AI in Medicine and Health and the Role of Neurocomputation: The BG Perspective

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Medicine and Health are the biggest benefiters of AI

Explore the AI impact by sector

Health care ›
Providers/Health Services
Pharma/Life Sciences
Insurance
Consumer Health
Automotive
Aftermarket & Repair
Component suppliers
Personal Mobility
as a Service
OEM
Financing
Financial services
Asset Wealth Management
Banking and Capital
Insurance
Transportation and Logistics
Transportation
Logistics
Technology,
communications
and entertainment
Technology
Entertainment. Media
and Communication
Retail
Consumer Products
Retail
Energy
Oil & Gas
Power & Utilities
Manufacturing
Industrial manufacturing

Personalization — 3.8

Utility — 3.9

% Adoption Maturity
- Near Term (0-3 yr)
- Mid Term (3-7 yr)
- Long Term (7+ yr)

40 / 37 / 23

Data Available — 4.4

Time Saved — 2.7

Potential AI Consumption Impact — 3.7

AI in Medicine and Health is ubiquitous with a strong BG participation across the globe

AI in Medicine and Health

Molecular research: DNA and gene data analysis; vaccine designs; microbiology; …

Precision medicine : Machine learning for personalised predictive modelling
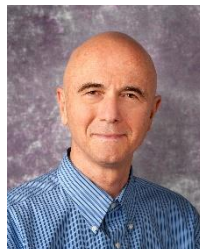
Global health data analysis: pandemics; population health.

Image analysis: brain images; EEG, fMRI, DTI,…

Robotics:
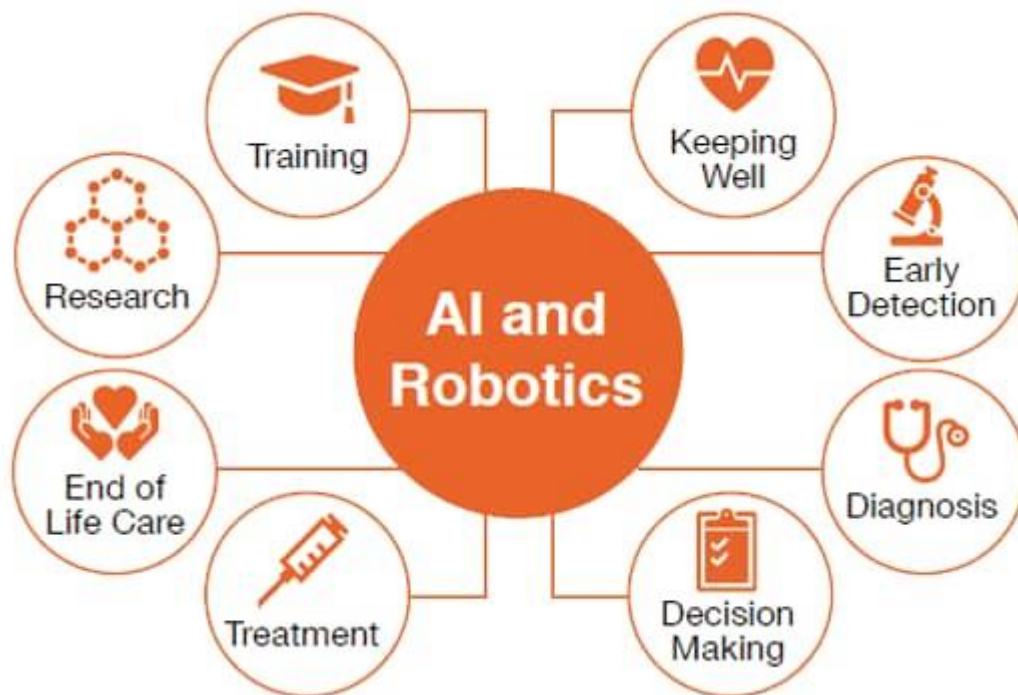- surgical robots;
- patient care robots
- Nano robots (drug delivery in the body)
- Brain implants

