Enabling various types of Healthcare Data to build Top 10 DL applications

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Even though healthcare industry is worth **$8 trillion** [1] only 20% of people have **access to quality healthcare.** We have aging population in the world. There is a pressing need for value based healthcare [2]. Healthcare industry is going towards **data driven approach.** The amount of personal health and population healthcare data that is available today is growing at rapid speed. Healthcare industry has resource and access **constraints.** On one hand there is a **shortage** of pathologists, radiologists and other clinicians and on the other hand the number of procedures and diseases such as cancer are **increasing.** Only way to solve it is through **technology.**

In this article, the focus is:

> *What are the different types of Healthcare data*
>
> *What kind of Deep Learning(DL) techniques are used in healthcare and*
>
> *How can we use that data and techniques to build Top 10 applications in Healthcare*

Let us start with **different types of data** which we use to build real world machine learning / deep learning models. Deep learning is a subset of machine learning. Hand crafting of features is not required in deep learning at the cost of providing more data to build the models.

There are 7 types of data namely, ***numerical, categorical, text, image, video, speech and signals*** irrespective of the domain to build deep learning models. Table 1 summarizes types of different data from healthcare domain. Based on the type of data the pre-processing steps may differ. Then we summarize the deep learning based healthcare applications for each type of healthcare data.

S. No	Types of Data	Healthcare Data	Pre processing Steps to use Deep Learning	DL based Healthcare Applications
1	Numerical	Blood reports	Normalization of the data	Classification of normal/ abnormal
2	Categorical	Medical test results	Encoding	Classification of normal/ abnormal
3	Text	Medical reports	Word2Vec, TF/IDF, ELMO kind of word embeddings	Automatic Report generation, Summarizing medical report
4	Image	X-ray	Image Normalization,	Classification, Segmentation
5	Video	CT, MRI, Ultrasound output	Slices/frames, image level preprocessing	Classification, Segmentation and object detection
6	Speech	Doctors and technicians discussions and instructions	Speech to text conversion	Capturing speech and generate report
7	Signals	ECG, EMG signals	Signals to vectors conversion	Classification of normal/ abnormal

Table 1: Types of data and healthcare applications

Next, I summarize various types of deep Learning techniques and how can we use those techniques in healthcare applications along with specific examples in table-2. The techniques range from simple Feed Forward Networks, Convolutional Neural Networks (CNN) to Recurrent Neural Networks(RNN) and latest Attention Networks.

Type of Deep Learning	Specific Model / Algorithm	Application in Healthcare	Specific Examples
Supervised learning	Feed forward networks	Personalized Treatment	Type 2 diabetes, cancer precision treatment
	Feed forward networks	Population Health	predict malaria outbreaks
Convolutional Neural Networks	Convolutional Neural Networks (CNN)	Radiology - Image classification	Detecting healthy vs cancerous tissues to help improve radiation treatments, Chest TB classification
	Convolutional Neural Networks (CNN) with multi task loss	Organ segmentation in radiology	Lung segmentation
Recurrent networks	Long Short Term Memory (LSTM)	Early warning	Sequence of parameters monitored to detect early the disease
	LSTM, Gated Recurring Units (GRU), Transformers for sequence modeling	Precision medicine	Dosage of BP level
	Neural Machine Translation with Seq2Seq models, Attention networks	Medical documents translation	Documents, medical transcription translation to local languages
Unsupervised learning	Auto encoder, Generative Adversarial Networks (GANs)	Drug discovery	Specific drug validation
Generative Adversarial Networks	AC-GANs, DCGAN, CGAN	Data Augmentation	Class specific data generation
Reinforcement Learning	Deep Q Network	Right treatment identification	Sequence of treatment for cancer, HIV

Table 2: Type of deep learning techniques and applications in healthcare

Another dimension to look for the deep learning applications in healthcare is based on the various stages of healthcare system, which is summarized in table-3. Prevention is better than cure. DL plays an import role both in early stages as well as advanced stages in the healthcare system [3].

Health Sequence/stage	Applications	Remarks
Regular Healthy Living	Monitor the parameters through app/watch which help to build the DL models - regular monitoring	Building forecast models
Preventive Stage	Monitor daily parameters and classify as normal / abnormal	Classification kind of models, alert when to visit the doctor
Diagnosis stage	Right diagnosis using DL models	Faster diagnosis, Identify relevant slices in CT volume for doctor's attention
Treatment stage	Personalization	
ICU / Operation stage	Robotic surgeries	Classification of cancer cells to assist doctor
Homecare/Elderly care	Alert when abnormality is detected	Model building along with IoT

Table 3: Heath sequence and deep learning applications

With this background, let us look into Top 10 Deep Learning applications in Healthcare using various types of data described earlier:

1. **Medical Imaging:**

- Convolutional Neural Network (**CNN**) 2D/3D plays an important role in medical imaging [4]
- We formulate Classification, Object detection and Segmentation kind of problems in medical imaging using advances in CNN
- This involves processing of huge number of images, refine its understanding and interpretation of the information
- ***Transfer learning*** from AlexNet, GoogleNet helps to build many image classification problems
- The DL models are getting ported to the Computed Tomography (CT), Magnetic Resonance Imaging (MRI) boxes to identify the ***quality of the reconstructed image*** and check for any issues such as motion detection

- Real time image reconstruction — Can do better reconstruction of the images in CT. This can reduce the patient radiation exposure.

