Ed Boyden's blog

Ed Boyden is an assistant professor in the MIT Media Lab. His lab broadly invents new tools to engineer brain circuits, in order to treat intractable disorders, augment cognition, and better understand the nature of existence.

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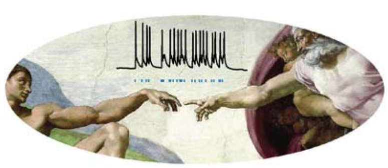
Tuesday, April 22, 2008

Training a Generation of Neuroengineers

Empowering students to improve a billion lives.

Neurological and psychiatric disorders such as traumatic brain injury, stroke, Parkinson's disease, autism, depression, post-traumatic stress disorder, and chronic pain affect well over a billion people worldwide. These disorders steal away not only life span, but also our selves and identities. More than $1,000,000,000,000 is spent yearly in the battle against these disorders, even in the absence of effective treatments for many of them. Compared with innovations in other fields, like cancer, neurotechnologies have trickled out of labs at a relatively slow pace, yielding a handful of good drugs, a couple of methods for brain stimulation, and a few ways to image and analyze brain structure and activity. Like many innovations in medicine and bioengineering, these triumphs often emerged in no small part by chance, which makes iterative improvement tricky. Clearly, something new is needed. That's why, over the past year, we've begun experimenting with a hands-on neuroengineering curriculum at MIT, in which undergraduate and graduate students actively engage in the process of becoming neuroengineers, learning to solve intractable problems of the brain by actually doing it.



Learning neuroengineering is a hands-on process. What do you need to learn to fix problems of the brain and nervous system? The answer is, in brief: whatever it takes. The brain is complex (with well over a hundred billion interconnected circuit elements), subtle (it mediates everything we sense, feel, decide, and do), and inaccessible (packed densely inside the skull). To be a neuroengineer, you must be able to take advantage of any idea or fact that you discover that lets you get a handle on a brain process or function. Teaching neuroengineering thus means empowering people to identify problems and create solutions, connecting often distant topics in logical and intuitive ways to arrive at elegant insights. In short, our students must learn neuroengineering by making it up as they go along.

With my colleagues at MIT, I've begun teaching students how to go through the neurotechnology life cycle, from concept to validation to revelation to the

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... : with devastating incidents like that...
joshuau : I'm wondering whether people reading...
bdas : I've become increasingly concerned at...
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... : Thanks for you thought, but my if...
nancyblake : Is the basic unit a physical entity,...
Ashar : Apparently you mentioned bloggers and...
... : Some people are better at this than...
koohii : I agree that once we recognize how...
CountZ3ro : Great! Let's go paranoid! :)
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world. We've concocted a series of three hands-on classes, which are still in the beta-testing stage, to teach design, laboratory, and entrepreneurship skills. Students pick projects and are mentored to make them as high-impact, feasible, and novel as possible. These classes are aimed at helping students learn the principles of operation of the nervous system from an engineering standpoint, implement their best ideas in the lab, and learn the process of translating technologies out of the lab and into the world. In the first class, **Principles of Neuroengineering**, students learn the basic principles governing the reading of information out from, and getting information into, the nervous system. They also, alone or in interdisciplinary teams, design and model fundamentally new technologies that gain information about, or positively alter, the operation of the brain. In the second course, **Applications of Neuroengineering**, students do lab work, learning how to implement, debug, and validate technologies. They make plans, revise them when failure encroaches, and learn how to find collaborators, make contingency maps, and manage time and resources. Finally, in the last course, **Neurotechnology Ventures**, students explore how to get their technologies out of the lab and into the world, writing up business-plan executive summaries and defending their projects in class, and attending guest lectures by entrepreneurs who are paving the way in neuroengineering. Anyone can participate--even freshmen can get involved. The ideas that yield the best neuroengineering inventions are often absurdly simple.

The classes started a beta-testing run in February 2007. Last year, in the Principles of Neuroengineering class, students designed never-before-seen methods for reading out brain activity in a wearable device, delivering therapeutic genes to specific cell types in the nervous system, and precisely measuring blood flow in the brain. Some of the students even built prototypes of their devices. For the Applications of Neuroengineering class, we just received a pilot grant from the MIT Alumni Class Funds to supply students with consumables, so that they can implement and validate their very best ideas in the lab, learning from failure and iteration. Students enter this class with concrete ideas, and get to make them reality. (We don't yet have a dedicated laboratory at MIT for teaching neuroengineering, so students who are safety- and procedure-certified to work in my lab can do their projects there. I try to help the rest find other collaborating labs on campus in which to work.) And in the first round of Neurotechnology Ventures, up to 50 people (including some professors) came to hear speakers talk about their companies (with post-talk discussions often lasting late into the night). Twenty students completed the key project, the creation of a concise business plan for a technology.

Although it's still the early days, perhaps this is the beginning of a Synthetic Neurobiology curriculum. Like many endeavors, this current set of classes has had a long, evolutionary path. Joost Bonsen and Rutledge Ellis-Behnke, my co-instructors in the Neurotechnology Ventures class, envisioned such a class almost half a decade ago. When I arrived at MIT in 2006, I was deluged by e-mails from undergraduates and graduate students eager to enter the business of engineering the brain and mind. The time had come. But our work is only beginning. We are still revising our educational vision daily, as we define the abstraction layers for engineering the brain. In the long term, I will measure the success of this mission by the number of laboratories, companies, inventions, and, ultimately, cures that are accomplished by people who pass through this class. Someday, we will understand the brain and know how to fix its problems. But for now, we must focus on jump-starting this effort by encouraging direct action by the best minds in the world, at an intellectual scale that exceeds all that has come before.

Numerical data in the first paragraph is from a recent report by NeuroInsights, LLC.

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Tags: education, brain, learning, MIT, mit media lab, neuroengineering, neurotechnology, synthetic neurobiology, neurology, psychiatry, autism, schizophrenia, entrepreneurship, epilepsy, hands-on learning, lab class, parkinson's, project teaching, stroke, teaching, traumatic brain injury

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Brain Waves

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Hi,
I m an ardent reader of your blog. I admire the knowledge that you have in the arena of neuro science. I wish to share a thought with you, from the past many days i have been thinking on brain waves. I understand that human brain in the process of functioning emits 4 waves of different wavelength. Till now I suppose science has managed to develop some technology which can read the waves. Will it be ever possible when we can write into the brain back.??

Awaiting your valuable reply

Cheers

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Great post Ed. I'm a big fan of the promotion of innovation and science to the next generation, and that's why I was pleased to read your post. I've been working with Intel on their International Science and Engineering Fair (ISEF), the preeminent science fair featuring the world's best young scientists- including several who are doing interesting work with Alzheimer's and other neurological disorders. It's a pretty exciting event and I urge you and your readers to check it out - the website is http://www.intelisef2008.org/

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