Brain-machine interfaces (BMI) for neurorehabilitation

Many other
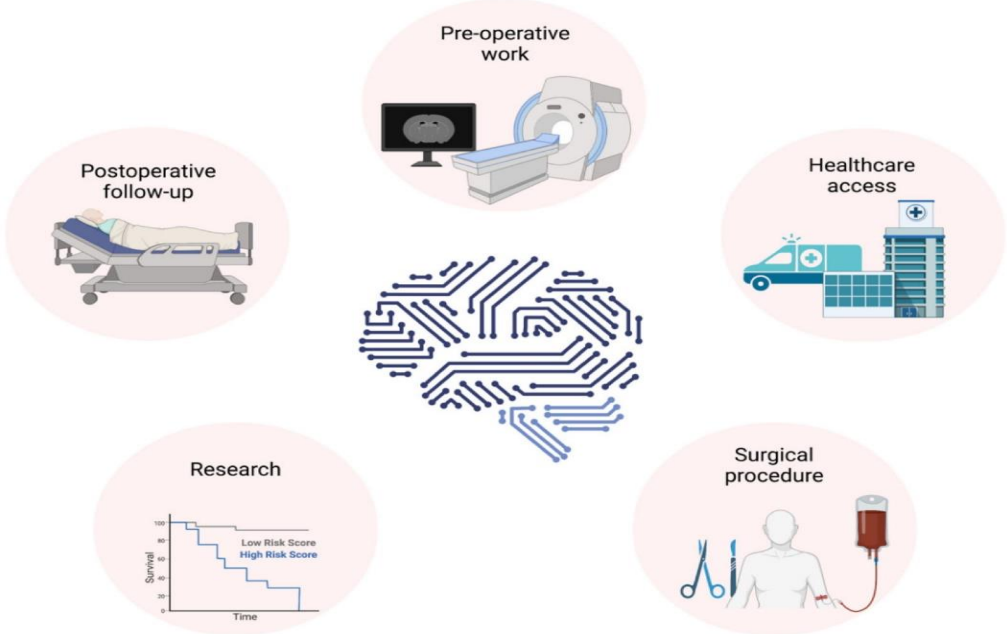
The BG participation

Dimiter Stanchev Dimitrov, PhD
Distinguished Professor of Medicine
Director, Center for Antibody Therapeutics.
University of Pittsburgh, USA
Awarded for his COVID research.

https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health/transforming-healthcare.html

AI in Health
Example: Neurosurgery

Number of publications on neurosurgery and AI between 2010 and 2020
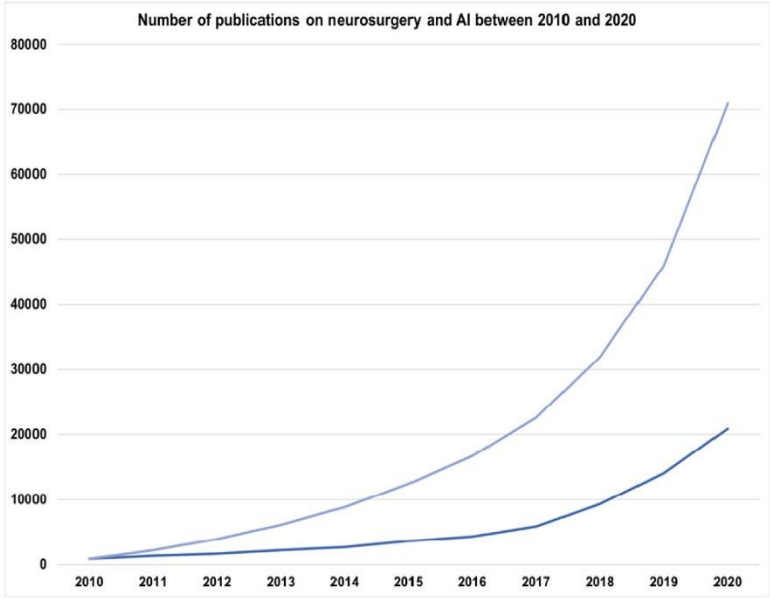
Absolute and the cumulative number of publications involved neurosurgery and artificial intelligence

AI in Neurosurgery: https://doi.org/10.3934/Neuroscience.2021025)
AIMS Neuroscience, 8(4): 477–495.

THE EUROPEAN ASSOCIATION OF NEUROSURGICAL SOCIETIES

Emerging Technologies and Innovations in Neurosurgery
EANS ETIN Task Force

Prof. Nikolay Gabrovsky
Institute Pirogov Sofia and BAS

AI in Health

Example: Precision medicine- Personalised modeling for early disease prediction and prevention

| Example Applications	PM	Other AI methods accuracy
Schizophrenia Predicting formal diagnosis in next six months using gene expression measures from blood test	98%	92-97.5%
Mindfulness Treatment Predicting response to depression treatment using EEG data	73%	48.5-58.5%
Methadone Predicting treatment programme outcome using EEG data	91%	60-63%
Stroke Predicting stroke events using patient and environmental data	94%	67.5-87.5%
AD/MCI/normal Prediction 2 years ahead	91%	40% (LSTM)
Knee pain prediction 12 months after surgery using only pre-operative data	92%	66%

