Design of Ontology Based GUI Framework to Increase Usability of GIS Applications

Research Scholar S. S. Pawar, Prof. P. A. Jadhav
Bharati Vidyapeeth University college of Engineering pune

Abstract
GIS has emerged as powerful tool which has potential to organize complex spatial environment with tabular relationships but still desktop GIS software’s fails to answer user’s spatial questions directly. GIS skills and functionality cause semantic gap between Complex hierarchical organization & user’s spatial thinking as non-expert user identify or use different GIS tools without specific training or skill. To overcome such problem we design a question based GUI framework which use different ontology's like spatial, domain & task ontology to identify core spatial concept & select appropriate tool to complete a task. This framework enhances performance of the GUI software not only for a desktop but on web map services also. The semantic framework would be useful to enhance the ability of spatial reasoning in web search engines (e.g. Google semantic search) and answering questions in location based services as well (e.g. iPhone Siri assistant).

Keywords: Ontology, GIS, Semantic, Spatial reasoning.

1. Introduction
GIS is now days become strong backbone for different services like web services, different GIS application. GIS basically work with spatial information which has direct or indirect reference to particular geographical area. GIS is kind of database management system which capture, store, manage, retrieve, analyze & display geographical information according to the need of particular application. GIS provides easy platform to map textual data to graphical interface through digital media. Using spatial analysis technique we can interact with GIS to answer questions, decision making etc. Different spatial analysis techniques are as follows:

1. Queries and reasoning
2. Measurements
3. Transformations
4. Descriptive summaries
5. Optimization
6. Hypothesis testing

Spatial analytics is core of any GIS software but complexity & hierarchical organization in these tools increase strenuous for non expert users. As computing trends are changing from grid to cloud the service-oriented architecture (SOA) starts performing tasks by chaining different types of services available on network rather than stand alone machine. GIS based different mapping services like ArcGIS Server, MapServer, and Google Maps API provide expert level services with the help of SOA. These services had developed complicated interactive maps that mirrored the interaction and complexity which leads to make it inconvenient to common peoples. By considering all aspects of services & user limitations we need to design a user interface which perform particular task by mapping spatial thinking with analysis tools. Goodchild (2011) has proposed to integrate the concepts of spatial thinking in the design of a new GIS user-interface and in organizing spatial analysis tools [1].

2. GIS FUNCTION TAXONOMIES
The few existing taxonomies of analytical GIS operations are limited either by the data structure that they are based on - or by the scope of applications for which they had been developed. They are not formalized and do not attempt to be truly universal. It is possible to perform most GIS analyses with a set of only 20 universal operations. Further analytical functionality can be achieved by combinations of those universal operations. All operations are defined from a user perspective rather than an abstract technical one. Their function is readily apprehended by any spatially aware person; they do not require any knowledge about abstract concepts of spatial domain. The universal applicability of these operations is ensured by having them based on the latest Open Geodata Interoperability Services (OGIS) and Spatial Archives Interchange Format (SAIF) technical references. Sample applications of the Virtual GIS (VGIS) system, which is based on universal GIS operations, reveal the advantages for a spatial dependent situations of environment. It provides the means to concentrate on the analytical process instead of having to cope with the intricacies of current GIS. Golledge (1995) stated that both simple and complex spatial concepts can be derived by using primitives of spatial knowledge (identity, location, magnitude and time) [2]. Selection of appropriate analytical tool is depending upon problem domain.
Tool selection process depends upon user’s memory & knowledge as non expert users unfamiliar with classification of GIS functionalities fails to deal with GIS software. Berry (1987) presented four classes of primitive GIS operations by organizing a set of analytic methods into a mathematical structure [3]. Goodchild (1988) grounded his taxonomy of functional operations in GISs database based on formalizing the object representation of spatial data [4]. Rhind and Green (1988) classified GIS functions based on data operations (data input and encoding, data manipulation, data retrieval, data analysis, data display, database management) [5]. Albrecht (1998) proposed a task orientated systematization (search, location, terrain, distribution/neighborhood, spatial analysis, measurements) [6]. Kuhn (2012) [7] proposed a set of ten core concepts of spatial information (location, neighborhood, field, object, network, event, granularity, accuracy, meaning, value), aiming at giving meaningful demonstration to scientists and researchers who are otherwise not specialists with regard to spatial information.

