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Medical Imaging using Machine Learning and Deep Learning Algorithms: A Review

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***Abstract*—Machine and deep learning algorithms are rapidly growing in dynamic research of medical imaging. Currently, substantial efforts are developed for the enrichment of medical imaging applications using these algorithms to diagnose the errors in disease diagnostic systems which may result in extremely ambiguous medical treatments. Machine and deep learning algorithms are important ways in medical imaging to predict the symptoms of early disease. Deep learning techniques, in specific convolutional networks, have promptly developed a methodology of special for investigating medical images. It uses the supervised or unsupervised algorithms using some specific standard dataset to indicate the predictions. We survey image classification, object detection, pattern recognition, reasoning etc. concepts in medical imaging. These are used to improve the accuracy by extracting the meaningful patterns for the specific disease in medical imaging. These ways also indorse the decision-making procedure. The major aim of this survey is to highlight the machine learning and deep learning techniques used in medical images. We intended to provide an outline for researchers to know the existing techniques carried out for medical imaging, highlight the advantages and drawbacks of these algorithms, and to discuss the future directions. For the study of multi-dimensional medical data, machine and deep learning provide a commendable technique for creation of classification and automatic decision making. This paper provides a survey of medical imaging in the machine and deep learning methods to analyze distinctive diseases. It carries consideration concerning the suite of these algorithms which can be used for the investigation of diseases and automatic decision-making.**

Keywords—Medical imaging; Machine learning; Deep learning; Image enhancement; Information retrieval;

I. INTRODUCTION

Machine and deep learning algorithms play an important role to train the computer system as an expert which can be used further for prediction and decision making. Machine learning is the field of study that provides computers the ability to learn without being explicitly programmed [1]. Deep learning is a type of machine learning that empowers systems to gain for a fact and comprehend the world regarding a pecking order of ideas [2]. These fields bring intelligence into a computer that can extract the patterns according to the specific data and then process for automatic reasoning [3] [4]. Medical imaging is the rapidly growing research area that is used to diagnose a disease for early treatment. The function of image processing in the health domain is relative to the growing position of medical imaging. The digital image processing offers significant effect on decision-making procedure based on some predictions. It gives better features extraction and accuracy. The procedure of functioning assessment is complicated and contains numerous diverse properties [5] [6]. The digital image processing techniques are implanted in many different computer systems. The authentication of image processing approaches is essential that gives an implementation of specific procedures which provides influence on the performance of these systems. Therefore, it brings decisions and actions based on approaches in medical imaging. It delivers a many rudimentary and refined image analysis and visualization tools [7]. The artificial intelligence is the main domain and machine learning and deep learning works under this domain as shown in *Fig. 1*. The AI is the major field to display human intelligence in a machine, machine learning is used to achieve artificial intelligence, while deep learning is a technique used to implement machine learning [8].

The various steps are performed on medical images before the detection of output. Initially, the medical image is inserted as input to the machine and deep learning algorithms. After that, the image is divided into different segments to zoom the interested area. Then, the features are extracted from these segments through information retrieval techniques. Next. The desired features are selected and the noise is removed.

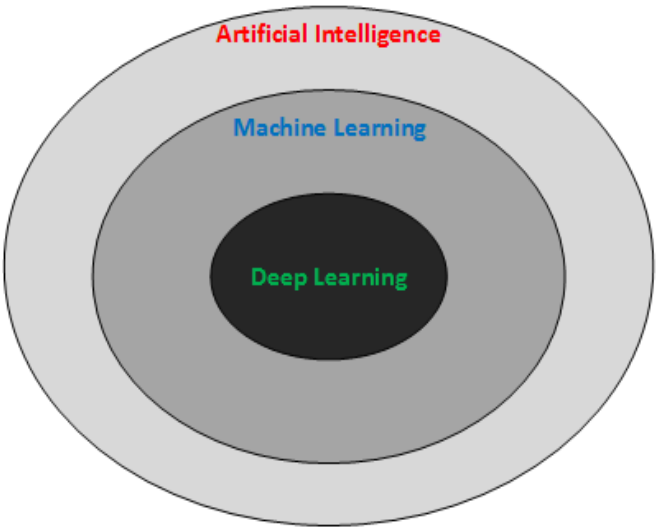

Fig. 1. Artificial Intelligence, Machine Learning and Deep Learning domain

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Finally, the classifier is used to classify the extracted data and make predictions based on this classification. These steps are used in every experiment of machine learning. The supervised, semi-supervised, unsupervised, reinforcement and active learning algorithms are the main categories of machine learning. Further, the deep learning methods are basically advanced phase of machine learning algorithms that classify data and predict more accurately using neural network [9] [10].

