

NEUROPRIVACY & BRAIN DATA

PROTECTING THE LAST FRONTIER



Baroum Mrad, MLaw, M.B.A., LL.M in Compliance, DPO^{HSG}
Chief Privacy & Compliance Officer EOC
Member of the Cantonal Commission on Data Protection and Transparency – Ticino
Author, *Healthcare Services Management* (Springer, 2025)

B A R O U M M R A D

A LITTLE BIT OF HISTORY

Baroum Mrad serves as Chief Privacy & Compliance Officer and Data Protection Officer (DPCO) at Ente Ospedaliero Cantonale (EOC), the cantonal hospital network of Ticino.

With a background spanning data science, business, and law, he focuses on making privacy and compliance workable in complex healthcare environments—especially where AI and connected medical technologies reshape how data is generated, inferred, and used. He is a member of the Cantonal Commission on Data Protection and Transparency (Ticino) and the author of *Healthcare Services Management* (Springer, 2025).

He trained in communication and data science at Rutgers University, completed an Executive MBA, and pursued advanced legal and compliance studies in Switzerland (including CAS DPO at HSG, an MLaw and an LLM in Compliance at the University of Fribourg).



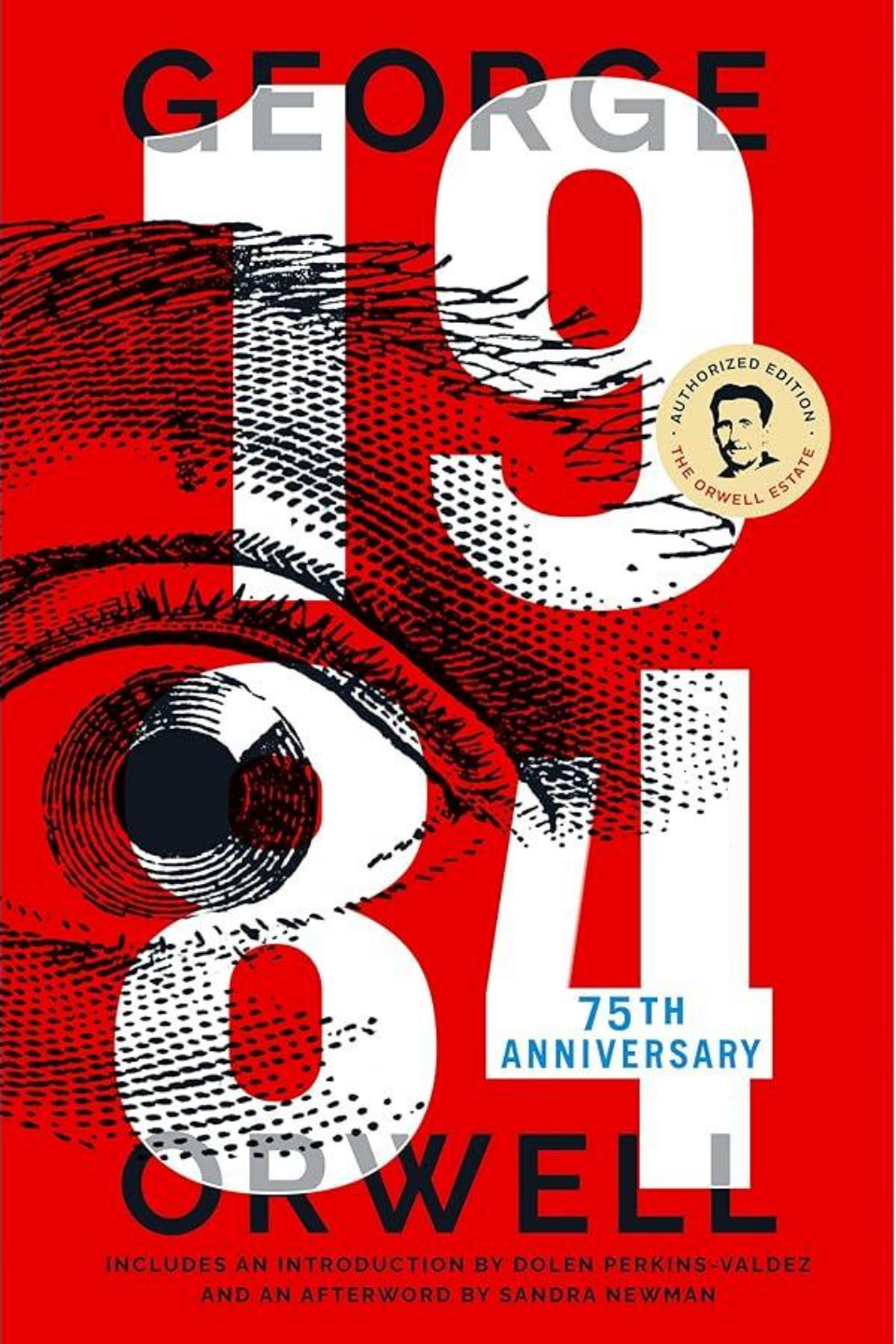
CYBERPUNK 2077



Neuroprivacy: when interference becomes intervention

This isn't a sci-fi talk. It's a governance talk about what happens when the nervous system becomes a data interface.





Control is distributed.

Orwell wrote about social control and surveillance long before digital platforms existed. Today we don't need a single Big Brother — we have a thousand little systems, quietly shaping what we see and what we become.

The algorithm doesn't show you the world — it shows you a reinforced version of your own lens.



NEUROSCIENCE



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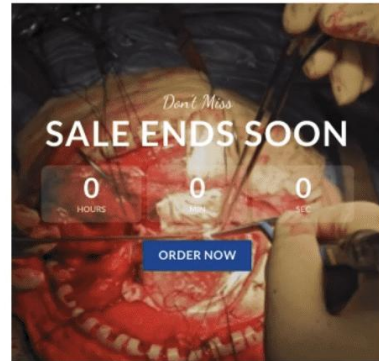
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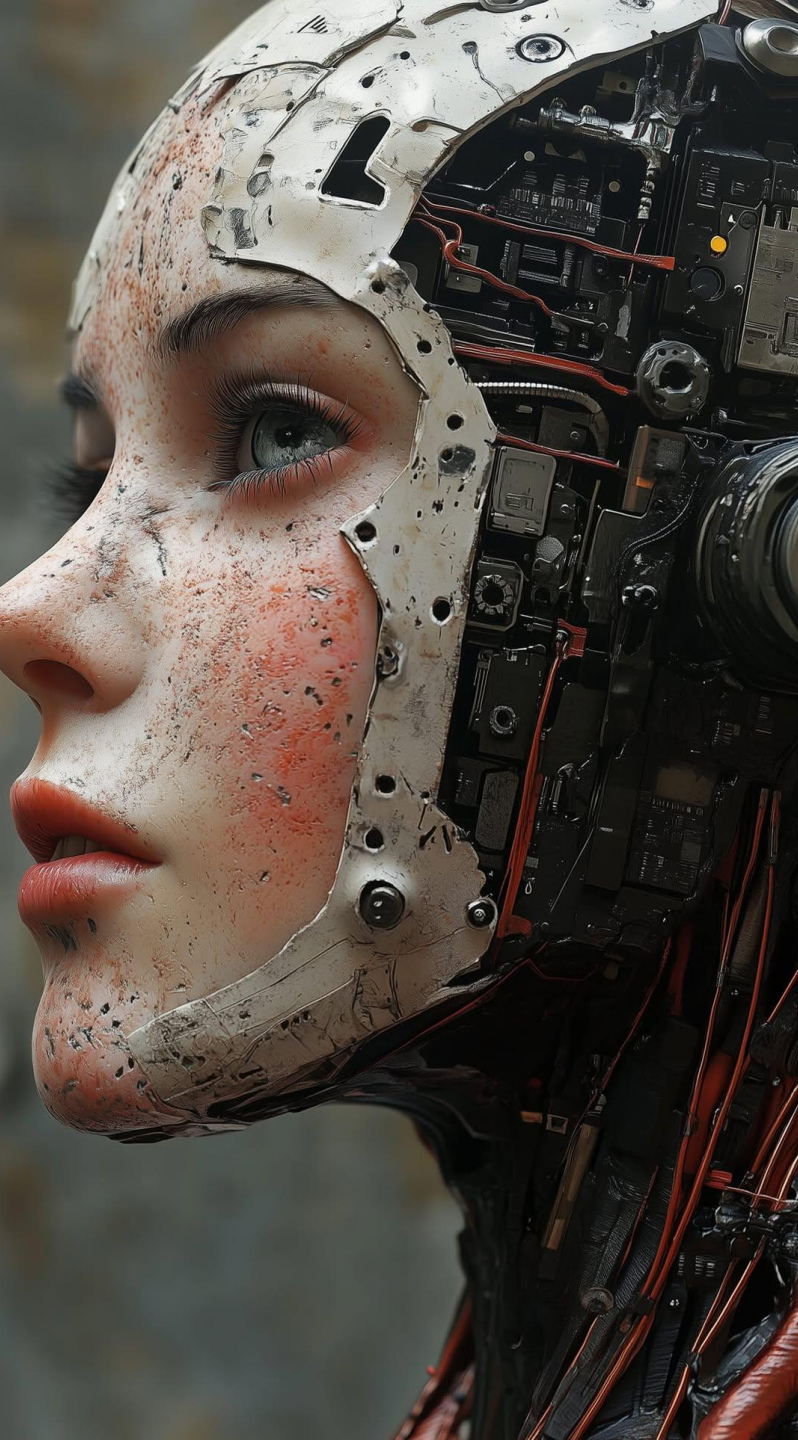
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INTERNET OF BODIES

