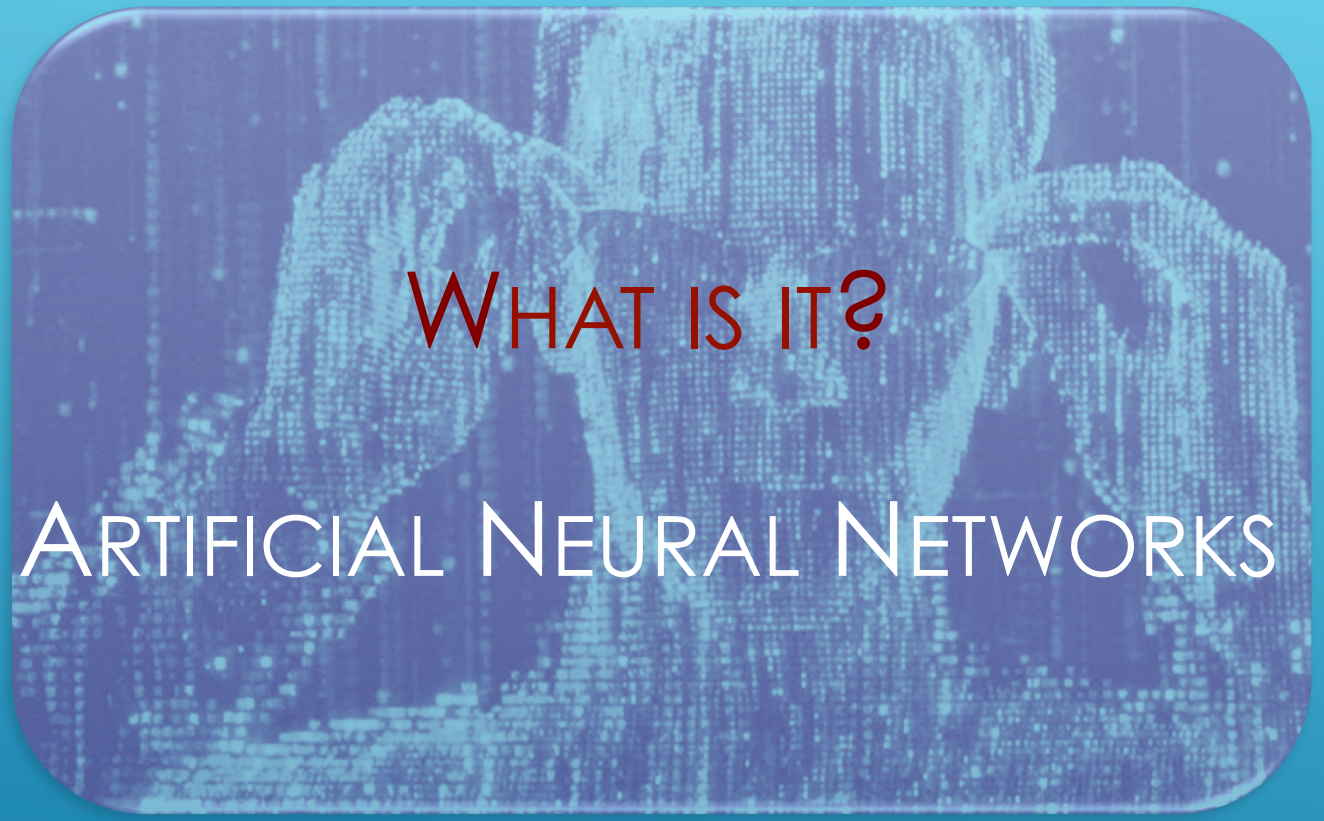
ARTIFICIAL INTELLIGENCE AND RADIOLOGY

William T. Herrington MD FACR

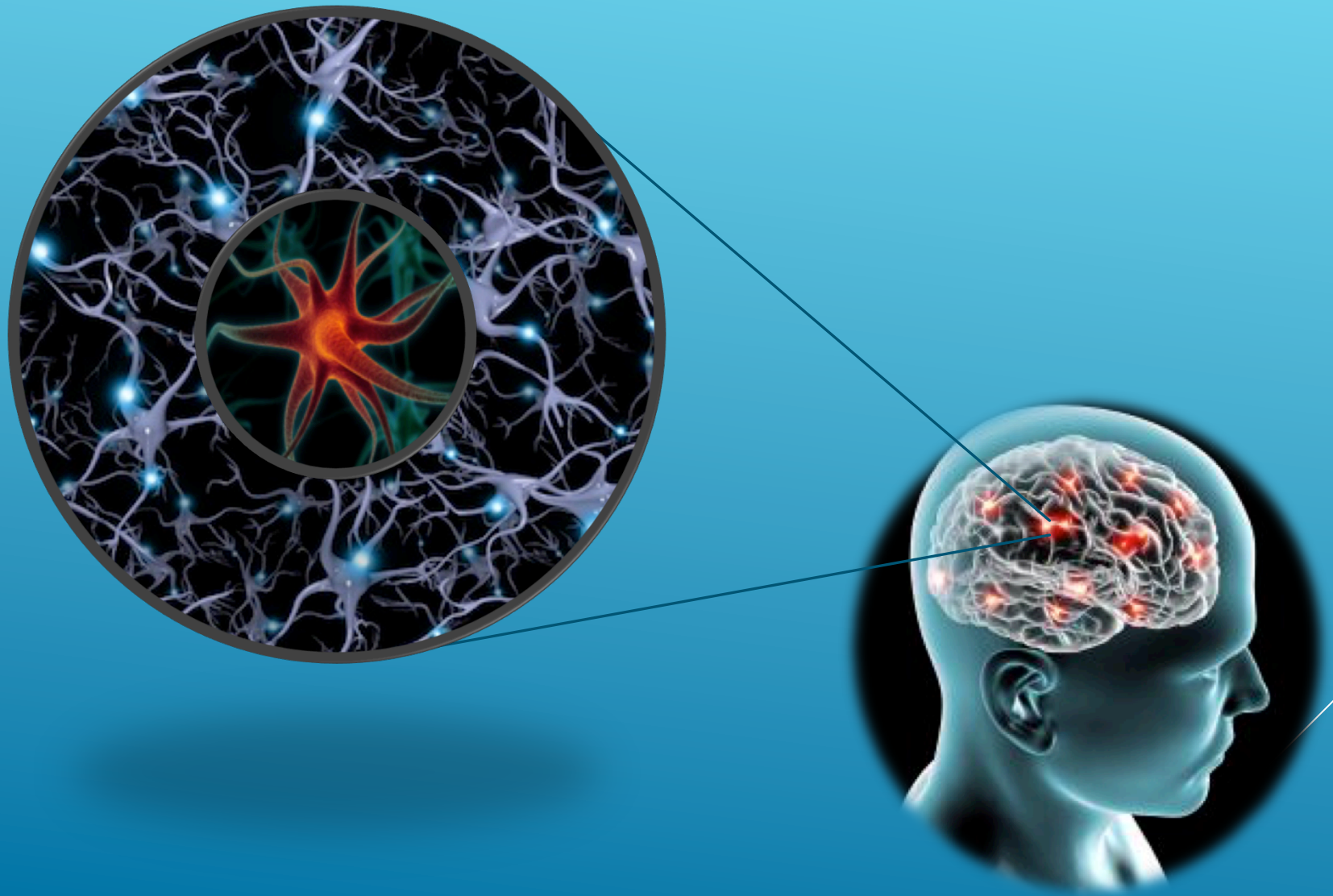
Deep Learning



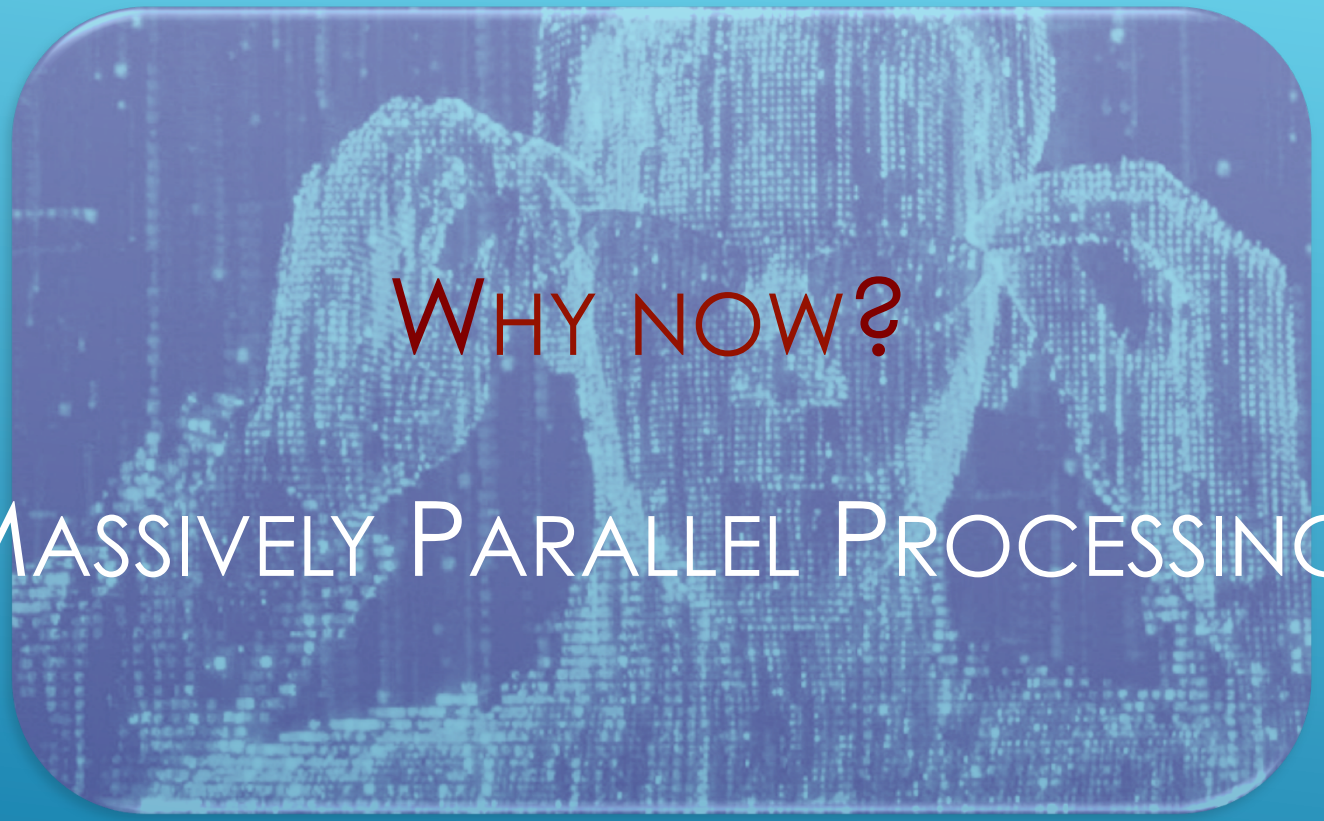
What is it?

