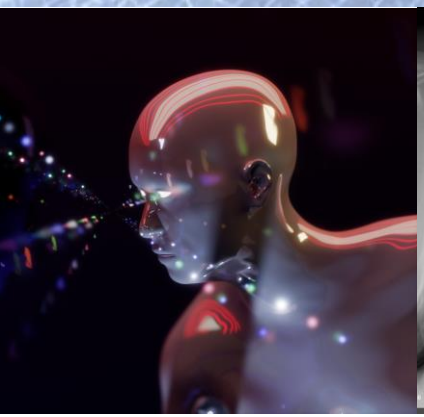
Second IPARCOS Workshop on Machine Learning and Applications to Physics



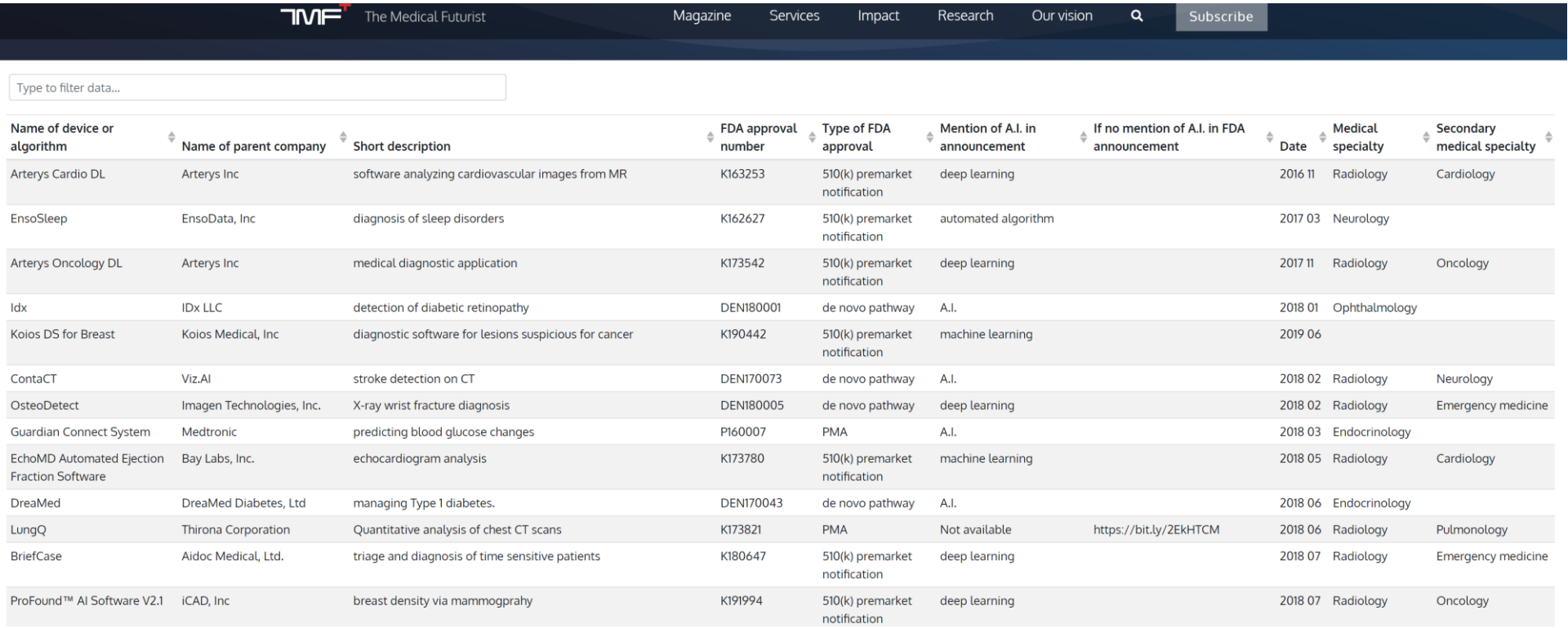
APLICACIONES DE IA EN MEDICINA

Joaquín López Herraiz.
Universidad Complutense de Madrid

Profesor Titular de Universidad
Grupo de Física Nuclear e IPARCOS. Universidad Complutense de Madrid
Instituto de Investigación Sanitaria del Hospital Clínico San Carlos (IdISSC), Madrid

IA EN BIOMEDICINA YA ES UNA REALIDAD

https://medicalfuturist.com/fda-approved-ai-based-algorithms/



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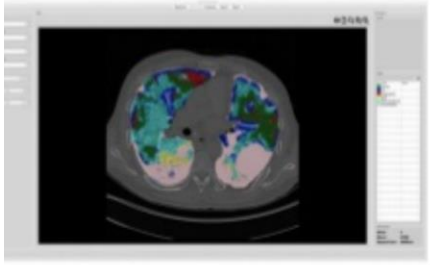
Type to filter data...

Name of device or algorithm	Name of parent company	Short description	FDA approval number	Type of FDA approval	Mention of A.I. in announcement	If no mention of A.I. in FDA announcement	Date	Medical specialty	Secondary medical specialty
Arterys Cardio DL	Arterys Inc	software analyzing cardiovascular images from MR	K163253	510(k) premarket notification	deep learning		2016 11	Radiology	Cardiology
EnsoSleep	EnsoData, Inc	diagnosis of sleep disorders	K162627	510(k) premarket notification	automated algorithm		2017 03	Neurology	
Arterys Oncology DL	Arterys Inc	medical diagnostic application	K173542	510(k) premarket notification	deep learning		2017 11	Radiology	Oncology
Idx	IDx LLC	detection of diabetic retinopathy	DEN180001	de novo pathway	A.I.		2018 01	Ophthalmology	
Koios DS for Breast	Koios Medical, Inc	diagnostic software for lesions suspicious for cancer	K190442	510(k) premarket notification	machine learning		2019 06		
ContaCT	Viz.AI	stroke detection on CT	DEN170073	de novo pathway	A.I.		2018 02	Radiology	Neurology
OsteoDetect	Imagen Technologies, Inc.	X-ray wrist fracture diagnosis	DEN180005	de novo pathway	deep learning		2018 02	Radiology	Emergency medicine
Guardian Connect System	Medtronic	predicting blood glucose changes	P160007	PMA	A.I.		2018 03	Endocrinology	
EchoMD Automated Ejection Fraction Software	Bay Labs, Inc.	echocardiogram analysis	K173780	510(k) premarket notification	machine learning		2018 05	Radiology	Cardiology
DreaMed	DreaMed Diabetes, Ltd	managing Type 1 diabetes.	DEN170043	de novo pathway	A.I.		2018 06	Endocrinology	
LungQ	Thirona Corporation	Quantitative analysis of chest CT scans	K173821	PMA	Not available	https://bit.ly/2EkHTCM	2018 06	Radiology	Pulmonology
BriefCase	Aidoc Medical, Ltd.	triage and diagnosis of time sensitive patients	K180647	510(k) premarket notification	deep learning		2018 07	Radiology	Emergency medicine
ProFound™ AI Software V2.1	iCAD, Inc	breast density via mammogprahy	K191994	510(k) premarket notification	deep learning		2018 07	Radiology	Oncology

Ejemplos de Aplicaciones

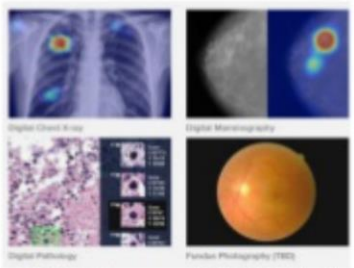
- Clinical trials on AI Medical Device (kFDA)
  - Vuno – Bone aging
  - Lunit - Chest PA X-ray Nodule CAD
  - JLK Inspection - Stroke MRI CAD
  - Midas IT – Dementia MRI Index

VUNO



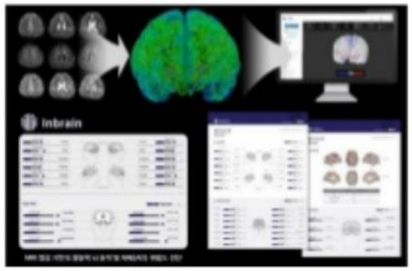
DILD lung disease

Lunit



Chest PA, Mammo CAD, Pathology, etc

MIDAS

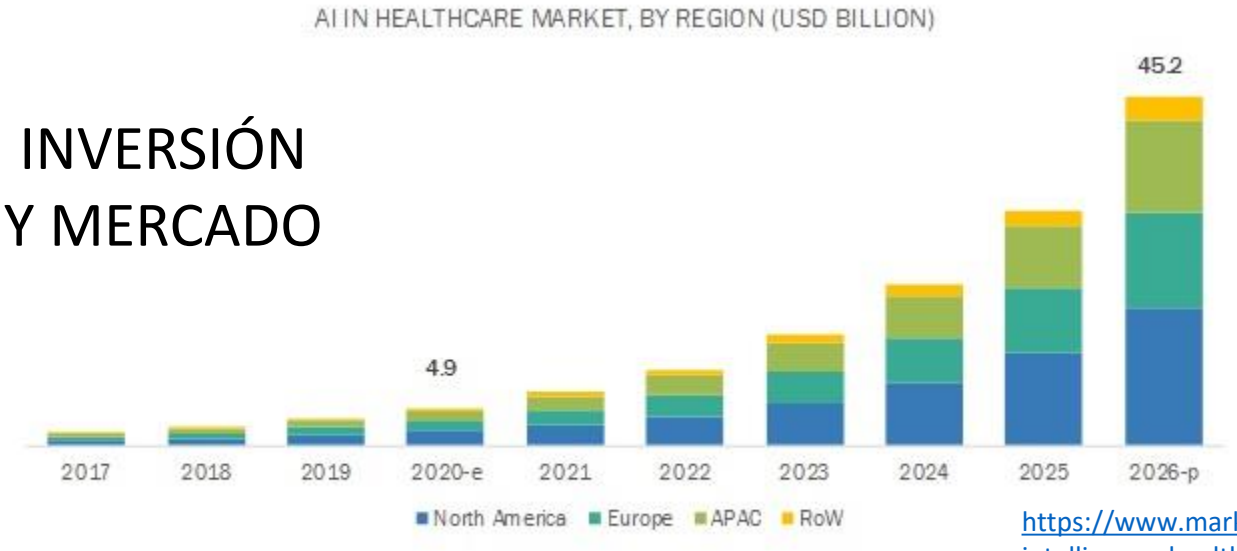


Dementia MRI

JLK INSPECTION

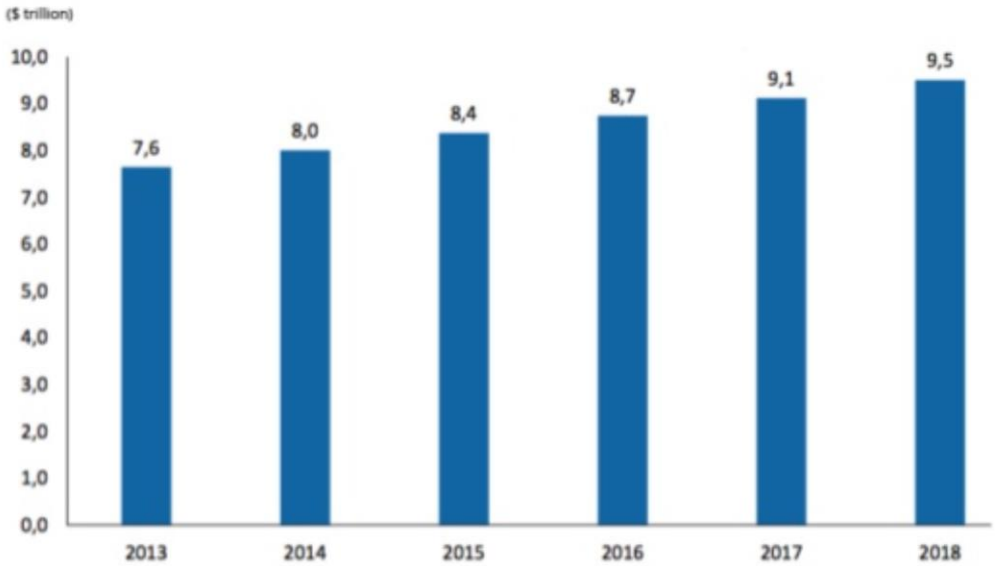
Stroke MRI CAD (3rd grade)

