Emerging Cognitive Neuroscience and Related Technologies: Progress and Prospects

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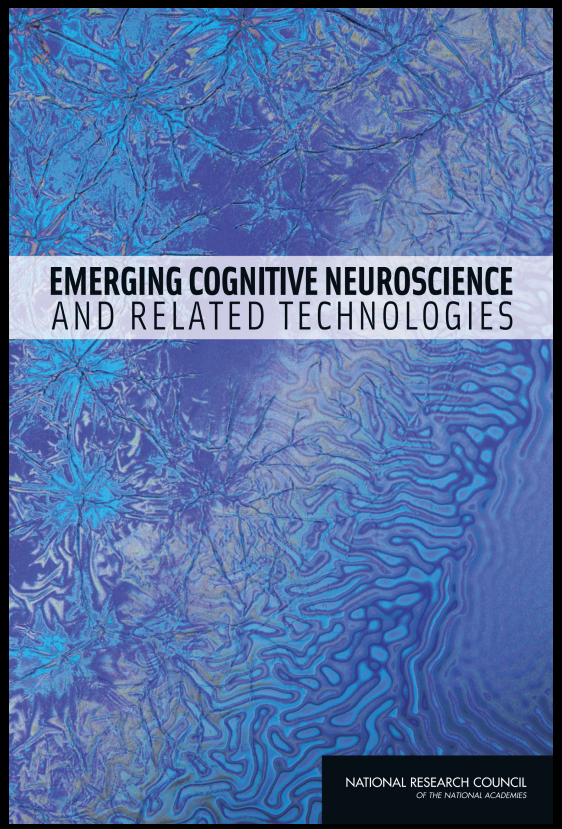
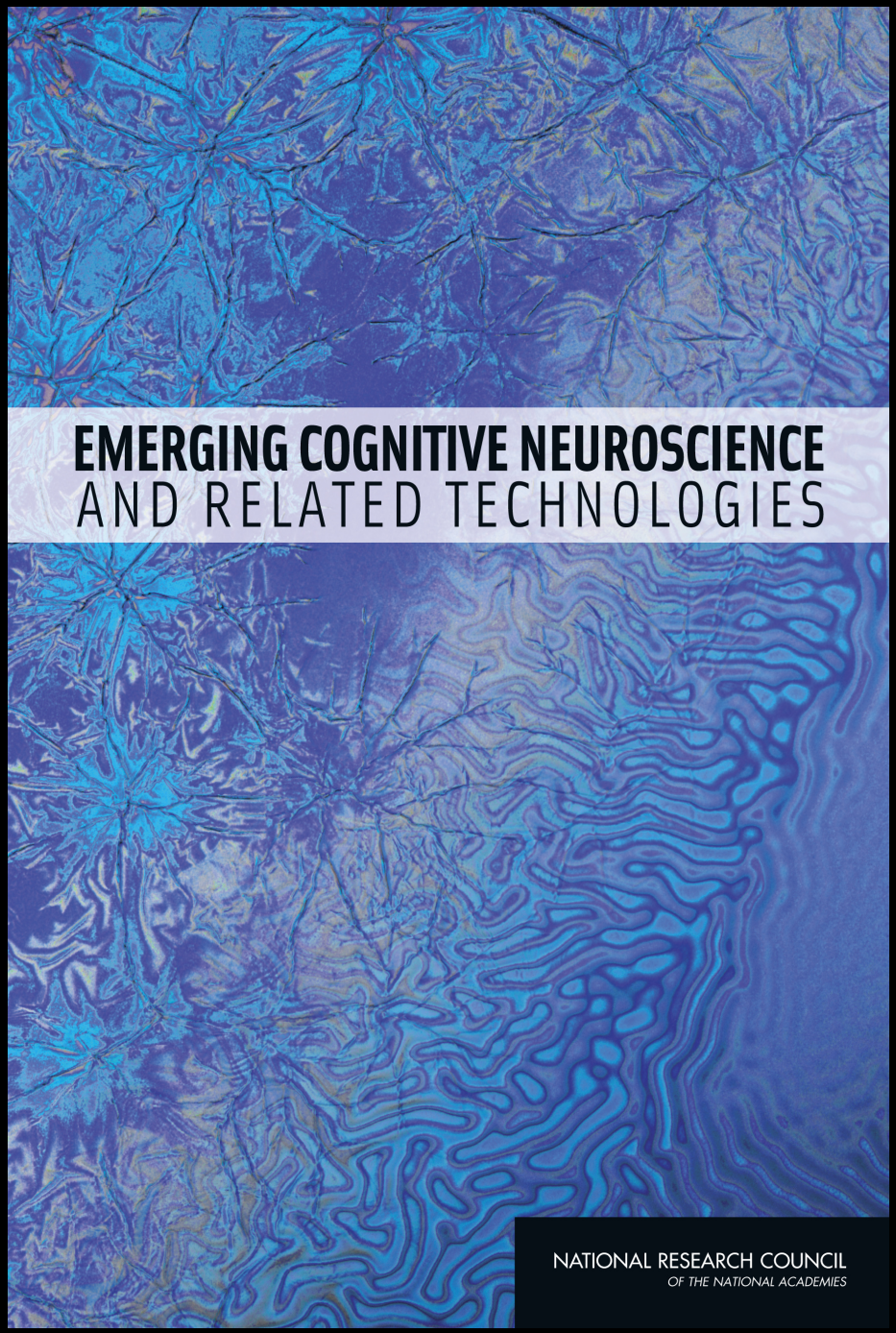
Selected Findings



