IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

AI AND ML BASED APPROACHES AND METHODS IN MRI FOR SMART HEALTHCARE

Prof. J. I. Nandalwar, Prof. P. K. Biradar, Prof. P.S. Sable, Prof. V. G. Kakade

Assistant Professor,
CSE, ENTC, CSE,CSE,
Shree Siddheshwar Women's College of Engineering, Solapur, Maharashtra, India

Abstract: Artificial intelligence (AI) and Machine learning (ML), and Deep Learning (DL) have been applicable practicable due to the advancements in computing facilities. Almost every application in general in Industry 4.0 is going to use these advanced mathematical tools and techniques of AI and ML and DL. SMART Healthcare is not an exception for this. In healthcare applications a lot of imaging data is generated as far as diagnostic imaging modalities like Magnetic Resonance Imaging (MRI) are concerned. MR imaging is a very popular noninvasive diagnostic imaging modality with very good soft tissue contrast. Therefore, imaging data resulting from MR imaging is used in this research. Although, there are several other medical imaging modalities. The same MRI has several clinical applications beyond routine imaging, which include functional MR Imaging (fMRI) of brain, Cardic MR imaging, MR Spectroscopy (MR) and MR Spectroscopic Imaging (MRSI), and many more. It requires that the data be processed automatically and in real time for the modern SMART healthcare diagnostic purpose. In spite of the technological developments in Magnetic Resonance Imaging, clinical applications demand accurate, reliable and real time data processing, for the purpose of making diagnostic decisions. Internet of things (IOT) has made it possible to collect the real time data and there are modern Data Analytics methods which make it possible to derive meaningful conclusions from the medical information that is available. This is then processed for providing medical diagnostic information to the medical expert, in a suitable form.

In this paper, the applicability of AI, ML and DL methods have been proposed to be investigated as applied to MR Imaging to make it suitable for providing SMART Healthcare solutions. Not only obtaining the diagnostic information but also the usability aspects of AI, ML and DL based approaches shall be attempted in this research. MR Imaging data from diagnostic centers or Hospitals, shall be used for this purpose. The results shall be compared with the standards methods in MR imaging and also verified with the experts from medical field.

Index Terms - Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), SMART Healthcare, Magnetic Resonance Imaging (MRI), Signal and Image Processing

I Introduction

Magnetic resonance imaging (MRI) is an indispensable tool for medical diagnosis, disease staging and clinical research due to its strong capability in providing rich anatomical and functional information and its non-radiation and non-ionizing nature. However, most of advanced applications such as cardiovascular imaging, functional MRI, magnetic resonance spectroscopy and parameter mapping are not yet widely used in clinic due to the long scanning time of MRI.

Magnetic Resonance Imaging is one of the important diagnostic imaging tools in healthcare industry. Now, the modern SMART healthcare applications demand much more from the imaging data that is collected using the medical imaging techniques like MRI. This is also driven by the clinical requirements of SMART healthcare as well as those specific to medical diagnosis. There are several potential research openings in MRI as the diagnostic tool, however the newer needs of research from SMART healthcare are also equally demanding. Therefore the problem is two-fold. It requires that the data generated from the imaging techniques be processed using the modern approaches of Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL). At the same time, it requires that the medical information be processed in a reliable manner, without any information loss which would otherwise not be acceptable for medical diagnosis. Keeping this as one of the objectives, it is proposed to collect the MR imaging data in the standard Digital Imaging and Communication in Medicine (DICOM) format. Routine ME image data as well as those from functional MR studies of human brain shall be used for this purpose, in order to demonstrate the applicability of AI, ML and DL methods. Other mathematical and statistical tools and techniques shall also be used as per the need. The results shall be obtained using MATLAB on real as well as on simulated data. The challenges in processing the raw data obtained from MR scanner also include validation of results using effective data driven methods.

II. Literature Review

In this section, a literature survey that is carried out on the applicability of modern AI, ML and DL as well as emerging trends in SMART healthcare applications and key technological developments that have a direct impact in these transitions in the field of MR imaging is discussed. The authors also reviewed different security considerations in smart healthcare systems and their consequences and counter measures.

The needs of data processing or signal and image processing in MRI and fMRI have been investigated through literature survey.

