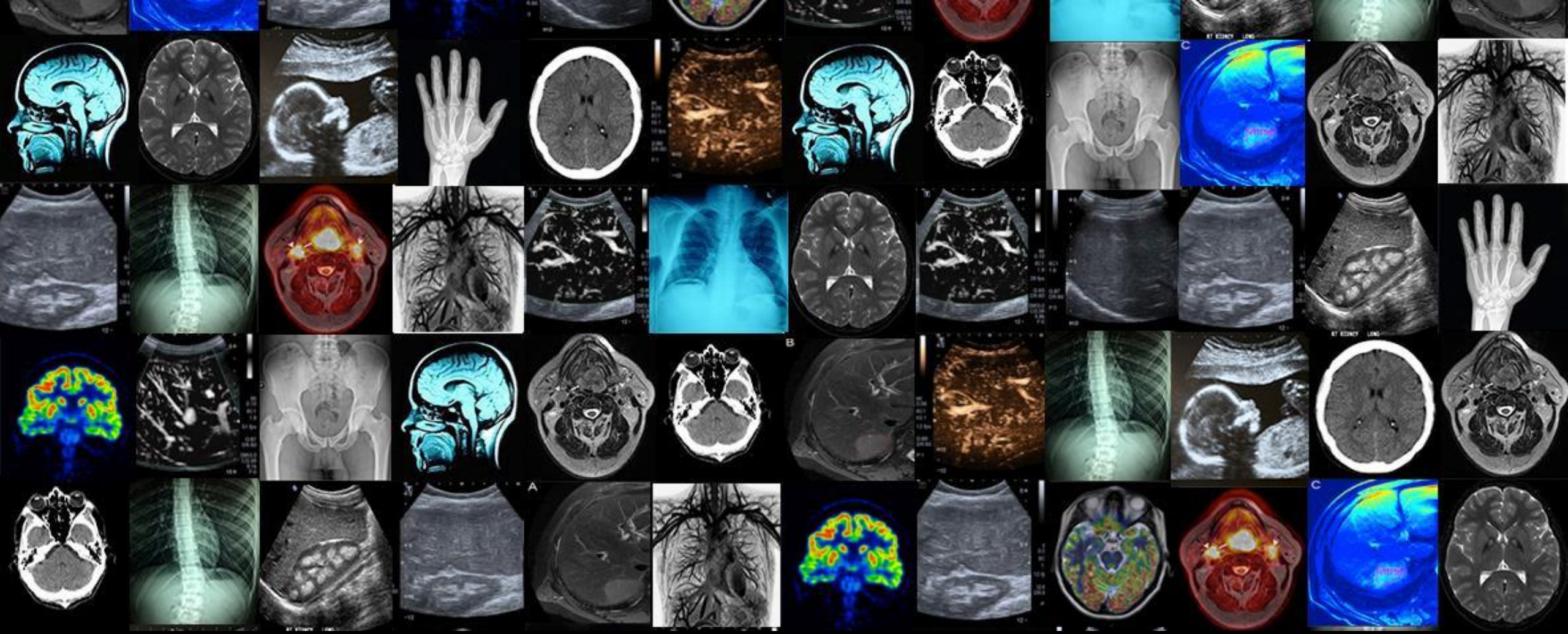


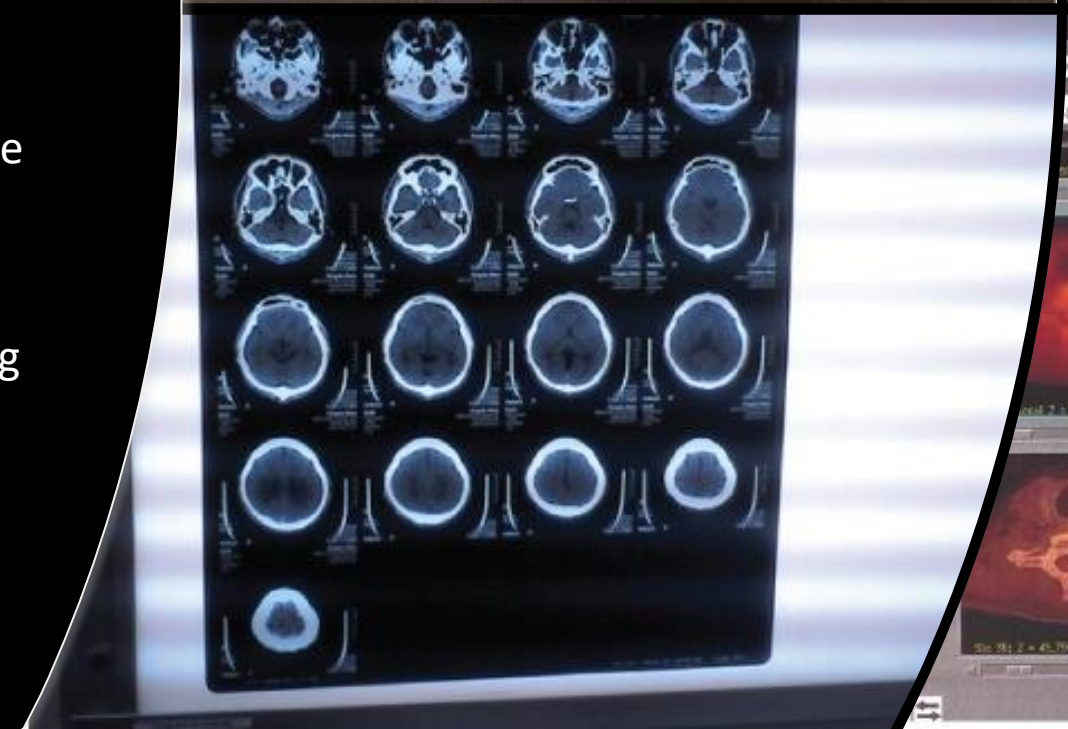
Deep Learning in Medical Imaging

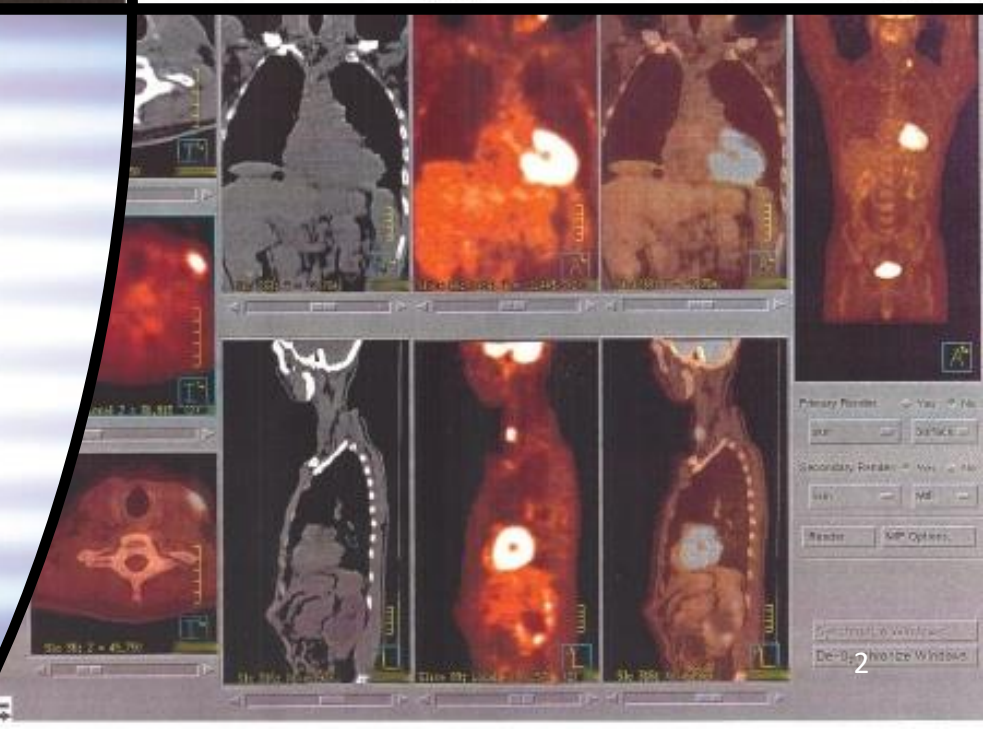
Prof. Kuan-Ting Lai

2024/12/9

Medical Imaging

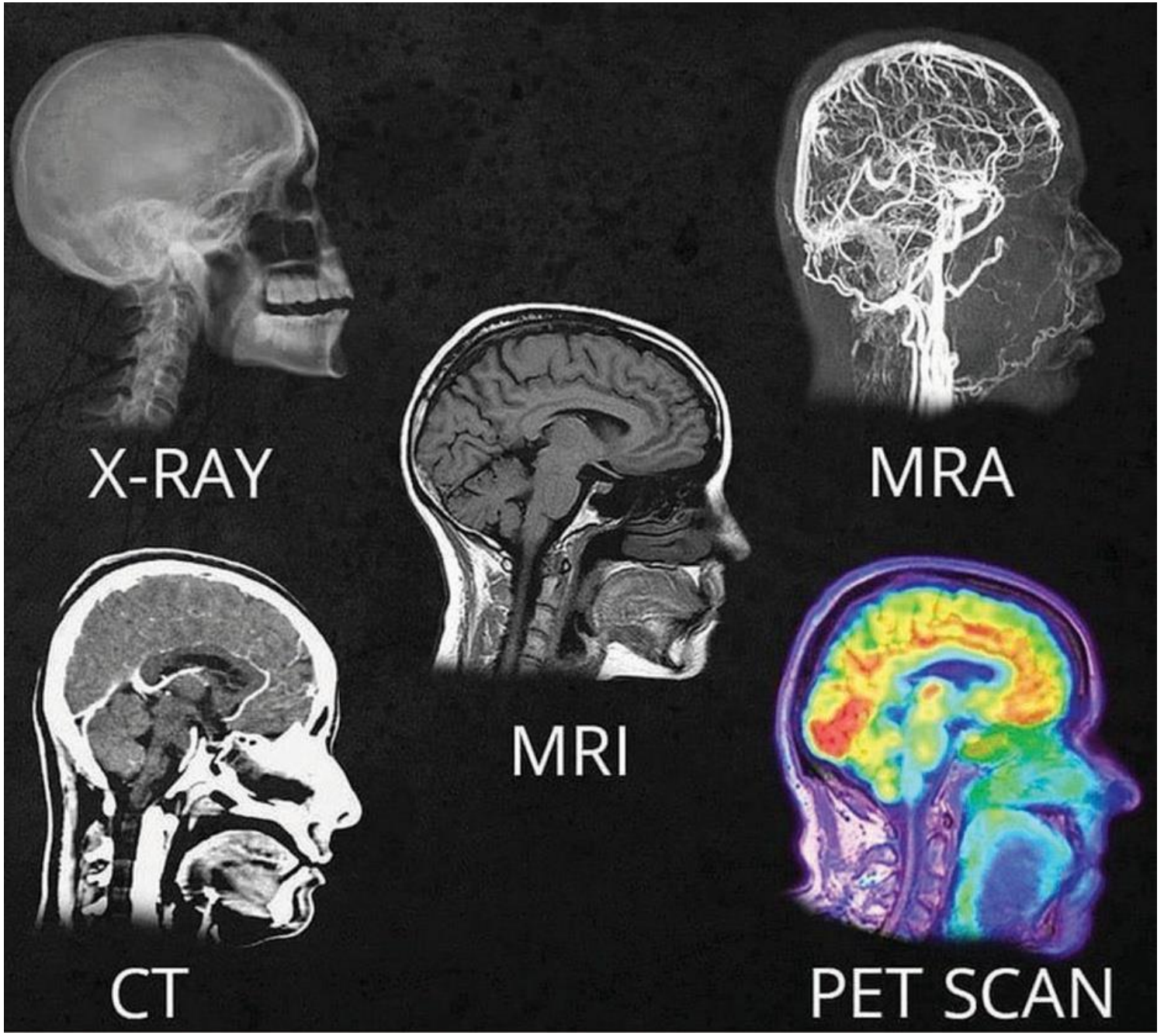
- Account for 90% of Medical Data
- X-rays
- CT (Computed Tomography) scan
- MRI (Magnetic Resonance Imaging)
- Ultrasound
- Nuclear medicine imaging
  - positron-emission tomography (PET)





Ex: Brain Imaging

- **X-Ray:** shows bone/skull only.
- **CT:** a quick test. Shows brain but detail not great.
- **MRI:** a long test. Shows brain and detail is great.
- **MRA:** shows the flow of blood in the brain.
- **PET scan:** shows activities of different parts of the brain. The more sugar used, the brighter the area. Cancer cells light up the most.



https://sdbif.org/index/whats-the-difference-between-all-the-different-head-scans/

CT Scan, MRI, Ultrasound, and X-Ray

Ohio State Medical Center

https://www.youtube.com/playlist?list=PLDQi4ZgipBq-4lpaWbIxJiK_XYu0_cE6H

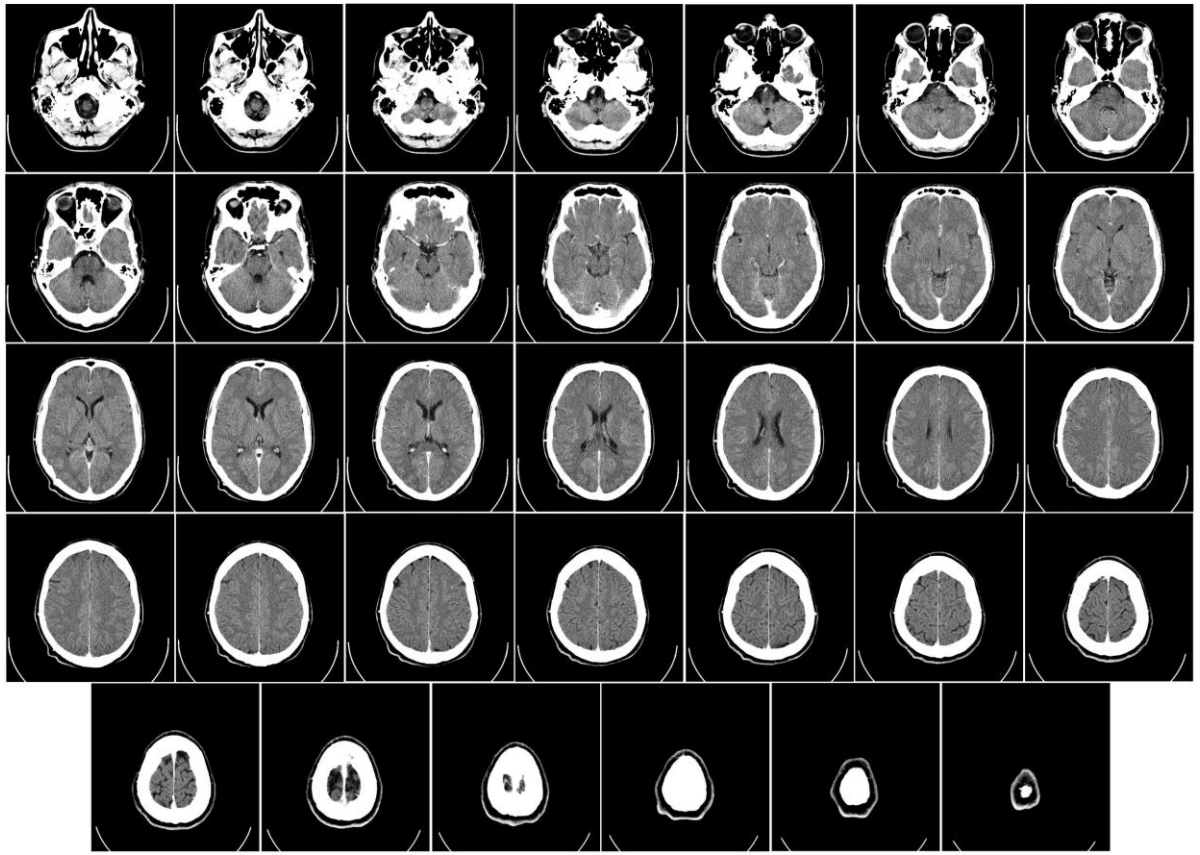
Computed Tomography (CT)

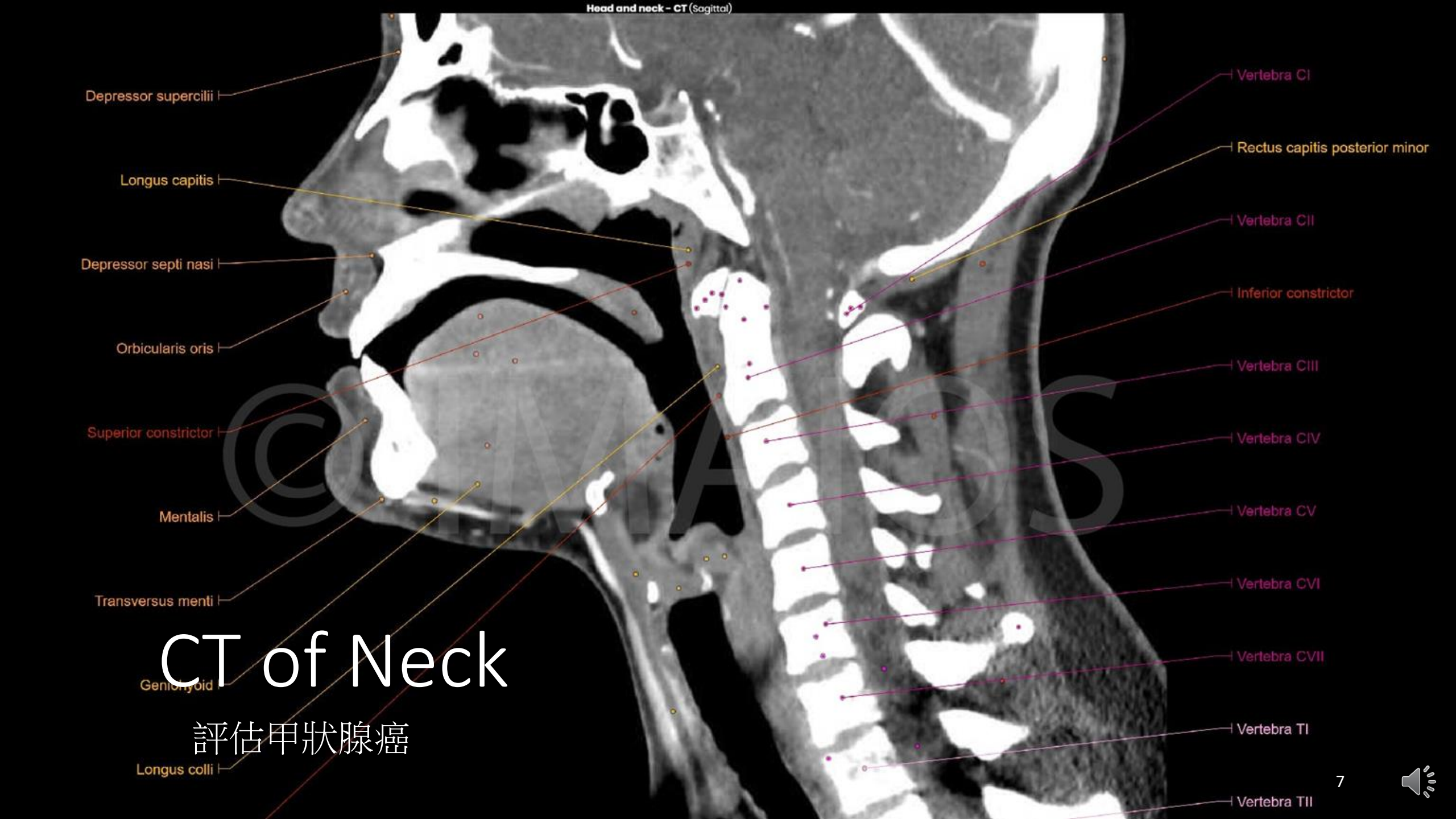
- Combinations of many X-ray measurements taken from different angles to produce cross-sectional (tomographic) images (virtual "slices")

https://en.wikipedia.org/wiki/CT_scan

CT of Head

- 主要用來診斷腦部血管病變以及顱內出血
  - 但是可以排除出血的可能性，判斷可否用凝血劑
- 診斷有外傷的顱骨及顏面骨的骨折
- 植牙重建的評估
- 診斷腫瘤的應用上效果較核磁共振影像（MRI）差



