Web GIS Development using Open Source Leaflet and Geoserver Toolkit

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Web GIS Development using Open Source Leaflet and Geoserver Toolkit

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Abstract

Popularity of location based web and mobile applications is increasing day by day. The visualization of locations is bit complicated than tabular data. Specialized software are required to build a web GIS (Geographic Information Systems) application providing easy access to geo-spatial data to a large number of people. This paper reviews a simple and easy to use methodology to create a web GIS application using open source tools. Leaflet, Geoserver and PostgreSQL have been used to create the application. Leaflet is used to create the GUI (Graphical user interface), Geoserver acts as a middleware and PostgreSQL is used as a backend data store. The web GIS has basic functionalities like pan, zoom, home, info window, measure, legend button, geo-location, search bar, layer selection, mini map, attribution, mouse position etc.

Keywords

Web-GIS, Leaflet, GeoServer, PostgreSQL, QGIS.

I. Introduction

Popularity of location based web and mobile applications is increasing day by day. The visualization of locations is bit complicated than tabular data. Specialized software are required to build a web GIS (Geographic Information Systems) application providing easy access to geo-spatial data to a large number of people. There are many software both commercial and FOSS (Free and Open Source Software) available on the internet to develop a web GIS application. In this study an attempt has been made to develop a web GIS application using the open source javascript library Leaflet, Geoserver and PostgreSQL database. Usually, a web GIS (Geographic Information System) mapping application has a three layer architecture, PostgreSQL in addition with PostGIS is used in the backend to store the geospatial data, Geoserver is used to create services of the data in the database and symbolize them, while the leaflet library is used to create the GUI. Leaflet is a javascript library for building web GIS applications across web browsers, desktops, and mobile devices. GeoServer is an open source software server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards. PostgreSQL is a powerful, open source object-relational database system that has bindings for many programming languages such as C, C++, Python, Java, PHP, and Ruby. It runs on all major operating systems. PostGIS adds support to store geographic objects in the PostgreSQL database.

Leaflet [1] is an open source JavaScript (js) library. It helps to create mobile-friendly interactive maps. It is simple, easy to use, light weight and provides enhanced performance. It works efficiently across all major desktop and mobile platforms. As it is open source, the developer community has contributed to create a lot of free plugins [2] to accomplish various tasks and add different kind of tools to the web map application. It has a well-documented API (Application Programming Interface) [3] and a simple, readable source code. Qgis2web a plugin for QGIS (Quantum GIS) has been used to prepare a basic web GIS

application. The basic application can be enhanced and customized by adding various leaflet plugins.

In addition to leaflet another popular javascript library for creation of maps is openlayers [4]. As compared to openlayers leaflet (approx 38 KB) is light weight due to which it provides better performance. Leaflet is more mobile friendly than openlayers. Leaflet has been used worldwide for the preparation of web mapping applications. [5] has implemented a free web mapping service for the mobile tourist guide based on OpenStreetMap, Leaflet, PostGIS, pgRouting, and Nominatim projects. [6] has designed a search engine which helps to extract the WMS (Web Mapping Service) services hidden in the javascript code, this engine represents an important step towards realizing land cover information integration for global mapping and monitoring purposes. Leaflet has been used in this project for the visualization of the WMS services. It has also been used for the rendering of maps for the project involving the Land cover change map comparisons using open source web mapping technologies by [7-8] has also prepared time series proportional symbol maps with Leaflet and JQuery.

II. Objectives

The objective of this study is to create a web GIS application using open source tools. Leaflet, Geoserver and PostgreSQL have been used to create the application. The web GIS has basic functionalities like pan, zoom, home, info window, measure, legend button, geo-location, search bar, layer selection, mini map, attribution, mouse position etc. While building a web GIS, major efforts are utilized in the creation of the GUI (Graphical User Interface), therefore this paper focuses more on the Leaflet Javascript Library. This paper proposes a simple, easy to use and a fast process to create a web GIS.

III. Tools & Methodology

Tools Used: Geoserver 2.12, PostgreSQL 9.4, QGIS 2.18.15, Apache Tomcat 9.0 and Leaflet 1.3.

A. Installation and Configuration of PostgreSQL Database

- Download and Install PostgreSQL from [9]. Refer [10] for the installation process. Change the Port number to 5433 while installation. Also download the PostGIS extension using stack builder by checking "Spatial Extension" option during the installation of PostgreSQL.
- Loading Shape files into the PostgreSQL Database: Before importing the shape file to the database, add PostGIS extension in the database. Open pgAdmin III, Connect to Database Server in Object Explorer, Explore Database then right click on "Extensions" and click on "New Extension", select the extension "PostGIS" from dropdown. Else, run the following command in SQL Editor:
- CREATE EXTENSION PostGIS;
- Open PostGIS Shape file Import/Export Manager and establish a connection by clicking on view connection details and

provide the connection parameters like Username, Password, Database, Server. Usually the values will be Host= "localhost" and Port="5433". Browse Shape file(geo spatial data) using Add File button and click on Import button.

