A Complete Guide on Machine Learning Model Deployment Using Heroku

Overview of Model Deployment Using Heroku

One of the most prevalent misunderstandings and mistakes for a failed ML project is spending a significant amount of time optimizing the ML model. Instead, teams that have completed a successful machine learning project devote time to gathering data, developing efficient data pipelines to reduce training-serving skew, and constructing dependable model serving infrastructure. The diagram below depicts the stages of machine learning development.

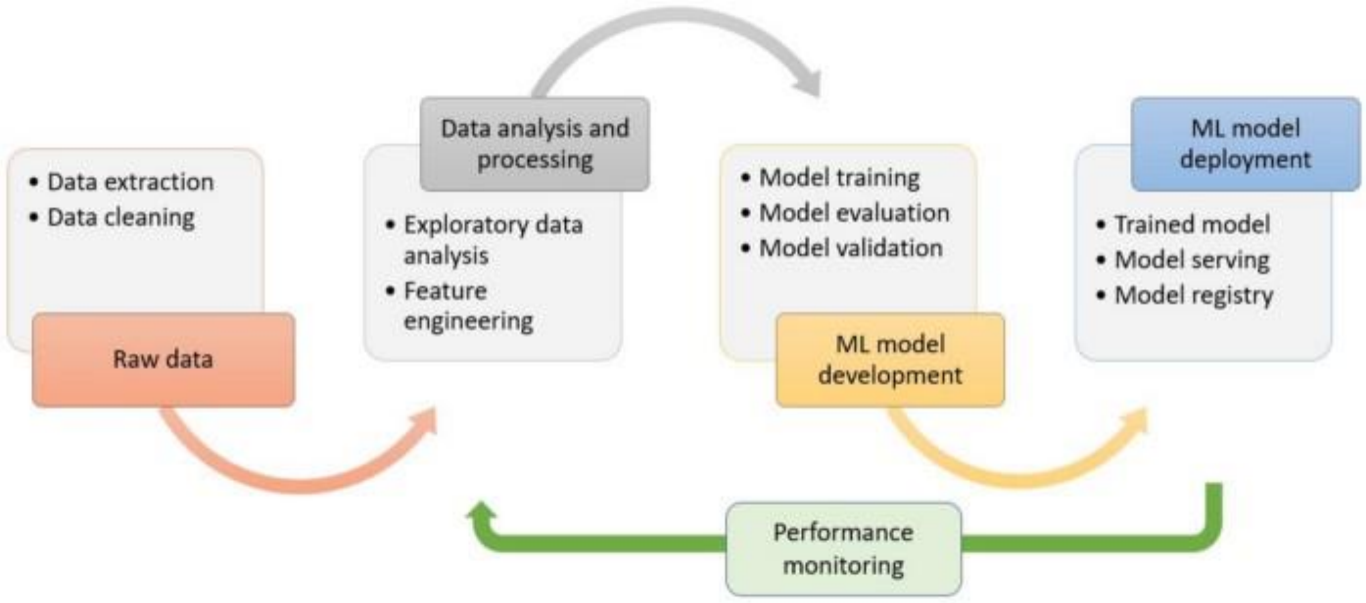


Image by Author

We can create a Machine Learning model, but it should predict the results for new data from the users. It is easy to consume by other applications after the deployment as a microservice.

I was so happy when I deployed my first Machine Learning model, where I spent a day working on the errors of Heroku and finally deployed it successfully.

This post aims to show you how to plan precisely when working with model deployment while explaining what to be aware of along the way. View the outcome of the final product here. (You may require patience when visiting the web apps because Heroku puts apps to sleep after a period of inactivity – the app will wake up with a delay of a few seconds.)

The post consists of three parts, they are:

- Setting up a Flask web application
- Creating a Machine Learning model
- Deploy the app on Heroku

Setting up a Flask Web Application for Model Deployment Using Heroku

We want the user to interact with our webpage, as opposed to a static website where the user merely reads the content. Web applications are websites that have functionality and an interactive element.

In our scenario, a user will have six input fields, and we provide a prediction to the user by collecting sample data. Before that, we must first comprehend how a browser interacts with other online pages by making requests. A standard browser will submit a GET request using the HTTP protocol and a POST request to send data through the web page. Hopefully, you will figure it out along the way.

To handle user requests, we have to create a lot of code as Python programmers. Instead of developing repeated code to handle requests, a guy named Armin Ronacher decided to put it in a library and call it flask as a joke.

Flask is a web server framework that requires us to organize our code in a specific way. Begin by creating two folders in your **MyApp** directory called **Models** and **Templates**. For the time being, we won't be using the **Static** folder, but feel free to include any optional CSS code. You should create a python file on the same root level as the files and name it app.py, just like I did. After that, make an index HTML file and save it in the templates directory. The fact that the app.py and index.html files are empty is unimportant; instead, concentrate on the framework.

Virtual Environment

We can easily install flask using pip (pip install Flask) and run our web application because flask is just a third-party library. A difficulty arises when the web application is dependent on specific versions of python and other third-party libraries. Imagine that your web application is working great until a third-party library update comes along and changes the names of particular functions. Your programme will become unusable as a result of this. We can use a so-called virtual environment to get around this problem(virtualenv).

Consider a virtual environment to be a folder that is ignorant of any other libraries on your computer. It can access only the libraries installed in this location.

We'll need you to install virtualenv on your current Python installation to build a virtual environment. To put it another way, open a terminal (or command) line and write the following:

```
pip install virtualenv
```

Use the following command to check whether you have it installed in the system:

```
virtualenv --version
```

After installation, you can create a virtual environment. We should generate virtual environment files inside the MyApp directory. Now change your current directory using CMD or open the MyApp folder and choose New Terminal.