Artificial Neural Networks

Biological Neural Network



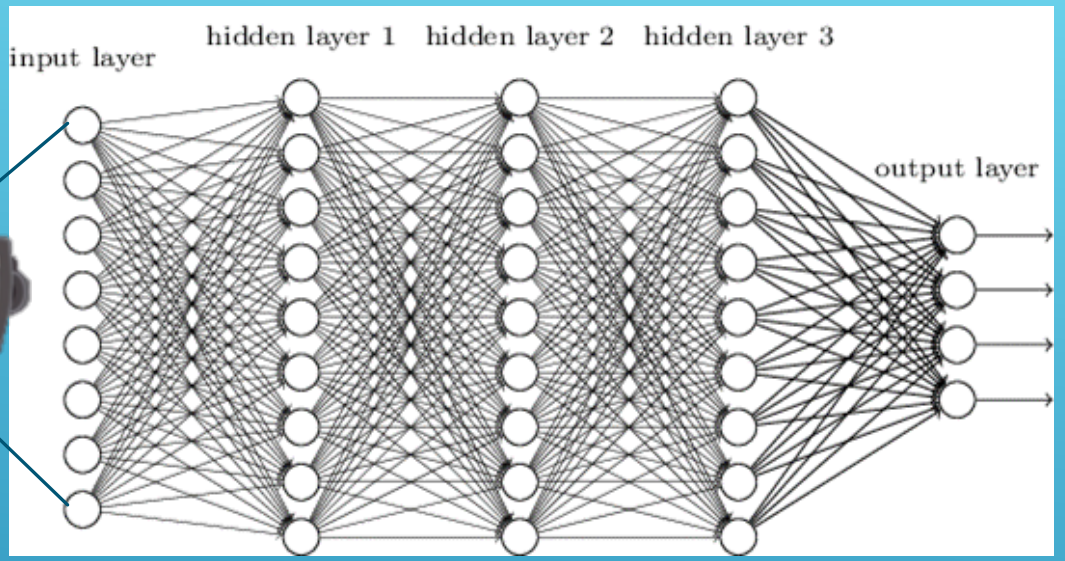
Deep Learning



Why now?

Massively Parallel Processing

Artificial Neural Network



Object
Person
Concept
Disease

$$
\begin{aligned}
\mathbf{w}^{\mathrm{T}}\mathbf{S}_W^{\phi}\mathbf{w} &= \left(\sum_{i=1}^{l}\alpha_i\phi^{\mathrm{T}}(\mathbf{x}_i)\right)\left(\sum_{j=1,2}\sum_{n=1}^{l_j}(\phi(\mathbf{x}_n^j)-\mathbf{m}_j^{\phi})(\phi(\mathbf{x}_n^j)-\mathbf{m}_j^{\phi})^{\mathrm{T}}\right)\left(\sum_{k=1}^{l}\alpha_k\phi(\mathbf{x}_k)\right)\\
&= \sum_{j=1,2}\sum_{i=1}^{l}\sum_{n=1}^{l_j}\sum_{k=1}^{l}\alpha_i\phi^{\mathrm{T}}(\mathbf{x}_i)(\phi(\mathbf{x}_n^j)-\mathbf{m}_j^{\phi})(\phi(\mathbf{x}_n^j)-\mathbf{m}_j^{\phi})^{\mathrm{T}}\alpha_k\phi(\mathbf{x}_k)\\
&= \sum_{j=1,2}\sum_{i=1}^{l}\sum_{n=1}^{l_j}\sum_{k=1}^{l}\left(\alpha_i k(\mathbf{x}_i,\mathbf{x}_n^j)-\frac{1}{l_j}\sum_{p=1}^{l_j}\alpha_i k(\mathbf{x}_i,\mathbf{x}_p^j)\right)\left(\alpha_k k(\mathbf{x}_k,\mathbf{x}_n^j)-\frac{1}{l_j}\sum_{q=1}^{l_j}\alpha_k k(\mathbf{x}_k,\mathbf{x}_q^j)\right)\\
&= \sum_{j=1,2}\left(\sum_{i=1}^{l}\sum_{n=1}^{l_j}\sum_{k=1}^{l}\left(\alpha_i\alpha_k k(\mathbf{x}_i,\mathbf{x}_n^j)k(\mathbf{x}_k,\mathbf{x}_n^j)\right.\right.\\
&= \sum_{j=1,2}\left(\sum_{i=1}^{l}\sum_{n=1}^{l_j}\sum_{k=1}^{l}\left(\alpha_i\alpha_k k(\mathbf{x}_i,\mathbf{x}_n^j)k(\mathbf{x}_k,\mathbf{x}_n^j)\right.\right.\\
&\quad\left.\left.-\frac{2\alpha_i\alpha_k}{l_j}\sum_{p=1}^{l_j}k(\mathbf{x}_i,\mathbf{x}_n^j)k(\mathbf{x}_k,\mathbf{x}_p^j)+\frac{\alpha_i\alpha_k}{l_j^2}\sum_{p=1}^{l_j}\sum_{q=1}^{l_j}k(\mathbf{x}_i,\mathbf{x}_p^j)k(\mathbf{x}_k,\mathbf{x}_q^j)\right)\right)\\
&= \sum_{j=1,2}\left(\sum_{i=1}^{l}\sum_{n=1}^{l_j}\sum_{k=1}^{l}\left(\alpha_i\alpha_k k(\mathbf{x}_i,\mathbf{x}_n^j)k(\mathbf{x}_k,\mathbf{x}_n^j)-\frac{\alpha_i\alpha_k}{l_j}\sum_{p=1}^{l_j}k(\mathbf{x}_i,\mathbf{x}_n^j)k(\mathbf{x}_k,\mathbf{x}_p^j)\right)\right)\\
&= \sum_{j=1,2}\alpha^{\mathrm{T}}\mathbf{K}_j\mathbf{K}_j^{\mathrm{T}}\alpha-\alpha^{\mathrm{T}}\mathbf{K}_j\mathbf{1}_{l_j}\mathbf{K}_j^{\mathrm{T}}\alpha\\
&= \alpha^{\mathrm{T}}\mathbf{N}\alpha.
\end{aligned}
$$

Art, Science and GPU's

Adam Savage & Jamie Hyneman

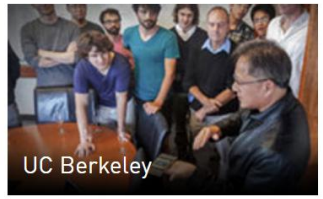
Explain Parallel Processing

THE WORLD'S FIRST AI SUPERCOMPUTER IN A BOX

Get faster training, larger models, and more accurate results on deep learning with the NVIDIA® DGX-1™. This is the world's first purpose-built system for deep learning and AI accelerated analytics, delivering performance equal to 250 conventional servers. It comes fully integrated with hardware, deep learning software, development tools, and runs popular accelerated analytics applications. This means you can immediately shorten data processing time, visualize more data, accelerate deep learning frameworks, and design more sophisticated neural networks.

NVIDIA DGX-1 is available through select NPN Accelerated Computing partners.