B. Installation and Configuration of Geoserver

- Install the Java Development Kit (JDK) downloaded from [11]. JDK is required to run and develop Java application on the computer system.
- Install the Apache Tomcat Server.
- Install the GeoServer package in Apache Tomcat, download it from [12]. Refer [13] for the installation process.
- Open any internet browser and type http://localhost:1234/dashboard/ to open the dashboard of Geoserver. (1234 is the port and may be changed)
- Login to the GeoServer using the address http://localhost:1234/geoserver/web/ (Default username is "admin" and password is "geoserver").
- Add a new Workspace in GeoServer using the link in the left panel. Workspaces: Add new Workspace and Type the "Workspace Name" in Name and Namespace URI text field and click "Submit".
- Add a new PostGIS store in GeoServer using the link in the left panel. Fill the basic store information and connection parameters.
- Click on the "Publish" tab and select the GIS layer projection system in "Declared SRS" and then compute the coordinates from "Bounding Boxes" and provide other details like styling (If required). Now layer can be viewed in the "Layer Preview" option.

C. Creation of a Basic Application Using QGIS and QGIS2Web Plugin

- Install QGIS (Quantum GIS).
- Install the qgis2web [14] plugin in QGIS.
- Create the map with the desired layers and symbology in QGIS.
- Import basic map view with the help of qgis2web plugin.
- Add inbuilt controls (zoom in/out, location, measure, layerselector, geocoder search) in the qgis2web plugin view.
- Preview the added layers in the application (in browser) .
- To zoom at a particular location on the added layer by default, change the "center" points in map section and zoom level can also be increased or decreased by editing the "zoom" property in map component of the same section.
- Export with the leaflet option (Figure 1). The basic start-up web GIS application is as shown (Figure 2) in the browser

D. Customization of the Basic Application

In addition to the tools added in the basic application, we can add other tools with the help of leaflet plugins. Some useful plugins are :

• **Mouse Position tool:** This tool [15] can be added to the application by referring the js (javascript) and css (cascading style sheets) files in the html page (index.html). This tool provides the current position of the mouse in longitude and latitude.

CSS- To add url of CSS file in html page
```
<link rel="stylesheet" href="css/L.Control.MousePosition.css">
```

JS (javascript)- To add url of javascript file in html page
```
<script src="js/L.Control.MousePosition.js"></script>
```

To declare a variable with script tag in html file than to write a script or code,
```
var mousePosition1;
mousePosition1 = L.control.mousePosition().addTo(map);
```

• **Zoom and Home tool:** Zoom/Home tool [16] can be added to the application by referring the JS (Javascript) and CSS (Cascading Style Sheets) files in the html page (index.html). The Zoom tool provides the zoom in (+) and zoom out (-) of map. Home button is used for back to original view of map.

• **Minimap tool:** A minimap [17] shows the map at a different scale to aid navigation. This is a simple minimap control that you can drop into your leaflet map, and it will create a small map in the corner which shows the same map, as the main map with a set zoom offset.

• **Panning tool:** Pan tool [18] is used to change the way the user is moving around the map i.e. up, down, left and right.

CSS- To add url of CSS file in html page
```
<linkrel="stylesheet" href="css/L.Control.Pan.css">
```

JS (javascript)- To add url of javascript file in html page
```
<script src="js/L.Control.Pan.js"></script>
```

To declare a variable with script tag in html file than to write a script or code,
```
var pan1; (declare variable)
map.addControl(new L.Control.Pan());
```

• **Attribution tool:** The attribution control allows you to display attribution data in a small text box on a map. It is put on the map by default unless you set its attribution Control option to false, and it fetches attribution texts from layers with the get attribution method automatically.

Code-
```
Var basemap0 = L.tileLayer('http://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png',
{
attribution: '&copy; <a href="http://abc/"> Name </a> contributors,
<a href="http://xyz/"> Name </a>',
maxZoom: 28
});
basemap0.addTo(map);
function setBounds() {
map.setMaxBounds(map.getBounds());
}
```

• **Add a button to open a legend (jpg file):** A button is created in javascript which helps to open a jpg file. Basically, the jpg file contains the symbology of the layers added to the map. The jpg can be created using MS-Power point or any other image processing software.

