



Cloud Computing

Implementation of Machine learning with Google cloud platform

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Anish joys yesuadimai michael

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1 Introduction

Cloud computing is a very hot and booming topic in the current era, lots of companies have already moved to cloud computing technologies and many companies are urging to move to cloud. There are lots of service providers for cloud like amazon web services, microsoft azure, google cloud, IBM cloud, oracle, salesforce. SAP etc. But the key players are AWS, azure and google cloud. Google cloud platform is Google's cloud. Similar to AWS and Azure, Google Cloud also offers similar services in various categories, including compute, storage, identity, security, database, AI and machine learning, virtualization, DevOps and many other technologies.

1.1 Motivation

The world is moving or has already moved towards cloud computing. The most important properties of cloud computing includes scalability, reliability, virtualisation and affordability. Cloud computing is one of the most advanced and secure systems to protect the data and information in the cloud. It was very much common in past days to store data and information through a manual process or in the hard drive of the computer. It is also very much difficult to recover the complete data and information once it gets lost or stolen. Now it is the safest and most advanced option to secure the data and information related to the business terms without any fear. There are many trusted cloud solutions providers you will surely get around to whom you can get the best cloud computing services to store your data and information securely on the cloud. Here you will also get to know about the benefits of getting cloud computing services. Data and information is the most important part of every business and it would be the best option to make sure that the relevant data is secure and protected. Hence cloud computing is the best solution to achieve the same.

1.2 Purpose

Increase in the flexibility of storage - Storage is the main requirement for any digital organisation and it is always incremental. If the company maintains a server, when its storage is over then they have to buy a new server, look for space, infrastructure and maintenance. But in terms of cloud the organisation need not work on the infrastructure and maintenance, just buy more space from the vendor. And most importantly storage can be extended immediately. So cloud storage is highly flexible.

Easy access and Data recovery - Storage data in local or some external devices privately may lead to loss of data in case if the device is lost or stolen, this can be very dangerous. But storing data in the cloud helps us recover data easily and securely.

Secure and protected - There might be lots of data which should be kept safe from breach and malware. Cloud providers provide lots of services by keeping the data safe from malicious factors and anonymous access.

No maintenance - Normally for private servers, the organisation needs to maintain the servers but in the cloud the organisation need not worry about maintenance, the service providers take complete responsibility.

Easy to share information - Through the cloud you can easily share data to any person and can ensure that the data is not shared with any anonymous person. Through cloud service, you can easily share your data through the secure network to anyone you want. There are many possibilities to share your data without any fear to anyone by sharing the relevant link to the concerned person. It will save the data from any type of malware and nobody can enter your privacy without authentication.

1.3 The aim of the work

The aim of using Google cloud platform in our project is to understand the architecture of the cloud computing platform, to understand some of the key components used, test the features and also deploy applications. In our project we planned to deploy a machine learning algorithm in GCP. For this we made a machine learning model to identify the number given as an image. We used python for achieving this task. GCP has a datalab platform which supports the usage of programming language python and deploying a machine learning model using python. Now the model is ready so we deployed an app which provides an option to upload an image, this was done in php. For our project we have created two virtual machines. One for deploying the machine learning model and another to deploy the application for uploading an image. These two virtual machines are designed to communicate with each other. Thus we have used Google cloud platform to develop and deploy a machine learning model and also have achieved it successfully. The structure or the architecture of our project is clearly described in the following image(Figure 1.1).

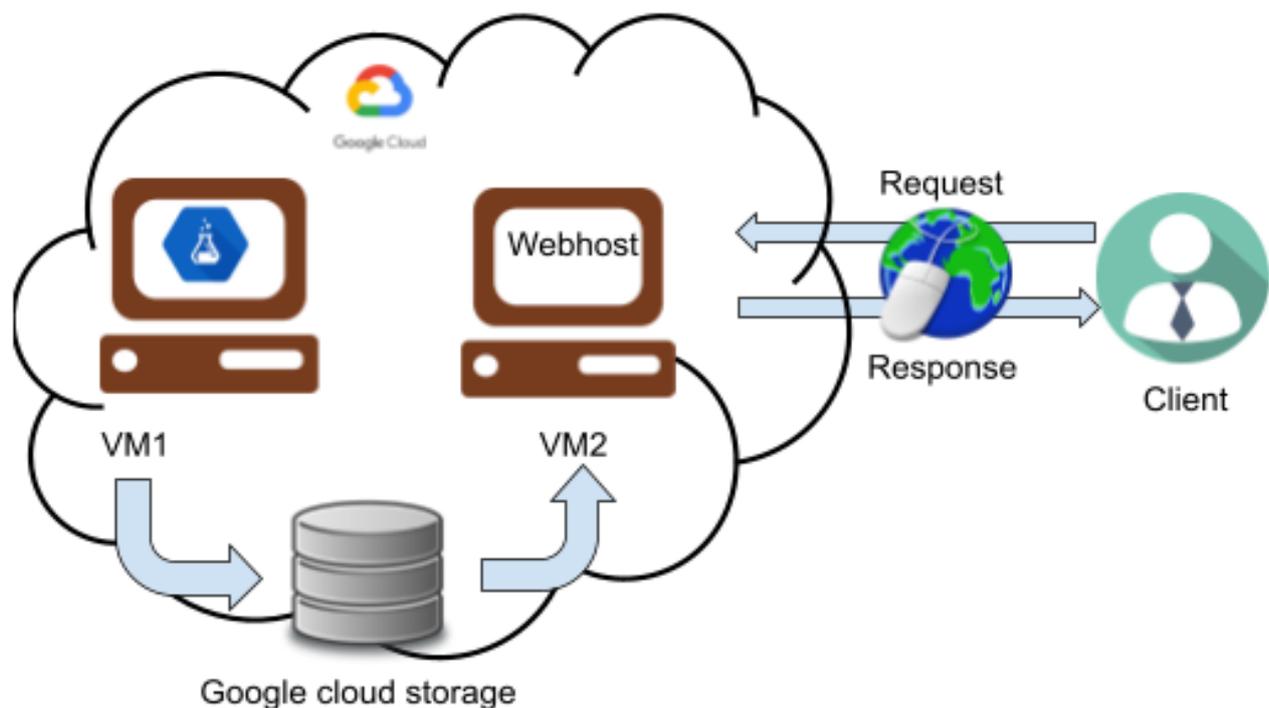


Figure 1.1 Schema of Projects

Now describing the mnist database, mnist is the set of data used in our machine learning algorithm to train the model and help in finding the number from the handwritten number images. Mnist(Modified National Institute of Standards and Technology) database has a huge set of handwritten digits which can be used for training and testing any machine learning models and also for improving and testing image processing systems. The database consists of many sets of

digits in black and white image formats and with a fixed resolution of 28x28 pixel. The mnist dataset has 60,000 training images and 10,000 testing images. We have successfully trained our machine learning model using this mnist dataset. (Dato, 2019)

