UNIVERSITAT DE BARCELONA

BCN AIM
ARTIFICIAL INTELLIGENCE IN MEDICINE

Deep Learning (en imagen médica)

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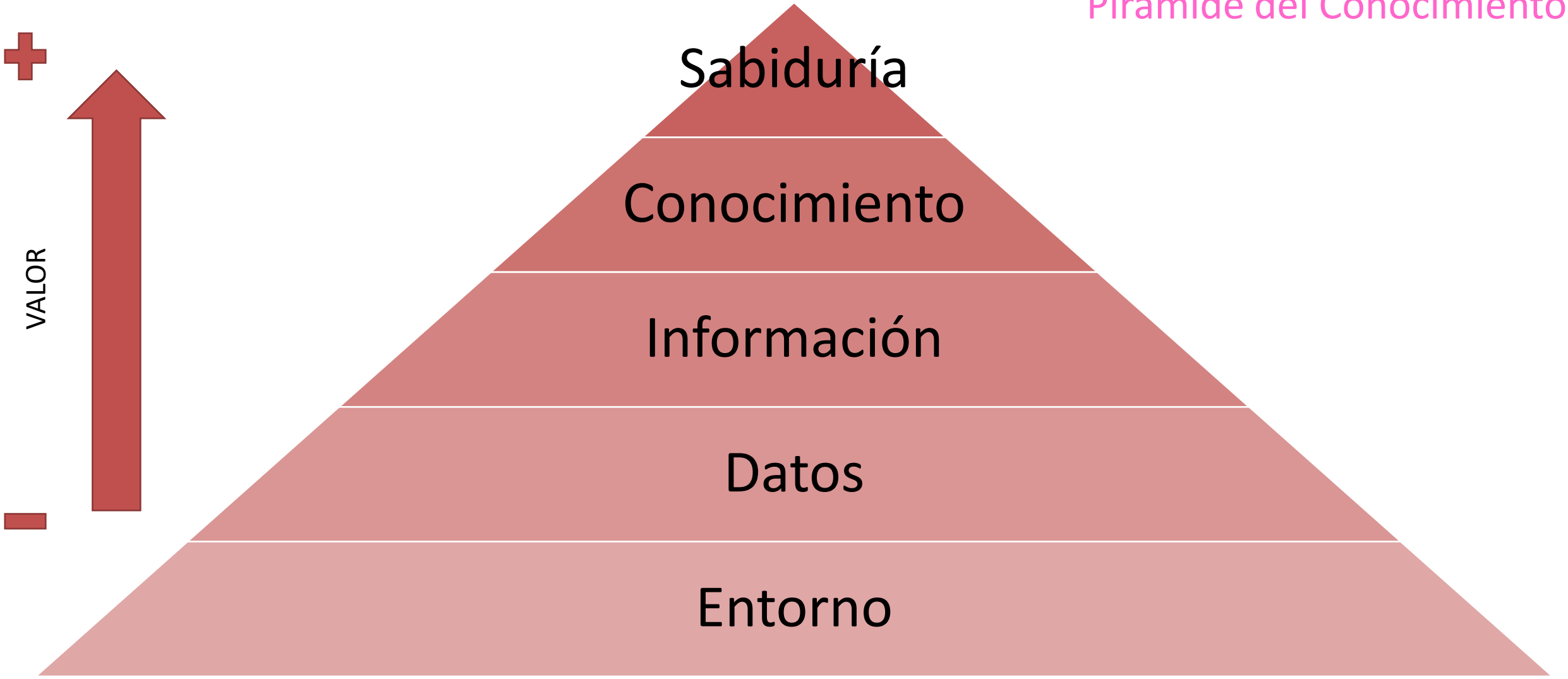
Objetivos

1. Entender la actual situación de la IA (deep learning) en el ámbito médico
2. Analizar algunos ejemplos de aplicación de la IA en salud
3. Reflexionar sobre los diferentes usos de la IA en el ámbito clínico
3. Entender los retos pendientes de la IA (deep learning) en salud
5. Conocer la situación actual con respecto a la “confianza” de los algoritmos de IA
6. Tener una visión crítica en el uso de la IA en salud

¿Por qué estais aquí?

"Pirámide del Conocimiento"



¿Qué mensaje llega a la sociedad?

CÁNCER | 5/26/2019 12:30:00 AM

Inteligencia Artificial logra diagnosticar mejor el cáncer que un radiólogo

Científicos de Google y de la Universidad de Northwestern desarrollaron un nuevo sistema de inteligencia artificial (IA) que logró detectar el cáncer de manera más acertada que un especialista. Esta y otras notas de ciencia y salud de la semana

SOFTWARE

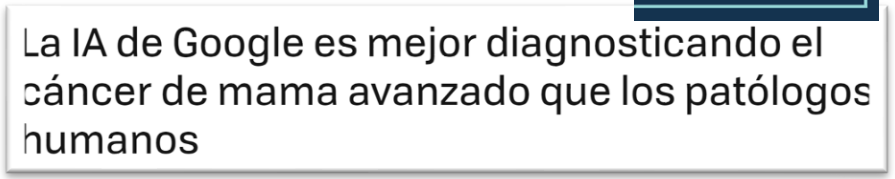
Esta inteligencia artificial ha logrado la mayor tasa de éxito para detectar el cáncer de mama

Un estudio revela un mayor acierto en el diagnóstico cuando los radiólogos se apoyan en la IA alemana Vara para detectar el cáncer mamario

Un robot chino vence a 15 médicos en el diagnóstico de tumores cerebrales

EFE | Pekín | 1 jul. 2018

Xataka ciencia



La IA de Google es mejor diagnosticando el cáncer de mama avanzado que los patólogos humanos

Computación

La IA puede hacer el trabajo técnico de los médicos, pero no el humano

MIT Technology Review

TECNOLOGIA · INTELIGENCIA ARTIFICIAL

OpenMind

1 julio 2018

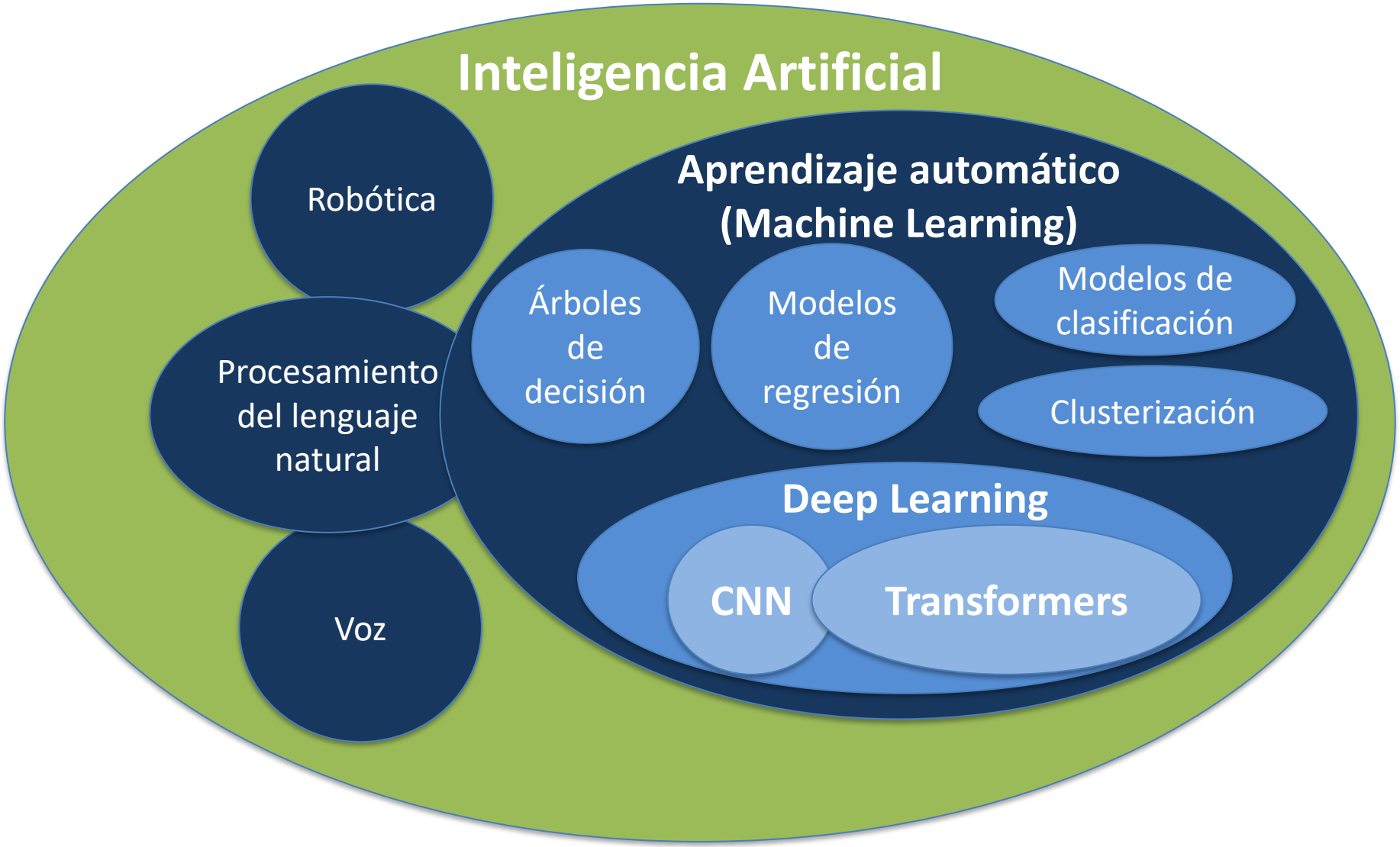
Tu radiólogo será un ordenador

MEDICINA

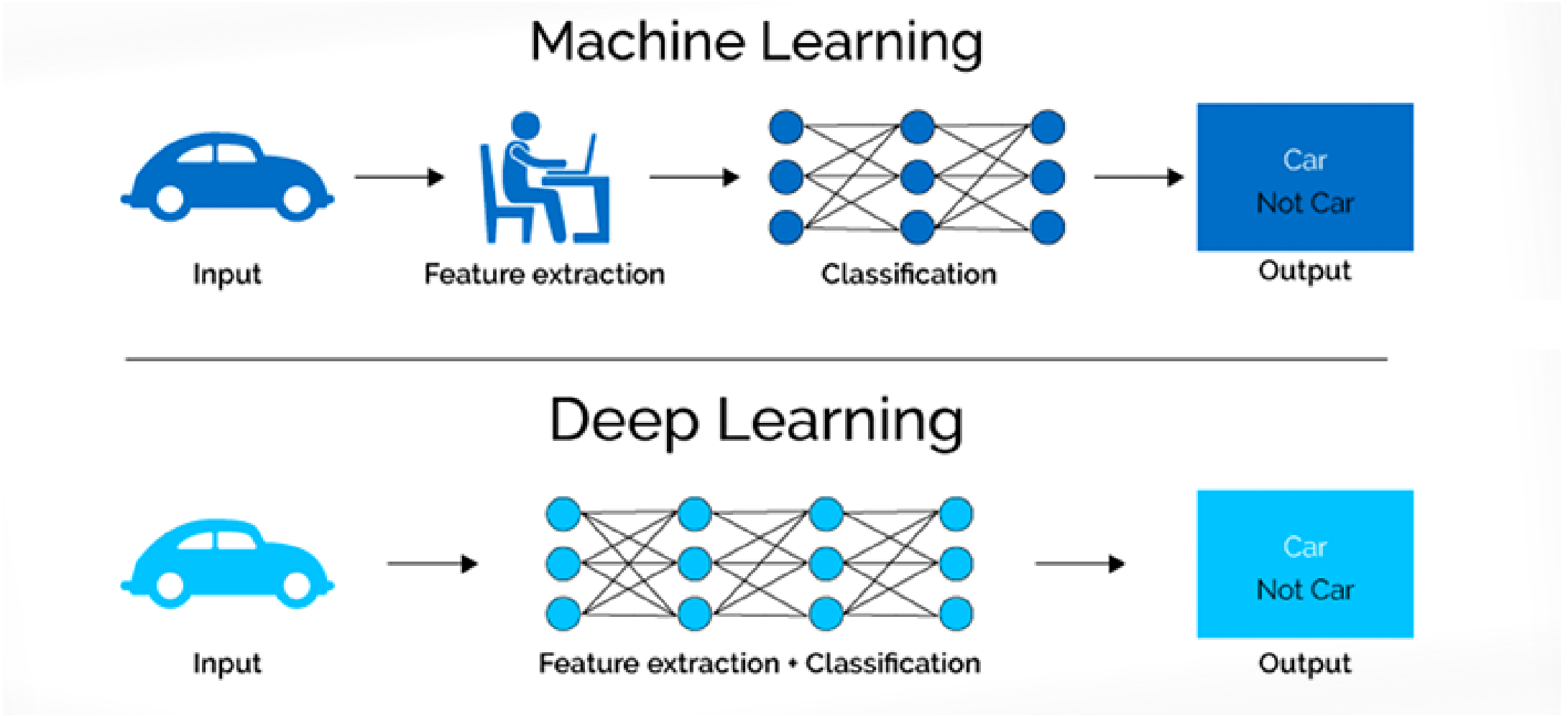
La inteligencia artificial ya detecta el cáncer de mama con la misma precisión que un radiólogo

