IJDI-ERET

INTERNATIONAL JOURNAL OF DARSHAN INSTITUTE ON ENGINEERING RESEARCH AND EMERGING TECHNOLOGIES
Vol. 12, No. 1, 2023
www.ijdieret.in

(Review Article)

Machine Learning in Healthcare: A Review

Debrupa Pal[1*], Animesh Ghosh[2], Sourav Majumdar[3], Ashadeep Pan[4], Debmitra Ghosh[5]

[1,2,3]Department of Computer Application, Narula Institute of Technology, Agarpara, West Bengal, INDIA*
[4,5]Department of Computer Science and Engineering, JIS University, Kolkata, West Bengal, INDIA

Abstract

This study makes an effort to introduce artificial intelligence and its important subfields in machine learning methods. It also covers the function of these subfields in many healthcare sectors, including bioinformatics, gene detection for cancer diagnosis, epilepsy seizure, and brain-computer interface. It also discusses the deep learning based medical image processing for conditions like tumors, gastrointestinal disorders, and diabetic retinopathy. The final section of this essay examines the challenges that must be faced in the real world in order to make AI techniques more accessible.

Keywords: Machine Learning, Healthcare, Artificial intelligence, Deep Learning

1. Introduction

Artificial intelligence (AI) is the process through which a computer learns on its own without being explicitly programmed or instructed.

It has a sense of decision-making and the development of algorithms from the input data since it is a branch of computer science that is simultaneously engaged in the learning process through commands and instructions. We also define artificial intelligence (AI) as a computer's capacity to transform input from an outside source into machine-understandable form, learn from that data, and repeat the process until the learning achieves a particular task or goal through flexible adaptation.

It creates artificial intelligence methods to deal with both organized and unstructured data. In contrast to unstructured data, which must first be processed before being analyzed by AI, structured data can be used directly for analysis. Machine learning (ML) is one of the AI tools with the highest implementation rates.

ML uses a variety of techniques to handle the data, including logistic regression, linear discriminant analysis, random forest, support vector machine, k-nearest neighbor classifiers, cluster analysis, contemporary deep learning, reinforcement learning, decision trees, etc. ML uses either supervised or unsupervised learning as its primary learning strategies. However, semi supervised learning, a newer sort of learning methodology, has emerged in recent years.

[*]Corresponding Author: e-mail: debrupa.pal@nit.ac.in, Tel-+91-9830698155
ISSN 2320-7590 (Print) 2583-3863 (Online)

It has many uses, including email management processes like automatically responding to incoming messages, organizing mail into folders, detecting spam, and thread summarizing. It is also helpful for computer vision, which refers to a machine's capacity to comprehend languages and images, signature detection, face and speech recognition, natural language processing, handwriting recognition, and other tasks.

Regression and classification are additional divisions of the supervised learning techniques based on the data supplied. While the other type of learning, unsupervised learning, is well suited for feature extraction. In unsupervised learning, we only have the input data with no corresponding expected output. Predictions here are purely based on the identification of input data patterns through our own discovering and adopting skills. The learning algorithm includes dividing the data into various groups of similar nature. We find the applications of this type of ML in astronomical data, speech detection, acoustic factor analysis for robust speaker verification. This sort of machine learning has applications in astronomical data, speech recognition, acoustic factor analysis for reliable speaker identification.

Clustering and principal component analysis (PCA) are the two primary unsupervised learning algorithms. Typically, PCA is used for dimension reduction. The presence of a feature variable. Without losing the majority of the information, PCA projects the data from multiple dimensions onto a small number of primary component directions.

Before data clustering, PCA is typically used to minimize some of the data's dimensions. While the clustering method is linked to gathering variables that exhibit comparable or shared qualities without employing output information. These methods produce cluster labels for the variable that have the highest degree of similarity both within and between clusters. Affinity propagation, mean shift, hierarchical clustering, k-mean clustering, Gaussian mixture clustering, and OPTICS are a few popular clustering algorithms.

