Neuroscience view on machine learning

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TOOPLOOX AI

Cognitive science

Psychology

Neuroscience

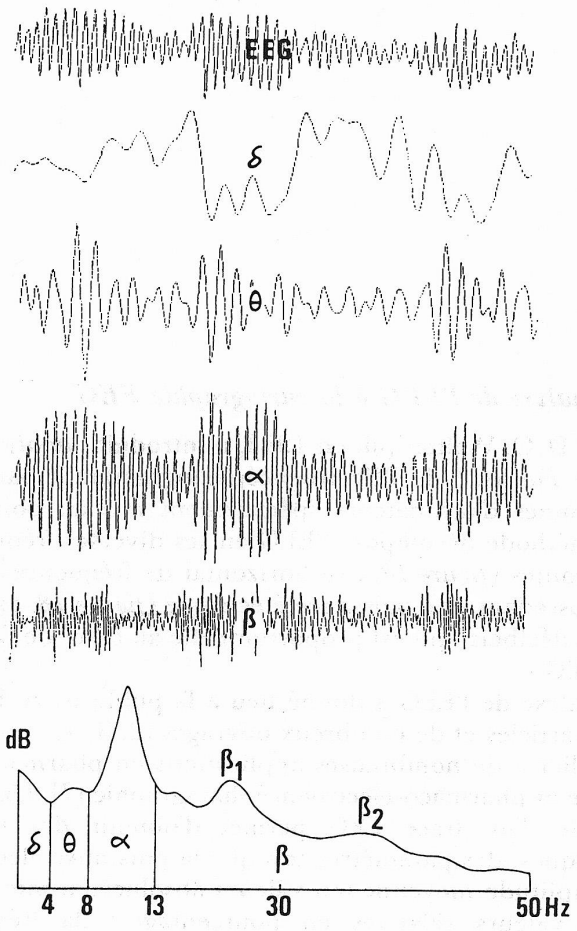
Artificial Intelligence

Philosophy

Linguistics

Signals of interest

- Behavioral (how fast did this person press a button?)
- Physiological heart rate, pupil dilation, EEG etc.
- **NEW: digital** (indirect collection of data from digital resources, e.g. Twitter, Reddit, Netflix, Google Analytics etc.)



Artificial Intelligence & Neuro/Cognitive Science

How do they go together?

Cognitive science → Artificial Intelligence

- **Cognitive modelling** - create formal models of human's cognition and test their validity
- Influence artificial intelligence with human-like cognitive structures (attention, memory, visual perception)
- Neural networks resembling real neural structures (**spiking neural networks**)
- **Intelligent agents** that mimic human's cognition

Artificial Intelligence → Cognitive Science

- **Computational neuroscience** - use of advanced computational tools in order to understand how brain works

- Use large datasets to investigate cognitive phenomena (e.g. depression prediction, intelligence prediction, **affective computing**)

Examples

1. What can you do with your brain/neural signal?
2. How can artificial neural network give you knowledge about cognition?

