MEDICAL IMAGE ANALYSIS USING DEEP LEARNING.

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INTRODUCTION

- ➢ Machine Learning algorithms have immense scope to be implemented in various fields of medicine :
    - ○ Drug discovery
    - ○ Decision making in medicine

- ➢ The proportion of medical practices primarily engaged in direct patient care that uses electronic health records increased : **175.6%** between 2007 and 2013, from **25.0% to 68.9%.**

- ➢ Medical reports primarily in the form of images play an critical aspect of a patient's EHR.

- ➢ EHRs are presently being analyzed by human medical professionals, who are limited by fatigue, accuracy, and speed.

- It takes years together along with great **financial expenses** to train a well-qualified radiologist.
- Certain healthcare systems outsource their reporting to cheaper countries like India.
- Deep learning will not only help to identify and extract features but also construct new ones.
- Predictive targets and prediction models to help medical practitioners efficiently.
- First premise where patients would experience the working of artificial intelligence mechanisms and paradigms in healthcare.

LITERATURE SURVEY

Sr. No	Paper Title	Authors	Summary	Year
1.	Deep Learning Applications in Medical Image Analysis.	1.) Justin Ker, National Neuroscience Institute, Singapore 2.)Lipo Wang , Nanyang Technological University, Singapore 3.) Jai Rao, National Neuroscience Institute, Singapore 4.)Tchoyoson Lim, National Neuroscience Institute, Singapore	This review introduces the machine learning algorithms as applied to medical image analysis, focusing on convolutional neural networks, and emphasizing clinical aspects of the field.We cover key research areas and applications of medical image classification, localization, detection, segmentation, and registration.	2017
2.	Breast Cancer Detection using Convolutional Neural Networks.	1.)Simon Hadush Nrea, Department of Computer Science and Engineering, Mekelle Institute of Technology - Mekelle University, Mekelle, Ethiopia. 2.)Yaecob Girmay Gezahegn, Mekelle Institute of Technology - Mekelle University,Mekelle, Ethiopia. 3.)Abiot Sinamo Boltena, Director-General, ICT Sector, FDRE Ministry of Innovation and Technology, Addis Ababa, Ethiopia.	Deep learning techniques are revolutionizing the field of medical image analysis and hence in this study, we proposed Convolutional Neural Networks (CNNs) for breast mass detection so as to minimize the overheads of manual analysis. CNN architecture is designed for the feature extraction stage and adapted both the Region Proposal Network (RPN) and Region of Interest (ROI) portion of the faster R-CNN for the automated breast mass abnormality detection.	2020

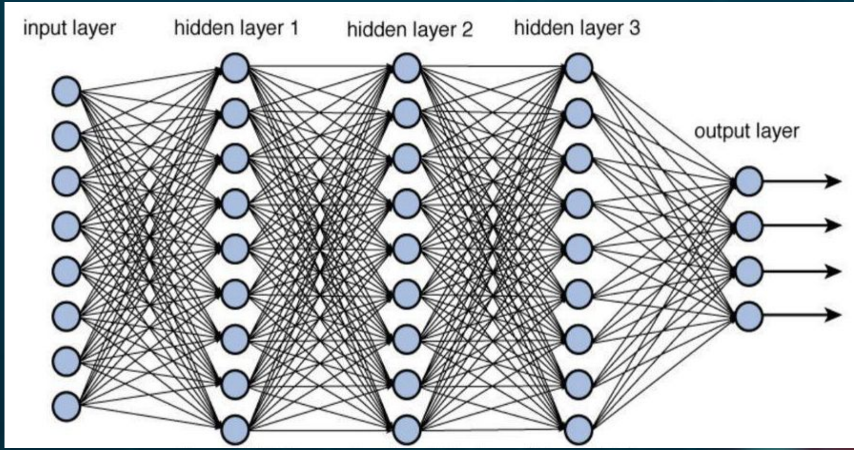
Sr. No	Paper Title	Authors	Summary	Year
3.	Deep Learning in Medical Image Analysis.	1.Dinggang Shen, Department of Radiology, University of North Carolina at Chapel Hill, NC, USA, 27599. 2. Guorong Wu, Department of Radiology, University of North Carolina at Chapel Hill, NC, USA, 27599 3. Heung-Il Suk, Department of Brain and Cognitive Engineering, Korea University, Seoul, Republic of Korea, 02841	In this article, we introduce the fundamentals of deep learning methods; review their successes to image registration, anatomical/cell structures detection, tissue segmentation, computer-aided disease diagnosis or prognosis, and so on.	2017

MACHINE LEARNING AND DEEP LEARNING ARCHITECTURES

Generalized Deep Learning architecture:

- A deep neural network comprises an **input layer, multiple hidden layers and an output layer.**

- The different types of deep learning algorithms which are in use are:
    - Convolutional Neural Networks(CNN)
    - Recurrent Neural Networks (RNN)
    - Deep Neural Network(DNN)
    - Deep Belief Network(DBN)
    - Deep Autoencode (DA)
    - Deep Boltzmann Machine(DBM),etc.