Disclaimer

The views that are expressed today are my own.

My remarks today should not be taken as representing the views of the National Academies, nor of the Florida Institute for Human and Machine Cognition (IHMC), nor any other entity.



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Committee Membership

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DIANE GRIFFIN (NAS/IOM), Vice Chair, Johns Hopkins Bloomberg School of Public Health
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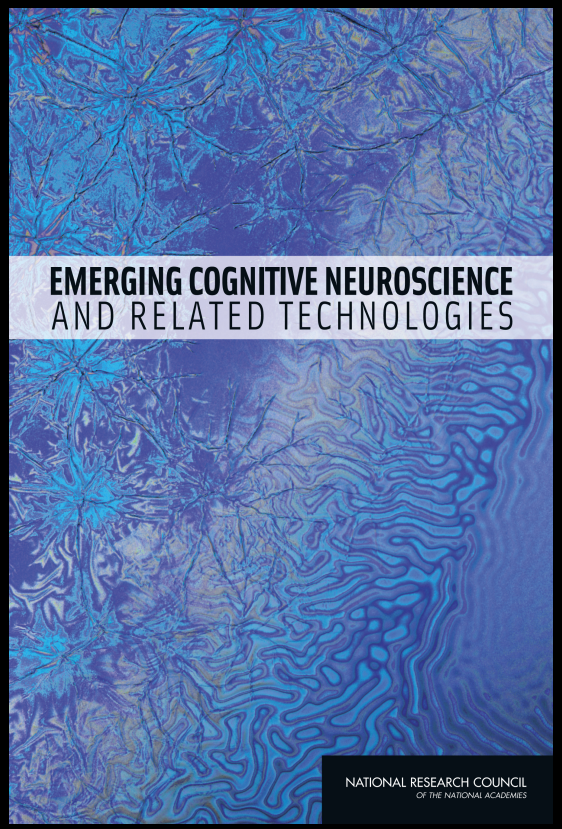
IOM, Institute of Medicine
NAS, National Academy of Sciences

Findings and Recommendations

Chapter 2

Current Cognitive Neuroscience Research and Technology: Selected Areas of Interest



Finding 2-1

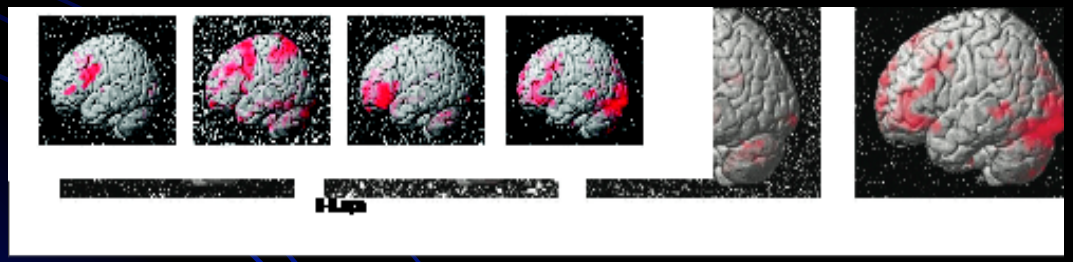
Cognitive neuroscientists can identify neurophysiological markers of general psychological states—for example, positive vs. negative affect; automatic vs. controlled cognitive processing, approach vs. avoidance motivation, attention vs. inattention—within individuals in specified contexts **but are not yet able to identify highly specific psychological states and intentions** —that is, exactly what a particular person is thinking, intending, or doing.