Phase 1 – Body External

Wearables

Fitbit, Apple Watch, fitness trackers, AR/VR, exoskeletons, external BCIs

Phase 2 – Body Internal

Ingestibles & Implantables

Pacemakers, insulin pumps, smart pills

Phase 3 – Body Melded

Internal Embedded Systems

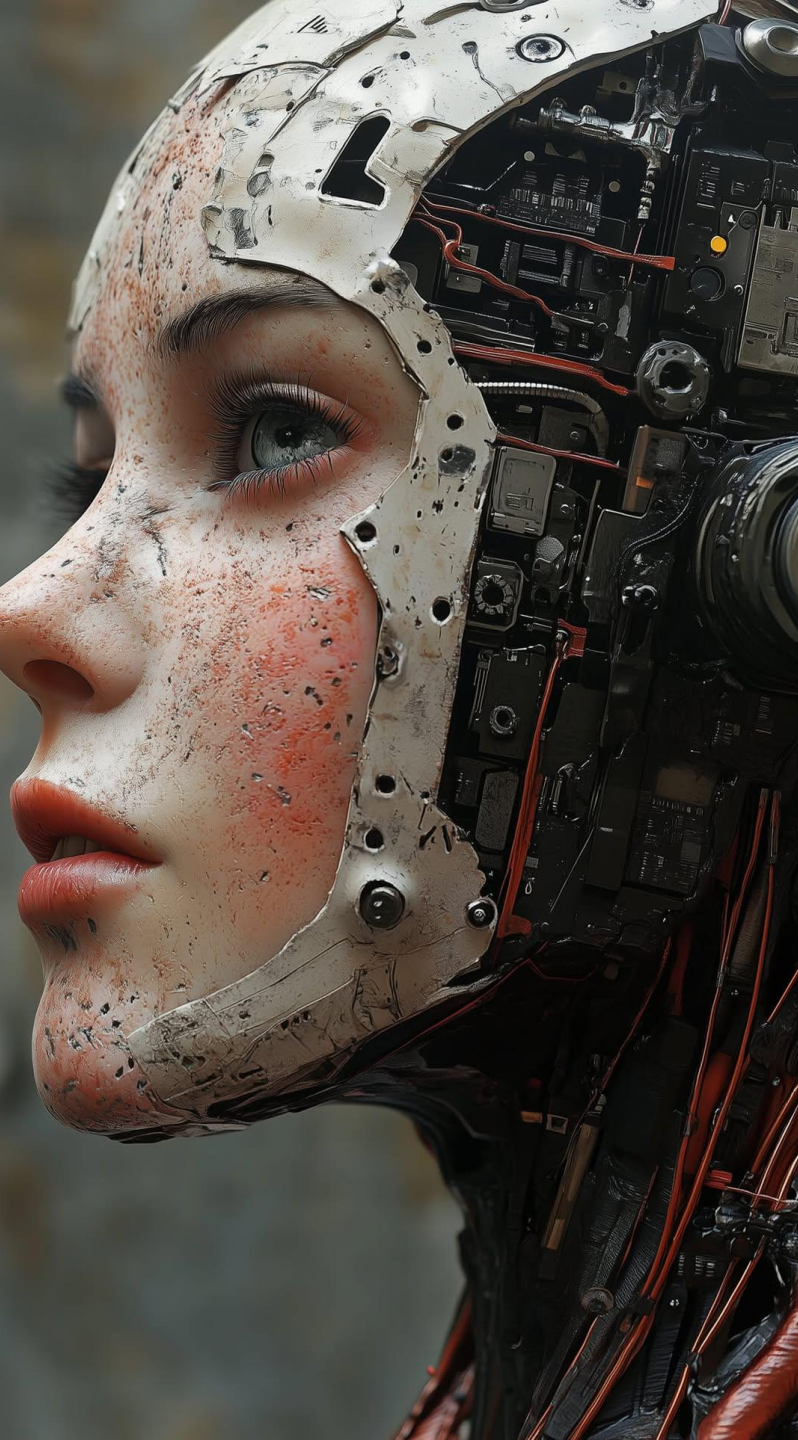
Integrated BCI, Melded body parts, synched cloud internal devices

◀ *We are here — Neuralink, closed-loop DBS*

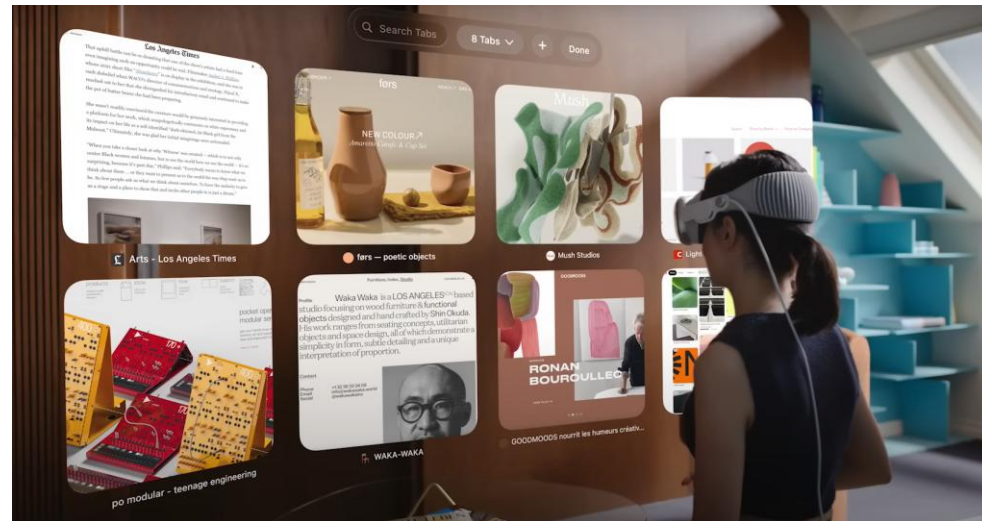
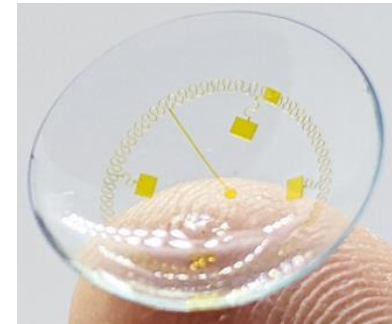
Phase 4

