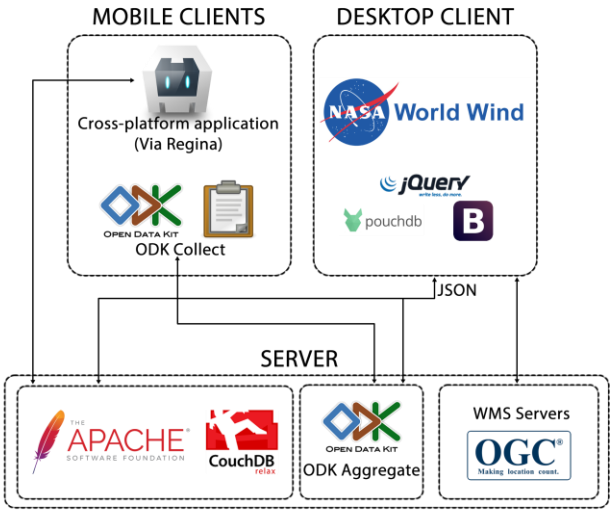

Figure 1. System architecture of the application

Figure 2. An example of queried information

This application can be used to let people report any ideas or issues related to the cities all around the world, and in this way involve citizens in the decision-making processes by informing authorities. The context of the application can be changed easily to fit different purposes modifying the two apps used to report points.

7. Conclusions

How technology tools can be used to empower citizens and foster the development of smart cities has been shown, through an application developed in the scope of OpenCitySmart. The application exploits an open source tool NASA Web WorldWind, which has been chosen as it allows the citizens to interact with the city and communicate information to responsible authorities as well to other citizens. Moreover, it is capable of running on desktop and mobile devices, on all major operating systems, without any software installation.

Foremost, the capacity of a powerful framework, NASA Web WorldWind, that can be used in many fields is demonstrated. It gives the programmers an opportunity to create numerous applications without too much effort. The framework, as previously mentioned, is still evolving, and the amount of applications using it in the last few years has grown rapidly, which notes that it has a great potential and it might become a point of reference in different fields, such as the smart city one.

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