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Role of Machine Learning and Deep Learning in Assisting the Special Children's Learning Process

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Abstract

Artificial Intelligence (AI) revolutionizes the field of education by providing a personalized, adaptive and online learning environment. Domains of AI such as Natural Language Processing (NLP), Machine Learning (ML) and Deep Learning (DL) were used in Educational data mining approach. The learning nature of Special Children's is heterogeneous in nature as they are in need of different types of educational need. Traditional way of teaching is not possible for these children. Tutoring Systems with intelligent incorporated with the help of AI, ML, DL can motivating and reinforce children towards teaching and learning environment. In this paper the application of Convolution Neural Network algorithm, SVM algorithm and decision tree algorithm in recognizing the MNIST Sign Language was compared. Results show that a maximum of 86% accuracy is achieved using Convolution Neural Network algorithm, and among the machine learning algorithm an accuracy of 84% is achieved by using the Support Vector Classification algorithm.

Keywords: Machine learning; Artificial Intelligence; educational data mining; Decision Tree classifier; Random forest Classifier; Deep learning; CNN; SVM

1. Introduction

The Introduction of AI revolutionizes the field of education. It provides various advantages such as: (1) Personalization: According to the learners preferences and need, learning opportunities were created and provided to them, (2) Adaptive learning: a computer based learning system which adapts according to the need of the user, (3)Intelligent tutoring system (ITS) provides a customizable learning environment and helps the students to gain a better learning condition,(4)online learning: It connects both the teacher and the students in different geographical location and time to interact with each other and paves way for knowledge sharing. Various domains of AI such as Natural Language Processing (NLP), Machine Learning (ML) and Deep Learning (DL) were used in Educational data mining approach

In Recent time especially during pandemic and lockdown time different approaches of ML and DL were integrated into online learning environment. It helps in predicting the students' learning aspects, student's behaviors during classes, scheduling of courseware, recommendation system and provides adaptive learning environment [9]. Deep learning is a subgroup of machine learning based on artificial neural network with learning capability enhanced. In deep learning approach, more number of hidden layers helps to optimize the result in a more accurate manner. Deep learning algorithm can work with unstructured data even without undergoing preprocessing stage and can easily finds out the most important features to distinguish each other.

They are a heterogeneous group of learners who differ by vision, hearing, ability, motor skills, health, experiences, and family background (Ferrell, Bruce, &Luckner, 2014). Children's with ASD, Visual impairments, Blind deaf needs special type of educational need as their learning style are heterogeneous in nature. AI comes in to the play by satisfying these different types of educational needs for these different types of special children. Deaf-blindness situation refer to person suffering from both hearing and visual disabilities. Children who are deafblind require individualized approaches to communication and literacy.

The potential issues of their education are (1) Understanding classroom lectures and (2) Participating in class discussions. Deaf-blind people use many different ways to communicate. They use tactile finger spelling, print on palm, tadoma, Braille etc. Modern technology has provided opportunities for students who are deafblind to access the general curriculum. Assistive technology devices that were created for these special children's to help them in their education.

Autism is a neuro developmental syndrome. It can be detected in the early stage of life (i.e infant to three years of life). A child with Autism spectrum disorder has problems in social interaction and communication. Different children have different range of symptoms and severity hence it is considered as a heterogeneous condition. Some children with ASD possess lower intelligence and few children with ASD possess high intelligence. These children have difficulty in learning and communicating what they learnt and how to apply it on real life. Traditional way of teaching cannot be carried out for these special children. Intelligent tutoring Systems (ITSs) with the capability of computer based teaching and learning environment with varied features, such as music, animation, vocalization can motivating and reinforce children with ASD towards education.

This paper is organized as, section 2 defines the various work carried out by different authors related to the role of AI in educational domain, role of intelligence for the teaching learning environment for children with visual and hearing impairments, role of intelligence for the teaching learning environment of children with ASD, down syndrome. Section 3 describes the various classification algorithms such as decision tree classifier, SVM machine learning and CNN deep learning algorithm used. Section 4 describes performance of these algorithms and their classification accuracy in identifying the sign language and finally section 5 concludes the work.

2. RELATED WORK

2.1. Role of Artificial Intelligence in education

Nil Goksel describes the importance of artificial intelligence in educational domains [4]. He takes the study of social network analysis (SNA) for defining the key concept of AI through natural language processing, machine learning, and deep learning. AI in education paves way for the design of adaptive cum personalization of learning, design of intelligent tutoring systems, eLearning and distance learning.

