Augmented Cognition

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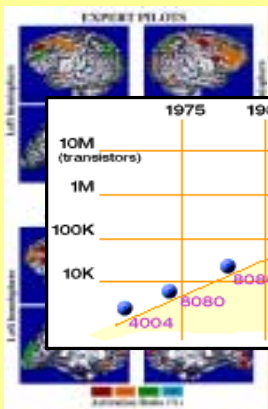
more of
Bringing the Brain on Task

Objective:

1, 2, or 3 Order of Magnitude Improvement in Net Human-Machine Information Capacity, Symbiotic Marriage

Symbiotic Marriage

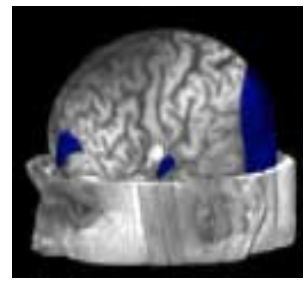
AugCog



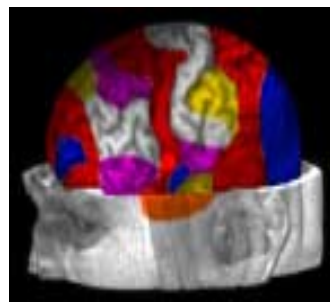
Decade of the Brain fMRI

Moore's Law

Cognitive Revolution



A Brain on Today's HCI



A Brain on Augmented Cognition

This Will Improve and Enhance the Quality of Military Decision Making

Cognitive and Neural Components

Capability:	Challenge:	Metrics:
1. Cognitive SET Management ✓ Cognitive re-load ✓ FMIQ interface ✓ Recall reset	➢ Representation of situations in ready to use format ***CET: Multimodal coding; Rich tagging***	• Rate of alternation of attention across n-tasks ***Impact: Graceful degradation under intervention***
2. Contextual Tracking ✓ Impedance Matching ✓ OPAM: Mode sentry ✓ Auto track ✓ Sensory Mode Optimization		
3. Cognition on Task ✓ Cognitive performance enhancement; DSO ✓ Memory, skills, etc. ✓ Veridical analysis		

Bringing More of the Brain on Task → New Class of Results

1. Cognitive SET Management

- Hard problems
  A. Rapid Context Switching
  B. Designing Interfaces Based on Cognition
  C. Developing Decision Forecasting Tools that Exploit Human Inquisitiveness

Cognitive SET Management (1A):

Rapid Context Switching

- Today: Limited transfer of information to the human when transmitting in parallel via different sensory channels; not enough is known about the parameters of each sensory channel, and very importantly how they interact.
- AugCog will: Develop guidelines and implement autonomous sensing and sensory channel mode switching algorithms to achieve optimal exploitation of channel bandwidth and facilitate mapping based on different types of tasks.
- How: Develop multimodal interactions to expand sensory channels that reduce cognitive crossmodal interference and attentional costs. Construct multimodal prioritization guidelines that enable judicious sensory channel use and manipulation. Create task by mode matrix of interoperability to productively map task categories onto modality properties.

Cognitive SET Management (1B):

Designing Interfaces Based on Cognition

- Today: Graphical User Interfaces are organized by application, not by content; and largely a single modality – vision.
- AugCog will: Develop “Cognitive Interfaces” – interfaces designed to meet the capabilities and limitations of the human cognitive system.
- How: Develop information representations that map directly onto human intuitive processes; a cognition-centric, technology based language of sight, sound, touch, smell, etc (vice text). Integrate and optimally present information in serial / parallel, by modality (vision, audition, etc.), within modality (e.g., vision – color, texture, size, motion, shape; audition - tone, pitch, timber, volume) based on cognitive capabilities and limits. Enrich stimuli to optimize accurate, fast comprehension in an intuitive, affordance-based design that reduces the processing bandwidth used by each chunk of information.

Cognitive SET Management (1C):

Developing Decision Forecasting Tools that Exploit Human Inquisitiveness

- Today: "What-if, fast-forwarding" results are typically calculated and displayed based on default visualization techniques (such as monotonic trend lines) which do not exploit human inquisitiveness, and in no way portray what is *not* likely to happen.
- AugCog will: Demonstrate forecasting tools and displays that provide a sense of "what might, what won't, and what it means" with, for example, knowledge net representation.
- How: Develop models of preference and tendencies based on cognitive style. Adapt intelligent software agents to accommodate information preferences; customize information/knowledge space (customizing a desktop but with cognitively-informed complexity).

