



UNIVERSITÀ  
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DI BERGAMO

Dipartimento  
di Ingegneria Gestionale,  
dell'Informazione e della Produzione



Control Automation Lab

# Data Analysis Lab

ICT/Electronic Lab

## Lecture 01: Introduction to Artificial Intelligence

SPEAKER

Prof. Antonio Ferramosca

PLACE

University of Bergamo

# Syllabus

1. Introduction to artificial intelligence
2. Introduction to data science and Machine Learning
3. Neural networks
4. Computer vision
5. NLP and GenAI



# What is artificial intelligence?

How would you define Artificial Intelligence?



# What is artificial intelligence?

«Artificial Intelligence (AI) is **a branch of computer science** focused on creating systems **capable of performing tasks** that typically require **human intelligence**. These tasks can include learning, reasoning, problem-solving, understanding language, recognizing patterns, and even making decisions.

AI seeks to simulate or mimic human cognitive functions using algorithms, data, and computational power.»

*ChatGPT, 6/03/2026*



# Types of AI

## Narrow AI (Weak AI):

**Definition:** AI systems designed to perform a specific task, such as facial recognition, language translation, or playing chess. They do not possess general intelligence.

**Example:** Virtual assistants like Siri or Alexa, Netflix recommendations, Instagram algorithm, chatbots, autonomous vehicles.

## General AI (Strong AI, AGI):

**Definition:** A hypothetical form of AI that would have the ability to understand, learn, and apply intelligence across a wide range of tasks, much like a human.

**Example:** This type of AI does not yet exist. It would involve machines capable of reasoning and adapting to new situations independently.



# Everyday examples of artificial intelligence

At Home 🏠



Amazon  
*Echo*



Google  
*Home*



Apple  
*Homepod*



Baidu  
*DuerOS*



Smart Thermostats

Voice Assistants



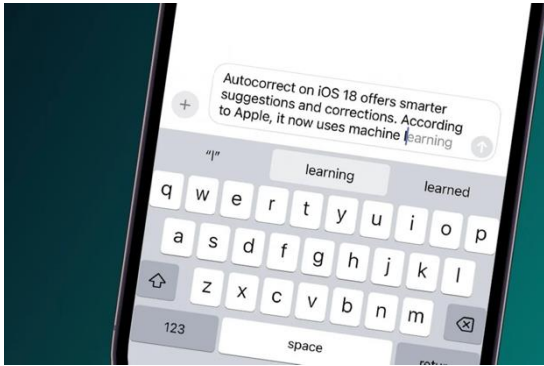
Smart cameras



Robotic Vacuum cleaners

# Everyday examples of artificial intelligence

On our phones 



Predictive text and autocorrect



Photos classification



Facial recognition



Personalized recommendations



Photos Enhancement

# Everyday examples of artificial intelligence

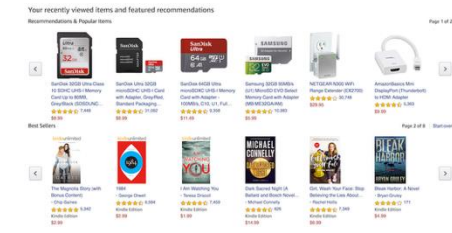
And much more



Transportation



Health and fitness



Shopping



Work and productivity

# Key areas in AI

## Machine Learning

AI algorithms that allows computers to learn from data.

**Example:** Netflix or Youtube recommendations, Instagram algorithm, Spam filters, Google Maps



## Natural Language Processing (NLP)

AI algorithms that understand, interpret, and respond to human language.

**Example:** Chatbot, Google Translate, Voice Assistants



# Key areas in AI

## Computer Vision

AI algorithms that interpret and process images.

**Example:** self-driving cars, vision for health diagnosis, face ID, social media filters



## Robotics

Robots + AI algorithms for autonomous decision-making in real world environment.

**Example:** Robots in manufacturing or medical surgeries, robotics arms in factories, drones



# Key areas in AI

## Expert systems / Decision systems

AI algorithms that mimic human decision-making based on sets of rules or learned data.

**Example:** medical diagnosis tools, smart home automation



## Generative AI

AI algorithms capable of creating new content — text, images, music, code, etc.

**Example:** ChatGPT, Copilot, Canva, Midjourney, Gemini, Nano Banana



# Wrap up

## Type of AI

 **Machine Learning (ML)**

 **Natural Language Processing (NLP)**

 **Computer Vision**

 **Robotics**

 **Expert / Decision Systems**

 **Generative AI**

## What It Does

Learns from data to predict or make decisions without being explicitly programmed.

Understands, interprets, and generates human language (text or speech).

Enables computers to “see” and interpret images and videos.

Combines AI with machines to perform physical tasks.

Uses rules or learned data to mimic human decision-making.

Creates new content — text, images, audio, video, or code.

## Everyday Examples

- Netflix or Spotify recommendations- Email spam filters- Smart thermostats (Nest)- Fraud detection in banking

- Siri, Alexa, Google Assistant- Autocorrect & predictive text- ChatGPT & chatbots- Google Translate- Grammarly

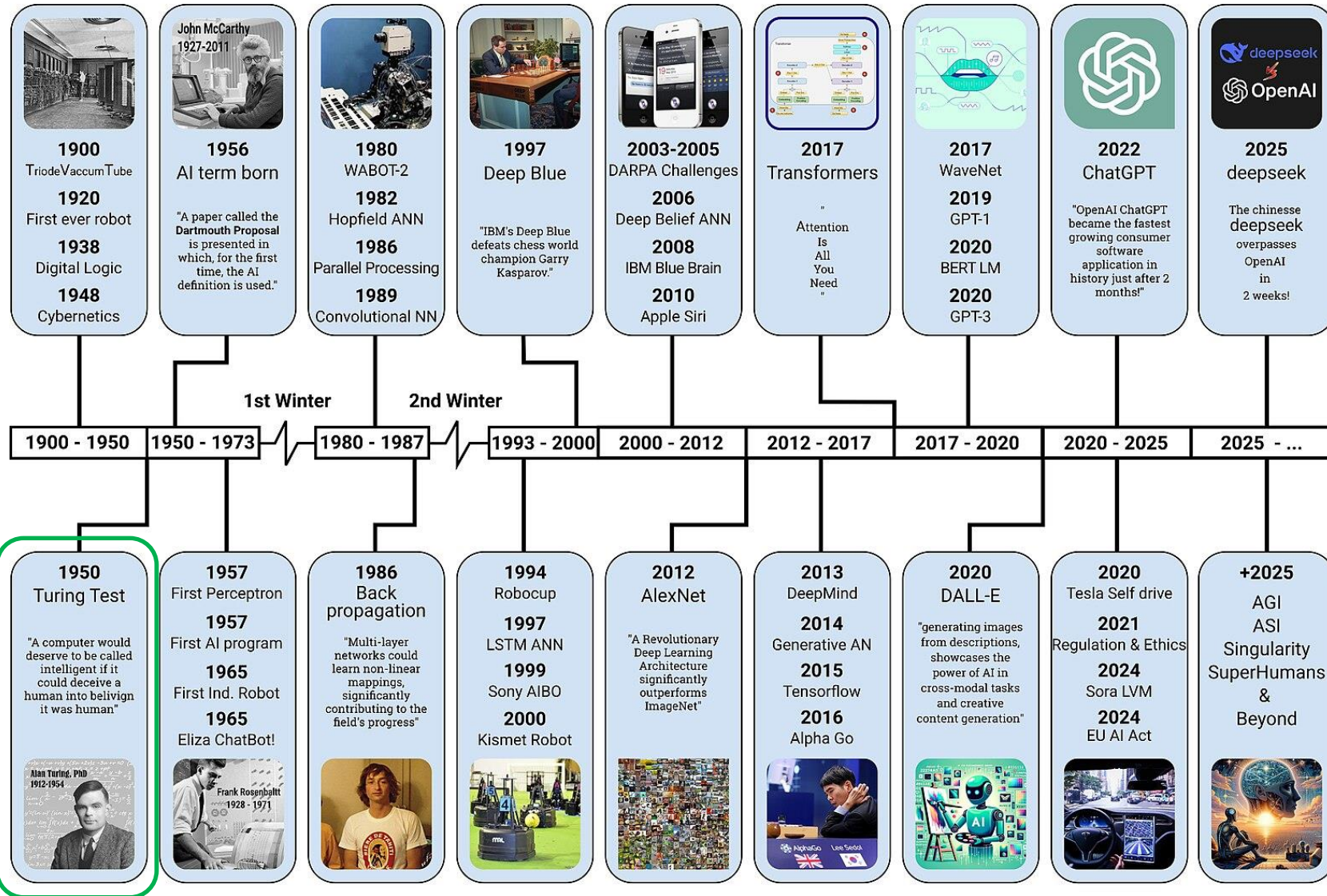
- Face ID on phones- Self-driving car cameras- Snapchat filters- Security camera motion detection- Google Photos face recognition

- Robot vacuums (Roomba)- Delivery drones- Factory robots- AI prosthetics- Service robots in hospitals or restaurants

- Medical diagnostic tools- Credit scoring systems- Smart home automation (“if motion, turn on lights”)- Car maintenance alerts

- ChatGPT writing text- DALL·E or Midjourney creating images- AI photo editing (object removal, enhancement)- AI music generation- Canva or PowerPoint design suggestions

# History of artificial intelligence



The one who decoded Enigma

# History of artificial intelligence

**1950 – Alan Turing:** Published “*Computing Machinery and Intelligence*”, introducing the **Turing Test** to assess machine intelligence.

A. M. Turing (1950) *Computing Machinery and Intelligence*. *Mind* 49: 433-460.

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## COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

### 1. The Imitation Game

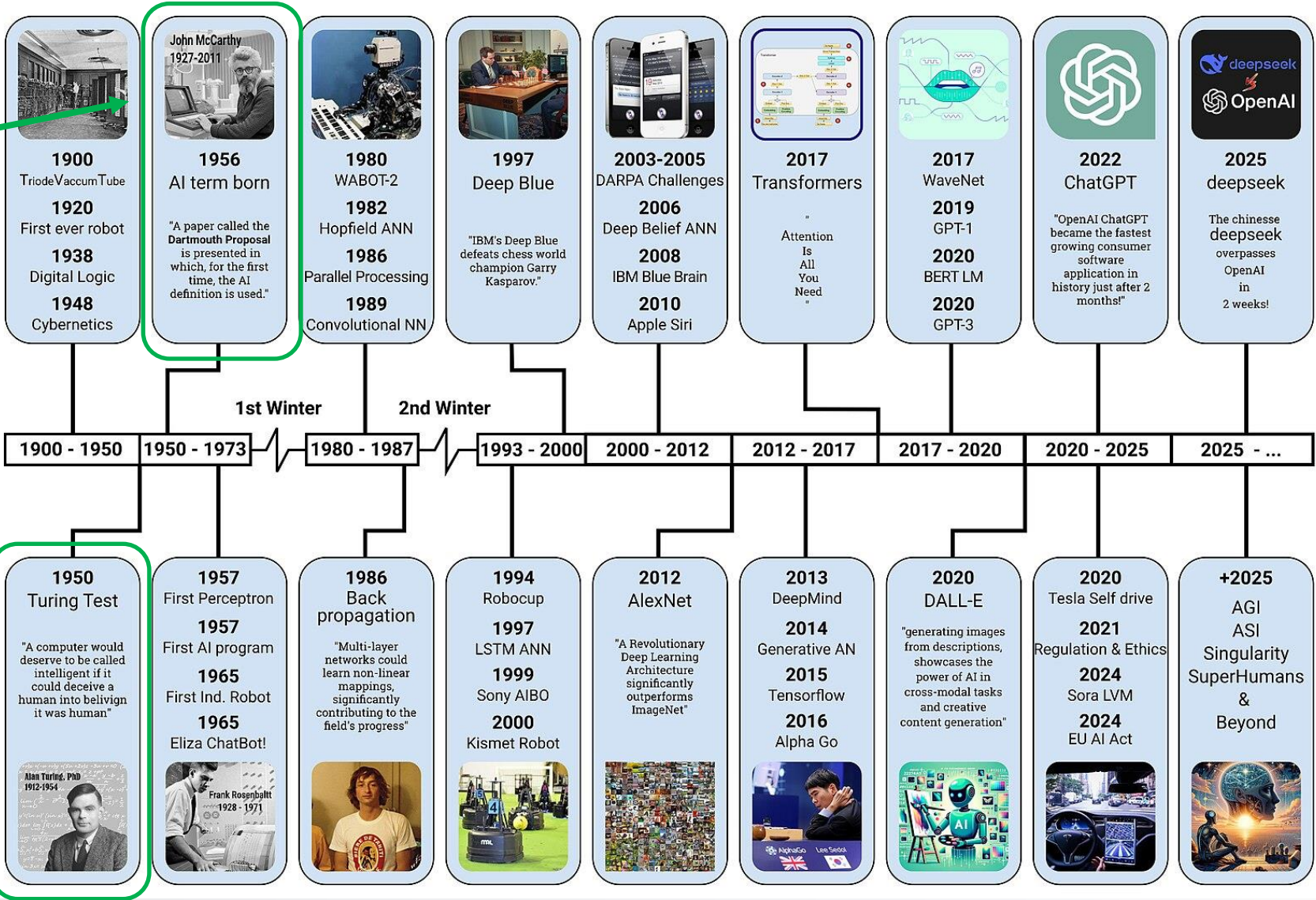
I propose to consider the question, "Can machines think?" This should begin with definitions of the meaning of the terms "machine" and "think." The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous, If the meaning of the words "machine" and "think" are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, "Can machines think?" is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

**The Imitation Game:** test involving a human interrogator communicating with a human and a machine via text-based inputs. If the interrogator cannot distinguish the machine from the human based on their responses, the machine passes the test.



