Deep Learning Applications for Healthcare

José María Lago - CEO DAIVEC

TABLE OF CONTENTS

José María Lago

MATHEMATICIAN & ENTREPRENEUR

WHO AM I ?

I am a mathematician concerned with the world of artificial intelligence and its real applications.

I have been working in other companies such as IBM, in startups and in research centers before starting my path as an entrepreneur

Recently, I decided to start my own path to guide my knowledge and effort to the community, helping companies to learn from their data using cutting edge algorithms and high end technology.

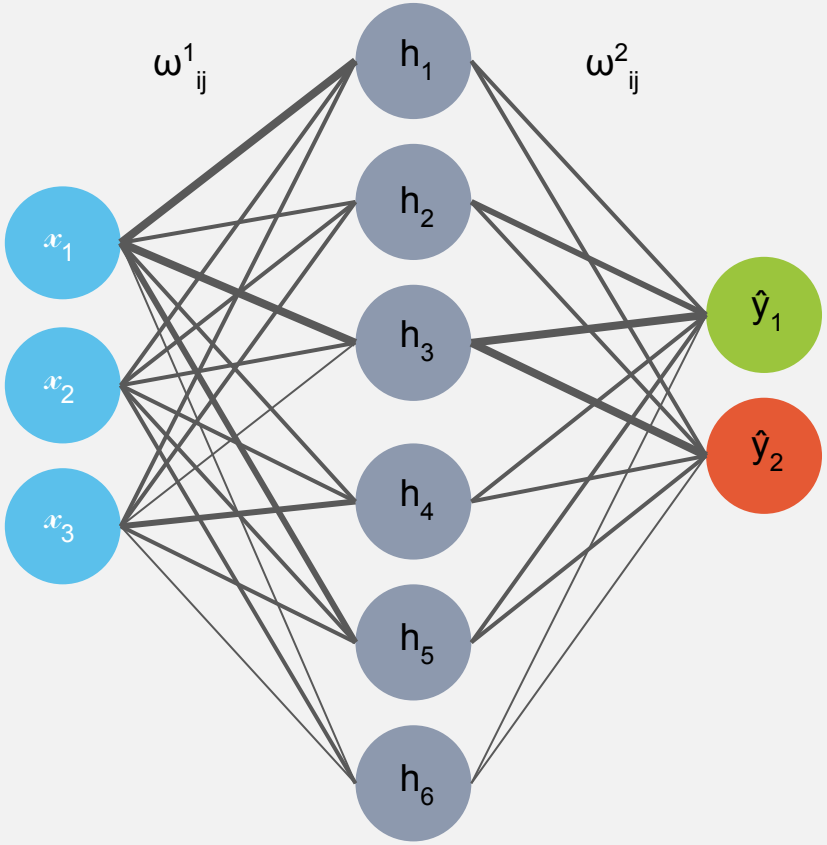
jmlago@daivec.com

WHAT IS DEEP LEARNING ?

Deep Learning (DL) is the set of models (functions) **based on neural network models** with more than one hidden layer

Given a dataset, DL models are **trained using backpropagation** algorithm

It can be applied to a **huge variety of tasks** such as image recognition, NLP, sound analysis, etc.



NEURAL NETWORK

$$\delta^L = \nabla_a C \odot \sigma'(z^L)$$

$$\delta^l = ((\omega^{l+1})^T \delta^{l+1}) \odot \sigma'(z^l)$$

$$\frac{\partial C}{\partial b^l_j} = \delta^l_j$$

$$\frac{\partial C}{\partial \omega^l_{jk}} = a^{l-1}_k \delta^l_j$$

BACKPROPAGATION ALGORITHM

HOW IT LEARNS ?

After the neuron computes the output for given inputs, it applies an activation function **σ**

All weights **ω** and biases **b** are initialized pseudo-randomly

It uses a cost function **C** to measure the predictions error such as MSE

WHY NOW ?