2 Fundamental

As we know that cloud computing model consists of front end and backend elements connected through the internet. Front end comprises the client devices, applications or interface that connect to the backend or cloud features. There are lots of providers who provide these cloud computing services. In our project we have used Google cloud computing services, where we have implemented our machine learning model.

2.1 Google Cloud

Google cloud is a cloud computing service suite provided by Google. It provides various services like machine learning, data storage and analytics. The registration needs a credit card or bank details but Google does not debit money automatically. This bank details verification is made to stop the misuse of the resources by the bots and dummy account holders. The Google Cloud Platform (GCP) is the public cloud platform from Google that serves as a collection of IaaS and PaaS services to provide consumers a highly stable and reliable on-demand service.

Google cloud services are well established for the modern developers to develop stable applications and publish them across the globe. GCP provides many features as a service in the Big Data analytics, artificial intelligence, and containerization spaces. Google's first venture into cloud computing was with Google App Engine, launched in April 2008 as a Platform as a Service (PaaS) feature. It has made it easy for developers to build and host apps on Google's infrastructure. In September 2011, App Engine came out of preview, and in 2013 the Google Cloud Platform name was formally given. After the official launch of Google cloud platform the company developed and launched a wide range of tools, such as its data storage layer, Cloud SQL, BigQuery, Compute Engine, and many other features thereby making Google cloud platform more optimistic and solid platform to work with.

The GCP IaaS resources also have a series of physical hardware infrastructure like computers, hard disk drives, solid state drives, and networking that is contained within Google's globally distributed data centers. This hardware is available in a nutshell as a service online to all the global customers in the form of virtualized resources, such as virtual machines (VMs). There are a lots of tools or features that are used to build up the GCP as a product or suite to the users some of the important ones are listed below: (Navin & Piyush, 2021) The following table 2.1 describes the various GCP services.

Services	Description
Google Compute Engine	Helpful in the creation of multiple virtual machines with an operating system in it and also allows to create various computers in the cloud.
Google Kubernetes Engine	Helpful in managing Container Orchestrator, also aids to deploy, scale, and release with the help of Kubernetes in the form of managed service.
Google Cloud Function	Helpful in implementing an event-driven serverless cloud platform and aids in creating infrastructure as code (i.e., infrastructure which is designed and implemented by the code).

Google Container Registry	Allows a very secure, private Docker image storage on GCP. It makes way for a unique platform for the teams to manage Docker images, perform vulnerability analysis, and manage who can access what information with fine-grained access control.
Google Stackdriver (now Google Operations)	It is helpful in delivering performance and diagnostics data to public cloud users and also serves as a hybrid cloud solution for Google cloud and AWS.

Table 2.1 Services and descriptions

2.2 Machine Learning

Machine learning is a part of artificial intelligence, where the problem is solved by considering the historical examples or previous examples. In contrast to artificial intelligence is machine learning. This is capable of finding hidden patterns within the data. It is used for predictions in the future. (Michael W., Azlinah H, & Wah , 2018)The practical implementation of machine learning is done by algorithms. Usually, different machine learning algorithms can be divided into three categories: Supervised learning, unsupervised learning and reinforcement learning. Another category is the so-called 'semi-supervised learning'. Semi-supervised learning is an approach to machine learning in which, during training, a small amount of labeled data is combined with a large amount of unlabeled data.

Semi-supervised learning falls between unsupervised learning (no labels of the training data) and supervised learning (using only labels of the training data). When non-label data is used in conjunction with a small amount of label data, a significant improvement in learning accuracy is achieved. Acquiring labeled data for a learning problem often requires a skilled human agent (e.g., to transcribe an audio segment) or a physical experiment (e.g., to determine the 3D structure of a protein or whether oil is present at a particular location).The costs associated with the labeling process may therefore make large, fully labeled training sets infeasible, while collecting unlabeled data is more cost-effective. In such situations, semi-supervised learning can have great practical value. Semi-supervised learning also has a theoretical interest in machine learning and also serves as a model for human machine learning and in Figure 2.1 is shown difference types of machine learning.

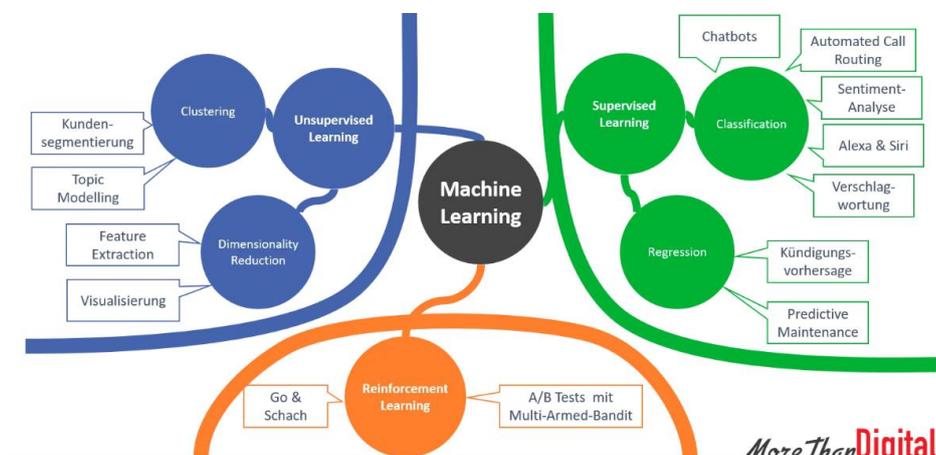


Figure 2.1 Types of Machine learning(<https://morethandigital.info>)

2.2.1 Supervised Learning

Supervised learning is a method that attempts to estimate a relationship between input parameters (independent parameters) and output (target). The discovered relationship is called a mathematical method. Usually, the model describes phenomena hidden in the data set. Thus, the output of a data set can be predicted when the output is unknown. Supervised learning can be used in a variety of domains. (Rokach & Maimon, 2005) It is useful to distinguish between two main supervised models: Classification models (classification) and Regression models. The regression models map the input space in a real value domain. For example, a regressor may predict the demand for a particular product based on its characteristics. On the other hand, classifications map the input space into predefined classes.

