**MiniTProjectTReportTon**



**DigitTRecognition-Image Processing**



**SubmittedTinTpartialTfulfillmentTofTtheTrequirementTforTtheTawardTofTtheTdegreeTof**

**BACHELORTOFTTECHNOLOGY**

**IN**

**COMPUTERTSCIENCETENGINEERINGT**

**SubmittedTby:T**

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**Dehradun,TUttarakhand**

**JulyT2023**



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**CANDIDATE’STDECLARATION**

ItherebyTcertifyTthatTtheTworkTwhichTisTbeingTpresentedTinTtheTprojectTreportTentitled**T”**DigitTRecognition**”**TinTpartialTfulfillmentTofTtheTrequirementsTforTtheTawardTofTtheTDegreeTofTBachelorTofTTechnologyTinTComputerTScienceTandTEngineering**T**ofTtheTGraphicTEraT(DeemedTtoTbeTUniversity),TdehradunTshallTbeTcarriedToutTbyTtheTunderTtheTmentorshipTofTMr.Ashwini.Kumar**,T**AssistantTProfessor,TDepartmentTofTComputerTScienceTandTEngineering,TGraphicTEraT(DeemedTtoTbeTUniversity),TDehradun.

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**ChapterT1**

**IntroductionT**

* 1. **Introduction**

HandwrittenTrecognitionTisTtheTabilityTofTcomputerTtoTinterpretThandwrittenTinputTfromTsourcesTlikeTpaperTdocuments,Tphotographs,TtouchTscreenTdevices,Tetc.TrecognitionTofThandwrittenTandTmachineTdigitsTisTinputTfromTsourcesTsuchTasTpaperTdocuments,Tphotographs,Ttouchscreens,TandTotherTdevices.TTheTmainTaimTofTthisTprojectTisTtoTcreateTsoftwareTthatTcanTeffectivelyTrecognizeTandTclassifyTdigitsTusingTtheTArtificialTNeuralTNetwork.

A picture containing diagram

Description automatically generated

* 1. **Theory**
     1. **WhatTareTNeuralTNetworks**

Neural network refer to either a neural circuit of biological neurons or a network of artificial neuronsT,TtheyT have served to identify better how the neurons in theT brain functions and provide the basis for efforts to create brilliantTsystemsTthatTareTintendedTtoTreplicateTtheTwayTthatTweThumansTlear.TNeuralTnetworksTcontainTinputTandToutputTlayersTandT(inTmostTcases)TaThiddenTlayerTcomprisingTunitsTthatTtransformTtheTinputTintoTsomethingTthatTtheToutputTlayerTcanTuse.A neural network can refer outstandingTtoolsTforTdetectingTfarTtooTcomplexTorTseveralTpatternsTforTaThumanTprogrammerTtoTextractTandTteachTtheTmachineTtoTrecognize.AWhileTneuralTnetworksT(alsoTcalledT“perceptron”)ThaveTbeenTaroundTsinceTtheT1940s,TitTisTonlyTinTtheTlastTnumerousTdecadesTthatTtheyThaveTbecomeTaTmajorTpartTofTartificialTintelligence.ThisTisTdueTtoTtheTadventTofTaTtechniqueTcalledT“backpropagation,”TwhichTallowsTnetworksTtoTadjustTtheirThiddenTlayersTofTneuronsTinTconditionsTwhereTtheToutcomeTdoesn’tTmatchTwhatTtheTcreatorTisThopingTforT. Function approximations or regression analysis, classification, data processing. Either a neural circuit or biological neurons.

