Promoting Repeatable Research and Collaboration – The Benefits of a Driving Simulation Wiki

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Driving simulation users face a daunting range of simulation platforms, scenarios, and measures that make it difficult to replicate and compare studies across institutions. Furthermore, the complexity of configuring a simulator, developing protocols for data collection, and managing the resulting data consumes many hours of researchers' time. These issues could be addressed using tools that enable closer collaboration and better knowledge management. We describe an internet-based resource for driving simulator users that promotes collaboration and resource sharing. Specifically, wiki technology, as demonstrated in the Wikipedia (http://en.wikipedia.org/wiki/Wiki), enables many users to share information and develop ideas rapidly and with relative ease. A wiki supports continuous cooperative evolution of ideas and knowledge from many authors, thereby creating a resource that is more comprehensive than that generated by an individual or group operating a conventional website. Specific resources available on the driving simulation wiki (http://www.drivingwiki.org) include specifications for commonly used scenarios, definitions and data reduction code for commonly used performance measures, and guidance for addressing common challenges, such as simulator sickness. Such resources make it possible to address the same issue with different populations and with simulators of differing levels of fidelity. This paper also discusses the challenges

in creating a sustainable community needed to support an effective driving simulation wiki and in ensuring content quality of a research-focused wiki.

Collaboration represents an iterative process between multiple people contributing to a common goal or intellectual endeavor (http://en.wikipedia.org/wiki/Wiki). Increasingly, scientific research depends on a distributed network of collaborators from different disciplines, universities, or research centers. Such collaboration often fails to achieve expectations because distance compounds interdisciplinary communication challenges. Consequently, distributed groups of interdisciplinary researchers need methods that enable effective information exchange and knowledge management.

Driving simulation represents an interdisciplinary research area that could benefit from improved collaboration. Driving simulator researchers confront a daunting range of simulation platforms, scenarios, and outcome measures. Often researchers must confront these challenges in isolation, sharing information and frustration with a small network of collaborators through direct conversations or email. More infrequently researchers share their experiences at conferences and in journals. This relative isolation leads to several problems. First, researchers devote considerable effort to simulator configuration, scenario development, and data reduction – issues that many other researchers have faced multiple times in the past. This redundant effort draws time away from productive research. Second, the complexity of driving simulation research and the limits of current venues for communicating the details of a study makes it difficult to replicate and compare studies. The page restrictions of conference papers and even journal articles make it impossible to completely describe the simulator, scenarios, or data reduction algorithms. Tools that enable closer collaboration and better knowledge management can reduce the isolation that many driving simulator researchers face and increase the pace and quality of research.

High frequency, high quality, and low cost communication facilitate the development of ideas, the execution of collaborative tasks and the likelihood and longevity of collaborative efforts (Kraut & Egido, 1988). Well-established mediums have begun to fulfill these communication requirements such as email, websites, and electronic publishing. Several websites have been developed to support simulator research. One cataloged standard scenarios (http://www.engineering.uiowa.edu/simusers); however, there was no easy method for people to update scenarios or add new scenarios to this website. These technologies enhance information distribution and idea development but leave important gaps in supporting collaboration. Wikis have recently begun to fill these gaps by providing a platform for collective authorship of shared resources.

Wiki technology is a tool for collaborative work designed by Ward Cunningham in 1995 (Cunningham & Leuf, 2001; Guzdial, Rick, & Kehoe, 2001) that supports interaction and communication among multiple, geographically dispersed individuals. Wikis are web-based documents that anyone can edit. Unlike traditional methods of communication, wikis promote a community of collaboration. Multiple users can edit and create information in an iterative process with other community members. This dynamic process – real-time refinement of knowledge – allows for accurate and timely information dispersion. Because wikis do not require a central organization to compile and edit contributions, they offer a low-cost way of collaborating. Wikis can produce contributions of a quality similar to those in standard print archives, such as

encyclopedias, because a community of researchers reviews and refines the contents (Emigh & Herring, 2005). Compared to email, a wiki eliminates data limitation, distribution, and attachment constraint problems, offers a centralized repository of information accessible from any location, and reduces redundant information (Emigh & Herring, 2005). These benefits suggest that wikis may be particularly useful for diverse communities, such as driving simulation researchers. This paper explores the benefits of a wiki designed to support driving simulator researchers.

