

Practice 5: Machine Learning

PTI - G12

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1. Environment

For this practice we will be using Ubuntu 22.04 LTS and the material provided by the guide. Firefox Mozilla is also used for checking some requests to the model's Central Node.

2. Part I - Training

In federated learning a server coordinates the training of the global AI model and clients with local AI models train our global model. So the first step is to start up our server by running the following commands:

Build Docker image (fl-server) for the server and run it on port 5000.

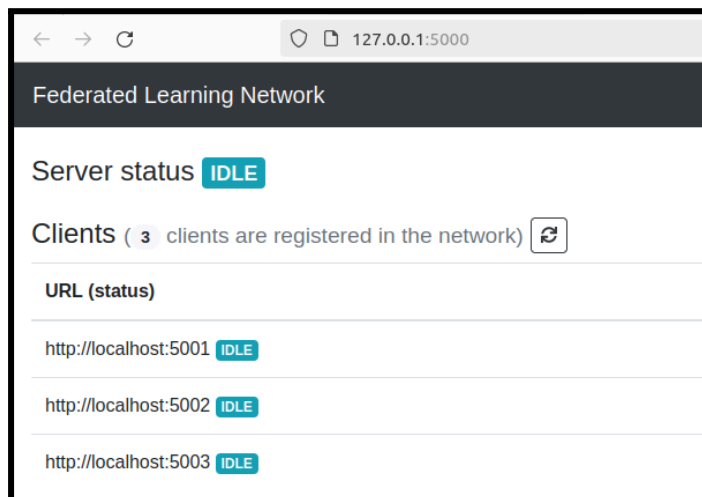
```
Unset
docker build -t fl-server -f Dockerfile .
docker run --rm --name fl-server -p 5000:5000 fl-server:latest
```

Now create the client's image (fl-client).

```
Unset
docker build -t fl-client -f Dockerfile .
```

Secondly we run our clients. We have chosen 3 for this case. After installing some more dependencies we start up the web app and register our 3 clients:

```
[oractfl] adri@adri:~$ docker run --rm --name fl-client -p 5000:5000 fl-client:latest
flask run --port 5003
I'm client 3
2024-03-14 18:36:33.006825: W tensorflow/stream_executor/platform/default/dso_loader.cc:64] Could not load dynamic library 'libcudart.so.11.0'; dlerror: libcudart.so.11.0: cannot open shared object file: No such file or directory
2024-03-14 18:36:33.006873: I tensorflow/stream_executor/cuda/cudart_stub.cc:29] Ignore above cudart dlerror if you do not have a GPU set up on your machine.
Initializing ChestXrayModelTrainer...
Warning: SERVER_URL environment variable is not defined, using DEFAULT_SERVER_URL: http://127.0.0.1:5000
Registering in central node: http://127.0.0.1:5000
Doing request http://127.0.0.1:5000/client
Response received from registration: <Response [201]>
Client registered successfully
* Serving Flask app "app.py"
* Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on all addresses (0.0.0.0)
* Running on http://127.0.0.1:5003
* Running on http://10.192.227.85:5003
press CTRL+C to quit
```



Also, we can see that everything is going well by checking the server log.

```
* Serving Flask app '__init__.py'
* Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on all addresses (0.0.0.0)
* Running on http://127.0.0.1:5000
* Running on http://10.192.227.85:5000
Press CTRL+C to quit
Request POST /client for client_url [ http://localhost:5003 ]
Registering new training client [ http://localhost:5003 ]
Client [ http://localhost:5003 ] registered successfully
127.0.0.1 - - [14/Mar/2024 19:05:22] "POST /client HTTP/1.1" 201 -
Request POST /client for client_url [ http://localhost:5002 ]
Registering new training client [ http://localhost:5002 ]
Client [ http://localhost:5002 ] registered successfully
127.0.0.1 - - [14/Mar/2024 19:05:26] "POST /client HTTP/1.1" 201 -
Request POST /client for client_url [ http://localhost:5001 ]
Registering new training client [ http://localhost:5001 ]
Client [ http://localhost:5001 ] registered successfully
127.0.0.1 - - [14/Mar/2024 19:05:31] "POST /client HTTP/1.1" 201 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/fontawesome/all.css HTTP/1.1" 404 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/bootstrap/bootstrap.min.css HTTP/1.1" 304 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/jquery/jquery-3.5.1.slim.min.js HTTP/1.1" 304 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/css/styles.css HTTP/1.1" 304 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/bootstrap/bootstrap.bundle.min.js HTTP/1.1" 304 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/fontawesome/all.min.js HTTP/1.1" 304 -
127.0.0.1 - - [14/Mar/2024 19:05:54] "GET /static/js/dashboard.js HTTP/1.1" 304 -
Request POST /training
There are 3 clients registered
```

The final step for the AI model training is to start the training by triggering the **Launch training button**. Given the previous configuration, telling docker which dataset it should integrate by adding the -v (volume) flag to the client running commands, the model is going to start its training with the provided dataset.