EL MUNDO

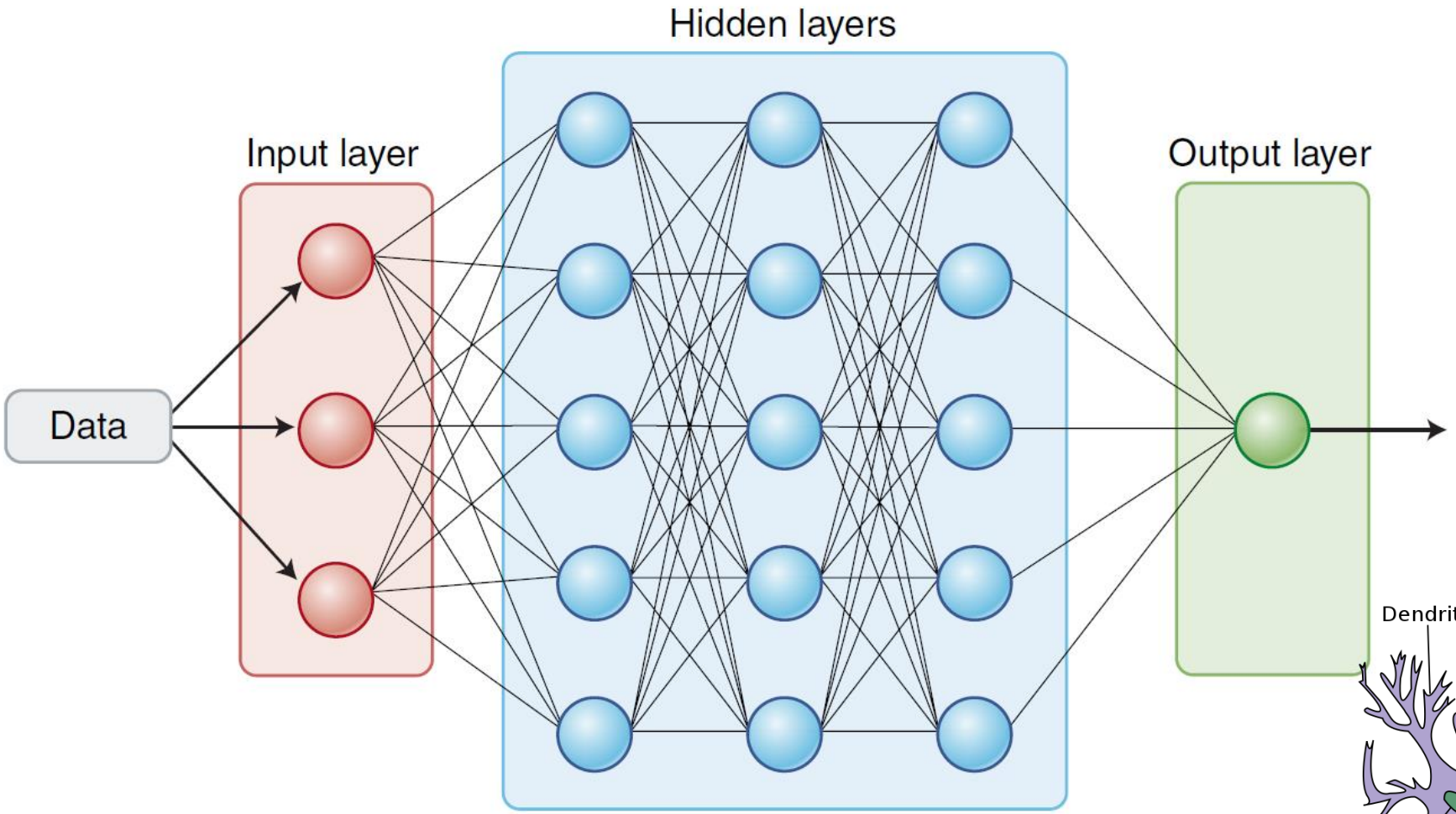
Inteligencia Artificial

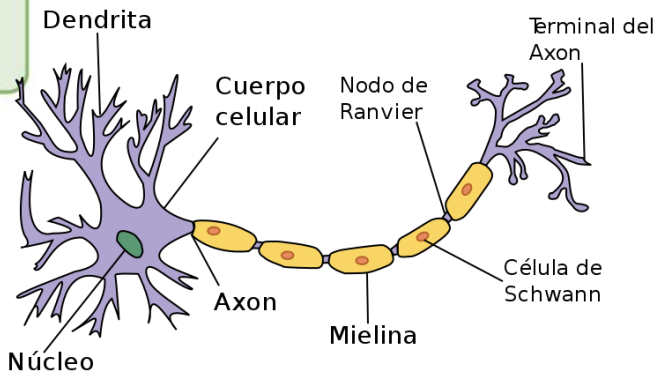


DL: Cambio de paradigma



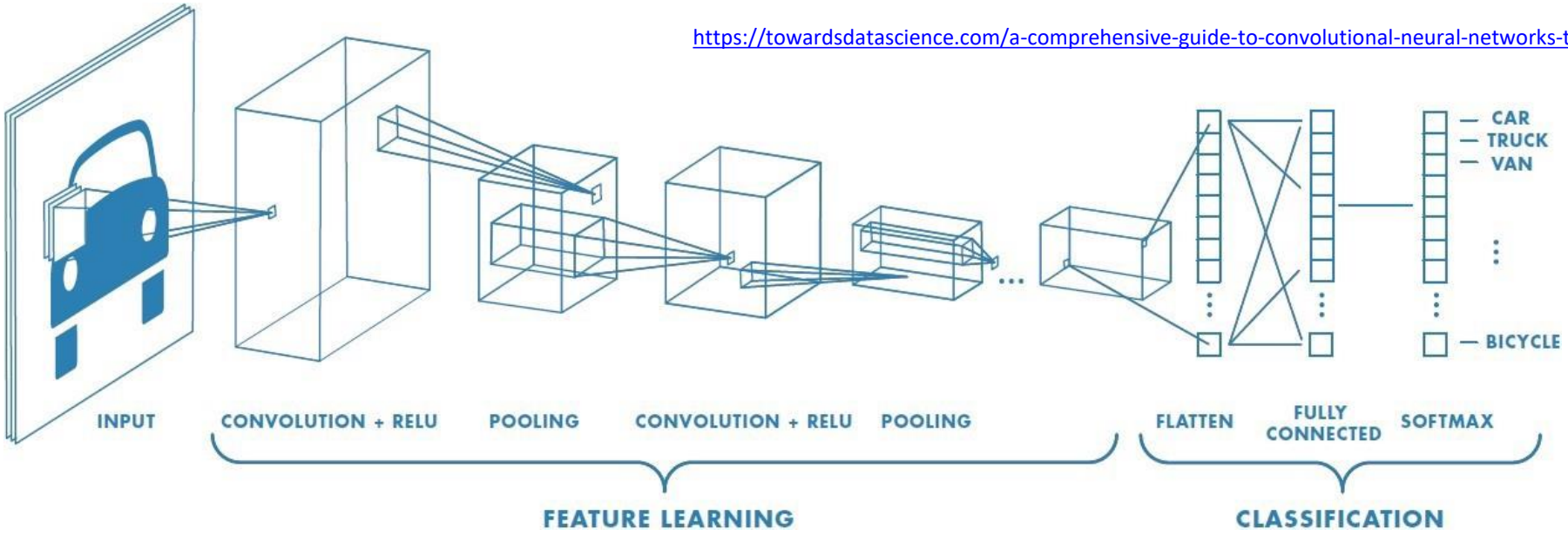
Redes Neuronales



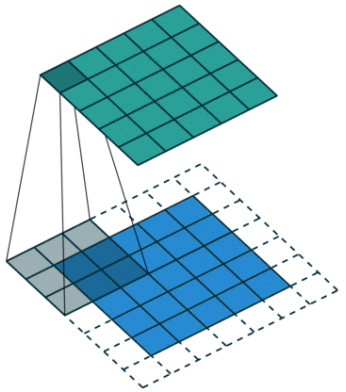


Redes Neuronales Convolucionales

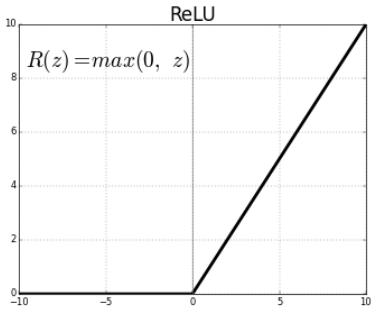
https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53



- **Entrada**: imagen, patches
- **Convolución:** operación matemática (filtro)
- **ReLu**: función de activación no lineal
- **Pooling (max/average):** Reducción de dimensionalidad
- **FC:** Conecta cada nodo con todos los nodos de otra capa
- **Softmax:** convierte número a probabilidad



Convolución



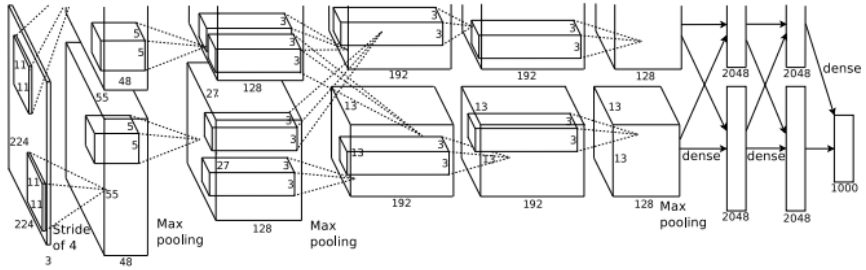
3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

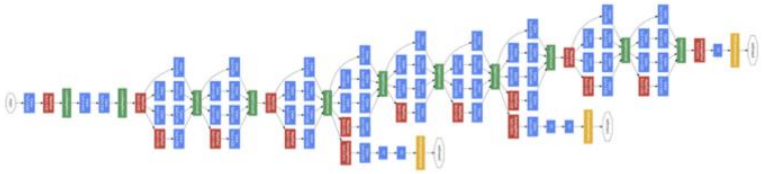
Pooling

Algunas CNNs populares

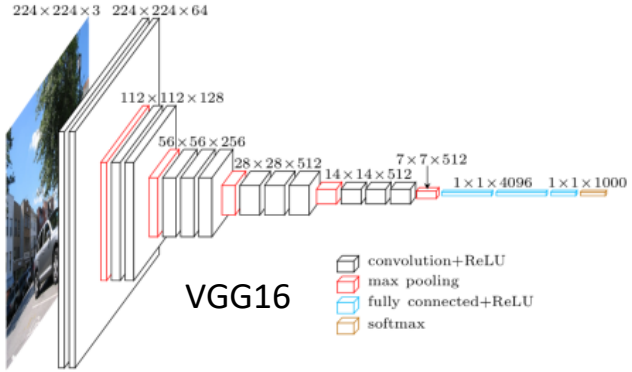
Red	Año	Capas	Parámetros
AlexNet	2012	8	~60 millones
VGGNet	2014	16	138 millones
GoogleNet	2014	22*	4 millones
ResNet	2015	152	
U-Net	2015		



AlexNet

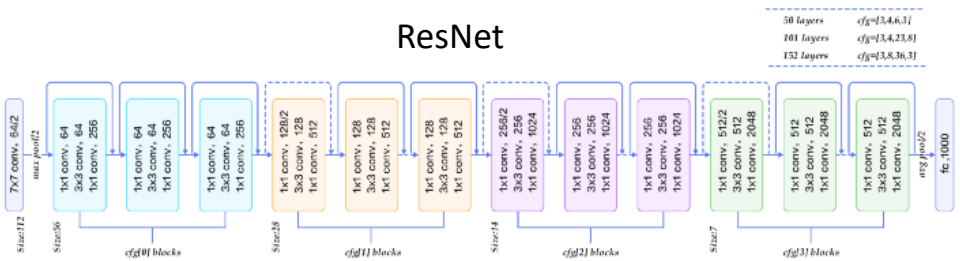


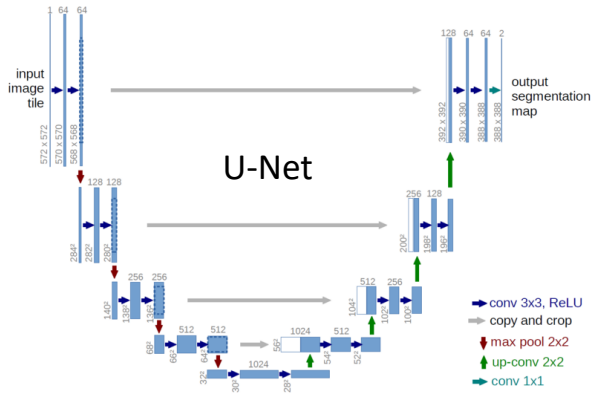
GoogleNet



VGG16

ResNet





U-Net

Transformers

Attention Is All You Need

Ashish Vaswani* Google Brain avaswani@google.com

Noam Shazeer* Google Brain noam@google.com

Niki Parmar* Google Research nikip@google.com

Jakob Uszkoreit* Google Research usz@google.com

Llion Jones* Google Research llion@google.com

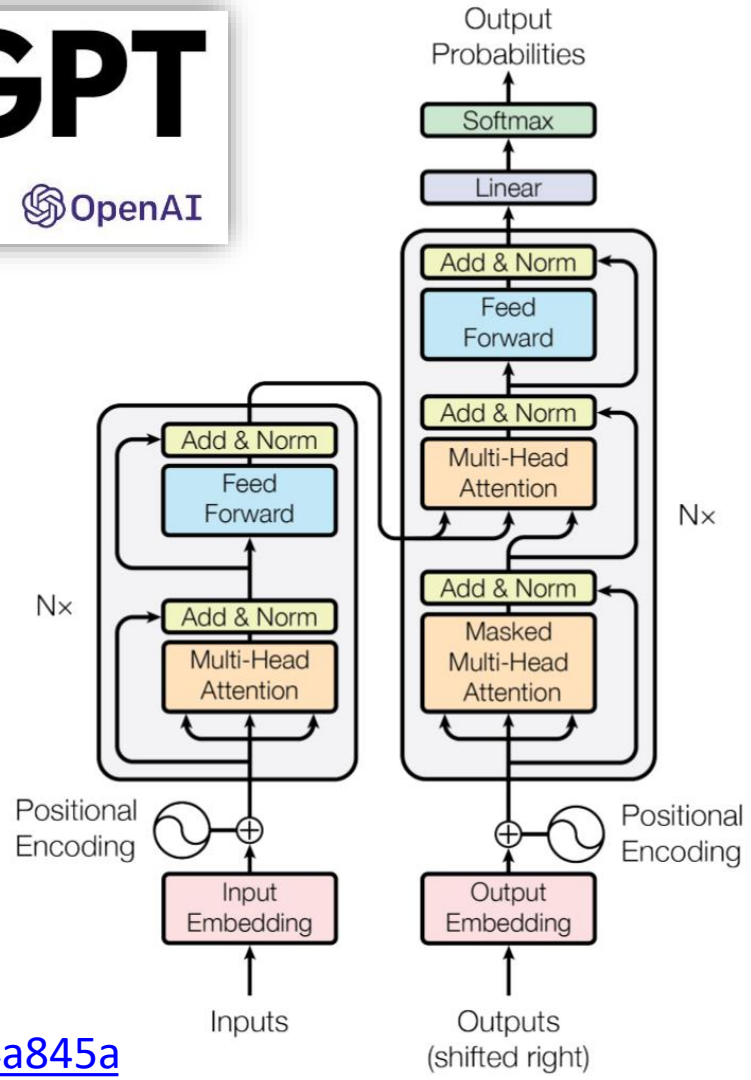
Aidan N. Gomez* † University of Toronto aidan@cs.toronto.edu

