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Trends in Human-Computer Interaction to Support Future Intelligence Analysis Capabilities

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Track 5 - Collaboration, Shared Awareness, and Decision Making

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Abstract

Collective command and control (C2) civil-military operations impose a strong requirement for organizations and people to work collaboratively and to interact with information more efficiently. Human-Computer Interaction (HCI) technology has been evolving at a great pace during the last decade and many novel HCI concepts and tools have become of interest to support not only analysts deployed in command centers but also warfighters deployed in the field. This will have an impact on how intelligence officers will operate in the future. In this regard, Defence Research and Development (R&D) (DRDC) Canada has undertaken a major initiative to look forward into Future Intelligence Analysis Capabilities (FIAC). This paper reports on HCI trends and applicability to support the FIAC and collective C2 in general. Topics of interest include smart-room and collaborative working environments, hardware display technology (e.g. large group displays, flexible displays, wearable displays), mixed/augmented reality, mobile and ubiquitous computing, multi-modal interaction (e.g. touch tables, speech and gesture recognition), biometry, intelligent and adaptive user interfaces, and advanced information visualization that allows to analyze and comprehend multi-dimensional and complex information.

1 Introduction

The level of operational complexity facing (military) intelligence has hugely increased in recent times (DLCD, 2009). Recent confrontations have been largely characterized by (Poussart, 2011):

- a prevalence of asymmetric warfare such as in urban environments or when dealing with rogue states or terrorism;
- the emergence of cyber warfare;
- the emergence of instantaneous connections between the tactical and the strategic levels, and the increased linkages between the local, regional and global spaces;
- the complexity and diversification of human terrains and contexts;
- the conduct of Joint, Interagency, Multinational and Public (JIMP) operations; and
- the continued progression of Communication and Information Technology, which provides significant opportunities to better conduct military operations.

In order to address the new context of military operations, from an intelligence perspective, DRDC is conducting the FIAC project. The core objective of the FIAC is to advance the state-of-the-art of intelligence methods and resources in order to adapt to and anticipate the new challenges of the Canadian Forces (CF). FIAC addresses information services from an all sources perspective, over the full intelligence cycle but with particular emphasis on advanced analysis capabilities. It seeks, in particular, to achieve synergy between human cognition and machine intelligence, fully exploiting collaborative interaction. FIAC seeks to address the demands of intelligence in the modern operating terrain and the expanding uncertainties that the CF are facing.

Over the last year, a number of initiatives have been conducted to set the stage for FIAC. This includes the development of a white paper (Poussart, 2011), the production of an illustration of a future multi-intelligence center (Figure 1), the development of a fiction narrative of a future intelligence environment, the development of Operating concepts and a state of the art review of technological trends in terms of HCI and intelligence analysis capabilities. This paper reports on the advances in HCI that could be exploited in future intelligence environments and FIAC.

Figure 1- Illustration of a future multi-intelligence center (Poussart, 2011)

2 Future Intelligence Context

The purpose of intelligence is to provide commanders and staffs with timely, relevant, accurate, predictive, and tailored information about the enemy and other aspects of the area of operations. Intelligence supports the planning, preparation, execution, and assessment of operations (Department of the Army, 2010).

Military analysts need to assess, understand and predict the development of a situation. To this end, they need to handle a continuously growing set of information of different primitive data types and of different sources. Sources include: communication and electronic signal information, geospatial intelligence, imagery, meteorological and oceanographic information, human intelligence, open-source intelligence, as well as information from other government departments and allied countries.

With an ever-expanding set of sensing modalities and sophisticated sensing platforms, and this increased volume of data and information that they need to collect and process, analysts are faced with data and cognitive overload. There is a need for more efficient information management and analysis capabilities, as well as better HCI capabilities to support collaboration and interaction with information. These enhanced capabilities must be provided both for analysts in command centers as well as for deployed collators or analysts.

From an HCI perspective, future intelligence environments should provide the following capabilities:

- Support productive collaboration among analysts with various backgrounds and expertise (multi-intelligence);
- Support collaboration under a JIMP framework; and,
- Support multiple parallel theatres of operations and deal with several possibly but not necessarily intelligence requests.

3 Hype Cycle for Human-Computer Interaction

The design of HCI should take into account three interaction aspects: physical, cognitive, and affective. “The physical aspect determines the mechanics of interaction between human and computer while the cognitive aspect deals with ways that users can understand the system and interact with it. The affective aspect is a more recent issue and it tries not only to make the interaction a pleasurable experience for the user but also to affect the user in a way that make user continue to use the machine by changing attitudes and emotions toward the user” (Karray et al., 2008).

The field of human-machine interface continues to go through rapid changes with the introduction of new multi-sensory interfaces (speech, sound, haptics) and metaphors (gestures, avatar in augmented or virtual reality world, shared cognitive spaces). Large interactive displays, smart devices and embedded systems become more and more pervasive.

Figure 2 shows the status of HCI technology on the hype cycle, a graphic representation of the maturity and adoption of technologies and applications, showing emerging technologies as well as indicating which technologies have gone through convincing focused experimentation (slope of enlightment) and have found adoption (plateau of productivity) (Gartner, 2010).

