FastAPI

Lecture 17

Dr. Colin Rundel

FastAPI - Basic Example

ex1/app.py

```python
from fastapi import FastAPI

app = FastAPI()

@app.get("/")
async def root():
    return {"message": "Hello World"}

@app.get("/add")
async def add(x: int, y: int = 0):
    return {"result": x+y}

@app.get("/user/{user_id}")
async def user_id(user_id: int, name: str | None = None):
    res = {"user_id": user_id}
    if name is not None:
      res["name"] = name

    return res
```

Defining endpoints

Similar to plumber, FastAPI transforms basic Python functions into API endpoints, which are made available by a Python-based webserver (uvicorn).

This transformation is performed using decorators that are used to specify the endpoints via a url path and http method.

For example,

```python
@app.get("/")
async def root():
    return {"message": "Hello World"}
```

Creates an endpoint at `/` that responds to http GET requests with the json `{"message": "Hello World"}`.

Running a FastAPI app

There are a couple of options for running your app,

- Running from Python using uvicorn (an HTTP server based on uv):

```
1 uvicorn.run(app, host="0.0.0.0", port=8181)
```

```
INFO:     Started server process [84680]
INFO:     Waiting for application startup.
INFO:     Application startup complete.
INFO:     Uvicorn running on http://0.0.0.0:8181 (Press CTRL+C to quit)
```

- Running from the command line using uvicorn

```
> uvicorn ex1.app:app --host 0.0.0.0 --port 8080
```

```
INFO:     Started server process [99168]
INFO:     Waiting for application startup.
INFO:     Application startup complete.
INFO:     Uvicorn running on http://0.0.0.0:8080 (Press CTRL+C to quit)
```

- Running from the shell using fastapi (you may need to run `uv add 'fastapi[standard]'` for this to work)

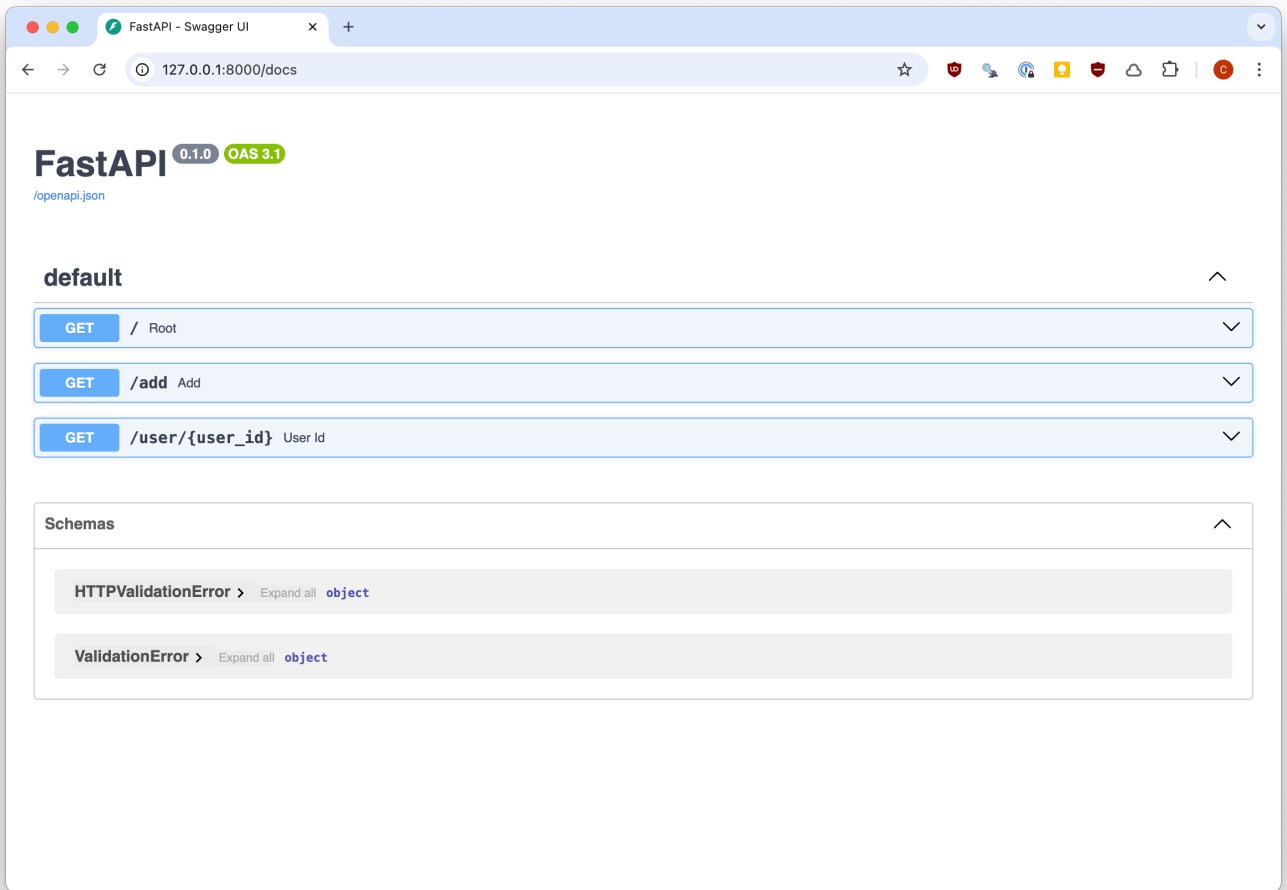
```
> fastapi run ex1/app.py
```

```
 FastAPI   Starting production server 🚀

           Searching for package file structure from directories with __init__.py files
           Importing from /Users/rundel/Desktop/Sta663-Sp26/website/static/slides/Lec17/ex1

  module   🐍 app.py

    code   Importing the FastAPI app object from the module with the following code:

           from app import app

     app   Using import string: app:app

  server   Server started at http://0.0.0.0:8000
  server   Documentation at http://0.0.0.0:8000/docs

           Logs:

    INFO   Started server process [99526]
    INFO   Waiting for application startup.
    INFO   Application startup complete.
    INFO   Uvicorn running on http://0.0.0.0:8000 (Press CTRL+C to quit)
```

