Tensorflow More for GAN

MNIST 분류 모델 리뷰 I - DNN

```
import tensorflow as tf

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

x_train = x_train.reshape(-1, 28, 28, 1) / 255
x_test = x_test.reshape(-1, 28, 28, 1) / 255
print(x_train.shape, y_train.shape)
```

```
(60000, 28, 28, 1) (60000,)
```

```
tf.keras.backend.clear_session()

x = tf.keras.Input(shape=(28, 28, 1))
h = tf.keras.layers.Flatten()(x)
h = tf.keras.layers.Dense(32, activation='swish')(h)
h = tf.keras.layers.Dense(32, activation='swish')(h)
y = tf.keras.layers.Dense(10, activation="softmax")(h)

model = tf.keras.Model(x, y)
model.compile(loss='sparse_categorical_crossentropy', metrics='accuracy')
model.fit(x_train, y_train, epochs=10, batch_size=128, validation_split=0.1)
```

sparse_categorical_crossentropy

종속변수의 원핫인코딩을

생략할 수 있는 Loss 함수

MNIST 분류 모델 리뷰 II - CNN

```
import tensorflow as tf

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

x_train = x_train.reshape(-1, 28, 28, 1) / 255
x_test = x_test.reshape(-1, 28, 28, 1) / 255
print(x_train.shape, y_train.shape)
```

```
(60000, 28, 28, 1) (60000,)
```

```
tf.keras.backend.clear_session()

x = tf.keras.Input(shape=(28, 28, 1))
h = tf.keras.layers.Conv2D(32, 3, 2, activation='swish')(x)
h = tf.keras.layers.Conv2D(64, 3, 2, activation='swish')(h)
h = tf.keras.layers.Conv2D(128, 6, activation='swish')(h)
h = tf.keras.layers.Flatten()(h)
y = tf.keras.layers.Dense(10, activation="softmax")(h)

model = tf.keras.Model(x, y)
model.compile(loss='sparse_categorical_crossentropy', metrics='accuracy')
model.fit(x_train, y_train, epochs=10, batch_size=128, validation_split=0.1)
```

sparse_categorical_crossentropy

종속변수의 원핫인코딩을

생략할 수 있는 Loss 함수

TF Dataset 사용

```
datasets = tf.data.Dataset.from_tensor_slices((x_train, y_train))
datasets = datasets.shuffle(1000).batch(128)
model.compile(loss='sparse_categorical_crossentropy', metrics='accuracy')
model.fit(datasets, epochs=10)
```

batch를 분리해서 직접 학습하기

```
datasets = tf.data.Dataset.from_tensor_slices((x_train, y_train))
datasets = datasets.shuffle(1000).batch(128)
for e in range(10):
    print(f"{e} epochs")
    for i, (x_batch, y_batch) in enumerate(datasets):
        result = model.train_on_batch(x_batch, y_batch)
        if i % 50 == 0:
            print(f"{i} batch, {result}")

    model.evaluate(x_test, y_test)
    print()
```

train_on_batch 대신 GradientTape 사용하기

```
model = tf.keras.Model(x, y)

# model.compile을 하지 않음.
loss_fn = tf.keras.losses.SparseCategoricalCrossentropy()
optimizer = tf.keras.optimizers.Adam()
accuracy = tf.keras.metrics.SparseCategoricalAccuracy()

for e in range(10):
    print(f"{e} epochs")
    accuracy.reset_states()
    for i, (x_batch, y_batch) in enumerate(datasets):
        with tf.GradientTape() as tape:
            y_pred = model(x_batch, training=True)
            loss = loss_fn(y_batch, y_pred)
            grads = tape.gradient(loss, model.trainable_weights)
        optimizer.apply_gradients(zip(grads, model.trainable_weights))
        accuracy.update_state(y_batch, y_pred)

        if i % 50 == 0:
            print(f"{i} batch, {loss}, {accuracy.result()}")

    print()
```

GradientTape를 이용할 때에는 학습에 사용하는 model을 이용할 때에 "training=True"를 반드시 넣어주어야 한다.

