CH2. Mathematical Building Blocks of Deep-learning

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Mathematical Building Blocs of Deep-learning

A first look on neural network

Data representations for neural network

The gear of neural networks: tensor operations

The engine of neural networks: gradient-based optimization

Looking back at our first example

A first look on neural network

Figure 2.1 MNIST sample digits

Mnist data analysis example

Hand written digit (28,28 pixcels) for 10 categories (0-9)

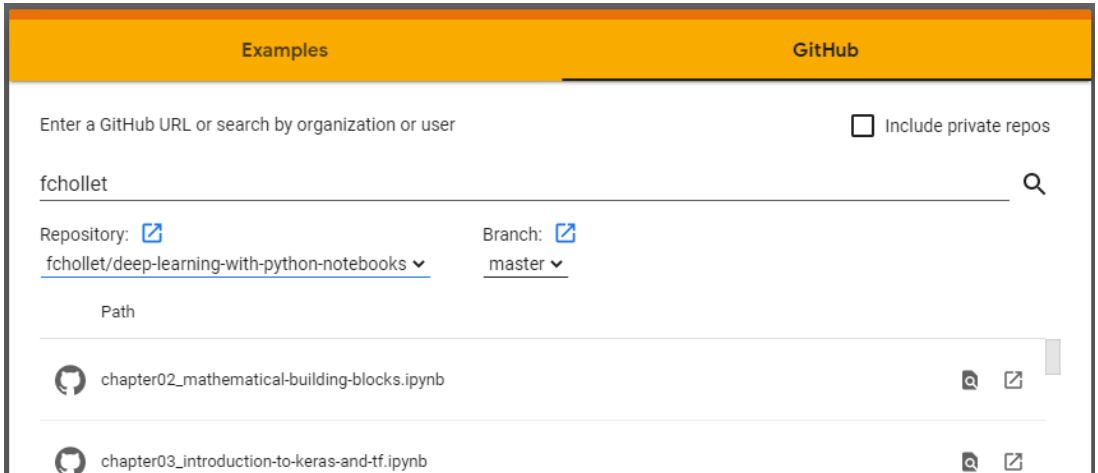
60,000 training set and 10,000 test set

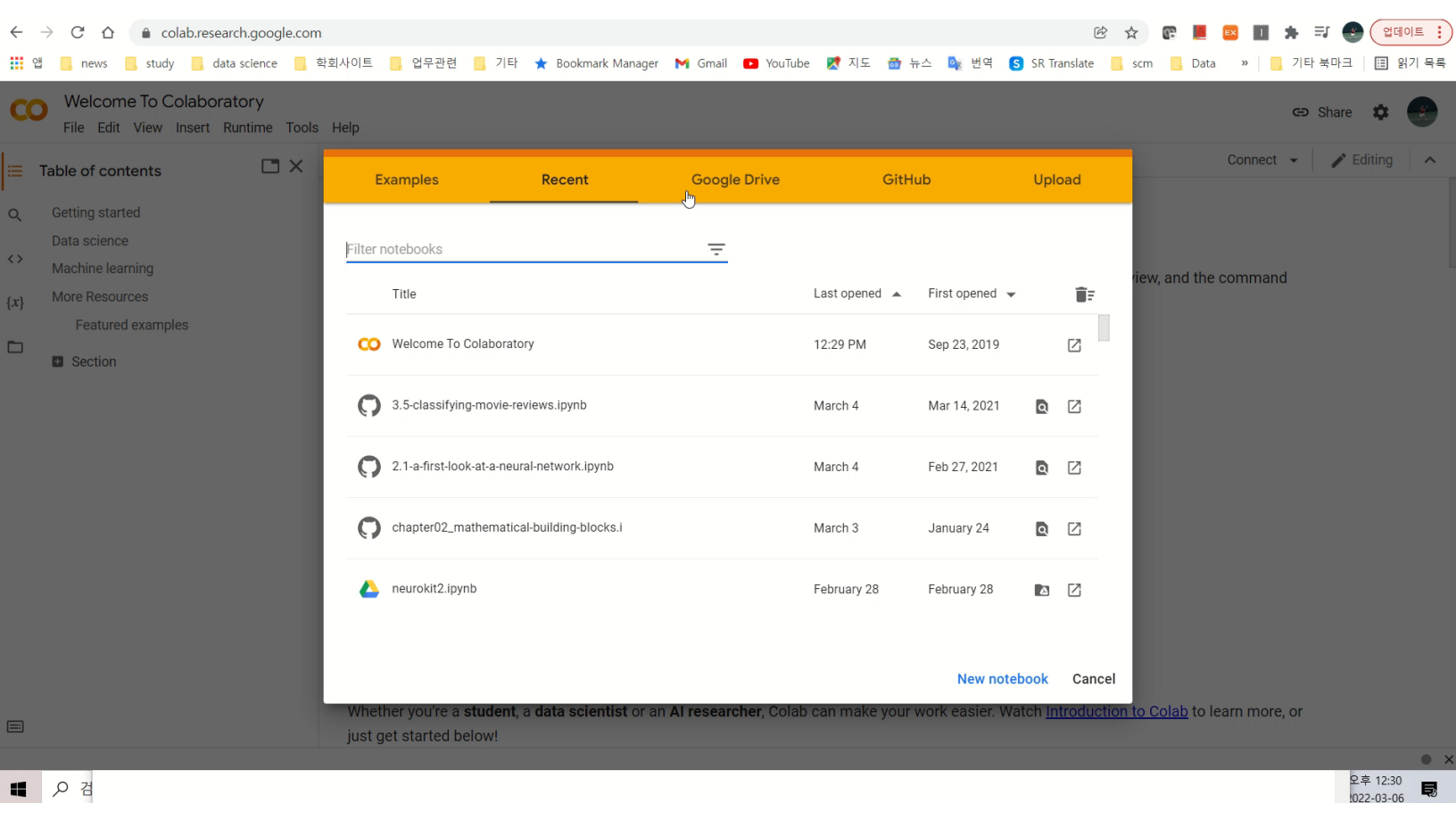