With reference to specific needs of advanced healthcare systems, there are methods described in the literature.

The objective is to identify the potential areas of research as far as the applicability of AI, ML and DL techniques are concerned, as applied to MRI for SMART healthcare systems

Bansal Priya et. al. [1] : This article has discussed various applications of AI, Artificial Neural Networks (ANN), and Convolutional Neural Networks (CNN) for different types of diseases for early diagnostics. This article has given a broad description about application of artificial intelligence in medical field. Data collection, magnetic imaging and mining algorithm covers 60% of this article. Deep learning includes Recurrent Neural network (RNN), Auto-encoder, Support vector machine (SVM), Deep Belief Network (DBN) and AUROC curve. This article has discussed the implementation of CNN aand ANN in medical area to assist diagnosis of various diseases in different medical fields like in Cardiology, Neurology, Oncology, Nephrology, Clinical Trial Design, Drug Design, Dentistry, Mental Health, Orthopedics, Nuclear Medicine, Dermatology etc. This article suggested that strong learning ability & generalization capacity of the new technologies should be developed to achieve human like intelligence in future that will improve diagnostic approach and decision-making system for availability of better quality and affordable medical services.

Fei Jiang et. al. [2] have reviewed various applications of AI for healthcare data. Popular AI techniques include machine learning methods for structured data, such as the classical support vector machine and neural network, and the modern deep learning, as well as natural language processing for unstructured data. Major disease areas that use AI tools include cancer, neurology and cardiology. We then review in more details the AI applications in stroke, in the three major areas of early detection and diagnosis, treatment, as well as outcome prediction and prognosis evaluation

Markus J. Ankenbrand, David Lohr et. al [3] in their research work demonstrates and quantifies the benefits of transfer learning for cardiac cine image segmentation. We provide practical guidelines for researchers planning transfer learning projects in cardiac MRI and make data, models. Their experiment on cardiac MRI was carried out at 7T where the segmentation task is challenging

AI applications have been covered as applied to healthcare applications

B.M. Zeeshan Hameed et. al. [5], reviewed the role of artificial intelligence (AI) and its contribution to data science as well as various learning algorithms in radiology. We will analyze and explore the potential applications in image interpretation and radiological advances for AI. Furthermore, we will discuss the usage, methodology implemented, future of these concepts in radiology, and their limitations and challenges

Shruti Agarwal et. al. [6], reviewed the applications of AI for Brain analysis. Different MRI techniques have been used for clinical study of brain. In order to detect dementia MRI and fMRI was used. The review aimed to find out the best use of technique among dataset pre-processing and brain imaging through artificial intelligence which is in clinical domain and detection of normal and abnormal dementia.

Andreas S. Panayide, Amir Amin et. al [7], review state-of-the-art research solutions across the spectrum of medical imaging informatics, discusses clinical translation, and provides future directions for advancing clinical practice. More specifically, it summarizes advances in medical imaging acquisition technologies for different modalities, highlighting the necessity for efficient medical data management strategies using AI.

Heinrich von Busch [8], demonstrates the applicability of AI in MRI applications for post processing and interpretation and attempt to provide a brief overview of the current state of development.

Maribel Torres-Velázquez [9], discussed the DL application to MRI, seeing the impact of DL on the medical imaging field, this article reviews the key concepts associated with its evolution and implementation. The review summarizes the milestones related to the development of the DL field and description of the elements of deep neural network. Key steps necessary to implement a supervised DL application are defined, and associated limitations are discussed.

Jin Liu, Yi Pan [10] discussed the applications of AI and DL for MRI images, including image detection, image registration, image segmentation, and image classification are discussed. The advantages and weaknesses of several common tools have been discussed. Several deep learning tools in the applications of MRI images are presented. Assessment of deep learning in MRI applications is presented, along with future developments and trends with regard to deep learning for MRI images.

Alexander Selvikvåg Lundervolda et. al. [11] have described various applications of AI in Medical Imaging. They introduced to deep learning and how deep learning has been applied to the entire MRI processing chain, from acquisition to image retrieval, from segmentation to disease prediction. This provides directions as a starting point for experimenting on deep learning for medical imaging.