# History of artificial intelligence

AI term first employed

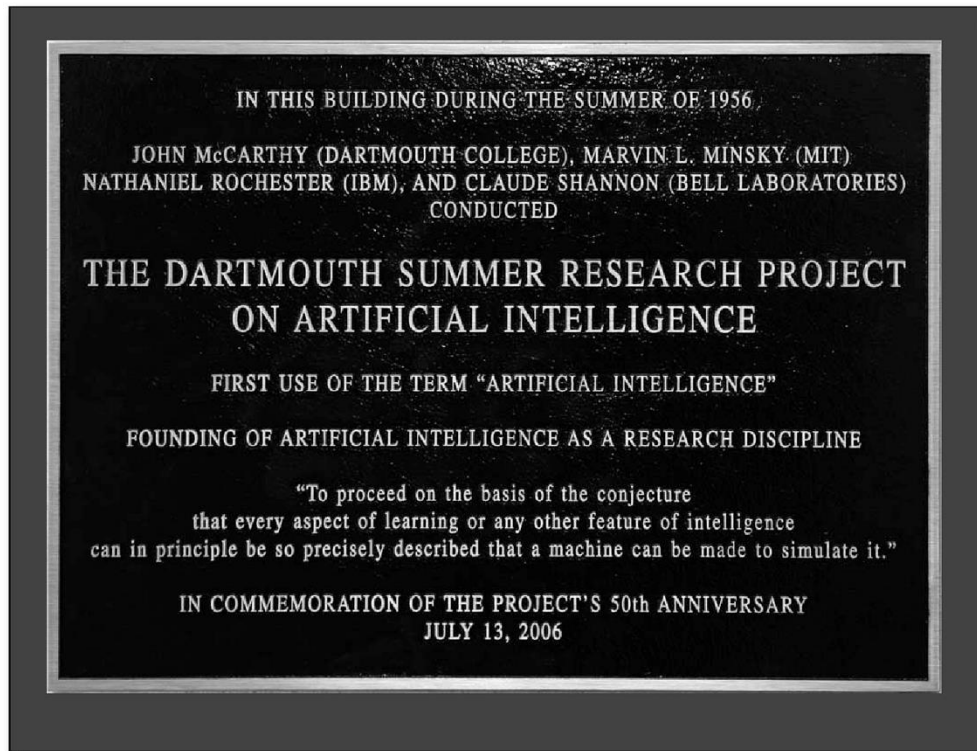


The one who decoded Enigma



# History of artificial intelligence

**1956 – Dartmouth Conference** (organized by John McCarthy, Marvin Minsky, Claude Shannon, and Nathaniel Rochester) was a Summer Workshop where it has been coined the term **“Artificial Intelligence”** — considered the official birth of the field.



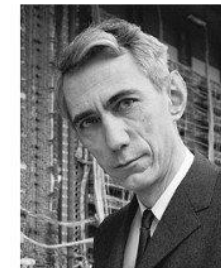
## 1956 Dartmouth Conference: The Founding Fathers of AI



John McCarthy



Marvin Minsky



Claude Shannon



Ray Solomonoff



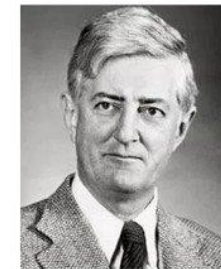
Alan Newell



Herbert Simon



Arthur Samuel



Oliver Selfridge








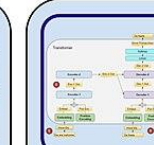
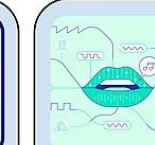
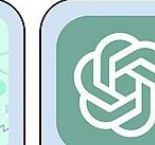
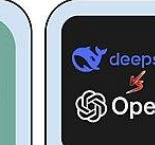
Nathaniel Rochester



Trenchard More

# History of artificial intelligence

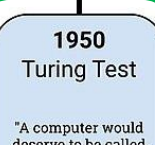
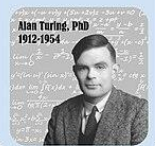
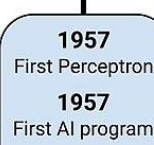

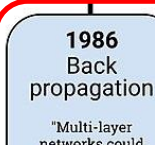

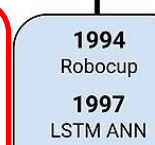



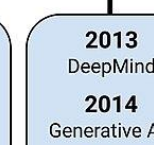

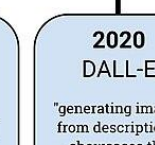

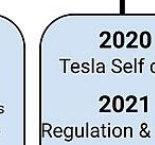

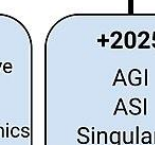

AI term first employed

 <p><b>1900</b> Triode Vacuum Tube</p> <p><b>1920</b> First ever robot</p> <p><b>1938</b> Digital Logic</p> <p><b>1948</b> Cybernetics</p>	 <p><b>1956</b> AI term born</p> <p>"A paper called the <b>Dartmouth Proposal</b> is presented in which, for the first time, the AI definition is used."</p>	 <p><b>1980</b> WABOT-2</p> <p><b>1982</b> Hopfield ANN</p> <p><b>1986</b> Parallel Processing</p> <p><b>1989</b> Convolutional NN</p>	 <p><b>1997</b> Deep Blue</p> <p>"IBM's Deep Blue defeats chess world champion Garry Kasparov."</p>	 <p><b>2003-2005</b> DARPA Challenges</p> <p><b>2006</b> Deep Belief ANN</p> <p><b>2008</b> IBM Blue Brain</p> <p><b>2010</b> Apple Siri</p>	 <p><b>2017</b> Transformers</p> <p>"Attention Is All You Need"</p>	 <p><b>2017</b> WaveNet</p> <p><b>2019</b> GPT-1</p> <p><b>2020</b> BERT LM</p> <p><b>2020</b> GPT-3</p>	 <p><b>2022</b> ChatGPT</p> <p>"OpenAI ChatGPT became the fastest growing consumer software application in history just after 2 months!"</p>	 <p><b>2025</b> deepseek</p> <p>The chinese deepseek overpasses OpenAI in 2 weeks!</p>
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1st Winter      2nd Winter

1900 - 1950    1950 - 1973    1980 - 1987    1993 - 2000    2000 - 2012    2012 - 2017    2017 - 2020    2020 - 2025    2025 - ...

The one who decoded Enigma

 <p><b>1950</b> Turing Test</p> <p>"A computer would deserve to be called intelligent if it could deceive a human into believing it was human"</p> 	 <p><b>1957</b> First Perceptron</p> <p><b>1957</b> First AI program</p> <p><b>1965</b> First Ind. Robot</p> <p><b>1965</b> Eliza ChatBot!</p> 	 <p><b>1986</b> Back propagation</p> <p>"Multi-layer networks could learn non-linear mappings, significantly contributing to the field's progress"</p> 	 <p><b>1994</b> Robocup</p> <p><b>1997</b> LSTM ANN</p> <p><b>1999</b> Sony AIBO</p> <p><b>2000</b> Kismet Robot</p> 	 <p><b>2012</b> AlexNet</p> <p>"A Revolutionary Deep Learning Architecture significantly outperforms ImageNet"</p> 	 <p><b>2013</b> DeepMind</p> <p><b>2014</b> Generative AN</p> <p><b>2015</b> Tensorflow</p> <p><b>2016</b> Alpha Go</p> 	 <p><b>2020</b> DALL-E</p> <p>"generating images from descriptions, showcases the power of AI in cross-modal tasks and creative content generation"</p> 	 <p><b>2020</b> Tesla Self drive</p> <p><b>2021</b> Regulation &amp; Ethics</p> <p><b>2024</b> Sora LVM</p> <p><b>2024</b> EU AI Act</p> 	 <p><b>+2025</b> AGI ASI Singularity SuperHumans &amp; Beyond</p> 
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NN birth



# History of artificial intelligence

## 1960s–1970s - Early Optimism and Symbolic AI

**1974–1980 – First AI Winter:** Decline in funding and interest due to **limited computing power, unmet expectations, and overpromised results.**

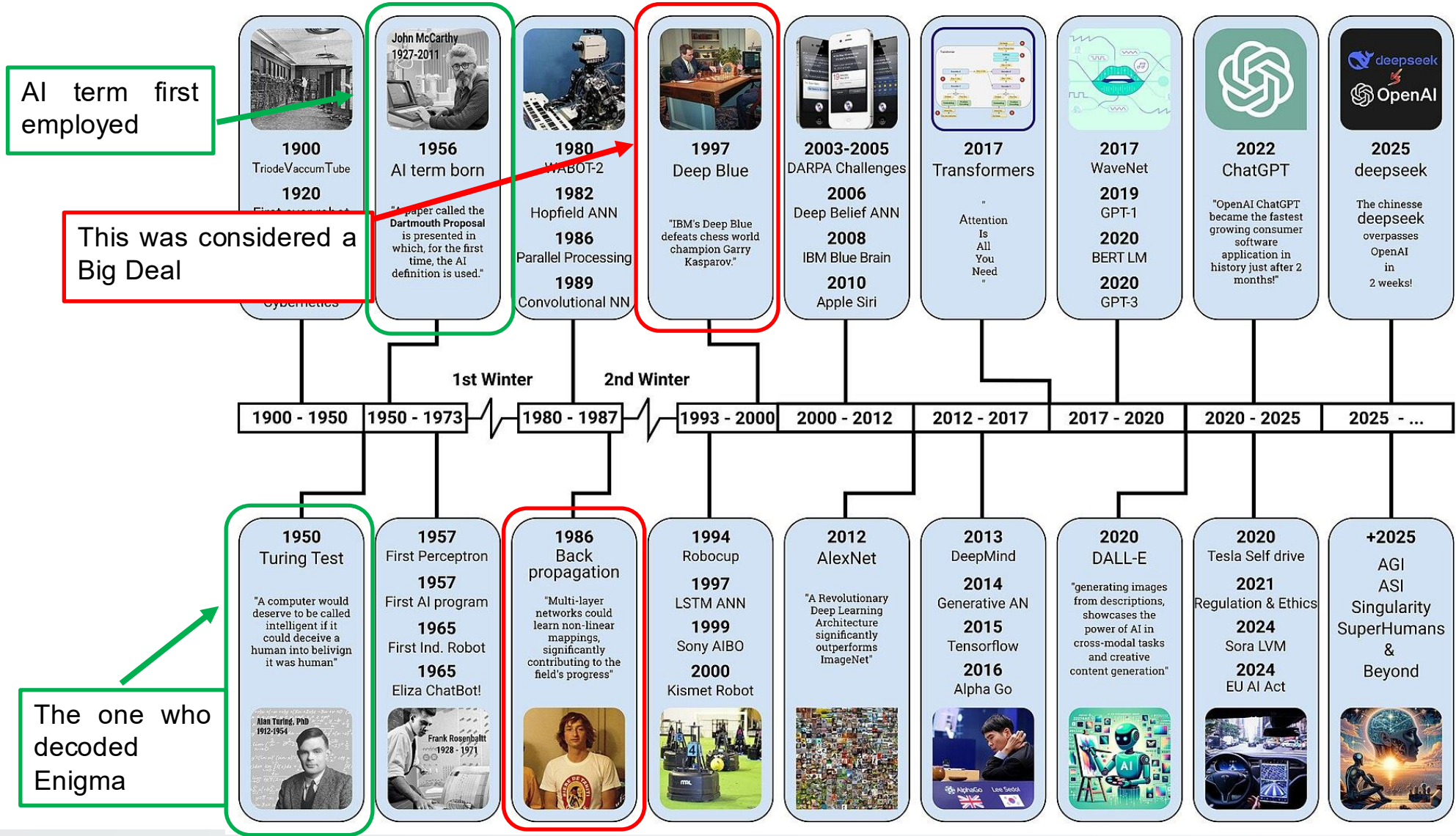
Research slowed dramatically during these periods.

## 1980-1990 – Rebirth: Expert Systems and Machine Learning

**1986 – Backpropagation** popularized by Rumelhart, Hinton, and Williams → revival of neural networks.



# History of artificial intelligence

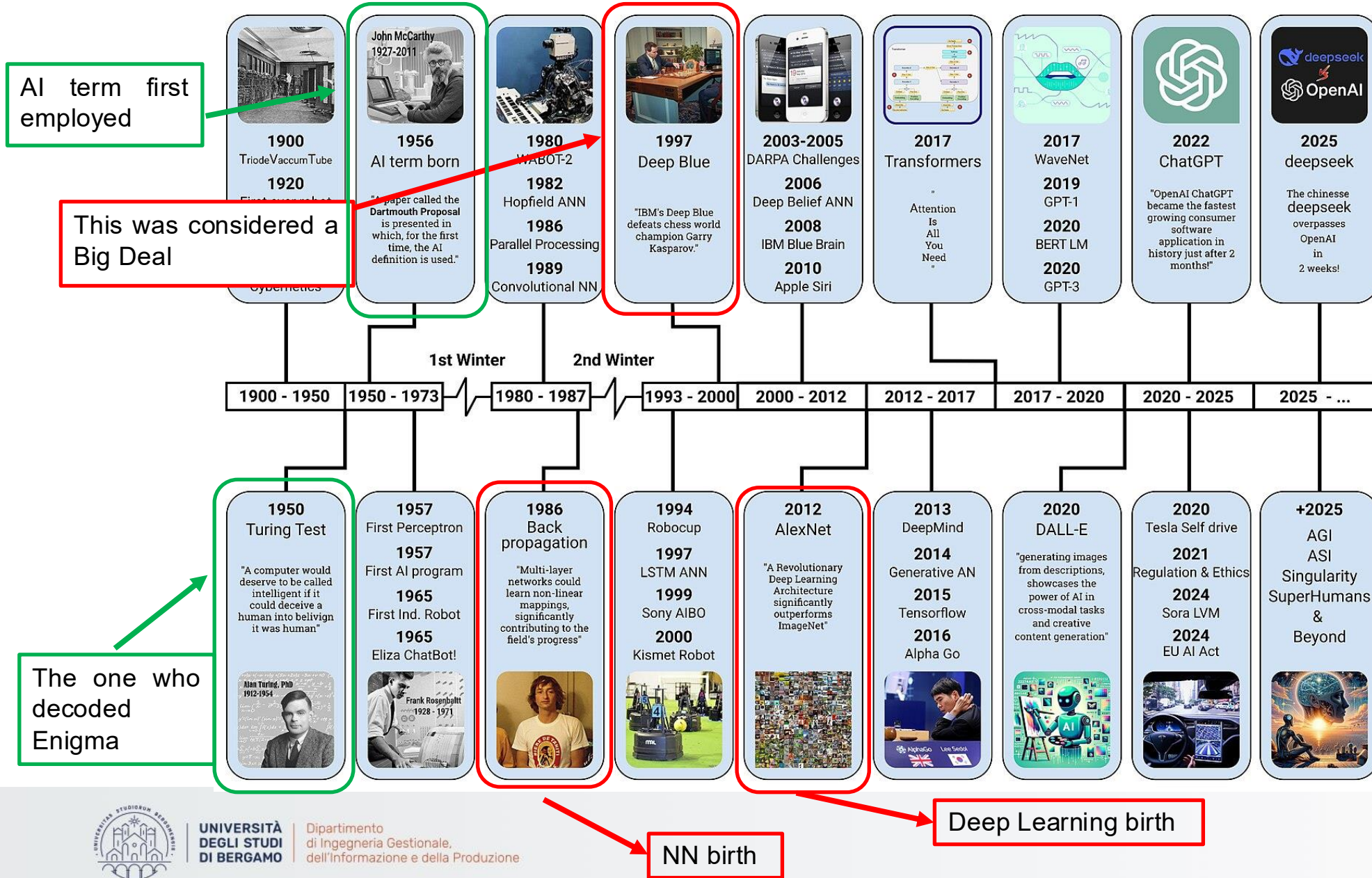


# History of artificial intelligence

**1997** – On May 11, 1997, chess grandmaster Garry Kasparov resigned after 19 moves in a game against Deep Blue, a chess-playing computer developed by scientists at IBM.



