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# NearMe: Dynamic Exploration of Geographical Areas

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**Abstract.** Web GIS offer precious data to explore geographic areas but they might overload the user with large amounts of information if (s)he is unable to specify efficient search queries. Services such as OpenStreetMap and Google Maps support focused information search, which requires people to exactly define what they are looking for. However, what can be searched within a specific area mainly depends on what is located there. Thus, the question is how to provide the user with an overview of the available data (s)he can look for, instead of forcing her/him to search for information in a blind way.
This paper attempts to address this issue by introducing the NearMe exploration model. NearMe offers a search lens which, positioned on a geographic map, enables the user to discover the categories of Points of Interest that are available in the selected area (e.g., services and Cultural Heritage items) and to choose the types of information to be displayed, based on a faceted-exploration search model. NearMe is based on a semantic representation of geo-data and it is integrated in the OnToMap Participatory GIS, which supports geographic information sharing. We carried out a preliminary user study with 25 participants to assess the User Experience with our model. The results show that NearMe is perceived as easy to use, understandable, attractive and that it efficiently supports exploratory search using geographic maps.

**Keywords:** GIS · Geographic information search · Semantic filtering lenses.

## 1 Introduction

Geographic information search may challenge users in different ways:

– Its exploratory nature makes it hard for people to define efficient search queries. If users are not familiar with a region, they simply do not know which Points of Interest (PoIs) they can find there. Thus, they should be guided in discovering the available options. This is in line with Marchiorini's discussion [21] that, in exploratory search, users typically have ill-formed goals because they are not familiar with what they are looking for. Therefore, they are unable to specify efficient search queries aimed at satisfying their information needs. As a consequence, they can be overloaded by possibly large amounts of irrelevant data.

– Users might be interested in exploring in detail the PoIs they can find near themselves, or in a very specific geographic area such as the neighborhood of a place, rather than viewing complex maps that cover large regions.

These issues can be addressed by changing the way geographic information systems interact with users. For instance, suppose that somebody has dinner in a restaurant and looks for nearby places to spend the rest of the night. Different options might be considered, such as visiting a pub, a club, or going to the bowling. Our idea is that, instead of asking the user to specify focused search queries that might lead to zero solutions, or visualizing whatever is located nearby, the system might show an overview of the categories of PoIs that are available in the selected area (e.g., clubs and pubs might be present, but not bowlings) and let her/him focus the search accordingly.

Starting from the concepts developed in the research about faceted search support [14, 19], we propose to guide the user by means of context-dependent search criteria that take the solution space into account to enhance information exploration. Specifically, we propose NearMe, an interactive model that uses an augmented lens metaphor to assist map-based information filtering and data visualization in restricted geographic areas. By placing the NearMe lens on a map, the user receives a list of data categories corresponding to the types of PoIs located in the area under the lens. Then, (s)he can select the categories to be visualized in an informed way, being guaranteed that (s)he will not receive an empty set of results [28, 14]. Moreover, the user can interactively revise the content of the lens to customize the view on the available PoIs, and (s)he can bookmark PoIs to make them permanent in the map. Combined with the possibility of sharing the map with other users in a persistent way, this model enables people to build Personal Information Spaces [5] for the organization of individual and group activities.

We carried out a preliminary user study to test the functions offered by NearMe. The experiment involved 25 participants and obtained very positive User Experience (UX) results. NearMe was perceived as easy to use, understandable and attractive. Moreover, participants felt that it efficiently supports exploratory search. These results encourage a general adoption of this model in geographic information exploration.

The remainder of this paper is organized as follows: Section 2 provides some background and positions our work in the related one. Section 3 describes the NearMe model. Sections 4 and 5 present the validation methodology we applied and the results of our user study. Section 6 concludes the paper.

## 2 Background and Related Work

### 2.1 Geographic Information Search Support

Web GIS constrain the information they present on maps in different ways. For instance, both OpenStreetmap [24] and Google Maps [13] steer the visualization of data categories to the zoom level of a map in order to progressively display more details while the user focuses on more restricted areas. This information filtering strategy does not enable people to select the types of PoIs they want to view. Thus, it fails to support the visualization of custom maps reflecting individual information needs.