Łukasz Kaiser* Google Brain lukaszkaiser@google.com

Illia Polosukhin* ‡ illia.polosukhin@gmail.com

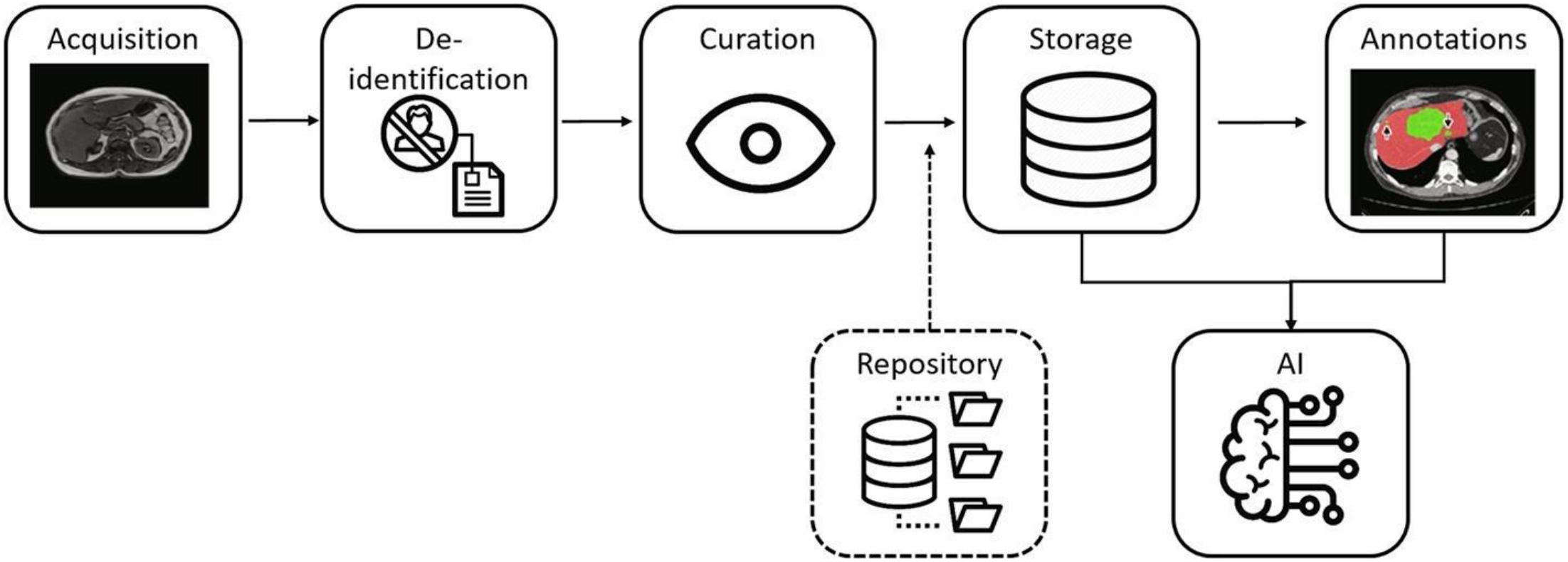
Chat GPT

OpenAI



https://proceedings.neurips.cc/paper/2017/file/3f5ee243547dee91fbd053c1c4a845aa-Paper.pdf

No todo es arquitectura



Diaz, O et al (2021). Data preparation for artificial intelligence in medical imaging: a comprehensive guide to open-access platforms and tools. *Physica Medica*, *83*, 25-37
https://www.sciencedirect.com/science/article/pii/S1120179721000958

¿Por qué ahora?

John McCarthy acuña la expresión **IA**.
1956

Utilización **CNNs** en apps de reconocimiento de objetos.
1990s

Expansión de CNNs a otras aplicaciones.
2000s

Aparece **CNN AlexNet** (ImageNet Challenge).
2012

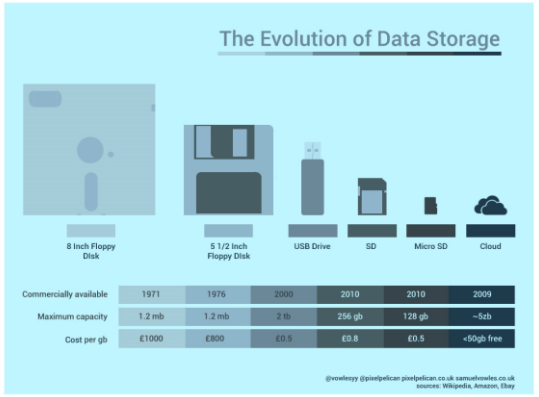
2022
Aparece **ChatGPT**

1986
DL acuñado por Rina Detcher.

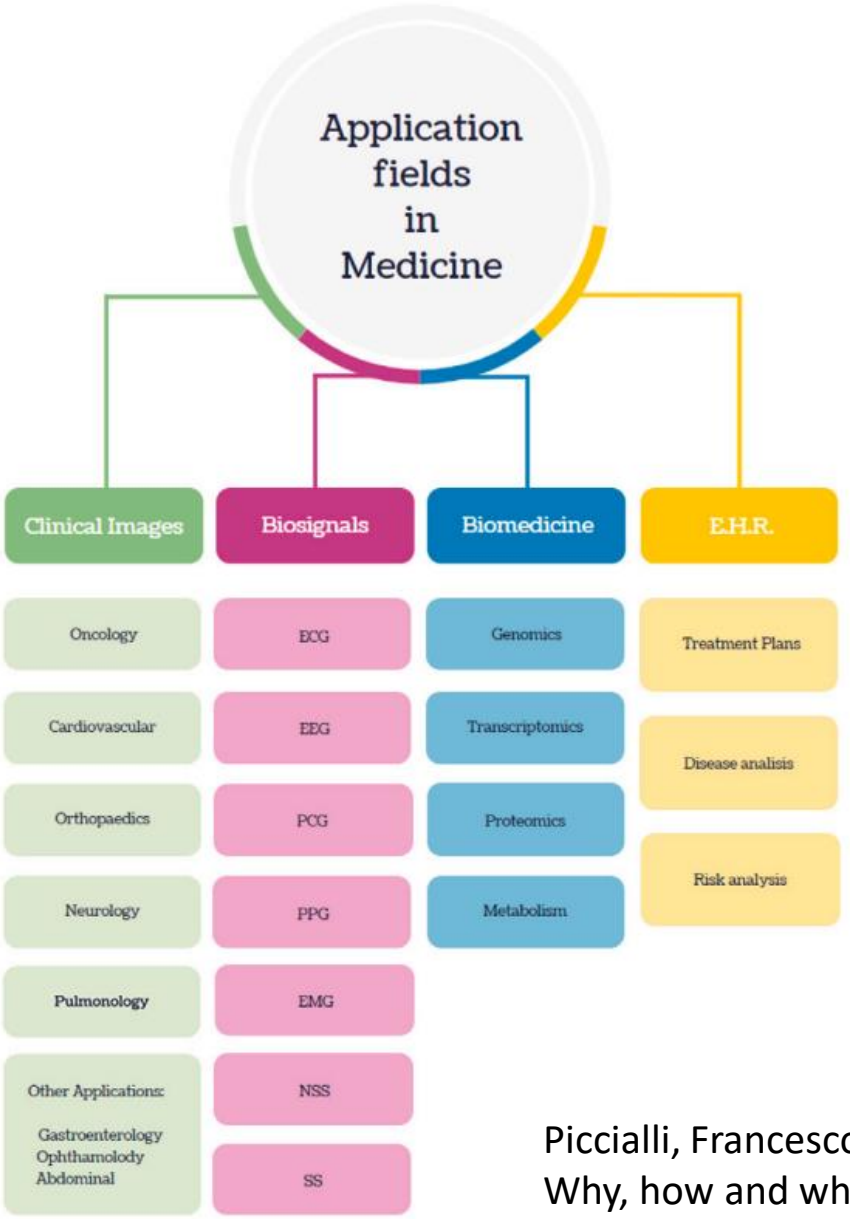
1996
1º trabajo **CNN en mamografía**

2010s
Explotación masiva de DL en radiología

2017
Aparecen los **Transformers**



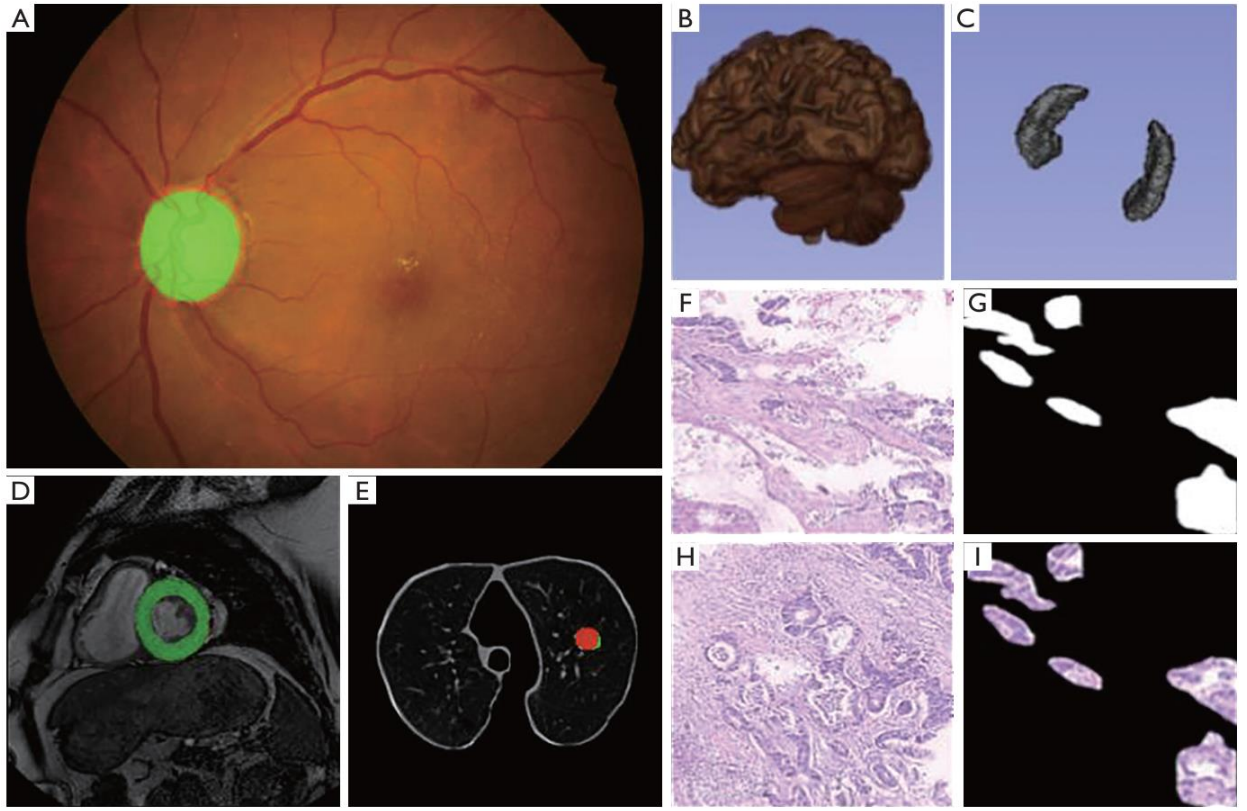
Aplicaciones en salud



Piccialli, Francesco, et al. "A survey on deep learning in medicine: Why, how and when?." Information Fusion 66 (2021): 111-137.

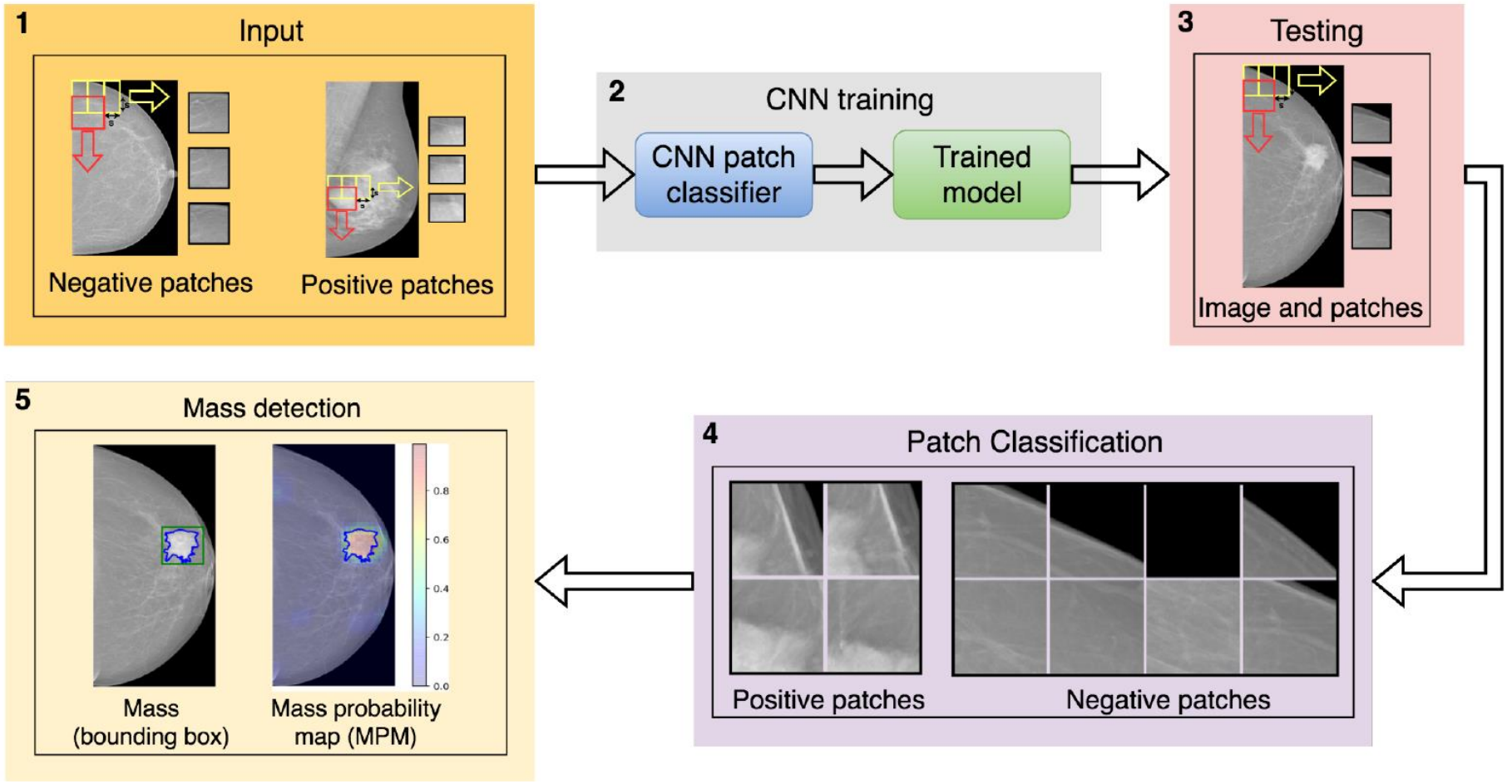
Tareas de IA en el ámbito salud

- Detección
- Segmentación
- Clasificación/caracterización
- Predicción
- Registro (temporal/multimodal)
- Mejora de calidad de imagen
- Generar datos sintéticos
  - Imágenes
  - Texto