# History of artificial intelligence



AI term first employed

This was considered a Big Deal

The one who decoded Enigma

Deep Learning birth

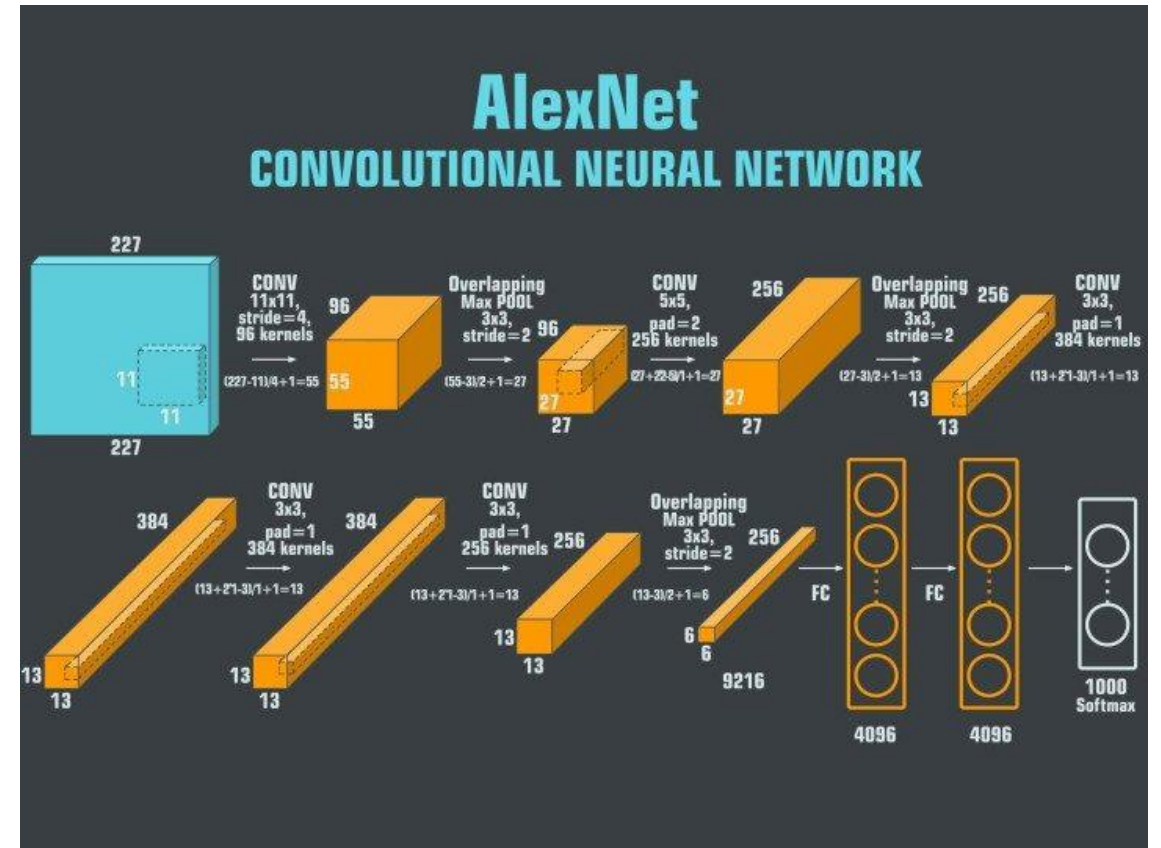
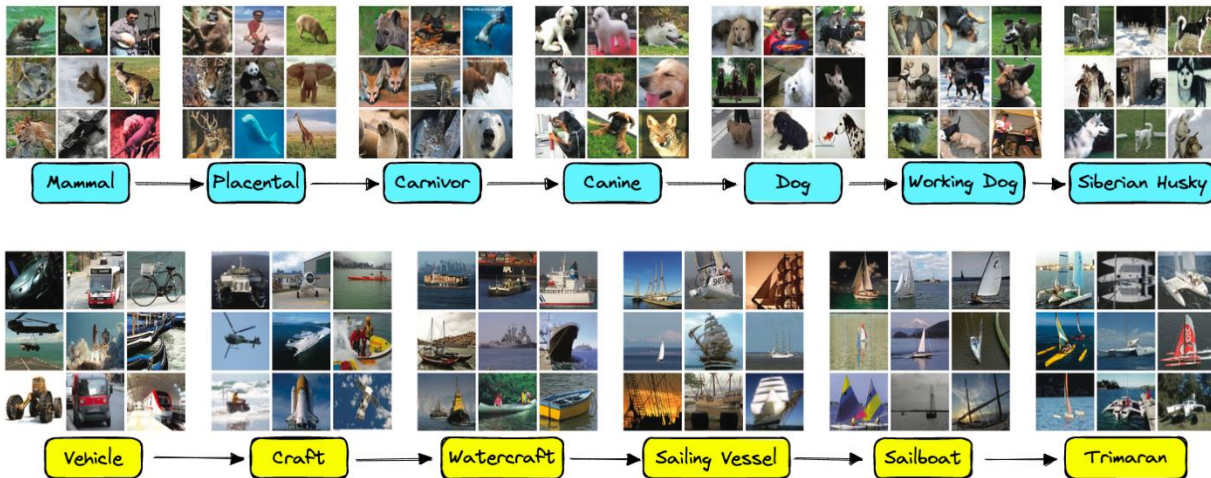
NN birth



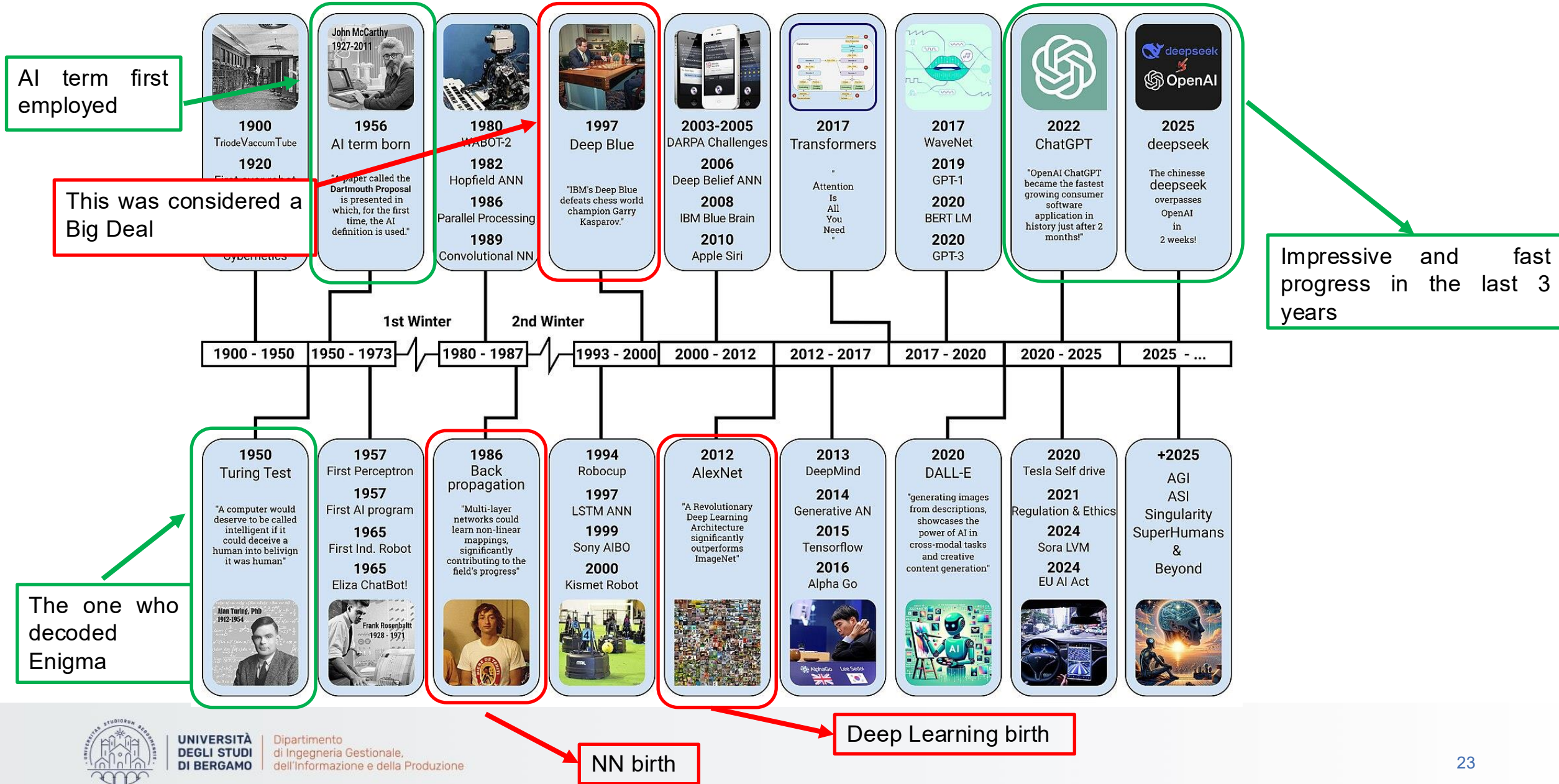
# History of artificial intelligence

2012 – AlexNet wins the ImageNet competition using deep convolutional networks — huge leap in computer vision.

It's the birth of deep learning and modern AI.



# History of artificial intelligence



# History of artificial intelligence

## Generative AI and Foundation Models era (2020s–present)

**2020 – GPT-3 (OpenAI)** demonstrates large-scale language modeling and few-shot learning.

**2022 – Stable Diffusion, DALL·E 2, Midjourney** popularize **AI image generation**.

**2022–2025 – ChatGPT & GPT-5.2** revolutionize **natural language interfaces** and public adoption of AI.

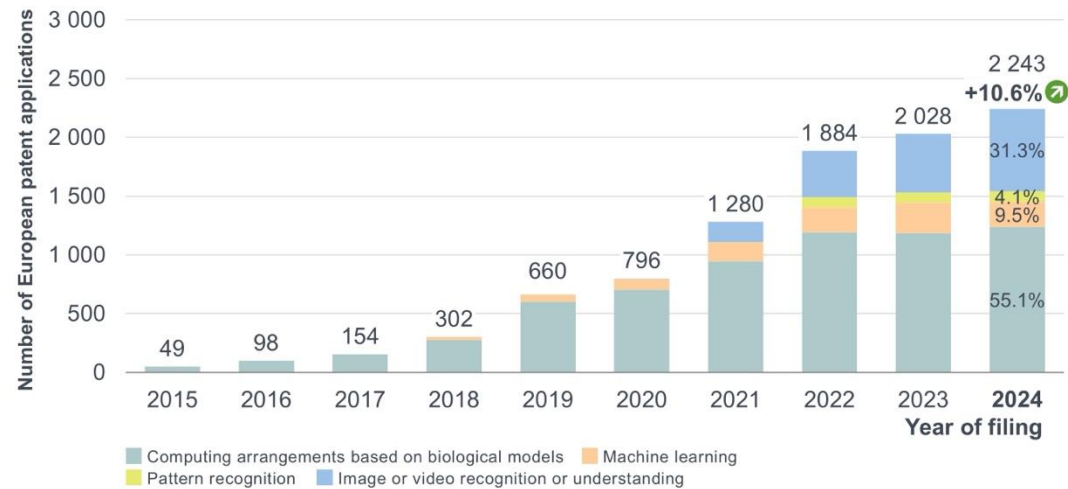
*... to be continued...*



# AI patents exponentially increased in last 15 years

## Europe

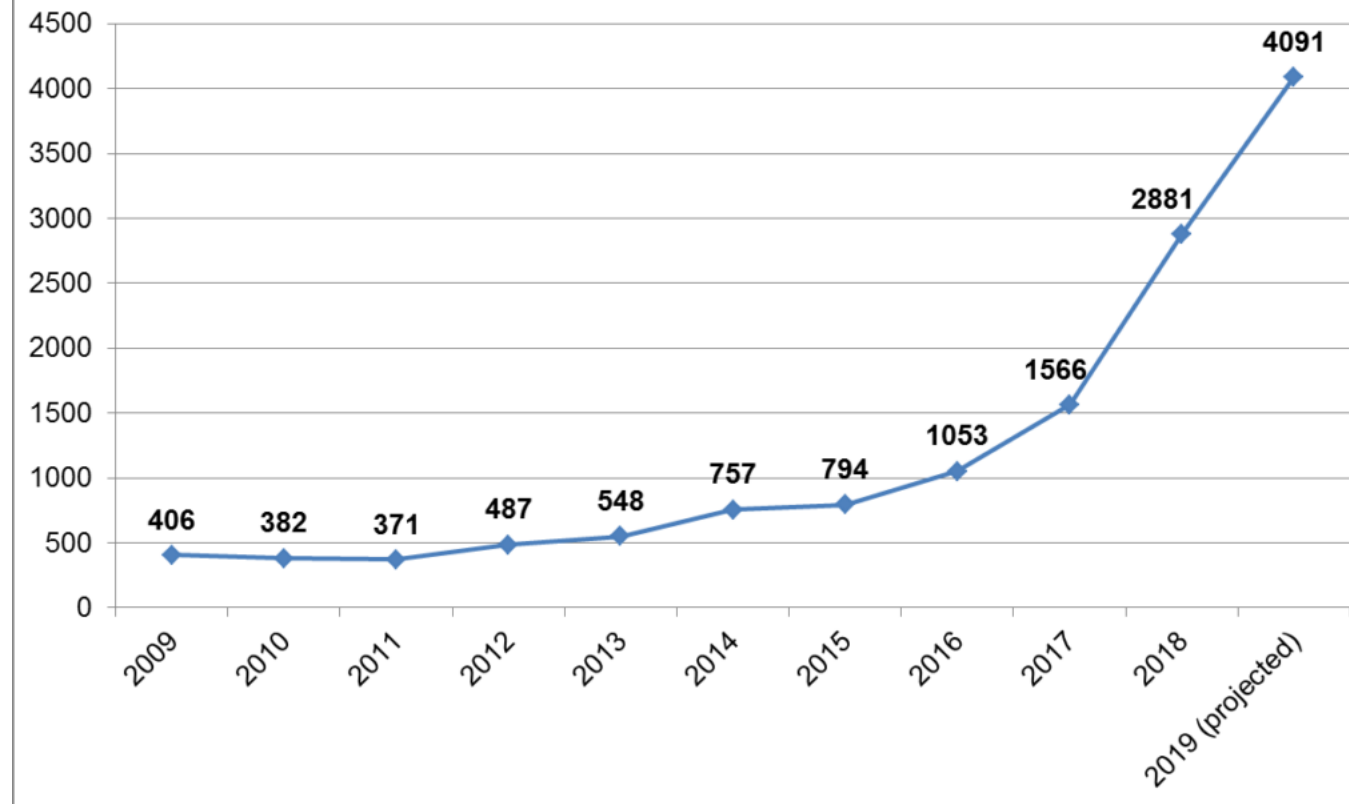
European patent applications – Areas of artificial intelligence