A wide range of social sectors, including agricultural, automotive, banking and economics, legal professions, healthcare, cybersecurity, military, advertising, art, and many more, are affected by machine learning. It is impossible to go into greater detail about its overall relevance. Therefore, we only focus on the healthcare sector in our analysis. One of the most important sectors of society, healthcare is required to provide a high standard of treatment and services, regardless of cost.

Before ML can be used in the healthcare industry, preparations must be made so that it can distinguish between different sorts of data, link together data of a similar kind, learn from the data, and produce the right results. Clinical records, diagnosis reports, screening records, demographic information, pictures, physical examination results, medical notes, etc. can all be examples of this data.

Diagnostic imaging, genetic testing, electro diagnosis, and other forms of data recognition are used at the diagnosis stage. While other significant data sources that can be recognized in the form of an image are medical notes and physical examinations. Since most genetic and electrophysiological (EP) data is obtained in an unorganized state, it cannot currently be used for analysis. Before being used for analysis, this data needs to be "filtered". And by "filtering" we mean transforming this data into an electronic medical record (EMR) form that can be read by a computer. Certain AI applications, including clustering algorithms, function well in this process.

2. Application of Machine Learning in Healthcare

2.1 Bioinformatics: For organizing and interpreting biological data, it is referred to as a multidisciplinary branch of biology and computer science applications. This information has grown astronomically in recent years. With the aid of ML algorithms, this data can be managed and the pertinent information extracted, turning it into biological knowledge. This biological information—which includes gene sequences, DNA sequences, gene expression, array analysis, combinatorial chemistry, etc.—along with machine algorithms established by scientists offer a readily comprehendible picture of human genomics.

[1] Demonstrated the significant role of bioinformatics which also can be termed computational biology. It can be defined as the development of algorithms and establishing the relationships among various biological systems using biological data. Deep learning has emerged as a crucial component of machine learning (ML) in recent years. In [2] it is claimed that deep learning is capable of handling non-linear functions while maintaining the desired accuracy level and has been applied to a variety of computational applications. Recent optimization approaches proposed by [3] rendered the deep neural network the most trustworthy and effective technique among rival systems.

*2.1.1 Understanding genomics: DNA classification***:** One of the key areas of bioinformatics is genomics, where ML tools and techniques are applied to gather useful data. The most promising field for ML applications is the gene discovery method. The approaches for gene prediction are reviewed in [4-9]. Using clustering algorithms of machine learning. In [10-13] a thorough explanation of DNA classification is provided through the identification of a group of people with similar types of genes or the degree to which these people have a particular gene using the color pattern of DNA microarray data. This is a classic case of unsupervised learning because the algorithm provides no prior knowledge about the person regarding to which group it belongs. Numerous optimization strategies have been suggested to simplify multiple alignment difficulties. The study performed in [14-17] is one of the most recent contributions on the application of deep learning algorithms for DNA-Binding proteins (DBP) discovery. [18-20] also completed work of a similar nature.

2.1.2 Analysis of gene expression data: Cancer diagnosis: Any uncontrolled cell development in the body is referred to as cancer. Today's medical research has identified over 100 different forms of cancer. Early cancer identification can prevent patients' health from deteriorating and save countless lives. This study can be carried out by analyzing gene expression to determine the type of cancer with the aid of ML algorithms like Bayesian network, neural trees, and Radial basis function (RBF) network.

2.1.3 Detection of epileptic seizures: Patients with epilepsy experience unpredictable, repeated seizures that happen suddenly and without any prior warning. Consequently, there may be a brief loss of judgement, memory, and coordination. Frequent seizures may increase the risk of dying and decrease the likelihood of suffering physical harm. With the aid of an Electroencephalogram (EEG), a non-invasive measure of brain activity, machine learning techniques can be used to build detectors that, in this case, are capable of swiftly and accurately detecting the onset of seizures based on the patient's medical state.

[21-23] analyze epileptogenicity localization using a convolutional neural network with the help of the data available on EEG and resting state -fMRI measurements from the electrocorticographic (ECoG) dataset and proposed the conclusion as normal p-value 1.85e-14 and p-Seizure value 4.64e-27 [24].

