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DESIGNING SUPPORT FOR INTELLIGENCE ANALYSTS

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Intelligence analysis is a prototypical example of a situation that can be described by the phrase "coping with complexity", given a variety of complicating factors including (but certainly not limited to) massive amounts of data, inherent uncertainty in the data, dynamism in the underlying world, and the risks associated with the conclusions drawn from the data. Given this complex nature of intelligence analysis, a wide variety of advanced visualization tools are continually being developed in hopes of designing support for the analysis process. In addition, a number of different cognitive analysis activities are ongoing in hopes of deriving requirements for future support tools. The goal of this panel is to present a sample from both areas in hopes of providing an integration of efforts and thus more effective support tools for intelligence analysts. We have four speakers presenting an analytic perspective, one from a tool development perspective, and one from a support function (the medium between analysis and design) perspective. This should provide an interesting set of complementary discussions into this topic area.

PANEL SUMMARY

Intelligence community analysts are faced with volumes of complex data from multiple sources and types that they must evaluate, correlate and use to support time critical decisions. Data sources for analysis may include message traffic, imagery and signal intelligence and geospatial data of various types including, text, maps, databases, photographic, video, other sensor data along with open source information to include newspapers, internet, and broadcast. The analyst prepares and presents reportable findings along with supporting information to peers, superiors and decision- makers. These tasks are often performed utilizing rapidly emerging data and in a rapid response time environment. Advancements in the effectiveness of visualization can provide improvements throughout the analytic process. These advancements should benefit the analyst's insight and understanding of complex issues, and how information and findings are integrated, composed, and presented.

Intelligence professionals are confronted by a number of challenges. The analyst must quickly view, extract information, fuse and integrate data from disparate sources. The analyst must quickly view different types of data coming in various modalities and genres, make sense of the information, summarize, extract, and provide analytical judgments to peers and the policy makers. Dealing with the resulting integrated data and communicating its relevant content and significance can be done more effectively in many cases using visual means. There is thus a need to develop methods and tools for visual analysis and presentation of integrated data.

In addition to finding and fusing data, the data facing analysts can quite often possess one, or more of the following characteristics. Clearly the worst case is when the data or information source in question entails all three characteristics:

- Very large volumes of data – difficult because of its size.
- Highly heterogeneous data – difficult because of its diversity or differences.
- Highly complex data – difficult because of the very high dimensionality and high degree of linkages that exist in the data.

The bottom line is that intelligence analysis is a domain that has a particularly difficult version of the data overload problem. The exacerbating trends of increased data availability and expanding monitoring responsibilities are transforming the nature of the cognitive tasks. In addition, there are dimensions of the domain that make the analysis process particularly difficult, including deception operations by the adversary, the need for integration and corroboration of second hand interpretations of data from multiple sources, and the difficulties in applying models to interpret events among many others.

Compounding the situation is the paucity of truly human-centered information technology. As in many modern socio-technical workplaces, the intelligence analyst often has to work with technologies that are user-hostile and require local kluges and workarounds. The technologies must support the user in making decisions and reaching their goals.

Information Visualization has the potential to be a powerful "force multiplier" within a number of distinct analysis and reporting functions used by all types of Intelligence Community Analysts across the entire spectrum of the Intelligence Community. But for any number of reasons the high potential that information visualization appears to offer has not yet been fully realized.

To fill the resulting 'support gap', many agencies and organizations have their own programs and initiatives to create new tools that they claim will perform amazing feats of analyzing data and achieving understanding. This wide assortment of tools and programs has had four negative consequences:

- Lack of mechanisms to support cross-agency awareness of similar efforts,
- Duplication of effort to create new decision aids,
- Duplication of effort to study and understand the analytical process, and
- An unnecessary "spreading thin" of the available funding and human resources.

An argument in favor of maintaining the status quo is that this competitive situation may promote the survival of the best designs of new methods and tools. On the other hand, even if good solutions are found for problems that may be unique to individual organizations, there might be a follow-on problem of integration, including applications to support joint forces.

Some in the community have expressed reservations about certain aspects of current programs and initiatives, and have concerns about whether ideas for new decision aids and displays are realistic in terms of what is possible in computer science, let alone truly human centered. Thus, there is a great need for communication and collaboration among researchers and developers in order to work toward building effective decision support for intelligence analysis.