Filippo Pesapane et. al. [12], described the opportunities and challenges in applying AI to medical images. The paper provides basics of terms commonly used when discussing AI applications, analyses various aspects related to the integration of AI in the radiological work.

JUSTIN KER et. al. [13], have presented key research areas and applications of medical image classification, localization, detection, segmentation, and registration. We conclude by discussing research obstacles, emerging trends, and possible future directions

Zhao Zhang et. al [14] have summarized recent research advances in ML and DL techniques for classifying human brain magnetic resonance images. The application of ML and DL methods to six typical neurological and psychiatric diseases is summarized, including Alzheimer's disease (AD), Parkinson's disease (PD), major depressive disorder (MDD), schizophrenia (SCZ), attention-deficit/hyperactivity disorder (ADHD), and autism spectrum disorder (ASD)

Zhao Zhang et. al. [15] described the clinical applications of AI that may change the healthcare of patients, including tools for development used currently by health care providers. Discussion on the clinical and cost effectiveness of specific AI technologies is covered.

Arkan Al-Zubaidi1 et. al. [16], used resting-state functional magnetic resonance imaging (rs-fMRI), which has become an essential measure to investigate the human brain's spontaneous activity and intrinsic functional connectivity. Several studies including their own previous work have shown that the brain controls the regulation of energy expenditure and food intake behavior. Accordingly, the authors expected different metabolic states to influence connectivity and activity patterns in neuronal networks.

Benjamin Fritz, Jan Fritz et. al. [17] , presented a clinically focused review of the current state of DL-based MRI diagnosis of joints. It has been observed that the deep learning-based MRI diagnosis is an emerging field of musculoskeletal radiology with various promising applications, including detection and characterization of anterior cruciate ligament and meniscus tears, rotator cuf disorders, complex segmentation of nerves, bones, and muscles, and recurrence prediction of musculoskeletal neoplasms.

Protima Khan et. al. [18], presented a survey on the brain disease detection processes using machine and deep learning. The survey reveals some important insights into contemporary ML/DL techniques in the medical field used in today's brain disorder research. With the passage of time, identification, feature extraction, and classification methods are becoming more challenging in the field of ML and DL. One of the most important factors mentioned in their work is to improve classification accuracy. For this, the number of training data needs to be increased. It is claimed that the more the data is involved, the more accurate the results will be. The use of hybrid algorithms and a combination of supervised with unsupervised and ML with DL methods are promising to provide better results.

Dong Wen et. al. [19], have applied the DL based methods for analyzing fMRI data. The main challenges for the development of deep learning methods for fMRI data analysis have been mentioned in training methods which used a smaller amount of data. Therefore, the studies of small sample may lead to obvious over-fitting problems. The training methods may take more time when number of sample increase, and more training time makes it more difficult to conduct in-depth and meticulous parameter adjustment work, resulting in hindered improvement of method performance.

Ohad Oren et. al. [20], have described that the outcome assessment in AI imaging studies is commonly defined by lesion detection while ignoring the type and biological aggressiveness of a lesion, which might create a skewed representation of AI's performance. The authors recommend to go for refinement of AI imaging studies via consistent selection of clinically meaningful endpoints such as survival, symptoms, and need for treatment.

Muralikrishna Puttagunta et. al. [21] reviewed DL based approaches to think of appropriate changes in medical image analysis. This paper discusses the new algorithms and strategies in the area of deep learning. In this brief introduction to DL in medical image analysis, two objectives have been discussed. The first one is an introduction to the field of deep learning and the associated theory. The second objective provides a general overview of the medical image analysis using DL covering history of neural networks. Several supervised and unsupervised DL algorithms are first discussed, including auto-encoders, recurrent, CNN, and restricted Boltzmann machines. Several optimization techniques and frameworks in this area include Tensor Flow applications.

Martin J. Willemink et. al. [22] discuss "machine learning" at broad and granular levels, providing an introduction into how such techniques can be developed and applied to imaging interpretation. Next, it provides examples of applications of machine learning in diagnostic radiology. The key barriers and challenges in clinical application of machine learning techniques have been elaborated addressing future directions.

Garry Choy et. al. [23] , in their paper, the authors describe fundamental steps for preparing medical imaging data in AI algorithm development, explain current limitations to data curation, and explore new approaches to address the problem of data availability.