Depending upon your system, use the following commands:

```
python3 -m venv virtual (Mac)
py -3 -m venv virtual (Windows)
```

Now the above command creates a **virtual** folder with necessary files. For the activation of the environment, use the below command.

```
. virtual/bin/activate (Mac)
virtualScriptsactivate (Windows)
```

Use deactivate to close the environment. Now you should see something similar to this in CMD.

```
(virtual)  myapp %
```

Now you can explore the bin folder inside virtual that consists of pip and python pre-installed. New libraries installed will be added to this folder.

Finally, use this command to download the flask framework.

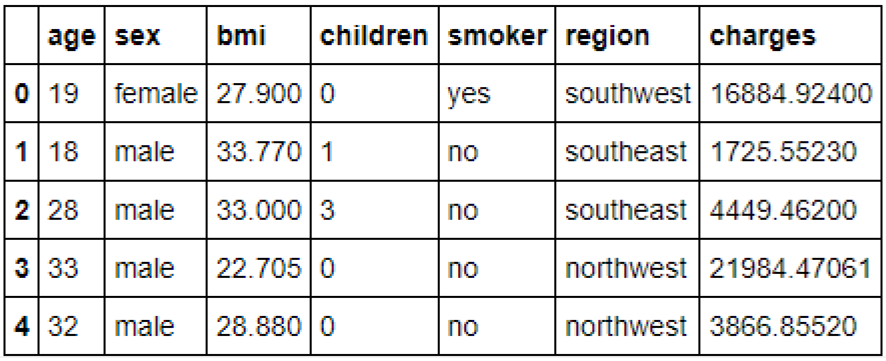
```
pip install Flask
```

Now you can see the flask files in your bin folder, and complement our mindset by saying words: I can accomplish anything if I focus my mind on it.

Creating a Machine Learning Model to Be Deployed Using Heroku

The second stage in our trip is to train a Machine Learning (ML) model, but our primary focus is on deployment, so we don't spend much time on this section.

We will build a simple Linear Regression model on Insurance data. The model will predict the insurance charges for patients based on six features; age, sex, BMI, children, smoker, region.



	age	sex	bmi	children	smoker	region	charges
0	19	female	27.900	0	yes	southwest	16884.92400
1	18	male	33.770	1	no	southeast	1725.55230
2	28	male	33.000	3	no	southeast	4449.46200
3	33	male	22.705	0	no	northwest	21984.47061
4	32	male	28.880	0	no	northwest	3866.85520

Image by Author

The focus here is on the deployment in Heroku rather than the model performance, so it makes no difference if the model is Linear regression, XGBoost, RF, or any other model.

Here we have a quick overview of two ways of creating a model:

Firstly, we create a model by importing the libraries and then train, save the trained model.

The second way is we use the Pycaret library to train our model and then save it for further requirements.

The below code helps in the creation of a model by following the general way.

```
import pandas as pd
import xgboost as xgb
import pickle

# Read the data
data = pd.read_csv('insurance.csv')

# Fit the data to an ML model
x = data[['age', 'sex', 'bmi', 'children', 'smoker', 'region']]
y = data['charges']

model = xgb.sklearn.XGBClassifier(nthread=-1, seed=1)
model.fit(x, y)

# Save the model
filename = 'model.sav'
pickle.dump(model, open(filename, 'wb'))
```

In the above code, we import libraries such pandas, xgb and pickle then read the data from CSV and split the features into x and y. Now define the xgb classifier and fit the model with our data. After this save our model using pickle.

Now we look at the second way of creating the model, and if you are not familiar with this library, check here.

```
from pycaret.regression import *
r2 = setup(data, target = 'charges', session_id = 123, normalize = True,
           polynomial_features = True, trigonometry_features = True,
           feature_interaction=True, bin_numeric_features= ['age', 'bmi'])
```

The above code performs preprocessing tasks such as scaling, automatic feature engineering and binning of numeric features and setups the data for model training.

For training the model, we use the below code:

```
# Model Training and Validation
lr = create_model('lr')
```

Here you can view the residual plot of our linear regression model by using the below code:

```
# plot residuals of trained model
plot_model(lr, plot = 'residuals')
```

Now we save the trained model and further helps in the prediction of results for new data.

```
# save transformation pipeline and model
save_model(lr, model_name = 'deployment_28042020')
```

Based on your convenience, train and save the model that is helpful in deployment.

App File of the Heroku Based App

Let’s open the ‘app.py’ file and begin adding code. The app file is the heart of your Heroku-based web application. It will monitor particular ports for user requests and respond with specific functions according to the type of request.

The application consists of three sections. Importing libraries and initializing the flask app are the first steps. To inform Flask where our app is, we utilize the Flask(name) method. Flask will look for templates and static files in the same directory as our app.

```
from flask import Flask,request, url_for, redirect, render_template, jsonify
from pycaret.regression import *
import pandas as pd
import pickle
import numpy as np
# Initalise the Flask app
app = Flask(__name__)
```

Now we use the load_model function to import our saved or pre-trained model.

```
# Loads pre-trained model
model = load_model('deployment_28042020')
```

Our web application will have one page, referred to as the default or main page. The home URL is the / route. By default, this should lead to the index.html file, which is the home page.

When a user hits the main page, we want to do a specified action. We constructed a function, which would respond to user queries based on the POST requests.

