Technical Evaluation Report

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ABSTRACT

The CSO-IST-116/RSY-028 symposium on VA (Visual Analytics) was held in Shrivenham, United Kingdom Oct 28-29, 2013. It addressed several key areas in the use of VA to solve complex defence and public security problems. VA, which is defined as the "science of analytical reasoning facilitated by visual interactive interfaces" [1], can attack certain problems whose size, complexity, and need for closely coupled human and machine analysis may make them intractable. [2] Military operations of the NATO nations frequently involve the collection and assimilation of vast amounts of complex, disparate, heterogeneous data, which is used to support the mission. Making sense of the information available and transforming it into a form that supports effective, and efficient decision-making is an extremely difficult task. Separating the irrelevant from the useful, creating viable hypotheses from the complex data set, which is full of various sorts of uncertainties, and deriving a viable, defensible understanding of the situation, remains a daunting challenge. VA holds forth the promise of aiding the analysis process and improving the understanding of the situation. The symposium covered both the development of VA as a technique and its application to relevant problems. The sessions were organized according to the following themes: Analytical Reasoning, Uncertainty and Cognitive Processing, Cyber Operations, Decision Support and Surveillance, and Aviation Safety. During the Symposium, several key messages came through:

- *measures of effectiveness for the assessment of how VA helps or hinders the analyst need to be developed;*
- *the analysis process must result in defensible conclusions, with clear analytical provenance, which can successfully withstand interrogation, but don't constrain the early analysis stages too much where the creation of many possible "loose stories" is important;*
- *must be able to deal with large degrees and types of uncertainty;*
- *analysts' attention is a valuable commodity – don't waste it;*
- *a framework to help us understand the "sense-making" process is needed;*
- *VA is a multidisciplinary problem space within which cognitive and perceptual psychology need to be brought together with Visual Analytics systems technology; and*
- *notable progress has been made in developing solutions for situation awareness, with part of the answer based on integrating complementary Open Source Intel derived from social media streams, such as Twitter.*

KEYWORDS: *Visual Analytics, Visualization Techniques, Perception, Cognition, Sense-making, Intelligence Analysis, All-source Intelligence, Analytical Reasoning, Information extraction,*

1.0 INTRODUCTION

The CSO-IST-116/RSY-028 symposium on VA (Visual Analytics) was held in Shrivenham, United Kingdom Oct 28-29, 2013. It addressed several key areas in the use of VA to solve key defence and public security problems. VA, which is defined as the "science of analytical reasoning facilitated by visual interactive interfaces" [1], can attack certain problems whose size, complexity, and need for closely coupled human and machine analysis may make them intractable. [2] Military operations of the NATO nations frequently involve the collection and assimilation of vast amounts of complex, disparate, heterogeneous data, which is used to support the mission. Making sense of the information available and transforming it into a form that supports effective, and efficient decision-making is an extremely difficult task. VA shows great promise in aiding the analytical reasoning procedures that underpin the sense-making process. Separating the irrelevant from the useful, creating viable hypotheses from the complex data set, which is full of various sorts of uncertainties, and deriving a viable, defensible understanding of the situation, remains a daunting challenge. Given this background, the goal of the symposium was to *"discuss methods by which interactive visualization for analysis can assist decision-makers in different problem domains to explore the possibilities in, or find necessary understandings from, the increasingly large amounts of heterogeneous data availability to them."[3]*

With these issues in mind, the symposium technical program committee asked for papers on the following topics:

- Analytical reasoning
- Cognitive processes
- Information abstraction
- Experimental measures
- Uncertainty
- Information trails
- All-source intelligence
- Evaluation and use-cases
- User-selectable complexity
- Networks
- Cyber operations
- Counter IED operations
- Humanitarian operations
- Bio-terrorism
- Spatio-temporal techniques
- Display characteristics affecting Visual Analytics
- Health safety and health services
- System safety and monitoring delivery
- Mathematical foundations of data transformations

From the abstracts received, 15 papers were selected for presentation at the meeting. In addition, two keynote addresses and one invited paper were given. The papers were organized within the following sessions: Analytical Reasoning, Cyber Operations, Decision Support and Surveillance, Uncertainty and Cognitive Processing, and Aviation Safety.

2.0 VIEWS AND OBSERVATIONS

2.1 General

The venue for the symposium was very good; no major issues were raised by the participants. Overall, the event was well organized and ran smoothly.