As we can see, the server requests clients to train their local AI models.

```
Request POST /training
There are 3 clients registered
Requesting training to clients...
Requesting training to client http://localhost:5003/training
Requesting training to client http://localhost:5002/training
Requesting training to client http://localhost:5001/training
Request PUT /model_params for client_url [ http://localhost:5003 ] and training type: CHEST_X_RAY_PNEUMONIA
Weights received length: 6
model weights SHAPE: (3, 3, 3, 32)
model weights SHAPE: (32,)
model weights SHAPE: (3, 3, 32, 64)
model weights SHAPE: (64,)
model weights SHAPE: (200704, 2)
model weights SHAPE: (2,)
Model params received length: 6
New model params received from client http://localhost:5003
127.0.0.1 - - [14/Mar/2024 19:06:17] "PUT /model_params HTTP/1.1" 200 -
Request PUT /model_params for client_url [ http://localhost:5002 ] and training type: CHEST_X_RAY_PNEUMONIA
Weights received length: 6
model weights SHAPE: (3, 3, 3, 32)
model weights SHAPE: (32,)
model weights SHAPE: (3, 3, 32, 64)
model weights SHAPE: (64,)
Client http://localhost:5003 started training
model weights SHAPE: (200704, 2)
model weights SHAPE: (2,)
Model params received length: 6
New model params received from client http://localhost:5002
127.0.0.1 - - [14/Mar/2024 19:06:18] "PUT /model_params HTTP/1.1" 200 -
Client http://localhost:5002 started training
Request PUT /model_params for client_url [ http://localhost:5001 ] and training type: CHEST_X_RAY_PNEUMONIA
Weights received length: 6
model weights SHAPE: (3, 3, 3, 32)
model weights SHAPE: (32,)
model weights SHAPE: (3, 3, 32, 64)
model weights SHAPE: (64,)
model weights SHAPE: (200704, 2)
model weights SHAPE: (2,)
Model params received length: 6
New model params received from client http://localhost:5001
Updating global model params
/home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/practfl/lib/python3.10/site-packages/numpy/core/shape_base.py:420: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples or ndarrays with different lengths or shapes) is deprecated. If you meant to do this, you must specify 'dtype=object' when creating the ndarray.
  arrays = [asanyarray(arr) for arr in arrays]
Model weights for CHEST_X_RAY_PNEUMONIA updated in central model
127.0.0.1 - - [14/Mar/2024 19:06:18] "PUT /model_params HTTP/1.1" 200 -
Client http://localhost:5001 started training
127.0.0.1 - - [14/Mar/2024 19:06:18] "POST /training HTTP/1.1" 200 -
```

And here is the client's log, where once the training is finished, the client sends calculated model weights to the central node (server).

```
max_pooling2d (MaxPooling2D) (None, 112, 112, 32) 0
)
conv2d_1 (Conv2D) (None, 112, 112, 64) 18496
max_pooling2d_1 (MaxPooling2D) (None, 56, 56, 64) 0
Flatten (Flatten) (None, 200704) 0
dense (Dense) (None, 2) 40140
=====
Total params: 420,802
Trainable params: 420,802
Non-trainable params: 0
Using default model weights
Create temp dataset...
Temporary folder for trainings: /home/adria/FIB/pti_2024/ml_application/federated-learning-network-main/client/tnp1/chest_xray/tnp1s0hnhxw
Loading CHEST_XRAY_PNEUMONIA dataset...
Found 200 images belonging to 2 classes.
Found 100 images belonging to 2 classes.
2
Epoch 1/2
2024-03-14 19:05:59.231919: W tensorflow/core/framework/cpu_allocator_impl.cc:82] Allocation of 32112640 exceeds 10% of free system memory.
2024-03-14 19:05:59.530376: W tensorflow/core/framework/cpu_allocator_impl.cc:82] Allocation of 28901376 exceeds 10% of free system memory.
2024-03-14 19:05:59.710906: W tensorflow/core/framework/cpu_allocator_impl.cc:82] Allocation of 32112640 exceeds 10% of free system memory.
2024-03-14 19:05:59.975496: W tensorflow/core/framework/cpu_allocator_impl.cc:82] Allocation of 32112640 exceeds 10% of free system memory.
2024-03-14 19:06:00.245460: W tensorflow/core/framework/cpu_allocator_impl.cc:82] Allocation of 28901376 exceeds 10% of free system memory.
10/10 - 8s - loss: 22.0694 - accuracy: 0.6000 - val_loss: 5.0995 - val_accuracy: 0.7200 - 8s/epoch - 810ms/step
Epoch 2/2
10/10 - 5s - loss: 2.0521 - accuracy: 0.8600 - val_loss: 1.7824 - val_accuracy: 0.8400 - 5s/epoch - 490ms/step
1/20 [>.....] - ETA: 3s - loss: 3.5610 - accuracy: 0.60 2/20 [==>.....] - ETA: 1s - loss: 7.9469 - accuracy: 0.70 3/20 [====>.....] - ETA: 1s - loss: 5.5933 - accuracy: 0.72 4/20 [=====] - ETA: 1s - loss: 4.6999 - accuracy: 0.70 5/20 [=====] - ETA: 1s - loss: 3.7600 - accuracy: 0.76 6/20 [=====] - ETA: 1s - loss: 3.1333 - accuracy: 0.80 7/20 [=====] - ETA: 1s - loss: 3.6657 - accuracy: 0.80 8/20 [=====] - ETA: 1s - loss: 3.2075 - accuracy: 0.82 9/20 [=====] - ETA: 0s - loss: 3.8309 - accuracy: 0.7710/20 [=====] - ETA: 0s - loss: 3.4478 - accuracy: 0.8011/20 [=====] - ETA: 0s - loss: 3.1245 - accuracy: 0.8112/20 [=====] - ETA: 0s - loss: 3.4602 - accuracy: 0.7813/20 [=====] - ETA: 0s - loss: 3.7517 - accuracy: 0.7816/20 [=====] - ETA: 0s - loss: 3.9719 - accuracy: 0.8019/20 [=====] - ETA: 0s - loss: 3.7629 - accuracy: 0.8120/20 [=====] - ETA: 0s - loss: 3.5748 - accuracy: 0.8220/20 [=====] - 2s 88ms/step - loss: 3.5748 - accuracy: 0.8200
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op while saving (showing 2 of 2). These functions will not be directly callable after loading.
Deleting content of temporary folder /home/adria/FIB/pti_2024/ml_application/federated-learning-network-main/client/tnp1/chest_xray/tnp1s0hnhxw
Deleting temporary dataset folder /home/adria/FIB/pti_2024/ml_application/federated-learning-network-main/client/tnp1/chest_xray/
model params SHAPE: (3, 3, 3, 32)
model params SHAPE: (32,)
model params SHAPE: (3, 3, 32, 64)
model params SHAPE: (64,)
model params SHAPE: (200704, 2)
model params SHAPE: (2,)
Sending calculated model weights to central node
response received from updating central model params: <Response [200]>
Model params updated on central successfully
Training finished...
127.0.0.1 - - [14/Mar/2024 19:06:18] "POST /training HTTP/1.1" 200 -
INFO:werkzeug:127.0.0.1 - - [14/Mar/2024 19:06:18] "POST /training HTTP/1.1" 200 -
```

