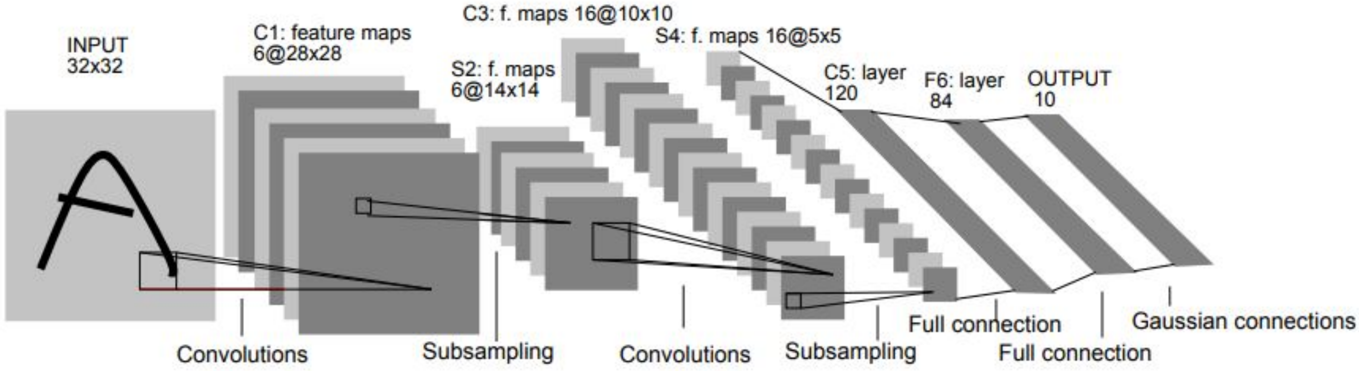
HW1: LeNet-5 with Post-training Quantization and Quantization Aware Training

LeNet is considered to be the first ConvNet.
Before we start, you may check Tensorspace-LeNet to play with LeNet and get familiar with this neural network architecture.



Ref.: LeCun et al., Gradient-Based Learning Applied to Document Recognition, 1998a

We are going to implement a neural network architecture similar to LeNet-5 and train it with MNIST dataset.

Ref.: MNIST database from Wikipedia

After that, we will go through several steps to do Post-training Quantization (PTQ), including

- Quantizing Weights

- Quantizing Activations
- Quantizing Biases

As for Quantization-aware Training (QAT), you need to trace the code and answer the questions. All the code for QAT is already implemented in `homework1.ipynb`.

Action Items:

- □ Learn how to use Jupyter Notebook and write python code.
- □ Fill in all TODOs in `homework1.ipynb`.
- □ Answer all questions in `homework1.ipynb`

How to launch Jupyter Notebook?

You should choose either option 1 or option 2. If you are familiar with Jupyter Notebook, you can just launch `homework1.ipynb` and start writing your homework.

Option 1: Using Google Colaboratory on the Cloud

1. Open your Colab
2. Upload `homework1.ipynb` to Colab.

   ```
   from google.colab import files

   uploaded = files.upload()

   for fn in uploaded.keys():
     print('User uploaded file "{name}" with length {length} bytes'.format(
         name=fn, length=len(uploaded[fn])))
   ```

3. It may warn some missing package of `torchinfo`.
   - Run `!pip install torchinfo` in Colab before using it.
4. If you train the neural network from scratch, you should enable GPUs for the notebook:
   - Navigate to Edit→Notebook Settings
   - Select GPU from the Hardware Accelerator drop-down menu

- We are not going to install `torchinfo` again or upload any additional files when checking your homework. Comment out all comments you use in Step 3 before submitting your homework.

Option 2: Using Conda on your computer

1. Install miniconda
2. Create a Conda virtual environment

```
conda create --name vlsi
conda activate vlsi
```

3. Install PyTorch
   - Check the official website and follow the procedures suitable for your computer.
4. Install the following packages for this homework

```
conda install -c conda-forge matplotlib
conda install -c anaconda jupyter
conda install -c conda-forge torchinfo
```

5. Type `jupyter notebook` and launch Jupyter Notebook!

What do I need to submit?

1. Make sure you have done everything in `homework1.ipynb`.
2. We are not going to install `torchinfo` again, upload/download any file to Colab, or retrain any models when checking your homework. Comment out those lines inside the source code for those processes!

```
# from google.colab import files
# uploaded = files.upload()

# for fn in uploaded.keys():
#     print('User uploaded file "{name}" with length {length} bytes'.format(
#         name=fn, length=len(uploaded[fn])))
...

# files.download(...)
...

# train(NET, trainloader, 2)
...

# train(NET_WITH_BIAS, trainloader, 2)
...

# train(model_fp32_prepared, trainloader, 2)
...

# !pip install torchinfo
```

3. Uncomment those lines inside the source code for loading the model in `homework1.ipynb`.

```
NET.load_state_dict(torch.load('lenet.pt'))
...

NET_WITH_BIAS.load_state_dict(torch.load('lenet_with_bias.pt'))
...

model_fp32_prepared.load_state_dict(torch.load('model_fp32_prepared.pt'))
```

4. Click `Kernel` and then click `Restart Kernel & Run All` on the Jupyter Notebook of `homework1.ipynb`.
   - Make sure everything goes smoothly without any warining or error messages while running your `homework1.ipynb`!
5. Upload `homework1.ipynb`, `lenet.pt`, `lenet_with_bias.pt`, and `model_fp32_prepared.pt` to EECLASS. Do not zip these files or put them in a folder! Just upload these four separate files.

Troubleshooting

Reloading modules

You might need to run and modify `homework1.ipynb` back and forth. If you have edited the module source file using an external editor and want to try out the new version without leaving the Python interpreter, you shoule reload these modules.

There are two alternatives:

- Autoreload
  - IPython extension to reload modules before executing user code. `autoreload` reloads modules automatically before entering the execution of code typed at the IPython prompt.

  ```
  %load_ext autoreload
  %autoreload 2
  ```

  - Please refer to link.
- Reload
  - reload() reloads a previously imported module.

  ```
  import importlib
  importlib.reload(module)
  ```

  - Please refer to link.

Sometimes, you may encounter the following error message:

```
super(type, obj): obj must be an instance or subtype of type
```

The straightforward solution is to restart the kernel and run it all.

- Please refer to link.