Artificial Intelligence in Agriculture and Healthcare: A Comprehensive Study

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ABSTRACT: Agriculture and health are two interrelated fields, as they are linked to human welfare, which is of utmost importance in today's world. They form the backbone of human life and the country's economic system. Agriculture is of vital importance in maintaining good health. Conversely, health also affects agriculture, as it requires good agricultural products. Nowadays, health is affected by the consumption of adulterated food. There is an urgent need to improve the quality of the agricultural products we use in order to maintain good health. Good health creates healthy people and communities, which in turn contributes to environmental and economic balance in the world.

Thinking bigger, we need to use technology to improve agriculture and healthcare to monitor various problems in both sectors. Nowadays, artificial intelligence (AI) plays an important role in almost all sectors. Machine Learning (ML) and Deep Learning (DL), which are part of artificial intelligence, are gaining more and more importance and benefits in various fields. In this paper, we see how Artificial Intelligence, Machine Learning and Deep Learning are making their impact especially in the field of agriculture and healthcare. The paper includes the main Artificial Intelligence algorithms and tools that are useful in these two sectors.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Healthcare, Agriculture, tools.

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1. INTRODUCTION

Farmers have taken the responsibility of feeding people all over the world. The majority of people in India depend on agriculture, which is also their livelihood. About 70% of the people in India depend on agriculture for their livelihood. Agriculture is one of the main sources of income for the country. Agriculture also serves as a source of raw materials for many industries. It is also the source of foreign exchange. Agriculture provides food security by preventing malnutrition. Therefore, agriculture must be given high priority and research must be done in this field to help farmers in various aspects of agriculture [15].

The survival of humans and animals on our planet depends on plants. Without plants, life on this world is not possible. Plants provide food for many organisms, create habitats for many organisms, help in maintaining biodiversity, global warming, etc. Many natural components come from plants and help us unlock many biological mysteries.

Plants also serve psychological purposes. Many plants also serve as natural medicines for many diseases that have no side effects. Plants are the source of energy for all living organisms on earth. Therefore, it is very important to cultivate plants and give high priority to agriculture. In almost all countries, about 10% of the annual budget is spent on agriculture [7].

We all know a famous saying that "health is wealth". Health plays a crucial role in a person's happiness. The two dimensions in which health is defined are longevity and quality of life. Health is also important because it affects labor productivity. Health care is an important factor that determines health. Health can deteriorate due to factors such as sudden illnesses, accidents, aging, and many others, so every individual needs health care services at one time or another in their lives [8]. Health care services are also needed to restore current health status and to recover from illness or injury [23]. Healthcare is a form of primary care for individuals and helps them to diagnose diseases and prevent them by arranging treatments [5].

India's healthcare expenditure is approximately 2.1% of GDP in 2021 [32]. This is mainly due to the Covid 19 pandemic. Therefore, healthcare is one of the most important areas to work on.

The structure of the paper is divided into different sections. Section 2 describes AI, ML and DL technologies. Section 3 describes the importance of ML and DL in agriculture and healthcare. Section 4 summarizes related work. Section 5 lists various tools and techniques used in different applications of AI, ML, and DL in agriculture and healthcare. Section 6 illustrates two case studies in agriculture and healthcare. Finally, Section 7 concludes the paper.

2. ABOUT AI, ML AND DL

Artificial intelligence allows computers to study any natural ability of a human or an animal. It is a technique that produces a wealth of clever insights. AI deals with general behavior with intelligence. Machine learning is about developing algorithms that allow machines to learn [11]. Deep learning deals with multiple layers to determine the efficiency of the system [8].

Machine learning gives computers the ability to learn, usually by providing statistical data, or it allows systems to learn by recognizing patterns and make decisions with as little human intervention as possible.

Deep learning is an important subfield of machine learning. Deep Learning also involves large and comprehensive datasets. Image classification is one of the most important applications of Deep Learning, which outperforms humans in classifying some images.

Figure 1 below shows how AI, ML, and DL are related.

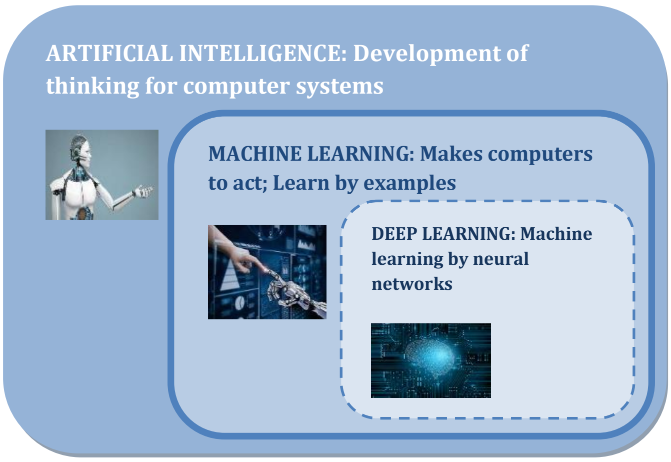

Figure 1: Artificial Intelligence v/s Machine Learning v/s Deep Learning

Table 1 below exhibits the comparison among AI, ML and DL techniques [25].

