GALGOTIAS UNIVERSITY
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Handwritten Digit Recognition using Computer Vision

A Report for the Evaluation 3 of Project 2

Submitted by

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Bachelor of Technology
IN
Computer Science and Engineering With Specialization of Data Analytics

SCHOOL OF COMPUTING SCIENCE AND ENGINEERING

Under the Supervision of
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Abstract:

Machine learning and deep learning plays an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing , learning, predictions and many more areas. This project presents recognizing the handwritten digits (0 to 9) from the famous MNIST dataset.

Machine learning gives the computer an abilityto learn from past data and make predictions about the future. It is the mosthot area right now with great career prospects.

In this project, I will learn about various machine learning algorithms and develop a machine learning model to recognize handwritten digits using MNIST data. This project will be my first application towards, using machine learning in computer vision.

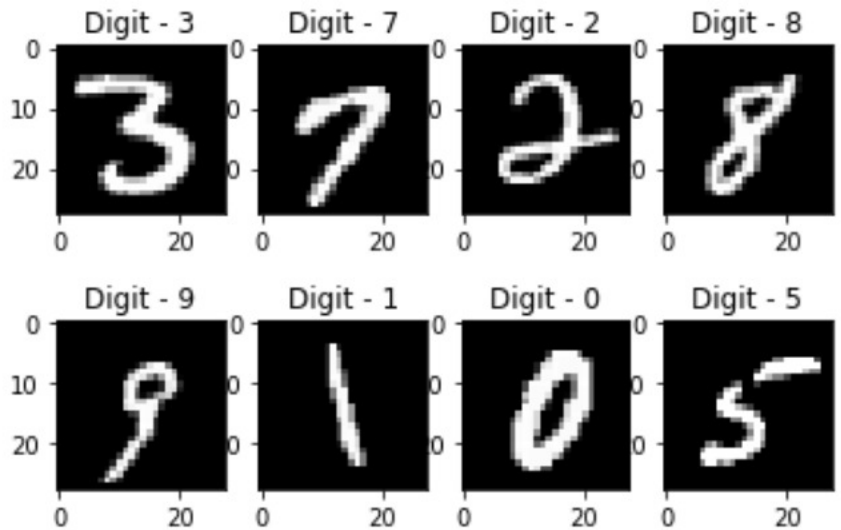
By developing this project I will learn about:

1. Mean Squared Error Function
2. Linear Regression & its types
3. Deep Learning
4. Neural Networks
5. Tensorflow & Keras Libraries

INTRODUCTION:

I. Overall Description:

Machine learning and deep learning plays an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and many more areas. This article presents recognizing the handwritten digits (0 to 9) from the famous MNIST dataset, comparing classifiers like KNN, PSVM, NN and convolution neural network on basis of performance, accuracy, time, sensitivity, positive productivity, and specificity with using different parameters with the classifiers.



II. Purpose

Handwritten digit recognition has gained so much popularity from the aspiring beginner of machine learning and deep learning to an expert who has been practicing for years. Developing such a system includes a machine to understand and classify the images of handwritten digits as 10 digits (0–9). Handwritten digits from the MNIST database are already famous among the community for many recent decades now, as decreasing the error rate with different classifiers and parameters along with preprocessing techniques from 12% error rate with linear classifier (1 layer NN) to achieving 0.23% error rate with hierarchy of 35 convolution neural networks [Yann LeCun, MNIST database of handwritten digits]. The scope of this article is to compare the different classifiers with different parameters and try to achieve near-human performance.

III. Scope

Digit recognition system is the working of a machine to train itself or recognizing the digits from different sources like emails, bank cheque, papers, images, etc. and in different real-world scenarios 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 (say — tax forms) and so on

MNIST DATASET

- Samples provided from MNIST (Modified National Institute of Standards and Technology) dataset includes handwritten digits total of 70,000 images consisting of 60,000 examples in training set and 10,000 examples in testing set, both with labeled images from 10 digits (0 to 9). This is a small segment form the wide set from NIST where size was normalized to fit a 20*20 pixel box and not altering the aspect ratio. Handwritten digits are images in the form of 28*28 gray scale intensities of images representing an image along with the first column to be a label (0 to 9) for every image. The same has opted for the case of the testing set as 10,000 images with a label of 0 to 9.
- Yann Lecun, Corinna Cortes, and Christopher Burges developed this MNIST dataset for evaluating and improving machine learning models on the handwritten digit classification problem.

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Available files in the dataset

So, before starting further deep in this topic, the better point should be to get familiar with the provided dataset. Following points are same in training and testing set along with the set of the images and labels files –

- Pixels are arranged row-wise, ranging from 0 to 255, as from RGB color code.
- Background as white (0 value from RGB) and foreground as black (255 value from RGB).
- Labels of digits classified from 0 to 9.