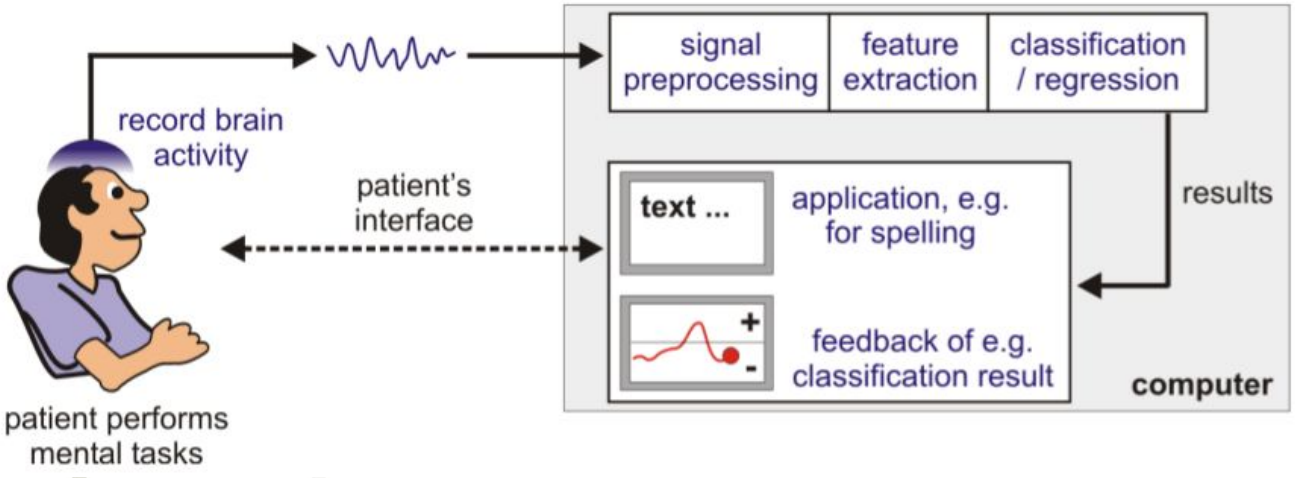
BCI - Brain-Computer Interface

BCI = Brain - Computer Interface

- Communication pathway between brain and computer
- Enables two-way communication (brain -> computer / computer -> brain)

Types of BCIs:

BCI - scheme of work



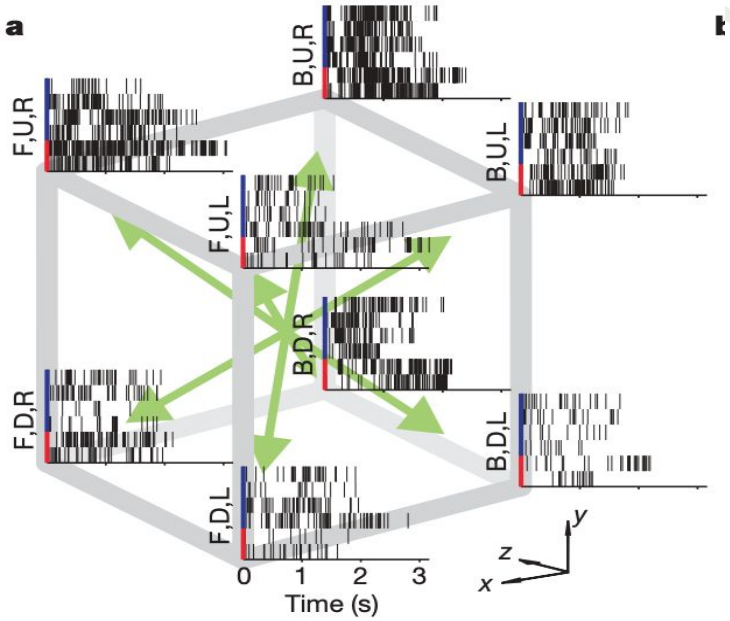
source

Do BCI + ML go together? Monkey robotic arm case

- First, monkeys learned to perform this task with a joystick
- Monkeys trained 10 days - 2 months on a variety of intermediate steps to achieve high performance
- Algorithm used: **PVA: Population Vector Algorithm**

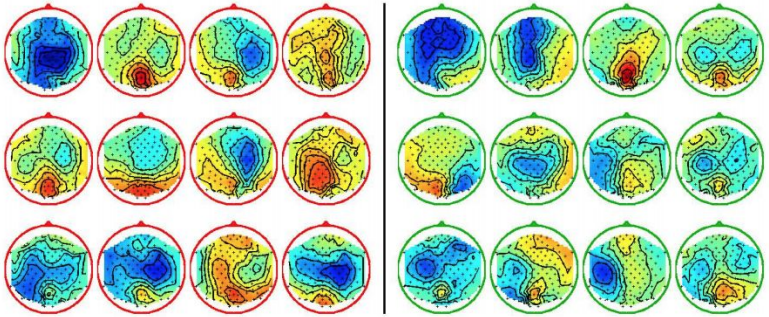
1. Calculate instantaneous firing rate for each unit
2. Smooth the response
3. Population vector = vector sum of preferred directions weighted by the normalized firing rates

