Naturalistic Ecologically Designed Ontology for Human-System Interaction in Immersive Environments

NDIA Human Systems Conference
Feb 4-5, 2014
Arlington, VA

Session 1: Systems Interface and Cognitive Processing

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The Problem

- DoD networks include vast array of intelligence sources (e.g. GEOINT, HUMINT, SIGINT) and non-intelligence sources (e.g. Spot Reports, After-Action reports etc.
- Various repositories hold numerous data sources in a variety of modes (e.g., text-based information, UAV or point of view videos, photographs, and audio files).
- Wading through vast amounts of information to acquire and maintain SA requires high levels of cognitive processing in order to perceive, comprehend and predict results

- Existing human machine interfaces require the intelligence analyst to continually reorient themselves to the mission and/or situation as they transition between data sources.
- Using interfaces within the real world (eg. mice/keyboards) while attempting to become a part of the virtual world can cause cognitive competition between the two environments
- The analyst is therefore unable to establish a primary egocentric reference frame – which prevents establishment of presence

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A Vision

IIVE UAV FEED
ALERT
ALERT
UAV SENDING DATA
4 ARMY MEDICAL TEAM
23N 1334S
FINDING LOCATION
GPS SYSYEM READY
ID: 732110029-005
STATUS - ACTIVE
FINDING LOCATION
GPS SYSYEM READY
ID: 732110029-005
STATUS - ACTIVE
LOADING DATA
JETS ONLINE
WEAPON READY
ID: 732110029-005
STATUS - ACTIVE
94%
Pressure detected 94%
Pressure detected 94%
2 ALERTS
COMMANDER
ONLINE
id# 21349772
2 ALERTS !!!
LOADING DATA.

The Challenge of the Remote Task

- Intelligence task is often done at locations far outside of the areas of interest
- Remote intelligence analysis allows an analyst to work on the same scenario, area, or human network for months or even years
- Systems used for intelligence analysis do not have to be scalable, or rugged, or otherwise portable

Major disadvantage:

- Analysts have physical detachment from the combat arena
- Lack of environmental presence, or spatial presence, can lead to increased workload
- Decreased critical SA and potentially impact decision-making abilities

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Potential Solution: Immersed VE

Rich, fully-immersive synthetically-augmented environments have been deployed successfully in several domains

- Naturalistic interactions with data and objects in virtual world
- Allow for creation and maintenance of a primary egocentric reference frame
- Optimize transitions between real world and virtual world through ecological design

Potential solution:

A naturalistic, ecologically-designed interface between the human and the fully-immersive synthetically-augmented environment can increase feelings of presence and immersion in addition to increasing situational awareness

Strategies to Enhance Cognitive Performance

- Model the operator’s Decision Making process,
- Identify techniques and cues within the immersive environment that may improve contributory components of the decision making process, and
- Apply those immersive cues to improve operator’s situation awareness and resultant decision making performance

Modelling Decision Making

- Identify cues within the immersive environment that may improve contributory components of the decision making process
- Apply those cues to improve the operator's SA and decision making performance
- The cycle is broken down into two sub-processes:
  - **Foraging loop:** gather information that is associated with the hypothesis/question being evaluated in sensemaking loop
  - **Sensemaking loop:** the analyst creates schemas and hypotheses based on the evidence extracted during the foraging cycle
- After developing hypotheses, a top-down process is used to determine if it is supported by all of the information provided.

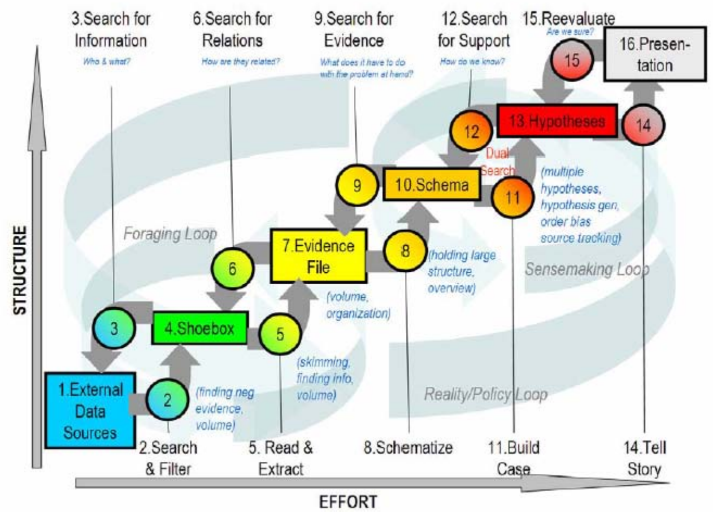

Figure 1. Think-Loop Diagram (Pirolli & Card, 2005)

