Making sense of brain data

Brains evolved to control movement, taking in sensory information to make decisions in the context of previous experience. This is accomplished with biological structures at many levels of organization, from the molecular to the system levels, across ten orders of magnitude of spatial scale. Understanding how all these levels give rise to complex behavior may be our greatest scientific challenge.

Neuroscience brings together researchers from many disciplines. Computational neuroscience is a newcomer whose origins can be traced back to the Hodgkin and Huxley model of the action potential. New computational tools from physics, engineering and mathematics have made it possible to explore computational principles across a wide range of brain levels, including neural circuits and large-scale brains systems.

The BRAIN Initiative has accelerated the technology for collecting data—the challenge ahead is to make sense of it. The ICoN Center in the McGovern Institute is well positioned to take a leadership role in using computational approaches to understand brain function.

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DATA TRANSFORMED

A new center for integrative computational neuroscience led by Ila Fiete will use mathematical tools to transform a deluge of data into deep understanding of the brain.

With the tools of modern neuroscience, data accumulates quickly. Recording devices listen in on the electrical conversations between neurons, picking up the voices of hundreds of cells at a time. Microscopes zoom in to illuminate the brain's circuitry, capturing thousands of images of cells' elaborately branched paths. Functional MRIs detect changes in blood flow to map activity within a person's brain, generating a complete picture by compiling hundreds of scans.

"When I entered neuroscience about 20 years ago, data were extremely precious, and ideas, as the expression went, were cheap. That's no longer true," says McGovern Associate Investigator Ila Fiete. "We have an embarrassment of wealth in the data but lack sufficient conceptual and mathematical scaffolds to understand it."

Fiete will lead the McGovern Institute's new K. Lisa Yang Integrative Computational Neuroscience (ICoN) Center, whose scientists will create mathematical models and other computational tools to confront the current deluge of data and advance our understanding of the brain and mental health. The center, funded by a $24 million donation from philanthropist Lisa Yang, will take a uniquely collaborative approach to computational neuroscience, integrating data from MIT labs to explain brain function at every level, from the molecular to the behavioral.

"Driven by technologies that generate massive amounts of data, we are entering a new era of translational neuroscience research," says Yang, whose philanthropic investment in MIT research now exceeds $130 million. "I am confident that the multidisciplinary expertise convened by this center will revolutionize how we synthesize this data and ultimately understand the brain in health and disease."

DATA INTEGRATION

Fiete says computation is particularly crucial to neuroscience because the brain is so staggeringly complex. Its billions of neurons, which are themselves complicated and diverse, interact with one other through trillions of connections. "Conceptually, it's clear that all these interactions are going to lead to pretty complex things. And these are not going to be things that we can explain in stories that we tell," Fiete says. "We really will need mathematical models. They will allow us to ask about what changes when we perturb one or several