Mnist data

Listing 2.1 Loading the MNIST dataset in Keras

```
from tensorflow.keras.datasets import mnist
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()
```

Try these codes from https://colab.research.google.com/github/

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February 28
New notebook
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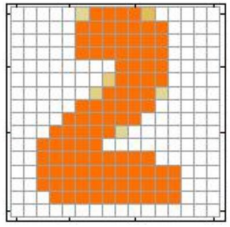
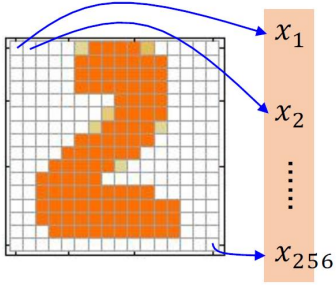
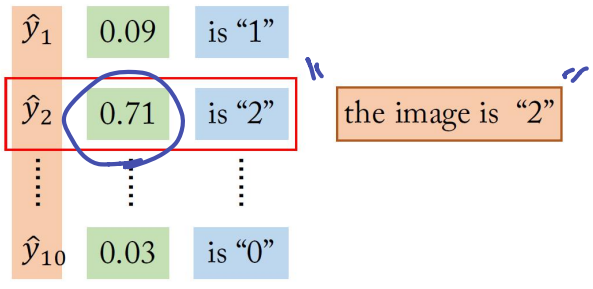


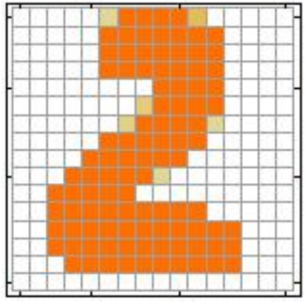
“2”



$16 \times 16 = 256$
ink → 1
no ink → 0



Each dimension represents the confidence of a digit.