INVERSIÓN Y MERCADO

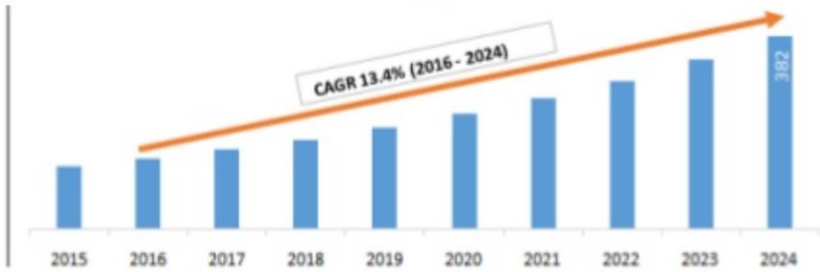


https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-healthcare-market-54679303.html

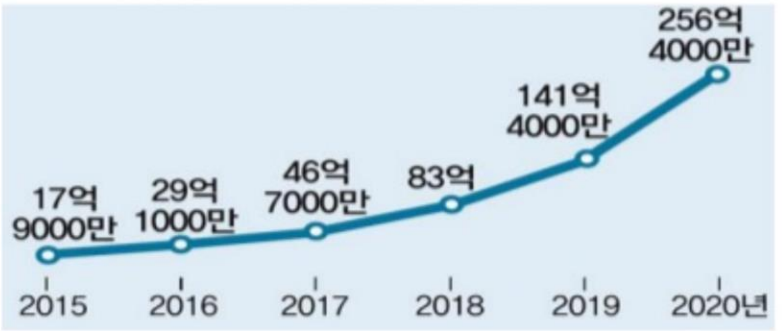
- Healthcare AI Market Size:
  - 10B USD(1조원)@ 2015 -> 67B USD(7조원)@2021, CAGR : 42%/y*



Global healthcare expenditure**



Global IT healthcare market**



AI healthcare market @ SouthKorea****

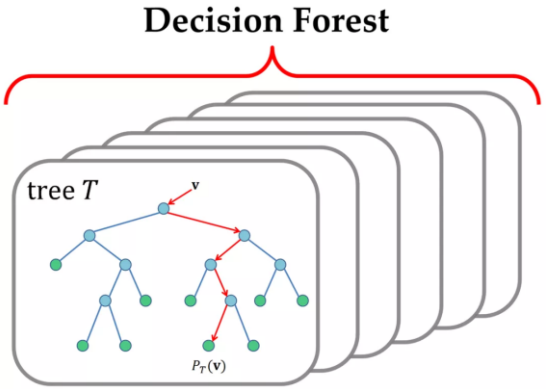
Ads 20B USD <<< Healthcare 9,500B USD (50x)

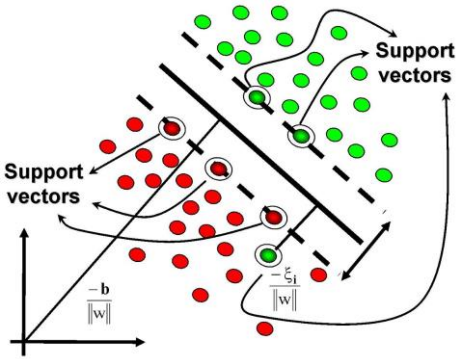
[CASO 0] ANÁLISIS DE TABLA DE DATOS DE CANCER DE MAMA

https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+%28Diagnostic%29

Machine Learning (Pre-DL)

1. Analizar el problema, definir y localizar ciertas características
2. Analizar esas características y seleccionar las más distintivas.
3. Aplicar algoritmos de ML (Classifiers, regression, clustering, etc.)





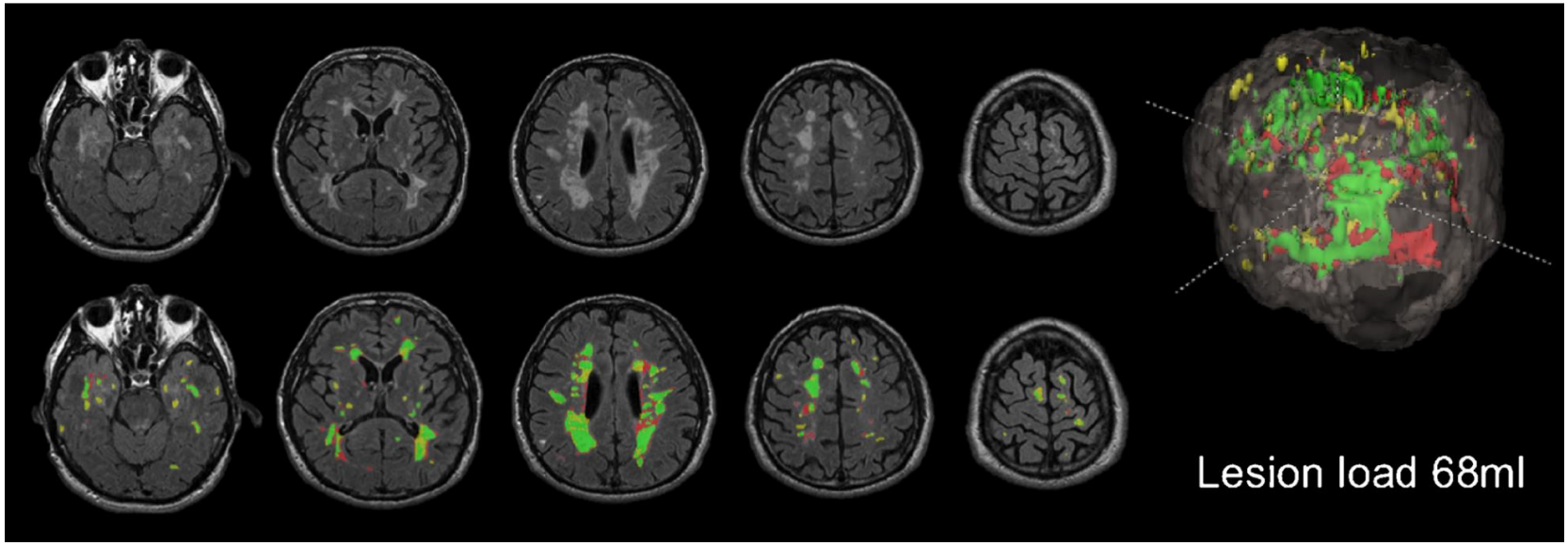
EJEMPLO (MUY COMPLETO):

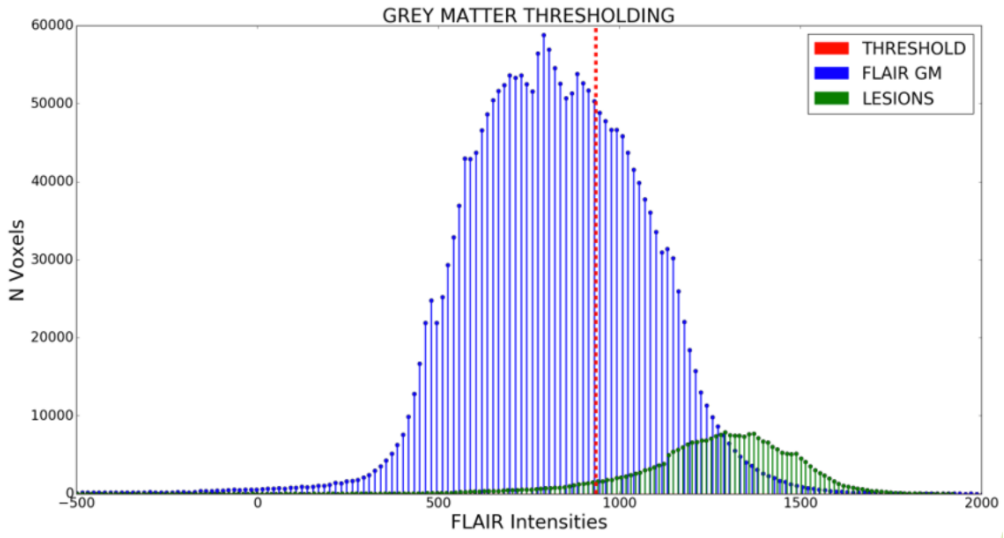
https://colab.research.google.com/github/gal-a/blog/blob/master/docs/notebooks/sklearn/sklearn_logistic_regression_vs_gbm.ipynb

EJEMPLO CON DEEP LEARNING:

https://colab.research.google.com/drive/1ynrs_swvE_KXvZePHiSy5dDj5pAZzd-U?usp=sharing

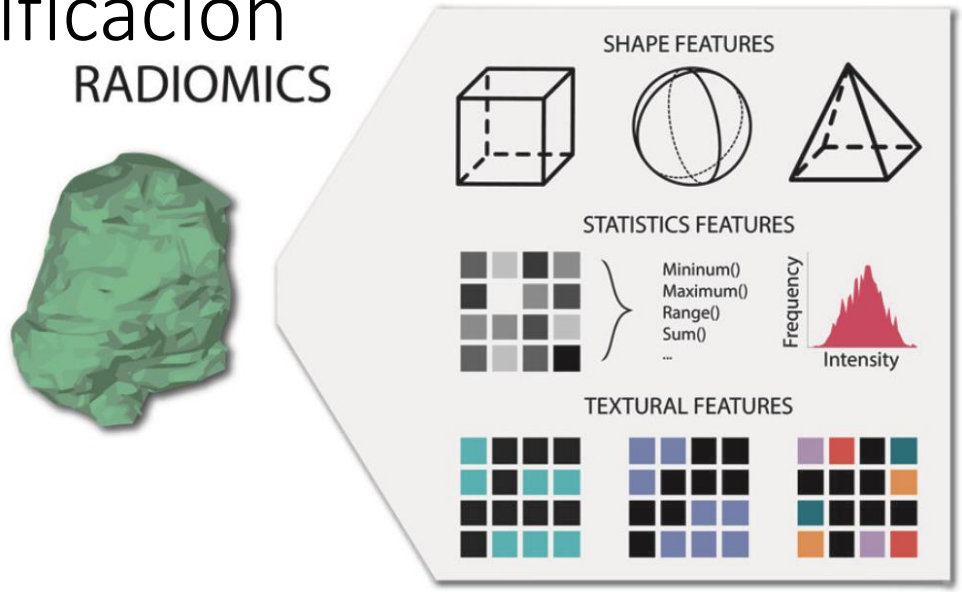
[CASO 1] Segmentación de lesiones de Esclerósis Múltiple en Imágenes de MRI

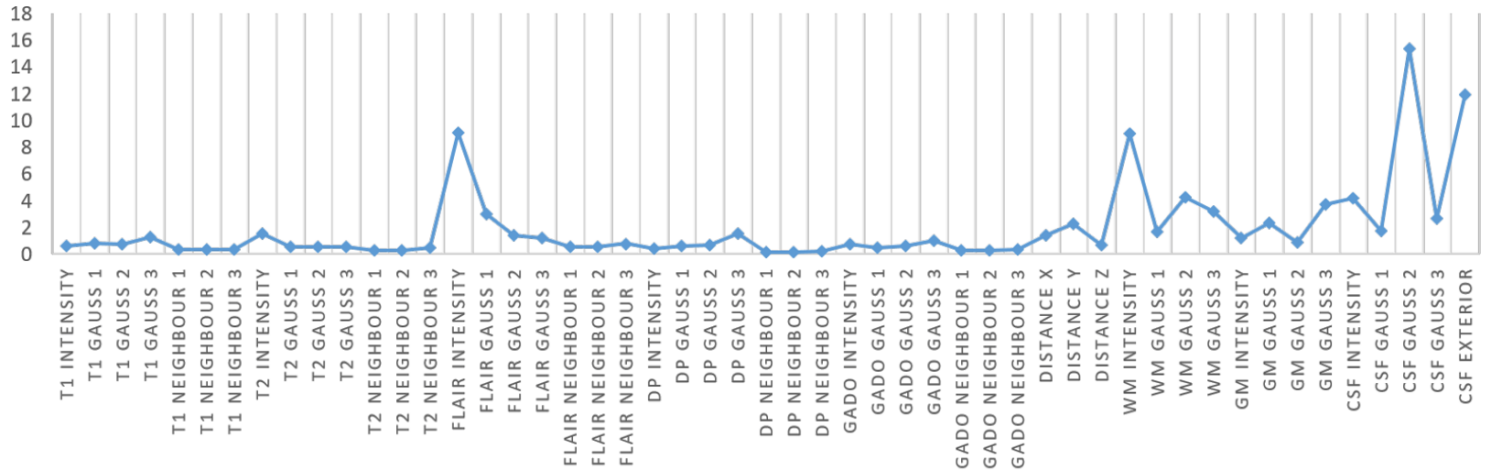




Un único parámetro no es suficiente para separar ambas distribuciones

Radiómica – Extracción de múltiples parámetros (Features) de las imágenes para mejorar clasificación