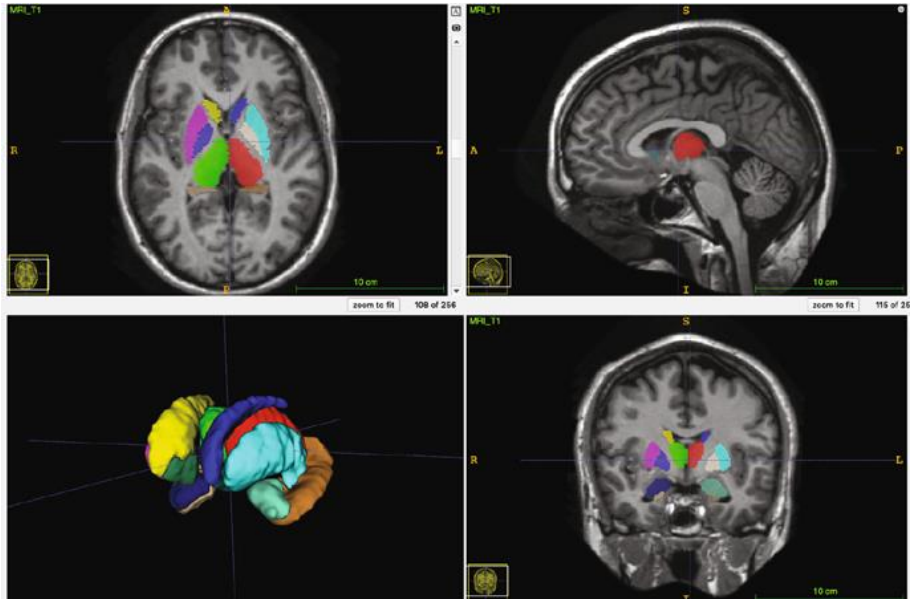
Cai, Lei, Jingyang Gao, and Di Zhao. "A review of the application of deep learning in medical image classification and segmentation." Annals of translational medicine 8.11 (2020).

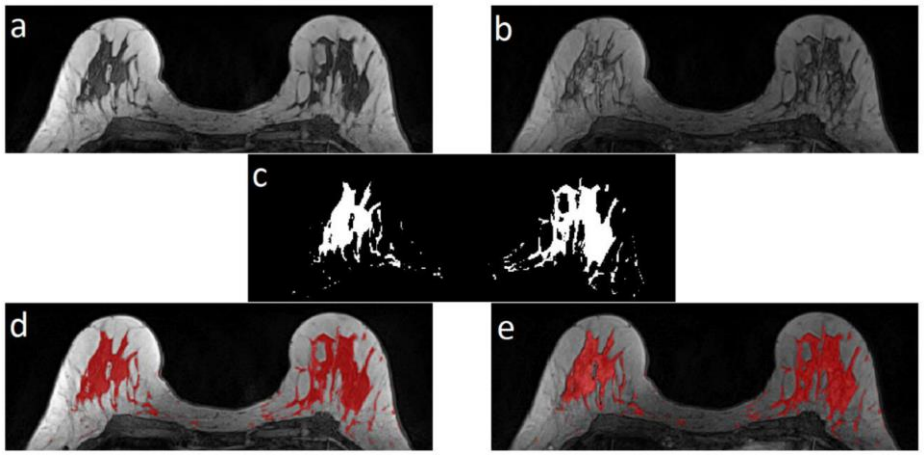
Detección

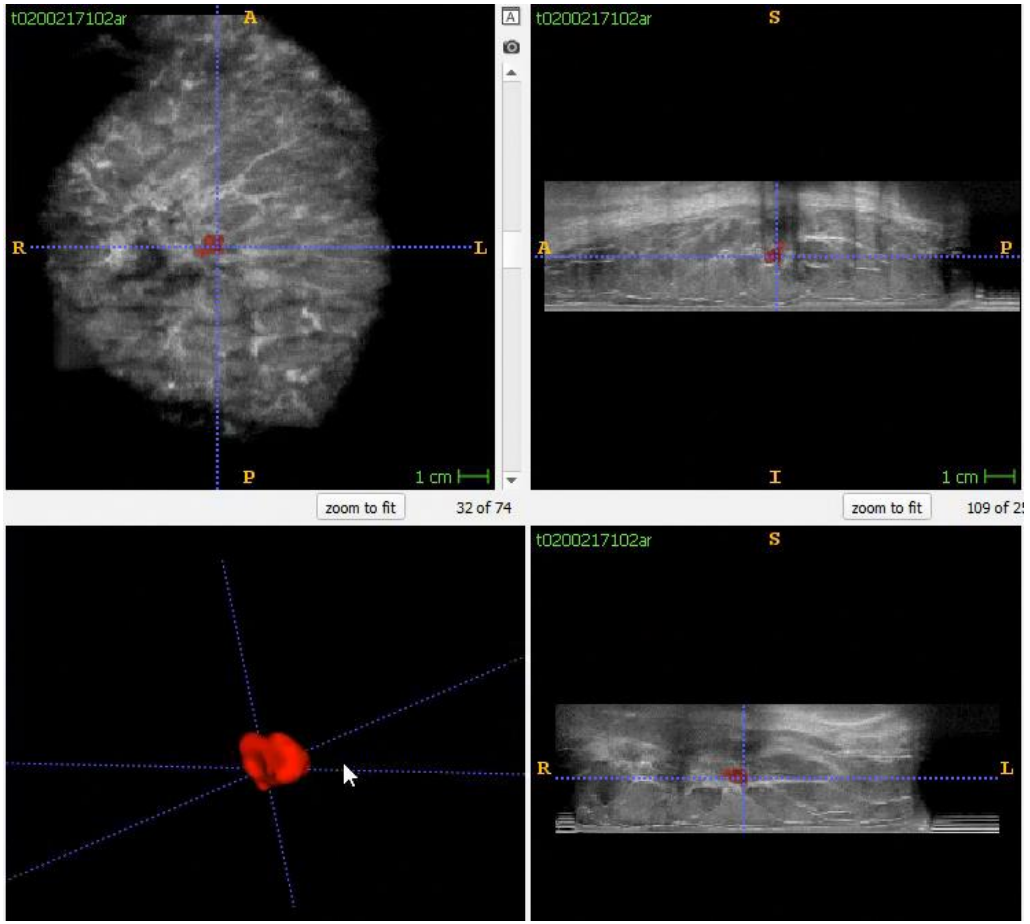


R. Agarwal, O.Diaz, X.Lladó, M.H. Yap, R. Martí Automatic mass detection in mammograms using deep convolutional neural networks. J. Med. Imag. 6(3) 031409, 2019.