Google Maps also helps the user explore the region around a place. However, it assumes that (s)he knows what (s)he is looking for, and that (s)he submits a search query satisfying her/his information goals in a rather precise way. As previously discussed, this type of interaction is challenging in exploratory search. Moreover, it limits the discovery of places that could interest the user but which do not belong to the data categories (s)he specifies. Furthermore, Google Maps assumes that the user focuses on a specific type of information within each search task. As each search query focuses on a single data category, results cannot be jointly visualized in the map. Therefore, the system exposes the user to a fragmented view of results, instead of providing her/him with a unified presentation of the area of interest.

Drive navigation systems, such as TomTom [29] and Google Maps, show nearby Points of Interest depending on the user's geographic location. However, they focus on routing and on the visualization of broadly inspected data related to driving, like speed cameras, fuel dispensers, and so forth. They also show other types of PoIs, if mapped, but they do not enable the user to select the categories (s)he is interested in (e.g., historical buildings versus hotels) and they do not provide in-depth information about PoIs. Waze [30] community driven GPS navigation app allows its users to report any travel-related information, which is then used to optimize route planning and to provide real-time traffic updates. In addition to specific places relevant to driving, it displays some categories of PoIs using distinct search icons. In this way, specific sites around the user can be viewed on the map by choosing one category out of parking, gas stations, food, drive-thru, cafes, and similar. Although the user can select a specific place near her/him to get detailed information about it, only sites belonging to a single information category at a time can be visualized on the map. In summary, we conclude that the above listed services are not sufficient to support the user while visiting a geographical area.

Personalized mobile guides, such as [7, 2, 10, 22], help people find PoIs relevant to their interests. They also present detailed information about places. However, they are based on the management of long-term user profiles that have to be bootstrapped before providing effective suggestions. Thus, they can hardy react to short-term search goals.

NearMe differs from all the above listed models because:

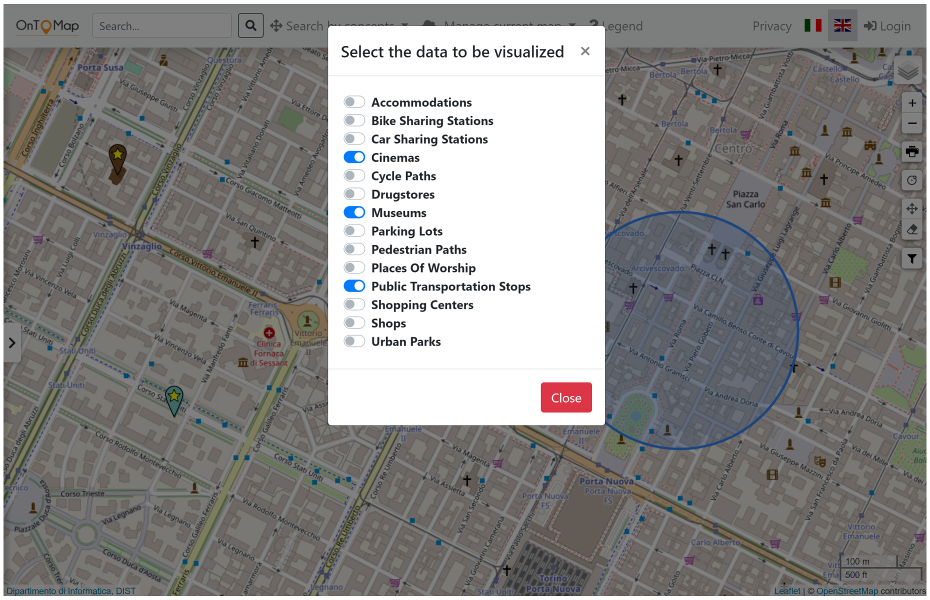


**Fig. 1.** NearMe: selection of information categories to be visualized within a lens.

- It provides the user with a synthesis of the categories of PoIs (e.g., schools, bus stations, libraries, cafes) that are available in the selected area and it enables her/him to manage a custom map by choosing the relevant data to be visualized.
- It supports the inspection of details about the items displayed in the map. Moreover, it enables the user to bookmark PoIs in order to create persistent maps that describe the areas of interest.
- It enables a flexible exploration of a geographic area by moving the lens on the map, thus exploring small areas in a continuous way.

