

Naive (commonsense) geography and geobrowser usability after ten years of Google Earth

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Abstract. In 1995, the concept of ‘naïve geography’ was formally introduced as an area of cognitive geographic information science representing ‘the body of knowledge that people have about the surrounding geographic world’ and reflecting ‘the way people think and reason about geographic space and time, both consciously and subconsciously’. The need to incorporate such commonsense knowledge and reasoning into design of geospatial technologies was identified but faced challenges in formalizing these relationships and processes in software implementation. Ten years later, the Google Earth geobrowser was released, marking the beginning of a new era of open access to, and application of, geographic data and information in society. Fast-forward to today, and the opportunity presents itself to take stock of twenty years of naïve geography and a decade of the ubiquitous virtual globe. This paper introduces an ongoing research effort to explore the integration of naïve (or commonsense) geography concepts in the Google Earth geobrowser virtual globe and their possible impact on Google Earth’s usability, utility, and usefulness. A multi-phase methodology is described, combining usability reviews and usability testing with use-case scenarios involving the U.S.-Canadian Yellowstone to Yukon Initiative. Initial progress on a usability review combining cognitive walkthroughs and heuristics evaluation is presented.

1. Introduction

While there is near-universal acceptance today of geobrowser virtual globes as a viable method or technology, questions do exist with exactly how virtual globes contribute to the practices of geography, support multiple types of geographic representation, and enable users’ spatial thinking [1]. Human-Computer Interaction (HCI) research in geographic information science (GIScience) [2] provides one approach for evaluating the usability and utility of virtual globes to better assess their impacts in society.

Formally proposed in 1995, the human cognition oriented theory of naïve geography has been offered as a potential contributor to the increased usefulness of geospatial technologies. This paper introduces an ongoing research effort to explore the integration of naïve (or commonsense) geography concepts in the Google Earth geobrowser virtual globe and their impact on Google Earth’s usefulness.

2. Virtual globes and the Google Earth revolution

Virtual (or digital) globes are software applications that enable interaction with a 3D representation of a planet, integrating satellite and aerial imagery with terrain models and other reference and thematic geospatial datasets. Earth-based virtual globes are considered a subset of software applications collectively known as geobrowsers, which include all modern Web-based dynamic maps [3].

Today’s virtual globe technology “is the result of 3D software, virtual reality and hypermedia, and remote-sensing technology developments that have been ongoing since the 1970s” [3, p. 3023] Though first operationalized in the late 1990s, the technology was not widely known until the release



of Google Earth in 2005. Virtual globes are popular to a wide audience due to their low cost, high-quality imagery, and ease of use in data exploration and display [4, 5].

By far the world's most widely used virtual globe, Google Inc.'s Google Earth software application was released in June 2005 [6]. The application originally existed as Earthviewer 3D, developed and produced by Keyhole, Inc. from 2001 until Keyhole's acquisition by Google in 2004 [7].¹ Distribution and use of the newly rebranded virtual globe application increased greatly with the worldwide reach of Google. Within 15 months, Google Earth had been downloaded more than 100 million times [8] and within three years that number had increased to more than 400 million [3]. A 2006 Nature news feature described Google Earth's attractiveness for both casual users and science and technology specialists. For casual users "the appeal... is the ease with which you can zoom from space right down to the street level" while more savvy users view it as "an easy way into GIS software" [9, p. 776]. Over the last decade, Google Earth has been utilized in a wide variety of ways for research across both the physical and social sciences and humanities, [4,10,11] as well as in geographic education, [12,13] though its ability to improve spatial thinking ability by students and lay persons has been questioned [14,15].