Both `run` and `dev` commands are available. The primary difference is the latter has auto-reload enabled which restarts the server when the underlying code changes. `dev` also binds `127.0.0.1` by default while `run` binds `0.0.0.0`.

API Docs

`/docs` `/redoc` `/openapi.json`



Basic Example (again)

ex1/app.py

```python
from fastapi import FastAPI

app = FastAPI()

@app.get("/")
async def root():
    return {"message": "Hello World"}

@app.get("/add")
async def add(x: int, y: int = 0):
    return {"result": x+y}

@app.get("/user/{user_id}")
async def user_id(user_id: int, name: str | None = None):
    res = {"user_id": user_id}
    if name is not None:
      res["name"] = name

    return res
```

`async`?

You may have noticed that all of the function definitions make use of `async def f(...)` - this allows FastAPI to execute these functions asynchronously.

If you don't know what this is generally you don't need to worry about it, but some general advice is:

- If you are using a third-party library that tells you to make calls using the `await` keyword then you definitely need `async`.
- If your function, or a library your function uses, communicates with something (e.g. a database, an API, the file system, etc.) and *does not* support `await`, then don't use `async`.
- If neither of the above apply, generally you should default to using `async` (as long as you avoid blocking calls inside the function).

Query parameters

Like plumber, endpoint functions' arguments are interpreted as query parameters. All arguments without defaults are assumed to be required.

```
1 import requests
2 url = "http://0.0.0.0:8000"
```

```
1 requests.get(url+"/add?x=1&y=1").json()
```

```
{'result': 2}
```

```
1 requests.get(url+"/add?x=-7&y=12").json()
```

```
{'result': 5}
```

```
1 requests.get(url+"/add?x=-7").json()
```

```
{'result': -7}
```

```
1 r = requests.get(url+"/add?y=-7")
2 r.status_code
```

```
422
```

```
1 pprint( r.json() )
```

```
{'detail':
  [{
    'type': 'missing',
    'loc': ['query', 'x'],
    'msg': 'Field required',
    'input': None
  }]
}
```

Type hinting

If type hinting is used when defining your function then FastAPI will attempt to validate the user's inputs based on those types.

```
1 r = requests.get(url+"/add?x=1.0&y=2.0")
2 r.status_code
```

200

```
1 r.json()
```

{'result': 3}

```
1 r = requests.get(url+"/add?x=abc&y=1")
2 r.status_code
```

422

```
1 r.json()
```

```
{'detail':
  [{
    'type': 'int_parsing',
    'loc': ['query', 'x'],
    'msg': 'Input should be a valid integer, unable to
    'input': 'abc'
  }]
}
```

```
1 r = requests.get(url+"/add?x=1.5&y=2.")
2 r.status_code
```