2.1.4 Evolving signal processing for brain computer interface (BCI): The brain and a mechanism that reads electrical signals from the brain and utilizes them to control some external actions, such moving the cursor or a prosthetic limb, work together to create a brain computer interface. It is essential to the support of disabled individuals, multimedia, virtual reality, video games, etc. The motor cortex, a reasonably well-understood part of the cortex, is where the muscle-controlling commands are sent. Many paralyzed patients' brains are capable of producing these commands, but sadly the information never reaches the muscles. This instance involves the development of a brain computer interface by [25-26].

3. Deep Learning

Deep learning, sometimes referred to as deep neural learning and the network as a deep neural network (DNN), is a subclass of machine learning that contains a network that can learn unsupervised from unstructured input. It is the capability of artificial intelligence that closely resembles the structure of the human brain and imitates the way the brain processes information for use in object detection, speech recognition, language translation, and decision-making.

It can learn from both structured and unstructured data without assistance from or oversight from humans. Among other things, it can aid in the detection of fraud or money laundering. The development of big data, also known as digital information that has evolved into practically every form on the planet, is where deep learning evolution first starts. Among other online resources, major sources of big data include search engines, e-commerce websites, social media, apps, and many more.

An early type of neural network called a perceptron that was inspired by the human brain. Frank Rosenblatt developed this algorithm in 1958 at Cornell Aeronautical Laboratory with funding from the US Office of Naval Research. It is a supervised learning ML technique for binary classifiers. It has an input layer that can classify linearly separable patterns and is directly coupled to the output layer. As data complexity expanded, neural networks were developed. These networks include layered architectures with input, output, and one or more hidden layers.

Convolutional neural network (CNN), recurrent neural network (RNN), deep neural network (DNN), multilayer perceptron (MLP), deep belief network (DBN), autoencoder, deep Boltzmann machine (DBM), deep belief network (DBN), deep conventional extreme ML (DC- ELM), and many others are now used in healthcare research areas.

*3.1 Deep learning in healthcare***:** Deep learning has the capacity to create new features, i.e., it can create new features in addition to identifying and extracting pertinent ones. It is utilized in the healthcare industry to aid doctors by aiding in disease diagnosis and model prediction with a specific objective for treatment. Extreme learning models (ELM), self-organizing maps (SOM), generative adversarial networks (GAN), recurrent neural networks (RNN), radial basis function networks (RBFN), long short-term memory (LSTM), autoencoders, extreme learning models (CNN), recurrent neural networks (RNN), radial basis function networks (RBFN), etc. are examples of deep learning algorithms that can work with raw data and automatically learn features.

Most deep learning algorithms perform effectively in a range of fields, including robotics, virtual assistants, entertainment, healthcare, and picture coloring [27-30]. A wide range of issues, from disease detection to personalized therapy, are addressed by deep learning applications. Ophthalmology, pathology, cancer detection, and radiology are some of the specific fields that have revolutionized deep learning algorithms. Deep learning revolutionized ophthalmology first, but pathology and cancer detection have received more attention and have applications that are highly accurate. With distinct datasets, analysis-based emotion recognition using deep learning networks produces results with valence accuracy of 49.52 percent and arousal accuracy of 46.03 percent.

3.2 Deep learning and medical imaging: Any image diagnosis task's fundamental goal necessitates the detection of an anomaly, the measurement of its intensity, or the quantification of the aberration. Automated image analysis systems that employ ML algorithms have the potential to enhance the quality of the analysis and, consequently, the interpretations. There are numerous sites in this field that have a wealth of data at their disposal for doctors. This information consists of pathological imaging, genomic sequencing, and radiological imaging, such as X-rays, CT scans, and MRI scans. Even though deep learning approaches can process a sizable amount of data, there are still not enough tools to convert the entire data set.

3.2.1 Diabetic retinopathy (DR): A metabolic disease called diabetes mellitus (DM) can cause excessive blood sugar levels [30]. Type-I diabetes results from incorrect insulin synthesis by the pancreas, while Type-II diabetes results from improper body tissue responses to generated insulin. Diabetic retinopathy (DR), also known as long-term DR, is an eye condition brought on by diabetes that can render a patient completely blind. Only if it is discovered in its earliest stages by retinal screening is it treatable. Automated DR detection using a deep learning model is far more accurate and produces better results than manual DR detection.