Harshita Bhagwat et. al. [24], describe an overview of the various machine learning algorithms, including SVM, CNN which are used in voice disorder detection processes. Using these algorithms, correct decisions could be made using proper data.

Tim Leiner et. al. [25] , discussed the applications of ML and DL for cardiac MRI CMR). It covers a non-technical overview of the basics of ML relevant to CMR. Survey of the various ways ML has been applied to the field of CMR providing an outlook on future directions and recommendations for reporting results. ML methods have been applied for characterizing the myocardial tissues.

Adnan Qayyum et. al. [26] present an overview of various application in healthcare that leverage ML based techniques from security and privacy point of view and challenges in this field. Potential methods have been described to ensure secure and privacy-preserving ML for healthcare applications. Current research challenges and directions for future research have been provided.

Liyan Sun et. al. [27] proposed a generative adversarial network called ANTGAN for translating a medical image containing lesions into a corresponding image where the lesion has been removed. This is an emerging Deep learning application.

K. He, X. Zhang et. el. [28] described Deep residual learning for image recognition. They covered residual learning framework to ease the training of networks that are having substantially deeper layers. They reformulate the layers as learning residual functions with reference to the layer inputs, instead of learning unreferenced functions.

R. Li et. al. [29] have applied Deep learning for brain disease diagnosis. They proposed a deep learning based framework for estimating multi-modality imaging data by developing a 3-D CNN model for completing and integrating multi-modality neuroimaging data. This model takes one volumetric data modality as input and another modality as output. The nonlinear relationship between different data modalities is captured by a large number of trainable parameters in the network. We applied this model to predict the missing PET patterns from the MRI data. Results showed that the predicted PET data achieved similar classification performance as the true PET images. Additionally, our data completion method significantly outperformed the previous methods.

A survey of deep learning application for medical image analysis has been discussed in [30] by G. Litjens et al. Convolutional deep neural networks have been applied for large scale image recognition by K. Simonyan et. al in [31] and deep learning image recognition [32] by K. He, X. Zhang, and work by Erickson BJ et. al. [33] on demonstrated machine learning for medical imaging. Wang S et. al. [34] have described the Machine learning applications in radiology. Some more applications of Deep learning in radiology have been covered by V. Antun et. al. [35], J.-G. Lee et al [36].

1. Comparative Study of Research Articles:

Indexing Year	Performance Evaluation Parameters	Theme	Algorithms/Technique/Approach	Findings	Limitations
2021	Clinical Applications of AI	Descriptive Review	Early Diagnostics	Applicability of AI, ANN, CNN	Validation and Usability
2020	Changes in Medical Image Analysis for improved diagnosis	Image Analysis	Applicability	Use of ANN, Tensor flow	Dealing with Real world data
2019	Improving the diagnostic Accuracy	prediction tool for Alzheimer disease,	Early diagnosis	For PET using a Deep Learning model of Brain	Need to be explored for practical application and validation
2018	Impact of Ml in Radiology	Automatic data integration, Predictive Analysis	Validation and Usability	ML and approvals from Regulating Bodies FDA	Real life and big data challenges, Validation and REliability
2017	Automatic Medical Diagnosis	AI, DL applicability	Focus on Disease	Use of AI, Deep Learning	Real life implementation is a challenging task

III. RESEARCH ADVANCES

Technological advancements in medical imaging modalities have been developed to maximum extent, however from usability and clinical application perspective there are efforts required, because of the fact that there are other changes to be addressed as a part of SMART healthcare solutions. Specifically for MRI, the shift from 1.5 T to 3 T magnets and the trend to go for higher fields again, is the additional need to be addressed. This changes not only engineering aspects but the clinical demands and solutions as well.

The data that is to be processed is a big data in real time. Data acquisition, storage, data management, data processing and interpretation are some of the issues to be carried forward for further research, because of the advances in healthcare technologies specifically for SMART healthcare. This has been further influenced due to the need of IOT based solutions, use of cloud computing and modern methods of Data Analytics.

Therefore, the problem is to address the modality specific needs as well as those arising from the requirements of SMART healthcare, where disruptive techniques like AI, ML and DL and many other similar data driven methods are used. This is the

advancement from classical methods to advanced disruptive technologies. Which change very fast making significant impact from the user perspective.