The educational data used by the author [5] is collected from the system called ASSISTments. It is freely available on https://sites.google.com/site/assistmentsdata/home/assistment-2009-2010-data. The DL method used by the author is recurrent neural networks (RNNs). He tries to explain the pedagogic way of how a topic in algebra was learnt and brings the progression of learning that is happening to the students.

2.2. Role of Intelligence for the Teaching Learning Environment for Children with Visual and hearing impairments

An image is a collection of several pixels arranged in rows and columns. The author introduce image to text conversion needed for blind people [6]. He develops a system to convert the image to text and then to speech. The author applies Canny Edge Detection algorithm to detect objects from input images. Canny edge detection algorithm will recognize the input image by detecting the edges of objects in the image. Object recognition is done on the basis of color, size, texture and shape of the object. The system makes a better provision for converting captured images as well as stored images to be converted into text and speech.

Ivanovaa Nedelina [7] designs a project called BiBiKit (Bimodal Bilingual Kit for reading and writing tool for sign language users) used both by students and teachers to link text to sign language video. Currently we don’t have any system which converts the sign language in to a written format or vice versa. The software is designed in such a manner they also enables the user of the system to link text to video in different levels such as at the word level or word phrase level or at sentence level.

Deaf-blind people use many different ways to communicate. Downing & Falvey describes Communication as one individual sends a message to another and that message is received and understood [8]. Communication can be expressed either in pre-lingual or lingual manner. Pre-lingual mode of communication happens through body movements and gestures. The two broad types of deaf blindness are: (1) Congenital deaf blindness: if a person is born with a sight and hearing impairment. This situation arises due to infections during pregnancy, premature birth, birth

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trauma and rare genetic conditions. (2) Acquired deaf blindness: if a person experiences sight and hearing loss in later part of life. This may be due to illness, accident or as a result of ageing.

2.3. Role of Intelligence for the Teaching Learning Environment of Children with ASD, Down syndrome

Clinical diagnosation revels children with Autism Spectrum Disorder (ASD) have impaired socialization and communicative abilities [1]. Instead of traditional way of teaching, computer based teaching and learning environment with varied features, such as music, animation, vocalization can motivating and reinforce children with ASD towards education. The author designs a maze game, "SmileMaze" where the children with ASD can play the game to collect the maximum number of candies [2]. The child can use the up, down, left and right key as well as facial expression for navigation. The system uses the Computer Expression Recognition Toolbox (CERT) and integrates it with a computer based curriculum Let's Face It! (LFI). CERT detects the facial expression of children with ASD using the laptop web cam. Smile-O-Meter will be filled as long as the child gives a smile, the obstacles in the path are removed and the child can collect the candies in the maze.

The author [2] develops an Intelligent Tutoring system (ITS) for children with Down syndrome. Down syndrome is associated with children having impairment on cognitive ability and physical growth. These children have varied learning styles and needs more way to illustrate the concept. If the illustration is not liked by the children, he/ she may get bored and restless. Design and development of an ITS for Down syndrome has to considered the following points, (1) Repeat the information more than once, (2) find out the way by which the child enjoys the learns process (i.e by the way of text / animation / video / sound / music) , (3) maintain the child preferences on the courses he/she learnt previously (4) plan for an assessment by which we can learn whether the child understand the concept clearly.

The author presents an Augmented Reality based teaching learning environment for the kindergarten and primary school children instead of traditional didactic materials based learning [3]. Traditional Logic Blocks can be used to teach concepts related to Set Theory ie classification based on one/ two /many factors (eg: take the square which is read in colour), building of simple English sentences etc. It enhances the children ability on problem solving techniques, logic thinking, mathematics, neuro-cognitive developmental etc. BlockMagic [1] combines both the hardware (RFID sensor) and a software platform (tutoring system) system to assist the kindergarten and primary school children teaching learning process in Italy, Spain and Greece. RFID tags are attached to the different logic block. When a children place the RFID tag to the reader connected to a laptop. The software on the laptop recognizes it and produces an audio oriented (sound) feedback in order to guide the child to solve the given problem. System was assessed in 4 schools with 257 normal children and 2 special children and found that many children and teachers welcomed this approach and few were found to have some weakness towards this approach. The observations about the system were validated based on the parameters of usefulness, satisfaction and ergonomy.

3. Machine Learning and Deep Learning Algorithm

3.1. Machine Learning Model

The machine learning algorithms are broadly divided into supervised and unsupervised model. Classification algorithm comes under the supervised learning model, as they use to identify the new observations based on the training data. Classification algorithms are grouped into linear (eg.SVM) and non-linear (eg.Decision Tree, Random Forest Classifier) model.