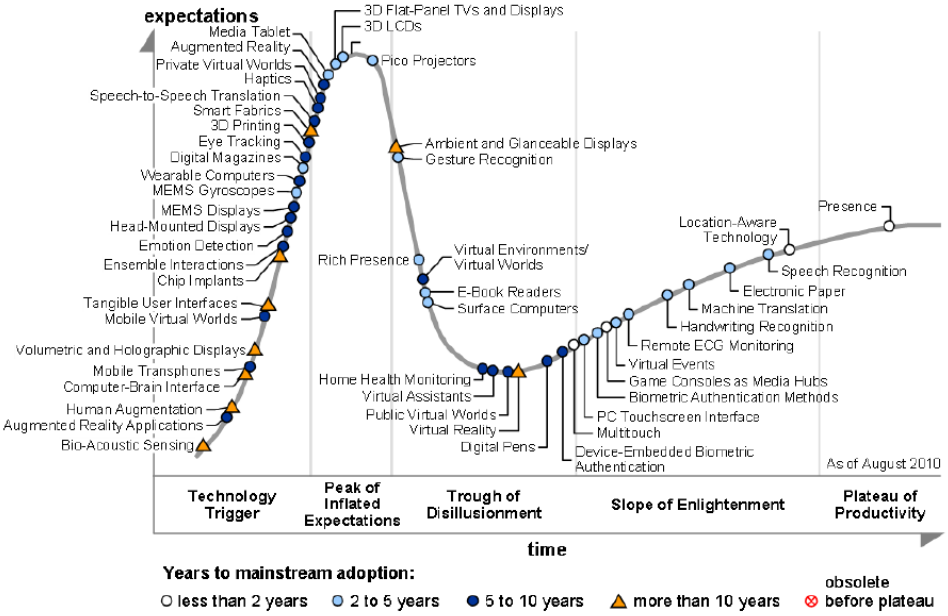


Figure 2 - Hype Cycle for Human-Computer Interaction, 2010 (Gartner, 2010)

The next sections examine a number of the most applicable or promising HCI technologies to support the military intelligence community.

4 Ubiquitous and Embedded Computing

Ubiquitous computing has been named the Third Wave of computing. The First Wave was the mainframe era, many people one computer. Then it was the Second Wave, one person one computer which was called Personal Computer era and now, Ubiquitous computing introduces the many computers one person era (Riva, 2005). People are able to interact with the technology that surrounds them in more accessible, intuitive and less restrictive ways.

In a growing ubiquitous computing world, computers will communicate through high speed local networks, over wide-area networks, and via infrared, ultrasonic, cellular, and other technologies. Data and computational services will be portably accessible from many, if not most, locations to which a user travels. Computation will pass beyond desktop computers into every object for which uses can be found. The environment will be alive and the addition of networked communications will allow many of these embedded computations to coordinate with each other and with the user.

Closely related to ubiquitous computing, location-aware technology includes sensors and methods for detecting or calculating the geographical position of a person, a mobile device or other moving objects. The most common location-aware technologies are Global Positioning System (GPS), Assisted GPS (A-GPS), Enhanced Observed Time Difference (EOTD) and Enhanced GPS (E-GPS). High-accuracy location technologies for private Wireless-Fidelity (Wi-Fi) networks also provide location services within buildings and hot spots (Gartner, 2010). Location-aware technology is key for situation awareness in the conduct of military operations.

5 Multimodal and Natural Interaction

“A multimodal interface acts as a facilitator of human-computer interaction via two or more modes of input that go beyond the traditional keyboard and mouse. The exact number of supported input modes, their types and the way in which they work together may vary widely from one multimodal system to another. Multimodal interfaces incorporate different combinations of speech, gesture, gaze, facial expressions and other non-conventional modes of input” (Oviatt, 2003).

5.1 Gesture Recognition

Gesture recognition involves determining the movement of a user’s fingers, hands, arms, head or body in three dimensions through the use of a camera; or via a device with embedded sensors that may be worn, held or body-mounted (Gartner, 2010).

The primary application for gestural interfaces at present is in the gaming and home entertainment market. However, for the military, the potential of hands-free control of devices, and the ability for several people to interact with large datasets, opens up a wide range of business applications, including data visualization and analytics, and the interaction with Large Group Displays (LGDs).

5.1.1 Handheld controllers

The commercialization of gesture interfaces began with handheld devices that detect motion, such as the Nintendo Wii’s three-dimensional (3D) controller (Figure 3a), 3D mice and high-end mobile phones with accelerometers. Sony has also revealed its alternative, called Move, which uses a handheld controller similar to the Nintendo Wii device, but claims greater resolution.

Figure 3a - WiiMote; Figure 3b - Xbox Kinect controllers

5.1.2 Camera-based recognition

Camera-based systems are now entering the market. One of the most visible examples is the newly launched Microsoft Kinect gaming controller for the Xbox 360 (Figure 3b). Using a webcam-style peripheral, it allows users to control and interact with the Xbox 360 through a natural user interface using gestures and spoken commands, and without the need to touch a game controller. Although it was intended for game play, developers saw the huge potential this low cost sensor could have for computer interaction and an open source PC driver was developed by hackers within days (hours). Microsoft announced they will support PC use of the Kinect motion controller (BBC, 2011).