IV. RESEARCH GAP

Research is required to address the changes from the traditional approach of manual inspection of medical images to fully automatic analysis. AI, ML and DL based approaches and methods are required to be devised and tested for this purpose. Any other statistical methods would also be required as a part of this work.

The paradigm shift from traditional methods to those required for providing SMART healthcare solutions is the major gap that is identified here.

Validation methods are also to be newly established as a part of applications of AI, ML and DL based approaches.

V. MOTIVATION

SMART healthcare has been both newer as well as popular field, where newer opportunities have been created for significant research in diversified areas in engineering as well as clinical fields. More to more, the diagnostic imaging methods specifically in Magnetic Resonance imaging are finding newer and newer demands from clinical angle. This itself gives rise to several technological challenges to be addressed in research. Right from the basic medical physics to engineering and technology there are potential areas of developments, where users as well as those who carry out research and development including manufacturers of medical equipment find a lot of scope to grab the opportunities in SMART healthcare. Therefore, need is the basic motivating factor for this research.

VI. PROBLEM STATEMENT

AI, ML and DL applications in SMART healthcare with a specific reference to Magnetic Resonance Imaging (MRI) have been identified to be the potential research problems. The aim is to derive and process the diagnostic information from raw images, in a reliable manner, without loss of any medically relevant information. For this purpose MRI image datasets form routine MRI as well as functional MRI of brain, have been identified as the potential domains where SMART healthcare applications shall be worked out.

- SMART healthcare requirements for medical imaging modalities specifically MRI shall be investigated, addressing the present status and future needs.
- Understanding and interpretation of the Medical images from MRI for diagnostic purpose shall be included as a part of this research. Clinical requirements and applicability of newer techniques including AI, ML and DL techniques shall be evaluated.
- Research problem include the statistical interpretation of MRI and fMRI data for deriving the diagnostic information. Further, modality specific research problems shall be addressed right from operational requirements, experimental planning for data collection, data processing strategies and interpretation of results.
- Paradigm shift from the present traditional approaches of processing medical information to the modern SMART healthcare systems shall be evaluated and this needs research to be carried out.
- Validation of results from diagnostic perspective, as well as from the usability angle is the key challenge to be addressed as a part of this research.

VII. RESEARCH OBJECTIVES AND SCOPE

Objectives:

- Investigating the applicability of AI, ML and DL techniques for processing the medical imaging data, specifically from Magnetic Resonance Imaging
- SMART healthcare requirements and

Scope:

- Data collection strategies
- Understanding and interpretation
- Algorithm development
- Validation of results
- Developing a scheme for SMART healthcare

