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Simplifying integration of field data and GIS: A WPS approach

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Abstract

Field data plays a vital role in various area of studies, scientific disciplines as well as in practice. It is one of the first steps for most of the studies and a crucial task for spatial information users. Accurate field data collection is also a necessary task for adequate spatial data analysis and proper decision making. Traditional field data collection methods are usually pen-and-papers based, seemingly most of the methods are time consuming and bulky tasks. It needs several materials and preliminary work before heading to the filed. However, significant changes have been occurred in filed data collection methods with the advancement of technologies such as Global Navigational Satellite Systems (GNSS) and development of smartphones. Advancement of Mobile phone and Web technologies enable conducting field data collection in a timely manner with the ability for users to actively and efficiently share the information. Moreover, progress of Geographic Information Systems (GIS) has led to carry out wide variety of spatial analysis. Integration of field data collection and GIS helps to solve numerous issues related to numerous fields such as health, agriculture, urban Planning etc. However, deploying and utilization of such integrated information systems required programming and high technological skills.

This study attempts to integrate and simplify field data collection and GIS as a WPS approach. The study carried out by utilizing FOSS applications. Open Data Kit (ODK) suit was used for data collection and integrate with ZOO-Project for web processing, further compared with Desktop GIS analysis. It demonstrates the importance and capabilities of WPS for further advance application and development. The concept and illustrations provide by this study would be able to attract unprecedented users to interact with geospatial science.

Keywords: Field data collection, GIS, FOSS, WPS ,Mobile GIS

1. Introduction

Filed data collection is one of the important tasks for many fields where it is one of the first steps for many studies which has become a crucial task for spatial information users, especially for geographers, geologists, biologists, crop scientists, ecologists, etc. Field data collection is a necessity for several reasons, such as collecting ground truth data collection for result validation, collecting soil contaminated sites, plant or animal species, and gathering public opinions for urban planning in order to analyze compatibility of proposed plan or identify the existing situation, disaster management and mitigation analysis, etc. Accurate field data collection is also an important requirement for adequate spatial data analysis and proper decision making.

Traditional field data collection methods are based on pen-and-papers. Those methods are time consuming and bulky tasks since of these methods require several materials and preliminary work. As an example, we need to prepare basemaps, collect an ancillary dataset, etc., before entering to the field. This is an unpractical method to be used in real-time disaster information collection, which occurs in unpredictable situations which requires a quick emergency response. However, with the development of technologies such as Global Navigational Satellite Systems (GNSS) and development of smartphones with wide variety of sensors, significant improvements have been occurred to the filed data collection methods. It enables to conduct field data collection in a timely manner. Moreover, there are various mobile application tools which capable of collection, management and sharing of filed data using mobile devices. Some examples are EpiCollect, OSMAnd, ONA, Geopaparazzi, Open Data Kit (ODK), etc. By contrast, available applications have several limitations when using them for field data collection,

especially some applications are unable to record and store multimedia data. Additionally, if the data are sensitive and secure, users should be able to setup their own system (Client and Server) for data collection. Open Data Kit (ODK) has the capabilities to address such issues. With the help of ODK an open-source suite of tools, data can be collected and sent to a centralized server using internet connected android devices in near real time by the user (Singh, 2013). Consequently, this study selected Open Data Kit (ODK) for mobile data collection. Besides, conversion and processing are the main actions which are performed after collecting the field data. Delivering geographic information via internet started soon after the emergence of World Wide Web in early 1990s with very primitive capabilities (Putz, 1994). However, with the emergence of Web 2.0 there have been changes in the way this geographic information is delivered. As a consequence, the terms GeoWeb 2.0 (Maguire, 2007) and Web Mapping 2.0 (Haklay et al. 2008) were coined in new era of web based spatial data management and analysis. After introducing such technologies, paradigms for publishing geographic information over the Web have radically changed in last decades. Also progress of geographic information systems (GIS) and more systematic use of the Open Geospatial Consortium Web Services (OWS) have led the availability of various technologies and methods to store and spread GIS data over the Internet (Fenoy, et al, 2013). With that Web Map Service (WMS) and Web Feature Service (WFS) have been introduced to store and spread spatial data over the Internet. There are many open source and proprietary software packages available to provide such functions and these methods have become very popular nowadays for Web GIS and mapping. Further, Web Processing Services (WPS) has been introduced and it enables the client to request the execution of a spatial calculation and algorithm through web service. WPS is designed to standardize the way that GIS algorithms are made available on the Internet (Fenoy, et al, 2013).