Table 1. Comparison of AI, ML and DL techniques

Artificial Intelligence	**Machine Learning**	**Deep Learning**
Invented by Marvin Minsky and John McCarthy from the 1950s	Invented by Arthur Samuel 1952	Invented by Rina Dechter in 1986
AI impersonates the intelligence or behavioral pattern of humans or any other living entity	ML is a technique where a computer learns from data, without using a complex set of rules. It includes training a model from dataset	DL is a technique that achieves machine learning inspired by humans brain neuron networks
Artificial Intelligence is subgroup of Data science	Machine Learning is subgroup of AI	Deep Learning is subgroup of ML
These may not need high computational power	These can work with normal low power computers without GPUs	These need high performance hardware with GPUs
Features may or may not be available hence problem solving time is less	Need to identify required features and hence takes more testing time than training time	High level features need to be learned from low level features, hence takes more training time than testing time
Requires a lot or very small data to work on	Requires small to large amount of data	Requires huge amount of data
It is a vast field with several algorithms and may not be easy to understand	Set of rules are defined which makes easy to understand the algorithms	Need to understand predicted values mathematically which makes difficult to understand algorithms
Algorithms include Q-learning, planning, problem solving, etc.	Algorithms include Linear regression, Logistic regression, SVM, Naïve Bayes, Random forest, etc.	Algorithms include Recurrent neural networks, Convolutional neural networks, LSTM, MLP, etc.
Key applications include Gaming, space exploration, autonomous vehicles, chatbot, social media, etc.	Key applications include Image recognition, speech recognition, traffic prediction, medical diagnosis, fraud detection, etc.	Key applications include Different Neural networks, transfer learning, Siamese network, etc.

We conducted a search for articles published between 2017 and 2021 that discuss the applications of ML and DL in various fields. In this study, we mainly focus on the applications of ML and DL in agriculture and healthcare.

3. IMPORTANCE OF ML AND DL IN AGRICULTURE AND HEALTHCARE

3.1 ML and DL in Agriculture

It is a great idea to use advanced technology in agriculture as it is one of the most important occupations in India. Due to the increase in population and decrease in agricultural land, the use of new technologies in agriculture has become increasingly important. AI, ML and DL play an important role in this regard. Conventional agricultural techniques are nowadays being replaced by automation [18]. The use of sensors in IOT, AI, ML and DL are important technologies used in agriculture, so we see a high degree of automation in agriculture today [7].

In agriculture, about 20 to 40% of crops are lost due to pests and diseases [18]. Therefore, crop preservation and crop quality are very important. Manual monitoring of crops is often associated with great risks, so we need to use the available advanced technologies to manage crops and plants.

Artificial intelligence, machine learning and deep learning have a wide range of applications in agriculture, to name a few: Crop disease detection, crop management, livestock management, greenhouse management, agricultural machinery, storage systems, irrigation systems [16,23]. Weed identification is another important concern in agriculture which needs to be removed from crops that reduces the crop yield[11]. Figure 2 shows some of the notable applications of AI and ML in agriculture.

Much of the work in agriculture is related to plant disease identification. Crop disease detection is important as it reduces crop yield [25]. Early detection of plant diseases is important because some of the plant diseases can spread faster and affect other plants [28]. Farmers need to monitor their crops regularly to prevent the spread of diseases. However, monitoring is always a tedious job for the farmer; therefore, modern crop monitoring technologies have been developed to help improve crop yield and quality. Disease detection involves the identification of the disease, the pathogen, and the measures to control the disease, all of which must be done accurately. Symptoms alone are not enough to identify the diseases, so image processing technique is used [35].

