Towards Collaborative Visual Analytics of a Vessel of Interest

Denis Gouin
Defence R&D Canada
2459 Pie XI Blvd North
Quebec, Qc, G3J 1X5
Canada
denis.gouin@drdc-rddc.gc.ca

Valérie Lavigne
Defence R&D Canada
2459 Pie XI Blvd North
Quebec, Qc, G3J 1X5
Canada
valerie.lavigne@drdc-rddc.gc.ca

Michael Davenport
Salience Analytics Inc.
87 West 41 Ave
Vancouver (BC) V5Y 2R8
Canada
mrd@SalienceAnalytics.ca

ABSTRACT

Defence R&D Canada has been exploring the use of Visual Analytics (VA) for Maritime Domain Awareness, including the collaborative analysis of vessels of interest. Visual analytics applications have been devised and a collaboration infrastructure, including a multi-touch table and a knowledge wall has been defined and is being developed and integrated.

Author Keywords

Collaborative Visual Analytics, Multi-touch tables, Knowledge Wall, Maritime Domain Awareness, Vessels of Interest.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

In the context of modern defence and security operations, analysts and decision makers are faced with increasing amounts of dynamic information, which they need to analyze in order to understand a situation and react promptly. Fortunately, Visual Analytics has emerged as an efficient way of handling and making sense of massive data sets by exploiting interactive visualization technologies and human cognitive abilities [15].

Defence R&D Canada (DRDC) is conducting an applied research project to explore the applicability of VA to Maritime Domain Awareness (MDA), including the collaborative VA of Vessels of Interest (VOIs). A number of VA applications have been devised [2]. In order to support collaborative work, a collaboration infrastructure has also been defined and is being implemented. This paper reports on this effort. First, we describe MDA and VOI. Next we introduce collaborative working. We then elaborate on some collaborative VA applications and describe the collaboration infrastructure being elaborated in the project.

MARITIME DOMAIN AWARENESS AND VOI

"MDA is the effective understanding of everything on, under, related to, adjacent to or bordering a sea, ocean or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances that could impact the security, safety, economy, or environment" [7]. Of particular importance, is the monitoring of VOIs, which are ships that may constitute a threat to a country or ships that may require a special protection. The threats can be of various natures, such as national security (e.g. terrorism), law enforcement (e.g. drug smuggling, illegal migration) and regulatory (e.g. transportation of dangerous goods).

In Canada, the analysis and management of a VOI require the collaboration of various analysts from federal departments forming the Maritime Security Operations Centers (MSOC), to collect and analyze information about this vessel, to understand its intentions and assess if it may represent a threat. To this end, various pieces of information need to be visualized and put in perspective in order to determine where the ship has been, what activities it might have conducted and where it seems to be heading to. It may be necessary to visualize individual track details, for example to see if a rendezvous has taken place. Vessel behaviour may also be examined in relation to national or international events such as a G8 summit.

COLLABORATIVE WORKING

In many instances, the MSOC analysts need to collaborate within and across agencies. However there are significant constraints: each organization uses different applications; there are jurisdiction constraints in sharing information; and teams are spatially and temporally dislocated.

Over the last several years, interesting work has been conducted to support collaborative visual analytics. Heer and Agrawala [4] have compiled design considerations for asynchronous collaboration in visual analysis environments, highlighting issues of work parallelization, communication, and social organization. Robinson [11] reports on a tabletop experiment dealing with the collaborative synthesis of visual analytics results. This includes the notion of a collaborative workspace and information tags. Oculus has developed a multi-user tool known as nSpace to collect, organize, and add meaning to analysis artifacts [10].

In order to support the collaborative analysis of a VOI, DRDC's proposed solution considers both collaborative applications and a collaboration infrastructure. These are examined in the following sections.

VA APPLICATIONS

DRDC has devised, analyzed and mocked-up a number of potential VA applications for MDA [2]. Design and development principles have been identified:

- In order to facilitate the transition of new technology, a development strategy through a series of incremental "improvements" is privileged.
- Collaborative VA applications will be implemented as a set of services in a service-oriented architecture (SOA).
- These services will be implemented as software applications or "apps", which will be single purpose, transient and self contained.