European Patent Office 2025

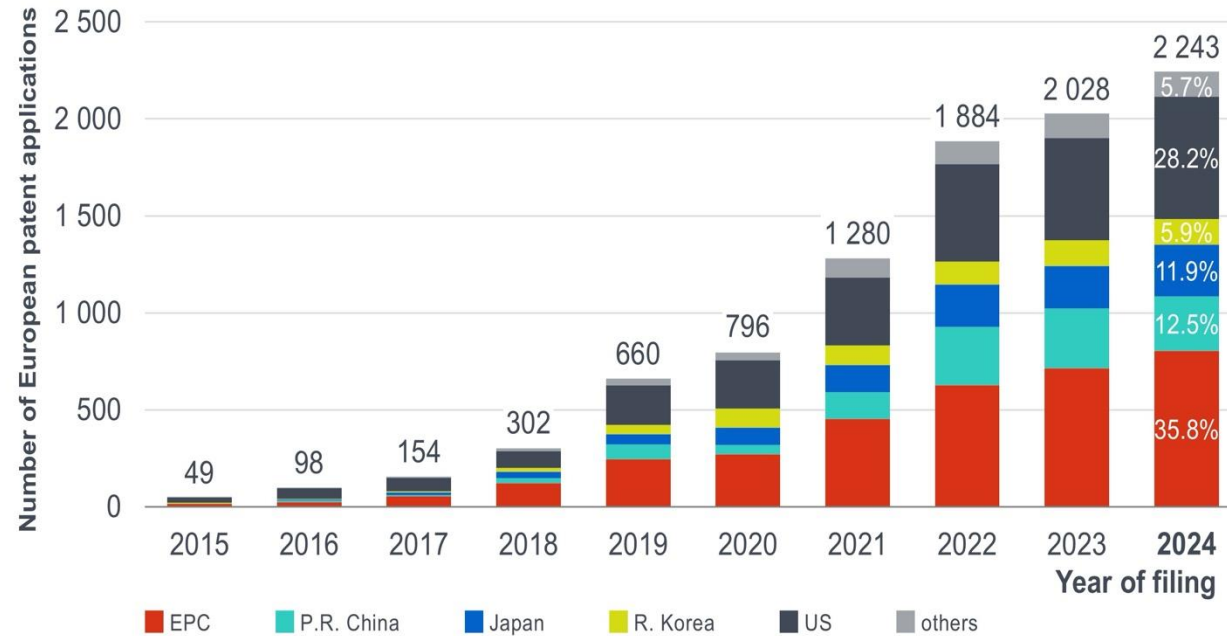
## USA

AI/ML-based Patent Publications by Year (USPTO)

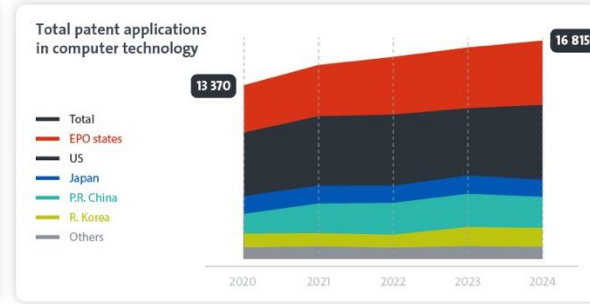
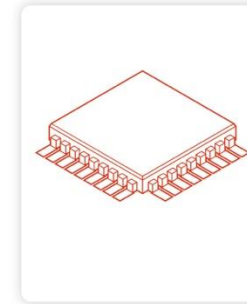


# AI is a worldwide phenomenon

## Artificial intelligence – Countries of origin



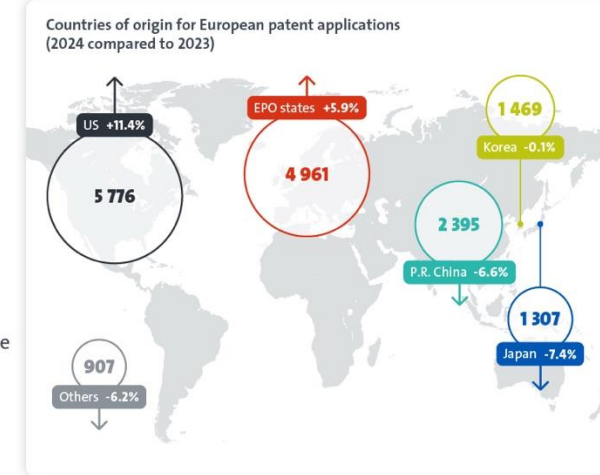
European Patent Office 2025



## 2024

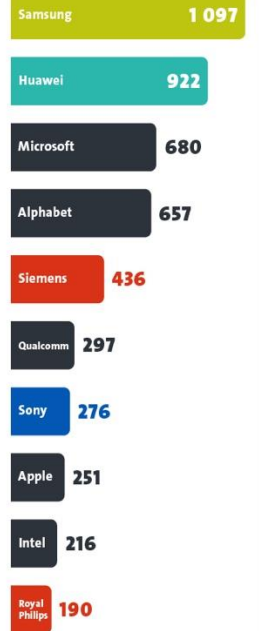
### Computer technology is the new top technical field in 2024

Surge of over 25% in last five years, in part driven by AI. The US and Europe lead.



epo.org/patent-index2024

### Top applicants 2024



<https://hai.stanford.edu/ai-index/2025-ai-index-report>



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# Someone is getting rich

## NVIDIA stocks value also exponentially increased

NVIDIA Corporation (NVDA)

208,06 +7,03 (+3,50%)

NasdaqGS - Nasdaq Real Time Price - USD

A partire dalle ore: 11:12:10 GMT-4. Apertura del mercato.

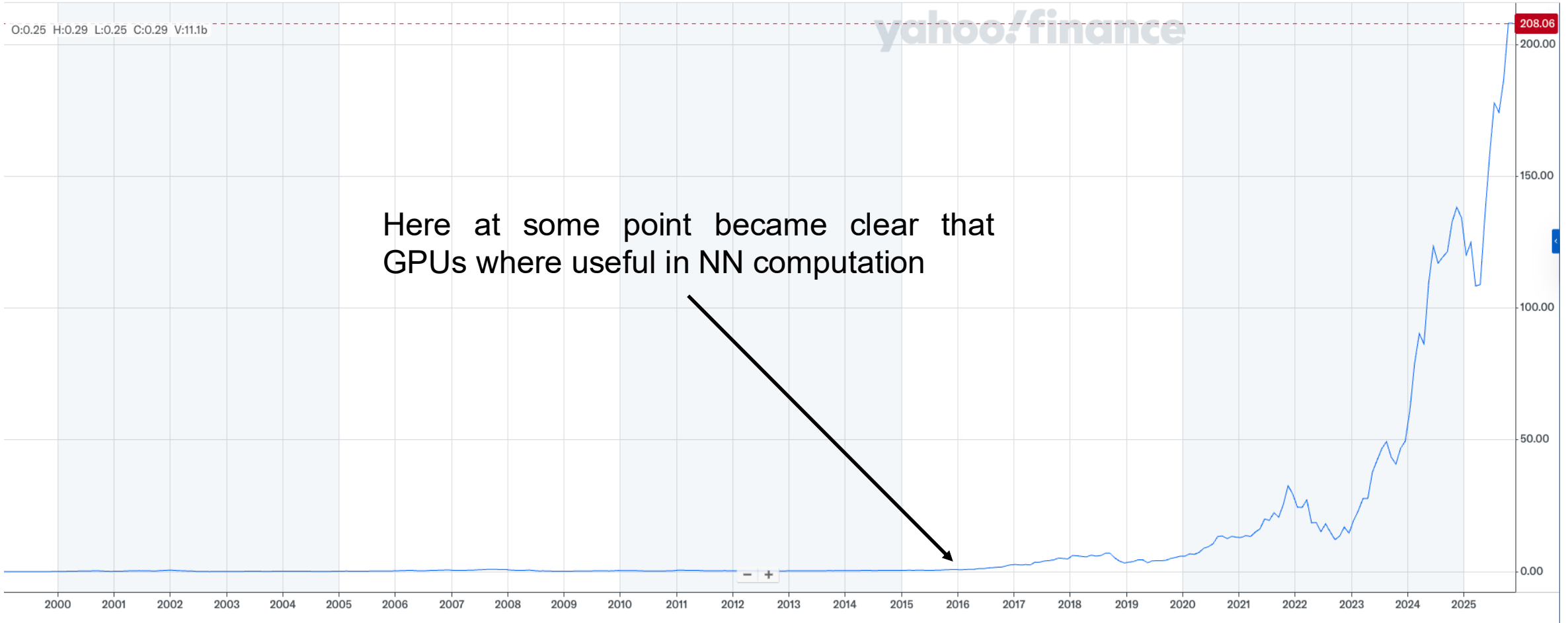
☆ Segui

Line  Impostazioni

O:0.25 H:0.29 L:0.25 C:0.29 V:11.1b

yahoo!finance

Here at some point became clear that GPUs where useful in NN computation



1G 5G 1M 3M 6M YTD 1A 5A Tutto  Intervallo: 1 mesi

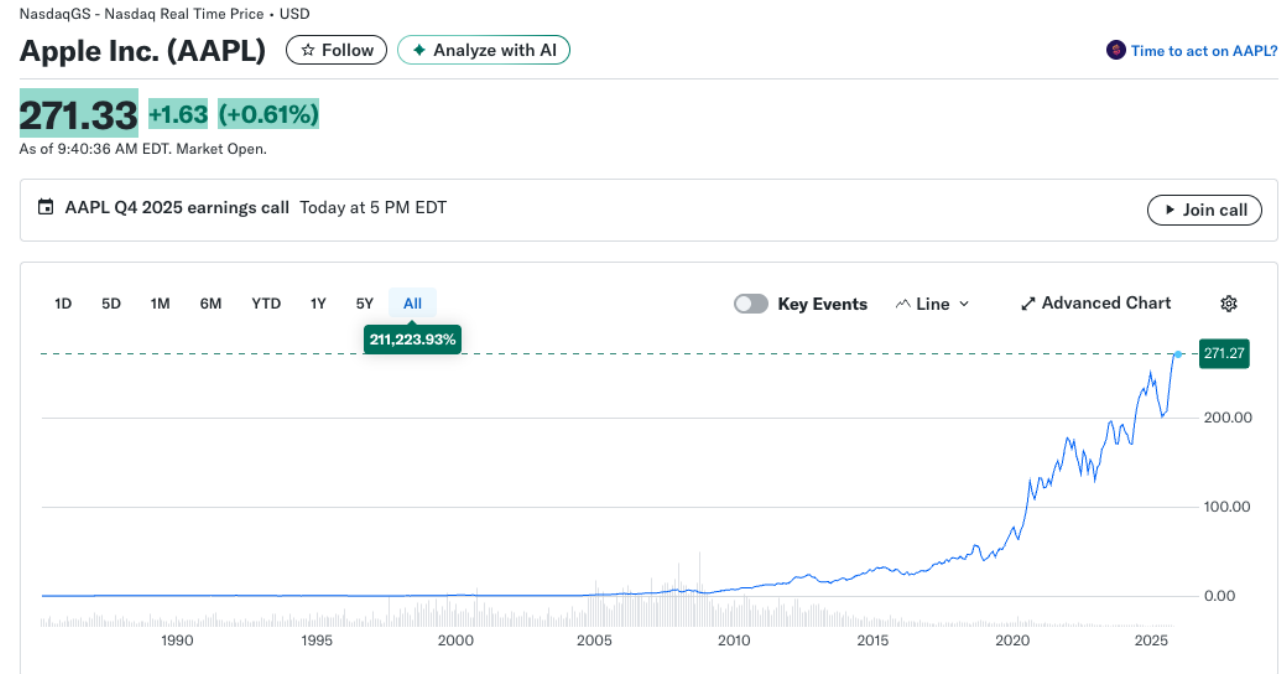


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# Someone is getting rich

All Big Tech market values are increasing.



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# Someone is getting rich

All Big Tech market values are increasing.

NasdaqGS - Nasdaq Real Time Price - USD

**Meta Platforms, Inc. (META)**

☆ Follow

🔍 Analyze with AI

🕒 Time to buy META?

**662.99** -88.68 (-11.80%)

As of 9:38:58 AM EDT. Market Open.

🔁 META Q3 2025 earnings call Replay the call for the latest insights.

📄 Read transcript

🔊 Play call



NasdaqGS - Nasdaq Real Time Price - USD

**Alphabet Inc. (GOOG)**

☆ Follow

🔍 Analyze with AI

🕒 Is GOOG a buy now?

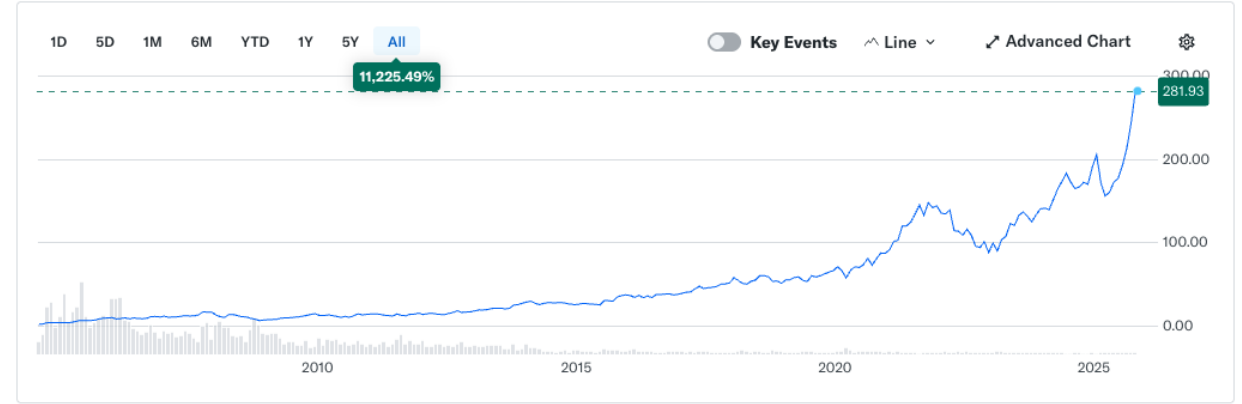
**281.67** +6.50 (+2.36%)

As of 9:39:12 AM EDT. Market Open.