@tf.function

```
model = tf.keras.Model(x, y)

# model.compile을 하지 않음.
loss_fn = tf.keras.losses.SparseCateg
optimizer = tf.keras.optimizers.Adam(
accuracy = tf.keras.metrics.SparseCat

@tf.function
def train_step(batch):
    x_batch, y_batch = batch
    with tf.GradientTape() as tape:
        y_pred = model(x_batch, training=True)
        loss = loss_fn(y_batch, y_pred)
        grads = tape.gradient(loss, model.trainable_weights)
    optimizer.apply_gradients(zip(grads, model.trainable_weights))
    accuracy.update_state(y_batch, y_pred)

    return loss, accuracy.result()
```

```
for e in range(10):
    print(f"{e} epochs")
    accuracy.reset_states()
    for i, batch in enumerate(datasets):
        loss, acc = train_step(batch)

        if i % 50 == 0:
            print(f"{i} batch, {loss}, {acc}")

    print()
```

Custom Model Class의 이용

```
def make_cnn():
    x = tf.keras.Input(shape=[28, 28, 1])
    h = tf.keras.layers.Conv2D(32, 3, 2, activation='swish')(x)
    h = tf.keras.layers.Conv2D(64, 3, 2, activation='swish')(h)
    h = tf.keras.layers.Flatten()(h)
    y = tf.keras.layers.Dense(10, activation="softmax")(h)
    return tf.keras.Model(x, y)
```

```
tf.keras.backend.clear_session()
cnn = make_cnn()
model = Custom(cnn)
model.fit(x_train, y_train, epochs=10, batch_size=128)
```

1. model.fit 함수를 이용할 수 있는 방향으로 class를 구성을 한 실습 예제.
2. class 구성에 따라 model 이용 방법은 달라질 수 있다.
3. Model Class를 자유롭게 사용하기 위해서는 다음의 공부가 더 필요합니다.
    a. python class
    b. Tensorflow Model

Class Custom

학습하는 부분을 직접 컨트롤 하기 위하여 custom model class를 직접 작성한다.

```
class Custom(tf.keras.Model):
    def __init__(self, cnn):
        super(Custom, self).__init__()
        self.cnn = cnn

        self.optimizer = tf.keras.optimizers.Adam()
        self.custom_loss = tf.keras.losses.SparseCategoricalCrossentropy()

        self.compile()

    def train_step(self, batch):
        x_batch, y_batch = batch

        with tf.GradientTape() as tape:
            y_pred = self.cnn(x_batch, training=True)
            loss = self.custom_loss(y_batch, y_pred)
            grads = tape.gradient(loss, self.cnn.trainable_weights)
        self.optimizer.apply_gradients(zip(grads, self.cnn.trainable_weights))

        return {'loss': loss}
```

accuracy metric 추가

```
class Custom(tf.keras.Model):
    def __init__(self, cnn):
        super(Custom, self).__init__()
        self.cnn = cnn

        self.optimizer = tf.keras.optimizers.Adam()
        self.custom_loss = tf.keras.losses.SparseCategoricalCrossentropy()
        self.loss_metric = tf.keras.metrics.Mean()
        self.acc_metric = tf.keras.metrics.SparseCategoricalAccuracy()

        self.compile()

    def update_metrics(self, loss, y_batch, y_pred):
        self.loss_metric.update_state(loss)
        self.acc_metric.update_state(y_batch, y_pred)

    def train_step(self, batch):
        x_batch, y_batch = batch

        with tf.GradientTape() as tape:
            y_pred = self.model(x_batch)
            loss = self.custom_loss(y_batch, y_pred)
            grads = tape.gradient(loss, self.model.trainable_weights)
        self.optimizer.apply_gradients(zip(grads, self.model.trainable_weights))

        self.update_metrics(loss, y_batch, y_pred)
        return {'loss': self.loss_metric.result(), 'acc': self.acc_metric.result()}
```

train step

1. batch 단위 학습 로직
2. grads – batch 입력에 대해서 계산된 미분값
3. apply_gradients – grads 값을 이용하여 Weight를 조정한다.
4. 출력할 log 내용을 dictionary 형태로 return 한다.

```
def train_step(self, batch):
    x_batch, y_batch = batch

    with tf.GradientTape() as tape:
        y_pred = self.model(x_batch)
        loss = self.custom_loss(y_batch, y_pred)
        grads = tape.gradient(loss, self.model.trainable_weights)
    self.optimizer.apply_gradients(zip(grads, self.model.trainable_weights))

    self.update_metrics(loss, y_batch, y_pred)
    return {'loss': self.loss_metric.result(), 'acc': self.acc_metric.result()}
```

$$grads = dloss/dW$$

validation/evaluation 을 위한 코드 추가

```
def test_step(self, batch):
    x_batch, y_batch = batch
    y_pred = self.model(x_batch)
    loss = self.custom_loss(y_batch, y_pred)
    self.update_metrics(loss, y_batch, y_pred)
    return {'loss': self.loss_metric.result(), 'acc': self.acc_metric.result()}
```

test_step 함수가 작성되면 다음의 코드를 이용할 수 있다.

```
tf.keras.backend.clear_session()

cnn = make_cnn()
model = Custom(cnn)
model.fit(x_train, y_train, epochs=10, batch_size=128, validation_split=0.1)
model.evaluate(x_test, y_test)
```