HARDWARE CAPABILITIES

Since 2009 prof Ng started using GPUs for efficiently training neural networks. Since then, many recent advances have occurred giving us the ability to train much complex models to solve real world problems

NEW IMPROVED ALGORITHMS

First self-learning algorithm was developed in 1958 by Rosenblatt. In 2006 Hinton discovers backpropagation method to train deep learning methods. Today there are many variants of the regular deep neural networks such as CNNs RNNs or GANs

MORE ACCESS TO DATA

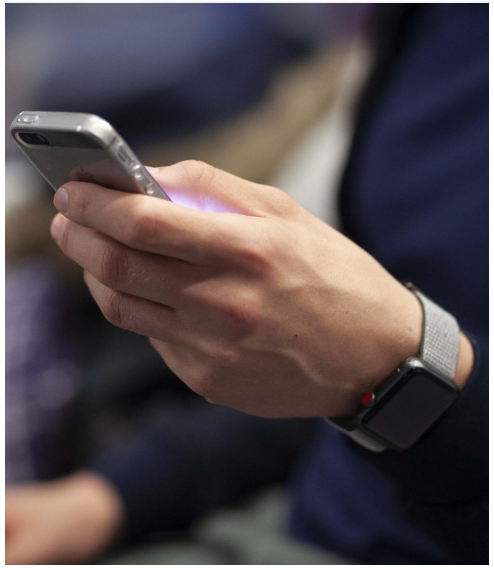
In 2010 world wide IP traffic surpasses 20 exabytes per month. Today, 2.71 billions of people use smartphones and hence they generate massive amount of data which is the nourishment for deep learning models

DEEP LEARNING BASED

HEALTHCARE APPLICATIONS

MEDICAL IMAGE ANALYSIS

AI technologies such as machine learning and deep learning are used in the intelligent analysis of medical imaging data



MONITORING WEARABLES

A wearable device is one that is worn on the body to track vital signs or health and fitness related data for further analysis conducted by AI algorithms.

DISEASE PREDICTION

Transform heterogeneous clinical data from electronic health records into clinically meaningful constructed features using deep learning

Lung detection example

MEDICAL IMAGE ANALYSIS

Convolutional networks have become a methodology for analyzing medical images.

Deep Learning algorithms have many uses in Medical Imaging. Some **relevant applications are object or lesion classification, organ or region landmark localization.**

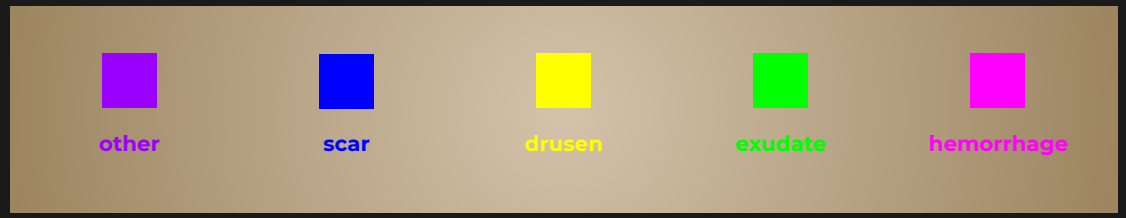
Moreover, **DL algorithms can be used for image enhancement and lesion segmentation.**