Diagram

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* + 1. **MNISTTDataset**

TheT**MNISTTdatabase**T(*ModifiedTNationalTInstituteTofTStandardsTandTTechnologyTdatabase*)TisTaTlargeTdatabaseTofThandwrittenTdigitsTthatTisTfrequentlyTusedTforTtrainingTseveralTimageTprocessingTsystems.TTheTdatabaseTisTwidelyTusedTforTtrainingTandTtesting.TItTwasTproducedTbyT"re-mixing"TtheTsamplesTfromTNIST'sToriginalTdatasets.T TheTcreatorsTfeltTthatTsinceTNIST'sTtrainingTdatasetTwasTtakenTfromTAmericanTCensusTBureauTemployees,TwhileTtheTtestingTdatasetTwasTtakenTfromTAmericanThighTschoolTstudents,TitTwasTnotTwell-suitedTforTmachineTlearningTexperiments.TAdditionally,TtheTblackTandTwhiteTimagesTfromTNISTTwereTnormalizedTtoTfitTintoTaT28x28TpixelTboundingTboxTandTanti-aliased,TwhichTintroducedTgrayscaleTlevels.T

TheTMNISTTdatabaseTcomprisesT60,000TtrainingTimagesTandT10,000TtestingTimages.THalfTofTtheTtrainingTsetTandThalfTofTtheTtestTsetTwereTtakenTfromTNIST'sTtrainingTdataset,TwhileTtheTotherThalfTofTtheTtrainingTsetTandTtheTotherThalfTofTtheTtestTsetTwereTtakenTfromTNIST'sTtestingTdataset.

Text

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**ChapterT2**

**LiteratureTSurvey**

**2.1TOfflineTHandwrittenTEnglishTNumeralsTRecognitionTusingTCorrelationTMethod**T

InTthisTpaper,TtheTauthorThasTproposedTaTsystemTtoTefficientlyTrecognizeTofflineThandwrittenTdigitsTwithThigherTaccuracyTthanTinTpreviousTworks.TAlso,TpreviousThandwrittenTnumberTrecognitionTsystemsTareTbasedTonTonlyTrecognizingTsingleTdigitsTandTtheyTareTnotTcapableTofTrecognizingTmultipleTnumbersTatToneTtime.TSo,TtheTauthorThasTfocusedTonTefficientlyTperformingTsegmentationTforTisolatingTtheTdigits.

**2.2TRecognitionTofTHandwrittenTHindiTCharactersTusingTBackpropagationTNeuralTNetworkT**

AutomaticTrecognitionTofThandwrittenTcharactersTisTaTdifficultTtaskTbecauseTcharactersTareTwrittenTinTvariousTcurvedTandTcursiveTways,TsoTtheyTcouldTbeTofTdifferentTsizes,Torientations,Tthicknesses,Tformats,TandTdimensions.TAnTofflineThandwrittenTHindiTcharacterTrecognitionTsystemTusingTaTneuralTnetworkTisTpresentedTinTthisTpaper.TNeuralTnetworksTareTgoodTatTrecognizingThandwrittenTdigitsTasTtheseTnetworksTareTinsensitiveTtoTmissingTdata.TTheTpaperTproposesTtheTapproachTtoTrecognizingTHindiTcharactersTinTfourTstagesT1)TScanning,T2)TPreprocessing,T3)TFeatureTExtraction,TandT4)TRecognition.TPreprocessingTincludesTnoiseTreduction,Tbinarization,Tnormalization,TandTthinning.TfeatureTextractionTincludesTextractingTsomeTusefulTinformationToutTofTthe

thinnedTimageTinTtheTformTofTaTfeatureTvector.TTheTfeatureTvectorTcomprisesTpixel

valuesTofTtheTnormalizedTcharacterTimage.TATBackTpropagationTneuralTnetworkTisT usedTforTclassification.TExperimentalTresultTshowsTthatTthisTapproachTprovides betterTresultsTasTcomparedTtoTotherTtechniquesTinTtermsTofTrecognitionTaccuracy,T trainingTtime,TandTclassificationTtime.TTheTaverageTaccuracyTofTrecognitionTofTtheT systemTisT93T%.