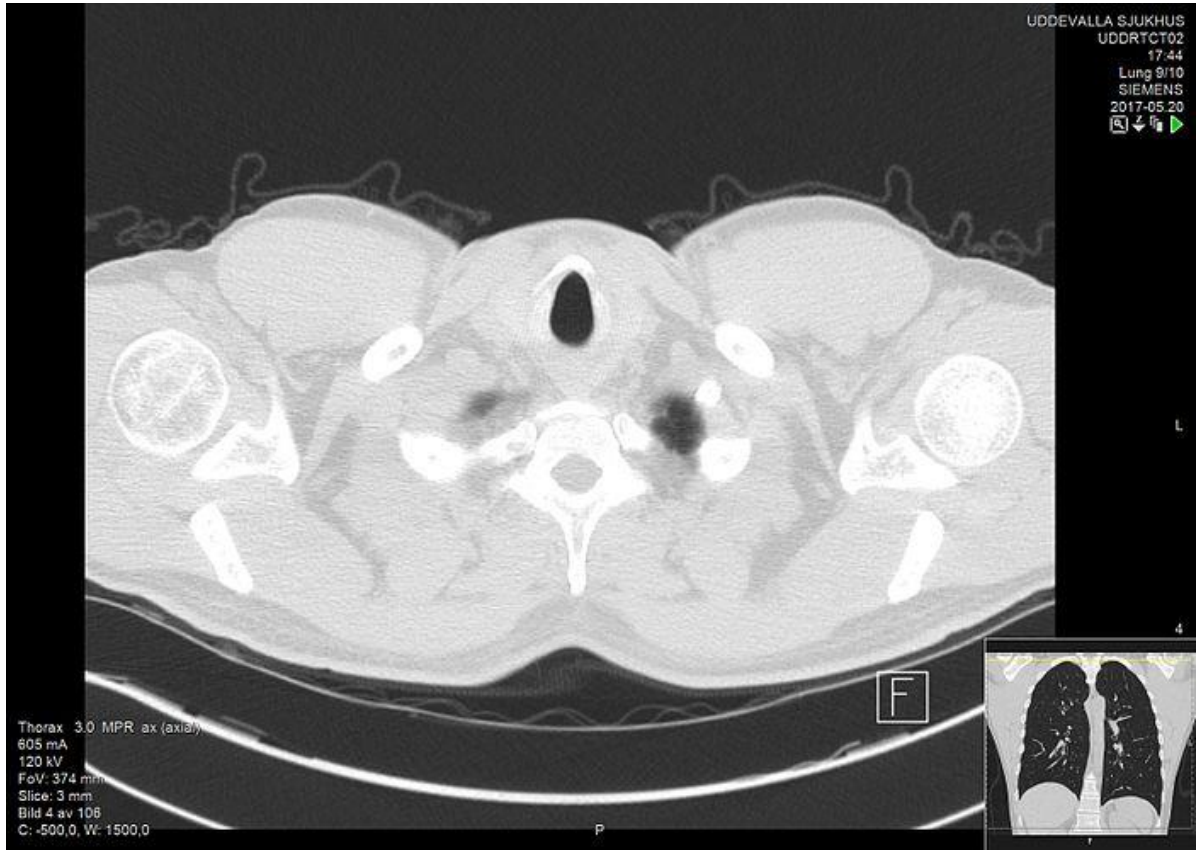


CT of Neck

評估甲狀腺癌

CT of Lungs

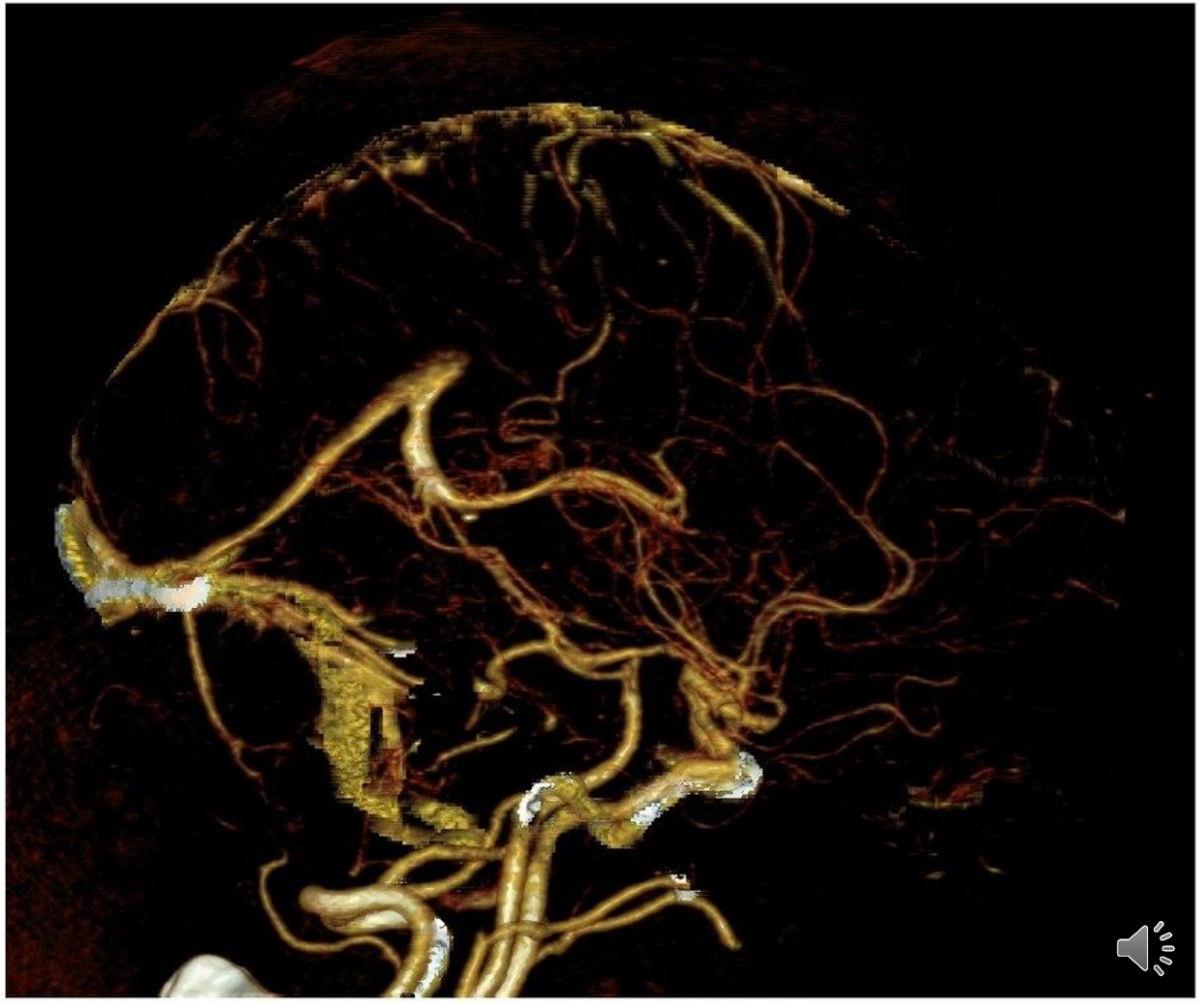
- 對於急性或是慢性的肺病病變都有很高的診斷價值
- 在觀察肺部病變空氣的變化，例如肺炎或是腫瘤，有很好的效果
- 胸腔斷層血管攝影（CTPA）是需要用精確快速的時間來作對比劑注射再加上高速的螺旋式描掃器



https://commons.wikimedia.org/wiki/Scrollable_high-resolution_computed_tomography_images_of_a_normal_thorax

電腦斷層血管攝影術 (CT Angiography)

- 引入造影劑使血液對X射線的通透性降低，使血管顯示為高密度

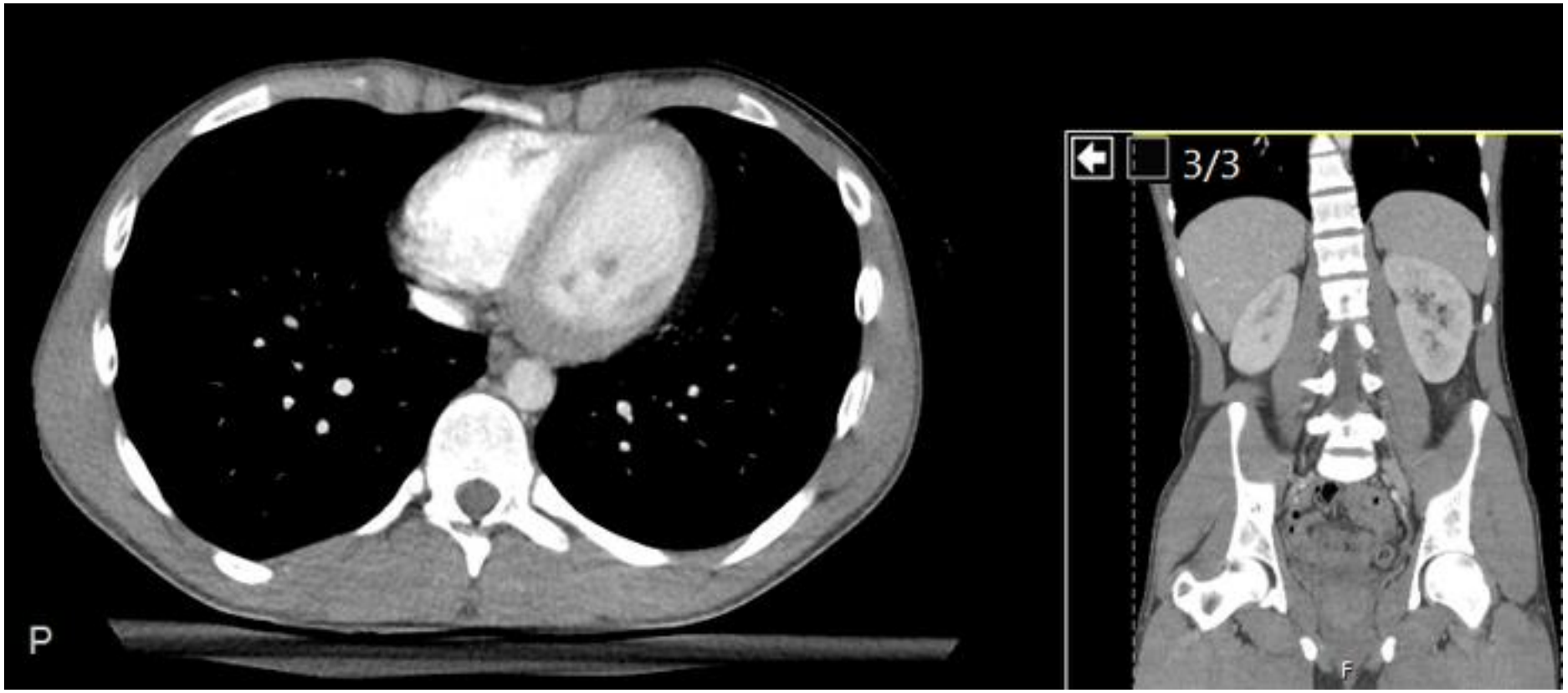


CT of Cardiac

- 心臟的多斷層切面檢查（Multi-slice Computed tomography, MSCT）有相當性的潛在危險，因為它的劑量相當於500張的胸腔x光

CT of Abdominal and Pelvic

- 對於腹部的疾病，X射線電腦斷層掃描的診斷價值極高
- 常用來定位腫瘤期數也用來做後續的追蹤，對急性腹痛的檢查也很有用。泌尿結石，闌尾炎，胰臟炎，憩室，腹部動脈瘤還有腸阻塞等

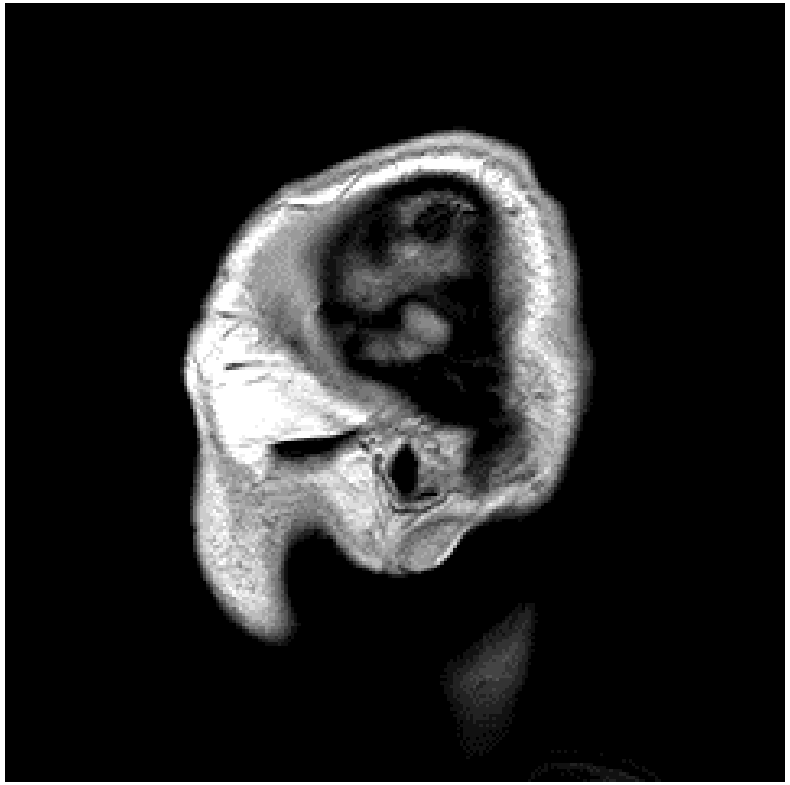


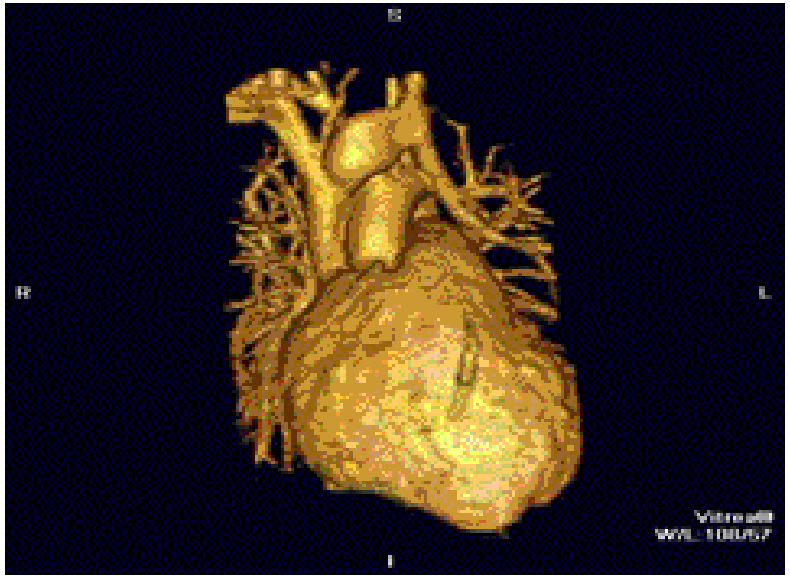
Scan Dose

檢查	對全身的有效劑量 (毫西弗)	對器官的吸收劑量 (毫戈雷)
全年背景輻射值	2.4[7]	2.4[7]
胸部X射線	0.02[8]	0.01–0.15[9]
頭部CT	1–2[10]	56[11]
有隔離的乳腺X射線檢查	0.4[12]	3[13][9]
腹部CT	8[8]	14[11]
胸部CT	5–7[10]	13[11]
CT結腸鏡檢查	6–11[10]	
胸,腹和骨盆CT	9.9[11]	12[11]
心血管CT	9–12[10]	40–100[9]
鋇劑灌腸攝影	15[13]	15[9]
新生兒腹部CT	20[13]	20[9]

Magnetic Resonance Imaging (MRI)

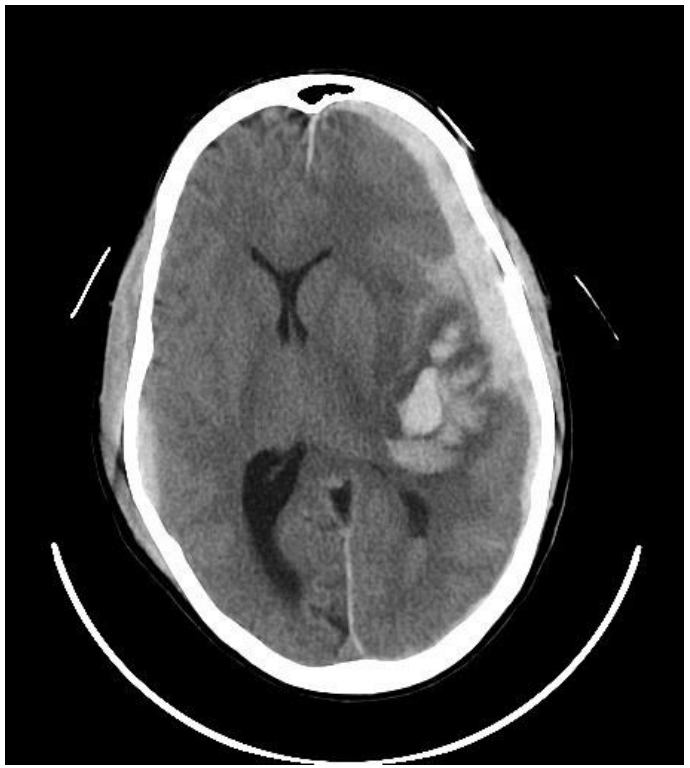
- MRI does not involve X-rays or the use of ionizing radiation
- MRI is an application of nuclear magnetic resonance (NMR)

