Neurorobotics: A strategic pillar of the Human Brain Project

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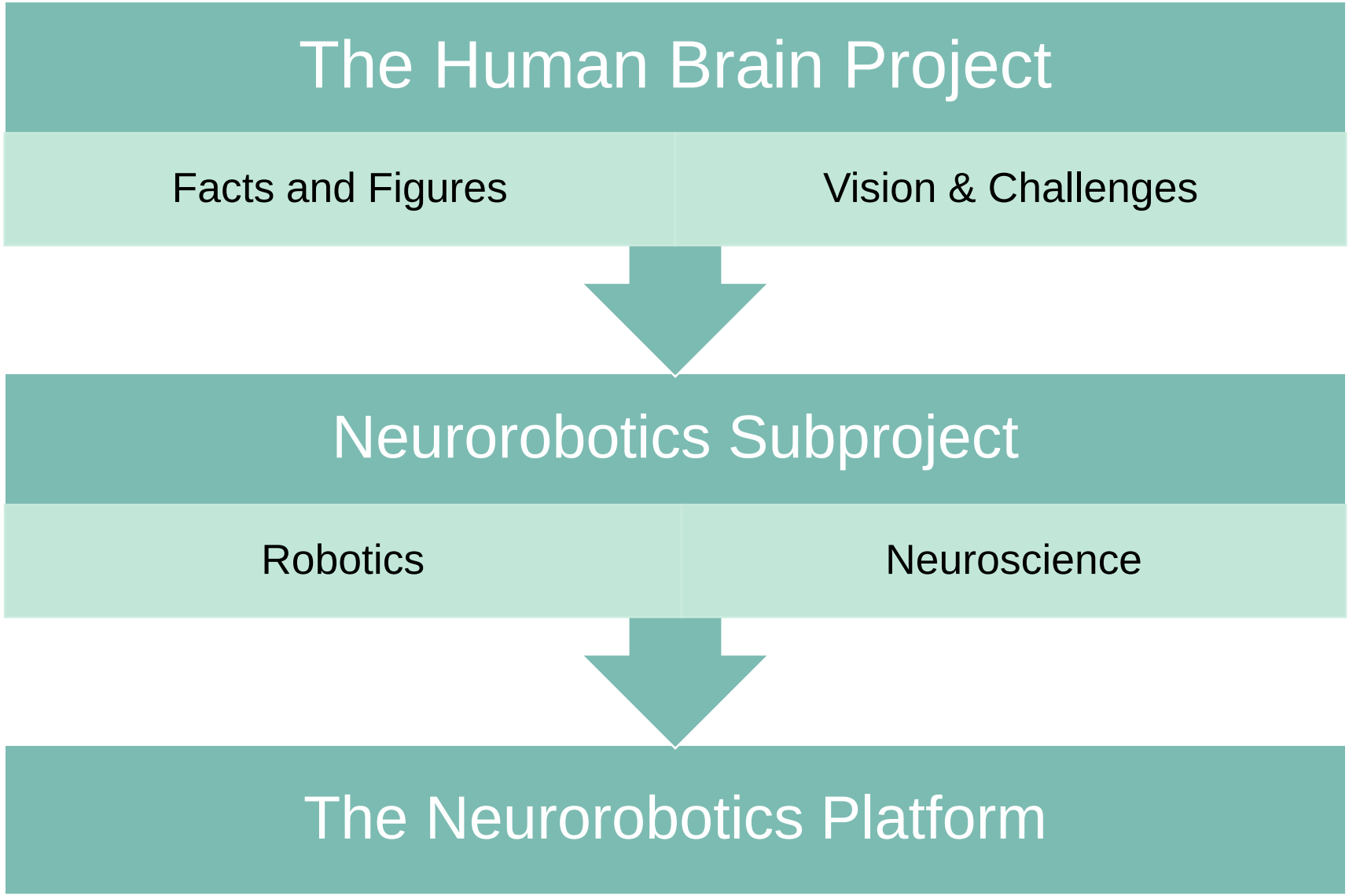
Workshop Agenda