[CASO 2]

- 52,799 new cases of salivary glands cancer per year and 22,176 registered deaths [Bray et al., 2018].
- Parotid gland tumors represent between 3 and 10% of head and neck tumors and less than 1% of all tumors in the body.
- The most common types are Pleomorphic Adenomas (PA) and Warthin Tumors (WT).
- **While pleomorphic Adenomas can grow larger and present a 5% risk of malignant evolution, the Warthin's tumor has less than 0.6% risk.**

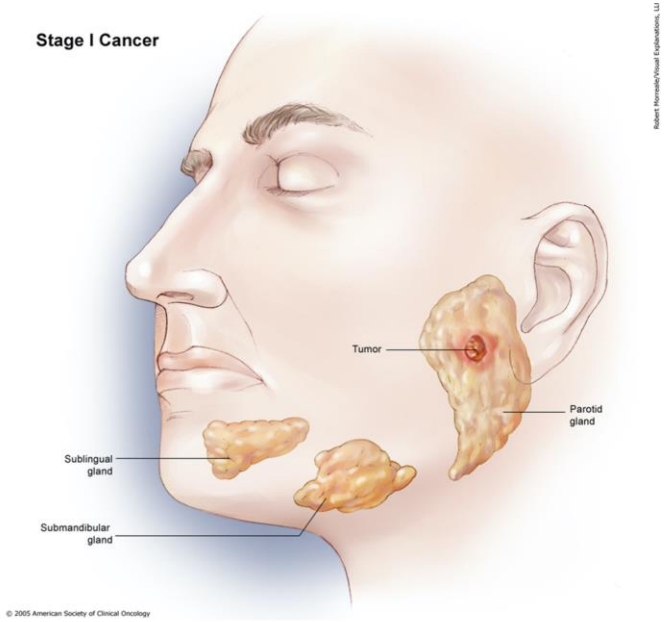
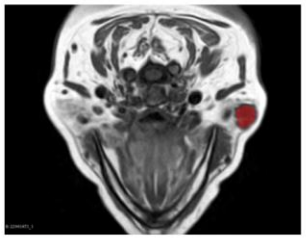
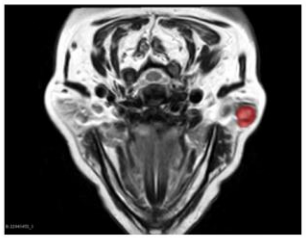


Figure 1: Salivary Gland Cancer (Stage I)

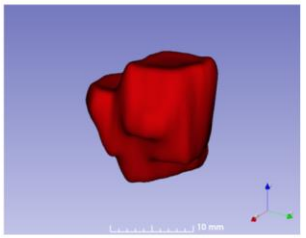
Detección de tipo de Tumor



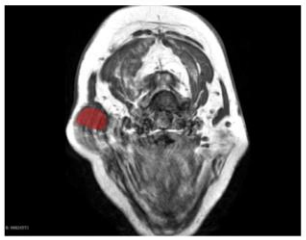
(a) PA on T1 sequence



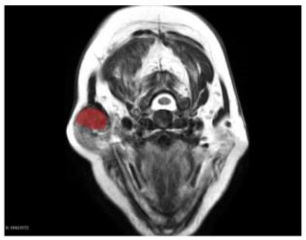
(b) PA on T2 sequence



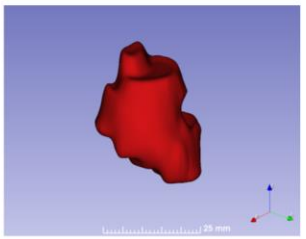
(c) 3D view of PA



(d) WT on T1 sequence



(e) WT on T2 sequence

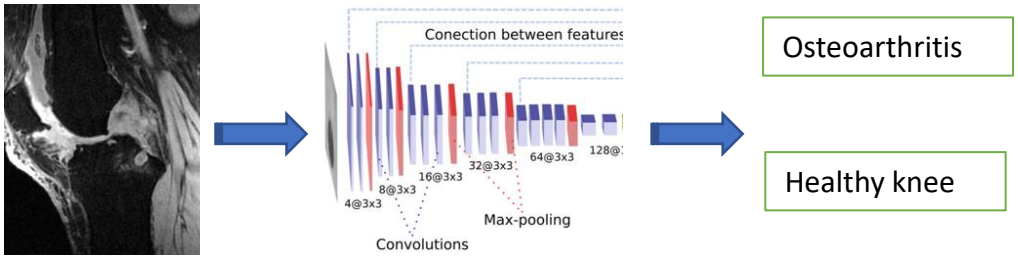


(f) 3D view of WT

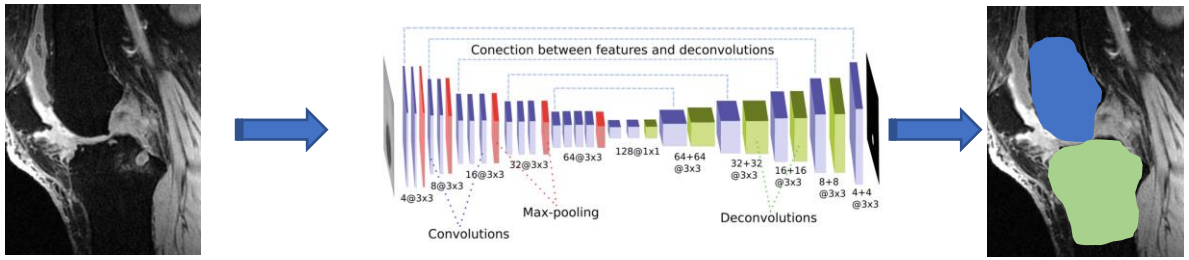
[CASO 3] – ANÁLISIS DE RODILLA

Clasificación vs. Segmentación

- Clasificación:



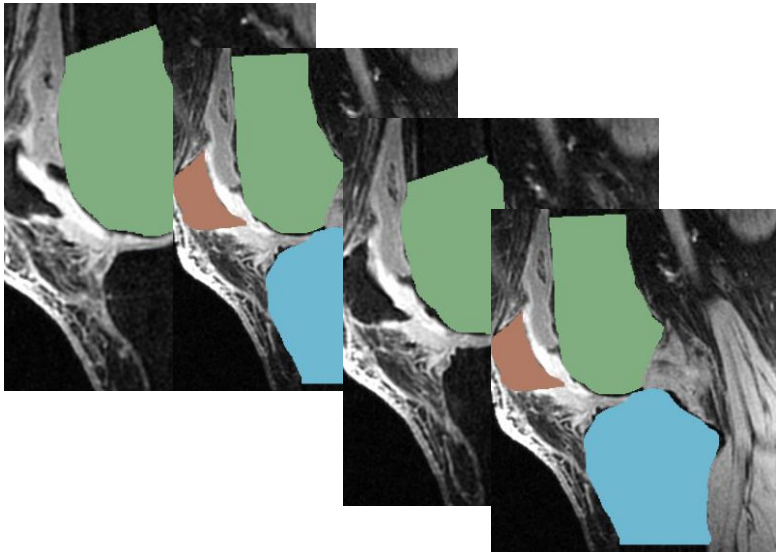
- Segmentación: Detección de regiones en la imagen



Big Data vs Smart Data

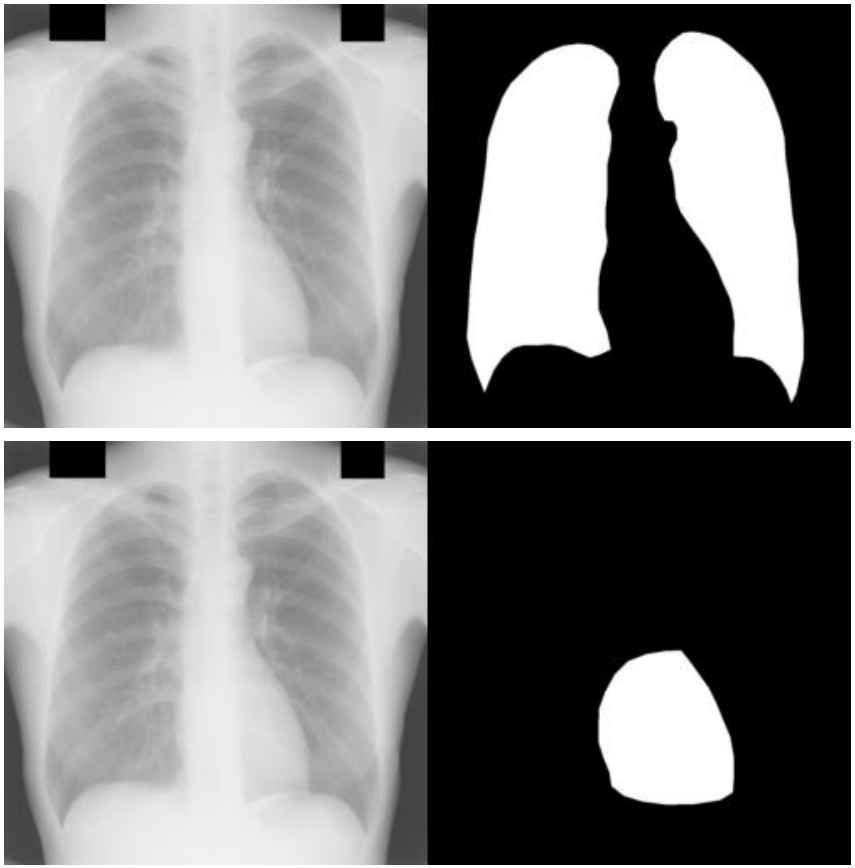
- El entrenamiento de los modelos requiere largas bases de datos, que cubran la mayor cantidad posible de casos y situaciones.

- Pero, más que la cantidad, importa la calidad. Hacen falta bases de datos bien anotadas (segmentaciones correctas, anotaciones útiles..)



[CASO 3B] – Segmentación de Pulmón

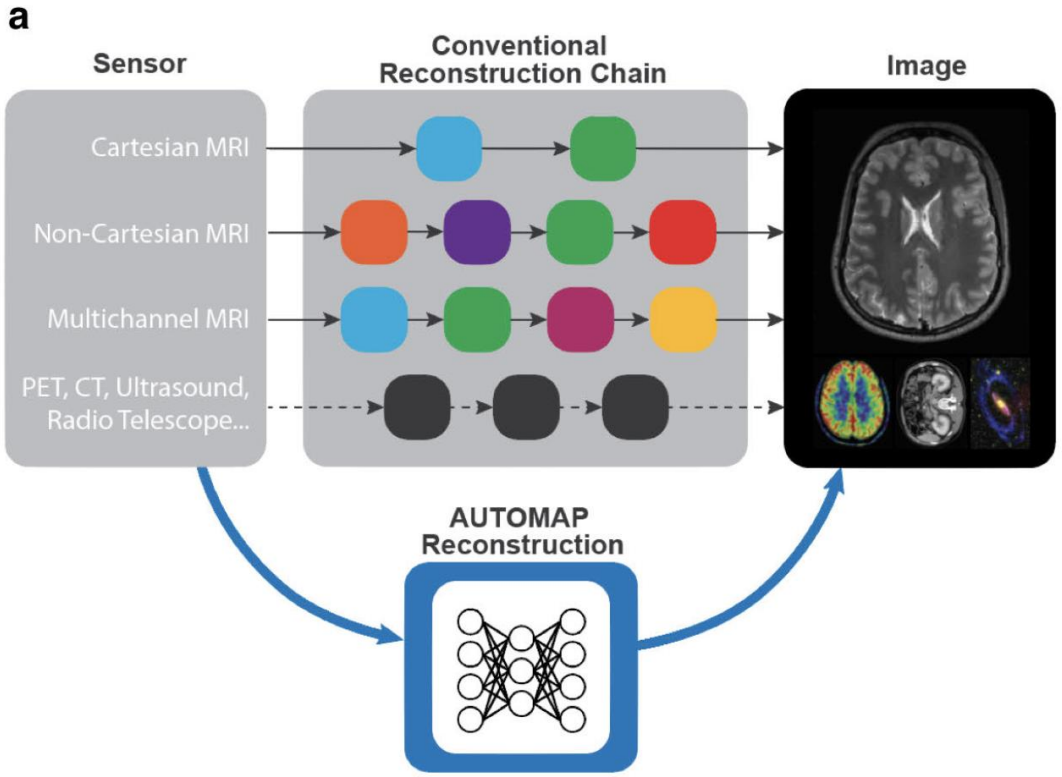
- Segmentación: Detección de regiones en la imagen