There are four files of training and testing are:

Training set images files (train-images-idx3-ubyte)
Training set labels file (train-labels-idx1-ubyte)
Test set images files (t10k-images-idx3-ubyte)
Test set label files (t10k-labels-idx1-ubyte)

Literature Survey:

CLASSIFIERS

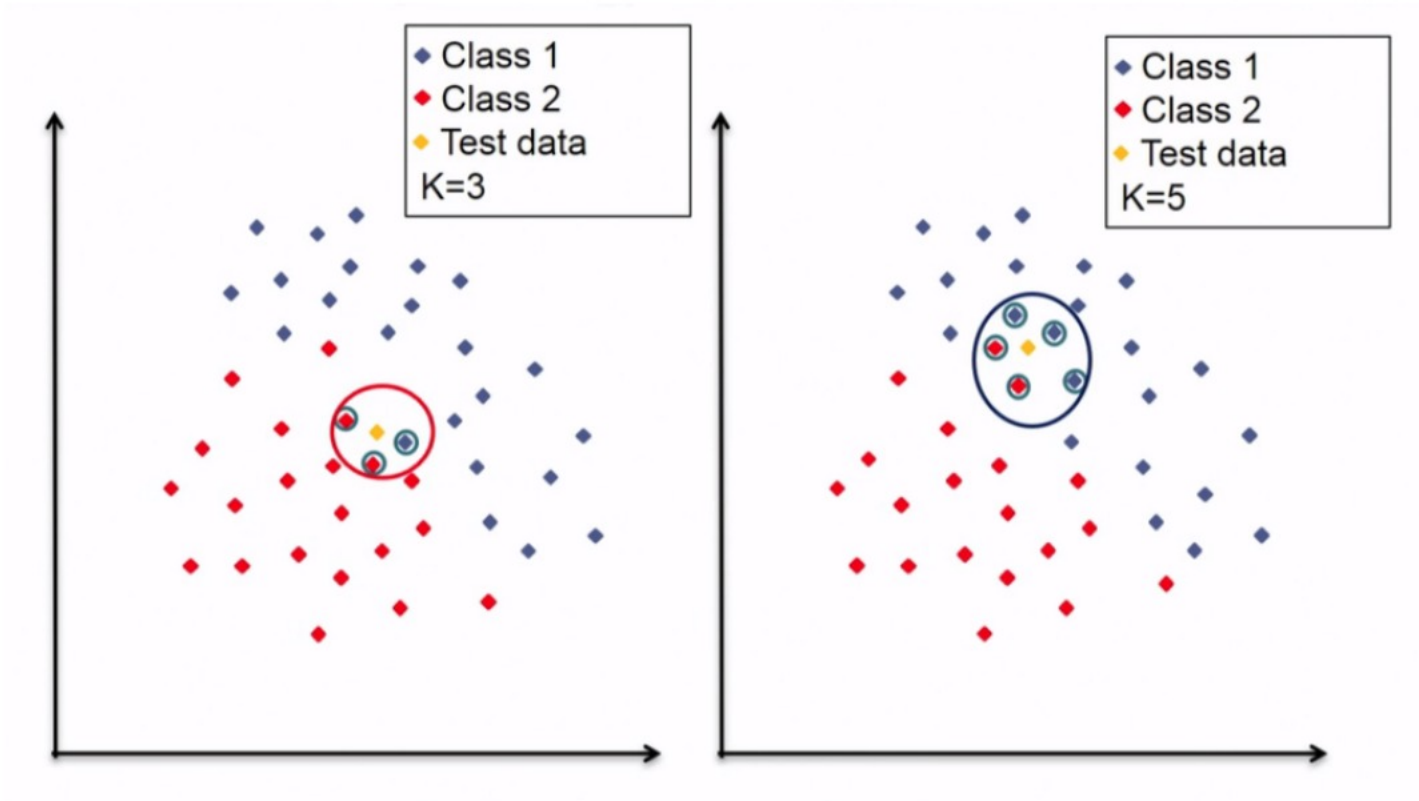
In this section, we will be discussing various algorithms of machine learning and deep learning for making predictions and accuracy. Classifiers in machine learning –

- **KNN (K nearest neighbors)**

KNN is the non-parametric method or classifier used for classification as well as regression problems. This is the lazy or late learning classification algorithm where all of the computations are derived until the last stage of classification, as well as this, is the instance-based learning algorithms where the approximation takes place locally. Being simplest and easiest to implement there is no explicit training phase earlier and the algorithm does not perform any generalization of training data.
The direct solution would be when these are nonlinear decision boundaries between classes or when the amount of data is large enough. Input features can be both qualitative and quantitative in nature. Whereas output features can be categorical values which are typical classes seen in data.
KNN explains categorical value using majority votes of K nearest neighbors where the value for K can differ, so on changing the value of K, the value of votes can also vary.

Algorithm

1. Compute the distance metric between the test data point and all labeled data points.
2. Order the labeled data points in increasing order of distance metric.
3. Select the top K labeled data points and look at class labels.
4. Look for the class labels that majority of these K labeled data points have and assign it to test data points.