Code to add a button (js)-

```
<script type="text/javascript">
$(document).ready(function()
{
$("#inner_div").hide();
$("button").click(function(){
$("#inner_div").toggle();
});
});
</script>
```

Code to add legend image (jpg) in html (index) file-

```
<div id="legend">
<button><b>L</b></button>
<div id="inner_div">
<img src="images/Legend.jpg">
</div>
</div>
```

• **Info tool:** Info tool functionality for WMS layers is not inbuilt in leaflet. To get the feature attributes from a WMS layer is bit complicated. For this Better WMS plugin [19] is required. This plugin will help to get the attributes of the features on clicking it.

JS (javascript)- To add url of javascript file in html page

```
<script src="L.TileLayer.BetterWMS.js"></script>
```

Code-

```
Var url = 'http://ip_address:8080/geoserver/abc/wms';
L.tileLayer.betterWms(url, {
layers: 'dwss_tm',
transparent: true,
format: 'image/png'
}).addTo(map);
```

And, Go to Better WMS javascript (js) file, To add layers and query layers statement parameters in getFeatureInfoUrl function.

Final view of the application after adding all the desired control/ tools is as shown in Figure 3.

IV. Varients of Leaflet

ESRI Leaflet [20]
A lightweight set of tools for using ArcGIS services with Leaflet. Esri Leaflet is a collection of API plugins for the open-source javascript mapping library leaflet. It is not a replacement for Leaflet, but rather additional code aimed at making it convenient, intuitive to mix data and services from ArcGIS Server and ArcGIS Online in Leaflet applications.

Leaflet for R [21]
Leaflet is one of the most popular open-source JavaScript libraries for interactive maps. This R package makes it easy to integrate and control Leaflet maps in R. A programmer can create maps right from the R console or RStudio.

V. Conclusion
From, this study we can conclude that powerful web GIS applications can be created within a short period of time, using free and open source tools. Even a person with less or no programming skills can create a web GIS application using the step by step methodology provided in this paper. If the amount of data is less then instead of using a database like PostgreSQL, data can be used in the form of JSON files, which makes the application setup even more quick and easy. Basic geoprocessing tools can also be added to the GIS application using turf.js [22], an open source javascript library.