A. Supervised learning

It gives a training set of instances with appropriate objectives to a computer system. Taking this training set system give response accurately on given possible inputs. The classification and regression are the categories of Supervised Learning.

- The inputs are distributed into different classes using classification methods, and the trained system must generate actions that allocate hidden inputs to these classes. This is called multi labeling process. The spam purifying is the case of classification, in which the emails are classified into "spam" and, "not spam".
- The regression is a supervised technique in which the outcomes are continuous rather than discrete. The regression predictions are evaluated using root mean squared error (RMSE), unlike classification predictions in which accuracy is used as a performance measure.

B. Unsupervised learning

The system will take the decision by itself rather train on the basis of some dataset. No labeling is given to the system that can be used for predictions. Unsupervised learning can be used to retrieve the hidden pattern with the help of feature learning of the given data.

- The clustering is an unsupervised learning approach that is used to divide the inputs into clusters. These clusters are not identified earlier. It builds groups on the basis of resemblance.

C. Semi-supervised learning

In Semi-supervised learning, the system is assumed to be partial training data. This type of training is used with some trained data that can target some missing results. This type algorithm is used on untagged data for training commitment. The semi-supervised learning algorithm trained on both labeled and unlabeled data and this learning exhibits the features the features of both the unsupervised-learning and supervised learning algorithms.

D. Active learning

In Active learning, the system gets that training tags only for a restricted set of occurrences. It is used to enhance its optimality of substances to gain tags for the goal. Such as budgets functions in an organization.

E. Reinforcement learning

In Reinforcement learning the trained data is provided only as a response to the program's activities in a self-motivated situation, such as to drive a vehicle or playing a video game.

F. Evolutionary Learning

It is mainly used in the biological field to learn biological organisms and to predict their survival rate and the casual of the offsprings. We can use this model by using the knowledge of fitness, to predict how to correct the result.

G. Deep learning

This is the advance phase of machine learning which mainly uses neural networks for learning and prediction of data. It is a group of different algorithms. These are used to design complex generalize system that can take any type of problems and give predictions. It uses the deep graph with numerous processing layer, made up of many linear and nonlinear conversion [11].

Nowadays, in medical disciplines, illness diagnostic assessment is a severe mission. It is the key task to comprehend the accurate diagnosis of patients by medical inspection and evaluation. The healthcare domain produces a large amount of data about medical evaluation, a statement concerning the patient, treatment, supplements, prescription etc. The main issue is that the quality of these reports gives an effect of association due to unsuitable managing of the data [12]. The improvements of this data are essential to mine and process these medical reports elegantly and efficiently. There are different types of machine learning algorithms are available that are used to use specific classifier for distributing data on the basis of their characteristics. The dataset can be separated into two or more than two classes. These types of classifiers are embedded for medical data examination and disease discovery. Firstly, machine learning algorithms were proposed and used to notice medical data sets. Today, for well-organized investigation of medical data the machine learning provides numerous techniques. The systems for data gathering and inspection are located in almost all new hospitals that are used for the collection and sharing of data. It is used for correcting diagnostic of different diseases by medical imaging. To use an algorithm, the accurate diagnostic patient documentation is inserted in a system and outcomes can be spontaneously acquired from the preceding cracked cases. The pattern recognition is the idea of machine learning that extracts features from medical images about any diseases to predict and generate conclusions for diagnosis and to plan treatment [13] [14]. There are different steps of machine learning and deep learning algorithms which are used in the medical imaging domain as shown in *Fig. 2.*

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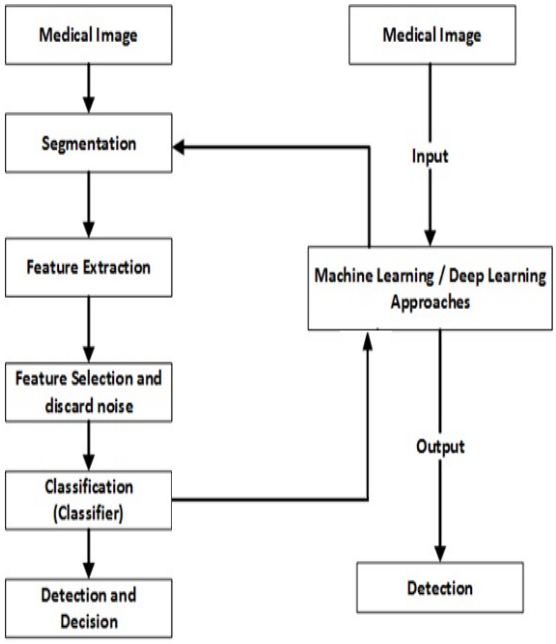