Distance Functions

Different distance functions used in KNN are-

1. Euclidean function
2. Manhattan function
3. Minkowski
4. Hamming distance
5. Mahalanobis distance

Distance functions

Euclidean $\sqrt{\sum_{i=1}^{k}(x_i - y_i)^2}$

Manhattan $\sum_{i=1}^{k}|x_i - y_i|$

Minkowski $\left(\sum_{i=1}^{k}(|x_i - y_i|)^q\right)^{1/q}$

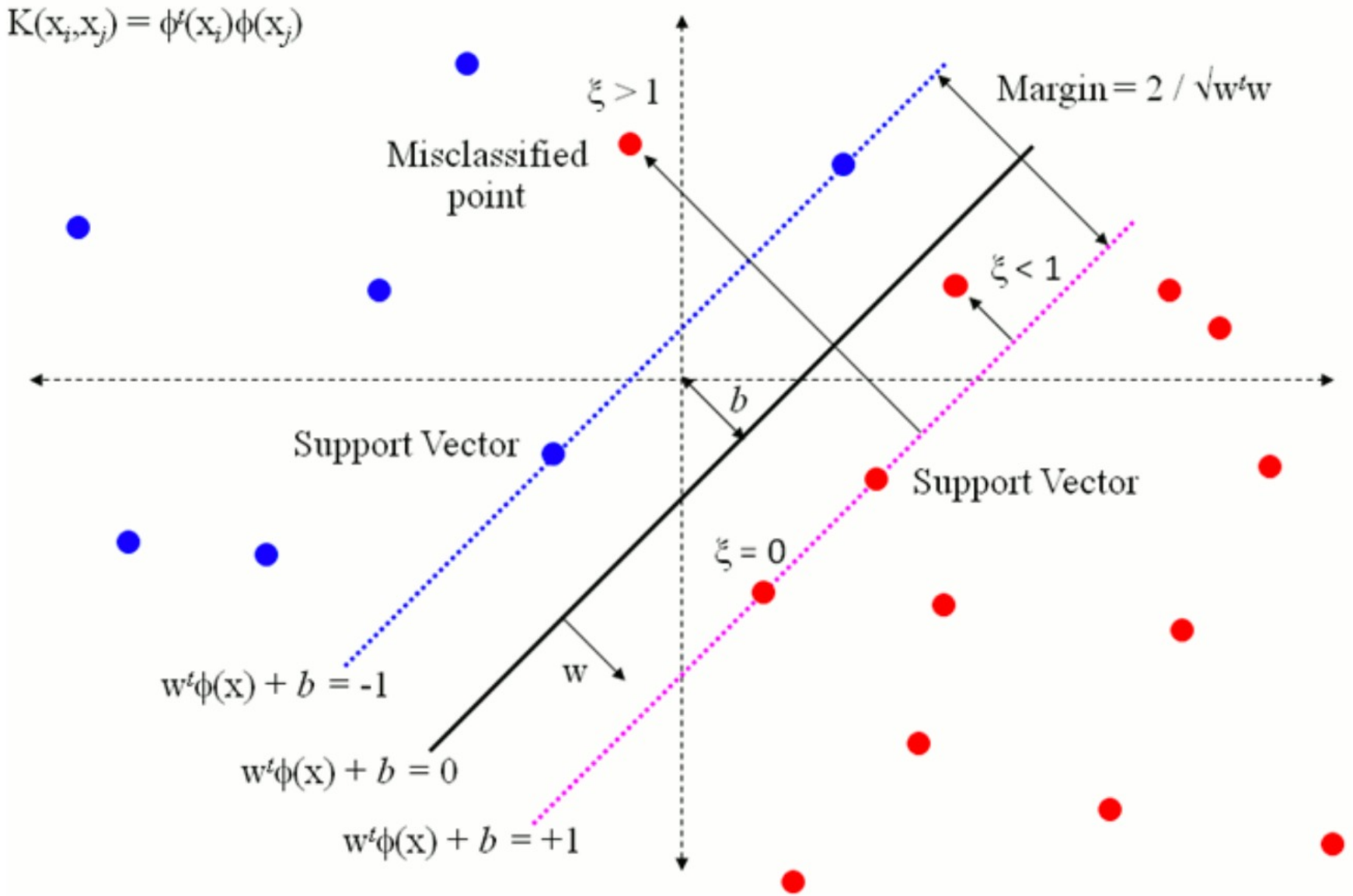
❖ SVM (Support Vector Machine)

SVM falls into the category of supervised learning, and with the bonus of classification as well as regression problems. Generally, SVM draws an optimal hyperplane which classifies into different categories. In two dimensional space, To start with we plot the data points of the independent variable corresponding to the dependent variables. Then, begin the classification process from looking the hyperplane or any linear or nonlinear plane differentiated the two class at its best.

Algorithm

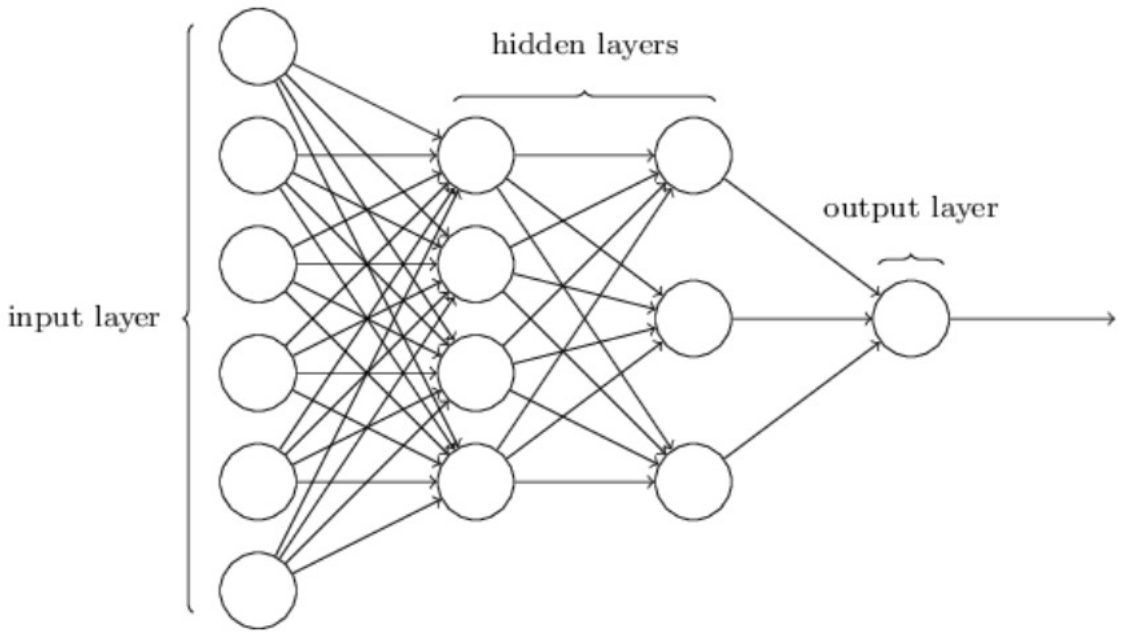
First understand, in the case of binary classification:

1. Identify the correct hyperplane which segregates the two classes better.
2. Look for the maximum distance between nearest data point (of either any class) and hyperplane, the distance is measured as margin. So look for hyperplane with maximum margin both sides equally. Hyperplane with higher margin is more robust, whereas low margin has changed for misclassification.
3. SVM selects the classifier accurately to maximized margin.
4. SVM is robust to the classifier and have a feature to ignore outliers and try to look for a hyperplane with maximum margin.


$K(x_i,x_j) = \phi^t(x_i)\phi(x_j)$
$\xi > 1$
Misclassified point
Margin = $2 / \sqrt{w^t w}$
$\xi < 1$
b
Support Vector
Support Vector
$\xi = 0$
w
$w^t\phi(x) + b = -1$
$w^t\phi(x) + b = 0$
$w^t\phi(x) + b = +1$

❖ NN (Neural networks)

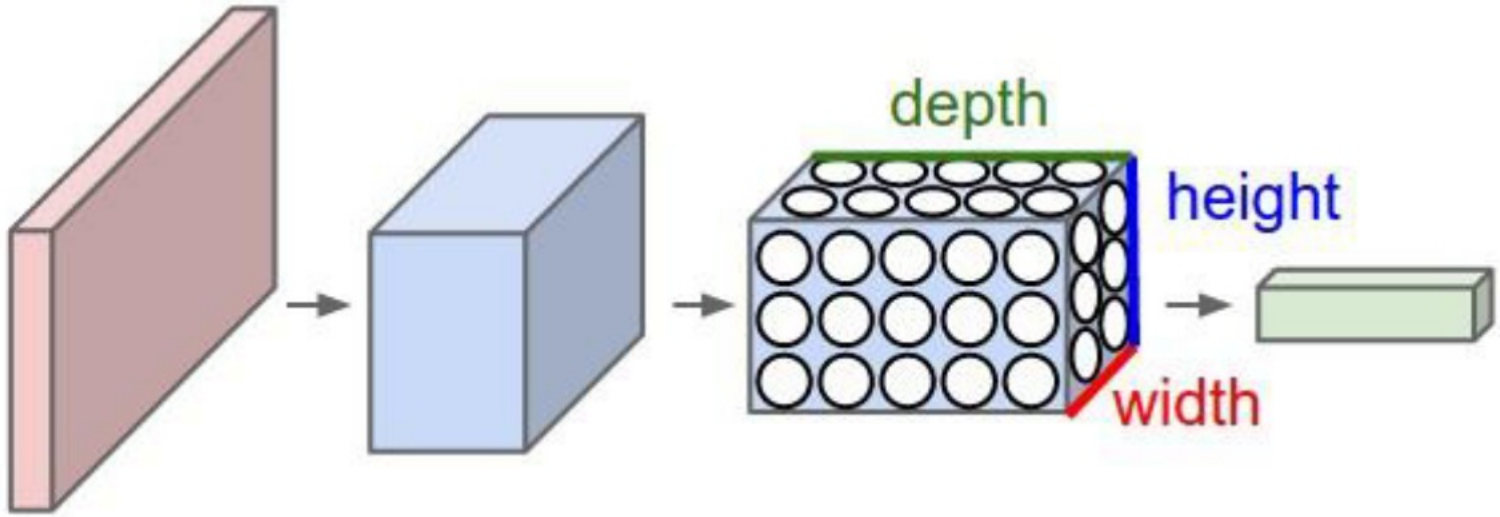
Neural Networks mimics the working of how our brain works. They have emerged a lot in the era of advancements in computational power.



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.

❖ CNN (Convolutional 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.



Use of CNN have spread as Facebook uses neural nets for their automatic tagging algorithms, google for photo search Amazon for their product recommendations, Pinterest for their home feed personalization and Instagram for search infrastructure. Image classification or object recognition is a problem is passing an image as a parameter and predicting whether a condition is satisfied or not (cat or not, dot or not), or the probability or most satisfying condition for an image. We are able to quickly recognize patterns, generalize from previous information and knowledge.