The event had 78 registrants, which may be the new normal for IST Panel events, given the current travel restrictions in most nations. Previous events have averaged over 100 registrants and some have been as high as

150. Participants came from 23 nations and at least two NATO organizations. From these 78 registrants, 20 completed surveys were returned, which made it possible to get some reasonable statistics on the audience's impression of the symposium. On the question of the "Overall Quality of the Event", the average score in the surveys was between "excellent" and "very good" with 8 votes given to "excellent", 12 to "very good", and two to "good". For "Overall Value to My Organization" the score was again high with an average of 81-90.

Overall, the quality of the papers was very good. At least 80% of the papers presented substantial results. The surveys indicated the majority of the presentations were well organized and effective.

Unfortunately, several presentations that were made, other than the keynote and invited presentations, lacked accompanying written papers. This tended to reduce the value of those presentations to future audiences, since their contributions will not be captured in writing in the symposium proceedings.

2.2 Keynotes

Dr. Rosenblum from the US National Science Foundation started the symposium with an excellent survey of the work that NSF has funded in VA and gave excellent insights into the hard technical problems and where he thought work was still needed. A few examples from his conclusions slide are:

- there is a confluence of a number of technological drivers – data acquisition technologies, displays, and interaction devices –that is driving VA;
- Big Data visualization algorithms and technologies need to co-develop with applications;
- it is critical to leverage human perceptual and cognitive processes in development of big data visualization tools; and
- need to couple the development of machine learning techniques with big data visualization.

The second keynote speaker, Dr. Wong from Middlesex University in the U.K., introduced Day 2 of the symposium. He discussed the tension between fluidity and rigour when designing VA systems. His presentation fit very nicely into the discussion in the symposium about cognitive processing and analytical reasoning. Dr. Wong contended that fluidity is required at the start of the intelligence analysis process where uncertainty in a given explanation can be high, but commitment to it should be low. On the other hand, rigour is required at the later stages where hypotheses need to be defensible, and able to stand up to interrogation. He explained that most tools for supporting intelligence analysis are intended to be used in a more formal manner –to assemble the answers, rather than to explore possible questions and stories. He argued that instead of just supporting the final stage of reasoning where we formalize our explanations as arguments, the system design should facilitate and support the construction and assembly of collections of data in ways that enable the creation of early loose stories or explanations. The formal argument structures should still be retained for the final stage, but the early stage of analysis should instead be supported by a free-form approach to the assembly of data, inferences, and conclusions that allows the easy and rapid evolution of the story. Key to this early part of the process are interaction and visualization tools that facilitate the modification of the relationships, groupings, themes, and even spatial-temporal arrangements in the data; that aid the questioning of the data's validity and accuracy; and that support the creation of story lines that help the analyst to understand and conceptualize new ideas.

Dr. Kielman, from the U.S. Department of Homeland Security, gave an invited talk on Cyber Security Applications for Visual Analytics. He outlined the DHS CASe (Cyber Security Analysis Suite) project that addresses the US Presidential Directive on protecting Cyber Critical Infrastructure. CASe is designed to develop and deliver a capability to discern, analyze and investigate, and predict multiple, large-scale cyber security threats to critical infrastructures. It applies modern informatics and decision-making techniques to issues of

cyber security and critical infrastructure protection, and heavily leverages work that has been done in the VA community. His presentation helped provide examples of where VA could be and would be applied to the cyber security problem, and described what tool sets would be used where, but did not tackle the VA issues directly.

2.3 Summary of Papers

The symposium sessions were organized in the following way: Analytical Reasoning, Cyber Operation, Cognitive Processing, Decision Support and Surveillance, and Uncertainty and Cognitive Processing, Aviation Safety, and a general poster and demonstration session. For purposes of discussion, it is convenient to regroup the sessions into two main themes: Analytical Reasoning and Cognitive Processing (which includes Uncertainty) and Applications of VA.