As a starting point for the design of effective support, it is essential to understand the work domain and associated tasks in intelligence analysis. However, given the difficulty of access, there have been a limited number of cognitive analyses of intelligence. One of the seminal works in this area was conducted by Patterson, Woods, and Roth (1999). The insights from their work include:

- The main cognitive task in intelligence analysis is *inferential analysis*, which involves determining the best explanation for uncertain, often contradictory and incomplete data.
- Another cognitive framing of intelligence analysis is that of a *supervisory controller* (the intelligence analyst) monitoring a process (national technological and human processes / capabilities) but without the opportunity to intervene in the process.
- The intelligence analysis domain is a socio-technical system with many similarities to other domains studied by cognitive systems engineers, containing dynamic and interconnected systems and performed under time pressure with high consequences for failure.
- One of the main complications for analysts is the relationship between events in the world, reports of information about events in the world, and sampled information about events.

Within the Patterson, et al., study, they identified the following prescriptive criteria for successful decision support solutions to the data overload problem of intelligence analysis. These are:

- Recognition of unexpected information. Bring analysts' attention to highly informative or definitive data and relationships between data, even when the practitioners do not know to look for that data explicitly.
- Management of uncertainty. Aid analysts in managing data uncertainty. In particular, solutions should help analysts identify, track, and revise judgments about data conflicts and aid in the search for updates on thematic elements.
- Broadening. Help analysts to avoid premature closing the analysis process. Solutions should broaden the search for or recognition of pertinent information, break fixations on single hypotheses, and / or widen the hypothesis set that is considered to explain the available data.

In a follow-up effort, Patterson, Woods, Tinapple, and Roth (2001) were then able to create "design seeds" as a strategy for aiding intelligence analysts for a particular leverage point based on a combination of research bases and cognitive task analysis findings. One such example of these design seeds was developed around the manipulation of "high profit" documents.

More recently, Elm et al., (in prep) have developed a descriptive model of intelligence analysis that is, at the highest level, a convergent broadening / narrowing process centered on three key activities – targeted collection and extraction of the essential, "on analysis" information sample from the available data, the construction of a corroborated accounting of the findings, and the construction of stories or hypotheses to explain the findings. While each of these activities possess natural pressures to narrow, there are complementary broadening processes that serve as counter-balances between these three activities. Based on this model, they were able to construct a "support function model" to define the functions within this convergent broadening / narrowing process that need to be supported by visualization tools. The objective of this effort was to establish an essential medium for communication between cognitive analysis efforts and visualization tool design efforts.

The goal of this panel is to present a sample from both analysis and design to provide a discussion of different efforts and perspectives to lead to an integration of efforts and thus more effective support tools for intelligence analysts. We have four speakers presenting an analytic perspective, one from a tool development perspective, and one from a "reverse engineering (from tools to decision support provided)" perspective. The first speaker is Malcolm Cook who will talk about analyzing intelligence failures in a manner similar to that of organizational contributions to accidents. Second, Frank Greitzer will talk about a particular analysis environment that provides data and visualization tools for intelligence analysis. Third, Robert Hoffman will be talking about the question of whether support tools should be based on models of human biases or expert reasoning. Fourth, Brian Moon will talk about the use of a generic concept mapping tool to the process of extracting nodes and links – link analysis. Fifth, Susan Hutchins will talk about the use of the critical decision method in the process of developing a computational model of the analyst's processes and analytic strategies. Last, Bill Elm will talk about the construction of a framework to help analysts and visualization tool designers understand support tools with respect to the decision support provided. This should provide an interesting set of complementary discussions into this topic area.

Panelist #1: Malcolm Cook
Analysing Intelligence Reports: The Role of Psychological Insight

Kuhns (2003) has identified intelligence failures as one of the most highly developed areas of academic study on intelligence and other analyses of intelligence have supported the existence of analytic failures with potentially consistent factors as their contributors (Herman, 2002). This paper will argue that intelligence failures can be analysed in a manner similar to accidents with a sequence of contributory causes leading up to significant events in a manner similar to that identified by James Reason for organisational contributions to accidents. The evidence from public domain accounts certainly suggest the existence of typical cognitive errors and failures like those limiting performance in other areas. For example, Posner's (2003) account of the failure to prevent the events of 9-11 suggest perseveration of hypotheses in the face of contradictory evidence and confirmation bias in the use and interpretation of information. There is certainly no doubt of the intelligence failures because of the rapid analysis of evidence immediately after the events, confirming the identity and nature of the assault conducted by the attackers (Miller, Stone and Mitchell, 2002).

It is proposed that there are significant ways to improve the use of analysis in achieving significantly improved results with limited data that is multi-source, multi-attribute, and dubious validation criteria. The following paper discusses a more detailed analysis of why experts with a knowledge of the critical issues fail to deliver the correct analysis of all-source intelligence material using evidence from think-aloud protocols, critical decision methods and structured interviews.