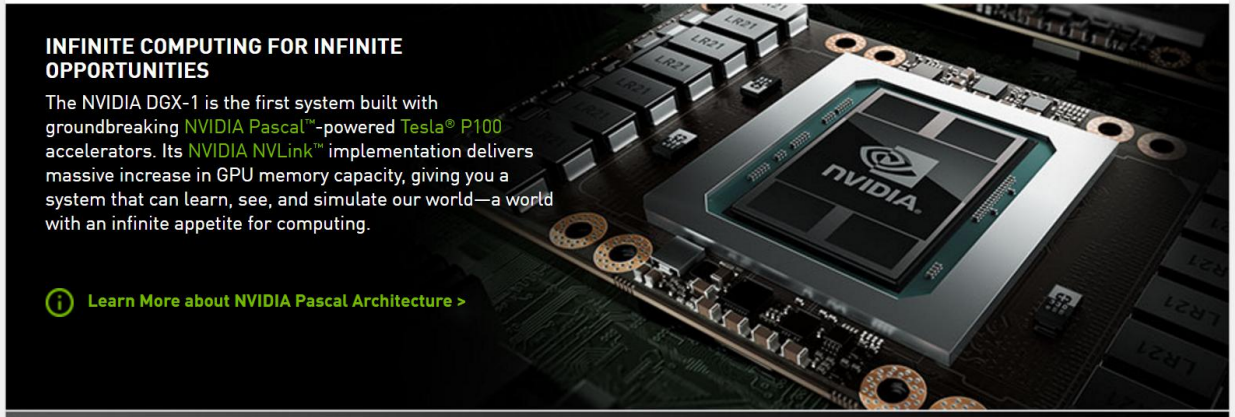
Learn how AI researchers are advancing deep learning and analytics with DGX-1

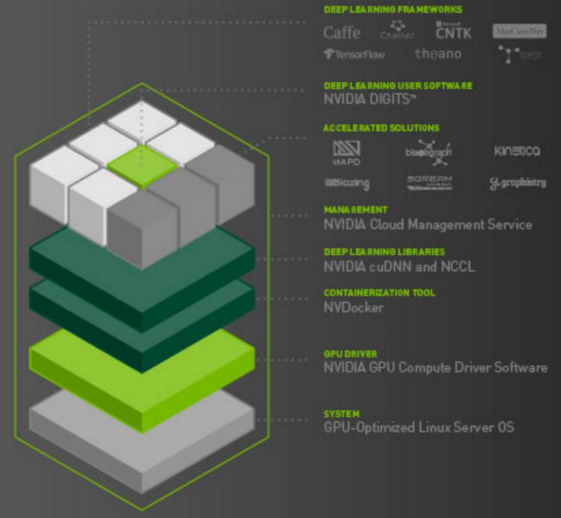


INFINITE COMPUTING FOR INFINITE OPPORTUNITIES

The NVIDIA DGX-1 is the first system built with groundbreaking NVIDIA Pascal™-powered Tesla® P100 accelerators. Its NVIDIA NVLink™ implementation delivers massive increase in GPU memory capacity, giving you a system that can learn, see, and simulate our world—a world with an infinite appetite for computing.

Learn More about NVIDIA Pascal Architecture >





ANALYZE. VISUALIZE. AI-ACCELERATE

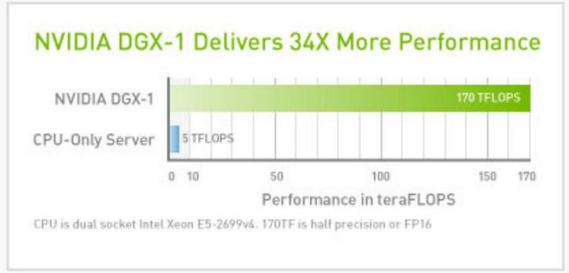
The NVIDIA DGX-1 software stack includes major deep learning frameworks, the NVIDIA DIGITS™ GPU training system, the NVIDIA Deep Learning SDK (e.g. CuDNN, NCCL), NVIDIA Docker, GPU drivers, and NVIDIA CUDA® for rapidly designing deep neural networks (DNN). It's the ideal stack for accelerating popular analytics and visualization software.

This powerful system includes access to cloud management services for container creation and deployment, system updates, and an application repository. The combination of these software capabilities running on Pascal-powered Tesla GPUs allows applications to run 12X faster than with previous GPU-accelerated solutions.

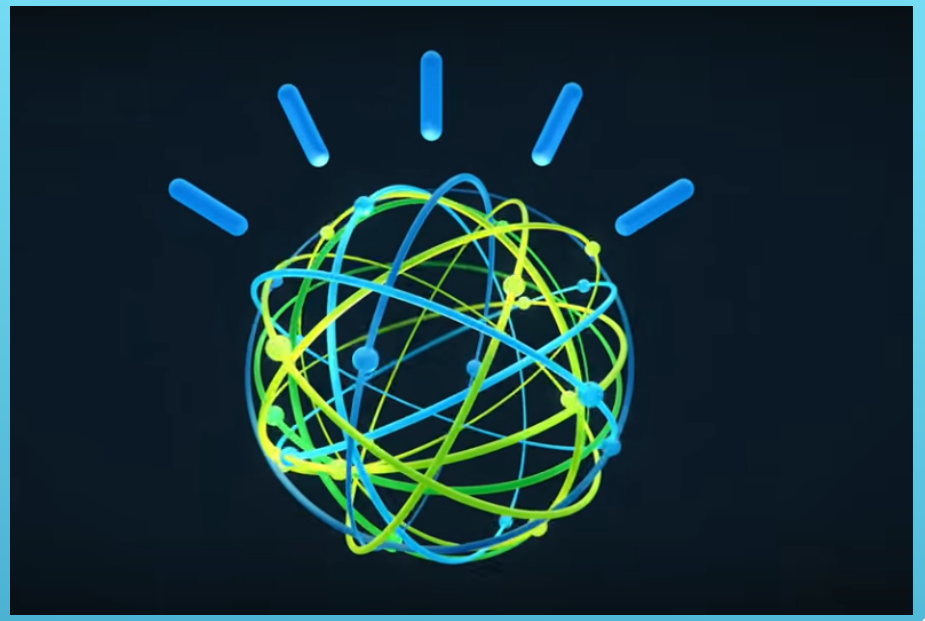
Get Started with Deep Learning Now >

ITERATE AND INNOVATE FASTER

High-performance training accelerates your productivity, which means faster time to insight and faster time to market.