A thing to take into consideration is to set the **USE_TRAINED_MODEL** variable to **True** in the **config.py** file in order to indicate the algorithm to use a previous trained model and avoid training our model from scratch every time we start a training.

As we can see, after a few training sessions our model gets acceptable results. In the image below the bottom right terminal corresponds to the central node and the others to the 3 different clients.

```
adria@adria-BQHK-WAX9X: ~/FIB/pti_2024/ml_application/fe...
10/10 - 5s - loss: 0.3274 - accuracy: 0.9600 - val_loss: 1.8491 - val_accuracy: 0.8800 - 5s/epoch - 483ms/step
1/20 [>.....] - ETA: 3s - loss: 2.7393e+05 - accuracy: 0.00
2/20 [==>.....] - ETA: 1s - loss: 3.6652 - accuracy: 0.80
3/20 [====>.....] - ETA: 1s - loss: 3.8725 - accuracy: 0.80
4/20 [=====] - ETA: 1s - loss: 2.9044 - accuracy: 0.85
5/20 [=====] - ETA: 1s - loss: 2.3235 - accuracy: 0.88
6/20 [=====] - ETA: 1s - loss: 2.3793 - accuracy: 0.86
7/20 [=====] - ETA: 1s - loss: 3.3650 - accuracy: 0.82
8/20 [=====] - ETA: 1s - loss: 3.2068 - accuracy: 0.82
9/20 [=====] - ETA: 0s - loss: 3.5804 - accuracy: 0.82
10/20 [=====] - ETA: 0s - loss: 3.6834 - accuracy: 0.82
11/20 [=====] - ETA: 0s - loss: 3.3935 - accuracy: 0.81
12/20 [=====] - ETA: 0s - loss: 4.6210 - accuracy: 0.81
13/20 [=====] - ETA: 0s - loss: 3.9931 - accuracy: 0.81
14/20 [=====] - ETA: 0s - loss: 4.0394 - accuracy: 0.81
15/20 [=====] - ETA: 0s - loss: 4.2221 - accuracy: 0.80
16/20 [=====] - ETA: 0s - loss: 4.3685 - accuracy: 0.78
17/20 [=====] - ETA: 0s - loss: 4.1489 - accuracy: 0.78
18/20 [=====] - ETA: 0s - loss: 4.0448 - accuracy: 0.77
19/20 [=====] - ETA: 0s - loss: 4.0240 - accuracy: 0.77
20/20 [=====] - 2s 93ms/step - loss: 3.8237 - accuracy: 0.7900

adria@adria-BQHK-WAX9X: ~/FIB/pti_2024/ml_application/fe...
10/10 - 4s - loss: 0.8886 - accuracy: 0.9600 - val_loss: 20.3450 - val_accuracy: 0.4400 - 4s/epoch - 402ms/step
1/20 [>.....] - ETA: 5s - loss: 2.7824 - accuracy: 0.80
2/20 [==>.....] - ETA: 3s - loss: 13.9957 - accuracy: 0.6
3/20 [====>.....] - ETA: 2s - loss: 13.3253 - accuracy: 0.6
4/20 [=====] - ETA: 2s - loss: 10.5233 - accuracy: 0.6
5/20 [=====] - ETA: 2s - loss: 10.4574 - accuracy: 0.6
6/20 [=====] - ETA: 1s - loss: 11.2405 - accuracy: 0.6
7/20 [=====] - ETA: 1s - loss: 10.6580 - accuracy: 0.6
8/20 [=====] - ETA: 1s - loss: 12.1993 - accuracy: 0.6
9/20 [=====] - ETA: 1s - loss: 11.9451 - accuracy: 0.6
10/20 [=====] - ETA: 1s - loss: 14.0028 - accuracy: 0.6
11/20 [=====] - ETA: 1s - loss: 15.0773 - accuracy: 0.6
12/20 [=====] - ETA: 1s - loss: 15.8470 - accuracy: 0.5
13/20 [=====] - ETA: 1s - loss: 16.3733 - accuracy: 0.5
14/20 [=====] - ETA: 0s - loss: 15.5286 - accuracy: 0.5
15/20 [=====] - ETA: 0s - loss: 14.8354 - accuracy: 0.5
16/20 [=====] - ETA: 0s - loss: 15.3483 - accuracy: 0.5
17/20 [=====] - ETA: 0s - loss: 16.0015 - accuracy: 0.5
18/20 [=====] - ETA: 0s - loss: 15.3250 - accuracy: 0.5
19/20 [=====] - ETA: 0s - loss: 14.9261 - accuracy: 0.5
20/20 [=====] - 3s 14ms/step - loss: 14.3632 - accuracy: 0.6000

adria@adria-BQHK-WAX9X: ~/FIB/pti_2024/ml_application/fe...
0.8400 - 4s/epoch - 403ms/step
1/20 [>.....] - ETA: 4s - loss: 0.0000e+00 - accuracy: 0.99
2/20 [==>.....] - ETA: 2s - loss: 2.8574 - accuracy: 0.99
3/20 [====>.....] - ETA: 1s - loss: 1.9050 - accuracy: 0.99
4/20 [=====] - ETA: 2s - loss: 3.2495 - accuracy: 0.99
5/20 [=====] - ETA: 2s - loss: 3.8407 - accuracy: 0.88
6/20 [=====] - ETA: 2s - loss: 3.8144 - accuracy: 0.86
7/20 [=====] - ETA: 2s - loss: 4.0156 - accuracy: 0.85
8/20 [=====] - ETA: 1s - loss: 3.5136 - accuracy: 0.87
9/20 [=====] - ETA: 1s - loss: 3.6592 - accuracy: 0.84
10/20 [=====] - ETA: 1s - loss: 3.3873 - accuracy: 0.84
11/20 [=====] - ETA: 1s - loss: 3.2160 - accuracy: 0.83
12/20 [=====] - ETA: 1s - loss: 3.4557 - accuracy: 0.81
13/20 [=====] - ETA: 1s - loss: 3.1899 - accuracy: 0.83
14/20 [=====] - ETA: 0s - loss: 3.4446 - accuracy: 0.82
15/20 [=====] - ETA: 0s - loss: 3.2048 - accuracy: 0.82
16/20 [=====] - ETA: 0s - loss: 3.2258 - accuracy: 0.82
17/20 [=====] - ETA: 0s - loss: 3.1425 - accuracy: 0.82
18/20 [=====] - ETA: 0s - loss: 2.9680 - accuracy: 0.82
19/20 [=====] - ETA: 0s - loss: 3.9454 - accuracy: 0.83
20/20 [=====] - 3s 158ms/step - loss: 2.8931 - accuracy: 0.8400
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit

adria@adria-BQHK-WAX9X: ~/FIB/pti_2024/ml_application/fe...
Request PUT /model_params for client_url [ http://localhost:5001 ] and training
Type: CHEST_XRAY_PNEUMONIA
Weights received length: 0
model weights SHAPE: (3, 3, 3, 32)
model weights SHAPE: (32,)
model weights SHAPE: (3, 3, 32, 64)
model weights SHAPE: (200704, 2)
model weights SHAPE: (2,)
Model params received length: 6
New model params received from client http://localhost:5001
Updating global model params
/home/adria/FIB/pti_2024/ml_application/federated-learning-network-main/practfl/tlb/pythons10/site-packages/numpy/core/shape_base.py:420: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples or ndarrays with different lengths or shapes) is deprecated. If you want to do this, you must specify 'dtype=object' when creating the ndarray
arrays = [asanyarray(arr) for arr in arrays]
Model weights for CHEST_XRAY_PNEUMONIA updated in central model
127.0.0.1 - - [16/Mar/2024 10:58:45] "PUT /model_params HTTP/1.1" 200 -
Client http://localhost:5001 started training
127.0.0.1 - - [16/Mar/2024 10:58:45] "POST /training HTTP/1.1" 200 -
```

