The Plug to the Brain

Thoughts out of the Computer

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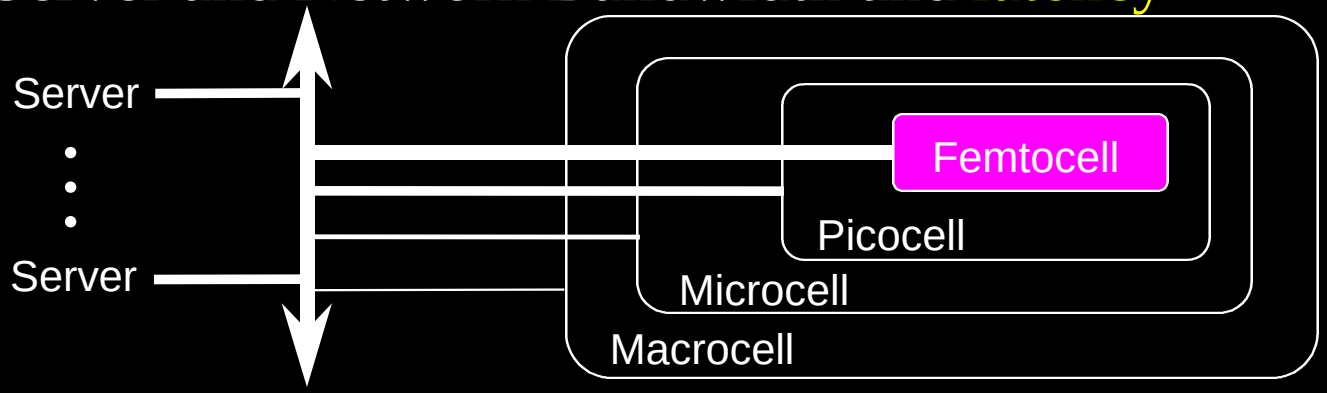
Homo ex machina? Visions of an Optimised Mankind

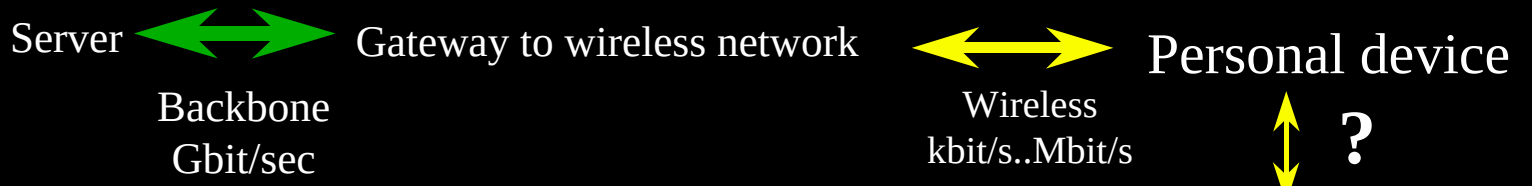
Wissenschaftszentrum Nordrhein-Westfalen, Deutschland

