ABSTRACT

Trending technologies like machine learning and Neural networks are used in different kinds of handwritten pattern recognition in various research areas. Hence, it is very hard to recognize different persons written digits, English alphabet characters with different stroke of writing. In this paper, we try to predict the images of Digits, English characters and Telugu vowel Characters from the dataset with the knowledge of Convolution Neural Network which is the most appropriate algorithm for classification of the images.

It has been an important research area that recognizes the handwritten digits, English and Telugu characters. The English characters and digits are of the balanced dataset and the telugu vowel characters are the images of 6 different vowels of telugu characters.

Here an Artificial Neural Network model is trained and the accuracy of the model is 70 percent without the hidden layers. Then added the Dense layers as the hidden layers and trained the model and the accuracy obtained is 75 percent. As when we are trying to create a model with simple Artificial Neural Network with and without hidden layers the accuracy of the model is very low. So to solve this problem with better accuracy we trained a model with Convolutional Neural Networks which performs better in classification of the images.

Keywords: Artificial Neural Network, Convolution Neural Network, EMNIST, Telugu vowel dataset.

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LIST OF ABBREVATIONS

NIST	National Institute of Standards and Technology
MNIST	Modified National Institute of Standards and Technology
EMNIST	Extended Modified National Institute of Standards and Technology
ANN	Artificial Neural Network
CNN	Convolutional Neural Network
LSTM	Long Short Term Memory
RNN	Recurrent Neural Network
KNN	K Nearest Neighbour
SVM	Support Vector Machine
CSV	Comma Separated Values
ReLU	Rectified Linear Unit
CR	Character Recognition
OCR	Optical Character Recognitio

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION:

In the past few decades, researchers have been exploring different techniques on handwritten character recognition which is challenging. When the tasks we solve becomes harder, learning becomes harder. We use deep neural networks which is appropriate to create and train the neural network architecture with better performance measure. Neural Networks and Deep Learning makes to train the model which we created by itself as if the human brain to learn itself from the experience that we gain. Many researchers have gained the attention on this deep neural networks because it can perform better when it deals with classification problems and to predict the image by the features of recognition of the patterns from the image. Convolutional Neural Network is of the of method of Deep Learning Algorithms. Apart from CNN we have so many algorithms that used based on the problem statement that we are working with. CNN model is trained by passing the image pixel values and the model gets created and then trained from the patterns of the input image which is an efficient feature extractor. Handwritten character recognition is challenging and researchers have been exploring different techniques in the past few decades. Recently, deep neural networks have drawn the attention of many researchers due to their capability of solving computer vision problems such as object detection, classification, recognition, etc. undoubtedly well. CNN is one of the most popular types of deep neural networks, it can learn and extract features from the 2D images.The CNN classifier can effectively recognize characters present in the image. The architecture of traditional CNN classifiers consists of convolutional layers for extracting features and fully connected layers followed by a soft-max layer for classification. CNN is an efficient feature extractor.

1.2 Data Mining:

Data mining is the process of discovering patterns in large data sets involving methods at the intersection of machine learning, statistics, and database systems. Data mining is an interdisciplinary subfield of computer science with an overall goal to extract information (with intelligent methods) from a data set and transform the information into a comprehensible structure for further use. The knowledge or extracted information can be used to predict results in near future based on discovered patterns. Data mining is the analysis step of the "knowledge discovery in databases" process or KDD. Aside from the raw analysis step, it also involves database and data management aspects, data pre-

processing, model and inference considerations, interestingness metrics, complexity considerations, post-processing of discovered structures, visualization, and online updating.