A POST request is made by a user when the information is being sent back to the webserver. We allow the user to fill in age, sex, BMI, children, smoker, and region. We retrieve this information from an HTML file by using the request.form.values() function. Now, we convert the list of features to NumPy array and store it in the final. We create a data frame by using the final. Then use the predict model function of pycaret to apply ML pipeline and generate predictions using the trained model. Finally, we display the predicted result on the webpage.

```
cols = ['age', 'sex', 'bmi', 'children', 'smoker', 'region']

@app.route('/')
def home():
    return render_template("home.html")


@app.route('/predict',methods=['POST'])
def predict():
    int_features = [x for x in request.form.values()]
    final = np.array(int_features)
    data_unseen = pd.DataFrame([final], columns = cols)
    prediction = predict_model(model, data=data_unseen, round = 0)
    prediction = int(prediction.Label[0])
    return render_template('home.html',pred='Expected Bill will be
{}'.format(prediction))


@app.route('/predict_api',methods=['POST'])
def predict_api():
    data = request.get_json(force=True)
    data_unseen = pd.DataFrame([data])
    prediction = predict_model(model, data=data_unseen)
    output = prediction.Label[0]
    return jsonify(output)


if __name__ == '__main__':
    app.run(debug=True)
```

You can see two functions where predict consumed by our web application hosted on Heroku in the preceding code. Consider what you'd have to do if you wanted to integrate our prediction with other corporate apps. You'd have to make an API call to give the input data and retrieve the predicted results, where our predicted API can be helpful in the future.

Templates

Now we will make the default page, which will greet the user. As I did in the previous walk-through, we will divide the home page code into two sections. If you have never read or written HTML code before, I recommend watching a simple HTML tutorial video.

The initial section of my index file is made up entirely of optional CSS code. Here we had linked styles.css stored in a static folder with other font formats.

The second part consists of a form with six input fields. Notice the required attribute, which ensures input from the user. Here name attribute was used as a reference in the app.py file that helps request.form.values() function to get the data.

Predict Insurance Bill

Predict

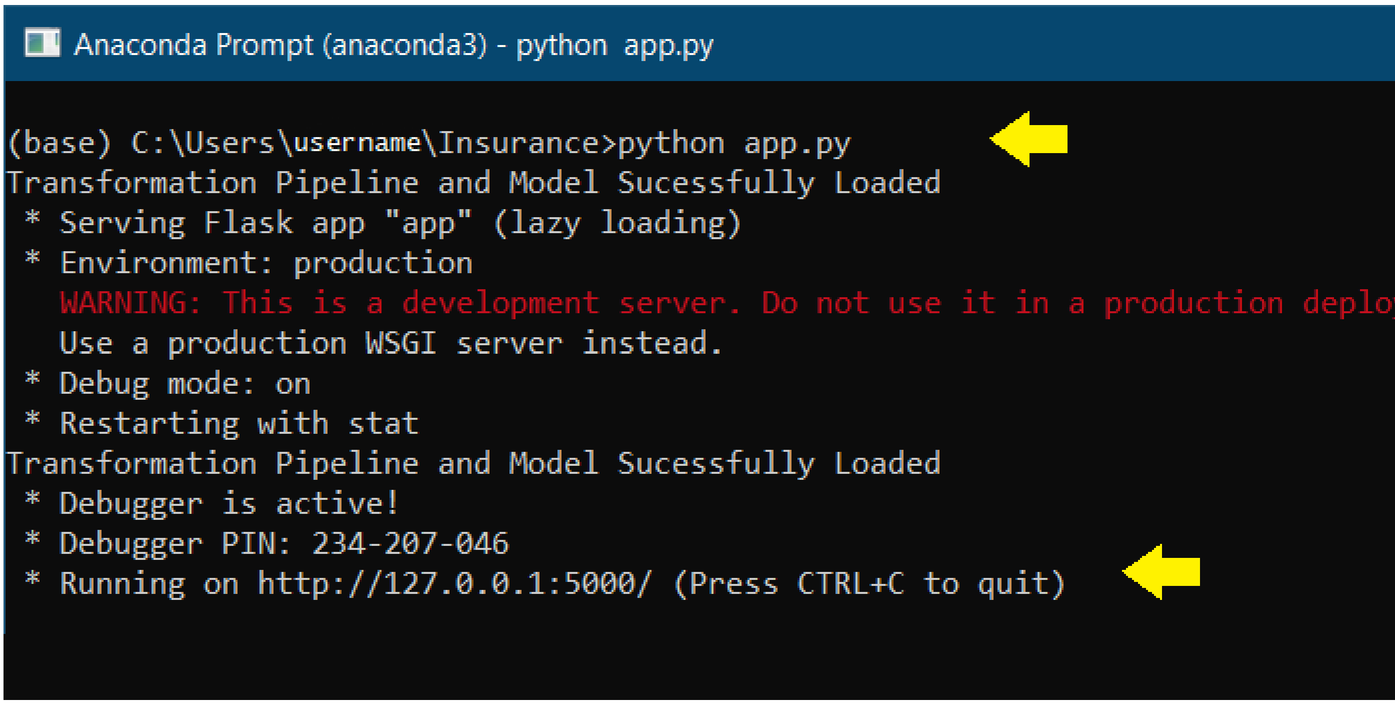
{{pred}}

You may have noticed the brackets in the previous paragraph. When you see something like this, you should automatically assume that we are using Jinja. Flask supports Jinja, a templating language that uses the percent% and syntax to add placeholder blocks and other code chunks. In this scenario, we had used url_for('predict') in the app.py file to call the predict function. At last, we display the predicted result to the user that we render in our app.py.