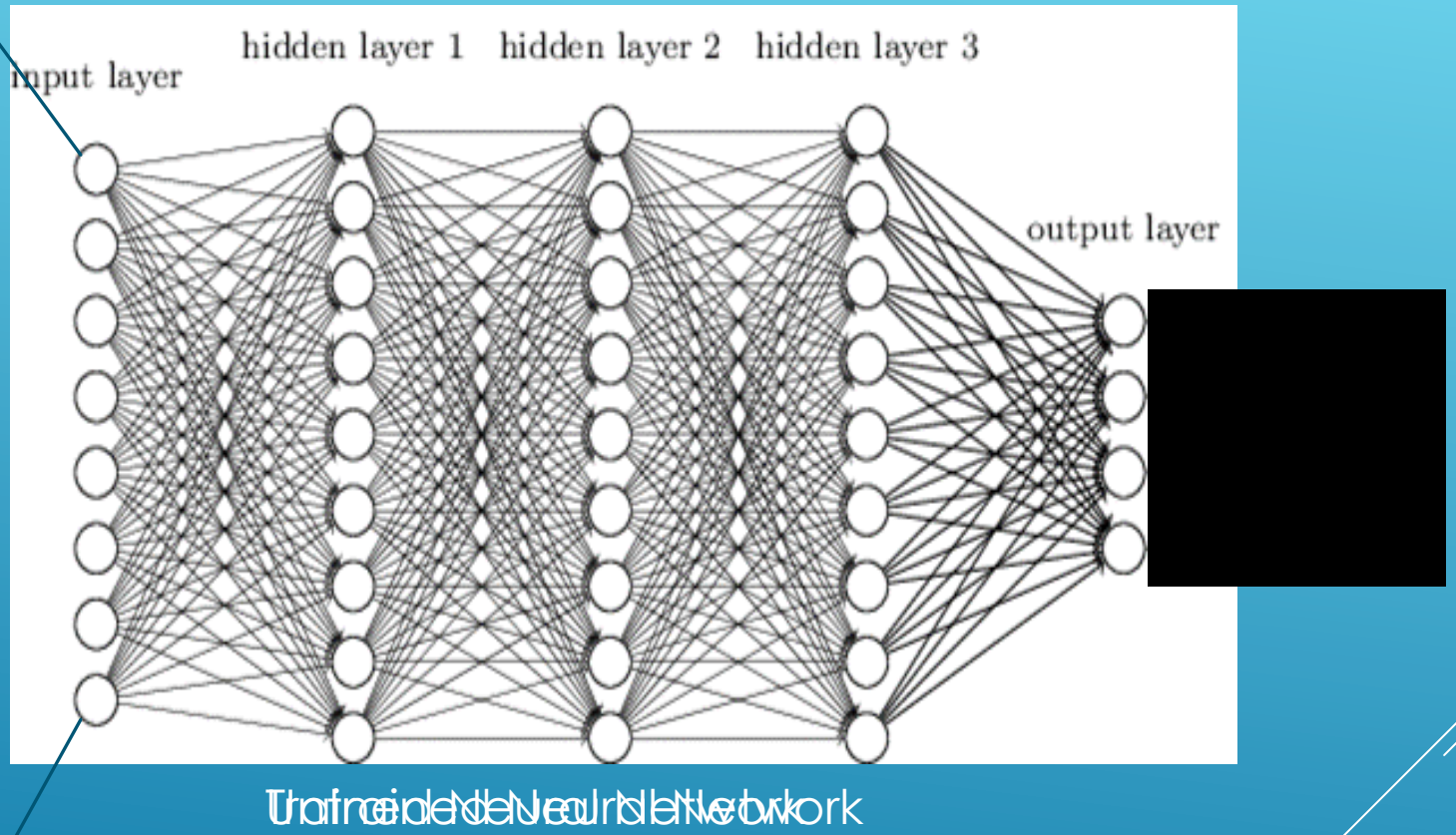


John J. Watson, IBM



Logo for Watson AI

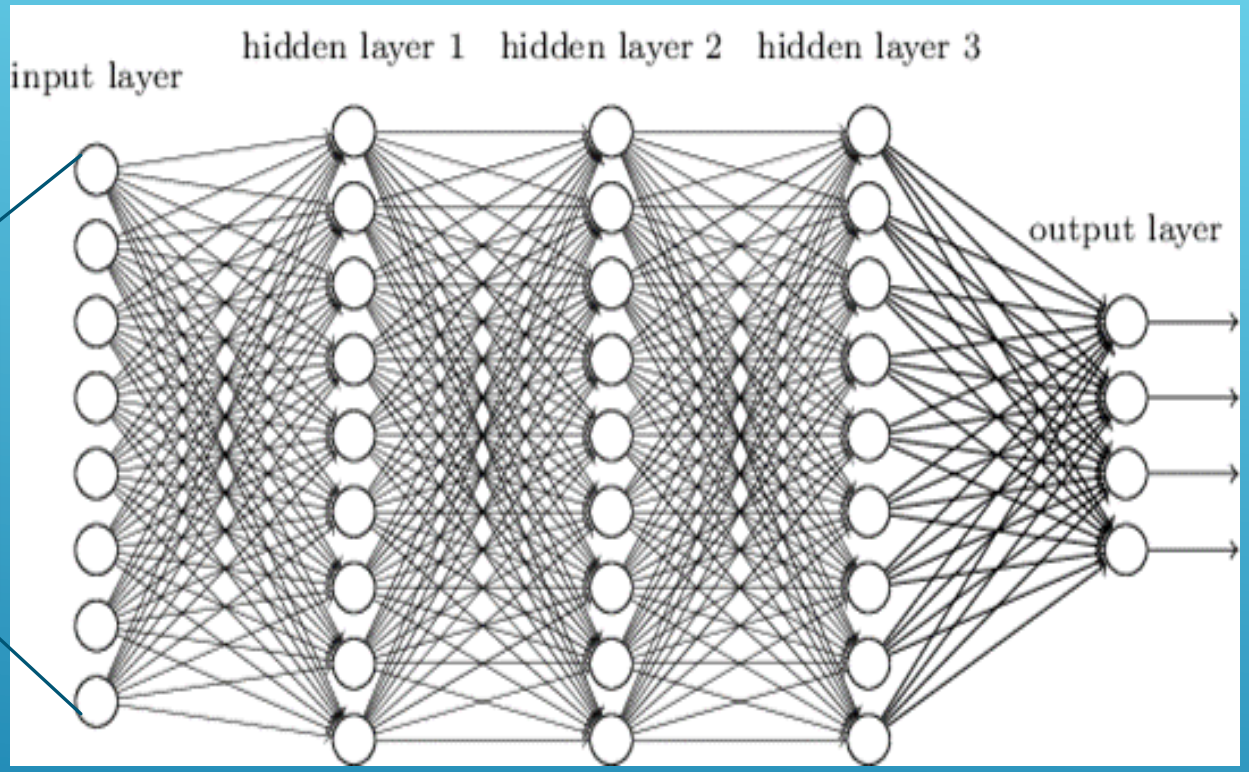
Deep Learning of Objects
Training Process



Trained Neural Network

Deep Learning of Objects
Application Process

Unknown

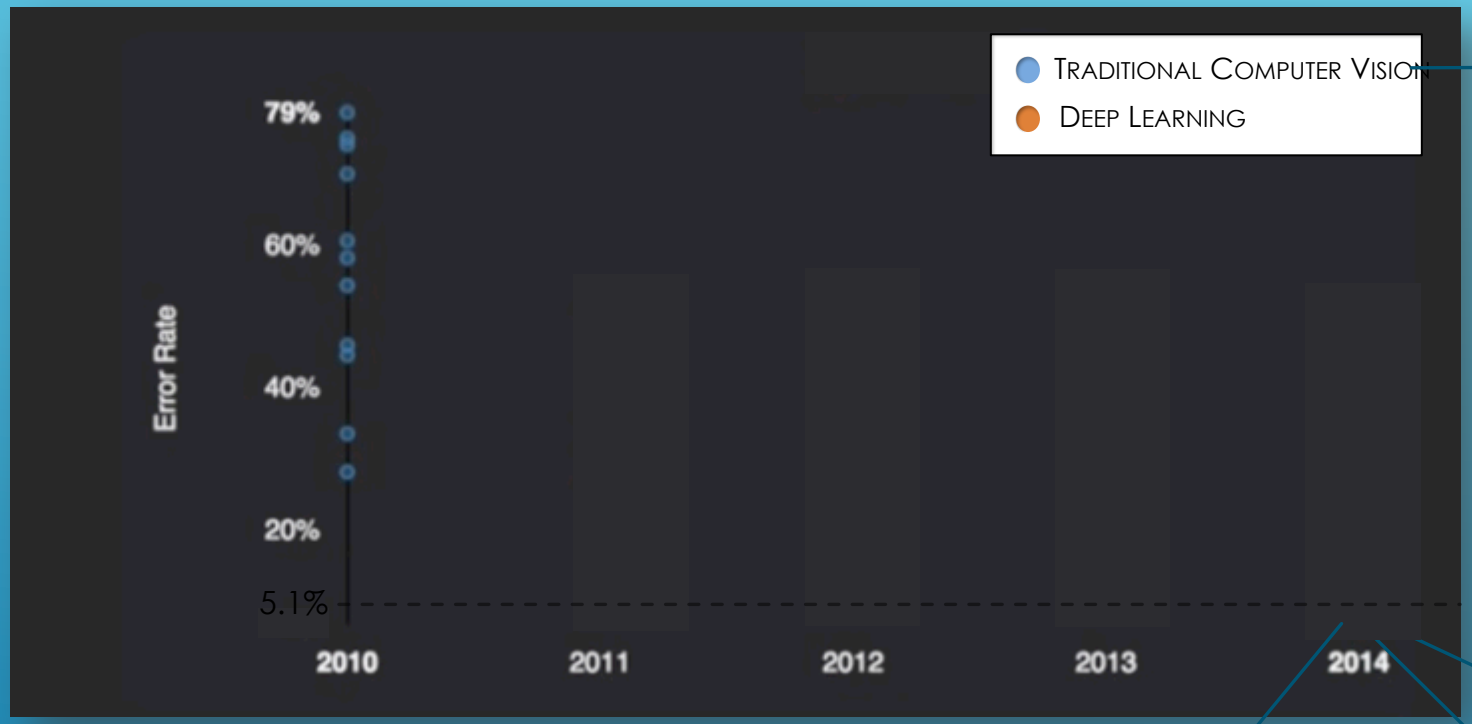


Trained Neural Network

IMAGENET

LARGE SCALE VISUAL RECOGNITION CHALLENGE

RECOGNITION ERROR RATE (2010 – 2014)



BREAST CAD

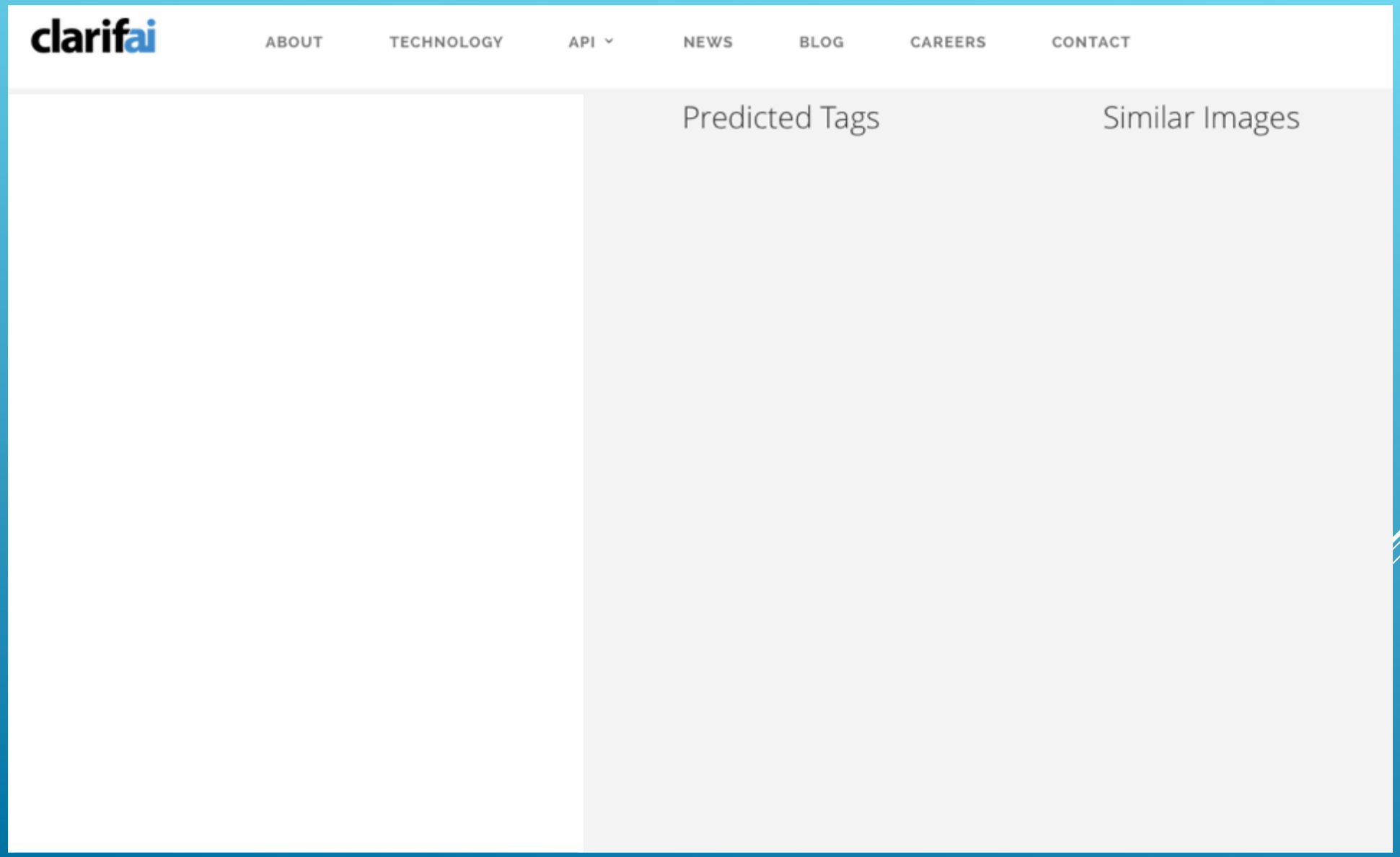
HUMANS (5.1%)