VIII.. PROPOSED METHODOLOGY

Figure 1- Patient journey: conventional verses artificial intelligence

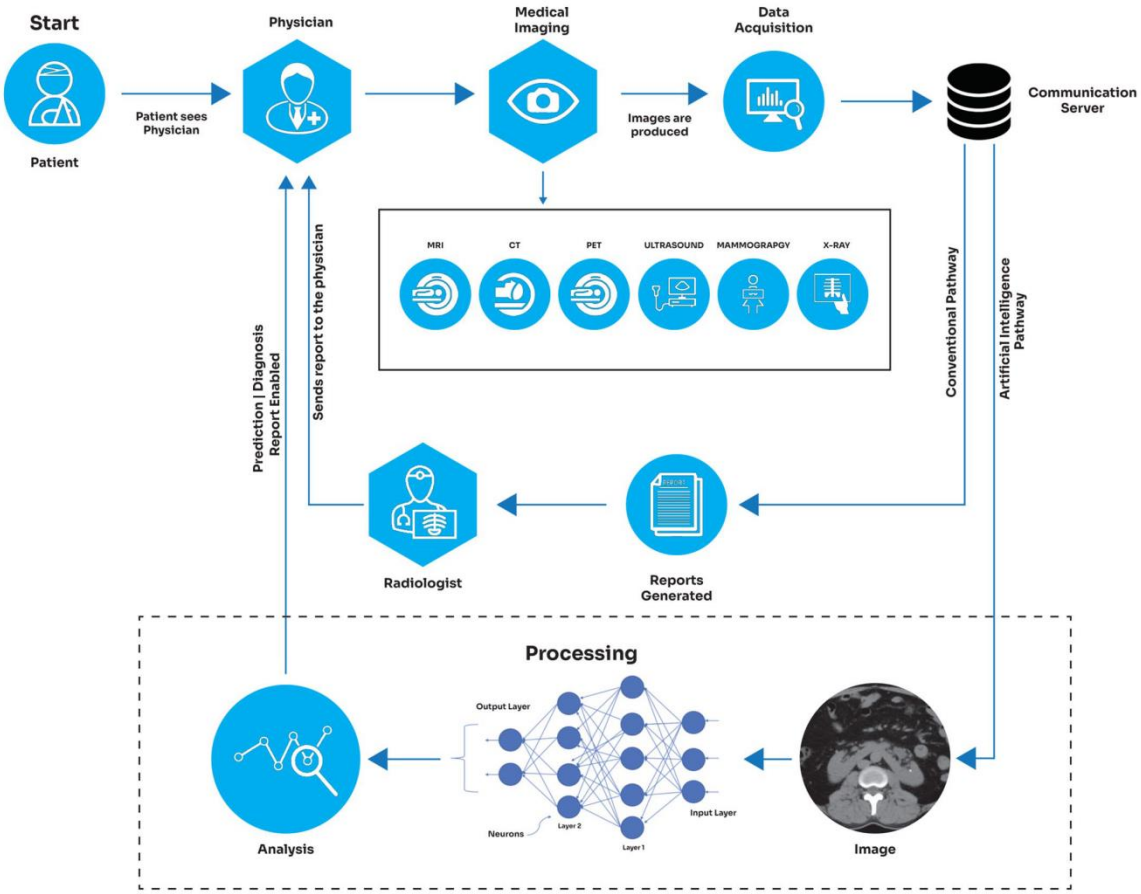
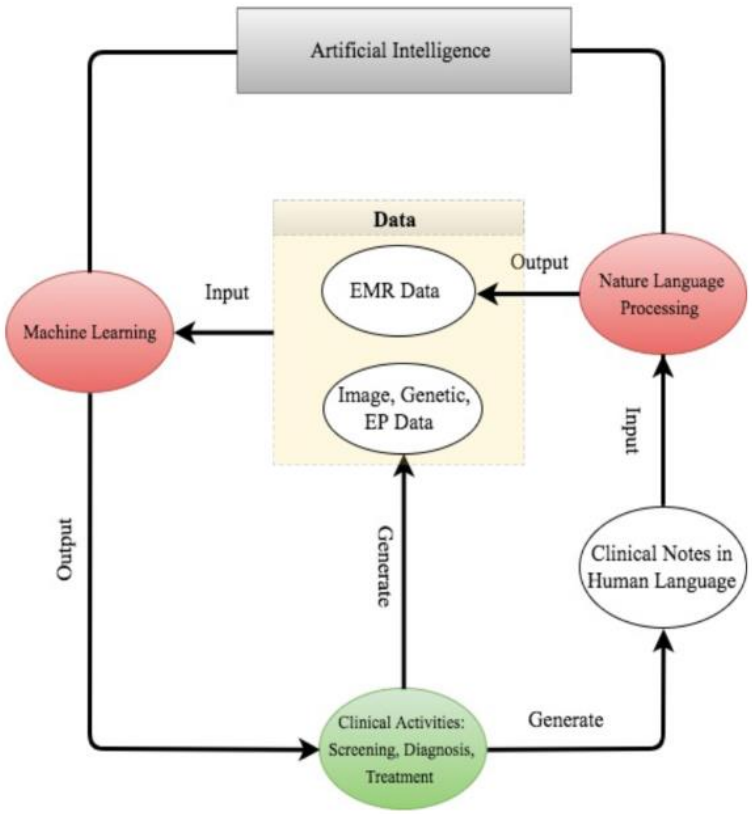


Figure 2- The road map from clinical data generation to natural language processing data enrichment, to machine learning data analysis, to clinical decision making. EMR, electronic medical record; EP, electrophysiological.



