GeoCollaborative Crisis Management: Designing Technologies to Meet Real-World Needs

Alan M. MacEachren [1+2], Guoray Cai [1+3], Michael McNeese [1+3], Rajeev Sharma [1,4+5], Sven Fuhrmann [6]
[1] GeoVISTA Center, Penn State University, University Park, PA 16802
[2] Department of Geography, Penn State University, University Park, PA 16802
[3] College of Information Sciences & Technology, Penn State University, University Park, PA 16802
[4] Dept. of Computer Science & Engineering, Penn State University, University Park, PA 16802
[5] VideoMining, Inc. State College PA
[5] Dept. of Geography, Texas State University, San Marcos, TX
{maceachren, gxc26, mdm25, rxs51}@psu.edu

ABSTRACT

Preventing, preparing for, responding to, and recovering from natural and human-induced disasters all require access to geographically referenced information and tools for making available information relevant to the tasks at hand. Goals of the research summarized here are to advance our scientific understanding of how groups (or groups of groups) work with geospatial information and technologies in crisis management and to use that understanding to guide development of tools that are intuitive for non-specialist users and that enable coordination within and across crisis management teams. This overview highlights progress on: understanding work in crisis management, enabling distributed information access through context-mediated geo-semantic interoperability, extension of natural, multimodal interface methods to mobile devices, development of a collaborative map-based web portal to support international humanitarian relief logistics, and technology transition into real-world practice. We also introduce our new DHS-supported Regional Visualization & Analytics Center, which builds directly upon our GCCM work.

Keywords

Multimodal Interfaces, Knowledge Elicitation, Human-Centered Design, GeoCollaboration, GIS, Crisis Management.

1. INTRODUCTION

The challenges faced by government and other organizations charged with responsibility for crisis management is immense. Information technology is fundamental in efforts to assess vulnerabilities, prevent undesirable events, minimize event impacts, and enable rapid recovery. Geographically referenced information and supporting technologies are central to many crisis management tasks and have been used effectively at all scales (from local ambulance dispatch, through response to major terrorist actions, to regional scale response such as that for hurricane Katrina).

Current geospatial information technologies (GITs) create the potential to integrate diverse information quickly; however, the technologies remain hard to use and ill-suited to group work. Impediments to wide-spread, real-world use include overly complex interfaces, limited support for analytical reasoning and decision-making, and for coordinated team work. Underlying these functional limitations are major gaps in understanding of how these technologies facilitate or impede individual and group work.

As outlined previously [1], our research addresses two overarching issues: (1) the understanding of GIT-based individual and group work in crisis situations and (2) the development of GIT that enables coordinated same-place and distributed crisis management activities. More specifically, our focus is on: (a) understanding cognitive readiness in real world geo-collaborative activity; (b) testing theories of cognitive readiness within team simulation environments; (c) understanding technology enabled group work; (d) developing natural, easy to use, multimodal interfaces to geospatial information technology, and (e) developing Computer Supported Collaborative Work Systems (CSCW) that use shared visual displays to mediate discussion of site situation, and action for crisis management.

2. ACCOMPLISHMENTS

During the past year, progress has been made on fundamental science questions as well as on technology implementation and its transition to real world applications. Technology transition will be touched upon in the next section. Here we sketch key science and technology implementation accomplishments in four areas.

2.1 Understanding work

We have applied the Living Lab Framework [2] as an integrated approach to understanding work in the real world and modeling that work to support testing of theory and technology. The approach includes: (1) *Cognitive fieldwork* within several crisis management domains (911 centers, police operations, emergency medical applications, and terrorist training exercises) [3]; (2) *Simulations* (using NeoCITIES, see: [4]) based upon realistic scenarios for emergencies that demand that team cognitive processes operate in uncertain, ill-defined situations. This provides a basis to develop user interfaces and visual analytics methods that address constraints present in teamwork and technology and produce more effective and efficient support of cognitive readiness.