Kinect is capable of simultaneously tracking up to six people, including two active players for motion analysis with a feature extraction of 20 joints per player, focused on the head, hands, feet and torso. However, Kinect is capable of tracking more points than those 20 points. For instance, Massachusetts Institute of Technology's (MIT's) Robot Locomotion Group and Learning Intelligent Systems Teams have shown that the Kinect can recognize ten fingers and some relatively small gestures, similar to the interaction shown in the movie Minority Report (Nosowitz, 2010).

A spin-off from the Minority Report movie, the G-Speak spatial computing operating system stands at the higher end of the market. It was developed by John Underkoffler at MIT Media Lab and now commercialized by Oblong Industries Inc. (Oblong, 2011). In addition to the camera-based gesture interaction (Figure 4), this system offers a management capability that allows data to be moved between different computing systems and displays.

Figure 4- G-Speak gesture interaction (Oblong, 2011)

5.2 Multitouch

“Multitouch refers to a touchscreen interaction technique in which multiple simultaneous touchpoints and movements can be detected and used to control objects in a user interface or other application. A user may, for example, zoom into a picture or Web page by placing thumb and index finger on a touchscreen and then moving them apart. To zoom back out, the user would then move the same two fingers back together…A multitouch user interface is becoming a must-have feature of smartphones, media tablets and portable consumer electronics devices… Multitouch will change use models and will have a significant impact on product design” (Gartner, 2010).

5.3 Multitouch Tables / Surface Computing

“Surface computers are large-screen displays that support direct interaction via touch or gesture (as opposed to external devices, such as mice or keyboards). They are typically horizontal, often built into the furniture, such as a table top, but may be delivered as vertical wall-mounted or free-standing displays. The displays incorporate much of the style of interaction (such as rotate, pinch, zoom and flick movements) found in multitouch devices but can typically recognize more than one set of touches at a time, enabling multiple users to interact or work collaboratively. Some also have the capability to recognize physical objects marked with a special identification tag, allowing context-sensitive information to be provided when items are placed on the display. Their size is constrained by the ability to physically reach across the surface. Larger displays may require a noncontact approach involving a gestural interface, where the user does not need to physically touch the surface” (Gartner, 2010).

In a military intelligence context multitouch table will likely be very valuable allowing various analysts to come together around the table to debate on a military situation.

5.4 Speech Recognition and Translation

Speech recognition converts spoken words to machine-readable input while voice recognition is a system trained to a particular user, which recognizes their speech based on their unique vocal sound. Transcription is the conversion of a spoken-language source into written / typewritten. Automatic translation is the conversion of a spoken-language source into another language and is still a very challenging task in terms of recognition of language structures.

Speech recognition can have large applicability in a military intelligence setting where input from deployed observers and collators are digitized or as part of collaboration activities where automated transcripts of discussions are produced. Considering that intelligence analysts need to digest messages and documents written in various languages, automatic translation has also a significant applicability. It also has applicability to the deployed collators interacting with local populations, using low-costs apps developed for the smart phones.

5.5 Emotion Recognition Multimodal Systems

People are able to perceive one’s emotional state based on their observations about one’s face, body, and voice. Research in multimodal systems have been conducted to allow the inferring of one’s emotional state based on various behavioral signals. A bimodal system based on fusing the facial recognition and acoustic information, provided an accurate classification of 89.1 percent in terms of emotion recognition of ‘sadness, anger, happiness, and neutral state’ (Karray et al., 2008).

In a military intelligence context, emotion recognition may provide valuable clues about a person’s stress level, intent, or trust level. This may be very important in a JIMP context where interaction takes place with people from various organizations, often through audio / video collaboration or in a context where interaction takes place with elusive and changing adversary.

6 Display Technology

6.1 Large Group Displays

For decades, command centers have been equipped with LGDs. However, these technologies are not always deployed and used effectively. In many cases, the usage contexts are not well thought through. Gouin et al. (2009) provide a number of human factor guidelines for the use of LGDs, including human perception/legibility, information organization and display control.

Technology for LGDs is continuously evolving, resulting in the availability of larger and more capable displays at lower costs as well as new interaction and collaboration technologies, such as the use of multi-modal interaction and more comprehensive support for co-located and distributed collaboration. Figures 5a and 5b show respectively a rear-projection display and a mosaic of LCD panels.

Figure 5a - BARCO OV-1015 100’’ SXGA+DLP Projection Module (Barco, 2011);
Figure 5b - Sharp PN-V601 60 Inch LCD Video Wall (Isignpak, 2011)

The Interactive DataWall (Figure 6) developed at the Air Force Research Laboratory (AFRL) is a good example of how multi-modal interaction can apply to LGDs. It is built using three horizontally tiled video projectors each displaying 1280 x 1024 pixels for a combined resolution of 3840 x 1024 pixels across a 12' x 3' screen area. The system also features speaker-independent voice activation and a wireless pointing device using camera tracked laser pointers (AFRL, 2001).

