Synthesizing Geovisual Analytic Results

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Abstract— Single analytical results are rarely "magic bullets." To complete most analytical tasks, analysts must combine results from multiple tools derived from heterogeneous data over a significant period of time. Current visual analytics tools do not offer much in the way of dedicated tools for this activity – a portion of the analytical process called synthesis. Moreover, we know little about the ways analysts currently accomplish this task. Here we describe a research project in progress intended to characterize and design interfaces for results synthesis in geovisual analytic tools.

Index Terms—Synthesis, geovisualization, geovisual analytics, user-centered design

1 Introduction

As the study of visual analytics matures and productive tools emerge for analysts, results they generate will become more prolific and detailed. The action of organizing, annotating, and assigning meaning to collected results is a process that can be called synthesis. The theory underpinning geovisualization development describes this stage as the transition from analysis to presentation. To date there has been little research to characterize or design for this stage of analytical work. This paper outlines research intended to fill that gap.

Geovisual analytic tools in development promise to make it possible for users to tackle complex tasks across heterogeneous types of data. Photos, news articles, and video clips will be interactively linked to traditional tabular geospatial databases [1]. As geovisual results become increasingly intricate, there is a need for research to examine how domain experts collect, organize, and assign meaning to their results, as a basis for the conceptualization and development of synthesis-support tools. Our focus is on infectious disease surveillance and bioterrorism intelligence, domains that require the synthesis of many types of geographic information.

2 Background

The theoretical basis for synthesis originated with a research process proposed by DiBiase [2] and expanded upon later by MacEachren [3, 4]. DiBiase describes a process that starts in the private realm with an analyst exploring data, developing hypotheses, and iteratively carrying out analytical tasks to evaluate and refine hypotheses. This process then transitions to the public realm of synthesizing results and evidence, and presenting those results with supporting arguments (Figure 1). Current geovisual analytic tools support exploratory and analytical tasks – the result of emphasis in early research on supporting those tasks. There remains a need to develop new tools to support synthesis – the transitional step between analysis and presentation. DiBiase describes this step as, "…synthesis or generalization of findings."

The (**cartography**)^3 framework of cartographic visualization (Figure 2) [4] depicts synthesis as a time for composing and generalizing exploratory and analytical results, as analytical tasks shift from knowledge construction to information sharing. Synthesis should support the act of condensing what has been discovered, as analysts switch goals from revealing unknown information to interpreting and explaining that new information.

Another theoretical framework by Gahegan and Brodaric [5] describes synthesis as the act of creating taxonomies from data – usually in the form of classification schemes. As an example, Gahegan and Brodaric describe how analysts might visually explore and identify appropriate classification schemes for a landcover dataset – identifying synthesis as an activity that occurs early on in the analytical process.

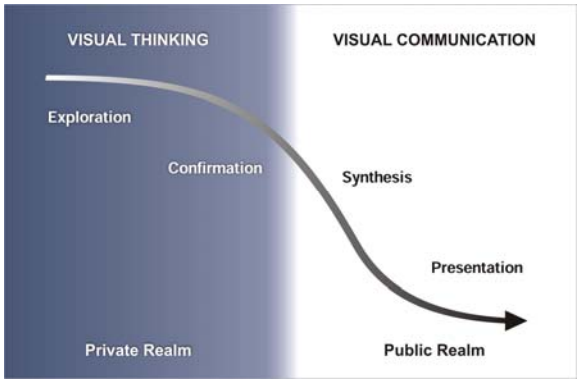

Fig. 1 The geovisual analytical process after DiBiase (1990)

In generic terms, the Oxford English Dictionary assigns a variety of meanings to synthesis [6]. Synthesis refers to the transition from causes to effects when used in logic. In chemistry and physics, synthesis is creation of a compound from individual constituents. Immanuel Kant described synthesis as the cognitive understanding acquired by combining perceptual inputs and prior experiences. Finally, the common popular definition of synthesis is the, "…putting together of parts or elements so as to make up a complex whole."

Since the definition of synthesis varies, it is important to decide which aspects apply to geovisual analytics. The relevant focus is on the result organization and generalization stage of the analytical process – a so far largely unexplored topic in geovisual analytics research. The term "synthesis" in the sense initially described by DiBiase [2] and MacEachren [4, 7] is appropriate, in contrast to the classification-centric synthesis that is described by Gahegan and Brodaric (2002). We propose our own definition of synthesis for geovisual analytics that is *the stage of an analytic process in which analysts organize and combine individual analytical results into coherent groups that are used to assign meaning and/or encapsulate complex ideas.*

3 Interfaces for Synthesis

Today, synthesis typically occurs inside word processing or presentation software. These tools provide limited connections (at best) to the analytical environments that produced the results.