Testing App

One last step before we deploy the application on Heroku is to examine the web app locally. Open Anaconda Prompt and navigate to the folder where you had saved app.py on your computer. Run the python file with the below code:

```
python app.py
```

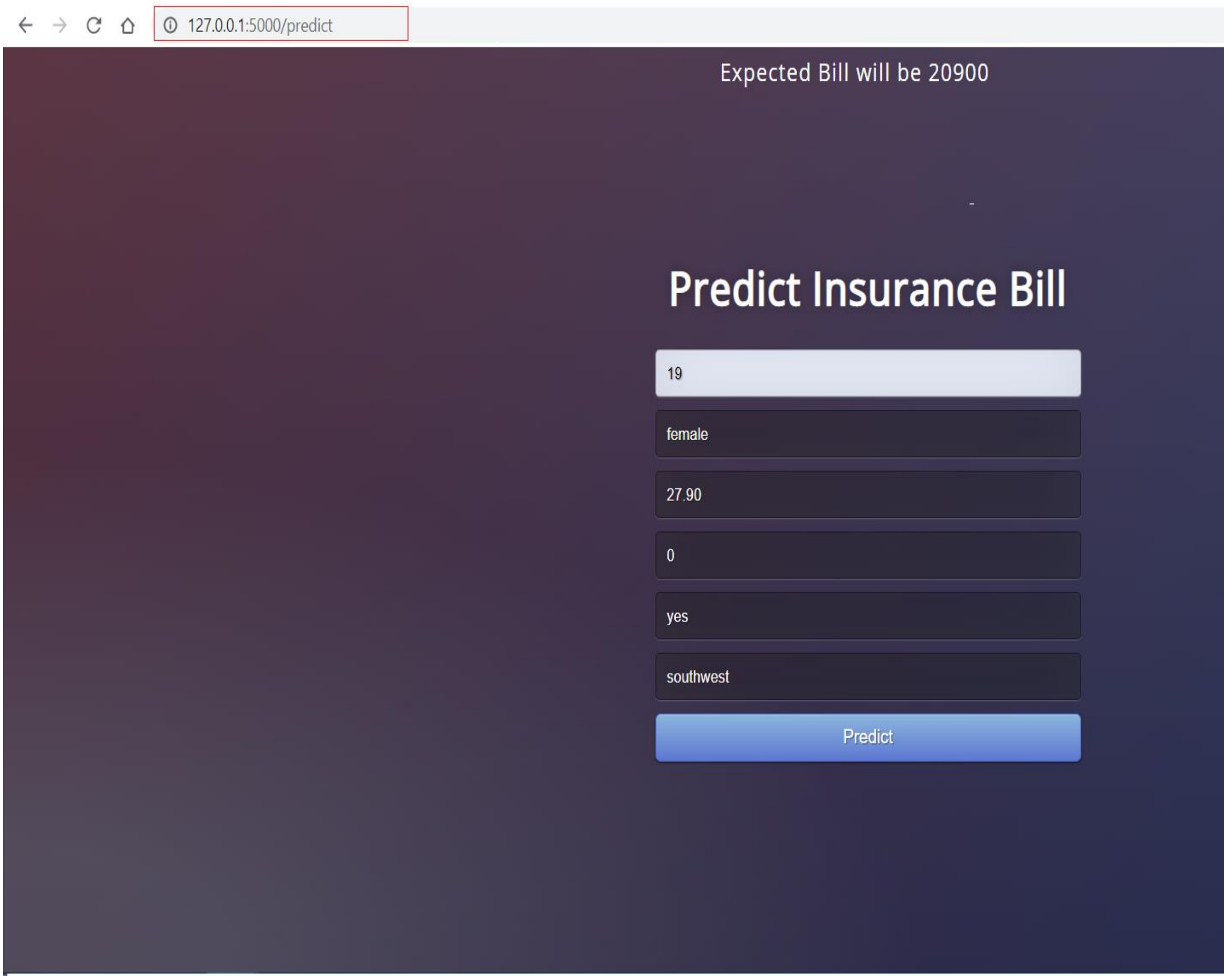


```
Anaconda Prompt (anaconda3) - python  app.py

(base) C:\Users\username\Insurance>python app.py
Transformation Pipeline and Model Sucessfully Loaded
 * Serving Flask app "app" (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deplo
   Use a production WSGI server instead.
 * Debug mode: on
 * Restarting with stat
Transformation Pipeline and Model Sucessfully Loaded
 * Debugger is active!
 * Debugger PIN: 234-207-046
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

Image by Author

After the execution, copy and paste the URL into a browser, and it will open a web application hosted on your local machine (127.0.0.1). Try entering test values to check whether the predict function is working. In the example below, a 19-year-old female smoker in the southwest with no children might expect to pay $20,900.



127.0.0.1:5000/predict

Expected Bill will be 20900

Predict Insurance Bill

19

female

27.90

0

yes

southwest

Image by Author

Congratulations! You’ve now created your first machine learning application. Now it is time to take this application from your local machine into the cloud so other people can use it with a Web URL.

Model Deployment using Heroku

Before going into our deployment process a quick brief about Heroku.