3. Naïve geography

Many areas of cognitive research within GIScience reflect the discipline's interest in human-computer interaction [16]. Among these research foci is work with cognitive geo-ontologies including *naïve geography*. The theory of naïve geography was first formally put forth in 1995 by GIScientists Max Egenhofer and David Mark:

Naïve Geography is the body of knowledge that people have about the surrounding geographic world. Naïve Geography captures and reflects the way people think and reason about geographic space and time, both consciously and subconsciously. Naïve stands for instinctive or spontaneous. [17, p. 4]

Geographic space – "space beyond the human body and that may be represented by many different geometries at many different scales"- is a central concept in naïve geography. Humans conceptualize and operate within geographic space in many different ways. People continually apply naïve geographic reasoning "to infer information about their environment, how it evolves over time, and about the consequences of changing our locations in space" [17, p. 4].

From a GIScience perspective, developing formal models of naïve geographic reasoning holds potential for design of geographic information systems (GIS) and related computer technologies (including geobrowsers and virtual globes) which support human intuition, ease-of-use, and improved usefulness by a diverse range of users, from formally trained spatial scientists to everyday neogeographers. As a framework for formalization development, Egenhofer and Mark proposed an initial series of possible naïve geography elements [17,18].

A review of the geographic information systems design literature indicates that naïve geography's influence on geospatial technology design has been somewhat limited. Baik et al [19] developed a prototype naïve geography-based analyst system which visually integrated formal naïve geography representation structures with imagery data in an interactive 3D environment for geospatial intelligence purposes. Cartwright et al [20] employed naïve geography concepts in developing an interactive Web-based 3D application supporting community collaborative decision making in an urban planning context. Huang and Chuang explored commonsense geography and web technology in a community mapping context, noting that the gap identified by Egenhofer and Mark still exists "between what common people want to do with a GIS and the spatial concepts presented by the GIS" [21, p. 92]. As such, questions remain as to whether or not the human-oriented naïve geography perspective supporting multiple points of view is formally implementable without violating the

¹ The last version of EarthViewer 3D was Keyhole 2.2; consequently Google's first release of Google Earth on June 28, 2005 was labelled Google Earth 3.0.

geometric rules upon which geographic information systems and related computer technologies are based [22].

4. Assessing naïve geography aspects of Google Earth usefulness

Software system usefulness refers to a system's ability to achieve some desired goal [23]. Usefulness is determined in large part by an assessment of (a) utility - whether the system provides the features and functionality needed by the user, and (b) usability – how well users can apply that functionality (e.g., ease-of-use, functionality) [23].

In deviation from standard software engineering practice, early development of geobrowsers / virtual globes lacked a formal functional requirements study [24] and usability studies were fairly limited and narrow in scope [25]. Highlighting Google Earth, Goodchild [24] identified potential use cases for the virtual globes of the late 2000s, including visualization, ease of use, and data mashups, as well as the spatial concepts of geographic (spatial) context and spatial anomalies.

As Google Earth has evolved, it is apparent that the role of more deliberate and sophisticated software engineering and testing of the application has grown [26]. From its beginning, Google Earth developers have acknowledged the importance of fostering use by entry level users through commonsense design [27]. However, the degree to which this naïve geography design approach has been implemented has not been formally well studied.

4.1. Methods

A wide range of methods are available for evaluating the usability of an information system. This project's research design incorporates both usability review and usability testing techniques in a multi-phase approach to explore the integration of naïve geography concepts in the Google Earth user interface, and assess their impact, if any, on the application's utility and usability. Analysis is carried out in the setting of a real-world case study appropriate for evaluating the unique qualities of a virtual globe application as it relates to context-specific integration of naïve geography concepts - in this case, continental-scale wildlife conservation. Major steps in the research design include (1) case study selection, (2) internal usability review, and (3) domain expert usability testing. These three sequenced activities – completed, in progress and planned, respectively - are described in greater detail below.

4.1.1. Yellowstone to Yukon Case Study Selection (Completed). Selection of a case study was based on a number of factors. Primary was the availability of thematic information meeting the criteria for virtual globe data suitability or thematic “globe-worthiness”, including (a) freedom from distortion, (b) global availability of data, (c) interpretation of data despite highly generalized representation, and (d) capability of combination with other data sets [28]. A case with rich context in terms of range of decision making activities and diverse user groups (i.e., participants, stakeholders) was also desirable.