Cognitive and Neural Components

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1.Cognitive SET Management ✓ Cognitive re-load ✓ FMIQ interface ✓ Recall reset	➢ Representation of situations in ready to use format ***CET: Multimodal coding; Rich tagging***	• Rate of alternation of attention across n-tasks ***Impact: Graceful degradation under intervention***
2. Contextual Tracking ✓ Impedance Matching ✓ OPAM: Mode sentry ✓ Auto track ✓ Sensory Mode Optimization	➢Effective external monitoring and match to computer mental model ***CET: Representation of CMM states are identifiable in system behavior***	• Fewer dead ends • Fewer failure paths ***Impact: Confident Tactical Replanning***
3. Cognition on Task ✓ Cognitive performance enhancement; DSO ✓ Memory, skills, etc. ✓ Veridical analysis		

Bringing More of the Brain on Task → New Class of Results

2. Contextual Tracking

- Hard problems
  A. Dynamic Modeling of Context
  B. Monitoring Decision Maker(s) Paths Through Context Rich Knowledge Space
  C. Continuous, Autonomous Reconciliation of Computer Behaviors to Human Mental Models and Decision-Making Needs

Contextual Tracking (2A):

Dynamic Modeling of Context

- Today: Models do not work in real time or provide the appropriate level of analysis to determine how concepts within a knowledge space relate.
- AugCog will: Extend the primitive concepts for modeling a decision space and map the fundamental concepts within that space, for a range of tasks, and do it quickly and efficiently in a dynamic environment, in order to understand and predict how a decision-maker is traversing through it.
- How: Develop automatic algorithms for modeling context. Create a synergy between human context and context tracking algorithms. Develop methods and modeling techniques to capture the results of knowledge engineering. Develop methods to relate concepts to each other given the different types of tasks expert / non-expert decision makers might perform within the knowledge space.

Contextual Tracking (2B):

Monitoring Decision Maker(s) Paths Through Context Rich Knowledge Space

- Today: Primitive pattern-based models. Virtually contextless – no external awareness. Reactive with no understanding of intent or individual differences or strategies.
- AugCog will: Develop algorithms that can monitor decision-makers in real time, in order to assess and proactively predict "decision-trajectories".
- How: Develop algorithms to monitor decision-makers path through context rich knowledge space based on physiological and behavioral inputs as well as measures of human outputs combined with contextually based Knowledge maps (an understanding of how well established concepts relate to each other in performing different kinds of tasks). Track individuals in movement in a knowledge space, assess the context in which they are operating, and then predict where they are likely to go next, given where they have been in the knowledge space.

Contextual Tracking (2C):

Continuous, Autonomous Reconciliation of Computer Behaviors to Human Mental Models and Decision-Making Needs

- Today: Efforts are almost non-existent
- AugCog will: Determine associative structures (patterns) in any number of factors that might affect human perception, behavior and decision-making.
- How: Develop tools that take advantage of context mapping algorithms to assist decision-makers in making better quality decisions faster. Develop methods and algorithms that function as Real-time, Automated "Radar O'Reileys“ Develop models that are responsive to human idiosyncrasies, shifts in situational factors, strategies i.e.,
  - Recognize that strategies are inherently Adaptive, Dynamic, Flexible
  - Allow for / adapt to Emotive aspects of Perception & Decision-Making
  - Take into account Intuition and Strategies

Cognitive and Neural Components

Capability:	Challenge:	Metrics:
1. Tactical Cognitive SET ✓ Cognitive re-load ✓ FMIQ interface ✓ Recall reset	➢ Representation of situations in ready to use format ***CET: Multimodal coding; Rich tagging***	• Rate of alternation of attention across n-tasks ***Impact: Graceful degradation under intervention***
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3. Cognition on Task ✓ Cognitive performance enhancement; DSO ✓ Memory, skills, etc. ✓ Veridical analysis	➢ Memory augmentation and skill amplification ***CET: Saliency precoding***	• Improved Quality of Decision Making • Higher Bandwidth control ***Impact: Supra-Optimal Performance and Manning***

Bringing More of the Brain on Task → New Class of Results

3. Cognition on Task

- Hard Problems
  - Designing System Interfaces That Help People Remember
  - Incorporating Uncertainty, Sensitivity, and Value Representations into Reasoning
  - Generating Context and Organizing Symbols into Manipulatable Semantic Structures

Cognition on Task (3A):

Designing System Interfaces That Help People Remember

- Today: Interfaces are designed to promote ease of use with little or no regard for the impact that they have on users' subsequent cognitive representations.
- AugCog will: Circumvent fundamental human limitations by engineering work environments that will make it easier for people to encode, store, and retrieve the information presented within them.
- How: Develop interfaces that are context-sensitive by presenting material in relation to the context in which it was encountered. This will be accomplished by embedding information in distinctive, image-able, and multi-sensory contexts, so as to provide memory hooks that naturally engage the human mind.

