

WTEC International Assessment of Brain-Computer Interface Research

Organization and Translation of BCI Research in the European Community



WTEC Workshop on Brain Computer Interface Research: 21 July 2006

Sponsors: NSF, TATRC, NIBIB, NINDS, DoED

General Conclusions - 1

Programmatic/Administrative Issues:

- European science and technology administrators have identified interdisciplinary research as an opportunity – BCI research has a high priority.
- European science and technology goals are conceived of and implemented in terms of decades-long trajectories – the long time course for the development and implementation of BCIs is integrated into programmatic design.
- Administrative overhead from EU programs is high, and in some cases, considered prohibitive – EU-supported BCI research has its price.

Funding Issues:

- The European funding system for collaborative research seems more flexible and appropriate than US counterparts – the large teams of interdisciplinary investigators necessary for BCI research can be realized.

WTEC Workshop on Brain Computer Interface Research: 21 July 2006

Sponsors: NSF, TATRC, NIBIB, NINDS, DoED

General Conclusions - 2

Funding Issues (cont.)

- The European system funds collaborative, interdisciplinary research at a substantially higher level than in the US – BCI research has a strong level of financial support.

Translation/Commercialization Issues:

- The European system has created specific mechanisms and institutions for cooperative activity between academia and industry – there is a high level of transitioning BCI research
- The European system is more effective than US systems in integrating industrial and academic efforts – there is substantial support from industry for BCI research.
- There are no special mechanisms for deciding issues related to IP; IP apparently is negotiated on a case-by-case basis; spin-offs are not uncommon; there are no obvious barriers to generating BCI-related IP

General Conclusions - 3

Training/Educational Issues:

- Surprisingly little attention is paid to developing BCI-specific training programs at the undergraduate, graduate, or postdoctoral levels.
- Cross-disciplinary training occurs in almost a haphazard manner; obtaining interdisciplinary training is the responsibility of the student, with the noted exception of Aalborg University.
- The US clearly has more comprehensive, well-developed educational/training programs in BCI, with greater sensitivity to recruiting underrepresented minorities
- Long-term industrial internships are common in Europe and allow students to conduct their thesis research at collaborating companies.
- Several universities are fostering entrepreneurship training for their students to help promote translation of research into industry.

Coordinated Long-Term Interdisciplinary Research

Information Technology Society in the 6th Framework Program:

*"The focus of IST in FP6 is on the **future generation of technologies** in which computers and networks will be integrated into the everyday environment, rendering accessible a multitude of services and applications through **easy-to-use human interfaces**. This vision of '**ambient intelligence**' places the user, at the centre of future developments for an **inclusive knowledge-based society** for all.*

*This research effort will therefore reinforce and complement the Europe objectives and **look beyond** them to the **2010 goals** of the Union (the **i2010 initiative**) of bringing IST applications and services to everyone, every home, every school and to all businesses."*

The WTEC BCI Panel was impressed with multiple interdisciplinary research programs characterized by: (1) **high-level vision with** (2) **collective credibility (top-to-bottom-buy-in)**, (3) **levels of support appropriate to the vision**, and (4) **vision-generated mechanisms for implementation**.

Examples of Funding/Collaboration - 1

- The EC is supporting several **networks of excellence** which bring together researchers of different countries and diverse backgrounds:
 - **Human**: Human-Machine-Interaction Network on Emotion aims development of systems that can register, model and/or influence human emotional and emotion-related states and processes
 - **Brain.net**: BrainNet Europe is a "Network of Excellence" funded by the European Commission in the 6th Framework Program "Life Science" It consists of 19 established brain banks across Europe and is coordinated by the Centre for Neuropathology and Prion Research Ludwig-Maximilians-University Munich, Germany. Its main goal is the collection and distribution of well-characterised high-quality post mortem brain tissues for basic research in neuroscience.
 - **Bernstein Centers for Computational Neuroscience**: Germany's ministry of research and education (BMBF) established four centers to integrate neurobiology, cognitive science, systems biology, and information sciences to advance brain research.
 - **The Fraunhofer-Gesellschaft**: 58 Fraunhofer Institutes, at over 40 different locations throughout Germany undertake applied research of direct utility to private and public enterprise and of wide benefit to society. 90% of its annual research budget of over one billion euros is generated through contract research.