MICROSOFT (4.94%)

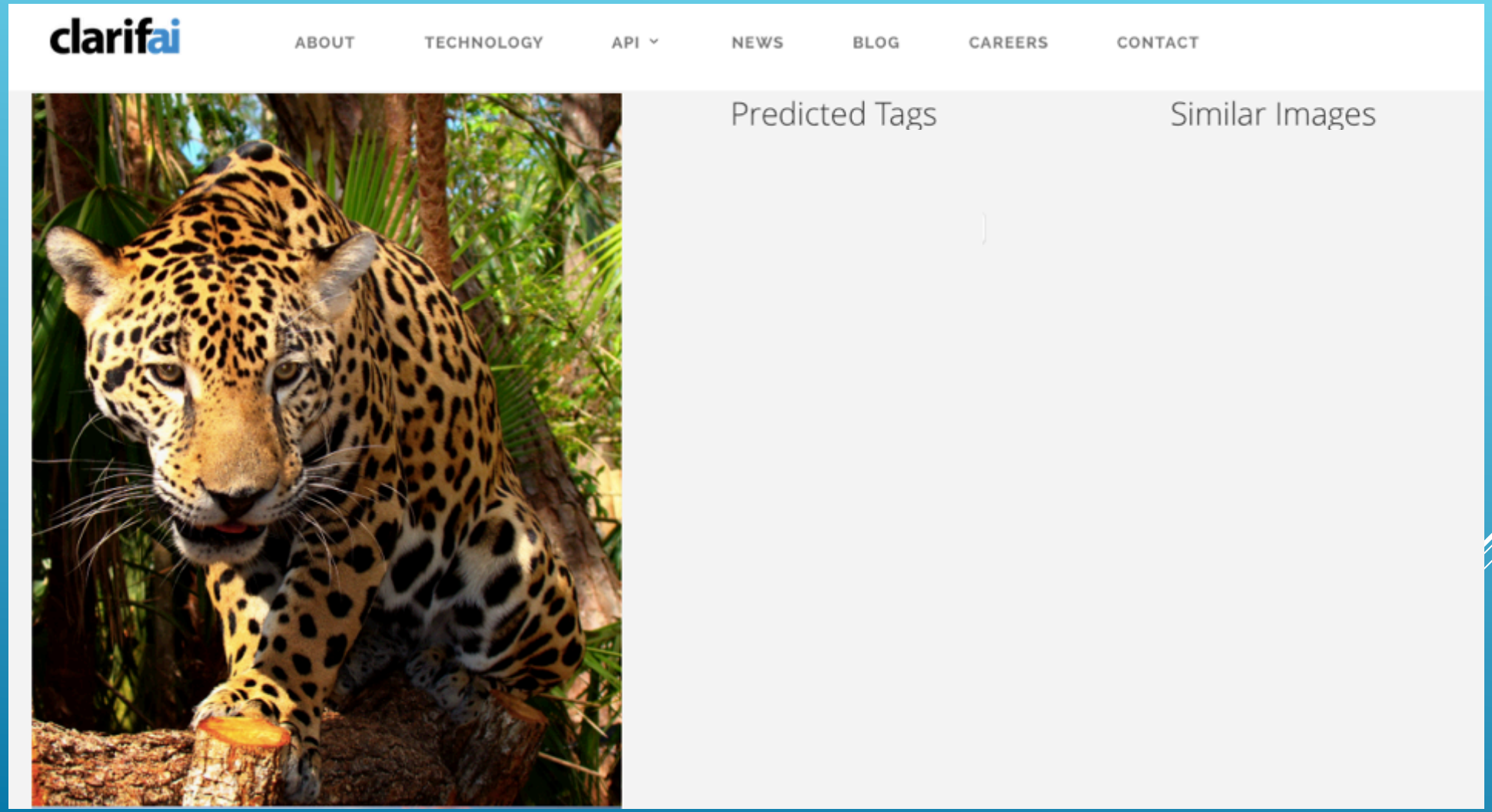
GOOGLE (4.90%)

clarifai

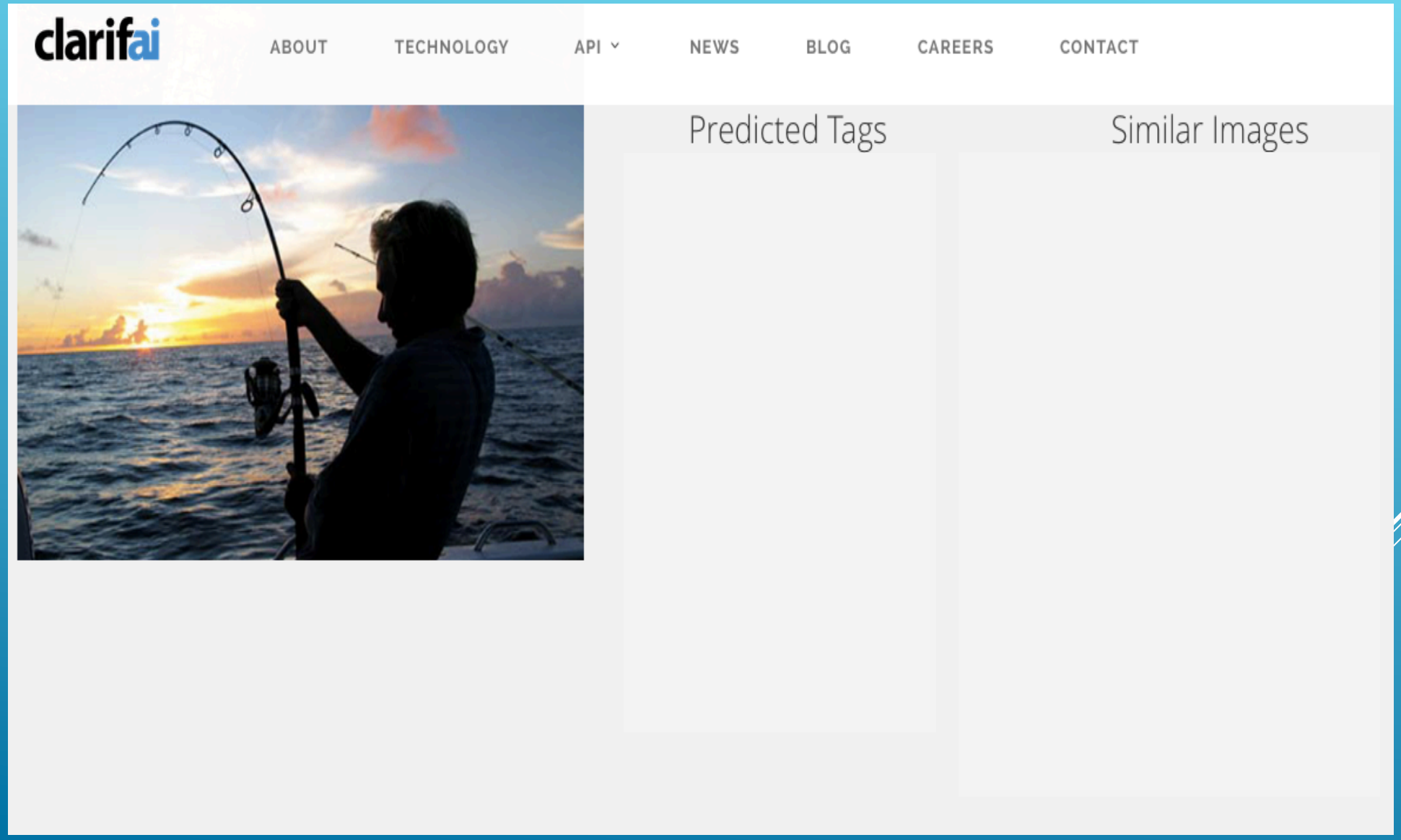
Deep Learning



Deep Learning



Deep Learning



Deep Learning

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Predicted Tags

Similar Images

Clarifai Demo Configure

GENERAL MODEL

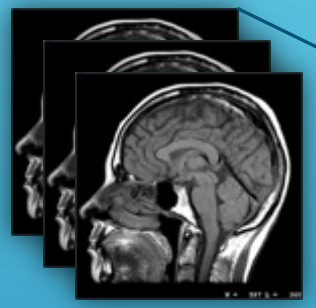
PREDICTED CONCEPT	PROBABILITY
golf	0.999
golfer	0.996
putt	0.992
course	0.989
club	0.981
golf club	0.979
hole	0.977
fairway	0.976
competition	0.972
grass	0.962
ball	0.962
recreation	0.951
tee	0.946
sport	0.940
putter	0.936
landscape	0.933

