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Deep Learning A Compass To Medical Sciences

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Abstract:

The outline of this paper is implications of deep learning in medical sciences, focusing on deep learning concerning natural language processing, computer vision, reinforcement learning, big data and Block chain influence on some foremost areas of medicine and construction of end- to -end systems with the help of these computational techniques are also addressed. The deliberation of computer vision in our study is mainly concerned with medical imaging, further usage of natural language processing to spheres such as electronic wellbeing record data. Application of deep learning in genetic mapping and DNA sequencing termed as genomics and Implications of reinforcement learning about surgeries assisted by robots is also overviewed.

Keywords: Big data, Block chain, CNN, Deep learning, Reinforcement learning

Introduction:

Deep learning[1] is a subpart of a machine learning family and has very high computational power. The sudden and extreme growth of deep learning is because of its very high computational power and the availability of huge datasets. The dramatic advancement in the field of deep learning is the manipulation capability of machines especially speech[2], images[3], and languages[4]. Due to the availability of the huge amount of data medical science is directly getting the advantage of deep learning. The estimated growth of data is increasing enormously across the globe among which contribution of United States 150 Exabytes alone, other than that the accelerated growth in medical equipment and other electronic record systems is also tremendous.

The refinements in mathematical formulas and up-gradation of systems with enormous speed in the present era, Data scientists and researchers have gained the ability to model many more virtual neurons that otherwise not happened before. This is possible because of the development of various deep models within neural networks by Geoffrey Hinton[1] and its associates by the mid

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of 1980 till that previous neural networks were able to counterfeit a small number of neurons at once. Hence to recognize the patterns of great complexity was impossible. The main limitations of deep models were the human intervention to label data and to recognize image and other complex speeches a very high computational power was required which was not available at that time.[1][2]

With the beginning of 2006 the development of efficacious ways by Hinton[1] to train each layer independently and sequentially, where first layer seeks how to learn primary features (edges in case of images and tiny sounds which are amalgam of pixels or sound waves) which are occurring very frequently than those that can occur by some chance. Once these layers have learned these specific features precisely and are then fed into the next layer which then trains itself to comprehend more complex features like amalgams of speech sounds or shape of the image. This process is then repeated many a time in each successive layer until the reliability of the system is enhanced to recognize objects clearly and hence makes the base of deep supervised learning models. Some common supervised deep learning models which come into existence are artificial neural networks, Convolutional neural networks, and recurrent neural networks and so on.[3][4]

Deep learning models can manipulate large datasets with the requirement of high computing hardware and will improve gradually with the increasing size of data and thus enhancing its capability to do better than many traditional machine learning approaches. The striking feature of deep learning is to accept many data types as input which specifies its aspect of specific pertinence for different health care data. Supervised learning methods are commonly used to train basic models where the dataset is generally the composition of input and output data. The input data could be anything like lesion for example in the case of prostate segmentation the input will be prostate gland lesion and the labels on output data after classification will be either normal or cancerous.

Reinforcement learning a subclass of machine learning which guides software agents and other machines how to learn by trial and error methods and its progress with the adoption of deep learning and hence helps in accomplishing extraordinary achievements in many areas like game

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playing (Go)[5] etc. In the domain of medical sciences where a learner requires physical demonstrations like learning how to suture after performing robotic-assisted surgery[6].

Why reinforcement learning?

Motivation: the main characteristics of reinforcement learning are to allow agents and machines on how to learn its behavior based on feedback received from the environment. Behavior learning could be done once for all or otherwise adapting changes over time. The modeling of a problem is the key issue in these cases of reinforcement learning. Handling problems clearly will push some reinforcement learning algorithms to the global level and thus maximizes the reward.

How does reinforcement learning work?

Technology: since multiple solutions to a given problem are available. Software agents actually will select the most optimum which would maximize the reward in the long run and not for the shortest duration or immediate future ultimately such algorithms are known to have infinite horizons.

