Domain : Artificial Intelligence
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PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGITRECOGNITION

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM

Domain : Artificial Intelligence

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submitted by

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CHAPTER 1
INTRODUCTION

a. PROJECT OVERVIEW

Machine learning and deep learning play an important role in computer technology and artificialintelligence. With the use of deep learningand machine learning,human effort can be reduced in recognizing, learning, predictions and inmany more areas.

Handwritten Digit Recognition is the ability of computer systems to recognise handwritten digits from various sources, such as images, documents, and so on. This project aims to let users take advantage of machine learningto reduce manualtasks in recognizing digits.

b. PURPOSE

Digit recognition systems are capable of recognizing the digits

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from different sources like emails, bank cheque, papers,images, etc. and in differentreal-worldscenarios for online handwriting recognition on computer tablets or system, recognize number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on.

CHAPTER 2
LITERATURE SURVEY

a. EXISTING PROBLEM

The fundamental problem with handwritten digit recognition is that handwritten digits do not always have the same size, width, orientation, and marginssince they vary from person to person. Additionally, there would be issues with identifying the numbers because of similarities between numerals like 1 and 7, 5 and6, 3 and 8, 2 and 5, 2 and 7, etc. Finally, the individuality and variation of each individual's handwriting influence the structureand appearance of the digits.

b. REFERENCES

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Improved Handwritten Digit Recognition Using Convolutional Neural Networks(CNN) (2020)

Ahlawat, Savita and Choudhary,Amit and Nayyar,Anand and Singh, Saurabh and Yoon,Byungun

This paper's primarygoal was to enhance handwritten digit recognition ability.Toavoid difficultpre-processing, expensive featureextraction, and a complex ensemble (classifier combination) method of a standard recognition system, theyexamined different convolutional neural network variations. Their current work makes suggestions on the functionof several hyper-parameters through thoroughevaluation utilizing an MNIST dataset. They also confirmed that optimizing hyper-parameters is crucial for enhancing CNN architecture performance. With the Adam optimizer for the MNIST database, they were able to surpassmany previously published resultswith a recognition rate of 99.89%. Through the trials, it is made

abundantly evident how the performance of handwritten digit recognition is affected by the number of convolutional layers in CNN architecture. According to the paper, evolutionary algorithms can be explored for optimizing convolutional filter kernel sizes, CNN learningparameters, and the quantity of layers and learning rates.

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An Efficient And ImprovedScheme For Handwritten Digit Recognition BasedOn Convolutional Neural Network (2019)

Ali, Saqib and Shaukat, Zeeshan and Azeem, Muhammad and Sakhawat, Zareen and Mahmood, Tariq and others

This study uses rectified linear units (ReLU) activation and a convolutional neural network (CNN) that incorporates the Deeplearning4j (DL4J) architecture to recognize handwritten digits. The proposed CNN framework has all the necessary parameters for a high level of MNIST digit classification accuracy. The system's training takes into account the time factor as well. The system is also tested by altering the number of CNN layersfor additional accuracyverification. It is importantto note that the CNN architecture consists of two convolutional layers,the first with32 filters and a 5x5 window size and the second with 64 filters and a 7x7 window size. In comparison to earlier proposedsystems, the experimental findings show thatthe proposed CNN architecture for the MNIST dataset demonstrates great performance in terms of time and accuracy. As a result, handwritten numbers are detected with a recognition rate of 99.89% and high precision (99.21%) in a short amount of time.

Improved Handwritten Digit Recognition Using Quantum K-NearestNeighborAlgorithm (2019)

Wang, Yuxiang and Wang, Ruijin and Li, Dongfen and Adu-Gyamfi, Daniel

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and Tian, Kaibin and Zhu, Yixin

The KNN classical machine learning technique is used in this research to enable quantum parallel computing and superposition. They used the KNN algorithm with quantum acceleration to enhance handwritten digit recognition. When dealing with more complicated and sizable handwritten digital data sets,their suggested method considerably lowered the computational time complexity of the traditional KNN algorithm. The paper offered a theoretical investigation of how quantum concepts can be applied to machine learning. Finally, they established a fundamental operational concept and procedure for machine learningwith quantum acceleration.