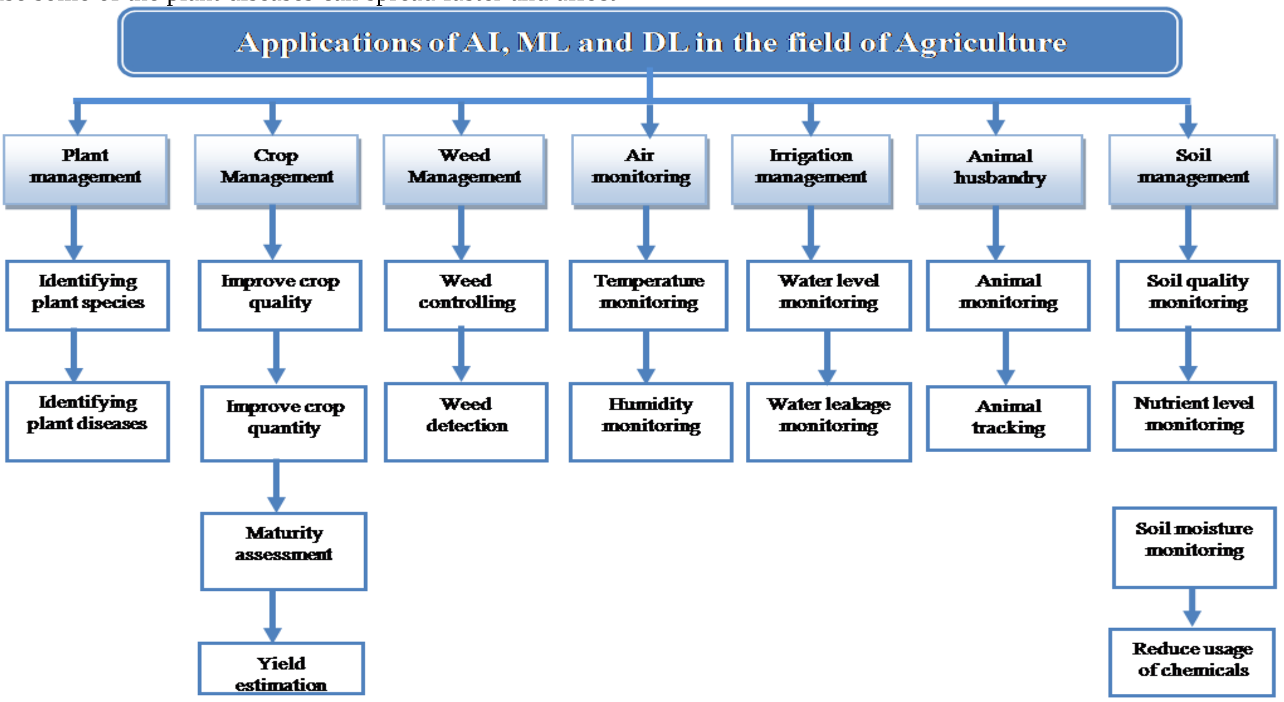

Figure 2: Applications of AI, ML and DL in Agriculture

3.2 ML and DL in Healthcare

The invention of sophisticated technologies such as machine learning and deep learning, problems in healthcare systems can now be easily monitored and solved. The application of machine learning and deep learning methods to solve problems in healthcare is very interesting [8]. The need for data is the main problem. ML Algorithms help to decipher hidden patterns and other needed information in a short time. Deep learning techniques are very promising and give hope for pattern recognition in healthcare [21].

Healthcare is an integral part of every human being, and everyone has the right to access healthcare [1]. However, many people below the poverty line do not have access to health care. People are vulnerable when they do not have access to health care [28]. Therefore, technologies can play an important role in providing healthcare services to the poor population.

One of the most important concerns of AI in healthcare is data management [18]. Today, AI, ML, and DL are revolutionizing healthcare systems. By using new technologies in healthcare, we can see many advances in this field [17]. The quality of treatment is improved, and the monitoring of treatment is improved. The use of these technologies helps in faster diagnosis of diseases; digital consultations are now possible [20]. Smart wristwatches are fitness trackers that record calories burned and number of steps taken. Another important area of AI in healthcare is disease prediction [10]. Researchers have worked on detecting many diseases, to name a few: Pneumonia, various cancers, tumor detection, cardiovascular disease, Alzeimer's disease, epilepsy, genetic diseases, Parkinson's disease, sclerosis, diabetes, lung adenocarcinoma, physical therapy in children, and many others [2,4,9]. In addition, AI can also be used for counseling depressed people [3]. Few diseases are listed in Figure 4 under the category of disease detection and diagnosis [6].

Some of the major applications of AI and ML in healthcare are shown in Figure 3.