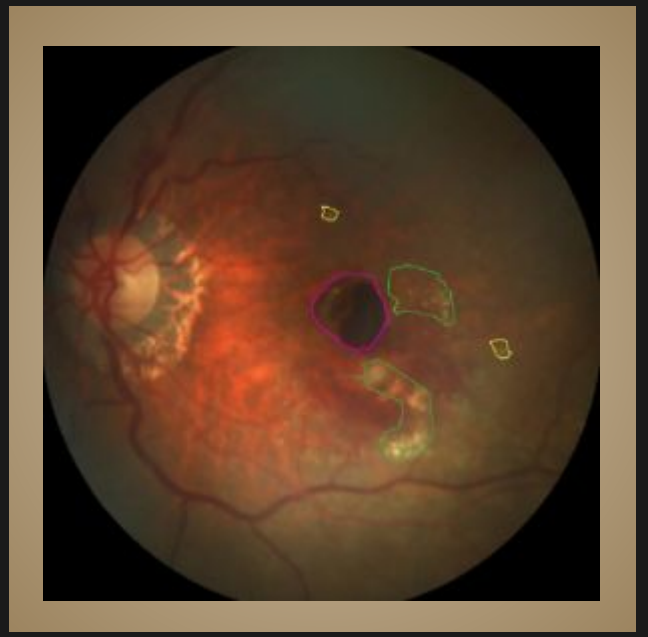
ANOTHER EXAMPLE

MEDICAL IMAGE ANALYSIS

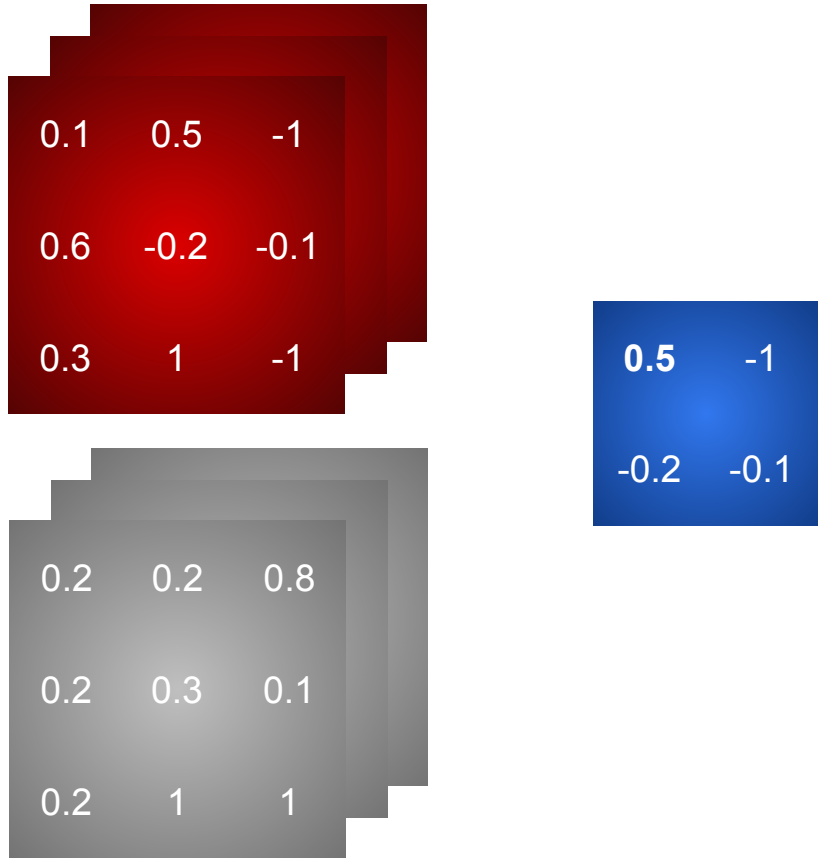
Those algorithms can be applied to a huge variety of anatomical areas, such as Liver, Heart, Brain, Knee, Skin, and Eyes.

This is just an example:

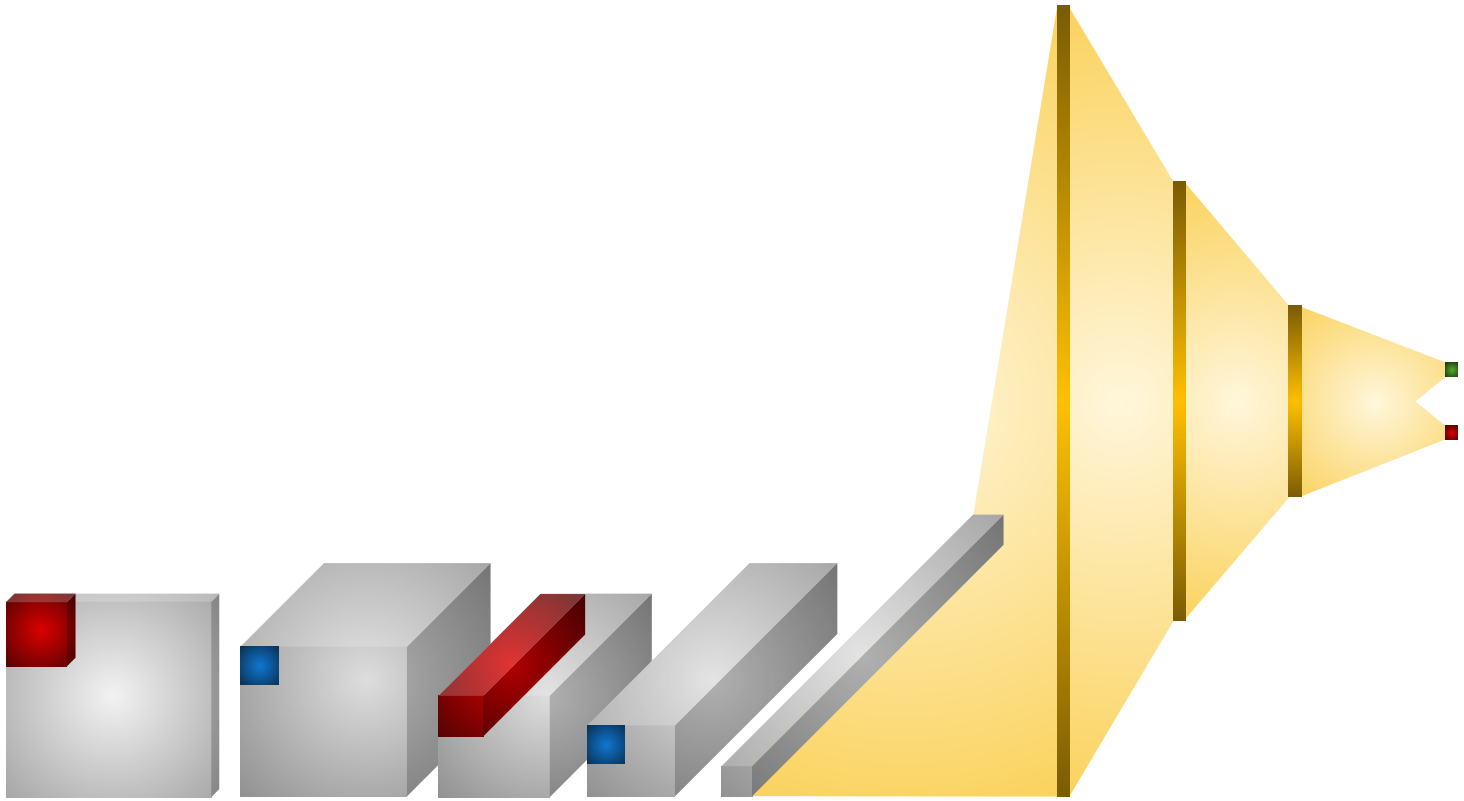




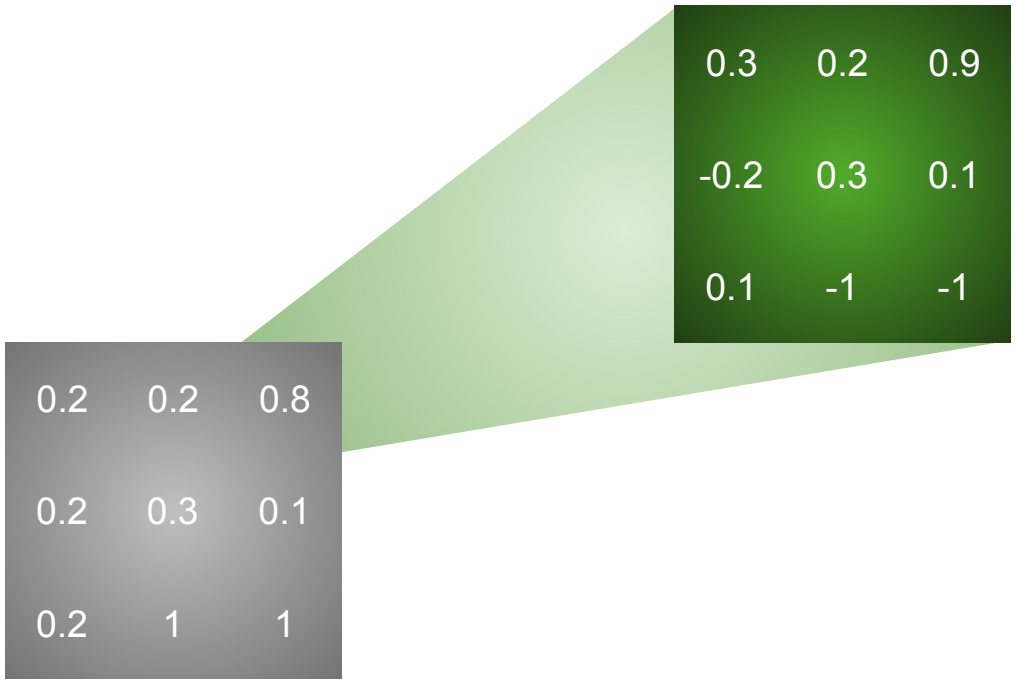
CONVOLUTIONAL KERNEL & MAX POOLING



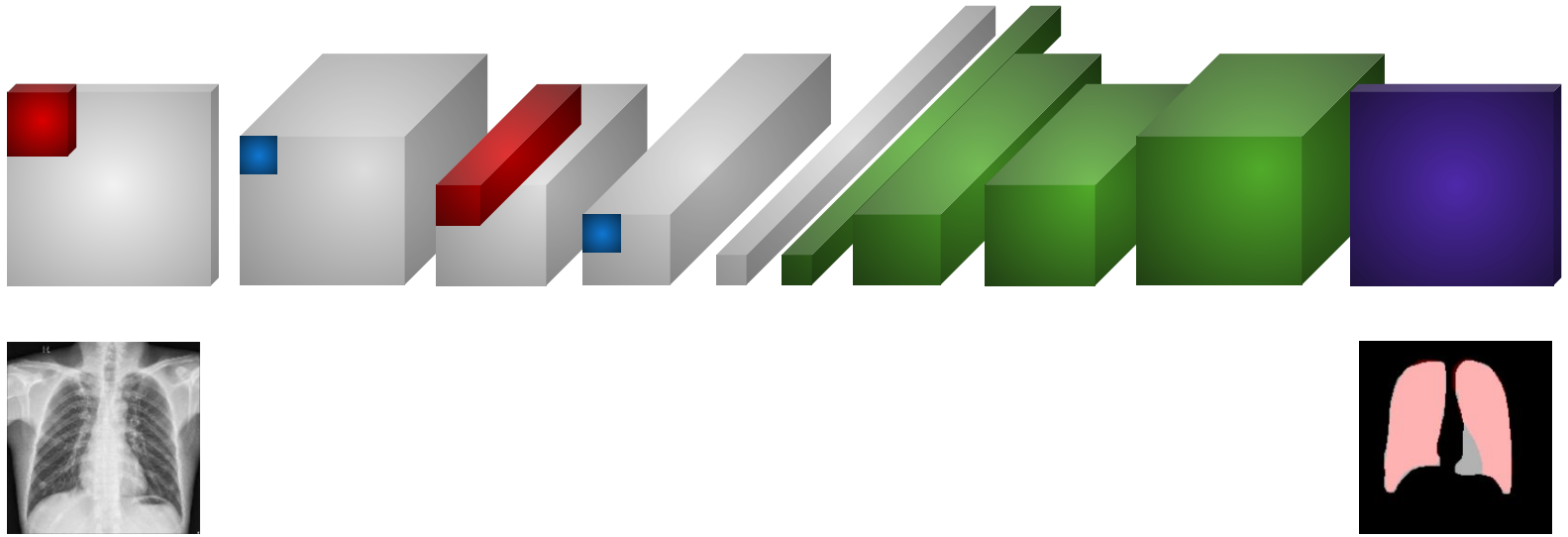
CONVOLUTIONAL NEURAL NETWORK



TRANSPOSED CONVOLUTIONAL KERNEL



DECONVOLUTIONAL CONVOLUTIONAL NETWORK



LIMITATIONS OF DL IMAGE MODELS

Those models **require abundant amounts of expert labeled data** to make them learn such complex tasks as those of medical imaging