Given the current state of knowledge about brain neurophysiology, it is highly likely that any advances in our knowledge about individual psychological states over the next two decades **will continue to occur in highly controlled situations where the number of candidate mental states is limited.**

The ability to determine a person's mental state strictly from neurophysiological markers without environmental controls is unlikely to be gained any time in the next two decades.

Finding 2-2

Consistent with the 2003 NRC study The Polygraph and Lie Detection, **the committee uniformly agreed that, to date, insufficient high-quality research has been conducted to provide an empirical answer regarding the use of any single** neurophysiological technology, including functional neuroimaging, to detect deception.



2-2.eps

Finding 2-3

Neurochemical systems modulate, and can be used to control, a wide range of human psychology. The number of neuropsychopharmacological drugs increased dramatically after the mid-1900s, along with their availability, and emerging technologies may improve the ability to harness drug effects or to produce targeted changes in human psychology.

Cognitive neuroscientists do not have specific understanding of how most drugs produce their effects. Basic research in the public or private sectors that identifies the specific mechanisms of disease and of drug effects might enable rapid development of new drugs.

New drugs may have unrecognized effects that emerge owing to variation in individuals, settings, or performance demands.

Finding 2-5

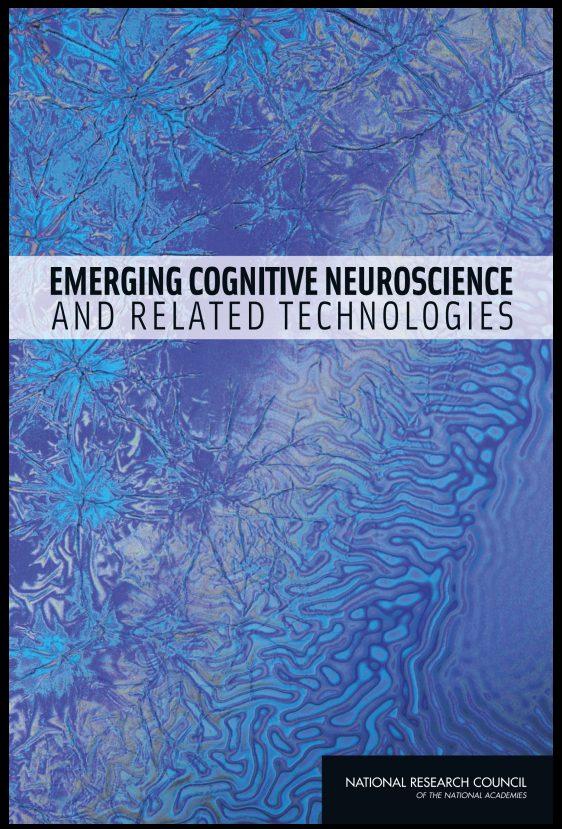
Functional neuroimaging is progressing rapidly and is likely to produce important findings over the next two decades. Two areas where such progress could be of great interest are **enhancing cognition and facilitating training.**

Additional research is still needed in other areas as well: states of emotion; motivation; psychopathology; language, imaging processing as adjuncts for use in measuring workload performance measurements; **and the identification of ethnographic differences between Western and non-Western cultures.**

Findings and Recommendations

Chapter 3

Emerging Areas of Cognitive Neuroscience and Neurotechnologies



Finding 3-1

The global scientific computing community is approaching an era in which high-end computing will, in principle, be sufficient in capacity and computational power to model the human brain.

However, there does not yet exist either an adequate and detailed understanding of *how* such modeling can be done, nor a complete model of how the brain interacts with complex regulatory and monitoring systems throughout the body.

These and other difficulties make it **highly unlikely that in the next two decades anyone could build a neurophysiologically plausible model of the whole brain** and its array of specialized and general-purpose higher cognitive functions.