Enhancing Presence in VE

Presence requires constant sampling of environment to determine responsiveness, judge realism and believability, and anticipate how it will react

Primary Egocentric Reference Frame (PERF)

- Individual's first person mental-model vantage of the world

To enhance presence VE, Witmer & Singer (11) have identified influential categorical factors that can be manipulated in interface design

Control	Sensory	Distraction	Realism
Degree	Modality	Isolation	Scene realism
Immediacy	Environmental Richness	Selective Attention	Information consistent with objective world
Anticipation of effect	Multimodal presentation	Interface Awareness	Salience
Mode	Consistency of Multimodal information		Separation Anxiety
Physical Environment modifiability	Movement Perception		Disorientation
	Active Search capability		

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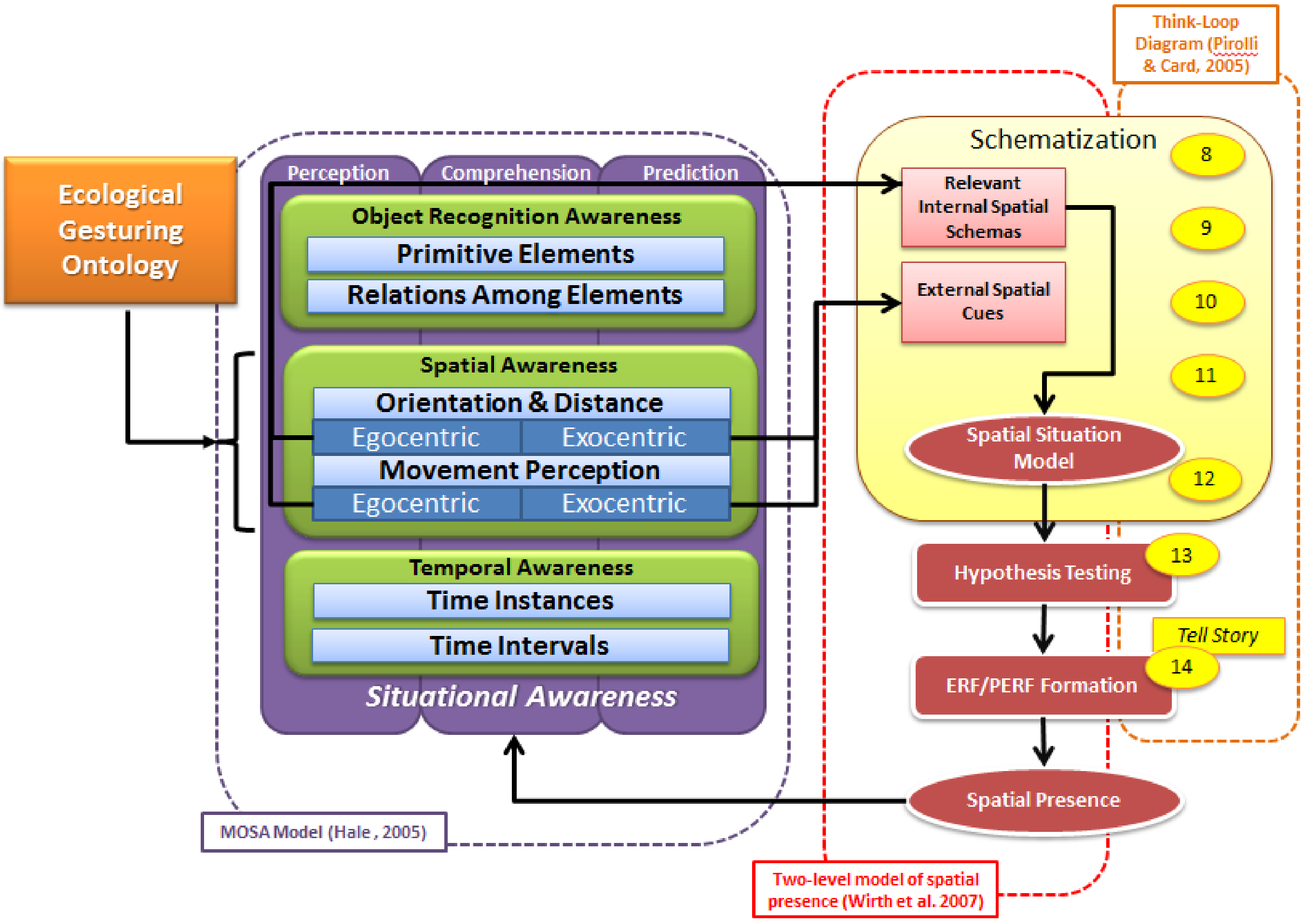
Performance Tradeoffs