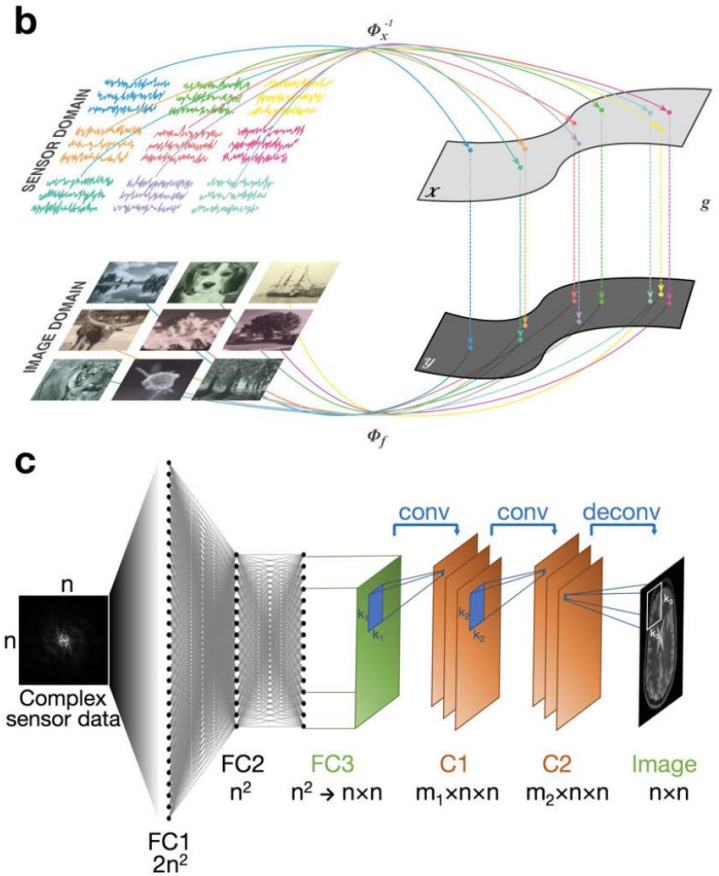


Se usa red neuronal entrenada con un número suficiente de casos de entrada
(Pares de imágenes de Chest X-ray & Segmented Organ)

[CASO 4]

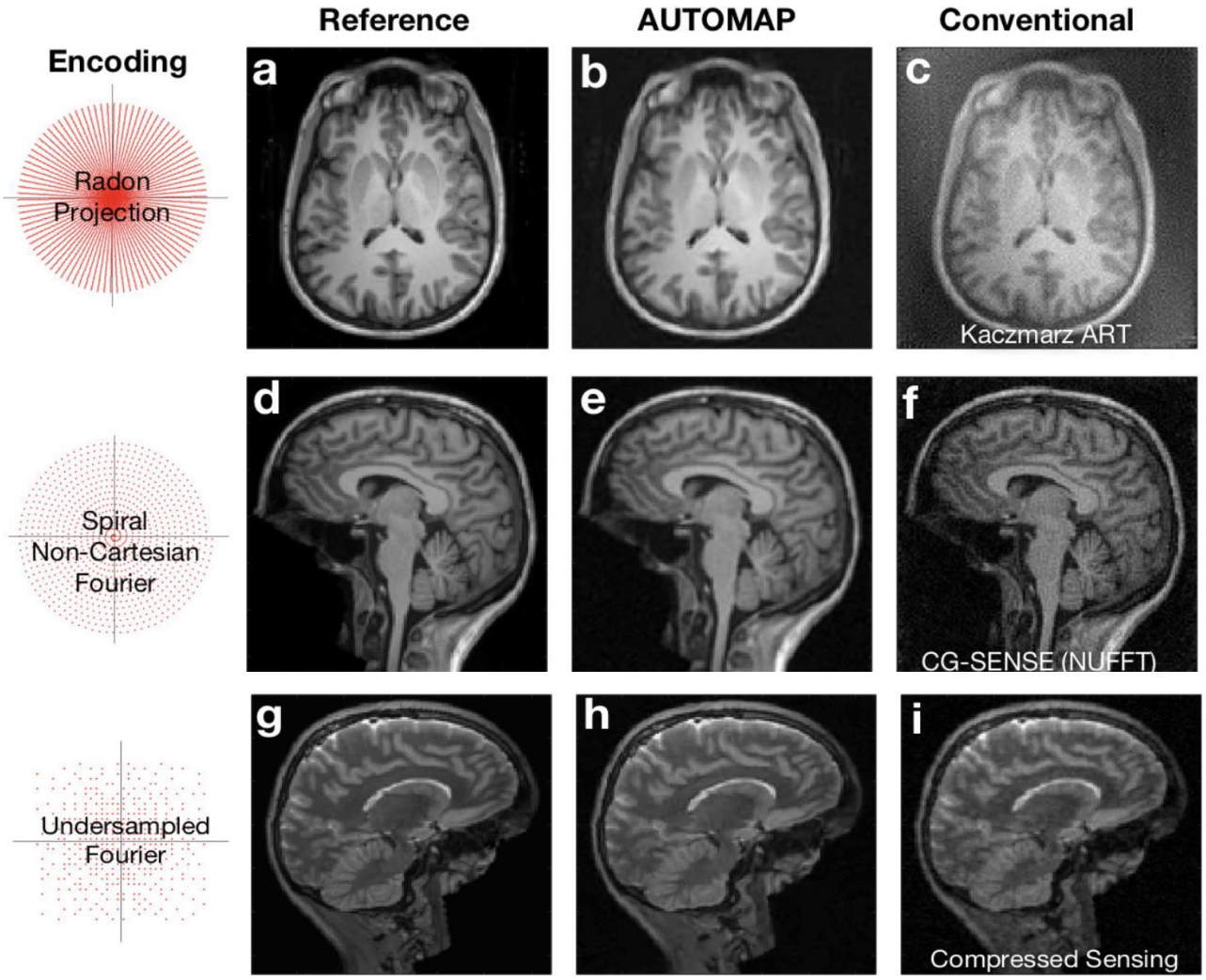
Adquisición y Reconstrucción de Imagen en Resonancia Magnética (Medidas mucho más rápidas)





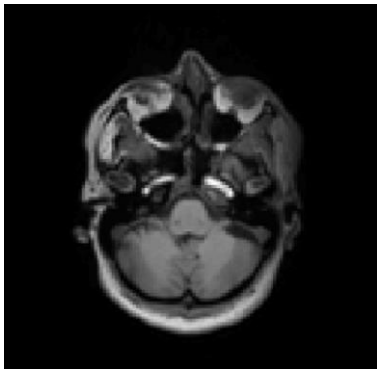
Zhou et al. Nature, 2017

DL based MR image acquisition

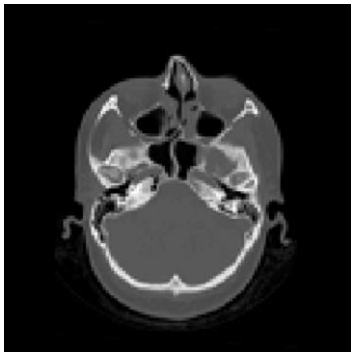


[CASO 5] Detección de Huesos en MRI

El hueso no aparece en las imágenes de MRI (con adquisiciones estándar), mientras que se observa muy bien en CT.