### 2.2 Map-based Information Visualization

As discussed by Kraak et al., maps are commonly used as visual thinking and analysis tools [16, 1]. Moreover, in participatory decision-making [12, 8], they are used as shared representations to collect information in long-lasting distributed projects. However, the presentation of large amounts of data may overload the user, also depending on her/his visual spatial abilities [9]. Various models have thus been designed to enable a selective visualization of information, either based on spatial or on time multiplexing.

Lobo et al. [20] found that Translucent Overlay [11, 18] and Blending Lens [26, 6] are the best performing visualization models for interactive map comparison. However, these models work on two layers only. Differently, we are interested in enabling a joint search on multiple types of related information, such as schools,

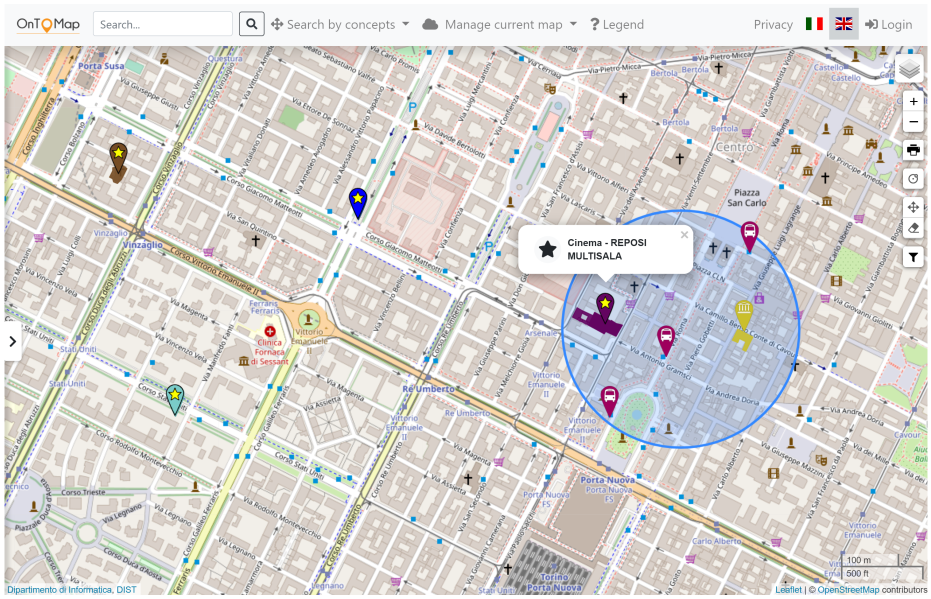


**Fig. 2.** Data visualization within the NearMe lens.

pharmacies and bus stops. In order to address this limitation, we propose a lens-based visualization model integrated with a faceted-search one [23] that supports interactive information filtering and semantic data visualization.

## 3 NearMe

NearMe exploits the OnToMap Web collaborative GIS [3, 4] as a semantic data container, information sharing service and map viewer.[1] OnToMap defines the data categories in an OWL [25] ontology that is mapped to the domain representations of external data sources in order to retrieve information from them. The ontology also specifies graphical details for map visualization. For instance, it stores the colors and icons to be displayed in the map when visualizing the items belonging to each category.

Fig. 1 shows a step of interaction with NearMe. In order to explore a geographical area, the user draws a circle on the map. In turn, the system shows a list of checkboxes corresponding to the categories of the items located in the bounding box. For each category *c*, the bounding area includes at least one PoI belonging to *c*. The user can choose the relevant categories by clicking on the checkboxes. For instance, in the sample interaction of Fig. 1, the user has selected categories Cinemas, Museums and Public Transportation Stops. In turn, the system visualizes in the map the related items; see Fig. 2.

[1] OnToMap is used as data container in "co3project: co-create, co-produce, co-manage", `https://www.projectco3.eu/it/`.