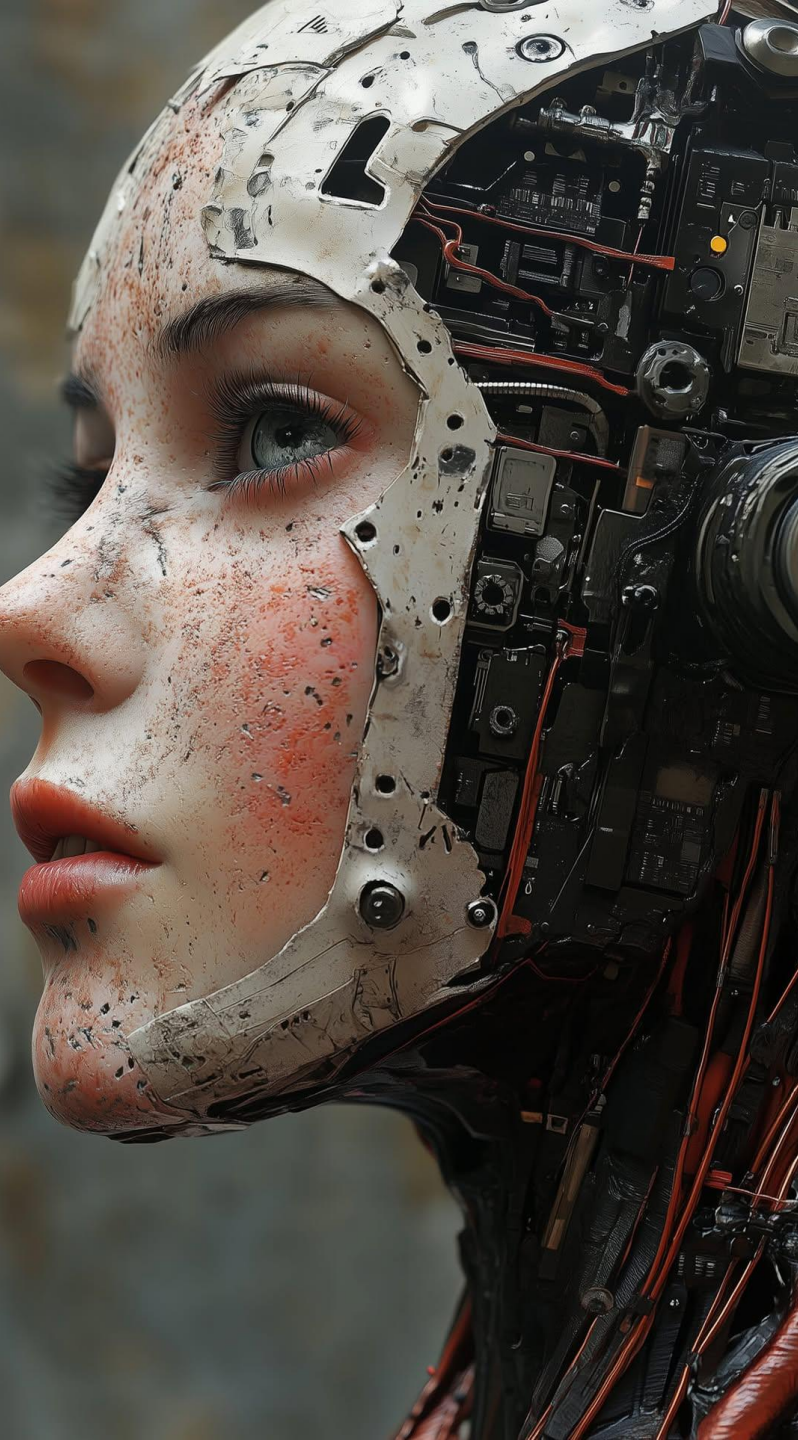
Distributed Cognition

◀ *Mind becomes one with technology.*

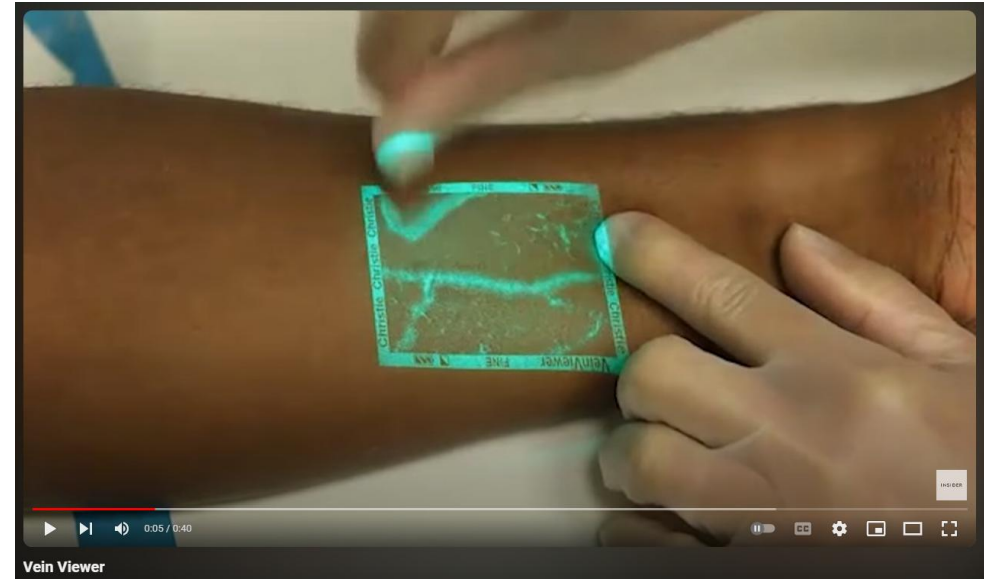


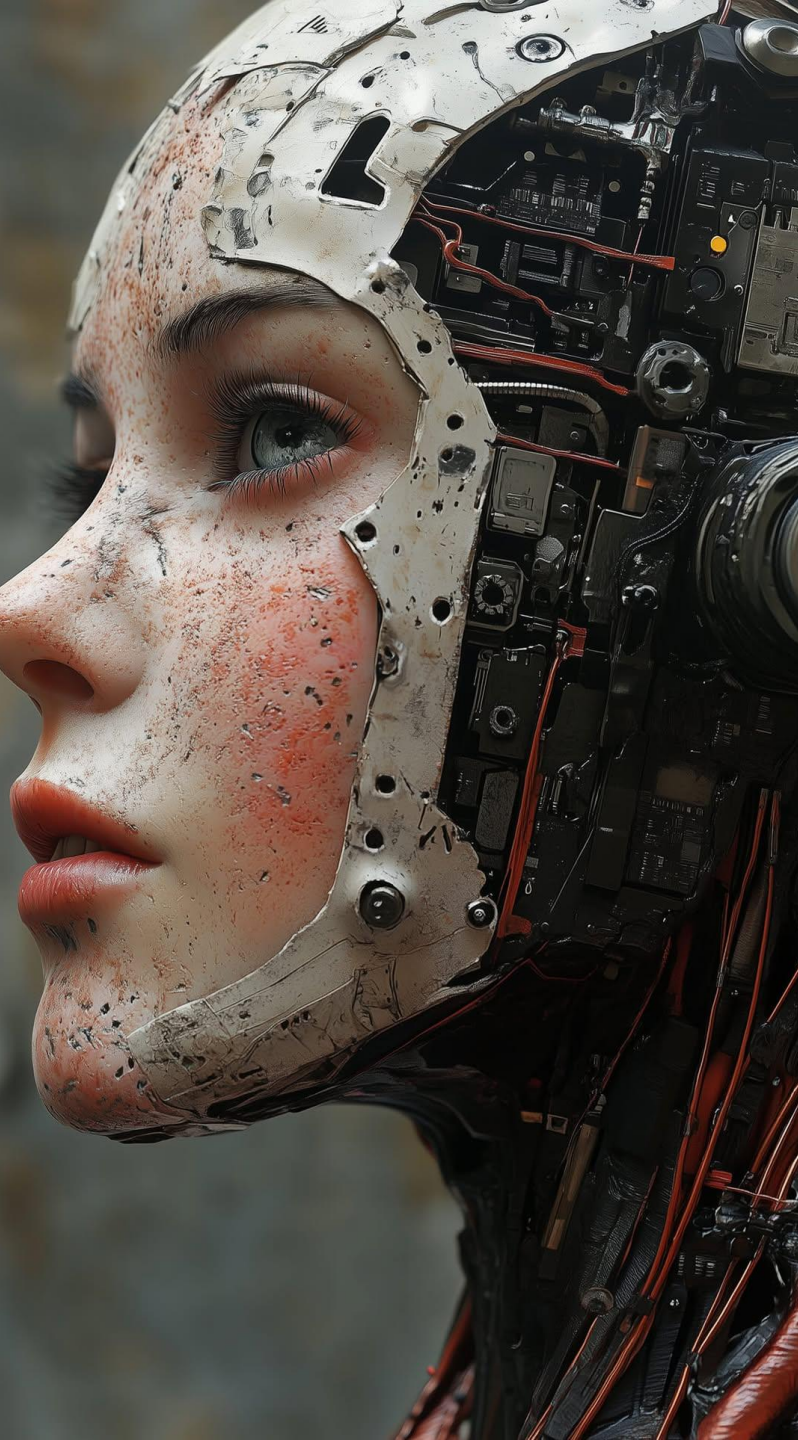
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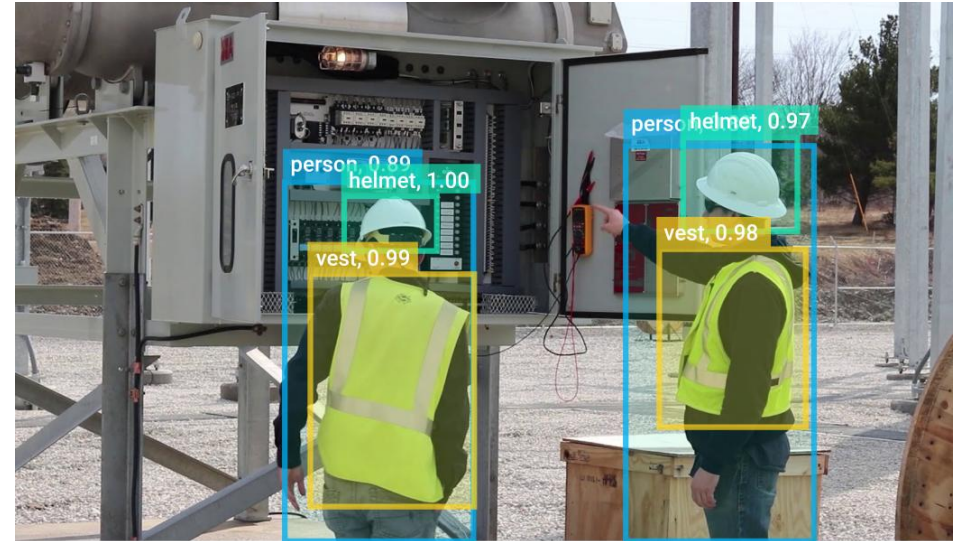


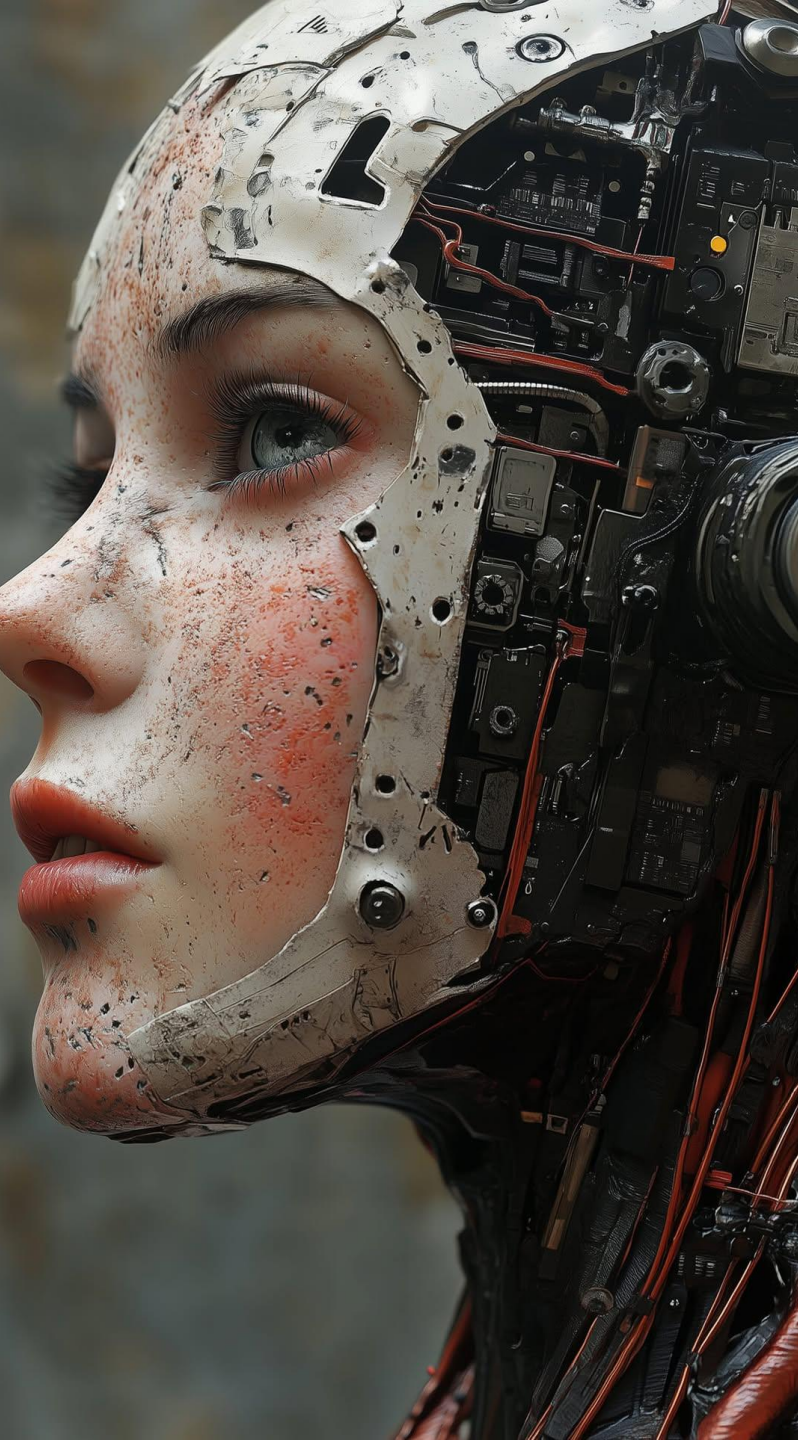
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BeamO