Several of the papers dealt with how to use micro-blog data of various sorts (e.g. Twitter, Facebook, Tumblr, Google+) as a measure of public sentiment and as a contribution to what could be called the "human terrain analysis" component of situation awareness. Scenarios presented were both in the military and public security/safety domains. One very useful data set that was used described a spill of toxic chemicals from a transport vehicle in a city called Vastopolis. This data set was produced for the 2011 annual IEEE (Institute of Electrical and Electronics Engineers) VAST (Visual Analytics Science and Technology) Challenge in which groups are invited to demonstrate how their VA techniques can be used to understand a complicated scenario. Entries are judged on both the correctness of the analysis (based on the availability of ground truth) and the utility of the tools in conducting the analysis. The VAST data sets are produced under the sponsorship of several U.S. government agencies. [4] The availability of such data sets is extremely important to researchers as it allows them to test their systems under fairly realistic conditions, and at relatively low cost to them. The use of micro-blog data is especially appropriate in public security/safety applications, where an understanding of crowd sentiment is important in planning next steps. It is obviously less likely to be useful with an opponent that is very focused on a particular course of action and not telling the world about it.

2.3.1 Analytical Reasoning and Cognitive Processing

Paper 1 introduced the concept of using monitoring and analysis of micro-blogs to assess crowd sentiment. In the Vastopolis example given in the presentation, people were falling ill from a toxic chemical spill and tweeting their symptoms and observations. Twitter data feeds were analyzed to assess what was going on. To analyze the complete set of data using natural language processing would take too long, so instead searches were made for groupings of words, called "ngrams". An example might be "ill, sick, nausea". The frequency of the occurrence of those words was plotted on a map and timeline. Bursts of tweets mapped by time, position and topic were used to help assemble a story line for the events unfolding. These snapshots were used to feed a storyboard-based visualization process that helps users plan, and explore stories. It was shown that different 'stories' from different standpoints could be created giving rise to the idea of multivocality. A tool called "epSpread", developed by the authors, was used to interact with the data, and to extract and plot on a timeline thumbnail visualizations encapsulating a given sentiment at a specific time and place. During the presentation and later in a demonstration session, interaction in epSpread was shown to enable exploration and discovery. In this scenario, tweets were used to provide a barometer of the opinions and sentiment of the population. The understanding of this sort of data appears tractable when the analyst is equipped with suitable tools, such as epSpread and ngram analysis, for storyboarding. Papers 7 and 9, discussed below, also dealt with the use of social media feeds to assess crowd sentiment, but for different application areas.

Paper 2 examined the use of VA to simplify and understand cognitive maps of ill-structured situations. Cognitive maps are created with a formal graphical language consisting of bundles describing a situation (cocaine price,

drug usage, street gangs), which can be numerically expressed (7 street gangs, 5 acres of coca) and factors (user's economic hardship), connected by arrows of positive or negative influence and weights. These maps have a fairly long history of use, however when they are applied to complicated, ill-structured situations, they can become a mass of spaghetti, undecipherable by humans. This paper examined a method of visual restructuring, or disentanglement based on Dijkstra's structured programming approach. This algebra, when applied to a formal description of the cognitive maps, was shown to reveal simplifications. For example, when several related factors all map to the same elements, these factors can be grouped into a larger entity. An iterative process with visualization of the resulting intermediate maps was shown to aid in the reduction of the cognitive map complexity. The approach was implemented using a couple of different software tools, augmented with visualization tools, and shown through experiments to result in untangled maps.

Paper 13 discussed the issue of Analysts' Attention in the face of a huge and increasing information flow. Whatever is done to try to aid the analyst should strongly take into account the need to not squander or divert their attention away from the key features of importance. An analogy was drawn using Nobel Laureate Herbert Simon's quotation: *"A rabbit rich world is a lettuce poor world ….Now, when we speak of an information-rich world, we may expect, analogically, that the wealth of information means a dearth of something else – a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, a need to allocate that attention efficiently among the overabundance of information sources that might consume it."* In the situation of the analyst's attention and information flow, the attention is the lettuce and the information flow is the rabbit. Don't let your techniques or data flows consume all the attention available. Using this context- setting analogy, the paper drew from the psychology literature to describe the nature of human perception and some of its weaknesses and pointed out the need to take these weaknesses into account when designing VA systems to aid human understanding. Failure to do this and to carefully monitor the effects on attention could lead to systems that impair rather than assist analysts in doing their job. The paper suggests that further R&D of a fairly basic and multidisciplinary nature is needed to understand the issues better, and that constant vigilance in system design is required to carefully manage the scarce resource of attention. This paper provoked a lively discussion.