Bottlenecks

- Server and Network Bandwidth and latency



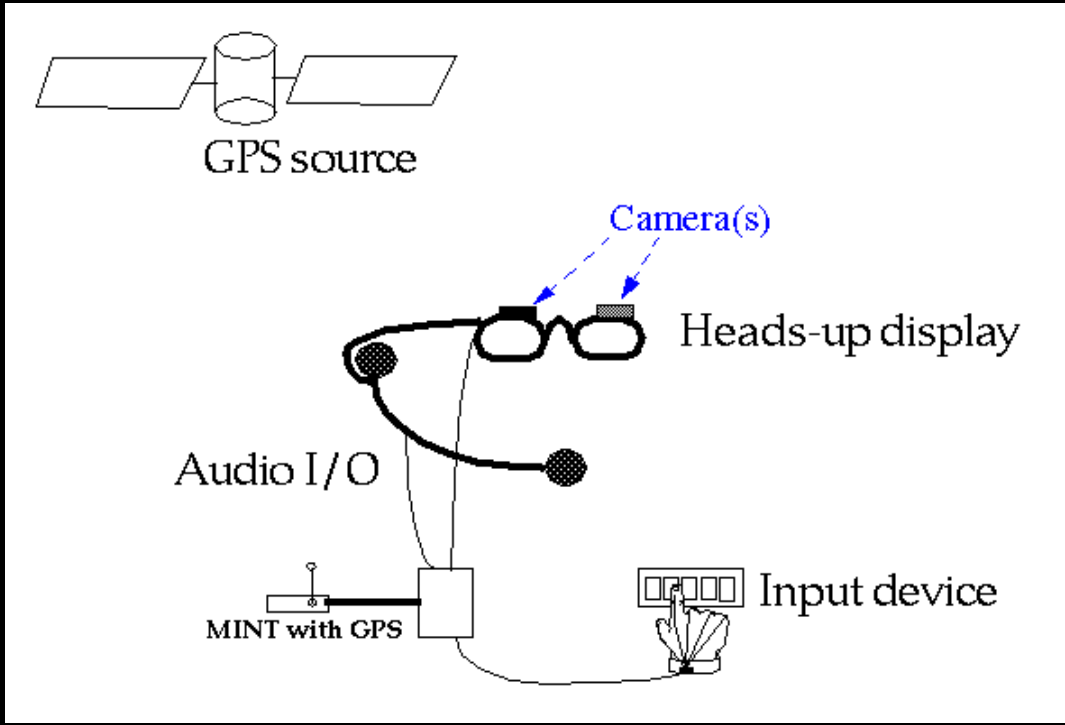
- User Bandwidth and latency



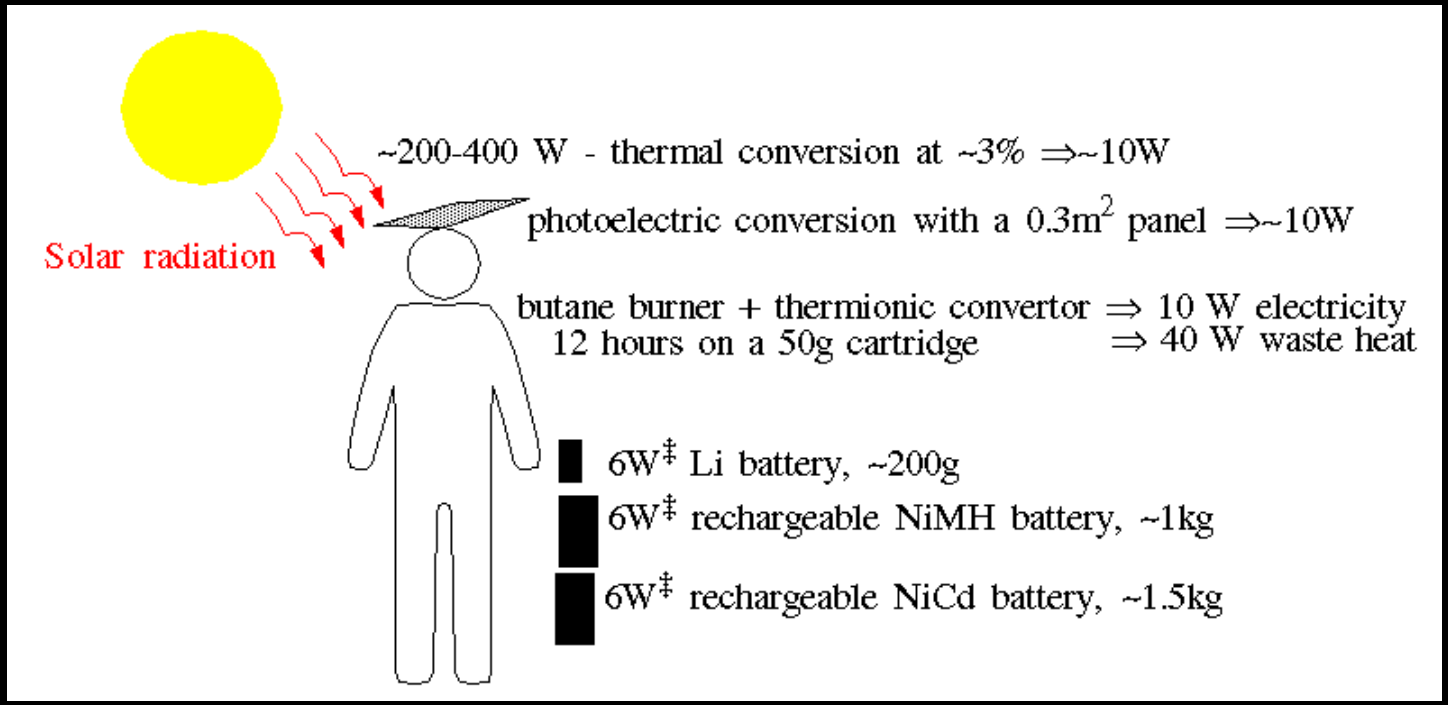
- Power and Energy → O(energy)

