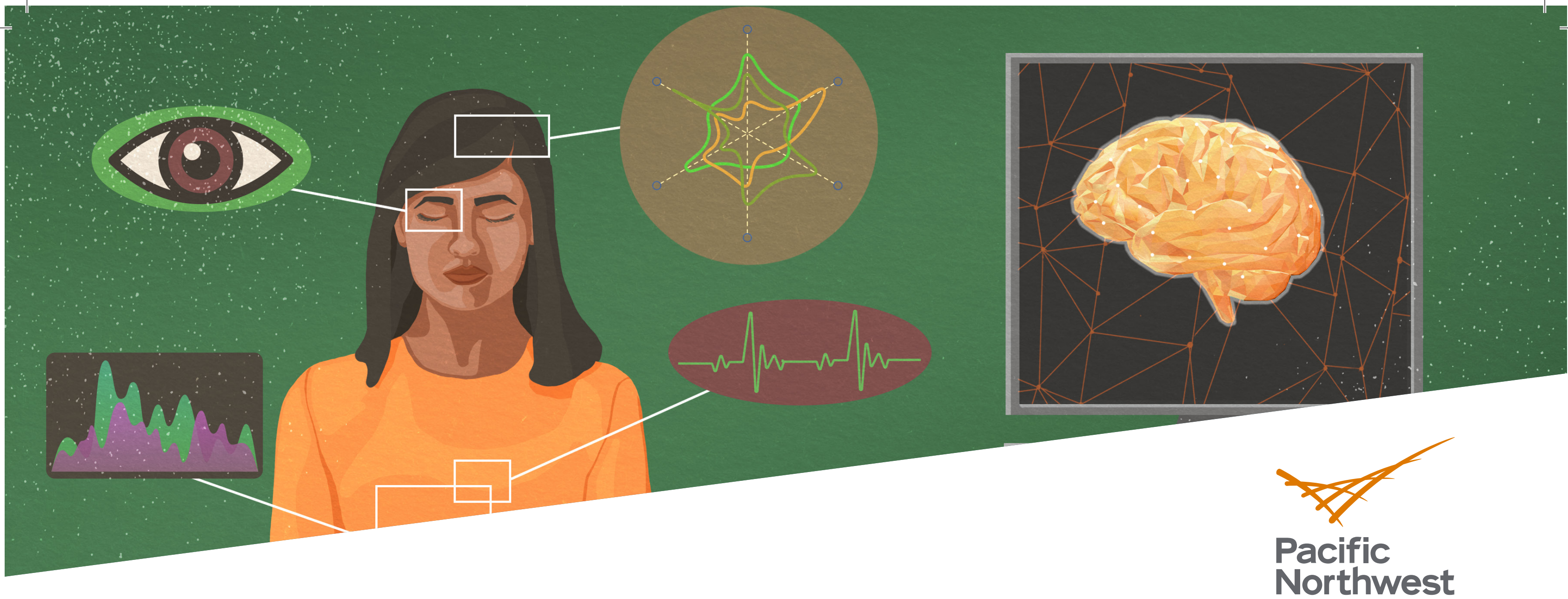


Cognitive Modeling

Simulating human thinking to predict and improve performance

THE CHALLENGE

Artificial intelligence and other computerized "thinking" algorithms are powerful tools, but one challenge is to make them behave more like humans. Cognitive modeling enables us to translate the way people think into computational models. Once refined, such models can be applied, like well-proven recipes, to various computer-driven tasks. The results improve research, task-critical decision-making, and task completion.

Cognitive modeling is an improvement over iterative user testing—a common technique used to design a visual data display or software tool. Iterative testing focuses on whether the human gets the "right" answer, and designers then adjust the display format subjectively. In contrast, cognitive modeling would reveal how people perceive the important attributes of the display and make decisions based on them. Such a model would communicate how humans interpret the color, size, shape, contrast, and sound associated with the visual pattern on the screen. Data scientists, in turn, could use this model to make other visual data displays more effective. This approach could save time and money by reducing the amount of testing required.