Consideration	Description
Degree of Control	Operator will be able to select the desired sensor system for display and processing or inhibition.
Immediacy of Control	System response times to the operator's inputs will be minimized
Anticipation	System processing functions, display selection and formatting will be consistent for all operations and maintain a uniform appearance
Mode of Control	Multimodal interactions are recommended to allow expanded operator cognitive capacity through use of appropriate pairing of cognitive processing requirements with task requirements

Gesture
Voice interaction
Tablet/touch screen

Other considerations: Physical Environment Modifiability; Sensory Modality; Environmental Richness; Consistency of Multimodal Information; Degree of Movement Perception; Active Search; Interface Awareness; Selective Attention etc.

Ecological Multimodal Ontology



Multimodal Ontology

Task	Action	PERF/ERF	Task/Technology Considerations	2015	2025
Navigate Three-Dimensional Terrain Maps	Turning Left, Right, Up, Down	Degree of Control, Immediacy of Control, Anticipation of Events, Mode of Control, Degree of Movement Perception, Active Search	Naturalistic movement is walking; not all technology space support walking. Users should be able to "walk" to a given location, and fly to farther locations.	Gesture: non-dominant hand moves left, right, up, down	Gesture: Slight seated leaning, head tracking
Navigate Three-Dimensional Terrain Maps	Moving Forward & Backward	Degree of Control, Immediacy of Control, Anticipation of Events, Mode of Control, Degree of Movement Perception, Active Search		Gesture: Non-dominant hand extension (forward) and contraction towards the head (backwards)	Gesture: Slight seated leaning

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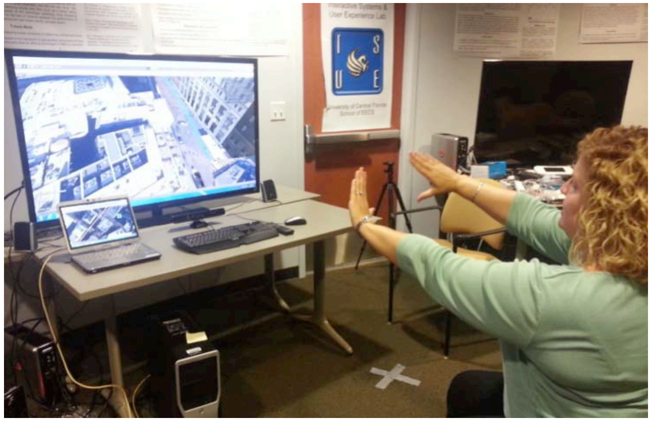
Application of the Ontology

Step	Task	Interaction	Attentional Focus	Considerations
1	Open UAV Feed Window	Voice Command	Heads-up Immersive Environment	Allows eyes-on UAV from Frame 1
2	Resize UAV Feed Window	Two-handed Gesture	Heads-up Immersive Environment	Maintains eyes-on UAV feed
3	Pan 3D Terrain	Non-Dominant Hand	Heads-up Immersive Environment	Frees up dominant hand for note-taking, other tasks; maintains eyes-on UAV feed



Future Considerations

Current Technologies	Future Integration
• Gesture recognition devices • Touch Screen sensitivity • Motion based recognition • Posture recognition • Voice recognition systems • User Identification techniques • Synthetic Augmentation of contextual information • Pointing devices • Augmented Cognition	• Anomaly detection programs • Automated assistance for prioritization and selection of sensor sources • Algorithmic generated recommendations for operator actions • Adversarial reasoning programs • Enhancements in Computer Vision techniques • Synthetic augmentation for sensor fusion

Concluding Remarks

- The Ecological Multimodal Ontology provides a framework for executing task within VE
- Ontology can provide interaction design and information presentation guide for optimizing decision making, SA and presence
- Ontology applies to enhancing traditional workstations through fully immersive VEs
- Applies to multiple domains analogous to ISR activities
    - Emergency incident command
    - Security and law enforcement operations
    - Unmanned system supervision and sensor control
    - Human-robot mixed team interaction and collaboration

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