GIS knowledge and Computer skills are required to analyze and process the geospatial (field) data. Additionally, Programming skills is necessary when developing/customizing mobile applications for filed data collection. This study attempts to develop a framework and demonstrate simplified integration of field data and GIS in two different ways. It explains the filed data integration with desktop application and Internet application in terms of processing, disseminating and sharing the contents.

1.1. Applications and Components

Several applications have been used in this study which can be categorized as Mobile data collection applications and GIS applications concerning Desktop and Web. The desktop GIS enables to utilize field data for advance analysis and processing. ODK was used as filed data mobile phone application. On the other hand, ZOO-Project was deployed to develop the Web GIS(Processing) application. All these applications are developed using Free and Open Source Software (FOSS).

1.2. QGIS

QGIS is a user friendly Open Source Geographic Information System (GIS). In the software, each imported map or map feature is defined as a Layer. Layers can be made of point locations, background images, polygons such as rivers, boundaries of a country, or more complex types of vector data, like WFS, WMS maps or ESRI shapefiles. QGIS has capabilities to manipulate various types of Spatial data formats such as KML, SVG, GeoTIFF, GeoJSON, PostGIS, SpatiaLite, MSSQL, WMS/WMTS, WCS, WFS (Randall, 2014). Moreover, QGIS can be adapted to any special need with the extensible plugin architecture.

1.3. ODK

ODK consists of three modules, those are ODK Build, ODK Aggregate and ODK Collect. ODK Build is used to create and design the field survey forms. The simple forms can be created by using a web application which is a HTML5 form designer with drag and drop interface. More complex forms can be designed by using an XLSForms.

ODK Aggregate is server-side module of the ODK suite of tools, which provides blank forms to ODK collect and work as a data repository which is ready-to-deploy as a server. It has capabilities to accept finalized forms from ODK collect and store the data in the database and visualize the data as maps and charts. Further, it can export the data into various formats. ODK Aggregate can be deployed on Google's App Engine or on the local user's server such as Apache Tomcat server which has a fixed IP address with a MySQL or PostgreSQL database server. It is the central place which is administer the users. ODK collect is the client-side module and it is an app which can be installed on the Android mobiles. The form which is created by ODK Build is loaded in to ODK collect. It has capabilities to record GPS location, text, multimedia content such as image, video, barcodes, options ect. Finally, it connects to the centralized server to store that collected data when the internet is available.

1.4. ZOO-Project

ZOO-Project is an Open Source Geospatial (OSGeo) Foundation project that enables existing open source libraries to interact through its WPS framework (http://www.zoo-project.org/). As it is a framework to create WPS compliant services it can be deployed in any HTTP Server environment. It runs as a CGI application. It consists with three components (i) the ZOO kernel that is the engine, written in C , that enable the managing and chaining of different processes written in different programming languages; (ii) the ZOO services that implements the processes by means of a configuration file and function implementing the process algorithms in one of the supported languages (C, Python, Perl, PhP, JavaScript, Java, Fortran); and (iii) the ZOO API that is a JavaScript library to easy service chaining and interface development (Fenoy, et al 2013).

The ZOO Project has been able to connect the numerous and OSGeo libraries together and to use them as Web Services. It has been tested with the widely using libraries such as GDAL/OGR library and GRASS GIS processing algorithms, GeoTools etc. It shows that the ZOO Kernel can use existing libraries as standardized Web Services.

2. Methodology

This study tries to develop a framework and demonstrates integration of field data with GIS. The implemented methodology, depicted in Figure 1, consists of a server-side and a client-side component. First, administrator has to create forms and upload it to aggregate server. Next, users download the forms to their mobile devices and start to collect field data. The collected forms can be pushed to aggregate server and store in the database. The stored data publish as WFS and WMS and it can be visualized or further processed. The process can be done in two ways either by using desktop application or WPS engine and user can visualize the WPS result by using web user interface of WPS engine.

