#Perpustakaan di PyTorch Komputer Vision

```
# Import PyTorch
import torch
from torch import nn

# Import torchvision
import torchvision
from torchvision import datasets
from torchvision.transforms import ToTensor

# Import matplotlib for visualization
import matplotlib.pyplot as plt

# Check versions
# Note: your PyTorch version shouldn't be lower than 1.10.0 and
torchvision version shouldn't be lower than 0.11
print(f"PyTorch version: {torch.__version__}\ntorchvision version:
{torchvision.__version__}")
```

```
PyTorch version: 2.0.1+cu118
torchvision version: 0.15.2+cu118
```

Mendapatkan Dataset

```
# Setup training data
train_data = datasets.FashionMNIST(
    root="data", # where to download data to?
    train=True, # get training data
    download=True, # download data if it doesn't exist on disk
    transform=ToTensor(), # images come as PIL format, we want to turn
into Torch tensors
    target_transform=None # you can transform labels as well
)

# Setup testing data
test_data = datasets.FashionMNIST(
    root="data",
    train=False, # get test data
    download=True,
    transform=ToTensor()
)
```

```
Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/train-images-idx3-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/train-images-idx3-ubyte.gz to
data/FashionMNIST/raw/train-images-idx3-ubyte.gz
```

```
100%|██████████| 26421880/26421880 [00:01<00:00, 16189161.14it/s]

Extracting data/FashionMNIST/raw/train-images-idx3-ubyte.gz to
data/FashionMNIST/raw

Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/train-labels-idx1-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/train-labels-idx1-ubyte.gz to
data/FashionMNIST/raw/train-labels-idx1-ubyte.gz

100%|██████████| 29515/29515 [00:00<00:00, 269809.67it/s]

Extracting data/FashionMNIST/raw/train-labels-idx1-ubyte.gz to
data/FashionMNIST/raw

Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/t10k-images-idx3-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/t10k-images-idx3-ubyte.gz to
data/FashionMNIST/raw/t10k-images-idx3-ubyte.gz

100%|██████████| 4422102/4422102 [00:00<00:00, 4950701.58it/s]

Extracting data/FashionMNIST/raw/t10k-images-idx3-ubyte.gz to
data/FashionMNIST/raw

Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/t10k-labels-idx1-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-
1.amazonaws.com/t10k-labels-idx1-ubyte.gz to
data/FashionMNIST/raw/t10k-labels-idx1-ubyte.gz

100%|██████████| 5148/5148 [00:00<00:00, 4744512.63it/s]

Extracting data/FashionMNIST/raw/t10k-labels-idx1-ubyte.gz to
data/FashionMNIST/raw
```

```
# See first training sample
image, label = train_data[0]
image, label
```

```
(tensor([[[0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
          0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
          0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
          0.0000, 0.0000, 0.0000, 0.0000],
```

```
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000],
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000],
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0039, 0.0000, 0.0000,
0.0510,
            0.2863, 0.0000, 0.0000, 0.0039, 0.0157, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0039, 0.0039, 0.0000],
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0118, 0.0000, 0.1412,
0.5333,
            0.4980, 0.2431, 0.2118, 0.0000, 0.0000, 0.0000, 0.0039,
0.0118,
            0.0157, 0.0000, 0.0000, 0.0118],
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0235, 0.0000, 0.4000,
0.8000,
            0.6902, 0.5255, 0.5647, 0.4824, 0.0902, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0471, 0.0392, 0.0000],
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.6078,
0.9255,
            0.8118, 0.6980, 0.4196, 0.6118, 0.6314, 0.4275, 0.2510,
0.0902,
            0.3020, 0.5098, 0.2824, 0.0588],
           [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
            0.0000, 0.0000, 0.0000, 0.0039, 0.0000, 0.2706, 0.8118,
0.8745,
            0.8549, 0.8471, 0.8471, 0.6392, 0.4980, 0.4745, 0.4784,
0.5725,
            0.5529, 0.3451, 0.6745, 0.2588],
```

```
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0039, 0.0039, 0.0039, 0.0000, 0.7843, 0.9098,
0.9098,
           0.9137, 0.8980, 0.8745, 0.8745, 0.8431, 0.8353, 0.6431,
0.4980,
           0.4824, 0.7686, 0.8980, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.7176, 0.8824,
0.8471,
           0.8745, 0.8941, 0.9216, 0.8902, 0.8784, 0.8706, 0.8784,
0.8667,
           0.8745, 0.9608, 0.6784, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.7569, 0.8941,
0.8549,
           0.8353, 0.7765, 0.7059, 0.8314, 0.8235, 0.8275, 0.8353,
0.8745,
           0.8627, 0.9529, 0.7922, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0039, 0.0118, 0.0000, 0.0471, 0.8588, 0.8627,
0.8314,
           0.8549, 0.7529, 0.6627, 0.8902, 0.8157, 0.8549, 0.8784,
0.8314,
           0.8863, 0.7725, 0.8196, 0.2039],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0235, 0.0000, 0.3882, 0.9569, 0.8706,
0.8627,
           0.8549, 0.7961, 0.7765, 0.8667, 0.8431, 0.8353, 0.8706,
0.8627,
           0.9608, 0.4667, 0.6549, 0.2196],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0157, 0.0000, 0.0000, 0.2157, 0.9255, 0.8941,
0.9020,
           0.8941, 0.9412, 0.9098, 0.8353, 0.8549, 0.8745, 0.9176,
0.8510,
           0.8510, 0.8196, 0.3608, 0.0000],
          [0.0000, 0.0000, 0.0039, 0.0157, 0.0235, 0.0275, 0.0078,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.9294, 0.8863, 0.8510,
0.8745,
           0.8706, 0.8588, 0.8706, 0.8667, 0.8471, 0.8745, 0.8980,
0.8431,
           0.8549, 1.0000, 0.3020, 0.0000],
```

```
          [0.0000, 0.0118, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.2431, 0.5686, 0.8000, 0.8941, 0.8118, 0.8353,
0.8667,
           0.8549, 0.8157, 0.8275, 0.8549, 0.8784, 0.8745, 0.8588,
0.8431,
           0.8784, 0.9569, 0.6235, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0706, 0.1725, 0.3216,
0.4196,
           0.7412, 0.8941, 0.8627, 0.8706, 0.8510, 0.8863, 0.7843,
0.8039,
           0.8275, 0.9020, 0.8784, 0.9176, 0.6902, 0.7373, 0.9804,
0.9725,
           0.9137, 0.9333, 0.8431, 0.0000],
          [0.0000, 0.2235, 0.7333, 0.8157, 0.8784, 0.8667, 0.8784,
0.8157,
           0.8000, 0.8392, 0.8157, 0.8196, 0.7843, 0.6235, 0.9608,
0.7569,
           0.8078, 0.8745, 1.0000, 1.0000, 0.8667, 0.9176, 0.8667,
0.8275,
           0.8627, 0.9098, 0.9647, 0.0000],
          [0.0118, 0.7922, 0.8941, 0.8784, 0.8667, 0.8275, 0.8275,
0.8392,
           0.8039, 0.8039, 0.8039, 0.8627, 0.9412, 0.3137, 0.5882,
1.0000,
           0.8980, 0.8667, 0.7373, 0.6039, 0.7490, 0.8235, 0.8000,
0.8196,
           0.8706, 0.8941, 0.8824, 0.0000],
          [0.3843, 0.9137, 0.7765, 0.8235, 0.8706, 0.8980, 0.8980,
0.9176,
           0.9765, 0.8627, 0.7608, 0.8431, 0.8510, 0.9451, 0.2549,
0.2863,
           0.4157, 0.4588, 0.6588, 0.8588, 0.8667, 0.8431, 0.8510,
0.8745,
           0.8745, 0.8784, 0.8980, 0.1137],
          [0.2941, 0.8000, 0.8314, 0.8000, 0.7569, 0.8039, 0.8275,
0.8824,
           0.8471, 0.7255, 0.7725, 0.8078, 0.7765, 0.8353, 0.9412,
0.7647,
           0.8902, 0.9608, 0.9373, 0.8745, 0.8549, 0.8314, 0.8196,
0.8706,
           0.8627, 0.8667, 0.9020, 0.2627],
          [0.1882, 0.7961, 0.7176, 0.7608, 0.8353, 0.7725, 0.7255,
0.7451,
           0.7608, 0.7529, 0.7922, 0.8392, 0.8588, 0.8667, 0.8627,
0.9255,
           0.8824, 0.8471, 0.7804, 0.8078, 0.7294, 0.7098, 0.6941,
0.6745,
           0.7098, 0.8039, 0.8078, 0.4510],
```

```
          [0.0000, 0.4784, 0.8588, 0.7569, 0.7020, 0.6706, 0.7176,
0.7686,
           0.8000, 0.8235, 0.8353, 0.8118, 0.8275, 0.8235, 0.7843,
0.7686,
           0.7608, 0.7490, 0.7647, 0.7490, 0.7765, 0.7529, 0.6902,
0.6118,
           0.6549, 0.6941, 0.8235, 0.3608],
          [0.0000, 0.0000, 0.2902, 0.7412, 0.8314, 0.7490, 0.6863,
0.6745,
           0.6863, 0.7098, 0.7255, 0.7373, 0.7412, 0.7373, 0.7569,
0.7765,
           0.8000, 0.8196, 0.8235, 0.8235, 0.8275, 0.7373, 0.7373,
0.7608,
           0.7529, 0.8471, 0.6667, 0.0000],
          [0.0078, 0.0000, 0.0000, 0.0000, 0.2588, 0.7843, 0.8706,
0.9294,
           0.9373, 0.9490, 0.9647, 0.9529, 0.9569, 0.8667, 0.8627,
0.7569,
           0.7490, 0.7020, 0.7137, 0.7137, 0.7098, 0.6902, 0.6510,
0.6588,
           0.3882, 0.2275, 0.0000, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.1569,
           0.2392, 0.1725, 0.2824, 0.1608, 0.1373, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000],
          [0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000,
0.0000,
           0.0000, 0.0000, 0.0000, 0.0000]]]),
 9)
```

#Bentuk masukan dan keluaran model visi komputer

```
# What's the shape of the image?
image.shape
```

```
torch.Size([1, 28, 28])
```

```
# How many samples are there?
len(train_data.data), len(train_data.targets), len(test_data.data),
len(test_data.targets)
```

```
(60000, 60000, 10000, 10000)
```