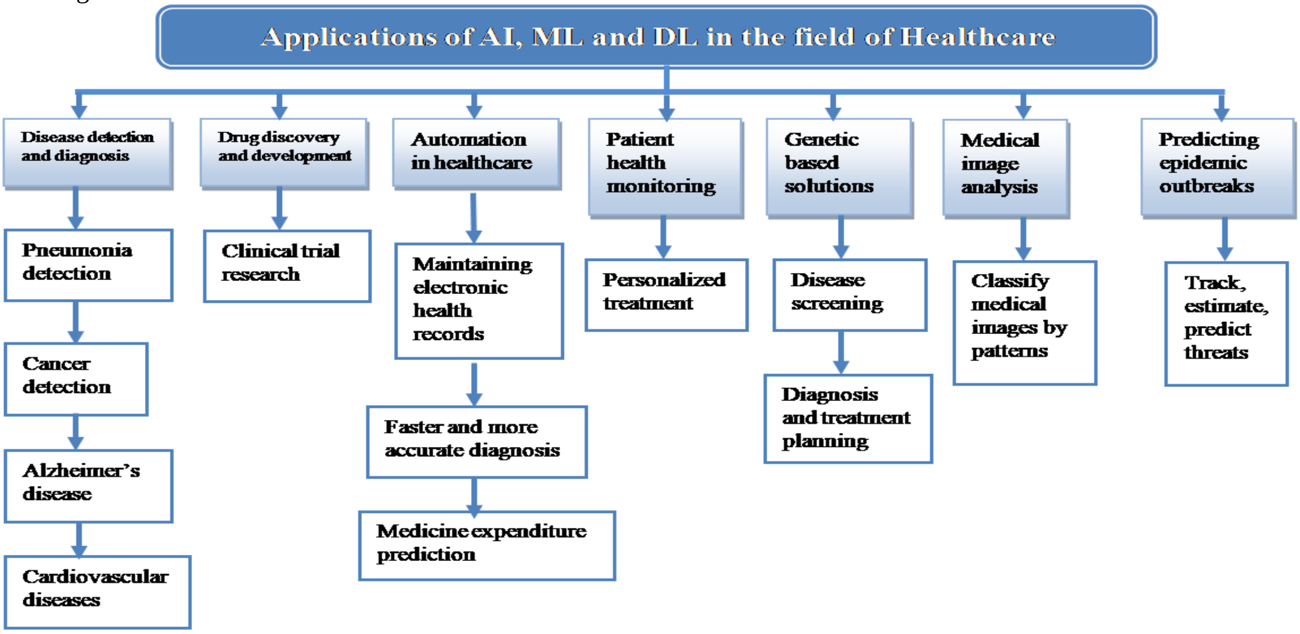

Figure 3: Applications of AI, ML and DL in Healthcare

4. RELATED WORK

Current work includes applications of AI, ML, and DL with respect to agriculture and healthcare. A brief overview of related work can be found in Table 2.

Table 2. Review of Related work

Category	Description
Identify plant leaf diseases	Pooja, V et al. [33], identification of diseases in plants using image processing techniques
Extracting and learning leaf features for plant classification	Sue Han Lee et al. [32], use of deep learning in extracting leaf features for plant classification
Crop Yield estimation	Y. Alebele *et al.* [20], estimation of yield of crops using Gaussian Kernel Regression
Maturity assessment of crop	A. Hassanzadeh et al. [27], maturity assessment of bean crop using machine learning
Deep learning methods in healthcare systems	Shahab Shamshirband et al. [24], deep learning approaches in healthcare systems
Deep learning model in COVID-19	Siwen Wang et al. [22], radiomics model based on deep learning to identify poor outcome in COVID-19 patients with other health issues
Medicine expenditure prediction	S. Kaushik et al. [30], prediction of medical expenses using variance- based generative adversarial network
Machine Learning model in COVID-19	Jiayi Lu et al. [19], diagnosis and prognosis of COVID-19 disease

Author Pooja V et al [33] explained various image processing techniques used in plant disease detection. Plants are highly susceptible to diseases as they are exposed to the environment. In plant disease control, accurate and rapid diagnosis is important to ensure remedial measures. The author has identified five types of plant diseases: Alternaria alternata, anthracnose, bacterial blight, Cercospora leaf spot disease, and mosaic disease. The images were segmented using the K-means clustering algorithm. The threshold was set according to the Otsu method. The feature extraction methods used are color, skewness, contrast and correlation to extract the features, especially color, shape and texture features. A support vector machine was used for classification. The overall disease detection rate was 92.4%, which is commendable.

Sue Han Lee et al [32] explained the plant features extracted for plant classification in his paper. The author used Convolutional Neural Networks (CNN) and gained knowledge about the features of the data using Deconvolutional Network (DN). The features considered are leaf shape and leaf veins. Leaf unfolding is a more powerful feature for plant classification. Deep learning not only uses shape as a feature of the plant, but also allows us to use other features in the leaf images. The approach of DL helps us to recognize the cognitive visual complexity of leaves. The author also says that the features are not limited to shape, color or texture, but can be extended to other specific leaf features such as leaf tip, leaf base, margin types and structural subdivisions. In this work, hybrid local-global features are used to improve plant recognition performance. The use of CNNs provides better feature representations. In this work, a hybrid leaf feature extraction model using late fusion and early fusion techniques are used.

Y. Alebele *et al*. [20], in this study the authors have explained about estimating yield of crops using Gaussian kernel regression and imaging techniques namely optical and SAR. The data used is from situ dataset and RS data collected from radar. Different vegetation indices used in the work includes NDVI, EVI, RDVI1, RDVI2, NDWI, VH & VV. Regression methods used are Bayesian Linear Regression, Bayesian Formulation from GPR, Gaussian Kernel Regression. The evaluation metrics used for performance measure are Root Mean Square Error (RMSE) and correlation coefficient. Gaussian kernel regression model showed best performance with 0.51 RMSE and 0.81 is correlation coefficient. RDVI1 and interferometric coherence are the better metrics for crop yield prediction.

A. Hassanzadeh et al. [27], in this study classification of snap bean crop according to its growth have been done using machine learning approaches. The growth of the crop includes four maturity stages, viz. plant growth, budding, flowering, and formation of seeds. Data was collected in a planthouse environment. Classifiers used are Logistic regression, Naive Bayes, Linear support vector machine, decision trees, Random forest and perceptron. They obtained promising results for better crop management which are as follows: KNN and perceptron were used in vegetative growth stage and achieved AUC of .051 and 0.77 respectively, NB and perceptron were used in budding stage with AUC of 0.69 and 0.53 respectively, LR was used in flowering stage with AUC of 0.82 and LSVM and RF were used for pod formation with AUC of 0.54 and 0.72 respectively.