Cognition on Task (3B):

Incorporating Uncertainty, Sensitivity, and Value Representations into Reasoning

- Today: Erroneous conclusions are frequently made by experienced individuals in situations where available data is not properly interpreted.
- AugCog will: Enhance the presentation of uncertainties in a form that will make it easier for people to incorporate them correctly into the decision-making process. Develop techniques to enhance the ability of individuals to quickly integrate and deliberate about uncertainty.
- How: Develop characterizations of uncertainty and variability, including distributions, variances, and possible states using different modalities in which interactive tools control the interplay between attention and a representation of uncertainty. Methods will provide the users appropriate controls over the representations to maximize their ability to assess the implications of uncertainties on their decisions.

Cognition on Task (3C):

Generating Context and Organizing Symbols into Manipulatable Semantic Structures

- Today: We are capable of sensing the environment, but not able to convert raw data stream into symbols for processing by a computer. Even if we had environmental information in symbols, we are not capable of generating a meaningful context from it.

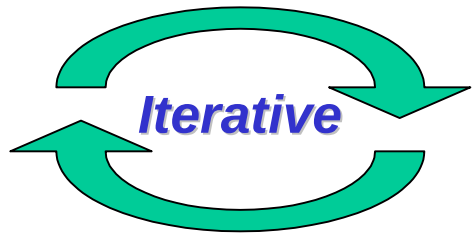
- AugCog will: Develop techniques for the generation of symbols from standard sensory input streams. Develop techniques to organize symbols into manipulatable semantic structures capable of capturing the essence of context. This context is capable of supporting both working memory and the decision making process in general.

- How: Adapt dynamic image processing techniques capable of extracting objects from a video feed. Develop machine learning algorithms capable of self-organizing semantic networks into a context structure.

Transformation Process

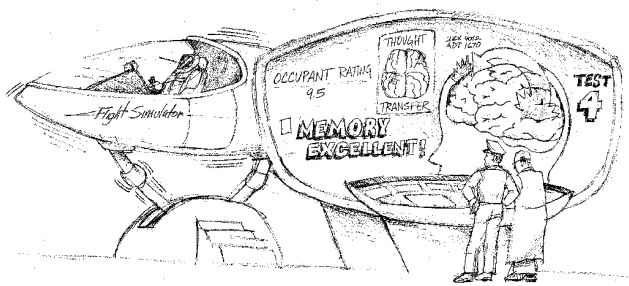
Psychological Science → Technology → Systems

- Approach
  - Develop Cognitive and Neural Components
  - Build Cognitive Amplification Environment
  - Evaluate Cognition Under Stress
  - Perform Operational Feasibility Experiments

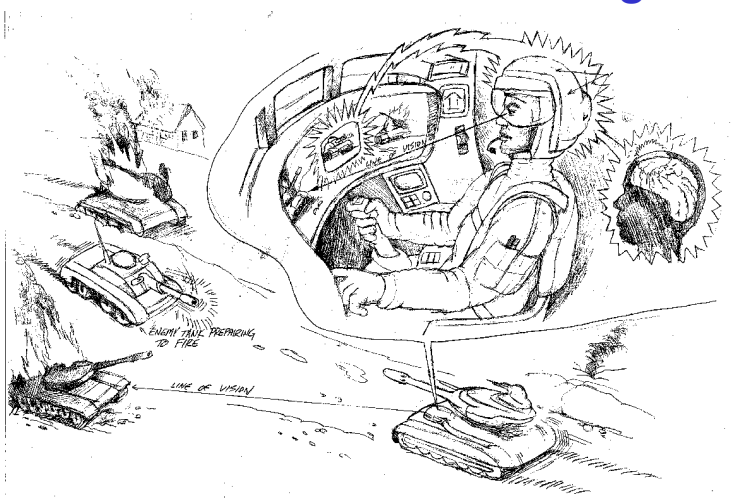


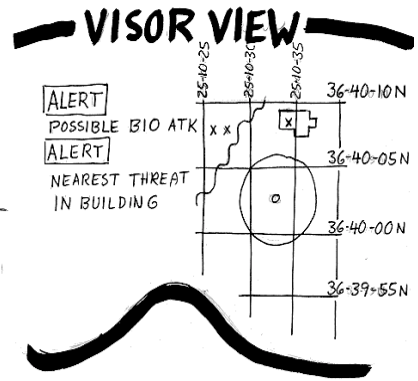
- Technique
  - 3-prong approach building technology on cognitive & neural science, computer science, and IT from industry, DoD labs, and academia.
  - Utilizing existing laboratories, test-beds, Fleet / DoD connectivity
  - Scenario driven (e.g. time-critical strike, air defense, land attack)
- Deliverables
  - Methods, Guidelines, Evaluation Results
  - Instrumentation,
  - Software Libraries, C3 “Plug-in’s”

Whose issue does AugCog address?



Trench Fighter or General Officer Level? Yes.





Summary

- Exploit convergence of two major advancements
  - Inexorable progress in digital computation & storage
  - Understanding of human brain function (i.e. learning & memory)
- Improve and Enhance the Quality of Military Decision Making
- Capability now exists to validate with measurable results