15 Min: Neurorobotics: A strategic pillar of the Human Brain Project (A. Kuhn)

40 Min: A comprehensive framework for connecting simulated robots to artificial brains: The NRP (E. Falotico)

30 Min: Using the NRP to its full potential (S. Murphy)

This workshop is designed to be interactive. So if you have any questions at any point, don't hesitate to ask!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Vision & Challenges
Neurorobotics Subproject
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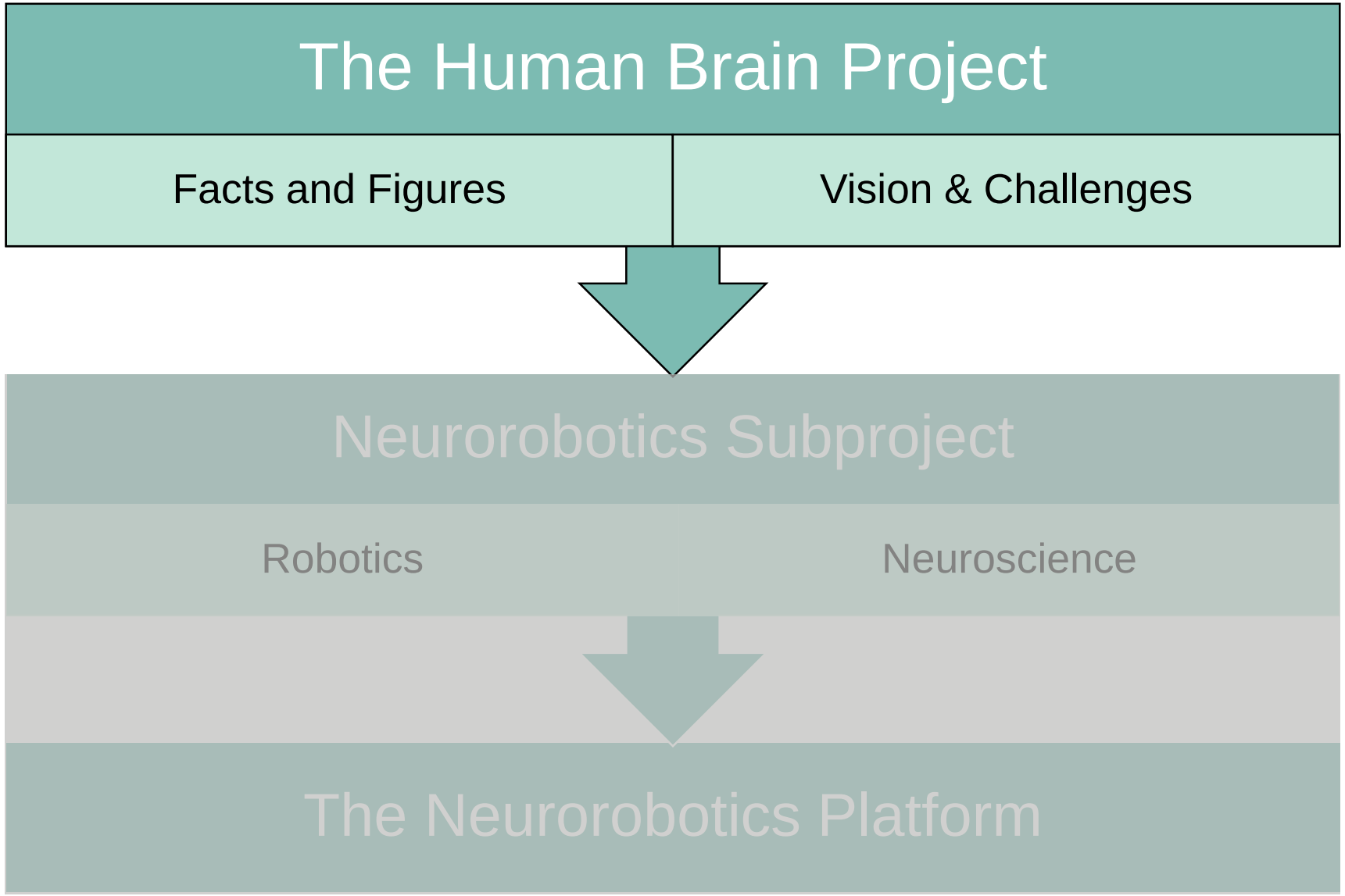
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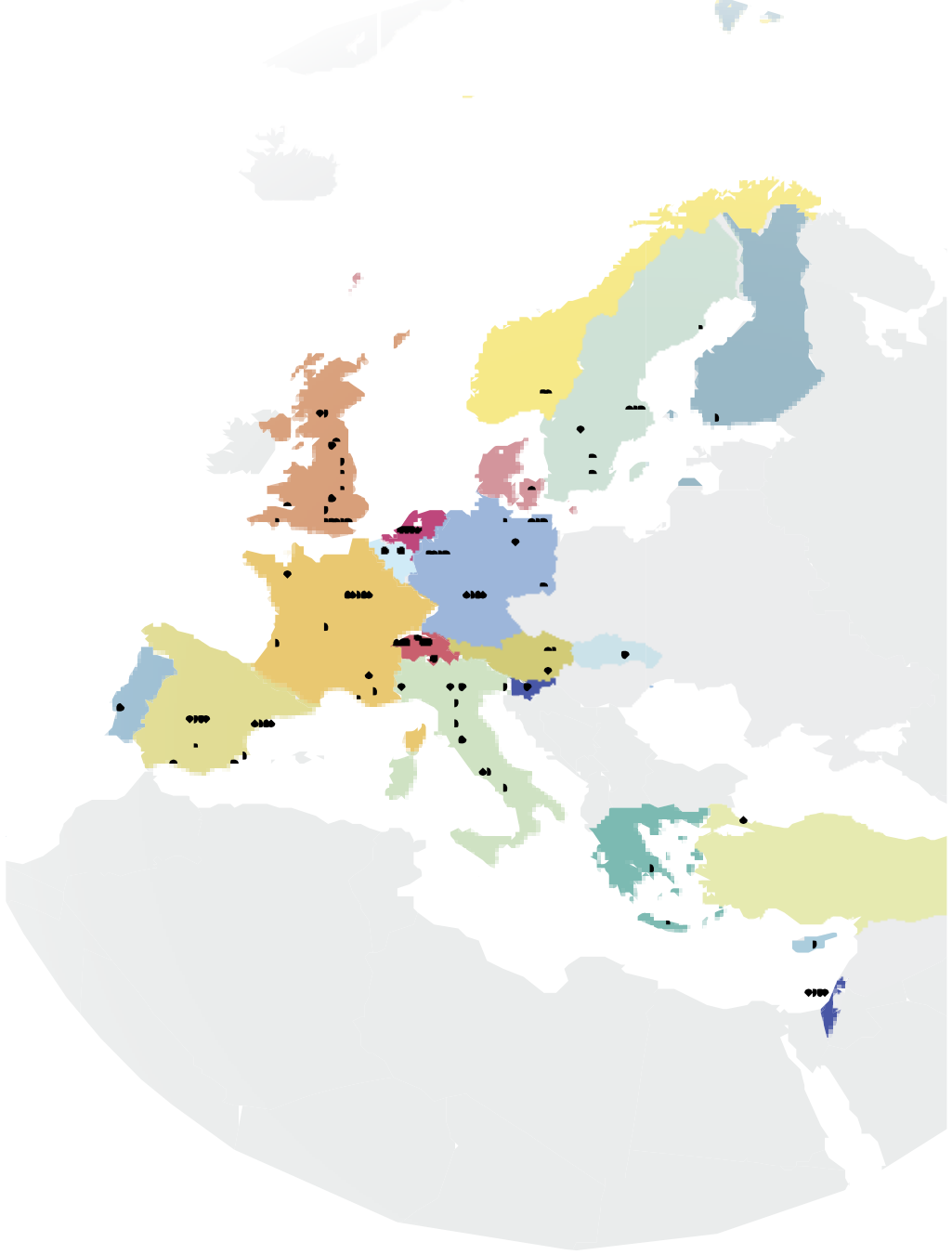
HBP Commitment

