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Model Deployment

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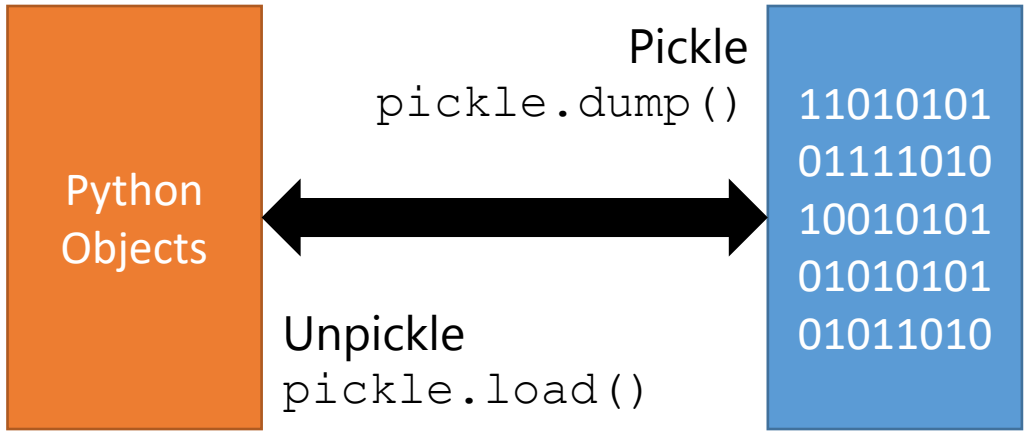
- Pickle
- API
- Flask
- Horeku

Python Pickle



- A module for (de)serialization
  - Storing a Python object into a file and later loading it back in another python script

Example

```
# Python3 program to illustrate store
# efficiently using pickle module
# Module translates an in-memory Python object
# into a serialized byte stream—a string of
# bytes that can be written to any file-like object.

import pickle

def storeData():
    # initializing data to be stored in db
    Omkar = {'key' : 'Omkar', 'name' : 'Omkar Pathak',
    'age' : 21, 'pay' : 40000}
    Jagdish = {'key' : 'Jagdish', 'name' : 'Jagdish Pathak',
    'age' : 50, 'pay' : 50000}

    # database
    db = {}
    db['Omkar'] = Omkar
    db['Jagdish'] = Jagdish

    # Its important to use binary mode
    dbfile = open('examplePickle', 'ab')

    # source, destination
    pickle.dump(db, dbfile)
    dbfile.close()

def loadData():
    # for reading also binary mode is important
    dbfile = open('examplePickle', 'rb')
    db = pickle.load(dbfile)
    for keys in db:
        print(keys, '=>', db[keys])
    dbfile.close()

if __name__ == '__main__':
    storeData()
    loadData()
```

- Output

```
Omkar => {'key': 'Omkar', 'name': 'Omkar Pathak', 'age': 21, 'pay': 40000}
Jagdish => {'key': 'Jagdish', 'name': 'Jagdish Pathak', 'age': 50, 'pay': 50000}
```

Python Pickle

- Advantages
  - A recursive object because it contains reference to itself
    - Pickle tracks the serialized object by its reference
    - The same object won't be serialized again
  - Object sharing by referencing to the same object from different places
    - Similar to self-referencing objects
    - Pickle ensures that all other references point to the master copy
    - Shared objects remain shared, which can be very important for mutable objects
  - User-defined classes and their instances
    - Pickle can save and restore class instances transparently
    - The class definition must be importable and live in the same module as when the object was stored

Further reading: https://docs.python.org/3/library/pickle.html

Serialize your model

```python
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression

class ai:

    def __init__(self, data, features, target, test_size):
        self.X = data.loc[:, features].values
        self.y = data[target].values.ravel()
        self.model = self.learn(self.X, self.y, test_size)

    def learn(self, X, y, test_size):
        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=test_size, stratify=y)
        clf = LogisticRegression(max_iter=10000, penalty="l2")
        clf.fit(X_train, y_train)
        return clf
```

- Let's train a logistic regression model from heart disease data
- Write source code in the OOP style
  - medml.py represents the blueprint of your experiment
  - mymodel.py represents your data preparation and modeling