Also, they **require massive computational power** and memory and thus, very **expensive hardware**

Bounded image resolution due to hardware limitations

34 Billions total

1 Billion AI market

MEDICAL IMAGING MARKET

With its improved productivity and accuracy and more personalized experience, AI is revolutionizing medical imaging. According to Signify Research, the world market for AI in medical imaging — comprising software for automated detection, quantification, decision support, and diagnosis — is about 1 billion USD.

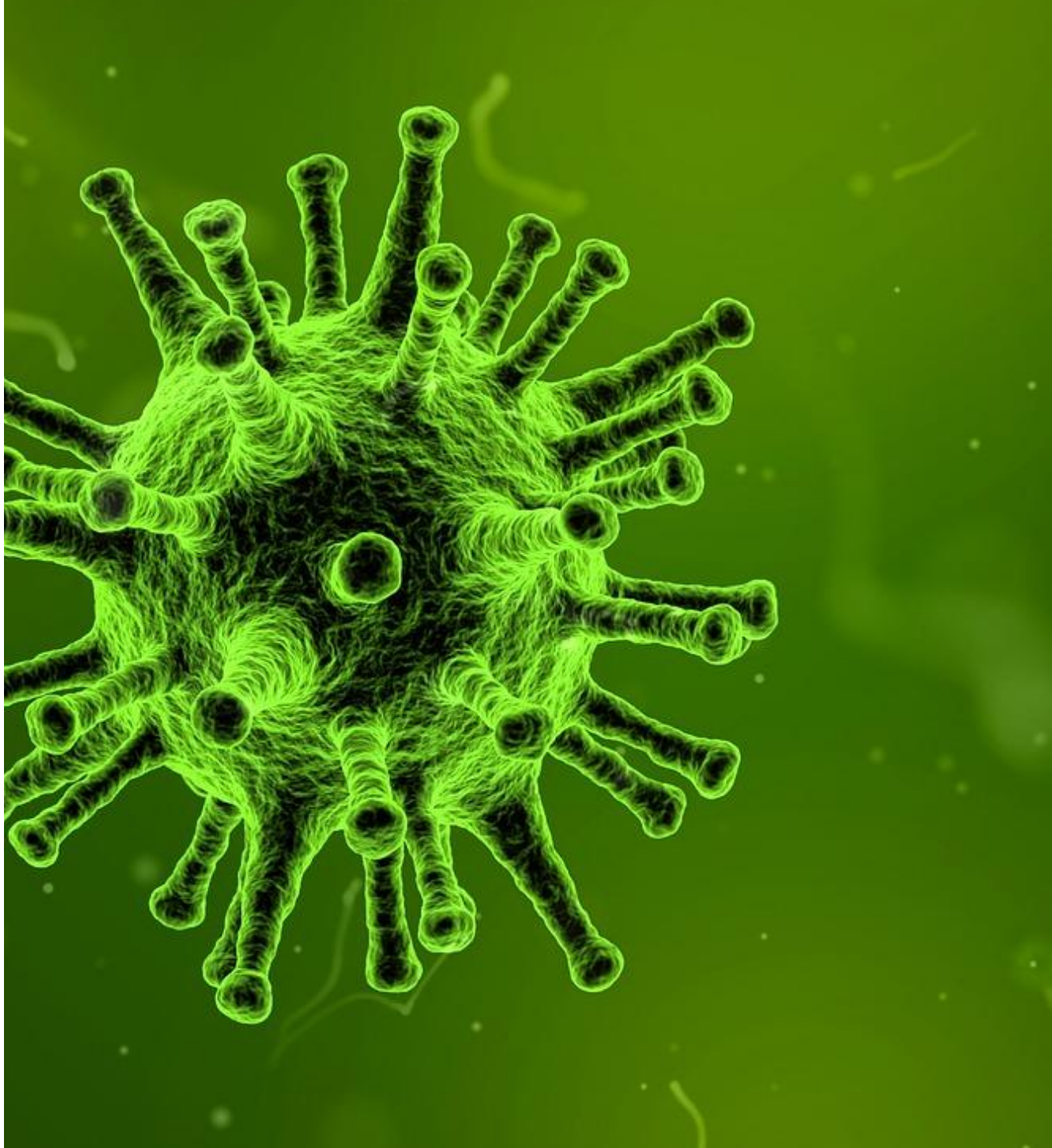
AI technologies utilized in medical imaging processing include deep learning, machine learning, AR, data mining, etc. These are capable of achieving a range of goals in disease screening, disease diagnosis, medical surgery and so forth.