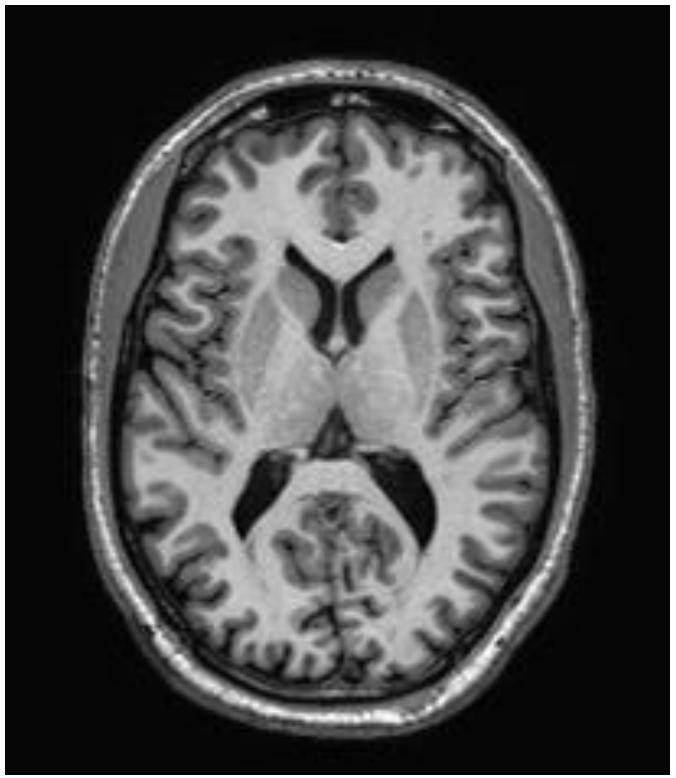




CT vs MRI

- Some people can’t do MRI (e.g., certain types of metal implants)
- MRI scans take a relatively long time and noisy
- Particular measurements that CT can’t provide (e.g., looking at bone structure)





CT vs MRI

	Magnetic Resonance Imaging (MRI)	Computed Tomography (CT)
原理	原理是將人體置於高磁場環境下，利用無線電波激發體內的氫原子，使其產生共振訊號，經電腦軟體運算得到影像。	利用X光射線穿透人體，取得影像訊號，經電腦運算處理得到立體影像，經由軟體後處理可組成各種切面的影像資訊。
檢查時間	約30分鐘/1部位	約5分鐘/1部位
檢查過程	隧道式/噪音大/平躺	環狀式/噪音小/平躺
輻射線	無	有
優勢	MRI對腫瘤、血管、軟組織及骨骼、肌肉、韌帶有很好的分辨率，除了解剖學影像外，在不注射對比劑的情況下也能得到功能性的影像。	CT檢查的時間快速，對早期的肺癌篩檢及心臟血管鈣化有很好的檢查效果。
禁忌	1.不能久躺的人 2.裝有心律調節器患者 3.幽閉恐懼症患者	1.懷孕或可能懷孕的婦女 2.尚在發育的小孩

http://www.knh.org.tw/sub/health/49/290

MRI Advantages

- 對軟組織有極好的分辨力。對膀胱、直腸、子宮、陰道、骨、關節、肌肉等部位的檢查比CT優良
- 多個成像參數能提供豐富的診斷資訊。例如肝炎和肝硬化的T1值變大，而肝癌的T1值更大，作T1加權圖像，可區別肝部良性腫瘤與惡性腫瘤
- 通過調節磁場可自由選擇所需剖面。能得到其它成像技術所不能接近或難以接近部位的圖像。對於椎間盤和脊髓，可作矢狀面、冠狀面、橫斷面成像，可以看到神經根、脊髓和神經節等。相對CT只能獲取與人體長軸垂直的橫斷面
- 對人體沒有游離輻射損傷

MRI意外: 吸入氧氣瓶

TVBS 新聞網 | 75k 人追蹤 ☆ 追蹤

死亡檢查！核磁共振機器吸來氧氣瓶 韓老翁遭活活夾斃

張士哲

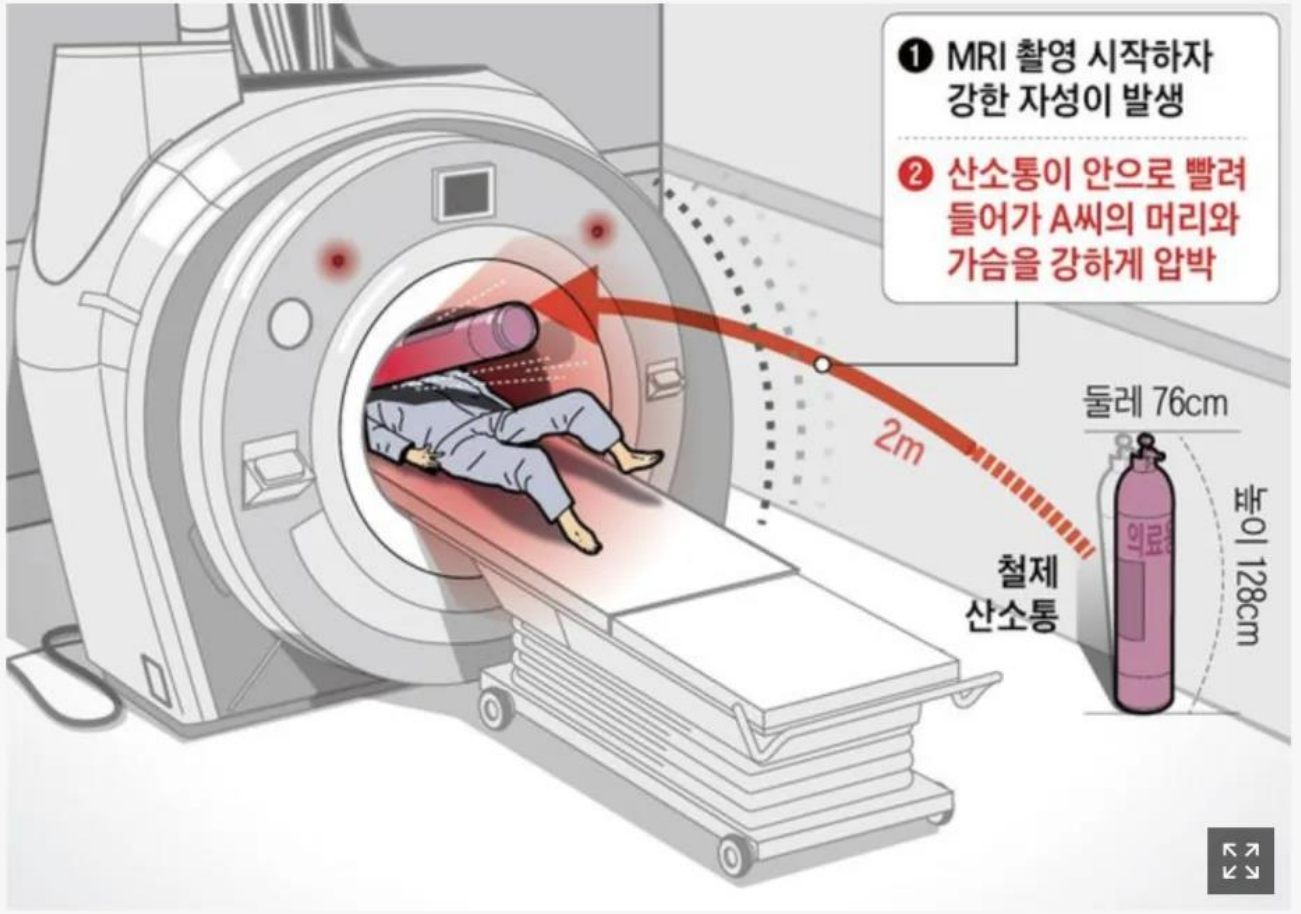
2021年11月18日 · 3 分鐘 (閱讀時間)

核磁共振成像（MRI）是醫院經常用來檢視患者體內構造的精密醫學儀器，不過日前南韓卻因為核磁共振檢查發生一起憾事，有名患者在做核磁共振檢查時，因為儀器的強大磁場吸起一旁的氧氣瓶，使得金屬瓶飛入儀器，導致患者被氧氣瓶擊中且與機器夾住，最終死亡，事實上，過去也曾發生過類似的案例。

根據《朝鮮日報》於上月18日的報導，10月14日，南韓慶尚南道金海市綜合醫院有一名60歲的老翁，因為發生了痙攣的症狀，為了釐清痙攣的確切原因，醫院安排老翁進行MRI的檢查，由於老翁有供氧的需求，MRI檢查室的吸氧裝置又出現問題，醫療人員就把氧氣瓶給搬進MRI檢查室。

[2011 TVBS] 死亡檢查！核磁共振機器吸來氧氣瓶 韓老翁遭活活夾斃

朝鮮日報



MRI(자기공명영상) 안전사고

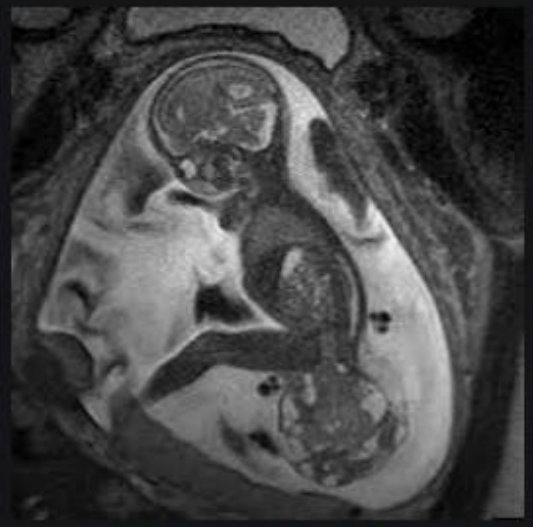

Scan Progress

MRI Scan of Unborn Babies

Katie on Twitter: "TOO LONG HAVE I BEE...
twitter.com

Katie on Twitter: "The real reason they di...
twitter.com

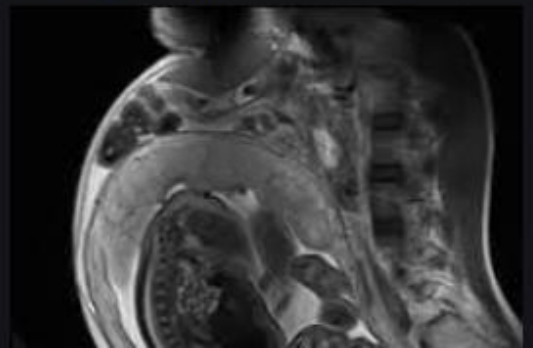
Mihaela Bereza on Twitter: "@ZiziFothSi ...
mobile.twitter.com



Fetal MRI | Children's Hospital of Philade...
chop.edu

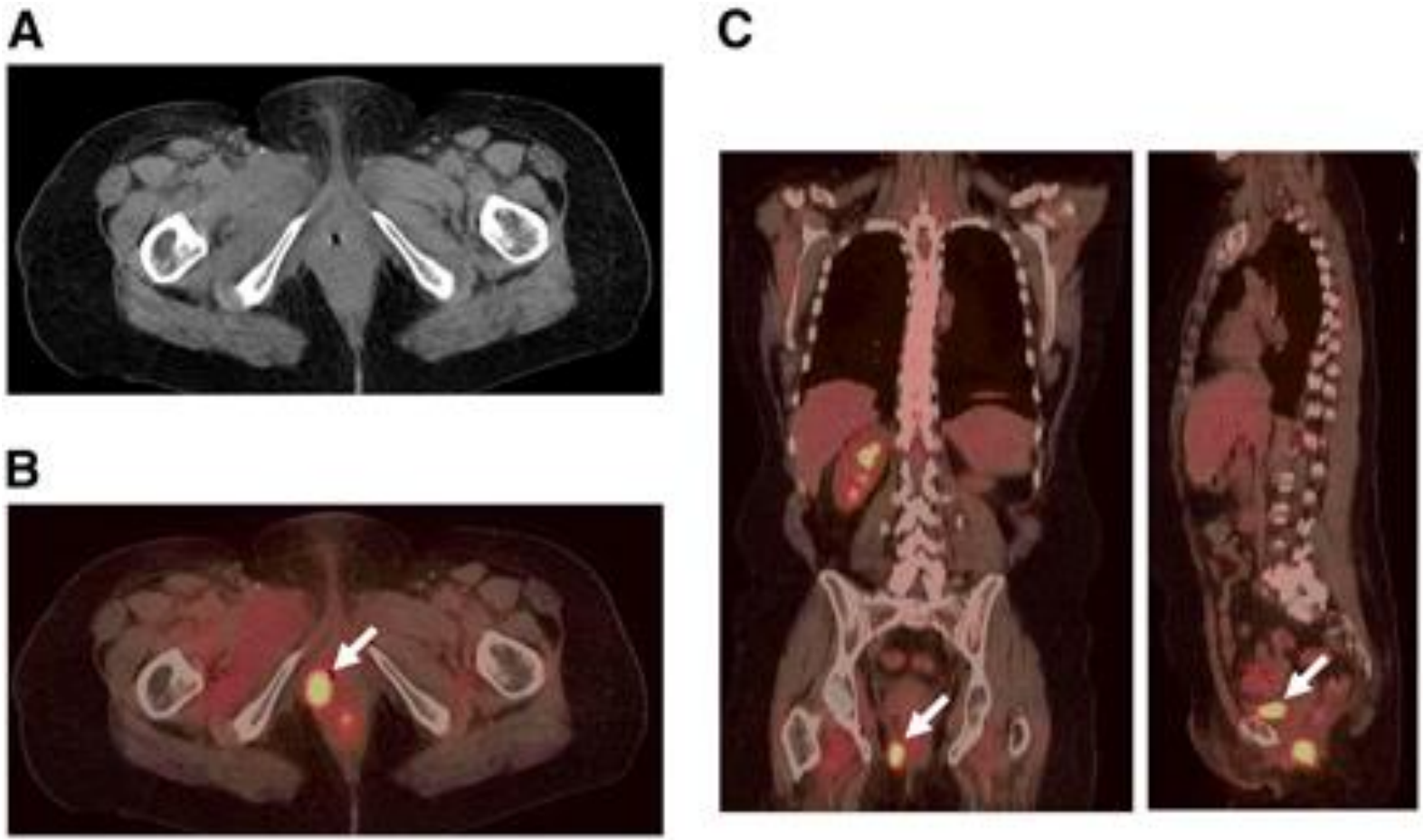
Mihaela Bereza on Twitter: "@ZiziFothSi ...
mobile.twitter.com

Unborn twins caught on video MRI for th...
newscientist.com



Nuclear Medicine and Molecular Imaging

- 核醫學操作項目採用的是事先經過放射性核素標記的藥物，即放射性藥物。首先將放射性物質施用於病人，繼而則是對放射性物質所發出的電離輻射加以檢測。



https://www.youtube.com/watch?v=BGNZMr34uf0

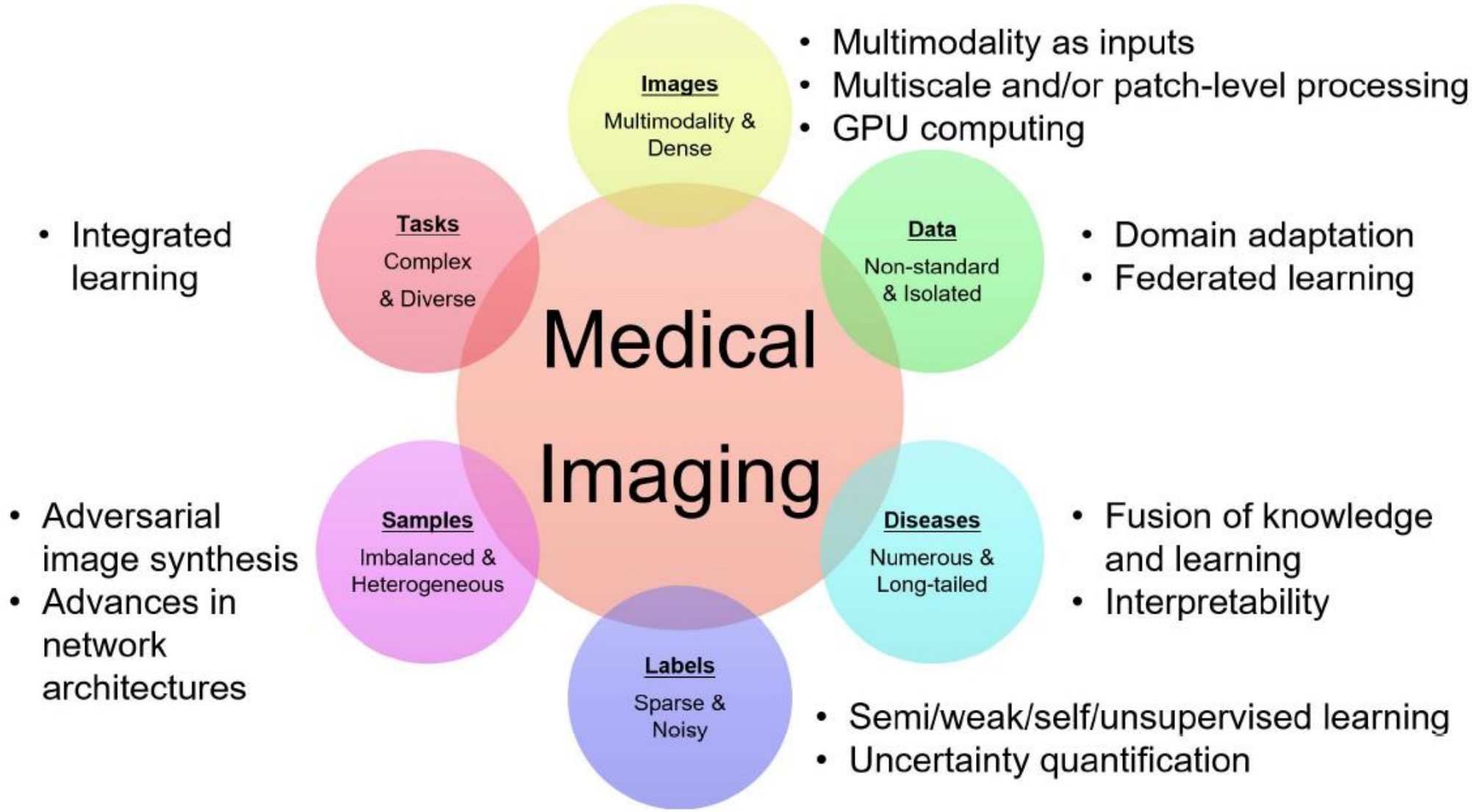
Pros and Cons of Medical Imaging Techniques