Do BCI + ML go together? Monkey robotic arm case

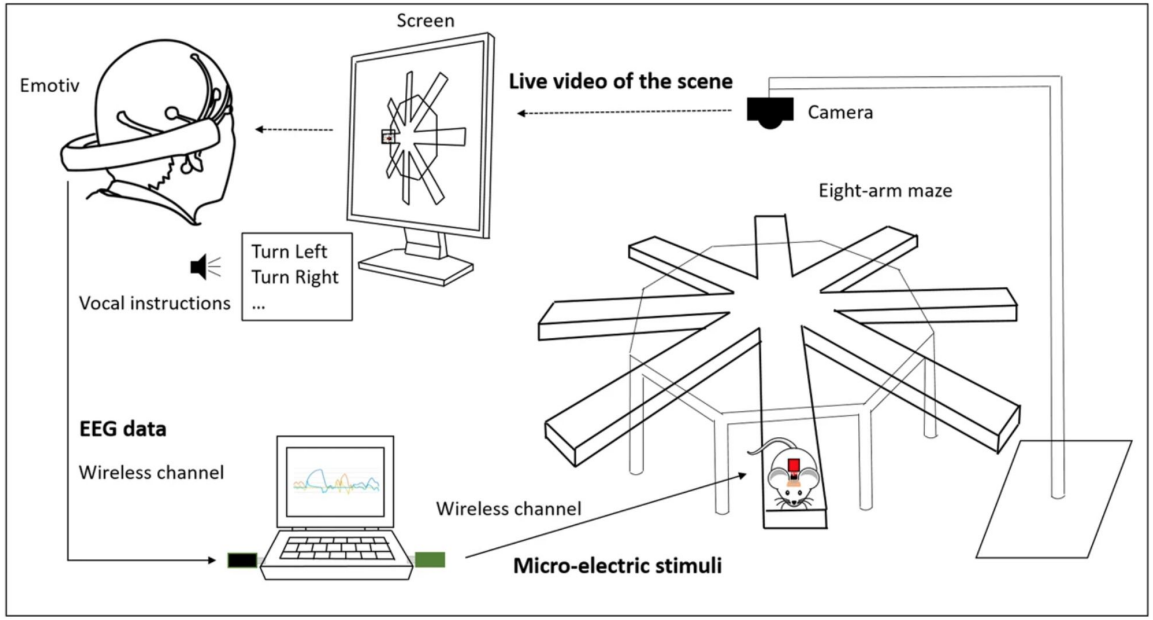


BCI + ML - challenges

- Great intra-subject variability
- Session-to-session variability
- Trial-to-trial variability
- Ecological validity
- Non-stationary signal



BBI - rats cyborgs



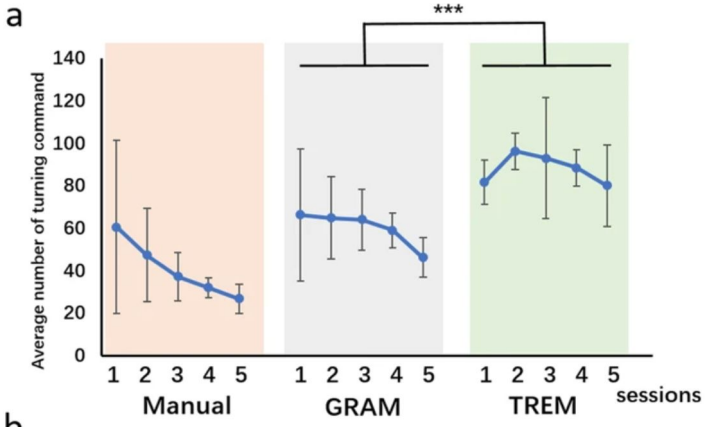
Procedure:

1. Human - trained to express the motor intent for Left/Right movement (blinking signal for forward)
2. Rat - chipped with electrode for virtual reward stimulation; trained to correlate reward stimulation with locomotion behaviors

BBI - rats cyborgs

Two models for generating Left/Right instructions:

- TREM (instructions generated when passing a threshold)
- GRAM (instruction generated when the gradient value between two possible results exceeded threshold)



