International Conference on Recent Trends in Data Science and its Applications
DOI: rp-9788770040723.060

Artificial Intelligence-Based Optimization Algorithm to Recognize the Handwritten Digits of Writers

Pilli. LalithaKumari
Associate Professor, Department of Computer Science and Engineering, Malla Reddy Institute of Technology, Secunderabad -500100 , Telangana State,India,
lalithakumari4@gmail.com

K. Jamberi
Assistant Professor, Department of Computer Science, S.A. College of Arts & Science, Veeraraghavapuram, Chennai-77, Tamil Nadu, India,
kjamberi111@gmail.com

K.Suriya,
Assistant Professor, Department of ECE, Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India,
kk.suriya@gmail.com

ShankerChandre
Assistant Professor, Department of Computer Science & Artificial intelligence,SR University, Warangal, Telangana-506371,
Shanker.chandre@gmail.com

V M Gobinath
Professor,Department of Mechanical Engineering, RajalakshmiInstitute of Technology, Chennai,Tamilnadu 600 124,India
vmgobinath@gmail.com

S.Sajith
Associate Assistant Professor, Department of Chemistry, BJM Government College, Sankaramangalam, Chavara, Kollam-691583, Kerala, India,
sajiththattamala@gmail.com

Abstract—The proliferation of technology has been credited with making processes that used to take a lot of time more easier to do. Machine learning (ML) enables software products to grow increasingly accurate at predicting outcomes without the need to be explicitly programmed to do so. This is possible because ML allows software to learn from past experiences. Machine learning algorithms make predictions about future output values by using data from the past as input. In the course of this investigation, we are going to investigate an artificial intelligence (AI)-based optimization method with the goal of recognizing the digits that are written by hand. Research in the fields of machine learning, image processing, and computer vision are making significant progress in the area of handwritten digit recognition. The style, shape, orientation, and size of a digit written by one person may be different from those written by another person. An algorithm for optimization is a procedure that repeatedly evaluates a number of potential solutions in order to locate the one that is most suitable. The phase of the design process known as computer-aided design has always included optimization ever since computers were first developed.

Keywords—Hand Written Digit Recognition, Artificial Intelligence (AI), Optimization Algorithm

I. INTRODUCTION

Challenges in research have arisen as a result of the exponential growth in data volume caused by handwritten papers, scientific instruments, and the usage of social media and channels. New areas of study have evolved in response to these problems that have attracted academics from many different disciplines. Users of social media sites often provide material for no cost, thus there is a wealth of information available in both organised and unstructured forms. Image processing, machine learning, and computer vision have all dedicated significant resources to the study of recognising handwritten digits [1]. There are several ways in which one person's numerical representation might diverge from another's for the same letter, including in terms of style, form, orientation, and size. These differences make it difficult for machine learning algorithms to recognize the digits automatically. It is a procedure that detects and recognizes any digit from a given image and then converts the digit into a machine-readable and editable format [2-3].An optimization algorithm is a method that matches various results iteratively till an optimum or acceptable solution is found. Optimization is a part of the computer-aided designing phase since the invention of computers [4].

Handwritten digit recognition is the ability of computers to recognize handwritten digits. Since handwritten numbers aren't always perfect and may come in aextensive range of combinations (in terms of both size and form), this operation is difficult for the computer [5]. A solution to this issue may be found in the handwritten digit recognition system, which proceeds a picture of a digit and determines whether or not that particular digit is present in the image.The capacity of a computer to recognize human handwritten digits from a variety of sources, such as papers, photographs, touch screens, etc., and then organize those digits into one of 10 predetermined categories is known as handwriting digit recognition (HDR) (0-9). Bottomless inquiry in the realm of deep literacy has been the focus of this article. The technique of number recognition is used in a wide variety of applications, including the sorting of postal communications, the processing of bank checks, and the identification of licence plate numbers [6]. In the field of handwritten number identification, we encounter a great deal of difficulty. Due to the fact that various people's handwriting tends to look different and that it is not an optical character recognition system. For the goal of handwritten number recognition, this investigation presents a complete comparison of several machine literacy and deep literacy algorithms [7].

The field of artificial intelligence (AI) considers the recognition of handwritten numbers as evidence that a person's neurons are in good functioning order and have been properly programmed. This particular use of artificial intelligence has been around for quite some time; its watershed moment occurred in 1989, when a dependable machine-enabled parsing of ZIP codes for postal services was finally accomplished.Almost immediately after that, it was shown that multi-layer feed-forward networks are capable of implementing any function. Shortly afterwards, the method for the automated parsing of account numbers that are printed on remittance slips for wire transfers or bank

DOI: rp-9788770040723.060

checks was adopted by the nation's financial institutions [8-9]. The identification of handwritten digits using a variety of AI algorithms is becoming more popular in academic circles nowadays for the purposes of teaching and learning.