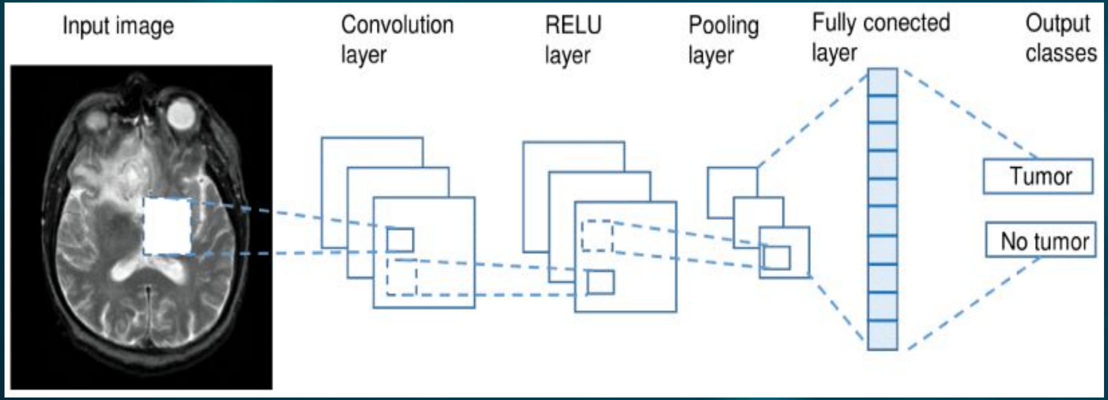
- Machine learning models are broadly classified into **Supervised, Unsupervised, Semi-supervised and Reinforcement** learning models.

SUPERVISED LEARNING MODELS

1. CONVOLUTIONAL NEURAL NETWORKS (CNNs) :

- CNN is by far the most popular choice of machine learning algorithm when it comes to image processing.
- The first CNN was created by **Yann LeCun.**
- **Multi-layer neural network** which is biologically inspired by the animal visual cortex.
- Preferred for medical image analysis because of its ability to **retain spatial information** while filtering images.
- CNNs can take as input and process both **2-D as well as 3-D images.**

Feature extraction of the input MRI image of performed via the Convolution, RELU and pooling layers, before classification by the fully connected layer.



- **Convolution Layer :**
  An operation taking place on two functions: one is the input image, i.e, the **pixel values of the input images** and the second function is the **filter** that we are going to apply. The filter is also called a kernel.

- **RELU Layer :**
  The function returns 0 if it receives any negative input, but for any **positive value** x it returns that value back.

- **Pooling Layer:**
  Progressively **reduces the spatial size** of the representation to reduce the number of parameters and calculations performed in the network.

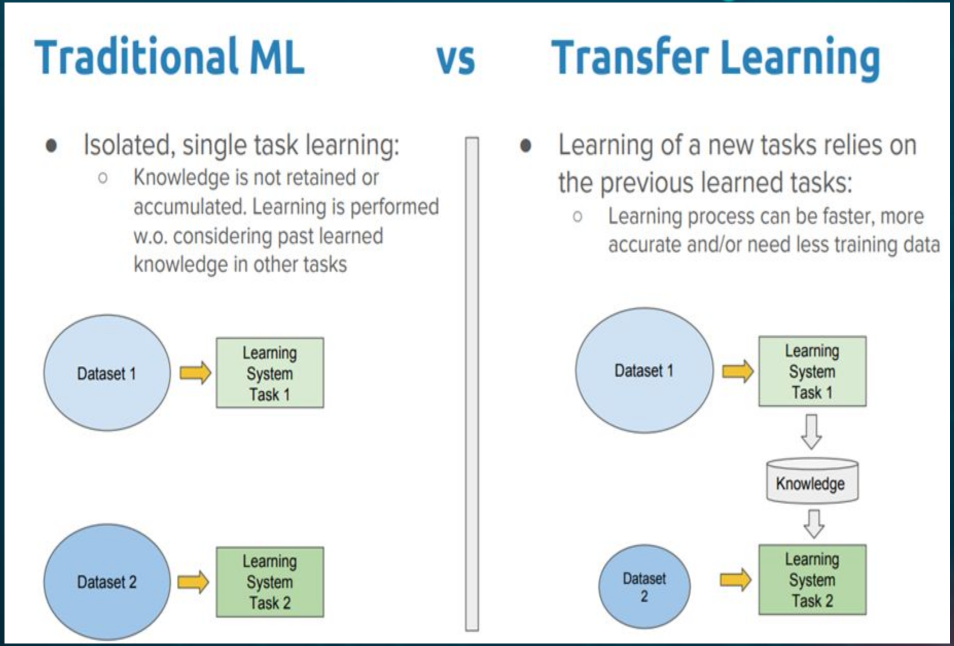
- **Fully Connected Layer:**
  Takes the results of either the convolution, pooling or RELU layers and **classify** the image into a label.