Examples of Funding/Collaboration - 2

Euron:
The EUROpean
RObotics research
Network is consists of
European robotics
groups and resources
in research, industry
and education joined
by a common interest
in working to make
better robots.



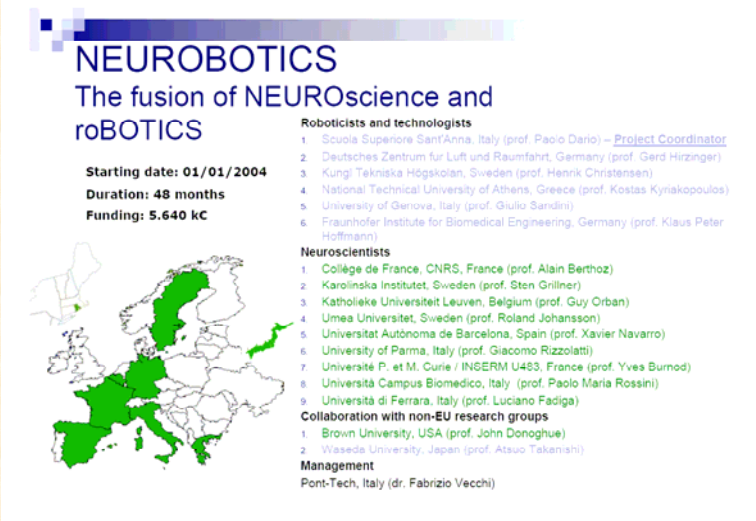
Examples of Funding/Collaboration - 3

- There is substantial funding for **high risk, paradigm shift, long term, interdisciplinary research**
 - MAIA: (Mental Augmentation through determination of Intended Action), a project for brain-wave control of robots, involving multiple European universities: IDIAP, Katholieke Universiteit Leuven, University Hospital of Geneva, Fondazione Santa Lucia-Rome, and Helsinki University of Technology
 - BACS: Bayesian Approach to Cognitive Systems, an Integrated Project under the 6th Framework Program of the European Commission which has been allocated EUR 7.5 million in funding, brings together researchers and commercial companies working on artificial perception systems to model neuronal functions and cognitive processes and to optimize existing learning algorithms, and to realize intelligent artificial systems.
 - CYBERHAND: a project to develop a hierarchical, distributed control, multi-degrees-of-freedom robotic hand for replacement of lost limbs; the hand is designed to respond to signals from the human nervous system; included in the DARPA Revolutionizing Prosthetics program
 - Blue Brain Project: massive project involving state-of-the-art experimental, theoretical, modeling, database, computational, and visual display technologies to realize a biologically-based representation of neocortical neurons, microcircuitry, and systems level structure and function

Examples of Funding/Collaboration - 4

- BBCI: Berlin Brain Computer Interface project – collaboration between the Fraunhofer FIRST Institute, Charite-University of Medicine, Technical Institute of Berlin, Bernstein Institute for Computational Neuroscience to develop BCI technology for commercial and medical uses
- BMI: Brain Machine Interface Initiative – collaboration between Bernstein Institute for Computational Neuroscience, Heidelberg Academy of Sciences and Humanities, METACOMP project (German-Israel Project Cooperation), University Hospital Freiburg, University Klinikum Freiburg to study neural dynamics as it relates to fundamental neurobiology and BCIs
- Presencia – an 7,000,000 € ECC funded collaboration between 16 different laboratories in 7 countries for the purpose of developing virtual reality environments within which BCI applications figure heavily
- GRIP: Demonstration of the feasibility of a regeneration type neural connector based on a micromachined structure incorporating through-holes for improved stimulation and recording selectivity and mechanical stability for FES control of a paralyzed human hand

Examples of Funding/Collaboration - 5



NEUROBOTICS
The fusion of NEUROscience and roBOTICS

Starting date: 01/01/2004
Duration: 48 months
Funding: 5.640 k€

Roboticians and technologists

- 1 Scuola Superiore Sant'Anna, Italy (prof. Paolo Dario) – Project Coordinator
- 2 Deutsches Zentrum für Luft und Raumfahrt, Germany (prof. Gerd Hirzinger)
- 3 Kungl. Tekniska Högskolan, Sweden (prof. Henrik Christensen)
- 4 National Technical University of Athens, Greece (prof. Kostas Kyriakopoulos)
- 5 University of Genova, Italy (prof. Giulio Sandini)
- 6 Fraunhofer Institute for Biomedical Engineering, Germany (prof. Klaus Peter Hoffmann)