Working together towards a unified understanding of the brain and its diseases and to build new, brain-inspired computing

Behind that statement:

- Launched in 2013
- A European Commission Future and Emerging Technologies Flagship
- A large-scale European collaborative research initiative
- More than 400 scientists from 117 institutions representing 19 countries
- A 10-year Research Roadmap with a budget of €1 billion

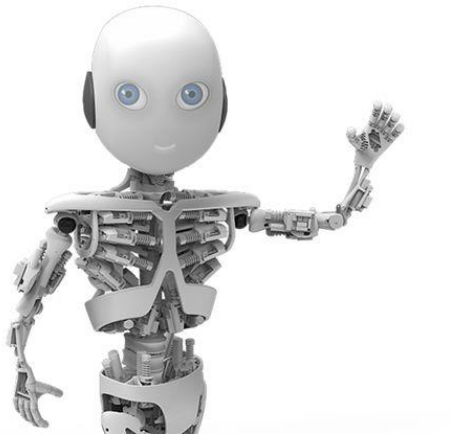


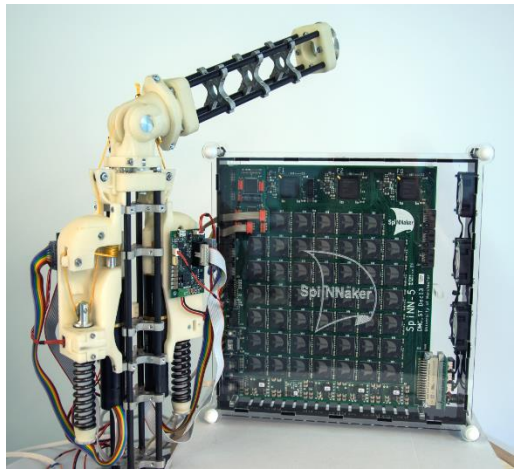
Vision, Challenges and Objectives

Co-funded by
the European Union

HBP Vision

- Understanding the human brain is one of the greatest challenges in 21st century science.
- If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain disease and build revolutionary new computing technologies.





HBP Challenges

- Healing brain diseases:
  - Annual cost for mental health diseases: €800 billion in Europe alone
  - Few effective treatments

- Using the brain as inspiration:
  - Our brain is immensely complex and powerful
  - Yet, it only consumes 30W of energy!

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HBP Objectives

Create HBP Brain Atlas

- Integrate multilevel maps of the mouse brain and the human brain

Simulation of the brain

- Develop Information Communication Technology (ICT) tools for digital reconstructions and simulations of the mouse brain, and ultimately the human brain.

Brain-inspired computing and robotics

- Develop ICT tools for models of the brain in neuromorphic computing and neurorobotic systems.

Interactive Supercomputing

- Develop hardware architectures and software systems for visually interactive, multi-scale supercomputing and extreme-scale big data analytics.