Clarifai Demo Configure

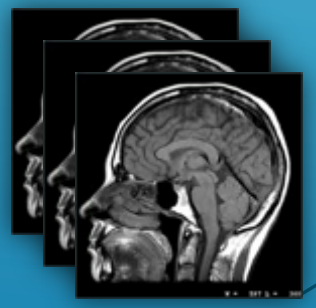
GENERAL MODEL

PREDICTED CONCEPT	PROBABILITY
golf	0.998
man	0.994
golfer	0.993
adult	0.992
golf club	0.987
people	0.987
recreation	0.977
woman	0.973
lifestyle	0.971
leisure	0.971
two	0.969
girl	0.946
outdoors	0.934
lid	0.930
togetherness	0.929
elderly	0.925

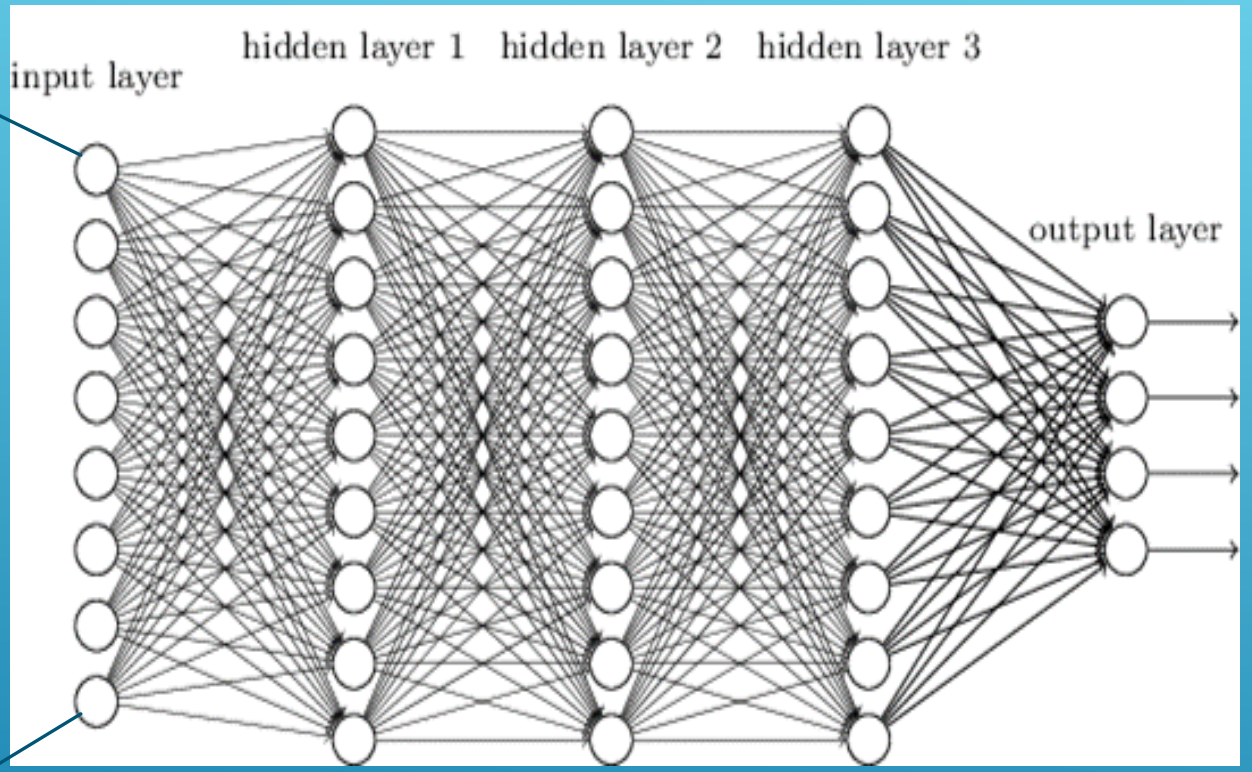
Deep Learning of Medical Images Training Process



Findings



No Findings



Trained Neural Network

Finding 1

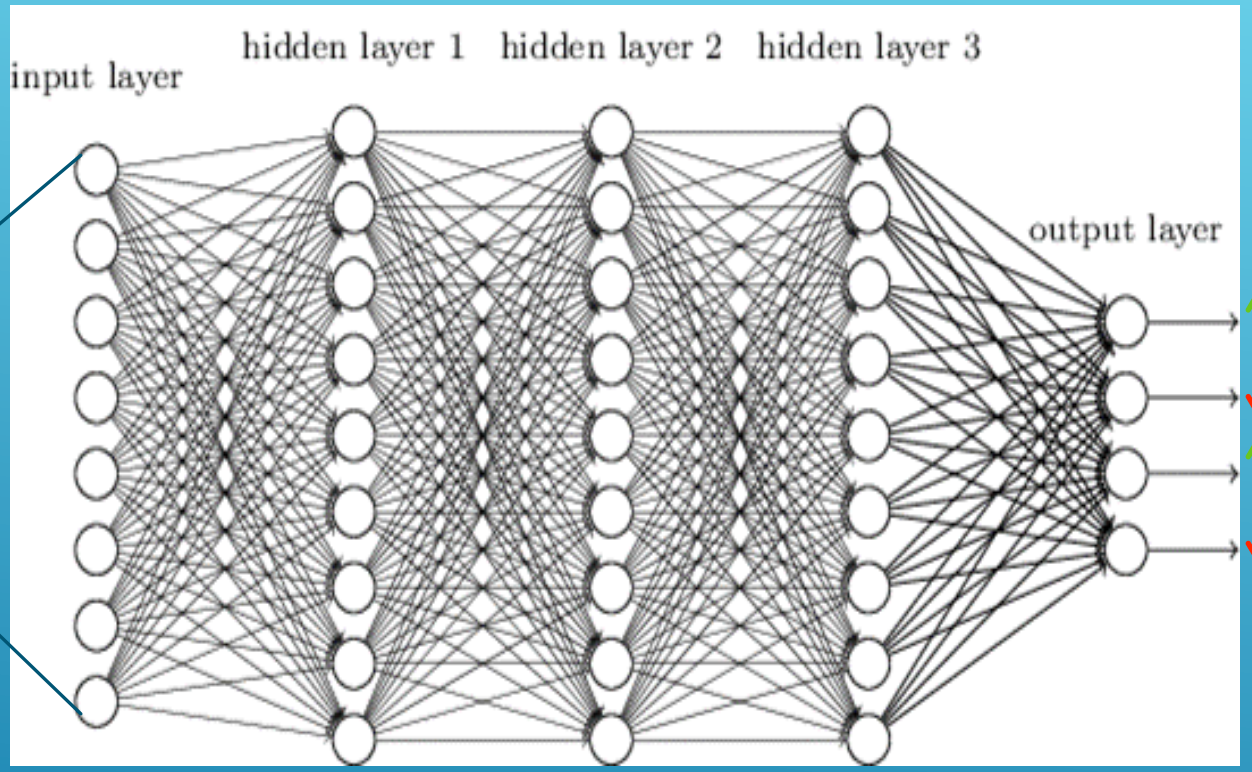
Finding 2

Finding 3

Finding 4

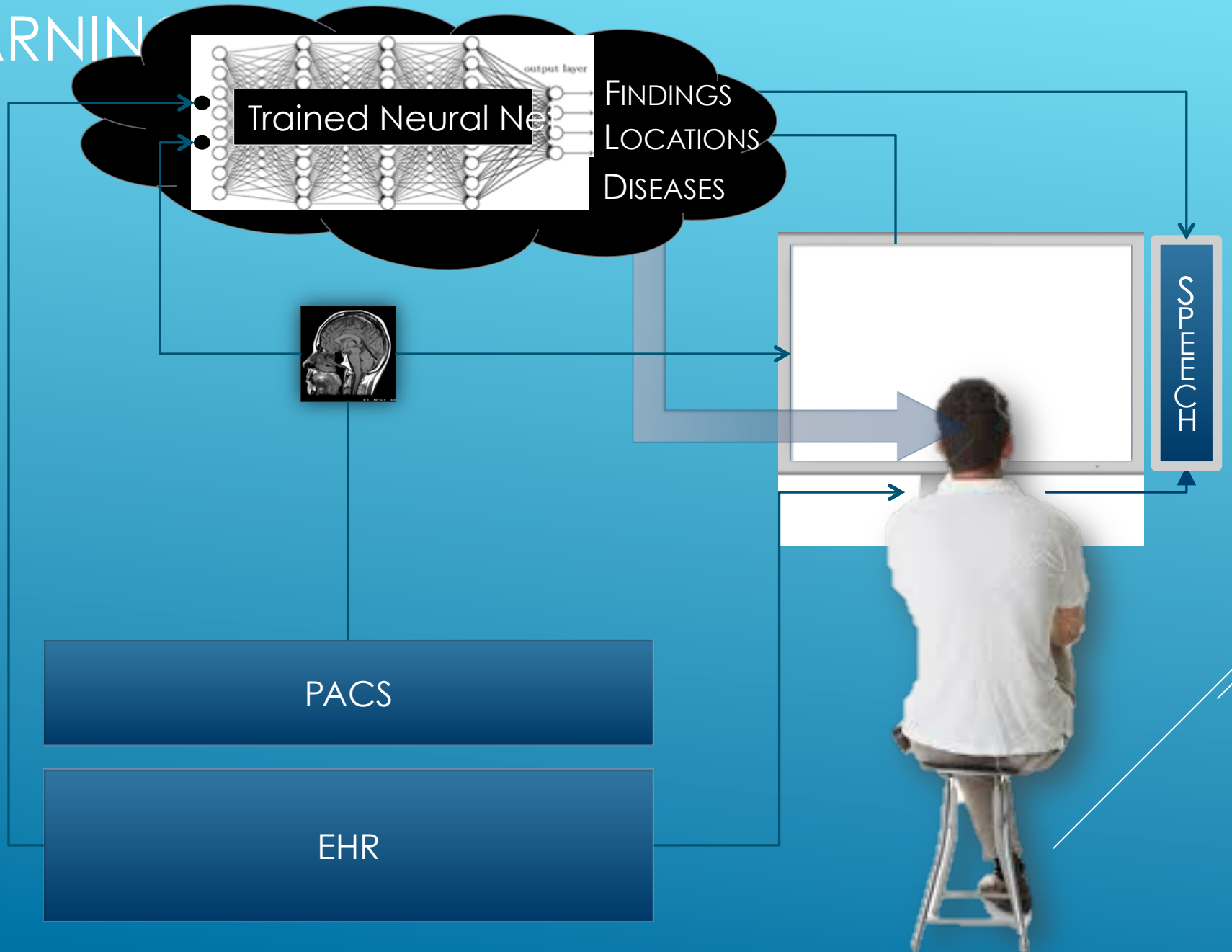
Deep Learning of Medical Images Application Process