input

x_1

x_2

$\vdots$

x_{256}

Machine

output

$\hat{y}_1$

$\hat{y}_2$

$\vdots$

$\hat{y}_{10}$

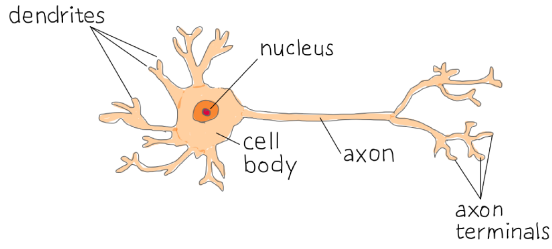
$f : R^{256} \rightarrow R^{10}$

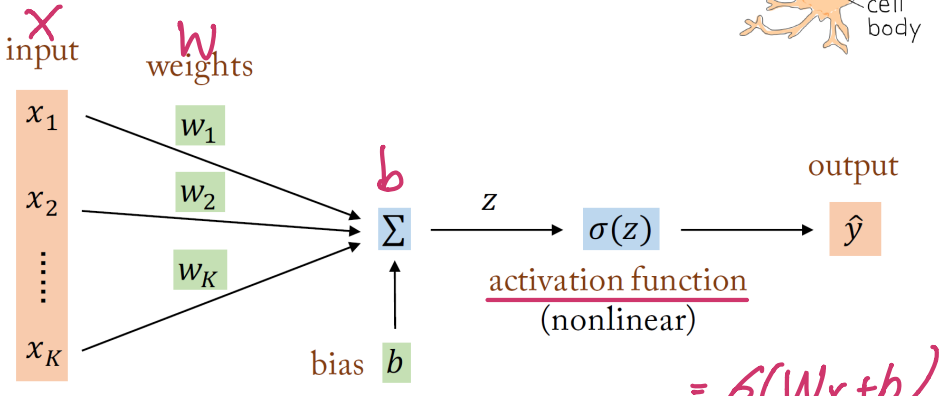
NN

In Deep Learning, the function f is represented by a Neural Network.

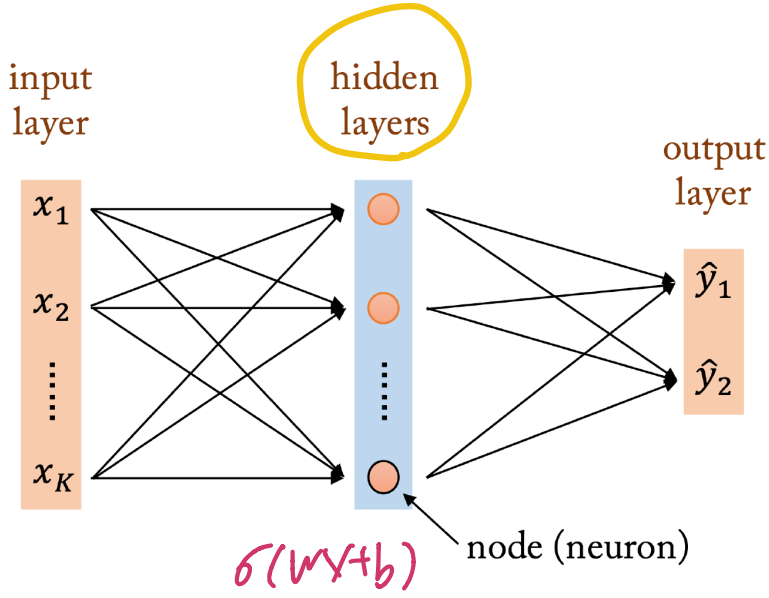
Perceptron (neuron) [Frank Rosenblatt, 1957]