Figure 6 - AFRL Interactive Data Wall (AFRL, 2001)

6.2 OLED Displays

Organic Light Emitting Diodes (OLEDs) are a flat display technology, made by placing a series of organic thin films between two conductors. OLEDs are called organic because they are made from carbon and hydrogen. When electrical current is applied, a bright light is emitted. Because OLEDs produce (emit) light they do not require a backlight (OLED Info, 2011). Some key advantages for the military of OLEDs over today’s flat-panel technology (Liquid Crystal Dsiplay (LCD) or plasma) are that they can be ultra-thin, flexible (Figure 7a) and transparent (Figure 7b), have low power consumption, a greater brightness, a fuller viewing angle and can operate in a broader temperature range. This provides the potential for curved OLED displays, placed on non-flat surfaces; wearable OLEDs; and transparent OLEDs embedded in windows or truck windshields.

Figure 7a - OLED flexible displays (Pink Tentacle, 2011);
7b - Samsung transparent OLED display (CES, 2009)

6.3 Head-Mounted Displays / Retinal Displays

“Head-mounted displays (HMDs) are small displays or projection technology integrated into eyeglasses or mounted onto a helmet or hat (Figure 8). Heads-up displays are a type of HMD that do not block the user’s vision, but superimpose the image on the user’s view of the real world. An emerging form of heads-up display is a retinal display that ‘paints’ a picture directly on the sensitive part of the user’s retina. Although the image appears to be on a screen at the user’s ideal viewing distance, there is no actual screen in front of the user, just special optics (for example, modified eyeglasses) that reflect the image back into the eye. Some HMDs incorporate inertial sensors to determine direction and movement (for example, to provide context-sensitive geographic information) or as the interface to an immersive virtual reality application” (Gartner, 2010).

Figure 8 - Head Mounted Displays (Nowak, 2007); (Park Service, 2011)

6.4 Pico Projectors

"Pico projectors are very small projector modules which can be integrated into mobile devices such as handsets or laptops, or used to create highly portable projector accessories for mobile workers" (Gartner, 2010). An example is shown in Figure 9.

Figure 9 - Pico Projector (Microvision, 2011)

6.5 Advanced Workstations

Intelligent analysts need workstations where they can organize and interact with information efficiently. Large screen real-estate is necessary to display various information elements together. Vertical and horizontal planes are considered. Following are examples of interesting workstations.

Zenview is commercializing a multi monitor workstation (Figure 10a). National Information and Communications Technology Australia (NICTA) has developed a collaborative workstation, known as Braccetto (Figure 10b).

Figure 10a – Zenview Multi monitor display (High Impact PC, 2011);
Fig 10b – Braccetto collaboration workstation (NICTA, 2011)

The Benddesk workstation (Figure 11) is a prototype workstation combining a vertical display together with a horizontal display, allowing continuous multitouch interaction between both areas (Edwards, 2010).

Figure 11 - Benddesk prototype workstation

7 Smart Phones

Over the last two years, smart phone technology, has gone through significant evolution. “Multitouch, inertial sensors, accelerometers, location awareness, video analysis and even direction are all becoming standard functionalities for high-end smartphones, enhancing familiarity with these nontraditional sensory interfaces and encouraging the move toward useful augmented reality applications” (Gartner, 2010). See Figure 12 for examples.

In the United States, smart phones are being adopted to support military operations. A brigade at Fort Bliss, Texas is being modernized through a range of electronic devices, including smartphones, tablet devices, e-reader and mini-projectors. Dedicated military applications will be developed, including one that allows soldiers to track colleague’s locations on the battlefield. Special card readers will allow secure access to data (Mobile, 2010).

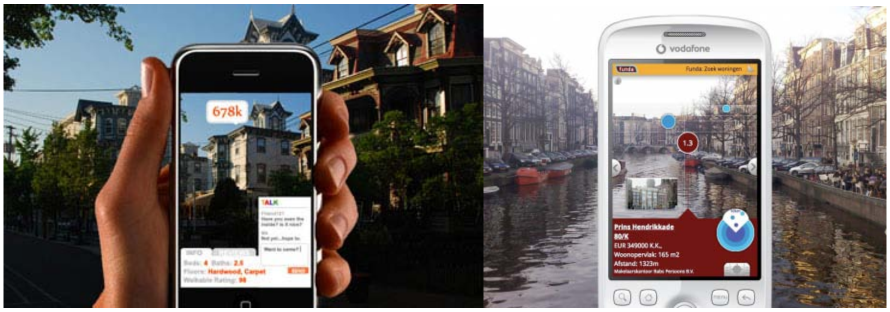


Figure 12 - Smart Phones with Augmented Reality (Zonkio, 2009) and (Moor, 2009)

One can think that a number of applications will be available for deployed intelligence collators and analysts, such as: conferencing, culturally-assisted translation, information aggregator, live status tracking, dynamic route finder (taking into account mission objectives and threats), biometry-based (e.g. facial) recognition, virtual assistant.

8 Collaboration Technologies

In a JIMP context, military operations are increasingly dynamic and complex and require significant collaboration and coordination between people from various military and civilian organizations.