Type	What It Reveals	Advantages	Disadvantages	Main Uses
Radiography	Bone and soft tissue anatomy	• Low radiation dose. • Inexpensive • Quick & No preparation	• Provides basic anatomic information for only a few tissue densities	• Skeleton, chest investigate, intra-abdominal disease
Computed tomography (CT)	Most organ systems in the body	• Multiplanar and 3D • Fast exam time • With IV contrast can examine organ and blood vessels	• Higher radiation dose than radiography • May require oral IV contrast	• Infection and abdominal • chest trauma
Magnetic resonance (MR) Imaging	High-contrast resolution pictures of organs	• No radiation exposure • Multiplanar and 3D • Does not require IV contrast • Superior depiction of soft tissue and organ contrast	• Long examine time, often requires sedation in children < 7 years • Expensive Scanner	• Central nervous system • Musculoskeletal • Cancer
Nuclear Medicine	Shape, structure, and function of organs, soft tissues, and bones	• Lower radiation dose than fluoroscopy or CT • Adverse reactions rare	• May take a long time and require sedation • Offers little anatomic information	• Regional perfusion, skeletal pathology, gastroesophageal, vesicoureteric reflux, gastric emptying, tumor

https://www.contemporarypediatrics.com/view/pros-and-cons-imaging-options

Deep Learning in Medical Imaging

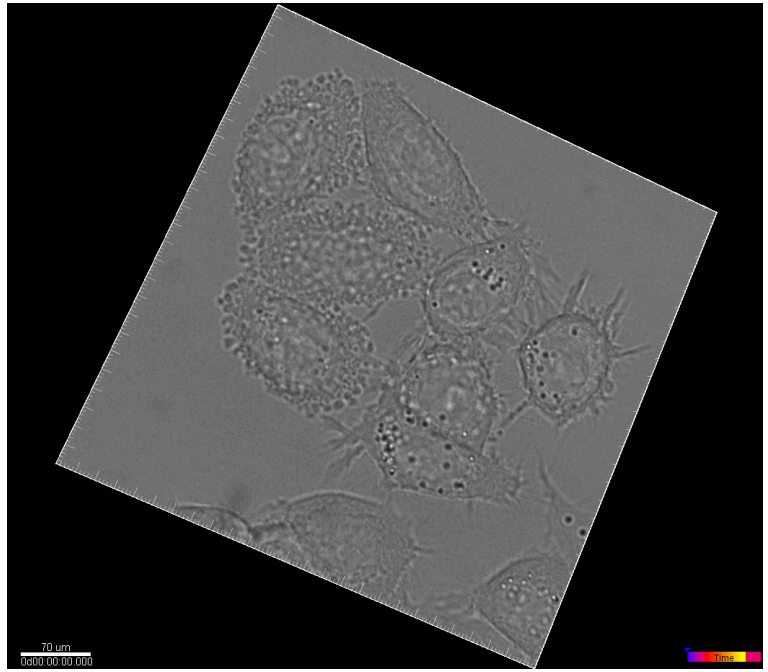
Characteristics of Medical Imaging

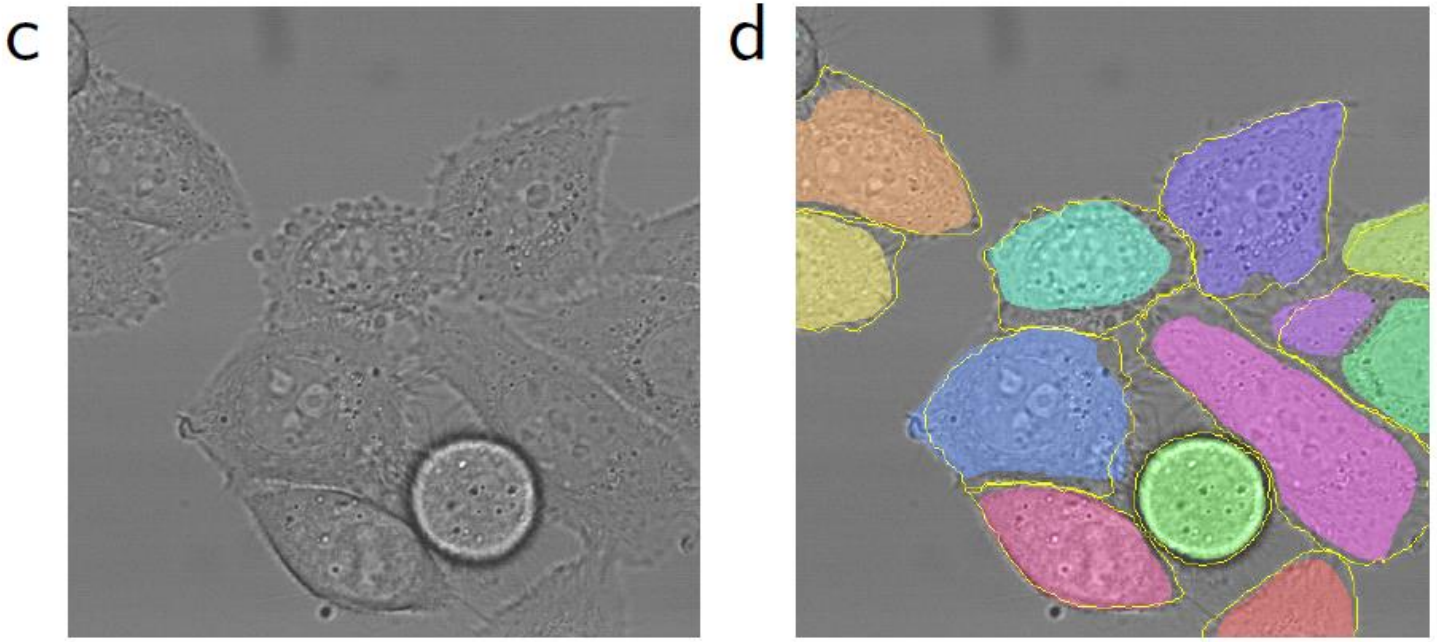


zhou et al., "A review of deep learning in medical imaging: Imaging traits, technology trends, case studies with progress highlights, and future promises," 2021

U-Net: CNN for Biomedical Image Segmentation

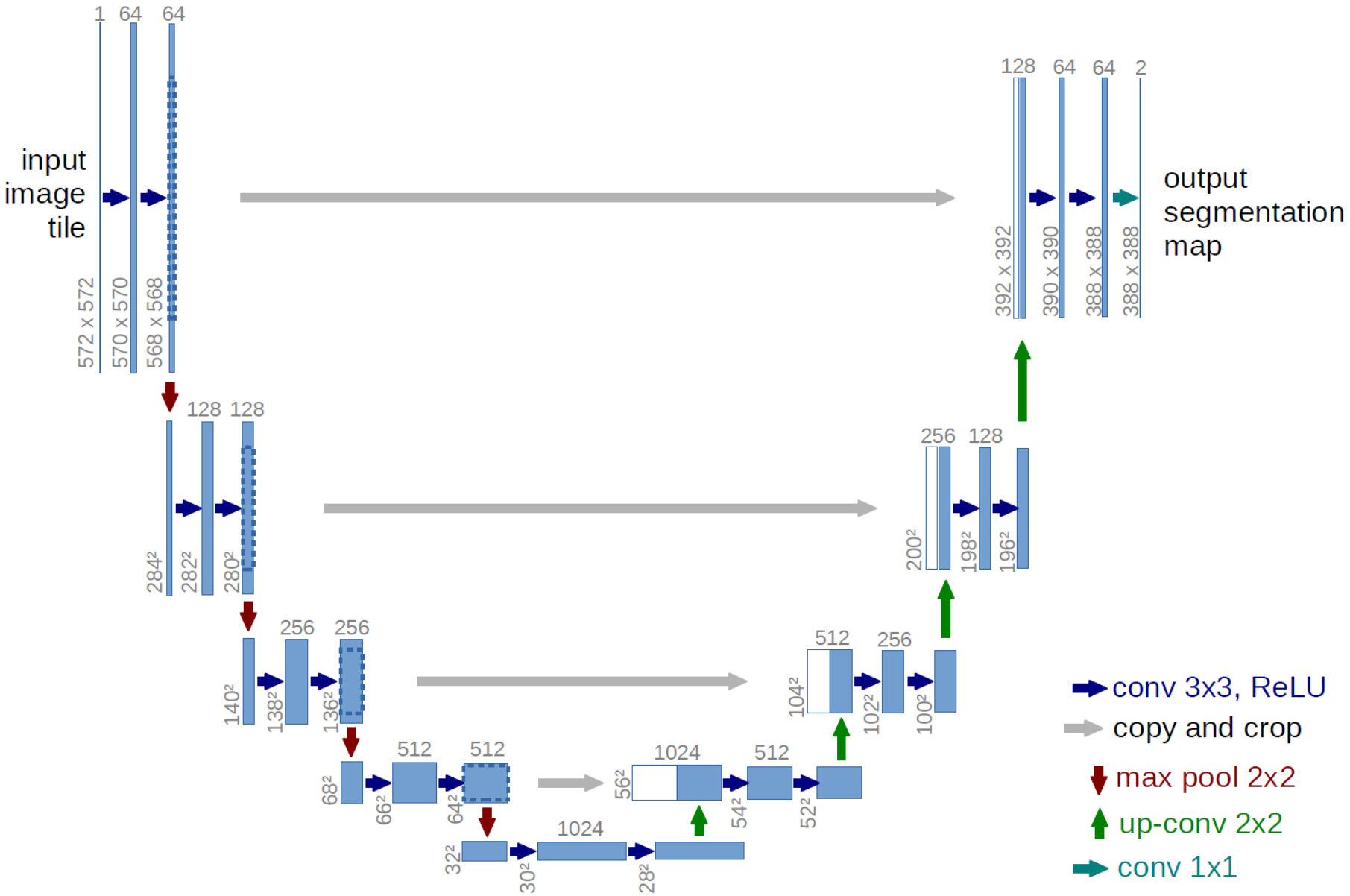
- Ronneberger et al. 2015
- One of the best models for image segmentation



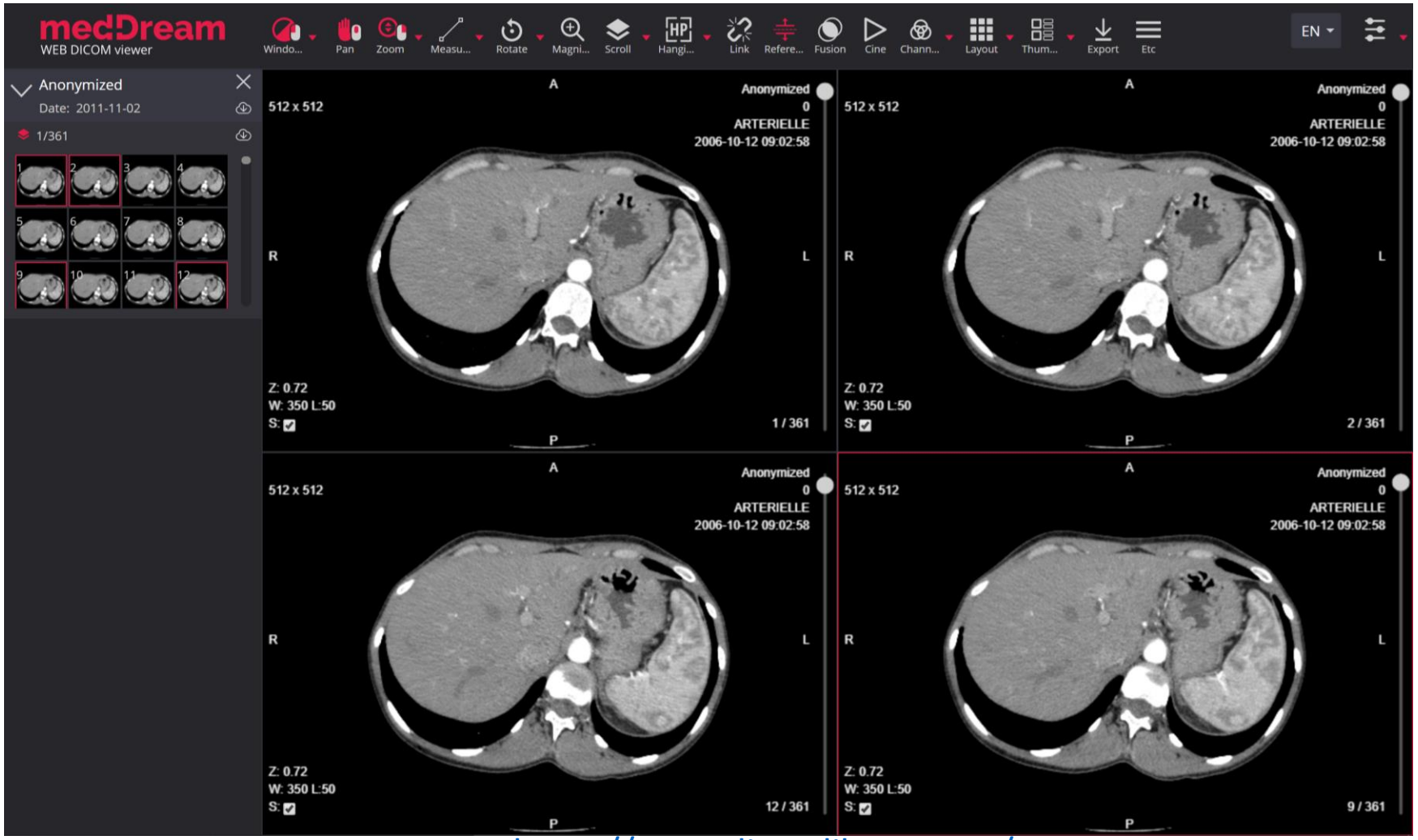


https://lmb.informatik.uni-freiburg.de/people/ronneber/u-net/

U-Net Architecture



Digital Imaging and Communication in Medicine (DICOM)



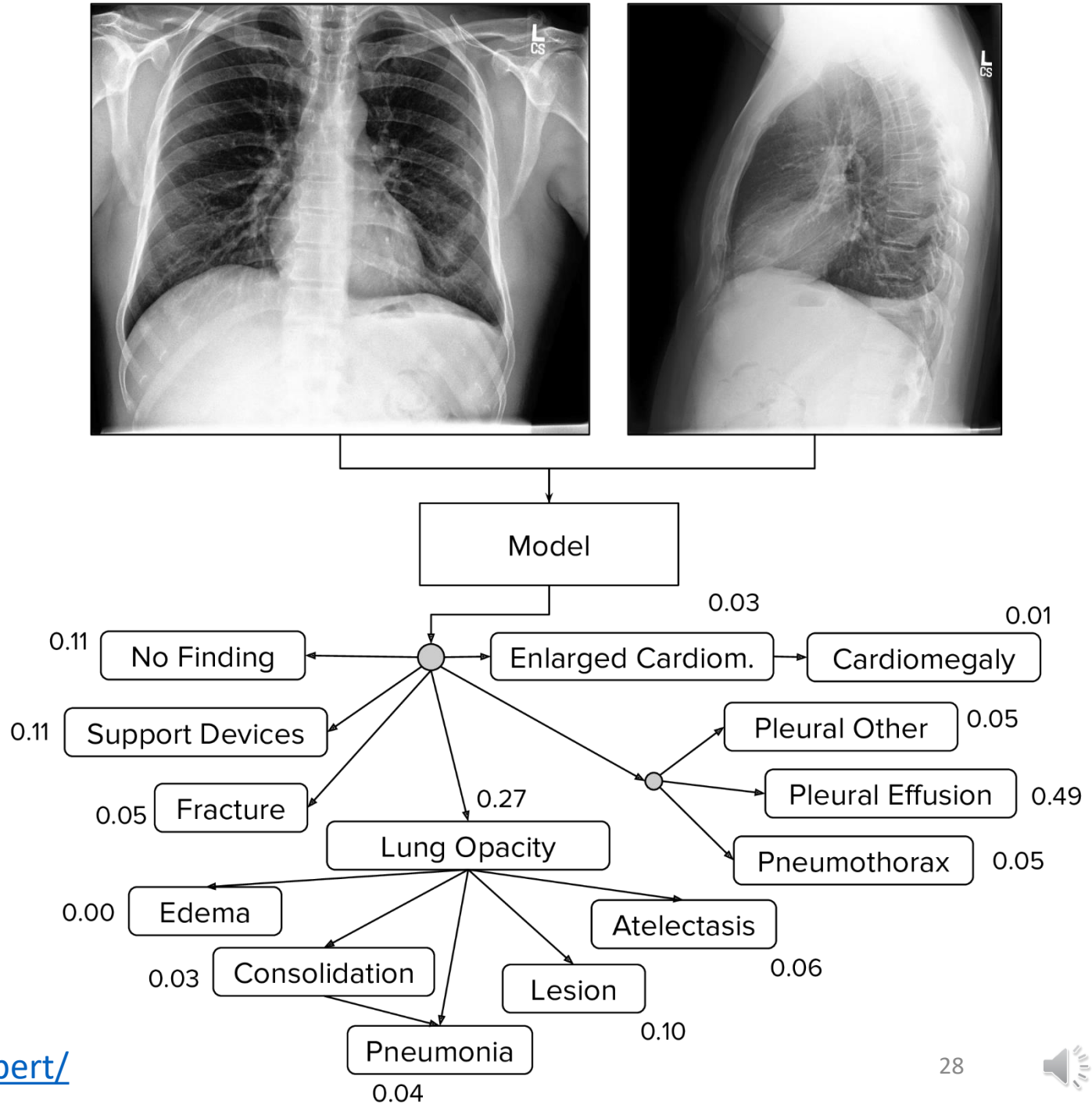
https://www.dicomlibrary.com/

Open Datasets

- Brainweb: Simulated normal and MS brains with tissue/lesion segmentations (MINC)
- Kirby 21: Set of 21 healthy patients scanned twice (NIfTI)
- IXI dataset: Set of 600 healthy subject scans (NIfTI)
- Qure.ai CT head scan data: Set of 491 head CT scans with pathology [no segmentation, but radiology report] (DICOM)
- BraTS 2018 Brain Tumor data: Large set of patients with brain tumors along with the tumor segmentation (mha)
- ISBI 2015 Multiple Sclerosis Challenge data: Set of 20 patients with multiple sclerosis (MS) [only 5 have lesion segmentations] (NIfTI)

CheXpert

- Stanford ML Group (Andrew Ng)



https://stanfordmlgroup.github.io/competitions/chexpert/

NGBoost

Probabilistic Prediction with Gradient Boosting

PROJECT WEBPAGE

CheXpert

A Large Chest X-Ray Dataset And Competition

PROJECT WEBPAGE

ECG Arrhythmia

Cardiologist-level arrythmia detection from ECG signals.