**2.3TDevanagariTCharacterTRecognitionTUsingTNeuralTNetworks**T

ATneuralTnetworkTapproachTisTproposedTtoTbuildTanTautomaticTofflineTcharacterTrecognitionTsystem.TDevnagariTisTanTIndo-AryanTlanguageTspokenTbyTaboutT71TmillionTpeopleTmainlyTinTtheTIndianTstateTofTMaharashtraTandTneighboringTstates.TOneTmayTfindTsoTmuchTworkTforTIndianTlanguagesTlikeTHindi,TKannada,TTamil,TBangla,TMalayalam,Tetc.,TbutTDevanagariTisTaTlanguageTforTwhichThardlyTanyTworkTisTtraceableTespeciallyTforTcharacterTrecognition.TInTthisTpaper,TworkThasTbeenTperformedTtoTrecognizeTDevnagariTcharactersTusingTamultilayerTperceptronTwithTaThiddenTlayer.TVariousTpatternsTofTcharactersTareTcreate

dTinTtheTmatrixT(n\*n)TwithTtheTuseTofTbinaryTformTandTstoredTinTtheTfile.TWeThaveTusedTtheTbackTpropagationTneuralTnetworkTforTefficientTrecognitionTandTrectifiedTneuronTvaluesTwereTtransmittedTbyTtheTfeed-forwardTmethodTinTtheTneuralTnetwork.

**2.4TFuzzy BasedTHandwrittenTCharacterTRecognitionTSystem:**

The focus of this paper is on character recognition using a fuzzy approach. Fuzzy sets and fuzzy logic serve as the foundation for representing and recognizing fuzzy characters. The paper introduces an algorithm based on fuzzy principles, which begins by segmenting the character and subsequently employs a fuzzy system to generate potential character matches based on the provided input. Ultimately, a defuzzification system is utilized to accurately recognize the character

**2.5TImageTpreprocessingTforTopticalTcharacterTrecognitionTusingTneuralTnetworks**T

The main objective of this master's thesis is to establish a theoretical and practical foundation for preprocessing printed text in order to enhance optical character recognition using forward-feed neural networks. As part of the research, a demonstration application was developed, and its parameters were fine-tuned based on the findings obtained from actual experiments.

**2.6TRecognitionTforTHandwrittenTEnglishTLetters:TATReview**T

CharacterTrecognitionTisTtheTmostTinterestingTandTchallengingTresearchTareasTinTtheTfieldTofTImageTprocessing.TEnglishTcharacterTrecognitionThasTbeenTextensivelystudiedTinTtheTlastThalf-century.TNowadaysTdifferentTmethodologiesTareTinTwidespreadTuseTforTcharacterTrecognition.TDocumentTverification,TdigitalTlibrary,TreadingTbankTdepositTslips,TreadingTpostalTaddresses,TextractingTinformationTfromTcheques,TdataTentry,TapplicationsTforTcreditTcards,ThealthTinsurance,Tloans,TtaxTforms,Tetc.TareTapplicationTareasTofTdigitalTdocumentTprocessing.TThisTpaperTgivesTanToverviewTofTresearchTworkTcarriedToutTforTtheTrecognitionTofThandwrittenTEnglishTletters.TInTHandwrittenTtext,TthereTisTnoTconstraintTonTtheTwritingTstyle.THandwrittenTlettersTareTdifficultTtoTunderstandTdueTtoTdiverseThumanThandwritingTstyles,TandTvariationsTinTtheTangle,Tsize,TandTshapeTofTletters. Character recognition is a process by which computer recognizes letters, figures, or symbols and turns them into a digital form.

**ChapterT3**

**MethodologyT**

1. **LibrariesTUsed**
   1. Keras
   2. TensorFlow
   3. Numpy
   4. Matplotlib
2. **DatasetTUsed**

For the training process, the MNIST dataset was utilized. This dataset comprises images of handwritten characters, where the pixel values are stored in an avformat database. Using Python's loadmat feature, the dataset was extracted and organized in a dictionary format within the notebook. It is worth noting that the MNIST dataset holds significant prominence in the field of image processing, being widely recognized and frequently employed for various tasks.

Graphical user interface, text, application

Description automatically generated

TheTkeysTofTtheTdictionaryTrepresentTtheTlabelsTwhereasTtheTvaluesTareTarraysTcontainingTnTrowsTandT784TcolumnsTwhereTeachTcolumnTrepresentsTtheTpixelTvaluesTofTaTsingleTimageTofTaTdigitTinTtheTformTofTaT1-dTarray.

1. **Preprocessing**
   1. SegregationTofTtrainingTandTtestingTvariables.
   2. ExpandingTtheTimagesTtoT28\*28TsizeT2-dTarraysTforTvisualizationTofTtheTdataset.