SVM: SVM can be used for classification problems. It supports both continuous and categorical variables. Basically SVM constructs an optimal hyperplane to classify the given data (new observation) into different classes by minimizing the error.

Decision Tree Classifier: The Decision Tree classifier predicts the class by using a simple decision rules inferred using the training data. It can be used both for classification and regressing problem. This approach use a tree structure model, where features present in the dataset represents the internal node, rules of the decision tree represented in the branches and finally the leaves represent the results.

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Random Forest classifier: Random forest is an extension of decision tree algorithm. It has the advantage of combining the results of multiple classifiers (decision tree) in predicting the final classification result. This type of classifier can also be used both for classification and regressing problem.

3.2. Implementing Machine learning Algorithm

Step-1. Import all the necessary libraries such as pandas, sklearn, tree, SVM, sklearn.metrics, accuracy_score, RandomForestClassifier, AdaBoostClassifier

Step-2. Load and split the dataset into training and testing set.

Step-3. Develop the ML algorithm by using different methods of sklearn library:

a) Call the decision tree classifier using the method tree.DecisionTreeClassifier() from sklearn

b) Call the random forest classifier using themethod RandomForestClassifier() from sklearn

c) Call the Ada Booster classifier using the method AdaBoostClassifier()from sklearn

d) Call the SVM classifier using the methodLinearSVM()from sklearn

e) Call the C-SVM classifier using the method svm.SVC()from sklearn

Step-4. Build the ML model using fit() and predict() method

Step-5. Validate the model and its accuracy is computed

3.3. Deep Learning Model

A Convolution Neural Network (CNN) otherwise called as ConvNet, a deep learning model has input layer, number of hidden layer and an output layer. The four major layers used for object detection by CNN are, Convolutional, pooling, dropout and Fully-Connected layer. (1) Convolutional layers: the input images pass through a set of convolutional filters which are used for the stimulating certain input features. The convolution operation is carried out as a dot product between input (image) data array and the filters. (2) Pooling: This is used for reducing the size of the input image. Two different types are of pooling is available in the literature i.e Max pooling and Average pooling as the name indicates the former returns the maximum pixel value and the later returns the average pixel value. (3) Dropout layers: It randomly reduces interconnecting neurons within the network. (4) Fully-Connected layer: It creates densely-connected neural network different activation functions used in literature are softmax, relu, Sigmoidal activation function etc.

In this paper we build a CNN model with three convolutional layers, two max pooling and two fully connected layers with the input image size as 28*28 and epochs is defined as 50. The size of the training and testing data are 27,455 and 7172 respectively. The summary of the model build is shown in figure 1.

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_5 (Conv2D)           (None, 26, 26, 32)        320

 max_pooling2d_4 (MaxPooling  (None, 13, 13, 32)       0
 2D)

 conv2d_6 (Conv2D)           (None, 11, 11, 32)        9248

 max_pooling2d_5 (MaxPooling  (None, 5, 5, 32)         0
 2D)