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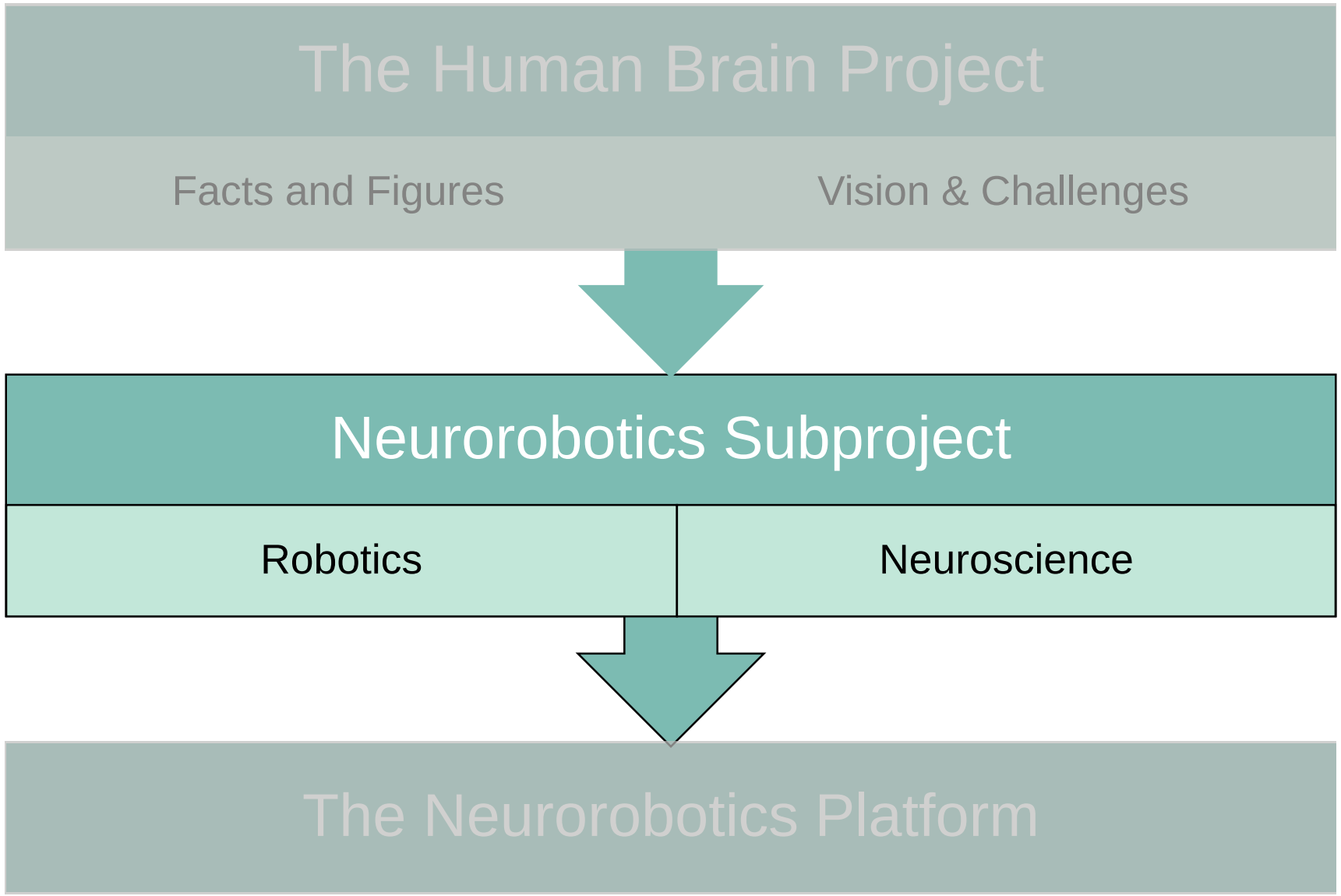
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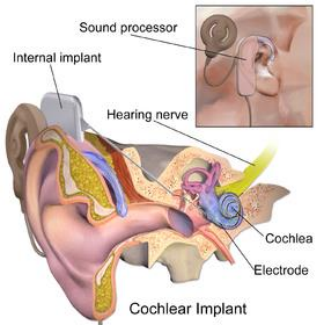
SP10

Neurorobotics Subproject (SP10)

Why Neurorobotics?