Shahab Shamshirband et al. [24], in this paper the author has explained applications of deep learning models in healthcare system and its comparative analysis has been done. The deep learning architectures focusing on healthcare (in the period between 2015 and 2019) discussed in this work are Convolutional Neural Networks (CNN), Deep Belief Networks (DBN), Auto-Encoder (AE) and Recurrent Neural Network (RNN) which are compared in Table 3.

The author gave the importance of DNN. DL methods are categorized into two groups: Single DL (S-DL) techniques: the methods that merely used deep learning in their model and Hybrid DL (H-DL) techniques: the methods that use DL concurrently with other conventional ML models.

Diseases identified using these techniques include Parkinson disease, Lung cancer, Breast cancer, Epilepsy, Eye disease, Gastric cancer, Diabetes, Brain tumor, Multiple sclerosis (MS), Heart disease, EEG Imagery.

Table 3. Comparison of CNN, DBN, AE and RNN

CNN	DBN	AE	RNN
Used in image analysis and classification	Learn high dimensional manifolds of the data Unsupervised learning: reduce dimensionality of features Supervised learning: build classification or regression models	Efficiently code the data. Helps to learn lower dimensional representation for higher dimensional data	Used in pattern recognition for data streams obtained in terms of speech, handwriting & text
Used to identify breast cancer- classifies mitotic and non-mitotic nuclei in breast cancer. Improved mitotic detection rate and reduced training time	A 4 layer deep Belief Network is used to 3D image patches to learn new image features. Used to detect masses in breast cancer.	Used in lung cancer diagnosis	Used in segmentation of images in brain cancer
Used for tissue segmentation in Brain tumor	Used in lung cancer diagnosis		
Used in lung cancer diagnosis			
13 layers CNN model was built for epilepsy diagnosis			
9 layered CNN was used for Parkinson's disease classification			

DL techniques and datasets used for identifying different diseases are listed in the below table 4.

Table 4. Deep Learning techniques and datasets used [5]

Disease	Method	Dataset
Breast cancer	CNN + DBN	INbreast
	CNN	DDSM, MIAS
	DCNN	DM, SFM-USF, SFM-UM
	CNN	MITOSIS12, TUPAC16
	DBN	227 SWE images of 121
Lung Cancer	CNN, DBN, DAE	LIDC/IDRI
Brain Cancer	CRF-RNN, FCNN	BRATS 2013, 2015, 2016
	CNN, SAE	Dataset III from BCI Competition II, Dataset 2b from BCI competition IV
Cancer	DNN	RNA-seq (LUAD, BRCA, STAD)
Multiple Sclerosis	CNN, DBN	Myelin and T1w images
Parkinson	CNN	PPMI, SNUH
Heart failure detection	RNN	Sutter PAMF dataset
	DNN, DAE	MIT-BIH, SVDB, INCART

Epilepsy and Seizure	CNN	EEG signals from the Bonn university database
Diabetic Retinopathy	CNN, HCF	e-ophtha DIARETDBI MESSIDOR

Siwen Wang et al. [22], the author in this work has developed a Computer Tomography-derived hybrid model integrating 3D-ResNet10, which is based on Deep Learning and 3D Radiomics model, to foresee the likelihood of Covid-19 patients having underlying health conditions reaching poor outcomes. The primary health conditions considered are diabetes, heart disease, hypertension, pulmonary disease, etc. Two outcomes that is survival time and survival status have been measured. For segmentation and preprocessing Flood fill algorithm is used. Radiomics model was developed using 20 layer 3D volume of interest with large area of lung mask in the image segment as the center. Features from the image are extracted by using recursive feature elimination method including 10-fold cross validation. The characteristic features that are selected are then fed to logistic regression. The proposed model uses 4 residual blocks with shortcut connections. Hybrid model ensemble the probabilities of deep learning model and Radiomics model through a multivariate logistic regression. Performance of these three models have been compared where Deep learning model is having the AUC of 0.759, Radiomics model with AUC of 0.872 and Hybrid model is having the AUC of 0.876. Hence, the Hybrid model outperforms other models and helps in stratification of risky patients and also helps in individual surveillance planning. As a future work larger dataset can be used to generalize the performance. Due to lack of clinical data, this model failed to capture changes in disease progression.

S. Kaushik et al. [30], developed an ML model for predicting medicine expenditure called Variance based Generative Adversarial Network (V-GAN). In this work the medicine expenditure prediction of a patient is done based on his/her history of expenditure data and other health variables like information about individual health plan, diagnosis, medicine purchase information, etc. The main aim of this model is to minimize the change in variance between the V-GAN model and the actual data.