DISEASE PREDICTION

The clinical studies and healthcare services fall into two major categories: **analysis of structured data** (images, genes and biomarkers), and **analysis of unstructured data**, (notes, medical journals or patients' surveys to complement the structured data). **Natural Language Processing (NLP)** algorithms are used to structure the unstructured data.

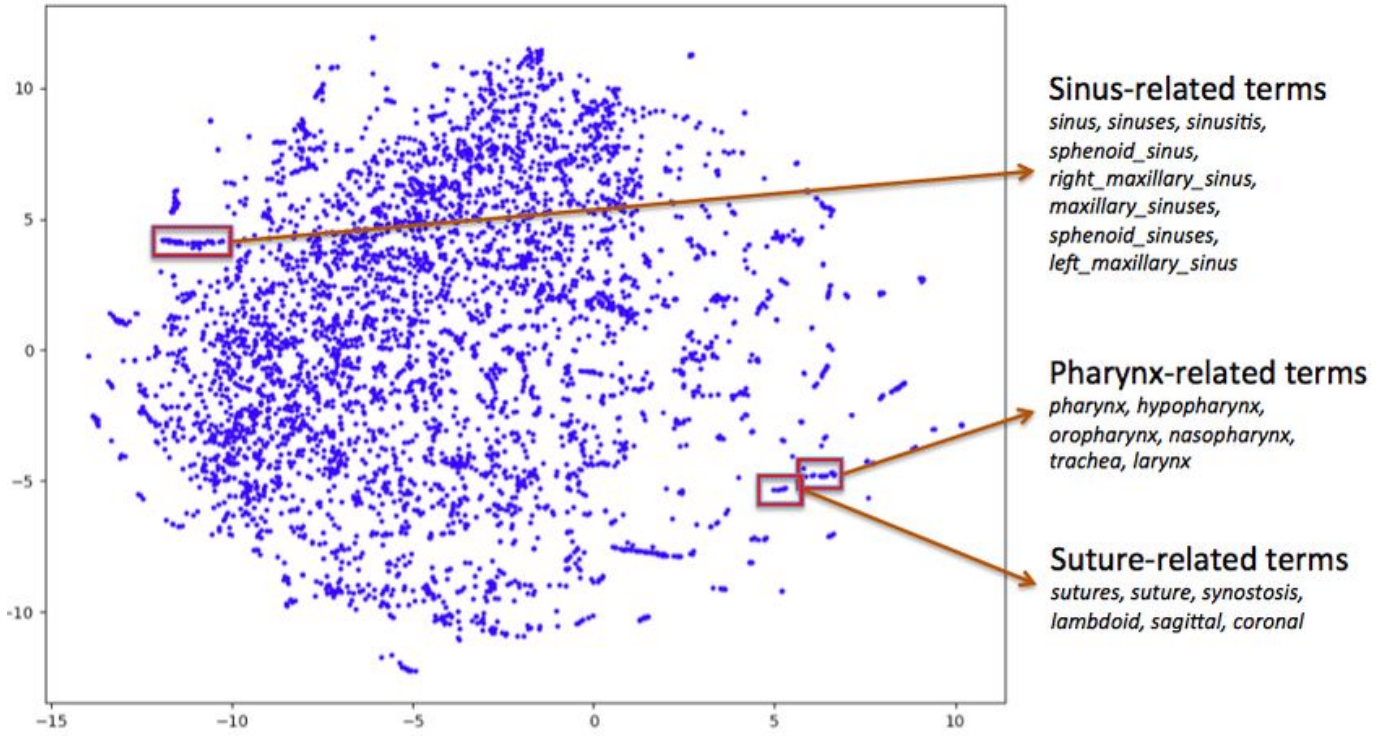
Some of the most powerful DL models integrate data structuring in their learning process. This is the case of **ULMFIT**, capable of dealing with texts of different lengths, to solve classification problems.

