A Comparison of Methods for Evaluating Cartographic Interfaces

Cartographic interfaces such as interactive mapping software, web map mashups, and advanced geovisualization/geovisual analytics applications are growing in their importance and ubiquity. As the employment of such tools to solve scientific and practical problems increases, so too must the time and resources allocated for ensuring these tools 'work'. ***Cartographic interface evaluation*** describes any approach to identifying and explicating usability or utility issues of a map-based application, to the end of improving it. This research unifies work in the domains of human-computer interaction (HCI), usability engineering, and GIScience to develop an initial framework for conceptualizing cartographic interface evaluation. The objectives of this research are threefold: (1) classify interface evaluation methods according to similarity, (2) enumerate the benefits and limitations of each method or class of methods, and (3) describe how each method or class of methods should be modified to evaluate interfaces that are explicitly cartographic.

Scenario-based Design

Scenario-based design makes the expected uses of an interface explicit through the description of a scenario, or story consisting of a problem setting, the interfaces available in the setting, and personas of the expected users of the interfaces.

Good when a work domain analysis cannot be completed due to limited resources or poor user accessibility, when actual use scenarios are well known or validated through user studies, when the interface needs to support a diverse set of users or objectives, when expert- or user-based studies relying on tasks are conducted at later stages in design/development, when the project team is large

Poor when little is known about the users, when the scenarios are not validated with user-based studies, when the scenarios are overly simplistic or include only a subset of the complete set of potential users or objectives, when an interface is in the final stages of development.

Tip for Cartography: Background knowledge in Geography is important for good scenario-based design, as the designers/developers need to understand the geographic phenomena represented in the interactive map when drafting the hypothetical scenario.

(2) Theory-based Methods

Theory-based methods require the interface designers and developers to evaluate the cartographic interface themselves by applying theoretical frameworks and guidelines established through scientific research.

Automated Evaluation

With automated evaluation, usability and utility measures are generated programmatically by applying specialized computer algorithms

Good when the goal is to improve and stablize source code, when long-term interface support is needed after deployment, when the fully-featured interface serves a large user community, when resources are limited to complete multiple rounds of user-based studies.

Poor when the interface is unique or novel, when the the usability measures for a specific type of application are poorly established, when the interface is simple and includes only several features.

Tip for Cartography: When the cartographic interface is designed for use by a diverse set of users, automated evaluation can be used to initiate changes in the interface according to past use; simple examples of such adaptive interfaces include ranking of items by 'most viewed' or adjusting default tool parameters according to the most frequent selections.

Secondary Sources

A secondary source is any piece of information not collected by the party using the information, and includes text documents, maps/images, and software applications.

Good when the designers/developers know little about the application domain, when a user-based work domain analysis cannot be completed, at the formative stage of design and development, when there are a large number of competing applications that implement similar functionality, when there were multiple previous versions of the interface.

Poor when the interface is designed to support a wide variety of application domains, when the interface is the first of its kind and has few extant parallels for comparison, when a robust work domain analysis already was completed, when at the final stages of development.

Tip for Cartography: Secondary sources are useful for understanding what types of questions or tasks should be included in future user-based studies (particularly for an initial work domain analysis).

Method Classification

The table below summarizes the reviewed methods; details about each method are provided in the marginalia.

	Method	Similar or Related Methods
Expert-based	**heuristic evaluation**	*rules of thumb*
	conformity inspection	*feature inspection, consistency inspection, standards inspection, guideline checklist*
	cognitive walkthroughs	*pluralistic walkthroughs, prototyping, storyboarding, Wizard of Oz*
Theory-based	**scenario-based design**	*personas, scenarios of use, use case, context of use, theatre*
	secondary sources	*content analysis, competitive analysis*
	automated evaluation	*automated interaction logs, unmoderated user-based methods*
User-based	**participant observation**	*ethnographies, field observation, MILCs, journal/diary sessions, screenshot captures*
	surveys	*questionnaires, entry/exit surveys, blind voting, cognitive workload assessment*
	interviews	*structured interviews, semi-structured interviews, unstructured interviews, contextual inquiry*
	focus groups	*supportive evaluation*
	Delphi	
	card sorting	*Q methodology, concept mapping, affinity diagramming, brainstorming*
	talk/think aloud	*verbal protocol analysis, co-discovery study*
	interaction study	*performance measurement, controlled experiments*

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The poster is available for download and educational use at http://www.personal.psu.edu/rer198/Roth_ICC2011.pdf.