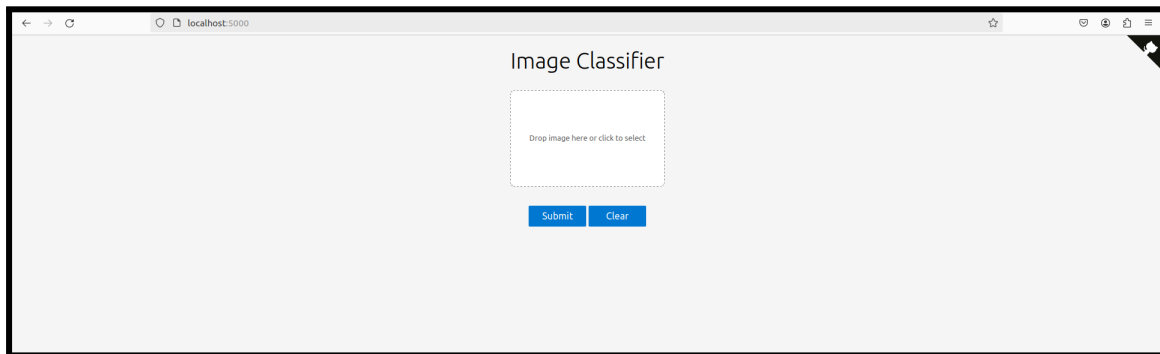
3. Part II - Web App

For the second part of the practice, we will be using a flask web-app to upload our images and determine if a person is suffering from pneumonia.

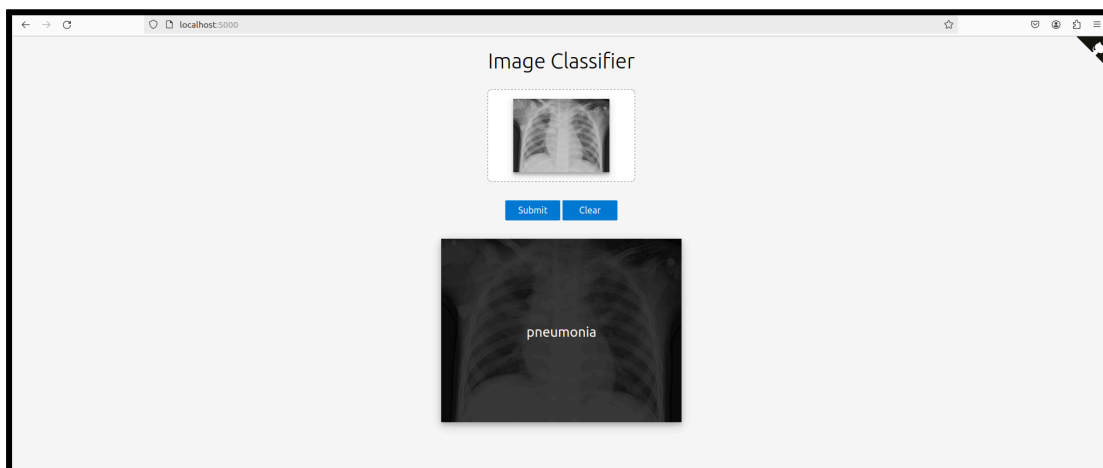
After installing the requirements we configure the **MODEL_PATH** in *app_pneu.py* we can run our server with:

```
Unset  
python3 app_pneu.py
```

Now we can see our web app in <http://localhost:5000>.



If we try to upload an image our model analyzes it and determines if the person suffers pneumonia.