Serialize your model

```
import pandas as pd
import medml as ml
column_names = ["age", "sex", "cp", "trestbps", "chol", "fbs",
                "restecg", "thalach", "exang", "oldpeak", "slope",
                "ca", "thal", "num"]
df = pd.read_csv("../data/processed.cleveland.data", header=None, names=column_names)
df = df[df["thal"] != "?"].reset_index(drop=True)
df = df[df["ca"] != "?"].reset_index(drop=True)

df["labels"] = df["num"].apply(lambda x: 1 if x > 0 else 0)

features = ["thal", "exang", "cp", "ca", "slope"]

# thal
thal = pd.get_dummies(df["thal"])
thal.columns = ["normal", "fixed defect", "reversable defect"]
df = pd.concat([df, thal], axis=1)

# cp
df["cp"] = df["cp"].map({1: "typical angina",
                         2: "atypical angina",
                         3: "non-anginal pain",
                         4: "asymptomatic"})
cp = pd.get_dummies(df["cp"])
df = pd.concat([df, cp], axis=1)

# slope
df["slope"] = df["slope"].map({1: "upsloping",
                               2: "flat",
                               3: "downsloping"})
slope = pd.get_dummies(df["slope"])
df = pd.concat([df, slope], axis=1)

data = df.loc[:, ["normal", "fixed defect", "reversable defect", "typical angina",
                  "atypical angina", "non-anginal pain", "asymptomatic",
                  "upsloping", "flat", "downsloping", "exang", "ca", "labels"]]

features = data.columns.tolist()
features.remove("labels")
heart = ml.ai(data=df, features=features, target="labels", test_size=0.2)
```

- Let's train a logistic regression model from heart disease data
- Write source code in the OOP style
  - medml.py represents the blueprint of your experiment
  - mymodel.py represents your data preparation and modeling

Serialize your model

```
In [47]: heart.model.coef_
Out[47]:
array([[-0.90843831, -0.10403861,  1.0125147 , -0.37344252, -0.04552741,
        -0.56073491,  0.97974262, -0.87401177,  0.60989188,  0.26415767,
         0.66072607,  1.40903355]])
```

- You have trained your model
- .coef_ is the class attribute to store model parameters for logistic regression object

Serialize your model

```
import pickle

pickle.dump(heart.model, open("logregheart.pkl", "wb"))
```

- Dump you model

Serialize your model

```
In [79]: myheart = pickle.load(open("logregheart.pkl", "rb"))

In [80]: myheart.coef_
Out[80]:
array([[-0.90843831, -0.10403861,  1.0125147 , -0.37344252, -0.04552741,
        -0.56073491,  0.97974262, -0.87401177,  0.60989188,  0.26415767,
         0.66072607,  1.40903355]])
```

- Yore model can be read back

Flask

- Flask is a fast, lightweight way to connect your Python scripts to a server
- Flask is a simple and robust framework to do
  - Small tasks (create a microblog, stand up a simple API) or
  - Complex tasks (Pinterest's API, create a twitter clone)

Hello World Example

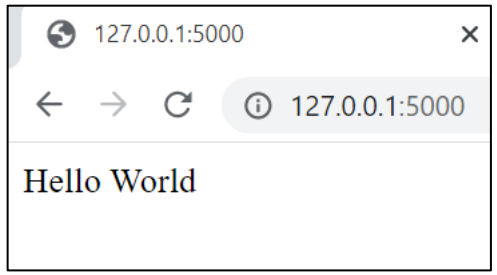
```
import flask
app = flask.Flask(__name__)

@app.route("/")
def hello():
    return "Hello World!"

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

- Create a new .py file, e.g. hello.py
- Flask constructor takes the name of current module (**__name__**) as argument
- The **route()** function of the Flask class is a decorator, which tells the application which URL should call the associated function
  - App routing is used to map the specific URL with the associated function
  - In this example, the URL ('/') is associated with the helllo function that returns “Hello World!” displayed on the web page

ref: https://www.tutorialspoint.com/flask/flask_application.htm

Hello World Example

```
(cebrama) G:\My Drive\Classroom\RADS 602\Original Files\src>python hello.py
 * Serving Flask app "hello" (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Restarting with windowsapi reloader
 * Debugger is active!
 * Debugger PIN: 193-478-798
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
127.0.0.1 - - [26/Jan/2020 17:11:28] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [26/Jan/2020 17:11:28] "GET /favicon.ico HTTP/1.1" 404 -
```



- Run your hello.py
- Your app is running at default url:port at http://127.0.0.1:5000
- Access the above url via your web browser

Hello World Example