V-GAN model has two segments: LSTM model, a generator network and CNN /MLP model, a discriminator network. Comparative analysis is done with respect to Linear regression (LR), Multilayer perceptron (MLP), Gradient boosting regression (GBR) and Long short term memory (LSTM).

Different loss functions used in V-GAN model are: Adversarial loss, Variance loss, Forecast error loss and Wasserstein distance loss. Dataset used in this work is Truven Marketscan dataset. Finally the author compared the proposed model with other GAN models namely, LR, GBR, MLP and LSTM and proved that V-GAN model outperforms all other models with low RMSE on test data.

Jiayi Lu et al. [19] has designed a model for monitoring COVID-19 disease. The model has two parts: trained diagnosis model, which is an infection prediction model and trained prognosis model, which is a mortality predicting model.

In order to explain the results the authors have used SHapley Additive exPlanations (SHAP) visualization tool. Term Frequency-Inverse Document Frequency (TF-IDF) algorithm is used to find the frequency of the words representing symptoms of the disease (say fever, hypertension, diabetes, etc.) in the documents. IDF give universality of the words. Results are obtained for diagnosis model using Gradient Boosting Decision Tree (GBDT) and for prognosis model using five ML models namely, SVM, RF, KNN and NN. Tool used is Scikit learn. The model can be improved by considering mental health status of the patient.

5. AI AND ML ALGORITHMS AND TOOLS

5.1 Algorithms

From the work that has been done we can find the methods mostly used in Artificial Intelligence, Machine Learning and Deep Learning in almost all domains. They are listed below [2, 6, 7, 25]:

1. Support Vector Machines (SVM): It is a miniature of supervised learning for classification, detection and regression.
2. Artificial Neural Networks (ANN): It is a network inspired by the organization of animal brains and they learn by analyzing the examples for avoiding human intervention. Most probably used ANNs are CNN and RNN.
3. CNN: Classification and object detection
4. KNN: Classification
5. RNN and LSTM: Time series analysis and classification
6. Logistic Regression: Used for classifying and predicting the probability of an event.
7. Random Forest: Used for classification and regression and it overcomes the problem of overfitting in decision trees.
8. Discriminant Analysis: Analyses object classification
9. Naive Bayes: Used for data classification and disease prediction.
10. K Means Clustering: unsupervised ML algorithm helps in grouping.

CNN based deep learning architectures mainly used are AlexNet, VGG16, VGG19, GoogleNet, InceptionV3, ResNet50, ResNet101, Xception, MobileNet, DarkNet53, SegNet [11, 12].

Some of the algorithms are explained in detail below.

1. Bayesian Linear Regression [20]:

It is given by $y = \beta_0 + \beta_1 x$

where, $\beta_0$and $\beta_1$are y-intercept and slope respectively.

Bayesian Formulation from GPR is given by

$$\Pr(\theta|y)\alpha \prod_{i=1}^{N} \Pr(yi\theta)\Pr(\theta)$$

where, $\Pr(yi\theta)$ is the likelihood and $\Pr(\theta|y)$is the posterior.

Gaussian kernel regression is given as

$$k(x) = \frac{1}{h\sqrt{2\pi}} e^{-0.5\left(\frac{x-xi}{h}\right)^2}$$

where, 'x' is the value of kernel function, 'xi' is the data point and h is bandwidth.

2. 3D-ResNet10 [22]: is based on Deep Learning and 3D Radiomics model. This model was developed using 20 layer 3D volume of interest with large area of lung mask in the image segment as the center. Features from the image are extracted by using recursive feature elimination method including 10-fold cross validation. Kappa metric was used to measure the feature subsets, which is given by

$$Kappa = \frac{P_{0-P_e}}{1 - P_e}$$

where, P_0 is the comprehensive accuracy of this model and lies between 0 and 1 and given as:

$$P_0 = \frac{TP + TN}{TP + FP + FN + TN}$$

P_e is the agreement between prediction and actual class values, given as:

$$P_e = \frac{(TP + FN) * (TP + FP) + (FP * TN) * (FN + TN)}{(TP + FP + FN + TN)^2}$$

where, TP – Non survivor correctly classified
TN – Survivor correctly classified
FP – Survivor wrongly classified as non-survivor
FN – Non-survivor wrongly classified as survivor

3. Variance based Generative Adversarial Network (V-GAN) [30]:

The computations in the work are given below:

- Average expenditure of each patient on a day is expressed as the ratio of total amount spent across all patients buying medicine on day t and total number of patients who refilled the medicine on same day. This is given as below.

$$Daily\ average\ expenditure_{t=}\ {i_t}/{j_t}$$

- The cross entropy derives adversarial loss between real and generated distributions and it evaluates the distance between two probability distributions and given as below.