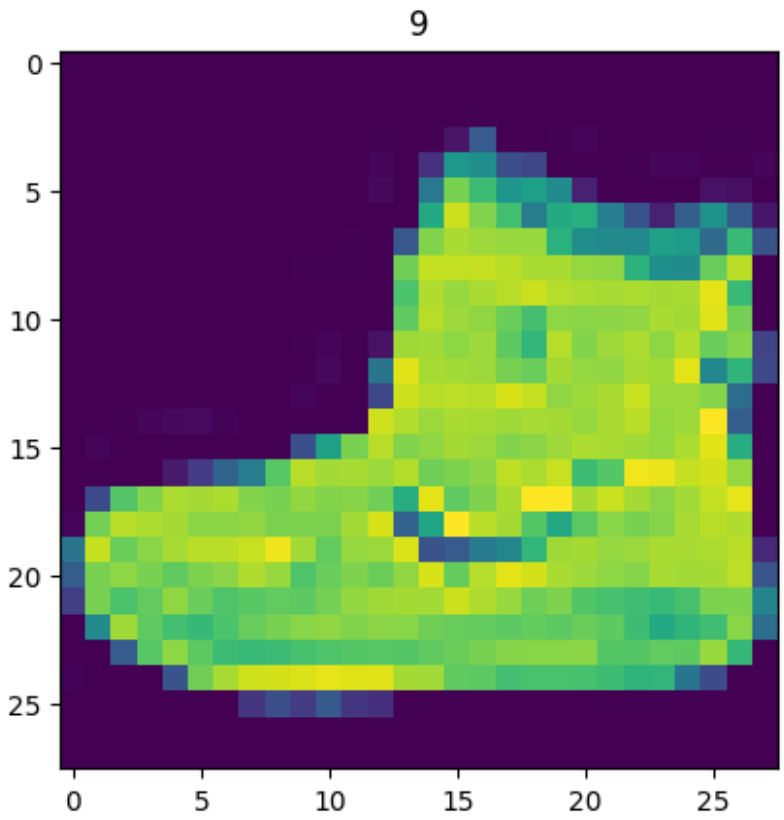
```
# See classes
class_names = train_data.classes
class_names
```

```
['T-shirt/top',
 'Trouser',
 'Pullover',
 'Dress',
 'Coat',
 'Sandal',
 'Shirt',
 'Sneaker',
 'Bag',
 'Ankle boot']
```

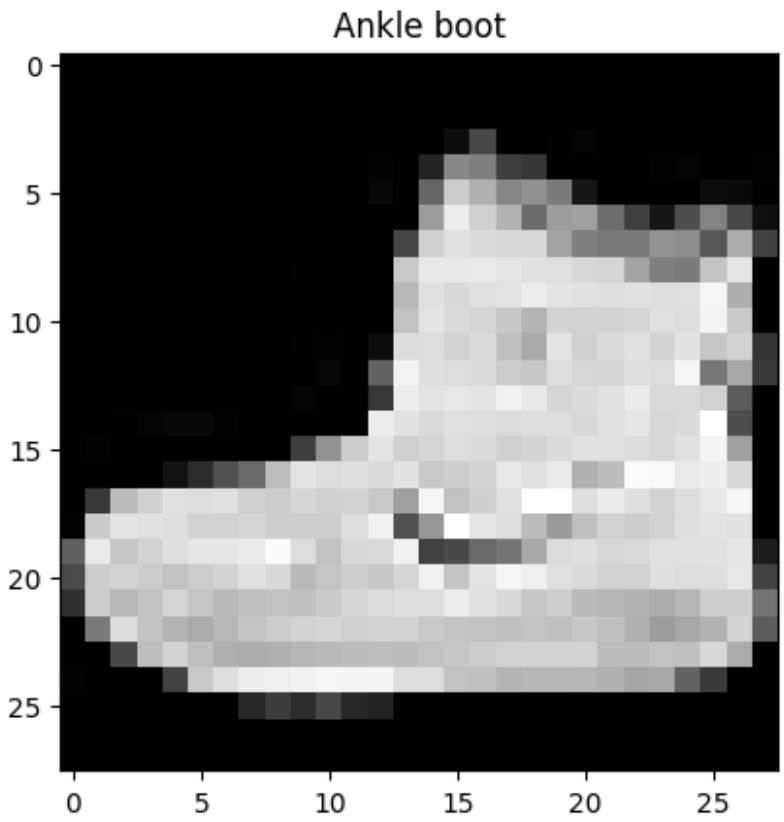
#Visualisasi data

```
import matplotlib.pyplot as plt
image, label = train_data[0]
print(f"Image shape: {image.shape}")
plt.imshow(image.squeeze()) # image shape is [1, 28, 28] (colour
channels, height, width)
plt.title(label);
```

```
Image shape: torch.Size([1, 28, 28])
```




```
plt.imshow(image.squeeze(), cmap="gray")
plt.title(class_names[label]);
```




```
# Plot more images
torch.manual_seed(42)
fig = plt.figure(figsize=(9, 9))
rows, cols = 4, 4
for i in range(1, rows * cols + 1):
    random_idx = torch.randint(0, len(train_data), size=[1]).item()
    img, label = train_data[random_idx]
    fig.add_subplot(rows, cols, i)
    plt.imshow(img.squeeze(), cmap="gray")
    plt.title(class_names[label])
    plt.axis(False);
```

#Siapkan DataLoader

```
from torch.utils.data import DataLoader

# Setup the batch size hyperparameter
BATCH_SIZE = 32

# Turn datasets into iterables (batches)
train_dataloader = DataLoader(train_data, # dataset to turn into
iterable
    batch_size=BATCH_SIZE, # how many samples per batch?
    shuffle=True # shuffle data every epoch?
```

```
)

test_dataloader = DataLoader(test_data,
    batch_size=BATCH_SIZE,
    shuffle=False # don't necessarily have to shuffle the testing data
)

# Let's check out what we've created
print(f"Dataloaders: {train_dataloader, test_dataloader}")
print(f"Length of train dataloader: {len(train_dataloader)} batches of
{BATCH_SIZE}")
print(f"Length of test dataloader: {len(test_dataloader)} batches of
{BATCH_SIZE}")
```

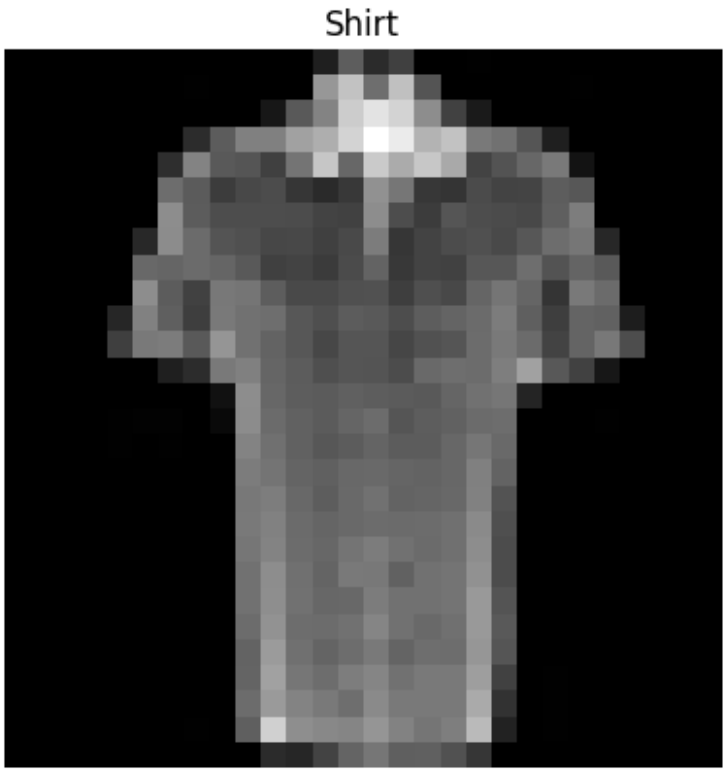
```
Dataloaders: (<torch.utils.data.dataloader.DataLoader object at
0x7fc991463cd0>, <torch.utils.data.dataloader.DataLoader object at
0x7fc991475120>)
Length of train dataloader: 1875 batches of 32
Length of test dataloader: 313 batches of 32
```

```
# Check out what's inside the training dataloader
train_features_batch, train_labels_batch =
next(iter(train_dataloader))
train_features_batch.shape, train_labels_batch.shape
```

```
(torch.Size([32, 1, 28, 28]), torch.Size([32]))
```

```
# Show a sample
torch.manual_seed(42)
random_idx = torch.randint(0, len(train_features_batch),
size=[1]).item()
img, label = train_features_batch[random_idx],
train_labels_batch[random_idx]
plt.imshow(img.squeeze(), cmap="gray")
plt.title(class_names[label])
plt.axis("Off");
print(f"Image size: {img.shape}")
print(f"Label: {label}, label size: {label.shape}")
```

```
Image size: torch.Size([1, 28, 28])
Label: 6, label size: torch.Size([])
```



#Membangun model dasar

```
# Create a flatten layer
flatten_model = nn.Flatten() # all nn modules function as a model (can
do a forward pass)

# Get a single sample
x = train_features_batch[0]

# Flatten the sample
output = flatten_model(x) # perform forward pass

# Print out what happened
print(f"Shape before flattening: {x.shape} -> [color_channels, height,
width]")
print(f"Shape after flattening: {output.shape} -> [color_channels,
height*width]")

# Try uncommenting below and see what happens
#print(x)
#print(output)
```

```
Shape before flattening: torch.Size([1, 28, 28]) -> [color_channels,
height, width]
Shape after flattening: torch.Size([1, 784]) -> [color_channels,
height*width]
```

```
from torch import nn
class FashionMNISTModelV0(nn.Module):
    def __init__(self, input_shape: int, hidden_units: int,
output_shape: int):
        super().__init__()
        self.layer_stack = nn.Sequential(
            nn.Flatten(), # neural networks like their inputs in
vector form
            nn.Linear(in_features=input_shape,
out_features=hidden_units), # in_features = number of features in a
data sample (784 pixels)
            nn.Linear(in_features=hidden_units,
out_features=output_shape)
        )

    def forward(self, x):
        return self.layer_stack(x)

torch.manual_seed(42)

# Need to setup model with input parameters
model_0 = FashionMNISTModelV0(input_shape=784, # one for every pixel
(28x28)
    hidden_units=10, # how many units in the hiden layer
    output_shape=len(class_names) # one for every class
)
model_0.to("cpu") # keep model on CPU to begin with
```

```
FashionMNISTModelV0(
  (layer_stack): Sequential(
    (0): Flatten(start_dim=1, end_dim=-1)
    (1): Linear(in_features=784, out_features=10, bias=True)
    (2): Linear(in_features=10, out_features=10, bias=True)
  )
)
```

#Menyiapkan metrik kerugian, pengoptimal, dan evaluasi

```
import requests
from pathlib import Path

# Download helper functions from Learn PyTorch repo (if not already
downloaded)
if Path("helper_functions.py").is_file():
  print("helper_functions.py already exists, skipping download")
else:
  print("Downloading helper_functions.py")
  # Note: you need the "raw" GitHub URL for this to work
  request =
requests.get("https://raw.githubusercontent.com/mrdbourke/pytorch-
```

```
deep-learning/main/helper_functions.py")
  with open("helper_functions.py", "wb") as f:
    f.write(request.content)
```

```
Downloading helper_functions.py
```

```
# Import accuracy metric
from helper_functions import accuracy_fn # Note: could also use
torchmetrics.Accuracy(task = 'multiclass',
num_classes=len(class_names)).to(device)

# Setup loss function and optimizer
loss_fn = nn.CrossEntropyLoss() # this is also called
"criterion"/"cost function" in some places
optimizer = torch.optim.SGD(params=model_0.parameters(), lr=0.1)
```