2. TRANSFER LEARNING WITH CNNs :

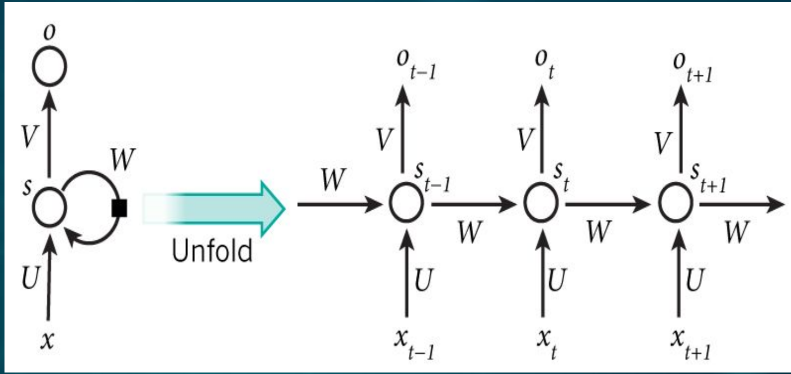
- The basic premise of transfer learning is simple: take a model trained on a large dataset and transfer its knowledge to a smaller dataset.

- Training a machine learning algorithm on a partially-related or unrelated dataset, as well as a labelled training dataset.

- Circumvents the obstacle of insufficient training data.



2. RECURRENT NEURAL NETWORKS (RNNs) :



- In an RNN, the output of a layer is fed as input to the next layer. This is then fed again into the same layer.
- This gives it the ability to retain certain pre-computed information, which serves as a **"memory".**
- In the domain of analyzing medical images, RNNs play the role of performing **segmentation.**

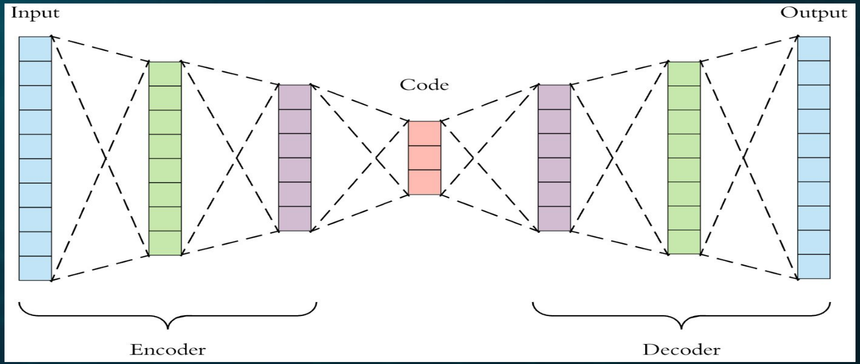
UNSUPERVISED LEARNING MODELS

1. AUTOENCODERS :

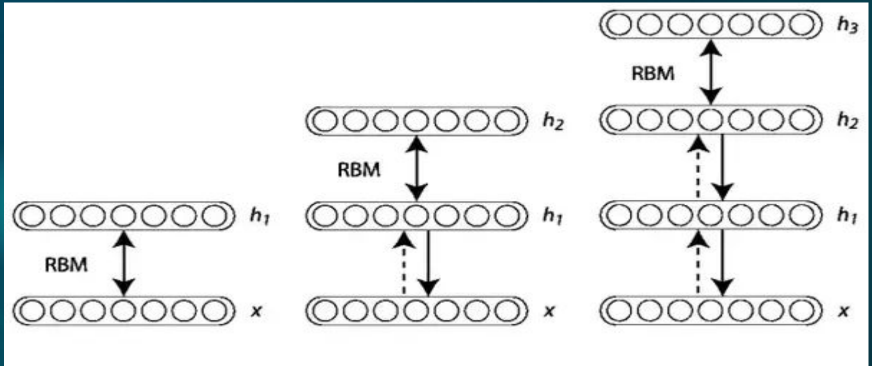
- Produces an output that is identical to the input fed into it.