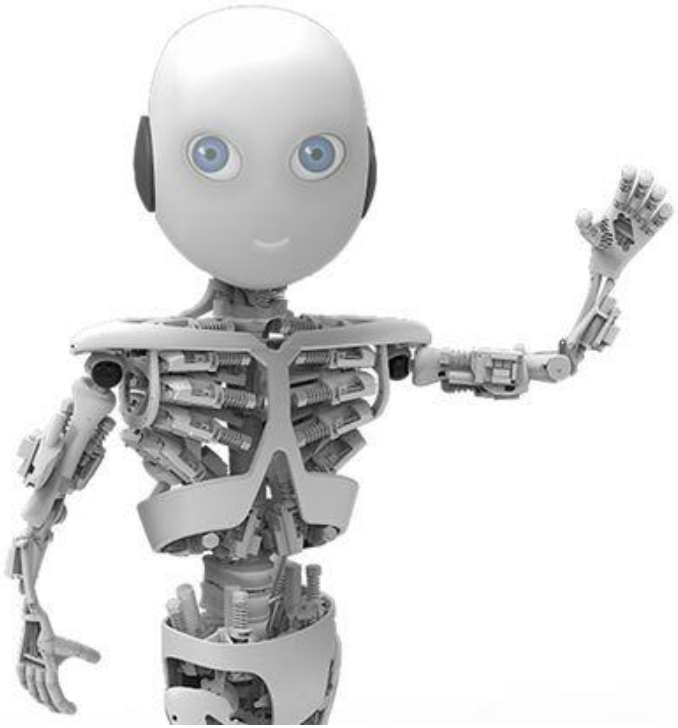
- Humans are the result of a VERY long evolutionary optimization (proven to be robust and efficient)
- Human brain is immensely powerful
  - Try to mimic its properties to make use of that power
  - Understand our brain better
  - Develop treatments (e.g. after stroke)
- World is built for humans
  - Humanoid robots fit ideally, people are used to humanoids in terms of cooperation
  - Soft (biomimetic, anthropometric) robots are lighter and not as harmful in human-robot cooperation
  - Improve **Neuroprosthetics**: Robotics similar to humans that fit seamlessly

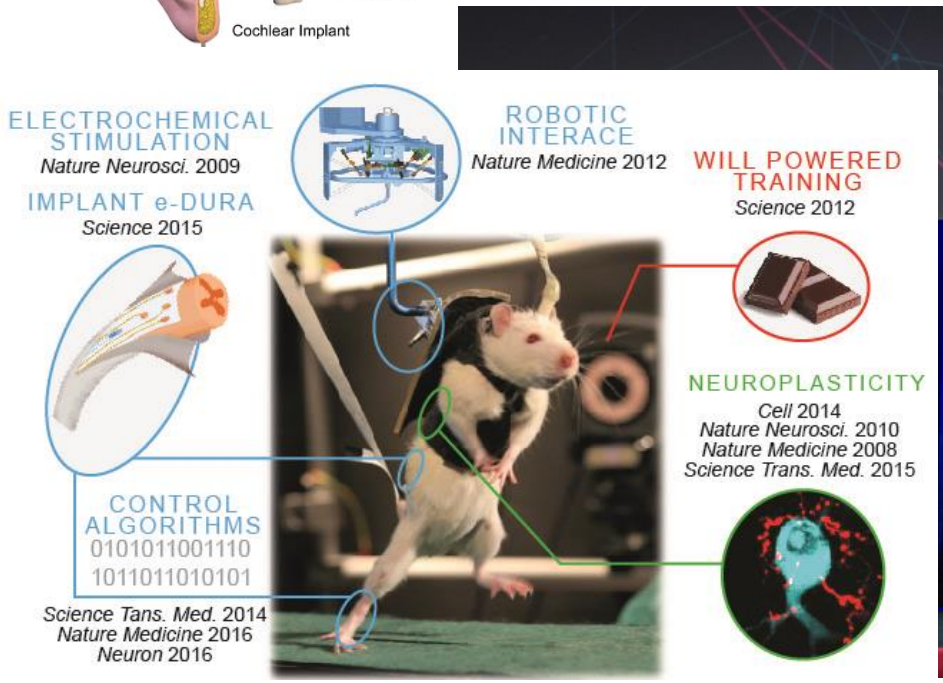
Neuroprosthetics



https://en.wikipedia.org/wiki/Cochlear_implant

http://www.bbc.com/news/health-26036429





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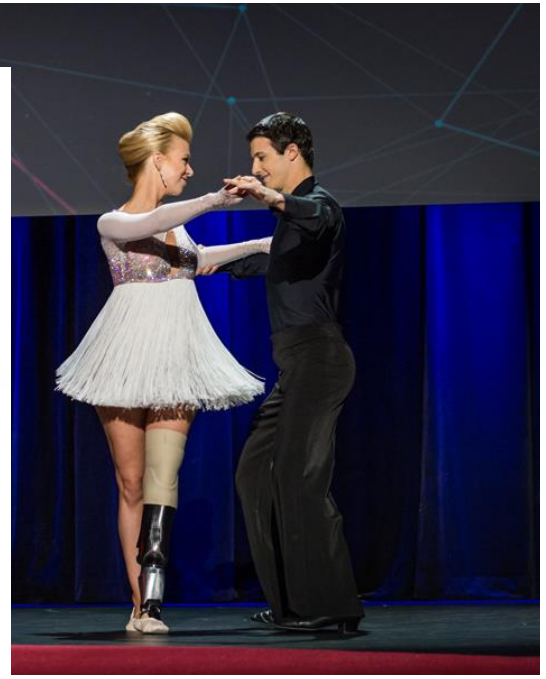
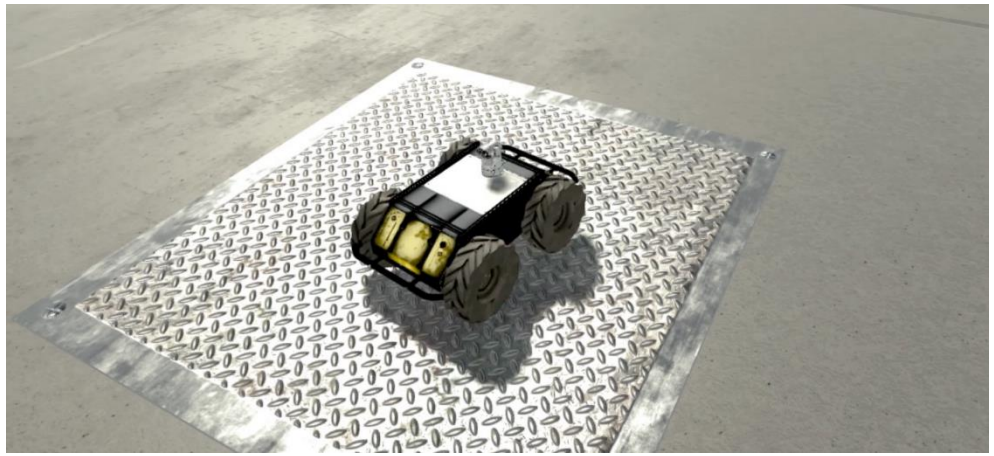