How a wiki helps fulfill the collaboration needs of the driving simulation community

Driving simulator researchers confront a variety of challenges that a wiki can address. These range from relatively simple concerns such as easier access to commonly used rating scales (e.g., NASA TLX) and strategies to reduce simulator sickness, to more substantive issues such as specifications of commonly used scenarios and measures. More generally, the value of driving simulators has not been maximized because people with simulator problems lack a connection to the community with the expertise to solve those problems. A wiki can bridge that gap by bringing together examples of simulator applications. A wiki can support driving simulator researchers by providing:

- Commonly used subjective rating scales for workload (Hart & Staveland, 1988), trust (Lee & Moray, 1994), and safety system acceptance (Van der Laan, Heino, & De Waard, 1997)
- Links to critical papers on driving and simulator use, essentially an online library of simulator literature that is filtered by the community to highlight the highest quality papers
- Definitions, examples, and algorithms for calculating common dependent measures
- Summaries of key research areas within driving simulation (e.g., driver distraction, simulator sickness, in-vehicle information systems)
- Standardized scenarios that can then be tailored to particular research questions such as driver distraction, age-related impairments, and imperfect automation
- List of recently published papers
- A complement for more traditional forms of publication that eliminates publication lags and increases the number of reviews by multiple domain experts
- An evolving documentation of commonly used simulators to help users address programming and operations problems
- An archive of simulator data to support cross-platform comparisons and meta analyses

Proposed structure of driving simulator wiki

A wiki can provide an interactive means to share knowledge on simulation research and methods that goes beyond a static website. Further, a wiki with different levels of access would provide a structure for tailoring information to the categories of users that would access the site. One way to think of a wiki for driving simulator research is as an on-line handbook that also includes a repository of software tools to support driving simulation such as descriptions of common scenarios and associated simulator code, data reduction techniques and associated matlab algorithms.

An important consideration in defining a wiki concerns the information needs of different groups of users. Three potential types of users and their corresponding information needs include:

- Individual research laboratory members – information is largely project-specific, relating to issues such as equipment and laboratory procedures.
- Researchers within a university community – information is structured around research areas and simulator methodology.
- International driving simulation research community – information is structured around a need for information sources that provide a broader understanding of research efforts and issues.

Overall, as the user population widens the information requirements move from the specific to the general and discussion formats become more appropriate. These levels of collaboration reflect qualitatively different types of information that need to be shared and restrictions on the sharing of information that must be respected. The specific needs of each user population are described below.

Individual research laboratory

Individual research laboratories that use driving simulators encounter project-specific issues such as data storage and archiving, protocol training, project management (e.g., participant forms, video tape catalogs), maintenance of data reduction and simulator code libraries, and participant questionnaires. Another concern represents the need for data sensitivity as a result of the constraints ethics boards and proprietary contracts impose. The specific needs of an individual driving simulation research laboratory include:

- Database of archived documents (e.g., presentations, posters, publications)
- Equipment schematics, set-up and troubleshooting guides (e.g., simulator, eye tracker)
- Standard scripts for operating a particular simulator
- Data archives and associated analysis code and documentation
- IRB forms and documentation

Housing the listed individual laboratory information on a wiki would allow users to access and revise information from any location (Lipnack & Stamps, 1997). For the Cognitive Systems Laboratory at The University of Iowa, this information is currently contained on a protected network with limited access in which laboratory members spend significant time transferring data collected from remote locations to the secured network, managing multiple versions of documents, and archiving dated data. A wiki would eliminate the communication cost of these tasks, thus freeing time for collaboration on data interpretation rather than on data storage and management. A wiki with the listed items would also reduce training time required for new members, who must learn to implement and troubleshoot simulator equipment, use scripting and coding languages for scenario creation and data reduction and analysis, and also develop procedures for submitting IRB forms. Wiki designs that support restricted access of the information to the users within the laboratory would address the issue of data sensitivity.