KNOWLEDGE ENGINEERING & DISCOVERY RESEARCH INSTITUTE
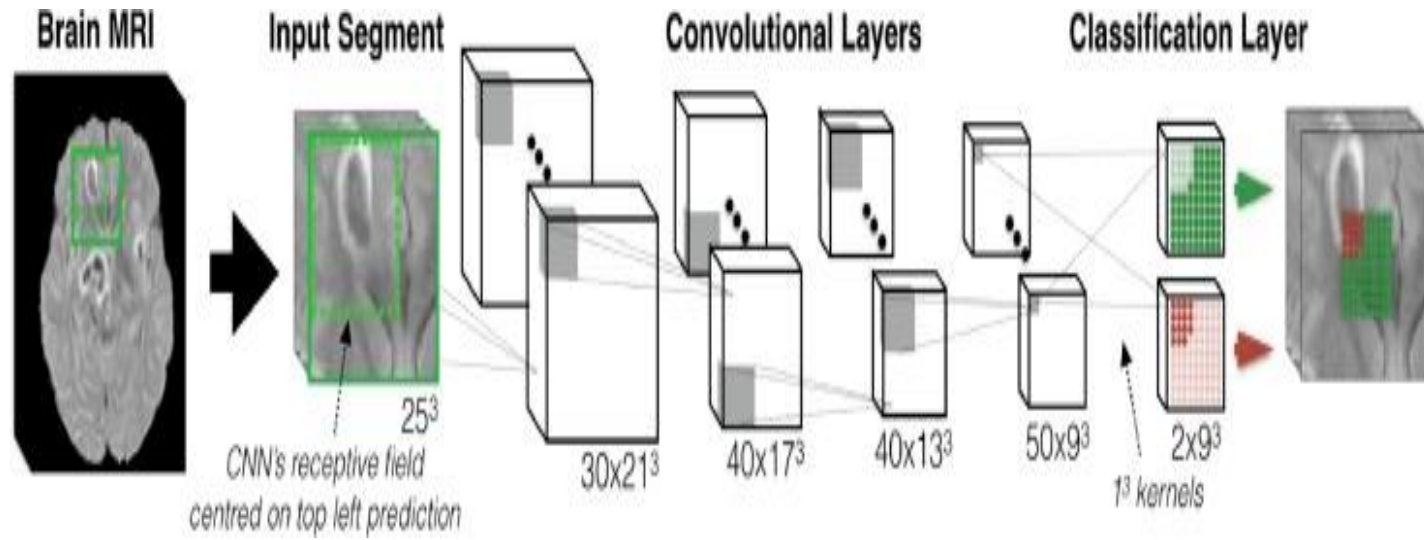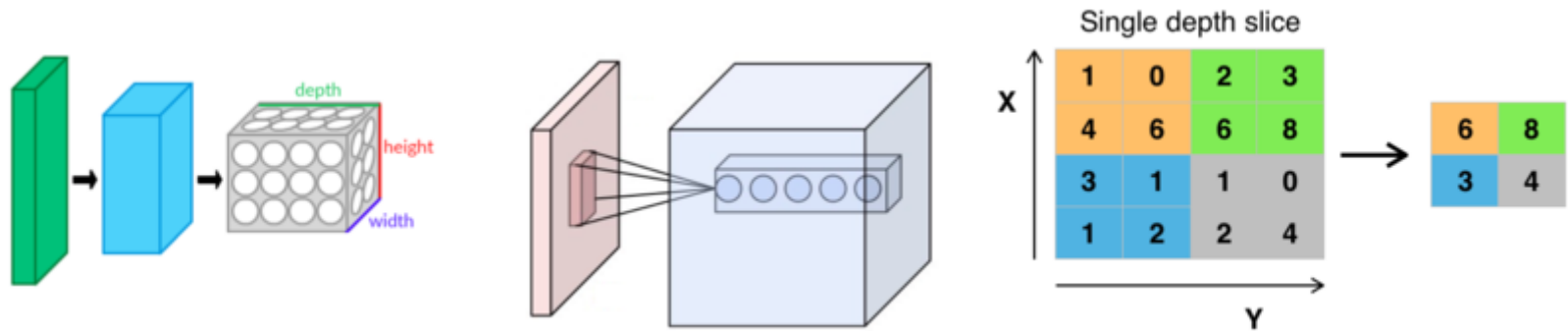AN