```python
import flask

app = flask.Flask(__name__)

@app.route("/")
def hello_world():
    return "Hello World"

@app.route("/greet/<name>")
def greet(name):
    return "Hello, {}!".format(name)

if __name__ == "__main__":
    app.run()
```

- Argument and Styling
  - Add the new function under hello() function
  - Go to url localhost:5000/greet/Rucci
  - Data type can be specified <str:name>
    - String: Default
    - int: Use to convert string to integer
    - float: Use to convert string to float

- Note: the section

  if __name__ == "__main__"

  should be the last section of your code

Hello World Example

```
@app.route("/")
def hello():
    return '''
    <body>
    <h2> Hello World! <h2>
    </body>
    '''
```

- Decorator
  - app.route(endpoint) tells Flask to listen to a URL, and what to do if requests are sent there
  - Since the return statement sends text to an HTML page, you can style it with HTML tags
  - The list of html tags can be found here https://www.w3schools.com/tags/ref_byfunc.asp

Adding ML to Flask

```
import flask
app = flask.Flask(__name__)

#-------- MODEL GOES HERE ----------#

#-------- ROUTES GO HERE ----------#

if __name__ == '__main__':
    '''Connects to the server'''

    HOST = '127.0.0.1'
    PORT = '4000'
    app.run(HOST, PORT)
```

- Structure
- Create a new .py file inside your working directory named **app.py**

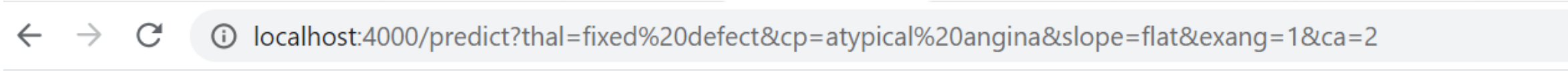
Adding ML to Flask

```python
import numpy as np
import flask
import pickle

# app
app = flask.Flask(__name__)

# load model
heart = pickle.load(open("logregheart.pkl","rb"))

# routes
@app.route("/")
def home():
    return """
           <body>
           <h1>Heart Disease Prediction<h1>
           </body>"""
```

```python
@app.route("/predict", methods=["GET"])
def predict():
    thal = flask.request.args["thal"]
    cp = flask.request.args["cp"]
    slope = flask.request.args["slope"]
    exang = flask.request.args["exang"]
    ca = flask.request.args["ca"]

    fmap = {"normal": [1, 0, 0],
            "fixed defect": [0, 1, 0],
            "reversable defect": [0, 0, 1],
            "typical angina": [1, 0, 0, 0],
            "atypical angina": [0, 1, 0, 0],
            "non anginal pain": [0, 0, 1, 0],
            "asymptomatic": [0, 0, 0, 1],
            "upsloping": [1, 0, 0],
            "flat": [0, 1, 0],
            "downsloping": [0, 0, 1]}

    # X_new = fmap[thal] + fmap[cp] + fmap[slope]

    X_new = np.array(fmap[thal] + fmap[cp] + fmap[slope] + [int(exang)] + [int(ca)]).reshape(1, -1)
    yhat = heart.predict(X_new)
    if yhat[0] == 1:
        outcome = "heart disease"
    else:
        outcome = "normal"
    prob = heart.predict_proba(X_new)

    return "This patient is diagnosed as " + outcome + " with probability " + str(round(prob[0][1], 2))

if __name__ == '__main__':
    """Connect to Server"""
    HOST = "127.0.0.1"
    PORT = "4000"
    app.run(HOST, PORT)
```

Adding ML to Flask

- Parsing your input variables
  - Example:
    - thal: fixed defect
    - cp: atypical angina
    - slope: flat
    - exang: 1
    - ca: 2



This patient is diagnosed as heart disease with probability 0.93

Applying ML to Flask