The research underway involves a case-study environment focused on geospatial-based science, management, and outreach activities associated with the Yellowstone to Yukon Conservation Initiative (Y2Y)[29]. First conceived in 1993, Y2Y is a joint U.S.-Canadian non-governmental organization whose mission is to protect and connect wildlife habitat from the mid-Rocky Mountains to the Canadian northwest region. The Y2Y encompasses approximately 1.3 million square kilometers, spanning five U.S. states, two Canadian provinces, and two Canadian territories. Its length is approximately 3,200 kilometers, while its width varies from 500 to 800 kilometers (Figure 1).

The Y2Y and associated available data products meet all four criteria for “globe-worthiness” cited above. While encompassing a near-continental geographic scale, some of the Y2Y's project management issues may also be examined at the terrain and local scale supported by Google Earth.

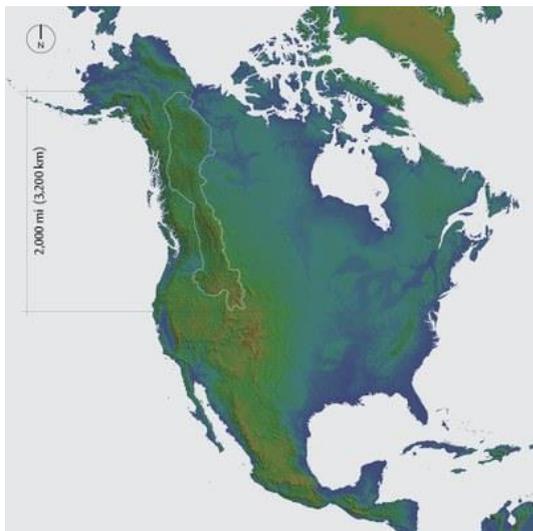


Figure 1: Approximate boundary of the Yellowstone to Yukon conservation region (outlined in white), extending from the northern Yukon and Northwest Territories, Canada to the Central Rocky Mountains in western Wyoming, USA.

4.1.2. Phase One Usability Review (In Progress). Usability reviews provide a structured means of examining the usability of an interactive system by evaluating it against a set of recognized best practice principles. Usability reviews can be either scenario-based or heuristic-based. The former evaluate a system against possible user scenarios, while the latter evaluate a system against a set of established best practices (or concepts), however, they are often used in combination [30]. This project's phase one usability review involves conducting a scenario-based review in the form of a cognitive walkthrough, to be followed by a heuristic-based assessment using a customized, context-specific usability scorecard.

A *cognitive walkthrough* [31] is a usability inspection method [32] that tests how well an information system supports a common user task in the form of a scenario. The first of two steps in the cognitive walkthrough involved defining a set of user scenarios to represent a range of situations where users execute common and important tasks. Three issue-specific scenarios were initially defined by the project team for the Y2Y case. Respectively, they involved the use of Google Earth for communication and understanding of (a) bioregion-scale connectivity (e.g., grizzly bear habitat across the Y2Y region); (b) watershed hierarchy and associated management issues (e.g., land-use impacts on water quality in designated wild and scenic stream); and (c) landscape-scale spatial and temporal barriers to animal movement (e.g., seasonal pronghorn migration between winter and summer ranges). For each scenario, user characteristics (who?), anticipated functional tasks (what?) and user objectives (why?) were defined. Select naïve geography elements proposed by Egenhofer and Mark [17] were then matched to each scenario. In addition, several concepts were identified as applicable in all of the scenarios (Table 1).

The second of two steps in the cognitive walkthrough (currently underway) involves identifying and stepping through three specific workflows representative of the individual scenarios. For example, the workflow for the grizzly bear habitat connectivity scenario is centred on the question of displaying and quantifying bear habitat in relation to various land management jurisdictions, along with topography and elevation, and vegetation types. The project team is identifying the anticipated steps necessary to carry this out in Google Earth, assessing if the user (i.e., a Y2Y stakeholder participant) will “know what to do”, “see how to do it” and “know whether their action is correct” [30]. Workflow documentation includes capture of a separate screenshot for each identified step combined with annotation of project team responses to each of the three questions above.

