Automated Dynamic Symbology for Visualization of Level 2 & 3 Fusion

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ABSTRACT

Symbols play an important role in identifying informative objects and are widely used in geo-spatial decision support systems and applications. In high-level fusion applications, however, simply placing symbols often lead to information over load problem; symbols quickly grow fast in many applications, such as the post disaster monitoring system we are interested in. This leads to cluttered and overlapped icons. With today's advanced technologies, new visual effects can lead to better visualization systems where iconic overload may be perceived as a problem. Therefore, conventional method of storage-indexing-retrieval of large sets of prepared icon images is not flexible enough for the visualization of higher fusion levels. Instead, we propose a dynamic symbology, which automatically generates symbols from parameterized components in a three-dimensional space. The extension to tactical graphics can provide better situation awareness from simplified and abstract visualization.

KEYWORDS

Symbology, information fusion, situation awareness, tactical symbol, visualization.

1.0 INTRODUCTION

A symbology refers to the methodology of symbolic representations and interpretations. It can simply mean established symbol sets for a specific use. Although the fundamental research has long been implemented in psychological fields, it has been actively studied and developed by military laboratories since the 1970s, when the automated data processing (ADP) systems were widely introduced to applications.

1.1 Issues on Symbols

The early symbology focused on evaluating human's visual preferences for graphical attributes of conventional military symbol sets [1], such as size, shape, color and text [2, 3]. For instance some experimental results showed that shape and color were superior to numerals for affecting hostility perception and shape was preferred more often than color, though the difference was small [4]. Human intrinsic and cultural backgrounds were also considered and evaluated in an investigation of natural associations between

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graphic symbology and concepts [5]. Evolving display technology has produced various types of symbols (Figure 1). Better displays, in the form of vector graphics and cathode ray tube (CRT), led to studies on additional visual attributes which utilize the inherent capabilities of the new display systems. That is, developing technology provided not only attractive and detailed displays, but also led to better visual factors that helped in effective visual cognition. For example, in the 1970s, researchers had to consider the jaggedness of icon outline due to the large pixels of CRT [3] (Figure 1-(d)), while a recent research investigated the usability of blurred images drawn on a high resolution display for uncertainty visualization [6]. Therefore, rather than specifying all the attributes of symbols and displays, researchers have set up display guide lines to obtain improved symbology based on the visual perception and human factor studies [7, 8].

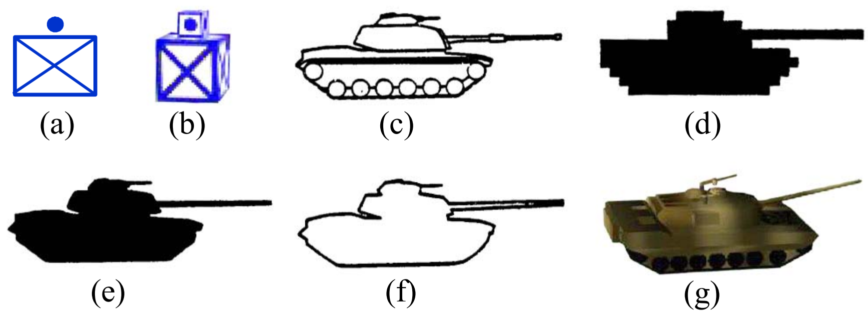

Figure 1: Various Types of Symbol: (a) tactical symbol, (b) image mapped on 3D cubes, (c) detailed icon, (d) blocked outline for larger pixel CRT, (e) filled silhouette, (f) outlined silhouette, and (g) detailed 3D model.

Task and tactic studies were not actively implemented until researchers realized its importance in the late 1970s. Well-organized goals and tasks were necessary for better abstraction, consistency and communication in symbol design. Early military study was implemented through a survey to experienced soldiers and the result showed that the most wanted tactical information categories are: friendly, enemy, time or capability, status, activities or procedures, terrain or route and planning, listed in the order of importance [9]. Based on extensive survey and with the help of experienced military tacticians, wide range of taxonomy, and the hierarchical structures were also developed [10]. Another advantage of the task and tactic study was the easy communication and work interoperability in joint military actions, such as with North Atlantic Treaty Organization (NATO) or United Nation (UN) peace-keeping forces [11]. Thus the topic of interoperability and compatibility became one of the main concerns and becomes a requirement to any collaborative tasks [12, 13]. Today's symbology also focuses more on flexibility in symbol generation and display. In the military case, past efforts on symbology were integrated in latest military war-fighting symbology standard MIL-STD-2525B [14].

1.2 Problems in Visualization

Limitations of conventional symbology are often found in a data intensive display, such as post-disaster visualization. Most informative objects can be identified with simple placements of symbols for the lower level of object identification (Level 0 & 1) [15, 16]. However, in higher fusion level of threat assessment (Level 2 & 3), decision support/making systems usually outputs so much information, that simple placement of symbols causes cognitive problems; a user could be overwhelmed with too many different symbols (Figure 2). As an approach to solution of these issues, we propose a dynamic symbology that synthesizes icon images and symbol components. Instead of conventional method of storing-indexingretrieving a large number of symbol sets, our system automates the parametric symbol generation for various symbol sets. Eventually, the parameters will be connected to fused outputs and user preferences will be seamlessly captured for both 2D tactical display, and 3D virtual environments.