By using the Messidor dataset to train a 5-layered connection mechanism, [31-34] was able to diagnose early-stage DR on the Retinopathy online challenge (ROC) and reach conclusions with up to 97% sensitivity, 96% specificity, 96% accuracy, and 0.988 area under the curve (AUC). He also asserts up to 0.98 AUC on the ROC dataset. 79% AUC.

3.2.2 Gastrointestinal (GI) disease detection: Diseases that affect the gastrointestinal tract (either the upper GI tract or lower GI tract) are referred to as gastrointestinal diseases. The

GI tract is made up of organs like the esophagus, stomach, large and small intestine, and rectum.

Different illnesses and disorders, such as inflammation, hemorrhage, infection, and cancer, can impact the digestive process. Diverticulitis caused by colon hemorrhage and a condition known as arteriovenous malformation (angiodysplasias or angio-ectasias) in the small intestine are other possible causes.

With the development of computer aided diagnosis systems, image processing and machine learning play a crucial role in the diagnosis of these types of diseases. There are now numerous imaging procedures that use machine learning algorithms, including wireless capsule endoscopy, the introscope, radiopaque dye and X-ray studies for colonoscopy or sigmoidoscopy, deep small bowel enterostomy, intraoperative enterostomy, computed tomography, and magnetic resonance imaging (MRI).

3.2.3 Tumor detection: A tumor or neoplasm is an abnormal development of cells that causes havoc in any portion of the body. Cancer may or may not be caused by a tumor. As a result, we divide tumors into malignant and benign tumors, which refer to cancerous and non-cancerous tumors, respectively. Since benign tumors do not spread to other bodily parts, they are significantly less harmful than malignant ones. While malignant can spread to other bodily regions and become challenging to treat**.**

[35-37] examined 482 patient images, of which 246 women with tumors were found. The patients ranged in age from 32 to 70.By first de-noising the examined images, the breast cancer was then segmented utilizing modified wavelet transformation, morphological operations, and region growth. Then, SVM and extreme learning machines received morphological and textured features for the classification and detection of breast tumors.

4. Limitations and Challenges

Technologies such as Artificial Intelligence (AI) and Machine Learning (ML) have the potential to help businesses make better use of the massive volumes of data. Still, these techniques depend on the computing power, quality, and quantity of the data provided. Getting consistent and accurate quality and quantity of the data is a challenge, since, there are no commonly accepted and widely adopted standards of data definitions and governance in enterprises. Finding or recruiting the proper team with AI expertise to work with is one of the most difficult hurdles in AI adoption. The appropriate talent is the essential to the success of any effort, and AI is no exception. AI is a lot more difficult ability to develop, thus there is undoubtedly a demand and supply mismatch in the market.

5. Future Scope

Machine learning's growing application will improve machine performance with less involvement from humans. The primary goals of machine learning integration across many domains are to minimize time and cost expenditures while improving real-time results. Today, numerous well-known businesses and startups, such as Enlitic, MedAware, and Google, have started large-scale initiatives aimed at advancing AI and ML and integrating it into the healthcare system. Examples of these initiatives include Google's DeepMind health project and IBM's Avicenna software [38]. Additionally, IBM Watson Health is working with the Cleveland Clinic and Atrius Health to integrate cognitive computing into their healthcare system, which experts anticipate will result in less physician burnout [39].

6. Conclusion

The human mind is constantly interested in new discoveries, advancements, and what lies beyond them. One such example is artificial intelligence, which emerged from the desire to create computers with the capacity to learn from their experiences.

The main accomplishment in the development of this kind of intelligence is that it allows users to handle a large amount of data that is impossible for the human mind to store. This kind of computer application will undoubtedly reduce the amount of work involved in handling data, but putting this technology into practice is not an easy undertaking. AI must be continuously trained using historical data. Additionally, the ongoing data input is essential for continued development and improvement once the system has been taught.