Scenario	User Characteristics	Functional Tasks	User Objectives	Naïve Geography Elements
Grizzly bear habitat connectivity (ecoregion)	NGO representatives; elected officials; basic technology fluency	Layering, querying similarity, measuring areal extent	Understand spatial extent, area representation, spatial connectivity	<ul style="list-style-type: none"> ▪ Maps are more real than experience
Land use - water quality impacts (watershed)	Local resource specialists, county planners, landowners, NGO representatives; basic technology fluency	Measuring distance, measuring direction, constructing gradients, aggregating, forming hierarchies, assessing proximity	Understand basic hydrologic processes, associating spatially distributed phenomena	<ul style="list-style-type: none"> ▪ First Law of Geography, ▪ Geographic information is frequently incomplete
Seasonal pronghorn migration (mountain range)	State and federal resource specialists, transportation engineers, NGO representatives; basic technology fluency	Measuring distance, measuring direction, constructing gradients and surfaces,	Understand spatio-temporal relationships, cost-surfaces, spatial connectivity	<ul style="list-style-type: none"> ▪ Geographic space and time are tightly coupled ▪ Distances are asymmetric
Naïve geography elements assessed across scenarios: <ul style="list-style-type: none"> ▪ People use multiple conceptualizations of geographic space ▪ Geographic space has multiple levels of detail ▪ People have biases toward north-south and east-west directions 				

Table 1: Y2Y Google Earth Cognitive Walkthrough Usability Review Scenarios

Following completion of the cognitive walkthrough, a heuristic-based evaluation will be conducted to complete the Phase One usability review. Whereas a cognitive walkthrough is more oriented to specific tasks, *heuristic evaluation* is a usability inspection method designed to more holistically identify usability issues in an application's user interface. While a number of usability heuristic variables have been published (Jakob Nielsen's [23] being the most widely recognized), a customized heuristics evaluation instrument is currently being developed which will combine the usability aspects of the Reeves and Harmon User Interface Rating Tool for Interactive Multimedia [33] with generic usability metrics centred on navigation, feedback and search that could link to commonsense cognitive mapping processes. In particular, the Reeves and Harmon instrument is being considered because of its emphasis on assessing visually dynamic interfaces and its prior use with geospatial applications, including naïve geography concept assessment [20]. Once finalized, the heuristic evaluation will be completed internally by members of the project team and will also be administered to a sample of scientists and resource managers working actively in the specific domains associated with the Y2Y use-case scenarios defined above.

4.1.3. Phase Two Usability Testing (Planned). In contrast to the usability review method described above – where an expert evaluator inspects a user interface without involving users, *usability testing* involves observing and evaluating how actual users of a software application directly interact with the system while engaging in specifically defined tasks of interest to the evaluators [23]. Usability testing processes typically involve systematic observation under controlled conditions. Though more involved than usability reviews in terms of time and resources required for execution and analysis, usability testing is potentially more effective in gaining understanding of actual user interactions with a system [34].

In the second phase of the project, usability testing will be conducted with actual Y2Y Google Earth users. Testing will examine user performance in carrying out specific tasks associated with the three scenarios described in Table 1 to better assess the influence of commonsense processes on execution time, accuracy, and user satisfaction. Comparison will be made between proficient users,

untrained professionals, and citizen stakeholders. Given the distributed nature of the user population, a moderated remote usability testing approach will be employed [35].

Figure 2 illustrates one draft version of on-screen specifications for a Y2Y usability test in Google Earth. In addition to direct observation of users' completion of pre-defined activities in Google Earth, it is anticipated that a questionnaire and small sample of semi-structured interviews will also be administered to more comprehensively assess perceptions of users about naïve geography linkages in the application.