INSTITUTE OF AUT UNIVERSITY
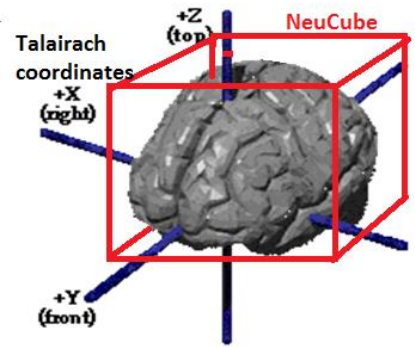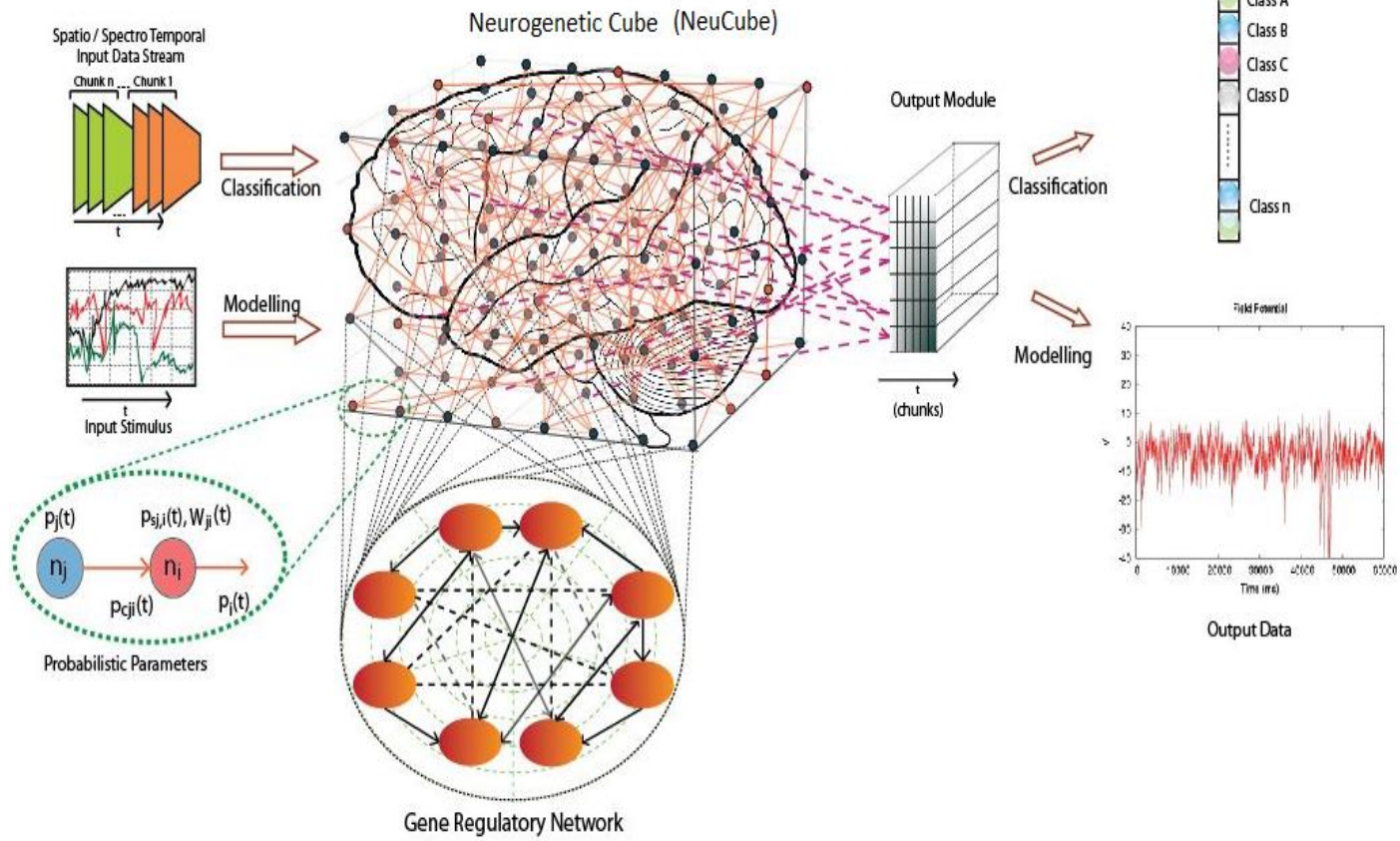
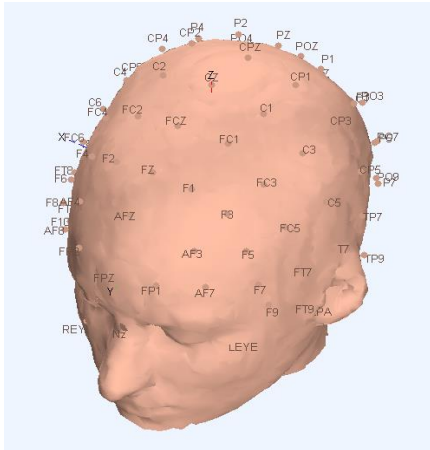# The