Revolutionary at-home checkup



Temperature | Heart | Respiratory system

A complete health checkup in just one minute.¹

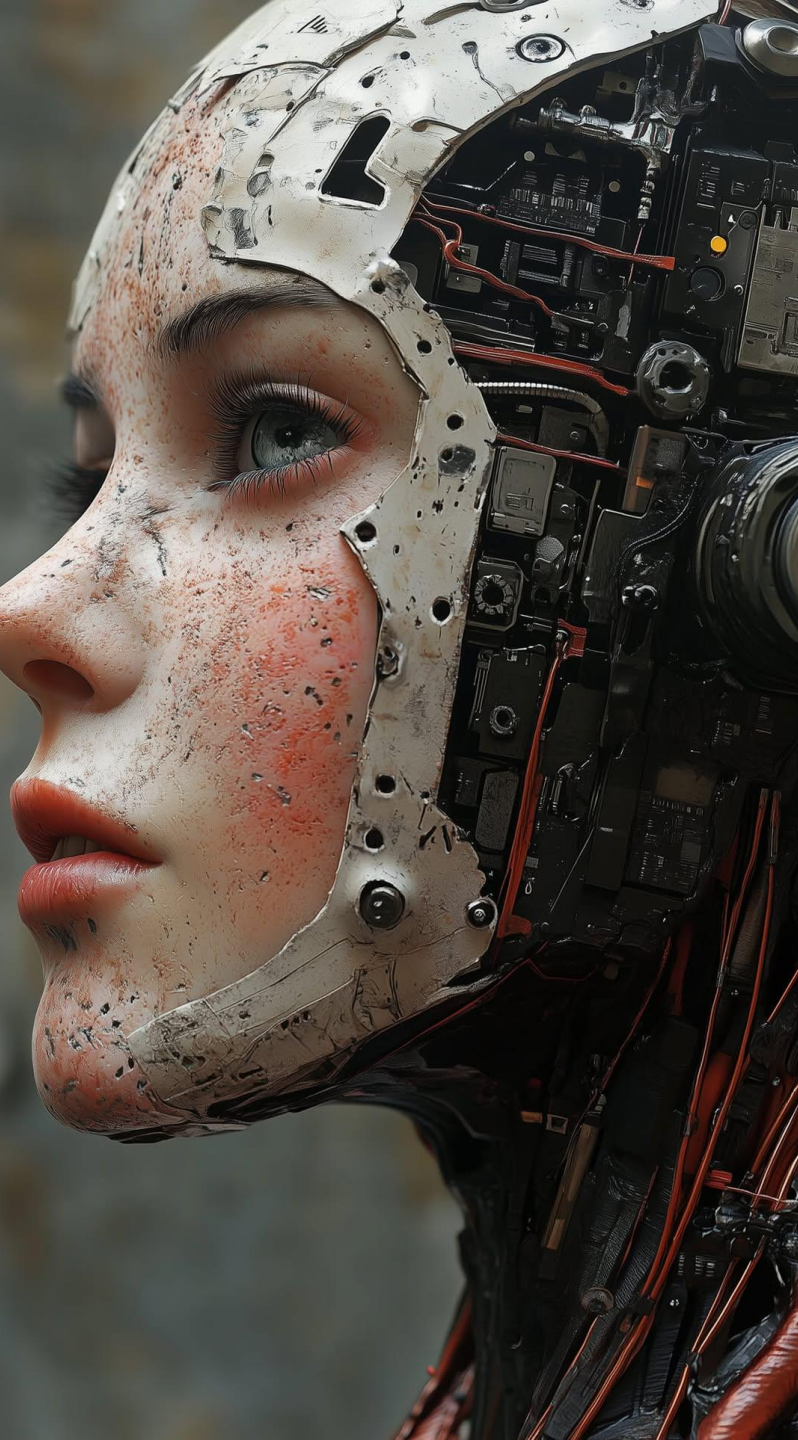


Body temperature¹
via automatic temporal artery detection

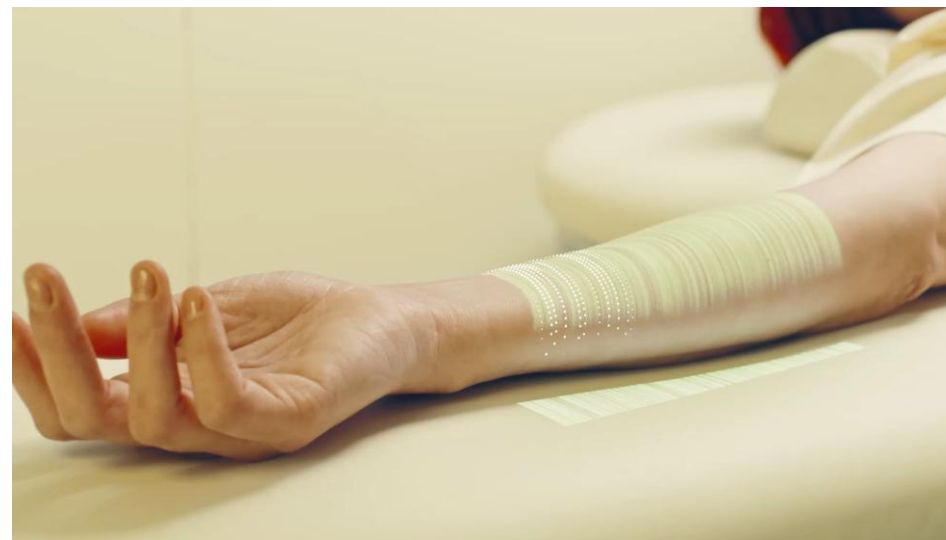
Digital stethoscope¹
to listen to the heart and lungs

Medical-grade ECG²
to detect possible cardiovascular issues² at
anytime

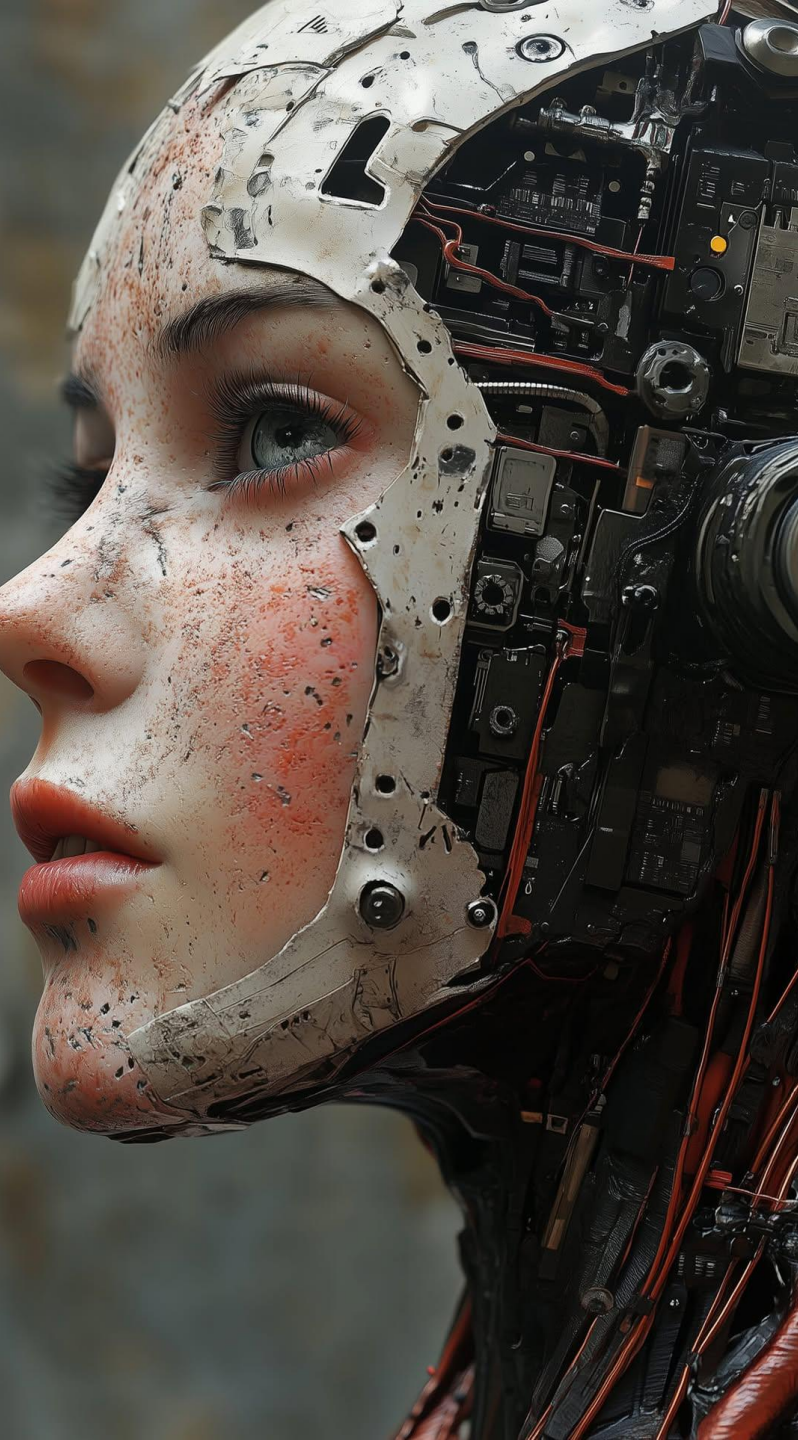
Blood oxygen level³
provides oxygen saturation which can help
assess part of your respiratory system³



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Source: <https://www.nekohealth.com/se/en>



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Article | Published: 11 September 2018

Monitoring of the central blood pressure waveform via a conformal ultrasonic device

[Chonghe Wang](#), [Xiaoshi Li](#), [Hongjie Hu](#), [Lin Zhang](#), [Zhenlong Huang](#), [Muyang Lin](#), [Zhuorui Zhang](#), [Zhenan Yin](#), [Brady Huang](#), [Hua Gong](#), [Shubha Bhaskaran](#), [Yue Gu](#), [Mitsutoshi Makihata](#), [Yuxuan Guo](#), [Yusheng Lei](#), [Yimu Chen](#), [Chunfeng Wang](#), [Yang Li](#), [Tianjiao Zhang](#), [Zeyu Chen](#), [Albert P. Pisano](#), [Liangfang Zhang](#), [Qifa Zhou](#) & [Sheng Xu](#) 

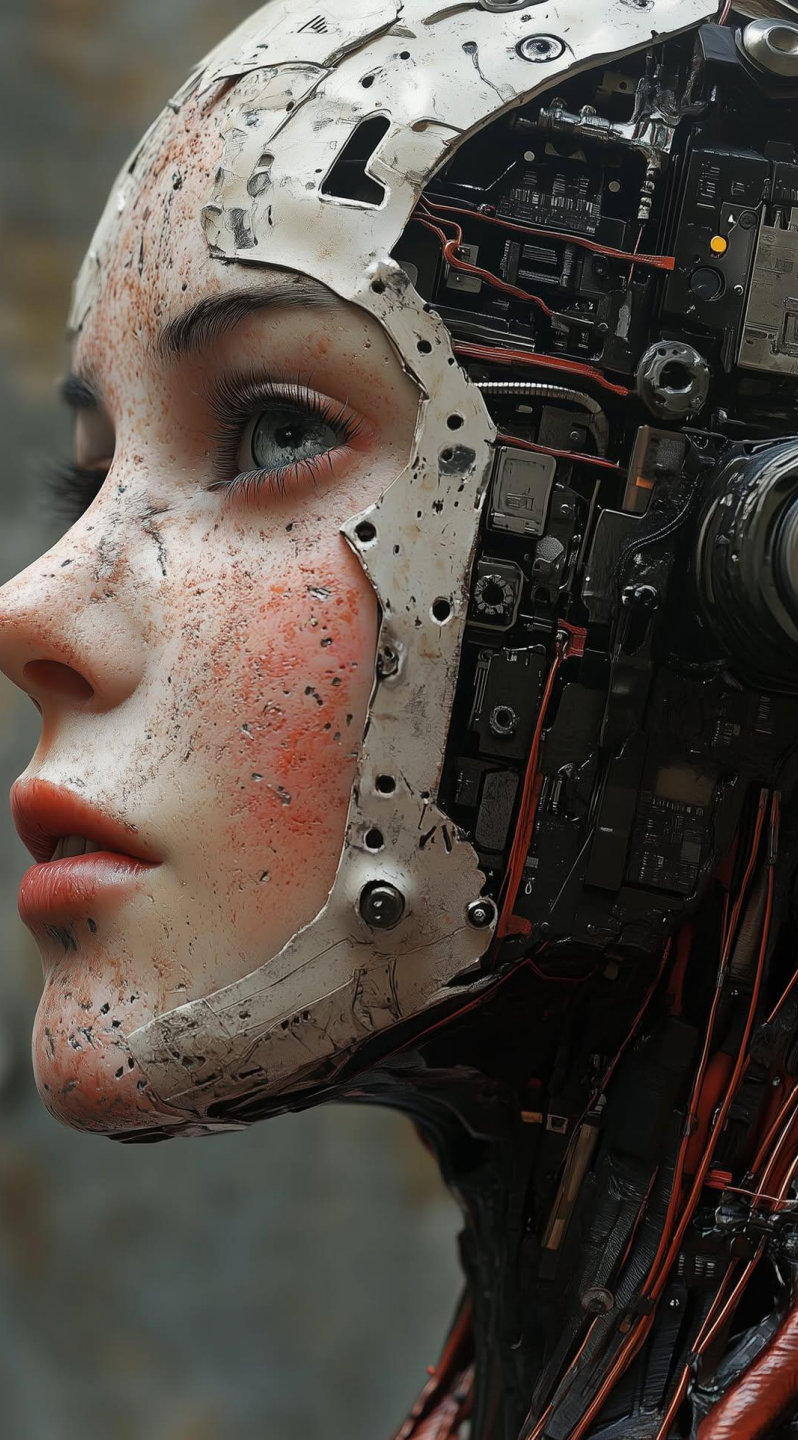
[Nature Biomedical Engineering](#), **2**, 687–695 (2018) | [Cite this article](#)