#Membuat fungsi untuk mengatur waktu percobaan kita

```
from timeit import default_timer as timer
def print_train_time(start: float, end: float, device: torch.device =
None):
    """Prints difference between start and end time.

    Args:
        start (float): Start time of computation (preferred in timeit
format).
        end (float): End time of computation.
        device ([type], optional): Device that compute is running on.
Defaults to None.

    Returns:
        float: time between start and end in seconds (higher is
longer).
    """
    total_time = end - start
    print(f"Train time on {device}: {total_time:.3f} seconds")
    return total_time
```

#Membuat loop pelatihan dan melatih model pada kumpulan data

```
# Import tqdm for progress bar
from tqdm.auto import tqdm

# Set the seed and start the timer
torch.manual_seed(42)
train_time_start_on_cpu = timer()

# Set the number of epochs (we'll keep this small for faster training
times)
epochs = 3
```

```
# Create training and testing loop
for epoch in tqdm(range(epochs)):
    print(f"Epoch: {epoch}\n-------")
    ### Training
    train_loss = 0
    # Add a loop to loop through training batches
    for batch, (X, y) in enumerate(train_dataloader):
        model_0.train()
        # 1. Forward pass
        y_pred = model_0(X)

        # 2. Calculate loss (per batch)
        loss = loss_fn(y_pred, y)
        train_loss += loss # accumulatively add up the loss per epoch

        # 3. Optimizer zero grad
        optimizer.zero_grad()

        # 4. Loss backward
        loss.backward()

        # 5. Optimizer step
        optimizer.step()

        # Print out how many samples have been seen
        if batch % 400 == 0:
            print(f"Looked at {batch *
len(X)}/{len(train_dataloader.dataset)} samples")

    # Divide total train loss by length of train dataloader (average
loss per batch per epoch)
    train_loss /= len(train_dataloader)

    ### Testing
    # Setup variables for accumulatively adding up loss and accuracy
    test_loss, test_acc = 0, 0
    model_0.eval()
    with torch.inference_mode():
        for X, y in test_dataloader:
            # 1. Forward pass
            test_pred = model_0(X)

            # 2. Calculate loss (accumatively)
            test_loss += loss_fn(test_pred, y) # accumulatively add up
the loss per epoch

            # 3. Calculate accuracy (preds need to be same as y_true)
            test_acc += accuracy_fn(y_true=y,
y_pred=test_pred.argmax(dim=1))
```

```
        # Calculations on test metrics need to happen inside
torch.inference_mode()
        # Divide total test loss by length of test dataloader (per
batch)
        test_loss /= len(test_dataloader)

        # Divide total accuracy by length of test dataloader (per
batch)
        test_acc /= len(test_dataloader)

    ## Print out what's happening
    print(f"\nTrain loss: {train_loss:.5f} | Test loss:
{test_loss:.5f}, Test acc: {test_acc:.2f}%\n")

# Calculate training time
train_time_end_on_cpu = timer()
total_train_time_model_0 =
print_train_time(start=train_time_start_on_cpu,
                                            end=train_time_end_on_cpu,

device=str(next(model_0.parameters()).device))
```

{"model_id":"0bd8f8b5ff4d4b50b03e3a65cc1446f0","version_major":2,"vers
ion_minor":0}

```
Epoch: 0
-------
Looked at 0/60000 samples
Looked at 12800/60000 samples
Looked at 25600/60000 samples
Looked at 38400/60000 samples
Looked at 51200/60000 samples

Train loss: 0.59039 | Test loss: 0.50954, Test acc: 82.04%

Epoch: 1
-------
Looked at 0/60000 samples
Looked at 12800/60000 samples
Looked at 25600/60000 samples
Looked at 38400/60000 samples
Looked at 51200/60000 samples

Train loss: 0.47633 | Test loss: 0.47989, Test acc: 83.20%

Epoch: 2
-------
Looked at 0/60000 samples
Looked at 12800/60000 samples
Looked at 25600/60000 samples
```

```
Looked at 38400/60000 samples
Looked at 51200/60000 samples

Train loss: 0.45503 | Test loss: 0.47664, Test acc: 83.43%

Train time on cpu: 32.349 seconds
```

#Buat prediksi dan dapatkan hasil Model 0

```
torch.manual_seed(42)
def eval_model(model: torch.nn.Module,
               data_loader: torch.utils.data.DataLoader,
               loss_fn: torch.nn.Module,
               accuracy_fn):
    """Returns a dictionary containing the results of model predicting
on data_loader.

    Args:
        model (torch.nn.Module): A PyTorch model capable of making
predictions on data_loader.
        data_loader (torch.utils.data.DataLoader): The target dataset
to predict on.
        loss_fn (torch.nn.Module): The loss function of model.
        accuracy_fn: An accuracy function to compare the models
predictions to the truth labels.

    Returns:
        (dict): Results of model making predictions on data_loader.
    """
    loss, acc = 0, 0
    model.eval()
    with torch.inference_mode():
        for X, y in data_loader:
            # Make predictions with the model
            y_pred = model(X)

            # Accumulate the loss and accuracy values per batch
            loss += loss_fn(y_pred, y)
            acc += accuracy_fn(y_true=y,
                               y_pred=y_pred.argmax(dim=1)) # For
accuracy, need the prediction labels (logits -> pred_prob ->
pred_labels)

        # Scale loss and acc to find the average loss/acc per batch
        loss /= len(data_loader)
        acc /= len(data_loader)

    return {"model_name": model.__class__.__name__, # only works when
model was created with a class
            "model_loss": loss.item(),
```

```
            "model_acc": acc}

# Calculate model 0 results on test dataset
model_0_results = eval_model(model=model_0,
data_loader=test_dataloader,
    loss_fn=loss_fn, accuracy_fn=accuracy_fn
)
model_0_results
```

```
{'model_name': 'FashionMNISTModelV0',
 'model_loss': 0.47663894295692444,
 'model_acc': 83.42651757188499}
```

Atur kode agnostik perangkat (untuk menggunakan GPU jika ada)

```
# Setup device agnostic code
import torch
device = "cuda" if torch.cuda.is_available() else "cpu"
device
```

```
{"type":"string"}
```

#Model 1: Membangun model yang lebih baik dengan non-linearitas

```
# Create a model with non-linear and linear layers
class FashionMNISTModelV1(nn.Module):
    def __init__(self, input_shape: int, hidden_units: int,
output_shape: int):
        super().__init__()
        self.layer_stack = nn.Sequential(
            nn.Flatten(), # flatten inputs into single vector
            nn.Linear(in_features=input_shape,
out_features=hidden_units),
            nn.ReLU(),
            nn.Linear(in_features=hidden_units,
out_features=output_shape),
            nn.ReLU()
        )

    def forward(self, x: torch.Tensor):
        return self.layer_stack(x)

torch.manual_seed(42)
model_1 = FashionMNISTModelV1(input_shape=784, # number of input
features
    hidden_units=10,
```

```
    output_shape=len(class_names) # number of output classes desired
).to(device) # send model to GPU if it's available
next(model_1.parameters()).device # check model device
```

```
device(type='cuda', index=0)
```

#Menyiapkan metrik kerugian, pengoptimal, dan evaluasi

```
from helper_functions import accuracy_fn
loss_fn = nn.CrossEntropyLoss()
optimizer = torch.optim.SGD(params=model_1.parameters(),
                            lr=0.1)
```

Memfungsikan loop pelatihan dan pengujian

```
def train_step(model: torch.nn.Module,
               data_loader: torch.utils.data.DataLoader,
               loss_fn: torch.nn.Module,
               optimizer: torch.optim.Optimizer,
               accuracy_fn,
               device: torch.device = device):
    train_loss, train_acc = 0, 0
    model.to(device)
    for batch, (X, y) in enumerate(data_loader):
        # Send data to GPU
        X, y = X.to(device), y.to(device)

        # 1. Forward pass
        y_pred = model(X)

        # 2. Calculate loss
        loss = loss_fn(y_pred, y)
        train_loss += loss
        train_acc += accuracy_fn(y_true=y,
                                 y_pred=y_pred.argmax(dim=1)) # Go
from logits -> pred labels

        # 3. Optimizer zero grad
        optimizer.zero_grad()

        # 4. Loss backward
        loss.backward()

        # 5. Optimizer step
        optimizer.step()

    # Calculate loss and accuracy per epoch and print out what's
happening
```

```
    train_loss /= len(data_loader)
    train_acc /= len(data_loader)
    print(f"Train loss: {train_loss:.5f} | Train accuracy:
{train_acc:.2f}%")

def test_step(data_loader: torch.utils.data.DataLoader,
              model: torch.nn.Module,
              loss_fn: torch.nn.Module,
              accuracy_fn,
              device: torch.device = device):
    test_loss, test_acc = 0, 0
    model.to(device)
    model.eval() # put model in eval mode
    # Turn on inference context manager
    with torch.inference_mode():
        for X, y in data_loader:
            # Send data to GPU
            X, y = X.to(device), y.to(device)

            # 1. Forward pass
            test_pred = model(X)

            # 2. Calculate loss and accuracy
            test_loss += loss_fn(test_pred, y)
            test_acc += accuracy_fn(y_true=y,
                y_pred=test_pred.argmax(dim=1) # Go from logits ->
pred labels
            )

        # Adjust metrics and print out
        test_loss /= len(data_loader)
        test_acc /= len(data_loader)
        print(f"Test loss: {test_loss:.5f} | Test accuracy:
{test_acc:.2f}%\n")

torch.manual_seed(42)

# Measure time
from timeit import default_timer as timer
train_time_start_on_gpu = timer()

epochs = 3
for epoch in tqdm(range(epochs)):
    print(f"Epoch: {epoch}\n---------")
    train_step(data_loader=train_dataloader,
        model=model_1,
        loss_fn=loss_fn,
        optimizer=optimizer,
        accuracy_fn=accuracy_fn
    )
```

```
    test_step(data_loader=test_dataloader,
        model=model_1,
        loss_fn=loss_fn,
        accuracy_fn=accuracy_fn
    )

train_time_end_on_gpu = timer()
total_train_time_model_1 =
print_train_time(start=train_time_start_on_gpu,
                                            end=train_time_end_on_gpu,
                                            device=device)
```