Role of Neurocomputation (Deep Learning)
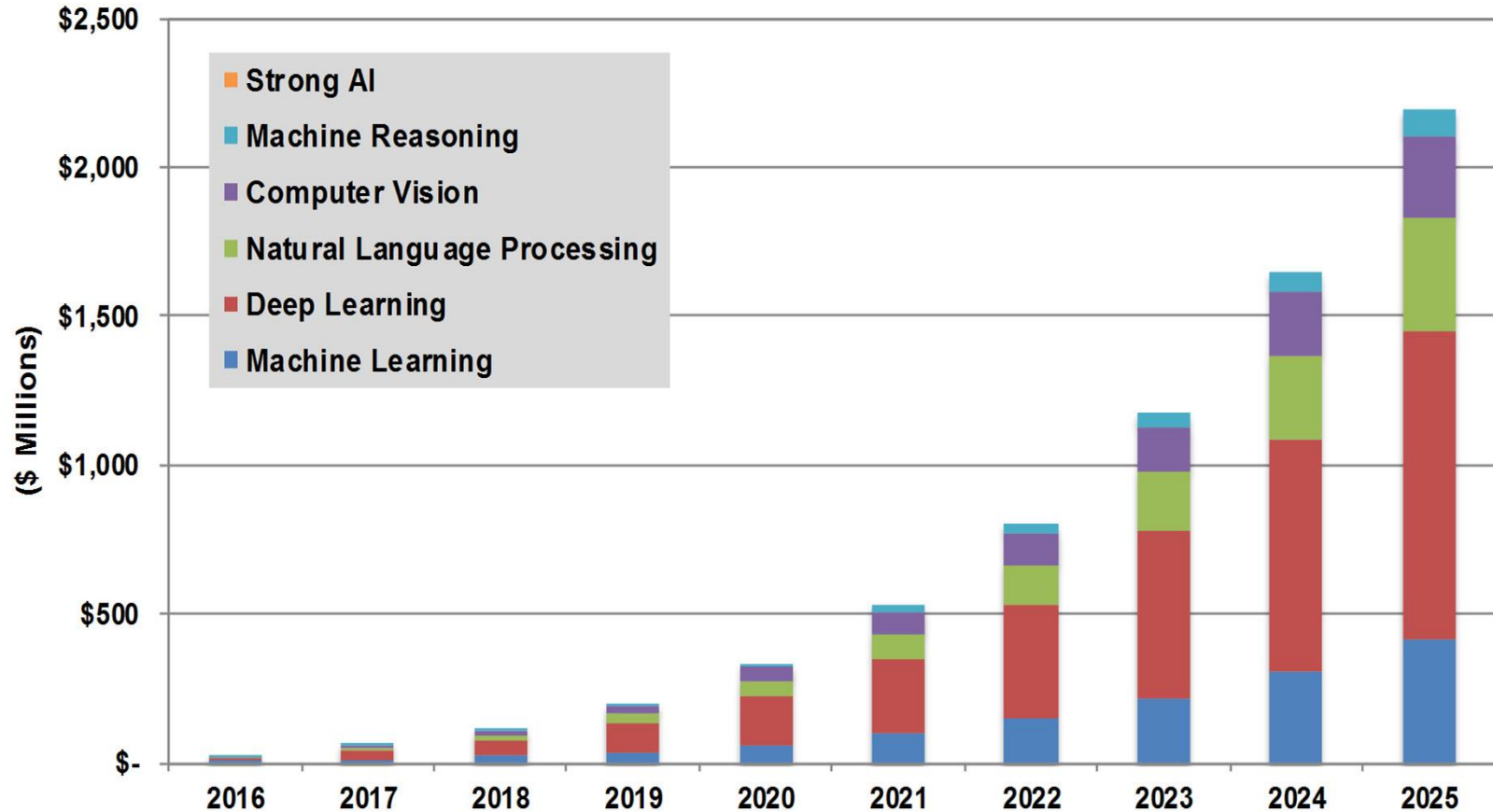
Deep Convolutional Neural Networks