PROJECT WEBPAGE

MRNet

Diagnosis of abnormalities from Knee MRs

PROJECT WEBPAGE

DATASET WEBPAGE

PPG Arrhythmia

Arrythmia detection from ambulatory free-living PPG signals.

PROJECT WEBPAGE

CheXNeXt

Chest radiograph diagnosis of multiple pathologies and comparison to practicing radiologists.

PROJECT WEBPAGE

MURA

Introducing a large dataset for abnormality detection from bone x-rays.

PROJECT WEBPAGE

Countdown Regression

New approach to probabilistic time to event predictions.

PROJECT WEBPAGE

CheXNet

Radiologist-level pneumonia detection from chest X-rays.

PROJECT WEBPAGE

Palliative Care

Using Electronic Health Record Data to direct palliative care resources.

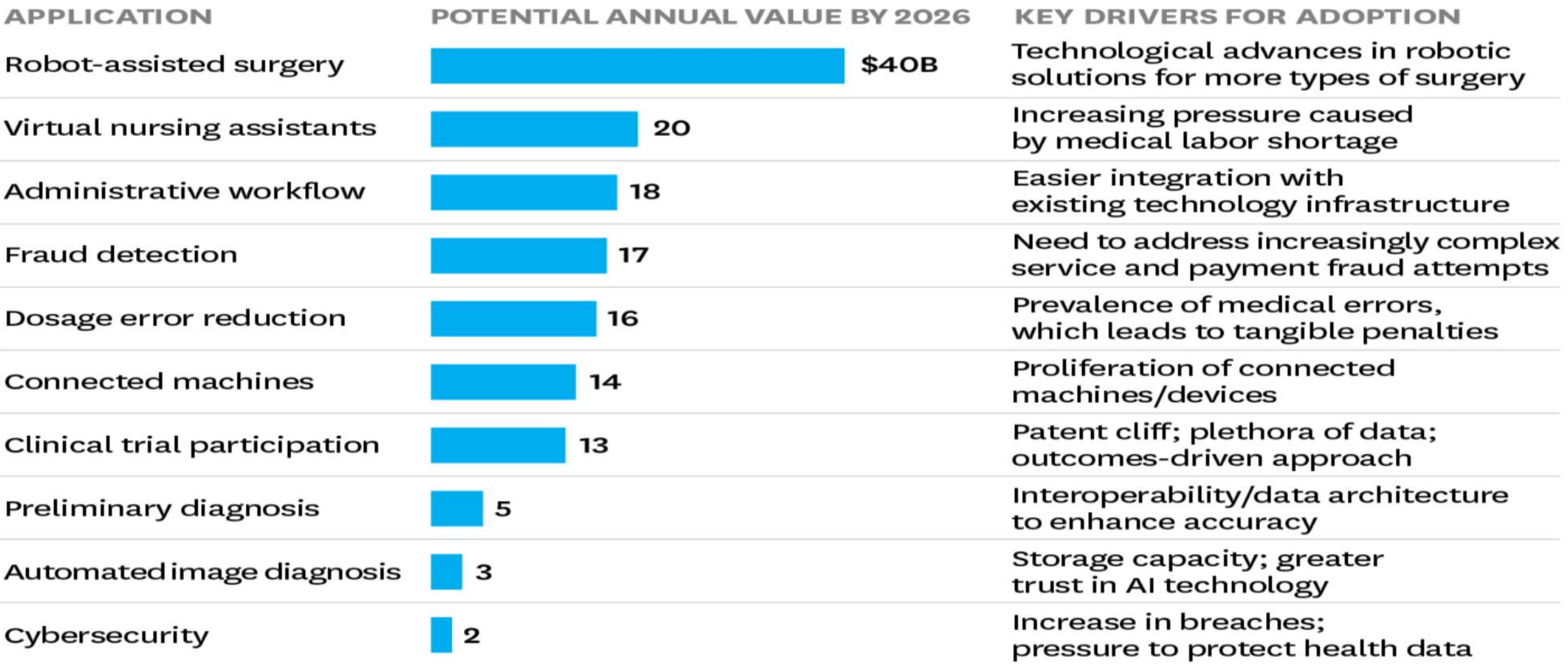
PROJECT WEBPAGE

Education

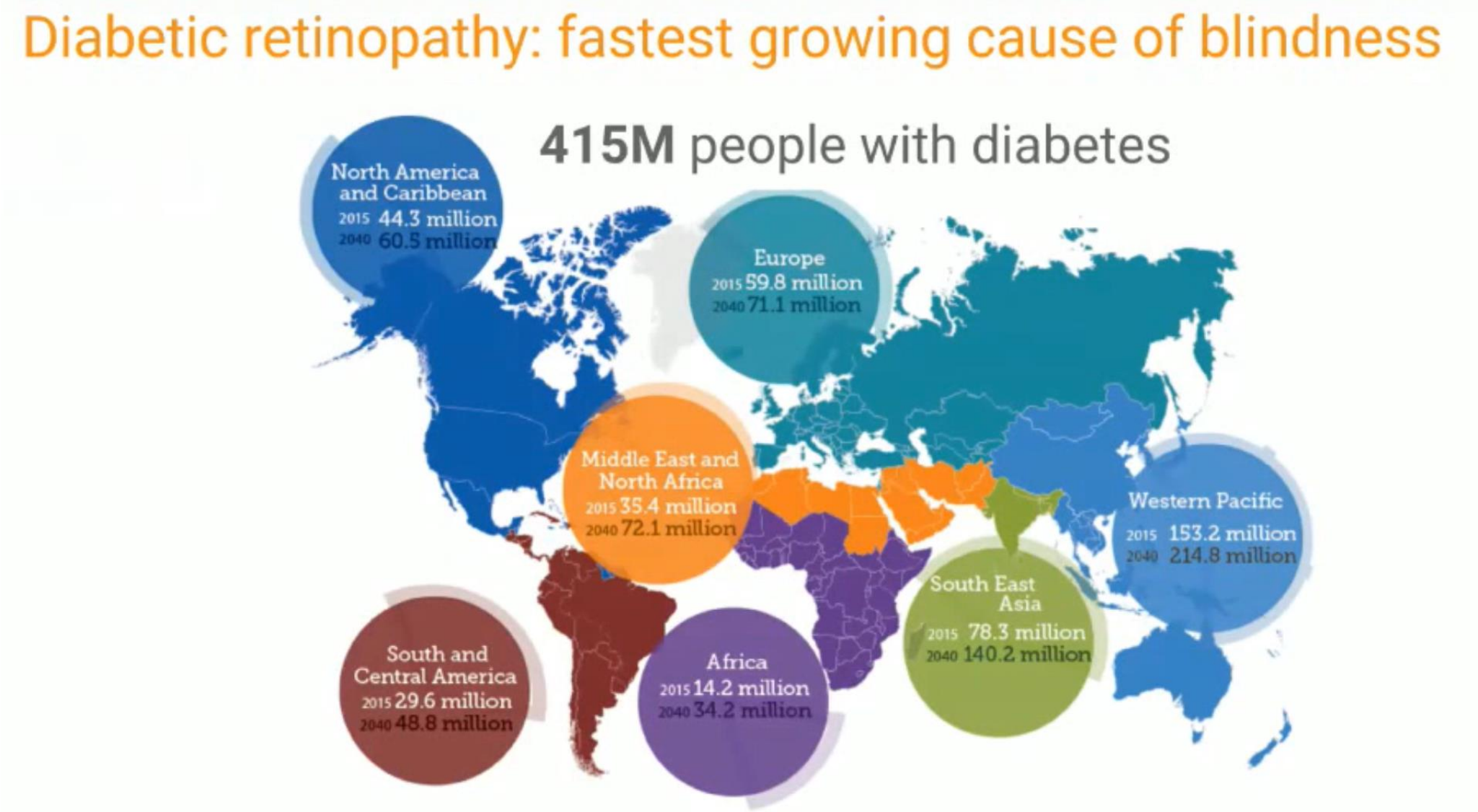
Designing natural language models to detect writing errors and provide feedback.

PROJECT WEBPAGE

10 Promising AI Applications in Health Care



Deep learning for Medical Imaging (Lily Peng, Google)



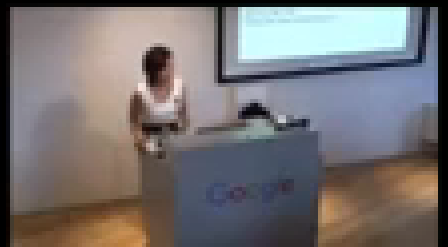
https://www.youtube.com/watch?v=AoWe1khMKzs

Google

Deep Learning for Medical Imaging

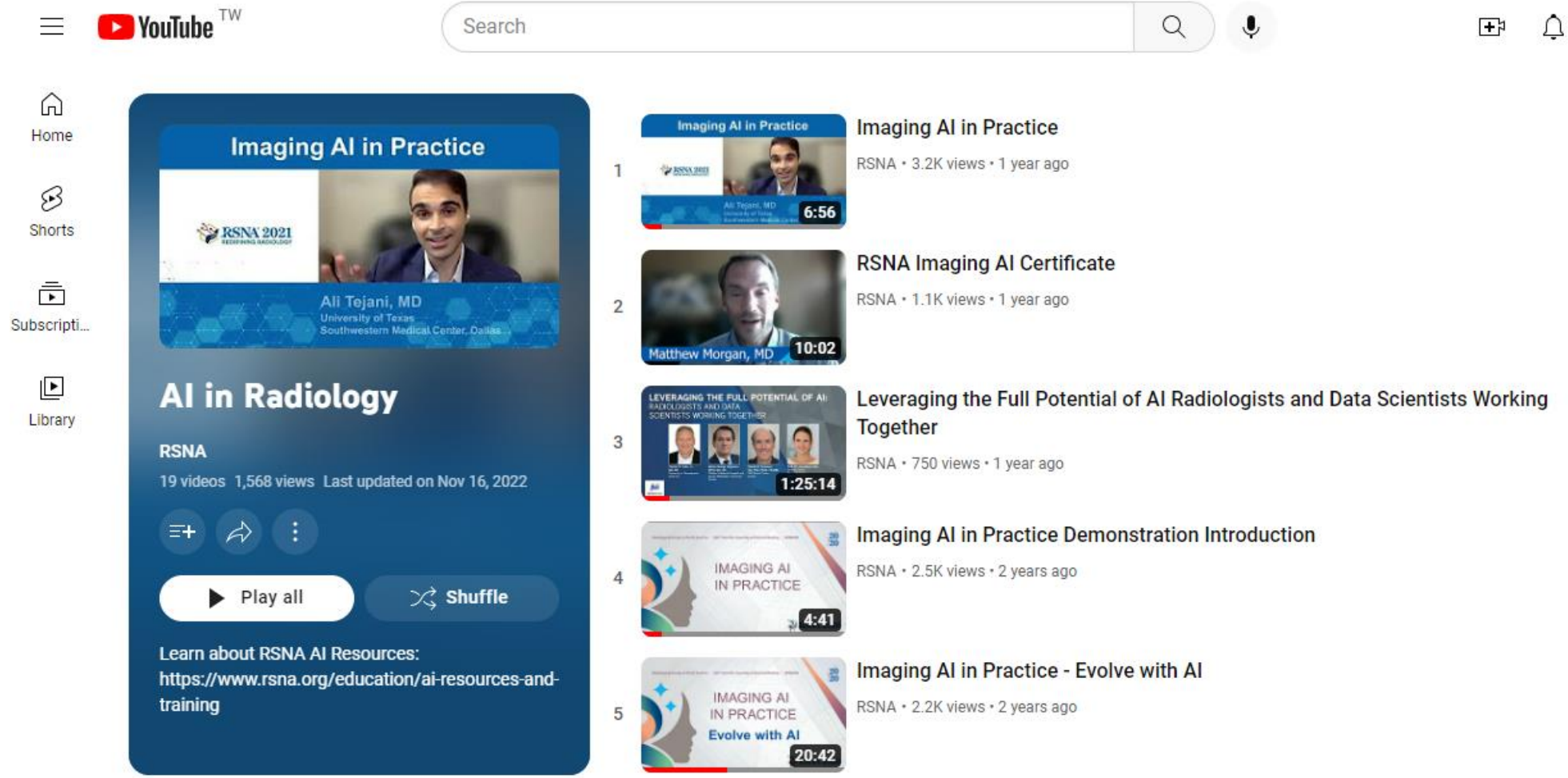
October 2017

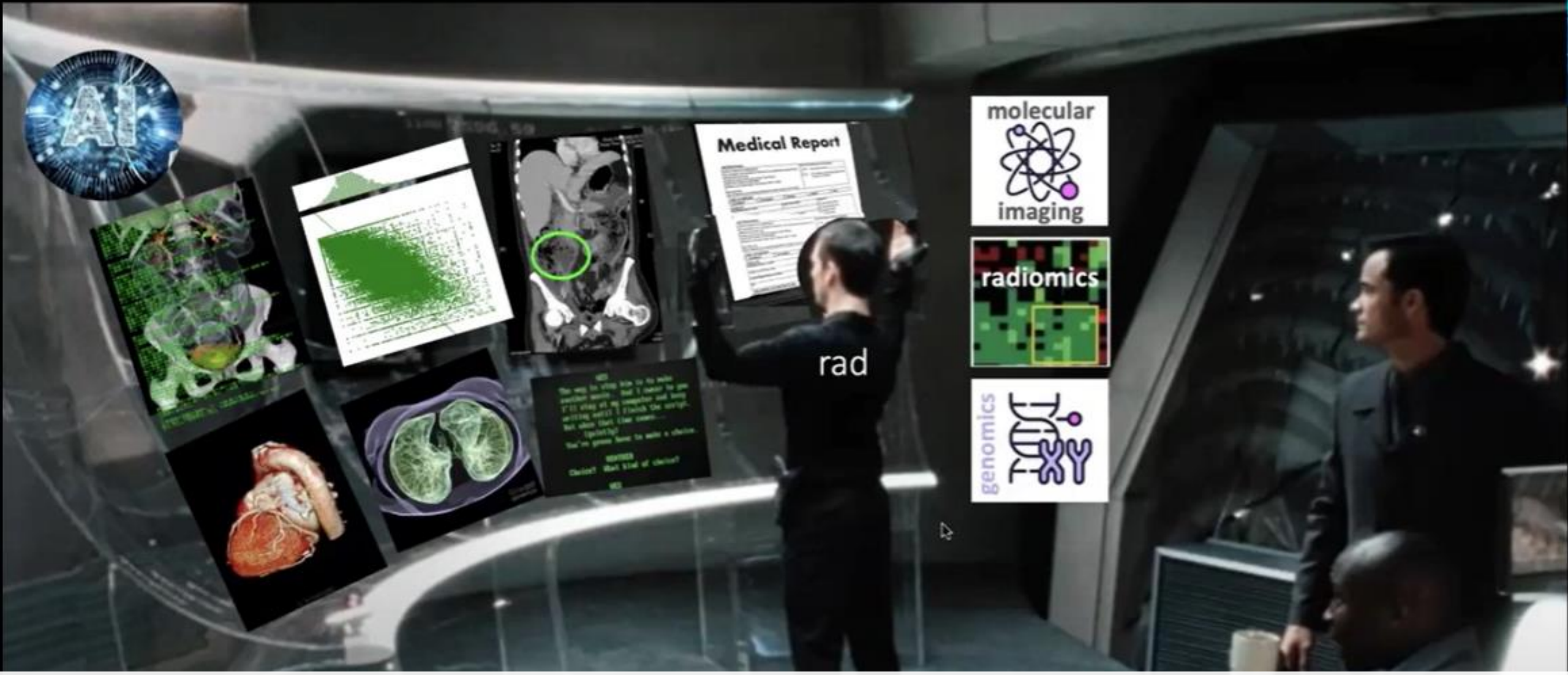
Lily Peng, MD, PhD
Product Manager, Google Research



AI in Radiology (RSNA)

- RSNA: Radiological Society of North America
- https://www.youtube.com/playlist?list=PLEUiLXWVNND1TGgjsnjZybcOkGhotFy2U