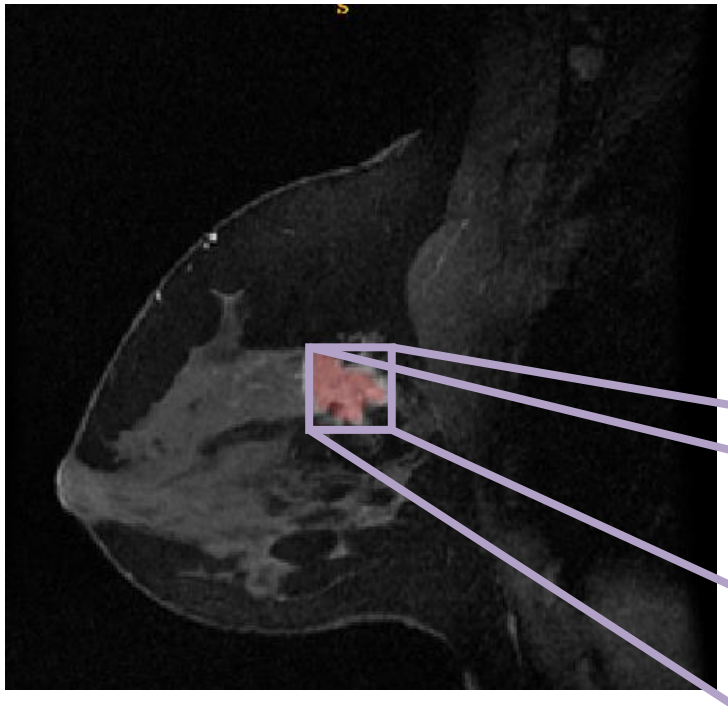
Segmentación de tejidos







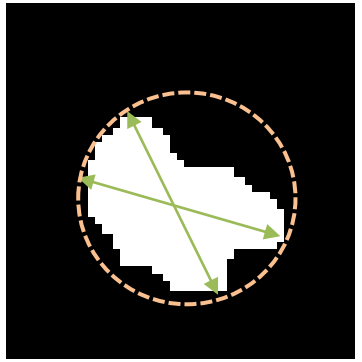
Segmentación de tejidos: Radiómica

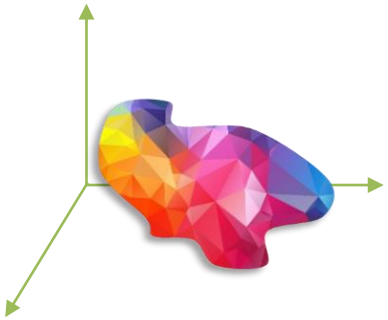


3	8	1	6	0	6	1	5
6	5	7	9	2	1	3	6
9	5	3	1	5	3	7	8
0	5	4	8	9	7	3	1
8	6	4	7	4	1	2	1

Características intensidad

Características morfológicas

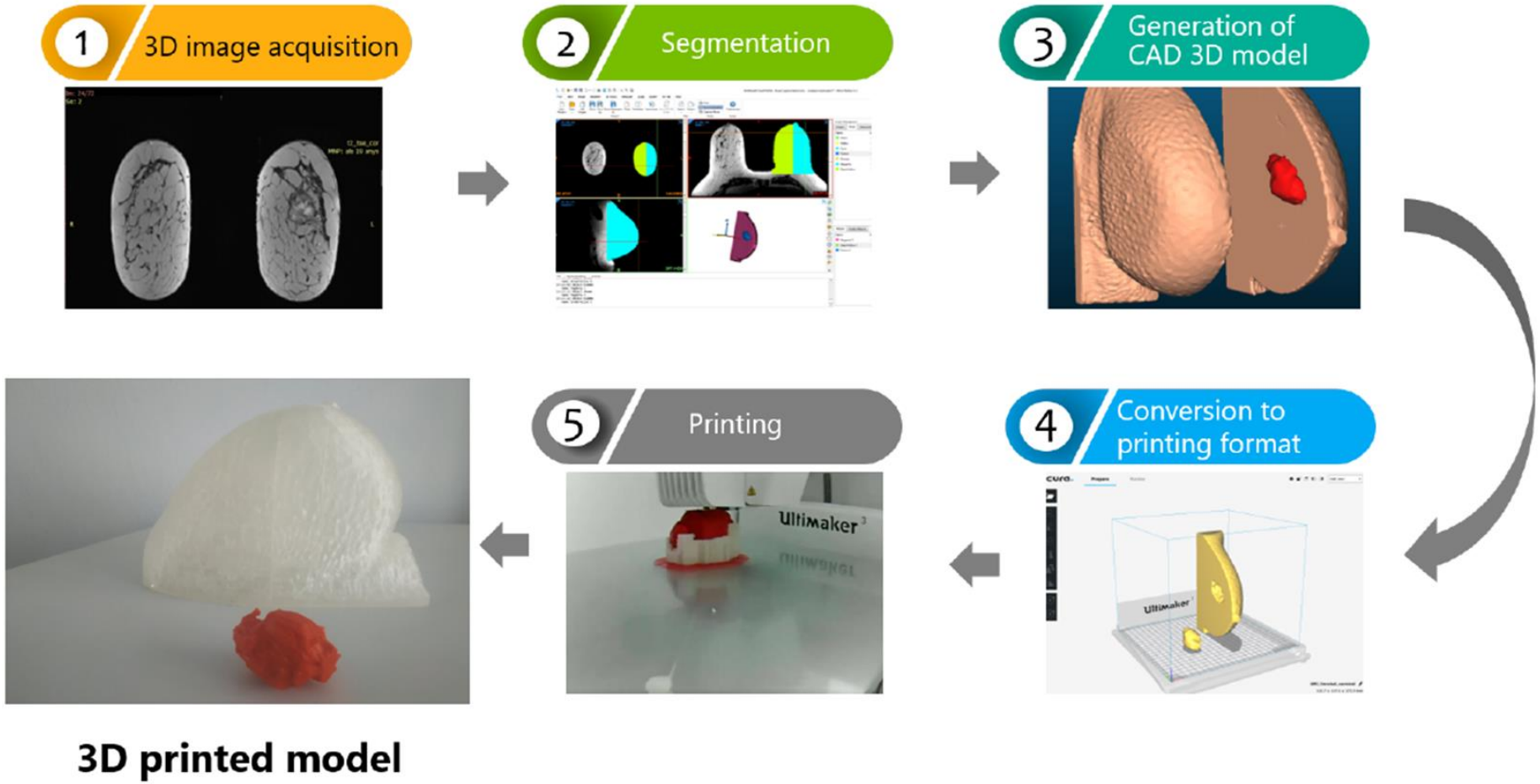




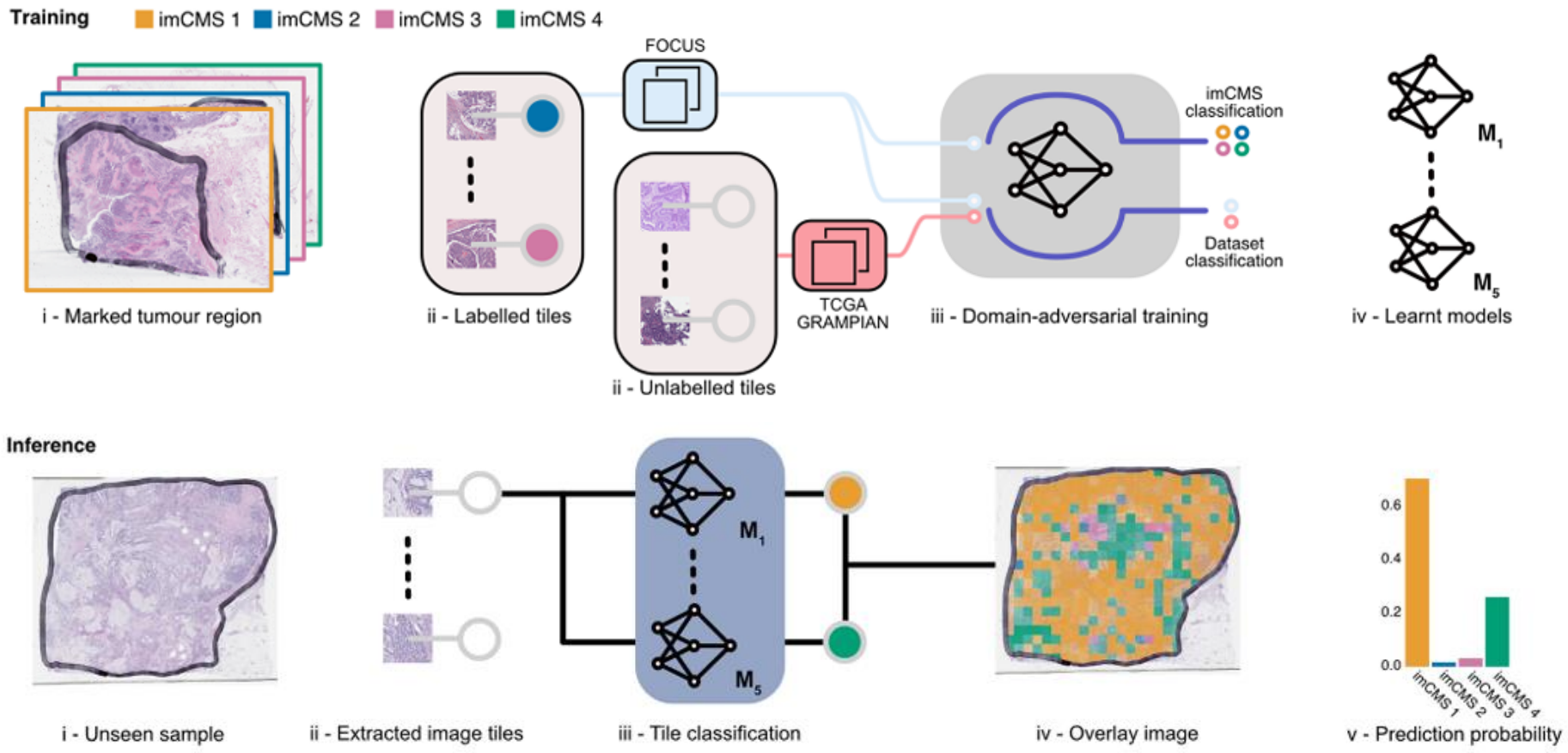
Características textura

1	4	4	1	2
4	5	5	4	3
3	4	4	5	4
2	3	4	4	1
2	4	5	3	1

Segmentación de tejidos: Impressión 3D

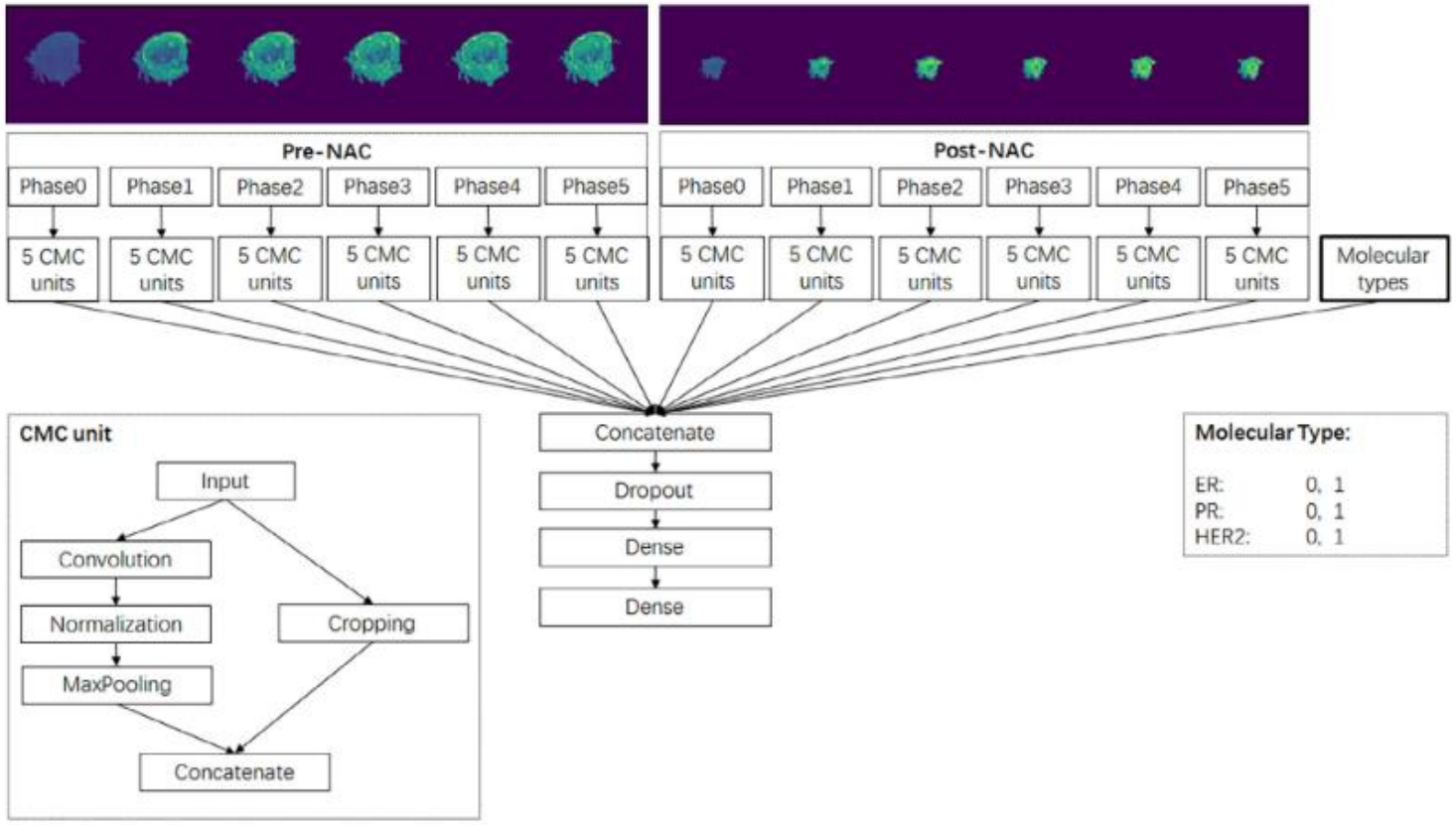


Clasificación/caracterización



Sirinukunwattana, Korsuk, et al. "Image-based consensus molecular subtype (imCMS) classification of colorectal cancer using deep learning." Gut 70.3 (2021): 544-554.

Predicción



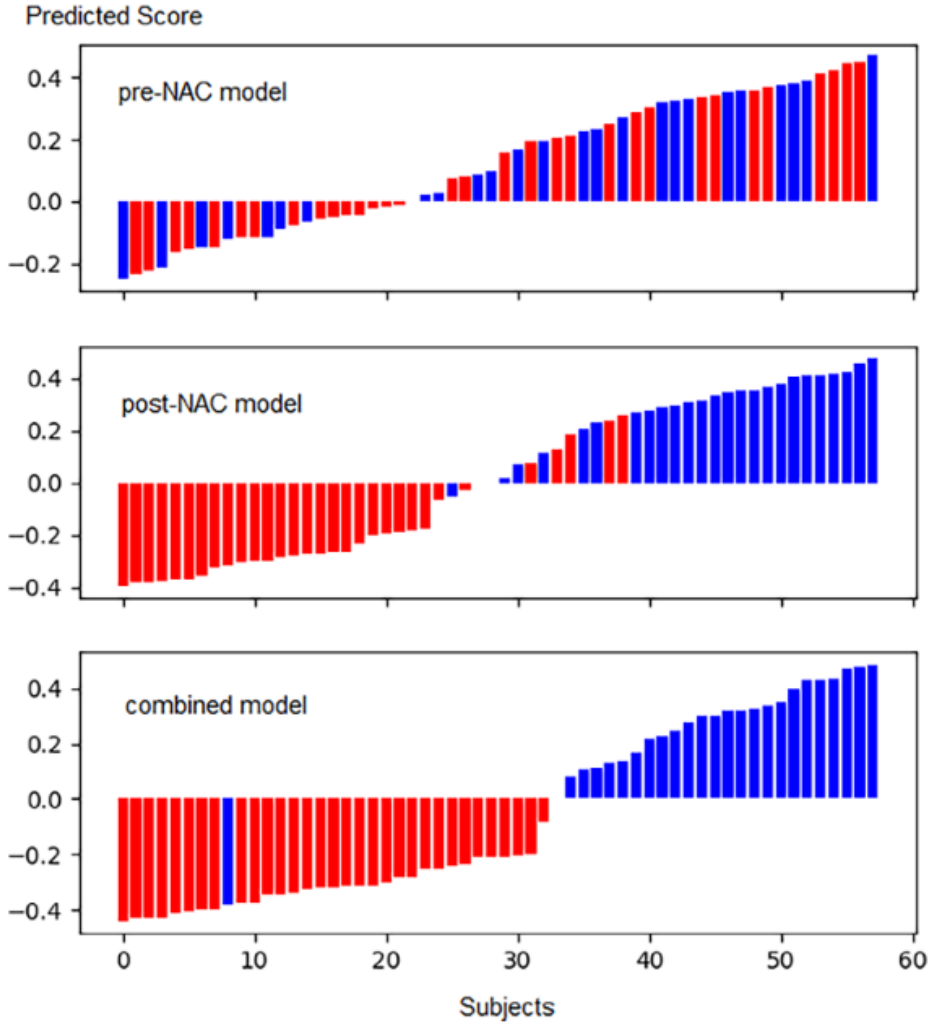
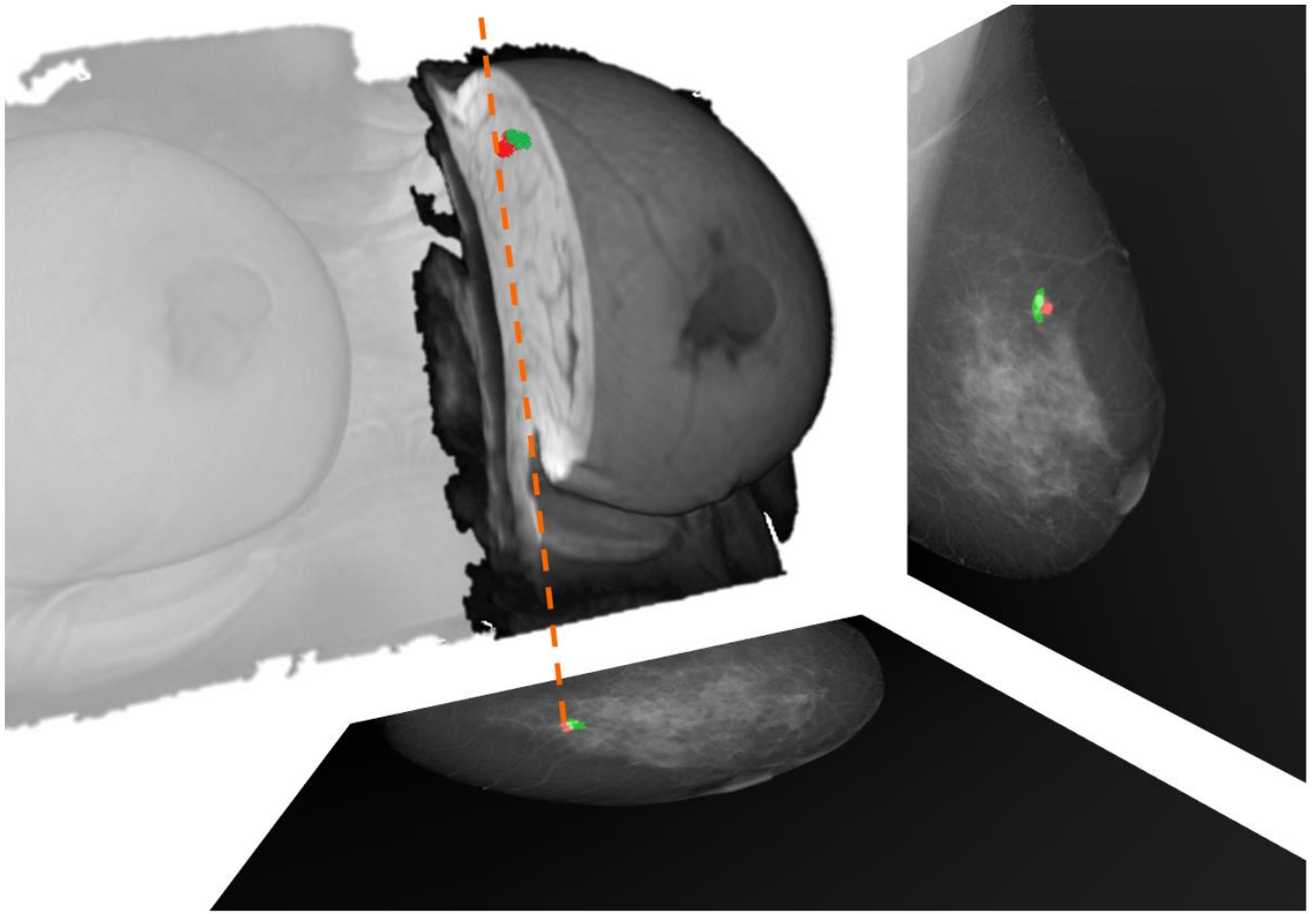