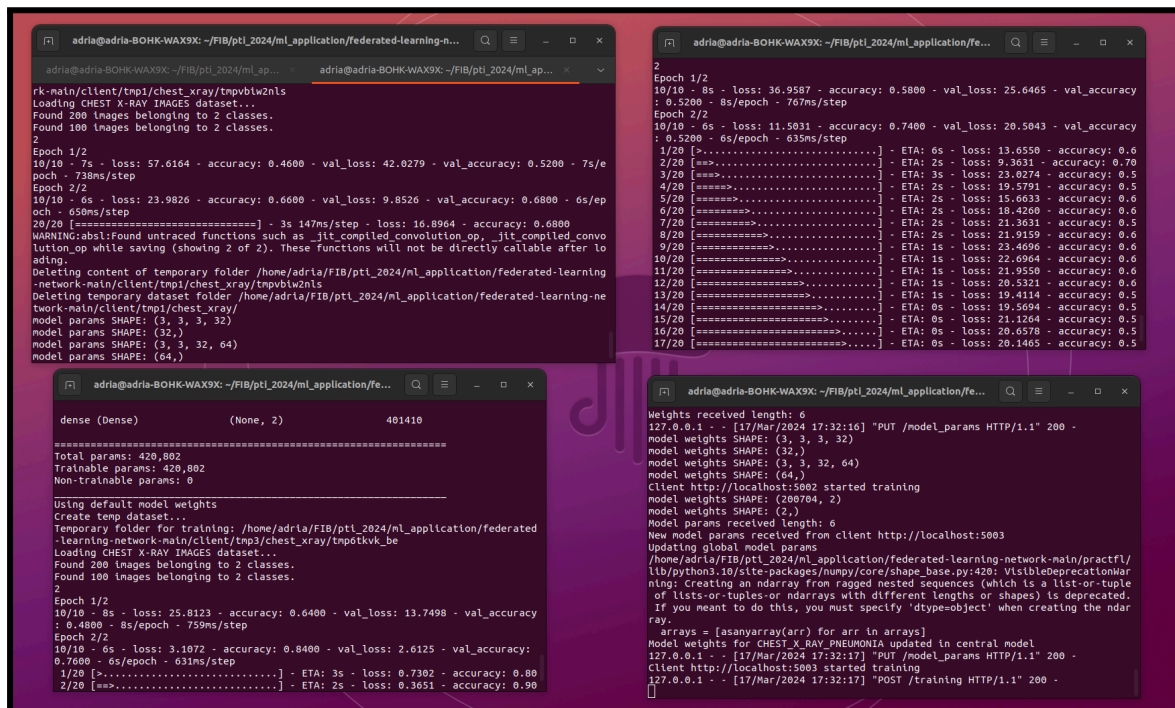


4. Extension

As the extension topic we have chosen to analyze the model's behavior when the Epochs value is modified. First we will do a brief introduction to "What is Epochs?"

An **epoch** refers to one complete pass of the entire training dataset through the learning algorithm. In other words, when all the data samples have been exposed to the neural network for learning patterns, one epoch is said to be completed. In other words, an epoch can be seen as the sets we do if we were in the gym. One set is a group of repetitions of the same exercise. The more sets we do, the more our muscles grow.