Other cool BCI examples

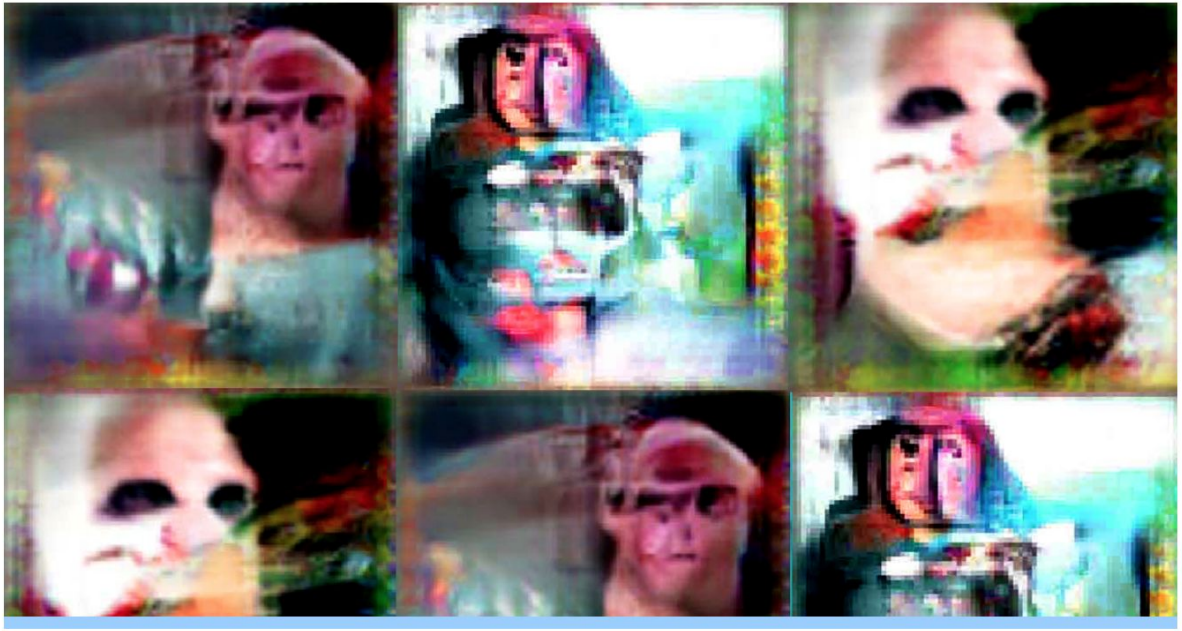
- Brain music / Other brain music
- Gameplay with no hands involvement
- Drone control
- F1 car controlled by quadriplegic

Seeing with a neural network

Decoding brain activity into interpretable images

Scientific problem: given the brain activity pattern from a fMRI (e.g.), how can we decode it into an understandable percept?

Sci-fi version: can we read people's minds?