{"model_id":"3ee8f4a32dae40a2954869aa28d511af","version_major":2,"version_minor":0}

```
Epoch: 0
---------
Train loss: 1.09199 | Train accuracy: 61.34%
Test loss: 0.95636 | Test accuracy: 65.00%

Epoch: 1
---------
Train loss: 0.78101 | Train accuracy: 71.93%
Test loss: 0.72227 | Test accuracy: 73.91%

Epoch: 2
---------
Train loss: 0.67027 | Train accuracy: 75.94%
Test loss: 0.68500 | Test accuracy: 75.02%

Train time on cuda: 36.878 seconds
```

```
torch.manual_seed(42)

# Note: This will error due to `eval_model()` not using device
agnostic code
model_1_results = eval_model(model=model_1,
    data_loader=test_dataloader,
    loss_fn=loss_fn,
    accuracy_fn=accuracy_fn)
model_1_results
```

```
---------------------------------------------------------------------------
-----
RuntimeError                              Traceback (most recent call
last)
<ipython-input-27-93fed76e63a5> in <cell line: 4>()
      2
      3 # Note: This will error due to `eval_model()` not using device
agnostic code
----> 4 model_1_results = eval_model(model=model_1,
```

```
      5     data_loader=test_dataloader,
      6     loss_fn=loss_fn,

<ipython-input-20-885bc9be9cde> in eval_model(model, data_loader,
loss_fn, accuracy_fn)
     20         for X, y in data_loader:
     21             # Make predictions with the model
---> 22             y_pred = model(X)
     23
     24             # Accumulate the loss and accuracy values per
batch

/usr/local/lib/python3.10/dist-packages/torch/nn/modules/module.py in
_call_impl(self, *args, **kwargs)
   1499                 or _global_backward_pre_hooks or
_global_backward_hooks
   1500                 or _global_forward_hooks or
_global_forward_pre_hooks):
-> 1501             return forward_call(*args, **kwargs)
   1502         # Do not call functions when jit is used
   1503         full_backward_hooks, non_full_backward_hooks = [], []

<ipython-input-22-a46e692b8bdd> in forward(self, x)
     12
     13     def forward(self, x: torch.Tensor):
---> 14         return self.layer_stack(x)

/usr/local/lib/python3.10/dist-packages/torch/nn/modules/module.py in
_call_impl(self, *args, **kwargs)
   1499                 or _global_backward_pre_hooks or
_global_backward_hooks
   1500                 or _global_forward_hooks or
_global_forward_pre_hooks):
-> 1501             return forward_call(*args, **kwargs)
   1502         # Do not call functions when jit is used
   1503         full_backward_hooks, non_full_backward_hooks = [], []

/usr/local/lib/python3.10/dist-packages/torch/nn/modules/container.py
in forward(self, input)
    215     def forward(self, input):
    216         for module in self:
--> 217             input = module(input)
    218         return input
    219

/usr/local/lib/python3.10/dist-packages/torch/nn/modules/module.py in
_call_impl(self, *args, **kwargs)
   1499                 or _global_backward_pre_hooks or
_global_backward_hooks
   1500                 or _global_forward_hooks or
```

```
_global_forward_pre_hooks):
-> 1501             return forward_call(*args, **kwargs)
   1502         # Do not call functions when jit is used
   1503         full_backward_hooks, non_full_backward_hooks = [], []

/usr/local/lib/python3.10/dist-packages/torch/nn/modules/linear.py in
forward(self, input)
    112
    113     def forward(self, input: Tensor) -> Tensor:
--> 114         return F.linear(input, self.weight, self.bias)
    115
    116     def extra_repr(self) -> str:

RuntimeError: Expected all tensors to be on the same device, but found
at least two devices, cuda:0 and cpu! (when checking argument for
argument mat1 in method wrapper_CUDA_addmm)
```

```python
# Move values to device
torch.manual_seed(42)
def eval_model(model: torch.nn.Module,
               data_loader: torch.utils.data.DataLoader,
               loss_fn: torch.nn.Module,
               accuracy_fn,
               device: torch.device = device):
    """Evaluates a given model on a given dataset.

    Args:
        model (torch.nn.Module): A PyTorch model capable of making
predictions on data_loader.
        data_loader (torch.utils.data.DataLoader): The target dataset
to predict on.
        loss_fn (torch.nn.Module): The loss function of model.
        accuracy_fn: An accuracy function to compare the models
predictions to the truth labels.
        device (str, optional): Target device to compute on. Defaults
to device.

    Returns:
        (dict): Results of model making predictions on data_loader.
    """
    loss, acc = 0, 0
    model.eval()
    with torch.inference_mode():
        for X, y in data_loader:
            # Send data to the target device
            X, y = X.to(device), y.to(device)
            y_pred = model(X)
            loss += loss_fn(y_pred, y)
            acc += accuracy_fn(y_true=y, y_pred=y_pred.argmax(dim=1))
```

```
        # Scale loss and acc
        loss /= len(data_loader)
        acc /= len(data_loader)
    return {"model_name": model.__class__.__name__, # only works when
model was created with a class
            "model_loss": loss.item(),
            "model_acc": acc}

# Calculate model 1 results with device-agnostic code
model_1_results = eval_model(model=model_1,
data_loader=test_dataloader,
    loss_fn=loss_fn, accuracy_fn=accuracy_fn,
    device=device
)
model_1_results
```

```
{'model_name': 'FashionMNISTModelV1',
 'model_loss': 0.6850008964538574,
 'model_acc': 75.01996805111821}
```

```
# Check baseline results
model_0_results
```

```
{'model_name': 'FashionMNISTModelV0',
 'model_loss': 0.47663894295692444,
 'model_acc': 83.42651757188499}
```

#Model 2: Membangun Jaringan Neural Konvolusional(CNN)

```
# Create a convolutional neural network
class FashionMNISTModelV2(nn.Module):
    """
    Model architecture copying TinyVGG from:
    https://poloclub.github.io/cnn-explainer/
    """
    def __init__(self, input_shape: int, hidden_units: int,
output_shape: int):
        super().__init__()
        self.block_1 = nn.Sequential(
            nn.Conv2d(in_channels=input_shape,
                      out_channels=hidden_units,
                      kernel_size=3, # how big is the square that's
going over the image?
                      stride=1, # default
                      padding=1),# options = "valid" (no padding) or
"same" (output has same shape as input) or int for specific number
            nn.ReLU(),
            nn.Conv2d(in_channels=hidden_units,
                      out_channels=hidden_units,
                      kernel_size=3,
```

```
                      stride=1,
                      padding=1),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2,
                         stride=2) # default stride value is same as
kernel_size
        )
        self.block_2 = nn.Sequential(
            nn.Conv2d(hidden_units, hidden_units, 3, padding=1),
            nn.ReLU(),
            nn.Conv2d(hidden_units, hidden_units, 3, padding=1),
            nn.ReLU(),
            nn.MaxPool2d(2)
        )
        self.classifier = nn.Sequential(
            nn.Flatten(),
            # Where did this in_features shape come from?
            # It's because each layer of our network compresses and
changes the shape of our inputs data.
            nn.Linear(in_features=hidden_units*7*7,
                      out_features=output_shape)
        )

    def forward(self, x: torch.Tensor):
        x = self.block_1(x)
        # print(x.shape)
        x = self.block_2(x)
        # print(x.shape)
        x = self.classifier(x)
        # print(x.shape)
        return x

torch.manual_seed(42)
model_2 = FashionMNISTModelV2(input_shape=1,
    hidden_units=10,
    output_shape=len(class_names)).to(device)
model_2
```

```
FashionMNISTModelV2(
  (block_1): Sequential(
    (0): Conv2d(1, 10, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
    (1): ReLU()
    (2): Conv2d(10, 10, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (block_2): Sequential(
```

```
    (0): Conv2d(10, 10, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
    (1): ReLU()
    (2): Conv2d(10, 10, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (classifier): Sequential(
    (0): Flatten(start_dim=1, end_dim=-1)
    (1): Linear(in_features=490, out_features=10, bias=True)
  )
)
```