So, in the next picture we can appreciate the results obtained by training the model with epochs=2 (default value) in *federated_learning_config.py*. Also, we can modify more values like *size_batch* and *learning_rate* that would also alterate the training behavior.



```
adria@adria-BOHK-WAX9X: ~/FIB/ptl_2024/ml_application/federated-learning-a...
adria@adria-BOHK-WAX9X: ~/FIB/ptl_2024/ml_ap...
rk-main/client/tmp1/chest_xray/tmpvbw2nls
Loading CHEST X-RAY IMAGES dataset...
Found 200 Images belonging to 2 classes.
Found 100 Images belonging to 2 classes.
2
Epoch 1/2
10/10 - 8s - loss: 57.6164 - accuracy: 0.4600 - val_loss: 42.0279 - val_accuracy: 0.5200 - 7s/epoch - 738ms/step
Epoch 2/2
10/10 - 6s - loss: 23.9826 - accuracy: 0.6600 - val_loss: 9.8526 - val_accuracy: 0.6800 - 6s/epoch - 650ms/step
20/20 [=====] - 3s 147ms/step - loss: 16.8964 - accuracy: 0.6800
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op while saving (showing 2 of 2). These functions will not be directly callable after loading.
Deleting content of temporary folder /home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/client/tmp1/chest_xray/tmpvbw2nls
Deleting temporary dataset folder /home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/client/tmp1/chest_xray/
model params SHAPE: (3, 3, 3, 32)
model params SHAPE: (32,)
model params SHAPE: (3, 3, 32, 64)
model params SHAPE: (64,)

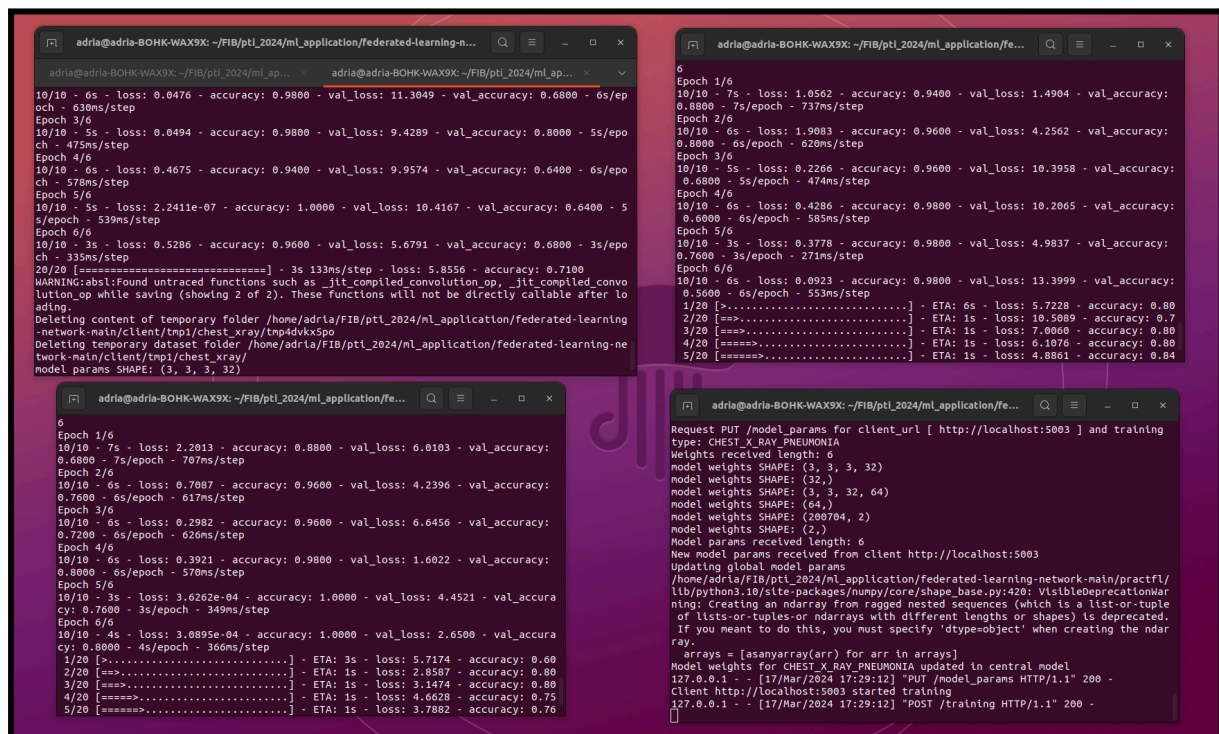
dense (Dense) (None, 2) 401410
=====
Total params: 420,802
Trainable params: 420,802
Non-trainable params: 0
Using default model weights
Create temp dataset...
Temporary folder for training: /home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/client/tmp3/chest_xray/tmp6tkvk_be
Loading CHEST X-RAY IMAGES dataset...
Found 200 Images belonging to 2 classes.
Found 100 Images belonging to 2 classes.
2
Epoch 1/2
10/10 - 8s - loss: 25.8123 - accuracy: 0.6400 - val_loss: 13.7498 - val_accuracy: 0.4800 - 8s/epoch - 759ms/step
Epoch 2/2
10/10 - 6s - loss: 3.1072 - accuracy: 0.8400 - val_loss: 2.6125 - val_accuracy: 0.7600 - 6s/epoch - 631ms/step
1/20 [>.....] - ETA: 3s - loss: 0.7302 - accuracy: 0.80
2/20 [==>.....] - ETA: 2s - loss: 0.3651 - accuracy: 0.90

Epoch 1/2