Decoding brain activity into interpretable images

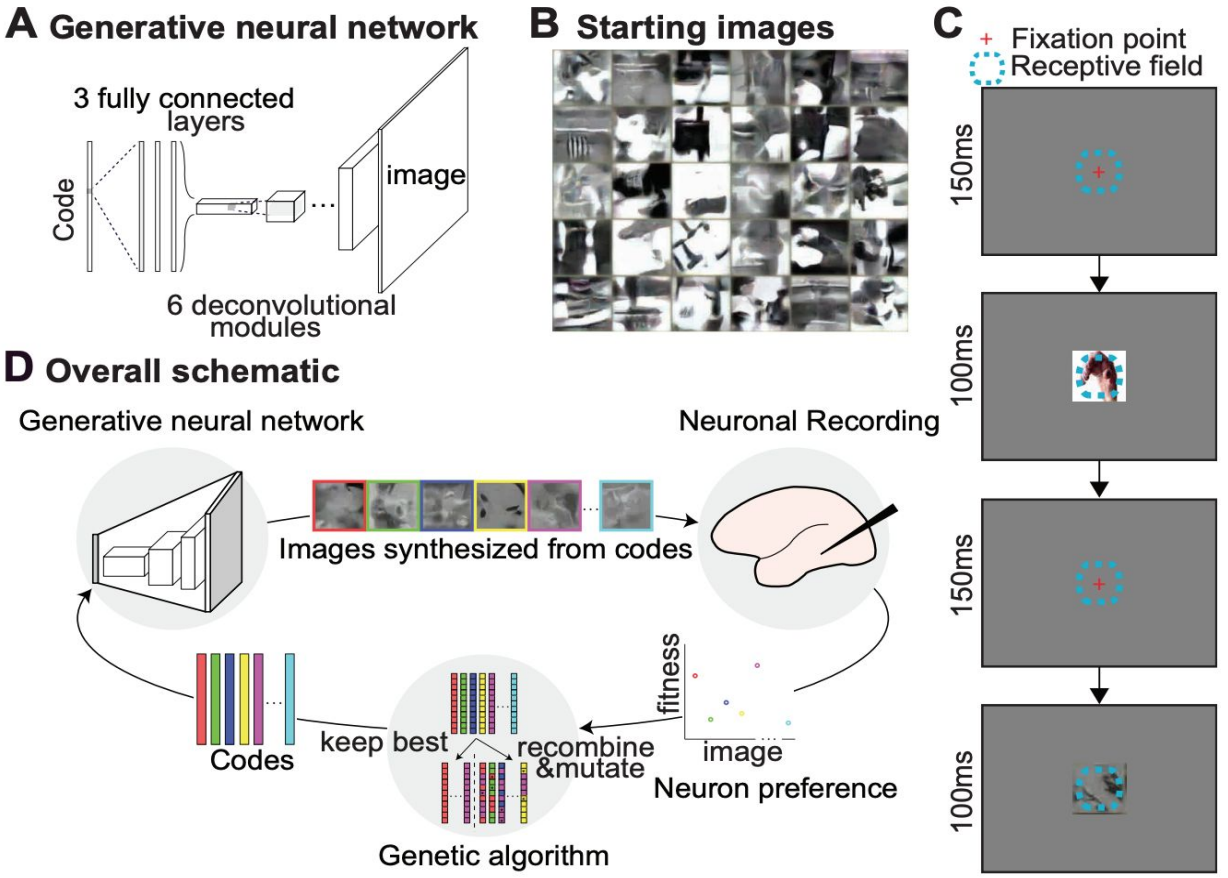