Paper 10 described a framework for understanding how interactive, exploratory visual analysis can be used to make sense of complex situations, or "wicked problems" in the operational environment. The framework is characterized by three essential dimensions: information retrieval/fusion, interactive visualizations and modeling and simulation. Using the framework, two research gaps were explored: the challenge of revealing and leveraging hidden structure within large corpora of data; and the ability to understand the structure and behaviour of integrated models, and the simulations they produce. To illustrate the first gap, the problem of automatically uncovering emerging significant events in a social media stream was considered. Events were detected by analyzing the shape, size, and duration of the burst of tweets on Twitter. In examining possible solutions to the second gap, a tool called Vu was used as an interface into various simulation models being integrated. Vu allowed the operator to gain insight into what the embedded model was doing. From the presentation it appeared that the framework was still under development and the tools developed were at a low TRL (Technology Readiness Level), i.e. they were still in a laboratory.

Paper 12 discussed how to deal with uncertainty in geospatial information systems. In particular, it addressed the understanding of uncertainty in data sources, the propagation and accumulation of uncertainty through the processing chain and how to portray it in the final product. A comprehensive list of types of uncertainty was introduced (ambiguity, completeness, consistency, credibility, etc.) and a framework for dealing with uncertainty was suggested. The results of preliminary research into how best to represent thematic, temporal and spatial uncertainty in geospatial products was assessed using questionnaires and sample visualizations presented to the user community. The key recommendations from the work were to create a repository of standardized geospatial

layer descriptions for representing uncertainty, and to capture uncertainty information and metadata consistently in the underlying business processes to aid in the subsequent standardized portrayal of uncertainty effects. This work was the first phase in the completion of a task in a UK Defence S&T Laboratory work program being carried out by a consortium of industry and university researchers. Proposals for the next phase cover three activities: an indication of how the framework would be used with defence data, processes and tools; an assessment of user reaction to visualizations of uncertainty; and a more complete definition of the uncertainty framework. It was too early in the research to assess how well this approach will work, but it should be revisited after there are further results.

2.3.2 Applications of VA

Although Paper 3 was included in the Analytical Reasoning session, it actually dealt with where and how US DTRA (Defense Threat Reduction Agency) plans to use visualization in its program. Included in the presentation was a call for partners to aid in the execution of their work plan. Visualization was to be applied to understanding the personnel, facilities, equipment, infrastructure and material associated with DTRA projects in their partner countries. Decision support tools, potentially supported by VA, were needed for operations planning and post event analysis. Unfortunately, no written paper was provided for this presentation.

Paper 4 was actually a presentation providing an introduction to the demonstration of the INVISQUE (Interactive Visual Search and Query Environment) tool. As described on the INVISQUE web-page [5], " INVISQUE is a prototype with non-conventional interface for searching and querying information. Search results are displayed in a large windowless and borderless two-dimensional display space. This allows the users to interact with the visualization directly for filtering and expanding the search results to find the information they want more efficiently. INVISQUE aims to present the design for the next generation of information search and retrieval systems that would support semantic analysis and access to massively large data sets." This tool was applied to searching datasets of articles. An interesting aspect of the tool is that physical gestures and display features can be used to help understand the theme being investigated. Entering a keyword anywhere on the white space of the display surface initiates a query. A keyword search is used to bring up sets of "cards" about the theme being searched for. The cards, similar to library index cards, contain metadata about the article linked to the search theme. The cards are displayed on the two-dimensional surface and can be organized in groupings by time and citation frequency. Size and brightness of the cards can be used to provide further information about the relevance of the cards to the initial search. The cards can then be physically manipulated to logically combine ideas related to the query. It is also possible to drill down in the data to the actual articles by clicking on the index card. INVISQUE is a prototype and lacks the backend interfaces and associated semantic analysis tools tailored to the various databases it would need to talk to, if it were to be an actual product. The project appears to have been completed in 2010 and it is not clear if there has been any follow-up.

Papers 5 and 6 both described approaches for using visual analytics in cyber operations centres. Both papers are from industry: Paper 5 from Thales France and Paper 6 from BT (British Telecom).