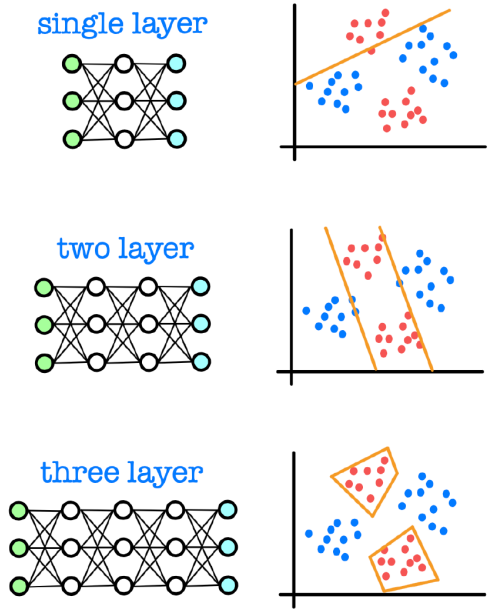
↳ One layer model





Multilayer Perceptron (MLP)



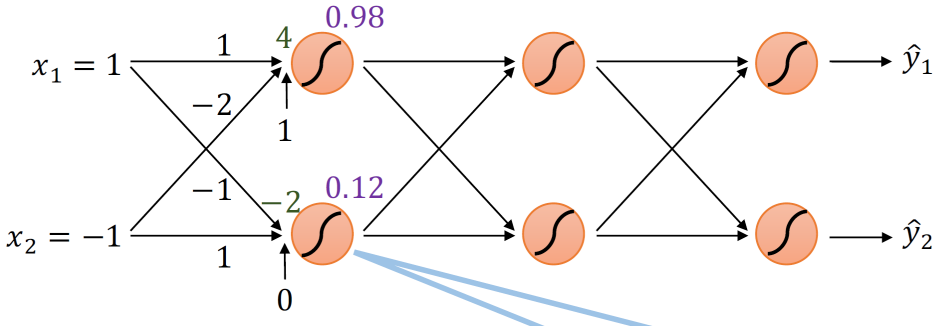


Forward pass computation

$\sigma(Wx+b)$

$$\sigma(w_1x_1 + w_2x_2 + \cdots + w_Kx_K + b)$$

$$0.98 = \sigma(1 \cdot 1 + (-1) \cdot (-2) + 1)$$

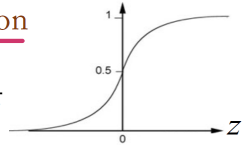


$$\sigma\left(\begin{bmatrix} 1 & -2 \\ -1 & 1 \end{bmatrix}\begin{bmatrix} 1 \\ -1 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix}\right) = \sigma\left(\begin{bmatrix} 4 \\ -2 \end{bmatrix}\right) = \begin{bmatrix} 0.98 \\ 0.12 \end{bmatrix}$$

W x b

sigmoid function

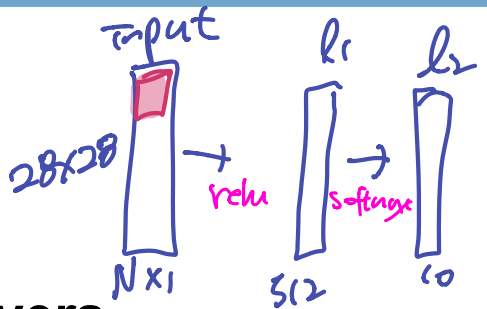
$$\sigma(z) = \frac{1}{1 + e^{-z}}$$



activation function

Listing 2.2 The network architecture

```
from tensorflow import keras
from tensorflow.keras import layers
model = keras.Sequential([
    layers.Dense(512, activation="relu"),
    layers.Dense(10, activation="softmax")
])
```



Core building block of NN is layers

Layers extract *representations*

This step define our model f(x; weights)

$$Y = \text{softmax}(W_2 \text{relu}(W_1 x + b_1) + b_2)$$

10×512 $\quad 512 \times N \quad N \times 1 \quad 512 \times 1 \quad 10 \times 1$

$\Rightarrow 512 \times 1$

$\Rightarrow 10 \times 1$

parameter: W_1, W_2, b_1, b_2

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RAM Disk Editing

```
[8] train_images.shape
```

```
(60000, 28, 28)
```

```
[9] len(train_labels)
```

```
60000
```

```
train_labels
```

```
array([5, 0, 4, ..., 5, 6, 8], dtype=uint8)
```

```
[11] test_images.shape
```

```
(10000, 28, 28)
```

```
[12] len(test_labels)
```

```
10000
```

```
[13] test_labels
```

```
array([7, 2, 1, ..., 4, 5, 6], dtype=uint8)
```

The network architecture

Warning: you are connected to a GPU runtime, but not utilizing the GPU. Change to a standard runtime

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What's next?