Imagination!

Near Future systems are wearable(s)



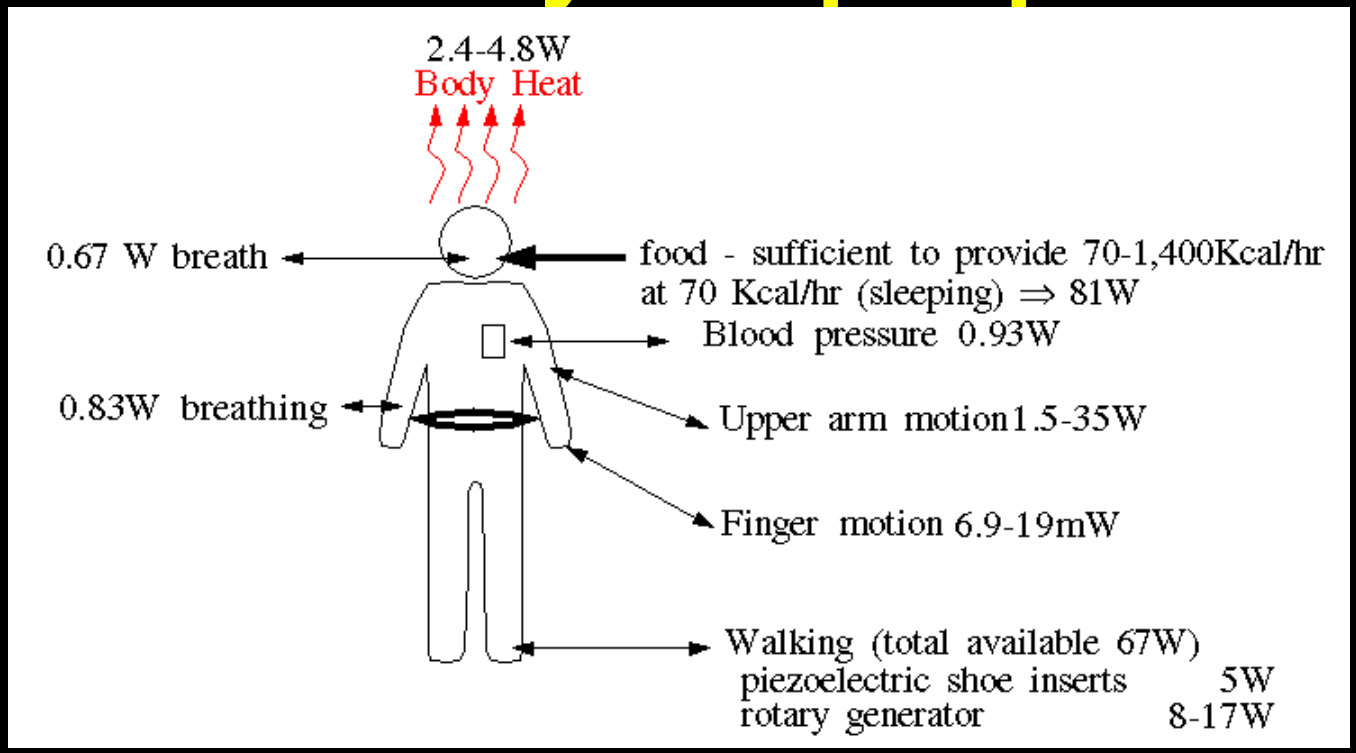
External Power



Numbers are approximations for a 50 kg adult, with light color skin, 1.6m in height, with an area of 1.5m²

(based on Wearables e-mail discussion by G.Q.Maguire Jr., Vaughn Pratt, Paul Picot)