In this study, we looked at the drivers behind the use of ML in healthcare. We also talk about ML, which is the main subcategory of ML. We discussed various healthcare data that deep learning has studied and surveyed while focusing on deep learning and its architecture. However, several ML technologies are garnering a lot of interest in medical research. Real-time implementation continues to have issues. One of these issues is regulation. Recent restrictions don't meet the ML system's efficiency, safety, and assessment standards.

The US FDA offers guidelines for evaluating ML systems that ensure to retain the safety and efficiency in order to get around this problem. Another barrier is the lack of incentives for data exchange on the system in the current healthcare context. As a result, ML training prior to adoption has been hampered. There are plans for the healthcare revolution to encourage data exchange among numerous nations.

References

[1] C. Abraham, “Clinical Features of Diabetic Retinopathy (Fundus and Fluorescein

Angiography)," in *Diabetic Retinopathy for the Clinician*, Jaypee Brothers Medical Publishers (P) Ltd., 2009, pp. 79–79. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.5005/jp/books/10205_7

[2] J. E. Allen, M. Pertea, and S. L. Salzberg, "Computational Gene Prediction Using Multiple Sources of Evidence," *Genome Research*, vol. 14, no. 1, pp. 142–148, Jan. 2004, doi: 10.1101/gr.1562804.

[3] B. Blankertz et al., "The BCI competition 2003: progress and perspectives in detection and discrimination of EEG single trials," *IEEE Transactions on Biomedical Engineering*, vol. 51, no. 6, pp. 1044–1051, Jun. 2004, doi: 10.1109/tbme.2004.826692.

[4] D. Pal, S. Palit, and A. Dey, "Brain Computer Interface: A Review," in *Lecture Notes in Electrical Engineering*, Singapore: Springer Singapore, 2021, pp. 25–35. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1007/978-981-16-4035-3_3

[5] M. Winterhalder et al., "Spatio-temporal patient–individual assessment of synchronization changes for epileptic seizure prediction," *Clinical Neurophysiology*, vol. 117, no. 11, pp. 2399–2413, Nov. 2006, doi: 10.1016/j.clinph.2006.07.312.

[6] G. A. Stolovitzky, "Bioinformatics: The Machine Learning Approach Bioinformatics: The Machine Learning Approach, Pierre Baldi and Søren Brunak MIT Press, Cambridge, Mass., 2001 [1998]. $49.95 (452 pp.). ISBN 0-262-02506-X," *Physics Today*, vol. 55, no. 12, pp. 57–58, Dec. 2002, doi: 10.1063/1.1537915.

[7] R. Durbin, S. R. Eddy, A. Krogh, and G. Mitchison, *Biological Sequence Analysis*. Cambridge University Press, 1998. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1017/cbo9780511790492

[8] G. R. Ball and S. N. Srihari, "Semi-supervised Learning for Handwriting Recognition," in *2009 10th International Conference on Document Analysis and Recognition*, 2009. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1109/icdar.2009.249

[9] L. Bao and Y. Cui, "Prediction of the phenotypic effects of non-synonymous single nucleotide polymorphisms using structural and evolutionary information," *Bioinformatics*, vol. 21, no. 10, pp. 2185–2190, Mar. 2005, doi: 10.1093/bioinformatics/bti365.

[10] J. Bockhorst, M. Craven, D. Page, J. Shavlik, and J. Glasner, "A Bayesian network approach to operon prediction," *Bioinformatics*, vol. 19, no. 10, pp. 1227–1235, Jul. 2003, doi: 10.1093/bioinformatics/btg147.

[11] G. Leban, B. Zupan, G. Vidmar, and I. Bratko, "VizRank: Data Visualization Guided by Machine Learning," *Data Mining and Knowledge Discovery*, vol. 13, no. 2, pp. 119–136, May 2006, doi: 10.1007/s10618-005-0031-5.

[12] Chandrakumar T and R Kathirvel, "Classifying Diabetic Retinopathy using Deep Learning Architecture," *International Journal of Engineering Research and*, vol. V5, no. 06, May 2016, doi: 10.17577/ijertv5is060055.