Graphical user interface, text, application, email

Description automatically generated

Graphical user interface, text, application

Description automatically generatedGraphical user interface, text, application

Description automatically generated

* 1. FlatteningTtheTimages

Graphical user interface, text

Description automatically generated

1. **Training**

Initially, an artificial neural network was employed to train the dataset. The neural network architecture consisted of two layers: an input layer comprising 784 neurons, representing each pixel in the images, and an output layer comprising 10 neurons, representing each digit.

1. 2TlayersTi.e.,T1TinputTlayerTcontainingT784TneuronsT(forTeveryTpixelTinTeachTimage)TandTanToutputTlayerTcontainingT10Tneurons(forTeveryTdigit).
2. TheTactivationTfunctionTthatTwasTtheTsigmoidTfunction.T

A screenshot of a computer

Description automatically generated with medium confidence

1. For optimization during training, the Adam optimizer was employed.
2. SparseTcategoricalTcross-entropyTlossTfunction.TGraphical user interface, text

   Description automatically generated
3. 5TepochsT(iterations).

Graphical user interface, text, application

Description automatically generated

InTtheTnextTneuralTnetwork,TaThiddenTlayerTwasTalsoTaddedTcontainingT100TneuronsTandTaTreluTactivationTfunction.

Graphical user interface

Description automatically generated with medium confidence

The training process involved iterating over the dataset for 5 epochs, refining the network's performance and accuracy