422

```
1 r.json()
```

```
{'detail':
  [{
    'type': 'int_parsing',
    'loc': ['query', 'x'],
    'msg': 'Input should be a valid integer, unable to
    'input': '1.5'
  }, {
    'type': 'int_parsing',
    'loc': ['query', 'y'],
    'msg': 'Input should be a valid integer, unable to
    'input': '2.'
  }]
}
```

Path parameters

Again, like plumber, arguments can be passed to the API using the request path - these are indicated using `{}` in the path definition and then having a matching argument name in the function definition.

```
1 r = requests.get(url+"/user/1234?name=Colin'
2 r.status_code
```

```
200
```

```
1 r.json()
```

```
{'user_id': 1234, 'name': 'Colin'}
```

```
1 r = requests.get(url+"/user/3141")
2 r.status_code
```

```
200
```

```
1 r.json()
```

```
{'user_id': 3141}
```

```
1 r = requests.get(url+"/user/Colin")
2 r.status_code
```

```
422
```

```
1 r.json()
```

```
{'detail':
  [{
    'type': 'int_parsing',
    'loc': ['path', 'user_id'],
    'msg': 'Input should be a valid integer, unab
    'input': 'Colin'
  }]
}
```

HTTP Methods

The HTTP method used in the decorator determines the type of operation the endpoint performs. REST conventions suggest:

Method	Purpose	Decorator
`GET`	Retrieve data	`@app.get()`
`POST`	Create a new resource	`@app.post()`
`PUT`	Replace a resource entirely	`@app.put()`
`PATCH`	Partially update a resource	`@app.patch()`
`DELETE`	Remove a resource	`@app.delete()`

Query and path parameters are most natural with `GET` and `DELETE`.

`POST`, `PUT`, and `PATCH` typically receive data via a request body.

Request body

When making `PUT`, `POST`, or `PATCH` requests, we are usually sending data to the API via the body of our request.

FastAPI makes use of `pydantic` models to define the expected body content. I would like to avoid getting into the weeds of `pydantic` and `typing` as much as possible, so we will go with the most basic use case.

The following `pydantic` model specifies an expected body that contains `name` and `price` entries that are a string and float respectively, and optionally a `description` string and `tax` float.

```
1 from pydantic import BaseModel
2
3 class Item(BaseModel):
4     name: str
5     description: str | None = None
6     price: float
7     tax: float | None = None
```

Usage

The preceding data model can be used as an argument for our endpoint function, and FastAPI will take care of processing everything for us.

```
items = []

@app.post("/items")
async def add_item(item: Item):
    items.append(item)
    return items
```

Usage - Demo

```
1 requests.post(url+"/items", json={"name": "Widget", "price": 9.99}).json()
```

```
[{'name': 'Widget', 'description': None, 'price': 9.99, 'tax': None}]
```

```
1 requests.post(url+"/items", json={"name": "Gadget", "price": 4.99, "description": "A useful g
```

```
[{'name': 'Widget', 'description': None, 'price': 9.99, 'tax': None},
 {'name': 'Gadget', 'description': 'A useful gadget', 'price': 4.99, 'tax': 0.25}]
```

```
1 r = requests.post(url+"/items", json={"name": "Widget"})
2 r.status_code
```

```
422
```

```
1 pprint(r.json())
```

```
{'detail':
  [{
    'type': 'missing',
    'loc': ['body', 'price'],
    'msg': 'Field required',
    'input': {'name': 'Widget'}
  }]
}
```

What's happening?

From FastAPI's Request body docs:

> With just that Python type declaration, FastAPI will:
>
> - Read the body of the request as JSON.
> - Convert the corresponding types (if needed).
> - Validate the data.
>   - If the data is invalid, it will return a nice and clear error, indicating exactly where and what was the incorrect data.
> - Give you the received data in the parameter item.
>   - As you declared it in the function to be of type Item, you will also have all the editor support (completion, etc) for all of the attributes and their types.
> - Generate JSON Schema definitions for your model, you can also use them anywhere else you like if it makes sense for your project.
> - Those schemas will be part of the generated OpenAPI schema, and used by the automatic documentation UIs.