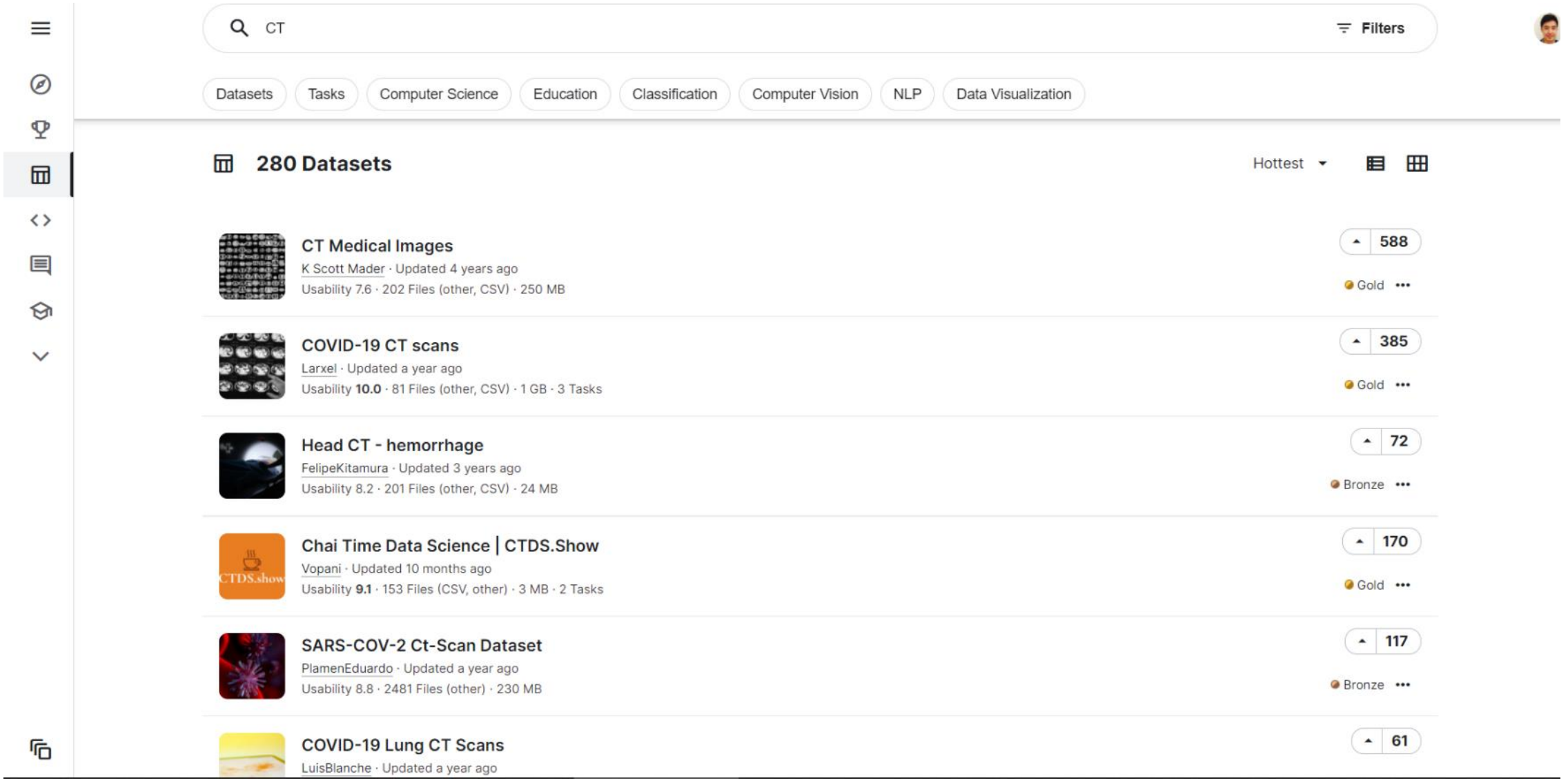




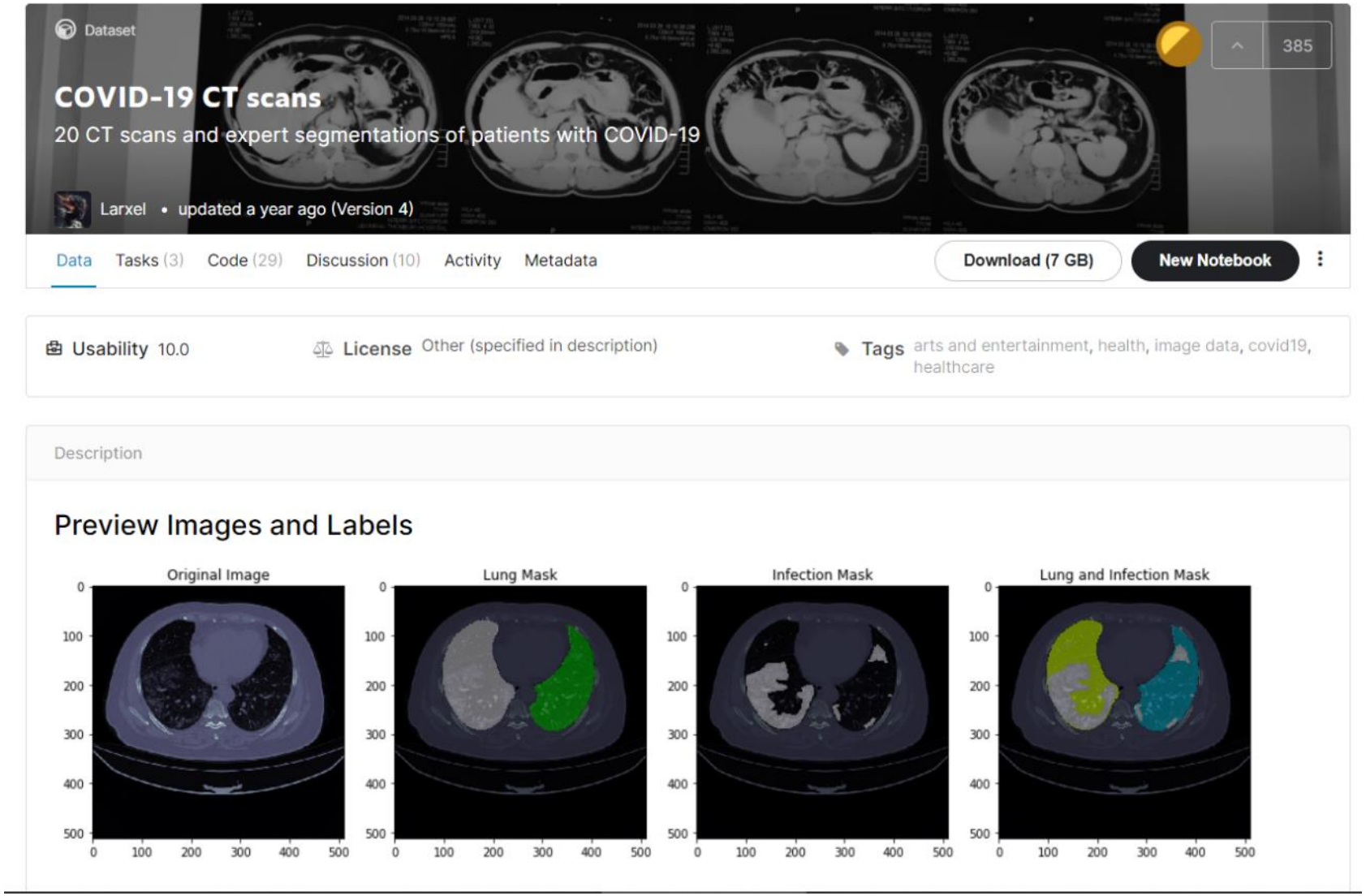
Future of Radiology and AI, Nina Kottler

https://www.youtube.com/watch?v=mgDSJtnWcG0

Medical Imaging Datasets on Kaggle



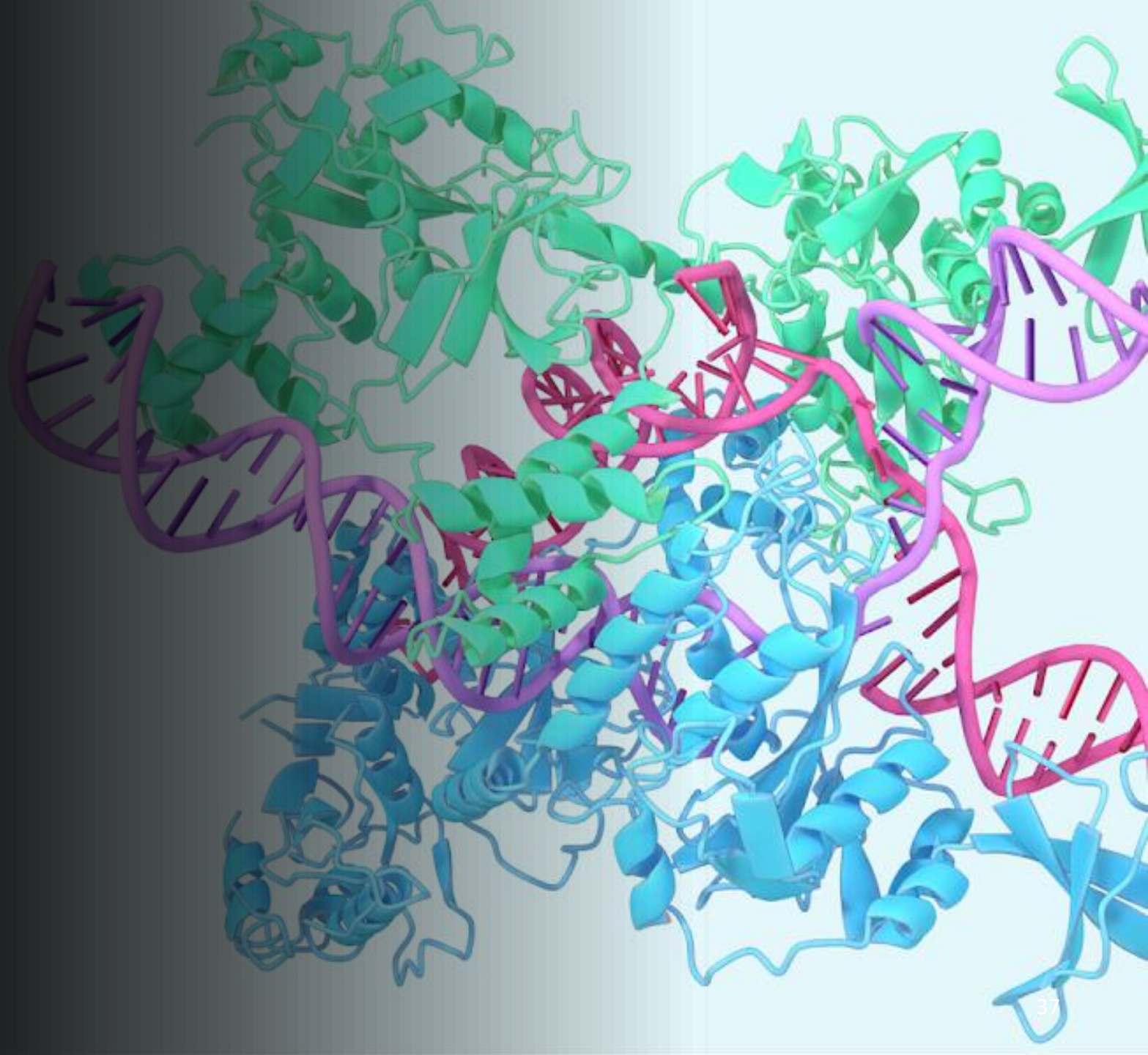
COVID-19 CT Scans Dataset



https://www.kaggle.com/andrewmvd/covid19-ct-scans

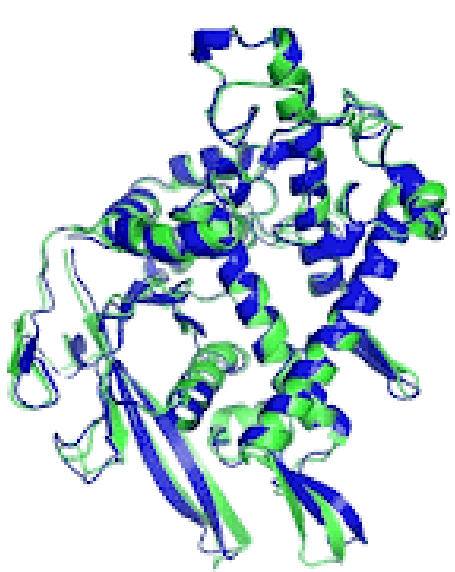
AlphaFold

DeepMind, Google

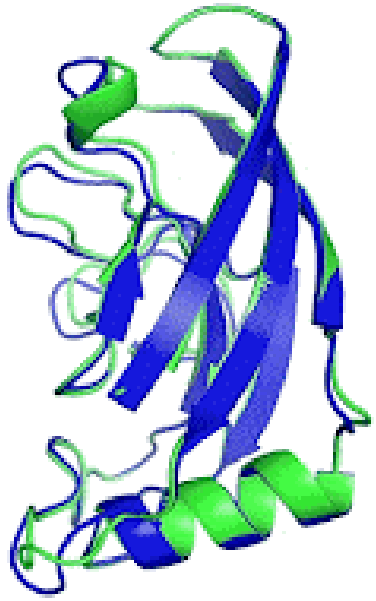


AlphaFold: Predict Protein 3D Structure

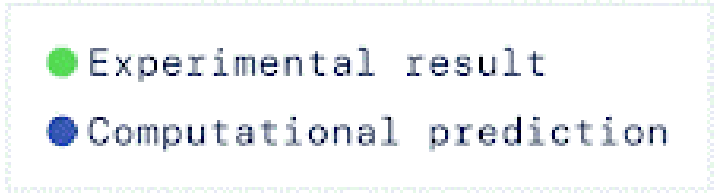
- https://alphafold.ebi.ac.uk/



T1037 / 6vr4
90.7 GDT
(RNA polymerase domain)



T1049 / 6y4f
93.3 GDT
(adhesin tip)



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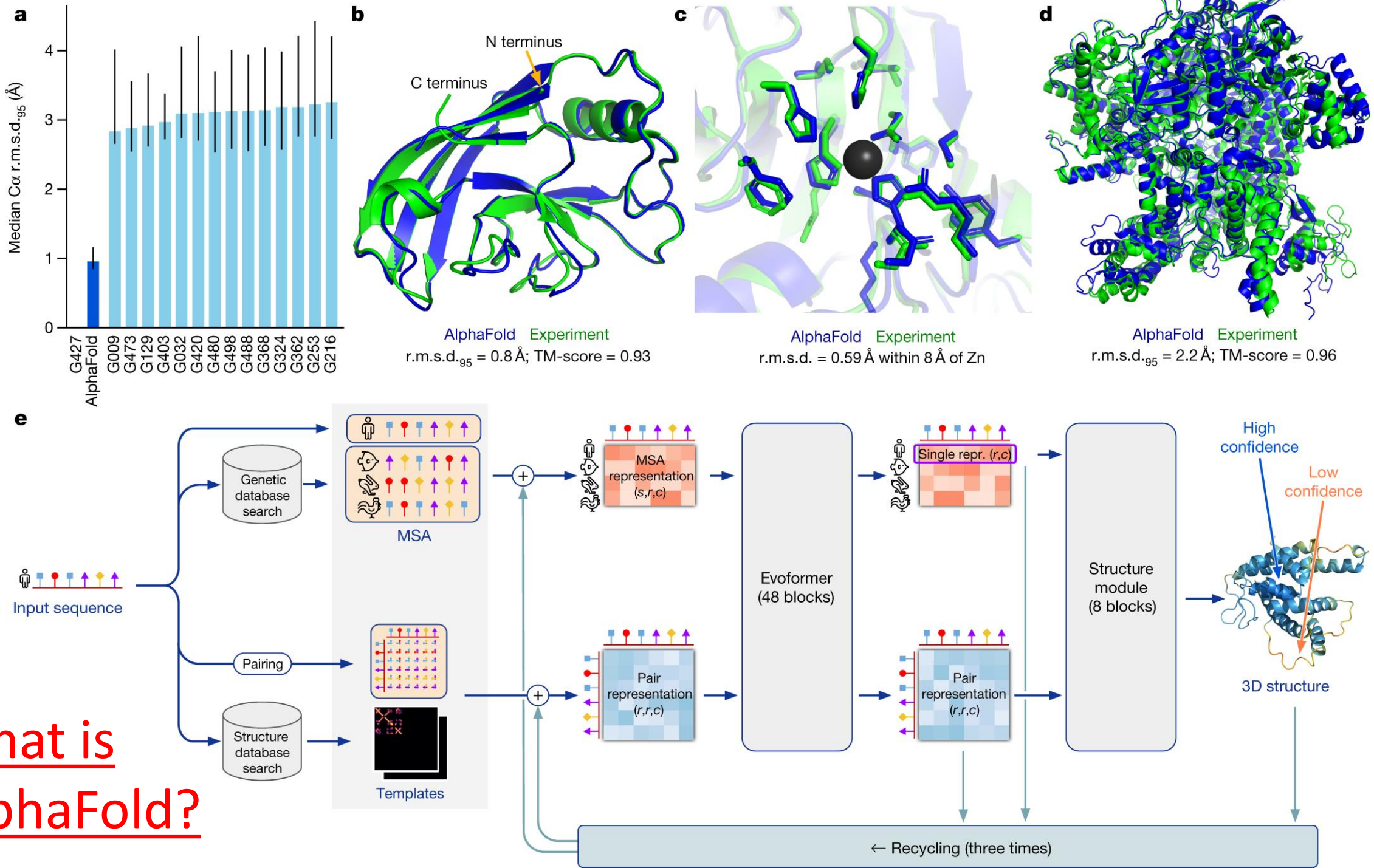
Article | Open access | Published: 15 July 2021

Highly accurate protein structure prediction with AlphaFold

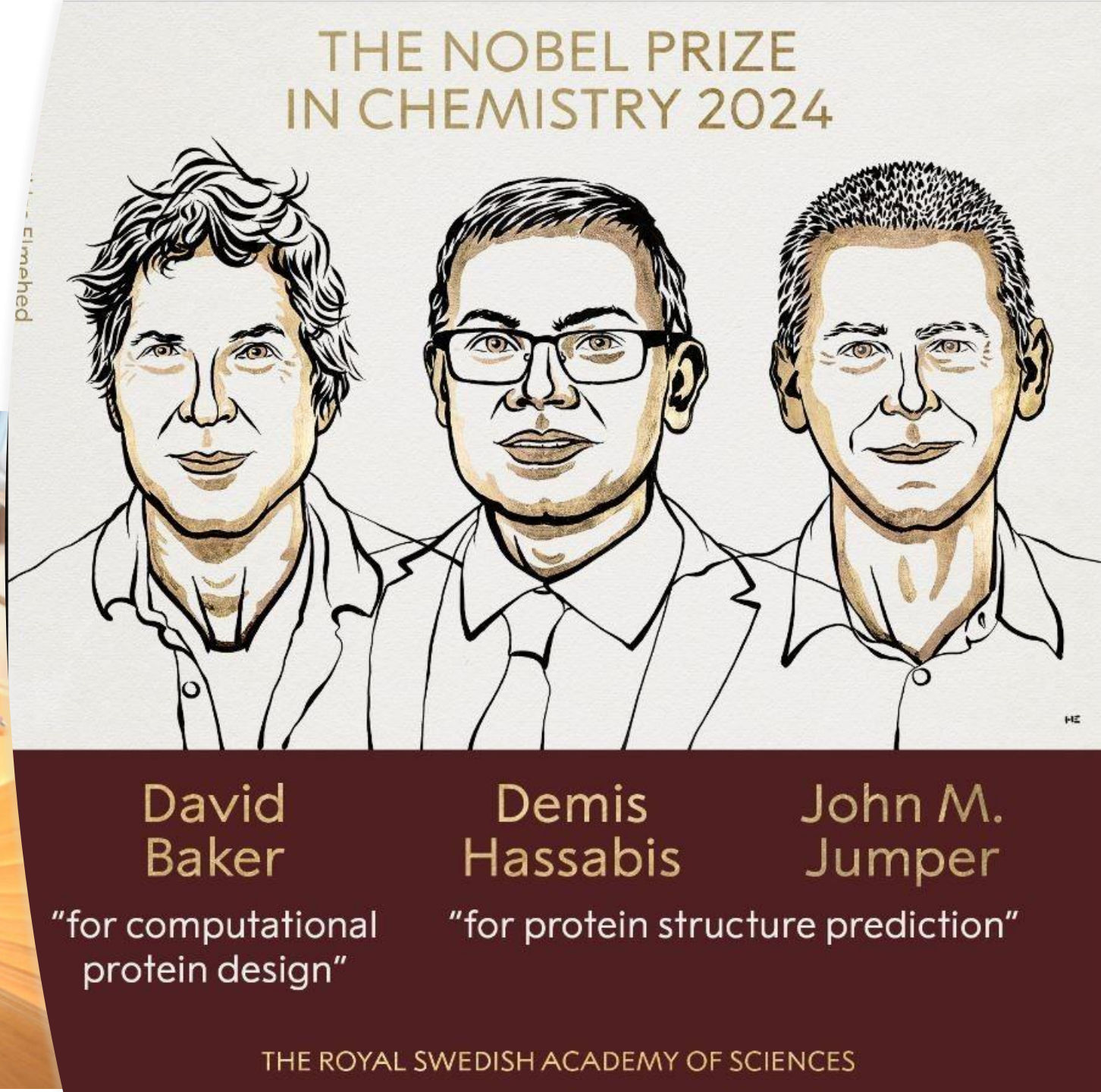
John Jumper ✉, Richard Evans, Alexander Pritzel, Tim Green, Michael Figurnov, Olaf Ronneberger, Kathryn Tunyasuvunakool, Russ Bates, Augustin Žídek, Anna Potapenko, Alex Bridgland, Clemens Meyer, Simon A. A. Kohl, Andrew J. Ballard, Andrew Cowie, Bernardino Romera-Paredes, Stanislav Nikolov, Rishub Jain, Jonas Adler, Trevor Back, Stig Petersen, David Reiman, Ellen Clancy, Michal Zielinski, Martin Steinegger, Michalina Pacholska, Tamas Berghammer, Sebastian Bodenstein, David Silver, Oriol Vinyals, Andrew W. Senior, Koray Kavukcuoglu, Pushmeet Kohli & Demis Hassabis ✉ — Show fewer authors

https://www.nature.com/articles/s41586-021-03819-2

What is AlphaFold?