2. **Faster Diagnosis:**

- Analyzing medical images/data can often be a difficult task and time-consuming process
- GPU-accelerated ***DL to automate analysis*** and increase the accuracy of diagnostician
- DL helps doctors ***to analyze the disease better*** and provide patients with the best treatment
- Can act as a **second** objective opinion

3. **Early detection / warning:**

- The DL models are built with access to the continuous data from various devices such as mobile apps, watches and observe the patterns
- The diseases can be ***detected much earlier*** say during the regular health check-ups (corrective actions can be taken before they develop)
- Discover symptoms early and suggest the visit to the doctor/diagnosis test on need basis instead of regular periodic visits

4. **Improve efficiency @ Radiology:**

- Radiologists can spend more time with patients instead of medical reports including tele-radiology
- ***Triage*** — pipelining the patients based on their criticality
- ***Workflow improvements*** with radiology as a service
- No misdiagnosis due to fatigue or other reasons

5. **Personalized treatment:**

- Everyone's health recommendations and disease treatments are tailored based on their ***medical history***, past conditions, diet, stress levels & similar patients
- ***Optimize treatment options*** based on person's medical history

6. **Genomics — Precision medicine:**

- To understand a genome and help patients get an idea about disease that might affect them
- ***Genetic factors*** like mutations lead to disease
- Lot of computational effort but active research area which can change the way medicines will be used in future [5,6]

7. **Drug discovery:**

- To correlate, assimilate, and connect existing data more rapidly in order to help ***discover patterns*** in the data pools
- Speed up of clinical trials research. A drug discovery may take up to 10 years and usage of DL and ML methods can reduce the time significantly. [7]
- ***Diverse data sets*** to avoid bias from unbalanced data. We can use latest techniques such as Generative Adversarial Networks (GAN) to handle unbalance in the data [8]

8. **Robotic surgery:**

- We know the importance of precision during the surgery say for cancer treatment
- DL Models help surgeons with more precision and fine detail [9]

9. **Population health:**

- Build models based on ***population data trend*** of pooled consumer data
- We can work with the Governments to collect the data at large scale and build the DL based models

10. **Information extraction:**

- From clinical notes using Natural Language Processing (NLP) to ***anonymize, annotate to do semantic analysis and inference***
- Use image captioning techniques to generate the report
- Build multi modal chat bots using extracted information

Next, let us look into challenges to implement these top DL applications and discuss future scope.

Challenges:

Common problem we hear is "Deep learning works but still treated as ***blackbox".*** i.e. How and why it works? which is important for both the data scientists and clinicians. The recent developments in Explainable AI (XAI) helps to build the trust for the results produced by deep learning models. I plan to publish another article on XAI so not covering those topics here.

Deep learning is at the early stage in the adoption cycle, however the **maturity** of the technology is not the only factor for adoption. We need to build the trust towards technology, should be able to reproduce the results with clinical validation. This can increase acceptance of the technology by the physicians.

Even though there is fear of replacement, actually the technology will complement the doctors [10]. There are few more challenges such as:

- Reach of **quality** and diversity of data for building models
- Data access issues across countries/hospitals
- Region specific data residency and privacy laws also limit the sharing of patient data such as General Data Protection Regulation (GDPR)
- Approvals from the **regulatory** environment

Future Scope:

We are expecting approval to use the Deep learning models to come to mainstream with FDA approvals. As prevention is better than cure , we can think of ***shift left*** strategy to

mitigate the damage. If an insured person fall sick, that is revenue generation for hospitals. However we are observing new revenue generation method from insurance companies. Get an insurance premium from the person and protect the person NOT falling sick is the new phenomenon.

With the advances in technology, we expect **wide acceptance** of deep learning models and AI in general by the doctors. "**Second opinion** by Software for diagnosis may become a trend within 10 years" — Dr. Devi Shetty, Chairman, Narayana Health.

Looking forward to live in better world with affordable healthcare through technology

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Dl In Healthcare Deep Learning In Health Medical Imaging Personalized Treatment

Ai For Doctors