```
<html>
  <head>
    <title> Heart Disease Prediction </title>
  </head>
  <body>
  <h3> Patient Profile <h3>
  <h5>
      <form action = "http://localhost:4000/result" method = "POST">
          <p>Thalassemia</p>
              <input type="radio" name="thal" value="normal"> Normal
              <input type="radio" name="thal" value="fixed defect"> Fixed defect
              <input type="radio" name="thal" value="reversable defect"> Reversable Defect
          <p>Chest Pain</p>
              <input type="radio" name="cp" value="typical angina"> Typical Angina
              <input type="radio" name="cp" value="atypical angina"> Atypical Angina
              <input type="radio" name="cp" value="non anginal pain"> Non-Anginal Pain
              <input type="radio" name="cp" value="asymptomatic"> Asymptomatic
          <p>Slope</p>
              <input type="radio" name="slope" value="upsloping"> Upsloping
              <input type="radio" name="slope" value="flat"> Flat
              <input type="radio" name="slope" value="downsloping"> Downsloping
          <p>Exercise induced angina (exang)</p>
              <input type="radio" name="exang" value=1> Yes
              <input type="radio" name="exang" value=0> No
          <p>Number of major vessels (0-3) colored by flourosopy</p>
              <input type="radio" name="ca" value=0> 0
              <input type="radio" name="ca" value=1> 1
              <input type="radio" name="ca" value=2> 2
              <input type="radio" name="ca" value=3> 3
          <p><input type = "submit" value = "submit" /></p>
      </form>
    <h5>
  </body>
</html>
```