Nobel Prize in Chemistry 2024



AlphaFold2 Colab Notebook

AlphaFold2.ipynb

檔案 編輯 檢視畫面 插入 執行階段 工具 說明 無法儲存變更

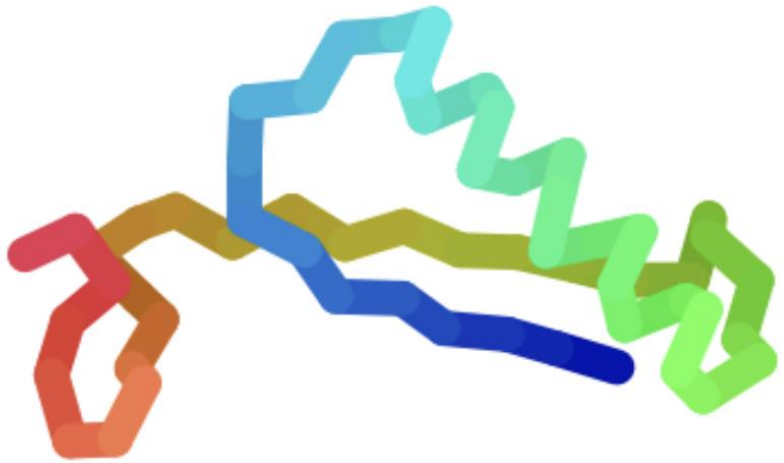
共用

+ 程式碼 + 文字 | 複製到雲端硬碟

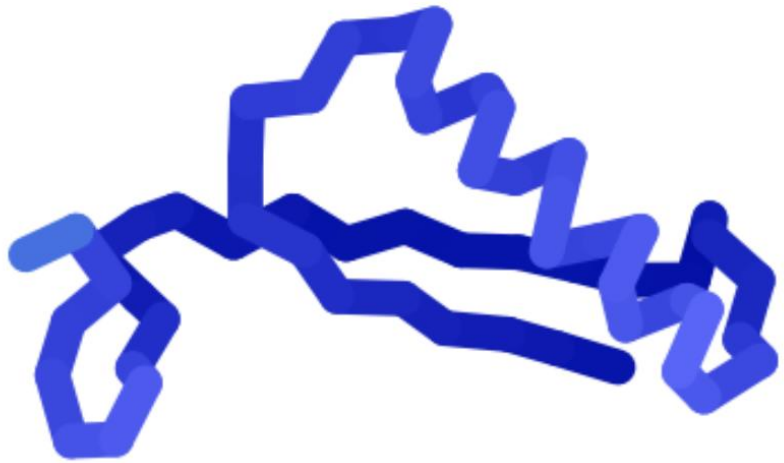
T4 大量 RAM RAM 磁碟 Gemini

顯示程式碼

colored by N→C



colored by pLDDT





台灣醫療AI技術發展

5大AI智慧醫療應用

協助醫療決策	發展醫院的數位決策管控中心，整理資料分析，有助於加速醫院處理急症的效率
增進醫病關係	導入數位科技與人工智慧（AI），協助改善流程，並增進患者體驗與醫病關係
簡化行政流程	透過流程機器人（PRA）和人工智慧等技術，讓照護者專注在照護工作，而非將時間耗費在行政工作
優化服務流程	分析醫院服務瓶頸，透過醫院服務流程設計優化，提升服務品質
提升營運效率	導入數位供應鏈、自動化及機器人等技術，提升營運管理和後台效率

https://www.bnext.com.tw/article/68429/itri040603

科技部醫療影像專案重點

- **當事人自主權**
  (動態同意 dynamic consent)
  - 書面告知
  - 回饋利用資訊
  - 當事人可選擇退出
- **資料服務平台**
  (國網中心)
  - 2階段去識別化，保護個資

- 15項資料集
- 5.9萬個案
- 2.9萬疾病標註個案
- 近百位醫師及AI專家協力

- **台灣大學 - 心血管疾病**
  風險評估
- **台北醫學大學 - 肺癌**
  早期病灶診斷
- **台北榮總 - 腦瘤**
  自動偵測

https://www.ey.gov.tw/Page/448DE008087A1971/4bcdf605-a37f-4110-95df-ced05f0551e8

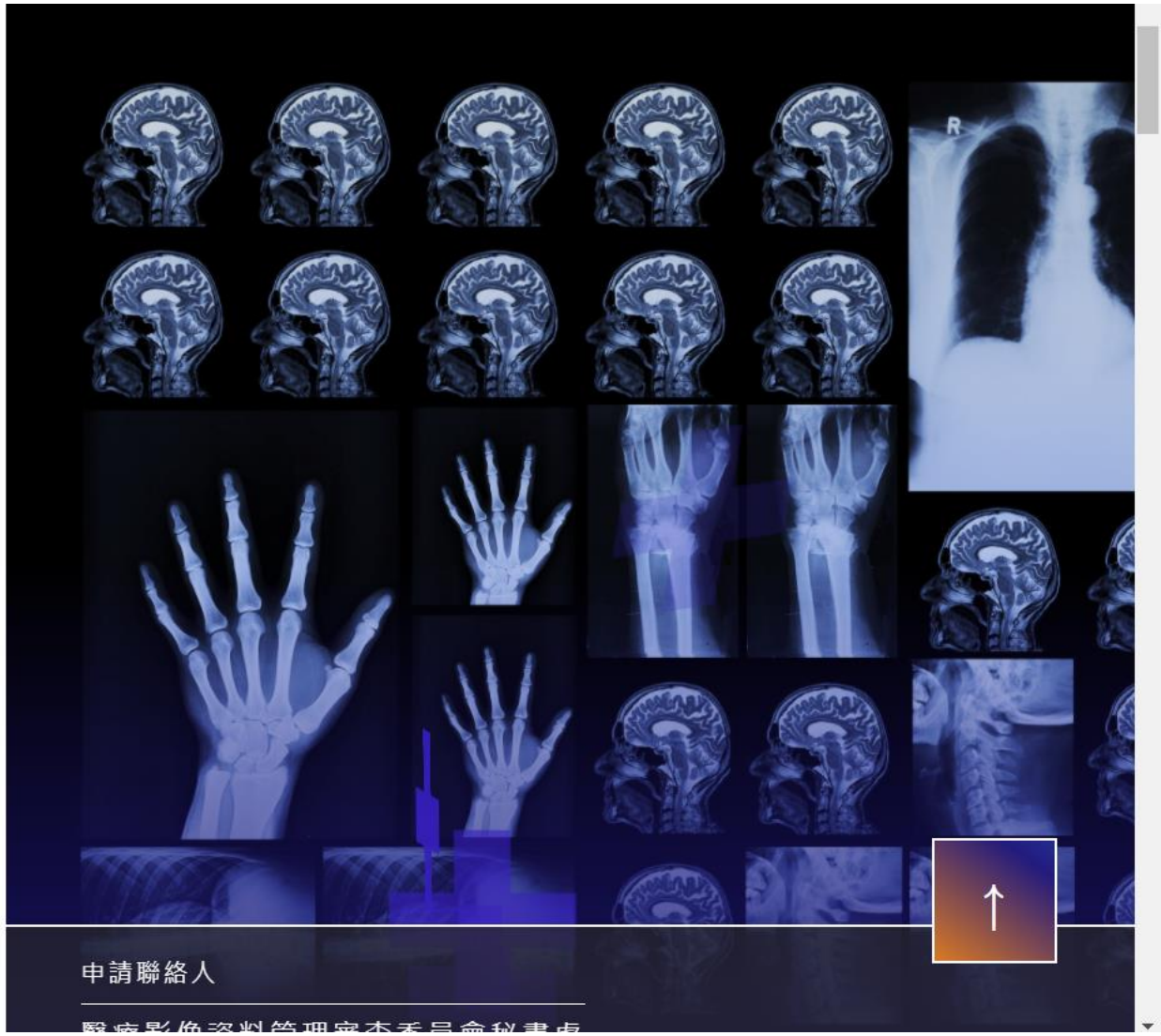
台灣醫療影像資料庫 (lions.nchc.org.tw/medImagedb.jsp)

醫療影像資料庫

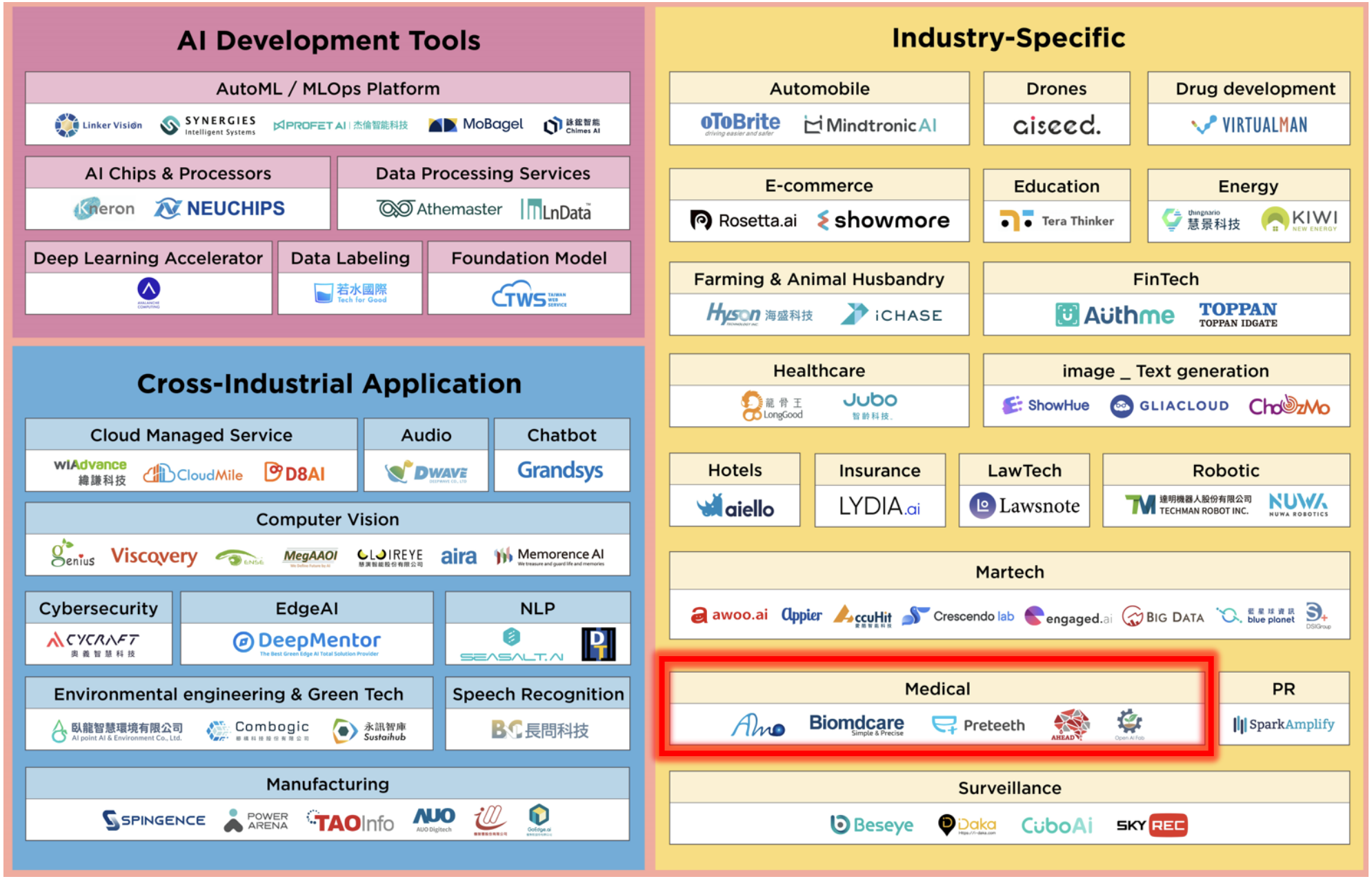
科技部補助成立

此資料庫為科技部補助，匯集國立臺灣大學、臺北榮民總醫院、臺北醫學大學等專業醫療團隊經驗，鎖定心、腦、肺等領域之醫療影像進行高品質標註，以供我國醫療AI研發與應用，未來將持續擴充。相關申請資訊與規範，請參閱以下文件：

- 醫療影像申請審查試辦作業規範
- 19個資料集說明
- 其他申請文件參考
- 醫療影像資料申請說明會之簡報



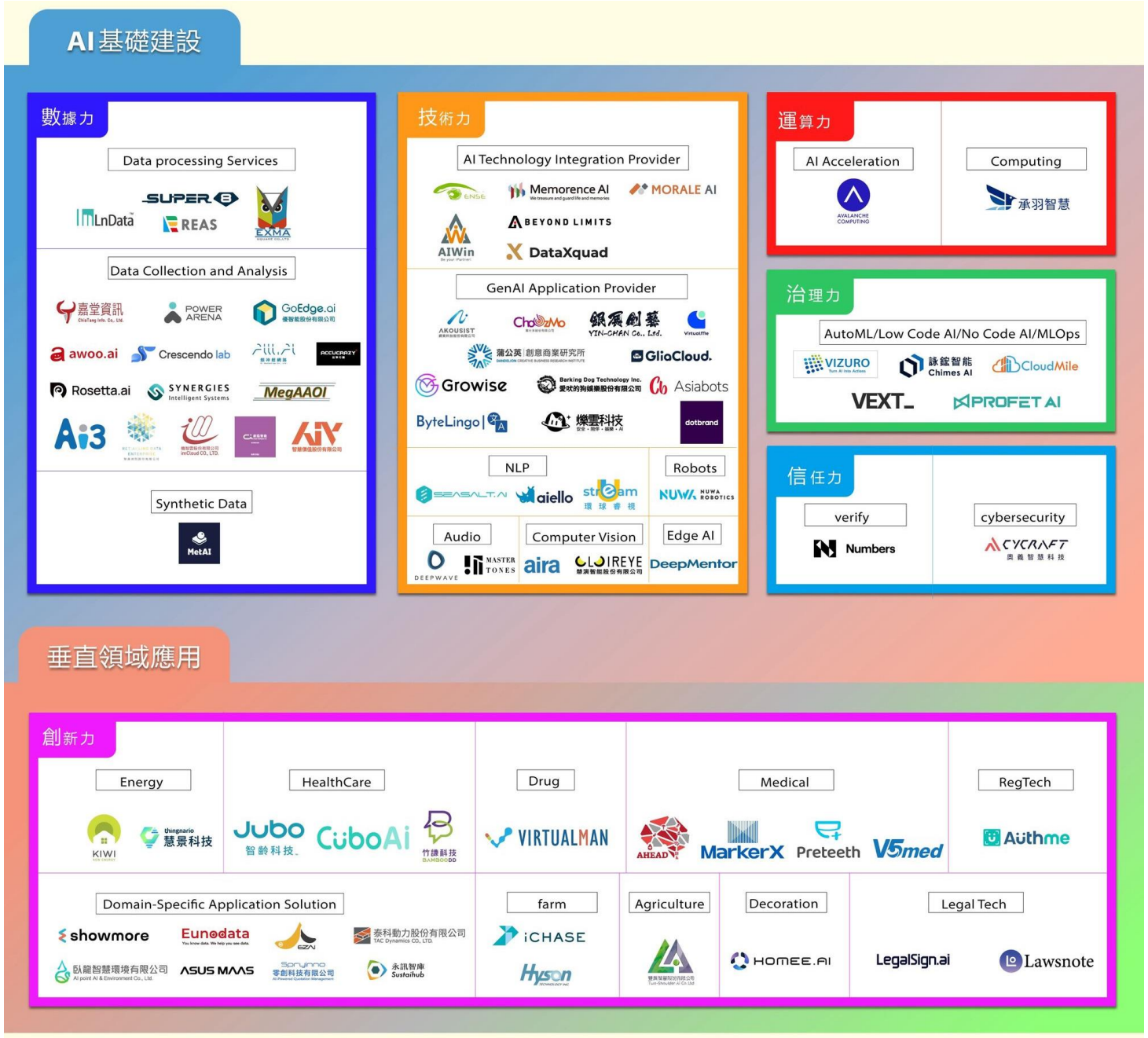
Taiwan's AI Company Map 2023



[知勢: 2023 上半年台灣AI生態系地圖發布：生成式AI、大型語言模型的下一步？]