Software Requirement specification

- **Operating System:**
  - Windows 10
- **Language:**
  - Python
- **Visualization Tool:**
  - Visual Studio Code

Output /Screenshots :

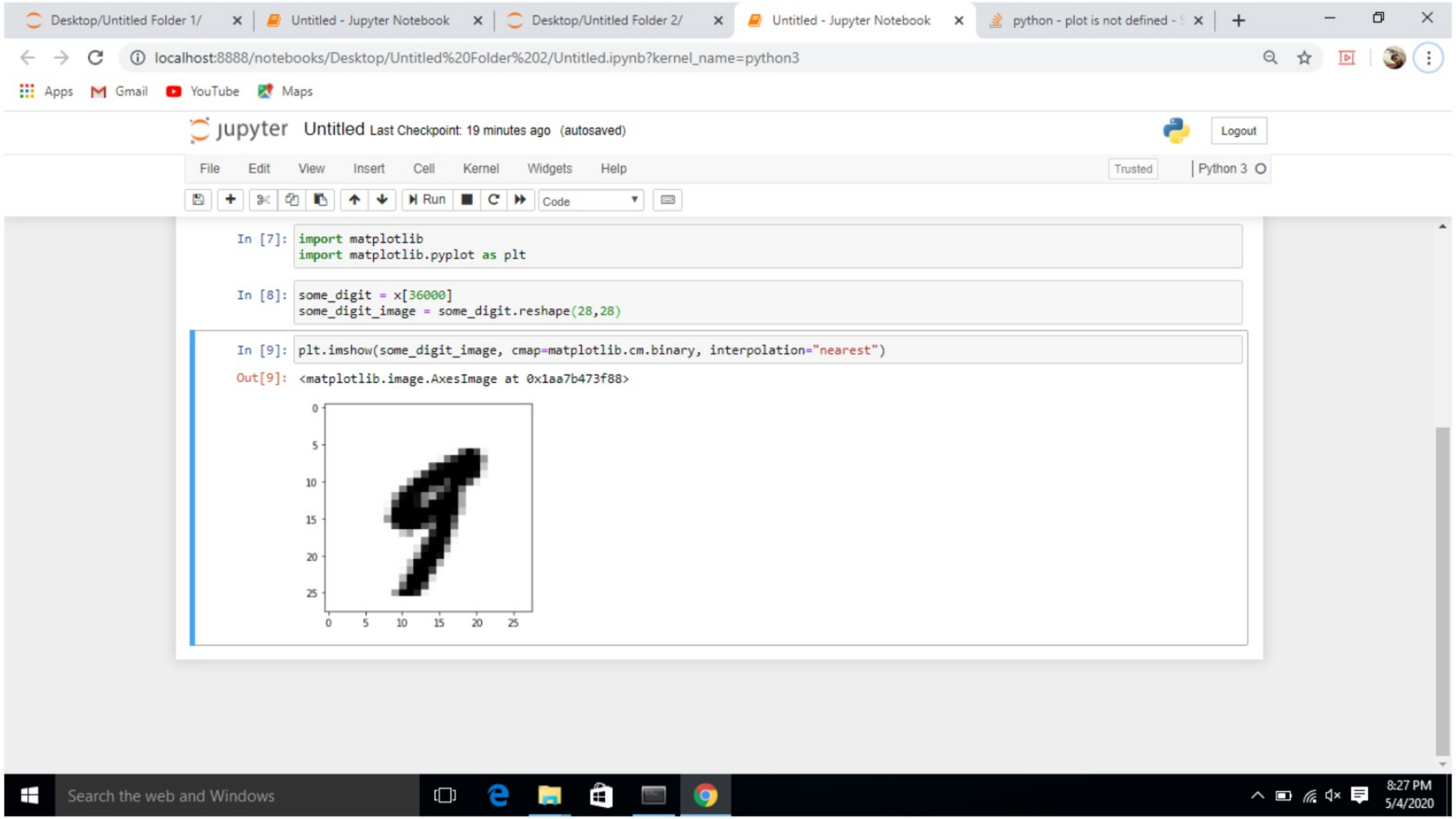