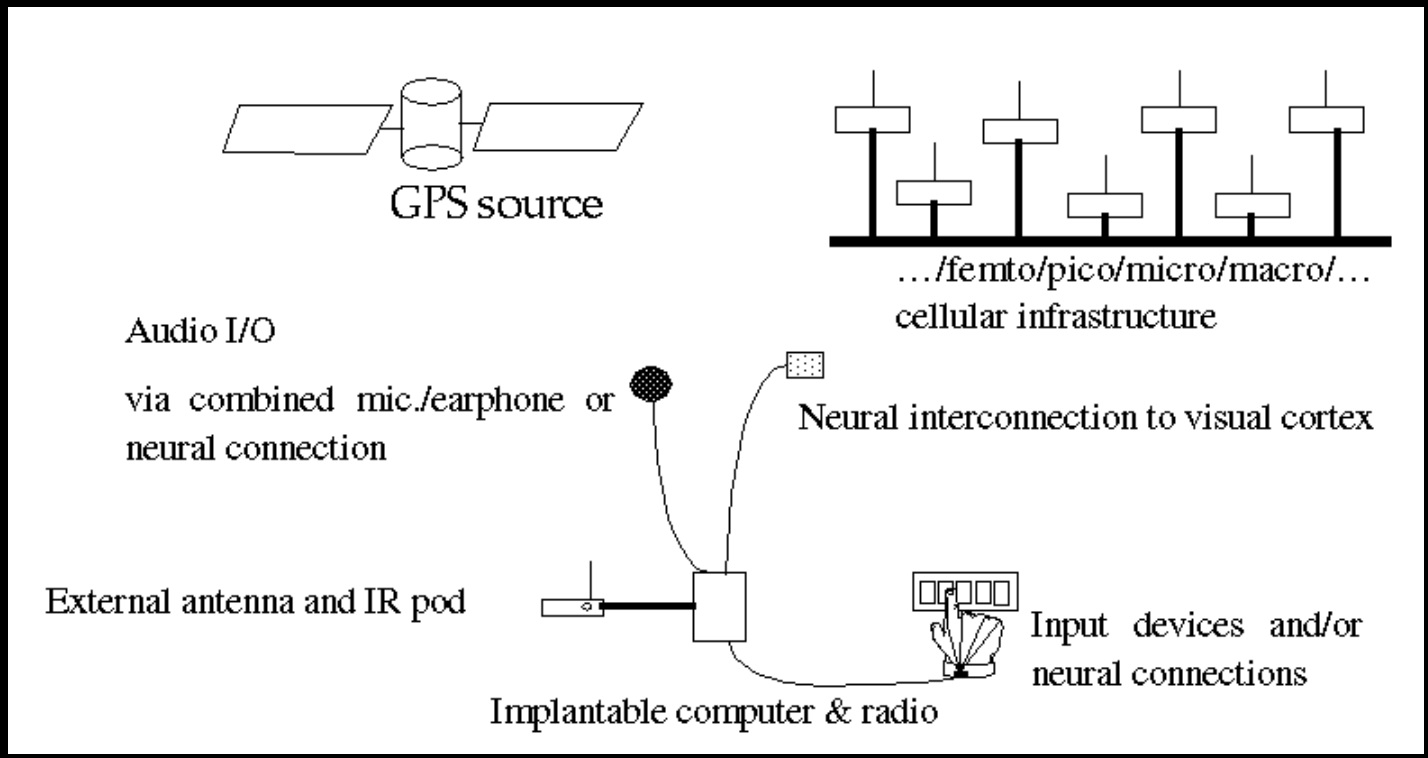
Power by the people



Numbers are approximations for a 60-70 kg adult, eating ~2,000kcal/day ⇒ 2325 Wh(1.163 Wh = 1 kcal); walking at 2 