[13] C. Caragea and V. Honavar, "Machine Learning in Computational Biology," in *Encyclopedia of Database Systems*, New York, NY: Springer New York, 2018, pp. 2157–2162. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1007/978-1-4614-8265-9_636

[14] Hong-Hee Won and Sung-Bae Cho, "Paired neural network with negatively correlated features for cancer classification in DNA gene expression profiles," in *Proceedings of the International Joint Conference on Neural Networks*, 2003. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1109/ijcnn.2003.1223664

[15] S. Degroeve, B. De Baets, Y. Van de Peer, and P. Rouzé, "Feature subset selection for splice site prediction," *Bioinformatics*, vol. 18, no. suppl_2, pp. S75–S83, Oct. 2002, doi: 10.1093/bioinformatics/18.suppl_2.s75.

[16] M. J. Coombs, "Artificial Intelligence and Cognitive Technology: Foundations and Perspectives," in *NATO ASI Series*, Berlin, Heidelberg: Springer Berlin Heidelberg, 1986, pp. 407–420. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1007/978-3-642-50329-0_27

[17] G. Wimmer, S. Hegenbart, A. Vecsei, and A. Uhl, "Convolutional Neural Network Architectures for the Automated Diagnosis of Celiac Disease," in *Computer-Assisted and Robotic Endoscopy*, Cham: Springer International Publishing, 2017, pp. 104–113. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-54057-3_10

[18] G. Huve, K. Takahashi, and M. Hashimoto, "Brain activity recognition with a wearable fNIRS using neural networks," in *2017 IEEE International Conference on Mechatronics and Automation (ICMA)*, Aug. 2017. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1109/icma.2017.8016051

[19] G. B. Fogel and D. W. Corne, "An Introduction to Evolutionary Computation for Biologists," in *Evolutionary Computation in Bioinformatics*, Elsevier, 2003, pp. 19–38. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1016/b978-155860797-2/50004-4

[20] Huan Wang, Wynne Hsu, Kheng Guan Goh, and Mong Li Lee, "An effective approach to detect lesions in color retinal images," in *Proceedings IEEE Conference on Computer Vision and Pattern Recognition. CVPR 2000 (Cat. No.PR00662)*.

Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1109/cvpr.2000.854775

[21] J. M. Bryan, P. J. Bryar, and R. G. Mirza, "Convolutional Neural Networks Accurately Identify Ungradable Images in a Diabetic Retinopathy Telemedicine Screening Program," *Telemedicine and e-Health*, Feb. 2023, doi: 10.1089/tmj.2022.0357.

[22] Guyon, Isabelle, and André Elisseeff (2003). An introduction to variable and feature selection. The Journal of Machine Learning Research 3: 1157-1182

[23] W. Liang, H. Pei, Q. Cai, and Y. Wang, "Scalp EEG epileptogenic zone recognition and localization based on long-term recurrent convolutional network," *Neurocomputing*, vol. 396, pp. 569–576, Jul. 2020, doi: 10.1016/j.neucom.2018.10.108.

[24] Acharya, U. R., Oh, S. L., Hagiwara, Y., Tan, J. H., & Adeli, H. (2018). Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals. *Computers in Biology and Medicine*, 100, 270–278. https://doi.org/10.1016/j.compbiomed.2017.09.017

[25] M. A. Lebedev and M. A. L. Nicolelis, "Brain–machine interfaces: past, present and future," *Trends in Neurosciences*, vol. 29, no. 9, pp. 536–546, Sep. 2006, doi: 10.1016/j.tins.2006.07.004.

[26] F. Cincotti et al., "Non-invasive brain–computer interface system: Towards its application as assistive technology," *Brain Research Bulletin*, vol. 75, no. 6, pp. 796–803, Apr. 2008, doi: 10.1016/j.brainresbull.2008.01.007.