Fig 1. digit image of 9 where x[36000] as shown in figure

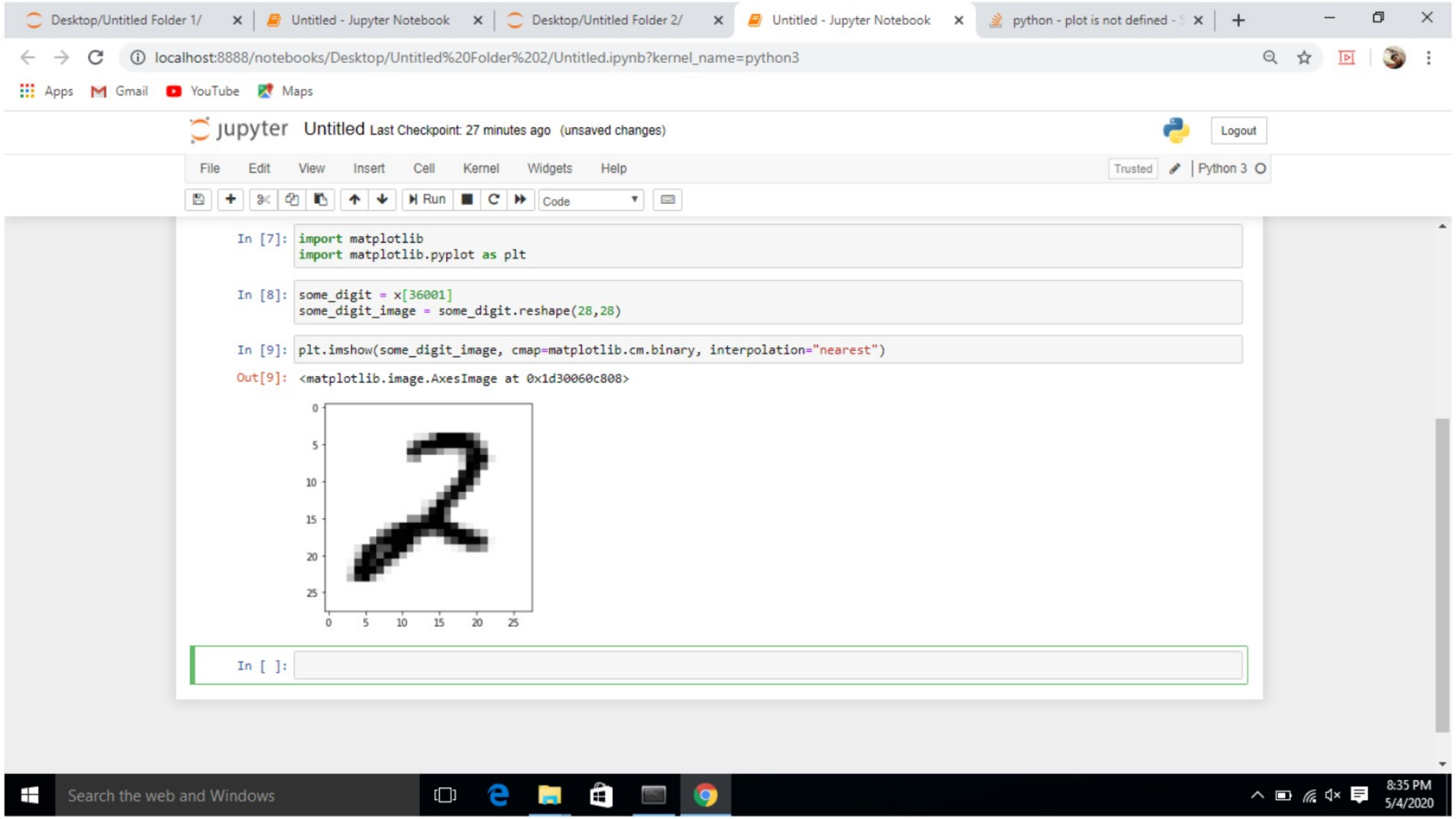


Fig 2. digit image of 2 where x[36001] as shown in figure

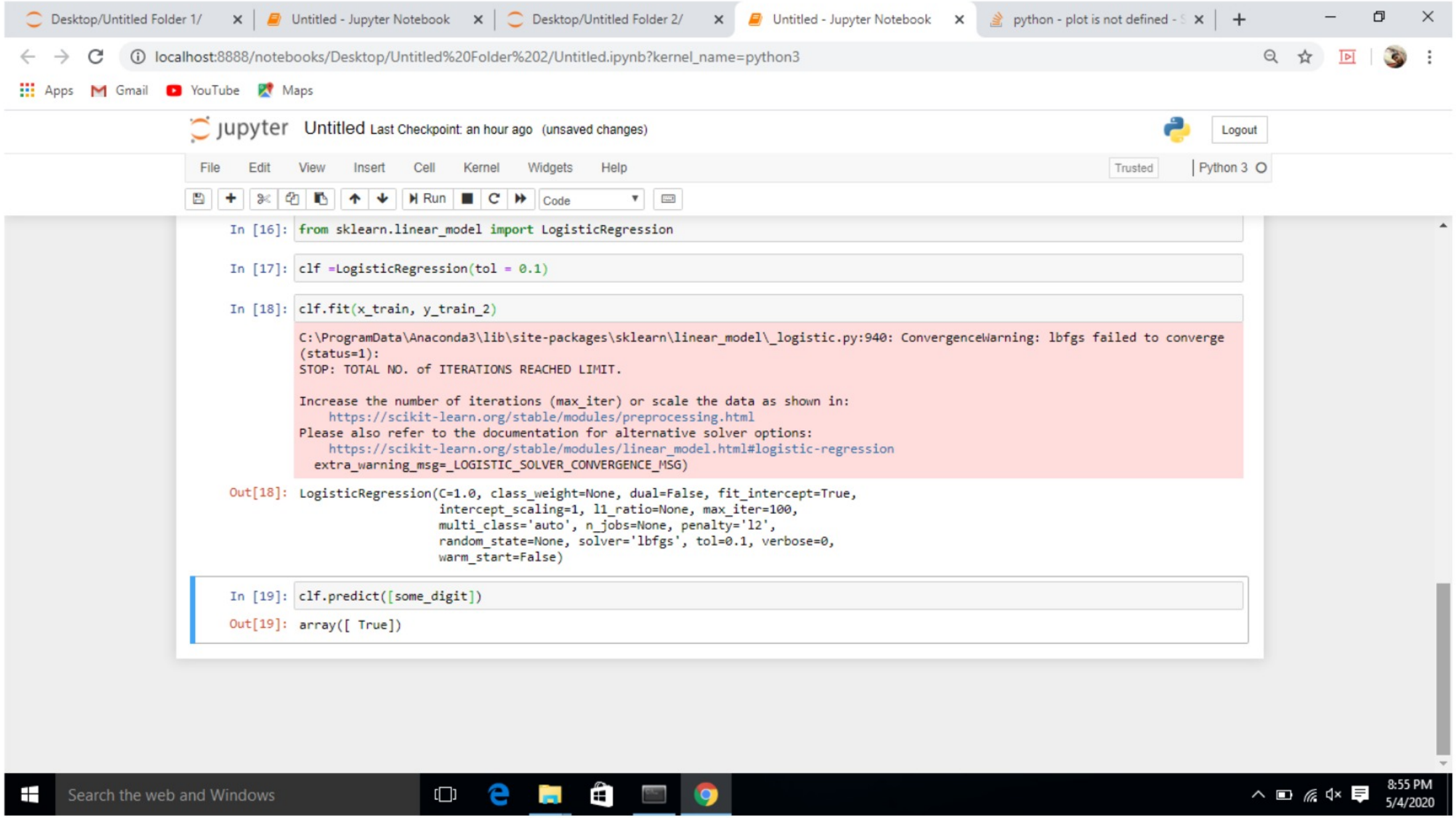


Fig 3. Used binary classifier Logistic Regression