Unknown

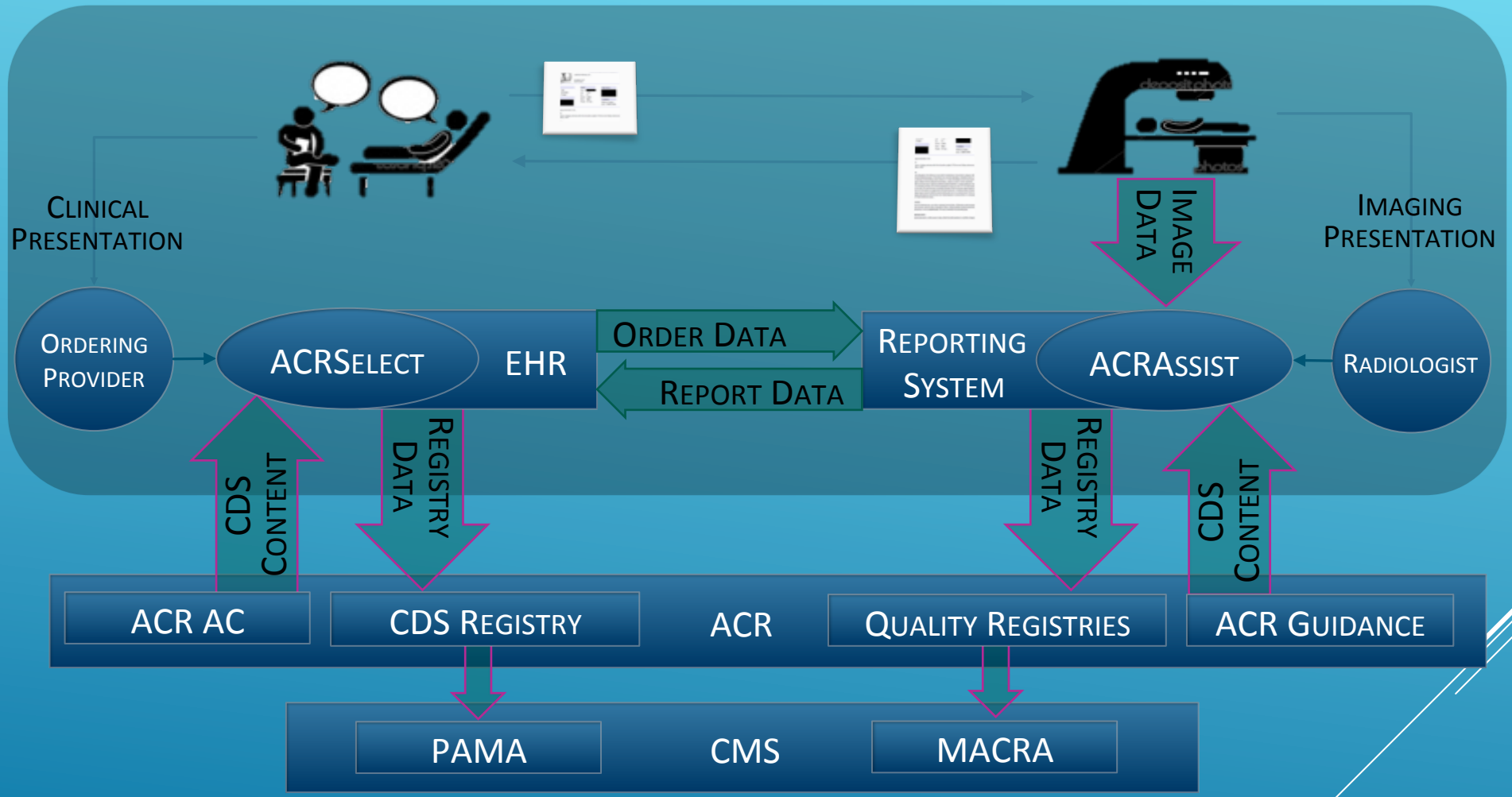


Trained Neural Network

Radiology Implementation of Deep Learnin



Imaging 3.0 Informatics Platform

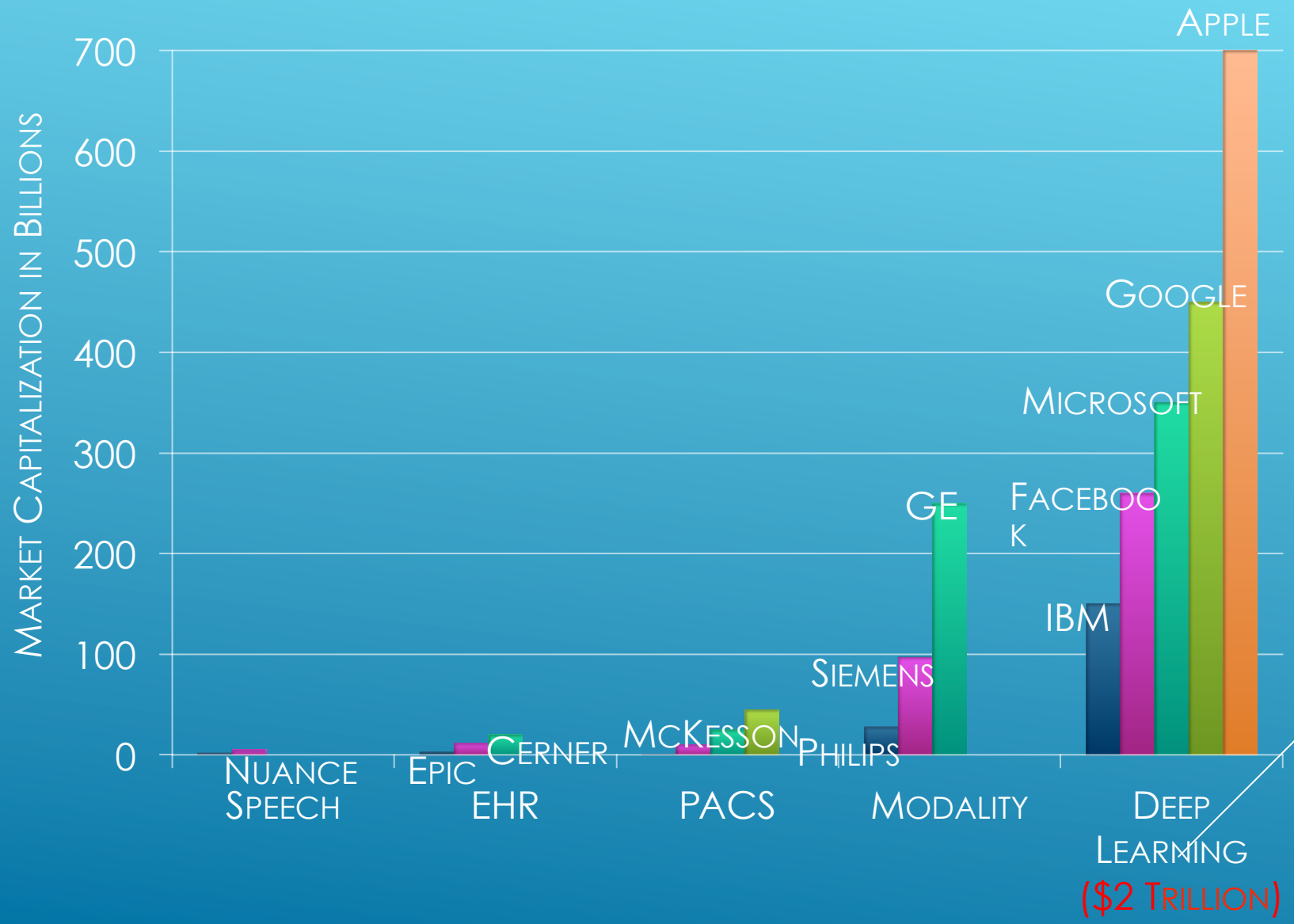


Deep Learning in Medical Imaging 2015

- Google Acquired DeepMind, $400M
- IBM Acquired Merge $1B
  - More acquisitions ($10-20B)
- Microsoft, Apple, Facebook advancing technology
- Many start ups are actively in Medical Imaging

Deep Learning Financial Power

Corporate Valuations by Sector



Resistance is Futile

- Circa 2000: PACS
  - Don't Resist: "Computer monitors will never be as good as film"
- Circa 2005: Speech Recognition (SR)
  - Don't Resist: "Computers will never understand what I say"
- Circa 2010: EHR
  - Don't Resist: "EHRs will never be as good as my RIS"
- Circa 2015: Deep Learning (DL)
  - Don't Resist: "Computers will never interpret medical images"

"HOW CAN WE USE THIS TECHNOLOGY TO IMPROVE OUR QUALITY AND EFFICIENCY?"