Heroku is a container-based cloud Platform as a Service (PaaS). Developers use Heroku to deploy, manage, and scale modern apps. Our platform is elegant, flexible, and easy to use, offering developers the simplest path to getting their apps to market.

Heroku is fully maintained, allowing developers to focus on their core product rather than having to worry about servers, hardware, or infrastructure. It provides tools, services, workflows, and support for polyglot—all intended to improve developer productivity.

We're ready to start our Heroku deployment now that our model has been trained, the machine learning pipeline has been set up, and the application has been tested locally. There are a few ways to upload your application source code onto Heroku. The easiest way is to link a GitHub repository to your Heroku account.

Although flask is fantastic, they help in local development. It does not handle the kind of queries that a typical web server does. We'll need to install the gunicorn python library to take care of a large number of requests.

We need to tell Heroku to use the gunicorn now that we've installed it. We accomplish this by generating a file called procfile that has no extension (for instance, Procfile.txt is not valid.). The file consists of commands to execute on the startup.

It's just one line of code that tells a web server which files to run first when someone logs into the application. In this case, the name of our application file is app.py, and the name of the application is also app.

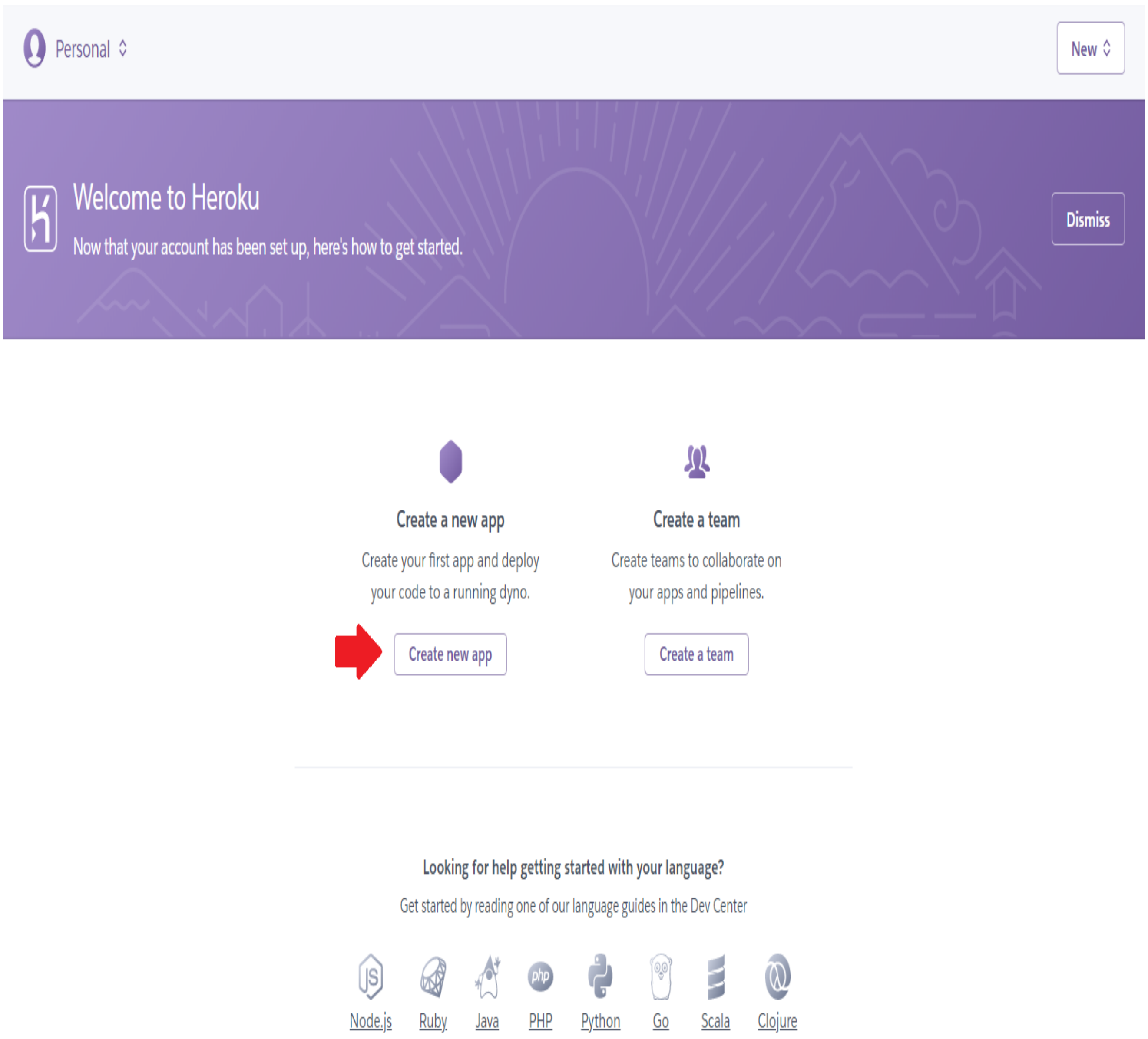
requirements.txt