```
@app.route("/page")
def page():
    with open("page.html", 'r') as viz_file:
        return viz_file.read()
```

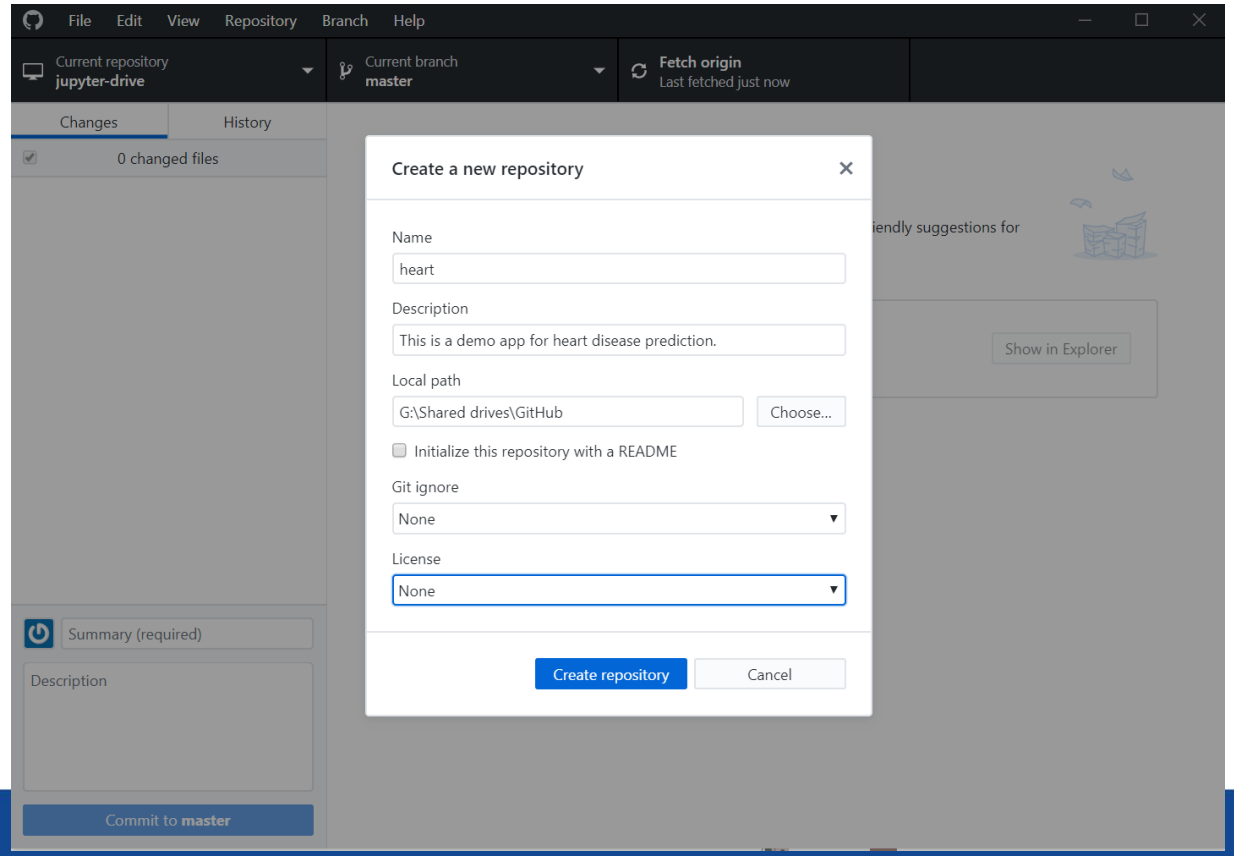
- Making the better one with web UI