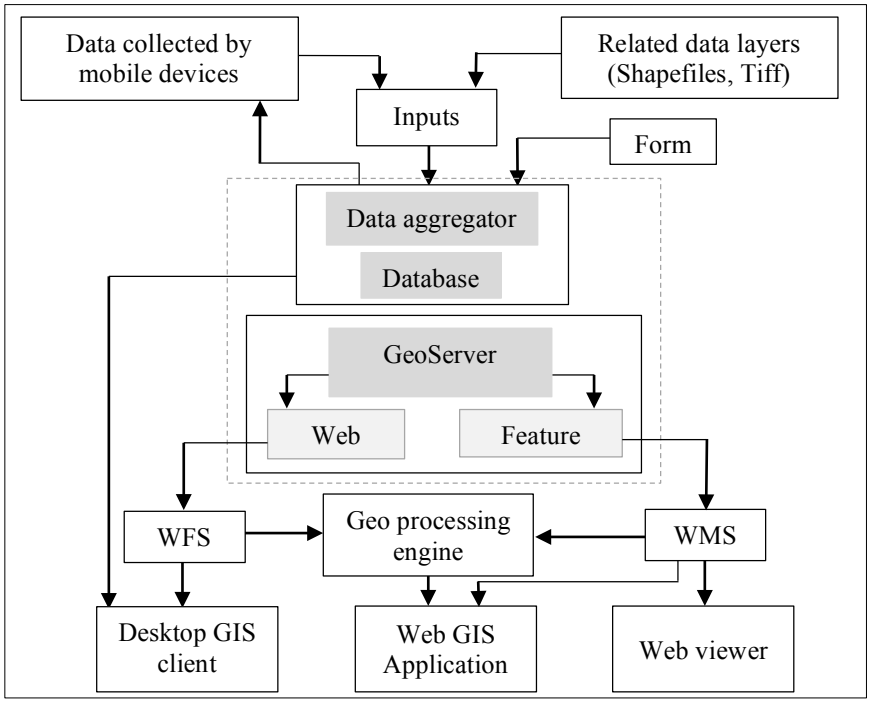


Fig. 1. Flow chart showing the workflow of methodology

2.1 System Architecture

Users can exploit their mobile devices to record/report field data with the help of Open Data Kit (ODK) suite because the modules of ODK suite are utilized to collect and aggregate the field data. The form and template are designed using open office, it is subsequently loaded into ODK Aggregate, which is running on an Apache Tomcat server backed with a PostgreSQL database. Collected field data is published through the web by the GeoServer. Published data can be visualized using OpenLayes based web viewer or it can be processed by ZOO-Project as WPS engine. Also, it can be processed by QGIS desktop client. WFS can be imported as input data for QGIS or directly retrieve from PostgreSQL databased by establishing a Secure SHell link. System architecture is demonstrated in figure 2.