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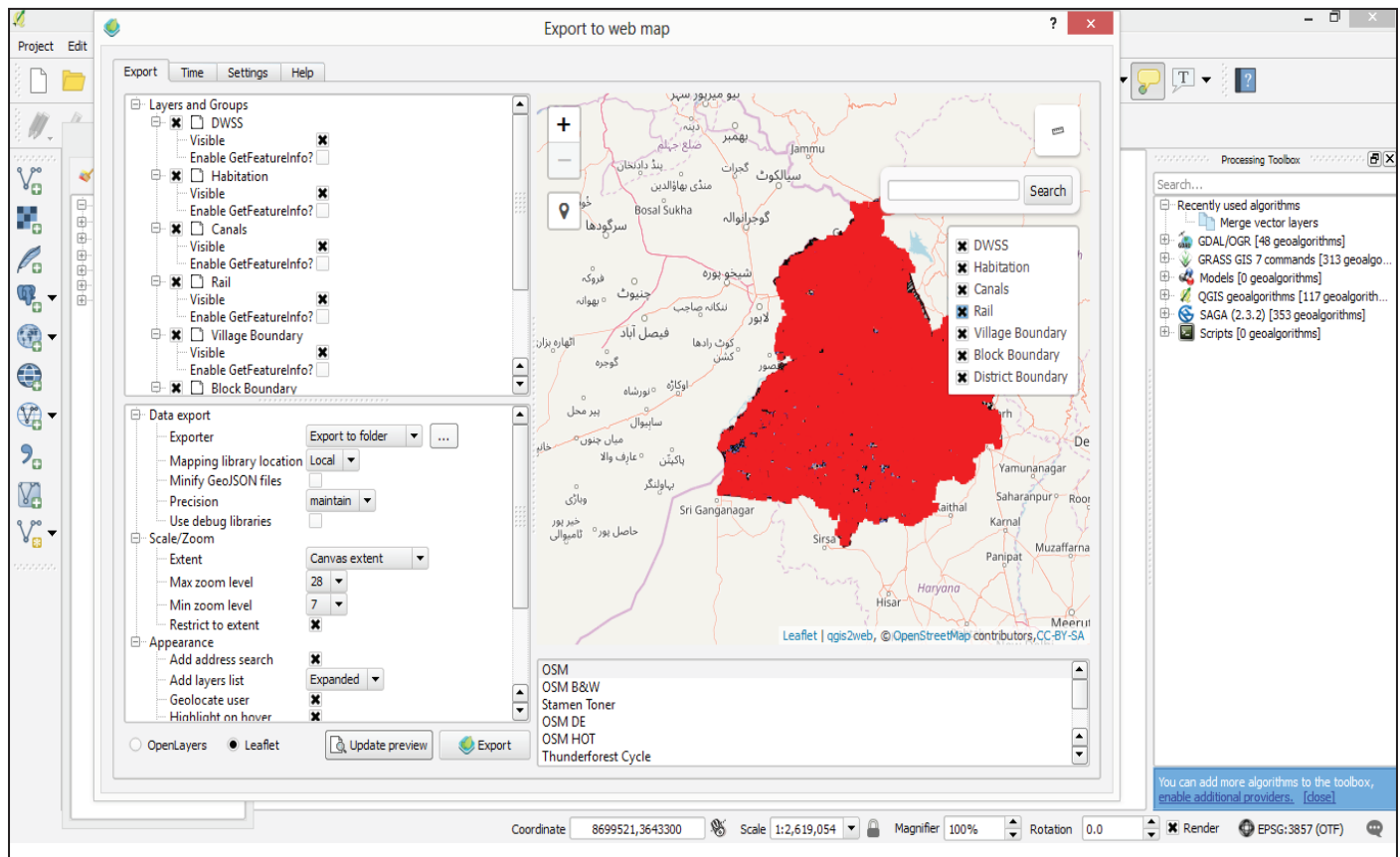
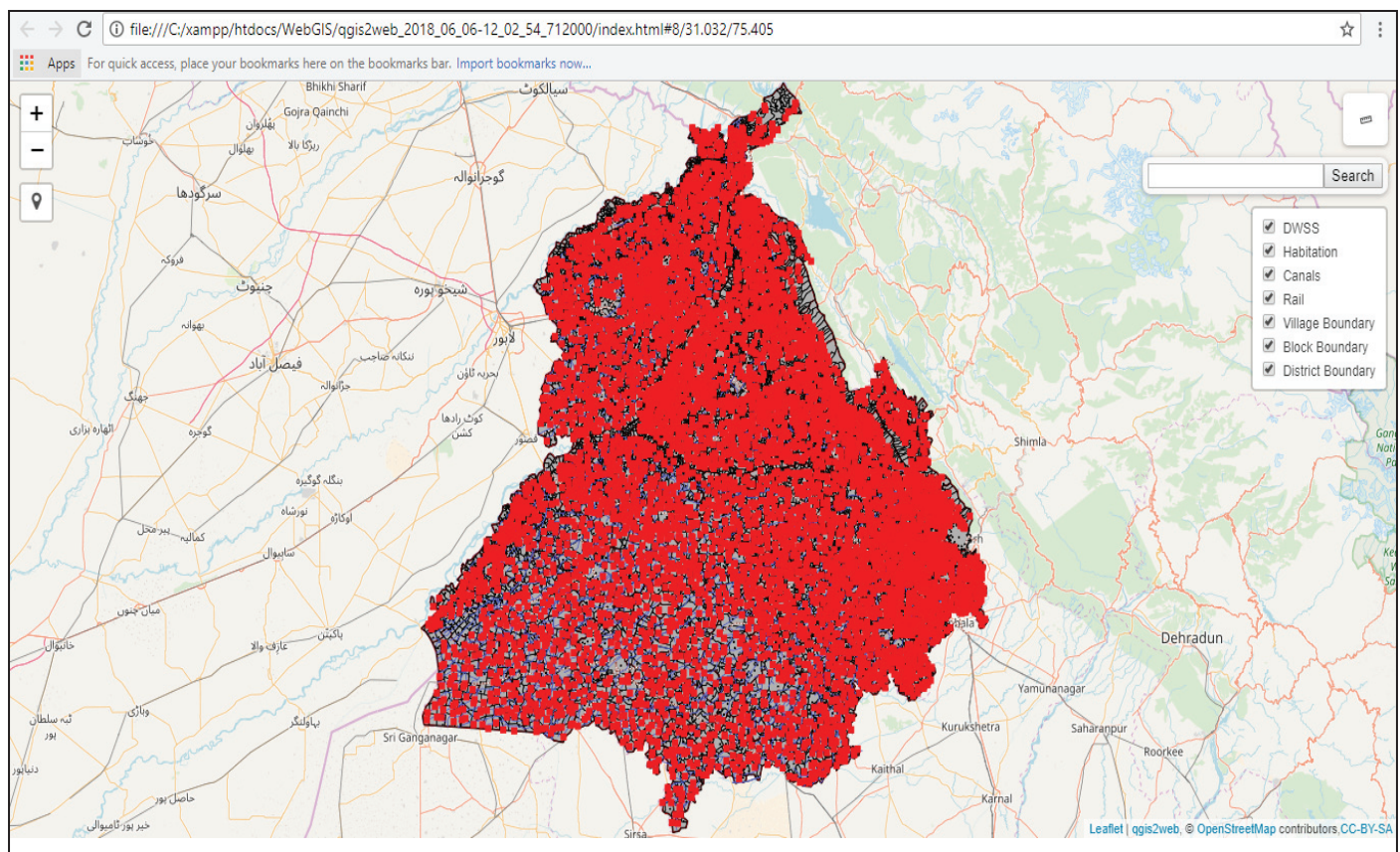