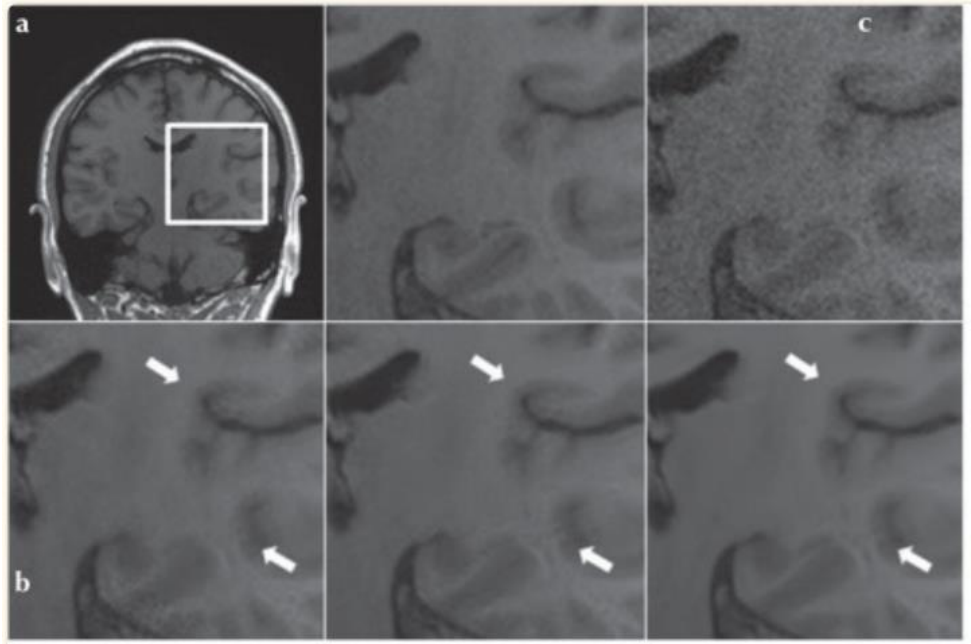
Figure 4 Predicted scores of 58 participants with locally advanced breast cancer in the validation set. Blue color indicates pCR proven by pathological analysis. Red color indicates non-pCR proven by pathological analysis. Bars above 0 are pCR predicted by DL models. Bars below 0 are non-pCR predicted by DL models.

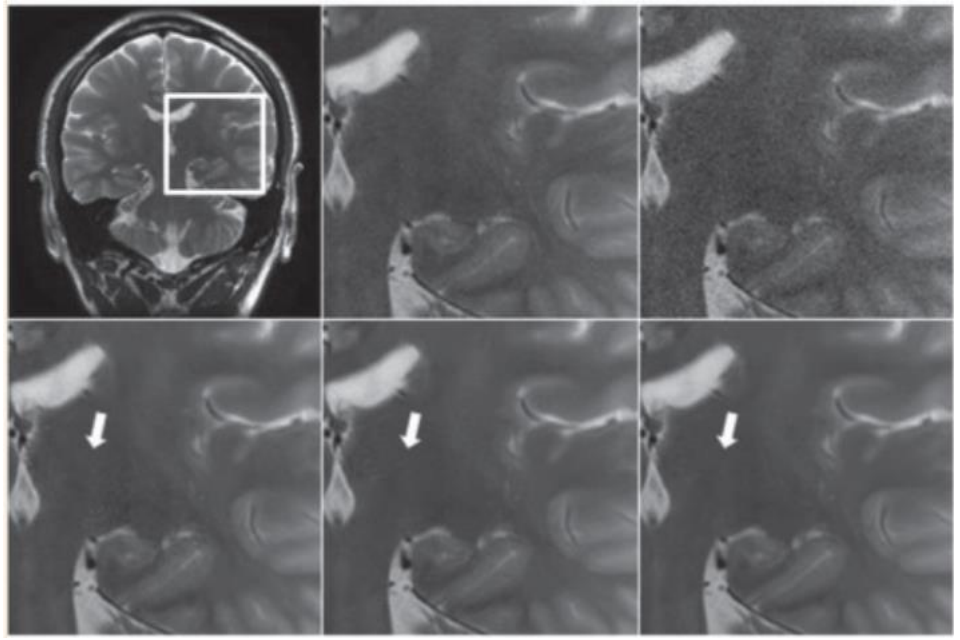
Qu, Yu-Hong, et al. "Prediction of pathological complete response to neoadjuvant chemotherapy in breast cancer using a deep learning (DL) method." Thoracic Cancer 11.3 (2020): 651-658.

Registro (temporal/multimodal)



Calidad de imagen: reducción de ruido

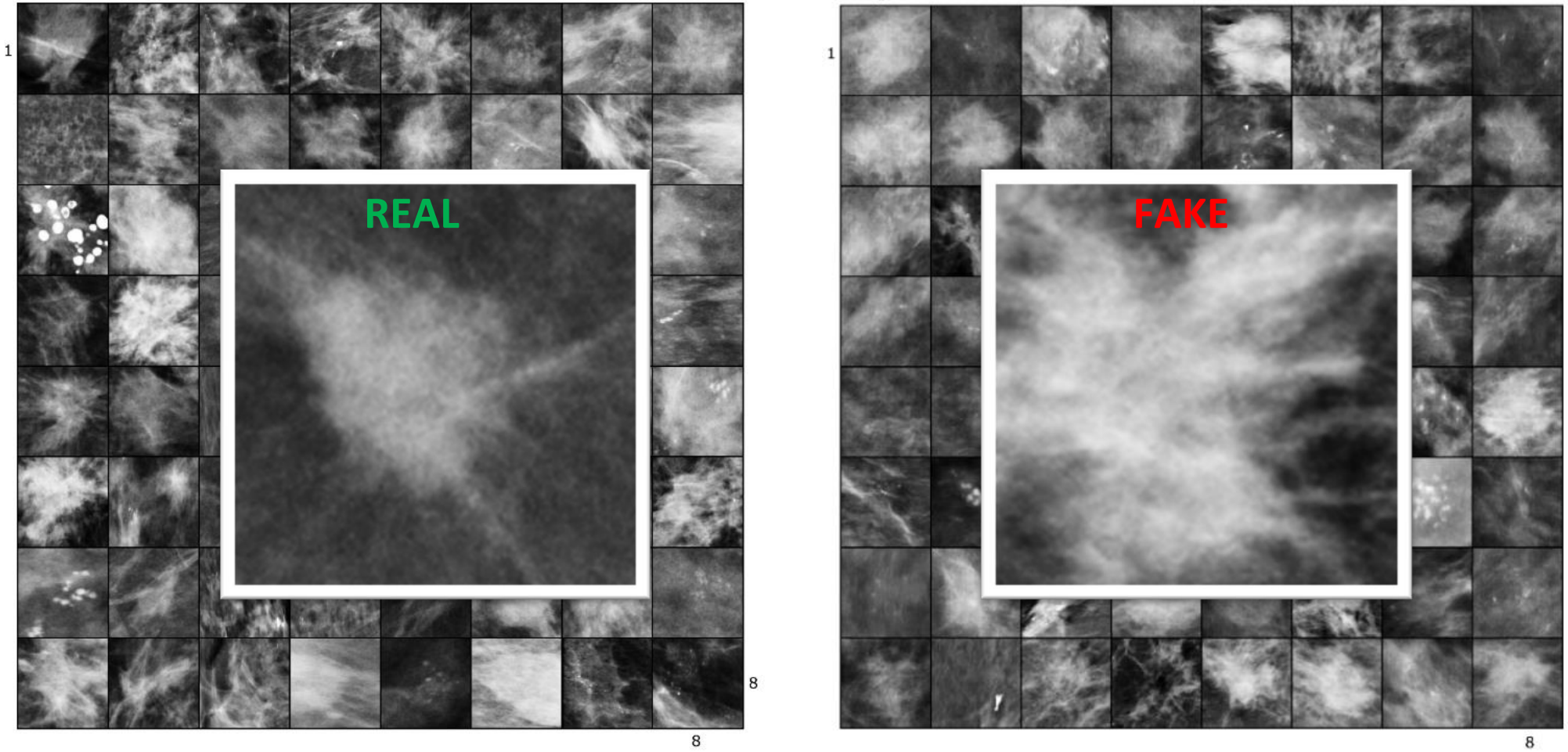




Ground Truth	Ground Truth	Noisy
DnCNN	SCNN	dDLR

Kidoh, Masafumi, et al. "Deep learning based noise reduction for brain MR imaging: tests on phantoms and healthy volunteers." Magnetic resonance in medical sciences 19.3 (2020): 195.

Generación de datos (imagen)



Alyafi et al (2020). Quality analysis of DCGAN-generated mammography lesions. *IWBI2020,* 11513, 115130B
Alyafi et al (2020). DCGANs for realistic breast mass augmentation in x-ray mammography. In *Medical Imaging 2020: CAD,* 11314, 1131420

Generación de datos (imagen)

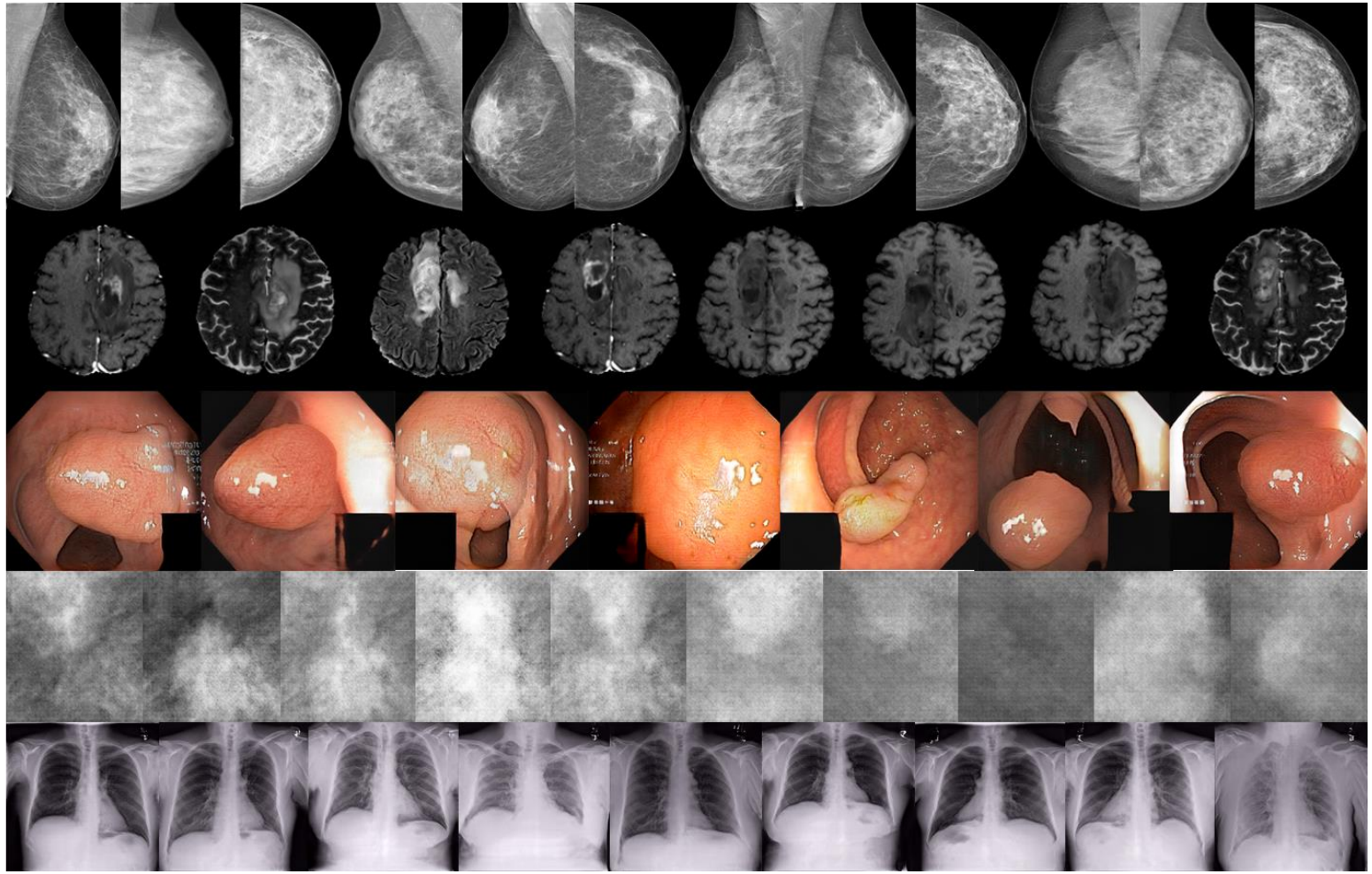
Model 3
Garrucho et al (2022)
image-to-image