Limitations of reinforcement learning: since the problem could be complex with multiple states and to store the value of each state large amount of memory is required and this makes it memory expensive, more ever to solve these complex problems, techniques with the highest approximation are required like neural networks or decision trees. By implementing these imperfect values estimation techniques there are chances of numerous consequences and thus researchers will be trying to make the impact minimal on the quality of the solution.[5][6]

Who uses reinforcement learning?

Reinforcement learning has applications in multiple domains because of its genericness of the problem specification. A more eventually large number of problems in artificial intelligence can be mapped to a decision process. Due to its unique same theory could be applied to other different domain-specific problems with minimal effort. Practically its range lies in the areas of controlling robotic arms to match out most efficient motor combinations, to robot navigation where chances of behavior collisions could be learnt by negative feedback from bumping into

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hindrances. Other applications of reinforcement learning in logic games are also remarkable as they define some sorted sequence of decisions.[7][8]

Computer vision

Computer vision, a research area where the main focus is on making computers see "Thepurpose of computer vision issues is to use the image data found to extrapolate something about world".[7]

Deep learning has a remarkable success rate in the field of computer vision. "Computer vision: Algorithms and Application" book published in 2010 outlines a list of high-end problems where computer vision has outstanding success[8]. Some problems among them are listed below:

1: Medical imaging
2: Fingerprint recognition and biometrics
3: Optical character recognition
4: Surveillance
5: Match movies (merging computer-generated imagery (CGI) with live actors in movies)

Computer vision is a very wide area of subject comprising many specific tasks and techniques and specialisms to target application areas. Computer vision is a multivalent field which is broadly called as subclass of artificial intelligence and machine learning, which possibly will oblige the use of specific methods and may implement some basic learning algorithms. The contribution of computer vision in the field of medical sciences has outstanding results for object detection, segmentation and classification. These help in determining whether a radiograph of a patient depicts the stage and type of disorder more clearly. Some of the promising results are achieved in some life threatening diseases where diagnosis is complex like dermatology, ophthalmology, and radiology. The automated information is extracted from images with the help of computer vision. The information could be whatsoever from 3D models, object detection and recognition to search and group image content.[9]

Computer vision and image processing

There is a distinction between image processing and computer vision. The basic definition of image processing is to draw out a new image from an existing image. This whole procedure is

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usually done by enhancing or simplifying the content of image in one or other way. The procedure followed in image processing is summarized as:

1: Photometric proprieties of the image are normalized like brightness or color.

2: Image cropping, such as centered alignment of the objects in the image is done.

4: unwanted digital noise is removed from the image.[10]

CNN and medical sciences:

Diagnosis and detection of diseases on the basis of images is very successful by implementing CNN based methods. Basic structure and working of CNN is shown in figure below. The main reason behind the success of CNN is because it has acquired performance up to the level of humans in case of object classification assignments [2] where CNN learns classification procedure of objects present within images. Satisfactory results out of these similar CNN networks are acquired in case of transfer learning.[10] We train CNN's initially on large datasets in case of transfer learning. Dataset is not however related to the specified task, for example ImageNet [2] a dataset comprising of millions of some common objects. Same CNN is further fine tuned on some other small dataset which is as per target requirement (medical images). The preliminary work of algorithm is to clout huge amount of data to learn basic information present in images e.g. curves, straight lines etc. higher layers of the algorithm are then trained again to make clear distinction between different diagnosis cases. Same procedure is then followed in image segmentation and object detection algorithms to identify those parts of images which correspond to specific objects.[11 12]

The Convolutional neural networks have outstanding results in the field of medical science. The brief description of some remarkable performance is outlined below:

1: Identification of a tiny pigmented spot called the mole in case of skin cancer, which is called melanoma in medical terminology.