- Composed of three important parts:
    - **Encoder**
    - **Code**
    - **Decoder.**

- The data is fed to the encoder. This data is then encoded and minimized. The decoder decodes this encoded data to reconstruct the output that looks identical to the input.



2. DEEP BELIEF NETWORKS AND RESTRICTED BOLTZMANN MACHINES :



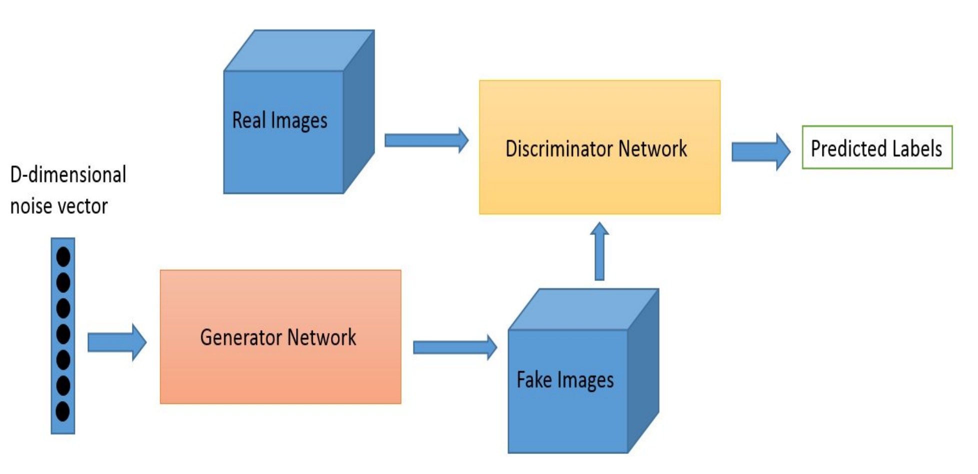
- Restricted Boltzmann Machine (RBM) is a unidirectional network that comprises visible and hidden layers.
- RBMs' parameters can be trained with contrast divergence algorithms and stacked to form a deep architecture commonly referred to as the Deep Belief Network .
- DBNs are generative in a sense that they 'generate' all the possible outcomes for a particular case.

3. GENERATIVE ADVERSARIAL NETWORKS (GANs) :

- Generative Adversarial Networks (GANs), as the name suggests, include two networks that are constantly competing against one another, hence the name 'adversarial'.

- **Generator** generates artificial training images.

- **Discriminator** determines whether the data generated by the generator are synthetic or real.



ADVANTAGES

- Machine learning algorithms have surpassed human performance in image recognition tasks.
- Significant hierarchical relationships within the data can be discovered without laborious hand-crafting .
- Patients can potentially avoid the ionizing radiation from a CT scanner altogether.
- Lowered cost and improved patient safety.
- Reduce the blurriness and improve quality of the medical images.

DISADVANTAGES

- Lack of labelled datasets.
- Black-Box characteristics of deep learning models.
- General lack of publicly available medical data.
- Public reception towards their health results being studied by a nonhuman actor.

APPLICATIONS

- CNNs perform the tasks of classification, localization, detection, segmentation and registration.
- From a medical perspective, **Classification** refers to determining if a disease is present or not.
- **Localization** refers to the presence of a normal body part.
- **Detection** refers to the identification of all the abnormalities present in the image.
- And lastly, **Segmentation** refers to the outlining the abnormality and studying its distance from the normal tissue thereby assessing whether the abnormality needs to be operated on or not.

Case Study

BREAST CANCER DETECTION USING CNN

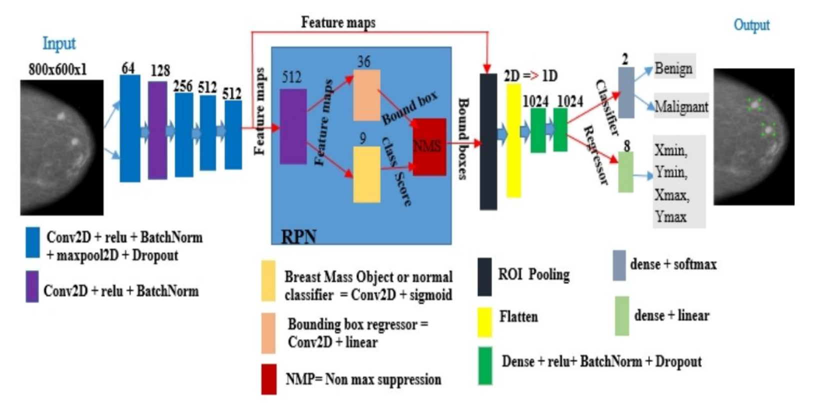
- A study was conducted by Simon Hadush et al. on breast cancer detection using **CNNs and R-CNNs.**
- The images were preprocessed with various filtering-layers: **Gaussian, median & bilateral filters**.
- This model had an **accuracy rate of 91.86%, & a sensitivity of 94.67%** in their prediction.