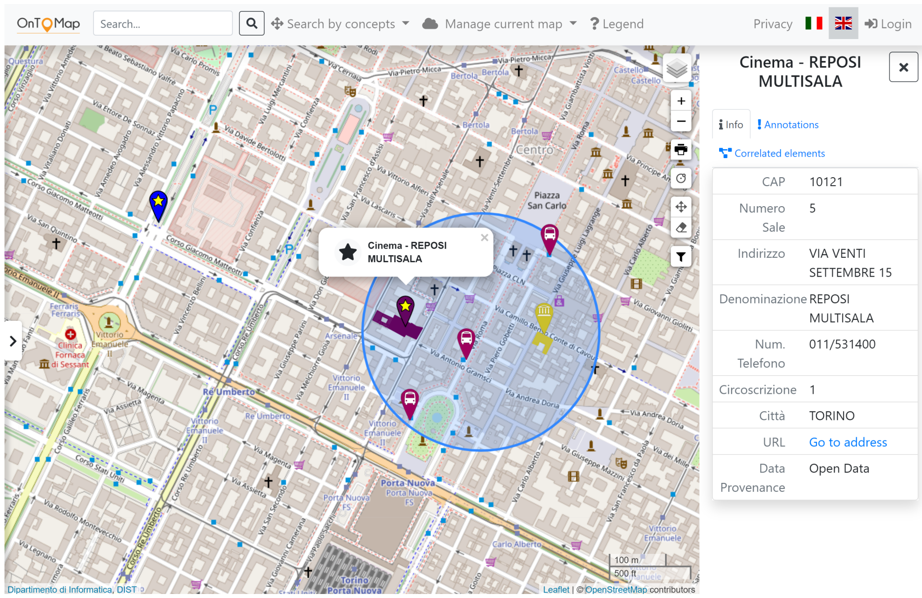


**Fig. 3.** Details about a Point of Interest.

In the map, PoIs are depicted using representative icons, or geometries, if they are available. Moreover, color-coding [15] is used to identify their categories. For instance, in Fig. 2 there are a cinema (REPOSI MULTISALA), represented as a violet geometry, a museum (yellow pointer and yellow area) and three public transportation stops (magenta pointers). The user can bookmark the visualized PoIs to make them persistent in the map. Bookmarked items are identified by pointers with yellow stars. In the example, the user has bookmarked cinema REPOSI MULTISALA, but (s)he previously bookmarked other three PoIs: a church (brown pointer), a parking lot (blue marker), and a shop (green marker).

The user can also interact with the PoIs visualized in the map to view their details. As shown in Fig. 3, in that case, OnToMap shows a table that reports specific information about them. This makes it possible to use the map as catalog presenting geographic data at different levels of detail. Notice that the user can drag the lens to other areas of the map, or revise the selected filters, to retrieve other Point of Interests. Overall, the lens complements the basic search support offered by OnToMap by enabling an incremental and interactive exploration of geo-data, focusing on small areas to reduce information overload.

## 4 Validation Methodology

To test the user experience with NearMe, we carried out an experiment involving 25 participants. People joined in the user study on a voluntary basis, without any compensation, and they signed a consent to the treatment of personal data.

The user study took place live, in video calls with shared screen due to COVID-19 pandemic. One person at a time performed the study which lasted about 20 minutes. Initially, the participant watched a video showing how the lens works. After that, (s)he interacted with OnToMap and with the lens on a sample map to get acquainted with the system. Then, we asked her/him to answer a pre-test questionnaire designed to assess demographic information, cultural background, as well as familiarity with map-based online applications.

During the study, we asked people to solve two map learning tasks in which they had to identify and possibly bookmark certain PoIs. The tasks (translated from the Italian language) are the following ones:

1. *Suppose that you arrive at the Porta Nuova train station to spend the afternoon in the city. We ask you to use* NearMe *to find information related to museums, cinemas, urban parks and bike sharing stations. Moreover, we ask you to bookmark three places that you would like to visit.*
2. *Suppose that you are going to live in a place nearby Torino Porta Susa train station. We ask you to use* NearMe *to find information about schools, parking lots, post offices, bike sharing stations and drugstores that you will find near your place.*

Participants carried out the two tasks by interacting with the NearMe lens. We did not put any time restrictions on the execution of the tasks.