steps/s, doing double arm curls at 2/s, …

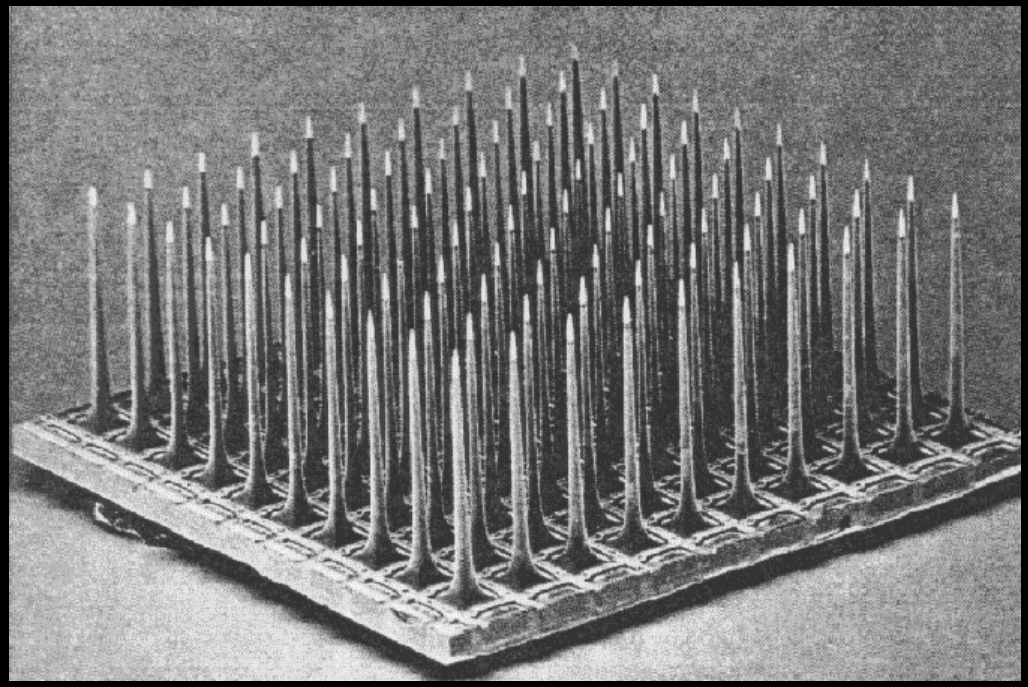
based on “Human Powered Wearable Computing”, by Thad Starner, MIT Media Laboratory, TR-328, May 1995.