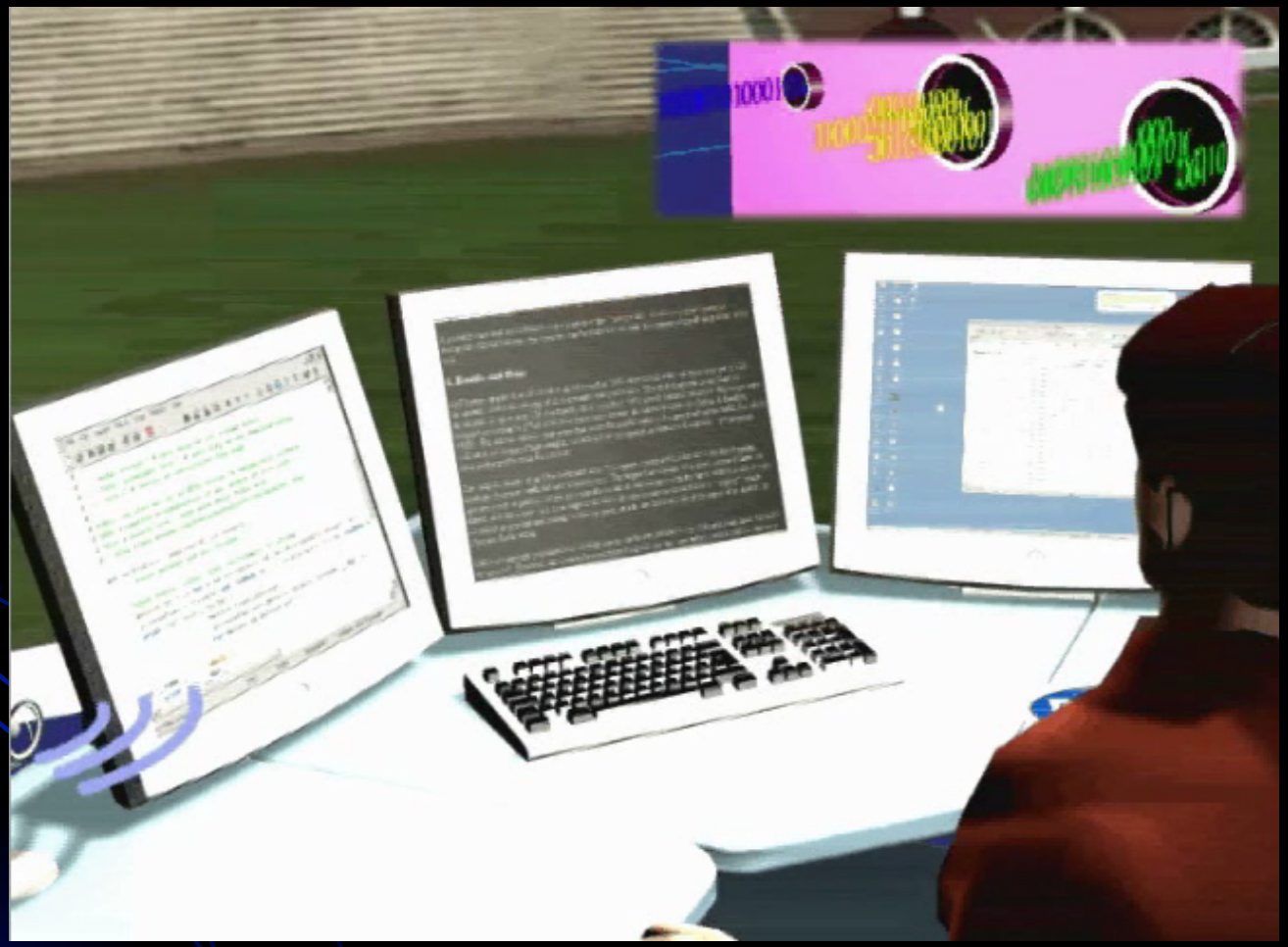
Finding 3-2

Research on brain–machine interfaces (BMIs) has progressed steadily, with the principal objective being to allow people to exert some degree of control over a prosthetic, pointing and tracking, or communication device. **The ultimate range of physiological potential and limitations for BMIs is not yet well understood.**

From the point of view of **enhancement** (vs. rehabilitation) **of human performance**, it has **not yet been established** that BMI is superior to other methods of control of computing functions and robotic vehicles.