Along with regression and probability estimation, classification is one of the most studied models, possibly one with the greatest practical relevance. The potential benefits of advances in classification are immense, as the technique has major implications for other areas, both within data mining and in its applications (Rokach & Maimon, 2005). Classifiers can be used, for example, to classify mortgage consumers as good (on-time full mortgage repayment) and bad (delayed repayment). There are many alternatives for representing classifiers, e.g., support vector machines (SVM), decision trees, probabilistic summaries, algebraic functions, etc.

To learn the algorithm, the dataset will be divided into 2 groups. The first group is called train-dataset data. A training dataset is a dataset of examples that is used during the learning process and is used to learn the parameters (e.g., weights), for example, a classifier to fit. Most approaches that search the training data for empirical relationships tend to overfit the data, i.e., they may identify and exploit apparent relationships in the training data that are generally not true.

Test data is used to estimate how well the model has been trained. It depends on the size of the data, the value to be predicted, and the input, among other factors. Furthermore, it provides information on how well the model properties have been estimated.

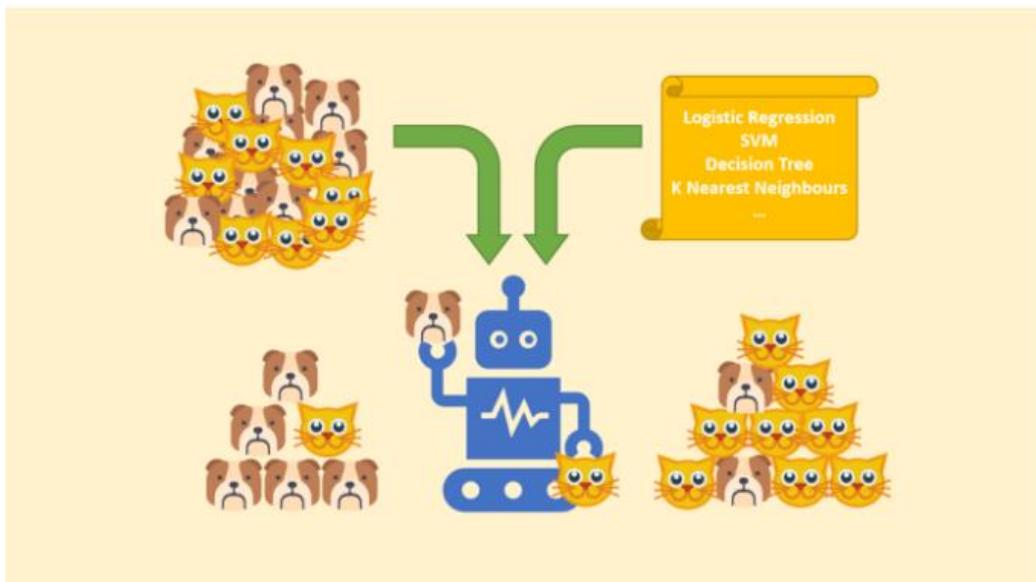


Figure 2.2 Supervised Learning Concept

As described earlier, the supervised learning problem can be divided into 2 groups (classification and regression). Classification (Figure 2.2) is a kind of technique to categorize any data into a desired and unique number of classes, assigning each class to a label. In the simplest way, this relationship (or model) is usually represented by linear regression. The accuracy of the model is assessed by a cost function. To determine the lowest value of the cost function, namely the best parameters of the model, the gradient-descent algorithm is used.

Classification in machine learning is a type of supervised learning approach where ML algorithms learn from the input data and what is learned is then used to classify the new data for accurate observation and prediction.

ML classification means that a data set can be divided into different classes for more in-depth observation. Some applications of classification problems are speech recognition, handwriting recognition, biometric identification, document classification, etc.

2.3 Image Processing

Image processing is a very interesting technique to perform some operations on an image, on account of getting an enhanced image or to gain some necessary data from it. It is a kind of signal processing system in which input is an image and output can be an image or some features or characteristics linked with that image. In recent times, image processing is one among rapidly growing technologies in the world. It has an in-depth scope in the research area within computer science and also in other engineering disciplines.



Figure 2.3 Image processing pipeline

The steps in the image processing pipeline (Figure 2.3) is not a constant process, the steps or setup may slightly vary according to the input data. The pipeline begins with the input of the image, which should be pre-processed. Pre-processing is a very commonly used terminology that can cover a large variety of image processing operations, like reduction of data, image registration, enhancement of images etc. Proceeding the steps in the image pre-processing techniques, image segmentation technique can be applied. The goal is to split the input image into different considerable or meaningful segments or areas. The final goal is to derive a geometric representation of the various areas or objects captured in the image and this phenomena is called geometry extraction. Practically, the image processing pipeline is not a predefined process or a fixed setup. The steps can be skipped, eliminated, changed or repeated multiple times with respect to the input data and also mainly according to the purpose of the project done (GILLMANN, 2018).

Machine learning is emerging as a very important technology in multiple sectors. It is used in engineering for autonomous cars, in the finance sector for predicting the stock market data, medical professionals utilize it for diagnostic purposes. While many open source and commercial repositories and libraries which have very good performances are also available which can be used to perform many machine learning activities. It is very important to create your own models

by using the existing libraries, creating or modifying the existing libraries. This helps us enhance our knowledge in the field of machine learning and create our own application or model. In our project we use machine learning to work with images. When large amounts of images are available like image archives or image repositories, image querying technologies are required to aid the user to find necessary information. In order to make such querying technologies possible, images have to be upgraded with content-based annotations because manual annotations are very expensive and hence system support is needed. This is the exact scenario where data and machine learning concepts and algorithms play a key role.