APPROACH

Pacific Northwest National Laboratory (PNNL) is developing adaptive systems that integrate cognitive models with machine intelligence. Our goal is to translate human thinking, conscious and unconscious, into a mathematical model that can be used by an artificial teammate for a variety of tasks. From mimicking human thinking and actions in the performance of mundane tasks to communicating complex algorithms in plain language, we believe that our approach can lead to significant breakthroughs for humankind.

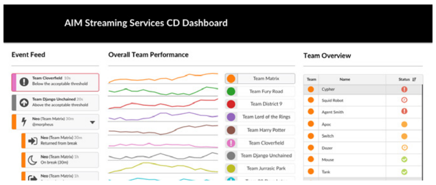
Cognitive models can be applied broadly to problem solving and performance—for example in manufacturing, engineering, and training. We are developing cognitive models as part of human-machine systems that can adapt, or change objectives, autonomously, based on different environments or specific domains, such as scientific discovery or national security.

PNNL's Human Performance Assessment and Modeling Laboratory offers a dedicated facility for conducting cognitive and behavioral research. Its instrumented user interfaces include Emotiv EEG units, a Tobii, Zephyr biometric devices, and specialized sensors for external applications. PNNL's Institutional Review Board approves all protocols involving test participants.

These sensors, which measure human cognitive processes or behaviors, serve as inputs to cognitive models which, in turn, inform systems about human performance. For example, a computer system could send alerts when users are nearing cognitive fatigue or suggest how someone might adapt in a training situation. We are also developing models to drive artificial intelligence by encoding human knowledge and context to shape intelligent behaviors in machines.

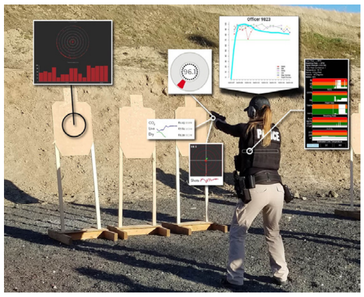
EXAMPLE PROJECTS

BIFROST



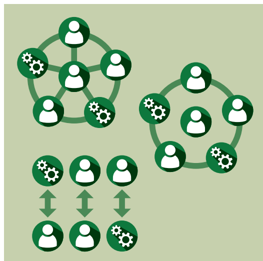
Humans are partnering with machines to perform complex tasks more than ever before. But human behavior can be irrational, slow, and unpredictable. PNNL is developing BIFROST, which stands for Bounded Informational Framework for the Optimization of Stream Systems. BIFROST uses models to incorporate economic game theory. This involves two entities—in this case the humans and machines—that continuously adapt their behaviors based on each other's actions. The models show how they can learn from each other and adapt simultaneously.

Quantified Marksman



PNNL is collaborating with federal and state law enforcement agencies and the military to optimize marksmanship skills for personnel. The current calendar-based, one-size-fits-all approach to evaluating and training shooters is ineffective and costly. The Quantified Marksman model PNNL is developing uses past performance, enabled by data from wearable sensors, to predict how often a person needs training, and in which skills specifically.

Cognitive Depletion



Continuously making decisions over extended time periods leads to cognitive depletion in humans. Mental fatigue increases impulsiveness and errors, slows evaluation of new information, and decreases memory retention. Our research uses cognitive models to create adaptive systems that can extend peak performance. The models predict the state of the users and recommend when they should take a break or increase the use of automated systems to avoid performance degradation.

About PNNL

PNNL advances the frontiers of knowledge, taking on some of the world's greatest science and technology challenges. Distinctive strengths in chemistry, earth sciences, and data analytics are the heart of our science mission, laying a foundation for innovations that improve America's energy resiliency and enhance our national security. PNNL's computing research encompasses data and computational engineering, high-performance computing, applied mathematics, and semantic and human language technologies.

Collaborate with us | Tap into our capabilities to meet your needs | Explore technology transfer opportunities | Join our team to grow your career

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BATTELLE

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