32k Accesses | **584** Citations | **373** Altmetric | [Metrics](#)

Abstract

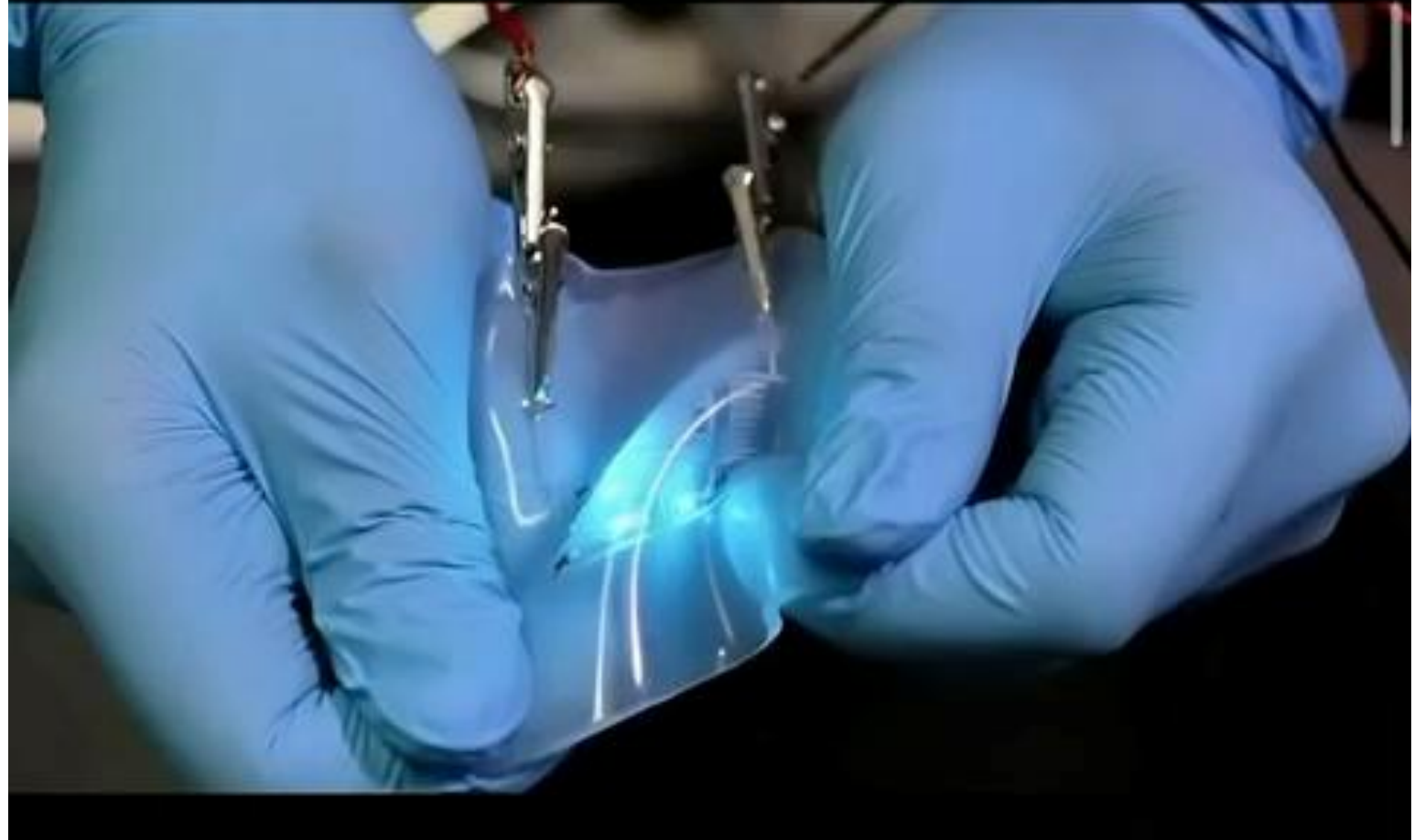
Continuous monitoring of the central blood pressure waveform from deeply embedded vessels such as the carotid artery and jugular vein has clinical value for the prediction of all-cause cardiovascular mortality. However, existing non-invasive approaches, including photoplethysmography and tonometry, only enable access to the superficial peripheral vasculature. Although current ultrasonic technologies allow non-invasive deep tissue observation, unstable coupling with the tissue surface resulting from the bulkiness and rigidity of conventional ultrasound probes introduces usability constraints. Here, we describe the design and operation of an ultrasonic device that is conformal to the skin and

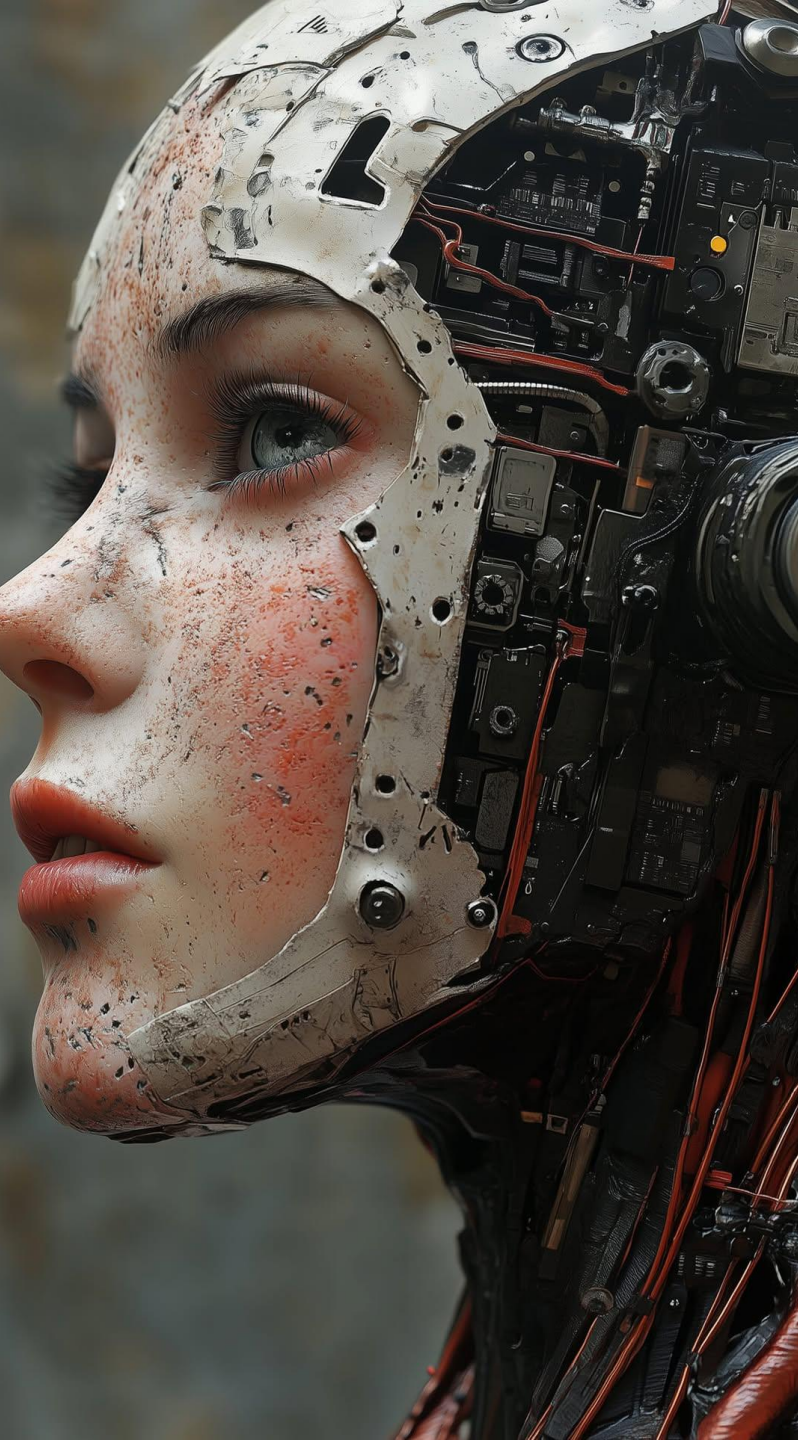
Source: <https://www.nature.com/articles/s41551-018-0287-x>



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Chinese scientists created a
stretchable circuit that never breaks





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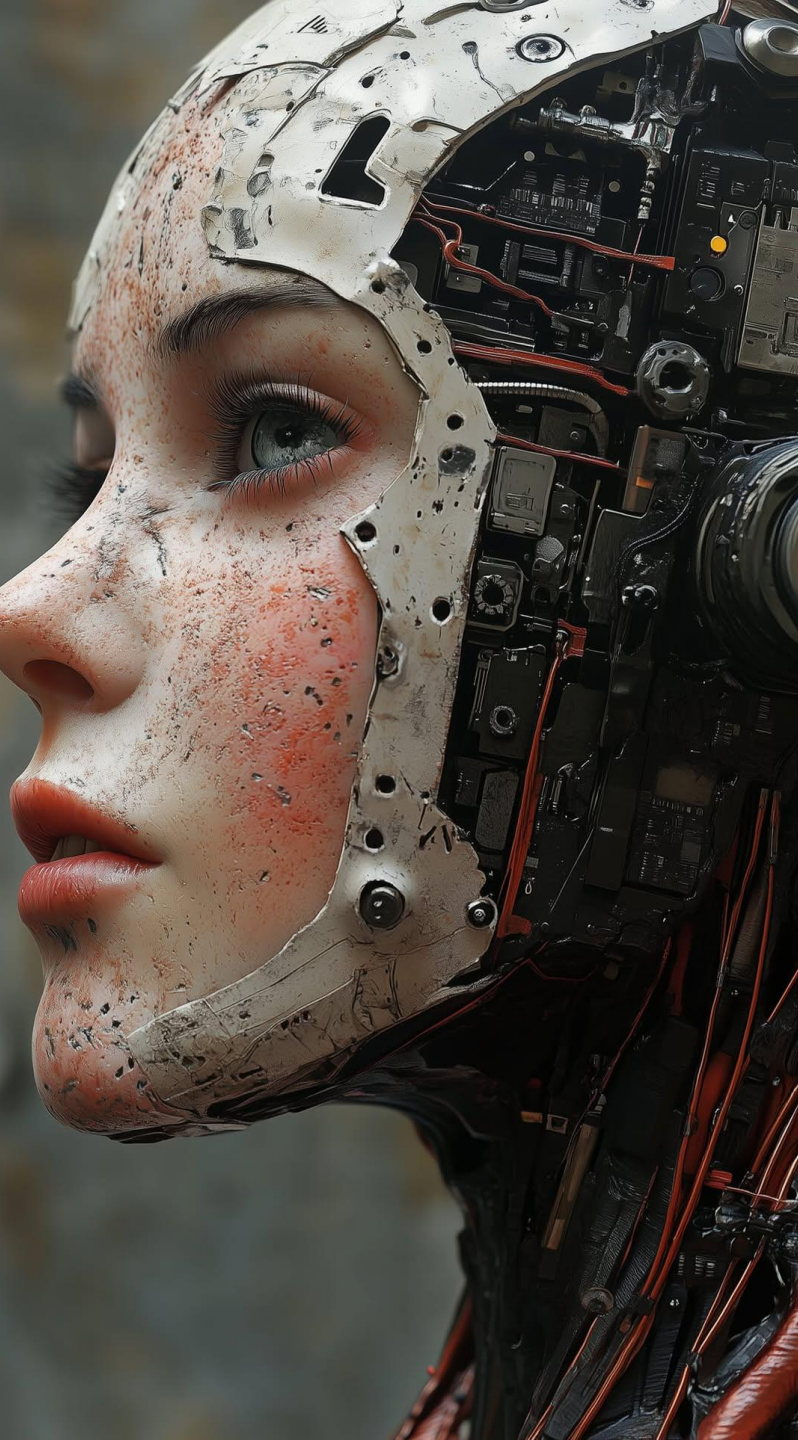


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Percept™ RC
neurostimulator

Delivering personalized,
upgradable therapy that
enables clinicians to adapt DBS
to patients' evolving needs.