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Manuscript received 30 June 2007; accepted X XXX 2007; posted online X XXX 2007.
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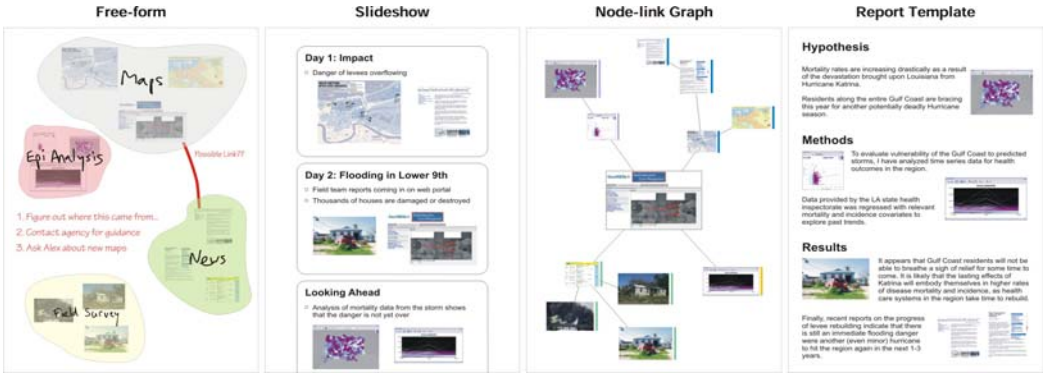

Fig. 2 Potential interface metaphors for synthesis support tools

This means that analysts have limited ability to reach back to prior analyses to compare incoming information, to assign meaning over time to results, and to collaborate efficiently with others.

Supporting synthesis in geovisualization will require specialized tools for collecting and annotating results. Interfaces to synthesis support tools could take advantage of a wide array of interface metaphors. We propose a number of potential synthesis support interface designs (Figure 3). These designs are inspired by common software-based and analog methods for organizing information. Our research methodology focuses on determining which methods (including others that analysts suggest) will best support synthesis.

The designs presented here assume that analytical results arrive into the synthesis environment in the form of individual "chunks." Research is needed to identify effective visual representations for analytical chunks for use during synthesis.

The free-form interface metaphor is inspired by analog and digital whiteboards that are commonly used in office and educational settings. Slideshow tools are commonly used to present results at meetings and conferences. The node-link graph interface is commonly used now for knowledge representation in the form of concept maps and hierarchies. Finally, the report template interface metaphor for synthesis would allow users to group and annotate analytical results under previously specified headings to match a standard reporting format.

4 Research Questions and Methodology

To characterize and design for synthesis of geovisual results, we have started a research project to explore the following questions through a longitudinal mixed-method study of analysts from the domain of disease surveillance:

- How do analysts currently synthesize their results?
- What do analysts wish they could do to better synthesize their results?
- How do analysts synthesize results in a simulated real-world situation, and what does this tell us about how synthesis is conceptualized?
- How does heterogeneous data influence results synthesis?
- What interface metaphors emerge from analysts' current, projected, and demonstrated synthesizing behavior?

Answers to these questions will come from analysts monitoring the spread of infectious diseases and bioterrorism threats at Pacific Northwest National Labs (PNL) and the Center for Infectious Disease Dynamics (CIDD) at Penn State. These users will soon be working with new geovisual analytic tools that integrate diverse media with traditional data sources. Analysts must react quickly to reports of emerging outbreaks or threats – comparing new information to what has happened in the past to create analytical reports for decision makers.

We will use evidence from knowledge elicitation activities to define general synthesis strategies and to develop specific tool design guidelines that can be used to design synthesis tools for future geovisualizations. Additionally, we will propose a framework for scientific study of geographic results synthesis.

There are four planned phases to this research. In the first phase, we will interview analysts about how they currently synthesize information. We will observe how analysts use results during project meetings, and we will conduct an experiment where analysts will synthesize physical artifacts from a prototypical analysis scenario on a large sheet of paper using common office supplies. This activity is intended to characterize synthesis apart from a digital environment.

In the second phase we will develop interactive prototype synthesis tools based on the interface metaphors and basic functionality suggested from the first phase results. Phase three will involve quantitative and qualitative evaluation of the prototype synthesis tools. Finally, Phase four will combine results from phases one and three into a set of design guidelines for synthesis tools.

Phase one is currently in progress. Analysts at PNL will complete first phase activities in mid-July, 2007, and analysts at CIDD will complete phase one activities in mid-August, 2007.

Acknowledgements

This research is supported by the National Visualization and Analytics Center, a U.S. Department of Homeland Security program operated by the Pacific Northwest National Laboratory (PNNL). PNNL is a U.S. Department of Energy Office of Science laboratory.

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