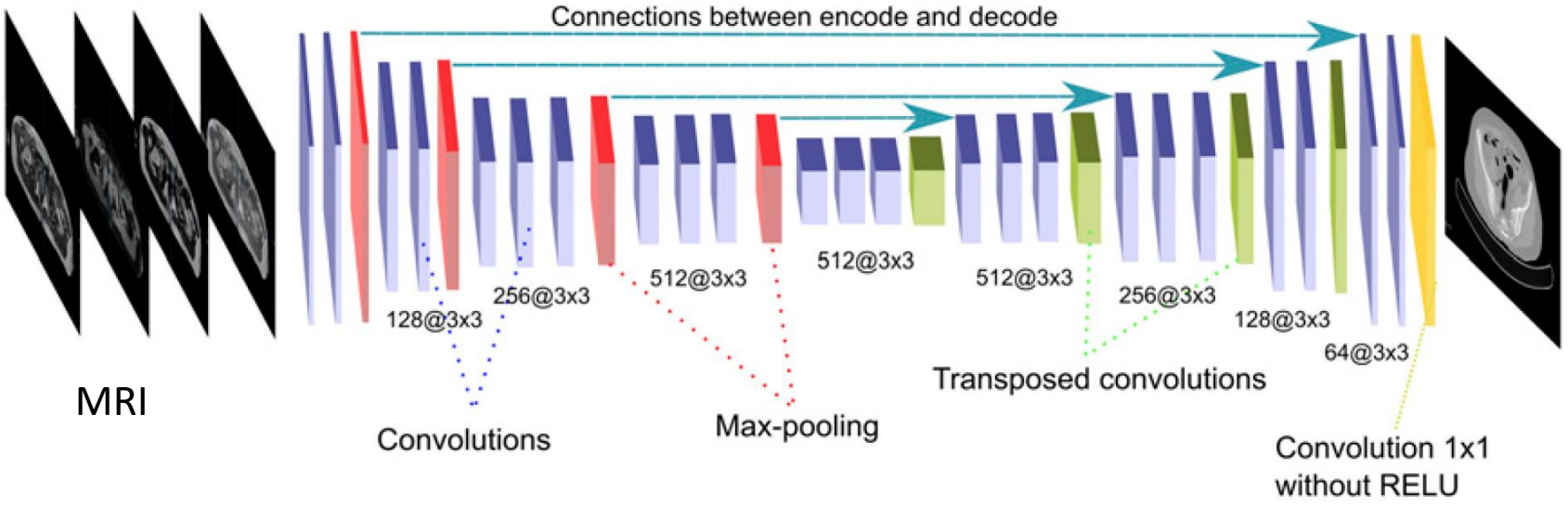


MRI

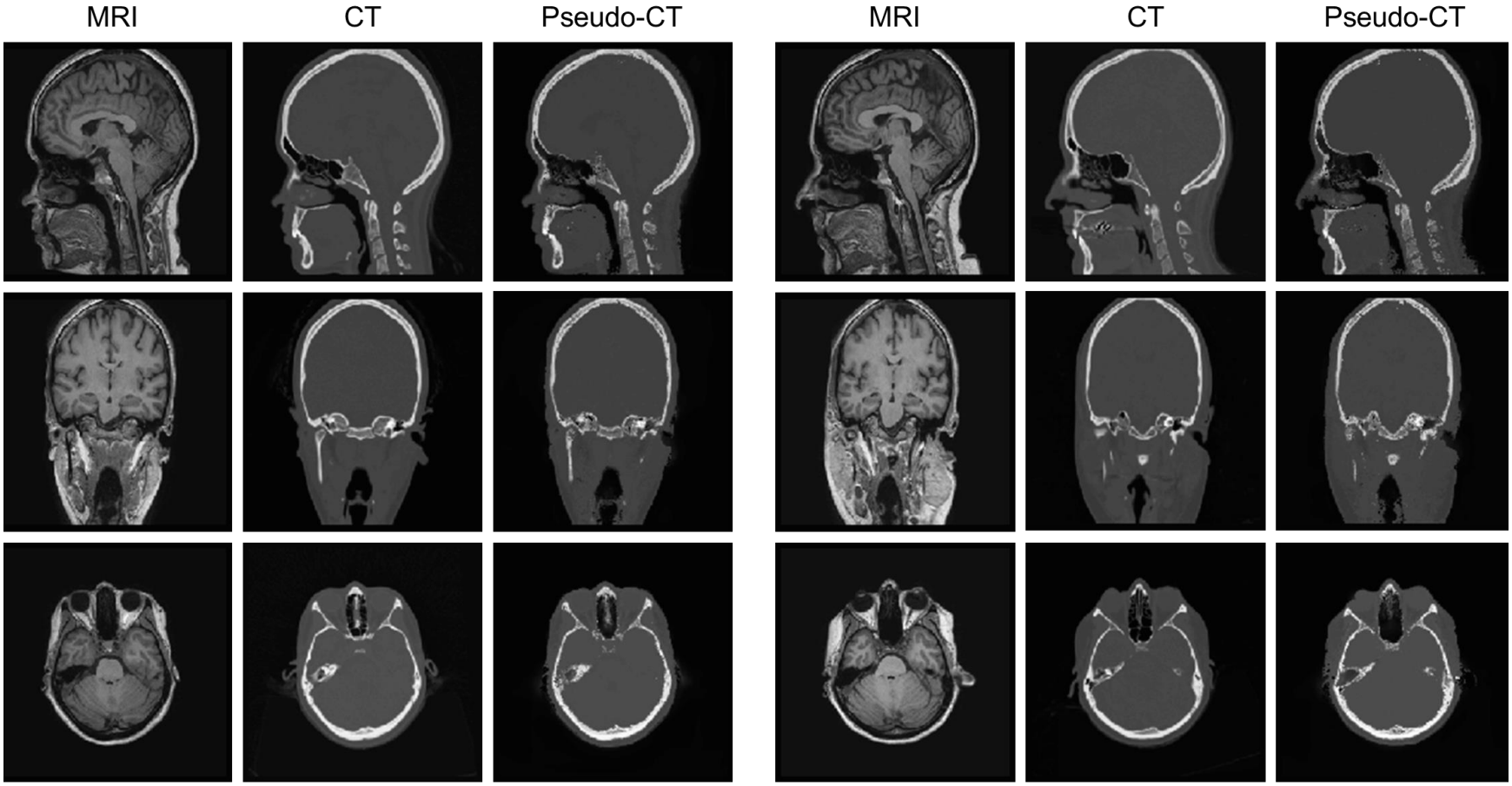


CT

Solución: Generar imágenes pseudo-CT a partir de MRI

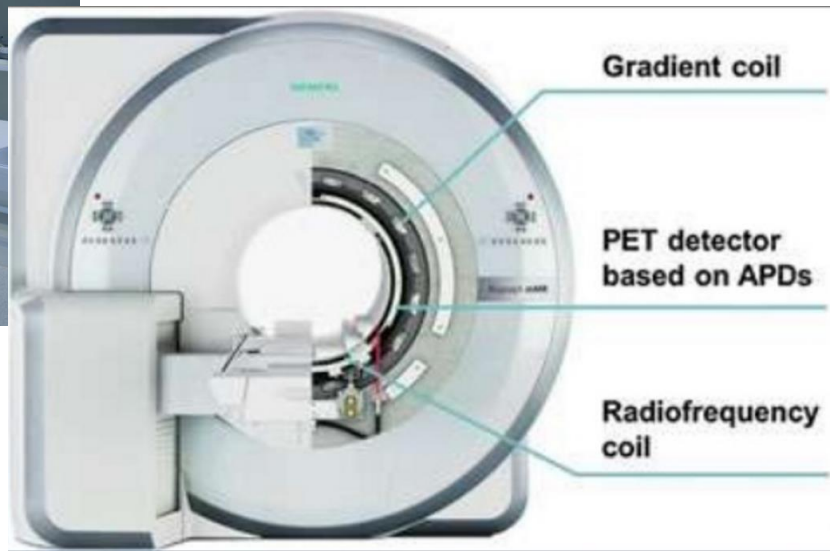


Resultado:



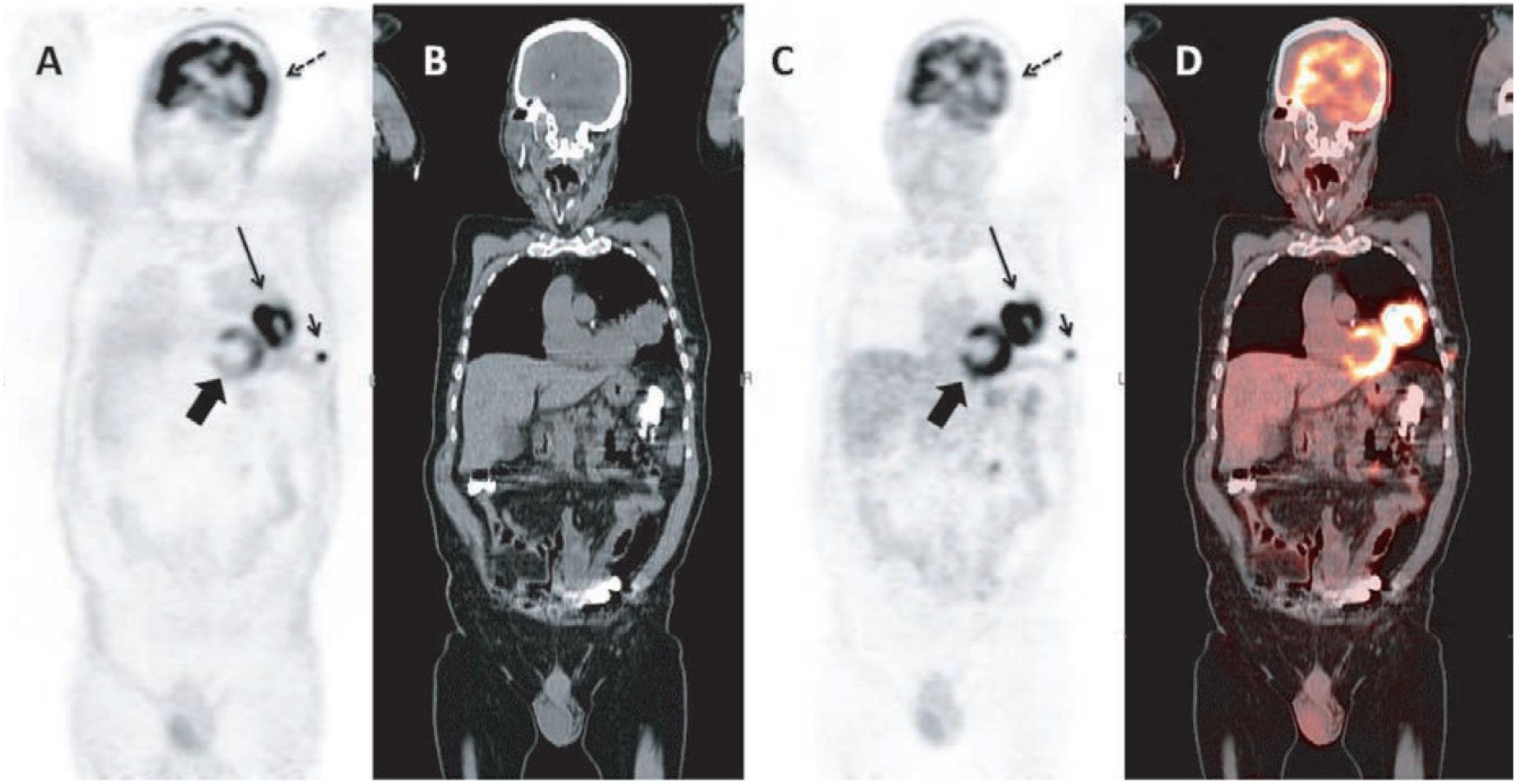
¿Para qué queremos ver los huesos?