Probability distribution for real data = $y_i \log(p(y_i))$

Probability distribution for generated data = $\hat{y}_i \log(p(\hat{y}_i))$

$$\text{Adversarial loss}\quad L_A(y, \hat{y}) = -\frac{1}{N}\sum_{i=1}^{N} y_i \log(p(y_i)) + \hat{y}_i \log(p(\hat{y}_i))$$

where, N is the total number of points generated

- Variance loss is used to measure deviation from the mean, which minimizes the squared difference of the variances between the actual and generated data. This is given as below.

$$L_B(y, \hat{y}) = (\sigma(y) - \sigma(\hat{y}))^2$$

where, σ is the variance in the data given by

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(Xi - \mu)^2}{N}}$$

where, σ is the population variance
X_i is each value
μ is the population mean
N is the total number of values in the population

This model is helpful for drug manufacturers, health insurance companies and hospitals. It also helps patients to plan their expenditures and savings for health accordingly.

- Forecast error loss is used to bring predicted data close to actual data. This is given as below.

$$L_c(y, \hat{y}) = \sqrt{\frac{1}{N}}\ (y - \hat{y})^2$$

- Wasserstein distance loss is used to measure the distance between the distributed data in training samples and distributed data in the generated samples.

$$W(X, Y) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} f_{i,j}\, d_{i,j}}{\sum_{i=1}^{m}\sum_{j=1}^{n} f_{i,j}}$$

where, X and Y are the probability distributions on region D.
$d_{i,j}$ is the ground distance between two clusters x_i and y_j
$f_{i,j}$ is the flow between x_i and y_j

The author developed different GAN models with reference to generator G and discriminator D model loss function are:
Adversarial GAN for G = L_A and for D = L_A
Variance GAN for G = $L_A + L_B$ and for D = L_A
Forecast error GAN for G = $L_A + L_C$ and for D = L_A
Variance and Forecast error for G = $L_A+L_B+L_C$ and for D = L_A
Variance and Wasserstein distance1 for G = L_A+L_B and for D = L_W
Variance and Wasserstein distance2 for G = L_A+L_B and for D = $L_A + L_W$

4. Term Frequency-Inverse Document Frequency (TF-IDF) [19]:

TF-IDF is the result of multiplying term frequency by scaling factor which is given by

$$TF - IDF(i, j) = TF(i, j) * \log\left(\frac{N}{DF(j)}\right)$$

where, N is the number of documents
D_i is one of the document
j is a term in the document
TF(i,j) is the word j appearing in document D_i
DF(j) is the number of documents that has the term j

SHAPley is the predictive model use and it is the sum of mean value of the target variables and the summation of contribution of j^{th} feature to sample x_i. This is given as below:

$$y_i = y_0 + \sum_{j=1}^{N} f(x_{ij})$$

where, $f(x_{ij})$ is the contribution of jth feature to sample xi
x_{ij} is the jth feature of the ith sample
y_i is the predictive value of the ith sample in model
y_0 is the baseline i.e., mean value of target variables

Performance is measured by considering the four criteria namely, accuracy, precision, recall and F1 score based on the predictive results True Positive (TP), False Positive (FP), True Negative (TN) and False Negative (FN) for the number of instances 'm'.

Accuracy is expressed as the ratio of sum of true positives and true negatives and number of instances, which is given as:

$$Accuracy = \frac{TP + TN}{m}$$

Precision is expressed as the ratio of true positive and sum of true positive and false positive, which is given as:

$$Precision = \frac{TP}{TP + FP}$$

Recall is expressed as ratio of true positive and sum of true positive and false negative, which is given as:

$$Recall = \frac{TP}{TP + FN}$$

F1 Score is the ratio of product of precision and recall multiplied by 2 and sum of Precision and Recall, which is given as: $F1\ score = \frac{2*Precision*Recall}{Precision+Recall}$

Macro average is half the summation of Precision, Recall and F1 score, given as:

$$\mathrm{Macro-avg(f)} = \frac{1}{2}\sum_{i=0}^{1} f_i$$

Weighted average is the product of reciprocal of number of samples in i^{th} class and summation of number of samples in i^{th} class and precision, recall and F1 score, which is given as:

$$\mathbf{Weighted-avg(f)} = \frac{\mathbf{1}}{\mathbf{m}}\sum_{i=0}^{1} \mathbf{m_i f_i}$$

5. PT-CNN (GoogleNet) [10]:

In this method optimization is done by objective function J(θ) and to chose the direction and minimizing the oscillations SGDM is used where ‘γ’ is added to the vector as below:

$$v_t = \gamma v_{t-1} + n\,\nabla_\theta J(\theta)$$

$$\theta = \theta - v_t$$

5.2 Tools

The important and most widely used languages to implement ML and DL algorithms are Python and R language. Below are the popular tools used in Python and R language to implement ML and DL algorithms [33].