2: Diabetic retinopathy: it is a complication that affects the eyes. The main cause of diabetic retinopathy is the damage of blood vessels present in the retina. The main problem is because of uncontrolled blood sugar level. The occurrence of this disease is very rare and cannot be cured completely. It can last for years or lifelong. The main symptoms of these diseases are difficulty in observing colors, blurriness, and blindness.

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3: Cardiovascular risk: it is the condition that creates a problem to heart like diseased vessels, blood clots, and other structural problems. Somebroad types of cardiovascular diseases are as under:

A: Coronary artery disease: it is a condition in which damage occurs to major blood vessels of the heart.

B: High blood pressure: the force of blood against the walls of the artery is very up.

C: Cardiac arrest: an abrupt, unforeseen loss of heart function, breathing and consciousness

4 breast lesion detection in the case of mammography: mammography is the most critical mode of breast imaging. a main capability of mammography is to detect micro calcification which cannot be detected by any other clinical investigation. There are two main types of lesions detected in mammography for prediction of cancer that is benign and malignant lesions.

5. Spinal analysis with MRI: it creates a detailed and crystal-clear image of the spine and its adjacent tissues. It is used to determine or ascertain some of the following abnormalities.

a. Birth defects

b. Trauma injury to the bone, disc, etc

c. Bone and other joint disease detection.

d. Neurodegenerative disorders and other tumor detection.

Challenges of computer vision:

The main challenge of computer vision is to build a “machine vision” or general purpose “seeing machine”. Machine vision is the ability of a computer to see. This process involves more than one video cameras analog to digital conversion (ADC) and digital signal processing. The main purpose of computer vision is to draw froth meaningful facts from images. This task is proved to be unexpectedly a demanding task as it has involved almost thousands of bright and ingenious minds over last few eras, in spite of that we are still far away from being able to develop a” machine vision” or “seeing machine”. The main problem arises when we equate the performance of algorithms with humans, where algorithms are restricted to diagnose by using the images at

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hand only. This increases diagnostic complexity for a human reader who in the real-world has access to multiple domains of patients including medical images, lab tests, and other patient history. Image segmentation and object detection in images is to be implemented in very critical care cases for e.g. a large -artery obstruction in the drain by using radiological images during which a patient has minimum time (a few minutes)before permanent brain damage occurs. Another important application of CNN is to discover biological features of tissues which are linked with survival problem.

The primitive restrain to build a supervised deep learning model for a new medical image processing task is to access large, labeled data set. For some basic tasks small data sets are easily collected. But results generated by algorithm on new data will be poor to tackle these situations augmentation techniques are effective to generalize algorithms. Unlabelled data set collection is easy to collect but will need to move towards semi-supervised and unsupervised techniques like generative adversarial networks (GAN).

Blockchain and medical science

Blockchain technology offers multifold advantages to the medical sciences. There are multiple domains in medical technology where Blockchain technology can make advancements in the future. These areas are summarized as:

1. Monitoring configuration
2. Administrative management.
3. Reduction in processing time at clinics by collecting complete data at a time, once a patient gets enrolled due to the availability of distributed ledger.

Due to the availability of previous honest medical history of a patient is not a matter of concern to the doctor because of the availability of actualauthenticated and crystal-clear source documented data in real-time, which will make reduction in the number of errors present in the medical history. In the same way, patients need not have to worry regarding any other doctor consultationbecause of the crystal clarity of data. Due to the availability of patient history records on a Blockchain network will help to make contact with others across the globe, with analogous medical circumstances as they retain which in turn will not be helpful for their well-

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being, but can help in understanding of patient feelings, support and will enhancedetermination to fight the disease. Patients would have whole control over their data and will choose to whom to partake the data. Therefore, Richie Etware in 2016 proposed at a book launch that the upcoming era will be termed as a freedom-As-A-Service. [13]

Several studies have been done to address the potential of Blockchain to facilitate better health care data sharing and to assist in several other diagnosis applications. Some of the studies are below

1. Healthcare data gateway method (HDG)[11] that will use a private Blockchain to monitor and store personal clinical data. Several benefits are provided to patients by this method such as easy accessibility, monitoring and controlling his own medical records. This whole information is stored on a private Blockchain (a central database system with limited access to authenticated users only).