2.4 Webhosting

Web hosting is the activity or service providing storage space to individuals or organizations, for the websites that are accessible via the World Wide Web. In other words, web hosting is a service that permits organizations and individuals to post a web page or a website onto the Internet. A web host, or web hosting service provider, is a company or a business that gives the technologies and services required for the website or webpage to be hosted and accessed via the Internet. Websites are hosted, kept or stored on some special high configuration central computers called the servers. If the internet users want to see, view or access your website hosted on the server, they have to put the URL, domain name or web address into the URL(Uniform Resource Locator) section of the browser used. This establishes a connection between the browser and the server where the web pages are hosted and displays the webpage on the browser.

Table 2.2 Types of web hosting services

Web Hosting Services	Description
Website Builders	Website builder services is a kind of hosting service that is very useful for the beginners who lack a lot of technical knowledge or skills, to host a website. Website builder services generally help you with an online browser-based interface to create your own website, and also host the website with default settings, so that no complex custom settings are necessary.
Shared Hosting	Shared hosting service environment lets you share your physical server and the software applications with other website owners, within the server. Shared hosting services are cost effective or cheap because the expenses to operate the server is split between you and the other website owners.
Dedicated Hosting	Dedicated hosting service is an environment where the users can have the entire server for themselves. They need not share it with other website owners. This is not cost effective since you have to bear the entire cost for the server and cannot share with other website owners. But you can experience high speed since you can utilise the complete resource capacity. This is useful for big organisations which require more resources and high levels of security to protect their content.
Collocated Hosting	Collocated hosting - you can buy a server and place it on your private premises or the host's private facility. You are the owner of the server

itself. The main highlight of this environment is that you can add your private scripts and also install any application for enhancing your server usage.

2.4.1 Basic of response and request

HTTP protocol and all other protocols based on HTTP rely on a very small and simple communication model. It works on request-reply method or request-response method to communicate with each other through a network. A client which is normally a web browser, sends a request to the server using the http or other protocols followed by the domain name or an ip address of the server or the receiver, and the server/receiver responds by sending back a response based on the request received and the configuration. A server/receiver resource can be anything for example a simple HTML file that displays a website on the web browser of the client or a program that creates a dynamic response immediately. The following image(Figure 2.4) represents a simple request-response model.

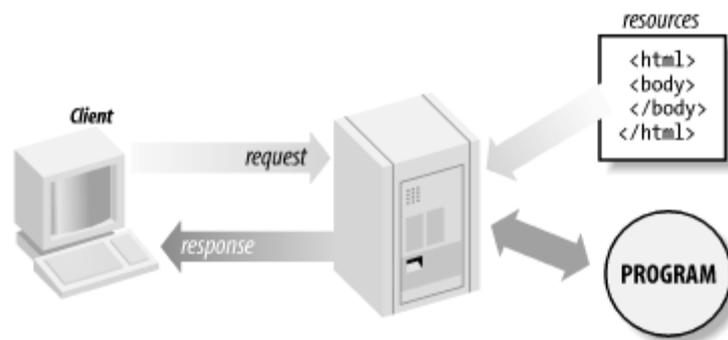


Figure 2.4 HTTP request/response

2.4.2 Describe PHP

PHP- Hypertext Preprocessor is a general purpose and open source scripting language suitable for web development. It is a server side scripting language, embedded in HTML and is very essential to build entire e-commerce sites. It can also be used to control the dynamic content, databases and session tracking. It is integrated with a number of popular databases including MySQL, PostgreSQL, Oracle, Sybase, Informix, Microsoft SQL Server, etc. can be integrated with PHP. PHP is very effective in performance when packaged/compiled as an Apache module in Unix. The MySQL server can execute a huge volume of datasets in a very short time span. The protocols supported by PHP are POP3, IMAP, and LDAP. PHP4 version included the support for Java and distributed object architectures which paved a way for PHP to work with multi-tier architecture.(Lerdorf, 1994)

PHP can work on files in a system with operations like create, open, read, write and close. It can also be used to gather data using forms, also send and return data through emails. Database functionalities like add, delete and modify elements are also possible through PHP. Nevertheless, it can access cookie variables and set cookies, encrypt data and also restrict user access or manage user permissions to some of the websites.

2.4.3 Putty to connection with host

Putty is a terminal emulator or terminal application, serial console or system/computer/root console and a network file transfer application. It was initially developed for windows and now available also for unix systems. It provides a text based user interface to remote computers that are hosted or running on some supported protocols like SCP, SSH, Telnet, rlogin and raw socket connection or a serial port.

SSH - secure shell is a protocol for secure connection to a remote server. In order to create a secure connection we need a SSH client app like Putty.

3 Implementation

Our project revolves around setting up Google cloud, creating virtual machines and deploying a machine learning model in one virtual machine and a web app in another virtual machine. The web app serves as an UI and gets input for the machine learning model deployed.

3.1 Log in Google Cloud

For our project we used the free trial offered by google cloud. The free trial is valid for first time google cloud users only. Registration requires country selection and payment profile creation. Payment profile can be created with your name, address and credit card or bank account. Once the registration is done we get a 90 days free trial with 300\$ credit. The free trial subscription ends after 90 days or if the credit is over before 90 days. Once the credit is over we have to purchase more credit or pay according to your usage. We have to pay for what we use and GCP has a price calculator for estimating our needs and usage. But our work is a student project not an enterprise project, so we try to keep the utilisation within the free credit. So once we provide the banking details for our free subscription we are ready to use the google cloud platform. The payment details are taken not to debit money but to avoid the wastage of cloud resources by the bots and dummy users. (Navin & Piyush, 2021)

3.2 Google Cloud Storage

The idea of this cloud computing course is to understand and describe the cloud computing model with detailed explanation. So we would like to describe the entire process of our cloud computing project using the screenshots.



✓ Name your bucket

Pick a globally unique, permanent name. [Naming guidelines](#)

Tip: Don't include any sensitive information

CONTINUE

Figure 3.1 Name the bucket

Creating Storage- In GCP there is something called bucket as shown in Figure 3.1, bucket is a feature or an option to create a storage or a folder in google cloud platform. To create a storage bucket we have to open the cloud storage browser then click on create a bucket. Specify a suitable name for your bucket and select continue.