8.1 Computer Supported Cooperative Work

Over the last several years, a diversity of tools has proliferated to support collaboration across distributed teams. This includes technologies such as audio / video conferencing, chat

/ instant messaging, electronic white board, application sharing, groupware, collaborative real-time editors, wikis, internet forums, blogs and microblogs, social network services (e.g. Facebook, Twitter), virtual worlds and crowd sourcing. Allied organizations are using these tools but belligerents are using them as well. Crowd sourcing has become a significant source of information when an emergency situation occurs and people report on it using cell phones video feeds and/or text messages.

8.2 Pervasive Human Sensing and Remote Assistance

Deployed military and civilian personnel could provide live data streams, using instrumentation such as head-mounted cameras, to a multi-intelligence center. These deployed personnel could also benefit from virtual assistance. Using HMDs collaboration could take place between deployed soldiers and a military specialist in a command centre. For example, using a bidirectional feed, the helpful advices of a translator, cultural expert, explosive device specialist, intelligence analyst or medical staff could be provided directly to a soldier in the field. Theses specialists could insert information directly into the HMD of the soldier. Local population could help soldiers on cultural and ethnic issues directly from a local command center and not be exposed as helping the forces.

8.3 Telepresence / Teleimmersion

Telepresence technology allows people to interact as if they were physically together in the same room. In telepresence videoconferencing, a higher level of fidelity is provided in terms of image and audio quality. Figure 13 is an example of Digital Video Enterprises (DVE) Telepresence system (DVE, 2011).

Figure 13 - DVE Telepresence system (DVE, 2011)

In a future telepresence setting, we could think that intelligence analysts will also be able to exchange documents just by moving them to the other participants, as if they were in the same room.

8.4 LiveSpaces

The Defence Science & Technology Organization (DSTO) in Australia has developed an environment called LiveSpaces, seamlessly integrating various technologies, to support both co-located and distributed teams engaged in intense collaborative activities such as analysis, planning and decision making (Phillips, 2008). These types of tasks have high cognitive requirements and cognitive abilities which can be easily overloaded when too much attention needs to be applied to simply managing and interacting with the environment, the devices, applications and required information.

Figure 14 shows an example of a LiveSpaces environment, where users have access to a range of shared displays including LGDs and a number of smaller displays used to provide ambient information and for activities such as video teleconferencing. The underlying LiveSpaces infrastructure supports various ways of managing, controlling, and interacting with the shared displays. As such, individuals can interact with the shared displays by simply moving the mouse cursor from their own screen onto the shared screens. Users can also easily share the information on their own screens with others. The LiveSpaces infrastructure also supports the federation of distributed sets of LiveSpaces.

Figure 14 - DSTO's Intense Collaboration Space, using LiveSpaces environment (Phillips, 2008)

9 Smart Room Environments

Smart room environments can be defined as physical spaces that encourage and enable better collaboration, more creative thinking, quicker decision making and increased productivity. Command centers will transform into smart room environments meant to support analysts and watch officers in their work. These environments will be equipped with a number of physical devices such as: large group displays, high-end analyst workstations, multi-touch tables, digital dash boards and ambient displays, telepresence and video conferencing equipment, multiple cameras and microphones, room and people sensors (motion detectors, acoustic analyzer, body tracker, eye-tracker), room controls (software-controllable lights and speakers), biometric authentication.

From a user experience and a capability perspective, smart room environments could provide: ubiquitous computing, adaptive user interfaces, speech recognition / speech transcription, scripted audio-video briefings, shared situation awareness, shared collaboration awareness (across meeting spaces), and supporting (recording, revisiting) the collaborative decision process. LiveSpaces (Section 8.4) is a good example of a collaboration infrastructure to support such a capability.

Naval Space and Warfare (SPAWAR) Systems Center Pacific in San Diego has developed a prototype of a facility of a Command Center called the Navy Command Center of the Future (CCoF). It is equipped with glass walls with many small video screens; a large video screen that serves as the central focus of those in the room; a small, and a private sound-proof room with glass walls that can automatically be darkened in case classified information needs to be discussed (Figure 15). On both sides of the glass-walled room, several video displays can be used to show live video, documents loaded by an artificial-intelligence system, news from commercial media, and just about anything the people need to see. Glass surfaces will allow decision makers to manipulate data and other information simply by running their fingers over the glass. CCoF would have Artificial Intelligence (AI) meant to discern what is being talked about during a teleconference and to know how to source up whatever documents are needed as they're needed. (Terdiman, 2009).

Figure 15 - Pictures of the Navy Command Center of the Future (Terdiman, 2009)

10 Mixed Reality

Mixed reality refers to the area between the two extremes of the real world and a fully virtual world (Figure 16). In mixed reality the merging of real and virtual worlds produces new environments and visualizations where physical and digital objects co-exist in real time. Augmented reality and mixed reality are now sometimes used as synonyms (Wikipedia, 2011b).

Figure 16 - Virtuality Continuum (Wikipedia, 2011b)

"Virtual reality provides a computer-generated 3D environment that surrounds a user and responds to that individual's actions in a natural way, usually through immersive head-mounted displays and head tracking. Gloves providing hand tracking and haptic feedback may be used as well. Room-based systems provide a 3D experience for multiple participants... The growing popularity of 3D entertainment using 3D glasses — and ultimately 3D screens and projections that do not require glasses — may relegate immersive virtual reality to permanently niche status" (Gartner, 2010).