Promising areas for continued BMI research include the control of robotic orthotics and the management of information flow to an individual **based on changes in the user's cognitive state.**

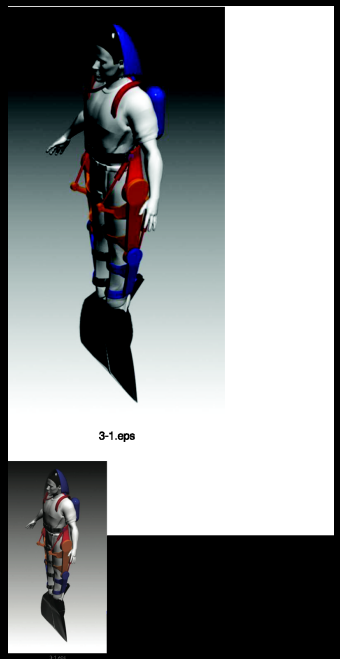
DARPA “Augmented Cognition” Vision



Finding 3-3

Research in robotic orthotics has produced a variety of exoskeletons to increase human strength, endurance, and speed.

Challenges include the development of alternatives to today's bulky actuators (i.e., artificial muscle) and of appropriate BMIs for control and feedback.



IHMC/Yobotics Biped

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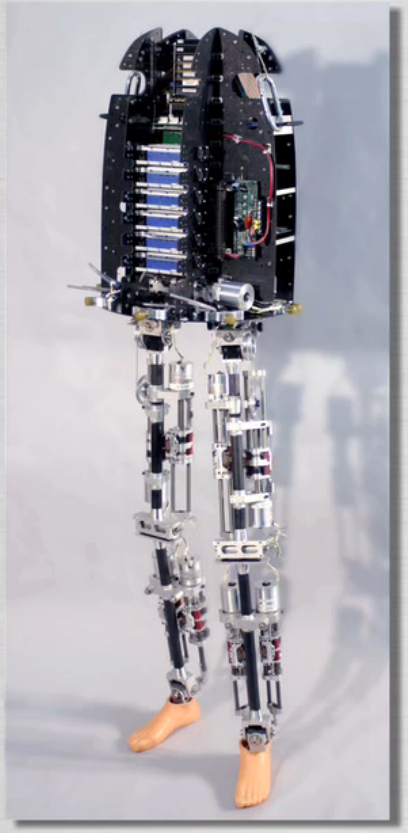

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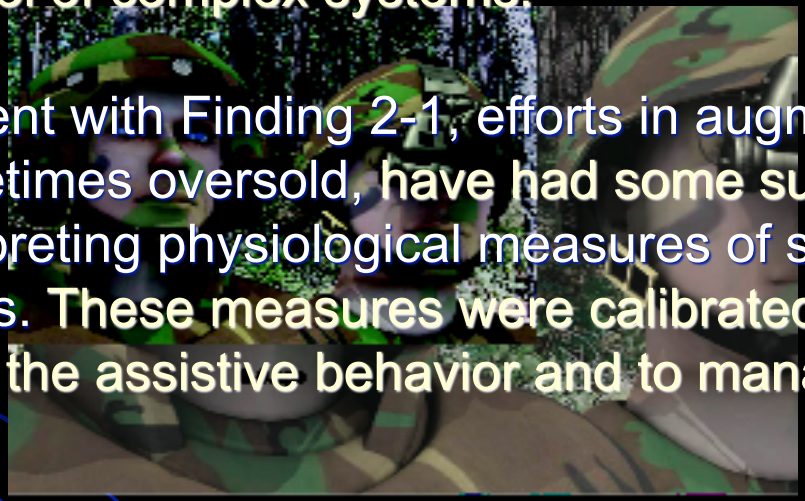
Finding 3-4

Researchers using sensory substitution interfaces in individuals with sensory loss have demonstrated **enhanced situational awareness** in their subjects. Thus use of similar cross-modal techniques with **multiple sensory channel substitution interfaces show promise for control of complex systems.**

Consistent with Finding 2-1, efforts in augmented cognition, which is sometimes oversold, **have had some success** in sensing and interpreting physiological measures of superordinate psychological states. **These measures were calibrated to individuals in real time to tailor the assistive behavior and to manage information flow.**



