The Human Brain Project
&
- Medical Informatics Platform –

Ferath Kherif
LREN
Département des Neurosciences Cliniques
CHUV
EU funded Collaborative project for understanding the human brain

25 Countries

400 Researchers  2013  10 Years
From Data to models of the Brain

Neuroscience

Unify

Medicine

Classify

Computing

Produce
Accessing the HBP Platform Ecosystem

The HBP Platforms provide strategic tools in:

- **Neuroinformatics**
- **High Performance Analytics and Computing (HPAC)**
- **Brain Simulation**
- **Neuromorphic Computing**
- **Medical Informatics**
- **Neurorobotics**
Subproject 8: Medical Informatics

1. Establish a framework for federating clinical data – all diseases, many hospitals
2. Develop federated query technology that respect anonymity requirements
3. Develop machine learning algorithms
4. Derive biological signatures of brain disease
• Athens University of Economics and Business (AUEB)
• University College London (UCL)
• Bordeaux University (UBO),
• Uppsala University (UU)
• Centro San Giovanni di Dio Fatebenefratelli (FBF)
• McGill University (MCGILL)
• University of Southern California (USC)
• University of Edinburgh (ED)

• Centre Hospitalier Universitaire Vaudois (CHUV)
• Ecole Polytechnique Fédérale de Lausanne (EPFL)
• Tel Aviv University (TAU)
• Josef Stefan Institute (JSI)
• University Medical Centre of Leids (LUMC)
• Geneva University Hospital (HUG)
• Athens University (UoA)
Evidence based medicine

Facilitate Knowledge exchange between medical informatics Communities

Facilitate the integration of life science research
Clinical research and patients care

Research: data analyses, hypotheses testing and **model building**

Clinic: data analyses, hypotheses testing and decision support

Developers: Create and **deploy apps**

General public: engagement, information **contribution** to small crowdsourcing task (curation)
Evidence based medicine

Going beyond symptoms based medicine: symptoms are not discriminative.

How big data can help: Bradford Hill (1965)

Inferring causality from observational data

1. **Strength**: effect size
2. **Consistency**: multiple evidence
3. **Specificity**: multiple disease
4. **Temporality**: Causality
5. **Biological gradient**: multiscale
6. **Biological Plausibility**: knowledge
7. **Coherence**: replicability
8. **Experiment**: Clinical trial
9. **Analogy**: Alternative models
Evidence based medicine

Going beyond symptoms based medicine: symptoms are not discriminative.
Evidence based medicine

Going beyond symptoms based medicine: symptoms are not discriminative.
Objective: Multiscale Disease Signatures

The MIP provides methods to analyse federated data from hospitals, research centres and biobanks and aim to federate the different communities of users from these different locations.
**Roadmap New Use Cases**

**First Disease Signatures from Hospital Data**
Demonstrate how clinicians and researchers can use the Platform to build models that can be applied to clinical practice.
- develop an objective, biologically grounded model of neurological and psychiatric diseases based on multi-level clinical data
- establish a first proof-of-concept for personalised medicine for neurology and psychiatry.

**Cross-Cutting Multi-Scale Studies Using the MIP Capabilities**
Demonstrate the interaction of SP8 with other SPs to generate deeper knowledge about brain disease mechanisms.
- use biological signatures of disease to provide the data required for high-fidelity reconstructions and simulations of disease
- create a brain disease atlas that can be used to map, classify and diagnose brain diseases.

**Operating the Platform for the Community**
Demonstrate how the clinical research community and other medical initiatives can use the Platform
- add new functionalities to the MIP
- Create via the Collaboratory new communities supported by the MIP.
The Medical Informatics platform

DATA
- 8’305 CHUV patients - 9’601 data points
- Clinical data - 58’028 diagnostic labels
Clinical outreach: Computer-based diagnosis

Provide bridge

Medical informatics community to explore the genomic and proteomic data for disease understanding.
Use case: Study replication

Mapping the effects of ApoE4, age and cognitive status on 18F-florbetapir PET measured regional cortical patterns of beta-amyloid density and growth.

Proof of Concept

912 Alzheimer’s patients
5566 Healthy controls

BRAIN IMAGING

PET

Organising
Tabulating

PROCESSING...

MRI

CLINICAL SCALES & MEASUREMENTS

PROTEINS

GENES

MRI data
PET data
Gene data
CSF data
Protein data

CSF
Methods

• Phenotype-led Semi-supervised clustering

• Derived model of genetic, proteomic variables to underline the subgroups of Alzheimer’s disease and healthy controls.
Methods

- Biology-led classification

- Intermediate phenotype of disease with

- Automated Diagnostic based on pathology

AD + Symptoms + Pathology

AD - Symptoms NO Pathology

HC + NO Symptoms + Pathology

HC - NO Symptoms NO Pathology
Methods

DEEP LEARNING ALGORITHM

A number of features extracted from a set of MRI scans is used to train a neural network with multiple hidden layers. Supervised training results in automated classification between e.g. healthy and Alzheimer subjects.
Proof of Concept
Foster Collaboration and Exchange

**New tasks and expertise**
- Genetic (ICM, Cardiff)
- Mental Health (ICM, DE)
- Data governance
- Data standards

**Novel collaboration** with
- SP2, SP5, SP6, SP7, SP9, SP10
  - Direct or via the CDP

**Collaboration:**
- Other Medical Initiative
- Share data, knowledge and Infrastructure
- IMI working groups (18 Months Roadmap)
  - One virtual cohort
  - Disease models
  - Share API

**Other Platforms**
- Part of Neurolink (Cbrain, Cati, Shanoir, VIP, ...)

**Medical neuroscience Network express interest in using the MIP as a Platform**
- NeuroMed (Italy)
- interTBI
- BrainMINDS (Japan)
The strategy is designed to be viable long term and ensure self-sustainability of the MIP, encouraging new data centres and hospitals to join the MIP community themselves and so participate to with data.
Bogdan Draganski  
Jing Cui  
Ferath Kherif  
Elisabeth Roggenhofer  
Fabrizio Pizzagalli  
Claudia Modenato  
Borja Hernandez  
Sara Lorio  
Remi Castella  
Lester Garcia-Melier  
Sandra Martin  
Ettore Accolla  
Ludovic Sautel

Renaud Marquis  
Richard Frackowiak  
David Slater  
Maria Knyazeva  
Anne Ruef  
Antoine Lutti  
Marzia der Lucia  
Valerie Beaud  
Melissa Saenz  
Yohan Boillat  
Elham Barzegharan  
Sandrine Muller  
Athina Tzovara

LREN, Laboratoire de Recherche en Neuroimagerie,  
Département de Neurosciences Clinique,  
CHUV - Université de Lausanne, Switzerland
Alzheimer's disease: advancing research through collaboration