10/10 - 8s - loss: 36.9587 - accuracy: 0.5800 - val_loss: 25.6465 - val_accuracy: 0.5200 - 8s/epoch - 767ms/step
Epoch 2/2
10/10 - 6s - loss: 11.5031 - accuracy: 0.7400 - val_loss: 20.5043 - val_accuracy: 0.5200 - 6s/epoch - 635ms/step
1/20 [>.....] - ETA: 6s - loss: 13.6550 - accuracy: 0.6
2/20 [==>.....] - ETA: 2s - loss: 9.3631 - accuracy: 0.70
3/20 [====>.....] - ETA: 3s - loss: 23.0274 - accuracy: 0.5
4/20 [=====] - ETA: 2s - loss: 19.5791 - accuracy: 0.5
5/20 [=====] - ETA: 2s - loss: 15.0633 - accuracy: 0.6
6/20 [=====] - ETA: 2s - loss: 18.4260 - accuracy: 0.6
7/20 [=====] - ETA: 2s - loss: 21.3631 - accuracy: 0.5
8/20 [=====] - ETA: 2s - loss: 21.9159 - accuracy: 0.6
9/20 [=====] - ETA: 1s - loss: 23.4696 - accuracy: 0.6
10/20 [=====] - ETA: 1s - loss: 22.6964 - accuracy: 0.6
11/20 [=====] - ETA: 1s - loss: 21.9550 - accuracy: 0.6
12/20 [=====] - ETA: 1s - loss: 20.5321 - accuracy: 0.6
13/20 [=====] - ETA: 1s - loss: 19.4114 - accuracy: 0.5
14/20 [=====] - ETA: 0s - loss: 19.5694 - accuracy: 0.5
15/20 [=====] - ETA: 0s - loss: 21.1264 - accuracy: 0.5
16/20 [=====] - ETA: 0s - loss: 20.6578 - accuracy: 0.5
17/20 [=====] - ETA: 0s - loss: 20.1465 - accuracy: 0.5

Weights received length: 6
127.0.0.1 - [17/Mar/2024 17:32:16] "PUT /model_params HTTP/1.1" 200 -
model weights SHAPE: (3, 3, 3, 32)
model weights SHAPE: (32,)
model weights SHAPE: (3, 3, 32, 64)
model weights SHAPE: (64,)
Client http://localhost:5002 started training
model weights SHAPE: (200704, 2)
model weights SHAPE: (2,)
Model params received length: 6
New model params received from client http://localhost:5003
Updating global model params
/home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/practfl/lib/python3.10/site-packages/numpy/core/shape_base.py:420: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you meant to do this, you must specify 'dtype=object' when creating the ndarray.
  arrays = [asanyarray(arr) for arr in arrays]
Model weights for CHEST X-RAY_PNEUMONIA updated in central model
127.0.0.1 - [17/Mar/2024 17:32:17] "PUT /model_params HTTP/1.1" 200 -
Client http://localhost:5003 started training
127.0.0.1 - [17/Mar/2024 17:32:17] "POST /training HTTP/1.1" 200 -
```

As we can appreciate, the training is completed in 6-8s/epoch.