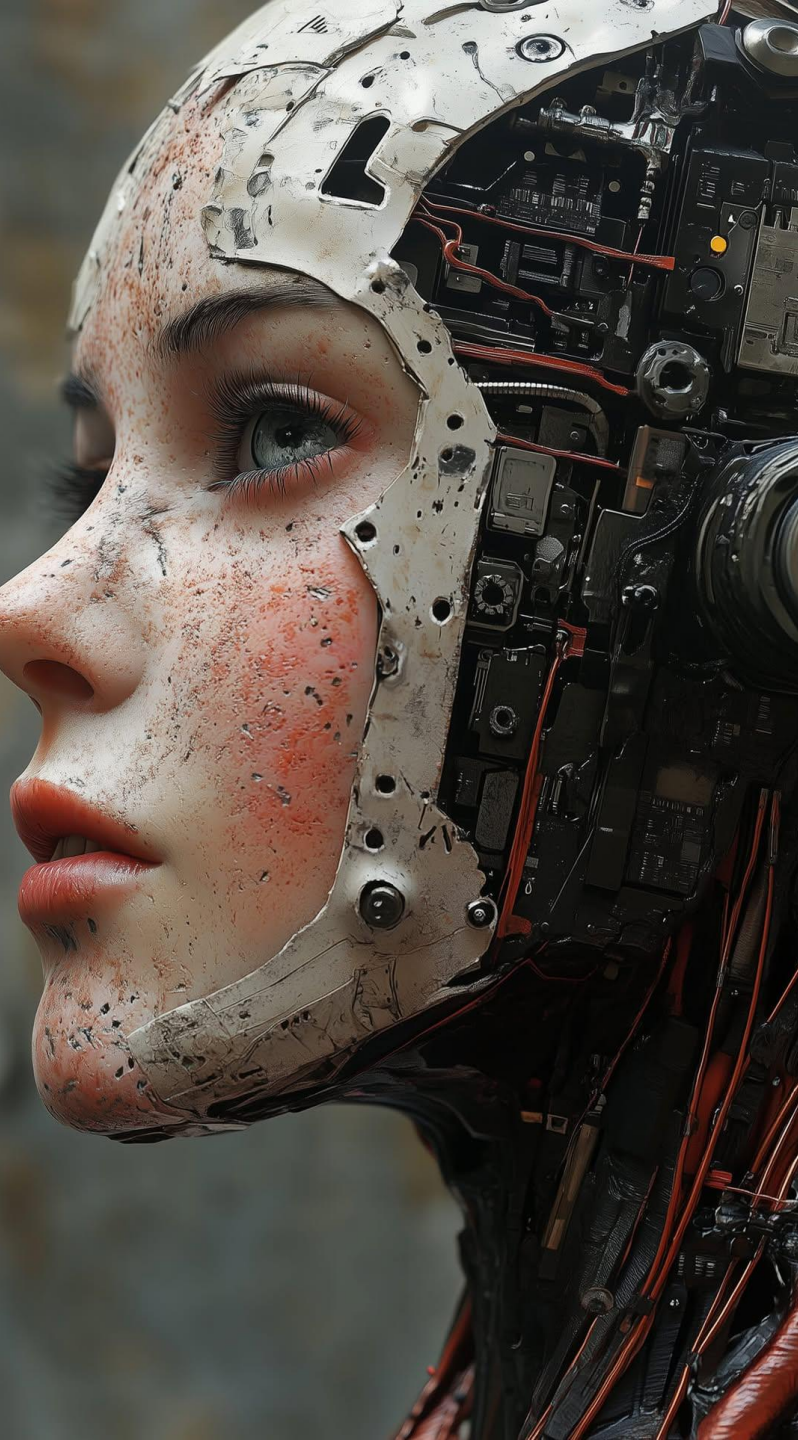
FDA Approved



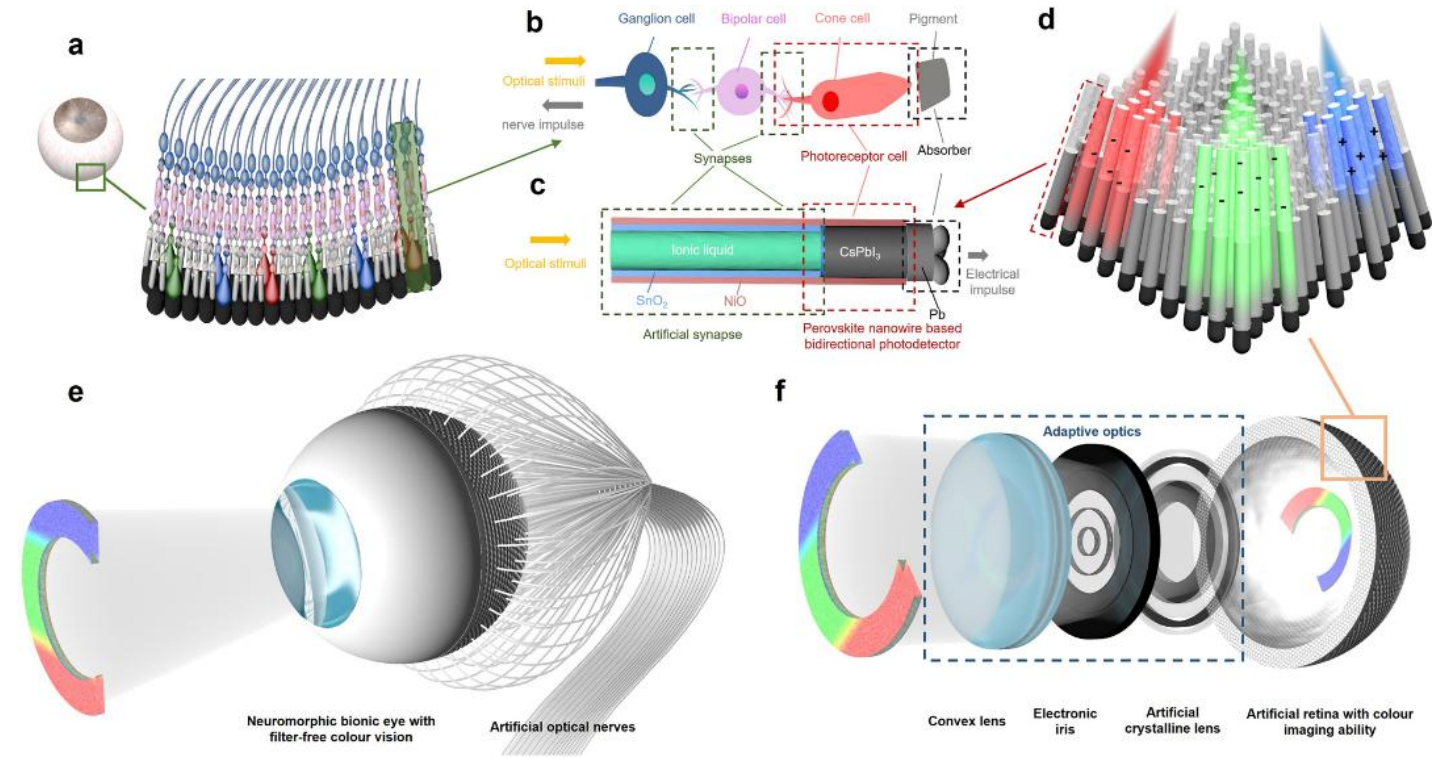
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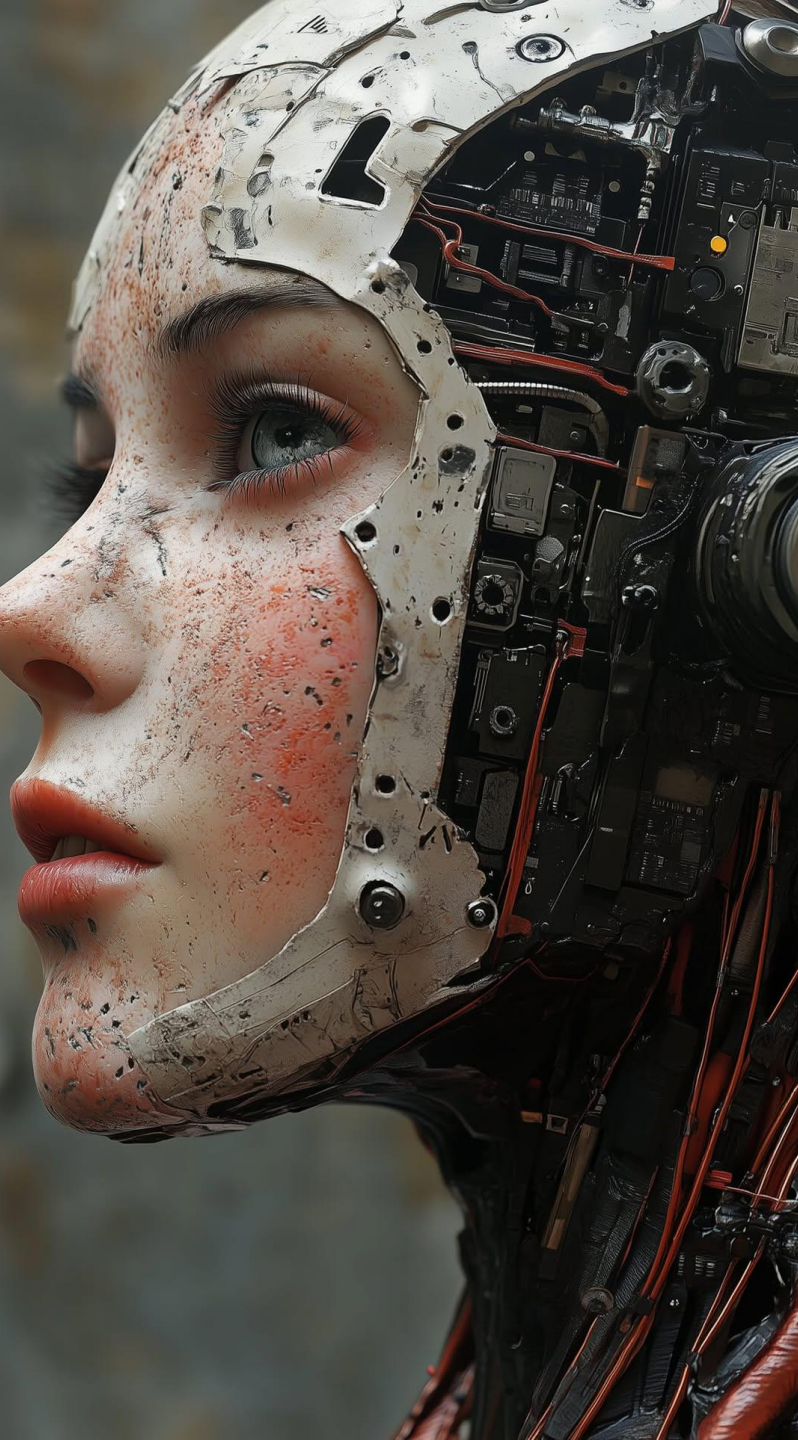


Noland Arbaugh, received the first Neuralink implant, in 2024.