$f_\theta(x) = y$

Loss function: How the network measure its performance

Optimizer: Mechanism through which the network will update itself based on the data it sees and its loss function

Metrics to monitor during training and testing: **Accuracy**

Listing 2.3 The compilation step

```
model.compile(optimizer="rmsprop",
              loss="sparse_categorical_crossentropy",
              metrics=["accuracy"])
```

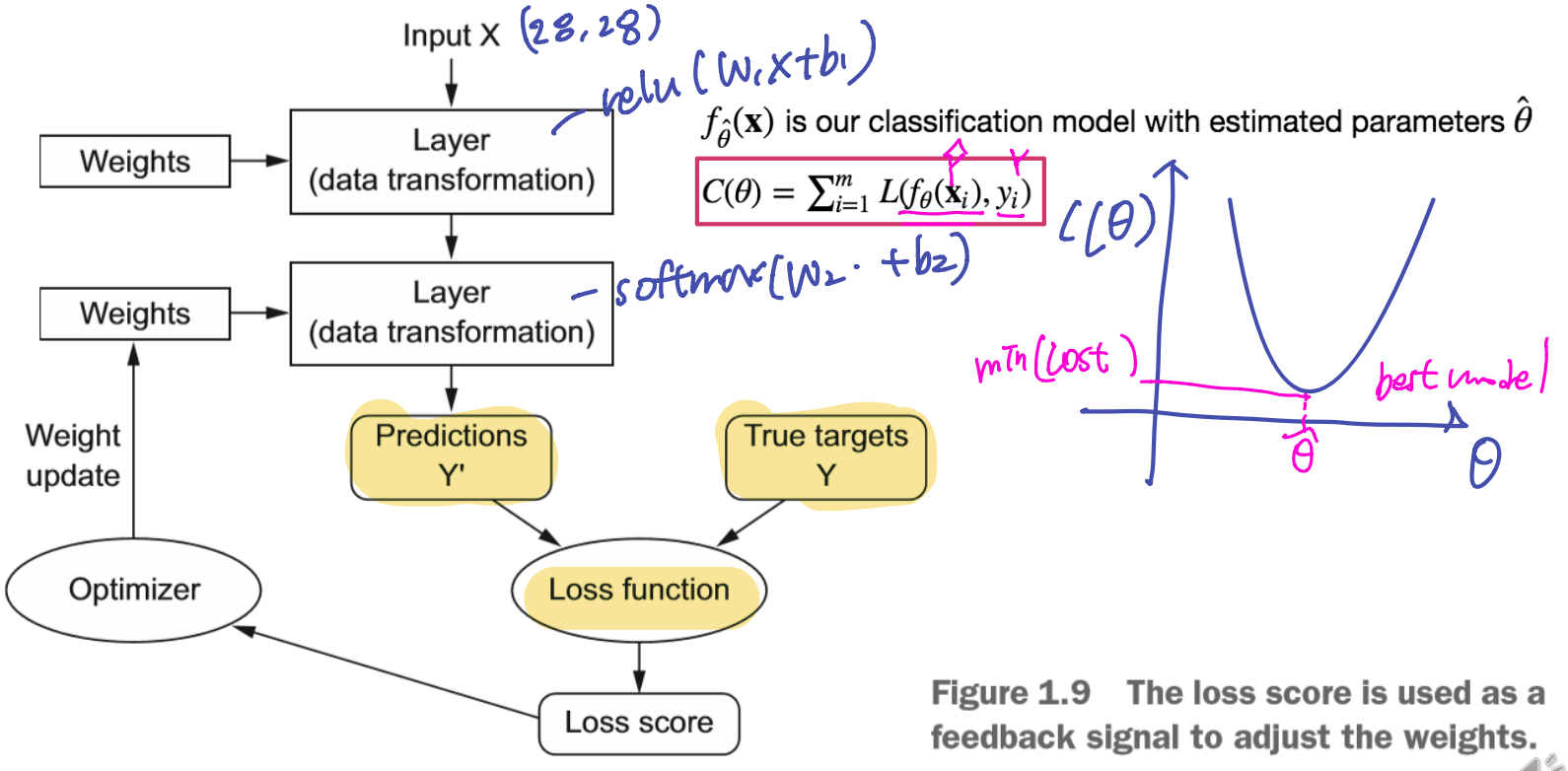

Figure 1.9 The loss score is used as a feedback signal to adjust the weights.

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[14] 3s
```
from tensorflow import keras
from tensorflow.keras import layers
model = keras.Sequential([
    layers.Dense(512, activation="relu"),
    layers.Dense(10, activation="softmax")
])
```

The compilation step

+ Code + Text

0s
```
model.compile(optimizer="rmsprop",
              loss="sparse_categorical_crossentropy",
              metrics=["accuracy"])
```

[ ]

Preparing the image data

[ ]
```
train_images = train_images.reshape((60000, 28 * 28))
train_images = train_images.astype("float32") / 255
test_images = test_images.reshape((10000, 28 * 28))
test_images = test_images.astype("float32") / 255
```

"Fitting" the model

[ ]
```
model.fit(train_images, train_labels, epochs=5, batch_size=128)
```

0s completed at 1:03 PM

Rescale values from [0,255] to [0,1]

Listing 2.4 Preparing the image data

```
train_images = train_images.reshape((60000, 28 * 28))
train_images = train_images.astype("float32") / 255
test_images = test_images.reshape((10000, 28 * 28))
test_images = test_images.astype("float32") / 255
```

Fitting the model

Listing 2.5 "Fitting" the model

```