II. Literature Review

Patil and Pranit (2020) illustrated the use of various Machine Learning algorithms,some of them to be noted are K-Nearest Neighbor Algorithm, SVM, CNN, Quantum Computing, and Deep Learning, in the Recognition technique for improving the productivity of the technique and reduce its complexity [10]. These algorithms include SVM, CNN, Quantum Computing, and K-Nearest Neighbor Algorithm. Arkiv Digital Sweden is a novel image-based handwritten historical digit dataset that was presented by Kusetogullari, Huseyin, et al. (2020) and Sridaran K et al. (2018). (ARDIS). The findings indicate that ML algorithms that are conditioned on previously collected data may have difficulty recognising digits effectively on our dataset. This demonstrates that the ARDIS dataset has different properties [11]. A novel model for identifying handwritten digits was presented by Haghighi et al. (2021) and Monika M et al. (2022). The model that has been suggested is a stacking ensemble classifier. This classifier's foundations are the Convolutional Neural Network (CNN) and a Bidirectional Long-Short Term Memory (BLSTM). The use of this database helps increase the performance of the recognition of challenging numbers [12]. To increase the accuracy of Farsi handwriting digit recognition, Nanehkaran, YaserAhangari, et al. (2021) and Balan. K (2022) developed a logical CBWME network structure system constructed on convolution bagging weighted common ensemble learning by merging CNN and BWME learning. Both Islam et al. (2019) and Latchoumi. T.P et al. (2022) focused on fine-tuning the algorithms by identifying the optimal values for the KNN, RF, SVM, MLP, and CNN hyper-parameters of the respective algorithms. They have presented Sankhya, which will act as the foundation for an open and verifiable evaluation process that will be repeated every two years from this point forward [13]. This process will also act as a benchmark for verifying newer and more innovative algorithms that will be mentioned in this field in the future.

Schrapel et al. (2018), Sivakumar P. (2015), and Vemuri et al. (2018) unveiled Pentelligence, a pen for handwritten digit identification that works on regular paper and does not need a separate tracking device. Pentelligence was developed by Schrapel et al. (2018). (2021). It picks up on the movements and sound emissions made by the pen tip when you are stroking it. DIGI-Net is a deep convolutional network that was proposed by Madakannu et al. (2020) and Buvana M et al. (2021). This network is able to learn and detect common characteristics from three various formats: natural photos, handwritten, and printed typeface of digits [14]. Experiments were conducted using the MNIST dataset, the CVL is a single-digit dataset, and the digits of the Chars74K dataset is suggested with DIGI-Net performed very well in all of them. A novel approach for the recognition of handwritten digit strings has been developed by Aly et al. (2019). This method does not need any explicit segmentation methods to be used. A unique hybrid principle component analysis network (PCANet) and SVM classifier cascade is used in the suggested technique. This network is referred to as PCA-SVMNet. The suggested approach is capable of achieving recognition accuracy that is equivalentwith the state-of-the-art methods that do not need segmentation [15]. The NN-based configurations for handwritten-based digit recognition that were proposed by Albahli, Saleh, and coauthors in 2020 and evaluated by varying the values of the hyper-parameters are discussed in this article.

III. Proposed Work

Handwritten digit recognition is the term given to the ability of computers to identify handwritten digits created by humans. Because handwritten numerals are not perfect and might vary from one person to the next, the computer has a challenging job. Handwritten digit recognition is the answer to this issue. This technique takes an image of a digit and determines whether or not that particular digit is present in the picture [16].An example of an AI-based optimization method is shown in Fig.1, and its purpose is to detect the handwritten digits of authors. The suggested technique is comprised of a number of diverse operations, the most significant of which are preprocessing, segmentation, feature extraction, and identification. The input picture is preprocessed by applying a Gaussian filter, going through a binarization process, and employing a method that detects skew. After that, the process of segmentation is carried out, which comprises the segmentation of both lines and characters. The split output is used as a source for the feature extraction. After the features have been extracted, the handwritten digits are fed into the most advanced artificial neural network available for recognition [17-18]. In this instance, a typical neural network is modified by the use of an optimization technique. The Optimization Algorithm is used to fine-tune a neural network's weights in order to achieve optimal performance. Metrics such as sensitivity, specificity, and accuracy are used in order to conduct the performance analysis of the suggested approach. The strategy that was suggested is put to the test, and the outcomes are assessed so that the performance can be seen. In order to put the suggested procedure into action, MATLAB will be used.