Hardware and Software requirement

- Imaging data from MRI scanners available in the Hospitals shall be used
- MATLAB/SCILAB shall be used for testing algorithms and deriving the results

Any other front end and back-end methodology / Method of data collection

- Experiments on fMRI shall be planned in order to get suitable data for this research
- Schemes for SMART healthcare shall be proposed

IX. IMPLICATIONS

[1] It will require collection huge data set
[2] Challenges in Implementing Machine Learning & AI on the medical data, without losing any medical information
[3] Challenges in Validating the results and applicability

X. CONCLUSIONS

The potential for applying AI, ML and DL in Medical Diagnostic Imaging specifically in MRI is very much promising. It facilitates the medical practitioners to predict and take early decisions, providing significant advantages in terms of medical decisions. AI, ML and DL have been very well understood tools and techniques in healthcare technologies specifically for SMART Healthcare. Data driven methods further, do not require any a prior knowledge of data. Big data analytics using modern statistical tools supports in deriving inferences in a real applications.

REFERENCES

[1] Bansal Priya et. al. "AI Revolutionizing Health Care: A Descriptive Review", J. Advanced Scientific Research, 12(2), 2020, pp 22-34

[2] Fei Jiang, Yong Jiang et. al. ,"Artificial intelligence in healthcare: past, present and future", Stroke and Vascular Neurology, 2017, pp. 230-243

[3] Markus J. Ankenbrand, David Lohr et. al. ," A Deep Learning Based Cardiac Cine Segmentation Framework– Transfer Learning Application to 7T Ultrahigh-Field MRI", IEEE Trans. Med. Img., Nov.2020

[4] "Introducing Deep Learning with MATLAB", Mathwork e-book

[5] B.M. Zeeshan Hameed, Gayathri Prerepa, Vathsala Patil et. al. " Engineering and clinical use of artificial intelligence (AI) with machine learning and data science advancements: radiology leading the way for future", Therapeutic Advances in Urology, vol. 13, 2021, pp 1-13

[6] Shruti Agarwal , Gaurav Kumar Srivastava, "A Review on the use of Artificial Intelligence Techniques in Brain MRI Analysis", Journal of Informatics Electrical and Electronics Engineering, 2021, Vol. 02, Iss. 02, S. No. 010, pp. 1-15

[7] Andreas S. Panayide, Amir Amin et. al. AI in Medical Imaging Informatics: Current Challenges and Future Directions", IEEE J. OF Biomedical and Health Informatics, vol. 24, no. 7, July 2020, pp 1837-1857

[8] Heinrich von Busch, "Artificial Intelligence for MRI", MAGNETOM Flash (74) 3/2019

[9] Maribel Torres-Velázquez, "Application and Construction of Deep Learning Networks in Medical Imaging", IEEE Trans. On Radiation and Plasma Medical Sciences, vol. 5. No. 2, Mar 2021, pp. 137-159

[10] Jin Liu, Yi Pan, Min Li, Ziyue Chen et. al. ," Applications of Deep Learning to MRI Images: A Survey", Big Data Mining and Analytics, vol. 1, no. 1, Mar 2018, pp. 1-18

[11] Alexander Selvikvåg Lundervolda and Arvid Lundervolda, "An overview of deep learning in medical imaging focusing on MRI", Z Med Phys , vol. 29 , 2019, pp. 102–127

[12] Filippo Pesapane, Marina Codari et. al., "Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine", European Radiology Experimental , 2018, 2:35, pp. 1-10

[13] JUSTIN KER , LIPO WANG, "Deep Learning Applications in Medical Image Analysis", IEEE Access, vol. 6, 2018, pp. 9375-9389.