of 2 dectector data from 0 to 9 digit too True or False .Here its shown True where y_train_2

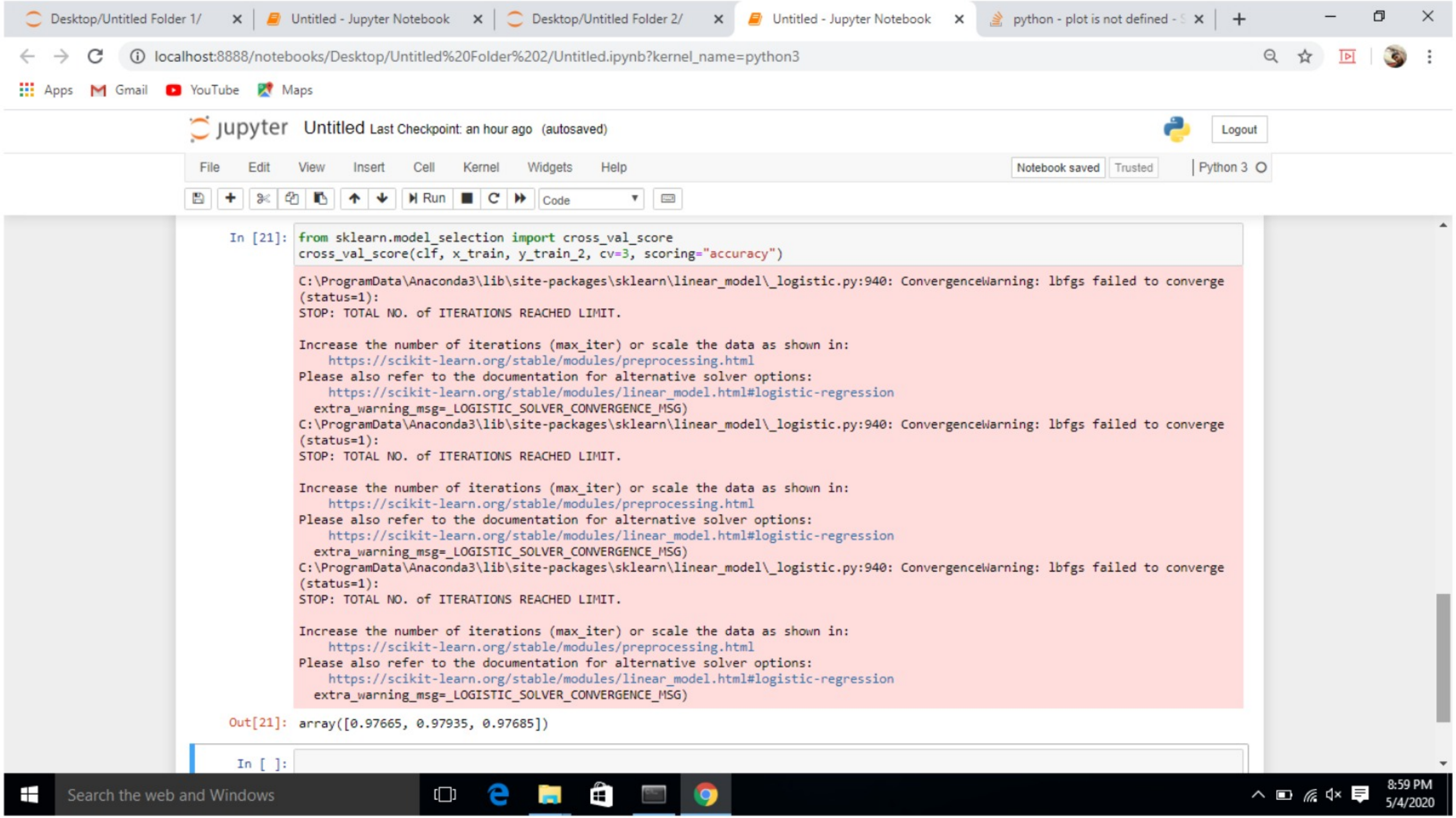


Fig 4. Here we used cross validation process to see the acurracy of x_train and y_train_2