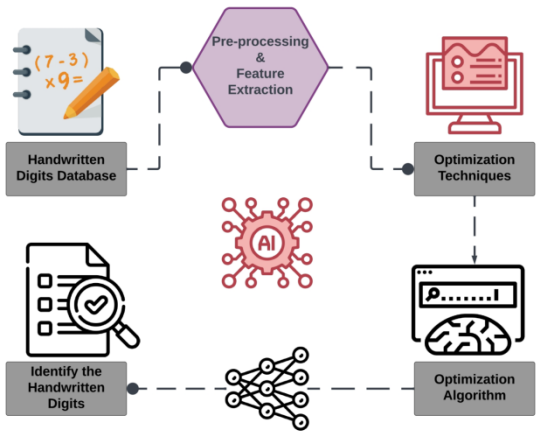

Fig.1 AI-based optimization algorithm for handwritten digits reorganization

Here in the below Equation (1), the average is approximated for ensuring the performance of recognizing

DOI: rp-9788770040723.060

the handwritten letters, whereas the equation can be modulated according to the duties that are differentiated in terms of analysis.

$$Y_i^m = \sum_{i=1}^{c} \frac{f_i}{f_i^c} + \sum_{T \to c}^{c} g(t_1 c_1 + t_2 c_2) \quad (1)$$

Wherein f_i^c signifies its terminal f_i knowledge dimensions to coordinate tasks regional basis. As a result, aentire letter is recognized by f_i scientists only at the small level portrayed in Equation (2).

$$f_i^n = \sum_{n \in f} (1 - \alpha_i) f_i^n + \int g(t_1 c_1 + t_2 c_2) \quad (2)$$

If diverse activities, including a t-norm or maybe even a n_i – co norm, are being used to interconnected in trying to reach letter identification, the condition is known as just an optimization input optimization algorithm along with the symbolization in Equation (3).

$$f_i^m = \sum_{i=1}^{m} \frac{n_i}{f_i^m} + \sum_{t \to c}^{c} g(t_1 c_1 + t_2 c_2) \quad (3)$$

These deviations in result along with the enhanced optimization design that is dependent on a novel optimization algorithm for various handwritten letter-identifying concepts is calculated in Equation (4).

$$f_i^m = \sum_{i=0}^{c} \frac{f_i}{a_i^c} + (1 - \alpha_i) f_i^n + \int g(t_1 c_1 + t_2 c_2) \quad (4)$$

For this identification system used in an AI-based managing system, a collection of Enhancing the Efficiency and Performance has been detailed once again. The user's computation time is comparable to an order of magnitude of the stands and the user's processing powers, and such heat has been supported by facts and optimization data.

IV. Experimental Results

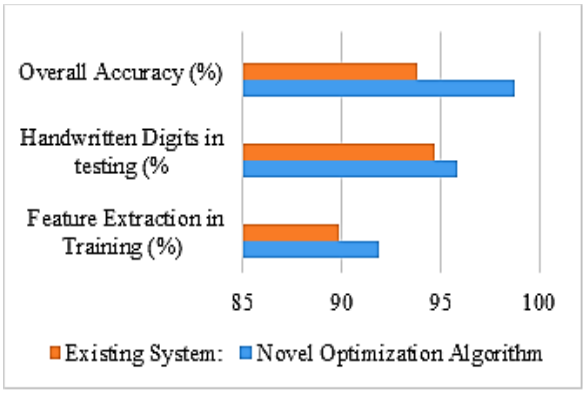

Fig.2 Efficiency and Performance of handwritten letter by the optimization algorithm

Several different NN-based models are used in order to investigate various facets of the same, the most important of which is accuracy dependent on the values of hyper-parameters. As a consequence of this, the broad experimental setup that is detailed in this article ought to result in the solution models that are the most accurate and the most time-efficient. An evaluation of this kind will be helpful in selecting hyper-parameter values that are optimum for jobs that are similar to those. Ramzan, Muhammad, and others (2018) carry out a comprehensive assessment of the many methods currently available for Hand-Written Digit Recognition (HWDR). This study is one of a kind due to the fact that is concentrated on HWDR and only examines the use of Neural Networks (NN) and its modified algorithms. It is examined that a general overview of NN as well as a variety of algorithms that are inspired by NN. Additionally, this research paper presents a comprehensive analysis of the use of NN, as well as its many forms, for the purpose of digit recognition in Table I.