The following VA apps have been selected or devised for the analysis of a VOI:

- **Mind Map with Time Slider** allows users to organize their ideas and capture the decision making process. A slider allows going back in time and seeing what was known at a certain point in time. Mind maps created by the analysts are interconnected and aware of each other.
- **Attention Maps** use a Theme River™ visualization to show the relative effort of all collaborators on a configurable set of topics [4].
- **Work Flow** supports developing and synchronizing process workflows.
- **Vessel Summary Cards** give key characteristics of a vessel visually, so analysts can rapidly flip through the information. Information is formatted so that the analyst can look for normally present or absent elements rather than having to read each card. The deck of summary cards can be visualized with a browser similar to iTunes, or played like a video, at varying speeds. Cards show a summary of the evolving consensus from all analysts.
- **Vessel Timeline** portrays events on a time line so that temporal patterns and temporal anomalies can be detected and analyzed. By displaying multiple timelines, analyses from multiple analysts can be compared and synthesized.

Figure 1 - Vessel Summary Card.

- **News and Chat River** visualizes which news and chat topics are currently attracting the most attention. This facilitates collaboration by revealing patterns in group activities, and draws analysts' attention to newsworthy topics.
- **Tag Browser** displays a collection of tags in a tableau format for rapid browsing, similar to iPhoto. Team members can tag events or objects in the various VA apps, insert yellow stickies to ask a question or state a hypothesis visible to other analysts.
- **Maritime Link Analysis** reveals patterns in relationships between objects, events, organizations, people, and abstract concepts. Analysts can share filtered and linked subsets of the whole dataset, and thus view the link patterns discovered by others. Yellow stickies can be inserted to ask a question or state a hypothesis that is visible to other analysts.
- **Geo-temporal Analysis** visualizes maritime chart in the X and Y axis and time in the Z axis, to reveal geo-temporal patterns, as done in GeoTime [10].
- **Time Slider on Ship tracks** provides a 2.5 dimensional view of the maritime domain using an interactive chart. Spatial information can be explored using standard zoom and pan controls, and temporal information can be explored using a smooth time-slider and a kinematic interpolation and extrapolation service.

Figure 2 - Time Slider on Ship Tracks.

- **Rendezvous Analysis** is an interactive "what if" tool to examine whether ships might be heading toward a rendezvous, and how assets might be able to respond.

COLLABORATION INFRASTRUCTURE

Enabling a collaborative environment has implications for both software and hardware infrastructures, as discussed in the following paragraphs.

Collaborative Software Elements

Collaboration between apps, whether under the control of a single user or multiple users, has been shown to be important for effective visual analytics [10]. The proposed solution will support multi-user collaboration between apps via shared software elements such as the following:

- **Analysis Log.** All apps by default will send brief summary reports of the work being done. Users can browse this long for team-awareness.
- **Tags.** Tags are small pieces of meta-information that are attached to data elements (e.g. text, image, task) and remain invisible unless specifically visualized. Tags set by analysts (and some software agents) insert meaning that can be tapped by the whole team.
- **Notifications**. Analysts (and some software agents) can publish notifications, and attach them to analysis products such as Mind Map entities, so that other team members exploring the same data will be aware of team insights.
- **Linked Views**. VA apps will routinely and effortlessly exchange "Analysis Sets" (e.g. a selection of vessels) so that, for example, objects selected in one view will be highlighted in the other views. This has been shown to be an effective way for analysts to identify patterns that transcend any single view [10].

Team-Defined Operational Picture

In accordance with User Defined Operational Picture (UDOP) concepts, team members can assemble the operational picture using a variety of apps, running on many portlets, on multiple displays, and if necessary in different locations. SitScape [14] for example allows users to easily aggregate and visualize disparate application and information sources into a collaborative UDOP for live monitoring, situational awareness, information sharing, and visual contextual collaboration.

Although the UDOP will be highly configurable, analysts will be more productive if the configurations are familiar to them. Thus when the team identifies a UDOP well suited for a specific situation, they can save and reload it as a "Thematic" or "Portfolio" view [3]. The use of personalized widgets and contextual menus will be examined, closely inspired by IdLenses [12] and FingerGlass [5].

Knowledge Wall

Perhaps the simplest model of collaboration is the Knowledge Wall, as shown in Figure 3. Control of the various portlets can be shared among an assembled team of analysts using keyboards and mice, each of whom can view contributions from the others in real time. Knowledge walls are already common in the Ops centres.