Neuroscientists

- 1 Collège de France, CNRS, France (prof. Alain Berthoz)
- 2 Karolinska Institutet, Sweden (prof. Sten Grillner)
- 3 Katholieke Universiteit Leuven, Belgium (prof. Guy Orban)
- 4 Umeå Universitet, Sweden (prof. Roland Johansson)
- 5 Universitat Autònoma de Barcelona, Spain (prof. Xavier Navarro)
- 6 University of Parma, Italy (prof. Giacomo Rizzolatti)
- 7 Université P. et M. Curie / INSERM U483, France (prof. Yves Burnod)
- 8 Università Campus Biomedico, Italy (prof. Paolo Maria Rossini)
- 9 Università di Ferrara, Italy (prof. Luciano Fadiga)

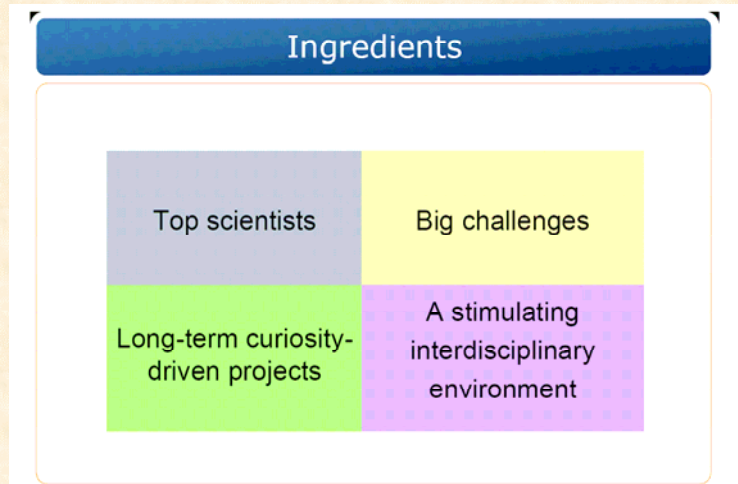
Collaboration with non-EU research groups

- 1 Brown University, USA (prof. John Donoghue)
- 2 Waseda University, Japan (prof. Atsuo Takanashi)

Management
Pont-Tech, Italy (dr. Fabrizio Vecchi)

The poster includes a map of Europe with several countries highlighted in green, indicating the geographical distribution of the project's participants.

Success of European Research Model



Translation and Commercialization - 1

- Specific mechanisms for joint academic/scientific and industrial collaboration
 - commercial entities can participate in EU-sponsored research as "just another project" – the only requirement is that each commercial entity must provide 50% of the costs of their project; often, industry-related projects are producing technologies ultimately sold to other research-related projects
 - EU projects require industrial involvement, so relevant businesses are actively pursued – but not pursued for money, instead pursued so businesses can receive money
 - Example outcomes of the EU encouragement of industry participation:
 - Multi-Channel Systems (MCS): leading world-wide supplier of multi-site electrodes and multi-channel recording/stimulation systems for brain slices/cultures; partner in many EU projects
 - g-TEC: grew out of activities of the University of Graz BCI Laboratory; now is a major world-wide supplier of multi-channel EEG amplifiers; partner in many EU projects