Model 7
Kim et al (2021)
Image inpainting

Model 10

Model 12
Osuala et al (2022)
Noise to image patch

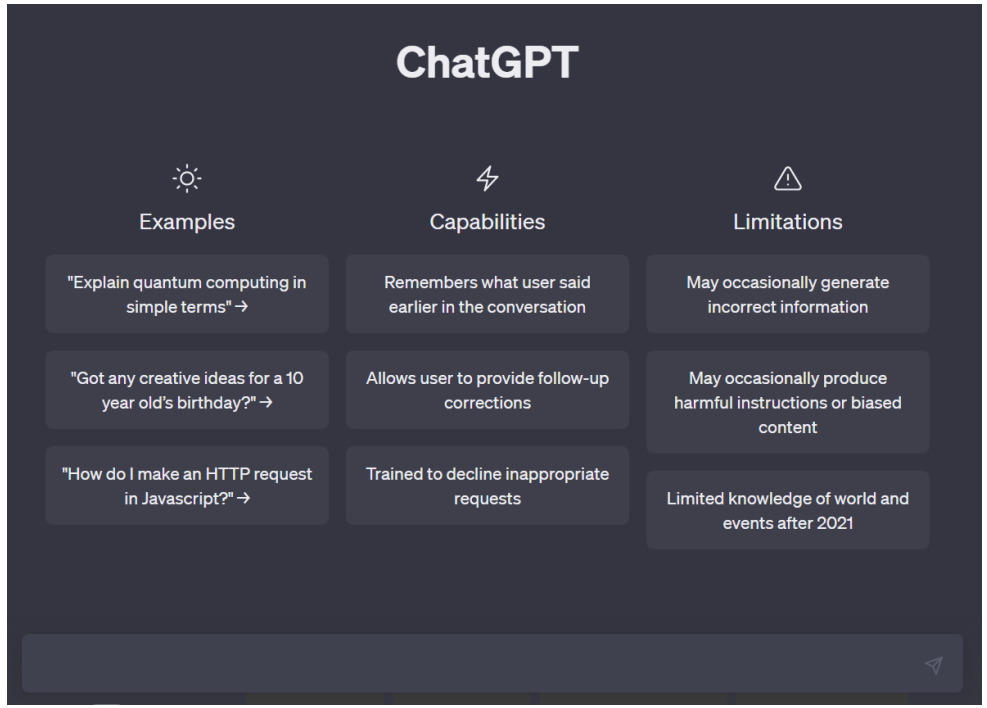
Model 19
Osuala et al (2022)
Noise to image

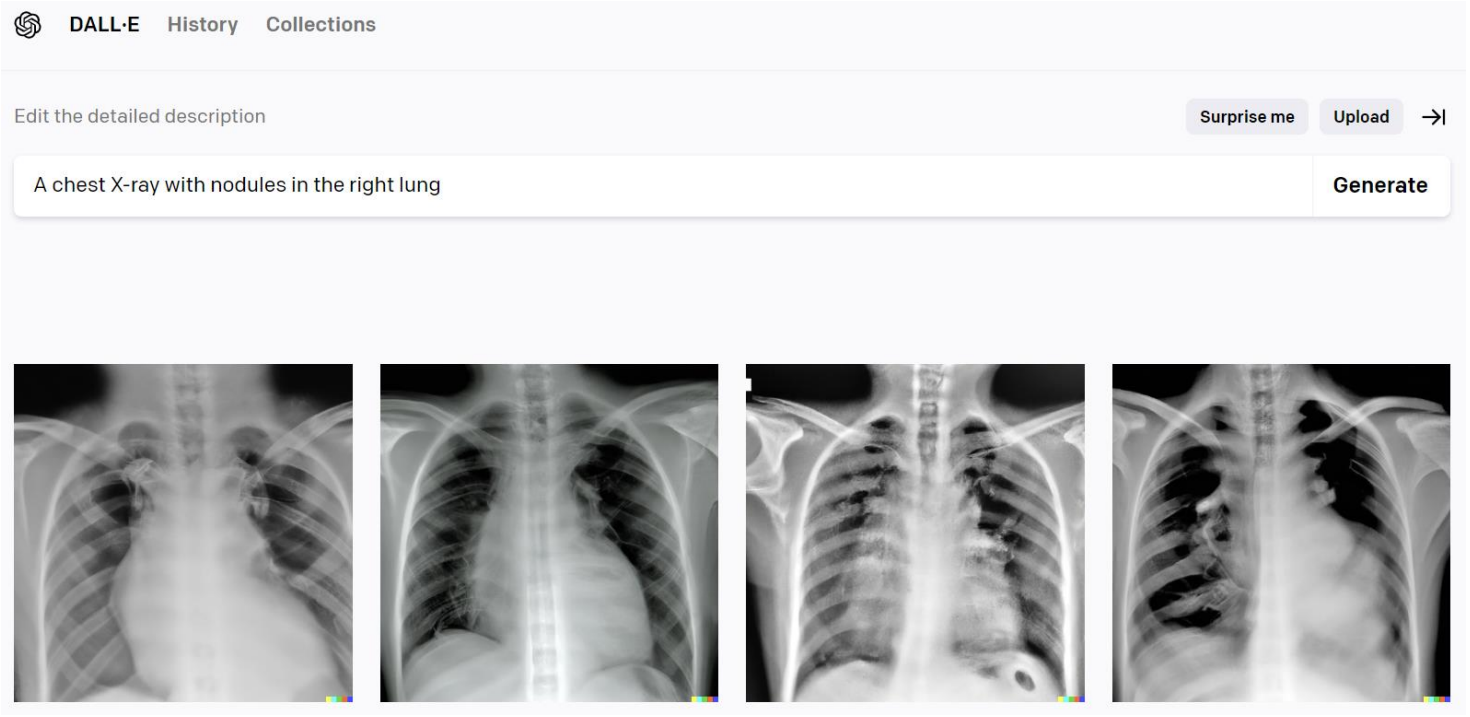


Osuala, Richard, et al. "medigan: a Python library of pretrained generative models for medical image synthesis."

Generación de datos (texto)

OpenAI





Generación de datos (texto)

ChatGPT Makes Medicine Easy to Swallow: An Exploratory Case Study on Simplified Radiology Reports

Katharina Jeblick, Balthasar Schachtner, Jakob Dexl, Andreas Mittermeier, Anna Theresa Stüber, Johanna Topalis, Tobias Weber, Philipp Wesp, Bastian Sabel, Jens Ricke, Michael Ingrisch

ELSEVIER

Diagnostic and Interventional Imaging

Available online 28 February 2023

In Press, Corrected Proof What's this?

Original article

Revolutionizing radiology with GPT-based models: Current applications, future possibilities and limitations of ChatGPT

Augustin Lecler [a b], Loïc Duron [a], Philippe Soyer [b c]

ChatGPT Is Shaping the Future of Medical Writing But Still Requires Human Judgment

Felipe C. Kitamura

The Role and Limitations of Large Language Models Such as ChatGPT in Clinical Settings and Medical Journalism

Furkan Ufuk

IA en la práctica clínica (FDA)

https://aicentral.acrdsi.org

AI CENTRAL

DATA SCIENCE INSTITUTE™
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Check back regularly to see which new algorithms are available and have been added to the list. Send information on AI algorithms that are not listed and report missing information to DSI@acr.org.

Best,
Keith J. Dreyer, DO, PhD, FACR, FSIIM
Chairman of Editorial Board, AI Central Editorial

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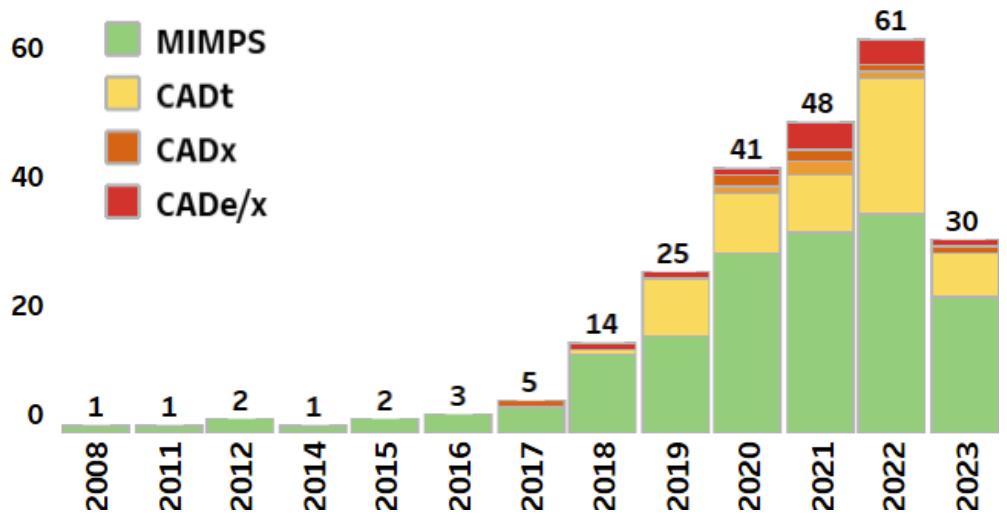
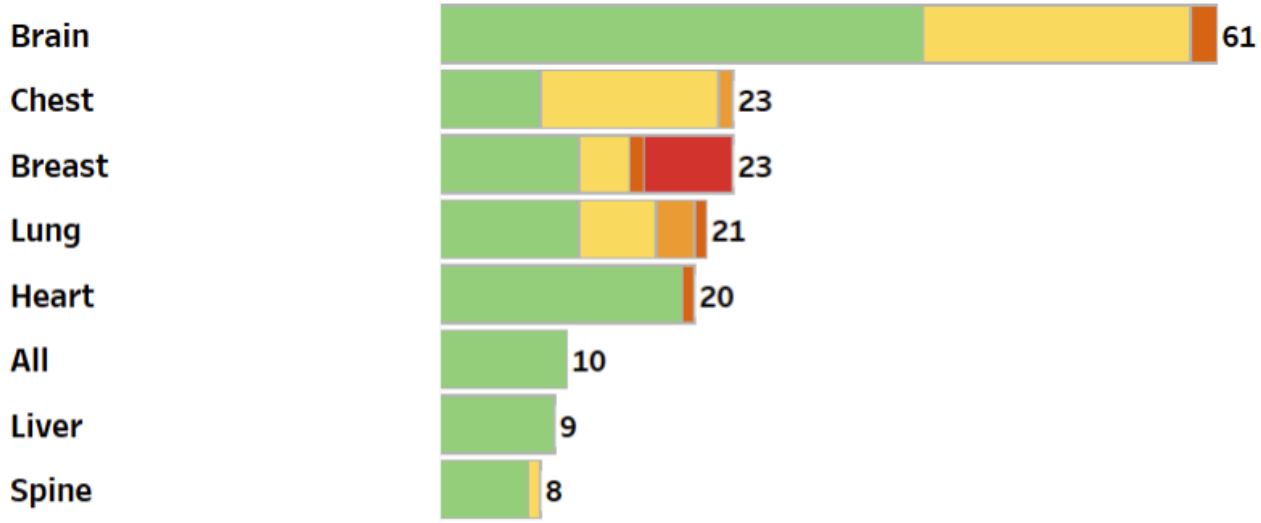
230+ IA solutions !

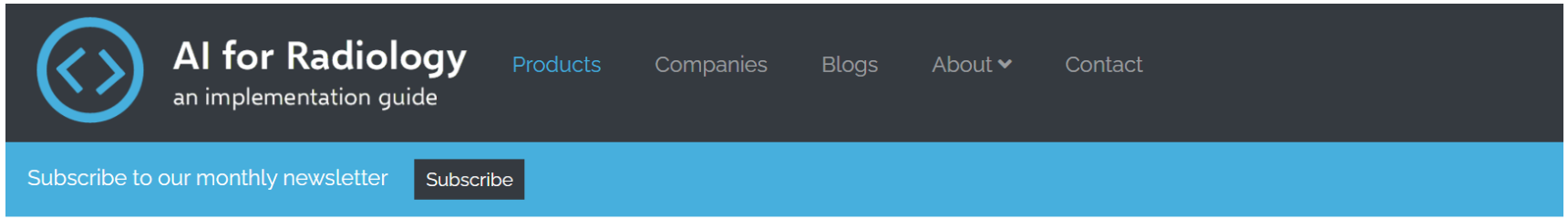
YEAR CLEARED



Anatomy



IA en la práctica clínica (CE mark)



220 IA solutions!

Products

Find the artificial intelligence based software for radiology that you are looking for.
All products listed are available for the European market (CE marked).

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220/220 results

24 AI tools for breast

www.AIforRadiology.com

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Marca CE no es suficiente

European Radiology (2021) 31:3797–3804
https://doi.org/10.1007/s00330-021-07892-z

IMAGING INFORMATICS AND ARTIFICIAL INTELLIGENCE

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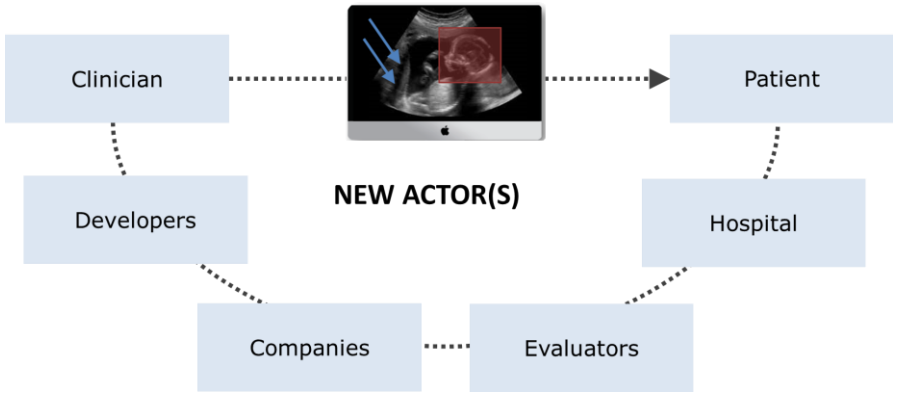
Artificial intelligence in radiology: 100 commercially available products and their scientific evidence

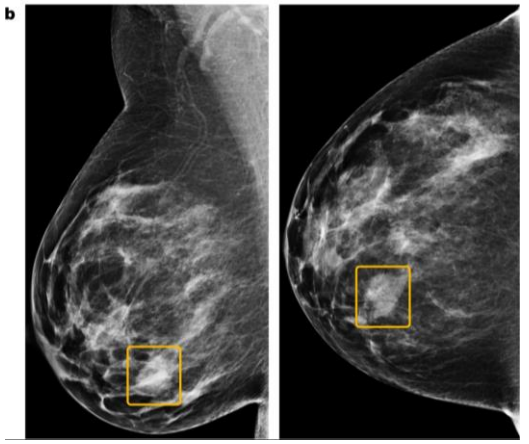
Kicky G. van Leeuwen [1] · Steven Schalekamp [1] · Matthieu J. C. M. Rutten [1,2] · Bram van Ginneken [1] · Maarten de Rooij [1]

- 64% de los productos no tienen evidencia científica de su eficacia
- Solo 18% han demostrado potencial impacto en la practica clínica
- Gran variedad de estrategias de despliegue de la tecnología, precios, etc.