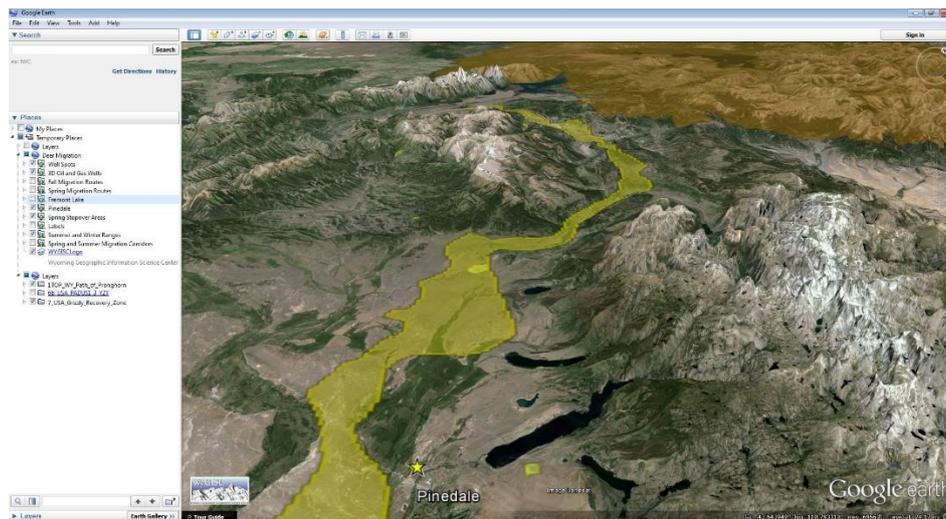


Figure 2: Mock-up of possible usability testing scenario involving Pronghorn migration dynamics in northwestern Wyoming, in the southern reaches of the Y2Y region.

4.2. Current Progress

At this time, a case study selection involving the Yellowstone to Yukon Initiative has been finalized, and work is on-going in the cognitive walkthrough component of the project's Phase One usability review. A challenge currently being addressed is whether or not the necessary level of expertise to recognize and apply the full functionality of Google Earth exists within the project team for carrying out a valid usability review, and if the necessary knowledge of realistic workflows undertaken by Y2Y scientists, managers and other stakeholders can be attained to accurately develop appropriate usability test scenarios. Both issues - reflective of a situation called the "evaluator effect" [36] - can lead to inconsistencies in usability research results. Although not something that can be completely eliminated, one strategy to minimize these concerns is to increase the number of experts involved in usability evaluations, and involve members of the targeted user community of interest in pre-testing scenario design.

The question also remains as to whether or not a usability-centred research design will ultimately be effective in assessing the degree to which naïve geography concepts are embedded in Google Earth and furthermore, how they might impact spatial thinking among Google Earth users. It is hoped that initial usability testing results will provide timely insight allowing for adjustments to research design methodology if necessary.

5. Summary

This paper has introduced an ongoing effort to adapt usability inspection and testing methods to explore the possible integration of cognitive geo-ontology principles in virtual globe software applications. "...one of cognitive GIScience's greatest challenges as an applied discipline [is] to clarify its value in the design and use of geographic information technologies" [16, p. 1836]. While this project seeks to identify and assess the role of naïve (commonsense) geography concepts in a

specific application of the Google Earth interface, full integration of true naïve geography concepts may not yet be attainable, especially given the constraints of existing representation formalizations [22]. It should also be noted that integrating naïve geography concepts into geospatial technology design may also carry with it a range of risks, including reductive bias, functional dissonance, and lessened user control [37]. Given these challenges, the Y2Y usability case will require sustained, longitudinal engagement in order to result in sufficiently transferrable findings that inform the design of the next generation of virtual globes.

6. References

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7. Acknowledgements

Thank you to the Yellowstone to Yukon Conservation Initiative (Wendy Francis, Interim President) for sharing Y2Y management unit and conservation lands data. Thanks also to Robert Kirkwood, Wyoming Geographic Information Science Center, for assistance with data formatting. Anonymous reviewer feedback and the guidance of ISDE Proceedings co-editor Dr. Danika van Proosdij improved the overall quality of the manuscript.