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Cognitive Walkthroughs

A cognitive walkthrough is the most 'hands-on' of the expert-based methods, as the expert must assume the role of the user and complete a set of tasks in the anticipated way that the user would perform them.

Good when the characteristics/behaviors of the targeted end users are well understood, when the expert has a great deal of experience working with users, when there is not enough time to study users firsthand, when the tasks included in the walkthrough represent real-world work objectives well, when multiple steps must be completed in order to use the interface, when only paper mockups are available.

Poor when experts are not familiar with the user group, when the tasks are ill-defined, open-ended, or have multiple solutions, when the research design is not informed by a study with users.

Tip for Cartography: It may be best to include experts and users together (i.e., a pluralistic walkthrough), as interactive map use often is exploratory and open-ended, making it difficult for experts to predict suboptimal interaction strategies on their own.

(1) Expert-based Methods

Expert-based methods solicit input and feedback about a cartographic interface from consultants with training and experience in cartographic interface design and evaluation.

Conformity Assessment

Conformity assessment requires experts to determine if the interface passes a set of requirements, such as a pre-determined feature list, design standards and conventions, or in-house specifications.

Good when there are multiple components of an interface requiring the same look/feel, when different teams of designers are working on different components of the application, when there are established design standards and conventions, when a work domain analysis has been completed.

Poor when the evaluation goal is to brainstorm potential usability issues rather than ensure the interface meets certain requirements, when the project consists of only several people working together closely, when there is little or no precedent on how a novel interface should look and behave.

Tip for Cartography: While there are few cartographic interface design standards, the Open Geospatial Consortium (OGC) has developed several guidelines and standards for the use and dissemination of geographic information.

Heuristic Evaluation

Heuristic evaluation requires experts to summarize potential usability and utility issues with an interface according to a pre-determined set of heuristics, or well-accepted cartographic interface design principles.

Good when input/feedback is needed quickly, when only a small set of experts are available, when used for several rounds of expert evaluation, when designers/developers are interested in uncovering a broad range of interface issues.

Poor when expert consultants are unavailable or expensive, when the experts are part of the project team, when targeting a specific kind of interface problem, when one or more of the heuristics is not relevant to the goals of interface evaluation, when there is excessive subjectivity in interpreting the heuristics.

Tip for Cartography: It is important that the experts performing the heuristic evaluation have experience in both Interactive Cartography and Usability Engineering; such restrictions may prohibitively narrow the pool of available experts.

Classifying Methods by Evaluator

An informal content analysis, or systematic background review, was conducted on secondary sources (academic manuscripts and popular websites) about interface evaluation found in the domains of HCI, usability engineering, and GIScience. First, comparison was made across extant classifications of interface evaluation methods, and members of each recommended category. Second, HCI and usability engineering literature was analyzed to identify the benefits and limitations for each identified method and the GIScience literature was analyzed to identify any modifications to the method that were recommended for application to cartographic interfaces.

Although many scholars organize interface evaluation methods by the project stage (e.g., before design, during development, after deployment), the analysis revealed a potentially more logical classification by ***interface evaluator***, or the type of person providing input and feedback about the cartographic interface. Sources of feedback include: ***(1) experts***, ***(2) theory,*** and ***(3) users***. Such a distinction is useful for ***user-centered design***—the recommended approach to cartographic interface design—as user-based and non-user-based methods are distinguished clearly.

Participant Observation

In participant observation, evaluators watch users interact with the interface during their daily work in order to generated an ethnography, or comprehensive narrative of the way in which the interface is used in practice.

Good when evaluators have excellent access to users, when evaluators want to build a strong connection with a particular set of users, when information is needed about how users currently work, when the project is large with design/development spanning multiple years, when the interface or a previous version of the interface already is in used.

Poor when access to users is limited, when users are diverse in their characteristics or application domain, when users are dispersed geographically, when feedback is needed quickly, when the interface is simple or supports few tasks.

Tip for Cartography: Participant observation may not be an efficient use of resources, as cartographic interfaces are often a single step in a larger workflow that includes many, non-cartographic applications.

Surveys

The survey method requires participants to respond to a series of predetermined, typically structured questions with no investigator interaction.

Good when input is required from a large number of diverse users, when characteristics of the targeted audience are not fully known, when the investigators cannot be present physically to adminster the evaluation, when the participants have very little time to provide feedback.

