ProDV – A Case Study in Delivering Visual Analytics

Derek Overby  
Department of Computer Science and Engineering  
Texas A&M University

John Keyser  
Department of Computer Science and Engineering  
Texas A&M University

Jim Wall  
Department of Industrial and Systems Engineering  
Texas A&M University

Figure 1: The ProDV framework architecture defines data sources, data operators, processing modules, cached data, and visualizations to provide a simple visual abstraction of the visualization pipeline.

ABSTRACT

We present a custom visual analytics system developed in conjunction with the test and evaluation community of the US Army. We designed and implemented a visual programming environment for configuring a variety of interactive visual analysis capabilities. Our abstraction of the visualization process is based on insights gained from interviews conducted with expert users. We show that this model allowed analysts to implement multiple visual analysis capabilities for network performance, anomalous sensor activity, and engagement results. Long-term interaction with expert users led to development of several custom visual analysis techniques. We have conducted training sessions with expert users, and are working to evaluate the success of our work based on performance metrics captured in a semi-automated fashion during these training sessions. We have also integrated collaborative analysis features such as annotations and shared content.

KEYWORDS: Visualization system and toolkit design

INDEX TERMS: H.5.1 [Information Interfaces and Presentation]: User Interfaces—Graphical user interfaces (GUI)

1 INTRODUCTION

Researchers in the Visual Analytics community have developed custom software applications for a variety of domains. We present work performed in conjunction with the test and evaluation community of the US Army. Our goal was to provide useful visual analytics capabilities to several distinct groups of domain experts within this community. After developing software based on design requirements elicited from expert users, we provided guided training sessions to introduce various analysis capabilities. Through long-term interactions with these experts, we have begun to observe analysts using skills from prior training sessions to propose new analytic requirements. We discuss our implementation and several analysis capabilities that have been employed by expert users, as well as the development of user-specified visual analysis requirements.

2 PRODV DESIGN AND IMPLEMENTATION

Users of our system required the ability to import data from different sources and interactively explore data within coordinated multiple view (CMV) visualizations. Our design framework, which we refer to as the Process-Oriented Data Visualization (ProDV) framework, is based on a simple abstraction of the visualization process that can be represented visually and is easily understood by domain experts. Because early interviews revealed that domain experts were not familiar with computational algorithms or complex data structures, the framework components we define in our abstraction are based on a simplified conceptual model of the visualization process as compared with formal reference models that have been defined in the visualization community [1-3]. A conceptual diagram of our framework and the interactive visual representation is shown in Figure 1.

3 USE CASES

We have implemented a variety of visual analysis capabilities for our customer using this framework, including analysis of network performance, engagements, and sensor performance.

3.1 Network Analysis

To enable visual analysis of network performance, we provided data importers for Access, SQL, text, and PCAP data sources, as well as data operators for accessing packet data of various types, parsing date/time and IP address information from text, and filters removing erroneous or irrelevant values. The interactive visualizations used in these examples include a line graph, a stacked bar graph, a parallel coordinate plot, and a radial chart based on the Radial Traffic Analyzer [4]. The visualization shown in Figure 2 provides interactive zoom and filter operations with details provided by mouse-over interactions. After initial training, analysts were able to use the visualization to recognize expected data features such as dominant senders and receivers of data within various segments of the
network. Subsequently analysts were able to quickly recognize deviations from the expected network profile.

Figure 2: An interactive network analysis application built by domain experts using ProDV.

We also provided cluster analysis capabilities using an interactive node graph. This allowed analysts to discover groups of nodes that had significant network traffic between them, and thus verify expected results under varying degrees of network load and other conditions.

3.2 Engagement Analysis
Engagement data from simulated kinetic engagements involving direct force, such as firing weapons, was used in our second example. We provided multi-dimensional visualization capabilities in the form of a parallel coordinate plot and a radial chart depicting the weapon, shooter, and target of each engagement. Interesting behaviors became easily detectable using this analysis technique. For example, when simulation players were colored according to their affiliation, friendly fire incidents were easily discerned. Analysts also used the parallel coordinate plot to validate expected results for different weapon types.

We provided a spatial visualization of non-kinetic interactions such as message transmissions between nodes. This visualization provided the capability to view where certain expected network interactions took place. The example in Figure 3 was used to conduct detailed message thread analysis.

Figure 3: Non-kinetic engagement analysis. Example shows successful completion of a message thread by stationary and moving players.

3.3 COP Currency
We implemented a custom visual analysis capability defined by our expert users. The goal was to identify correlations between increased network latency and the currency of a player’s common operating picture (COP). We display a graph of a user-defined COP currency metric along with a geospatial visualization that allows the user to visualize the perspective of a specific player. Only one perspective can be displayed at a time, and the display shows the perceived and actual positions. The example in Figure 4 shows a low point of COP currency for a particular player.

Figure 4: COP currency visualization. Circles indicate actual player locations, diamonds indicate perceived locations.

3.4 Sensor Performance Analysis
We developed several visual analysis methods for identifying anomalies and conducting detailed analysis of sensor performance by combining traditional and new techniques. Using the custom technique shown in Figure 5, analysts were able to easily detect anomalous temporal sensor patterns from large datasets involving multiple spatial sensors recorded over multiple days. Additional analysis techniques enabled the identification of anomalous spatial sensor data and data collection errors.

Figure 5: Example of custom temporal pattern analysis visualization. Triangles indicate periods between signals.

4 Conclusion
We have shown how ProDV has been designed and developed to support multiple analysis modes within a specific community via several distinct use cases. We recently implemented several collaborative analysis features including annotations and content sharing, and are continuing our work by evaluating the long-term effectiveness of using this approach to enable collaborative visual analysis activities within this community.

5 REFERENCES