1.2.1 Types of Data that can be Mined?

Data mining can be performed on the following types of data:

- **Relational Database:** A relational database is a collection of multiple data sets formally organized by tables, records, and columns from which data can be accessed in various ways without having to recognize the database tables. Tables convey and share information, which facilitates data searchability, reporting, and organization.
- **Data warehouses:** A Data Warehouse is the technology that collects the data from various sources within the organization to provide meaningful business insights. The huge amount of data comes from multiple places such as Marketing and Finance. The extracted data is utilized for analytical purposes and helps in decision- making for a business organization. The data warehouse is designed for the analysis of data rather than transaction processing.
- **Data Repositories:** The Data Repository generally refers to a destination for data storage. However, many IT professionals utilize the term more clearly to refer to a specific kind of setup within an IT structure. For example, a group of databases, where an organization has kept various kinds of information.
- **Object-Relational Database:** A combination of an object-oriented database model and relational database model is called an object-relational model. It supports Classes, Objects, Inheritance, etc. One of the primary objectives of the Object-relational data model is to close the gap between the Relational database and the object-oriented model practices frequently utilized in many programming languages, for example, C++, Java, C#, and so on.
- **Transactional Database:** A transactional database refers to a database management system (DBMS) that has the potential to undo a database transaction if it is not performed appropriately.

1.3 Neural Networks and Deep Learning:

Deep learning is probably one of the hottest tech topics right now. Large corporations and young startups alike are all gold-rushing this fancy field. If you think big data is important, then you should care about deep learning. The Economist says that data is the new oil in the 21st Century. If data is the crude oil, databases and data warehouses are the drilling rigs that digs and pumps the data on the internet, then think of deep learning as the oil refinery that finally turns crude oil into all the useful and insightful final products. There could be a lot of “fossil fuels” hidden underground, and there are a lot of drills and

pumps in the market, but without the right refinery tools, you ain't gonna get anything valuable. That's why deep learning is important. It's part of the data-driven big picture.The good news is, we are not going to run out of data and our "refinery machine" is getting better and better. Today, just about doing anything online will generate data. So data, unlike oil, is "sustainable" and growing "explosively". In the meantime, as long as the data isn't garbage-in, then there's no garbage-out from deep learning. Hence the more data, the merrier. Also, this "oil refinery" is improving on both software and hardware. Deep learning algorithms have improved over the past few decades and developers around the world have contributed to open source frameworks like TensorFlow, Theano, Keras, and Torch, all of which make it easy for people to build deep learning algorithms as if playing with LEGO pieces. And thanks to the demand from gamers around the world, GPUs (graphics processing units) make it possible for us to leverage deep learning algorithms to build and train models with impressive results in a time-efficient manner. Here's a short list of general tasks that deep learning can perform in real situations:Identify faces (or more generally image categorization), Read handwritten digits and texts, Recognize speech (no more transcribing interviews yourself), Translate languages, Play computer games, Control self-driving cars (and other types of robots).

Deep learning (also known as deep structured learning) is part of a broader family of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised. Deep-learning architectures such as deep neural networks, deep belief networks, graph neural networks, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, speech recognition, natural language processing, machine translation, bioinformatics, drug design, medical image analysis, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance. Artificial neural networks (ANNs) were inspired by information processing and distributed communication nodes in biological systems. ANNs have various differences from biological brains. Specifically, neural networks tend to be static and symbolic, while the biological brain of most living organisms is dynamic (plastic) and analogue. The adjective "deep" in deep learning refers to the use of multiple layers in the network. Early work showed that a linear perceptron cannot be a universal classifier, but that a network with a nonpolynomial activation function with one hidden layer of unbounded width.

1.3.1 Convolutional Neural Network:

CNN are made up of a large number of interconnected neurons that have learnable weights and biases. In the architecture of CNN the neurons are organized as layers. It consists of an input layer, many hidden layers and an output layer. If the network has a large number of hidden layers the same are generally referred as deep neural networks. The neurons in the hidden layers of CNN are connected to a small region of the input space