[14] Zhao Zhang , Guangfei Li, et. al. "Application of Artificial Intelligence in the MRI Classification Task of Human Brain Neurological and Psychiatric Diseases: A Scoping Review", Diagnostics 2021, pp. 1-27

[15] Jeff Mason, Andra Morrison and Sarah Visintini , "An Overview of Clinical Applications of Artificial Intelligence ", ADTH Issues in Emerging Health Technologies, 114, 2018

[16] Arkan Al-Zubaidi , Alfred Mertins,"Machine Learning Based Classification of Resting State fMRI Features Exemplified by Metabolic State (hunger/satiety)", Frontiers of Human Neuroscience, vol. 15, no. 164, pp. 1-14

[17] Benjamin Fritz, Jan Fritz, "Artifcial intelligence for MRI diagnosis of joints: a scoping review of the current state-of-the-art of deep learning-based approaches", Skeletal Radiology, vol. 51, 2022, pp. 315–329

[18] Protima Khan, M. D. Fazlul Kader," Machine Learning and Deep Learning Approaches for Brain Disease Diagnosis: Principles and Recent Advances", IEEE Access, vol. 9, 2021, pp. 37622-37655

[19] Dong Wen, Zhenhao Wei ,"Deep Learning Methods to process fMRI data and Their Application in the Diagnosis of the Cognitive Impairment: A Brief Overview and our Opinion", Frontiers in Neuroinformatics, vol. 12, no. 23, pp. 1-5

[20] Ohad Oren, Bernard J Gersh, Deepak L Bhatt" Artificial intelligence in medical imaging: switching from radiographic pathological data to clinically meaningful endpoints", vol. 2, 2020, pp-486-488

[21] Muralikrishna Puttagunta and S. Ravi," Medical image analysis based on deep learning approach", Multimedia Tools and Applications (2021) vol. 80, 2021, pp. 24365–24398

[22] Garry Choy, Omid Khalil zadeh et. al. ," Current Applications and Future Impact of Machine Learning in Radiology", Radiology, vol. 288, 2018, pp. 318–328

[23] Martin J. Willemink, Wojciech A. Koszek ,"Preparing Medical Imaging Data for Machine Learning", Radiology, vol. 295, 2020, pp. 4–15

[24] Harshita Bhagwat and Uttara Gogate," Reviewing Machine Learning Algorithms in the Domain of Healthcare", International Journal of Engineering Research & Technology, Vol. 10 Issue 04, April-2021, pp. 41-43

[25] Tim Leiner, Daniel Rueckert, "Machine learning in cardiovascular magnetic resonance: basic concepts and applications", Journal of Cardiovascular Magnetic Resonance , vol. 21, no. 61, 2019, pp. 1-14

[26] Adnan Qayyum , Junaid Qadir, " Secure and Robust Machine Learning for Healthcare: A Survey", 2020, pp. 1-22

[27] Liyan Sun, Jiexiang Wang, "An Adversarial Learning Approach to Medical Image Synthesis for Lesion Detection", IEEE Journal of Biomedical and Health Informatics, vol. 24, no. . 8, August 2020, pp. 2303-23-14

[28] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in Proc. IEEE Conf. Comput. Vision Pattern Recognition, 2016, pp. 770–778

[29] R. Li et al., "Deep learning based imaging data completion for improved brain disease diagnosis," in Proc. Int. Conf. Med. Image Comput. Comput. Assisted Intervention, 2014, pp. 305–312

[30] G. Litjens et al., "A survey on deep learning in medical image analysis," Med. Image Anal., vol. 42, pp. 60–88, 2017

[31] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," in Proc. Int. Conf. Learn. Representations, 2015

[32] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in Proc. IEEE Conf. Comput. Vision Pattern Recognit., 2016, pp. 770–778

[33] Erickson BJ, Korfiatis P, Akkus Z, Kline TL. Machine learning for medical imaging. RadioGraphics , vol. 37 no. 2, 2017, pp. 505–515

[34] Wang S, Summers RM. Machine learning and radiology. Med Image Anal ", vol. 16, no. 5, 2012, pp. 933–951

[35] V. Antun, F. Renna, C. Poon, B. Adcock, and A. C. Hansen, "On instabilities of deep learning in image reconstruction and the potential costs of AI," Proc. Nat. Acad. Sci. USA, May 2020, Art. no. 201907377, doi: 10.1073/pnas.1907377117.

[36] J.-G. Lee et al., "Deep learning in medical imaging: General overview," Korean J. Radiol., vol. 18, no. 4, pp. 570–584, 2017, doi: 10.3348/kjr.2017.18.4.570.

[37] G. Chartrand et al., "Deep learning: A primer for radiologists," Radio Graphics, vol. 37, no. 7, pp. 2113–2131, Nov. 2017, doi: 10.1148/rg.2017170077