https://tedconfblog.files.wordpress.com/2014/03/adrianne-1.jpg?w=900&h=599

http://virtualreality.duke.edu/project/walk-again-project/

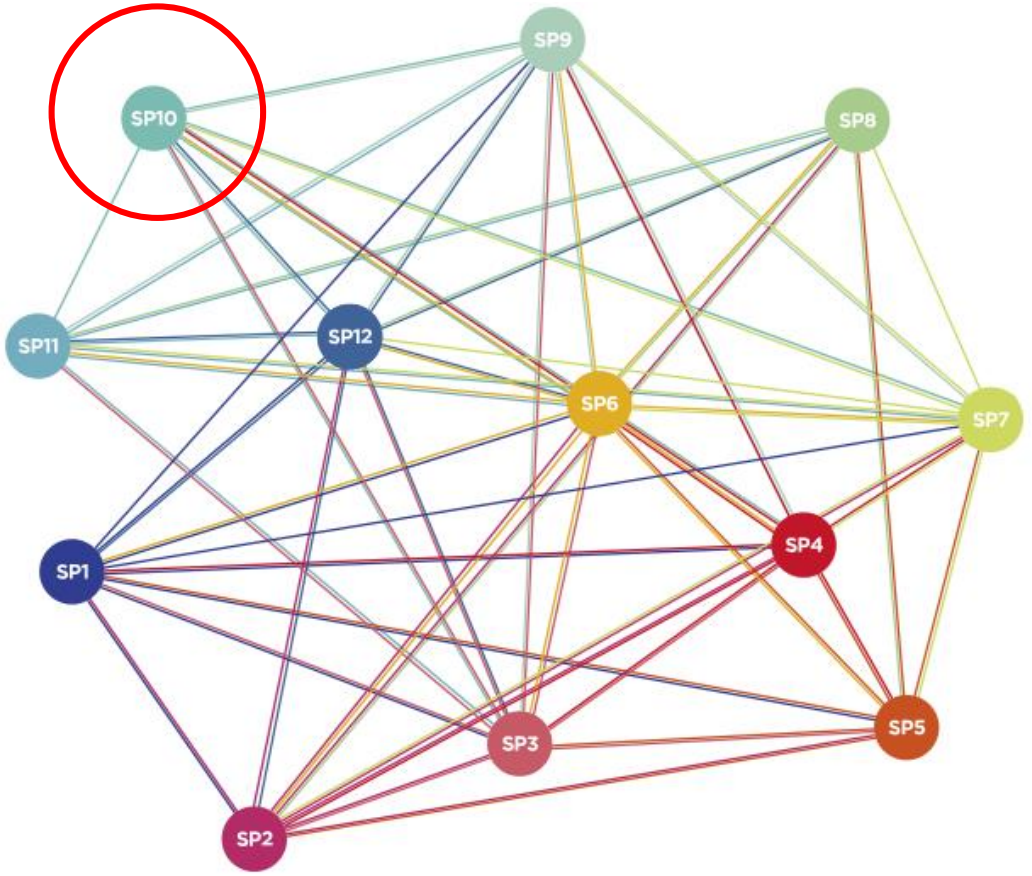
Why Virtual Neurorobotics?

- Increased speed allows genetic algorithms:
  - Parallel evolutionary search for optimal parameters
  - Faster than real time
- Change parameters to simplify experiments
- No sensor imperfections
- Repeat runs without deviations
- Reset experiment automatically => save time
- No need for expensive robots
- No risk of breaking robots