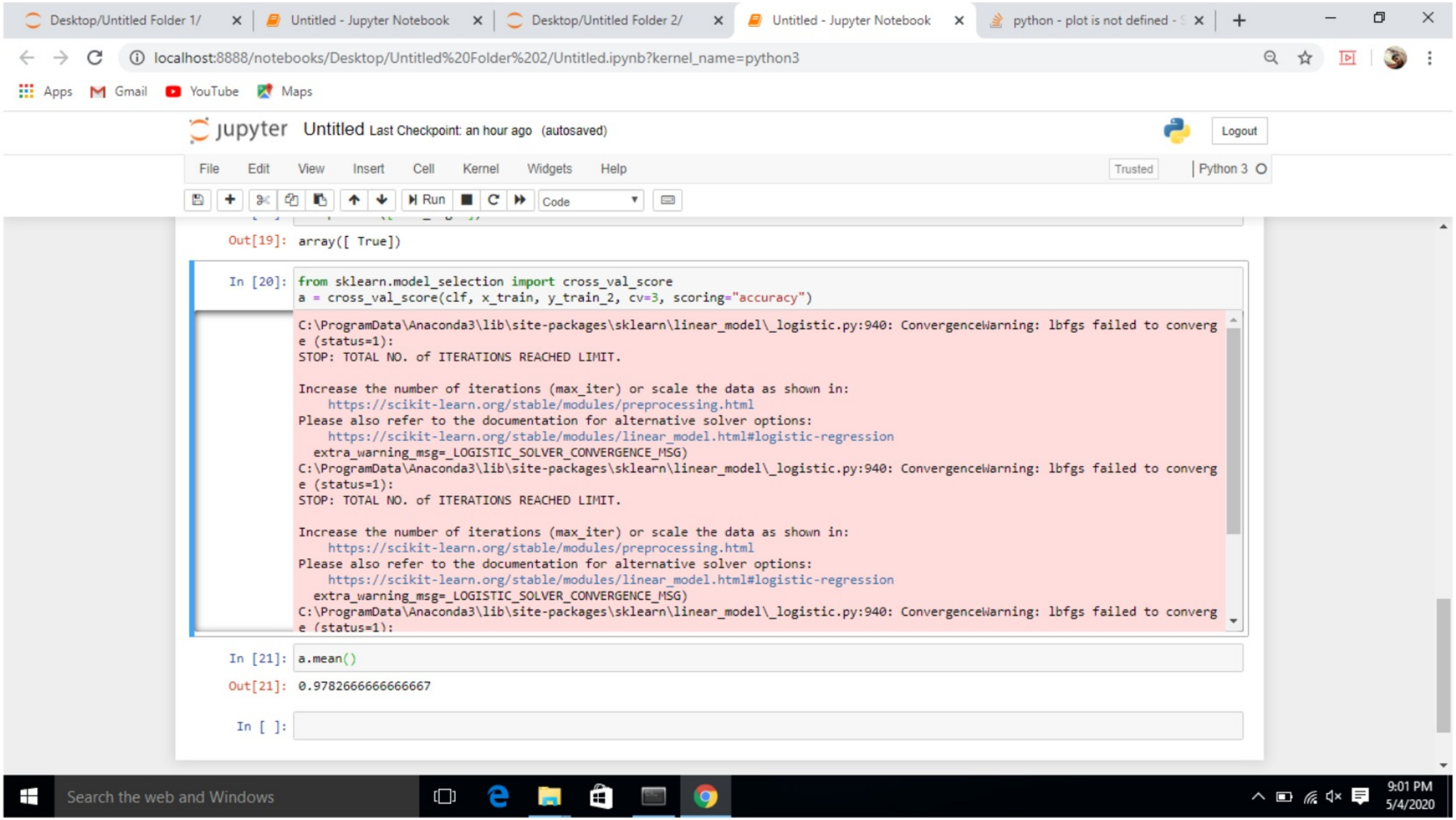


Fig 4. Here we shown the mean acurracy of 2 digit.That is [0.9782500000000001]

Conclusion/Future Enhancement :

In this article, we have successfully built a Python deep learning project on handwritten digit recognition app. We have built and trained the Convolutional neural network which is very effective for image classification purposes using Kernel Library. Later on, we build the GUI where we draw a digit on the canvas then we classify the digit and show the results.
As a general conclusion, we can see how during two decades, there has been no significant changes in the artificial intelligence techniques used for computer vision. Indeed, most of the merit of the good performance can be attributed instead to hardware improvements, which has eventually led to more complex architectures and the ability to deal with higher amounts of data. Still, some works are proposing novel developments or improvements, which are often combined with convolutional neural networks, reporting outstanding results.Although accuracy in MNIST is very close to 100% and will hardly increase, these novel developments might hold the key for breaking more complex computer vision problems.

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BONAFIDE CERTIFICATE

Certified that this project report **"HANDWRITTEN DIGIT RECOGNITION USING COMPUTER VISION"** is the bonafide work of **"ASHISH SHEKHAR (1613112012)"** who carried out the project work under my supervision.

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