PROCEDURE :
This model was implemented with the help Python and Keras and used Tensorflow as the backend.

1. Data collection:
The experimental data that was to be used for this model was collected from various hospitals in Ethiopia.

2. Preprocessing of Mammogram images:
The images of the mammograms were preprocessed in order to reduce the image-noise.

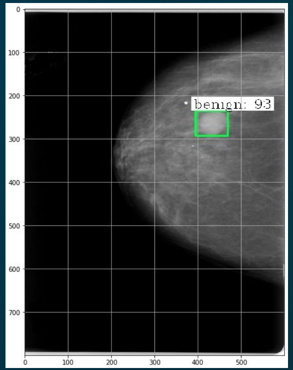
3. Training the Model:
For training the model, a series of 5 convolution layers were used.



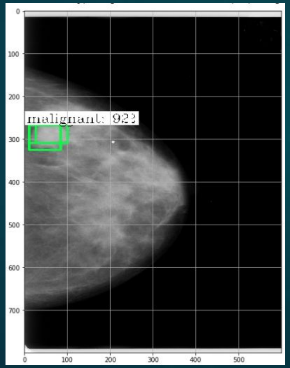
RESULTS

- The dataset was split for various needs as follows:
  - 80% for training
  - 10% for validating
  - 10% for testing

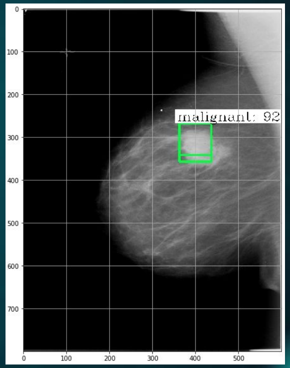
- The image formats of DICOM were converted to .png during the pre-processing of images.



Benign



Malignant



Malignant

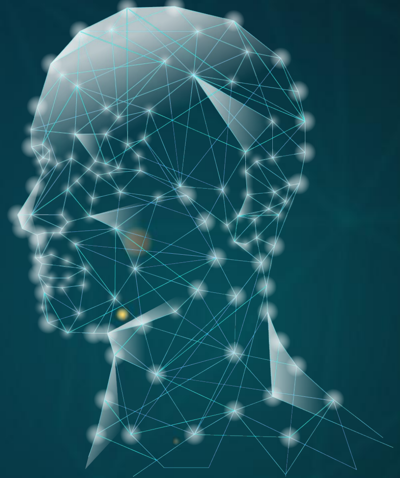
Figures above show the detected mass-abnormalities in the x-ray images.

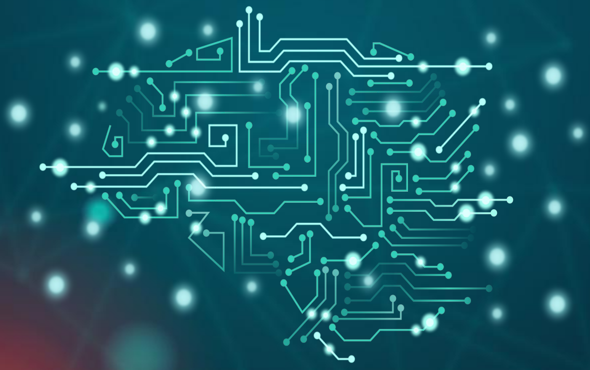
Evaluation Criteria	Accuracy	Precision	Sensitivity	Specificity	AUC-ROC
Results(%)	91.86%	87.65%	94.67%	89.69%	92.2%

FUTURE SCOPE

➢ Immense scope in healthcare.

➢ Revolutionizing the medical sector owing to the big data that’s being generated on a day-to-day basis.





➢ GAN’s could be used to produce CT scans from already taken MRI images of patients.

➢ Cost-effective and a safer option for people.

➢ Image-resolution of medical images could be improved.

- Histopathological images were used to study and classify the subtypes of lung cancer for predicting probable genetic mutations.
- This model outperformed a human pathologist.
- Enables medical practitioners to foretell chances and probability of a patient’s survival.
- Guide the patient to make the right choice of therapy.

Thank You