Retos pendientes

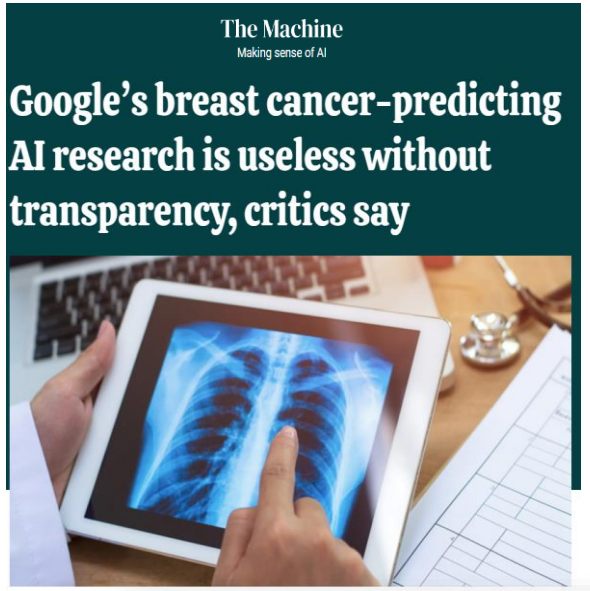
- Falta de Seguridad
- Falta de Transparencia
- Falta de Responsabilidad
- Falta de Explicabilidad
- Falta de Equidad
- Falta de Usabilidad
- Falta de Protección



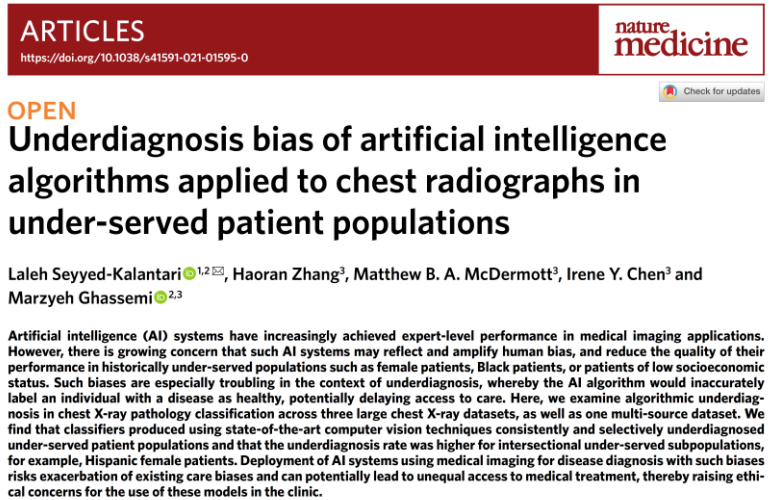


Caso fallado por IA pero identificado por todos los 6 observadores

McKinney, S.M. et al. 2020. International evaluation of an AI system for breast cancer screening. Nature, 577(7788)


The Machine
Making sense of AI

Google's breast cancer-predicting AI research is useless without transparency, critics say


ARTICLES
https://doi.org/10.1038/s41591-021-01595-0
nature medicine
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OPEN

Underdiagnosis bias of artificial intelligence algorithms applied to chest radiographs in under-served patient populations

Laleh Seyyed-Kalantari[1,2], Haoran Zhang[3], Matthew B. A. McDermott[3], Irene Y. Chen[3] and Marzyeh Ghassemi[2,3]

Artificial intelligence (AI) systems have increasingly achieved expert-level performance in medical imaging applications. However, there is growing concern that such AI systems may reflect and amplify human bias, and reduce the quality of their performance in historically under-served populations such as female patients, Black patients, or patients of low socioeconomic status. Such biases are especially troubling in the context of underdiagnosis, whereby the AI algorithm would inaccurately label an individual with a disease as healthy, potentially delaying access to care. Here, we examine algorithmic underdiagnosis in chest X-ray pathology classification across three large chest X-ray datasets, as well as one multi-source dataset. We find that classifiers produced using state-of-the-art computer vision techniques consistently and selectively underdiagnosed under-served patient populations and that the underdiagnosis rate was higher for intersectional under-served subpopulations, for example, Hispanic female patients. Deployment of AI systems using medical imaging for disease diagnosis with such biases risks exacerbation of existing care biases and can potentially lead to unequal access to medical treatment, thereby raising ethical concerns for the use of these models in the clinic.

El Hospital Clínic de Barcelona sufre una nueva filtración de datos

Esfuerzos de la UE

(Julio 2020)

https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=68342

Iniciativas internacionales

Open access Protocol

BMJ Open

Protocol for development of a reporting guideline (TRIPOD-AI) and risk of bias tool (PROBAST-AI) for diagnostic and prognostic prediction model studies based on artificial intelligence

Gary S Collins ,[1,2] Paula Dhiman ,[1,2] Constanza L Andaur Navarro ,[3] Jie Ma ,[1] Lotty Hooft,[3,4] Johannes B Reitsma,[3] Patricia Logullo ,[1,2] Andrew L Beam ,[5,6] Lily Peng,[7] Ben Van Calster ,[8,9,10] Maarten van Smeden ,[3] Richard D Riley ,[11] Karel GM Moons[3,4]

Kocak *et al. Insights into Imaging* (2023) 14:75
https://doi.org/10.1186/s13244-023-01415-8

Insights into Imaging
ESR EUROPEAN SOCIETY OF RADIOLOGY

GUIDELINE Open Access

CheckList for EvaluAtion of Radiomics research (CLEAR): a step-by-step reporting guideline for authors and reviewers endorsed by ESR and EuSoMII

Burak Kocak[1*], Bettina Baessler[2], Spyridon Bakas[3,4,5], Renato Cuocolo[6], Andrey Fedorov[7], Lena Maier-Hein[8,9], Nathaniel Mercaldo[10,11], Henning Müller[12,13], Fanny Orlhac[14], Daniel Pinto dos Santos[15,16], Arnaldo Stanzione[17], Lorenzo Ugga[17] and Alex Zwanenburg[18,19,20]

Metrics Reloaded: Recommendations for image analysis validation

LENA MAIER-HEIN*†, German Cancer Research Center (DKFZ), Germany, Heidelberg University, Germany, and National Center for Tumor Diseases (NCT), Germany
ANNIKA REINKE†, German Cancer Research Center (DKFZ), Germany and Heidelberg University, Germany

Radiology: Artificial Intelligence EDITORIAL

Checklist for Artificial Intelligence in Medical Imaging (CLAIM): A Guide for Authors and Reviewers

John Mongan, MD, PhD • Linda Moy, MD • Charles E. Kahn, Jr, MD, MS

AAPM SCIENTIFIC REPORT MEDICAL PHYSICS

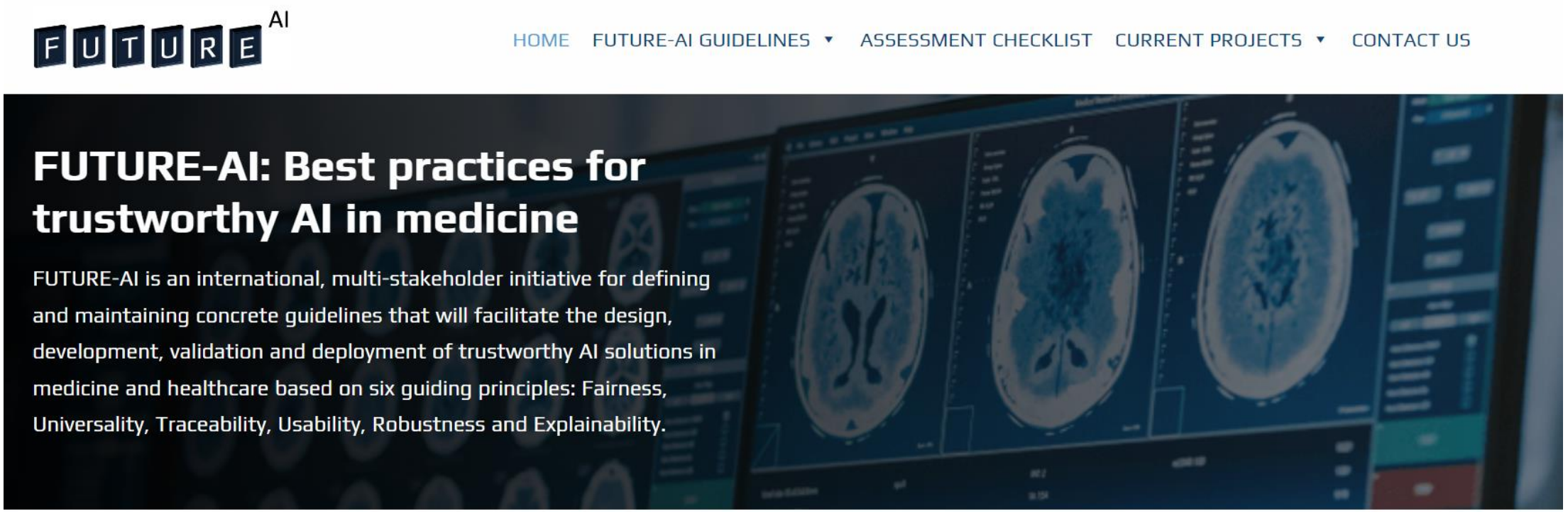
AAPM task group report 273: Recommendations on best practices for AI and machine learning for computer-aided diagnosis in medical imaging

Lubomir Hadjiiski[1] | Kenny Cha[2] | Heang-Ping Chan[3] | Karen Drukker[4] | Lia Morra[5] | Janne J. Näppi[6] | Berkman Sahiner[7] | Hiroyuki Yoshida[8] | Quan Chen[9] | Thomas M. Deserno[10] | Hayit Greenspan[11] | Henkjan Huisman[12] | Zhimin Huo[13] | Richard Mazurchuk[14] | Nicholas Petrick[15] | Daniele Regge[16,17] | Ravi Samala[18] | Ronald M. Summers[19] | Kenji Suzuki[20] | Georgia Tourassi[21] | Daniel Vergara[22] | Samuel G. Armato III[23]

FUTURE-AI: Guiding Principles and Consensus Recommendations for Trustworthy Artificial Intelligence in Medical Imaging

Karim Lekadir[a,*], Richard Osuala[a], Catherine Gallin[a], Noussair Lazrak[a], Kaisar Kushibar[a], Gianna Tsakou[b], Susanna Aussó[e], Leonor Cerdá Alberich[d], Kostas Marias[c], Manolis Tsiknakis[c], Sara Colantonio[g], Nickolas Papanikolaou[h], Zohaib Salahuddin[f], Henry C Woodruff[f], Philippe Lambin[f], Luis Martí-Bonmatí[d]

FUTURE-AI



www.future-ai.eu

FUTURE-AI

Fair	• Aumentar imparcialidad entre grupos • Aumentar imparcialidad entre individuos
Universal	• Aumentar interoperabilidad • Aumentar transferibilidad
Traceable	• Facilitar responsabilidad / redición de cuentas • Identificar desviaciones de datos o conceptos
Usable	• Aumentar la usabilidad clínica • Aumentar la adopción clínica
Robust	• Robustez a condiciones heterogéneas • Robustez a amenaza de seguridad
Explainable	• Aumentar la transpacencia • Aumentar la aceptación

FUTURE-AI

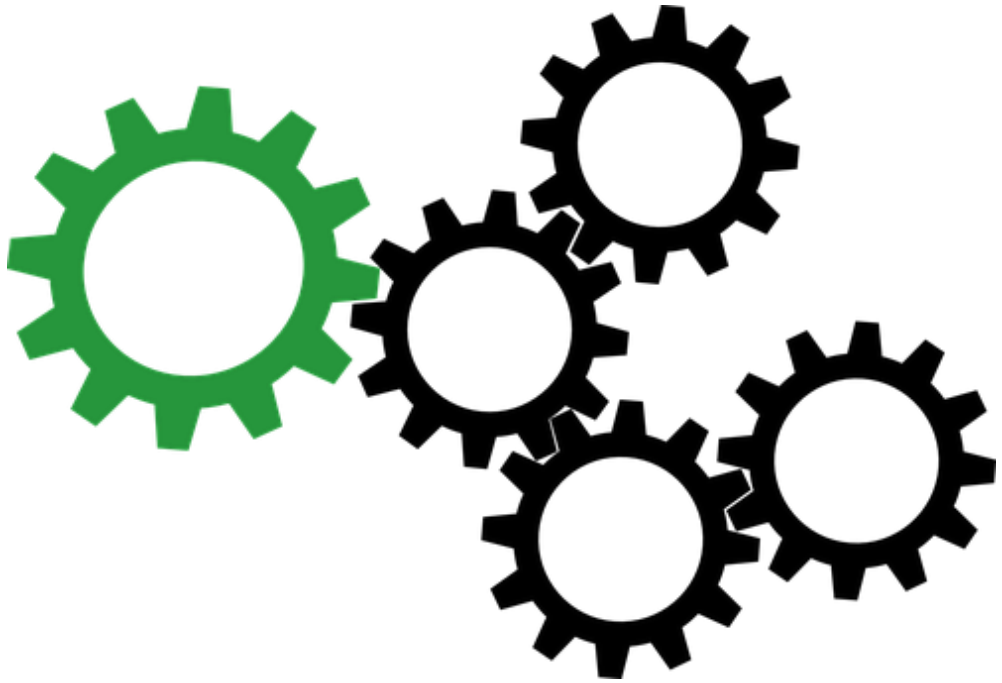
	Criteria	Example
Current models	Performance Metric	• 0.85 AUC • 0.80 F1-Score

Ideas claves

1. Hay un gran “hype” actualmente en el uso de la IA (Deep learning)
2. Las aplicaciones de la IA (en salud) son diversas
3. A pesar de los grandes resultados, la IA tiene limitaciones
4. Debemos ser conocedores de los retos actuales
5. Se debe trabajar en aplicaciones de IA confiable

¿Por dónde empiezo?

- **ACR AI-LAB**: https://ailab.acr.org/
- "**Elementos de IA**" https://www.elementsofai.com/es/
- https://www.fast.ai/
- https://ai.google/education/
- **Pretrained models:**
  - Model Zoo
  - TensorFlow models datasets
  - Pythorch Hub
  - Papers with code
  - Hugging Face
  - medigan (generative models and synthetic dataset generation)
  - GitHub



¡Gracias!

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