3-3.eps

Finding 3-5

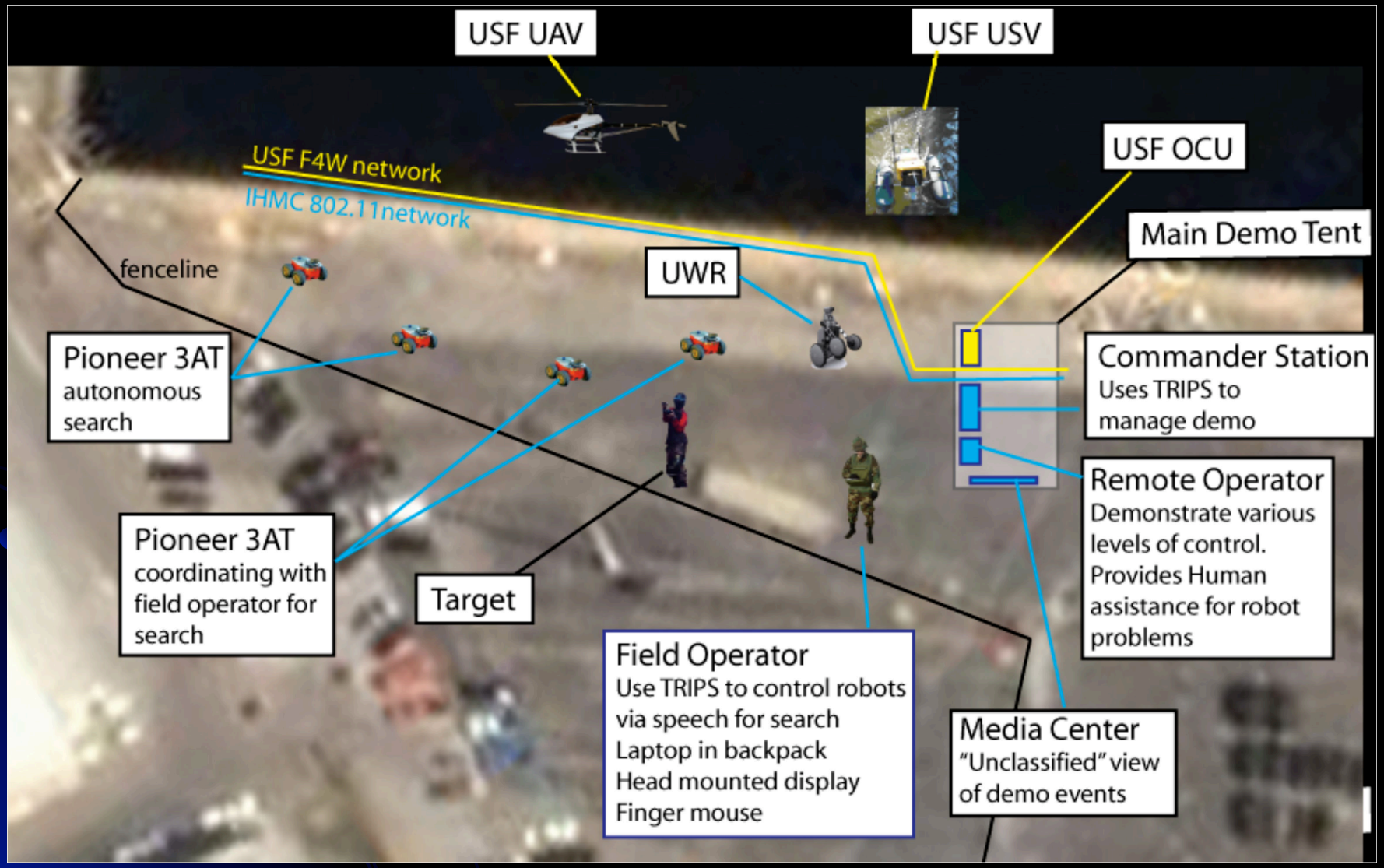
Software and **robotic assistants** are designed to improve or extend human performance in the physical and cognitive domains. Much of the newer research has shifted from deliberation to doing, from reasoning to acting remotely.

Progress will require investments in the development of (1) **reusable software components** that embody the intelligence needed to support **specific human tasks** and (2) assistants that can coordinate their interaction with humans and artificial assistants in ways that emulate natural and effective teamwork within groups of people.

