ABSTRACT

In recent times, with the increase of Artificial Neural Network (ANN), deep learning has brought a dramatic twist in the field of machine learning by making it more artificially intelligent. Deep learning is remarkably used in vast ranges of fields because of its diverse range of applications such as surveillance, health, medicine, sports, robotics, drones etc. The Handwritten Digit Recognition is one such ability of computers to recognize human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different flavours. The goal of this project is to provide the solution to this problem which uses the image of a digit and recognizes the digit present in the image by using the concept of Convolutional Neural Network. In this project, we train our model using Modified National Institute of Standards and Technology (MNIST) dataset. This dataset is trained using convolutional neural network algorithm with the help of Keras which is python library for extensive computation of neural nodes supported by Tensorflow framework at backend. After training, iterative testing with more accurate model is formed. With this formed model, we will be able to predict the handwritten digits in an image. Once model gets the desired testing results, a GUI is developed for users where they can make their inputs either by drawing the digits by themselves or inserting an image file which consist of handwritten digits to get the prediction and accuracy percentage from my model.

Literature Review

1. Handwritten Digit Recognition System Based on Convolutional Neural Network

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With the rapid development of electronic information, computer input has become more and more common, but handwriting is still an irreplaceable way for people to transfer information. As a link combining handwritten characters and computer input, handwriting recognition has received more

and more attention for its practicability. Handwriting recognition technology is the basis of handwriting interpolation and handwriting identification. In the past decade, machine learning and pattern recognition have extended many highly intelligent handwriting recognition classifications, including artificial neural networks (ANN) [1], support vector machine (SVM) [2], modified quadratic discriminant function (MQDF) [3] and hidden Markov model [4], etc. Arabic numerals are the only universal symbols in the world, and they have an indelible contribution to the development of world science and culture. Convolutional neural networks have advantages in image processing in all neural networks, so this paper designs a handwritten digit recognition system based on convolutional neural networks.

2. Handwritten Digit Recognition by Multi-Objective Optimization of Zoning Methods

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A zoning method can be defined as a partition of the pattern image that allows the extraction of local information useful for recognition. Formally speaking, given a pattern image B, a zoning ZM={z1, z2, ..., zM} of B can be considered as a partition of B into M sub-images, named zones, each one providing information related to a specific part of the pattern [1, 2]. Traditional zoning methods are based on static approaches in which zoning design is obtained by standard grids that are superimposed on pattern images. In this case, no a-priori information on feature distribution is considered for defining the zoning method. When dynamic zoning methods are used, zoning design is considered as an optimization problem and the optimal zoning method is generally found as the zoning which optimizes a well-suited cost function [3]. In literature both constrained and unconstrained dynamic zoning methods have been proposed so far. When constrained methods are considered, the optimal zoning topology is selected within a set of topologies having well-defined characteristics defined a–priori. For example, the system of Valveny and Lopez [4] divide the pattern image into five rows and three columns. The size of each row and column is then determined according to the discriminating capabilities of the diverse

regions of the image. Radtke et al. [5] use a predefined 6x6 regular grid that can be optimized according to two diverse optimality criteria: a minimal number of non-overlapping zones and an error rate as low as possible. Gagné and Parizeau [6] use a hierarchical zoning for handwritten character classification. Their recognizer uses a multilayer perceptron as a classifier and operates on a hierarchical feature space of orientation, curvature, and center of mass primitives. The nodes of the hierarchy represent rectangular zones of their parent node whereas the tree root corresponds to the entire image pattern.

3. Handwritten Digit String Recognition using Deep Autoencoder based Segmentation and ResNet based Recognition Approach

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Recognition of isolated handwritten digits is a well studied research problem and several models show high recognition accuracy on different standard datasets. But the same is not true while we consider recognition of handwritten digit strings although it has many real-life applications like bank cheque processing, postal code recognition, and numeric field under standing from filled-in form images. The problem becomes more difficult when digits in the string are not neatly written which is commonly seen in freestyle handwriting. The performance of any such model primarily suffers due to the presence of touching digits in the string. To handle these issues, in the present work, we first use a deep autoencoder based segmentation technique for isolating the digits from a handwritten digit string, and then we pass the isolated digits to a Residual Network (ResNet) based recognition model to obtain the machine-encoded digit string. The

proposed model has been evaluated on the Computer Vision Lab (CVL) Handwritten Digit Strings (HDS) database, used in HDSRC 2013 competition on handwritten digit string recognition, and a competent result with respect to state-of-the-art techniques has been achieved.

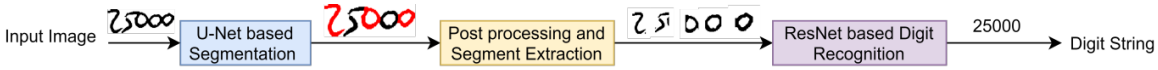

Fig. 1: An overview of the steps used in the proposed method

4. Graph-based Handwritten Digit String Recognition

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The handwritten digit recognition is a key problem for such applications as automatic postal address and bank check reading. Such methods as statistical classifi ers [l], neural networks [2],structural classifiers [3] can be mentioned among different approaches to handwritten digit recognition. T.Pavlidis and J.Rocha in [4] use graph approach to describe symbol prototype. The input image is skele tonized, and the image skeleton is interpreted as graph, where nodes are breaking points of a pen trace (ending points), pen trace: self-crossing points (branch points), points of strong curvature, inflection points and some other points described below, and edges are the skeleton sections between two nodes. Such an approach allows to solve problems of structural classifiers caused by broken symbols. For these: purposes small gaps are eliminated by inserting additional edges, which can be either taken into account or ignored by the recognizer, depending on the prototype. In [4], like in most works using graph for handwrit ten text recognition, graph is a result of skeletonization of the initial image (one of possible methods is described in [5]). In our approach we use another technique of graph construction, where nodes and edges of graph rep resent the input image information more completely (similar technique is used in [6]). First lines of approximately the same width - the pen width - are selected. Then all those lines are removed from the image and only their face segments are left. As a result branch and ending points are obtained which can be interpreted as graph nodes and the lines as graph edges. Such graph allows to determine

line curvatures more accurately; be sides it contains information about shapes and sizes of nodes as well as about edges widths.

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