[27] V. K. B and S. Borra, "Real-Time Face Detection and Recognition on Raspberry Pi using LBP and Deep Learning," in *Proceedings of the International Conference on Data Science, Machine Learning and Artificial Intelligence*, Aug. 2021. Accessed: May 26, 2023. [Online]. Available: http://dx.doi.org/10.1145/3484824.3484903

[28] J. Miseikis et al., "Lio-A Personal Robot Assistant for Human-Robot Interaction and Care Applications," *IEEE Robotics and Automation Letters*, vol. 5, no. 4, pp. 5339–5346, Oct. 2020, doi: 10.1109/lra.2020.3007462.

[29] S. N. Mohanty, G. Nalinipriya, O. P. Jena, and A. Sarkar, Machine Learning for Healthcare Applications. John Wiley & Sons, 2021.

[30] K. Breitman, "Semantic Web Technologies: trends and research in ontology-based systems; de John Davies, Rude Studer & Paul Warren," *RECIIS*, vol. 3, no. 1, Mar. 2009, doi: 10.3395/reciis.v3i1.245pt.

[31] D. Das, S. Kr. Biswas, and S. Bandyopadhyay, "A critical review on diagnosis of diabetic retinopathy using machine learning and deep learning," *Multimedia Tools and Applications*, vol. 81, no. 18, pp. 25613–25655, Mar. 2022, doi: 10.1007/s11042-022-12642-4.

[32] J. M. Wolterink, T. Leiner, M. A. Viergever, and I. Išgum, "Automatic Coronary Calcium Scoring in Cardiac CT Angiography Using Convolutional Neural Networks," in *Lecture Notes in Computer Science*, Cham: Springer International Publishing, 2015, pp. 589–596. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-24553-9_72

[33] X. Jia and M. Q.-H. Meng, "A deep convolutional neural network for bleeding detection in Wireless Capsule Endoscopy images," in *2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Aug. 2016. Accessed: May 23, 2023. [Online]. Available: http://dx.doi.org/10.1109/embc.2016.7590783

[34] M. Atzori et al., "Electromyography data for non-invasive naturally-controlled robotic hand prostheses," *Scientific Data*, vol. 1, no. 1, Dec. 2014, doi: 10.1038/sdata.2014.53.

[35] T. Saba, A. Sameh Mohamed, M. El-Affendi, J. Amin, and M. Sharif, "Brain tumor detection using fusion of hand crafted and deep learning features," *Cognitive Systems Research*, vol. 59, pp. 221–230, Jan. 2020, doi: 10.1016/j.cogsys.2019.09.007.

[36] M. Nazir, S. Shakil, and K. Khurshid, "Role of deep learning in brain tumor detection and classification (2015 to 2020): A review," *Computerized Medical Imaging and Graphics*, vol. 91, p. 101940, Jul. 2021, doi: 10.1016/j.compmedimag.2021.101940.

[37] D. V. Gore and V. Deshpande, "Comparative Study of various techniques using Deep Learning for Brain Tumor Detection," in 2020 *International Conference for Emerging Technology (INCET)*, Jun. 2020. Accessed: May 26, 2023. [Online]. Available: http://dx.doi.org/10.1109/incet49848.2020.9154030

[38] T. Simonite, "IBM's Automated Radiologist Can Read Images and Medical Records," *MIT Technology Review*, Feb. 04, 2016. Accessed: May 29, 2023. [Online]. Available: https://www.technologyreview.com/s/600706/ibms-automated-radiologist-can-read-images-and-medical-records

[39] "Caradigm takes end-to-end enterprise approach to population health," *Health Data Management* https://www.healthdatamanagement.com/articles/[objectObject] (accessed Jun 01, 2023).

Biographical notes

Debrupa Pal is pursuing his Ph.D. from NIT Durgapur in Electronics and Communication Engineering and is an Assistant Professor in Narula Institute of Technology, West Bengal, India.

Animesh Ghosh is a student in Department of Computer Application in Narula Institute of Technology, West Bengal, India.

Sourav Majumdar is a student in Department of Computer Application in Narula Institute of Technology, West Bengal, India

Ashadeep Pan is a student in Department of Computer Science and Engineering in JIS University, West Bengal, India.

Debmitra Ghosh is an Assistant Professor in Department of Computer Science and Engineering in JIS University, West Bengal, India.