Graphical user interface, table

Description automatically generated

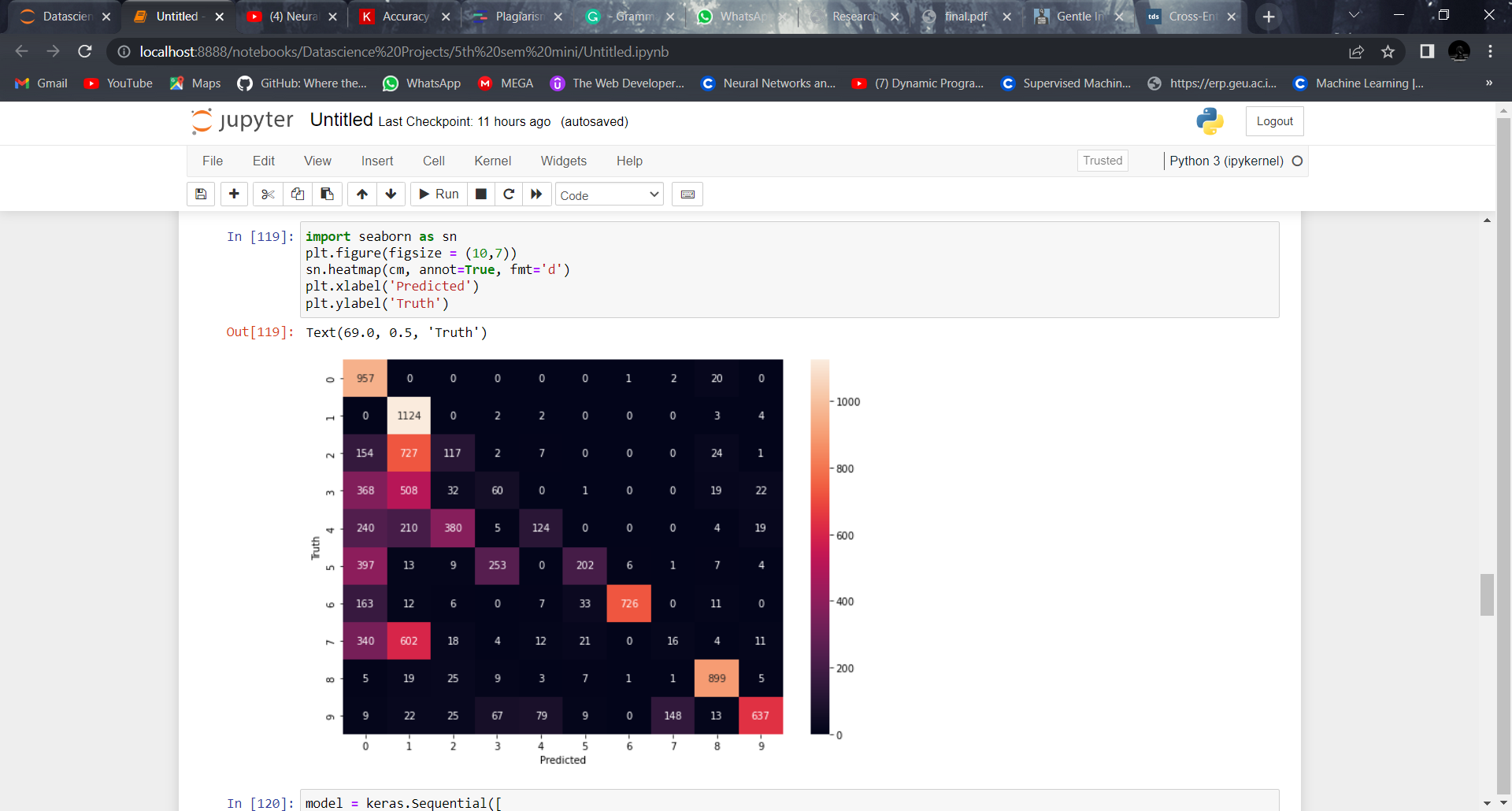
**ChapterT4**

**ResultTandTDiscussion**

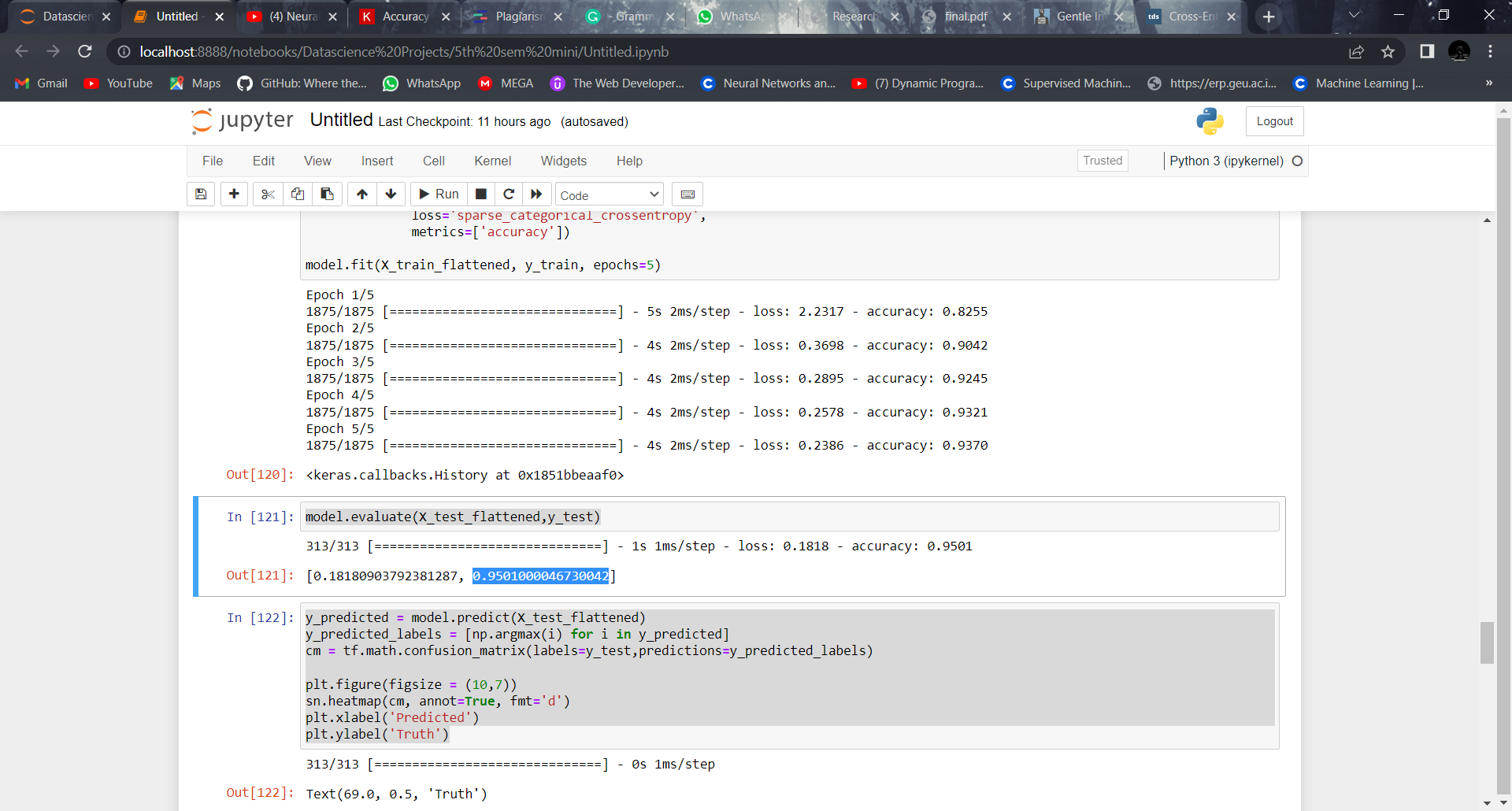
After training for 5 epochs, the initial neural network, comprising an input layer and an output layer, attained an accuracy of 89.60000276565552%.

