BIOS 694 Final Project - Teacher Model

2025-04-17

```r
library(torch)
library(torchvision)
library(luz)
library(reshape2)
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(tibble)
library(caret)
```

```
## Loading required package: lattice
```

```r
library(here)
```

```
## here() starts at C:/Users/mince/Desktop/McGill/Courses/BIOS694/Project
```

MNIST dataset

```r
torch_manual_seed(42)
dir <- "./dataset/mnist"

train_ds <- mnist_dataset(
  dir,
  download = TRUE,
  transform = transform_to_tensor
)

test_ds <- mnist_dataset(
  dir,
  train = FALSE,
  transform = transform_to_tensor
)

train_dl <- dataloader(train_ds, batch_size = 128, shuffle = TRUE)
test_dl <- dataloader(test_ds, batch_size = 128)
```

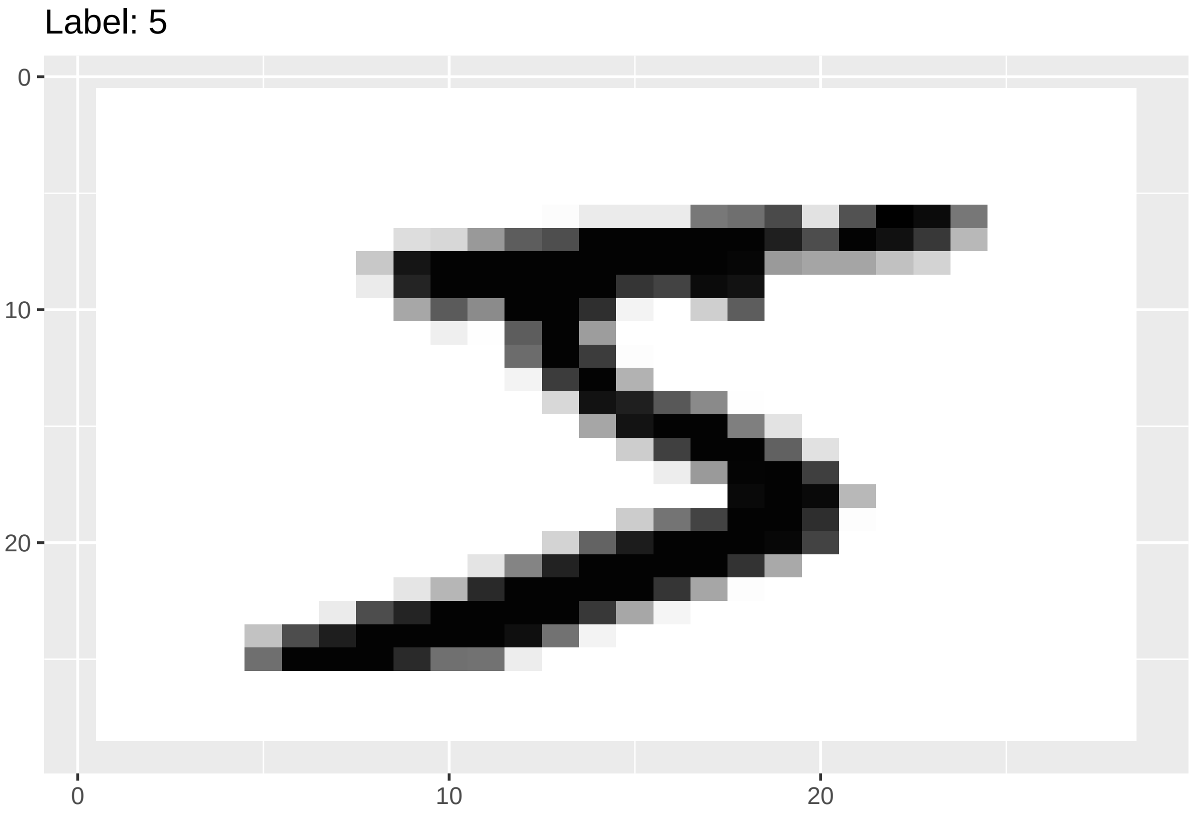
```
length(train_ds)
```

```
## [1] 60000
```

```
length(test_ds)
```

```
## [1] 10000
```

```
# An example image
image <- train_ds$data[1, 1:28, 1:28]
label <- train_ds$targets[1] - 1 # Targets are 1-10 but should be 0-9
image_df <- melt(image)
ggplot(image_df, aes(x = Var2, y = Var1, fill = value))+
  geom_tile(show.legend = FALSE) +
  xlab("") + ylab("") +
  scale_fill_gradient(low="white", high="black") +
  ggtitle(paste("Label:", label)) +
  scale_y_reverse()
```