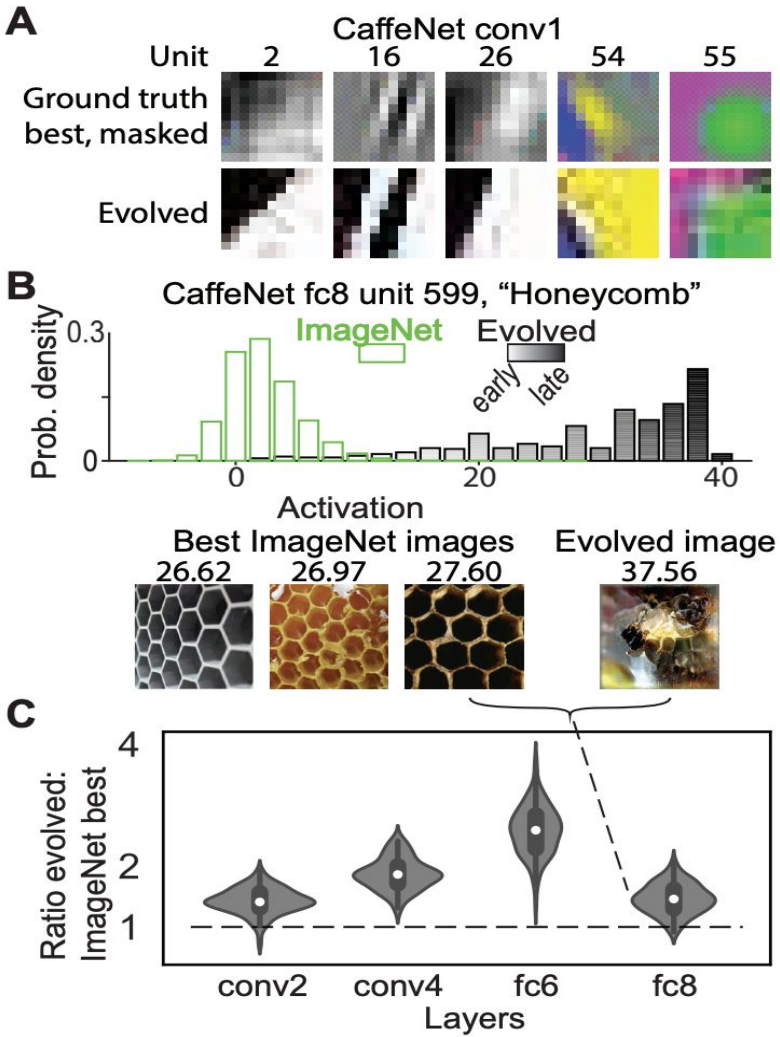
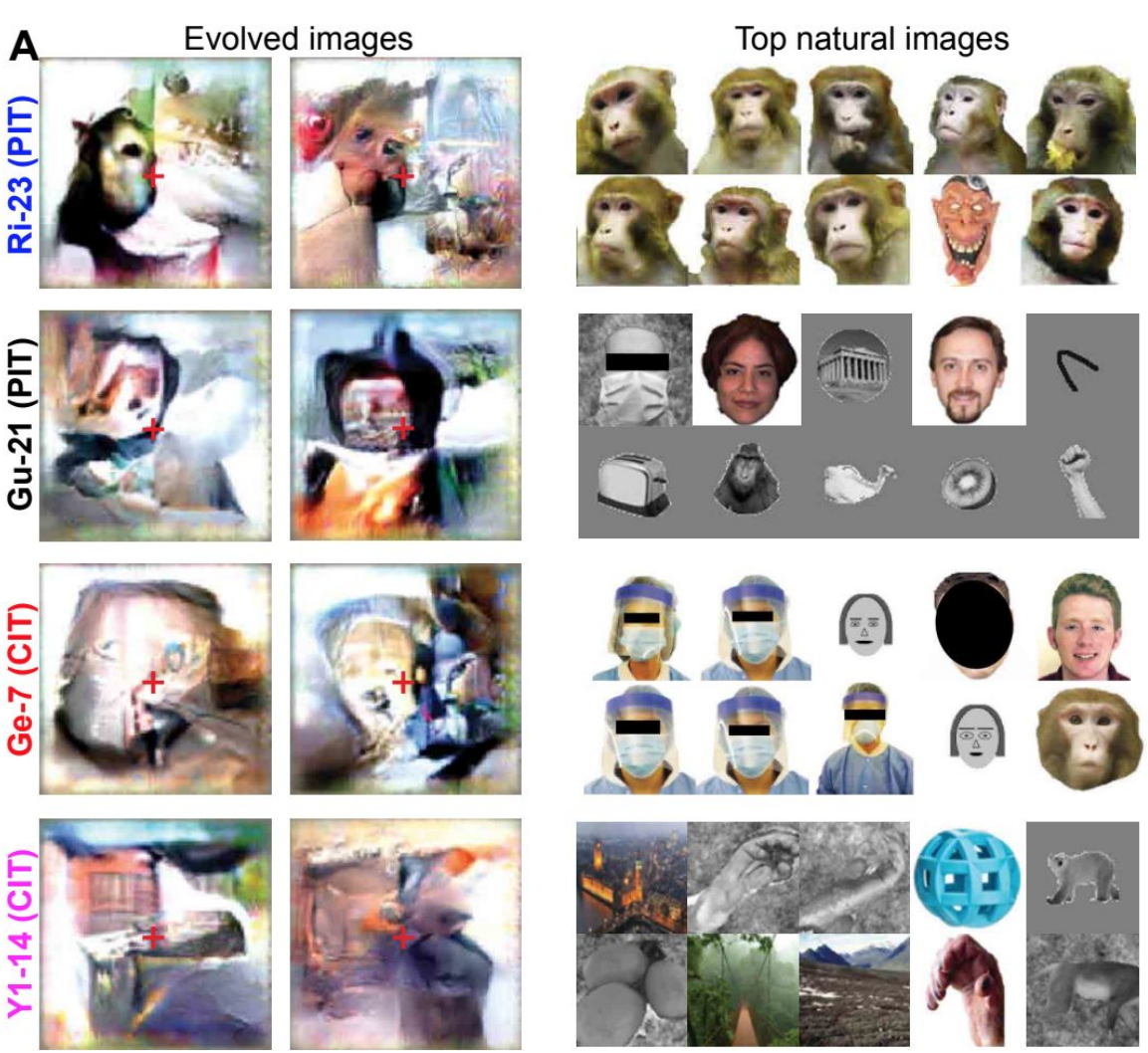