Development in GIS field cause transformation in GIS functionality but user interface remain complex & function dependent. To increase GIS functionality we need to bridge spatial thinking & computer process. With the help of user friendly UI we can easily bridge spatial analysis with user. Our design depends upon two things:

i. Spatial thinking questions

ii. An interface to select appropriate analysis tool using ontologies work at different levels

3.1 EXISTING GIS FUNCTIONALITIES AND WEB MAP SERVICES

GIS is a computer software system developed to capture, store, manipulate, analyze and show all types of geographical data. GIS also provide, management, retrieval of spatial data entry and visualization functions. We analyze following existing system.

3.2 ARC MAP

ArcGIS is a Geographic Information System(GIS) for dealing with maps and geographic information[9]. This system provides the platform or infrastructure for creating maps and geographic information available throughout an organization, across a community, and explicitly on the Web. ArcMap is the main part of Esri’s ArcGIS suite of geospatial processing programs, and also used primarily to view, edit, create, and examine geospatial data. One of ArcMap’s most prevailing features is its ability to be customized for specific, unique types of analyses, by means of its customizable interface.

Figure 1 Arc Map interface [10]

3.2.1GRASS

GRASS is free, open source GIS software used for geospatial data management, spatial modeling and visualization. The U.S. Army Construction Engineering Research Laboratories firstly developed GRASS in 1985. It offers broad levels of GIS analysis functions for both vector and raster datasets. Quantum GIS can embed all GRASS functions by means of a graphic user interface (GUI) for easier public use. Recently, the new version of GRASS added a new 3D vector engine in order to support vector-based network analysis [11].
3.2.2 GOOGLE MAP API

Google Maps is a type of desktop and mobile web mapping service application and technology provided by Google which offering satellite metaphors, street maps, and Street View perspectives, as well as tasks such as a route planner for travelling by foot, car, bicycle (beta test), or with public transportation[12]. Google map API is user friendly and can be easily understood by user as it follows the human computer interaction rules. Google map API has launched by Google in 2005, to allow developers to integrate Google Maps into their websites. With the Google maps API, it is possible to implant Google Maps site into an external website, on to which site specific data can be superimposed.

4. THE DESIGN OF QUESTION BASED USER INTERFACE

A semantic framework of the user interface has vertical flow data consist of 3 main parts as shown in fig.3:

1. functional levels
2. operational Ontology’s
3. Natural Language Processing (NLP)

4.1 Functional levels

The semantic framework of question-based GIS user interface at the vertically can be divided into three levels:

i. Spatial Question level
ii. Semantic level
iii. Implementation level

4.1.1 Spatial Question layer: The interface allows users to ask spatial questions based on their thoughts or to select some question examples listed on the user interface.

4.1.2 Semantic layer: It uses natural language processing (NLP) methods to parse questions to the core spatial concepts by referring to the spatial concept ontology. It also employs specific domain ontology to understand the descriptive structure of questions for capturing the user’s purpose. The output of the semantic layer is a single task or a workflow of multistep tasks that need to be implemented to answer users’ questions.

4.1.3 Implementation layer: It resorts to possible GIS tools or functions to accomplish the task on desktop-GIS software. Also, it could provide a set of uniform and simple restful style geo-processing web services in the age of cloud computing [8]

4.2 Operational Ontology

The framework uses different levels of ontologies to guide the process of extracting the core spatial concepts from questions and translating them into a set of computational or operative tasks to invoke GIS functions. We use 3 types of ontology’s.
4.2.2 Spatial concept ontology:
It describes the ontology design pattern for spatial concepts based on Kuhn’s spatial information theory [7] and Albrecht’s universal elementary GIS functions [6]. Spatial concept ontology consist of common parameters of spatial concept like location, neighborhood, field, object, network, event, distribution, connectivity, proximity, adjacency, pattern, direction/orientation, hot-spot, relation, overlay, buffer, and join etc.