PET/MR IMAGING



HOSPITAL UNIVERSITARIO
HOSPITALES hm puerta del sur

Corrección de atenuación en PET

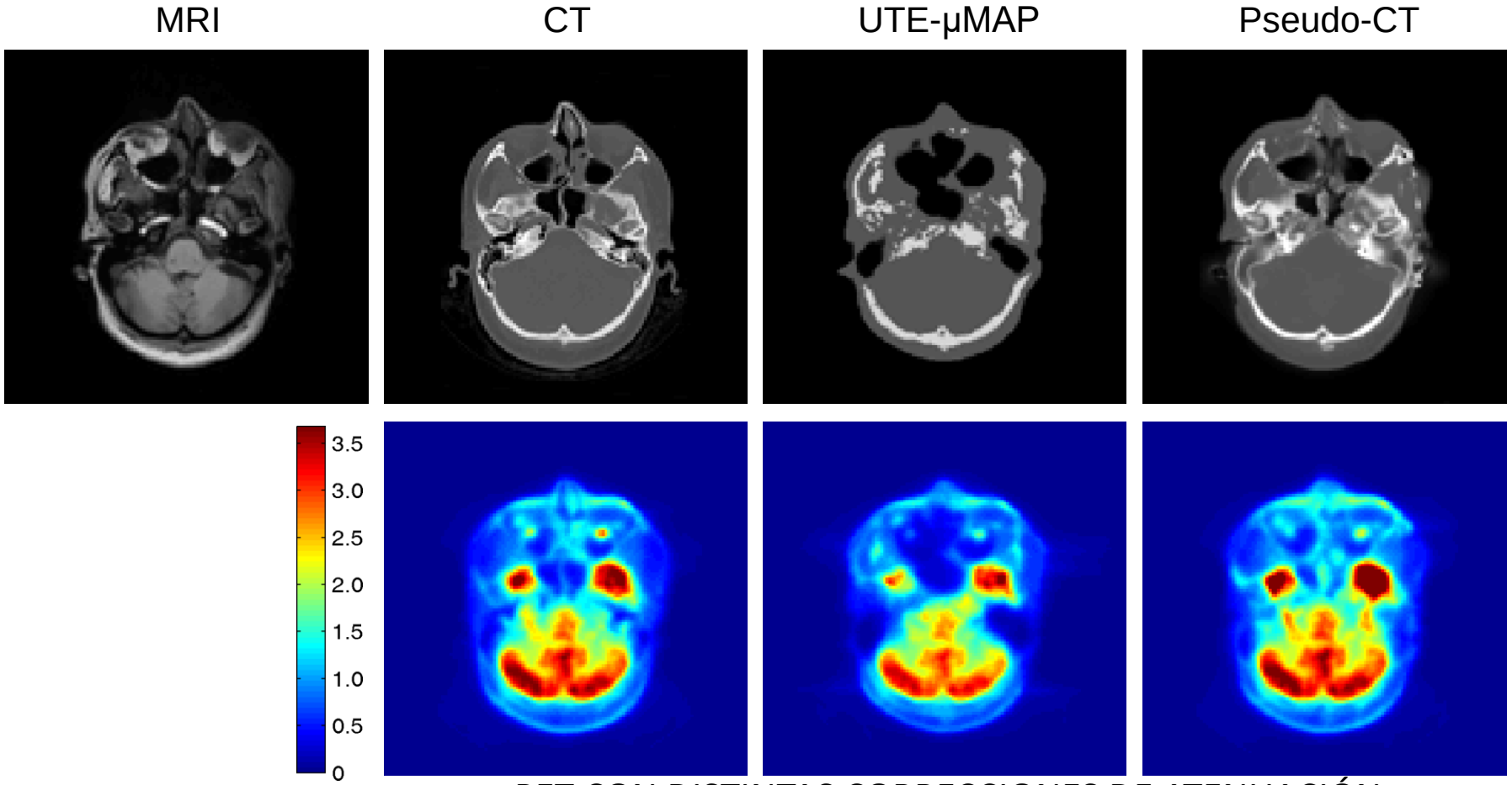


SIN CORRECCIÓN

CON CORRECCIÓN

Coronal slice of a PET/CT acquisition. From Suetens, 2009

Results. Clinical data

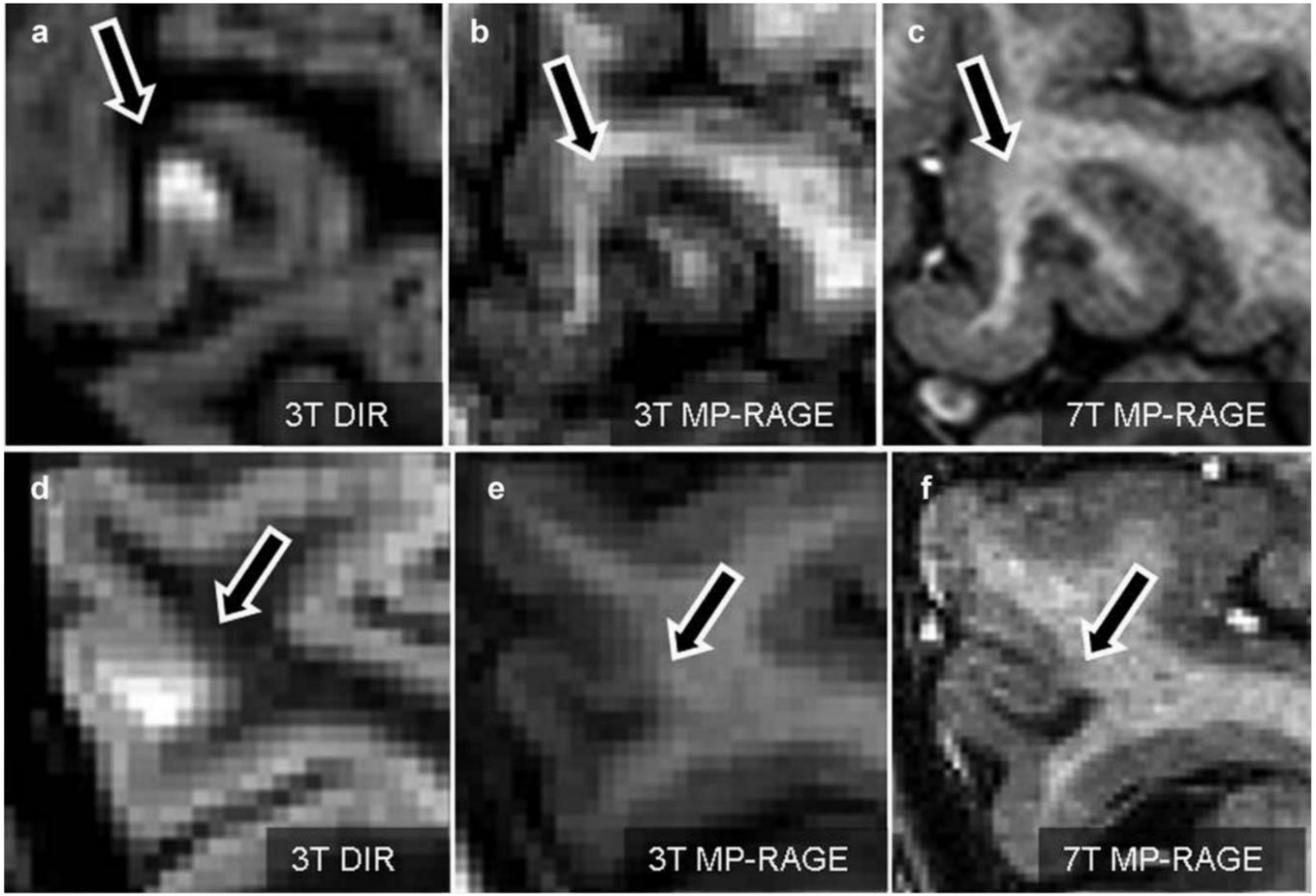


PET CON DISTINTAS CORRECCIONES DE ATENUACIÓN

Torrado-Carvajal, J.L. Herraiz et al. Journal of Nuclear Medicine, 2016

[CASO 6]

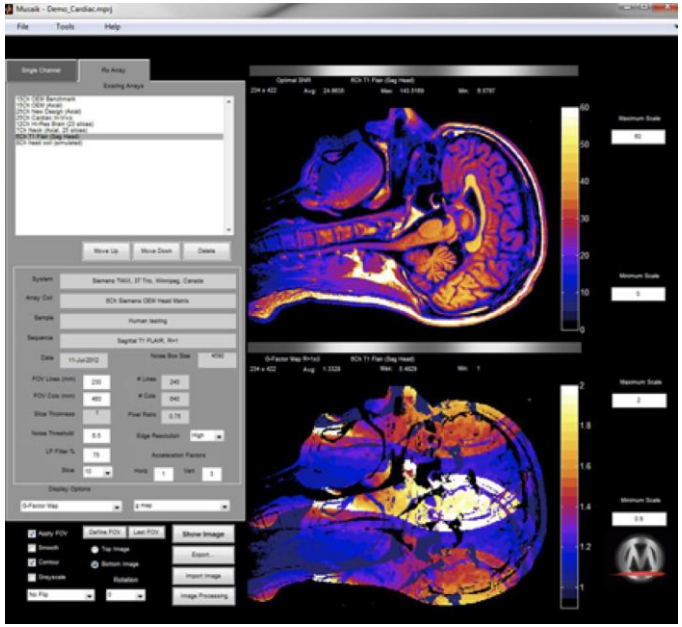
Mejora de la detección de Lesiones de Esclerosis múltiple con MRI de alto campo magnético

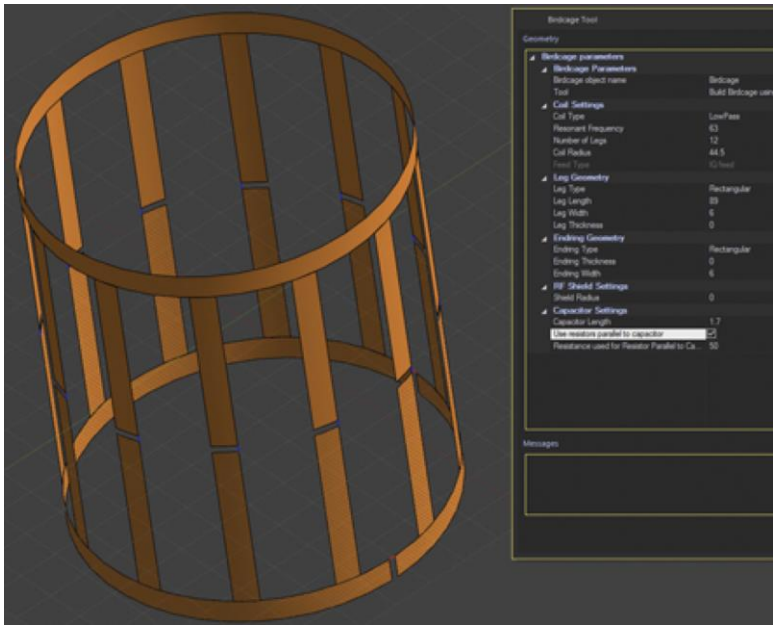


Tallantyre at al. JMRI 2010

Limitación principal en MRI-7T: SAR

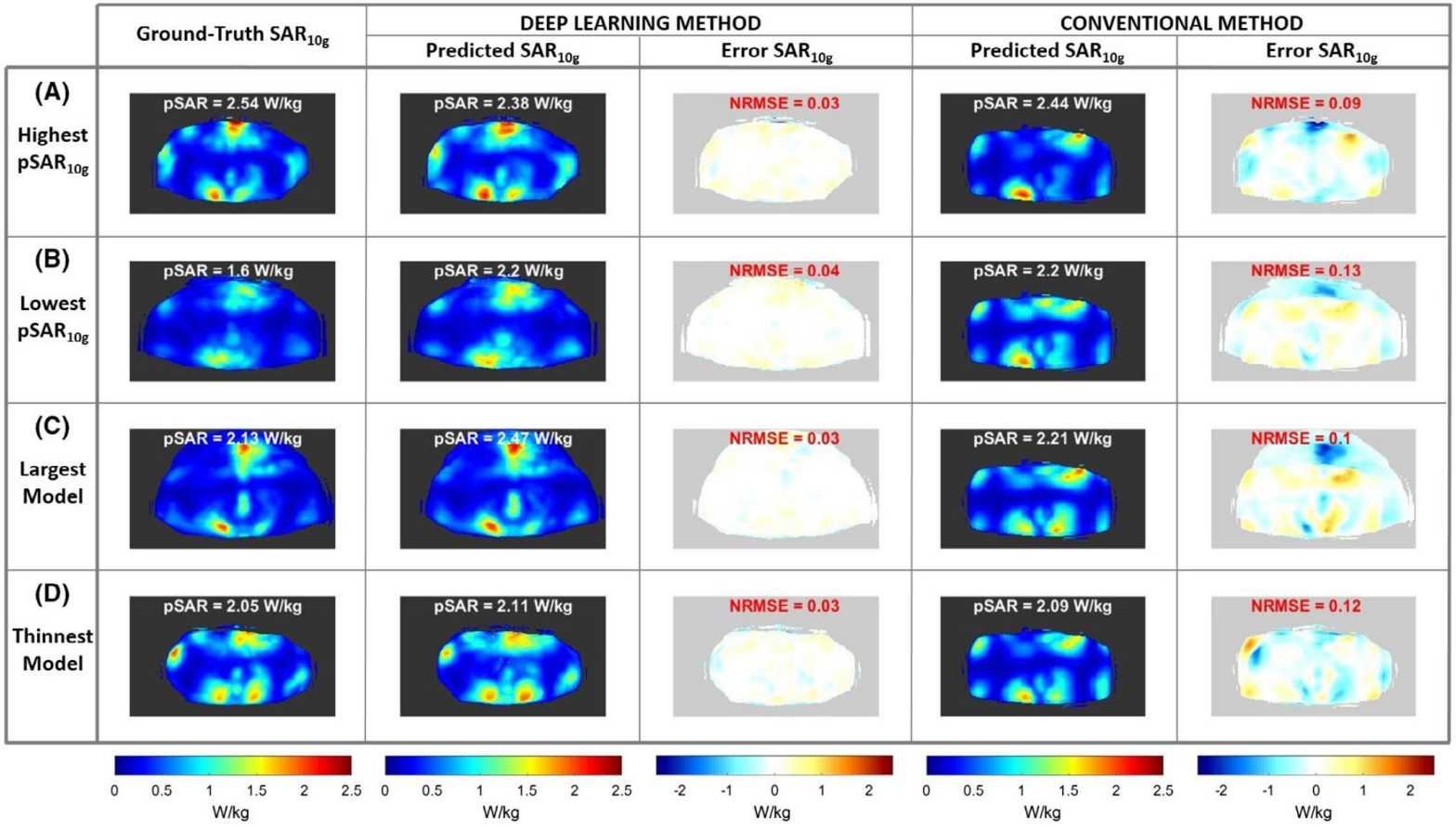
- SAR (Tasa de Absorpción Específica) determina la deposición de energía de radiación electromagnética en un tejido. Importante para MRI de alto campo magnético. Se puede superar el límite permitido
- ¡Riesgo de calentar tejidos en el cerebro!





SIM4Life, Zurich Med Tech

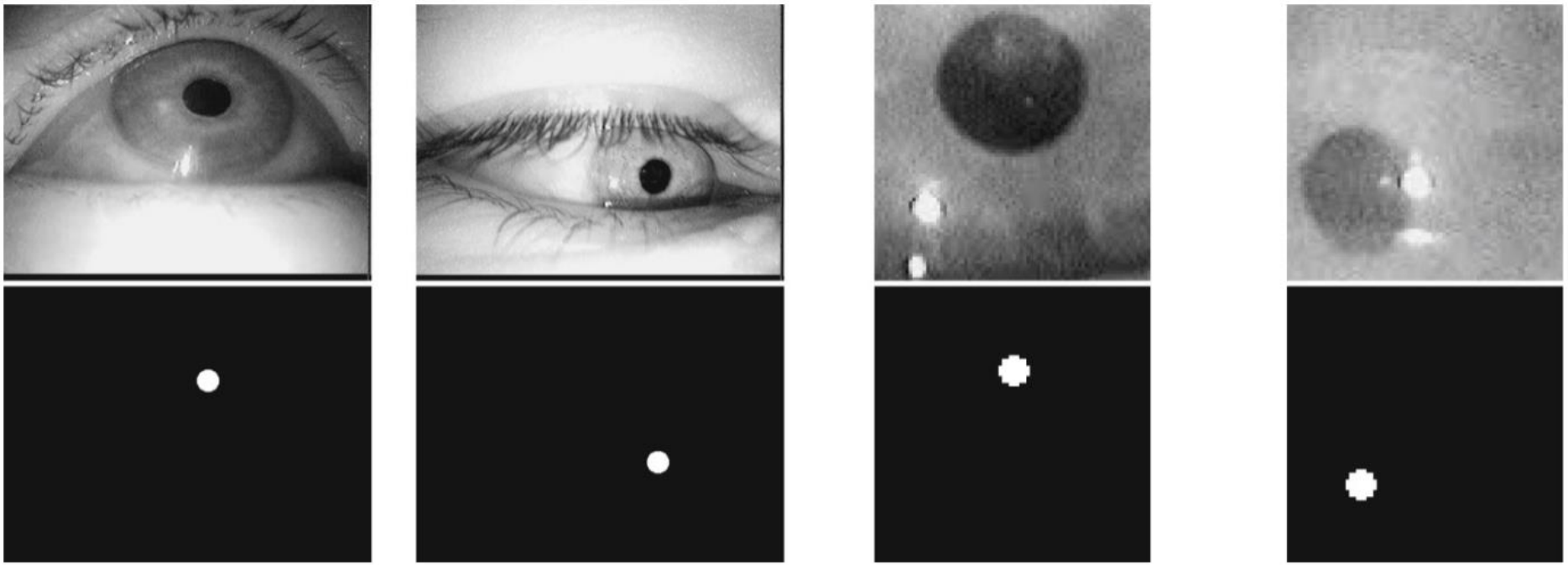
Resultados de DL-based SAR estimation.



Límite legal: 4W/kg
(Preferible no superar 2W/kg)

Meliado et al. MRM, 2019

[CASO 7] ¿Dónde estás mirando?



