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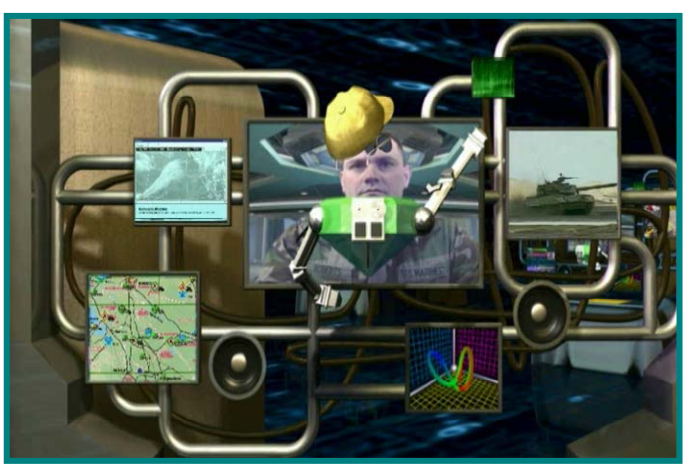
The Heart of the Mind

In the midst of a fierce firefight, using advanced sensors and a satellite-fed heads-up display, a platoon leader recognizes a diversionary move by his adversary. Recalling similar situations, the lieutenant anticipates the follow-up action, quickly redeploys his personnel, and catches the enemy by surprise.

Using the ultimate Command Post of the Future and high-bandwidth communication links, a brigade commander calls his key officers together and faces the problem of a stranded crew member. With a quick brainstorming session, they produce a solution that none of the individuals alone had thought of. Thirty minutes later, a civilian rescue vehicle diverts to pick up the young captain before any harm can befall him.

On a ship's bridge, the first officer steps up to the captain and, using an immersive situation awareness display, explains the problem-solving strategy the leadership group just used to respond to enemy fire was probably misguided. She suggests an alternative. And, with that change, a potentially disastrous engagement turns into a successful one.



Whether these scenarios take place in the 23rd century or in the 21st, they have one key element in common that gives them their power, and it's not the whiz-bang DARPA technology that you—and we—all know and love so much. No, it's the human mind in action in these complex, real-world situations that makes all the difference.

This incredible machine, housed in a 1,400-gram lump of unattractive organic material seems to be at the heart of what each of us is

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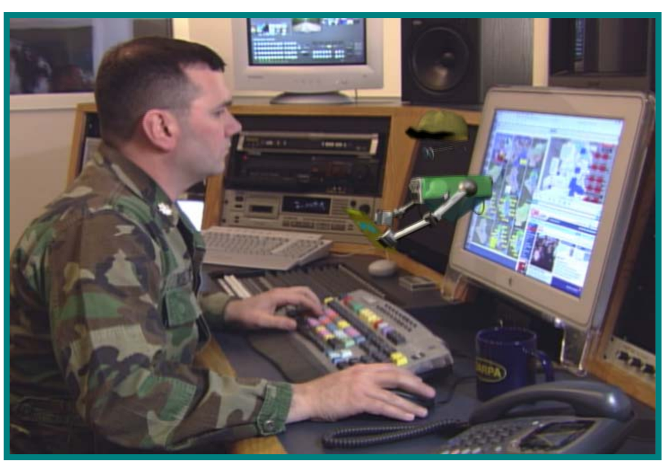
capable of doing alone and together. And when you take a close look, it's really quite remarkable.