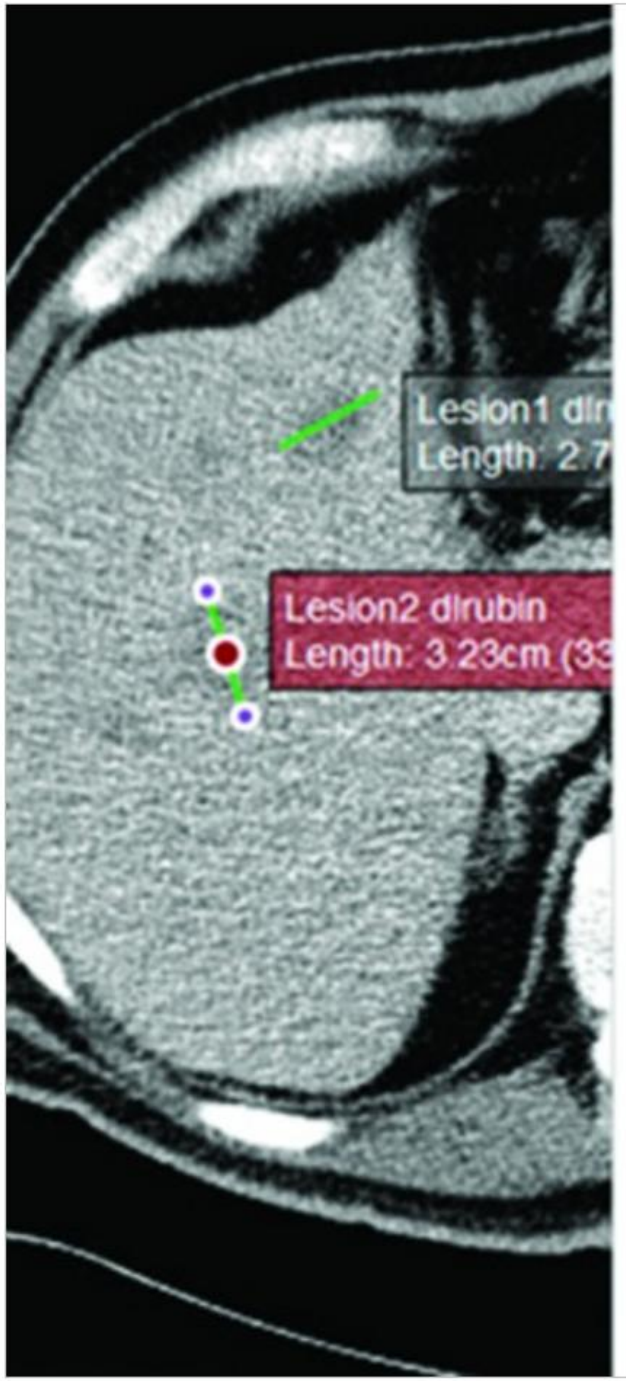
Deep Learning (DL) ACR Strategy

- Promote DL Development Environments
  - Expand ACRCommon to include DL concepts
  - Promote AMC creation of 'known' image sets

- Promote DL Transparency
  - Publish DL accuracy results for consumers
  - Provide ACR DL certification & DL registries

- Promote DL Industry Adoption
  - Expand Imaging 3.0 framework to include DL
  - Define DL integration to existing HCIT

- Promote DL Radiologist Adoption



Detail | List | **RECIST**

Patient: seven

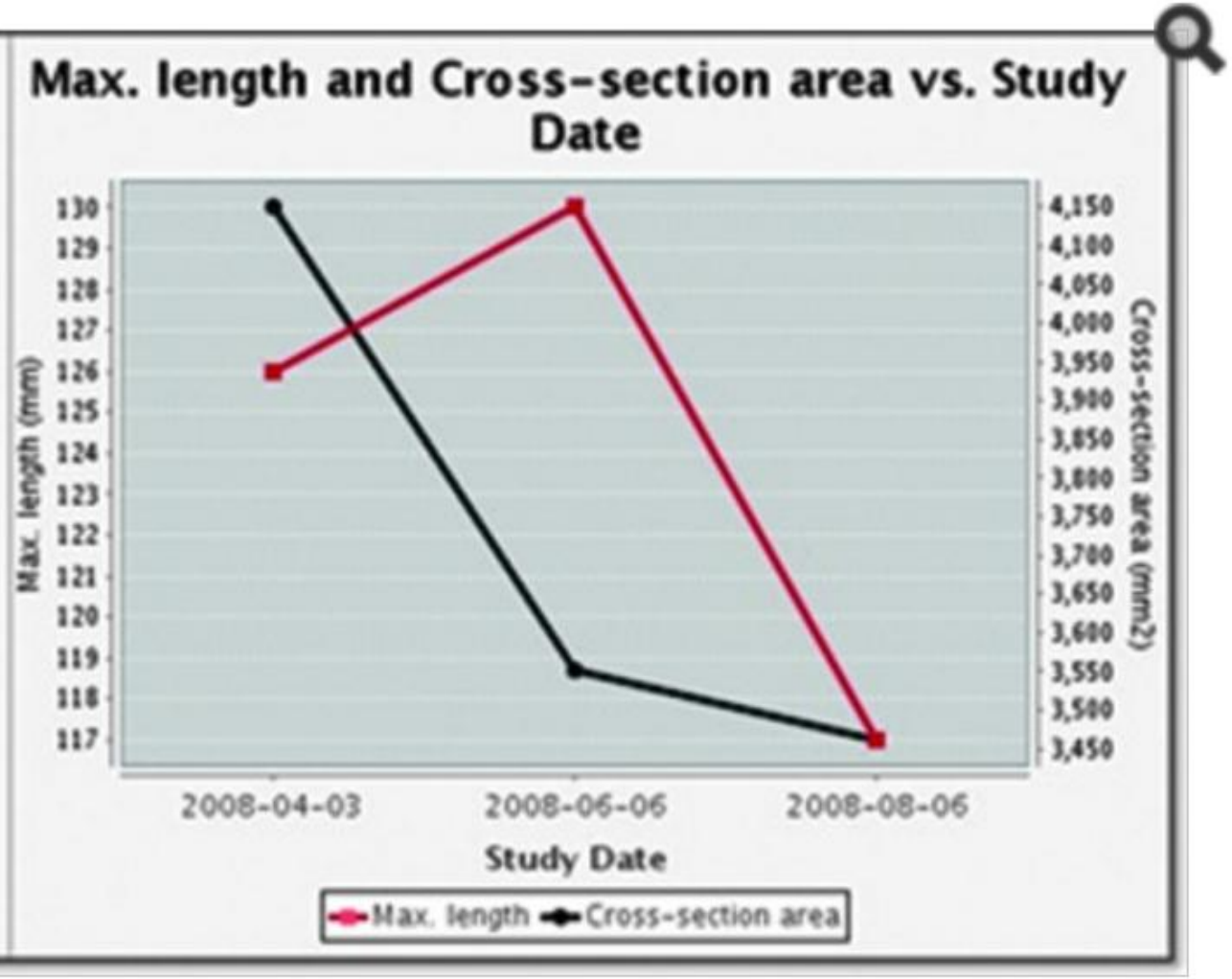
Table | Graph

Target	Location	2008-04-03	2008-06-06	2008-08-06	2008-10-09
Lesion1	liver	2.762	3.774	3.11	2.717
Lesion2	liver	3.228	1.656	3.661	2.248
Lesion3	pancreas	5.987	6.673	5.18	5.335
Sum Lesion Diameters (cm):		11.977	12.104	11.95	10.301
RR from Baseline:		0%	1.06%	-0.23%	-13.99%
RR from Minimum:		16.27%	17.5%	16.01%	0%
Response Category:		BL	SD	SD	SD

Baseline | Follow Up | Target | New | Resolved | Non-Target | Error

Save | Close

Date of Study:	2008-04-03	2008-06-06	2008-08-06
Target Lesion Count:	3.00	3.00	3.00
Sum Longest Diameters:	126.00	130.00	117.00
Response Rate:	NA	3.17%	-7.14%
Response Category:	NA	SD	SD
Lesion Identifier:	L02	L03	L02
Lesion Location:	pancreas	pancreas	pancreas
Lesion Identifier:	L03	L02	L03
Lesion Location:	pancreas	pancreas	pancreas
Lesion Identifier:	L01	L01	L01
Lesion Location:	pancreas	pancreas	pancreas

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Deep Learning in Medical Imaging