IWINAC 2017 19 June in A Coruña Spain
Base de Datos Anotada

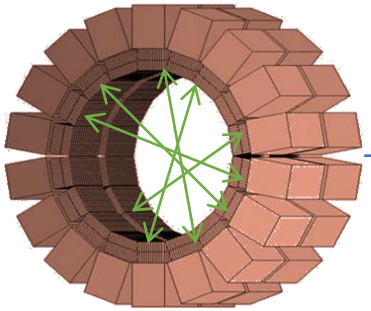
[CASO 8]

RECONSTRUCCIÓN TOMOGRAFICA

1) Adquisición de Datos

PACIENTE O ANIMAL

ESCANER PET



DATOS

2) Reconstrucción de Imagen (Problema Inverso)

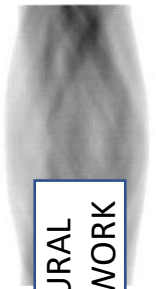
IMAGEN

NEURAL NETWORK

Análisis Automático

TRAINED
NEURAL NETWORK

DATOS

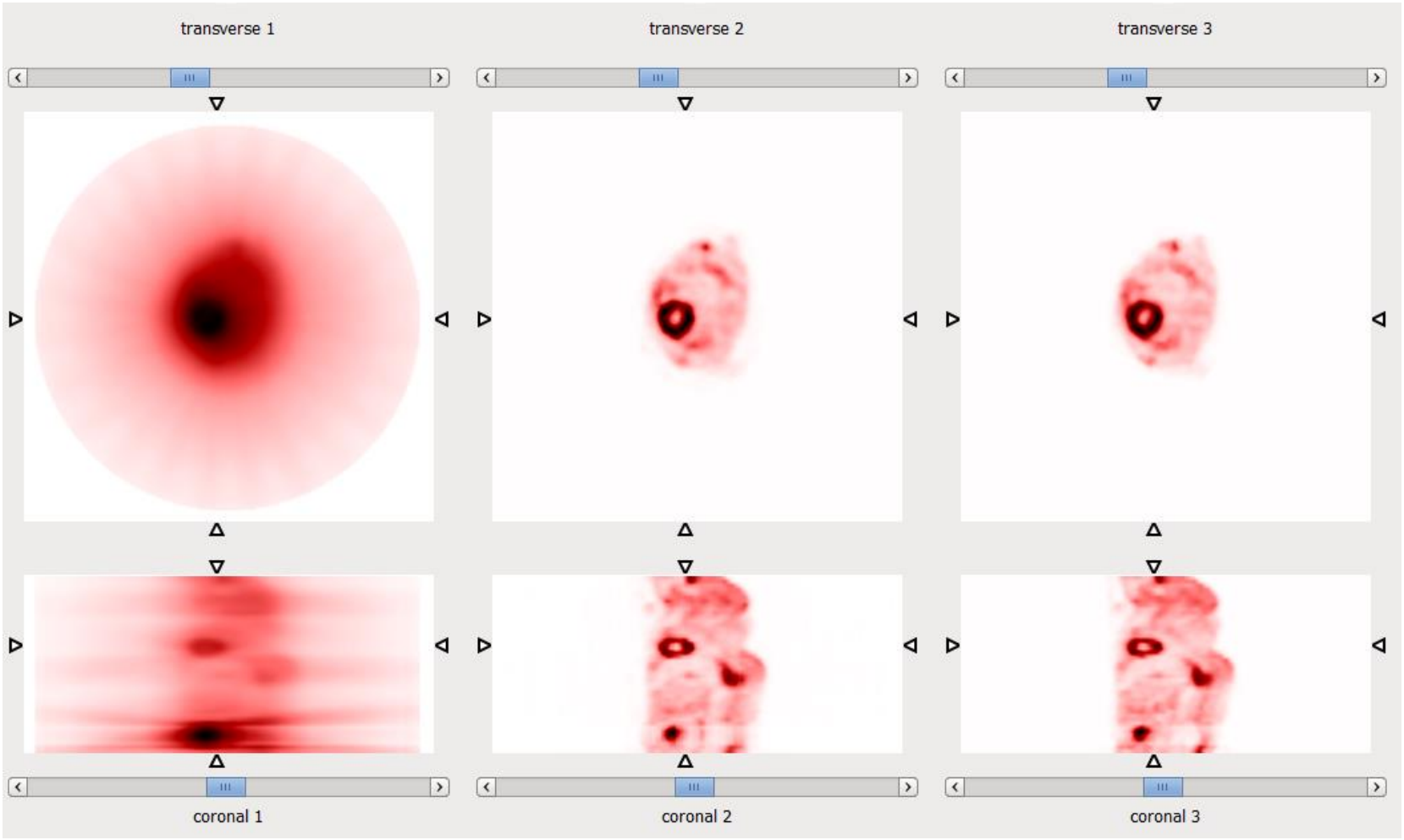


NEURAL NETWORK

Análisis Automático

TOMOGRAFIA CON PIX2PIX

DATOS RECONSTRUCCIÓN NN REFERENCIA

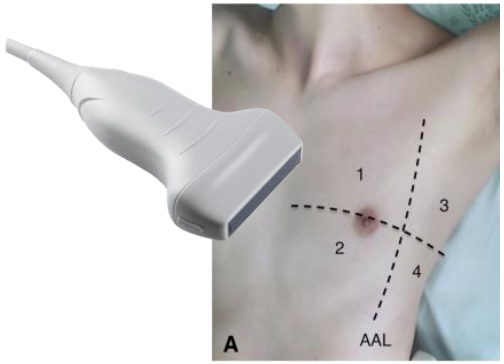


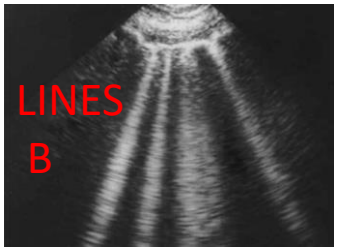
[CASO 9]

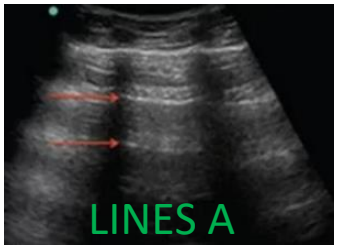
AI IN LUNG ULTRASOUND

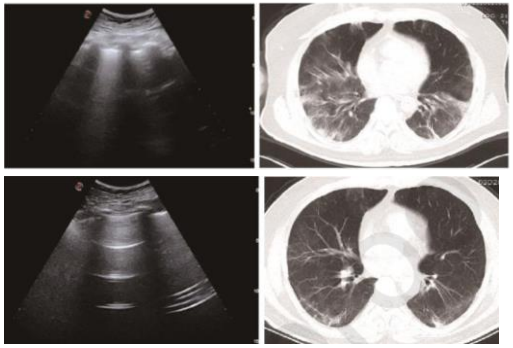
ULTRACOV

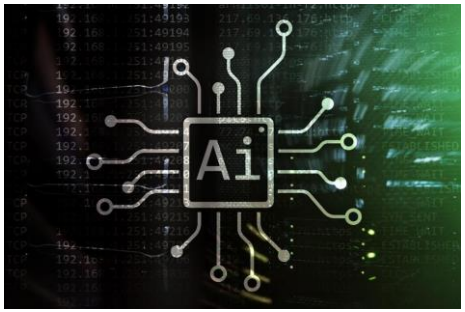
http://ultracov.daselsistemas.com/











SCORE

CDTI Centro para el Desarrollo Tecnológico Industrial

dasel sistemas

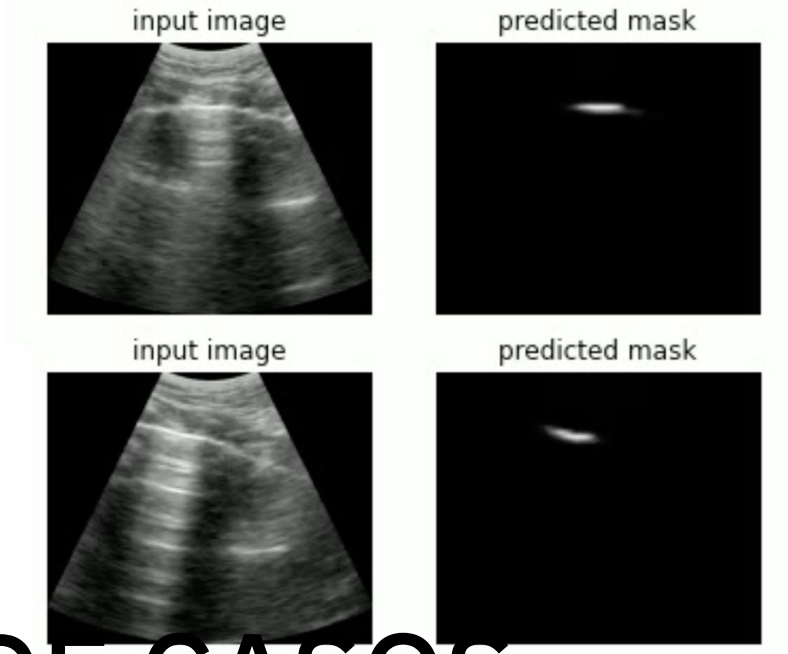
Gobierno de España · Ministerio de Ciencia, Innovación y Universidades

Universidad Complutense Madrid

Servicio de Urgencias Hospital Universitario La Paz

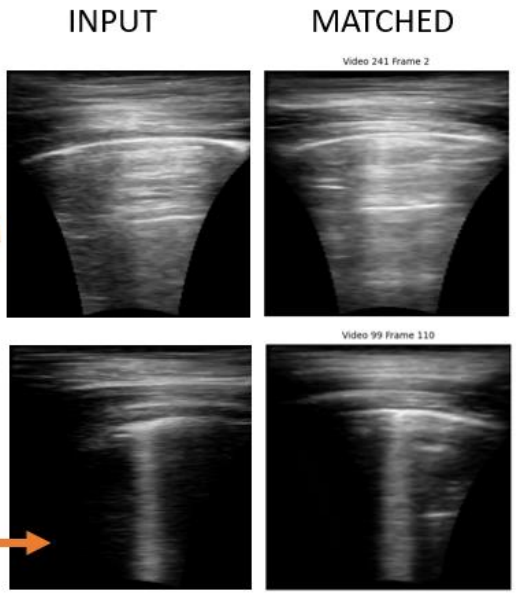
CSIC Consejo Superior de Investigaciones Científicas

IDENTIFICACIÓN AUTOMÁTICA DE LA PLEURA



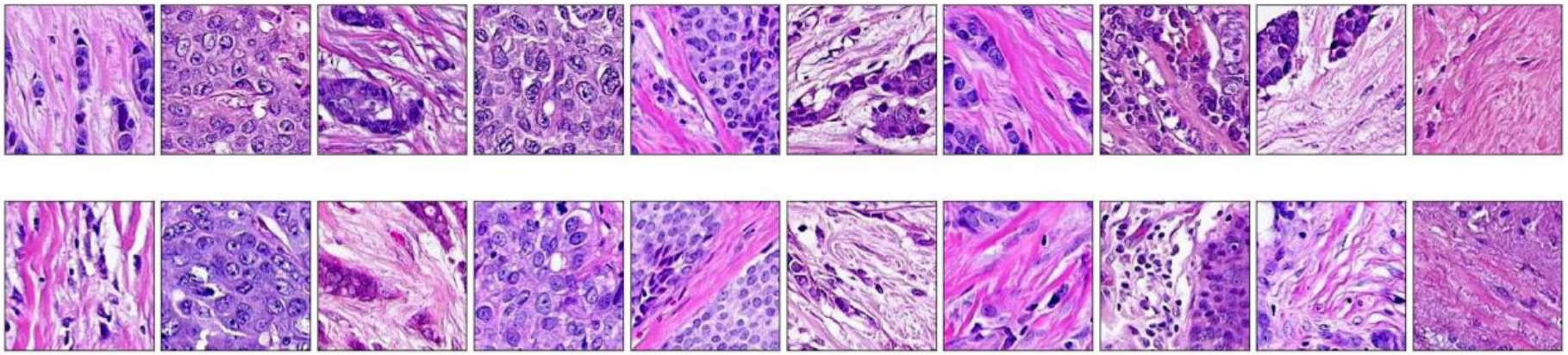
IDENTIFICACIÓN DE CASOS SIMILARES

VIDEO INPUT	LABEL	VIDEO REF	LABEL	DISTANCE
0	'A- Lines'	109	'A- Lines'	0.026
20	'A- Lines'	78	'A- Lines'	0.017
204	'Pleura Irregularity' 'B- Lines'	230	'Pleura Irregularity' 'B-Lines'	0.027
3	'A- Lines'	241	'A- Lines'	0.026
4	'A- Lines'	19	'A- Lines'	0.024
9	' Confluent B- Lines'	99	'B- Lines'	0.052