2.2 Context and geo-semantic interoperability

Geospatial data semantics deal with representations of the geographical world as interpreted by individual human users or a community of practitioners. Ontology-based approaches have been accepted as the panacea for all sorts of geospatial semantic

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problems, and identifying categories, concepts, relations, and rules that prescribe theories of the geospatial domain.

Our work proposes an extension of ontology-based methods with an explicit model of context that broadly characterizes typical applications and scenarios of use, and complements traditional abstraction and modeling methods .Specifically, we propose a semantic model of geographical data that supports the reasoning of spatial data meaning based on context. Conceptually, we represent geospatial database semantic knowledge using a contextualized geo-ontology that represents an unambiguous and coherent theory about a piece of geographical reality within a prescribed context. Multi-range contexts allow multiple ontologies to co-exist in a system and jointly describe multiple data source semantics. At run-time, data sharing or communication contexts are used to mediate ontology alignment and semantic conflict resolution. This is accomplished through an intelligent agent that explicitly captures knowledge about defining features and proper behaviors of a context in the form of contextual schemas (C-schemas) [5], and provides a holistic solution to geospatial semantics.

2.3 Adaptive interfaces for mobile devices

The dynamic nature of user multitasking, work environment switching, and shifts of internal goals make context awareness, relevancy and adaptation critical in mobile computing. Existing studies and models of mobile contexts recognize physical, cognitive and social contexts as major categories, but are unclear about contextual influence on mobile application behavior and treat context using ad hoc adaptation strategies. We addresses these issues by establishing a computational model of mobile context relevancy [6] that binds contexts, activities and adaptation strategies at run-time with a degree of consciousness about changing contexts and an autonomy in choosing a proper dynamic adaptation strategy. This system actively regenerates a model of ongoing activity by sensing, communicating, and interpreting changing conditions, resources and processes. This allows contextual factors to be associated with an activity based on how factors contribute to various components of an evolving collaborative plan.

2.4 Collaborative map-based portal

A Geocollaborative Web Portal (GWP) application has been designed and (partially) implemented to provide a common interface that supports asynchronous, geocollaborative activities for humanitarian relief logistics operations. The GWP emphasizes support for situation assessment, positioning and monitoring of field-teams and distribution sites, and supply routing. For details, see our demonstration description (Tomaszewski, et al, this volume).

3. TWO SHORT SUCCESS STORIES

3.1 Port Authority of NY and NJ (PANYNJ)

In June 2005, an alpha version of the Geospatial Multimodal Interaction Platform (GeoMIP) was delivered to our government partners at the PANYNJ, by our industry partner VideoMining (formerly Advanced Interfaces). Working with PANYNJ has helped identify long-term tasks to make adoption of the GeoMIP system easier for crisis management. Examples include: (a) integrating the GeoMIP system with existing EOC software tools, (b) dynamically synchronizing GeoMIP system GIS data with master GIS datasets, and (c) providing role-specific, expertise collaboration to enable seamless group decision-making.

3.2 Supporting homeland security

The Pacific Northwest National Laboratory, through their Department of Homeland Security's National Visualization and Analytics Center, (http://nvac.pnl.gov/) or NVAC^{TM}, selected Penn State as the site for one of five new Regional Visualization and Analytics Centers (RVAC). The Penn State RVAC research builds directly upon our current GCCM project, a previous Digital Government project focused on development of visual analysis and communication methods, and the common NVAC goals to develop, implement, test, and deploy new visual analytics methods and technologies supporting the DHS mission.

The fundamental scientific objective underlying the PSU RVAC efforts will be understanding how individuals and teams carry out analytical reasoning and decision making tasks with complex information and using this understanding to develop and assess information technologies that enable these processes.

4. FUTURE CHALLENGES

In the coming year, will continue to implement and assess our approach to web-based geocollaboration for multi-organization response to crisis events, with a focus on international humanitarian logistics. We plan to leverage visual analytics methods that are developed through the RVAC introduced above, to extend the original capabilities planned for a collaborative, map-based web portal and to study use of this web portal to enable team work through extensions to our NeoCITIES simulation environment.

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