Taiwan's AI Company Map 2024

[2024 台灣 AI 新創地圖發布：落地應用與 AI 代理人是觀察重點]



aetherAI

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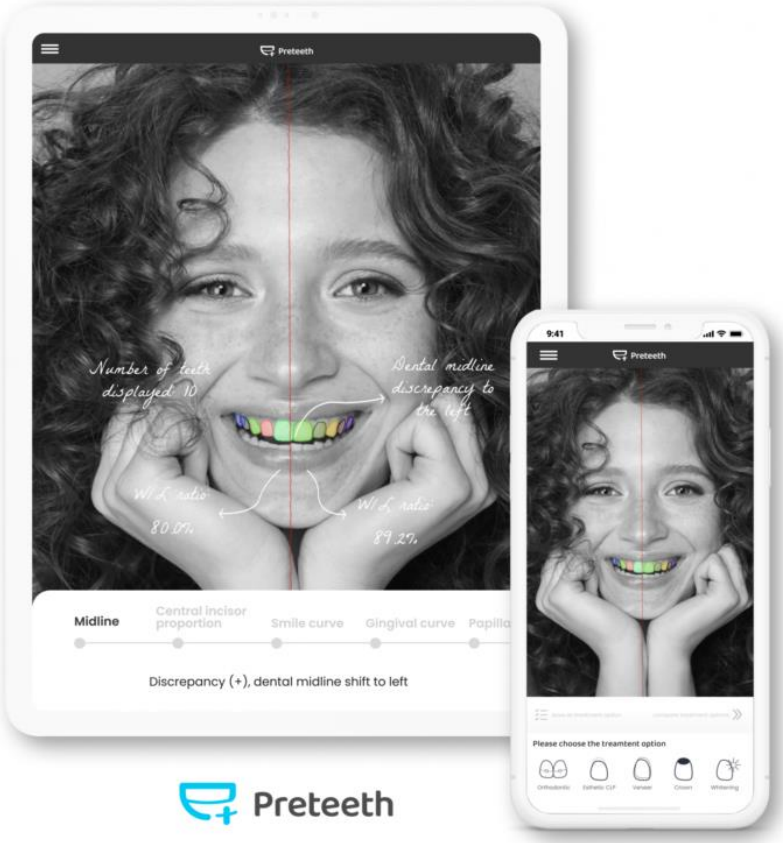
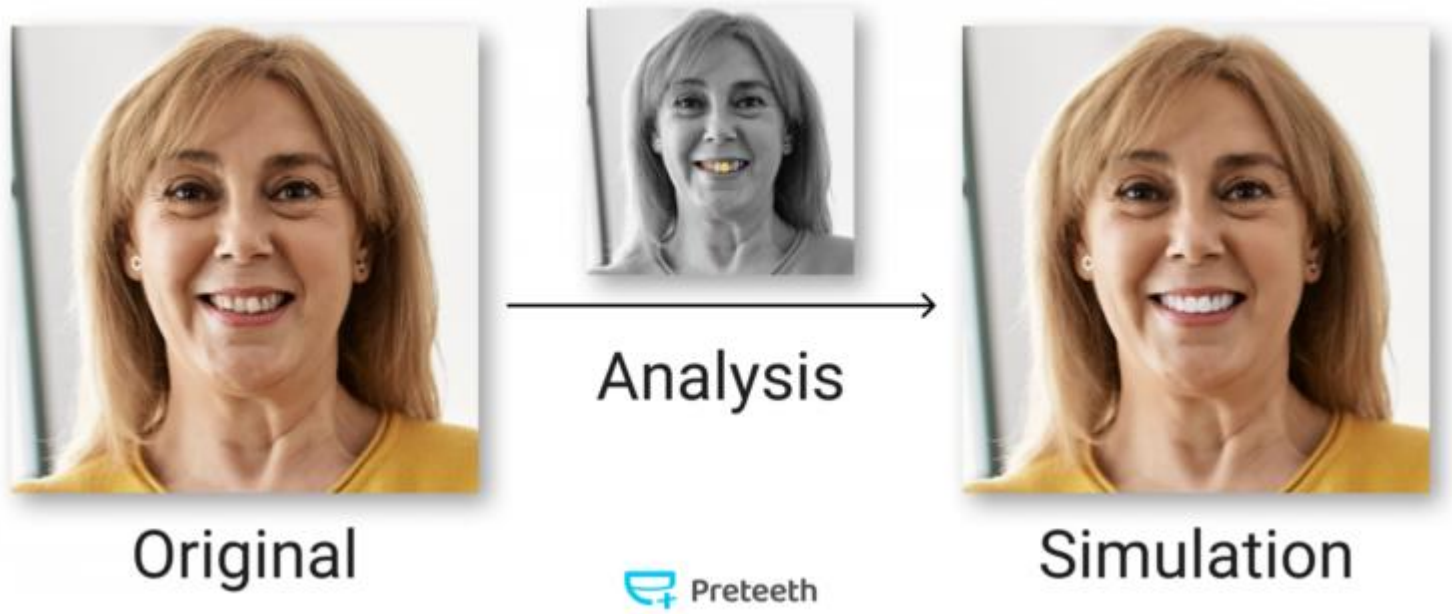
雲象科技

https://www.youtube.com/watch?v=tLf9F0JUHpU

Preteeth AI 德睿生醫

- https://preteeth.com/

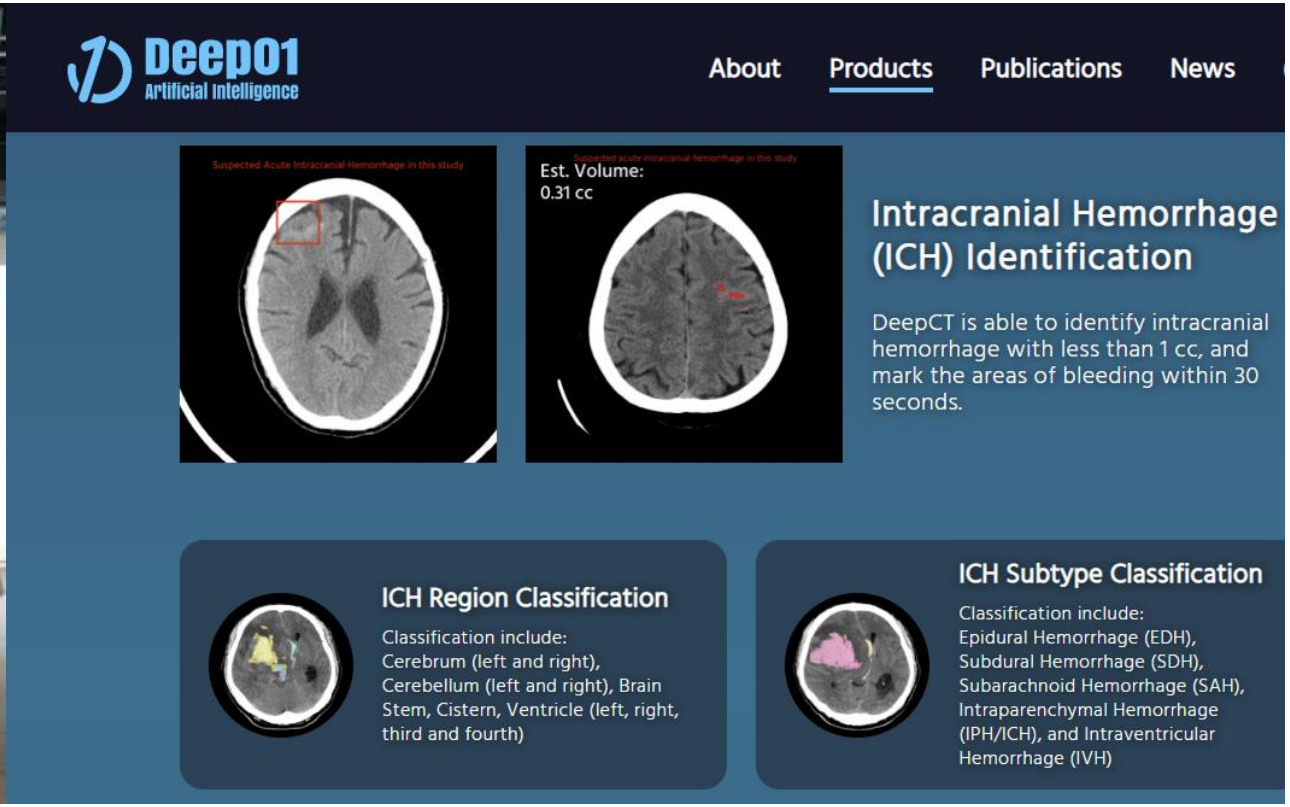




https://technews.tw/2022/06/11/preteeth-ai/

Deep01 愛因斯坦人工智慧

- https://www.deep01.com/



JelloX 捷絡生物科技

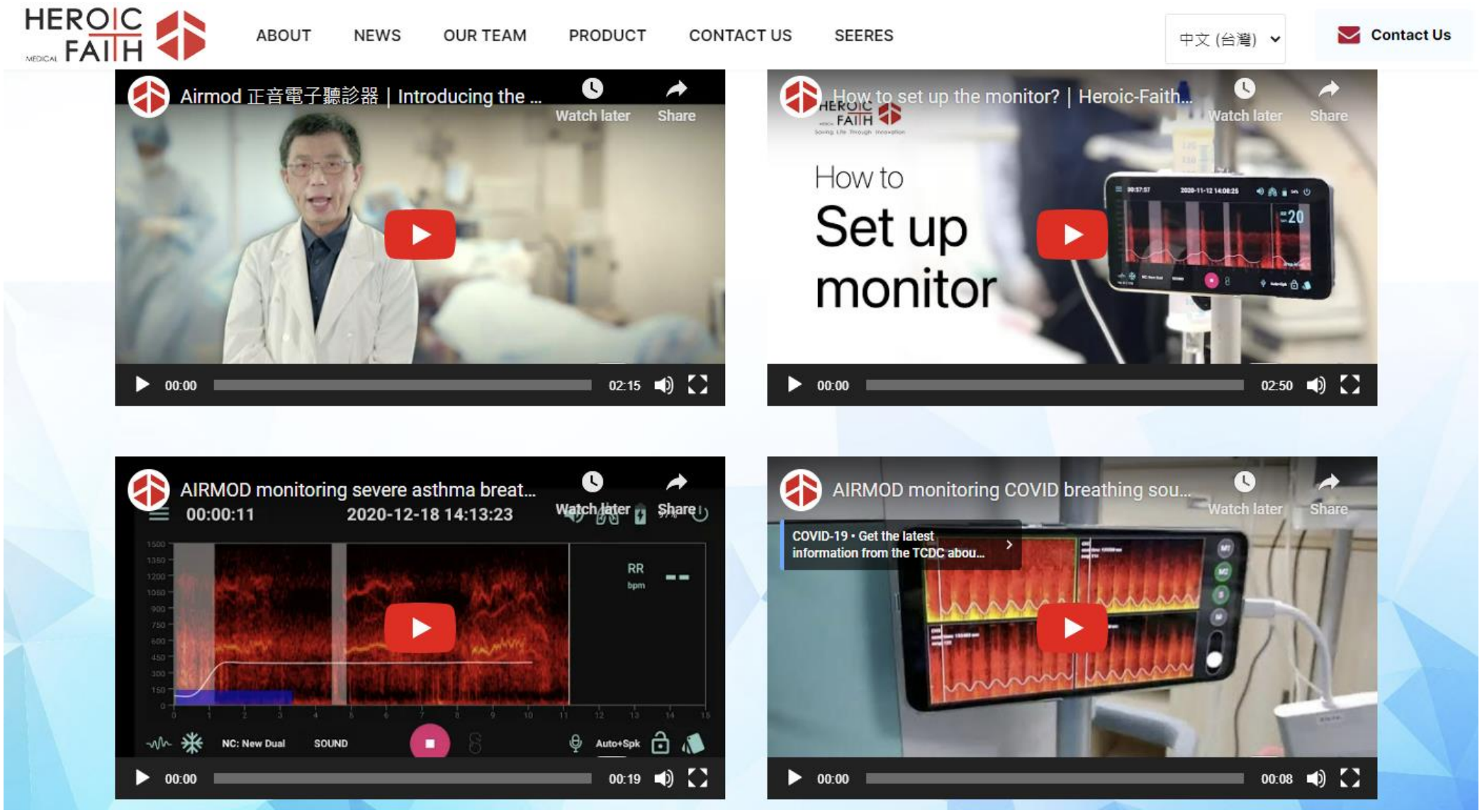
捷絡生技是以3D病理影像支援精準醫療診斷的公司，已開發全球首創搭載AI模組的3D病理分析軟體Metalite，輔助判斷臨床檢體組織型態變異與腫瘤標靶分子分佈，提升癌症診斷與新藥開發成功率，拓展數位病理與AI醫療全新商機。

林彥穎

CEO, JelloX Biotech Inc.

- https://jellox.com/

Heroic Faith 聿信醫療科技



- https://heroic-faith.com/

AHEAD Intelligence 先勁智能

- https://www.aheadmedicine.com/

aheadmedicine.com/news

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AHEAD concluded the inaugural cohort of Berkeley-Taiwan Health Innovation Accelerator Program with a high note.

Berkeley Public Health, 2021-11

先勁智能（AHEAD Intelligence）榮獲EE Awards-亞洲金選獎

第一屆EE Awards Asia在4月初開放報名，在一個多月的時間內就聚集了來自全球133家公司、超過300份報名表格。在新創獎部份，透過多個新創育成中心、加速器推薦新創團隊來自世界各地，如台灣、美國、英國與以色列等等，各懷「獨門絕技」。先勁智能（AHEAD Intelligence）脫穎而出榮獲Start-Up Award 新創獎。

EET TAIWAN, 2021-11

矽谷台灣新創團隊 人工智慧七秒診斷血癌

先勁智能（AHEAD Intelligence）用人工智慧幫助醫生七秒判讀血癌檢驗資料，大幅縮短病患要等最高兩周才能拿到檢驗報告的現況，增加就醫黃金時間。先勁智能與Mayo Clinic以及匹茲堡大學（University of Pittsburgh）都有合作計畫，與Mayo合作的初步成預計於本月份的臨床流式細胞醫學會(ICCS)發表，而與匹茲堡大學的研究成果也獲得美國臨床病理期刊所接受。

世界新聞網, 2021-10

CAN WE BE IMMORTAL?

References

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- https://towardsdatascience.com/deep-learning-with-magnetic-resonance-and-computed-tomography-images-e9f32273dcb5
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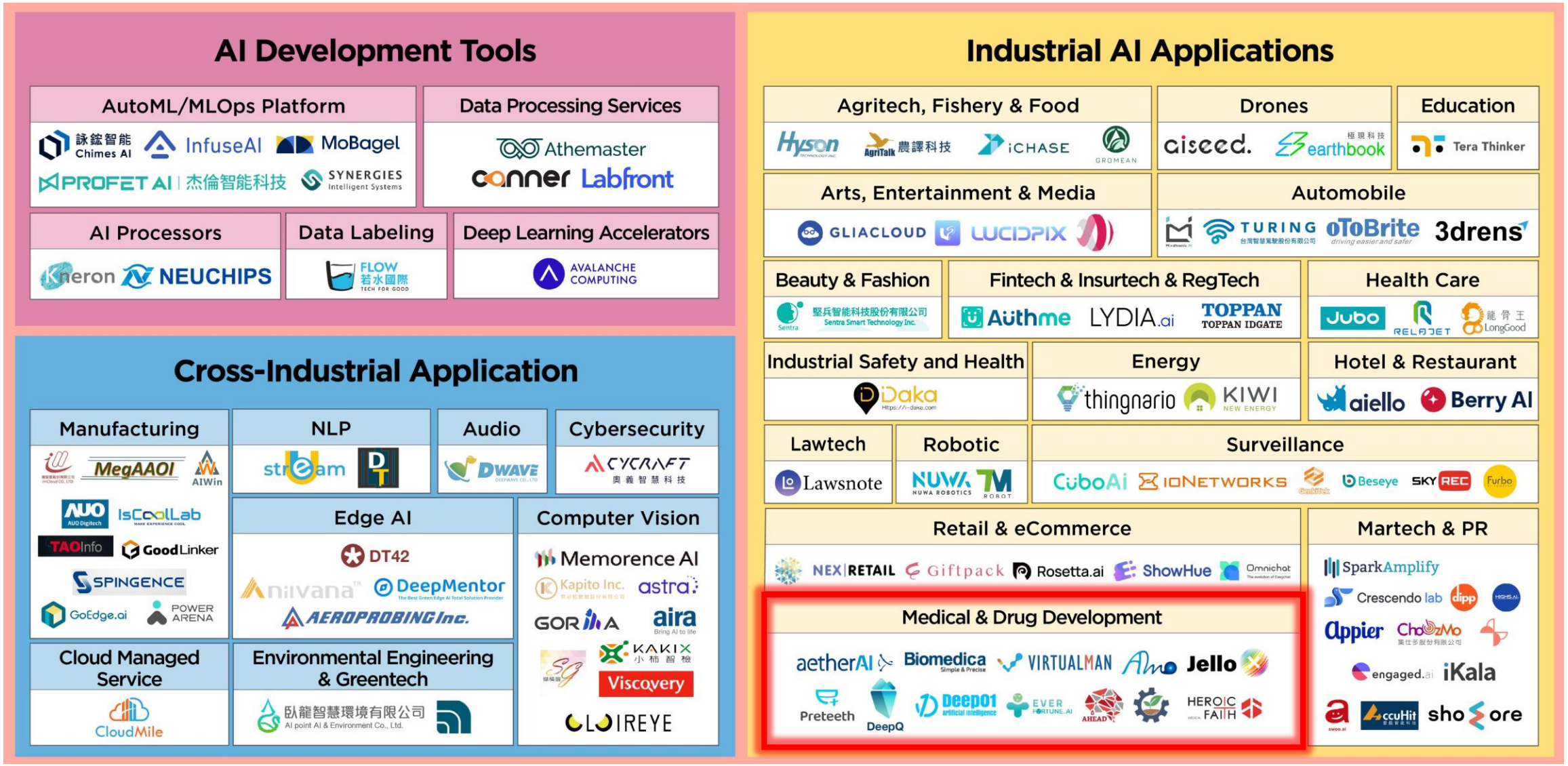
- https://www.ey.gov.tw/Page/448DE008087A1971/4bcdf605-a37f-4110-95df-ced05f0551e8
- https://lexica.art/

Taiwan's AI Company Map 2022



https://edge.aif.tw/2022secondhalf-ai-map/