#Melangkah melalui nn.Conv2d()

```
torch.manual_seed(42)

# Create sample batch of random numbers with same size as image batch
images = torch.randn(size=(32, 3, 64, 64)) # [batch_size,
color_channels, height, width]
test_image = images[0] # get a single image for testing
print(f"Image batch shape: {images.shape} -> [batch_size,
color_channels, height, width]")
print(f"Single image shape: {test_image.shape} -> [color_channels,
height, width]")
print(f"Single image pixel values:\n{test_image}")
```

```
Image batch shape: torch.Size([32, 3, 64, 64]) -> [batch_size,
color_channels, height, width]
Single image shape: torch.Size([3, 64, 64]) -> [color_channels,
height, width]
Single image pixel values:
tensor([[[ 1.9269,  1.4873,  0.9007,  ...,  1.8446, -1.1845,  1.3835],
         [ 1.4451,  0.8564,  2.2181,  ...,  0.3399,  0.7200,  0.4114],
         [ 1.9312,  1.0119, -1.4364,  ..., -0.5558,  0.7043,  0.7099],
         ...,
         [-0.5610, -0.4830,  0.4770,  ..., -0.2713, -0.9537, -0.6737],
         [ 0.3076, -0.1277,  0.0366,  ..., -2.0060,  0.2824, -0.8111],
         [-1.5486,  0.0485, -0.7712,  ..., -0.1403,  0.9416, -
0.0118]],

        [[-0.5197,  1.8524,  1.8365,  ...,  0.8935, -1.5114, -0.8515],
         [ 2.0818,  1.0677, -1.4277,  ...,  1.6612, -2.6223, -0.4319],
         [-0.1010, -0.4388, -1.9775,  ...,  0.2106,  0.2536, -0.7318],
         ...,
         [ 0.2779,  0.7342, -0.3736,  ..., -0.4601,  0.1815,  0.1850],
         [ 0.7205, -0.2833,  0.0937,  ..., -0.1002, -2.3609,  2.2465],
```

```
         [-1.3242, -0.1973,  0.2920,  ...,  0.5409,  0.6940,
1.8563]],

        [[-0.7978,  1.0261,  1.1465,  ...,  1.2134,  0.9354, -0.0780],
         [-1.4647, -1.9571,  0.1017,  ..., -1.9986, -0.7409,  0.7011],
         [-1.3938,  0.8466, -1.7191,  ..., -1.1867,  0.1320,  0.3407],
         ...,
         [ 0.8206, -0.3745,  1.2499,  ..., -0.0676,  0.0385,  0.6335],
         [-0.5589, -0.3393,  0.2347,  ...,  2.1181,  2.4569,  1.3083],
         [-0.4092,  1.5199,  0.2401,  ..., -0.2558,  0.7870,
0.9924]]])

torch.manual_seed(42)

# Create a convolutional layer with same dimensions as TinyVGG
# (try changing any of the parameters and see what happens)
conv_layer = nn.Conv2d(in_channels=3,
                       out_channels=10,
                       kernel_size=3,
                       stride=1,
                       padding=0) # also try using "valid" or "same"
here

# Pass the data through the convolutional layer
conv_layer(test_image) # Note: If running PyTorch <1.11.0, this will
error because of shape issues (nn.Conv.2d() expects a 4d tensor as
input)

tensor([[[ 1.5396,  0.0516,  0.6454,  ..., -0.3673,  0.8711,  0.4256],
         [ 0.3662,  1.0114, -0.5997,  ...,  0.8983,  0.2809, -0.2741],
         [ 1.2664, -1.4054,  0.3727,  ..., -0.3409,  1.2191, -0.0463],
         ...,
         [-0.1541,  0.5132, -0.3624,  ..., -0.2360, -0.4609, -0.0035],
         [ 0.2981, -0.2432,  1.5012,  ..., -0.6289, -0.7283, -0.5767],
         [-0.0386, -0.0781, -0.0388,  ...,  0.2842,  0.4228, -
0.1802]],

        [[-0.2840, -0.0319, -0.4455,  ..., -0.7956,  1.5599, -1.2449],
         [ 0.2753, -0.1262, -0.6541,  ..., -0.2211,  0.1999, -0.8856],
         [-0.5404, -1.5489,  0.0249,  ..., -0.5932, -1.0913, -0.3849],
         ...,
         [ 0.3870, -0.4064, -0.8236,  ...,  0.1734, -0.4330, -0.4951],
         [-0.1984, -0.6386,  1.0263,  ..., -0.9401, -0.0585, -0.7833],
         [-0.6306, -0.2052, -0.3694,  ..., -1.3248,  0.2456, -
0.7134]],

        [[ 0.4414,  0.5100,  0.4846,  ..., -0.8484,  0.2638,  1.1258],
         [ 0.8117,  0.3191, -0.0157,  ...,  1.2686,  0.2319,  0.5003],
         [ 0.3212,  0.0485, -0.2581,  ...,  0.2258,  0.2587, -0.8804],
         ...,
```

```
         [-0.1144, -0.1869,  0.0160,  ..., -0.8346,  0.0974,  0.8421],
         [ 0.2941,  0.4417,  0.5866,  ..., -0.1224,  0.4814, -0.4799],
         [ 0.6059, -0.0415, -0.2028,  ...,  0.1170,  0.2521, -
0.4372]],

        ...,

        [[-0.2560, -0.0477,  0.6380,  ...,  0.6436,  0.7553, -0.7055],
         [ 1.5595, -0.2209, -0.9486,  ..., -0.4876,  0.7754,  0.0750],
         [-0.0797,  0.2471,  1.1300,  ...,  0.1505,  0.2354,  0.9576],
         ...,
         [ 1.1065,  0.6839,  1.2183,  ...,  0.3015, -0.1910, -0.1902],
         [-0.3486, -0.7173, -0.3582,  ...,  0.4917,  0.7219,  0.1513],
         [ 0.0119,  0.1017,  0.7839,  ..., -0.3752, -0.8127, -
0.1257]],

        [[ 0.3841,  1.1322,  0.1620,  ...,  0.7010,  0.0109,  0.6058],
         [ 0.1664,  0.1873,  1.5924,  ...,  0.3733,  0.9096, -0.5399],
         [ 0.4094, -0.0861, -0.7935,  ..., -0.1285, -0.9932, -0.3013],
         ...,
         [ 0.2688, -0.5630, -1.1902,  ...,  0.4493,  0.5404, -0.0103],
         [ 0.0535,  0.4411,  0.5313,  ...,  0.0148, -1.0056,  0.3759],
         [ 0.3031, -0.1590, -0.1316,  ..., -0.5384, -0.4271, -
0.4876]],

        [[-1.1865, -0.7280, -1.2331,  ..., -0.9013, -0.0542, -1.5949],
         [-0.6345, -0.5920,  0.5326,  ..., -1.0395, -0.7963, -0.0647],
         [-0.1132,  0.5166,  0.2569,  ...,  0.5595, -1.6881,  0.9485],
         ...,
         [-0.0254, -0.2669,  0.1927,  ..., -0.2917,  0.1088, -0.4807],
         [-0.2609, -0.2328,  0.1404,  ..., -0.1325, -0.8436, -0.7524],
         [-1.1399, -0.1751, -0.8705,  ...,  0.1589,  0.3377,
0.3493]]],
       grad_fn=<SqueezeBackward1>)
```

```
# Add extra dimension to test image
test_image.unsqueeze(dim=0).shape
```

```
torch.Size([1, 3, 64, 64])
```

```
# Pass test image with extra dimension through conv_layer
conv_layer(test_image.unsqueeze(dim=0)).shape
```

```
torch.Size([1, 10, 62, 62])
```

```
torch.manual_seed(42)
# Create a new conv_layer with different values (try setting these to
whatever you like)
conv_layer_2 = nn.Conv2d(in_channels=3, # same number of color
channels as our input image
                         out_channels=10,
```

```
                        kernel_size=(5, 5), # kernel is usually a
square so a tuple also works
                        stride=2,
                        padding=0)

# Pass single image through new conv_layer_2 (this calls nn.Conv2d()'s
forward() method on the input)
conv_layer_2(test_image.unsqueeze(dim=0)).shape
```

```
torch.Size([1, 10, 30, 30])
```

```
# Check out the conv_layer_2 internal parameters
print(conv_layer_2.state_dict())
```

```
OrderedDict([('weight', tensor([[[[ 0.0883,  0.0958, -0.0271,  0.1061,
-0.0253],
          [ 0.0233, -0.0562,  0.0678,  0.1018, -0.0847],
          [ 0.1004,  0.0216,  0.0853,  0.0156,  0.0557],
          [-0.0163,  0.0890,  0.0171, -0.0539,  0.0294],
          [-0.0532, -0.0135, -0.0469,  0.0766, -0.0911]],

         [[-0.0532, -0.0326, -0.0694,  0.0109, -0.1140],
          [ 0.1043, -0.0981,  0.0891,  0.0192, -0.0375],
          [ 0.0714,  0.0180,  0.0933,  0.0126, -0.0364],
          [ 0.0310, -0.0313,  0.0486,  0.1031,  0.0667],
          [-0.0505,  0.0667,  0.0207,  0.0586, -0.0704]],

         [[-0.1143, -0.0446, -0.0886,  0.0947,  0.0333],
          [ 0.0478,  0.0365, -0.0020,  0.0904, -0.0820],
          [ 0.0073, -0.0788,  0.0356, -0.0398,  0.0354],
          [-0.0241,  0.0958, -0.0684, -0.0689, -0.0689],
          [ 0.1039,  0.0385,  0.1111, -0.0953, -0.1145]]],


        [[[-0.0903, -0.0777,  0.0468,  0.0413,  0.0959],
          [-0.0596, -0.0787,  0.0613, -0.0467,  0.0701],
          [-0.0274,  0.0661, -0.0897, -0.0583,  0.0352],
          [ 0.0244, -0.0294,  0.0688,  0.0785, -0.0837],
          [-0.0616,  0.1057, -0.0390, -0.0409, -0.1117]],

         [[-0.0661,  0.0288, -0.0152, -0.0838,  0.0027],
          [-0.0789, -0.0980, -0.0636, -0.1011, -0.0735],
          [ 0.1154,  0.0218,  0.0356, -0.1077, -0.0758],
          [-0.0384,  0.0181, -0.1016, -0.0498, -0.0691],
          [ 0.0003, -0.0430, -0.0080, -0.0782, -0.0793]],

         [[-0.0674, -0.0395, -0.0911,  0.0968, -0.0229],
          [ 0.0994,  0.0360, -0.0978,  0.0799, -0.0318],
          [-0.0443, -0.0958, -0.1148,  0.0330, -0.0252],
          [ 0.0450, -0.0948,  0.0857, -0.0848, -0.0199],
          [ 0.0241,  0.0596,  0.0932,  0.1052, -0.0916]]],
```

```
       [[[ 0.0291, -0.0497, -0.0127, -0.0864,  0.1052],
         [-0.0847,  0.0617,  0.0406,  0.0375, -0.0624],
         [ 0.1050,  0.0254,  0.0149, -0.1018,  0.0485],
         [-0.0173, -0.0529,  0.0992,  0.0257, -0.0639],
         [-0.0584, -0.0055,  0.0645, -0.0295, -0.0659]],

        [[-0.0395, -0.0863,  0.0412,  0.0894, -0.1087],
         [ 0.0268,  0.0597,  0.0209, -0.0411,  0.0603],
         [ 0.0607,  0.0432, -0.0203, -0.0306,  0.0124],
         [-0.0204, -0.0344,  0.0738,  0.0992, -0.0114],
         [-0.0259,  0.0017, -0.0069,  0.0278,  0.0324]],

        [[-0.1049, -0.0426,  0.0972,  0.0450, -0.0057],
         [-0.0696, -0.0706, -0.1034, -0.0376,  0.0390],
         [ 0.0736,  0.0533, -0.1021, -0.0694, -0.0182],
         [ 0.1117,  0.0167, -0.0299,  0.0478, -0.0440],
         [-0.0747,  0.0843, -0.0525, -0.0231, -0.1149]]],


       [[[ 0.0773,  0.0875,  0.0421, -0.0805, -0.1140],
         [-0.0938,  0.0861,  0.0554,  0.0972,  0.0605],
         [ 0.0292, -0.0011, -0.0878, -0.0989, -0.1080],
         [ 0.0473, -0.0567, -0.0232, -0.0665, -0.0210],
         [-0.0813, -0.0754,  0.0383, -0.0343,  0.0713]],

        [[-0.0370, -0.0847, -0.0204, -0.0560, -0.0353],
         [-0.1099,  0.0646, -0.0804,  0.0580,  0.0524],
         [ 0.0825, -0.0886,  0.0830, -0.0546,  0.0428],
         [ 0.1084, -0.0163, -0.0009, -0.0266, -0.0964],
         [ 0.0554, -0.1146,  0.0717,  0.0864,  0.1092]],

        [[-0.0272, -0.0949,  0.0260,  0.0638, -0.1149],
         [-0.0262, -0.0692, -0.0101, -0.0568, -0.0472],
         [-0.0367, -0.1097,  0.0947,  0.0968, -0.0181],
         [-0.0131, -0.0471, -0.1043, -0.1124,  0.0429],
         [-0.0634, -0.0742, -0.0090, -0.0385, -0.0374]]],


       [[[ 0.0037, -0.0245, -0.0398, -0.0553, -0.0940],
         [ 0.0968, -0.0462,  0.0306, -0.0401,  0.0094],
         [ 0.1077,  0.0532, -0.1001,  0.0458,  0.1096],
         [ 0.0304,  0.0774,  0.1138, -0.0177,  0.0240],
         [-0.0803, -0.0238,  0.0855,  0.0592, -0.0731]],

        [[-0.0926, -0.0789, -0.1140, -0.0891, -0.0286],
         [ 0.0779,  0.0193, -0.0878, -0.0926,  0.0574],
         [-0.0859, -0.0142,  0.0554, -0.0534, -0.0126],
         [-0.0101, -0.0273, -0.0585, -0.1029, -0.0933],
```

```
          [-0.0618,  0.1115, -0.0558, -0.0775,  0.0280]],

         [[ 0.0318,  0.0633,  0.0878,  0.0643, -0.1145],
          [ 0.0102,  0.0699, -0.0107, -0.0680,  0.1101],
          [-0.0432, -0.0657, -0.1041,  0.0052,  0.0512],
          [ 0.0256,  0.0228, -0.0876, -0.1078,  0.0020],
          [ 0.1053,  0.0666, -0.0672, -0.0150, -0.0851]]],


        [[[-0.0557,  0.0209,  0.0629,  0.0957, -0.1060],
          [ 0.0772, -0.0814,  0.0432,  0.0977,  0.0016],
          [ 0.1051, -0.0984, -0.0441,  0.0673, -0.0252],
          [-0.0236, -0.0481,  0.0796,  0.0566,  0.0370],
          [-0.0649, -0.0937,  0.0125,  0.0342, -0.0533]],

         [[-0.0323,  0.0780,  0.0092,  0.0052, -0.0284],
          [-0.1046, -0.1086, -0.0552, -0.0587,  0.0360],
          [-0.0336, -0.0452,  0.1101,  0.0402,  0.0823],
          [-0.0559, -0.0472,  0.0424, -0.0769, -0.0755],
          [-0.0056, -0.0422, -0.0866,  0.0685,  0.0929]],

         [[ 0.0187, -0.0201, -0.1070, -0.0421,  0.0294],
          [ 0.0544, -0.0146, -0.0457,  0.0643, -0.0920],
          [ 0.0730, -0.0448,  0.0018, -0.0228,  0.0140],
          [-0.0349,  0.0840, -0.0030,  0.0901,  0.1110],
          [-0.0563, -0.0842,  0.0926,  0.0905, -0.0882]]],


        [[[-0.0089, -0.1139, -0.0945,  0.0223,  0.0307],
          [ 0.0245, -0.0314,  0.1065,  0.0165, -0.0681],
          [-0.0065,  0.0277,  0.0404, -0.0816,  0.0433],
          [-0.0590, -0.0959, -0.0631,  0.1114,  0.0987],
          [ 0.1034,  0.0678,  0.0872, -0.0155, -0.0635]],

         [[ 0.0577, -0.0598, -0.0779, -0.0369,  0.0242],
          [ 0.0594, -0.0448, -0.0680,  0.0156, -0.0681],
          [-0.0752,  0.0602, -0.0194,  0.1055,  0.1123],
          [ 0.0345,  0.0397,  0.0266,  0.0018, -0.0084],
          [ 0.0016,  0.0431,  0.1074, -0.0299, -0.0488]],

         [[-0.0280, -0.0558,  0.0196,  0.0862,  0.0903],
          [ 0.0530, -0.0850, -0.0620, -0.0254, -0.0213],
          [ 0.0095, -0.1060,  0.0359, -0.0881, -0.0731],
          [-0.0960,  0.1006, -0.1093,  0.0871, -0.0039],
          [-0.0134,  0.0722, -0.0107,  0.0724,  0.0835]]],


        [[[-0.1003,  0.0444,  0.0218,  0.0248,  0.0169],
          [ 0.0316, -0.0555, -0.0148,  0.1097,  0.0776],
          [-0.0043, -0.1086,  0.0051, -0.0786,  0.0939],
```

```
          [-0.0701, -0.0083, -0.0256,  0.0205,  0.1087],
          [ 0.0110,  0.0669,  0.0896,  0.0932, -0.0399]],

         [[-0.0258,  0.0556, -0.0315,  0.0541, -0.0252],
          [-0.0783,  0.0470,  0.0177,  0.0515,  0.1147],
          [ 0.0788,  0.1095,  0.0062, -0.0993, -0.0810],
          [-0.0717, -0.1018, -0.0579, -0.1063, -0.1065],
          [-0.0690, -0.1138, -0.0709,  0.0440,  0.0963]],

         [[-0.0343, -0.0336,  0.0617, -0.0570, -0.0546],
          [ 0.0711, -0.1006,  0.0141,  0.1020,  0.0198],
          [ 0.0314, -0.0672, -0.0016,  0.0063,  0.0283],
          [ 0.0449,  0.1003, -0.0881,  0.0035, -0.0577],
          [-0.0913, -0.0092, -0.1016,  0.0806,  0.0134]]],


        [[[-0.0622,  0.0603, -0.1093, -0.0447, -0.0225],
          [-0.0981, -0.0734, -0.0188,  0.0876,  0.1115],
          [ 0.0735, -0.0689, -0.0755,  0.1008,  0.0408],
          [ 0.0031,  0.0156, -0.0928, -0.0386,  0.1112],
          [-0.0285, -0.0058, -0.0959, -0.0646, -0.0024]],

         [[-0.0717, -0.0143,  0.0470, -0.1130,  0.0343],
          [-0.0763, -0.0564,  0.0443,  0.0918, -0.0316],
          [-0.0474, -0.1044, -0.0595, -0.1011, -0.0264],
          [ 0.0236, -0.1082,  0.1008,  0.0724, -0.1130],
          [-0.0552,  0.0377, -0.0237, -0.0126, -0.0521]],

         [[ 0.0927, -0.0645,  0.0958,  0.0075,  0.0232],
          [ 0.0901, -0.0190, -0.0657, -0.0187,  0.0937],
          [-0.0857,  0.0262, -0.1135,  0.0605,  0.0427],
          [ 0.0049,  0.0496,  0.0001,  0.0639, -0.0914],
          [-0.0170,  0.0512,  0.1150,  0.0588, -0.0840]]],


        [[[ 0.0888, -0.0257, -0.0247, -0.1050, -0.0182],
          [ 0.0817,  0.0161, -0.0673,  0.0355, -0.0370],
          [ 0.1054, -0.1002, -0.0365, -0.1115, -0.0455],
          [ 0.0364,  0.1112,  0.0194,  0.1132,  0.0226],
          [ 0.0667,  0.0926,  0.0965, -0.0646,  0.1062]],

         [[ 0.0699, -0.0540, -0.0551, -0.0969,  0.0290],
          [-0.0936,  0.0488,  0.0365, -0.1003,  0.0315],
          [-0.0094,  0.0527,  0.0663, -0.1148,  0.1059],
          [ 0.0968,  0.0459, -0.1055, -0.0412, -0.0335],
          [-0.0297,  0.0651,  0.0420,  0.0915, -0.0432]],

         [[ 0.0389,  0.0411, -0.0961, -0.1120, -0.0599],
          [ 0.0790, -0.1087, -0.1005,  0.0647,  0.0623],
          [ 0.0950, -0.0872, -0.0845,  0.0592,  0.1004],
```

```
          [ 0.0691,  0.0181,  0.0381,  0.1096, -0.0745],
          [-0.0524,  0.0808, -0.0790, -0.0637,  0.0843]]])), ('bias',
tensor([ 0.0364,  0.0373, -0.0489, -0.0016,  0.1057, -0.0693,  0.0009,
0.0549,
        -0.0797,  0.1121]))])

# Get shapes of weight and bias tensors within conv_layer_2
print(f"conv_layer_2 weight shape: \n{conv_layer_2.weight.shape} ->
[out_channels=10, in_channels=3, kernel_size=5, kernel_size=5]")
print(f"\nconv_layer_2 bias shape: \n{conv_layer_2.bias.shape} ->
[out_channels=10]")
```

```
conv_layer_2 weight shape:
torch.Size([10, 3, 5, 5]) -> [out_channels=10, in_channels=3,
kernel_size=5, kernel_size=5]

conv_layer_2 bias shape:
torch.Size([10]) -> [out_channels=10]
```