(Kamnitsas et al., 2017)

Brain-inspired spiking neural network systems

Kasabov, N., NeuCube: A Spiking Neural Network Architecture for Mapping, Learning and Understanding of Spatio-Temporal Brain Data, Neural Networks, vol.52, 2014.

Progress in Neurocomputers
From von Neumann principles and Atanassov's ABC to Neuromorphic Computers

- The computer architecture of John von Neumann separates data and programmes (kept in the memory unit) from the computation (ALU); uses *bits*. First machine ABC by Atanassov and Berry.

- A Neuromorphic architecture integrates the data, the programme and the computation in a SNN structure, similar to how the brain works; uses *spikes* (bits at times) (e.g. S.Furber SpiNNaker; IBM True North; Akira; ETH/EZH Indiveri; Intel Loihi ..)
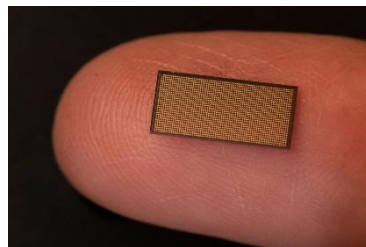
- A quantum computer uses *q-bits* (bits in a superposition) (IBM D-Wave).


The Von Neumann or Stored Program architecture
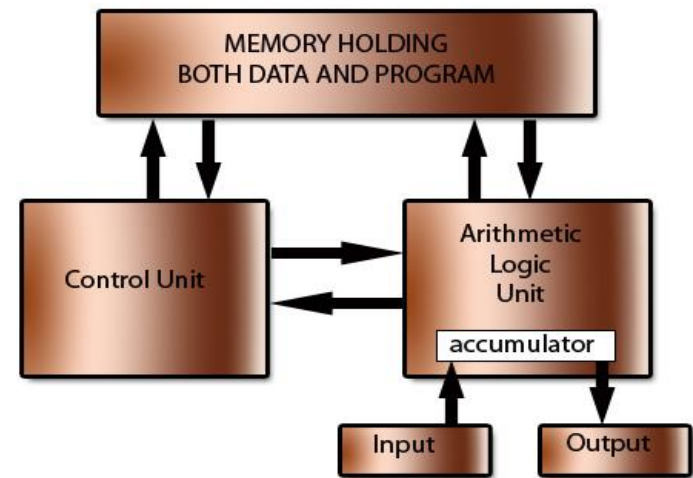
(c) www.teach-ict.com

N. Sengupta et al, (2018), From von Neumann architecture and Atanasoffs ABC to Neuromorphic Computation and Kasabov's NeuCube: Principles and Implementations, Chapter 1 in: Advances in Computational intelligence, Jotzov et al (eds) Springer 2018.

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Challenges in AI and opportunities for BG participation
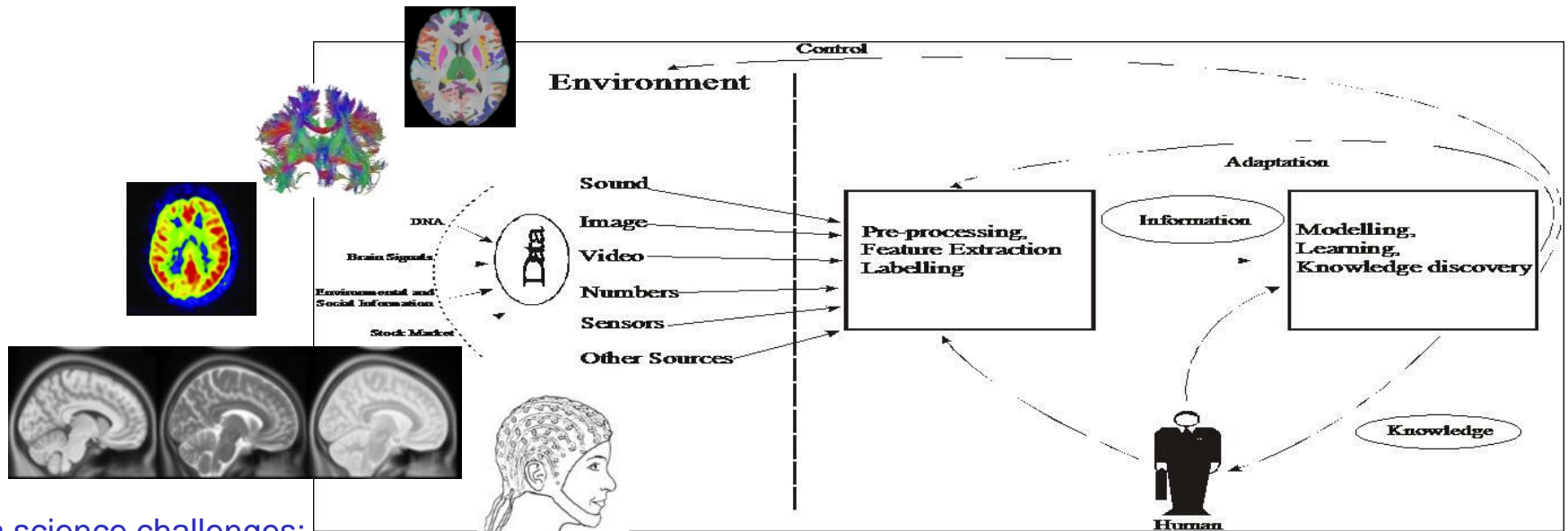
Data science challenges:

1.   Multiple modality (e.g. neuroimages, videos, signals, movement, cognitive).
2.   Different types of data
3.   Efficient learning of data (incremental, adaptive, life-long)
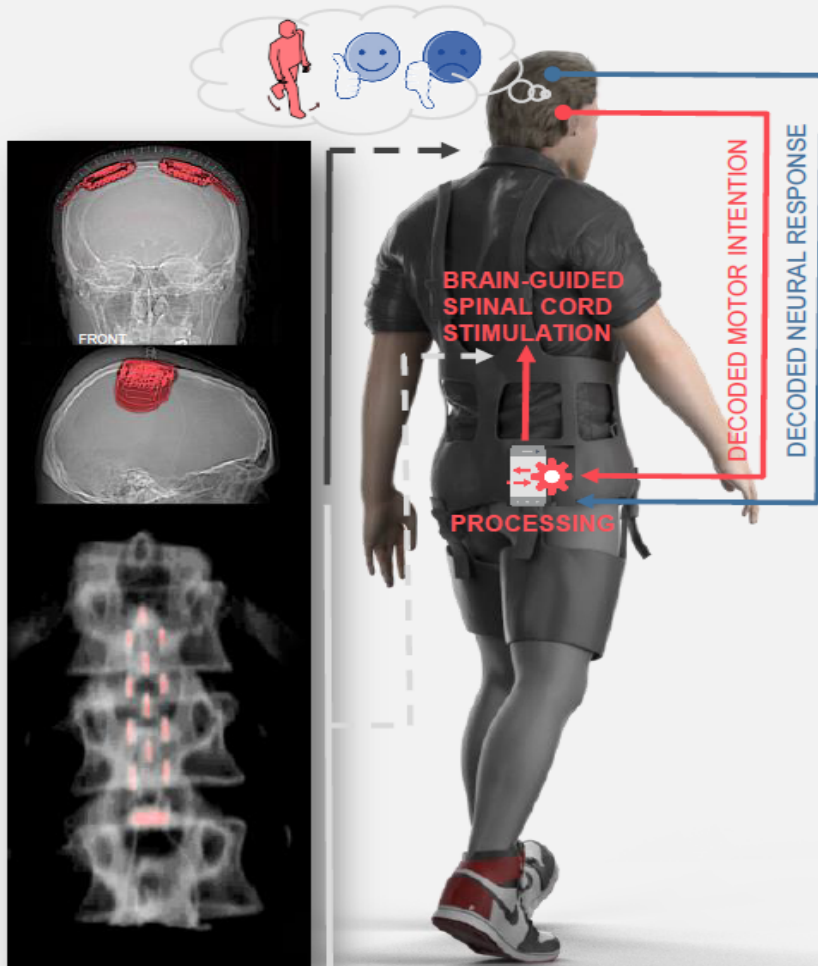4.   Explainability

Applications:

1. Data science: Biochemistry and molecular biology

2. Precision medicine: Predictive personalised modelling

3. Brain-machine interfaces (BMI)

4. Robotics/Tele-robotics

5. Bio-inspired devices, neurocomputers, software development

6. Other applications of bioinspired neurocomputers: cybersecurity; finance; environment.

7. AI ethics

The BG Perspective:
Joint projects of BG teams with leading international partners
Example: NEMO-BMI, funded by the EC, 2022-2025

FULLY EMBEDDED AUTO-ADAPTIVE BRAIN MACHINE INTERFACE

DECODED MOTOR INTENTION

DECODED NEURAL RESPONSE

BRAIN-GUIDED
SPINAL CORD
STIMULATION

PROCESSING

FRONT

IMPLANTABLE MEASURE – STIMULATION TECHNOLOGY
- CHRONIC WIRELESS BRAIN RECORDING WIMAGINE IMPLANT
- SPINAL CORD STIMULATION ONWARD IMPLANT
- 2 CLINICAL TRIALS ONGOING: BRAIN MACHINE INTERFACE PROOF OF CONCEPT

AUTO-ADAPTIVE MOTOR BMI DECODING   IICT-BAS
- NATURAL CONTROL BASED ON PATIENT'S INTENTION
- MULTIPLE DEGREES OF FREEDOM CONTROL
- DECODING OF NEURAL RESPONSE LINKED TO INTENTION/ACTION COHERENCE
- REAL-TIME AUTO-ADAPTIVE DECODER
- ASSISTANCE FREE
- NEUROMORPHIC DECODING ALGORITHMS

BRAIN-GUIDED SPINAL CORD STIMULATION
- EPIDURAL ELECTRICAL TARGETED DYNAMIC STIMULATION
- AUTO-ADAPTATIVE STIMULATION PATTERNS

MINIATURIZATION OF BMI TECHNOLOGY
- LOW POWER INTEGRATED CIRCUIT FOR ACCELERATING THE DECODING ALGORITHMS
- HIGH SYSTEM LEVEL INTEGRATION
- PORTABLE BATTERY-POWERED SOLUTION