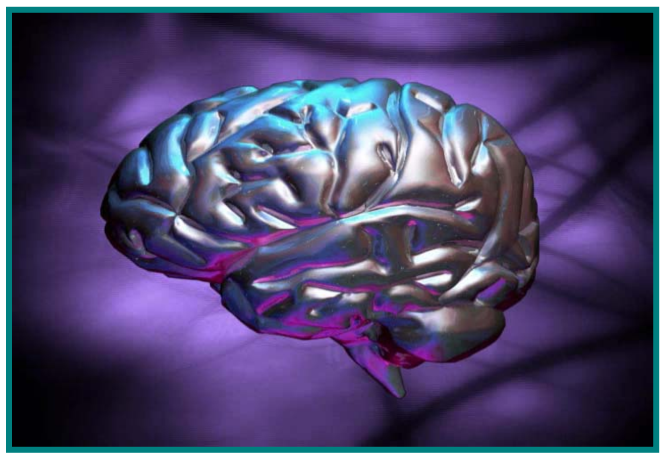
The human brain has about 100 billion neurons, many of which die every day. It's small, it's flawed, and its millisecond impulse propagation speed looks very slow compared to today's high-speed digital circuitry. It makes lots of mistakes and it doesn't remember everything it sees. Yet its powers go far beyond those of any technology that we've been able to create. It can reason, collaborate, and respond to new situations. It can anticipate the future. It can deal with uncertainties and likelihoods and instantly recall experiences that might apply to its current situation. Perhaps most remarkably, it can adapt and learn so its performance is always improving.

Think how far the PC on your desk or the server in your operations center is from being able to function as well as an average child. No machine that humans have built can come close to doing the incredible things the human mind can do.



Imagine for a moment if we could succeed in the dream of building a machine that could. Every Soldier could have a dedicated personal assistant that would extend his ability to see and remember things and to interpret data that comes in to him at an ever-increasing rate. A commander running a major operation would have all the information he needs presented at exactly the time he needs it and in exactly the way he likes to see it, taking into account his personal experiences and way of thinking. Decision-making would become timelier and more agile. People from different cultures could speak directly to one another, supported by instantaneous, flawless translation.

Our critical information systems could immunize themselves against attacks and failures. Our units would not need to spend 20 percent of their



resources on communications and computer support. All these possibilities lay before us, if we can only get to the heart of the mind and understand how to emulate some of its most important functions in our computer systems.

This is, of course, an extraordinarily challenging goal, the stuff of fantasies and admittedly slow technical progress. But because the potential upside is so incredible for the defense of our nation, this is exactly the kind of problem that DARPA should be tackling. The daunting problems DoD is facing—software producibility, network reliability, and systems integration—demand that we raise our vision well above the kind of incremental computer science we are used to. We need to move from a conventional view of data processing to a cognitive view, one that will allow our systems to be more responsible for their own configuration and maintenance and less vulnerable to failure and attack.

If we want to build an artificial cognitive system, what are the major elements we need to understand and implement? Building a machine that can do all this sounds like science fiction. But in this series of articles you will read not only about ambitious goals, but also the significant achievements our IPTO programs have begun to demonstrate.

Several of our program managers will now introduce you to our efforts to solve the fundamental mysteries of the mind and, we hope, to realize unprecedented potential for serving our national security.

Mari Maeda will open the mind's window on the world, its remarkable capability of perception. Can we emulate the incredible human powers of seeing and hearing and understand what's going on about us given the complex, constantly changing, and unpredictable nature of our visual and auditory world?

Another critical human faculty is our ability to communicate with one another. Natural language allows us to build on each others' ideas. Joe Olive will paint a picture of how we communicate as humans and will tell us about some of the great challenges we face in conversing with cognitive systems.

A key capability of the mental world is inference, the ability to draw conclusions that are only implicit in facts and experiences. Another is learning, the ability to take advantage of what we have seen and build on things we have experienced. Dave Gunning will take you deep into the heart of the mind, exploring how we might build systems that reason and adapt.

We've all seen examples of how teams can do things individuals can't do by themselves. The power of cooperation is extraordinary, and future cognitive systems will need to collaborate with one another and with humans to produce wholes that are greater than the sum of their parts. Tom Wagner will address the concept of multiple minds working together.

Charlie Holland will make some observations about the computing foundations that might make cognitive computing possible. Artificial minds will be housed in artificial brains, and we may need some radical changes in our computing foundations to get there.

Barbara Yoon will pull all this together and remind us how these pieces, operating separately, don't quite get us where we want to go. We need an architecture for integration. The ultimate challenge of the cognitive systems idea is to build a fully integrated system that does perception, communication, reasoning, learning, and cooperation, and knows what it is doing. Barbara will help us imagine how we can put all the pieces together. It's time to get started on our journey to the heart of the mind.