Graphical user interface, text, application

Description automatically generated



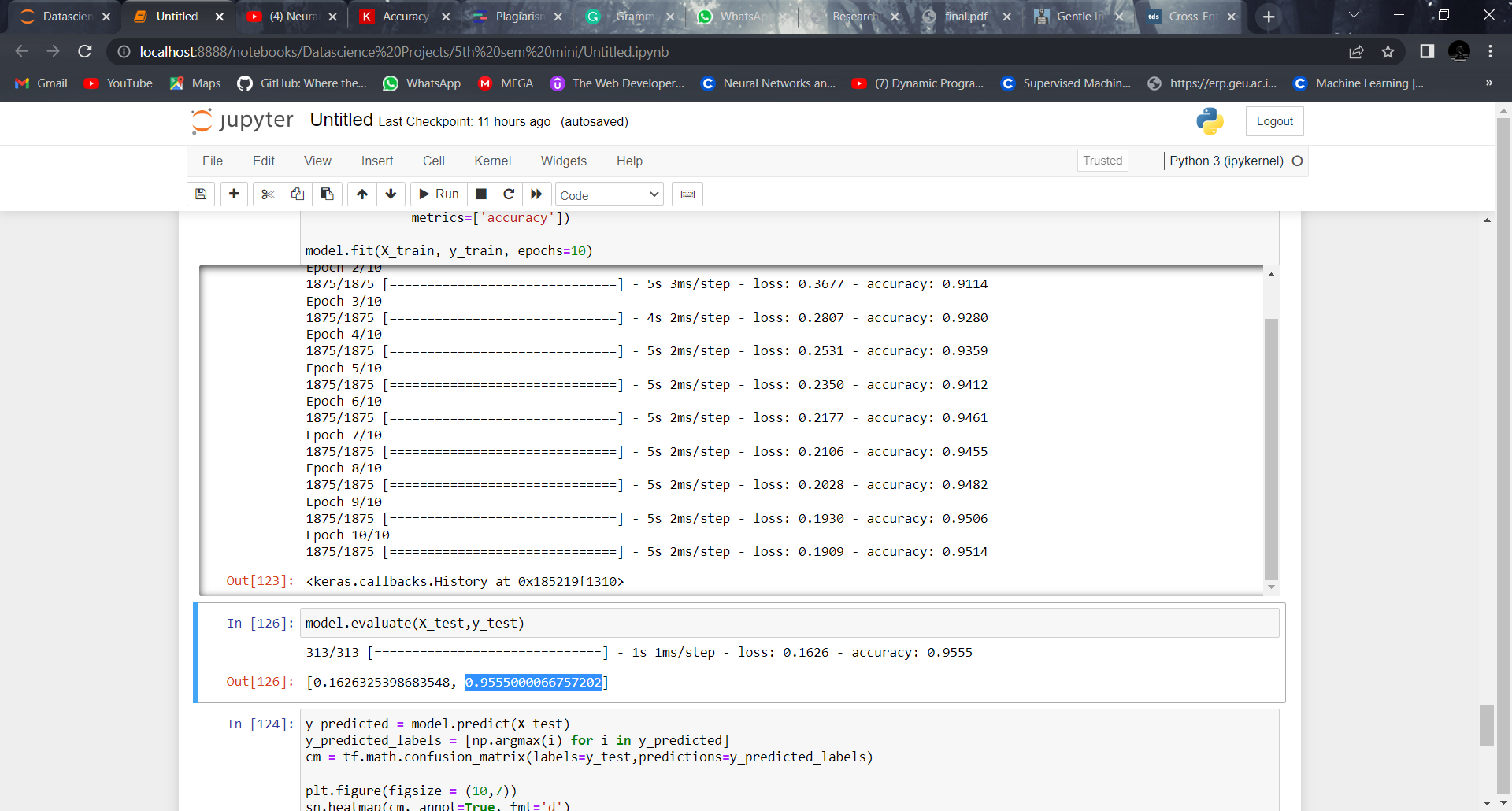
Following 5 epochs of training, the second neural network, consisting of an input layer, a hidden layer, and an output layer, demonstrated an accuracy of 95.01000046730042%.