It is a text file containing the python packages required to execute the application. If these packages do not found in the environment application is running, it will fail. I recommend you mention the particular versions of all your libraries.

Steps for Model Deployment Using Heroku

Once files had uploaded to the GitHub repository, we are now ready to start deployment on Heroku. Follow the steps below:

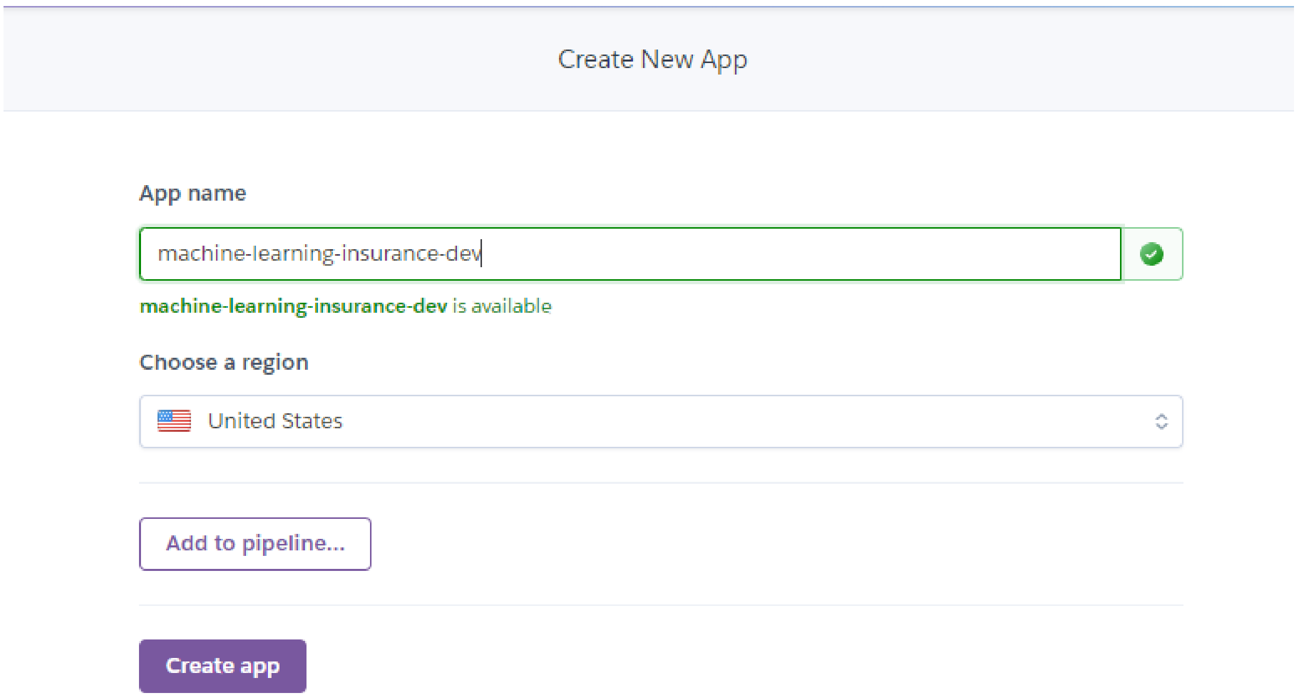
1. After sign up on **heroku.com** then click on **Create new app.**



Personal
New
Welcome to Heroku
Now that your account has been set up, here's how to get started.
Dismiss
Create a new app
Create your first app and deploy your code to a running dyno.
Create new app
Create a team
Create teams to collaborate on your apps and pipelines.
Create a team
Looking for help getting started with your language?
Get started by reading one of our language guides in the Dev Center
Node.js
Ruby
Java
PHP
Python
Go
Scala
Clojure

Image by Author

2. Enter **App name and region.**



Create New App

App name

machine-learning-insurance-dev

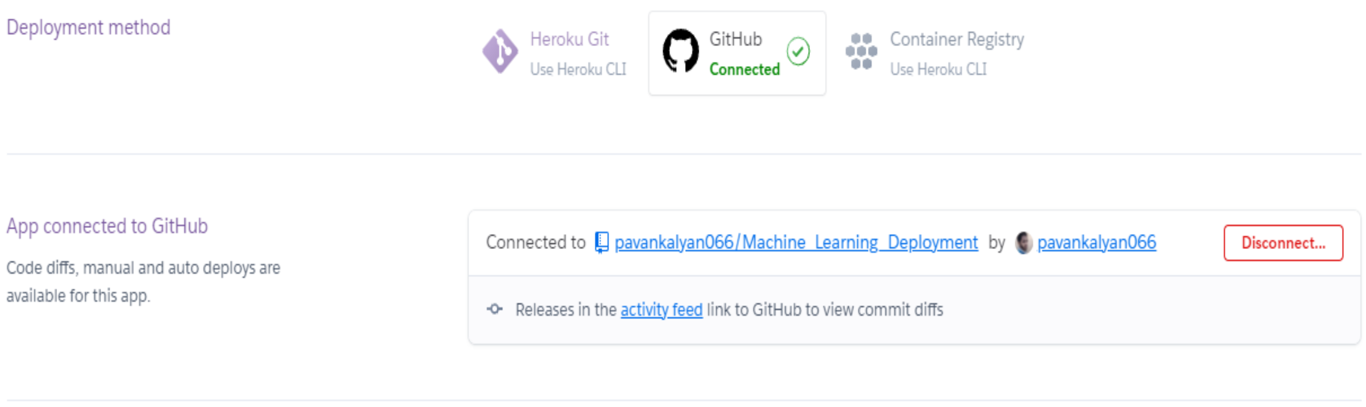
machine-learning-insurance-dev is available

Choose a region

United States

Image by Author

3. Connect to your GitHub repository where code is uploaded.



Deployment method

App connected to GitHub

Code diffs, manual and auto deploys are available for this app.

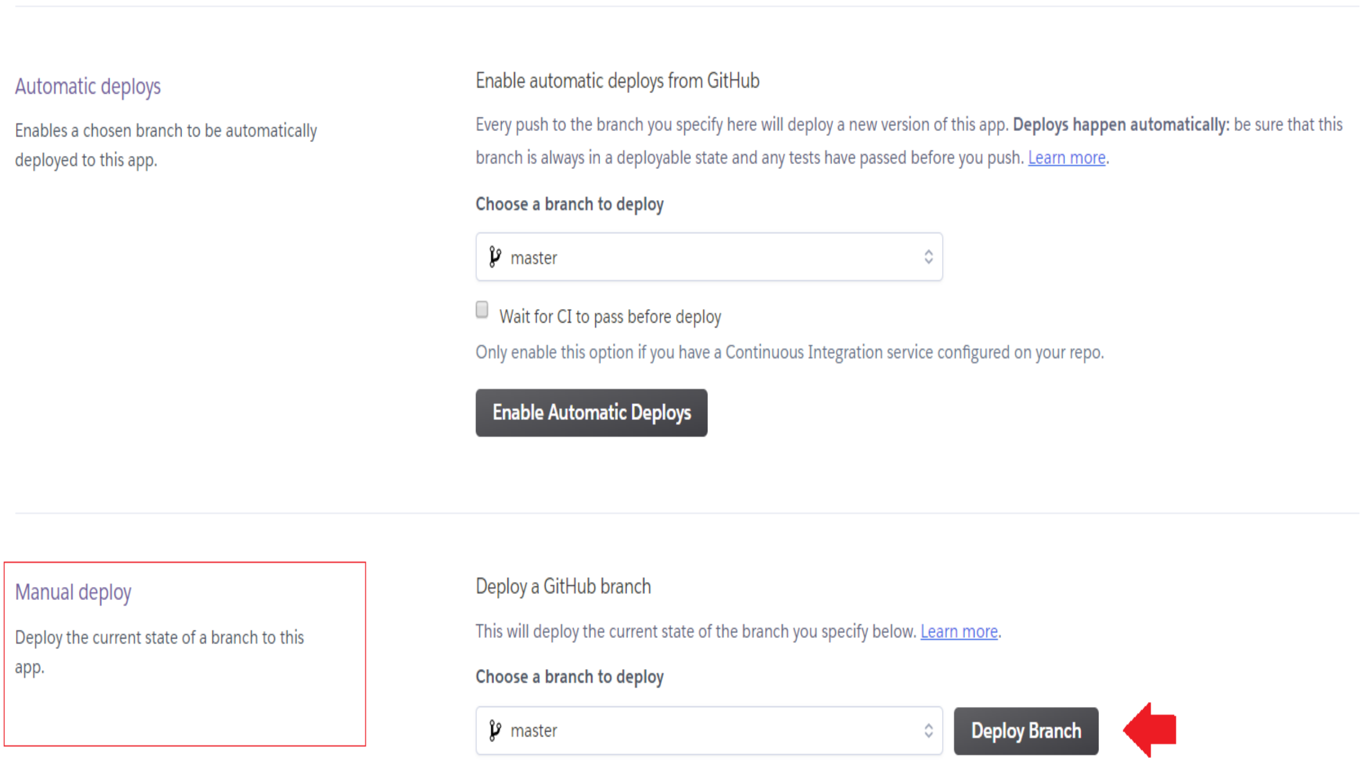
Connected to pavankalyan066/Machine_Learning_Deployment by pavankalyan066

Releases in the activity feed link to GitHub to view commit diffs