  - Create a html file page.html
  - Add app.route("/page") in your app.py

Exercise

- Add a new method to print out the logit model

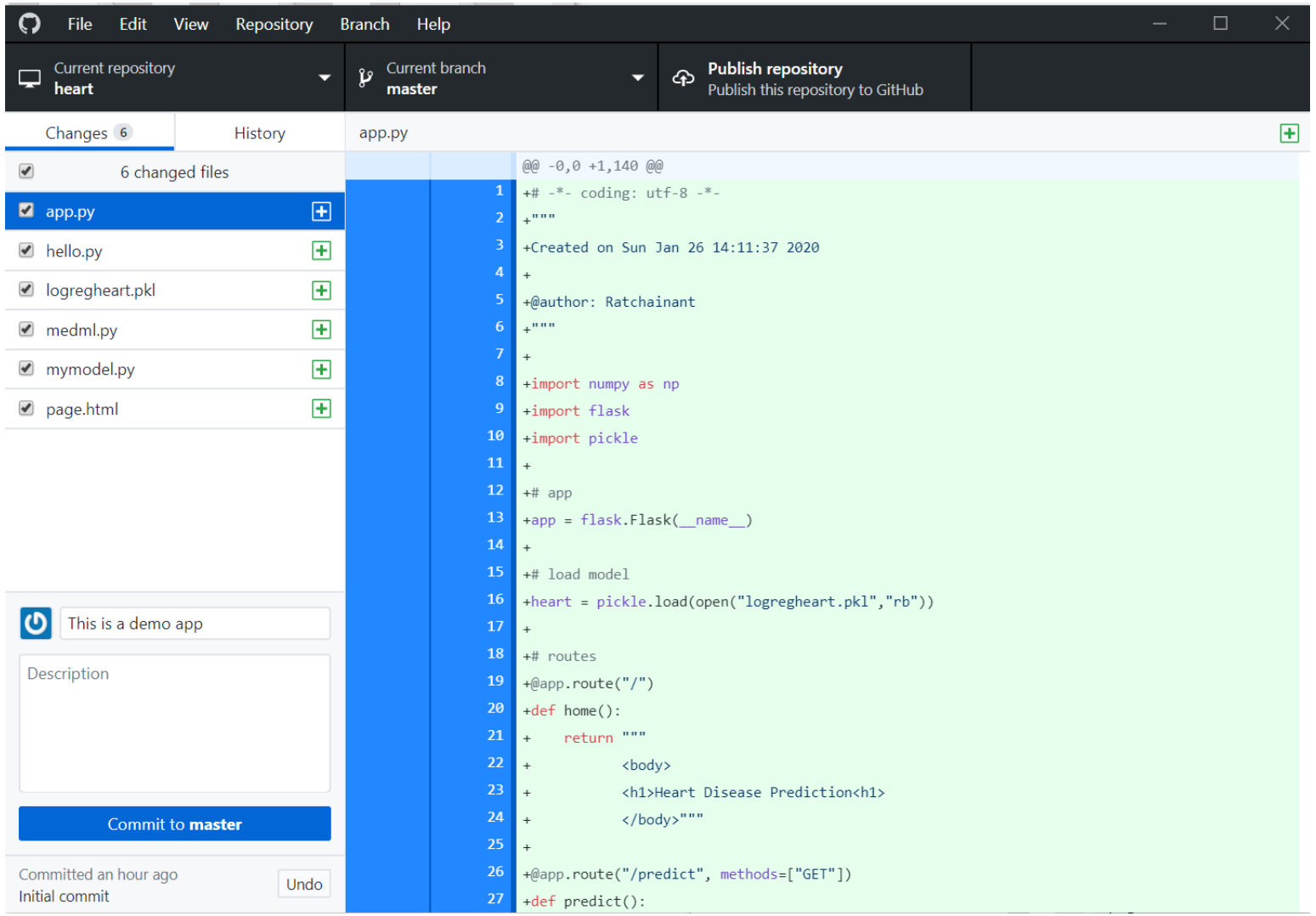
GitHub