One of the most used NLP techniques are the **Embeddings**. The embedding move from a discrete space, such as language, to a continuous space of smaller dimension.



NLP FOR HISTORICAL CLINICAL RECORD ANALYSIS

WORD EMBEDDING FOR CLUSTERING CONCEPTS



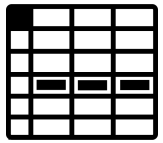
All word embeddings (4,442 words)-visualized in two dimensions using t-SNE. The figure illustrates **ability of the embedding to automatically organize concepts and implicitly learn the relationships** between them.

EXAMPLES

OTHER ML / DL MODELS FOR CLASSIFICATION

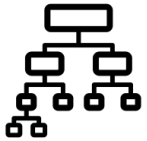
WORD EMBEDDING FEATURES

Data extracted from word embeddings in vector space form



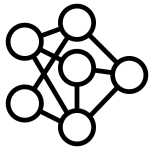
NUMERICAL FEATURES

Other clinical data such as genomics or other numerical data types



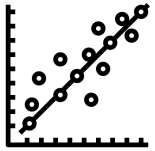
RANDOM FORESTS

One of the most usual learning algorithm used for classification which gives good acc levels



DEEP NEURAL NETWORKS

Deep Learning models can be integrated even with word embeddings end to end



OTHER CLASSIFICATION METHODS

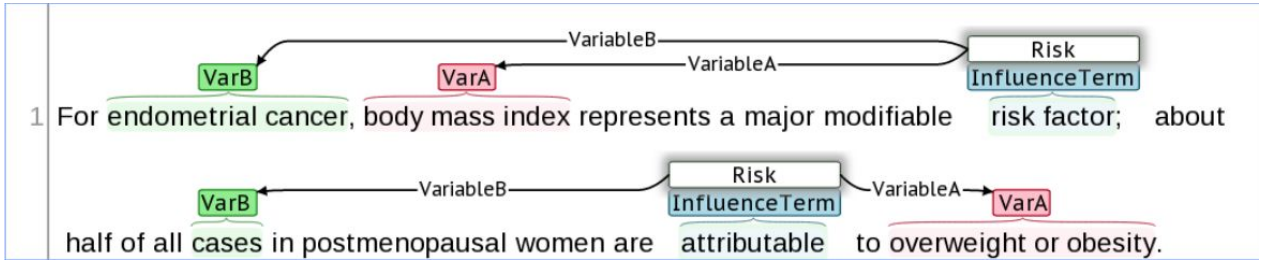
Other methods such as linear regression or perceptrons can be used to process the data

LIMITATIONS OF DL IN NLP

In general, NLP DL models, have the same limitations as other DL models.

Additionally, languages and idioms can change across countries and regions. Thus, DL models which consume abundant amounts of data can have worse performances.

Other DL translation models are used to solve this issue.



DL NLP MARKET

NLP as a branch of Artificial Intelligence (AI) is primarily concerned with reducing the human-machine gap.

As NLP is becoming crucial with day to day communication, solution providers are focusing on designing the software that can understand, analyze, and generate languages that can be understood by humans.

1 Billion USD

Thank you!