University community
The specific needs of driving simulation researchers within a university community include:

- Scenario development tool, downloadable version
- Driver model within scenario development tool
- Discussion forum for simulator troubleshooting
- Brief summary of studies being conducted in simulators for each laboratory

International driving simulation community
The specific needs of the international driving simulation research community include:
Research areas

- Summary of key research areas within simulator community with links to domain experts and key papers

Research process / simulation development

- Database of downloadable documents (e.g., questionnaires)
- Standard scenarios with associated scripts for HyperDrive or other simulators

Research methods

- Definitions, examples, and algorithms for calculating common dependent measures
- Secondary task (e.g., Email VB) programs
- Simulator data archives

Researcher profiles

- Laboratory and individual member bios, including areas of interest/specialization, and past and ongoing projects
- Descriptions of individual laboratory simulator configurations

Contribution and collaboration tools

- Discussion forum for simulator laboratories
- Article discussion forum
- Postings for collaborations and job opportunities
- Simulator users group (SUG) meeting information, such as summaries of past SUG meetings and upcoming ones
- Highlights of generally interesting content, such as the most frequently read pages; the most frequently altered pages; who is making the most contributions; the most recommended papers

Publications

- Publication list of studies that have included standard scenarios
- Recommended simulator reading(s)
- List of recently published papers

The resources at the university and world levels provide for standardization of scenarios and of protocols, thus making it possible to address the same research issues with different populations and with simulators of different levels of fidelity. This standardized information and the discussion forums would allow researchers to build on collective knowledge of simulator and scenario configuration and data collection to work to extend the domain knowledge. This wiki for interdisciplinary communication eliminates distance constraints because researchers can create and edit content from any geographic

location, thus providing for e-proximity amongst researchers. Such a feature is particularly important as studies show that proximity is a primary determinant of successful, productive collaborations (Kraut & Egido, 1988).

The three-tiered access structure of the driving simulation wiki (http://www.drivingwiki.org) conflicts somewhat with the completely open philosophy of wikis. The typical implementation of wikis assumes a completely open structure that anyone can edit and read. Recent commercial applications of wikis show that different domains require different structures, which must consider information structure in its influence on collaborative work.

Challenges for wikis and collaboration

Wiki technology has a very limited history and its potential to support driving simulator users remains untested. A general challenge with wikis concerns the effort required for authors to contribute information and for users to extract information; it is important to minimize effort and to maximize benefits. Success of a wiki depends on the perceived utility of the provided information and if users view it as part of a suite of everyday communication tools (McAfee & Sjornan, 2006); the relevance, quality and extent of information provided in the initially populated site plays an important role in the success of the wiki. Because wikis are social software, ideas are more transparent and as such may present a risk to people who need to protect their ideas for proprietary reasons. The culture of collaboration in the particular community also determines how well-received a wiki is (i.e., the amount and frequencies of entries and edits; Pfeil, Zaphiris, & Ang, 2006).

Additional risks of wikis include inaccuracy of information, biasing motives of article contributors (e.g., political, opportunistic, vandalizing), uncertain or inadequate expertise of contributors, volatile content that undermines a particular citation, a biased self-selected set of contributors, an unrepresentative set of topics, and a lack of independent non-Internet sources (Denning, Horning, Parnas, & Weinstein, 2005). Several concerns focus on quality associated with collaborative editing (Dondio, Barrett, Weber, & Seigneur, 2006). These concerns affect the ability to create a sustainable community needed to support an effective driving simulation wiki. If users do not trust the information provided in the wiki, they are unlikely to use the tool. An example of the importance of trustworthy information is described in Dondio et al. (2006). They evaluated 8,000 articles within Wikipedia that comprised 65% of the editing activity. Trust in article content was higher for featured articles (i.e., special articles considered the best of Wikipedia; these are listed under a category entitled “Featured articles”) than standard articles. Thus, level of trust is likely to influence editing behavior.

Authoritative cross-referencing, an initial application-specific structure, and access levels may address some of the concerns. Management and filtering of information through editors can also ensure accurate, consistent information. Wikipedia.org relies on contributors to help with editing and assigns administrative capabilities to contributors who demonstrate trustworthy behavior and high-quality edits and entries. Scholarpedia (http://www.scholarpedia.org), a wiki that is authored and edited by invited or peer-

selected experts, enforces quality-control through an index that assigns rights and privileges to users based on reviewer contribution and dedication to the site, and assigns curators to manage the content and quality of each article. In addition to the levels of access, it might be useful to impose this type of top-down control – contribution-based provision of authoring rights and/or topic management by an editorial board – to some subset of the driving simulation wiki to ensure accurate content, particularly for pages that require specific domain expertise or that are volatile.

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