Image by Author

In the search, choose the repository where you had uploaded the project code.

4. Deploy branch



Automatic deploys

Enables a chosen branch to be automatically deployed to this app.

Enable automatic deploys from GitHub

Every push to the branch you specify here will deploy a new version of this app. **Deploys happen automatically:** be sure that this branch is always in a deployable state and any tests have passed before you push. Learn more.

Choose a branch to deploy

master

☐ Wait for CI to pass before deploy

Only enable this option if you have a Continuous Integration service configured on your repo.

Manual deploy

Deploy the current state of a branch to this app.

Deploy a GitHub branch

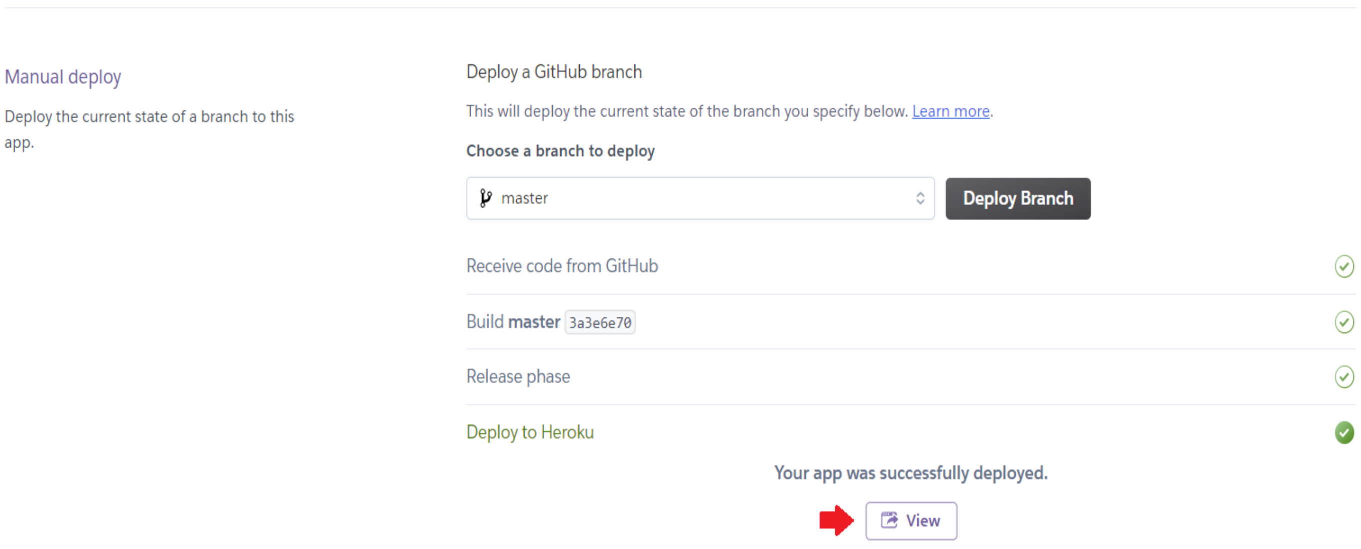
This will deploy the current state of the branch you specify below. Learn more.

Choose a branch to deploy

master

Image by Author

5. Wait 5–10 minutes and **BOOM**


Manual deploy

Deploy the current state of a branch to this app.

Deploy a GitHub branch

This will deploy the current state of the branch you specify below. Learn more.

Choose a branch to deploy

master

Deploy Branch

Receive code from GitHub

Build **master** 3a3e6e70

Release phase

Deploy to Heroku

Your app was successfully deployed.

View

Image by Author

The app is published at URL: https://machine-learning-insurance.herokuapp.com/

Another way you can use the command line to interact with Heroku.

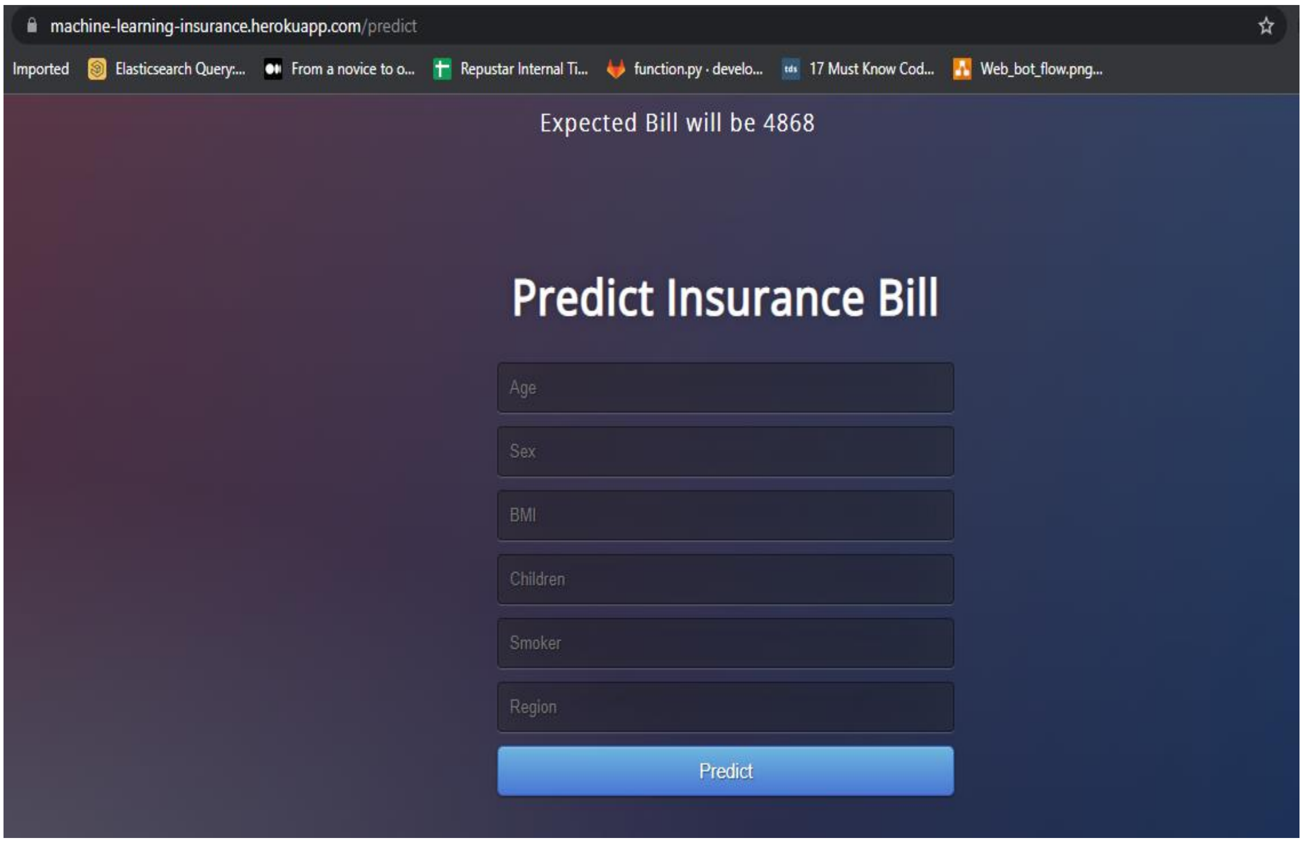


Image by Author

Login to Heroku

Open the command line from the project folder and type