🔁 GOOG Q3 2025 earnings call Replay the call for the latest insights.

📄 Read transcript

🔊 Play call

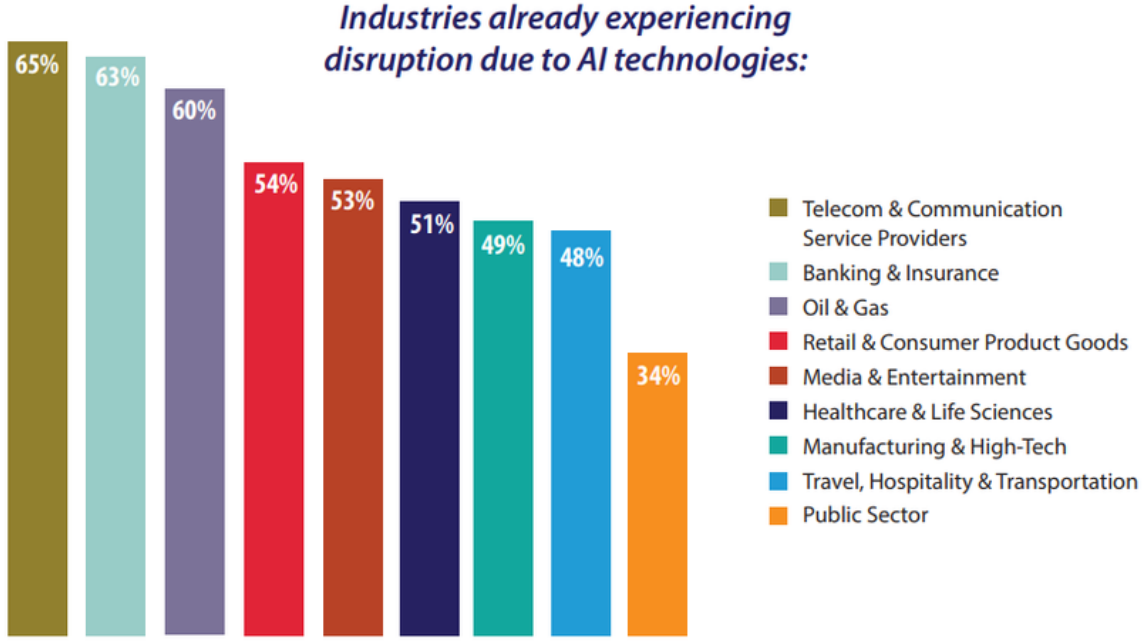
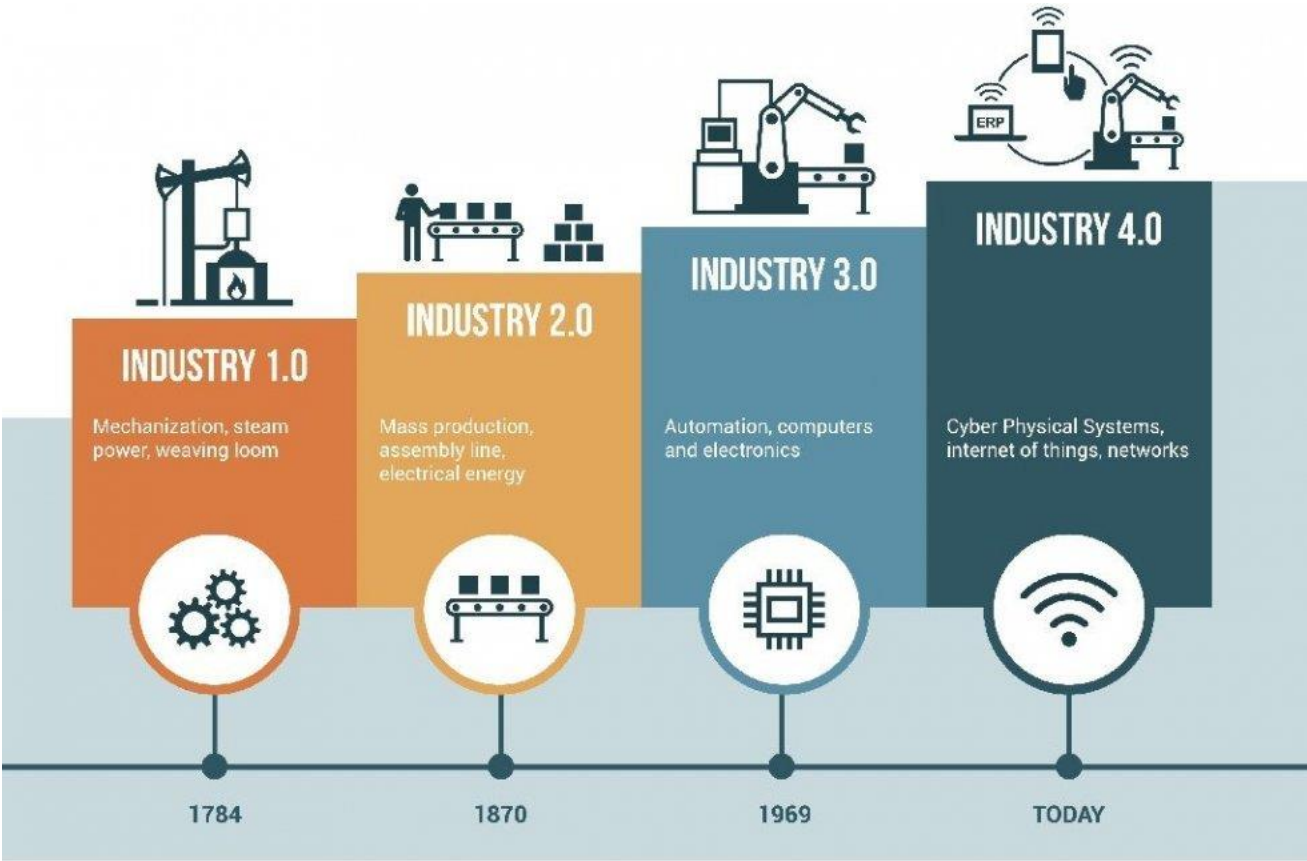


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# AI impact in industries

AI is the most transformative technology of the 21<sup>st</sup> century.

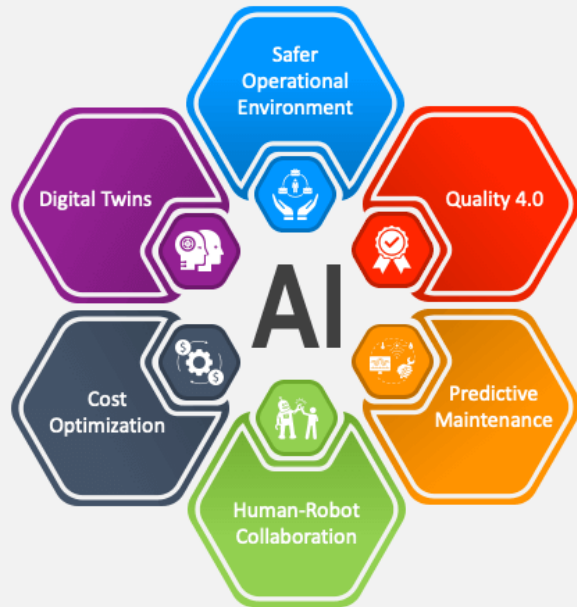


# AI impact in manufacturing industry

AI is the most transformative technology of the 21<sup>st</sup> century.

## AI IN MANUFACTURING INDUSTRY

Impact of AI in the Manufacturing Industry



Precedence  
RESEARCH

## Artificial Intelligence (AI) in Manufacturing Market Size 2023 to 2034 (USD Billion)



Source: <https://www.precedenceresearch.com/artificial-intelligence-in-manufacturing-market>



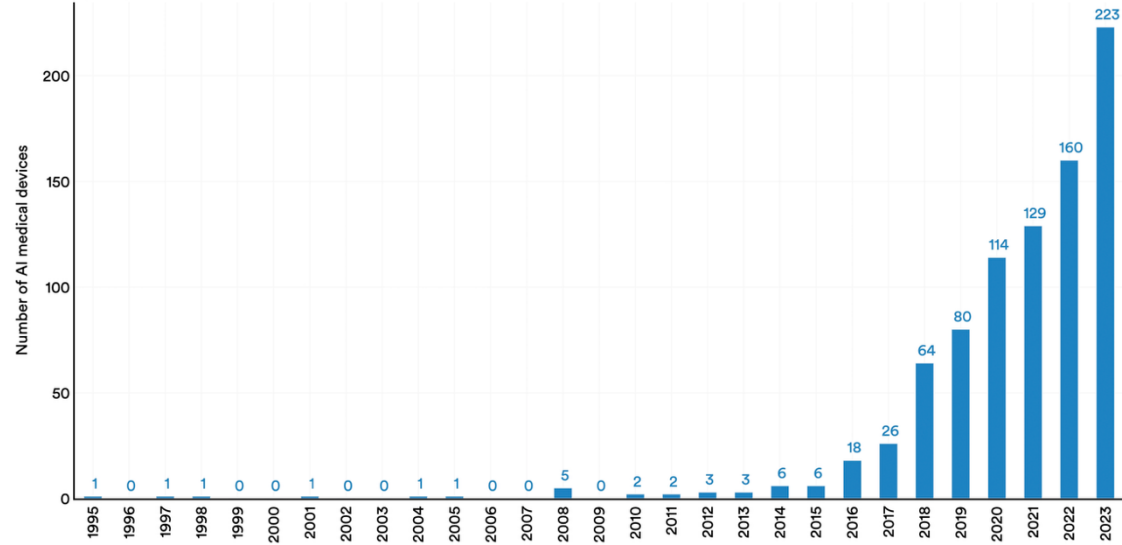
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# AI predominant also in healthcare

Number of AI medical devices approved by the FDA, 1995–2023

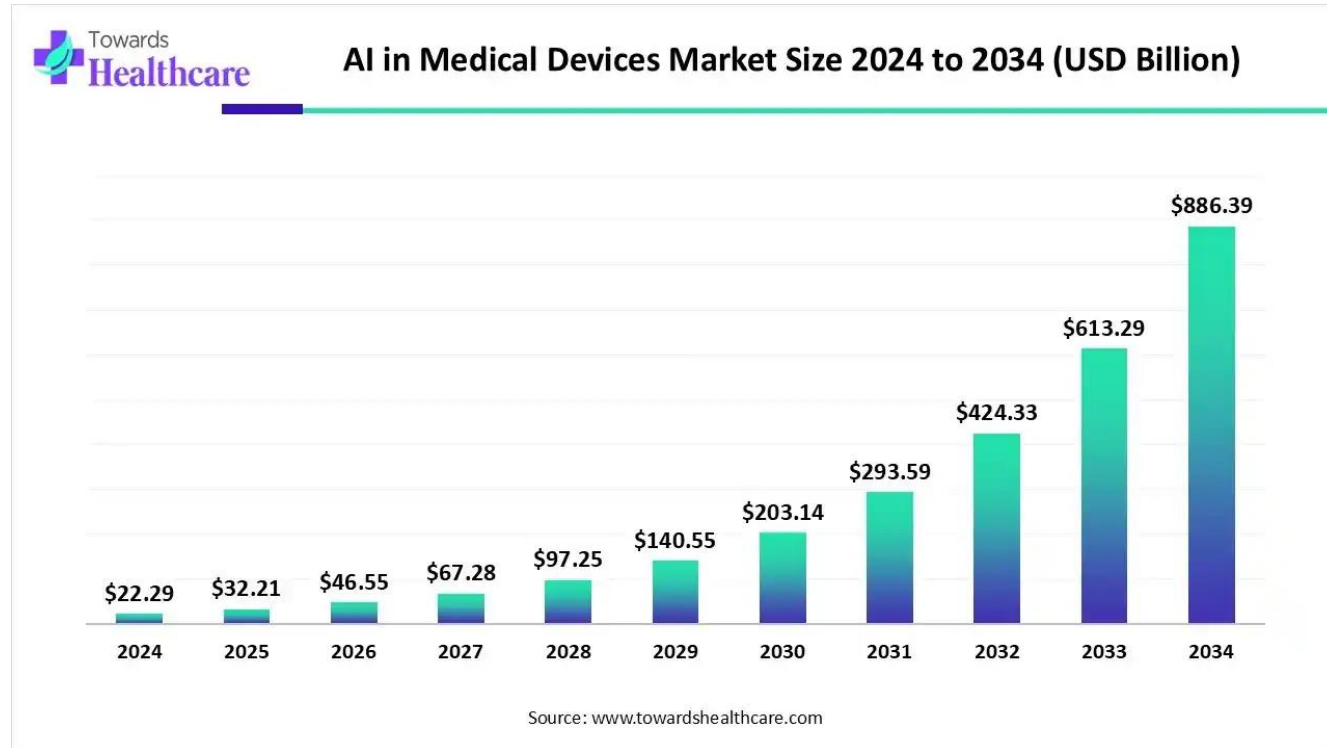
Source: FDA, 2024 | Chart: 2025 AI Index report



## Global AI in medical devices market size

- 1) US\$ 22.29 billion in 2024,
- 2) grew to US\$ 32.21 billion in 2025,
- 3) projected to reach around US\$ 886.39 billion by 2034.

The market is expanding at 44.53% rate between 2025 and 2034.



