Situation Awareness in Crisis Situations: Development of a User Defined Operational Picture

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ABSTRACT

This paper describes an effort underway to develop an operational concept and technical implementation for a User Defined Operational Picture (UDOP). The purpose of the UDOP capability is to create, visualize, and share decision-focused views of the operational environment for decision-makers to support accurate situation awareness and timely decision-making. Unlike a traditional Common Operational Picture (COP), a UDOP allows the user to select what information should be included in- or excluded from the data set defining the operational picture at the source. This paper provides an overview of the UDOP capabilities, as well as a description of the initial prototype implementation in an operational setting.

Keywords

Command & control, common operational picture, situation awareness, user defined operational picture.

INTRODUCTION

Emerging network-centric technologies will provide operators in command centers with access to unprecedented amounts of real-time information, and they offer the potential to enable Command and Control (C2) capabilities that improve operational effectiveness through shared situation awareness. Effective, intuitive, agile decision support and visualization capabilities will be a key driver of the shared awareness at all echelons of C2.

Supporting such shared awareness in a distributed C2 setting relies on creating a suitable Common Operational Picture (COP). A COP facilitates collaborative planning and assists the command in achieving consistent situation awareness. Today, large, cumbersome information products and data must be pushed, melded and exploited to produce useful operational pictures. This results in inefficiency and lack of agility and motivated the development of a User Defined Operational Picture (UDOP) concept, in which the information content can be tailored to meet the needs of an individual or community of interest (Loomis, Porter, Hittle, Desai, and White, 2008).

This paper describes the development trajectory of an operational concept of a UDOP. An overview is provided of the UDOP capabilities, as well as a description of the initial implementation of the UDOP in an operational field test. The UDOP concept development is part of the Situational Crisis Management (SCM) project in which an integrated security system was developed.

Related Work

Crisis Management and Emergency Response Systems

Myers, Malkin, Bett, Waibel, Bostwick and Miller (2002) describe a flexi-modal large displays tool to support collaboration, communication and overview for people in a military command post. They stress the importance of being able to interact with the system in different ways, depending on the situation. Jiang et al. describe the use of shared displays to support collaborative work of US firefighters operating under the incident command system (Jiang, Hong, Takayama and Landay, 2004). Holzman (2004) describes a system of different technologies to support emergency medical care in the field. The focus is on mobile, field-based information systems, communication between the care providers in the field, and the exchange of data between the field and hospitals.

Collaboration in Distributed Settings

Psychologists have repeatedly found evidence of lower productivity of distributed groups, in relation to face-to-face groups. They have attributed these performance issues to the extra communication costs for distributed groups due to reduction of useful cues in the distributed setting. McGrath and collaborators reported that "a reduction in cues such as eye contact and head nods [. . .] creates disruptions in the flow of communication" (Straus and McGrath, 1994).

The challenges for distributed groups pose a problem for emergency management groups who often collaborate in a distributed fashion—at times not ever having had the chance to meet face-to-face beforehand. A lack of any previous joint actions presents a large hurdle for newly formed groups to quickly and effectively share the relevant content and coordinate the work process; not least in part due to the group members' different areas of expertise or roles that imply different languages, responsibilities, and priorities (Bolstad, Cuevas, Gonzalez and Schneider, 2005). This increases the need for group members to quickly build enough shared knowledge as well as to continually maintain awareness of one another's actions and intentions in order to communicate, coordinate, and perform well (Bharosa, Janssen, Rao and Lee, 2008). The current development of a UDOP responds to this growing need.

Enabling the UDOP Capability

Visualization and Presentation

Several core pieces of functionality are needed to design a UDOP capability. The main focus of the current paper lies on visualization and presentation. Other functions needed are (1) data access and publish mechanisms to allow the UDOP capability to retrieve the data to be visualized and to share this information so that others can consume it and (2) domain-specific logic to create derived, added-value information products from the raw data inputs and displayed data and to extract insight based on the content therein (e.g. anomaly detection).

Once the necessary data products are retrieved into the UDOP environment, it must be visualized. The UDOP capability should allow the user to create and display a tailored information environment that stitches together multiple modalities of data (geospatial, temporal, tabular, textual, etc.).

Complete situation awareness relies not just on understanding the current circumstances, but also on how that situation evolved and how it is likely to progress into the future. Thus, the visualization tools should provide functionality to provide user-controlled animation between past, present, and anticipated future.

Any UDOP presentation should reflect the quality of the data used to build it, so that decision-makers are cognizant of the limitations in their knowledge of some operational situation. The network-centric warfare conceptual framework defines eight attributes that can be used to describe information quality: correctness, consistency, currency, precision, completeness, accuracy, relevance, and timeliness (Signori, Hollywood, Kingston and Gonzales, 2002).