Paper 5 described two proof-of-concept tools for use in a Cyber Security support system. The first tool was an OSINT (Open Source Intelligence) system that analyzed data coming from social media sources such as Twitter, Facebook, blogs and forums. The idea was to discover the latest potential threats and exploits being discussed in the hacker community. The innovative contribution of the authors was in the text and link mining. The tools developed are, according to the authors, able to synthesize knowledge by combining a deep analysis of social conversation contents with a deep analysis of the organization and members of social networks. Their approach is to first collect social data from the feeds and annotate it to identify the most relevant terms (names, places dates, etc), and then extract links based on relational metadata (e.g. position, time). The links and text are then

mined for relevant relationships, and the results are visualized according to four dynamically changing sets of information: the authors, the content of the texts, the sources, and the topics. Two main visualizations are employed. The first provides oversight of the data collected and presents it in a statistical way. For example, the number and frequency of posts on a topic, the number of authors contributing to it, and the links or citations associated with a given topic, are all tracked and plotted. The second visualization uses graphs that show the dynamic relationships among the authors, the content of the texts, the sources, and the topics.

The second main tool described in Paper 5 was for network situation awareness. Visual Analytics was used to provide the operator with both a picture of the current situation awareness, as wells as tools to investigate abnormal behaviours of their systems in a passive, non-intrusive and automatic way. It does this by analyzing the underlying network logs, and coupling the analysis to graphical representations of the network devices and their associated data flows on a network map. A demonstration of the visualizations used with both tools was provided in the presentation, but little insight was given into how the data mining of social networks was done. The two tools, when used together, form part of the suite of tools that would be required for cyber defence. The first tool could provide critical intelligence on what to expect, at least from non-state hackers who converse in social media. The second tool could allow real-time visualization of what is happening on the network, and in doing so permit attacks and exploits to be detected. It is not clear what the current TRL is of these tools.

Paper 6, which was selected as the best paper, described the actual use in British Telecom's Operations Centre of a VA cyber defence tool called Saturn. Saturn consists of four main components: an *Acquisition & Persistence (A&P) module* to read in and store raw data; a *Data Explorer* visual tool to construct user-defined queries; *Metis, a* middleware layer for data ingress; and *Tornado,* a web-browser-based graphical user interface. The concept is to aid the Operations Centre staff in better applying their contextual knowledge by automating the data intensive tasks where possible, and allowing them to concentrate their attention on the critical issues of analysis, aided by an intuitive visual interface. The VA tool provides a customizable array of multiple views of the network data. It also allows the analyst to bring up additional events that might be relevant to the ones currently being monitored, and through its agile intuitive interface provides an important capability in finding APTs (Advanced Persistent Threats). Saturn is being developed in iterative cycles, with new capabilities being introduced each cycle, and feedback being captured from the operators each iteration. There are no quantitative measures of effectiveness being applied, but qualitative information is captured. This paper provoked a good deal of positive discussion in the question period. What impressed the audience about the approach was that it was being used in a real world situation to solve real problems (the tool was real and of reasonably high TRL), and that iterative cycles of development and feedback were being employed to gain some measure of how well the tool was helping the analysts. A beneficial offshoot of the work is that VA may provide a means to allow the analysts to explain cyber threats and attacks to their management. The authors indicated that several fundamental research questions remain, such as how to best semantically map relevant functional relationships to a visualization, how to connect data fragments into a coherent intelligence picture, and how to better understand collaborative decision making by teams.

Paper 7 presented the early results obtained with the HTES (Human Terrain Exploitation Suite) concept development and demonstration of the US Army Research Lab. The HTES combines four complementary VA tools for the exploitation of open source information. The objective of the project was to provide the commander with a better understanding of the sentiments and culture of the local population prior to engaging in dialogue with their senior leadership. Of the four tools available, three are used to analyze feeds from open source information (blogs, Twitter, news feeds, intelligence reports) and perform the following tasks: topic and sentiment analysis, people to topic association, and semantic search. The fourth tool performs a data proximity analysis to attempt to link individuals discovered in the social network analysis to a set of reference descriptors, and thereby establish where they are located in the social hierarchy. The tools were tested in a military exercise

and from an early assessment it was found that the tools were easy to learn, their operation was generally intuitive, and they greatly increased the operators' ability to exploit open source material. However, it was found that more integration of the products, and correlation of the various results from the tools, need to be a focus of future development. The overall HTES system is at the concept demonstrator level of maturity.