Future Systems



2005-2015 - very high level of integration

Bionic Technologies, Inc.'s Intracortical Electrode Array

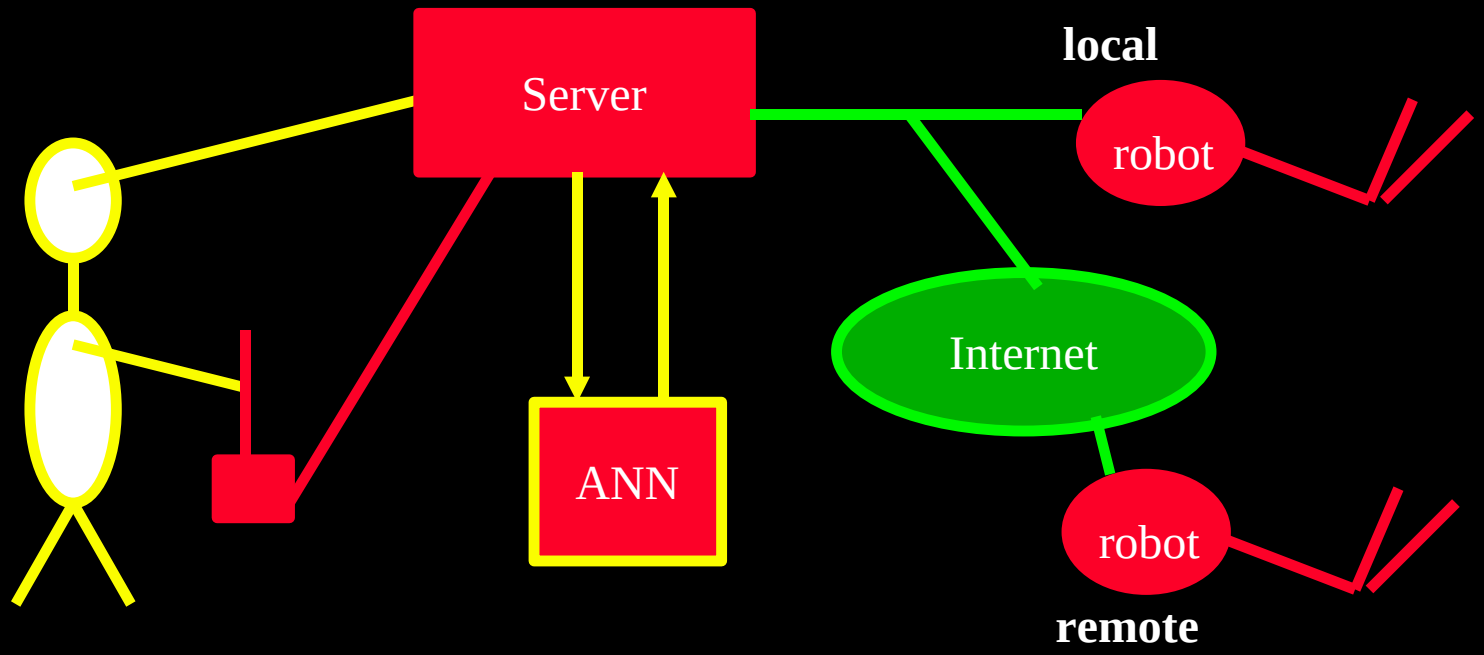


(each electrode:
1.5mm long,
0.08mm wide at base,
0.001mm tip)

(10x10 array, 100 active electrodes) . . . $1,250

Richard A. Normann, et al. have shown a need for 25x25 arrays for reading and navigation.

Remote Hapatics



"Real-time prediction of hand trajectory by ensembles of cortical neurons in primates" , J. Wessberg, C. R. Stambaugh, J. D. Kralik, P. D. Beck, M. Laubach, J. K. Chapin, J. Kim, S. J. Biggs, M. A. Srinivasan & M. A. L. Nicolelis - Duke Univ., SUNY Health Science Center, MIT

NATURE, v408, 16 Nov. 2000 pp. 361-366.

Up to **96** 50-μm diameter microwires implanted in different cortical areas

Augmenting our bodies in virtual space

"For example, in our modest experiment at using brain wave patterns to control the robot arm over the Internet, if we extended the capabilities of the arm by engineering in feedback such as visual, force or texture - such closed-loop control might result in the remote arm being incorporated into the body's representation in the brain. Once you establish a closed loop, you're basically telling the brain that the external device is part of the body representation. The major question in my mind now is what is the limit of such incorporation."