Poor when important design decisions are based soley upon the results, when the investigators are unfamiliar with the user objectives or expectations and therefore do not know what questions to ask, when access to end users is limited, when users are asked to recall experiences or usage strategies from a significant amount of time prior to taking the survey.

Tip for Cartography: Surveys for cartographic interface evaluation should include questions specific to both cartographic representation (i.e., the design of the maps themselves) and cartographic interaction.

Interviews

An interview is a purposeful conversation between the evaluator and user in which the user answers a series of structured and unstructured questions.

Good when the user needs and expectations are poorly known, when the software supports a small number of highly-specialized users or stakeholders, when transitioning an interface to a new application domain.

Poor when the participants are not representative of the target users, when the user group is diverse, when investigators have limited time to perform the evaluation and analyze the results.

Tip for Cartography: The interviews may benefit from having users provide map examples from discussion during the interviews or from having participants demonstrate their software to clarify the interview discussion.

Focus Groups

The focus group is the multi-person equivalent to the interview, where a group of targeted end users (3-10) discuss topics posed by a session moderator.

Good when the user needs and expectations are poorly known, when investigators have access to a intermediate number of users and stakeholders (more than required for interviews, but much less than required for surveys), when the focus of summative evaluation is user satisfaction, when the investigators do not have time to complete interviews.

Poor when access to users is limited, when users are diverse in their characteristics or application domain, when users are dispersed geographically, when feedback is needed quickly, when the interface is simple or supports few tasks.

Tip for Cartography: Focus groups may benefit from including a mixture of map mapmakers and map users in each session.

(3) User-based Methods

User-based methods solicit input and feedback about a cartographic interface from a representative sample of targeted end users; administration of user-based methods is fundamental to a user-centered design approach and the only way to ensure success of the cartographic interface.

Delphi

The Delphi method is a distributed approach to focus groups that collects multiple rounds of anonymous feedback, with moderator summaries distributed between rounds.

Good when the interfaces and the problems they support are extremely complex, when the users are geographically dispersed or the feedback needs to be collected online, when the superiors of one or more users also are included in the group communication.

Poor when the feedback is required quickly, when there is not a team member available to moderate the sessions, when users have little personal investment in the tool (as there may be a high drop out rate over time).

Tip for Cartography: It may be useful to anchor the discussion threads to an interactive map using asynchronous/different-place geocollaboration and geodeliberation techniques.

Card Sorting

Card sorting is an activity in which participants group a given set of items, or cards, according to their similarity.

Good when there are a large set of functions included in the interface (between 30-200) or these functions include a large set of parameters, when the optimal categorization or structure is not currently known, when an existing categorization resulted in usability issues and needs to be revised, when the interface requires a large amount of navigation among multiple pages or menus.

Poor when the set of items is small (less than 30) or extremely large (200+), when the goal is to refine a single feature in the interface, when users can customize the layout/organization of the interface.

Tip for Cartography: The card sorting technique is particularly promising for hierarchically grouping feature types and associated map symbols in an expandable, interactive legend.

Talk-Aloud & Think Aloud

In this method, users are guided through a series of benchmark tasks by a session moderator and instructed to describe verbally either what they are doing (talk aloud) or what they are thinking (think aloud).

Good when evaluators are interested in identifying a broad range of usability issues, when feedback is required quickly on only the most important problems, when project resources are limited, when there are multiple ways to complete the same objective.

Poor when the tasks the interface should support are poorly known, when the participants are not representative of the target audience, when each task requires a large amount of time to complete, when evaluators are more interested in utility than usability, when participants are already familiar with the interface.

Tip for Cartography: Because most people interact with maps in an unstructured way, it is important that the task protocol includes both close-ended, simple tasks with a 'right answer' as well as open-ended, exploratory tasks that may lead to divergent solutions.

Interaction Study

Interaction studies require users to complete a set of benchmark tasks with the interface in a controlled setting while their interactions are captured in an interaction log.

Good when the project spans multiple years and includes iterative rounds of interaction studies, when the kind of interface evaluated has an established optimal score in the applied performance measures, when evaluators are interested both in expanding the understanding of interactive cartography broadly as well as improving the cartographic interface specifically.

Poor when user objectives are not known, when time and resources are lacking to collect and analyze the copious interaction logs, when the performance measures poorly support the evaluation goals, when evaluators are interested in capturing subjective satisfaction.

Tip for Cartography: In addition to the interaction log, information about the user's eye movements also can be captured during an interaction study.