Handwritten Digit Recognition Using Machine And Deep LearningAlgorithms(2021)

Pashine, Samay and Dixit, Ritikand Kushwah, Rishika

In this study, they developed three deep and machine learning-based models for handwritten digit recognition using MNIST datasets. To determine which model wasthe most accurate, they compared them based on their individual properties.
Support vector machines are among the simplest classifiers, making them faster than other algorithms and providing the highest training

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accuracy rate in this situation. However,due to their simplicity, SVMs cannot categorize complicated andambiguous images as accurately as MLP and CNN algorithms can. In their research,they discovered that CNN produced the most precise outcomes for handwritten digit recognition. This led them to the conclusion that CNN is the most effective

solution for all types of prediction issues, including those using picturedata. Next, by comparing the execution times of the algorithms, they determined that increasing the number of epochs without changing the configuration of the algorithm is pointlessdue to the limitation of a certainmodel, and they discovered that beyond a certainnumber of epochs,the model beginsover-fitting the datasetand provides biasedpredictions.

c. PROBLEM STATEMENT DEFINITION

For years,the traffic department has been combatingtraffic law violators. These offenders endanger not only their own lives, but also the lives of other individuals. Punishing these offenders is critical to ensuring that others do not becomelike them. Identification of these offenders is next to impossible becauseitis impossible for the averageindividual to write down the license plateof a reckless driver. Therefore, the goal of this project is to help the traffic department identify these offendersand reduce traffic violations as a result.

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CHAPTER3
IDEATION AND PROPOSED SOLUTION

a. EMPATHY MAP CANVAS

b. IDEATION & BRAINSTORMING

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c. PROPOSED SOLUTION

S. NO	PARAMETER	DESCRIPTION
1	Problem Statement	To create an application that recognizes handwritten digits

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2	Idea / Solution Description	The application takes an imageas the input and accurately detectsthe digits in it.
3	Novelty / Uniqueness	Instead of recognizing every text, the application accuratelyrecognizes onlythe digits
4	Social Impact / CustomerSatisfaction	This application reduces the manual tasks that need to beperformed. This improves productivity in the workplace.
5	Business Model	The application can be integrated with traffic surveillance cameras to recognize vehicle number plates The application can be integrated with Postal systemsto recognize the pin codes effectively
6	Scalability of the Solution	The application can easily be scaled to accept multipleinputs and process them parallelly to further increase efficiency

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d. PROBLEM SOLUTION FIT

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CHAPTER4
REQUIREMENT ANALYSIS

a. FUNCTIONAL REQUIREMENTS

FR.NO	FUNCTIONAL REQUIREMENTS	SUB REQUIREMENTS
FR-1	Model Creation	Get access the MNIST dataset
		Analyze the dataset
		Define a CNN model
		Train and Test the Model

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FR-2	Application Development	Create a website to let the userrecognize handwritten digits.
		Createa home pageto uploadimages
		Createa result pageto displaythe results
		Host the websiteto let the usersuseit from anywhere
FR-3	Input ImageUpload	Let users uploadimages ofvarious formats.
		Let users uploadimages ofvarious size

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		Preventusers from uploadingunsupported image formats
		Pre-Process the image to use iton the model

		Createa database to store allthe input images
FR-4	Display Results	Displaythe result from themodel

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		Display input image
		Display accuracy the result
		Display other possible predictions with their respectiveaccuracy

b. NON FUNCTIONAL REQUIREMENTS

NFR	NON-FUNCTIONAL REQUIREMENTS	DESCRIPTION
NFR-1	Usability	The application mustbe usablein all devices
NFR-2	Security	The application mustprotectuser uploaded image
NFR-3	Reliability	The application must give anaccurate result as much as possible
NFR-4	Performance	The application must be fast andquick to load up