✓ **Choose where to store your data**

This permanent choice defines the geographic placement of your data and affects cost, performance, and availability. [Learn more](#)

Location type

Region
Lowest latency within a single region

Dual-region
High availability and low latency across 2 regions

Multi-region
Highest availability across largest area

Location

us (multiple regions in United States) ▼

CONTINUE

Figure 3.2 Location the store

Bucket location - Then the bucket asks for location of storage(Figure3.2). Region is a city or most probably the current city for example Frankfurt. Dual-region includes two countries like Germany and Spain Multi-region - This includes a wide geographical location like the United States or Europe.

The dual and multi region options help in the availability of your data even in case of a very huge disruption. But this introduces a concept called redundancy, since the data is distributed the request response takes a bit longer than the region with lowest latency. But in the modern era the latency is in microseconds so latency does not make a very huge impact.

✓ **Choose a default storage class for your data**

A storage class sets costs for storage, retrieval, and operations. Pick a default storage class based on how long you plan to store your data and how often it will be accessed. [Learn more](#)

Standard ?
Best for short-term storage and frequently accessed data

Nearline
Best for backups and data accessed less than once a month

Coldline
Best for disaster recovery and data accessed less than once a quarter

Archive
Best for long-term digital preservation of data accessed less than once a year

CONTINUE

Figure 3.3 Class for storage

Storage class(Figure 3.3) - for creation of every storage bucket we have to specify a storage class. When we add contents to the bucket they are created as objects that inherit the specified storage class. The default storage class is set to be standard.

Table 3.1 Types of storage classes

Storage Class	Name of API and gsutil	Minimum storage duration	Usage
Standard storage	STANDARD	None	Best for short-term storage and frequently accessed data
Nearline storage	NEARLINE	30 days	Best for backups and data accessed less than once a month
Coldline storage	COLDLINE	90 days	Best for disaster recovery and data accessed less than once a quarter
Archive storage	ARCHIVE	365 days	Best for long-term digital preservation of data accessed less than once a year

In our project we have used standard storage as the default storage class. (Google, 2020)

- **Choose how to control access to objects**

Access control

Fine-grained
Specify access to individual objects by using object-level permissions (ACLs) in addition to your bucket-level permissions (IAM). [Learn more](#)

Uniform
Ensure uniform access to all objects in the bucket by using only bucket-level permissions (IAM). This option becomes permanent after 90 days. [Learn more](#)

- **Advanced settings (optional)**

Figure 3.4 Access control

In this section we have to specify the required access control to objects as referred in Figure 3.4. Uniform allows uniform or same access to all the objects in a storage bucket. Permissions can be managed only at bucket level. Fine grained allows to manage object level permissions inside a storage bucket. Permissions can be managed at both bucket level and individual object level.

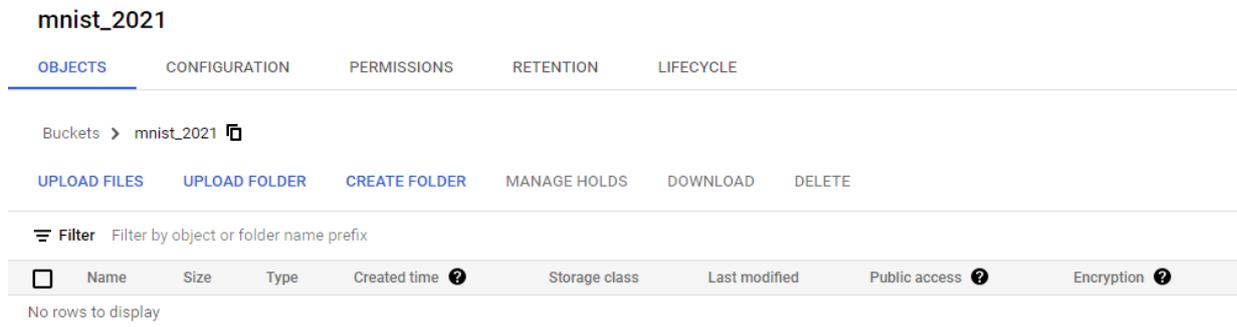


Figure 3.5 Folder created

Now the bucket or a cloud folder is created in GCP(refer Figure 3.5), we can use this cloud folder to store any information in the cloud. This files in this location can be accessed from any GCP tools and can be accessed or available anywhere anytime using a device with internet connectivity. All the files added to this storage will be created as objects that inherits the standard storage class.

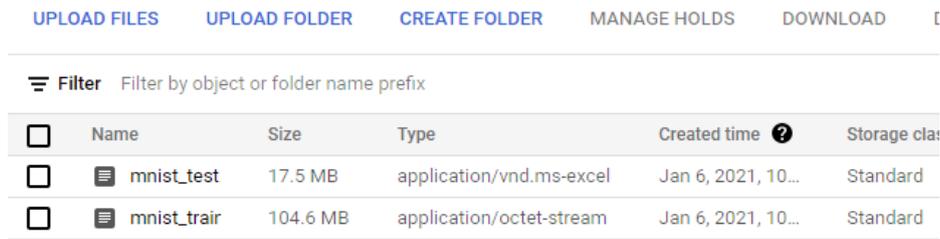


Figure 3.6 Mnist upload

Mnist dataset - is a set of data which contains a digit in the first column and has the details of each pixel of the black and white image with 28x28 pixel, in the next 784 columns (28*28 =784). The mnist has test and train datasets. These data sets are in csv format and can be downloaded from this link - [kaggle](https://www.kaggle.com/dhruvkhatri/mnist-dataset). The train list contains around 60,000 rows of data and the test data set contains around 10,000 rows of data.

3.3 Datalab for implementing image processing

Datalab is a tool in google cloud. It is a very interesting suite which helps in easily analyse, explore , visualise and transform data using very popularly and effective programming languages like python and SQL. It has pre-installed Jupyter notebooks which help in data manipulation, data analysis, data visualisation and many other functionalities for model development. It is a very interactive tool hosted in datalab that makes our task of creating a machine learning model easier.