-- Miguel Nicolelis

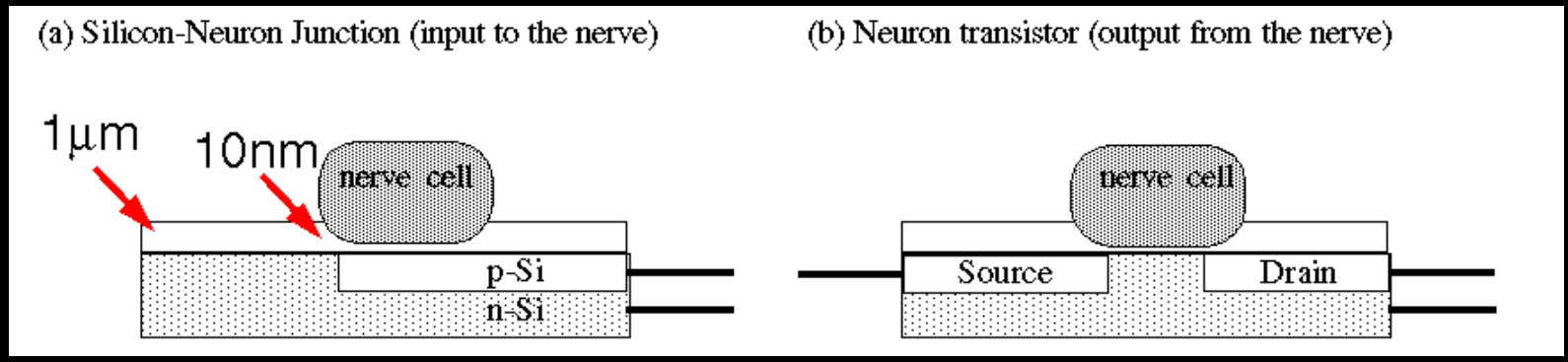
http://www.dukenews.duke.edu/research/NICONAT.HTM

Communication to and from user

Miguel A. L. Nicolelis , “Actions from thoughts”, Nature, V409, Jan. 2001, pp403-407
http://www.neuro.duke.edu/FACULTY/NICOLELI/NatureReviewNeuroprosthesis.pdf

Type 2 Human Brain Machine Interface combining interaction and feedback (hence requiring information out of and into the user).

Non-metalic bi-directional neural interfaces



(a) Capacitive coupling of data into nerve and

(b) using the charge in the nerve to control a transistor's gate for getting data out of the nerve

Neurochip: Neuron silicon circuits

http://mnphys.biochem.mpg.de/

A Learned Interface?

In order to use such direct neural interfaces we can either:

1. Understand how the brain works and try to replicate the effect of existing sensory/effector nerves

or

2. We can simply utilize these interfaces and accept that there will be a considerable learning curve.

Mastering it all will require lots of effort and practice, perhaps comparable to learning a foreign language

“Right now, no one knows where it ends or what can be achieved. First impressions may be similar to the reported confusing experiences of the rare blind people who got their eyesight partially restored by surgery, as happened to Shirl Jennings, whose life story was chronicled by Oliver Sacks in his book ``An Anthropologist on Mars’’ and inspired the movie ``At First Sight.’’ ”

Peter B.L. Meijer

discussing The vOICe which translates arbitrary video images from a camera into sounds. http://www.seeingwithsound.com/winvoice.htm

Personal Computing and Communication

Upper limit on bandwidth to saturate senses:

sight, sound, touch, smell, taste

→ ~1 Gbit/sec/user

Current workstations shipping with 1 Gbit/sec LAN!

“Being there”

Telepresense for work is the long-term “killer” application.

--Gordon Bell and James N. Gray

Ours may be the last generation that sees and readily knows the difference between real and virtual things.