Virtual Reality can provide value for intelligence collators by providing them with a platform to conduct a mission rehearsal in the environment in which they will operate, in particular in hostile urban settings.

Augmented Reality or mixed reality is a particular technology which allows adding sensations, images and information generated by a computer to the normally perceived reality (Figure 17). Additional information on the real environment such as images, writings and virtual objects are provided to the user through special visors worn by the individual or projection in his immediate environment. (Contactum, 2011)

Augmented reality applications, which superimpose information on the user's view of the real world, rather than blocking out the real world, will overtake virtual reality based on rapidly growing activity in the mobile marketplace (Gartner, 2010).

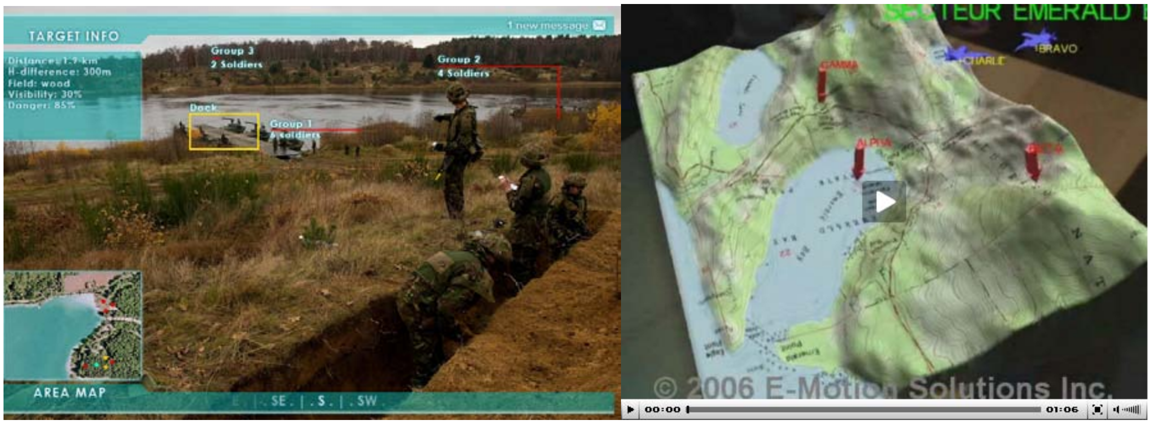


Figure 17a - Army Augmented Reality (Contactum, 2011);
17b - Mirage Augmented Reality system (Arcane, 2011)

The Mirage Augmented Reality System (Figure 17b) is a complete solution allowing you to create your own Augmented Reality experience by inserting virtual content to the real environment and using stereo video see-through OLED HMD (Arcane, 2011).

11 Biometry

Biometry refers to the automatic identification or identity verification of living persons using their enduring physical or behavioral characteristics. Among the features measured are: face, fingerprints, hand, handwriting, iris, retinal, vein, Deoxyribonucleic acid (DNA) and voice. Biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solutions. To be effective, a biometric system must compare captured biometric data to a biometric database. Emerging biometric technologies include: DNA, odor, facial thermography, nail bed, skin reflectivity and lip movement recognitions (GBT, 2011).

In a military context, biometry has the following applicability:

- Authentication. Security management of users to a facility (e.g. command center), computer. Security management of the privileges. Profile management of user roles and preferences.
- Identification / Recognition. Identification of belligerents. Forensics operations (e.g. scene investigation of an explosion).

12 Augmented Cognition

Augmented Cognition (Aug Cog) is an emerging field of science that has the explicit goal to extend a user’s abilities via computational technologies, which are explicitly designed to address bottlenecks, limitations, and biases in cognition and to improve decision making capabilities. It proposes to do this through continual background sensing, learning, and inferences to understand trends, patterns, and situations relevant to a user’s context and goals (ACIS, 2011).

Augmentation Cognition has significant applicability to military intelligence, as analysts must frequently perform cognitively demanding tasks in stressful environments. Defense Advanced Research Program Agency (DARPA), through its AugCog Program has developed technologies to mitigate sensory or cognitive overload and restore operational effectiveness by extending the information management capacity of the warfighter. This is accomplished via closed-loop computational systems strategies including (DARPA, 2011a):

- Intelligent interruption to improve limited working memory;
- Attention management to improve focus during complex tasks;
- Cued memory retrieval to improve situational awareness and context recovery;
- Modality switching (i.e., audio, visual) to increase information throughput.

13 Virtual Assistant / Virtual Advisor

A virtual assistant or advisor is a conversational, computer-generated character that simulates a conversation and that are capable of providing guidance, bringing updates, pointing to missing elements, and generating automatic triggers and alerts as required. A virtual assistant incorporates natural-language understanding, dialogue control, domain knowledge and a visual appearance that changes according to the content of the dialogue.

In a military intelligence context, virtual assistants will be growing in importance in terms of providing a natural and contextual interface between the user and an AI engine that will perform automated reasoning and knowledge management activities on the situation and information at hand. An interesting example of this is the DARPA initiative Personalized Assistant that Learns (DARPA, 2011b).