Table 5. Popular tools used for implementing Machine Learning and Deep Learning methods

Tool name	Description
Scikit-learn	Open source package in ML helps in regression, classification and clustering
Knime	Open source tool and GUO based, helps in data related operations
Tensorflow	Open source framework for large scale ML and numerical
Pytorch	Deep learning framework
Google Cloud AutoML	Pre-trained model for speech, text recognition
Azure Machine Learning Studio	Provides ML services to users
Google Colab	Environment based on Jupyter Notebook
NLTK	Python library helps in Natural Language Processing
Rstudio	IDE with R language
IBM Watson	Web interface
Open NN	Software library for implementing Neural Networks
Torch7	ML library for scientific purposes
MLLIB	Used in classification, regression, filtering, etc.
Pandas	Basic library to practice ML
Numpy	Used in scientific calculations
MatPlotLib	Graph plotting library used in Python
DeepLearning4j	Deep learning library
MLPY	ML package used in python
Spyder	Python language IDE for scientific usage
Keras	Advanced Neural Network API
DLIB	ML toolkit based on C++
OpenCV	Helps in Computer Vision

6. CASE STUDIES

6.1 Case Study 1: Yield prediction of crops using advanced machine learning models

Crop yields always depend on climatic changes in nature, which are unpredictable. In this paper, three supervised machine learning models are proposed, namely Crop Random Forest (CRF), Crop Gradient Boosting Machine (CRBM) and Crop Support Vector Machine (CSVM). These models predict the yield of four crops, namely potato, bean, tea and coffee in fourteen East African countries: Burundi, Comoros, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Uganda, Zambia, Zimbabwe, Eritrea, and Ethiopia. The average temperature in the selected area is 23º C and rainfall varies from 17 mm to 212 mm. The dataset was used by Streamsets. The features used in the dataset include 14 East African countries, four crops, amount of pesticides, nitrous oxide value in agricultural soil, average rainfall and average temperature, yield and logarithmic transformation of yield.

The experiment is conducted using an Intel Core i5 CPU, 8GB RAM in a Linux environment. The implementation of the work is done using Python 3.8.8.

The functioning of the model includes pre-processing of data (crop production, pesticides and climate), feature engineering by coding variables, applying normalization and log transformations to targets and 70% of data is considered for training and 30% for testing. This processed data is fed into the training phase where RF, GBM and SVM are used. Later testing and evaluation is done using performance metrics to estimate crop yield. Performance metrics used in the study include accuracy, Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and runtime.

CRF shows a high accuracy of 92.272%, CGBM with 90.186% and CSVM with 86.377%. Root Mean Square Error for CRF is 0.343, for CGBM 0.4 and for CSVM 0.474. The Mean Absolute Percentage Error for CRF is 2.314%, for CGBM 3.198% and for CSVM 3.504%. The run time of CRF is 0.2754s, that of CGBM is 0.0826s, and that of CSVM is 0.0310s [14].

From the above observations, it is clear that CSVM is nine times better than CRF and three times better than CGBM. The scope of the study can be extended by considering other characteristic features such as water availability, other natural disasters and various soil features.

6.2 Case Study 2: Predicting Epileptic Seizures using ML

Epilepsy is a neurological disorder that affects people of all ages. Remote medical help helps people cope better with the disease. ML Techniques help detect the disease early and accurately using EEG signals.

The experiment is performed with the data in binary format. The training data includes various parameters such as EEG records, data length in seconds, sampling frequency, channels and sequence. Fourier transform is performed with four frequencies: δ, θ, α and β with values from 0 to 4, 4 to 8, 8 to 14 and 14 to 30, respectively. Each instance has 270002 attributes. Scikit-learn is the tool used. The dataset was used from Kaggle and iEEG.org websites. The performance metrics used are sensitivity, specificity and AUC. The methods used are KNN, Decision Trees, SVM, Naïve Bayes, RF, and KNN Bagging.

The accuracy in terms of AUC of the different algorithms is given below:

KNN varies between 0.52 and 0.55.

SVM is less than or equal to 0.5, when using the sigmoid function it is 0.3 and the RBF function 0.5.

Decision trees vary between 0.67 and 0.7 Random Forest varies between 0.5 and 0.7.

KNN with different parameters - KNN Bagging varies from 0.73-0.74.

KNN with DT and NB varies from 0.68 to 0.7.

Two KNNs and NB varies from 0.55 to 0.56.

KNN Bagging achieved better performance compared to the other methods.

The experiment was conducted for canine EEG signals; the work can be continued for human EEG signals [29].

7. CONCLUSION

Artificial intelligence, Machine Learning and Deep Learning are important in almost every field worldwide today and are the great explorers in technology. The medical sector is one of the leading applications where these technologies are used. Agriculture is one of the most important sectors in India that needs to be improved and we find that the application of AI, ML and DL helps to bring many improvements in the agriculture sector as well.

In this paper, we have seen how AI technology is helping in healthcare and agriculture. The article gives an insight into various applications of AI, ML and DL, various algorithms and tools used in AI, ML and DL, especially in healthcare and agriculture. We also reviewed various research papers and case studies in healthcare and agriculture.

There are many opportunities for researchers in the future to work on Artificial Intelligence, Machine Learning and Deep Learning technologies in different fields. Results can be improved with more accuracy in different applications. Researchers can propose their innovative ideas and use the technologies more efficiently for many other applications as well.

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