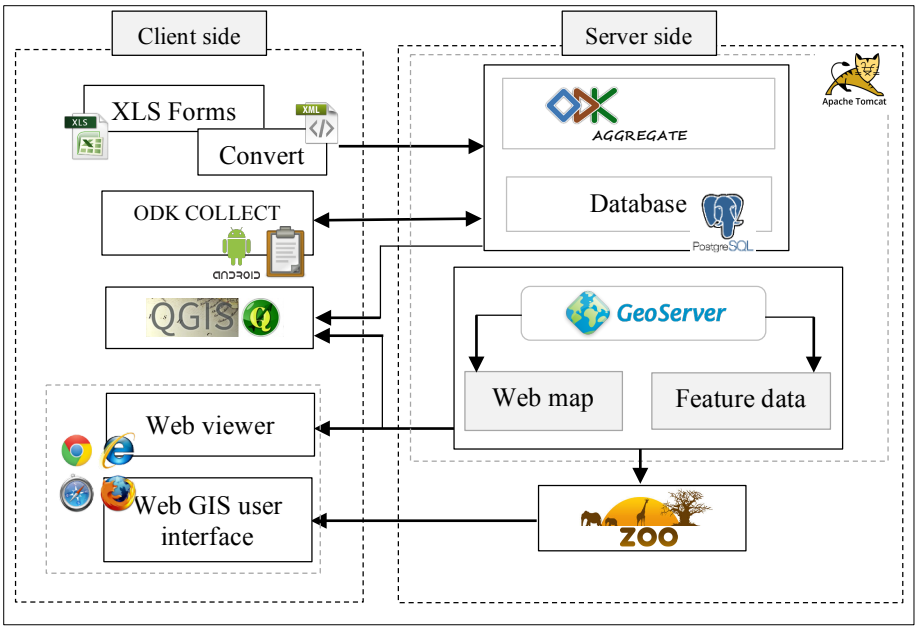


Fig. 2. Flow chart showing the system architecture

3. Application and Results

There is a great concern on how to build up an interoperable geospatial information system in relation to public health, flood hazard monitoring and management, etc. for public information programmes. There are some major issues still remaining in public information programmes that related to data collecting, visualization and processing. Therefore, after revealing the integration of field data and GIS the experiments are being carried out to demonstrate the functionalities of the system.

First the form has to be created to collect field survey data for a specific purpose. In This study, the form has developed (Fig 3) for an imaginary flood scenario for flood mapping survey. The data fields have been identified based on past studies. Purpose of this survey is to identify and evaluate the damages from flood hazard and to estimate a base flood elevation in the particular area.

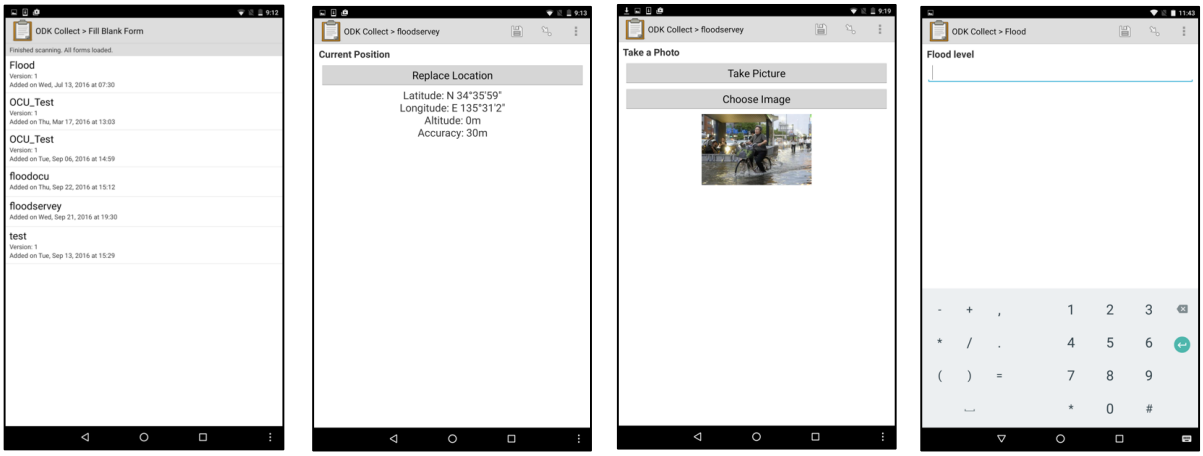
floodservey.xls - LibreOffice Calc

	A	B	C	D	E	F	G
1	**type**	**name**	**label**	**hint**	**required**		
2	date	date_today	Enter a date:				
3	text	name	Name				
4	select_one select_gender	gender	your gender				
5	integer	age	Your age				
6	select_one select_yesno	flood	Has your building or property ever been flooded				
7	text	level	how deep did it get				
8	geopoint	location	Current Position				
9	select_one select_damage	damage	did your property damaged?				
10	image	image	Take a Photo				
11							

Fig. 3. XLSFrom

Date, GPS Location and Water Level are the main fields in the questionnaire. After uploading the questionnaire to ODK Aggregate, user has to download the form to their android devices. Downloaded forms can be seen as shown in Fig 4 (a). After that, users can start using the application.