TABLE I. Result Analysis for the Existing Method

Algorithm	Feature Extraction in Training (%)	Handwritten Digits in testing (%	Overall Accuracy (%)
Novel Optimization Algorithm	91.89	95.87	98.76
Existing System: Neural Network Algorithm	89.87	94.66	93.8

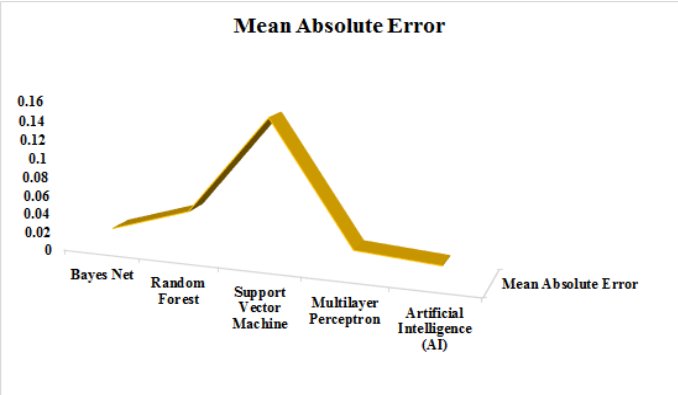

Fig.3 Mean Absolute Error Analysis

Though the model provides higher accuracy rate in identifying the handwritten letters, it is also necessary to find the error rate of any model. In this research, the proposed intelligent system is compared with certain existing algorithms such as Bayes Net, Random Forest, Support Vector Machine, and Multilayer Perceptron. Fig. 3 represents the Mean Absolute Error Analysis of the models which is used

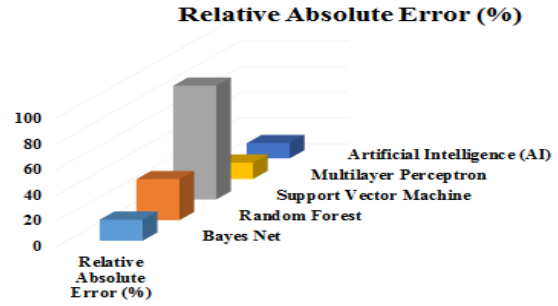

Fig. 4 Relative Absolute Error analysis

to analyze the prediction quality. From the results it is observed that the proposed intelligent system on the identification of the handwritten characters has obtained a very low Mean Absolute Error of 0.0185. The analysis of Mean Absolute Error is followed by the Relative Absolute Error analysis in the Fig.4. This analysis is used to determine the approximation error between the exact error and the resulting error. It is observed from the results that the proposed model maps the exact error rate.

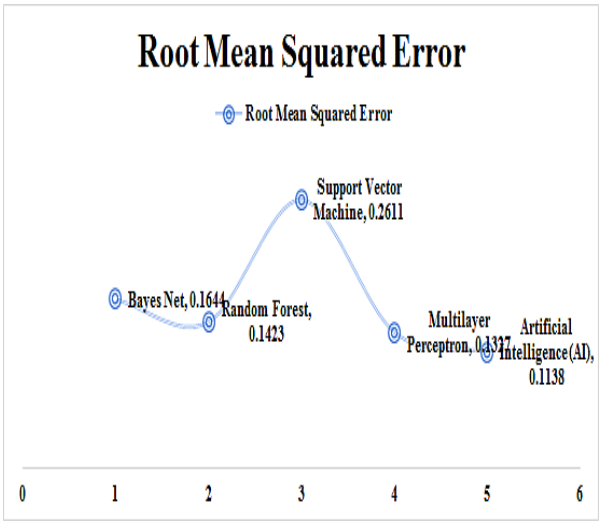

Fig.5. Analysis on Root Mean Squared Error

Analysis on the Root Mean Squared Error is represented in the Fig.5 which is used to represent the measurements for the evaluation metrics of the variables of predictions. The error rate obtained using the proposed model is less with 0.1138 which makes a minimum difference of 3% in comparison with the Random Forest Model.

V. Conclusion

The researchers claim that the proposed method is far superior to traditional handwritten digit recognition methods. The proposed methodology allows for the optimization of handwritten digits. An optimization algorithm is a method that iteratively compares different solutions until an optimum solution is found. Since the invention of computers, optimization has been a part of the computer-aided design phase. It aims to improve optimization by deploying algorithms and has achieved good accuracy.

References

[1] P. Patil, “Handwritten digit recognition using various machine learning algorithms and models,” International Journal of Innovative Research in Computer Science & Technology (IJIRCST) ISSN, PP. 2347-5552, 2020.