#Melangkah melalui nn.MaxPool2d()

```
# Print out original image shape without and with unsqueezed dimension
print(f"Test image original shape: {test_image.shape}")
print(f"Test image with unsqueezed dimension:
{test_image.unsqueeze(dim=0).shape}")

# Create a sample nn.MaxPoo2d() layer
max_pool_layer = nn.MaxPool2d(kernel_size=2)

# Pass data through just the conv_layer
test_image_through_conv = conv_layer(test_image.unsqueeze(dim=0))
print(f"Shape after going through conv_layer():
{test_image_through_conv.shape}")

# Pass data through the max pool layer
test_image_through_conv_and_max_pool =
max_pool_layer(test_image_through_conv)
print(f"Shape after going through conv_layer() and max_pool_layer():
{test_image_through_conv_and_max_pool.shape}")
```

```
Test image original shape: torch.Size([3, 64, 64])
Test image with unsqueezed dimension: torch.Size([1, 3, 64, 64])
Shape after going through conv_layer(): torch.Size([1, 10, 62, 62])
Shape after going through conv_layer() and max_pool_layer():
torch.Size([1, 10, 31, 31])
```

```
torch.manual_seed(42)
# Create a random tensor with a similiar number of dimensions to our
images
random_tensor = torch.randn(size=(1, 1, 2, 2))
```

```
print(f"Random tensor:\n{random_tensor}")
print(f"Random tensor shape: {random_tensor.shape}")

# Create a max pool layer
max_pool_layer = nn.MaxPool2d(kernel_size=2) # see what happens when
you change the kernel_size value

# Pass the random tensor through the max pool layer
max_pool_tensor = max_pool_layer(random_tensor)
print(f"\nMax pool tensor:\n{max_pool_tensor} <- this is the maximum
value from random_tensor")
print(f"Max pool tensor shape: {max_pool_tensor.shape}")
```

```
Random tensor:
tensor([[[[0.3367, 0.1288],
          [0.2345, 0.2303]]]])
Random tensor shape: torch.Size([1, 1, 2, 2])

Max pool tensor:
tensor([[[[0.3367]]]]) <- this is the maximum value from random_tensor
Max pool tensor shape: torch.Size([1, 1, 1, 1])
```

#Siapkan fungsi kerugian dan pengoptimal untuk model_2

```
# Setup loss and optimizer
loss_fn = nn.CrossEntropyLoss()
optimizer = torch.optim.SGD(params=model_2.parameters(),
                            lr=0.1)
```

#Pelatihan dan pengujian model_2 menggunakan fungsi pelatihan dan pengujian kami

```
torch.manual_seed(42)

# Measure time
from timeit import default_timer as timer
train_time_start_model_2 = timer()

# Train and test model
epochs = 3
for epoch in tqdm(range(epochs)):
    print(f"Epoch: {epoch}\n---------")
    train_step(data_loader=train_dataloader,
        model=model_2,
        loss_fn=loss_fn,
        optimizer=optimizer,
        accuracy_fn=accuracy_fn,
        device=device
    )
    test_step(data_loader=test_dataloader,
```

```
        model=model_2,
        loss_fn=loss_fn,
        accuracy_fn=accuracy_fn,
        device=device
    )

train_time_end_model_2 = timer()
total_train_time_model_2 =
print_train_time(start=train_time_start_model_2,
                                            end=train_time_end_model_2,
                                            device=device)
```