2.0 SYMBOLOGY OF HIGHER FUSION LEVEL

Recent advances in symbology provide not only visual images, but also task planning and situation management functions, called *tactical symbology*. A tactical symbology can be categorized into two groups: *tactical symbols* and *tactical graphics* [14].

2.1 Tactical Symbols

Tactical symbols are objects that present information that can be pinpointed to one location at a particular point in time. The main role of tactical symbols is to show the identifications and locations of informative objects in a particular time. Unlike conventional method of retrieving indexed image files, the dynamic symbology controls all the components of a symbol. The main components of a symbol are *frame, fill, numeric, icon, text and graphic modifier*, as shown in Figure 2 (left). The mapping polygon is the base geometry on which the icon image is mapped, and can be extended to represent detailed objects in three-dimensional space.

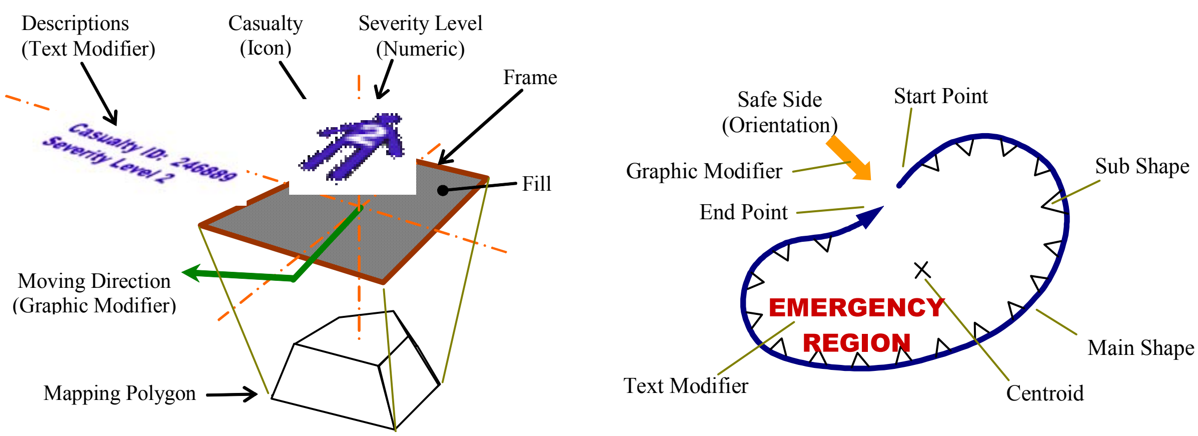

Figure 2: Components of a Tactical Symbol (left) and a Tactical Graphic.

2.2 Tactical Graphics

Tactical graphics are graphic objects that are necessary for planning and management. Figure 2 (right) shows the components of a tactical graphics for isolation task. Although the detailed images and descriptions of tactical symbols, tactical graphics often produce better results in situation understanding, especially for experienced users [17]. Because tactical graphics was elicited from task and tactic study, its integrative and goal-oriented characteristics are more suitable to higher fusion levels that require information aggregation for situation awareness (SA).

2.3 Seamless Transition in Display

The seamless display of higher fusion level can also help in situation awareness. LeGare describes it this way: "A seamless transition from a digital C2 (Command and Control) system screen to gaining contact with the enemy – with no surprise in between – is the truest indicator of situation dominance" [18]. However, most applications, such as digital tactical maps or battle field visualizations, usually have no relationship between tactical symbols and tactical graphics. Hence the design of dynamic symbology involves interaction between two symbol categories to obtain smooth transition. When connected to fusion outputs, it will display seamless transitions that give a user both detail identity and aggregated information.

3.0 AUTOMATION OF DYNAMIC SYMBOLS

The automation of tactical graphics can contribute to an improvement in SA. The parameters of tactical symbols and graphics can be obtained as an output of a fusion algorithm (Figure 3).

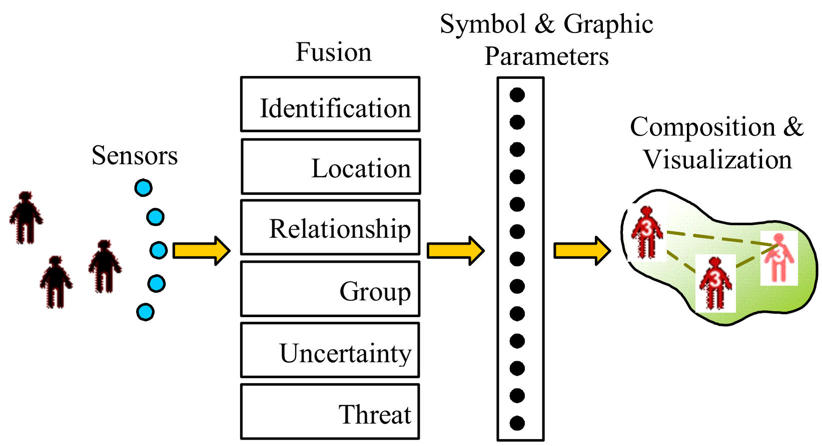

Figure 3: A Dynamic Symbology for Situation Awareness.