Now let's try to change epochs to 10.



```
adria@adria-BOHK-WAX9X: ~/FIB/ptl_2024/ml_application/federated-learning-n...
adria@adria-BOHK-WAX9X: ~/FIB/ptl_2024/ml_ap...
10/10 - 6s - loss: 0.0476 - accuracy: 0.9800 - val_loss: 11.3049 - val_accuracy: 0.6800 - 6s/epoch - 630ms/step
Epoch 3/6
10/10 - 5s - loss: 0.0494 - accuracy: 0.9800 - val_loss: 9.4289 - val_accuracy: 0.8000 - 5s/epoch - 475ms/step
Epoch 4/6
10/10 - 6s - loss: 0.4675 - accuracy: 0.9400 - val_loss: 9.9574 - val_accuracy: 0.6400 - 6s/epoch - 578ms/step
Epoch 5/6
10/10 - 5s - loss: 2.2411e-07 - accuracy: 1.0000 - val_loss: 10.4167 - val_accuracy: 0.6400 - 5s/epoch - 539ms/step
Epoch 6/6
10/10 - 3s - loss: 0.5286 - accuracy: 0.9600 - val_loss: 5.6791 - val_accuracy: 0.6800 - 3s/epoch - 335ms/step
20/20 [=====] - 3s 133ms/step - loss: 5.8556 - accuracy: 0.7100
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op while saving (showing 2 of 2). These functions will not be directly callable after loading.
Deleting content of temporary folder /home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/client/tmp1/chest_xray/tmp4ddvks5po
Deleting temporary dataset folder /home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/client/tmp1/chest_xray/
model params SHAPE: (3, 3, 32)

adria@adria-BOHK-WAX9X: ~/FIB/ptl_2024/ml_application/fe...
Epoch 1/6
10/10 - 7s - loss: 2.2013 - accuracy: 0.8800 - val_loss: 6.0103 - val_accuracy: 0.6800 - 7s/epoch - 707ms/step
Epoch 2/6
10/10 - 6s - loss: 0.7087 - accuracy: 0.9600 - val_loss: 4.2396 - val_accuracy: 0.7600 - 6s/epoch - 617ms/step
Epoch 3/6
10/10 - 6s - loss: 0.2982 - accuracy: 0.9600 - val_loss: 6.6456 - val_accuracy: 0.7200 - 6s/epoch - 626ms/step
Epoch 4/6
10/10 - 6s - loss: 0.3921 - accuracy: 0.9800 - val_loss: 1.6022 - val_accuracy: 0.8800 - 6s/epoch - 570ms/step
Epoch 5/6
10/10 - 3s - loss: 3.6262e-04 - accuracy: 1.0000 - val_loss: 4.4521 - val_accuracy: 0.7600 - 3s/epoch - 349ms/step
Epoch 6/6
10/10 - 4s - loss: 3.0895e-04 - accuracy: 1.0000 - val_loss: 2.6500 - val_accuracy: 0.8000 - 4s/epoch - 366ms/step
1/20 [>.....] - ETA: 3s - loss: 5.7174 - accuracy: 0.60
2/20 [==>.....] - ETA: 1s - loss: 2.8507 - accuracy: 0.80
3/20 [===>.....] - ETA: 1s - loss: 3.1474 - accuracy: 0.80
4/20 [====>.....] - ETA: 1s - loss: 4.6628 - accuracy: 0.75
5/20 [=====] - ETA: 1s - loss: 3.7882 - accuracy: 0.76

Request PUT /model_params for client_url [ http://localhost:5003 ] and training type: CHEST_X_RAY_PNEUMONIA
Weights received length: 6
model weights SHAPE: (3, 3, 3, 32)
model weights SHAPE: (32,)
model weights SHAPE: (3, 3, 32, 64)
model weights SHAPE: (64,)
model weights SHAPE: (200704, 2)
model weights SHAPE: (2,)
Model params received length: 6
New model params received from client http://localhost:5003
Updating global model params
/home/adria/FIB/ptl_2024/ml_application/federated-learning-network-main/practf1/lib/python3.10/site-packages/numpy/core/shape_base.py:428: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples or ndarrays with different lengths or shapes) is deprecated. If you meant to do this, you must specify 'dtype=object' when creating the ndarray.
  arrays = [asanyarray(arr) for arr in arrays]
Model weights for CHEST_X_RAY_PNEUMONIA updated in central model
127.0.0.1 - - [17/Mar/2024 17:29:12] "PUT /model_params HTTP/1.1" 200 -
client http://localhost:5003 started training
127.0.0.1 - - [17/Mar/2024 17:29:12] "POST /training HTTP/1.1" 200 -
```

As we see, we obtain better results. But it's not all a bed of roses, we have experienced an increase in the training time (note that the s/epoch is almost the same) and most resources of our pc were used in order to complete the training.

Lastly, we must say that we have tried to change **batch_size** and **learning_rate** and we had some troubles due to hardware limitations.

5. References

<https://deeptai.org/machine-learning-glossary-and-deep/epoch>