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Where Meaning Emerges: Human–AI Dialogue, Distributed Cognition, and the Cognitive Intraface

***A Systems-Theoretical
Approach to Thought
beyond Instrumental AI***



Sougwen Chung and D.O.U.G._1 in collaborative drawing performance. From Drawing Operations Unit: Generation 1 (Mimicry), 2015.

Source: <https://intralation-culture-theory-posthuman-pedagogy.ghost.io/where-meaning-emerges-human-ai-dialogue-distributed-cognition-and-the-cognitive-intraface/>

The claim is narrow. And measurable.

In December 2022, when I wrote my MLaw thesis on the regulatory challenges of Internet of Bodies (IoB) technologies, this opening was a warning and a thought experiment.

LLM 2022 Thesis



UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

Exploring the Regulatory Challenges of Expanding Internet of Bodies Technologies

*Examining the potential for transformation in Healthcare Delivery and
future implications*

Author: Baroum Mrad
Supervisor: Richard Magnan
Word count: 21,787

Submitted in accordance with the requirements for the degree of
LLM in Compliance
University of Fribourg
School of Law
December 2022

The claim is narrow. And measurable.

Three pressure points: classification, consent, and time.

THESIS 2022: Phase IV IoB — Distributed Cognition — BCIs moving from therapeutic devices to continuous cognitive interfaces. Called speculative. Reviewers called it 'forward-looking conjecture.'

2026: January 2024: Neuralink implanted its first human. Since then, first-in-human implants have moved from speculation to reality, and product roadmaps have accelerated. The regulatory framework around what these systems collect — and what can be inferred — is still catching up.

THESIS 2022: The classification gap — the same neural signal could pass through GDPR's framework without triggering Article 9 because the inference layer carries no classification at point of collection.

2026: June 2024: The EDPS TechDispatch 1/2024 on neurodata explicitly highlighted that neurodata combined with AI can generate highly sensitive inferences (including about mental states) and that the inference layer is where legal ambiguity concentrates. Eighteen months after my thesis, a supervisory authority put the core risk in writing.

Convergence

LLM 2022 Thesis

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Exploring the Regulatory Challenges of Expanding
Internet of Bodies Technologies

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Table of Contents	
Abstract	3
Table of Abbreviations	5
1. Introduction	6
2. Defining the Internet of Bodies	10
2.1 The Internet of Humans	11
2.1.1 Reverse engineering IoT	11
2.2 The three phases of IoT	12
2.3 A symbiotic relationship between humans and devices	15
3. Internet of Bodies and healthcare: a revolution	18
3.1 The benefits of IoT	18
3.2 Application of IoT devices in healthcare	20
3.2.1 Medical and non-medical devices	21
3.2.2 Human body: the biggest data platform	26
3.2.3 Artificial Intelligence (AI): the elephant in the room	30
3.2.4 Personalized and precision medicine	32
3.3 The risks and challenges of IoT	35
3.3.1 Connected devices and the downside of interoperability	37
3.3.2 Privacy risks	38
3.3.3 Cyber and physical security risks	47
3.3.4 Ethical frontier	48
4. Exploring the legal frameworks	52
4.1 Digital health framework	53
4.1.1 Digital Content Directive and Liability	53
4.1.2 Medical and non-medical devices	55
4.2 Privacy and security framework	56
4.2.1 Privacy and data protection	58
4.2.2 Security and cybersecurity	58
4.3 Ethics and fundamental rights	59
5. The future of IoT	63
5.1 Code is law, the law is code	63
5.1.1 A symbiotic relationship between law and machine	64
5.2 Phase four: transhumanism	65
5.3 A technological singularity	67
6. Conclusion	67
7. References	70

4

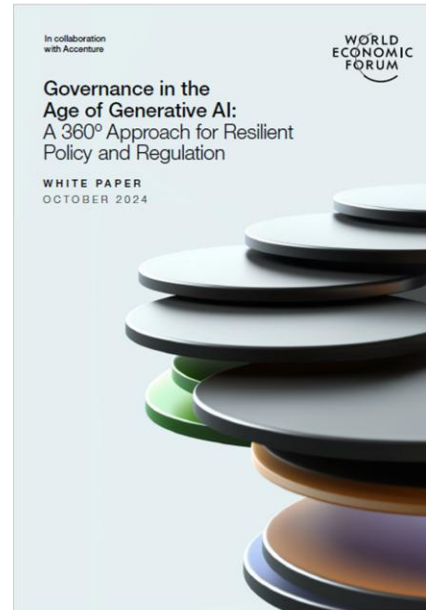
5. The future of IoT	63
5.1 Code is law, the law is code	63
5.1.1 A symbiotic relationship between law and machine	64
5.2 Phase four: transhumanism	65
5.3 A technological singularity	67

5.3 A technological singularity

The rapid increase of technological progress has given rise to a new generation of more connected and interdependent people; we now have access to nearly all the information known to man from the comfort of our homes and on the go using mobile devices.²⁶⁹ At the outset, a strong sense of euphoria is similar to worlds explored by Orwell or video games like *Cyberpunk 2077*. However, it raises the question of whether technology has made us any more human or any less so. This does not imply that the future will be some Orwellian nightmare, but rather the question is whether it has made us less human. There is a major difference between the world we live in now and those fictional ones: we are unaware that this transition is happening. We have yet to realize that we have entered an era of technological singularity.

CONVERGENCE

Convergence



Pillar 3

Plan future

Generative AI governance demands preparedness, agility and international cooperation to address evolving sociotechnical impacts and global challenges.



Synthetic biology



Neurotechnology



Quantum computing

Convergence

As a powerful general-purpose technology, generative AI can amplify other technologies, old and new, exposing complex governance challenges. For example, social media is under scrutiny due to its potential to distribute harmful

AI-generated deepfakes,⁶⁴ such as non-consensual pornography⁶⁵ – including CSAM⁶⁶ – and election disinformation.⁶⁷ Looking ahead, the convergence of generative AI with advanced technologies can pose unprecedented opportunities and risks, as both the technologies and their governance frameworks are in the early stages.

Emotional entanglement

As generative AI applications become more complex and computationally powerful, the risk of emotional reliance between humans and generative AI applications tends to increase.

NEUROSCIENCE - NEUROPRIVACY

Neuroprivacy is the moment where privacy law stops being about information and starts being about agency.

Not “what data says about me,” but “what systems can *do to me*—in real time—based on what they infer.”

INTERFERENCE

The risk concentrates in the inference layer

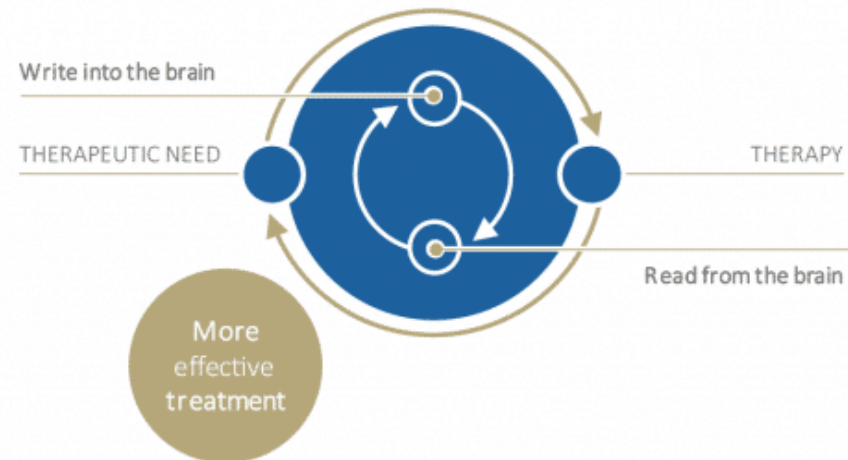
The raw signal is not the end of the story — the risk lives in what we infer and what we do next.

INTERFERENCE

Inference becomes intervention.

Closed-loop systems don't just observe — they act, in real time, inside the brain.

Closed Loop is the future of neuromodulation
Adapting therapy based on patient's needs



INTERFERENCE

Inference becomes intervention.

Closed-loop systems don't just observe — they act, in real time, inside the brain.

Closed-loop neurotech turns processing into control, and control at **millisecond** scale makes consent/oversight operationally brittle even if the principles are sound.



CLASSIFICATION GAP

Two lawful pathways carry most clinical neurotech — both become fragile in closed loop

Raw neural signal → Model inference → Mental/health conclusion

Neural data can enter a system as a ‘signal’, but it leaves as a conclusion about health or mental state—so protection must attach at the inference layer, not only after the label becomes obvious.

