Open Source GIS-Based System for Displaying Data in Smart Grid

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Abstract. Smart Grid produces a large amount of data from applications such as AMI, SCADA, Renewable Energy Management System, Asset Management System, Weather data, etc. To convert these massive data into useful information, visualization is an effective solution. Visualization is an established methodology in scientific computing. It has been used in many fields because of its strong capability in large data management and information display. However, its applications in power systems, especially in Smart Grid are still in infancy stage. In this paper, a technique to visualize the Smart Grid data by using a system that consists of GIS (Geographic Information System) for buffer spatial analysis and Google Earth for display is proposed.

Keywords: GIS, Smart Grid, visualization techniques, Google Earth

1. Introduction

A large number of novel information visualization techniques have been developed over the past decade, allowing visualizations of ever larger and more complex, or multidimensional, data sets. There are listed in many research publications [2][3]

The role of GIS in power system visualization was also mentioned in some earlier researches [9] [10] such as visualization of power system security assessment [22] and renewable energy distribution [12]. Moreover, the importance of GIS in Smart Grid was studied not only in Transmission [6] but also in Distribution system [7] [8].

Visual exploration of massive data sets also rose from telecommunication networks, services, and property management. Eleftherios E. Koutsofios et al in their research at AT&T Lab implemented SWTFT-3D, an integrated data visualization and exploration large scale network analysis that included pixel-oriented 2D maps, interactive 3D maps, statistical displays, network topology diagrams and an interactive drill-down query interface [4]. On the other hand, to manage property, Jin-Tsong Hwang developed overlay analysis with ERSI ArcObjec for zone query and display the query result in webpage which Google Earth/Map embedded in it [11].

Location (spatial) and time (temporal) are two main references for data processing and information extraction in Smart Grid [1].This includes applications such as fault detection and alarm system. There are some tools that could be used to collect spatial data, like precise satellite images similar to Google Earth [20] and National Lightning Detection Network (NLDN) [18].GIS provides a framework to integrate spatial and temporal data. Therefore in a Smart Grid, GIS helps to evaluate distribution system losses [14] and improve the reliability of Energy Outage System [13] [16] [17].

Since GIS is one of the powerful techniques in visualize data in Power System, especially in Smart Grid, it was adopted for this project. To have a better display, GIS was integrated with Google Earth. For benefit of research community, the project is restricted to an open source platform for visualizing Smart Grid data, which is based on Quantum GIS and Google Earth.

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2. Methodology

QGIS and Google Earth are freely downloadable system. These two systems have a set of APIs support. Since QGIS and Google Earth are two separate APIs, a middleware is required to create with Visual C++ 2008 in order to glue them together. Thus, all the data will be nicely viewed in Google Earth which is preferred by non-GIS users [16]. The task to analyze the geographic data will be conducted separately with QGIS functions. Dividing the tasks of analyzing and displaying is one way to reduce the complexity of the system.

The architecture of the proposed visualization system is shown in Figure 1a. There are three main tasks to implement this proposed architecture such as GE Plug-in Application, QGIS, and integrating GE-QGIS. The following sections will describe the detail implementation of this methodology.

One of the challenges in this project is to integrate QGIS and Google Earth. In another word is to answer the question of how to pass data between these two environments. Passing coordinates captured by GE to QGIS is one of the solutions. After QGIS finishes query tasks by attribute from database and carry out spatial analysis, the output results are in format of layer or shape file, which is not supported by GE. Hence, they must be converted to KML file (the extension supported by Google Earth). That whole process is described in the following diagram (Figure 1b).
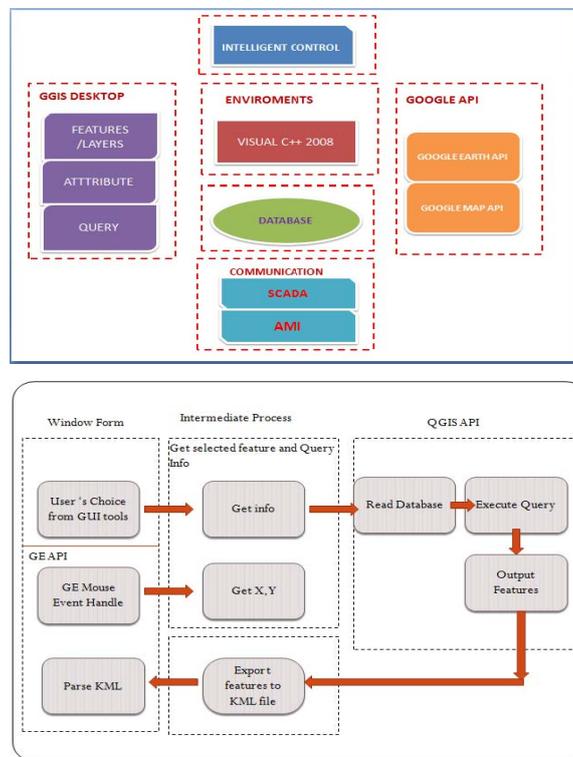

Fig. 1: Methodology

3. Embedded Google Earth into Application

Google Earth Plug-in can be embedded into Visual C# Applications as a Web Browser form. This is achieved by using Google Earth API and Javascript.