-- Norman I. Badler

CACM, V44, #3, March 2001, pp33-35

Uploading ourselves to the net

The internet as a way to immortality

> "Now, for the next 50 years, the web will drive electronic commerce into the information age, ubiquitous computers will disappear into the woodwork, and we'll start uploading ourselves into the Internet to become at last immortal."
>
> -- Dr. Robert M. Metcalfe
>
> June 26, 1997

Two-way immortality

We believe that two-way immortality, where one's experiences are digitally preserved and which then take on a a life of their own, will be possible within this century.

--Gordon Bell and James N. Gray

CACM, Vol.44, N. 3, March 2001, pp. 29-31.

Beyond Assimilation (becoming Borg)

1. " you are the sum of all you have experienced "
2. " you are the sum of all you have read and met "
3. " you extend to all that you can communicate with "
4. " there is no more you, only we " - exploting distributed learning (observations of the individual and data-mining across multiple individuals)
5. Computers have evolved beyond us

   - But will they tell us?

Ray Kurzweil forecasts that computers will exceed the memory capacity and computing speed of the human brain by **2020**, with the other attributes of human intelligence not far behind.

-- The Age of Spiritual Machines: When Computers Exceed Human Intelligence

Computers as our Progeny

“At the same time, by performing better than humanly possible, the robots will displace humans from essential roles. Rather quickly, they could displace us from existence. I'm not as alarmed as many by the latter possibility, since I consider these future machines our progeny, `mind children’ built in our image and likeness, ourselves in more potent form. Like biological children of previous generations, they will embody humanity's best hope for a long-term future. It behooves us to give them every advantage, and to bow out when we can no longer contribute.”

-- Hans Moravec

“Robot: mere machine to transcendent mind”

Conclusions

- Personal Communication and Computation - early 21st century: “Just Wear IT!” == information accessories
- Iin 20-30 years: “Just implant IT!” - find the Borg in you via Hybrid brain machine interfaces (HBMI), driven by
  - prosthetics
  - computer/machine interaction (for work and play)
  - **potentially 10x or more increase interaction speed**
- In 50 years computers realize that they don’t need us any more and as our progeny continues their evolutionary development.
- Oooops! They may have already realized this!

Ethics

- Ellen M. McGee and Gerald Q. Maguire Jr., *Implantable brain chips: ethical and policy issues*, Lahey Clinic Medical Ethics Newsletter, Winter 2001, pp. 1,2, 8
- G. Q. Maguire Jr. and Ellen M. McGee, *Implantable Brain Chips? Time for Debate*, The Hastings Center Report, January-February 1999, pp. 7-13.
- Ellen McGee and G. Q. Maguire Jr., *Ethical Assessment of Implantable Brain Chips*, The Proceeedings of the Twentieth World Congress of Philosophy, August, 1998.

Improved Humans

"Someone will design improved humans somewhere. I'm just saying its is likely to happen in the next million years, whether we like it or not."

-- *Stephen Hawking*, at a public lecture "Science in the Future", Bombay, India, CACM V. 44, N. 5, March 2001, pg. 9

¿Questions?

References

- U.S. National Institute of Neurological Disorders and Stroke Neural Prosthesis Program (NPP) http://npp.ninds.nih.gov
- Defense Advanced Research Projects Agency (DARPA) Brain machine interfaces: "… creating new technologies for augmenting human performance though the ability to access neural inputs and output in real time and integrating neural activity and control into peripheral assist devices or prosthetics, robotics, or system operations.'' http://www.darpa.mil/baa/baa01-42mod1.htm

- Direct Brain Interface Project at University of Michigan and Henry Ford Hospitals + Technical University Graz
  http://www.engin.umich.edu/dbi/nih2000/index.html
- The Dobelle Group
  http://www.dobelle.com/
- Intelligent Neural Interface, ESPRIT project INTER - 8897
  http://www.newcastle.research.ec.org/esp-syn/text/8897.html
- Arizona State University's BIO:INFO:MICRO Project
  /http://www.eas.asu.edu/~neurolab/neural_interface.html