Fig. 2. Machine and Deep Learning algorithms workflow in medical image

II. MACHINE LEARNING IN MEDICAL IMAGING

Machine learning algorithms are very effective in medical imaging to study specific diseases. Different types of entities such as lesions and organs in medical image processing can be too complicated and cannot be shown correctly by a simple mathematical solution. In [15], the author used the pixel-based investigation to analyze medical images for diseases. The pixel analysis in machine learning appeared in medical image processing, which uses certain values in images straight away instead of features extraction from chunks as input data. The enactment of this method may possibly be better than that of simple feature-based classifiers for specific problems. The image with low contrast is a challenging problem in order to investigate its properties. The feature calculation and segmentation is not required for pixel-based machine learning, unlike ordinary classifiers which avoid errors generated from inaccurate segmentation and feature calculation. The pixel analysis utilizes long training time because of the high dimensionality of data (a large number of pixel in an image) in [16], the author targeted the low contrast medical images for analysis. The furthermost efficient technique used for contrast improvement is Histogram Equalization (HE). The authors proposed a technique named "Modified Histogram-Based Contrast Enhancement using Homomorphic Filtering" (MH-FIL). It used two phases handling process, in the first phase global contrast is improved using histogram modification. Further, second phase homomorphic filtering is projected for image sharpening. The low contrast chest X-ray 10 medical images are investigated in the experiment. The MH-FIL has minimum values in all 10 images computer to other techniques. The medical image clarification is the highest responsibility of radiologists, with the assignments involving equally images with better quality and its analysis. The computer-aided design CAD has developed for several years.

There are numerous machine learning methods analyzed through medical images, for example, linear discriminant analysis, support vector machines, decision trees, etc. In [17], the author used machine learning approaches in medical image evaluation. In specific, they used local binary patterns extensively contemplated among texture descriptors. Further, a study on new trials using several low binary patterns descriptors of biomedical images. The dataset of neonatal facial images for categorizing pain conditions beginning from facial descriptions. Especially, the outcomes on the extensively premeditated 2D-HeLa dataset and the suggested descriptor gains the maximum implementation including all the numerous texture descriptors. A linear support vector machine classifier is applied on the 2D-HeLa dataset and in the PAP dataset. The 92.4 % accuracy got which is the highest values among all other descriptors on the mentioned dataset. The neural network technique is used in medical images to investigate the disease details [18]. The neural network groups are retained for cancer discovery. It is used to critic where a cell is normal with excessive assurance where each distinct network has only two outcomes either it will be a normal cell or cancer cell. The predictions of these cells' network are merged by a predominant method, i.e. plurality voting. The results showed that the neural network collectively accomplished a high rate of accuracy and a low value of false negative analysis.

The machine learning expert systems provide contrivances for the production of premises from patients' information. Different rules are mined from the information of specialists to paradigm an expert system. The group of clinical problems that can be used as examples, knowledge in intelligent systems may achieve by machine learning approaches that can be used to generate a methodical description of clinical characters that distinctively describe the clinical circumstances. Therefore, information can be articulated in the arrangement of simple rules, or often as a decision tree. A typical example of this category of the scheme is KARDIO, which is grown to translate ECGs [19]. In medical image analysis, the good standard for evaluating image feature is a statistical analysis. The channelized Hoteling observer (CHO), is generally used for specifically in nuclear medicine imaging. The channels are enthused by the idea of amenable subjects in the human visual structure. This method is used to detect image quality evaluation and further, the CHO has defensibly and positive influence on the medical imaging. The subsequent algorithm is named a channelized SVM (CSVM). There are two medical physicists assessed the flaw discernibility in 100 noisy images and then the score confidence of a lesion actuality contemporary on a six-point scale. After that, a training session is used to involve an extra 60 images. The human spectators achieved this assignment for six diverse selections of the flattening filter with two dissimilar choices of the number of repetitions in the OS-EM rebuilding algorithm [20].