 conv2d_7 (Conv2D)           (None, 3, 3, 32)          9248

 flatten_2 (Flatten)         (None, 288)               0

 dense_4 (Dense)             (None, 512)               147968

 dense_5 (Dense)             (None, 25)                12825

=================================================================
Total params: 179,609
Trainable params: 179,609
Non-trainable params: 0
```

Fig.1. Summary of CNN

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3.4. *CNN Algorithm*

Step-1. Import all the necessary libraries such as numpy, pandas, tensorflow, keras, sklearn and matplotlib

Step-2. Load and split the dataset into training and testing set.

Step-3. Design the convolution neural network model (CNN) with:

a) Three Convolutional layers with input size defined as 28 x 28 x1 and activation function relu using theConv2D() method of the Keras Sequential API.

b) Two Max pooling layer with MaxPooling2D() methods.

c) Fully-Connected dense layer are created using the tf.keras.layers.Dense() with softmax and relu activation function.

Step-4. Build the CNN model using the fit() method with the training and testing data and define the epoch size.

Step-5. Validate the model and its performance (precision, recall and f-score) are obtained using classification_report() method

4. RESULT AND DISCUSSION

4.1 Data set

In this paper the data set used for analysis is MNIST Sign Language [10] from kaggle. The dataset is given in CSV format with labels (0 to 23 represents English alphabet except j and z respectively) and 784 pixels values per sample in single rows. It shows the hand gesture image data. The number of training data is 27,455 and test data is 7172.

Fig 2: Image representation of Alphabets in MNIST Sign Language

Figure 2 represents the images of the alphabetical representation using Sign Language. Antonio Hernández-Blanco [9] gives a details summary of popularly available Educational Data Mining data sources used in literature. Few of the popular data sources are listed Table 1.

Table 1: Educational Data Mining Data sources

Author	**Data set used**
Zhang et al., 2017 [17]	ASSISment
Sharada et al., 2018 [16]	ASSIStment 2018
Tang et al., 2016 [15]	Kaggle Automated Essay Scoring
Piech et al., 2015 [11]	Virtual student dataset and Assistments 2009-2010 dataset
Wang et al., 2017 [18]	KDD Cup 2015 dataset
Mohammed WaleedKadous	Australian Sign Language signs Data Set
A. Gardner, R. R. Selmic, J. Kanno	Motion Capture Hand Postures Data Set (UCI)
Paulo Cortez [11]	Student Performance Data Set

Dr. SadiqHussain[12]	Student Performance on an entrance examination Data Set
DrSadiqHussain[13]	Student Academics Performance Data Set

4.2 Experimental Setup

Google Colaboratory supports numerous machine learning and deep learning algorithms in different domains such as health care, retail, marketing, educational data mining etc. It provides various python interface to design, develop and test the various ML and DL algorithms in a easy and convinent manner. Neural networks architecture for object detection and classification (CNN, Alexnet and VGG) are build using TensorFlow and Keras. TensorFlow (https://www.tensorfow.org/) is an open-source platform that helps the user to easily build and deploy various machine learning models. Keras (https://keras.io/)a simple, flexible and widely used framework consist of numerous API to help the used to easily build deep learning architecture.

4.3 Result and discussion

Training and testing accuracy were compared among the machine learning and deep learning algorithm using the MNIST sign language dataset. Results indicate that a maximum of 86% accuracy is achieved using Convolution Neural Network algorithm in recognizing and classifying the sign language accurately. Among the different machine learning algorithm a maximum of 84% is achieved using Support Vector Classification algorithm.

Table 2: Comparison of classification accuracy of ML and DL algorithm

Algorithm	**Accuracy**
DecisionTreeClassifier	0.44
AdaBoostClassifier	0.32
Linear SVM	0.61
RandomForestClassifier	0.81
C-Support Vector Classification	0.84
CNN	0.86

The CNN algorithm is executed five times with different number of Epoch starting with 10 to a maximum of 50 epoch. Table 3 gives the accuracy of the CNN algorithm.

Table 3: CNN algorithm with different number of Epoch

Algorithm	**No of Convolution layer**	**Type and number of Pooling**	**Activation function used**	**No. of Epoch**	**Accuracy**
CNN algorithm	3	Max Pooling	Relu	10	0.8727
				20	0.8543
				30	0.8678
				40	0.8653
				50	0.8560

Figure.3 show the performance of CNN algorithm in recognizing and classifying the sign language accurately during the training and validation phased for different number of epoch. Results indicate the algorithm behaves in a similar fashion both during the training and testing phases.

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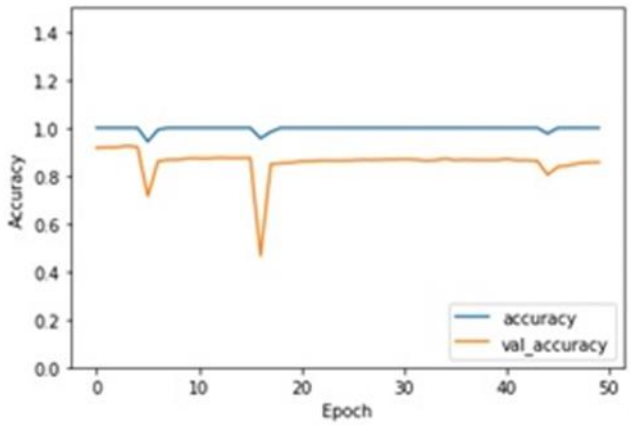

Fig 3: Accuracy Vs Epoch for CNN algorithm

5. Conclusion

Personalized and adaptive way of learning is possible with the help of Machine Learning (ML) and Deep Learning (DL) algorithms. Traditional way of teaching is not applicable for the special children as they have a heterogeneous learning style. In this paper, we use Decision Tree Classifier, Random Forest Classifier, AdaBoost Classifier, Linear SVM, C-Support Vector Classification and CNN algorithm in recognizing the Sign Language by using the MNIST data set. Results show that a maximum of 86% accuracy is achieved using Convolution Neural Network algorithm.

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