```
heroku login
```

Now, use the email and password used while creating your Heroku account. The above command will open a browser window, and if you prefer to go with the command line, use the below command.

```
heroku login -i
```

The login might be unsuccessful when you are in the wrong environment. In this case, the latter command might be helpful: *conda deactivate*

Tell Git about you

Before sending our files from git to Heroku, config your git name and email. It is necessary because every Git commit uses this information.

Follow the below command to do it:

```
git config --global user.name "John"
```

and then type this:

```
git config --global user.email john@example.com
```

Do not forget to change your email address and name in those lines while maintaining the double quotes. If you choose the — global option, you only have to do this once.

Create a git repository for your web app

Use the below command to create a local git repository:

```
git init
```

Then use the below command to add your local files:

```
git add .
```

The dot above means it adds the entire directory to the repository.

Use the below command to commit your files:

```
git commit -m "Initial commit"
```

The comments can be of your choice.

Create an empty app on Heroku

The following steps consist of creating a new app on Heroku and upload the files to that app, and we will be using git for sending the files.

Use the below command to create Heroku app

```
heroku create
```

After the finish of app creation, you can able to get the overview in Heroku account.

Moving all of our files, pushing them to Heroku, and then activating the app are the final steps:

```
git push heroku master
```

Use the below command to activate the app and set the number of dynos (anything higher than one will cost)

```
heroku ps:scale web=1
```

Access app and see performance

If everything went good, then you should be ready to access your app at:

```
.herokuapp.com
```

One can open it by using the URL above or typing:

```
heroku open
```

It may take some time for it to work fine, so be patient. If everything is good, you should now have a web-based app. You should be proud of your accomplishments.

Good to know

The following commands have helped in dealing with all of the common issues encountered on the way:

- **heroku local:** is Used for opening Heroku on the local server.
- **heroku logout:** should be self-explanatory.
- **heroku run 'ls -al':** To list the directory contents, you'll need a copy of your dyno. It is helpful if you want to double-check that new files had added to Heroku.
- **heroku logs –tail:** this command provides you with the information about the app's performance once it is up and running.
- **heroku restart:** should be self-explanatory.
- **heroku apps:rename** to change the name of your app.