Body vs path & query parameters

Endpoints can use any mixture of body, path, and query parameters.

FastAPI uses the following rules to determine what each argument is:

> The function parameters will be recognized as follows:
>
> - If the parameter is also declared in the path, it will be used as a path parameter.
> - If the parameter is of a singular type (like `int`, `float`, `str`, `bool`, etc) it will be interpreted as a query parameter.
> - If the parameter is declared to be of the type of a Pydantic model, it will be interpreted as a request body.

Error handling - `HTTPException`

For intentional errors (e.g. a requested resource not found), FastAPI provides `HTTPException`:

```python
from fastapi import HTTPException

@app.get("/items/{item_id}")
async def get_item(item_id: int):
    if item_id >= len(items):
        raise HTTPException(status_code=404, detail="Item not found")
    return items[item_id]
```

```python
requests.get(url+"/items/0").json()
```

```
{'name': 'Widget', 'description': None,
 'price': 9.99, 'tax': None}
```

```python
r = requests.get(url+"/items/99")
r.status_code
```

```
404
```

```python
r.json()
```

```
{'detail': 'Item not found'}
```

FastAPI vs plumber

plumber (R)

```r
#* @get /add
function(x, y = 0) {
  list(
    result = as.integer(x) + as.integer(y)
  )
}

#* @post /items
function(req) {
  item <- jsonlite::fromJSON(req$postBody)
  items[[length(items)+1]] <<- item
  items
}

#* @get /items/<item_id:int>
function(item_id) {
  if (item_id > length(items))
    stop("Item not found")
  items[[item_id]]
}
```

FastAPI (Python)

```python
@app.get("/add")
async def add(x: int, y: int = 0):
    return {"result": x + y}

@app.post("/items/")
async def add_item(item: Item):
    items.append(item)
    return items

@app.get("/items/{item_id}")
async def get_item(item_id: int):
    if item_id >= len(items):
        raise HTTPException(404, "Item not
    return items[item_id]
```

Example 2 - A model API

FastAPI - A model API

ex2/app.py

```
from fastapi import FastAPI, HTTPException
from fastapi.responses import RedirectResponse, StreamingResponse

from pydantic import BaseModel

import matplotlib
matplotlib.use("Agg")
import matplotlib.pyplot as plt

import numpy as np
from sklearn.linear_model import LinearRegression
import io

lm = LinearRegression()
X_train = None
y_train = None

class Data(BaseModel):
  X: list[list[float]]
```

Fitting the model

```
rng = np.random.default_rng(seed=1234)
n = 100
X = rng.normal(size=(n, 5))
b = np.array([5, 0, 0, 3, -2]).reshape(-1, 1)
y = (X @ b).squeeze() + rng.normal(scale=0.5, size=n)
```

```
r = requests.post(url+"/fit", json={"X": X.tolist(), "y": y.tolist()})
r.status_code
```

```
200
```

```
pprint(r.json())
```

```
{'intercept': 0.028,
 'coef': [4.988, 0.051, -0.032, 3.015, -1.993]}
```

Predicting from the model

```
1 r = requests.post(url+"/predict", json={"X": X.tolist()})
2 r.status_code
```

```
200
```

```
1 pprint(r.json()["y_hat"][:5])
```

```
[7.432, -2.145, 3.218, 11.876, -5.003]
```

```
1 pprint( requests.get(url+"/coefs").json() )
```

```
{'intercept': 0.028,
 'coef': [4.988, 0.051, -0.032, 3.015, -1.993]}
```

Returning a figure - `StreamingResponse`

Rather than JSON, FastAPI can return raw binary data using `StreamingResponse` (or other `Response` subclasses).

The key pattern for returning an in-memory figure:

```
buf = io.BytesIO()          # in-memory binary buffer
fig.savefig(buf, format="png")
buf.seek(0)                 # rewind buffer
plt.close(fig)              # free memory

return StreamingResponse(buf, media_type="image/png")
```

The `media_type` tells the client how to interpret the bytes — a browser or Python client receiving `image/png` knows to render it as an image rather than text.

`matplotlib.use("Agg")` is set before importing `pyplot` on the server to select a *non-interactive* backend (no display

Residuals plot

```
1  r = requests.get(url+"/plot")
2  r.status_code
```

```
200
```

```
1  r.headers["content-type"]
```

```
'image/png'
```

```
1  from IPython.display import Image
2  Image(r.content)
```