Translation and Commercialization - 2

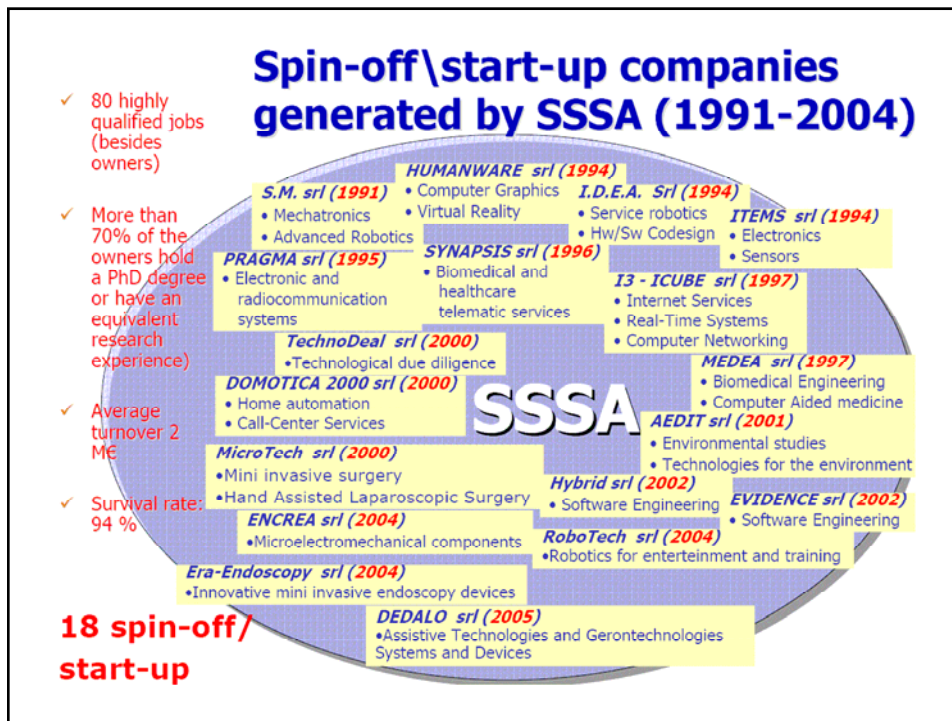
- At least in Germany, there are several forms of institutes that actively promote interactions with industry and garnering support from industry
 - Fraunhofer Institute (Berlin) for Computer Architecture and Software Technology
 - pursues the development of BCI research and technology both for medical applications and commercial applications (e.g., gaming; auto industry)
 - director of a given research group in the Fraunhofer holds 80% appointment in the University and 20% in the Fraunhofer
 - 30% of funding through the Fraunhofer must come from industrial sources
 - patenting is encouraged; royalties shared; spin-offs encouraged with licenses back to inventors

Translation and Commercialization - 3

- Natural Sciences and Medical Institute (NMI), Reutlingen
 - one of 11 institutes of applied research in the state of Baden-Wuerttemberg; NMI conducts interdisciplinary applied research in natural science and medicine
 - 13 "competence teams"; multiple disciplines; network of clinics, universities, other research institutes to develop new products
 - each team responsible for its own cash flow; high flexibility
 - wealth of technologies and support staff for academic researchers and small businesses to access cutting-edge approaches to their problem, e.g., MCS, Inc.
 - incubator for small start-ups and spins-offs, e.g., Retina Implant, Inc.
 - last two years, collaborated with >230 companies on research projects totaling 70M euros

Translation and Commercialization - 4

- Examples of Industrial Collaborations (non-exhaustive)
 - Fraunhofer Institute (Berlin): Volkswagen, Daimler Chrysler, Dupont, Schering, ITSO, idalab, overture/yahoo, KPMG, IBM, Honda, Sony, Voice Trust, Microsoft, Financial companies
 - NMI (Reutlingen): Abbot Laboratories, Bayer, BMI Biomedical Informatics, Boehringer Ingelheim Pharma, Carl Zeiss SMT AG, Accelab GmbH, BIBraun Aesculap AG, Brucker Daltonic, Altana Pharma, Biopharm, CellMed, Evotec Technologies, MAN, Mikrogen, MultichannelSystems, TETEC, Robert Bosch, and ZF friedrichshafen
 - University of Freiburg (Bernstein Center): Boehringer-Ingelheim, GIF, Honda, and Multichannel Systems
 - EPFL (Swiss Fed. Inst. Technology), Lausanne: IBM (\$20M), Silicon Graphics, and other sources



Translation and Commercialization - 5

- Industrial Collaboration was not Universal
 - Oxford, England: some, but minimal, industrial partnerships and commercialization
 - Edinburgh, Scotland: no identified translational activities
 - Tuebingen, Germany: virtually non-existent; deliberate limiting of focus on BCI development and delivery to patients' homes; government pays for equipment