- Create the new repository



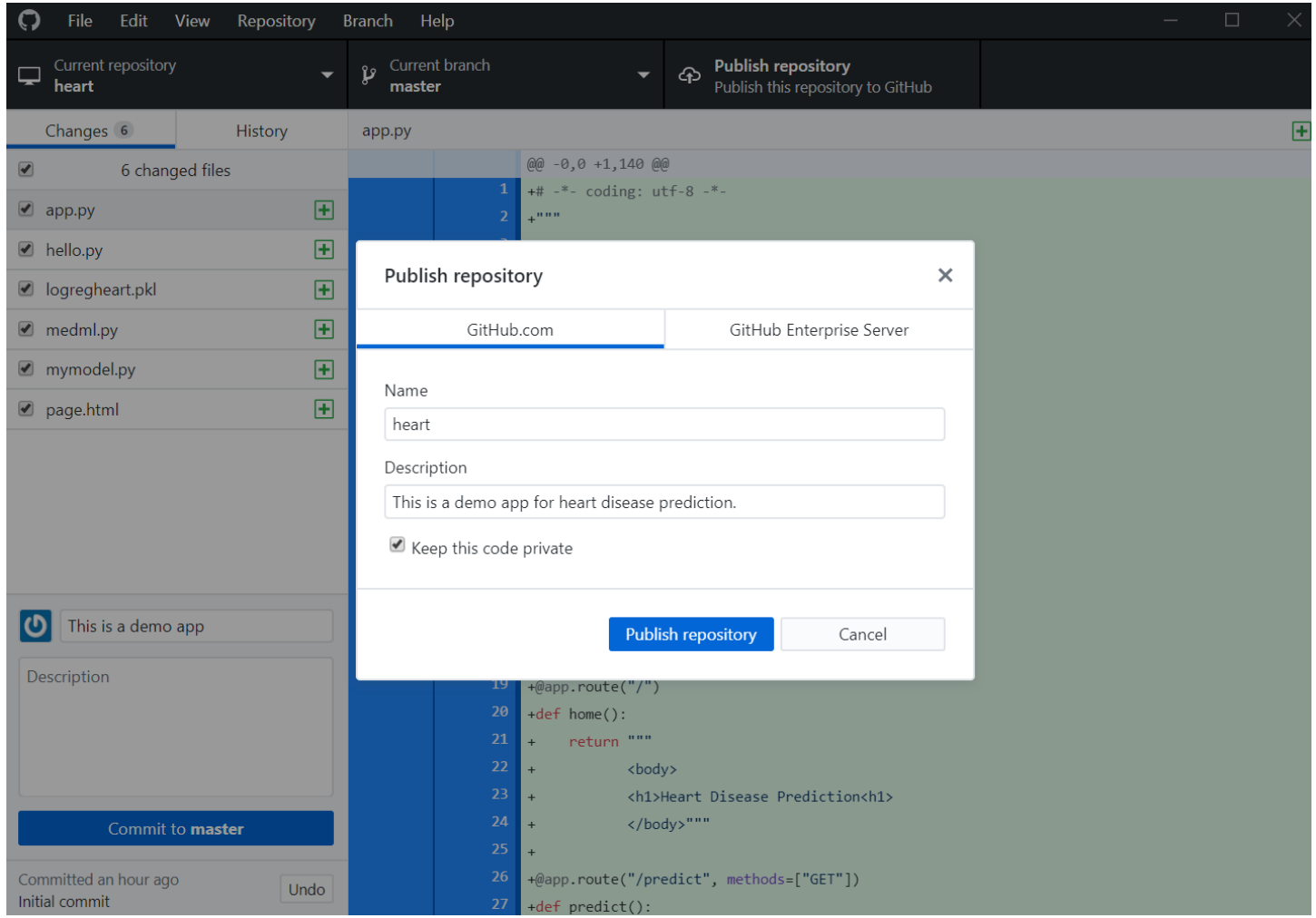
GitHub

- Add your files



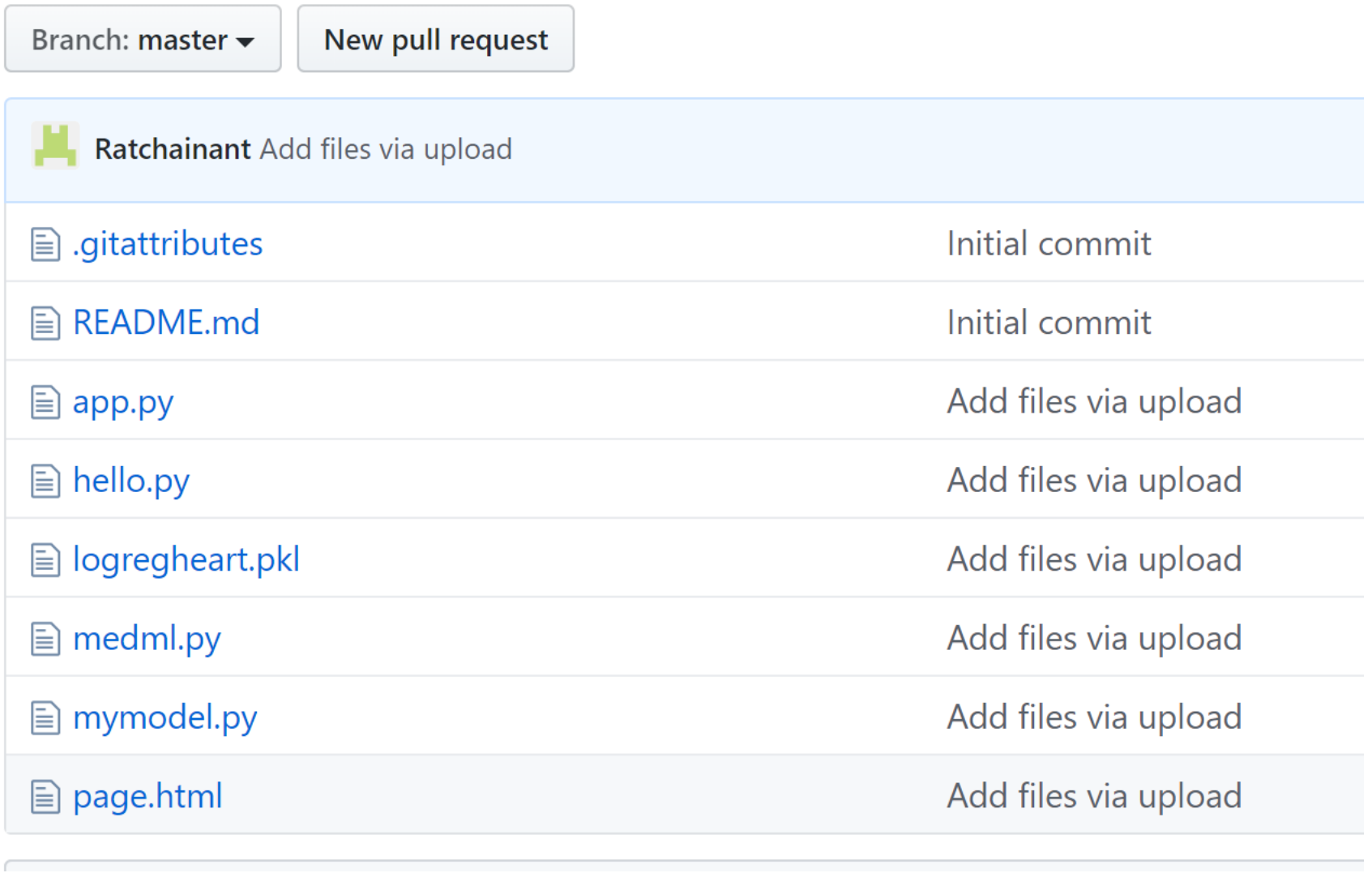
GitHub

- Publish repository



GitHub

- Upload your files



Horeku