generated from the previous layer instead of connecting to all, as in the fully connected network like Multi Layered Perceptron (MLP) networks. This approach reduces the number of connection weights (parameters) in CNN compared to MLP. As a consequence, CNN takes less time to train for the networks of similar size . The input to the typical CNN are two dimensions (2D) arrays of data such as images. Unlike the regular neural network the layers of a CNN are arranged in three dimensions (width, height and depth). In deep learning, a convolutional neural network (CNN, or ConvNet) is a class of deep neural network, most commonly applied to analyze visual imagery. They are also known as shift invariant or space invariant artificial neural networks (SIANN), based on the shared-weight architecture of the convolution kernels or filters that slide along input features and provide translation equivariant responses known as feature maps. Counter-intuitively, most convolutional neural networks are only equivariant, as opposed to invariant, to translation. They have applications in image and video recognition, recommender systems, image classification, image segmentation, medical image analysis, natural language processing, brain-computer interfaces, and financial time series. CNNs are regularized versions of multilayer perceptrons. Multilayer perceptrons usually mean fully connected networks, that is, each neuron in one layer is connected to all neurons in the next layer. The "full connectivity" of these networks make them prone to overfitting data. Typical ways of regularization, or preventing overfitting, include: penalizing parameters during training (such as weight decay) or trimming connectivity (skipped connections, dropout, etc.) CNNs take a different approach towards regularization: they take advantage of the hierarchical pattern in data and assemble patterns of increasing complexity using smaller and simpler patterns embossed in their filters. Therefore, on a scale of connectivity and complexity, CNNs are on the lower extreme. Convolutional networks were inspired by biological processes in that the connectivity pattern between neurons resembles the organization of the animal visual cortex. Individual cortical neurons respond to stimuli only in a restricted region of the visual field known as the receptive field. The receptive fields of different neurons partially overlap such that they cover the entire visual field. CNNs use relatively little pre-processing compared to other image classification algorithms. This means that the network learns to optimize the filters (or kernels) through automated learning, whereas in traditional algorithms these filters are hand-engineered. This independence from prior knowledge and human intervention in feature extraction is a major advantage.

A convolutional neural network consists of an input layer, hidden layers and an output layer. In any feed-forward neural network, any middle layers are called hidden because their inputs and outputs are masked by the activation function and final convolution. In a convolutional neural network, the hidden layers include layers that perform convolutions. Typically this includes a layer that performs a dot product of the convolution kernel with the layer's input matrix. This product is usually the Frobenius inner product, and its activation function is commonly ReLU. As the convolution kernel slides along the input matrix for the layer, the convolution operation generates a feature map, which in turn

contributes to the input of the next layer. This is followed by other layers such as pooling layers, fully connected layers, and normalization layers.

1.4 Deep Learning:

Deep learning is an artificial intelligence (AI) function that imitates the workings of the human brain in processing data and creating patterns for use in decision making. Deep learning is a subset of machine learning in artificial intelligence that has networks capable of learning unsupervised from data that is unstructured or unlabeled. Also known as deep neural learning or deep neural network. Deep learning is the acronym for Neural Networks, the network connected with multilayers. The layers are composited form nodes. A node is just a perception which takes an input performs some computation and then passed through a node's activation function, to show that up to what context signal progress proceeds through the network to perform classification.

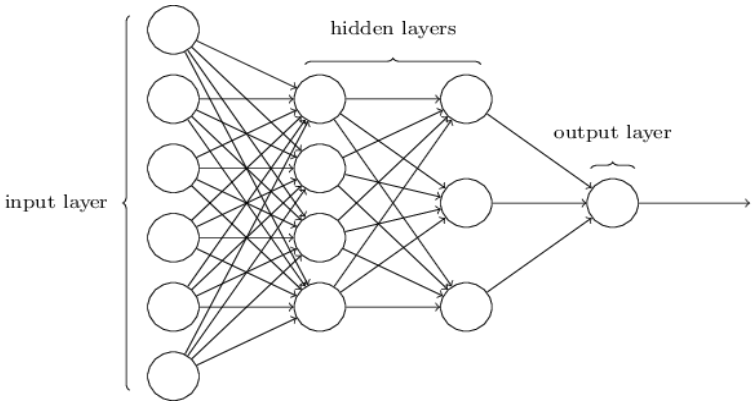

Figure 1.1 Sample Neural Network

1.5 Motivation of the work:

The motivation of the work is to get the recognition of the Handwritten digits, english characters and telugu vowel characters with better accuracy and by reducing the overfitting and underfitting problems using convolutional neural networks. This will be useful in the domain of the bank cheque numbers and handwritten amount in the cheque. reading the postal address code in the postal department, vehicle number plate detection, etc. The main motivation of this project is to predict the digits in better way and the extension to this is of about the english characters of the emnist dataset of the balanced class and also for the telugu vowel characters. Hand writing recognition of characters has been