The BG Perspective

NEMO-BMI

Our IICT/BAS/BG team

Team leaders

Prof. Petia Koprinkova-Hristova

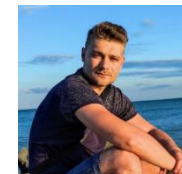Prof. Nikola Kasabov

Researchers

Programmers

Assistant Simona Nedelcheva

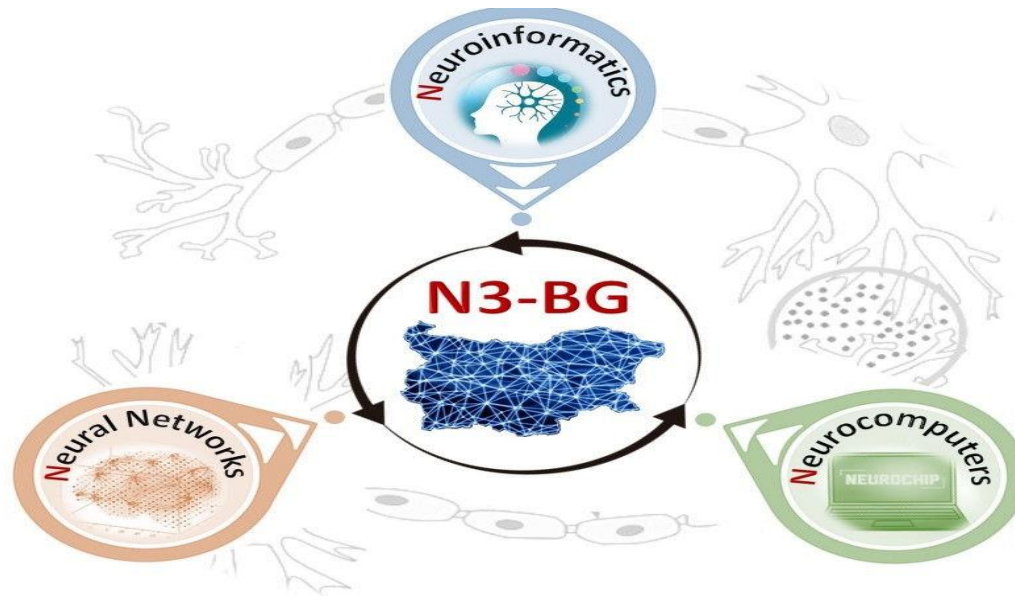Dimitar Penkov

MSc Eng. Alexandar Banderov

Svetlozar Yordanov

The BG Perspective

N3-BG group (Neuroinformatics, Neural Networks and Neurocomputers)

https://www.knowledgeengineering.ai/n3-bg

New members are welcome. It is free and most informative !

Nikola Kasabov   Roumen Trifonov, TU   Petia Koprinkova, BAS   Nikolay Gabrovsky   Iman AbouHassan, TU

(Leading organisers)

Main organisers and presenters

The N3-BG group

(*Neuroinformatics, Neural Networks and Neurocomputers*)

https://www.knowledgeengineering.ai/n3-bg
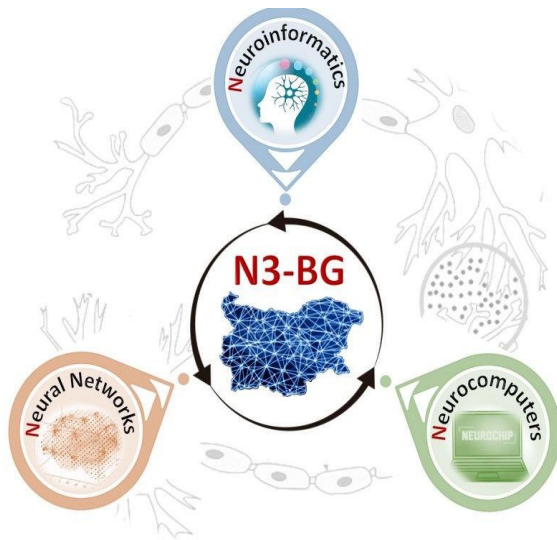
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The BG Perspective
Sponsoring best students in BG, from primary schools to Universities
https://www.knowledgeengineering.ai/sponsorships

55 students from years 5 to 12, sponsored in SU 'Bacho Kiro", Pavlikeni, 2008-2023 for excellent achievements in Mathematics, Biology, Physics, Informatics, Technology

2008, Valentin Mandev (year 12)

2010, Nadejda Dimitrova (year 7), now a graduate of MIT and a scientist in Boeing, USA

2023, Kuentin Borger, year 8, first prize in a national software competition for the invention of a new programming language. SU "Bacho Kiro", Pavlikeni

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