4.2.3 Domain ontology:
This part could be linked to domain ontology’s existing elsewhere in other collections and standard formats, such as the ontology of USGS land-use and land-cover classification which support a remote sensing image processing in a GIS environment.

4.2.4 Task ontology:
It describes the combined actions to complete a specific task and presents relationship between different functions, e.g. in hydrology GIS application, the function to generate watershed only can be executed if the user has finished the preliminary function named as Flow Direction based on the digital elevation model (DEM) dataset.

4.3. Natural Language Processing (NLP)
The natural language is core domain in research. Natural language is hard to interpretation. Orthodox user has non formal queries which need to be interpreted exactly by GIS application, the interface implements ontology as base to understand the queries of user.

5. PROPOSED ALGORITHMIC PROCEDURE
We Propose a Algorithmic Rule procedure for Working of Ontology mold GIS Application interface. A model of input taxonomy of query is considered with expected output mold based on ontology concept. The algorithmic rule facilitates implementation of domain ontology, Task ontology, user spatial concept ontology which facilitates desktop GIS applications and location based services effective delivery. The function is heuristic process implementing fine solution extraction from universal ontology concept. The procedural function considers input data set of queries from user. A supportive dictionary facilitates concept mapping to user query. Token matching file facilitates exact check to user query and expected solution generation from dataset. The corpus is sort of web pages from various domain related information. Mapping set of queries to set of dataset corpus is carried via master rule vector Mc. the vector is hand written expert rule for natural language processing. A rank list of solution is presented and then only accurate solution is presented in forward to user. Preceding figure depicts the algorithmic flow of procedure.

```
Input:
- Query: User spatial question.
- SDc: Support Dictionary.
- Rank list of Tokens in Token file with Pattern Matching.
- User and written NLP rules.
- Dataset contains Extracted web document contents.

Output: Accurate reply.

Process Flow:
2. SDc+ [Support Dictionary words matching user concept requirement, all...[end]]
3. ap: Preprocessed SQ, Query atomic words after processing of SDc.
5. Matching process.
6. For d <- 1, n do
7. If Nc € S Simp
8. Mark S: As Simp.
9. End If
10. End For
11. End For
12. For q <- 1 to Do
13. If ap € S Simp
14. Match ap As Token
15. Else
16. Mark ap As Proper noun, PN.
17. END IF
18. END For
19. For q <- 1, topic do
20. If Simp € EEl
21. Then
22. End If
23. END For
24. End if
25. Display.

Fig 4: Algorithmic Procedure of GIS user interface
```
6. CONCLUSION
The proposed interface is a step towards exact solution fetching from structured, unstructured knowledge resources. A common prototype model is proposed which can be integrated new GIS Features. The existing system has been built for Desktop GIS Application which will be extended to online support web services. Spatial reasoning is incorporation fetches exact solution to user queries. It concludes with a general semantic web interface on top of ontology for GIS Applications and LBS (location based services). The research Area covered is Geo semantic web, a Web of information in Geographical domain.

7. FUTURE SCOPE
An Enhancement area in domain is incorporation of Artificial intelligence which would enhance the results fetched by GIS interface. A map function to represent nearest hotels, railway station, hospitals, shopping centers on visual Map A web interfacing would bring in platform independent access to application. The application is web services which can be enterprise level for commercially built for specific domain area. Implementation of YAGOO ontology is future scope.

ACKNOWLEDGEMENT
I am very thankful to prof.P.A.Jadhav for facilitating the research project. I express my gratitude to prof.S.B.Nikam of computer department Bharati Vidyapeeth College of engineering Pune for providing right guidance in completion of my work. The utter encouragement of Head of department Prof.S.Z.Gawali has been our stand support.

References

AUTHOR
1) S.S.Pawar is Research scholar pursuing Mtech.IT from Bharati Vidyapeeth University College of Engineering Pune-41 Maharashtra.
2) Prof.P.A.Jadhav is Research Scholar pursuing PhD in computer engineering with research experience of more than 5 years, Assistant Professor at Bharati vidyapeeth university college of Engineering Information technology Department.