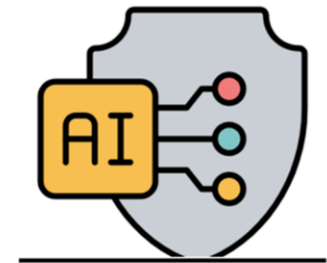




ETHIC



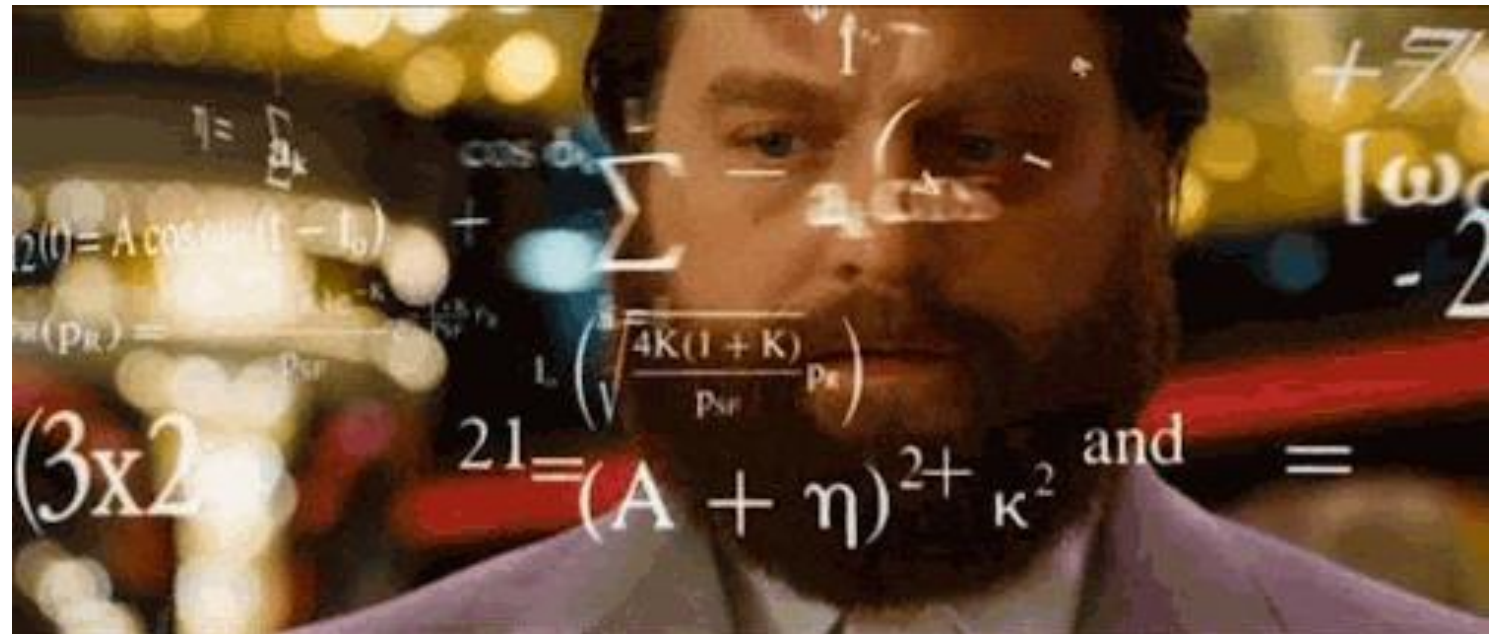
COMPLIANCE



SECURITY

QUANTUM

Harvest now. Decrypt later



QUANTUM

Harvest now. Decrypt later

Neural data can remain sensitive for decades — so retention and encryption choices today create irreversible exposure tomorrow. Explicit consent promises control — but it becomes fragile when processing is continuous and the model's outputs and purposes evolve over time.

STORAGE LIMITS

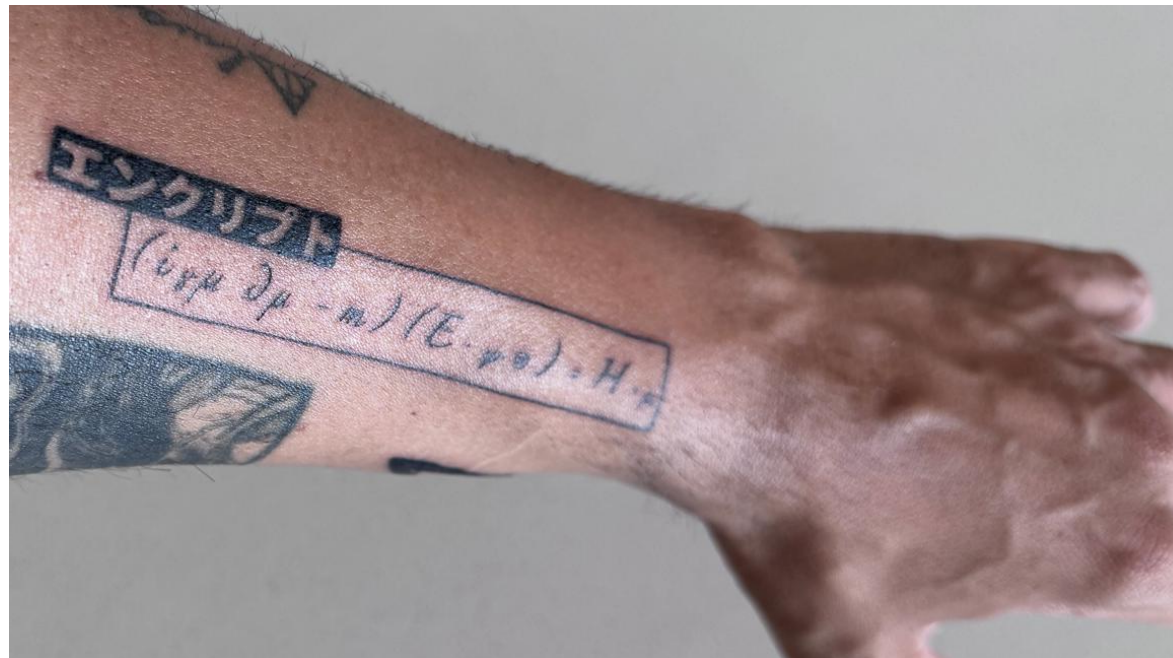
Estimates based on bacterial genetics suggest that digital DNA could one day rival or exceed today's storage technology.

	 Hard disk	 Flash memory	 Bacterial DNA	WEIGHT OF DNA NEEDED TO STORE WORLD'S DATA
Read-write speed (μ s per bit)	> ~3,000–5,000	~100	<100	 ~1 kg ©nature
Data retention (years)	>10	>10	>100	
Power usage (watts per gigabyte)	~0.04	~0.01–0.04	<10 ⁻¹⁰	
Data density (bits per cm ³)	~10 ¹³	~10 ¹⁶	~10 ¹⁹	

QUANTUM

Quantum encryption

Core Equation (neural privacy via quantum encryption)



Disclaimer: The conceptual design and symbolic formulation of this equation are protected as intellectual property, and any reproduction, adaptation, or commercial use is subject to the author's prior authorization.

Code was law. Now law must become code.

That's the last frontier: when systems act at the speed of the nervous system, rights must be engineered into the loop.

The law still works—until inference becomes intervention.

Data protection law historically protects the person through information controls—collection, use, disclosure.

Neurotechnology adds a new dimension: it can turn signals into inferences, and inferences into interventions that shape agency.

THE PROPOSITION

HUMAN BY DESIGN

Any technology interfacing with the human mind must be designed to preserve, protect, and prioritize human autonomy, identity, and cognitive liberty above all other design objectives.

- 1 **Neural Data Sovereignty**
- 2 **Cognitive Consent**
- 3 **Algorithmic Guardianship**
- 4 **Post-Mortem Neural Rights**
- 5 **Neuro-Impact Assessment**

THE PROPOSITION

HUMAN BY DESIGN

The question is not whether quantum computing will break current BCI encryption. It will.

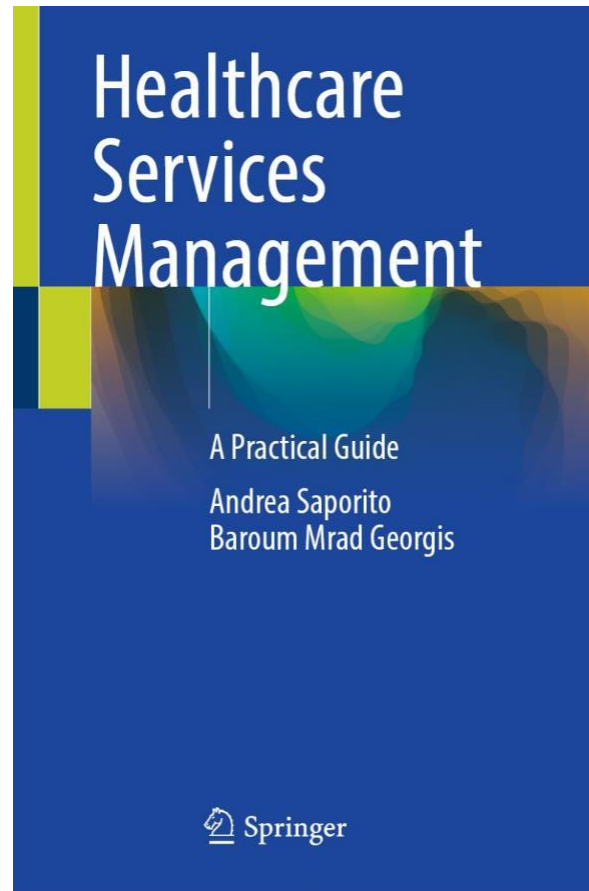
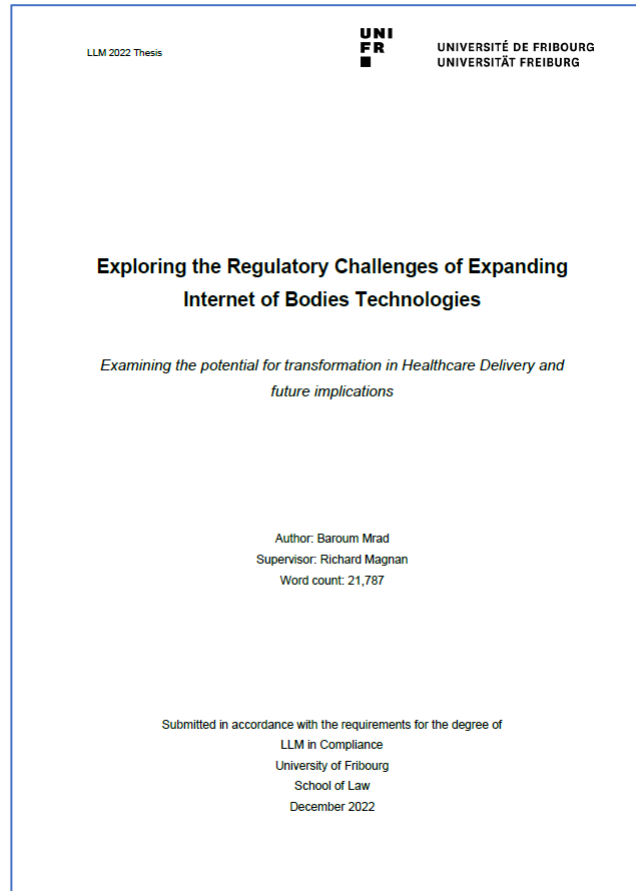
The question is whether the legal and technical architecture we mandate today will be quantum-resistant by the time it matters — or whether we will spend the 2030s litigating the consequences of a design decision we had the opportunity to make in 2026.

TRANSHUMANISM

ENGINEERING THE HUMAN CONDITION



Healthcare Services Management: A Practical Guide



SPRINGER NATURE

Andrea Saporito, Baroum Mrad Georgis

Healthcare Services Management

A Practical Guide

A structured, practical guide to healthcare management for
professionals and administrators

Comprehensive coverage of key management topics including
finance, operations, and policy

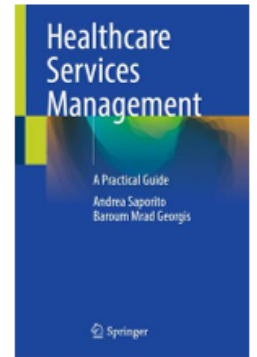
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Baroum Mrad Georgis, LL.M., DPO-HSG
Master of Laws (LL.M.) and Data Protection
Officer (DPO-HSG) - Chief Privacy Officer - M...



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RELENTLESS

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