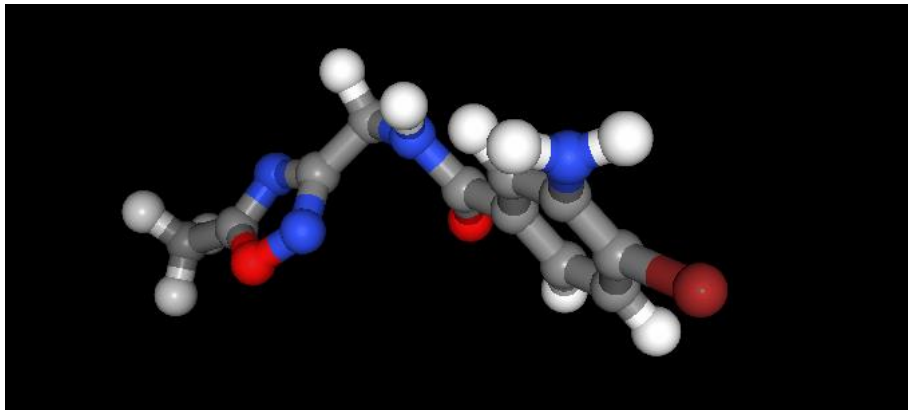
[CASO 10]

APLICACIONES EN CIENCIAS

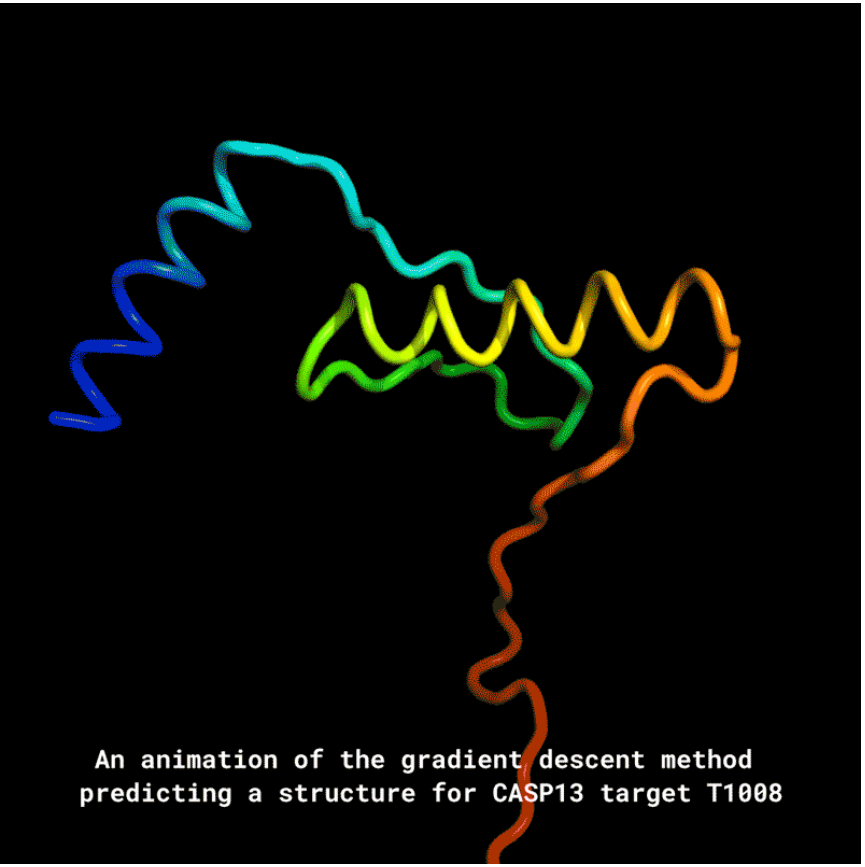


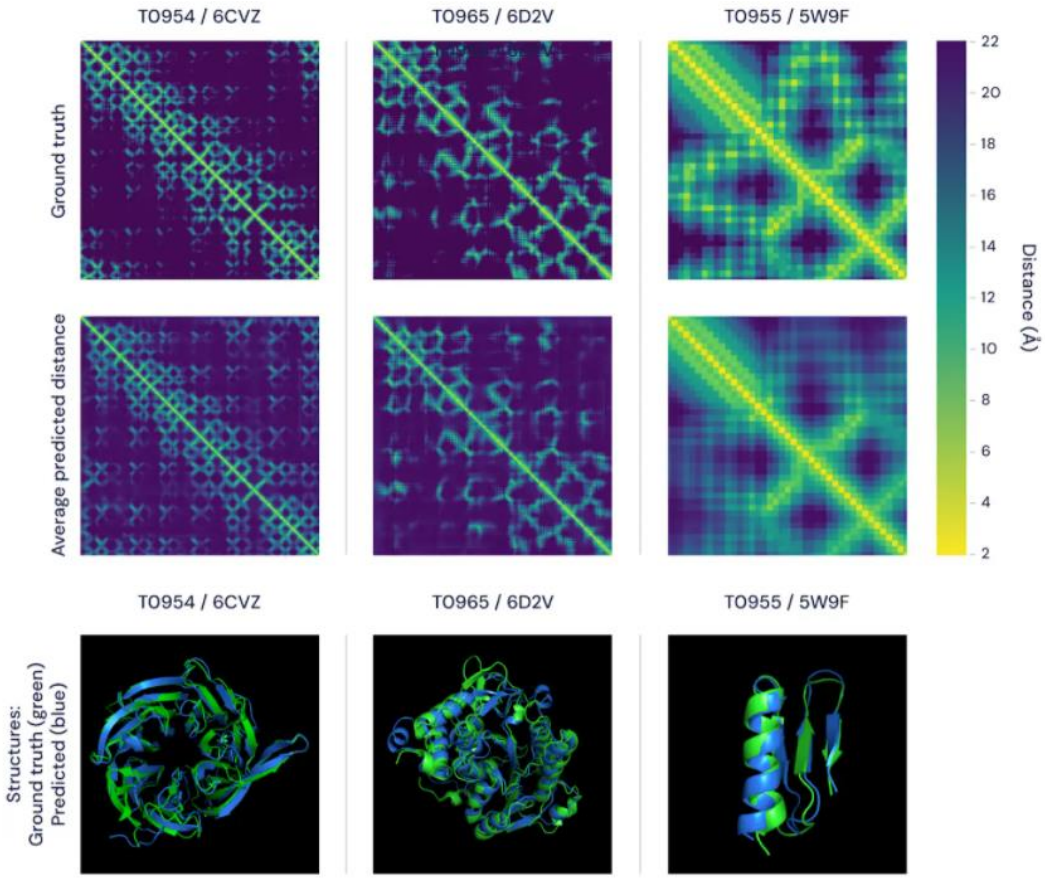
https://arxiv.org/abs/1907.02644

https://thischemicaldoesnotexist.com



[CASO 11] – PLEGAMIENTO DE PROTEINAS (ALPHAFOLD 2)





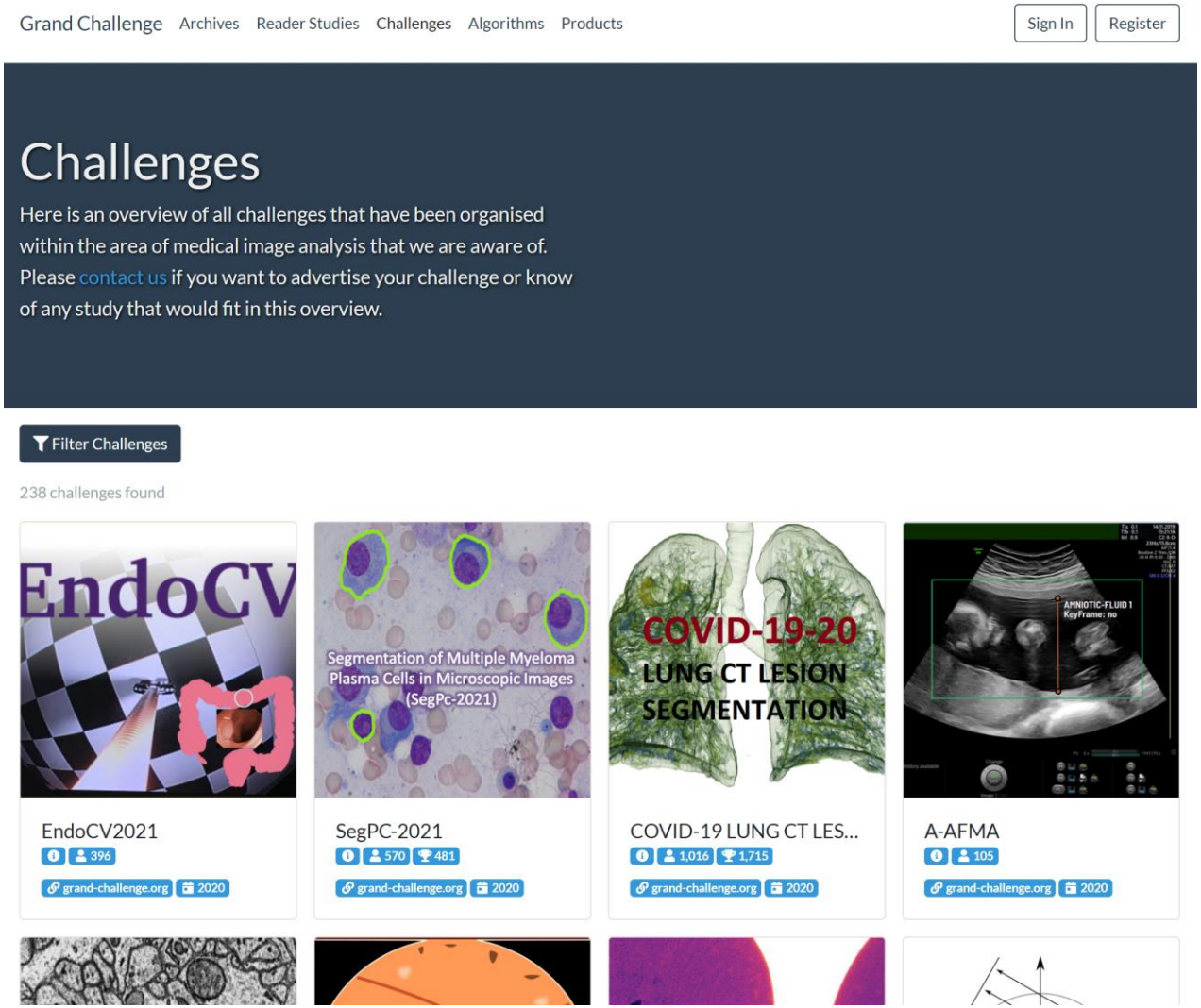
https://deepmind.com/blog/article/AlphaFold-Using-AI-for-scientific-discovery

https://alphafold.ebi.ac.uk

Highly accurate protein structure prediction with AlphaFold – *Nature, 15 July 2021*

¿Dónde conseguir datos?

https://grand-challenge.org/challenges/



CUESTIONES ÉTICAS DE IA EN MEDICINA

- Los errores en Medicina son más graves que en Visión por Computador. Considerar el peor caso posible es importante (no vale con quedarse con la media).
- ¿Qué sucede en los casos en los que la IA falla?

  ¿De quién es la culpa? ¿Quién es responsable?
- Los casos con los que ha aprendido la red ¿Son suficientemente representativos? ¿Qué pasa con las minorías, enfermedades raras..?

RETOS DE MACHINE LEARNING EN MEDICINA

- ¿Cómo usar el conocimiento previo? ¿Lo tiramos?
- ¿Cómo elegir la mejor métrica? El error global no es una buena opción. Los detalles son lo que más importa!

- Robustez: Los errores en Medicina son más graves que en Visión por Computador. Considerar el peor caso posible es importante (no vale con quedarse con la media).
- Datos: ¿Dónde conseguir más datos? ¿Están bien etiquetados?¿Son suficientemente representativos?
- Consideraciones Éticas:

"Artificial Intelligence in Radiology—Ethical Considerations (Brady et al. Diagnostics, 2020)"
https://www.mdpi.com/2075-4418/10/4/231

PRACTICA:

SEGMENTACION DE PULMONES

https://colab.research.google.com/drive/1KbLzEMeuq_Ds-DKLl_vW-uxmw_vS46bH?usp=sharing

SEGMENT ANYTHING

https://colab.research.google.com/drive/1i4rmWcHhSt7KGmuiGa0FDCnwjbCe844k?usp=sharing