After having completed the tasks, each participant answered a questionnaire to assess her/his User Experience (UX) with the system. Moreover, (s)he could provide free-text feedback by answering an open question. In order to measure UX, we used the Italian version of the UEQ questionnaire [17]. UEQ supports a quick assessment of a comprehensive impression of user experience covering perceived ergonomic quality, hedonic quality, and attractiveness of a software product. Questions are proposed as bipolar items, e.g., `[annoying 1 2 3 4 5 6 7 enjoyable]`. Moreover, in order to check user attention, half of the items start with the positive term (e.g., "good" versus "bad") while the other ones start with the negative term (e.g., "annoying" versus "enjoyable") in randomized order. The range of values of the questions is mapped to the [-3, +3] interval for the UX evaluation, where -3 is very negative. Each question corresponds to an individual UX aspect and it belongs to one of six *UEQ factors* that describe broader user experience dimensions: "Attractiveness", "Perspicuity", "Novelty", "Stimulation", "Dependability", and "Efficiency". Table 1 shows the bipolar items of our questionnaire.

## 5 Results

### 5.1 Data about Participants

For the user study we recruited 25 participants (52% women; 48% men; 0% not declared). Their age is between 21 and 60 years, with a mean value of 29.36. 68% of participants are students of different Schools of the University of Torino, 16% are full-time employees and 16% are teachers. Overall, 44% have a Bachelor or Master degree, 52% have a Secondary School diploma and 4% have a middle school certificate. Participants' background can be split as follows: 64% scientific, 16% technical, 16% humanities, and 4% linguistic.

Regarding familiarity with technology, 56% of participants declared to have a middle level, 20% beginners, 20% experts and 4% totally unfamiliar with it. Moreover, 48% of people stated that they use online maps such as Google Maps every week, 32% monthly, 12% daily and 8% a couple of times per year.

**Table 1.** Detailed results of the UEQ [27] questionnaire. The Aspect column shows the bipolar item that is the object of the question posed to the user. The Factor column shows the UX Factor to which the aspect belongs. All results are positive, as denoted by the ↑ symbol preceding the mean value for each question.

| Question | Mean | Variance | St. Dev. | Aspect | Factor |
|---|---|---|---|---|---|
| 1 | ↑ 2.0 | 1.5 | 1.2 | annoying/enjoyable | Attractiveness |
| 2 | ↑ 2.2 | 0.8 | 0.9 | not understandable/understandable | Perspicuity |
| 3 | ↑ 2.0 | 1.2 | 1.1 | creative/dull | Novelty |
| 4 | ↑ 2.4 | 0.7 | 0.8 | easy to learn/difficult to learn | Perspicuity |
| 5 | ↑ 2.1 | 0.6 | 0.8 | valuable/inferior | Stimulation |
| 6 | ↑ 1.7 | 0.8 | 0.9 | boring/exciting | Stimulation |
| 7 | ↑ 2.5 | 0.3 | 0.6 | not interesting/interesting | Stimulation |
| 8 | ↑ 1.2 | 1.4 | 1.2 | unpredictable/predictable | Dependability |
| 9 | ↑ 1.6 | 2.8 | 1.7 | fast/slow | Efficiency |
| 10 | ↑ 1.8 | 1.6 | 1.3 | inventive/conventional | Novelty |
| 11 | ↑ 2.4 | 0.4 | 0.6 | obstructive/supportive | Dependability |
| 12 | ↑ 2.4 | 0.4 | 0.6 | good/bad | Attractiveness |
| 13 | ↑ 2.2 | 1.2 | 1.1 | complicated/easy | Perspicuity |
| 14 | ↑ 2.0 | 1.0 | 1.0 | unlikable/pleasing | Attractiveness |
| 15 | ↑ 2.0 | 1.4 | 1.2 | usual/leading edge | Novelty |
| 16 | ↑ 2.4 | 0.4 | 0.6 | unpleasant/pleasant | Attractiveness |
| 17 | ↑ 2.4 | 0.5 | 0.7 | secure/not secure | Dependability |
| 18 | ↑ 2.0 | 0.8 | 0.9 | motivating/demotivating | Stimulation |
| 19 | ↑ 2.0 | 1.5 | 1.2 | meets expectations/does not meet expectations | Dependability |
| 20 | ↑ 2.4 | 1.2 | 1.1 | inefficient/efficient | Efficiency |
| 21 | ↑ 2.3 | 1.7 | 1.3 | clear/confusing | Perspicuity |
| 22 | ↑ 2.2 | 0.8 | 0.9 | impractical/practical | Efficiency |
| 23 | ↑ 2.6 | 0.3 | 0.6 | organized/cluttered | Efficiency |
| 24 | ↑ 2.2 | 0.6 | 0.8 | attractive/unattractive | Attractiveness |
| 25 | ↑ 2.2 | 0.8 | 0.9 | friendly/unfriendly | Attractiveness |
| 26 | ↑ 2.0 | 1.1 | 1.1 | conservative/innovative | Novelty |

### 5.2 User Experience Results

**Answers to Individual UEQ Aspects.** Table 1 shows the mean values of participants' answers to the questions of UEQ. As the scores given by participants are mapped to the [-3, 3] interval, values $\geq 0.8$ denote positive evaluations.