{"model_id":"2b9c90ceb8554eaaaaf33acacecbcc11","version_major":2,"version_minor":0}

```
Epoch: 0
---------
Train loss: 0.59302 | Train accuracy: 78.41%
Test loss: 0.39771 | Test accuracy: 86.01%

Epoch: 1
---------
Train loss: 0.36149 | Train accuracy: 87.00%
Test loss: 0.35713 | Test accuracy: 87.00%

Epoch: 2
---------
Train loss: 0.32354 | Train accuracy: 88.28%
Test loss: 0.32857 | Test accuracy: 88.38%

Train time on cuda: 44.250 seconds
```

```
# Get model_2 results
model_2_results = eval_model(
    model=model_2,
    data_loader=test_dataloader,
    loss_fn=loss_fn,
    accuracy_fn=accuracy_fn
)
model_2_results
```

```
{'model_name': 'FashionMNISTModelV2',
 'model_loss': 0.3285697102546692,
 'model_acc': 88.37859424920129}
```

#Bandingkan hasil model dan waktu pelatihan

```
import pandas as pd
compare_results = pd.DataFrame([model_0_results, model_1_results,
```

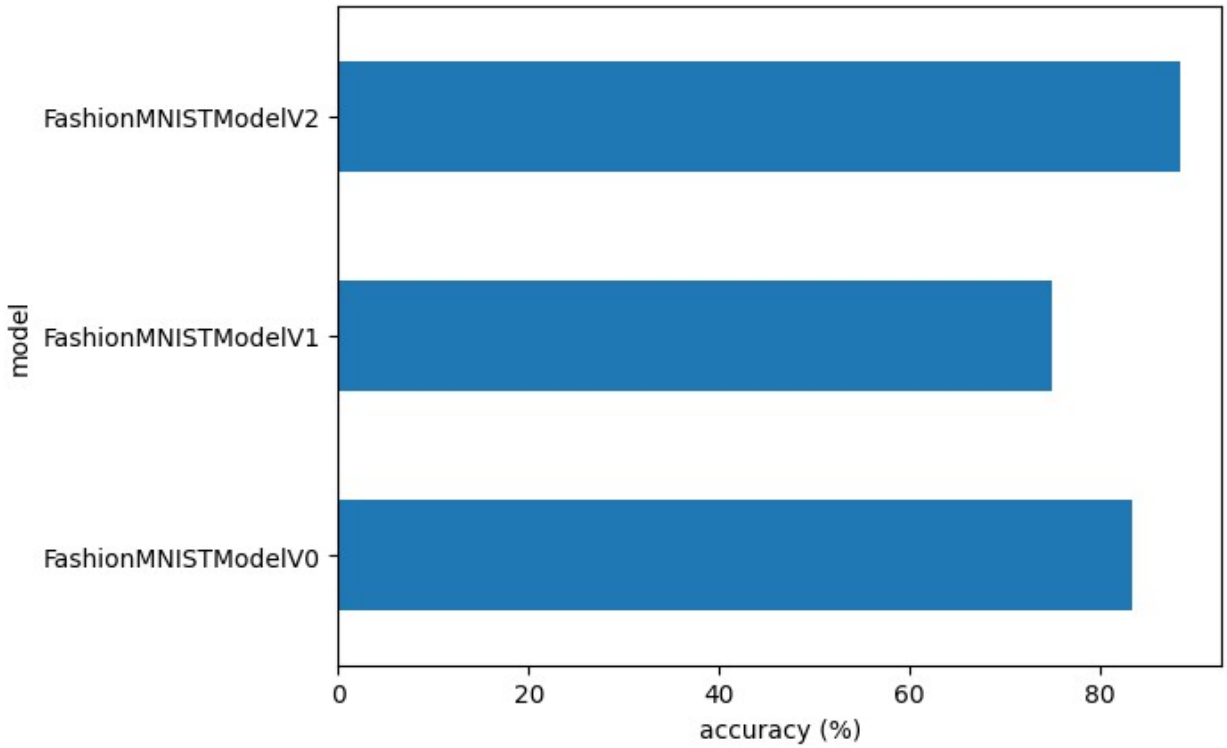
```
model_2_results])
compare_results
```

	model_name	model_loss	model_acc
0	FashionMNISTModelV0	0.476639	83.426518
1	FashionMNISTModelV1	0.685001	75.019968
2	FashionMNISTModelV2	0.328570	88.378594

```
# Add training times to results comparison
compare_results["training_time"] = [total_train_time_model_0,
                                    total_train_time_model_1,
                                    total_train_time_model_2]
compare_results
```

	model_name	model_loss	model_acc	training_time
0	FashionMNISTModelV0	0.476639	83.426518	32.348722
1	FashionMNISTModelV1	0.685001	75.019968	36.877976
2	FashionMNISTModelV2	0.328570	88.378594	44.249765

```
# Visualize our model results
compare_results.set_index("model_name")["model_acc"].plot(kind="barh")
plt.xlabel("accuracy (%)")
plt.ylabel("model");
```



#Membuat dan mengevaluasi prediksi acak dengan model terbaik

```
def make_predictions(model: torch.nn.Module, data: list, device:
torch.device = device):
    pred_probs = []
    model.eval()
    with torch.inference_mode():
        for sample in data:
            # Prepare sample
            sample = torch.unsqueeze(sample, dim=0).to(device) # Add
an extra dimension and send sample to device

            # Forward pass (model outputs raw logit)
            pred_logit = model(sample)

            # Get prediction probability (logit -> prediction
probability)
            pred_prob = torch.softmax(pred_logit.squeeze(), dim=0) #
note: perform softmax on the "logits" dimension, not "batch" dimension
(in this case we have a batch size of 1, so can perform on dim=0)

            # Get pred_prob off GPU for further calculations
            pred_probs.append(pred_prob.cpu())

    # Stack the pred_probs to turn list into a tensor
    return torch.stack(pred_probs)

import random
random.seed(42)
test_samples = []
test_labels = []
for sample, label in random.sample(list(test_data), k=9):
    test_samples.append(sample)
    test_labels.append(label)

# View the first test sample shape and label
print(f"Test sample image shape: {test_samples[0].shape}\nTest sample
label: {test_labels[0]} ({class_names[test_labels[0]]})")
```

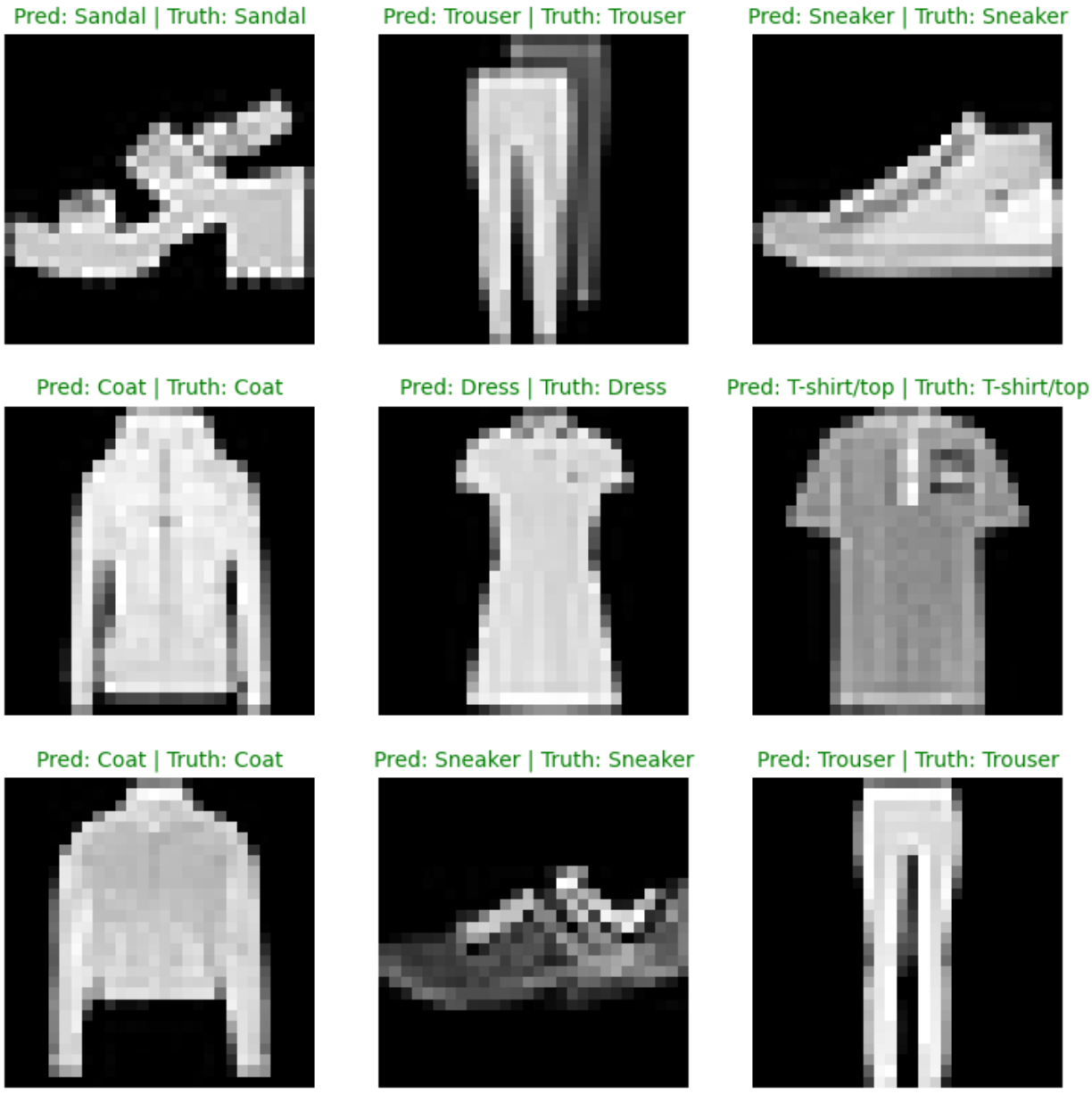
```
Test sample image shape: torch.Size([1, 28, 28])
Test sample label: 5 (Sandal)
```

```
# Make predictions on test samples with model 2
pred_probs= make_predictions(model=model_2,
                             data=test_samples)

# View first two prediction probabilities list
pred_probs[:2]
```

```
tensor([[2.4012e-07, 6.5406e-08, 4.8069e-08, 2.1070e-07, 1.4175e-07,
9.9992e-01,
         2.1711e-07, 1.6177e-05, 3.7849e-05, 2.7548e-05],
        [1.5646e-02, 8.9752e-01, 3.6928e-04, 6.7402e-02, 1.2920e-02,
```

```
4.9539e-05,
         5.6485e-03, 1.9456e-04, 2.0808e-04, 3.7861e-05]])

# Make predictions on test samples with model 2
pred_probs= make_predictions(model=model_2,
                             data=test_samples)

# View first two prediction probabilities list
pred_probs[:2]

tensor([[2.4012e-07, 6.5406e-08, 4.8069e-08, 2.1070e-07, 1.4175e-07,
9.9992e-01,
         2.1711e-07, 1.6177e-05, 3.7849e-05, 2.7548e-05],
        [1.5646e-02, 8.9752e-01, 3.6928e-04, 6.7402e-02, 1.2920e-02,
4.9539e-05,
         5.6485e-03, 1.9456e-04, 2.0808e-04, 3.7861e-05]])

# Turn the prediction probabilities into prediction labels by taking
the argmax()
pred_classes = pred_probs.argmax(dim=1)
pred_classes

tensor([5, 1, 7, 4, 3, 0, 4, 7, 1])

# Are our predictions in the same form as our test labels?
test_labels, pred_classes

([5, 1, 7, 4, 3, 0, 4, 7, 1], tensor([5, 1, 7, 4, 3, 0, 4, 7, 1]))

# Plot predictions
plt.figure(figsize=(9, 9))
nrows = 3
ncols = 3
for i, sample in enumerate(test_samples):
  # Create a subplot
  plt.subplot(nrows, ncols, i+1)

  # Plot the target image
  plt.imshow(sample.squeeze(), cmap="gray")

  # Find the prediction label (in text form, e.g. "Sandal")
  pred_label = class_names[pred_classes[i]]

  # Get the truth label (in text form, e.g. "T-shirt")
  truth_label = class_names[test_labels[i]]

  # Create the title text of the plot
  title_text = f"Pred: {pred_label} | Truth: {truth_label}"

  # Check for equality and change title colour accordingly
  if pred_label == truth_label:
```

```
      plt.title(title_text, fontsize=10, c="g") # green text if
correct
  else:
      plt.title(title_text, fontsize=10, c="r") # red text if wrong
  plt.axis(False);
```