2. A private Blockchain,[12]which is grounded on the Ethereum protocol, which easesharmless and protected use of medical sensors and also get rid of security risks linked with a remote patient monitoring system. This Blockchain-based strategy will provide protected real-time remote monitoring which in turn allows consultants to track the health care state of their respective patients from remote locations and also will help in keeping an up to date, safe and secure history of patients.

Adoption of Blockchain technology in medical technology as a mechanism for sharing data, privacy, and security can be enhanced among medical specialists and healthcare entities. An innovative architecture that can protect sensitive data of a patient, [13]critical data security issues are addressed and implement a Blockchain software system throughout a hospital system. Blockchain technology has also evidence of great prospects in biomedical research and clinical domains. The actual implementation of Blockchain technology will be beneficial for storing all clinical consents, plans, and protocols even before the commencement of clinical trials or examinations. Thus, the sensitive data related to clinical trials will be secure, up to date, and time-stamped and publically open to all. More ever smart covenants could also be deployed, replicated and then executed within various phases of clinical trials to cinch transparency. However this could be achieved only if followed and validated correctly.

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Research Challenges in Blockchain

Due to large application of Block Chain in the field of financial service, cyber security, Iot, Brain Research etc. has accomplishedsignificant attention. There has been outstanding interest witnessed in applying applications of Blockchain for the delivery of safe and protected healthcare data management. The one important benefit of using Blockchain technology is to reduce the traditional health care services which are not so reliable. This advanced technology is safe and secure in terms of diagnosis and treatment. In coming years Block chain would be more authentic and secure with nexus real time clinical data and reflecting up to date setup.

Big data and medical sciences

To analyze pictorial information so that medical diagnosis, monitoring, and therapy through imaging is an effective tool for every working professional in multiple domains like radiography, medical imaging, etc.[16] Big data is a focus center in the present era and has become very crucial for big companies like Microsoft, Google, IBM, etc. Big data is consociated with the concept of "4 V's" and is based upon the concept of Moor's law.

V=Volume: Quantity of Big data in healthcare means Volume, which is appraised to sudden and extreme increase until the order of Zettabytes (1021by 2020). The report published by Stanford Medicine 2017, the Volume of healthcare data is increasing at an astronomical rate approx. 153 Exabytes where 1 Exabyte=1 billion gigabytes were produced in 2013 and 2314 Exabytes are going to be produced in 2020.

V=Variety: is defined as a heterogeneous type of healthcare big data collection including their different characteristics and structured and unstructured nature.

V=Velocity: real-time patient data generation and collection is termed as Velocity. Regularly millions of patients endure medical image diagnostic procedures, which consist of a crystal clear workflow in which information is gathered through a device and then stored.

V=Veracity: defined as the source that impacts accuracy like inconsistencies, missing data, redundancy, fraud, spam, and latency. Data quality and Veracity are basic fundamental issues in healthcare. The soul dependence of life or death depends upon the trustability of information. These are responsible for bringing more data analytical challenges. Big data has been proven to be very beneficial in multiple domains such as medical science, sports, and advertising. The

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promising outcome of Big data in the field of healthcare is in diseases, prediction and investigation to achieve significant results researchers are utilizing huge volumes of images, signal and other genomics data either independently or combining several modes from different sources to accomplish desired results[14]

Conclusion

This Article presents the role of deep learning in different areas of Research and how deep learning can be used in medical diagnosis of many unfolded diseases and genetic issues leading to cancer or dementia.

The Article presents the trends of different types of machine learning approaches can be used for early diagnosis and understanding various aspect of transition of patient from one stage to other.

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