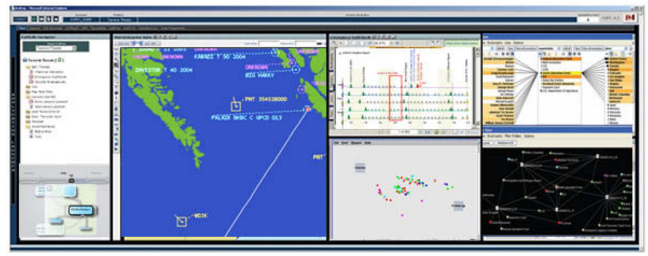

Figure 3 - Example of a VA Knowledge Wall.

Multi-Touch Table

"The use of a multi-touch table environment has much potential for use with visual analytics. The most exciting prospect is the ability for multiple analysts to simultaneously explore the same data/information space" [1]. A unique advantage of multi-touch tables is that at all times, all collaborators have equal opportunity to participate in the analysis – control is neither centralized nor passed from person to person. Users can gather around the display surface; eye-to-eye interaction is provided; information is at the users' fingertips; multi-touch interaction can improve user efficiency for several tasks; and globally, this can lead to improved shared awareness.

In the context of maritime operations, the map is key and would constitute the main element of information displayed on the tabletop surface. This has a close reminiscence with the former naval operation centers that used to lay out charts on tables [13]. The main map can be zoomed and panned using simple gesture interaction but not rotated. Other smaller portlets can be rotated for users along the different edges of the table.

Various techniques are available to track which individual makes each gesture so that roles, responsibilities and privileges specific to individuals can be supported, Techniques include instrumenting the users, using pens, smart phones, tracking users' locations around the tabletop, orientation of fingers or hand contour [12].

Workstation and Tablet Computers

A common collaboration pattern is to assign sub-tasks to individuals who work separately and then bring the results back to the collaboration space. Resources appropriate for those sub-tasks may range from tablet computers to multi-screen workstations. Tablets hold particular appeal because they can "move with the group" as collaboration takes different shapes, as sketched in Figure 4.

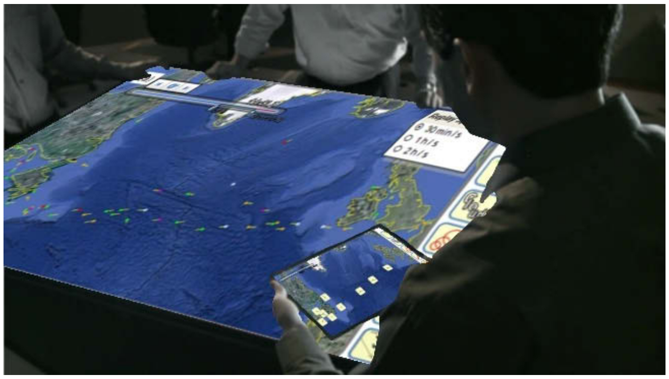

Figure 4 – Combining Personal Device and Multi-Touch Table Interaction (adapted from [9]).

Livespaces

One key component of the considered collaboration infrastructure is the use of Livespaces, an integration framework developed by the Defence Science and Technology Organization, in Australia, to support advanced meeting spaces and distributed multi-site collaboration [8]. Rather than developing collaboration services in each application, the collaboration services are provided by the framework. One of the services allows any user to easily take control of an applications running on a shared space, just by moving the mouse cursor off the top of his personal workstation. The knowledge wall and the multitouch table will be incorporated as devices integrated into the Livespaces framework.

Multi-Agency Common Space

As already indicated, there are jurisdiction and security constraints in the sharing information between the various MSOC agencies. The various agencies will be networked into a common area, using data diodes, in order to allow them to push and share information on a VOI. This shared area will be exploited by the collaboration infrastructure and applications.

CONCLUSION

Visual analytics of Vessels of Interest require significant collaboration between analysts. Through the use of mock-ups, DRDC has designed a number of collaborative VA applications and defined a collaboration infrastructure to respond to that requirement. Core design elements include connectivity between apps (e.g. through the use of tags and analysis sets) and configurable portlets shared between knowledge walls, tablets, workstations, and a multi-touch table, all integrated into a collaboration framework.

The next phase of the project will be to develop a prototype that will be used to validate the proposed solution, through proper experimentation. Advancement regarding the VA prototype will be described and discussed further in subsequent papers.

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