Paper 8 discussed early work in assessing an actual communications device used by firefighters. There was not a lot of detail on VA, but rather on the results of a study of user requirements. How the users employ the current device, their satisfaction with it, and suggestions for improvement were captured by means of questionnaires and focus groups. The paper described the first phase, which was information and requirements-gathering, in a longer-term project linked to a PhD dissertation.

Paper 9 applied VA to the problem of monitoring and managing critical infrastructures, and in particular discovering and mitigating cascading effects. In this scenario, VA was applied to social media analysis to help understand the unusual power draws on a hybrid electrical grid, supplied by photo-voltaic and traditional sources of energy, and controlled by a network-based SCADA (Supervisory Control and Data Acquisition) system. In the approach outlined in the paper, a real-time analysis of social media feeds was used to provide a situation awareness sensor for the operators of the power grid. The analysis automatically detected anomalies consisting of spatio-temporal clusters of messages and then examined the cluster to derive common keywords or phrases. The clusters were then plotted in space and time and labeled according to their common content. To aid with detection of topics highly relevant to the system operator, a set of SVM (support vector machine) classifiers were customized for the given scenario and then these classifiers were adjusted and combined with each other and with some simple filter-type keywords specifying conditions such as time and space. In the use- case presented, the electrical grid system operators were seeing a situation of puzzling low power consumption in the morning when industrial production was supposed to increase the load. By means of social media analysis, they determined that there was an outbreak of gastrointestinal illness that was keeping the workers at home. The TRL level of this work appears to be low (still in the research and proof of concept stage).

Paper 11 explored the use of VA to improve the clarity of the recognized maritime picture when tracking vessels. The objective was to suppress mundane information and reveal subtle patterns, some normal and some dangerous, while co-displaying multi-modal information (text, maps, photos), and providing visibility into what was not known (data gaps and uncertainty). The approach taken was to try to more effectively engage the human analysts, rather than try to replace the human by an automated system. The software consisted of a set of VA widgets for the exploration of vessel tracks and non-kinematic vessel properties, and the identification, management and refinement of sets of vessels worthy of special attention. The Analysis Set Manager widget uses a rule-based approach to create sets of vessels for further analysis, using track and vessel information that already exists in the MDA system as input. The Set Manager feeds the other widgets, which consist, among others, of: a "magnets" type display where ships are like magnetic grains attracted to a specific attribute; a temporal event plotting tool; and a visual summary card and record browser, which works with virtual index cards containing ship information. Various means of plotting ship track information to provide visual alerting were also developed (e.g. a continuous ribbon track showing expected and actual ship tracks); as well as cues for indicating specific activities of interest, such as a near-miss, a stop and rendezvous, or a package drop off, etc. The system is to be evaluated for both usability and potential performance improvement in a task-based exercise with military operators in November 2013. Its present TRL is at the prototype stage.

Papers 14 and 15 discussed the problem of bird strikes on airplanes in the vicinity of airports and the attempts being made to understand the bird's behaviour and possible ways to mitigate the problem. Paper 14 was a presentation from the user community in the Netherlands Military Aviation authority. There was no accompanying paper. The presentation was used to introduce the problem of bird strikes, the damage inflicted,

and the costs in terms of materiel and human life. There was no discussion of VA in the presentation. Paper 15 used this introduction to then show how some VA techniques can be used to get insights into what was happening in the bird strike situation. The paper used some graphical and map-based VA approaches to assess and explore the available data sets, and to establish some promising directions for analysis. An assessment of the types of aircraft and bird species involved in strikes at a specific airport led to an investigation of how the approximate kinetic energy of the strike can be correlated to the damage inflicted. The preliminary work showed some promise in answering four of five questions posed by the authors to frame the work: where was the strike, when did it happen, which species were involved, and what number of strikes occurred. The fifth question (why there are birds at that location) was not addressed. This pair of papers showed how some fairly simple VA techniques, judiciously applied, can help solve real problems.

2.4 Positive Examples of Outreach in Symposium

A good example of outreach by the symposium organizers to the broad VA stakeholder community was shown by the attendance at the meeting of researchers from the following groups:

- the UK Visual Analytics Consortium of five universities, who are collaborating with UK MOD;
- participants in the IEEE VAST Grand Challenge for 2012, which depicted a public safety crisis in Vastopolis;
- VisMaster European consortium of universities;
- other academics in VA field;
- national public security organizations such as DHS, DTRA;
- US National Science Foundation; and
- the community of NATO R&D researchers.