**Table 2.** User Experience results grouped by UX factor. Values are obtained by averaging the ratings given by participants to individual UX aspects of UEQ.

| | NearMe |
|---|---|
| **Attractiveness** | ↑ 2.187 |
| **Perspicuity** | ↑ 2.300 |
| **Efficiency** | ↑ 2.220 |
| **Dependability** | ↑ 1.990 |
| **Stimulation** | ↑ 2.060 |
| **Novelty** | ↑ 1.950 |

Moreover, values in (-0.8, 0.8) are neutral and lower values than -0.8 are negative. It can be noticed that:

- all the mean scores received by the questions are $\geq 1.2$;
- 22 mean values out of 26 are $\geq 2.0$;
- 14 mean values out of 26 are $\geq 2.2$.

Moreover, standard deviation values are low. They range between 0.6 and 1.3, with the only exception of the efficiency value, which is slightly higher, and equal to 1.7. This means that, overall, participants appreciated our model quite a lot.

The questions that received the lowest scores concern the predictability (question 8, mean value = 1.2) and speed (question 9, mean value = 1.6) of the system. However, these values are counterbalanced by the other aspects belonging to the same UX factors. Specifically, users evaluated NearMe as supportive (question 11), secure (question 17) and meeting their expectations (question 19). Moreover, even though participants perceived the system as a bit slow, they considered it efficient, practical and organized.

**Results by UX Factor.** Table 2 provides the reader with a more compact description of results. The individual questions of UEQ are grouped by UX factor and the mean values of each question are further averaged to obtain a single, representative value of the factor, such as Attractiveness, Perspicuity, and so forth. This gives a more general view of users' perceptions, which abstracts from the possible fluctuations occurred in individual questions. Also in this case, we can see that NearMe has received very high evaluations: all the mean values are near or above 2. Participants perceived NearMe as particularly perspicuous (i.e., easy to use, understandable, etc.), efficient and attractive. Moreover, they evaluated it as dependable (i.e., predictable, supportive, etc.) and they appreciated its novelty.

**Answers to the Open Question.** In the free-text answers, several participants confirmed that they appreciated the system. Moreover, they gave some suggestions. For instance, a user proposed to visualize the scale of the circle, in order to understand the size of the area below it. Moreover, another participant complained that, each time the user creates a lens, a new list of checkboxes representing PoI categories appears. She asked to enable the positioning of the widget aside in the user interface.

As far as predictability is concerned, which received the lowest mean evaluation (question 8), a participant suggested to include in the user interface of the system a video tutorial showing the main functions offered by NearMe, similar to the one we proposed before experimental tasks. This might be interpreted as a need to clarify what can be done when interacting with the lens, and a need for help in learning to use the system.

**Discussion.** The experimental results suggest that NearMe successfully supports geographic information exploration and can be a useful extension to a Web GIS such as OnToMap, in order to help the user focus on small areas when looking for specific categories of PoIs.

There are however some limitations, which we plan to address in our future work. In particular, we tested our model on a small sample of people, most of whom are University students. In order to acquire more significant results, a larger set of participants has to be involved in the user test. Another limitation is the fact that people tested the system by using laptops and desktop PCs. Another test should be carried out to measure User Experience when the system is used on mobile phones.

## 6 Conclusions

We presented the NearMe information filtering model, aimed at supporting the exploration of geographical maps by focusing on small size areas. In this model, we provide the user with a lens that can be positioned on an area in order to discover which categories of PoIs are available, and to select those to be visualized. Basically, the lens offers a preview of the available options, in that it only proposes categories having at least one available PoI located in the area under the lens. Thus, it guides the user in an informed navigation of the solution space, preventing the zero-results effect. A user test involving 25 participants showed that NearMe is perceived as easy to use, understandable, attractive and efficient in supporting geographic information exploration.

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