Currently, there is only one point vector layer, that is power substation. This layer is represented by a point or placemark which can be created by using GE API. The detail information of each substation such as power consumption, voltage, current are displayed in balloon callout corresponding to each placemark. The colour of each placemark represents the energized state of each substaion, e.g. green is energized and red is not.As shown in Figure 2a, the left pane of the GUI is the list of all the 16 substations. Clicking on any one of these will result in flying into each point where detail parameters are displayed. Another benefit of this application is to allow user select the region of interest by dragging the mouse in GE browser to define the area and subsequently displaying the total power consumption over that area.

The above feature required the "select area" checked box to be checked in order to enable Mouse Click and disable Mouse Navigation. To find out the sum of power over the chosen area, the Mouse Down, Mouse Move and Mouse Up event must be captured in order to get the range of coordinates (longitude and latitude). The power of all substations located inside that region will be display as new window message, as shown in Figure 2b.

Fig. 2: Embedded Google Earth into VC# Application

4. Buffer Spatial Analysis Using Qgis

Quantum GIS (QGIS) is a powerful Open Source GIS. The software allows users to design their own map with custom features (represented by point, line, and polygon) [19].

Spatial analysis uses spatial information to extract new and additional meaning from GIS data. GIS Applications normally have spatial analysis tools for feature statistics (e.g. how many vertices make up this polyline) and geoprocessing such as buffer, symmetric, difference, and so on [19].

Buffering usually creates two areas: one area is within a specified distance to selected features, is called the buffer zone. Area which is beyond the specified distances is none-buffer zone [19].

In a GIS Application, buffer zones are always represented as vector polygons enclosing other polygon, line or point features as shown in Figure 3.

(a) A buffer zone around vector points.   (b) A buffer zone around vector polylines.   (c) A buffer zone around vector polygons
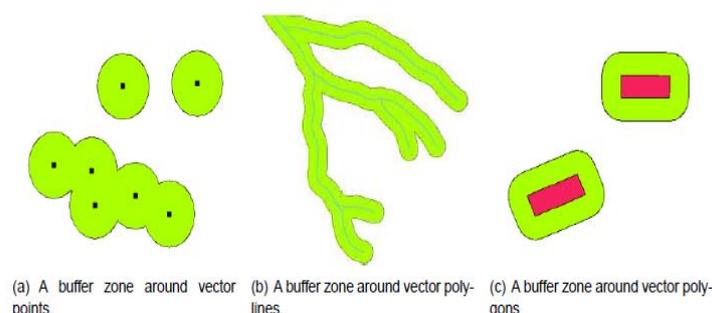
Fig. 3: Buffering vector points, polylines and polygons [19]

Buffer zones often have dissolved boundaries so that there are no overlapping areas between the buffer zones. In some cases though, it may also be useful to remain boundaries of buffer zones, so that each buffer zone is a separate and the overlapping areas can be identified.

In this project, the point features in GIS are designed to represent the power substation in Smart Grid. All the detail information of each substation is stored in GIS database. The information in database is compliance with ODBC standard, which can be accessed by any development tools.

5. Integrating QGIS- Goole Earth

5.1. KML

KML (Keyhole Markup Language) is an XML grammar and file format for modelling and storing geographic features such as points, lines, images, polygons, and models for displaying in Google Earth [20]. KML can be used to share places and information between different Google products such as Google Earth and Google Maps.

5.2. QGIS

To have a development environment of QGIS under Linux/Window/MacOS, the software should be first installed from source with its required package and dependencies via Cmake environment.

C++, Python and Qt are three programming languages supported by QGIS. While C++ and Python are alternative for developing QGIS Application and Plugin, Qt provides the interface GUI library for this software.

Different from other applications, a CMakeList file is mandatory for building QGIS software, which provides all the information of linking library, header and source file, etc.

The shape or vector layer file can be called via the QGIS API function as below:

Stringmy LayerPath = D:/data/layer2.shp";

QStringmy LayerBaseName   = "layer2";

QString myProviderName   = "ogr";

*Qgsvectorlayer * myplayer = new qgsvectorlayer(mylayerpath, mylayerbasename, myProviderName);*

Buffer analysis is one of the functions in Geometry Analyzer. This function will return an output shape file which is a polygon vector layer, a buffer zone.

Figure 5a and 5b show the result buffer zone with and without dissolve feature.
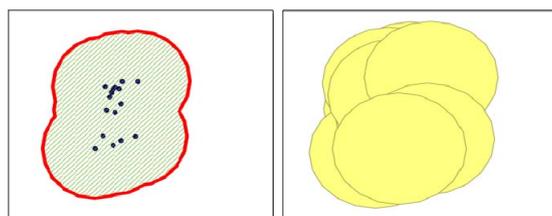

Fig. 5: Buffer zone

5.3. Converting QGIS shape file to KML file

QGIS shape file can be manually converted to KML file by writing to the text file in KML format.

The Kml file output then can be displayed in Browser (Figure 6) via GE API function, ParseKML

Fig.6: Buffer zone in Google Earth

6. References

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