GradientTape

https://www.tensorflow.org/api_docs/python/tf/GradientTape

GradientTape - 미분값을 구하는 도구

$$y = x^2$$

$$dy/dx = 2x$$

```
import tensorflow as tf

x = tf.constant(3.0)
with tf.GradientTape() as g:
    g.watch(x)
    y = x * x
    dy = g.gradient(y, x)  # dy = 2 * x at x = 3
print(dy)
```

이차 도함수 구하기

$$y = x^2$$
$$dy/dx = 2x$$
$$d^2y/dx^2 = 2$$

```
import tensorflow as tf

x = tf.constant(5.0)
with tf.GradientTape() as g:
    g.watch(x)
    with tf.GradientTape() as gg:
        gg.watch(x)
        y = x * x
        dy = gg.gradient(y, x)  # dy = 2 * x at x = 5
        print(dy)
    ddy = g.gradient(dy, x)  # ddy = 2 at x = 5
    print(ddy)
```

이차 도함수 구하기

$$y = x^2$$
$$z = y^2$$
$$dy/dx = 2x$$
$$dz/dy = 2y$$
$$dz/dx = 4x + 3$$

```
x = tf.constant(3.0)
with tf.GradientTape(persistent=True) as g:
    g.watch(x)
    y = x * x
    z = y * y

dy_dx = g.gradient(y, x) # dy_dx = 2 * x at x = 3
print(dy_dx)

dz_dy = g.gradient(z, y) # dy_dy = 2 * y at y = 9
print(dz_dy)

dz_dx = g.gradient(z, x)  # dz_dx = 4 * x ^ 3 at x = 3
print(dz_dx)
```

Callback.on_epoch_end

https://www.tensorflow.org/api_docs/python/tf/keras/callbacks/Callback#on_epoch_end

on_epoch_end

epochs 단위 학습이 끝날 때 실행

```
import matplotlib.pyplot as plt
import numpy as np

class Monitor(tf.keras.callbacks.Callback):
    def on_epoch_end(self, epoch, logs=None):
        sample = np.random.randint(1, 10000, 5)
        y_pred = self.model.cnn.predict(x_test[sample])

        for i, rnd in enumerate(sample):
            plt.subplot(1, 5, 1 + i)
            plt.axis('off')
            plt.title(f"{rnd}:{np.argmax(y_pred[i])}")
            plt.imshow(x_test[rnd].reshape(28, 28), cmap='gray_r')
        plt.show()
```

```
tf.keras.backend.clear_session()

cnn = make_cnn()
model = Custom(cnn)
model.fit(x_train, y_train, epochs=10, batch_size=128, callbacks=[Monitor()])
```

numpy.random.randint [link]

```
random.randint(low, high=None, size=None, dtype=int)
```

size 개수 만큼의 low(포함)에서 high(제외) 까지 임의의 정수를 반환합니다.

```
def on_epoch_end(self, epoch, logs=None):
    sample = np.random.randint(1, 10000, 5)
    y_pred = self.model.model.predict(x_test[sample])

    for i, rnd in enumerate(sample):
        plt.subplot(1, 5, 1 + i)
        plt.axis('off')
        plt.title(f"{rnd}:{np.argmax(y_pred[i])}")
        plt.imshow(x_test[rnd].reshape(28, 28), cmap='gray_r')
    plt.show()
```

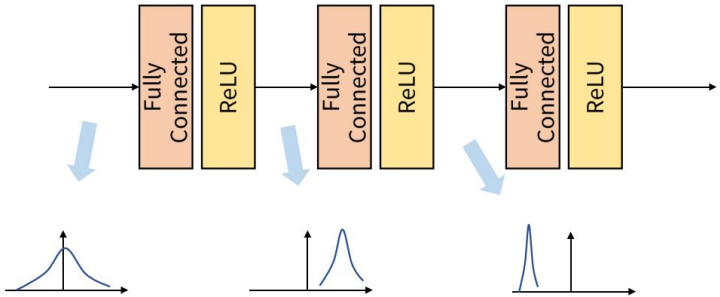
BatchNormalization

https://www.tensorflow.org/api_docs/python/tf/keras/layers/BatchNormalization

Batch Normalization

- Layer 사이에 중간 결과 데이터들을 batch 단위로 표준정규화하는 계층
  - 학습 단계에서는 batch 단위로 정규화하고
  - 모델 적용시의 σ, μ는 사용하던 값들의 이동평균값을 이용한다.
- 모델의 학습을 속도를 획기적으로 빠르게 한다.
- parameter에 대한 민감도가 낮아진다.
- 일반적으로 activation 전에 normalization을 한다.