>>> model.fit(train_images, train_labels, epochs=5, batch_size=128)
Epoch 1/5
60000/60000 [==============================] - 5s - loss: 0.2524 - acc: 0.9273
Epoch 2/5
51328/60000 [=====================>.....] - ETA: 1s - loss: 0.1035 - acc: 0.9692
```

Make Predictions

Listing 2.6 Using the model to make predictions

test data 중 10개만 예측해봐

```
>>> test_digits = test_images[0:10]
>>> predictions = model.predict(test_digits)
>>> predictions[0]
array([1.0726176e-10, 1.6918376e-10, 6.1314843e-08, 8.4106023e-06,
       2.9967067e-11, 3.0331331e-09, 8.3651971e-14, 9.9999106e-01,
       2.6657624e-08, 3.8127661e-07], dtype=float32)
```

→ 1번 image에 대하여 예측값.

↳ label = 7 이다!!

Evaluating the model

Listing 2.7 Evaluating the model on new data

x y

```
>>> test_loss, test_acc = model.evaluate(test_images, test_labels)
>>> print(f"test_acc: {test_acc}")
test_acc: 0.9785
```

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```
from tensorflow import keras
from tensorflow.keras import layers
model = keras.Sequential([
    layers.Dense(512, activation="relu"),
    layers.Dense(10, activation="softmax")
])
```

[param]

401920 = 512 × 784 + 512

5130 = 10 × 512 + 10

The compilation step

```
model.compile(optimizer="rmsprop",
              loss="sparse_categorical_crossentropy",
              metrics=["accuracy"])
```

Preparing the image data

```
train_images = train_images.reshape((60000, 28 * 28))
train_images = train_images.astype("float32") / 255
test_images = test_images.reshape((10000, 28 * 28))
test_images = test_images.astype("float32") / 255
```

"Fitting" the model

```
model.fit(train_images, train_labels, epochs=5, batch_size=128)
```

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