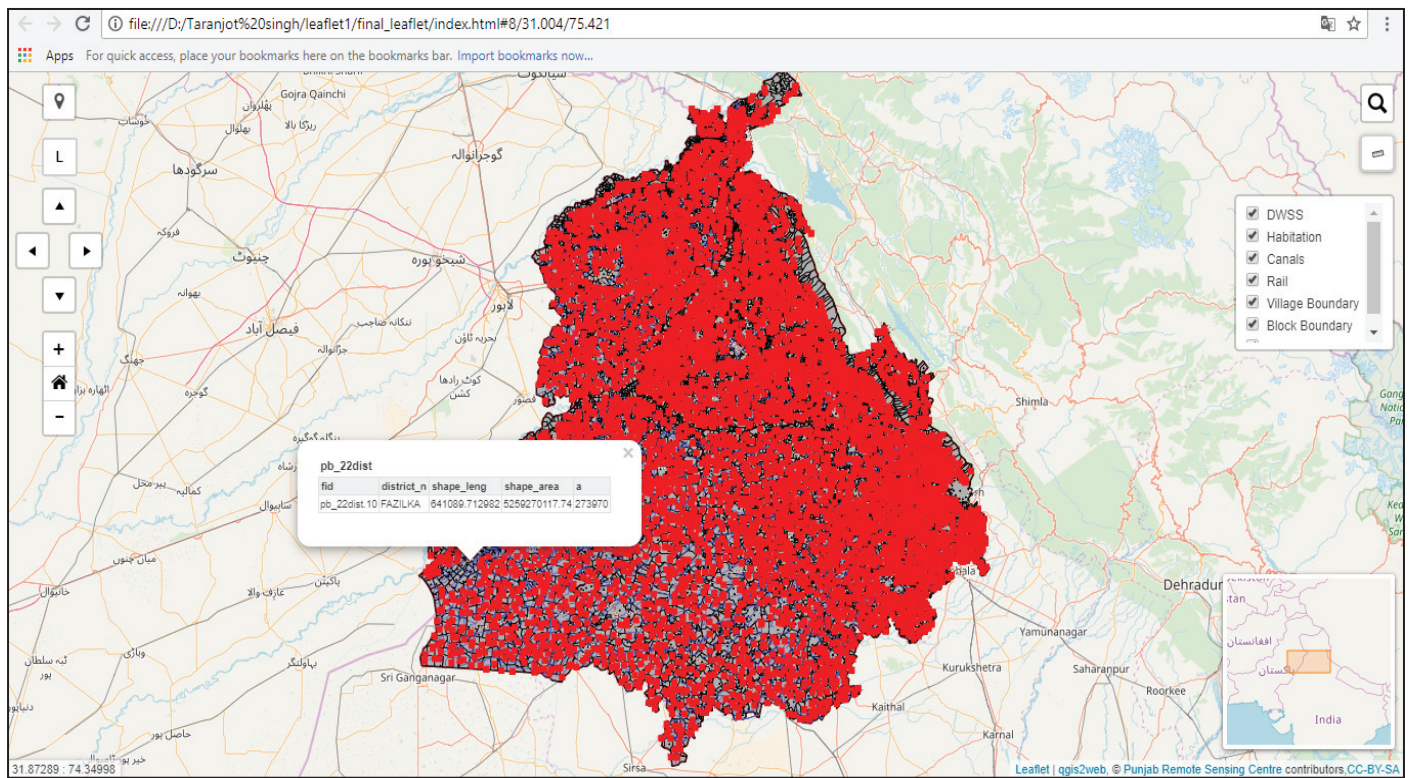Fig. 1: Creation of a Basic Application Using qgis2web Plugin

Fig. 2: Basic Application View in Browser

Fig. 3: Final Application