# Why AI is important in medicine?



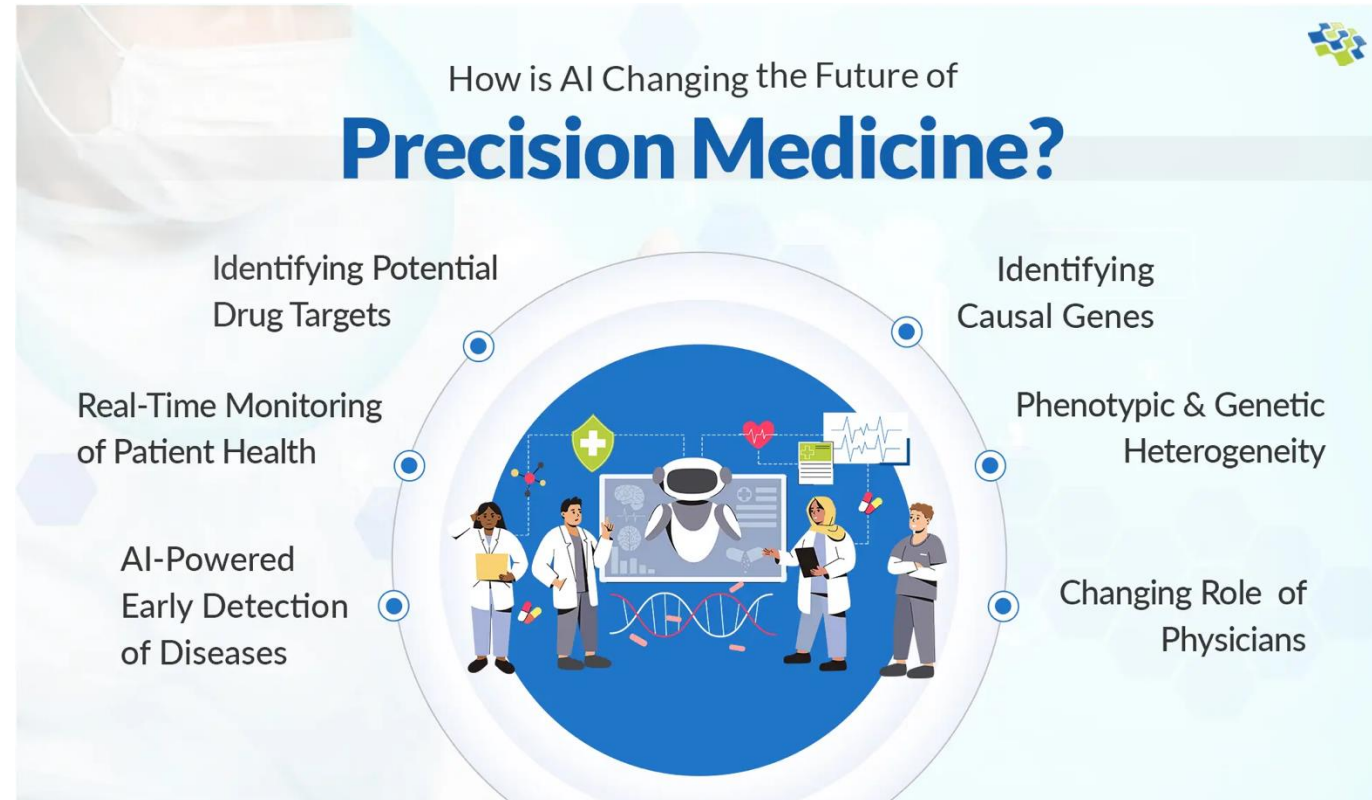
- ✓ Artificial Intelligence is reshaping healthcare at every level—from research to bedside.
- ✓ Massive clinical data, powerful models, and new computational paradigms enable smarter, faster, and more personalized medicine.
- ✓ Healthcare generates vast multimodal data: imaging, genomics, clinical notes, sensors.
- ✓ Clinicians cannot process this scale of information unaided.
- ✓ AI enables pattern discovery and predictive insight across modalities.



# Precision and Personalized Medicine



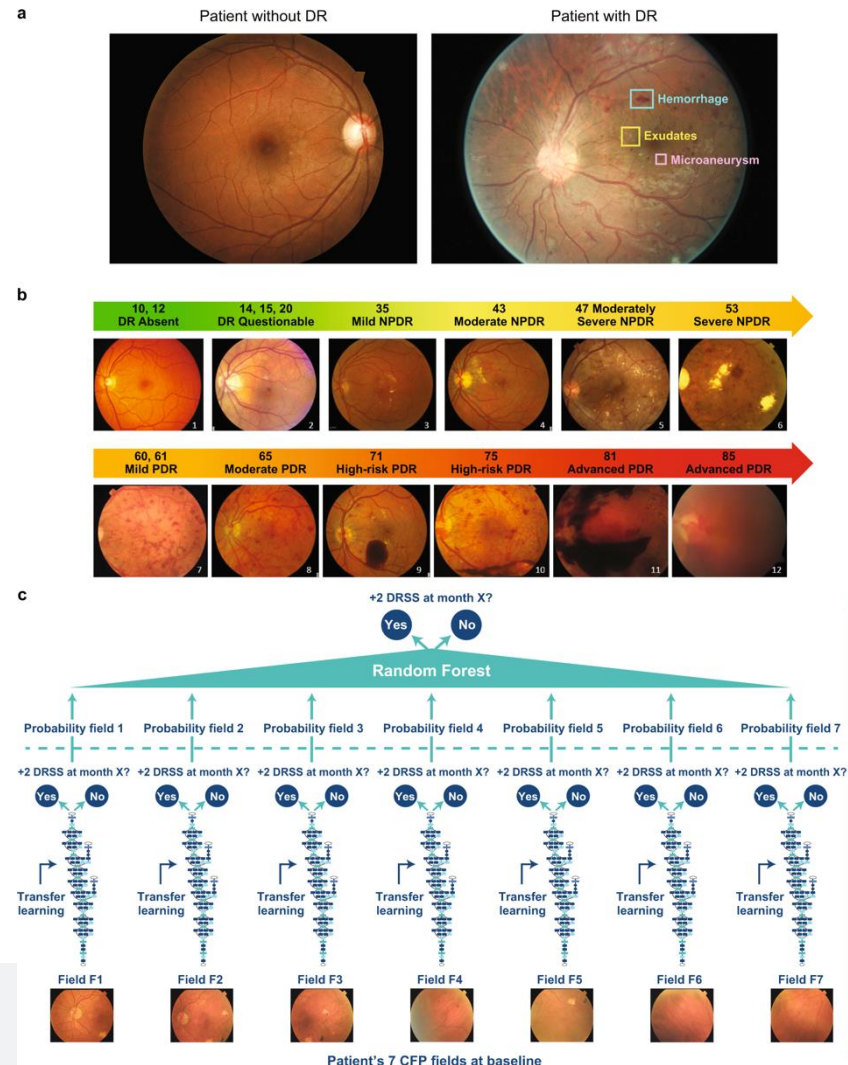
- AI tailors therapy to individual profiles (genetic, clinical, behavioral).
- Predicts disease risk, drug response, and optimal treatment.
- Example: Deep learning in genomics identifies patient-specific mutations.



# Clinical Decision Support



- AI augments—not replaces—physician judgment.
- Applications: disease diagnosis, image interpretation, triage systems.
- Example: DeepMind’s retinal analysis system detects over 50 eye conditions.



# Imaging and Diagnostics

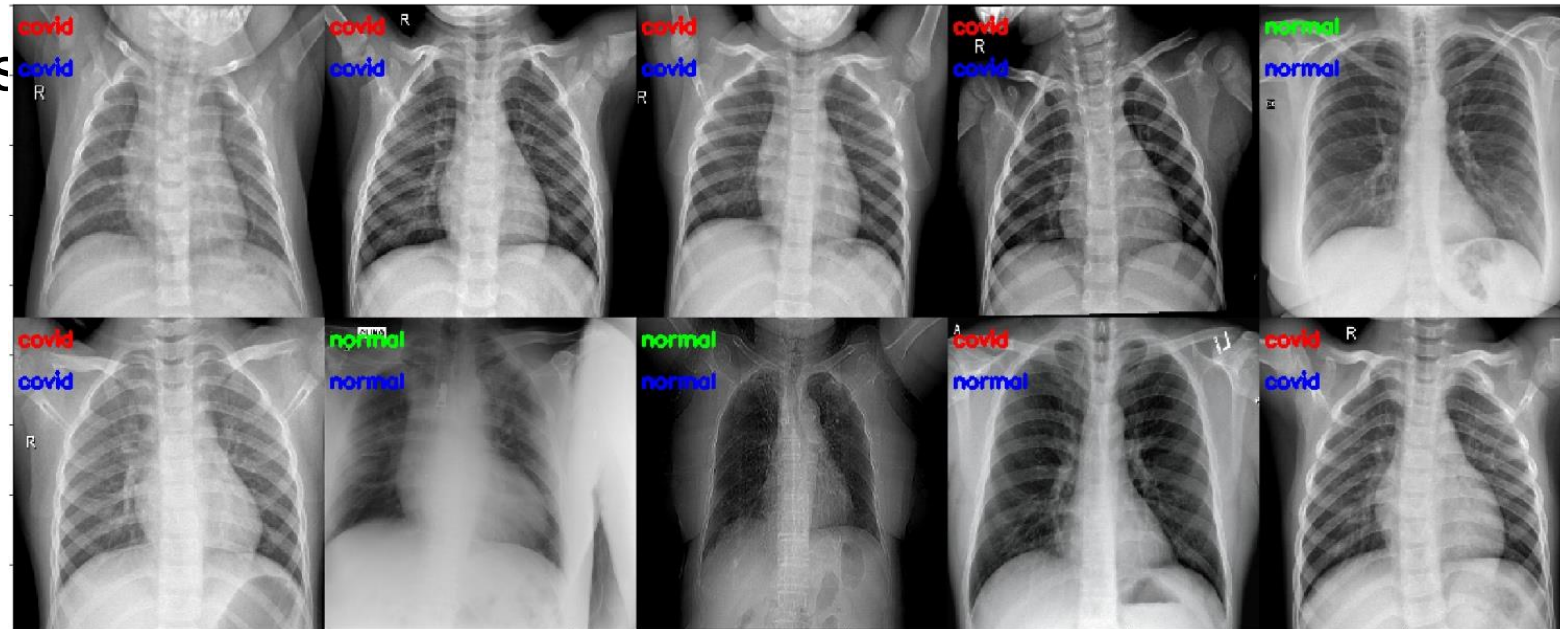


➤ Computer vision models outperform humans in select imaging tasks.

**Predicted covid label**  
**Predicted healthy label**  
**True label**

➤ Examples: cancer detection (pathology), chest X-ray analysis, dermatology screening.

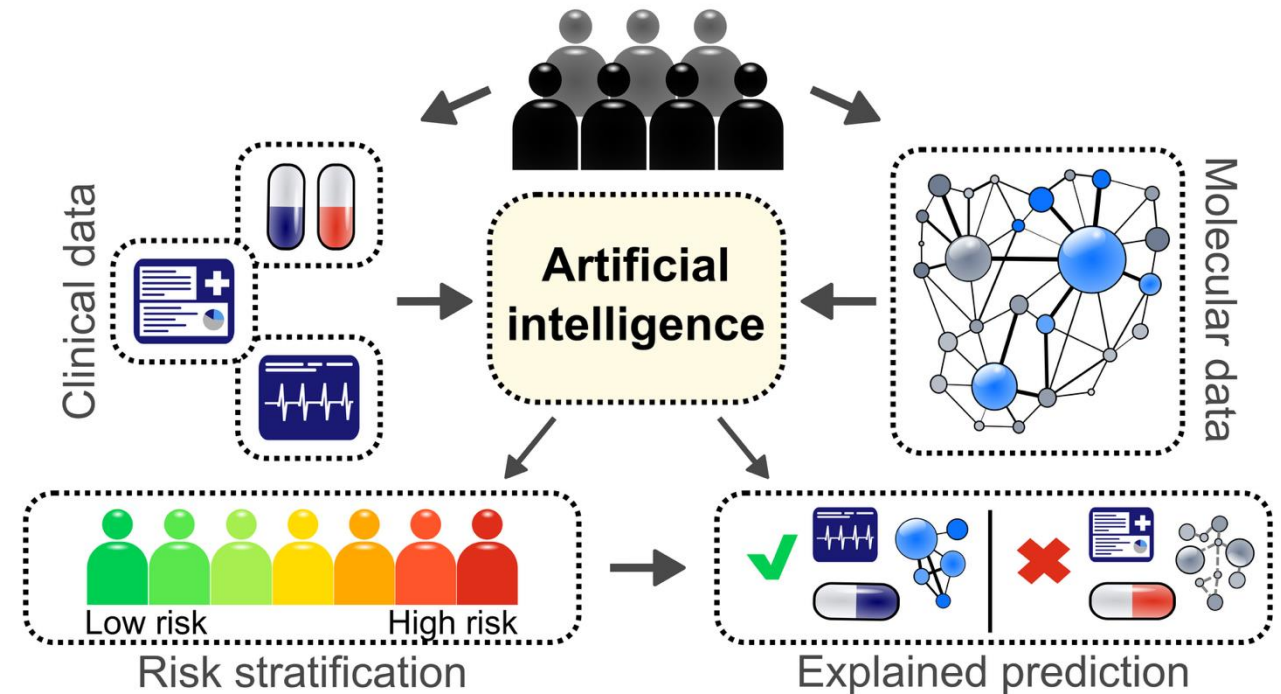
➤ AI enhances accuracy, consistency, and speed in interpretation.



# Predictive and Preventive Medicine

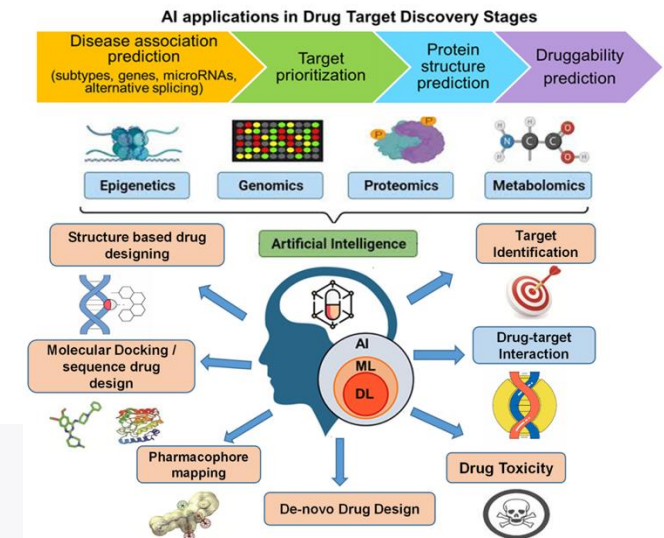


- AI anticipates disease onset, enabling early intervention.
- Predicts hospital readmission, sepsis, or cardiac arrest risk.
- Supports population-level health strategies.



# Drug Discovery and Biomedical Research

- Traditional R&D takes 10–15 years; AI accelerates every step.
- AlphaFold solved the protein-folding problem.
- Generative models design new drug candidates and predict molecular binding.