[2] H.Kusetogullari, A.Yavariabdi, A.Cheddad, H.Grahn,and J. Hall, “ARDIS: a Swedish historical handwritten digit dataset,” Neural Computing and Applications, vol. 32, no. 21, pp. 16505-16518, 2020.

[3] F.Haghighi,and H. Omranpour, “Stacking ensemble model of deep learning and its application to Persian/Arabic handwritten digits recognition,” Knowledge-Based Systems, vol. 220, p. 106940, 2021.

[4] Y. A.Nanehkaran, J. Chen, S.Salimi,and D. Zhang, “A pragmatic convolutional bagging ensemble learning for recognition of Farsi handwritten digits,” The Journal of Supercomputing, vol. 77, no. 11, pp. 13474-13493, 2021.

[5] A. Islam, F.Rahman,and A. S. A. Rabby, “Sankhya: an unbiased benchmark for bangla handwritten digits recognition,” In 2019 IEEE International Conference on Big Data (Big Data), IEEE, pp. 4676-4683, December, 2019.

[6] M.Schrapel, M. L.Stadler,and M. Rohs, “Pentelligence: Combining pen tip motion and writing sounds for handwritten digit recognition,” In Proceedings of the 2018 CHI conference on human factors in computing systems, pp. 1-11, April, 2018.

[7] A.Madakannu,and A. Selvaraj,“DIGI-Net: a deep convolutional neural network for multi-format digit recognition,” Neural Computing and Applications, vol. 32, no. 15, pp. 11373-11383, 2020.

[8] Moshika, A., Thirumaran, M., Natarajan, B., Andal, K., Sambasivam, G., &Manoharan, R. (2021).Vulnerability assessment in heterogeneous web environment using probabilistic arithmetic automata. IEEE Access, 9, 74659-74673.

[9] S. Albahli, F. Alhassan, W. Albattah,and R. U. Khan, “Handwritten digit recognition: Hyper-parameters-based analysis,” Applied Sciences, vol. 10, no. 17, p. 5988, 2020.

[10] M.Ramzan, H. U. Khan, S. M.Awan, W.Akhtar, M.Ilyas, A.Mahmood,and A. Zamir, “A survey on using neural network based algorithms for hand written digit recognition,” International Journal of Advanced Computer Science and Applications, vol. 9, no. 9, 2018.

[11] T. P.Latchoumi, K. Raja, Y.Jyothi, K.Balamurugan,and R. Arul, “Mine safety and risk prediction mechanism through nanocomposite and heuristic optimization algorithm,” Measurement: Sensors, p. 100390, 2022.

[12] B.Karnan, A.Kuppusamy, T. P.Latchoumi, A. Banerjee, A.Sinha, A.Biswas,and A. K. Subramanian, “Multi-response Optimization of Turning Parameters for Cryogenically Treated and Tempered WC–Co Inserts,” Journal of The Institution of Engineers (India): Series D, pp. 1-12, 2022.

[13] Sitharthan, R., Vimal, S., Verma, A., Karthikeyan, M., Dhanabalan, S. S., Prabaharan, N., ...&Eswaran, T. (2023). Smart microgrid with the internet of things for adequate energy management and analysis.Computers and Electrical Engineering, 106, 108556.

[14] P. Sivakumar, “Effectual web content mining using noise removal from web pages,” Wireless Personal Communications, vol. 84, no. 1, pp. 99-121, 2015.

[15] Vemuri, RatnaKumari, Pundru Chandra Shaker Reddy, Puneeth Kumar, Jayavadivel Ravi, Sudhir Sharma, and SivakumarPonnusamy. “Deep learning based remote sensing technique for environmental parameter retrieval and data fusion from physical models,” Arabian Journal of Geosciences, vol. 14, no. 13,pp. 1-10, 2021.

[16] M.Buvana, K.Loheswaran, K.Madhavi, S.Ponnusamy, A.Behura,and R. Jayavadivel, “Improved resource management and utilization based on a fog-cloud computing system with IOT incorporated with classifier systems,” Microprocessors and Microsystems, p. 103815, 2021.

[17] C. Bhuvaneshwari, and A. Manjunathan,“Advanced gesture recognition system using long-term recurrent convolution network”, Materials Today Proceedings, vol. 21, pp.731-733, 2020.

[18] C.Bhuvaneshwari, and A.Manjunathan, “Reimbursement of sensor nodes and path optimization”, Materials Today: Proceedings, vol. 45, pp.1547-1551, 2021.