III. DEEP LEARNING IN MEDICAL IMAGING

To guide computers to learn features that can characterize the data for the given issue. This idea lies at the foundation of several deep learning procedures. The models that comprised of various layers that transmute input images to give outputs about the specific diseases because of cramming gradually high-level features. The better type of these models for image analysis is convolutional neural networks (CNNs). The CNNs

comprise several layers that convert the input with convolution filters. The task of employing deep learning methods to the medical field frequently use in familiarizing current architectures in distinctive input formats such as three-dimensional data. Previously, the purposes of CNNs to big data, full 3D convolutions and the subsequent huge number of constraints are avoided by separating the volume of Interest into portions [21].

A. Classification

1) Image classification

The classification if medical image is the main task in deep learning in order to investigate for clinical-related issues for early treatment of the patient. The classification might be classically or multiple images as input with a single diagnostic mutable as result (disease yes or no). In these cases, each diagnostic test is a model and dataset sizes are characteristically minor related to those in computer vision. In [22], the fine modification evidently outdid feature extraction, attaining 57.6% accuracy in multiclass score evaluation of knee osteoarthritis against 53.4%. But, the [23] shown that by CNN feature retrieval performed fine-tuning in cytopathology image classification accuracy with 70.5% versus 69.1%.

2) Object classification

The object classification targets on the small interested chunks of the medical image. These chunks can be projected into two or more classes. For better accuracy, the local information of these chunks and global conceptual information are very important. In [24], the author used three CNNs methods of deep learning to patch the image at a different scale of objects. The results of these three techniques finally reflected the features matrix of the overall image properties.

B. Detection: Organ and region

The object detection and localization is the next phase after classification. It is an important step in segmentation where we can extract the importance of each object and focus only the interested object and discard the noise. To challenge this issue, a 3D data parsing approach is used using deep learning algorithms. The author used three independent groups 2D and 3D MRI chunks in medical image. It is used to locate the regions of different related objects which focus on some specific diseases such heart, aortic arch, descending aorta [25, 26].

C. Segmentation

The segmentation process is used to process the organs and substructures of the medical images. It is used for quantitative analysis of the clinical features. For example, cardiac or brain examination. It is also used in CAD for functions. It is the identifying of specific pixels that make up the object of interest. The U-net is the combination of upsampling and downsampling layers architectures. It merged the connections of convolution and de-convolution samples of layers [27].

D. Registration

The registration is the process of transforming different sets of data into one coordinate system. It is a necessary step in medical images in order to provide comparison or integration of the data obtained from a different viewpoint, time, depth, and sensors etc. This is the iterative process in which we select a specific type of parameters as a standard. It is used to calculate the similarity parameters of two images using deep learning algorithms [28]. The registration is used in medicine i.e. Computer Tomography (CT) and NMR data. This is quite helpful to attain patient information, observing tumor growth, cure confirmation, and the comparison of the patient's information with anatomical atlases. The mutual information obtained in [29] using Powell's and Brent's method to register MR, CT is different from [30] which is used on breast MR images.

IV. CONCLUSION

The machine learning skills are grown in past few years. Currently, machine learning methods are tremendously vigorous to practical circumstances, and the structures really advantage of the learning process. It previously pertains in the rehearsal of medical imaging, and it will perhaps cultivate at a quick stride in the coming future. The use of machine learning in medical imaging has important inferences for the medication. It is very significant that this research area ensures better care to patients. The possessions of machine learning tackles are serious to confirming that they are applied in the greatest real way. In the medical image analysis, the deep learning algorithms help to categorize, classify, and enumerate disease patterns from image processing. It also permits to extend analytical goals and generates prediction models of treatment for patients. The medical imaging researchers are considering these challenges, deep learning in health care research domain and imaging is enduring to flourish. It is improving rapidly, as deep learning is in numerous other applications other than of health care.

REFERENCES

[1] Valiant, L., G. A theory of the learnable. Commun. ACM, 27(11):1134–1142, November 1984.

[2] Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1). Cambridge: MIT Press.

[3] Robert, C., Machine learning, a probabilistic perspective. 2014, Taylor & Francis.

[4] Aiken, A., Moss: A system for detecting software plagiarism. http://www/.cs.berkeley.edu/~aiken/moss.html, 2004.

[5] Doi, K., Computer-aided diagnosis in medical imaging: historical review, current status and future potential. Computerized medical imaging and graphics, 2007. 31(4-5): p. 198-211.

[6] Mahesh, M., Fundamentals of medical imaging. Medical Physics, 2011. 38(3): p. 1735-1735.