```
web: gunicorn app:app
```

- Preparation
  - A Procfile specifies the commands that are executed by a Heroku app on startup. To create one
  - Open up a new file named Procfile (no extension) in the working directory and paste the following

Heroku

```
pip freeze > requirements.txt
```

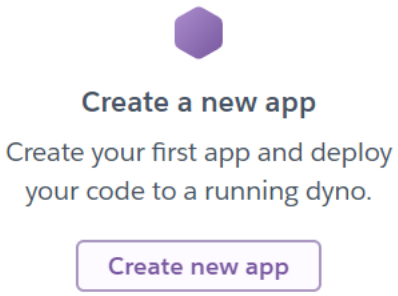
- Create a requirement.txt
- You may need to run this command at your working directory

```
$ pip install -r requirements.txt
```

  - If you ger error “access denied”, add --user after the above command

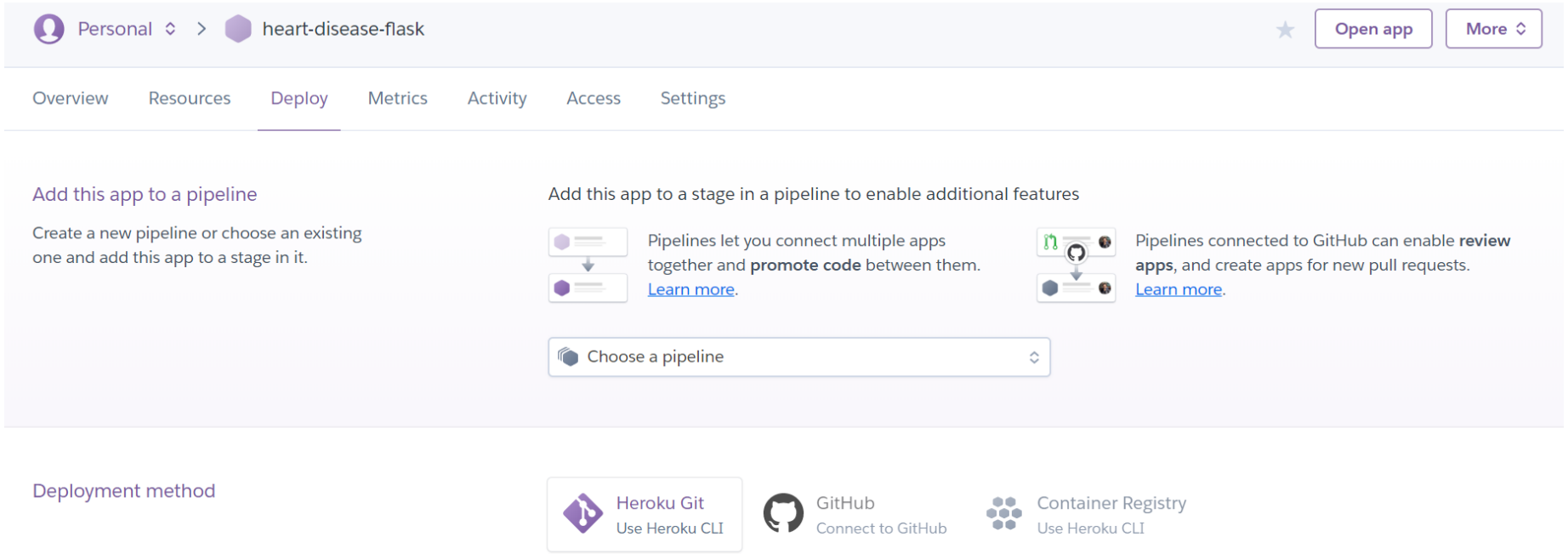
Heroku

- Create the new app



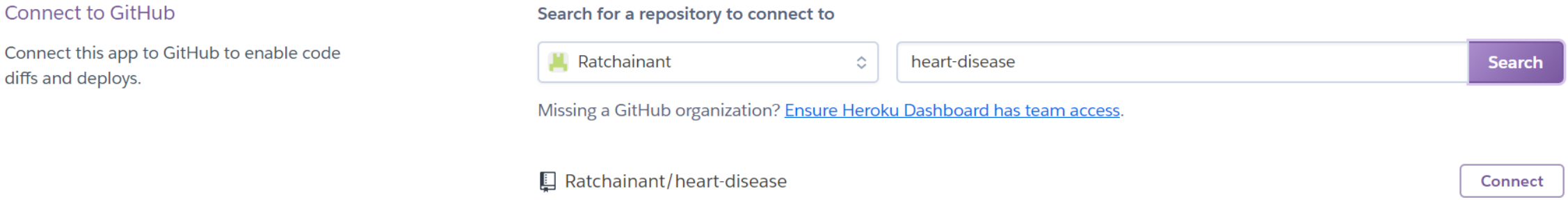
Heroku

- Deploy from your GitHub



Heroku

- Search for the correct repository and click connect



Heroku

- And then just scroll to the bottom of the page and click **Deploy Branch**