14 Advanced HCI Concepts & Techniques

14.1 Advanced information visualization / Visual Analytics

“Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces” (Thomas and Cook, 2005). “The basic idea of visual analytics is to combine the strengths of automatic data analysis with the visual perception and analysis capabilities of the human user. It uses visualizations, user interaction and data analysis techniques to find insight from complex, conflicting and dynamic information. Visual analytics is especially focused on situations where the huge amount of data and the complexity of the problem make automatic reasoning impossible without human interaction” (Jarvinen et al., 2009).

Figure 18 provides two examples of Visual Analytics. The first one shows a River Theme where the main news feeds are depicted in time and allow understanding which events have drawn more attention and in some cases, spun off other topics of interest. The second example is a Galaxy view based on the extraction of concepts from a large set of documents and the regrouping of the documents into concept clusters.

Visual Analytics is going through a significant growth. It will also be a technology of choice in the military intelligence world as analysts must digest vast amounts of collected data and make sense of them, identify patterns and trends. In particular, through the use of Visual Analytics, intelligence analysts will be able to (Thomas and Cook, 2005):

- Synthesize information and derive insight from massive, dynamic, ambiguous, and often conflicting data;
- Detect the expected and discover the unexpected;
- Provide timely, defensible, and understandable assessments; and,
- Communicate assessment effectively for action.

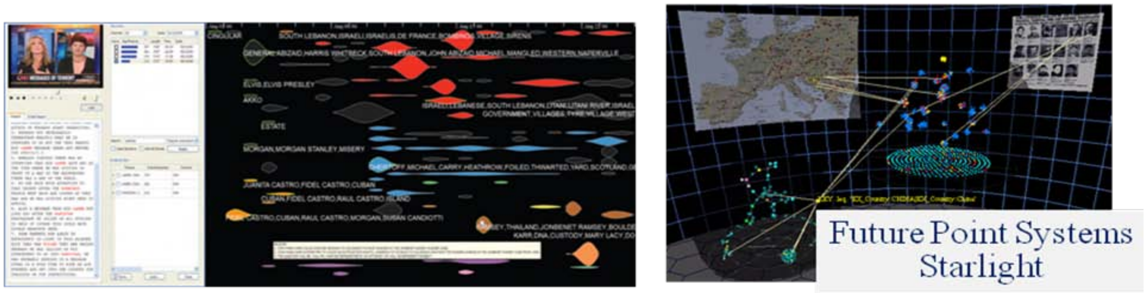


Figure 18 – Visual Analytics examples: River Theme visualization (Ribarsky, 2009); Galaxy visualization (Future Point, 2011)

14.2 Context Sensitive / Adaptive User Interfaces

An adaptive user interface changes its layout and element of information based on the user roles, his needs and preferences. This allows tailoring the interface to the task at hand. Adaptive user interfaces are also good to overcome the information overload problem by focussing on the required information and processes. Eye-tracking could be used to observe where the user is looking at and customize accordingly the user interface.

14.3 Advanced Interface Widgets

A widget is an element of a graphical user interface that displays an information arrangement changeable by the user, such as a window or a text box, and enabling direct manipulation of a given kind of data (Wikipedia, 2011a). Interface widgets can significantly facilitate the task of a user. Slap widgets (Figure 19) are physical interface components that add movable, tactical controls to a device such as a multitouch table.

Figure 19 - Slap Widgets (Weiss, 2009)

14.4 Smart Lenses

As illustrated in Figure 20, smart lenses technology, such as the Pliable Display Technology from Idelix Systems, allow a user to handle vast amounts of data and accurately interact with critical details in context (Baar and Shoemaker, 2004).

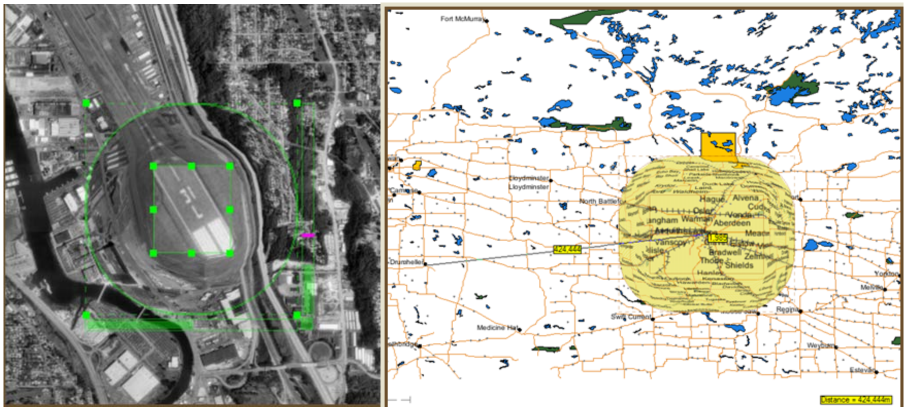


Figure 20 - Examples of Smart Lenses from Idelix (Baar and Shoemaker, 2004)

15 Precision Information Environments

In order to appreciate how the evolution of HCI could benefit future intelligence analysis, it is very informative to examine the work carried out by the US Department of Homeland Security (DHS) and Pacific Northwest National Laboratory (PNNL) to design and develop future work environments for the emergency management community. Called Precision Information Environments (PIEs), these environments are meant to provide planners and responders with precise, relevant information and with tools that aid collaboration, information sharing, and decision support (DHS / PNNL, 2010).