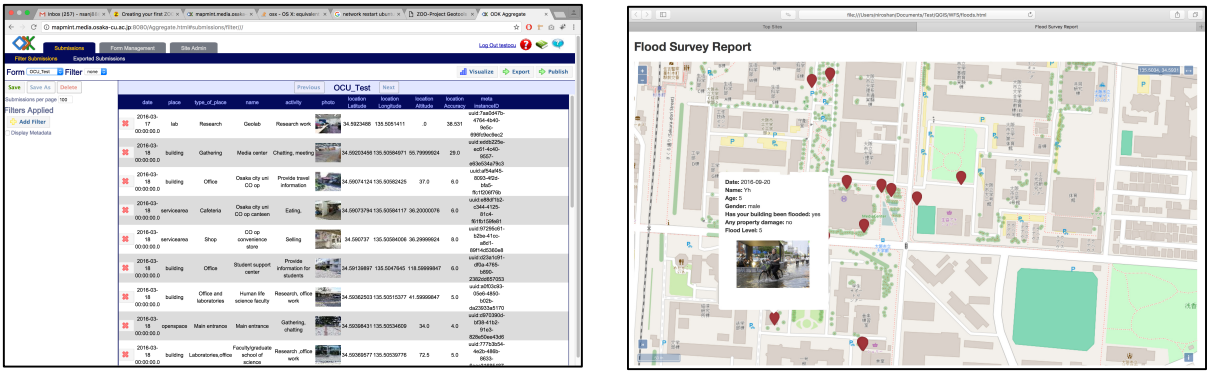
Most importantly, the application lets the user to insert the GPS location automatically [Fig 4(b)]. Then if the area was flooded, application lets user to select a photo of the location which can be taken using the camera of the mobile device [Fig 4 (c)], also water level need to be added [Fig 4(d)]. Completed forms are uploaded to the ODK Aggregate when the network (Cellular internet or Wi-Fi network) is available.



(a) (b) (c) (d)

Fig. 4. ODK Collect - Survey form

Collected data can be seen in ODKAggregate[Fig 5(a)]. Then the inserted data is placed on the map as a points [Fig 5 (b)], which can be opened as a popup and showing the data inserted once the user click on the point. It is possible to see the inserted data for the user or anybody.

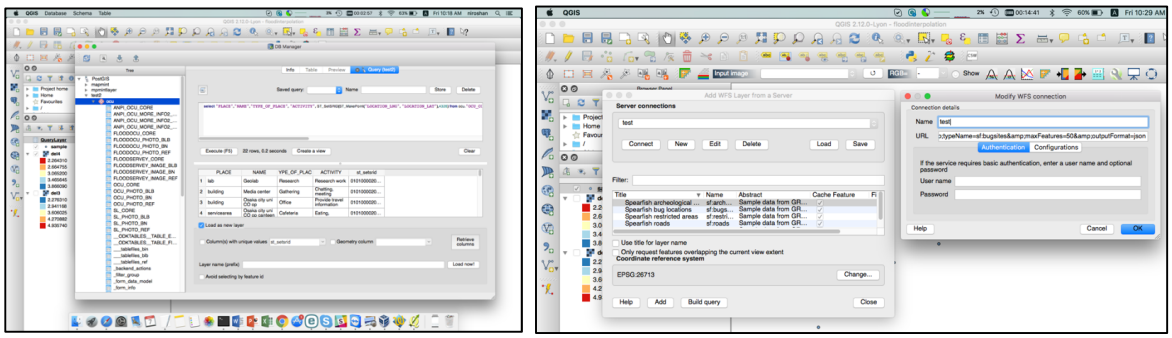


(a) (b)

Fig. 5. Data Visualization

Additionally, data can be imported to QGIS in two different ways. This study attempt to demonstrate the both ways.