IHMC DHMS Research Areas

- Cognitive and Robotic Prostheses
  - Automation is experienced as if it was part of “self”
  - Hard problem of maintaining illusion of “oneness” in time, space, and over imperfect human-automation interfaces
  - “Be one”
- Human-Automation Teamwork
  - Automation is experienced as “other”
  - Hard problem of maintaining coordination and (limited) common ground among separate agents with (partially) shared objectives
  - “Be many, but act as one in joint activity”

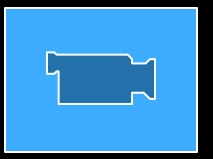
Coordinated Operations Scenario

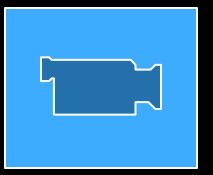


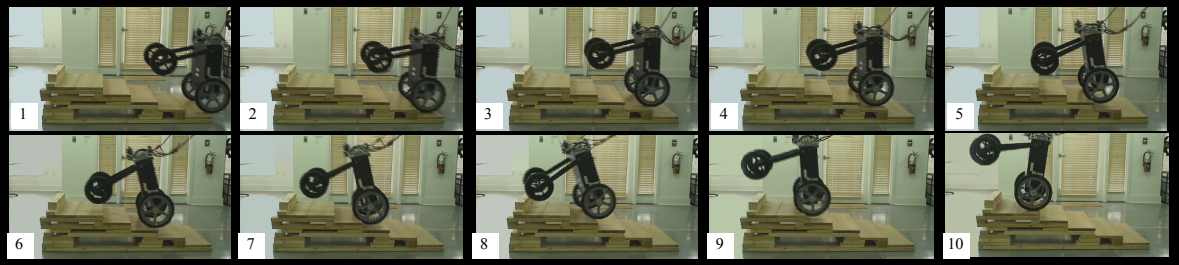
Pratt: tBot

V0.2 - Reduced degree of freedom prototype.

- Demonstrates balance control.
- Demonstrates stair climbing capability
- Integrated with KAoS HART Services







V1.0 –Fully functional 10 actuator robot

- Assembly completed Aug ’07.
- Capable of stable 10 mph in 4 wheel mode.
- Turn in place in two wheel mode.
- Climb stairs and over obstacles.
- Active suspension for operation in two wheel mode on uneven terrain.
- Top mount payload for high vantage point.

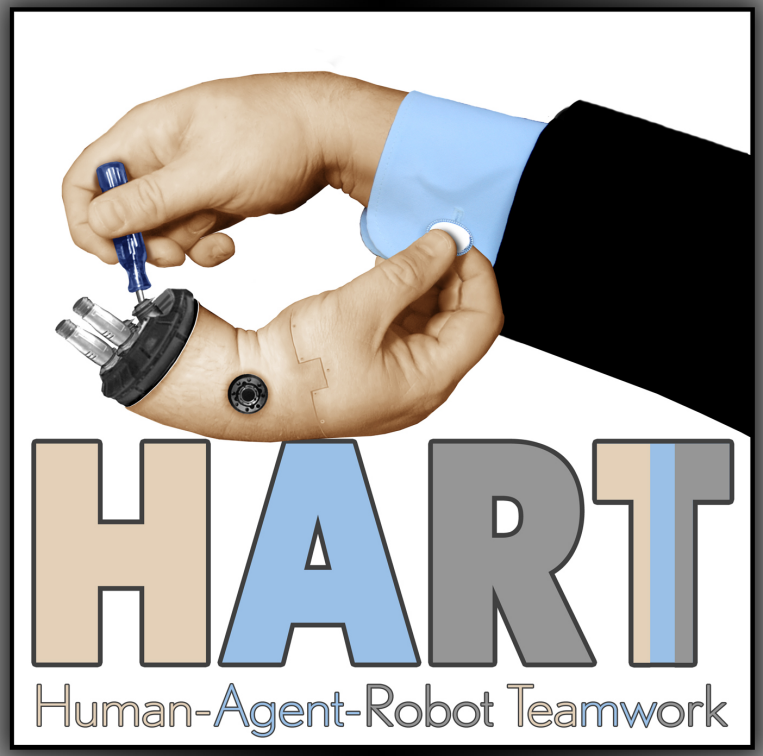
Co-located with: esaw2009 www.cs.uu.nl/esaw2009/

21 November 2009
Utrecht, The Netherlands

Sponsored by: STKS

HART Workshop

Supporting Joint Activity in Human-Agent-Robot Teamwork



http://www.jeffreymbradshaw.net/HART/

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