#Membuat matriks konfusi untuk evaluasi prediksi selanjutnya

```
# Import tqdm for progress bar
from tqdm.auto import tqdm

# 1. Make predictions with trained model
```

```
y_preds = []
model_2.eval()
with torch.inference_mode():
  for X, y in tqdm(test_dataloader, desc="Making predictions"):
    # Send data and targets to target device
    X, y = X.to(device), y.to(device)
    # Do the forward pass
    y_logit = model_2(X)
    # Turn predictions from logits -> prediction probabilities -> predictions labels
    y_pred = torch.softmax(y_logit, dim=1).argmax(dim=1) # note: perform softmax on the "logits" dimension, not "batch" dimension (in this case we have a batch size of 32, so can perform on dim=1)
    # Put predictions on CPU for evaluation
    y_preds.append(y_pred.cpu())
# Concatenate list of predictions into a tensor
y_pred_tensor = torch.cat(y_preds)
```

{"model_id":"d3ab200da5f940d5b45396f83bd835e2","version_major":2,"version_minor":0}

```
# See if torchmetrics exists, if not, install it
try:
    import torchmetrics, mlxtend
    print(f"mlxtend version: {mlxtend.__version__}")
    assert int(mlxtend.__version__.split(".")[1]) >= 19, "mlxtend verison should be 0.19.0 or higher"
except:
    !pip install -q torchmetrics -U mlxtend # <- Note: If you're using Google Colab, this may require restarting the runtime
    import torchmetrics, mlxtend
    print(f"mlxtend version: {mlxtend.__version__}")
```

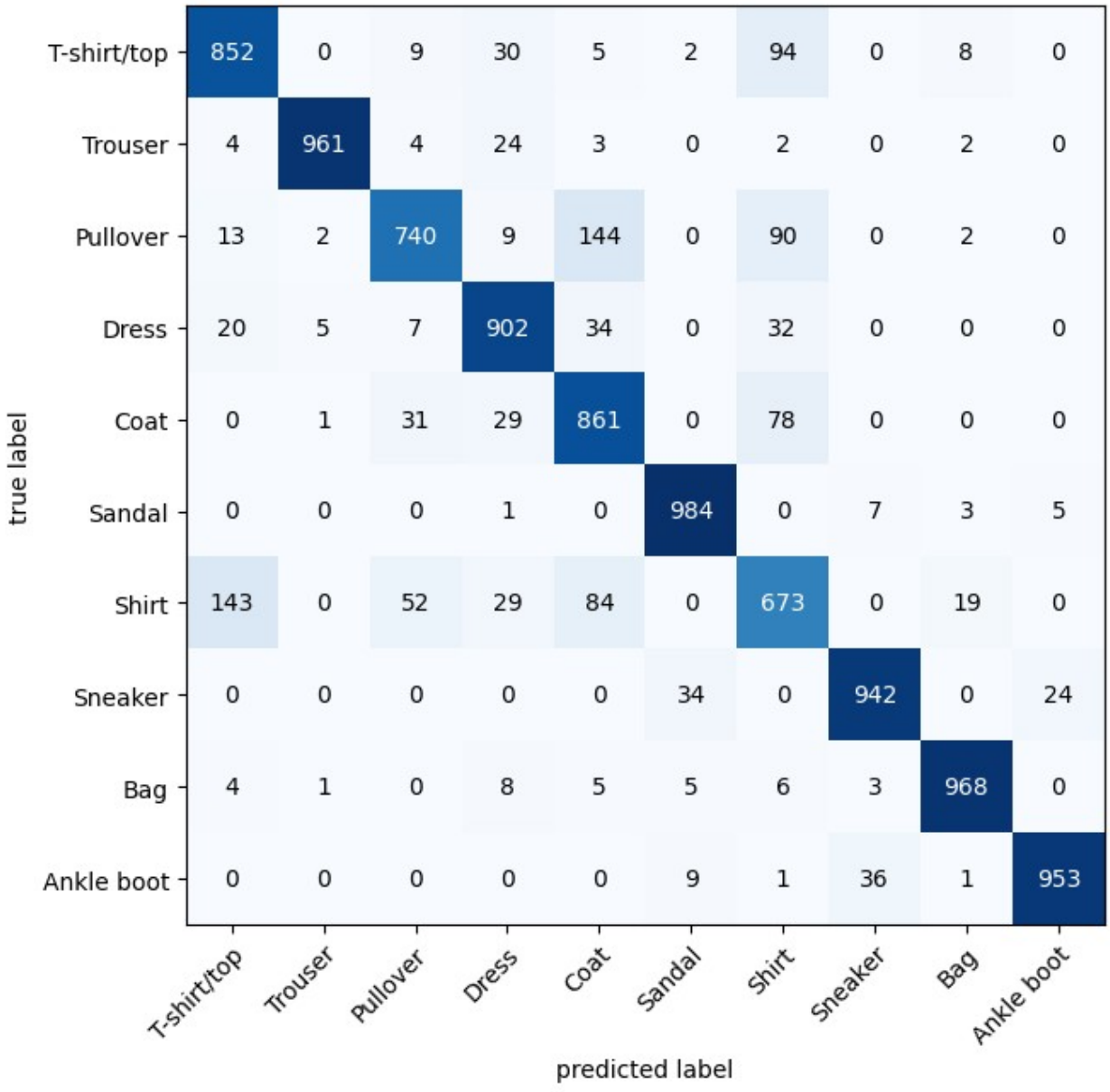
```
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 519.2/519.2 kB 10.8 MB/s eta 0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.4/1.4 MB 54.9 MB/s eta 0:00:00
lxtend version: 0.22.0
```

```
# Import mlxtend upgraded version
import mlxtend
print(mlxtend.__version__)
assert int(mlxtend.__version__.split(".")[1]) >= 19 # should be version 0.19.0 or higher
```

```
0.22.0
```

```
from torchmetrics import ConfusionMatrix
from mlxtend.plotting import plot_confusion_matrix

# 2. Setup confusion matrix instance and compare predictions to
```

```
targets
confmat = ConfusionMatrix(num_classes=len(class_names),
task='multiclass')
confmat_tensor = confmat(preds=y_pred_tensor,
                         target=test_data.targets)

# 3. Plot the confusion matrix
fig, ax = plot_confusion_matrix(
    conf_mat=confmat_tensor.numpy(), # matplotlib likes working with
NumPy
    class_names=class_names, # turn the row and column labels into
class names
    figsize=(10, 7)
);
```



Simpan dan muat model dengan performa terbaik

```
from pathlib import Path

# Create models directory (if it doesn't already exist), see:
https://docs.python.org/3/library/pathlib.html#pathlib.Path.mkdir
MODEL_PATH = Path("models")
MODEL_PATH.mkdir(parents=True, # create parent directories if needed
                 exist_ok=True # if models directory already exists,
```

```
don't error
)

# Create model save path
MODEL_NAME = "03_pytorch_computer_vision_model_2.pth"
MODEL_SAVE_PATH = MODEL_PATH / MODEL_NAME

# Save the model state dict
print(f"Saving model to: {MODEL_SAVE_PATH}")
torch.save(obj=model_2.state_dict(), # only saving the state_dict()
only saves the learned parameters
           f=MODEL_SAVE_PATH)
```

```
Saving model to: models/03_pytorch_computer_vision_model_2.pth
```

```
# Create a new instance of FashionMNISTModelV2 (the same class as our
saved state_dict())
# Note: loading model will error if the shapes here aren't the same as
the saved version
loaded_model_2 = FashionMNISTModelV2(input_shape=1,
                                     hidden_units=10, # try changing
this to 128 and seeing what happens
                                     output_shape=10)

# Load in the saved state_dict()
loaded_model_2.load_state_dict(torch.load(f=MODEL_SAVE_PATH))

# Send model to GPU
loaded_model_2 = loaded_model_2.to(device)

# Evaluate loaded model
torch.manual_seed(42)

loaded_model_2_results = eval_model(
    model=loaded_model_2,
    data_loader=test_dataloader,
    loss_fn=loss_fn,
    accuracy_fn=accuracy_fn
)

loaded_model_2_results
```

```
{'model_name': 'FashionMNISTModelV2',
 'model_loss': 0.3285697102546692,
 'model_acc': 88.37859424920129}
```

```
model_2_results
```

```
{'model_name': 'FashionMNISTModelV2',
 'model_loss': 0.3285697102546692,
 'model_acc': 88.37859424920129}
```

```
# Check to see if results are close to each other (if they are very
far away, there may be an error)
torch.isclose(torch.tensor(model_2_results["model_loss"]),
              torch.tensor(loaded_model_2_results["model_loss"]),
              atol=1e-08, # absolute tolerance
              rtol=0.0001) # relative tolerance
```

```
tensor(True)
```