SP10: Neurorobotics

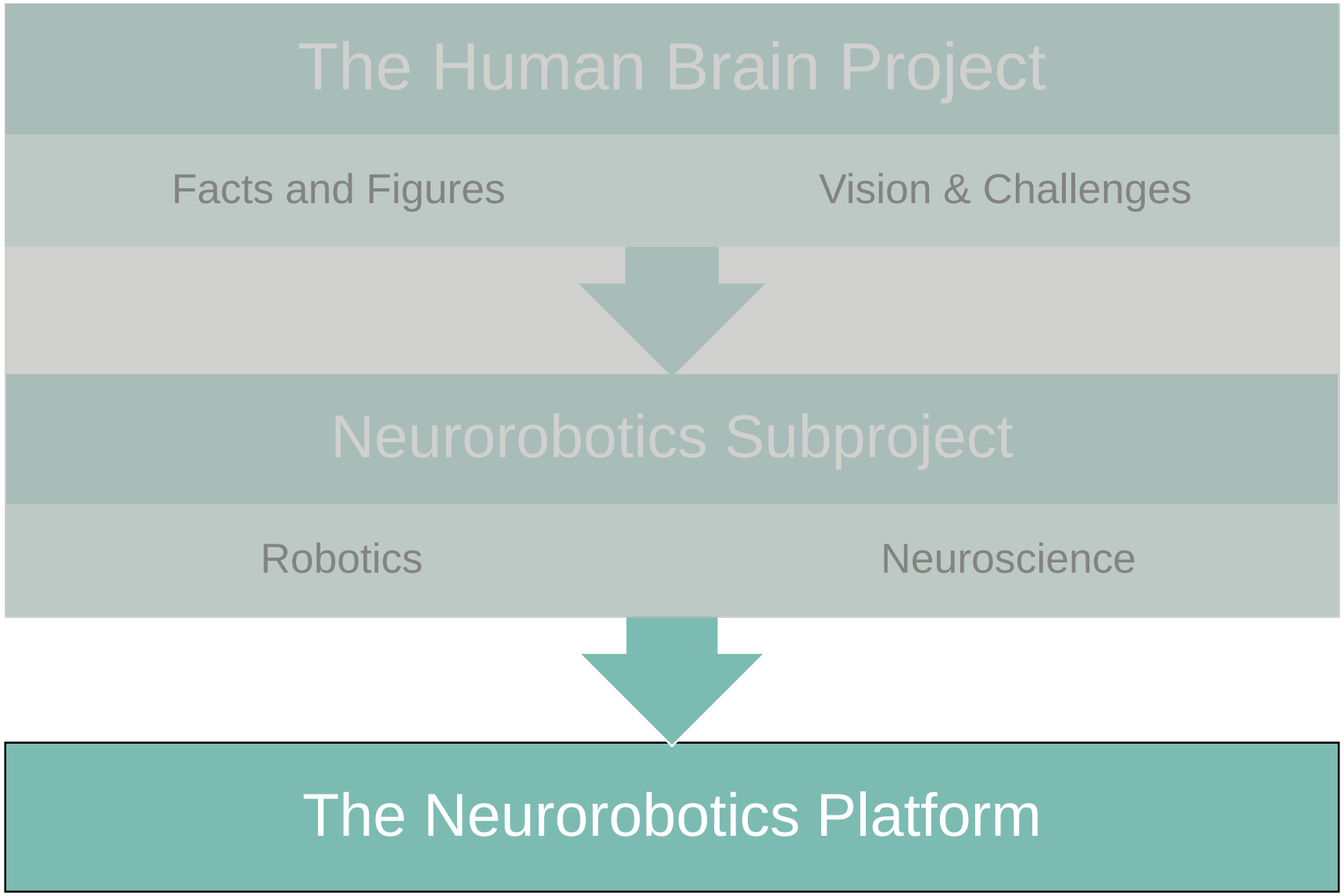
- Robotics: conventional and biologically inspired
- Neuroscience: novel control architectures, brain models
- SP10 develops one of 6 HBP ICT platforms
- This platform allows to run virtual neurorobotics experiments
- Part of the HBP Collaboratory to easily include external partners for sharing data and easy communication amongst researchers



The HBP's emphasis on collaboration is exemplified by the interdependence of its twelve research Subprojects

SP10: Neurorobotics

- Biologically inspired robots are making huge progress
- Mouse brain research will give us extremely detailed **brain maps**
- **Neuromorphic hardware** can facilitate learning to implement cognitive capabilities based on spiking neural networks
- With a world wide interest in neurorobotics, we tried to incorporate these concepts in our open source **Neurorobotics Platform (NRP)**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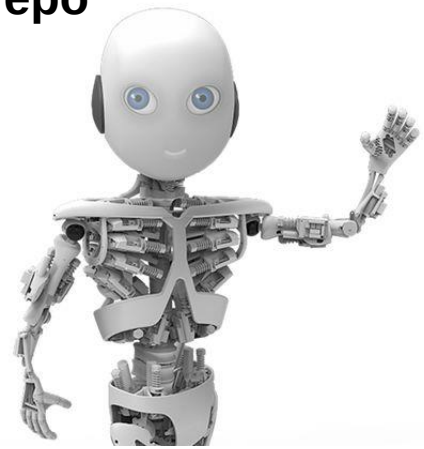
Applied neurorobotics as part of the HBP Collaboratory