In addition, the organizers of the symposium arranged for demonstrations of VA software discussed during the meeting to be provided in the breaks, which allowed the attendees to gain deeper insights into the products.

2.5 Some Further Observations on Outreach

One shortcoming in the outreach of the symposium was the lack of users from the Intelligence Community who could or already make use of Visual Analytics. They could have provided more insight into the requirements from their point of view and also comment on what they think would help, and what would hinder their efforts. Although it is difficult to attract users from this community to an open forum such as this symposium, perhaps it might be possible to arrange a future closed, and if necessary, classified specialists' meeting to get better insights into this community's needs.

Another observation, more than an issue, was that the balance in requirements and "use-cases" was tilted more towards the Safety and Security community and less towards Defence. This is understandable since it is harder to discuss the defence applications, but given that the sponsor was NATO, a larger defence emphasis would have been appreciated by the attendees.

3.0 KEY MESSAGES

In analyzing the content of the papers, as outlined above, and taking into account the discussions at the event, several key messages emerged from the symposium. The following list provides a quick summary for the reader:

- measures of effectiveness for the assessment of how VA helps or hinders the analyst need to be developed;
- the analysis process must result in defensible conclusions, with clear analytical provenance, which can successfully withstand interrogation, but don't constrain the early analysis stages too much where the creation of many possible "loose stories" is important;
- must be able to deal with large degrees and types of uncertainty;
- analysts' attention is a valuable commodity – don't waste it;
- a framework to help us understand the "sense-making" process is needed;
- VA is a multidisciplinary problem space within which cognitive and perceptual psychology need to be brought together with Visual Analytics systems technology; and
- notable progress has been made in developing solutions for situation awareness, with part of the answer based on integrating complementary Open Source Intel derived from social media streams, such as Twitter.

4.0 CONCLUSIONS AND RECOMMENDATIONS

One main message from the symposium was that VA works, but in the absence of MOEs, it isn't clear how well. Exactly what techniques to apply where, and to what effect, is also not yet at the handbook level. A fair amount of educated guesswork is being used. During the presentations there was a valuable exchange of views on lessons learned and what tools are being used, where and why. Several good suggestions for the next steps to deal with the methodology question, as well as other issues, were provided by the speakers. These could be grouped roughly into two main clusters: issues where the future work should go, and areas where the community could use help.

It was clear from the symposium that more work is required on evaluation. No measures of effectiveness have as yet been proposed and most use-case examples in the symposium relied on qualitative feedback from users, in the examples where feedback was sought. Reliable methods for evaluation would help advance VA as a dependable part of the analysts' tool set. It was also clear that further work is required on sense-making. VA should be put on a more solid footing in terms of aiding the cognitive processing employed by the analyst. A clearer understanding of the psychology involved in aided understanding would allow the development of better algorithms and supporting information technology.

There are three main areas where the community working on military application of VA could use help.

- The community could use a list, vetted by military users, of "wicked problems" where Visual Analytics could help. This could be a discussed with ACT (Allied Command Transformation).
- Given that in the military context, VA has lots of potential application to intelligence analysis, further contact with Intel community would be very desirable. They could help focus efforts and provide feedback on "use-cases", and what helps them and what does not.
- Access to relevant datasets to test their techniques, such as Grand Challenge datasets that might be available nationally, or from civilian sources, such as IEEE would be very useful.

In terms of new activities, the workshop IST-117/RWS-028, which immediately followed this symposium discussed the results of the symposium and suggested areas for further research. These areas corresponded well to the list of challenges in the key messages section. As a minimum, the sponsoring task group, IST-110/RTG-085 "Visualization for Analysis", plans to incorporate some of the topics into their remaining program of work and upcoming workshops. Consideration should also be given to holding a closed, and if necessary, classified specialists meeting in the future to get better insights into the intelligence community's needs.

In summary, the symposium accomplished its objective of discussing methods by which interactive visualization for analysis can assist decision-makers in different problem domains to explore and make sense of the increasingly large amounts of heterogeneous data availability to them. Concrete examples of where VA is working now, and what needs to be done next were discussed. Overall, the level of discussion was high and probed the issues well.

5.0 REFERENCES

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