Finally, any presentation of a certain set of information should be tunable to the needs of the different decision-makers. The UDOP capability will provide tools to perform this tuning. The following categories of content manipulation are envisioned:

• **Distillation**: Reduce or filter full data sets in an operational picture to focus on specific items of interest. Items not of principal interest may be hidden or de-emphasized in their appearance (icon size, color intensity, etc.);

• **Annotation**: Augment machine-based data with human-derived content (notes, explanations, visual features such as lines and arrows, etc.) that facilitates understanding and interpretation of the situation;

• **Aggregation**: Combine multiple entities in the picture into a single composite entity, which may use different or derived symbology. A common example would be to show several similar entities such as aircraft or ground units with symbols that denote groups of those entities.

UDOP CONCEPT DESCRIPTION

The concept development trajectory for the UDOP consisted of several steps:

• Literature review on common features for crisis management and emergency response systems to provide a state-of-the-art overview on C2 support systems such as COPs and UDOPs;

• Interviews and workshops with operational experts to establish a list of user requirements for the UDOP design;

• Integration sessions with operational and technical experts to couple the UDOP design with the involved hard- and software modules;

• Operational demonstration (or field test) to assess the UDOP on its functionality.

This approach in which theoretical concepts are materialized into tentative technology use and brought into field tests for evaluation to reach new insights for future design and re-design activities can be referred to as action-design research (Sein, Henfridsson, Purao, Rossi, and Lindgren, 2011).

Field Testing of Prototype UDOP

Sensor Integration Platform

Within the research scope several sensors were available to use in the operational test. These sensors (or data products) provided information to be integrated in the UDOP capability. These sensors included radars, IR/EO camera’s on ground and air, and blue force trackers. The aim was to cover the entire operational area of interest with the sensors available. Moreover, the research team studied how video feeds from (unmanned) aircraft could be integrated in the UDOP. Due to the flexibility in the observation positioning, an aerial system can fill in the blind spots of the fixed position sensors, thus providing continuity and, if desired, additional details.

The research team has worked on the integration and visualization of operational (sensor) information for the UDOP, in which the focus was on overview imagery that operators in the command post can use in an intuitive manner. For this, specific attention was focused on the enormous flow of information made available by the connected sensors and on how this information is displayed. This involved the data from various sensors being reduced to that which the user is interested in; i.e. abnormal behavior can easily be recognized (anomaly detection).

Test Scenario

A test scenario was designed together with operational experts, including representatives of the Dutch Army, Air Force, Navy and Military Police, to ensure a high level of operational relevance. The scenario was designed in such a way that specific technical functionalities of the UDOP could be tested. The field test was located at a military base in the Netherlands.

Scenario specifics were:

• Two vehicles each with two operators (friendly, blue forces) on a reconnaissance mission;

• Both vehicles equipped with an UDOP;

• One vehicle (unknown) enters the scene, pulls over, and two persons get out of the vehicle and act suspiciously;

• The participants (in total 6) were Dutch Army soldiers;

• The blue forces need to work together in a distributed manner and use their UDOP to identify and classify the unknown entity.

UDOP Capability in Field Test

The developed UDOP is set up as a geographic information system (GIS) application. Using GIS as a base for the UDOP offers flexibility to the use of the operational picture; i.e. several layers can easily be added or removed by the operator in the current GIS application. The functionalities that were implemented within the scope of the current research are built on the requirements following from the literature review and the feedback from the operational experts. The main features are presented below (Figure 1 shows an impression the developed UDOP):

• Adding different map layers to the application (forests, rivers, roads, railways, buildings);

• Choosing map services (satellite imagery, street maps);

• Zooming map in and out (with 3D view);

• Tilting map (with 3D view);

• Identifying track entity (person, vehicle, aircraft);

• Classifying track entity (friendly, neutral, hostile);

• Presenting list of entities detected;

• Creating draw layers and drawing lines, polygons and text on it with different styles;

• Importing images and (live) video feeds and georeferencing them;

• Interacting with tracks and objects within the video feed (changing track ID and entity, selecting buildings);

• Showing sensor coverage on the map (taking account of 3D obstacles such as buildings);

• Showing tracks in- and outside operational picture zoom (beyond line of sight view);

• Making (and sharing) snapshots of the operational picture;

• Showing operational picture zoom of other UDOP users (blue forces);

• Centralizing track in the picture;

• Showing age of the track by fading symbol image on the map;

• Adding label information to the track (speed, heading, altitude).

These features are all implemented and tested in the operational test scenario, i.e. in a physical product that was used on-site.