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NFR-5	Availability	The application must be available to use all the time
NFR-6	Scalability	The application mustscale alongwith the user base

CHAPTER5
PROJECT DESIGN

a. DATA FLOW DIAGRAM

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b. SOLUTION & TECHNICALARCHITECTURE

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c. USER STORIES

User Type	Functional Requirements	User Story Number	User Story / Task	AcceptanceCriteria	Priority	Release

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Customer	Accessing the Application	USN-1	As a user, I should be able to access the application from anywhere and use on any devices	User can access theapplication using the browser on any device	High	Sprint-4
	Uploading Image	USN-2	As a user, I should beable to upload images to predict the digits	User can uploadimages	High	Sprint-3
	Viewingthe Results	USN-3	As a user, I should be able to view the results	The result of the prediction is displayed	High	Sprint-3
	ViewingOther Prediction	USN-4	As a user,I should be able to see other close predictions	The accuracy of othervalues must be displayed	Medium	Sprint-4

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	Usage Instruction	USN-5	As a user, I should have a usage instruction to knowhow to use the application	The usage instruction is displayed on the home page	Medium	Sprint-4

CHAPTER6
PROJECT PLANNINGAND SCHEDULING

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a. SPRINT PLANNINGAND ESTIMATION

SPRINT	USER STORY / TASK	STORY POINTS	PRIORITY	TEAM MEMBERS
Sprint - I	Get the dataset	3	High	Mubashshira S
	Explore the data	2	Medium	Mubashshira S Nithya M
	Data Pre-Processing	3	High	Mubashshira S

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	Prepare training and testing data	3	High	Mubashshira S Santhiya B
Sprint - II	Create the model	3	High	Mubashshira S
	Train the model	3	High	Nithya M
	Test the model	3	High	Mubashshira S Nandhini P
Sprint - III	Improve the model	2	Medium	Mubashshira S Nithya M

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	Save the model	3	High	Mubashshira S
	Build the Home Page	3	High	Nandhini P Santhiya B
	Setup a database to store input images	2	Medium	Nithya M
Sprint - IV	Build the results page	3	High	Mubashshira S Nithya M

	Integrate the model withthe application	3	High	Nithya M
	Test the application	3	High	Mubashshira S Nithya M

b. SPRINT DELIVERYSCHEDULE

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SPRINT	TOTAL STORY POINTS	DURATION	SPRINT START DATE	SPRINT END DATE (PLANNED)	STORY POINTSCOMPLETED (AS ON PLANNED DATE)	SPRINT RELEASEDATE (ACTUAL)
Sprint - I	11	6 Days	24 Oct 2022	29 Oct 2022	11	29 Oct 2022
Sprint - II	9	6 Days	31Oct 2022	05 Nov 2022	9	05 Nov 2022
Sprint - III	10	6 Days	07 Oct 2022	12 Nov 2022	10	12 Nov 2022
Sprint - IV	9	6 Days	14Nov 2022	19 Nov 2022	9	19 Nov 2022

CHAPTER 7

CODING & SOLUTIONING

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CHAPTER8
TESTING

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a. TEST CASES

Test case ID	Feature Type	Component	Test Scenario	Expected Result	Actual Result	Status
HP_TC_001	UI	Home Page	Verify UI elements inthe Home Page	The Home page must be displayed properly	Working as expected	PASS
HP_TC_002	UI	Home Page	Check if the UI elements are displayed properly in different screen sizes	The Home page must be displayed properly in all sizes	The UI is not displayed properly in screen size 2560 x 1801 and 768 x 630	FAIL
HP_TC_003	Functional	Home Page	Check if usercan upload their file	The inputimage should be uploaded to the application successfully	Working as expected	PASS
HP_TC_004	Functional	Home Page	Check if usercannot uploadunsupported files	The application should not allow user to select a non image file	User is able to upload any file	FAIL