Panelist #2: Frank Greitzer
(with Paula J. Cowley, and Rik J. Littlefield)

Monitoring User Activities in the Glass Box Analysis Environment

The Advanced Research and Development Activity (ARDA), through its Novel Intelligence from Massive Data (NIMD) program, has undertaken a research program to assist intelligence analysis (IA). As part of this program, Battelle's Pacific Northwest Division developed a Glass Box Analysis Environment (GBAE) to provide data and visualization tools to increase researchers' understanding of cognitive foundations and to provide an integration/test environment for NIMD-developed tools. A continuing challenge was to define requirements for automated data collection functions that are unobtrusive, yet robust and complete enough not only to capture lower-level data on human-computer transactions but also to shed light on the analyst's higher-level cognitive processes. The GBAE instrumentation software has produced an extensive repository of automated human-computer interaction data augmented by user-initiated annotations. This paper discusses the challenges and lessons learned during the design and development of the GBAE, as well as its other potential uses in human factors research.

Panelist #3: Robert Hoffman

Biased About Biases: The "Theory of the Handicapped Mind" in the Psychology of Intelligence Analysis

A great deal of research in the tradition of laboratory experimental psychology, especially classic researches by Tversky and Kahneman, have led to the widespread belief that human reasoning is biased in a number of ways. Many efforts on creating performance and decision aid technologies are premised on a goal, sometimes the single goal, of compensating for human biases. An example is the landmark work, "The psychology of intelligence analysis" by Richards Heuer, which clearly shows the impact of the research on bias in the recurrent theme of human limitations and weaknesses.

The fact that a reasoning sequence leads to wrong answers is by itself not enough (i.e., the "bias" is not inherently a property of the final decision, but is attributable instead to the process that led to the decision). A breakdown of the defining features is very revealing. When each entry in the pantheon of biases is compared to the defining features, none of them stands up well under scrutiny.

The assumption that the purpose of aiding technologies is to compensate for biases leads to the creation of models of bias to inform the creation of technologies that compensate for human limitations. An alternative view called "Amplified Intelligence," is that technologies should be based on models of expert reasoning, perceptual, and collaborative capabilities, so that these might be amplified and extended. Aids created from the two differing viewpoints would have different features and uses.

Panelist #4: Brian Moon

Collaborative Concept Mapping as an Approach to Link Analysis

Support tools for link analysis in the intelligence community range from paper and pencil to algorithms and visualization techniques that automate the process of extracting nodes and links. While both ends of the spectrum offer necessary features, neither is sufficient. Manual approaches offer great flexibility and mitigate memory constraints by requiring analysts to 'go through the motions.' However, the connection between the analysis and its underlying data typically resides within the analysts, and collaborators must usually be collocated. Automated techniques enable analysts to work with large datasets and save time in the construction process. However, they require knowledge of their underlying algorithms to understand the meaning of the generated links, and many are inflexible in allowing manual manipulations.

Collaborative concept mapping using CMapTools bridges the spectrum of these support tools by providing a highly flexible, user-centered modeling environment. This presentation will demonstrate application to the link analysis task.

Panelist #5: Susan G. Hutchins (with Peter Pirolli and Stuart Card)

A New Perspective on the use of the Critical Decision Method with Intelligence Analysts

The ability to sort through vast amounts of information, produced from a variety of sources, and represented in many different forms, to construct an accurate depiction of a situation and make predictions regarding the situation, represents the hallmark of the intelligence analyst's (IAs) job. Intelligence analysts engage in information seeking, evaluation, prediction, and reporting behavior in an information-intensive work environment. A Cognitive Task Analysis (CTA) was conducted on IAs to capture data that will provide input to support development of a computational model of the analyst's processes and analytic strategies. A hybrid method was developed and used to conduct the CTA, including a modified version of the critical decision method. The essential distinction was that participants were asked to describe an example of a strategic analysis problem versus a critical decision problem. Procedures used to conduct the critical analysis method are described in this paper along with initial results.

Panelist #6: William Elm (with Scott Potter)

Finding the Decision Support Beneath the Visualization

As part of ARDA's GI^{2}Vis program to find the decision support provided by visualization technologies, insights and lessons learned from decades of Cognitive Systems Engineering have shown promise for identifying the essential nature of cognitive support that must be provided by the decision aid under design. These lessons learned were applied to a functional model of intelligence analysis to build a model of decision support functions. This effort focuses on building a precise understanding of cognitive support based on a model of intelligence analysis support functions rather than a surface-level description of the capabilities of the visualization.

This talk will discuss a research effort specifically aimed at designing as well as evaluating visualizations based on the degree of underlying decision support provided. Designing visualizations from their decision support nature will dramatically improve the way visualizations are used by analysts to analyze and present their results, as well as for system developers to select features for their decision support systems during design. As a result, the analyst will be able to manage and control a significantly more challenging problem with dramatically improved decision quality.

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