[7] Jannin, P., C. Grova, and C.R. Maurer, Model for defining and reporting reference-based validation protocols in medical image processing. International Journal of Computer Assisted Radiology and Surgery, 2006. 1(2): p. 63-73.

[8] Michalski, R. S., Carbonell, J. G., & Mitchell, T. M. (Eds.). (2013). Machine learning: An artificial intelligence approach. Springer Science & Business Media.

[9] Norris, D.J., Machine Learning: Deep Learning, in Beginning Artificial Intelligence with the Raspberry Pi. 2017, Springer. p. 211-247.

[10] Jankowski, N. and M. Grochowski. Comparison of instances seletion algorithms i. algorithms survey. In International conference on artificial intelligence and soft computing. 2004. Springer.

[11] Schmidhuber, J., Deep learning in neural networks: An overview. Neural networks, 2015. 61: p. 85-117.

[12] Warwick, W., et al., A framework to assess healthcare data quality. The European Journal of Social & Behavioural Sciences, 2015. 13(2): p. 1730.

[13] Ghassemi, M., et al., Opportunities in Machine Learning for Healthcare. arXiv preprint arXiv:1806.00388, 2018.

[14] Dua, S., U.R. Acharya, and P. Dua, Machine learning in healthcare informatics. 2014.

[15] Suzuki, K., Pixel-based machine learning in medical imaging. Journal of Biomedical Imaging, 2012. 2012: p. 1.

[16] Agarwal, T.K., M. Tiwari, and S.S. Lamba. Modified histogram based contrast enhancement using homomorphic filtering for medical images. In Advance Computing Conference (IACC), 2014 IEEE International. 2014. IEEE.

[17] Nanni, L., A. Lumini, and S. Brahnam, Local binary patterns variants as texture descriptors for medical image analysis. Artificial intelligence in medicine, 2010. 49(2): p. 117-125.

[18] Shi, Z. and L. He. Application of neural networks in medical image processing. In Proceedings of the second international symposium on networking and network security. 2010. Citeseer.

[19] Bratko, I., I. Mozetič, and N. Lavrač, KARDIO: a study in deep and qualitative knowledge for expert systems. 1990: MIT Press.

[20] Narasimhamurthy, A., An overview of machine learning in medical image analysis: Trends in health informatics, in Classification and Clustering in Biomedical Signal Processing. 2016, IGI Global. p. 23-45.

[21] Prasoon, A., et al. Deep feature learning for knee cartilage segmentation using a triplanar convolutional neural network. In International conference on medical image computing and computer-assisted intervention. 2013. Springer.

[22] Antony, J., et al. Quantifying radiographic knee osteoarthritis severity using deep convolutional neural networks. In Pattern Recognition (ICPR), 2016 23rd International Conference on. 2016. IEEE.

[23] Kim, E., M. Corte-Real, and Z. Baloch. A deep semantic mobile application for thyroid cytopathology. In Medical Imaging 2016: PACS and Imaging Informatics: Next Generation and Innovations. 2016. International Society for Optics and Photonics.

[24] Shen, W., et al. Multi-scale convolutional neural networks for lung nodule classification. In International Conference on Information Processing in Medical Imaging. 2015. Springer.

[25] Wang, C.-W., et al., Evaluation and comparison of anatomical landmark detection methods for cephalometric x-ray images: a grand challenge. IEEE transactions on medical imaging, 2015. 34(9): p. 1890-1900.

[26] De Vos, B.D., et al. 2D image classification for 3D anatomy localization: employing deep convolutional neural networks. In Medical Imaging 2016: Image Processing. 2016. International Society for Optics and Photonics.

[27] Çiçek, Ö. et al. 3D U-Net: learning dense volumetric segmentation from sparse annotation. In International Conference on Medical Image Computing and Computer-Assisted Intervention. 2016. Springer.

[28] Wu, G., et al. Unsupervised deep feature learning for deformable registration of MR brain images. In International Conference on Medical Image Computing and Computer-Assisted Intervention. 2013. Springer.

[29] F. Maes, A. Collignon, D. Vandermeulen, G. Marchal, P. Suetens, Multimodality image registration by maximization of mutual information, IEEE Transactions on Medical Imaging 16 (1997) 187–198.

[30] D. Rueckert, C. Hayes, C. Studholme, P. Summers, M. Leach, D.J. Hawkes, Non-rigid registration of breast MR images using mutual information, Proceedings of the Medical Image Computing and Computer-Assisted Intervention MICCAI'98, Cambridge, Massachusetts, 1998, pp. 1144–1152

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