Teacher model

Define the Teacher model

```
TeacherNet <- nn_module(
  "TeacherNet",

  initialize = function(T = 1) {
    self$T <- T   # Temperature
    self$conv1 <- nn_conv2d(1, 32, kernel_size = 3, padding = 1)
    self$conv2 <- nn_conv2d(32, 64, kernel_size = 3, padding = 1)

    self$dropout1 <- nn_dropout2d(0.25)
    self$dropout2 <- nn_dropout(0.5)

    self$fc1 <- nn_linear(12544, 128)
    self$fc2 <- nn_linear(128, 10)
  },

  forward = function(x) {
    x %>%                                  # N * 1 * 28 * 28
      self$conv1() %>%                     # N * 32 * 28 * 28
      nnf_relu() %>%
      self$conv2() %>%                     # N * 64 * 28 * 28
      nnf_relu() %>%
      nnf_max_pool2d(kernel_size = 2) %>%  # N * 64 * 14 * 14
      self$dropout1() %>%
      torch_flatten(start_dim = 2) %>%     # N * 12544
      self$fc1() %>%                       # N * 128
      nnf_relu() %>%
      self$dropout2() %>%
      self$fc2() %>%                       # N * 10 (logits)
      { . / self$T }                       # Apply temperature scaling
  }
)
```

Train the Teacher model

```
fitted_teacher <- TeacherNet %>%
  setup(
    loss = nn_cross_entropy_loss(),
    optimizer = optim_adam,
    metrics = list(luz_metric_accuracy())
  ) %>%
  set_hparams(T = 3) %>%
  fit(train_dl, epochs = 5, valid_data = test_dl)
```

Evaluate the Teacher model

```
eval_teacher <- evaluate(fitted_teacher, test_dl)
acc <- get_metrics(eval_teacher) %>%
  filter(metric == "acc") %>%
  pull(value)

cat(sprintf("Test accuracy of teacher model: %.2f%%\n", acc * 100))
```

```
## Test accuracy of teacher model: 98.75%
```

```
num_errors <- (1 - acc) * length(test_ds)
cat(sprintf("The teacher model achieves %.0f test errors out of %d test cases.\n",
            num_errors, length(test_ds)))
```

```
## The teacher model achieves 125 test errors out of 10000 test cases.
```

```
preds <- predict(fitted_teacher, test_dl)
pred_classes <- torch_argmax(preds, dim = 2)$to(device = "cpu") %>% as_array()

# Dataframe to compare truth and predictions
pred_df <- tibble(
  id = 1:length(test_ds),
  true = test_ds$targets,
  pred = pred_classes
) %>% mutate(true = true - 1,
             pred = pred - 1) # Convert 1-10 to 0-9
```

```
# All the wrong predictions
wrong_pred <- pred_df %>% filter(true != pred)
head(wrong_pred)
```

```
## # A tibble: 6 x 3
##      id       true  pred
##   <int> <dbl[1d]> <dbl>
## 1   321         9     8
## 2   322         2     7
## 3   360         9     4
## 4   446         6     0
## 5   496         8     0
## 6   544         8     7
```

Save the Teacher model

```
luz_save(fitted_teacher, here("model/mnist-cnn-teacher.pt"))
```