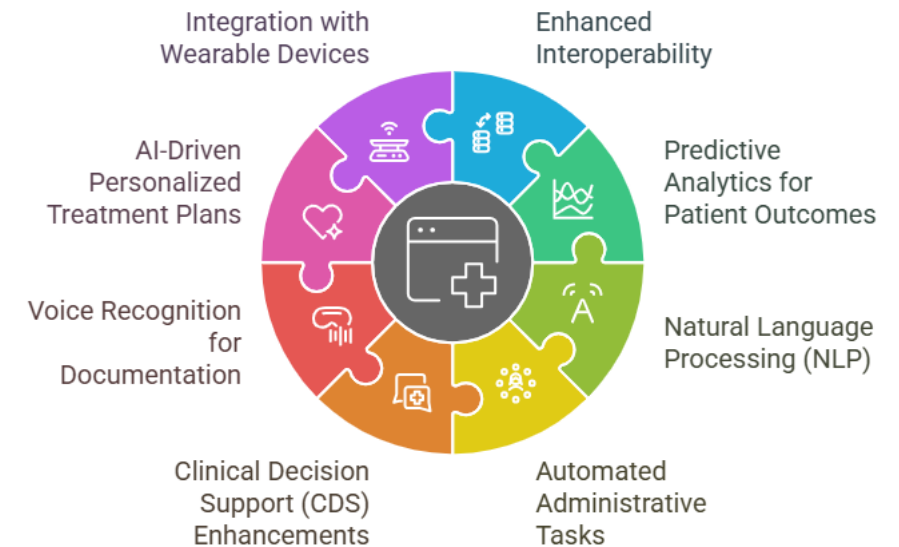


# Automation and Efficiency

- AI automates repetitive administrative and clinical tasks.
- Electronic Health Records (EHR) summarization, medical coding, and workflow optimization.
- Frees clinicians' time for patient-centered care.



## Features of AI-Powered EHR Systems



# Case studies

## ➤ AI-assisted robotic surgery.



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https://doi.org/10.1007/s11701-025-02485-0

REVIEW



### The rise of robotics and AI-assisted surgery in modern healthcare

Jack Ng Kok Wah<sup>1,2</sup>

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#### Abstract

The integration of robotics and artificial intelligence (AI) in surgery represents a transformative advancement in modern healthcare, promising enhanced precision, efficiency, and patient outcomes. Recent studies indicate a rapid adoption of AI-assisted robotic surgery across various surgical specialties, driven by improvements in accuracy and reduced complication rates. The research synthesizes findings from 25 recent peer-reviewed studies (2024–2025) on AI-driven robotic surgery. Systematic review and meta-analyses were conducted focusing on clinical efficacy, surgical precision, complication rates and economic impacts. Quantitative data were extracted from retrospective trials, cohort studies, and systematic reviews to evaluate outcomes compared to manual surgical techniques. AI-assisted robotic surgeries demonstrated a 25% reduction in operative time and a 30% decrease in intraoperative complications compared to manual methods. Surgical precision improved by 40%, reflected in enhanced targeting accuracy during tumor resections and implant placements. Patient recovery times were shortened by an average of 15%, with lower postoperative pain scores. Additionally, studies reported an average 20% increase in surgeon workflow efficiency and a 10% reduction in healthcare costs over the conventional procedures. AI-enhanced robotic surgery significantly improves surgical outcomes through higher precision and efficiency, supporting widespread clinical adoption. Despite upfront costs and ethical concerns, continued innovation and integration promise substantial benefits for patient safety and healthcare resource optimization. Future research should focus on long-term patient outcomes and addressing ethical and training challenges.

**Keywords** AI-driven robotic surgery · Smart surgical automation · Digital twin-assisted procedures · Intraoperative AI video analysis · Minimally invasive robotic systems

#### Introduction

The integration of robotics and artificial intelligence (AI) is reshaping modern surgery, offering levels of precision, control, and intelligence once beyond reach. Robotic-assisted surgery (RAS) initially improved visualization and dexterity, making minimally invasive procedures more accessible. Now, AI is taking it further enabling real-time decision support, predictive analytics, and even semi-autonomous actions in the operating room [1]. AI-driven systems are already powering surgical innovations like digital twin simulations [3], image-based tissue segmentation [8], and vision models capable of autonomous suturing [18].

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https://doi.org/10.1007/s11701-024-01867-0

REVIEW



### Clinical applications of artificial intelligence in robotic surgery

J. Everett Knudsen<sup>1</sup> · Umar Ghaffar<sup>2</sup> · Runzhuo Ma<sup>2</sup> · Andrew J. Hung<sup>2</sup>

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#### Abstract

Artificial intelligence (AI) is revolutionizing nearly every aspect of modern life. In the medical field, robotic surgery is the sector with some of the most innovative and impactful advancements. In this narrative review, we outline recent contributions of AI to the field of robotic surgery with a particular focus on intraoperative enhancement. AI modeling is allowing surgeons to have advanced intraoperative metrics such as force and tactile measurements, enhanced detection of positive surgical margins, and even allowing for the complete automation of certain steps in surgical procedures. AI is also Query revolutionizing the field of surgical education. AI modeling applied to intraoperative surgical video feeds and instrument kinematics data is allowing for the generation of automated skills assessments. AI also shows promise for the generation and delivery of highly specialized intraoperative surgical feedback for training surgeons. Although the adoption and integration of AI show promise in robotic surgery, it raises important, complex ethical questions. Frameworks for thinking through ethical dilemmas raised by AI are outlined in this review. AI enhancements in robotic surgery is some of the most groundbreaking research happening today, and the studies outlined in this review represent some of the most exciting innovations in recent years.

**Keywords** artificial intelligence · robotic surgery · robot-assisted surgery · intraoperative enhancement · clinical improvement · ethical considerations of AI

#### Introduction

Since its inception and widespread adoption, artificial intelligence (AI) has revolutionized nearly every aspect of human life. AI is the study and development of algorithms that give machines the ability to reason and perform cognitive functions such as problem-solving and decision-making [1]. From finance to agriculture, manufacturing to education, AI has fundamentally altered our ability to understand and respond to complex problems. Perhaps the most impactful adoption of AI on human life is in the field of medicine where AI is being used to help physicians make more precise decisions and predict patient outcomes with a higher

degree of certainty. Within the medical field, surgery has experienced one of the largest impacts with the adoption of AI as more and more surgeries are performed using robotic assistance. Current surgical robots are controlled by a “master–slave” dynamic where the robot itself does not have any autonomy if it does not have a human operator. However, recent advances in AI and machine learning (ML) seek to expand the capabilities of surgical robots and augment the surgical experience in the operating room. Surgical robots rely on data captured through sensors and images to operate, and this plethora of data capture is the key driver behind AI innovations in robotic surgery [1].

In this review, we focus on the recent advancements that AI brings to the world of robotic surgery with a particular emphasis on intraoperative applications. We also outline important ethical considerations for the incorporation of AI into robotic operations. Broadly, intraoperative enhancements provided by AI can be classified into two categories: robotic autonomy and surgical assessment/feedback. Advances in each of these categories are focused on creating environments for safe, data-informed surgical decision-making and enhancing surgical education (Fig. 1). Robotic surgery’s continued integration of

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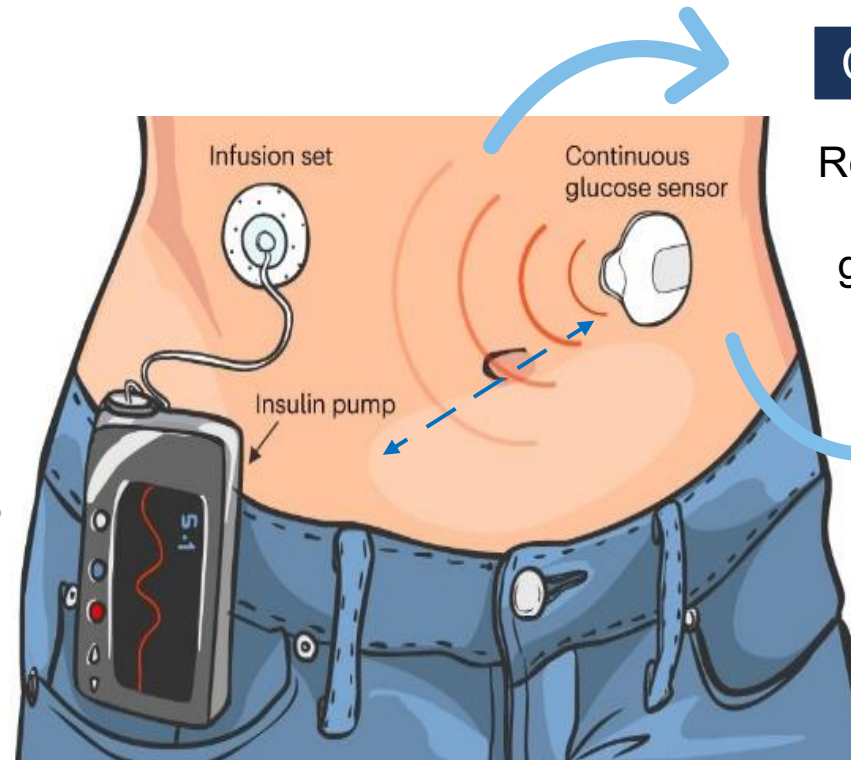
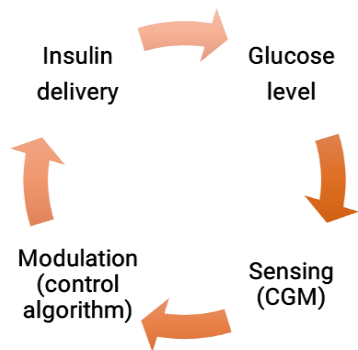
# Case studies

- Artificial Pancreas helps T1DM patients managing their disease.



## INSULIN PUMP

Small computerized device programmed to deliver insulin into the fatty tissue under the skin via a thin cannula, which is inserted into the skin



## CONTROL ALGORITHM

Regulates the delivery of insulin based on measured blood glucose and other information

## GLUCOSE

Continuously monitors interstitial glucose levels using a small sensor that inserted under the patient's skin

# Case studies

## ➤ Adaptive Deep Brain Stimulation in Parkinson's disease.

Open Access Article

### Adaptive vs. Conventional Deep Brain Stimulation: One-Year Subthalamic Recordings and Clinical Monitoring in a Patient with Parkinson's Disease

by Laura Caffi <sup>1,2,3</sup> , Luigi M. Romito <sup>4,†</sup> , Chiara Palmisano <sup>1,2,†</sup>, Vanessa Aloia <sup>5</sup>, Mattia Arlotti <sup>5</sup>, Lorenzo Rossi <sup>5</sup>, Sara Marceglia <sup>6,7</sup> , Alberto Priori <sup>7</sup> , Roberto Eleopra <sup>4</sup>, Vincenzo Levi <sup>8</sup>, Alberto Mazzoni <sup>3,9</sup> and Ioannis U. Isaias <sup>1,2,\*</sup>  

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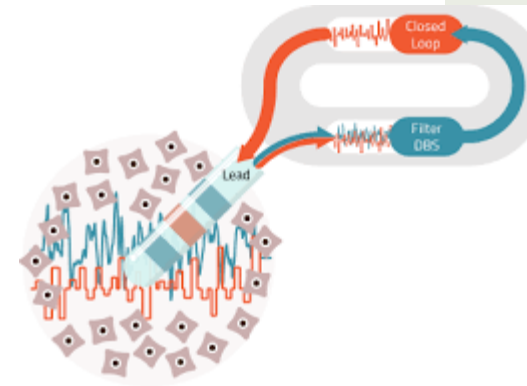
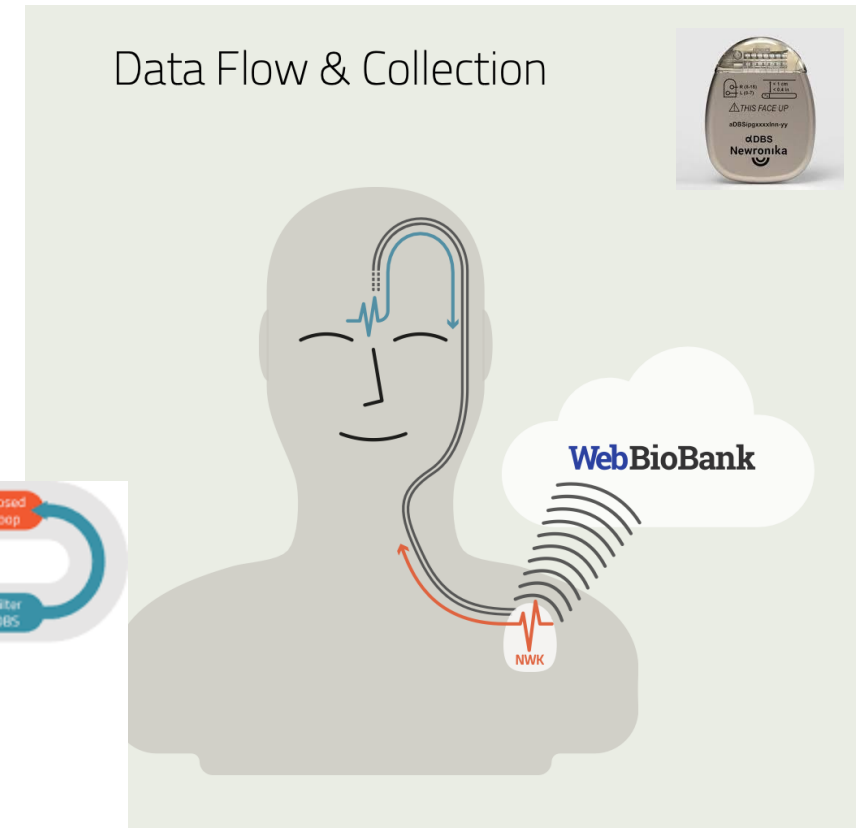
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† These authors contributed equally to this work.



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# Case studies

## ➤ Apple's AI heart diseases detection.

### ORIGINAL RESEARCH

## Diagnostic Accuracy of Apple Watch Electrocardiogram for Atrial Fibrillation A Systematic Review and Meta-Analysis



Sufyan Shahid, MBBS,<sup>a</sup> Minahil Iqbal, MBBS,<sup>b</sup> Humza Saeed, MBBS,<sup>c</sup> Sara Hira, MBBS,<sup>d</sup> Amna Batool, MBBS,<sup>d</sup> Salman Khalid, MD,<sup>e</sup> Naeem Khan Tahirkheli, MD<sup>f</sup>

### ABSTRACT

**BACKGROUND** Electrocardiography (ECG) is the gold standard for the diagnosis of atrial fibrillation (AF). Recently, smartwatches like the Apple Watch have emerged as a promising, user-friendly device for rapid detection and diagnosis of AF, but the reliability and diagnostic accuracy still remain controversial.

**OBJECTIVES** The purpose of this study was to perform a systematic review and diagnostic test accuracy meta-analysis evaluating the diagnostic performance of the Apple Watch ECG in detecting AF.

**METHODS** The literature search was conducted on PubMed, Embase, and Cochrane Library through April 2024 for studies comparing the diagnostic accuracy of Apple Watch to standard 12-lead ECG. Statistical analysis was performed using R Software version 4.4.0 and OpenMeta[Analyst]. Pooled analyses of sensitivity, specificity, and area under the receiver operating characteristic curve were determined along with their 95% CIs. The quality of studies was analyzed using the QUADAS-2 tool.