The dynamic symbology was designed for three-dimensional applications and was built by platform-independent software, using C/C++ and OpenGL, so that it retains interoperability between different operating systems. It utilizes DevIL (Developer's Image Library) for the internal image processing and can be adapted to CAVELib™ for the virtual environment (VE) simulation.

4.0 IMPLEMENTATION OF VISUALIZATION

Present research investigates usability of various visual effects available with advanced display devices. For instance, blurred icons can be used for uncertainty visualization for casualties [6]. Traditionally blurred symbol icons of this nature are image processed in Adobe Photoshop or a similar image editing software. This is a very time consuming process.

In the current work the symbology is dynamically created (no offline editing of image is required), thus making this a much more efficient method for creating blurred symbols. To demonstrate this advantage, a set of blurred tactical symbols was generated to show its usability for uncertainty visualization. Figure 4 demonstrates the use of blurred icons for uncertainty visualization. The icons were generated with Gaussian blurring to simulate uncertain casualties. The one at the center is for 100% certain casualty and the rest are blurred depending on the radial distance from the center.

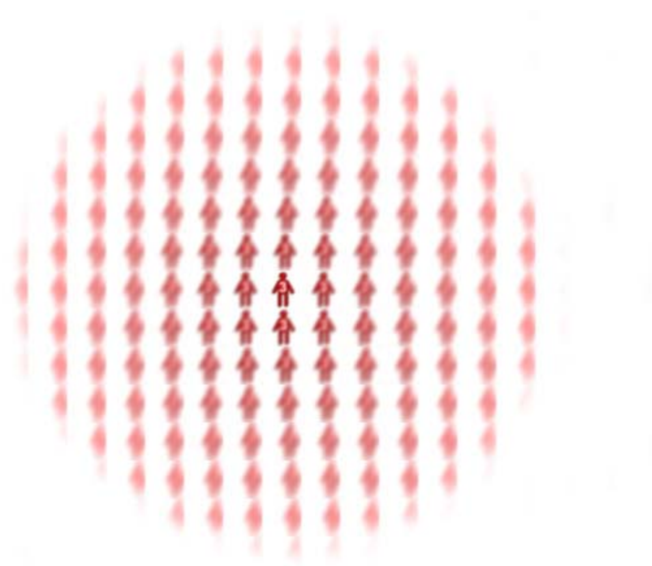

Figure 4: An Example of Automated Casualty Symbol – Visualization of Uncertainty with Blurred Icons. This dynamic symbology was simulated by a linear radial distance parameter as blurring factor. One hundred levels of icons were generated at run-time from just one JPG icon image file.

We have also implemented seamless transition concept during visualization (Figure 5). The icons of casualties with three severity levels are cluttered and overlapped in the raster map. As the visualization system gradually takes the realism of the raster map out of the display, it also puts information (shape and pattern) of the group. This gives the viewer better understanding of the situation.

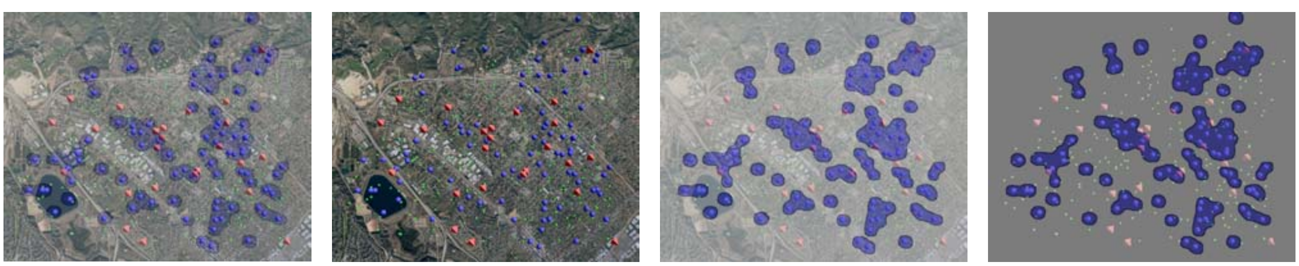

Figure 5: Seamless Transition of Display from Left to Right. Scattered casualties are grouped and the raster map is slowly replaced with visualization of pattern and shape.

5.0 CONCLUSION

A visualization system for a high level fusion demands a flexible and visually compelling symbology. As a component of the human-centered visual system for post-disaster fusion, we have developed a new dynamic symbology system to help higher level fusion analysis task that concerns situation awareness and threat assessment. The dynamic symbology is capable of composing the elements of symbols and automatically generating visual effects at run-time. Its tactical graphics can further contribute to better performance in situation awareness. Our system is platform-independent and works on both PC and UNIX/Linux based systems. It is capable of generating both 2D and 3D symbology. The future research will be focused on developing effective tactical graphics for a more refined and aggregated fusion visualization. We also plan to perform human factor study to evaluate the effectiveness of the dynamic symbology concept.

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