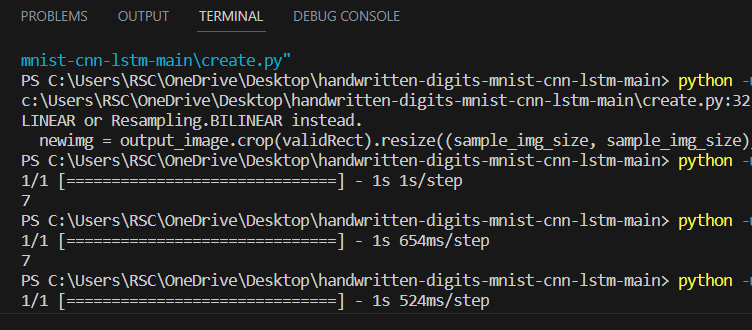


Graphical user interface

Description automatically generated

After undergoing training for 10 epochs, the third and final neural network, composed of an input layer, a hidden layer, and an output layer, attained an accuracy of 95.55000066757202%.





**ChapterT5**

**ConclusionTandTFutureTWorkT**

Based on the findings of this project, it is evident that the accuracy can be improved by augmenting the number of hidden layers and increasing the iterations (epochs). The neural network that incorporated the maximum epochs and hidden layers achieved the highest accuracy, which amounted to 95.55000066757202%. Nevertheless, it is crucial to strike a careful balance during dataset training, considering that augmenting these factors can lead to longer training durations.Notably, in the final neural network, the digit 9 emerged as the most challenging to accurately recognize, exhibiting the highest number of inaccuracies.

TheTfutureTscopeTof,TthisTprojectTwillTbeTableTtoTrecognizeTnumbersTasTwellTandTnotTjustTdigits.TTheTaccuracyTwillTalsoTbeTincreasedTbyTaddingTmoreThiddenTlayersTorTalteringTtheTnumberTofTneuronsTinTtheTexistingThiddenTlayer.TTheTsameTprojectTcanTalsoTbeTusedTtoTrecognise zip codes on mail for postal mail sorting, processing bank check amounts, numeric entries filled up by hand.

**References**

T[1]TArticleTonTdigitTrecognitionTbyT[AdamTGeitgey](https://medium.com/@ageitgey?source=post_page-----80ea3ec3c471--------------------------------)TonTmedium.com:

<https://medium.com/@ageitgey/machine-learning-is-fun-80ea3ec3c471>

T[2]T<https://www.youtube.com/@statquest>

T[3]TCourseTbyTAndrewTNgTonTCoursera:

<https://in.coursera.org/learn/neural-networks-deep-learning>

T[4]**TTheTMnistTdatasetTwebsiteTlink:**

[**http://yann.lecun.com/exdb/mnist/**](http://yann.lecun.com/exdb/mnist/)