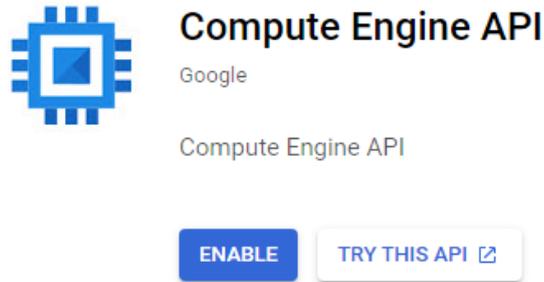


Figure 3.7 Compute Engine API

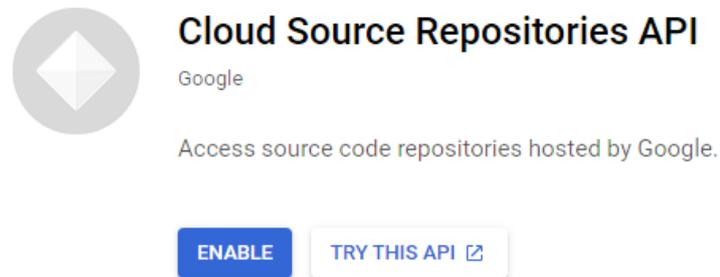


Figure 3.8 Cloud Source Repositories API

These two api in the screenshot above compute engine API (Figure 3.7)and cloud source repositories API(Figure 3.8) are the prerequisite for the datalab. We have to enable them in order to use the datalab functionality.

Datalab create mnist-ml

Now we use the google cloud console to create a notebook in datalab, `datalab create (name)` is the command used to create a workspace for python scripts.

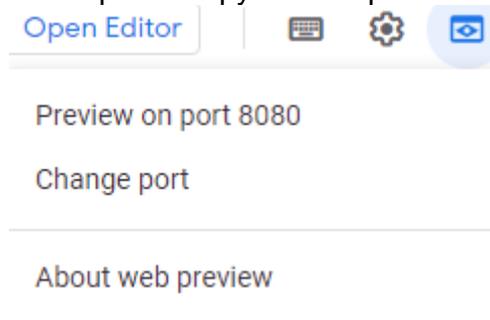


Figure 3.9 Change port

This is the area where we specify the port(Figure 3.9). While working with multiple systems it is important to specify a unique port for each function or a file. So this can be achieved by using

open editor → change port → specify port number. In our case we have used 8081. This is the location in the cloud where we store our mnist test and train data set. After creating the storage bucket we can use the upload files option to upload any file, here in our case it is the mnist dataset. Again the storage is in cloud, so it is accessible anywhere any time with internet connectivity

```
from google.datalab import Context
import google.datalab.storage as storage
import pandas as pd
from io import BytesIO as StringIO
import numpy as np
%%gcs read -o gs://mnist_2021/mnist_test.csv --variable tests
%%gcs read -o gs://mnist_2021/mnist_train.csv --variable trains
df_trains=pd.read_csv(StringIO(trains))
df_tests=pd.read_csv(StringIO(tests))
df_trains_Y=df_trains['label'].values
df_test_Y=df_tests['label'].values
```

It is very important to specify some necessary libraries such as google.datalab and io. After that with command `%%gcs read <directory of google cloud storage> --variables <name>` can import the Excel file as a variable.

```
df_trains_X=df_trains.drop('label',axis=1).values/255*1.00
df_tests_X=df_tests.drop('label',axis=1).values/255*1.00
```

After that it is necessary to scale the value of pixels between 0 and 1. This Method help us to reduce the executing time and improves the performance of code.

```
df_trains_Y.shape[0]
train_Y=np.zeros((df_trains_Y.shape[0],10))
j=0
for i in df_trains_Y:
    train_Y[j,i]=1
    j=j+1
```

Since this project belong to a classification problem, we have to use one hot-encoder because the numbers are only between 0 and 9. For each of sample we have to create one array with length 10. If one picture indicates 2, then the index of second element must be 1 and the values of other elements must be 0.

```
W = tf.Variable(tf.zeros([784,10]))
b = tf.Variable(tf.zeros([10]))
y = tf.matmul(x,W) + b
y_true = tf.placeholder(tf.float32, [None,10])
```

```
cross_entropy =
tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(labels=y_true,
logits=y))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.5)
train = optimizer.minimize(cross_entropy)
```

This section of code creates a machine learning model. In our model Linear regression algorithm and mnist data sets are used.

```
With tf. Session() as sess:
    Sess.run(init)
    for step in range(10):
        sess.run(train, feed_dict={x:df_trains_x,y_true:train_Y})
    matches=tf.equal(tf.argmax(y,1),tf.argmax(y_true,1))
    acc=tf.reduce_mean(tf.cast(matches,tf.float32))
    writer=tf.summary.FileWriter('./CNN',sess.graph)
    writer.close()
    save_path=saver.save(sess,"./model_tensorflow/model.ckpt")
```

This section opens the tensorflow session then starts to train the model with the values from the mnist train data set. Then the trained model is stored in the cloud storage bucket. The name of the model is 'model.ckpt'. The name and the storage location can be customized.

```
!gsutil cp -r "file://model_tensorflow" gs://mnist_2021
!gsutil cp -r "file://CNN" " gs://mnist_2021"
```

We have used gutil to route the created model to the apt location or storage. This is a very important package that has various functionalities, but we have used few like `cp - copy` and `r - read gs://(bucket name)` - this format is used in specifying the path or location in cloud.

<input type="checkbox"/>	Name	Size	Type
<input type="checkbox"/>	📁 CNN/	–	Folder
<input type="checkbox"/>	📄 mnist_test.csv	17.5 MB	application/vnd.ms-excel
<input type="checkbox"/>	📄 mnist_train.csv	104.6 MB	application/octet-stream
<input type="checkbox"/>	📁 model_tensorf	–	Folder

Figure 3.10 upload the CNN and model in google cloud storage

The model has been created successfully and stored in the bucket, under the model_tensorflow folder as shown in Figure 3.11.

```
ten_board=ml.TensorBoard.start(['./CNN'])
```

TensorBoard was started successfully with pid 5801. Click [here](#) to access it.