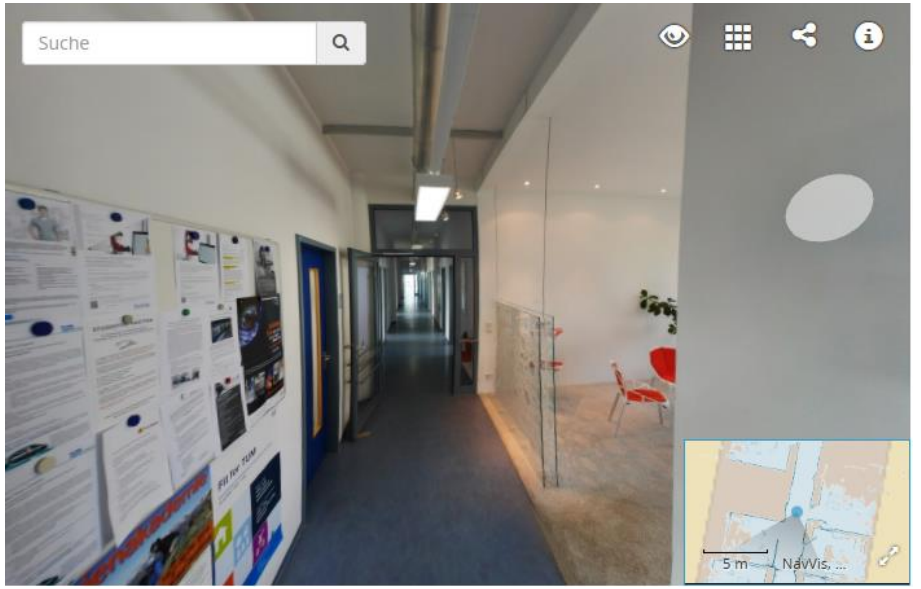
NRP: Core concepts

- **Researchers can collaboratively design and run virtual experiments using brain models**
- **Easy access:**
  - The NRP is based on modern web technology (No installation – on any device)
- **Collaboration**
  - Data sharing and collaborative experiments on Centralized data hub
- **Resource sharing**
  - Access to resources of limited availability (High performance clusters)
- **Open Source**
  - Published as and relying on reliable open source software

Physical Robot Integration

- In the end, the goal is to control physical robots
- Virtual results need to be verified on actual hardware
- Physical robots integration with the NRP
  - Same development environment for virtual and physical experiments
  - Grant remote access to robots (shared hardware)
  - Requires local installation of the NRP
  - **Available on a private Dockerhub repo**

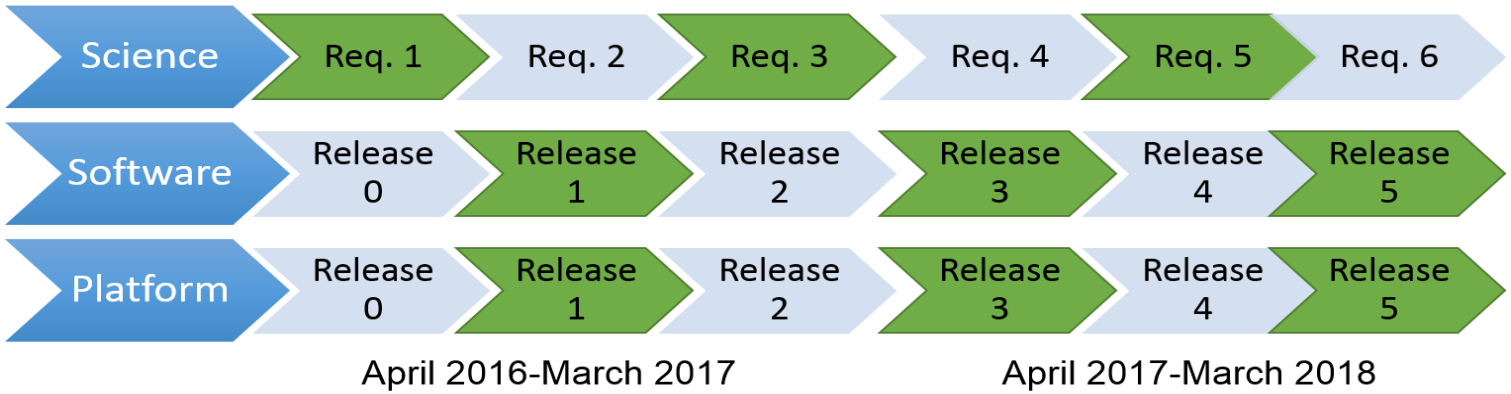




http://www6.in.tum.de/Main/VirtualTour

Roadmap

- 6 Month release cycles (documented on our website)
- Lively Exchange between Science Team and Development Team
- Progress Reports for both teams to synchronize efforts
- Next releases: End of March, September



Completely open!

- The NRP is completely open to researchers from universities and companies
- We welcome you all
  - To create and share experiments, get involved and
  - give us feedback
- …so we can develop the NRP to fit your needs!
- Our goal is to create a useful open-source tool and to tackle challenges together

- Come talk to us, sign up if you are interested in joining our next workshop
- Regular updates can be found on our website http://neurorobotics.net

Get in touch!

www.humanbrainproject.eu

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Please send your questions to info@neurorobotics.net