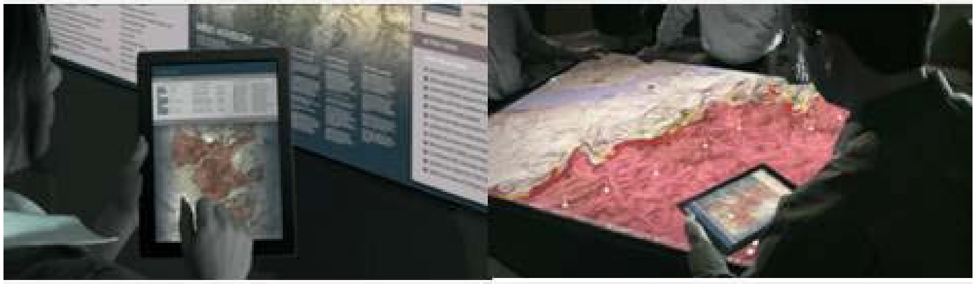
A video illustrating the concepts of a PIE environment to support fire fighters has been developed (DHS / PNNL, 2010) and exhibits many of the HCI trends described in the current report. Some of the key concepts are the following:

- **Pervasive Sensor Network.** Live data streams from instrumentation in the field give emergency management personnel an intimate view of remote conditions.
- **Synthetic Environments.** Data feeds from the field are synthesized into a navigable virtual environment through which collaborators can better understand an event and explore response strategies.
- **Adaptive User Interface.** User models define the roles, responsibilities and perspectives of each person using a PIE. Software interfaces adapt their form to support each user's tasks and preferences (Figure 21a).
- **Live Status Tracking**. The tasks of every PIE user are tracked so that a clear picture of a response activity is always available (Figure 21b).
- **Seamless Information Transfer.** Through natural interaction, information can be moved from one interface to another; relevant information follows the user and adapts its form to the device on which it is shown (Figure 21c).

- **Multimodal Interaction**. Use of surface computing is used for collaborative interaction towards shared situation awareness and decision making (Figure 21d).

a: Intelligent / contextual desktop

b: Smart dashboards



c: Gesture-based drag-and-drop

d: Surface-computing collaboration

Figure 21 - Illustration of Precision Information Environments concepts (DHS / PNNL, 2010)

Intuitive Collaboration. Distributed users can interact with each other and with PIE software as if they were co-located. In the illustration shown in Figure 22a, distributed collaborators interact easily with each other and with the information using a live wall. Remote-users are embedded in the image, in mirror mode in order to reflect when they look at the same information on live wall.

- **Advanced HCI Widgets.** Users are provided with advanced graphical user interface widgets and natural interaction mechanisms (Figure 22b).
- **Seamless Communications.** Information that is relevant to the user given his role, mission and context is automatically presented, and in form appropriate to the device on which he is interacting.
- **Ubiquitous Displays.** The PIE architecture allows information to be shared across devices easily (Figure 22c); to support more in-depth analysis, the view from a mobile device can be shared with a nearby display. As illustrated in Figure 22d, the truck's windshield, equipped with an embedded OLED display, is used as an alternate display and controlled by the wrist computer as an input device.
- **Decision Support in the Field.** Personnel in the field will have as much computational support as those in the operations center. By understanding each user's tasks, PIE offers customized data and recommendations.
- **Augmented Reality.** New interfaces will give users a unique view of their world, populating it with context-sensitive, task-appropriate information.

a: Live wall / distributed collaboration

b: Advanced HCI widgets

c: Wearable displays

d: Ubiquitous computing / novel devices

Figure 22 - Illustration of Precision Information Environments concepts (DHS / PNNL, 2010)

16 Conclusion

The nature of military operations has changed significantly over the last decade. Asymmetric warfare, urban and human terrain settings have increased the complexity of these operations. Military intelligence analysts are faced with a huge amount of information, of various types, which they need to make sense of, in order to improve overall situation awareness. They also need to collaborate with different military and civilian organizations within a JIMP context. Luckily, communication and information technologies have progressed significantly to support them in their work.

In particular, new and future HCI technology provides significant opportunities to support deployed intelligence collators as well as analysts working in command centers. The trend in ubiquitous communications and computing will continue and people will be able to interact with the technology that surrounds them in more accessible, intuitive and less restrictive ways. Smart phones / smart personal device assistants have gained a significant momentum and will be provided with a large variety of advanced intelligence applications, such as augmented reality and culturally-assisted translation. Smart room environments will provide better shared multi-intelligence situation awareness and collaboration. Multimodal and natural interaction will be the common interface of the future. Systems will be designed with intelligent, adaptive interfaces, understanding the user roles and the situation at hand. Advanced visual analytics approaches will allow to derive insight, identify patterns and trends. Virtual / synthetic environments will be used to predict situations.

Although this paper is focussed on the military intelligence capabilities, it would be of interest to broaden the scope and engage in a multi-agency, joint and coalition discussion. The HCI trends identified in this paper could be revisited and see how applicable they would be to modern defence and security operations, considering activities such as humanitarian assistance and disaster response coordination.

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