Figure 3.11 Start Tensorboard

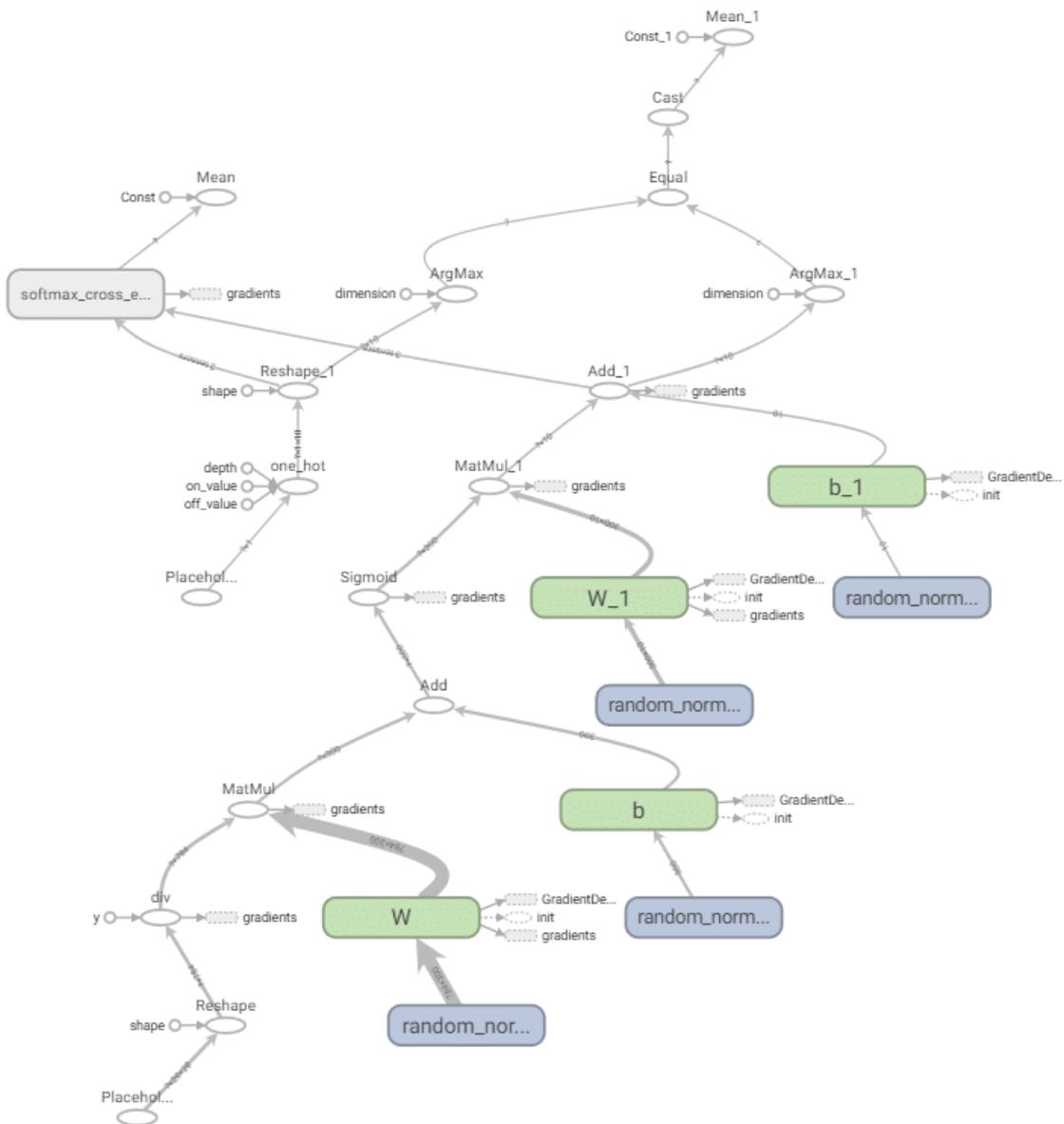


Figure 3.12 Tensorboard view

Tensorflow is a library used to display the data flow. It is a free and open source software. Tensorboard provided a set of tools to display tensorflow information. This board is very useful in

understanding the flow of the model developed and is highly recommended and used by machine learning model developers. This is a very important tool used for visualising any data. In our project we have also used the Tensorboard which can be seen in the Figure 3.13 and Figure 3.12.

3.4 Create Web Host

We have created a new virtual machine instance for hosting our application. We need an apache server for hosting our web.

```
sudo apt install apache2
sudo systemctl status apache2
sudo apt install php libapache2-mod-php php-mysql
```

With this command we can install and deploy the Apache2 and PHP. After that we create index.php of the website, which the user can upload the picture submits it to server or virtual machine.

```
<html>
<head>
<link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Sofia">
<style>
body {
  background-image:
url(https://st4.depositphotos.com/1006536/20704/v/1600/depositphotos_20
7044150-stock-illustration-internet-of-things-cloud-
computing.jpg);font-family: "Sofia", sans-$
}
</style>
</head>
<body>

<br>
<h1>please upload your picture </h1>
<form action="example.php" method ="post" enctype="multipart/form-
data">
  <input type="file" name="file" style="color:black;text-
align:center;font-size:30px;" />
  <input type="submit" value="submit" name="submit"
style="color:black;text-align:center;font-size:30px;" />
</form>
</body>
</html>
```

The index.php is conventionally used as the home page of any php application. This section displays our application's home page where we have to upload the image with dimensions 28*28 pixels.