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HP_TC_005	Functional	Home Page	Check if the page redirects to the result page once the input is given	The page should redirect to the results page	Working as expected	PASS

BE_TC_001	Functional	Backend	Check if all theroutes are working properly	All the routes should properly work	Working as expected	PASS
M_TC_001	Functional	Model	Check if the model can handle various imagesizes	The model shouldrescale the imageand predict the results	Working as expected	PASS
M_TC_002	Functional	Model	Check if themodel predicts thedigit	The model shouldpredict the number	Working as expected	PASS
M_TC_003	Functional	Model	Check if the model can handle complex inputimage	The model shouldpredict the number in the complex image	The model failsto identify thedigit since themodel is not built to handlesuch data	FAIL
RP_TC_001	UI	Result Page	Verify UI elements inthe Result Page	The Result page must be displayed properly	Working as expected	PASS

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RP_TC_002	UI	Result Page	Check if the input image isdisplayed properly	The input image should be displayed properly	The size of theinput image exceeds the display container	FAIL
RP_TC_003	UI	Result Page	Check if the result is displayed properly	The result shouldbe displayed properly	Working as expected	PASS
RP_TC_004	UI	Result Page	Check if the other predictions are displayed properly	The other predictions shouldbe displayed properly	Working as expected	PASS

b. USER ACCEPTANCE TESTING

i. DEFECT ANALYSIS

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Total
By Design	1	0	1	0	2
Duplicate	0	0	0	0	0
External	0	0	2	0	2
Fixed	4	1	0	1	6

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Not Reproduced	0	0	0	1	1
Skipped	0	0	0	1	1
Won't Fix	1	0	1	0	2
Total	6	1	4	3	14

ii. TEST CASE ANALYSIS

Section	Total Cases	Not Tested	Fail	Pass
Client Application	10	0	3	7
Security	2	0	1	1
Performance	3	0	1	2
Exception Reporting	2	0	0	2

CHAPTER9
RESULTS

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a. PERFORMANCE METRICS

CHAPTER 10
ADVANTAGES & DISADVANTAGES

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ADVANTAGES

i. Reduces manual work
ii. More accurate than average human
iii. Capable of handling a lot of data
iv. Can be used anywhere from any device

DISADVANTAGES

v. Cannot handle complexdata
vi. All the data must be in digital format
vii. Requires a high performance serverfor faster predictions
viii. Prone to occasional errors

CHAPTER 11

CONCLUSION

This project demonstrated a web application that uses machine learning to recognise handwritten numbers. Flask, HTML,

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CSS, JavaScript, and a few other technologies were used to create this project. The model predicts the handwritten digit using a CNN network. During testing, the model achieved a 99.61% recognition rate. The proposedproject is scalableand can easilyhandle a huge number of users.Sinceit is a web application, it is compatible with any device that can run a browser.This project is extremely usefulin real-world scenariossuch as recognizing numberplates of vehicles, processing bank cheque amounts, numeric entries in forms filledup by hand (tax forms) and so on. There is so much room for improvement, which can be implemented insubsequent versions.

CHAPTER 12
FUTURE SCOPE

This project is far from complete and there is a lot of room for improvement.

Someof the improvements that can be made to this project are as follows:

ix. Add supportto detect from digits multipleimages and save the results
x. Add supportto detect multipledigits
xi. Improve model to detect digits from complex images
xii. Add support to differentlanguages to help users from all over the

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world

This project has endless potentialand can always be enhancedto become better.Implementing this concept in the real world will benefit several industries and reduce the workloadon many workers, enhancing overall work efficiency.

APPENDIX

SOURCE CODE

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MODELCREATION

FLASK APP

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RECOGNIZER

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HOME PAGE (HTML)

HOME PAGE (CSS)

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HOME PAGE (JS)

PREDICT PAGE (HTML)

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GITHUB

https://github.com/IBM-EPBL/IBM-Project-40041-1660621871