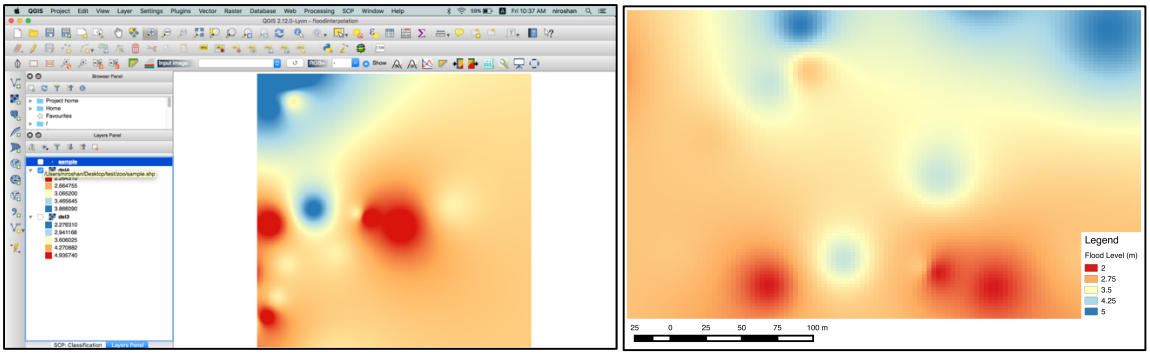
First attempt tries to connect the database directly to the QGIS [Fig 6 (a)]. It allows user to select the required fields for the analysis. Selected data fields can be seen as attributes in the imported layer.



(a) (b)

Fig. 6. (a) Import from PosrgreSQL database; (b) Import as WFS

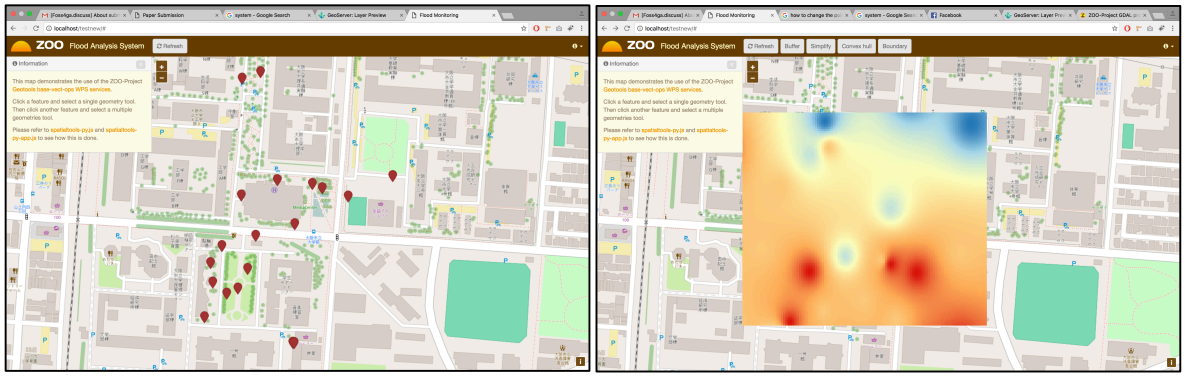
The second attempt tries to import the data as WFS to QGIS [Fig 6 (b)]. It allows user to save the layer as ESRI shapefile. QGIS offers user to carry out the analysis according to the requirement [Fig 7 (a)]. As a demonstration, this study tries to generate the flood depth levels. In order to generate the map, interpolated water surface elevations using Inverse Distance Weight (IDW) method for generating the water elevation map [Fig 7(b)].



(a) (b)

Fig. 7. Water level (Interpolated map)

User should have the knowledge on GIS and spatial analysis to carry out this type of analysis. Therefor this study attempt to simplify the spatial analysis by developing a web processing system. In order to reveal the web application similar to GIS, Spatial Interpolation analysis method has been deployed through ZOO-Project. Collected data automatically push to the Web Processing user interface [Fig.8(a)] and user can simply perform the analysis and derive the water surface elevations model and the result is shown in the same web interface [Fig.8(b)].



(a) (b)

Fig. 8. Web processing User interface

4. Conclusion

Advancement of Mobile phone and Web technologies has been able to simplify the spatial analysis and field data collection. For geospatial science to truly address the current issues, information gaps and technological barriers should be minimized. Deploying and utilization of such information systems should be able to carry out by non-programmers, minimally- trained users and organizations. The concept and explanation of this paper provides an opportunity for unprecedented users to interact with geospatial science.

The study mainly focuses on integration and simplification of field data and GIS, demonstrating importance and its capabilities for various study fields such as public health, spatial planning, geography, epidemiology, and etc. ZOO-Project platform considered as advanced web processing engine with many capabilities. ZOO-Project take it a step further, by applying it to field data analysis and processing.

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