Figure 1. **Synthesis of optimum images via neuron-guided evolution.** (**A**) Generative network. Architecture of the pre-trained deep generative network (Dosovitskiy & Brox, 2016). The network comprised three fully connected layers and six deconvolutional modules. (**B**) The initial synthetic images were random achromatic Simoncelli and Portilla textures. (**C**) Behavioral task. Animals fixated within a 2.0°-diameter window while images were presented for 100 ms followed by a 100 to 200 ms blank period. Red cross: fixation point; dashed line, population RF. (**D**) Experimental flow. Image codes were forwarded through the deep generative network to synthesize images presented to the monkey.

Decoding brain activity into interpretable images



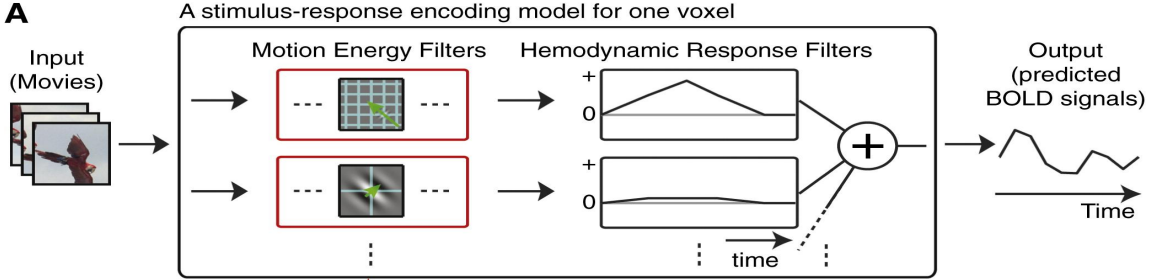
Decoding brain activity into interpretable images

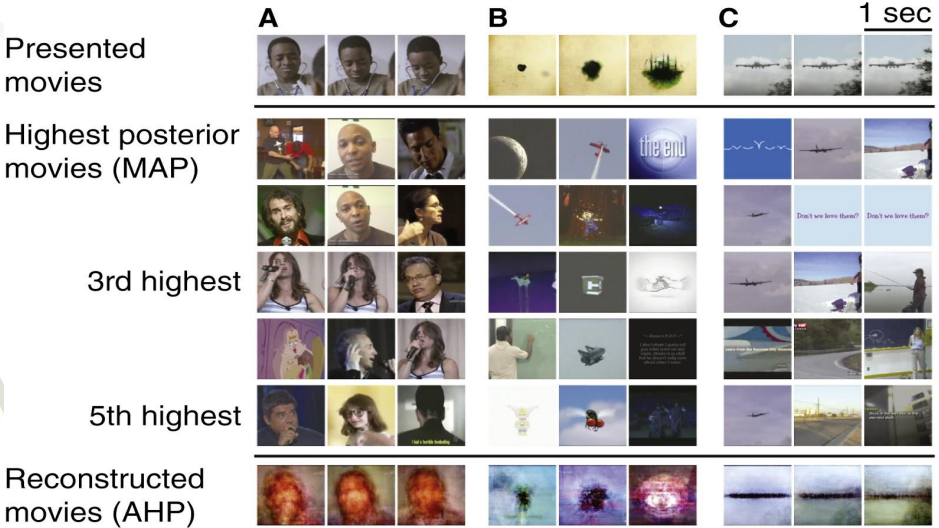


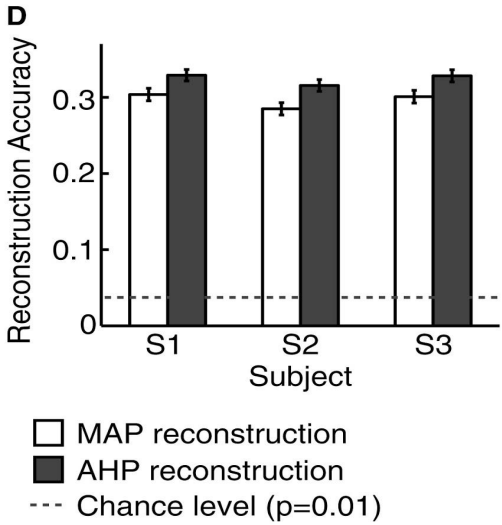
Decoding brain activity into interpretable images

Link to the video:
https://ars.els-cdn.com/content/image/1-s2.0-S0960982211009377-mmc2.mpg (download begins)

Decoding brain activity into interpretable images







Don’t know where to start?

- Recently released Google Dataset Search: https://datasetsearch.research.google.com/
- And maybe my blogpost focused on the brain data repositories
- Brainhack Warsaw 2020
- Useful concepts: emotion recognition, visual perception, neuroprosthetics, psychophysiology, biohacking, sensory models

References

1. Brain computer interfacing: Applications and challenges
2. Human Mind Control of Rat Cyborg's Continuous Locomotion with Wireless Brain-to-Brain Interface
3. Cortical control of a prosthetic arm for self-feeding
4. Evolving super stimuli for real neurons using deep generative networks
5. End-to-End Deep Image Reconstruction From Human Brain Activity
6. Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies

If you want to chat more about brainz&computerz, I will be very happy to answer:

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