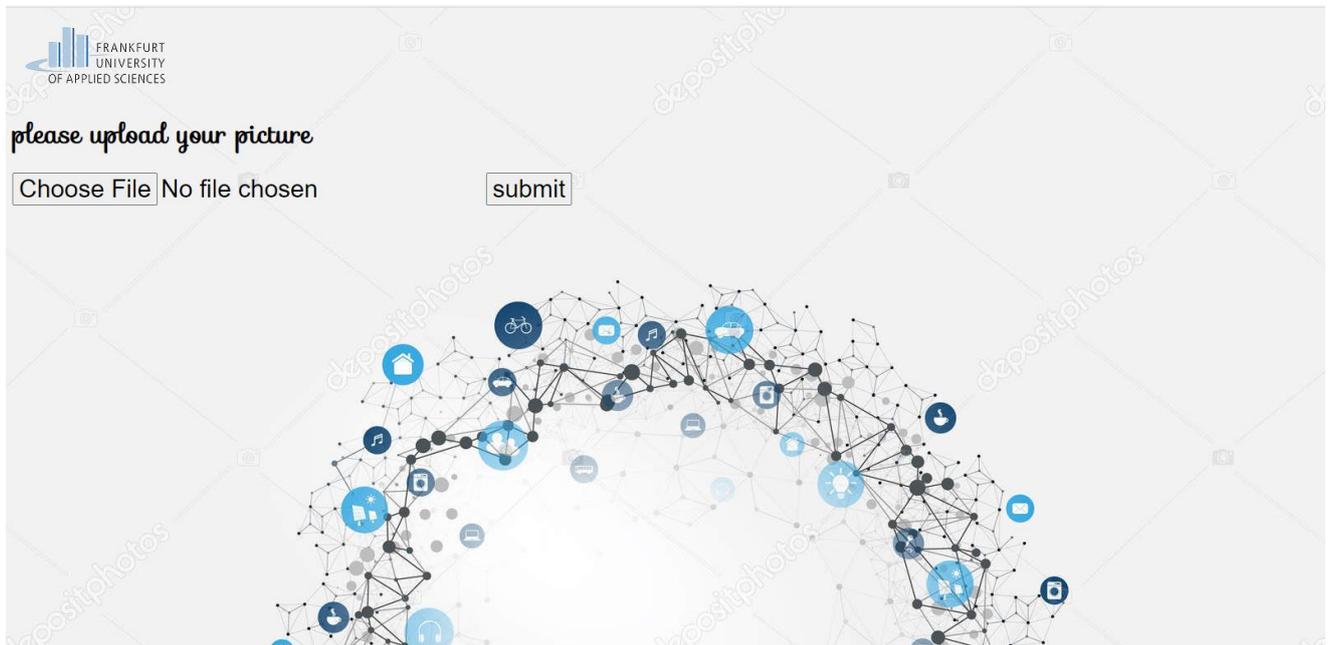


Figure 3.13 Webapp input page

```
from PIL import Image, ImageOps
import numpy as np
import argparse
import tensorflow as tf
parser = argparse.ArgumentParser()
parser.add_argument("img", help="name of picture please :)")
args = parser.parse_args()
image = Image.open(args.img)
image=ImageOps.grayscale(image)
numpydata = np.asarray(image)
numpydata= (255-numpydata)/255.0
x = tf.placeholder(tf.float32, shape=[None, 784])
W = tf.Variable(tf.zeros([784, 10]))
b = tf.Variable(tf.zeros([10]))
y = tf.matmul(x,W) + b
init = tf.global_variables_initializer()
saver=tf.train.Saver()
with tf.Session() as sess:
    sess.run(init)
    saver.restore(sess, '/var/www/html/model_tensorflow/model_tensorflow_model.ckpt')
    print('ML says:The number in the picture is
', np.argmax(sess.run(y, feed_dict={x:numpydata.reshape(1, 784)})))
```

Once we upload the image (28 pixels by 28 pixels) gets saved to the virtual machine and triggers the python script which processes the image according to our model and predicts the number in the uploaded image.

Now we need one script to show the results and send it to users.

```
<html>
<head>
<link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Sofia">
<style>
body {
  background-image:
url(https://st4.depositphotos.com/1006536/20704/v/1600/depositphotos_20
7044150-stock-illustration-internet-of-things-cloud-computing.jpg);
color:#000066;
}
h2{color:#000066;text-align:center;font-size:30px;font-family: "Sofia",
sans-serif; }

</style>
</head>
<body>

<br>

<?php
  if (file_exists("upload/" . $_FILES["file"]["name"]))
  {
    echo $_FILES["file"]["name"] . " already exists. ";
  }
  else
  {
    $t = move_uploaded_file($_FILES["file"]["tmp_name"],
"/var/www/html/" . $_FILES["file"]["name"]);

  }

  echo "<h2>".exec("/usr/bin/python3 /var/www/html/test.py " .
$_FILES["file"]["name"] ." 2>&1")."</h2>";

?>
<?php echo "<br/>";?>
<?php echo "<h2 >the picture was uploaded by user:</h2>";?>
<?php echo "<br/>";?>
<br>
<br>
```

```
<br>
<br>
<br>
<br>
<br>
<br>
<img src=<?php echo $_FILES["file"]["name"]; ?> style="margin-
left:auto;margin-right:auto;display:block;width:20%;">

</body>
</html>
```

4 Evaluation and results



Figure 4.1 view of result

As shown in Figure 4.1 image 2 was uploaded in black and white and with 28x28 pixel format and our model predicted that the number was 2. This is an example of a positive response from our model. Similarly image 4 was uploaded in the required format and the model predicted that the number was 1 which is an example for wrong prediction. The number 4 format looks slightly different from the original digit 4 and it looks partially like 1 so the model gave the best fit as a result. This can happen because the numbers are hand written and the format differs every time from the original ones. To resolve this issue we need to have more data with different formats for training and improving the model.

5 Summary and outlook

In the following, the essentials of this work are summarized as well as an outlook on which open questions still exist and require further research.

5.1 Summary

In this project, we have analysed the architecture of the Google Cloud Computing platform, leveraged some of the important features of the google cloud like bucket, datalab, console, tensorflow and virtual machine. Successfully deployed a machine learning model to predict the numbers in the image and also deployed an app in another VM to upload images in the specified format that will be used for by the machine learning model.

5.2 outlook

Overall our project goal is complete. We have experienced a complete and very challenging cloud computing environment throughout the project period, right from setting up the cloud environment till proper utilisation of the limited resources in an efficient way to complete the desired goal of our project. We have achieved 84.71% efficiency rate which is a decent progress. We could train only 10 iterations in google cloud because of resource constraints otherwise we could have trained more iterations which could have increased the efficiency rate. Also we have displayed some of the failures as an example there by creating a scope for further development and enhancement of the model in the future.

We could have used the AI-API which is a complete suite for AI developers which could have been more efficient. We have used linear regression algorithms to train our model but we can also use various other powerful algorithms or combination of algorithms to build a better model, but due to the availability of limited resources and the complexity in implementing them we chose this approach. Nevertheless, we had a great experience with one of the most used cloud computing environments.

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