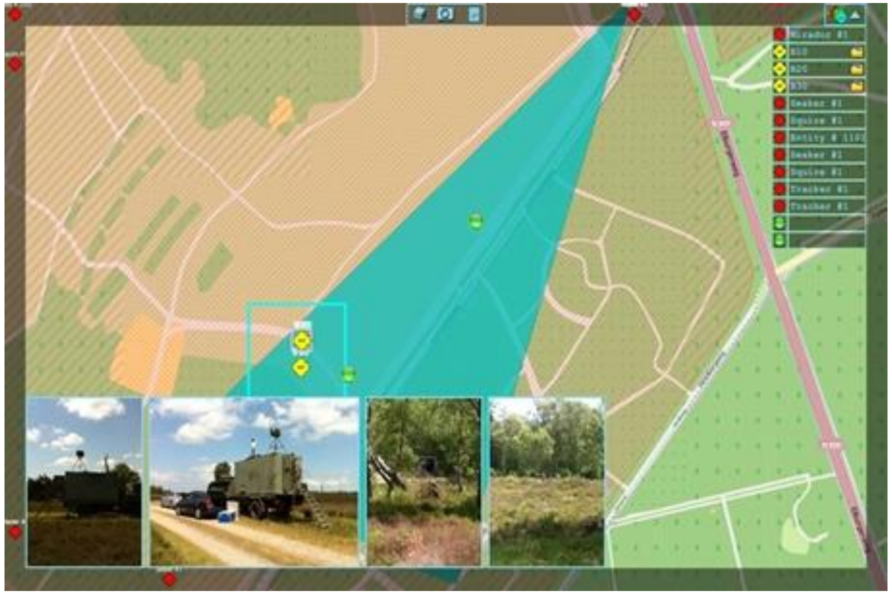

Figure 1. Screenshot of the developed UDOP in field test

UDOP Touch-based Interaction

The interaction of the operator with the UDOP occurred via touch. For the current field test a ruggedized tablet-sized device was used. As the research focus was on the functionality of the UDOP, the possible impact of the size and weight of such a device on its operational use was not considered explicitly.

RESULTS AND DISCUSSION

Some crises or emergencies demand fast and effective whole of responses, as their scale is beyond the handling capability of individual agencies or group of departments. This requires collaboration between numerous people and groups: the personnel at an incident site, in the emergency vehicles, at the command and dispatch centers, at hospitals, etc. The collaboration mentioned here often instigates several problems related to information sharing and coordination in such situations, such as lack of incentives for sharing, mismatch between goals, reliance on protocols or information overload (Bharosa, Lee and Janssen, 2010; Chen, Sharman, Rao and Upadhyaya, 2008). In crisis situations, situation awareness is of great importance to ensure efficient and effective team coordination and decision-making (Kulyk, Van der Veer and Van Dijk, 2008).

The purpose of a UDOP capability is to create, visualize, and share views of the operational environment to support accurate situation awareness and timely decision-making in a distributed net-centric C2 environment. Net-centric C2 architectures make available a considerable amount of information that can be injected into an operational picture; the UDOP capability enables transformation of that universe of data into a narrative of the situation tailored to meet the needs of an individual or community of interest.

The current work designed and developed an UDOP that enabled all of the required functionalities defined by operational experts. Generic functionalities for crisis management systems have been established (Nilsson and Stølen, 2011), as well as the challenges and hurdles that accompany the development of such systems (Kyng, Nielsen and Kristensen, 2006; Azadehdel, Dadashtabar and Enami, 2009) or the shortcomings of current situations (Bharosa, Lee, Janssen and Rao, 2009). Although the focus of the underlying work was on a military C2 environment, the implemented functionalities can also be of value in other crisis management or emergency response settings.

Situation Awareness for C2 Operators

The UDOP enabled the operators to see where the blue forces are located in the field (in- and outside their current operational picture zoom). The operators were also able to see what the blue forces could see; i.e. by looking at the operational picture zoom of other UDOP users. The use of a 3D perspective allowed for an actual insight if the operator is in the position the see beyond a certain building for example. This provides valuable information in an operational scene allowing for a better team coordination and situation awareness within the team of C2 operators.

Team coordination could also be improved with the use of drawing lines, polygons and text on the operational picture zoom, and thus adding specific information to the operational picture. A snapshot of this picture could be shared within the team with the purpose of creating shared (or team) situation awareness.

The UDOP enabled the operators to locate, identify and classify track entities in the field. Several functionalities implemented in the current UDOP assisted in this process and therewith improved decision-making for the team of C2 operators. The main functionalities that evoked this were:

• Adding specific label information to the track. The current study implemented speed, heading, altitude as label information, but also threat level (if available) could be considered for future work.

• Showing the age of the track by fading the symbol image on the map. Knowing when a sensor had last detected a specific track was very important in the localization of this track entity.

• Importing images and (live) video feeds and georeferencing them. If there was sensor coverage and the camera could shoot images and videos, the UDOP was capable of showing these feeds and appointing them on the map. This was possible because the UDOP has been set up as a GIS application. Being able to see the unidentified entities in live action surely was of added value in the process of identifying and classifying the tracks.

The operational demonstration was executed to assess the technical functionality of the UDOP (in isolation) in the field, not to validate the UDOP concept as a whole. Future work will focus on the validation of the operational concept and workflow with users, and to assess the concept's utility in real-world use.

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