**RESULTS** The meta-analysis included 11 studies comprising 4,241 participants. Their mean age was  $62.56 \pm 3.92$  years, and 28% of the patients were females. The pooled sensitivity and specificity of the Apple Watch for detecting AF were 94.8% (95% CI: 91.7% to 96.8%;  $I^2 = 67%$ ) and 95% (95% CI: 88.6% to 97.8%;  $I^2 = 88%$ ), respectively. The area under the receiver operating characteristic curve was 0.96 (95% CI: 0.92-0.97).

**CONCLUSIONS** The Apple Watch ECG carries high accuracy in detecting atrial fibrillation, providing a convenient diagnostic option for patients. (JACC Adv. 2025;4:101538) © 2025 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

**A**trial fibrillation (AF) is a prevalent cardiac arrhythmia characterized by an irregular rhythm, which is evident on an electrocardiogram (ECG) due to the loss of coordinated atrial contractility. The risk of developing AF is around 37% after 55 years of age.<sup>1</sup> AF usually presents with symptoms like palpitations, fatigue, lightheadedness, and fainting and can also be asymptomatic.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

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ISSN 2772-965X

<https://doi.org/10.1016/j.jaccadv.2024.101538>

## Apple used AI to uncover new blood pressure notification feature in Watch

By Stephen Nellis

September 19, 2025 7:16 PM GMT+2 · Updated September 19, 2025



[1/2] The series 11 Apple watch sits on display at the Apple Store in New York City, U.S., September 19, 2025. REUTERS/Shannon Stapleton [Purchase Licensing Rights](#)

Research Briefing | Published: 14 November 2022

## AI detection of cardiac dysfunction from consumer watch ECG recordings

[Nature Medicine](#) 28, 2478–2479 (2022) | [Cite this article](#)

6987 Accesses | 6 Citations | 57 Altmetric | [Metrics](#)

**To enable large-scale screening for left ventricular dysfunction – a serious and under-detected cardiac disease – we applied artificial intelligence to electrocardiograms recorded by patients using their own Apple watches in a prospective, digital, remote study. We found that patients engaged with the system and that the watch electrocardiograms effectively screened for the disease.**



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# Case studies

## ➤ Google's AI breast cancer detection.

Google for Health About Empowering individuals Advancing AI Working collaboratively

AI IN MAMMOGRAPHY

## Improving breast cancer screening with artificial intelligence

We're working with clinicians, patients, and partners to build an AI system for mammography, which could help radiologists detect breast cancer more accurately, quickly, and consistently.



We've worked with [Northwestern Medicine](#) to research how the research model can help prioritize high risk cases and shorten time to diagnosis for screened individuals.



We are working with [Imperial College London](#) and three NHS trusts to understand whether the research model can act as a "second independent reader" in UK double read screening systems and allow radiologists to focus on high priority cases while improving consistency and quality of screening.

### Article

## International evaluation of an AI system for breast cancer screening

<https://doi.org/10.1038/s41586-019-1799-6>

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Screening mammography aims to identify breast cancer at earlier stages of the disease, when treatment can be more successful<sup>1</sup>. Despite the existence of screening programmes worldwide, the interpretation of mammograms is affected by high rates of false positives and false negatives<sup>2</sup>. Here we present an artificial intelligence (AI) system that is capable of surpassing human experts in breast cancer prediction. To assess its performance in the clinical setting, we curated a large representative dataset from the UK and a large enriched dataset from the USA. We show an absolute reduction of 5.7% and 1.2% (USA and UK) in false positives and 9.4% and 2.7% in false negatives. We provide evidence of the ability of the system to generalize from the UK to the USA. In an independent study of six radiologists, the AI system outperformed all of the human readers: the area under the receiver operating characteristic curve (AUC-ROC) for the AI system was greater than the AUC-ROC for the average radiologist by an absolute margin of 11.5%. We ran a simulation in which the AI system participated in the double-reading process that is used in the UK, and found that the AI system maintained non-inferior performance and reduced the workload of the second reader by 88%. This robust assessment of the AI system paves the way for clinical trials to improve the accuracy and efficiency of breast cancer screening.

Breast cancer is the second leading cause of death from cancer in women<sup>3</sup>, but early detection and treatment can considerably improve outcomes<sup>4,5</sup>. As a consequence, many developed nations have implemented large-scale mammography screening programmes. Major medical and governmental organizations recommend screening for all women starting between the ages of 40 and 50<sup>6,7</sup>. In the USA and UK combined, over 42 million exams are performed each year<sup>8,9</sup>.

Despite the widespread adoption of mammography, interpretation of these images remains challenging. The accuracy achieved by experts in cancer detection varies widely, and the performance of even the best clinicians leaves room for improvement<sup>10,11</sup>. False positives can lead to patient anxiety<sup>12</sup>, unnecessary follow-up and invasive diagnostic procedures. Cancers that are missed at screening may not be identified until they are more advanced and less amenable to treatment<sup>13</sup>.

AI may be uniquely poised to help with this challenge. Studies have demonstrated the ability of AI to meet or exceed the performance of human experts on several tasks of medical-image analysis<sup>14–19</sup>.

As a shortage of mammography professionals threatens the availability and adequacy of breast-screening services around the world<sup>20–22</sup>, the scalability of AI could improve access to high-quality care for all.

Computer-aided detection (CAD) software for mammography was introduced in the 1990s, and several assistive tools have been approved for medical use<sup>23</sup>. Despite early promise<sup>24,25</sup>, this generation of software failed to improve the performance of readers in real-world settings<sup>22,23,26</sup>. More recently, the field has seen a renaissance owing to the success of deep learning. A few studies have characterized systems for breast cancer prediction with stand-alone performance that approaches that of human experts<sup>27,28</sup>. However, the existing work has several limitations. Most studies are based on small, enriched datasets with limited follow-up, and few have compared performance to readers in actual clinical practice—instead relying on laboratory-based simulations of the reading environment. So far there has been little evidence of the ability of AI systems to translate between different screening populations and settings without additional training data<sup>21</sup>. Critically, the pervasive use of follow-up intervals that are no longer than 12 months<sup>29,30,32,33</sup>

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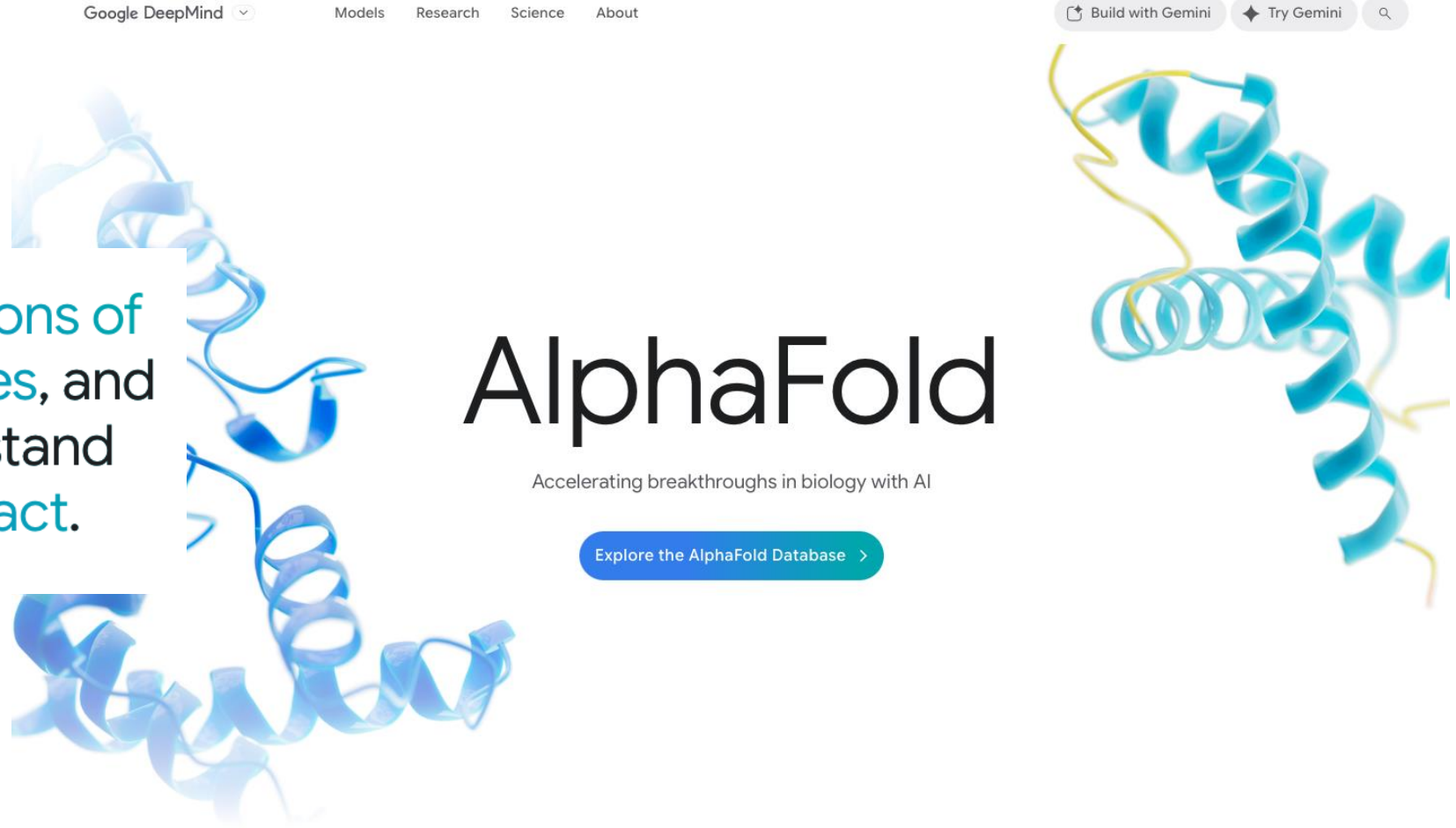
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# Case studies

- DeepMind's AlphaFold revolutionized biology.

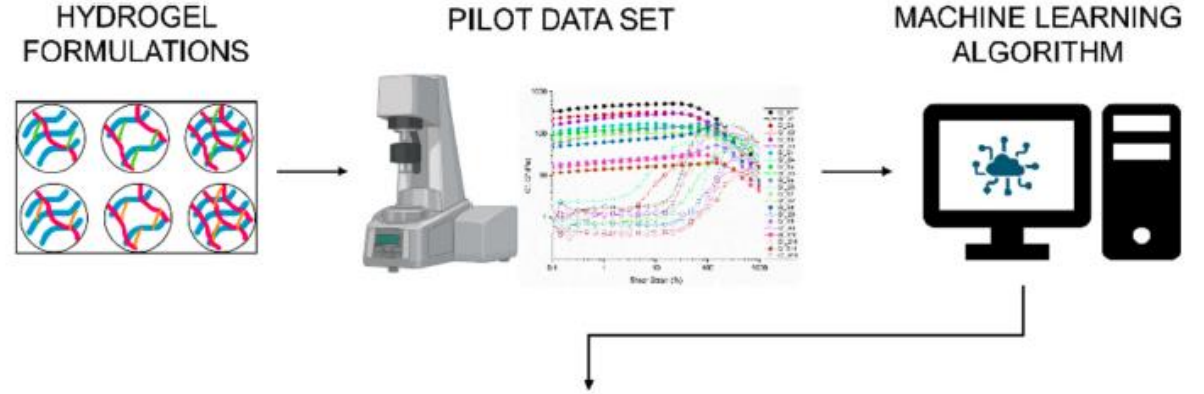
AlphaFold has revealed millions of intricate 3D protein structures, and is helping scientists understand how life's molecules interact.



# Case studies



Extracellular matrix (ECM) design of biomimetic hydrogels tailored on rheological properties, for regenerative medicine and 3D bioprinting.



G' and G'' values of DA hydrogel formulations obtained through amplitude sweeps tests.

	HA-SMF (mg/mL)	Gel-SMF (mg/mL)	4arm-PEG-MA (mg/mL)	G' [Pa]	G'' [Pa]
D1	3.0	27.0	15.0	25.1	1.9
D2	2.0	28.0	15.0	23.4	2.0
D3	3.7	26.3	10.0	22.4	3.2
D4	2.7	28.0	10.8	16.8	2.4
D5	3.0	27.0	10.0	14.7	2.1
D6	1.3	28.7	10.0	8.0	1.3
D7	2.0	28.0	10.0	6.9	1.5
D8	2.0	28.0	5.0	3.7	1.1
D9	1.3	18.7	10.0	3.0	0.8

Selected and experimental values G' and G'' of DA hydrogels predicted formulations.

	Selected values		Predicted formulations			Experimental values	
	G' [Pa]	G'' [Pa]	Hyaluronic acid [mg]	Gelatin [mg]	4arm-PEG-MA [mg]	G' [Pa]	G'' [Pa]
DP1	20.0	2.0	2.8	27.0	13.7	26.2	2.9
DP2	12.0	1.5	2.0	27.6	10.8	10.3	1.4
DP3	5.0	1.0	1.6	25.1	8.2	3.7	0.9

Selected and experimental values G' and G'' of SPAAC hydrogels predicted formulations.

	Selected values		Predicted formulations			Experimental values	
	G' [Pa]	G'' [Pa]	Hyaluronic acid [mg]	Gelatin [mg]	4arm-PEG-DBCO [mg]	G' [Pa]	G'' [Pa]
SP1	250.0	1.0	2.4	18.0	7.6	133.7	0.9
SP2	69.0	0.7	1.6	28.6	4.8	48.9	0.7
SP3	39.0	0.6	1.4	22.7	5.0	31.6	0.6
SP4	18.0	0.5	1.6	19.6	3.2	15.6	0.8

USER – FRIENDLY INTERFACE

**INPUT VALUES**

Storage modulus (G')     69 Pa  
 Loss modulus (G'')     0,74 Pa

**FORMULATION PREDICTION**

HA:                             1.64 mg  
 GELATIN:                    28.61 mg  
 Crosslinker:                4.77 mg

SMARTPHONE



Hyperparameters for SPAAC and DA models for the first and second neural network models.

Hyperparameter	First neural network model	Second neural network model
	Values	Values
Batch size	1, 11	1, 5, 16, 32
Epochs	10, 20, 30	10, 20, 30, 50, 100
Hidden layer size	2, 3, 5	2, 3, 4, 5
Learning rate	0.0001, 0.001, 0.005	0.0001, 0.001, 0.005, 0.01, 0.1

The ML models developed allow hydrogel formulations to be predicted and customized based on desired rheological properties, eliminating the need for time-consuming trial and error testing procedures in 3D bioprinting.





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