$$BN(\mathbf{x}_i) = \gamma \odot \left(\frac{\mathbf{x}_i - \mu_B}{\sigma_B}\right) + \beta,$$



https://arxiv.org/pdf/1805.11604.pdf

Batch Normalization

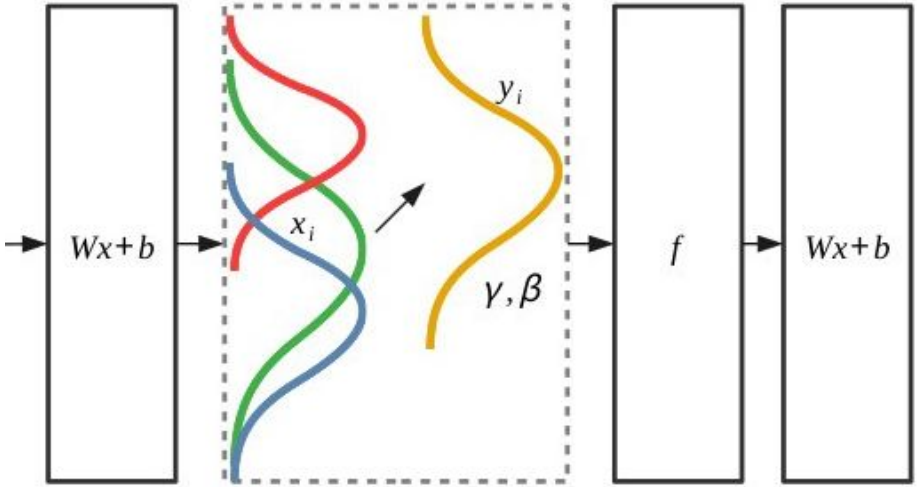
Input: Values of x over a mini-batch: $\mathcal{B} = \{x_{1...m}\}$;
Parameters to be learned: γ, β
Output: $\{y_i = \mathrm{BN}_{\gamma,\beta}(x_i)\}$

$$\mu_{\mathcal{B}} \leftarrow \frac{1}{m}\sum_{i=1}^{m} x_i \qquad \text{// mini-batch mean}$$

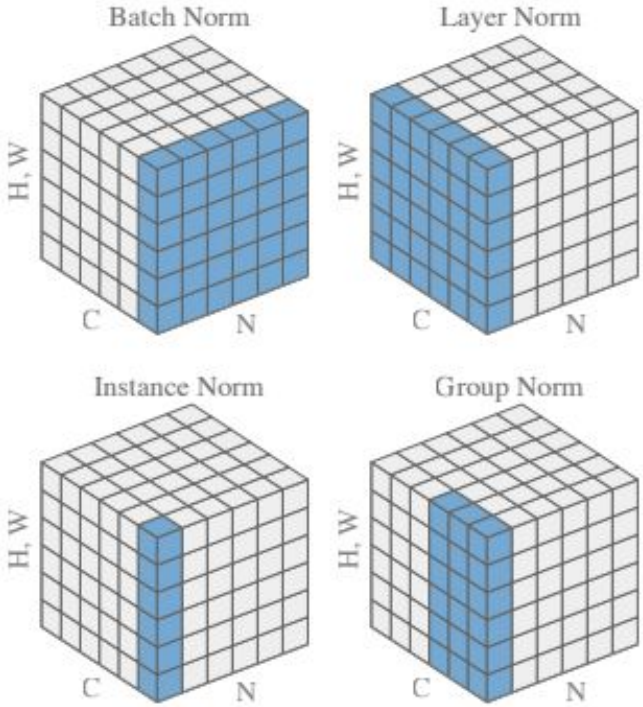
$$\sigma^2_{\mathcal{B}} \leftarrow \frac{1}{m}\sum_{i=1}^{m}(x_i - \mu_{\mathcal{B}})^2 \qquad \text{// mini-batch variance}$$

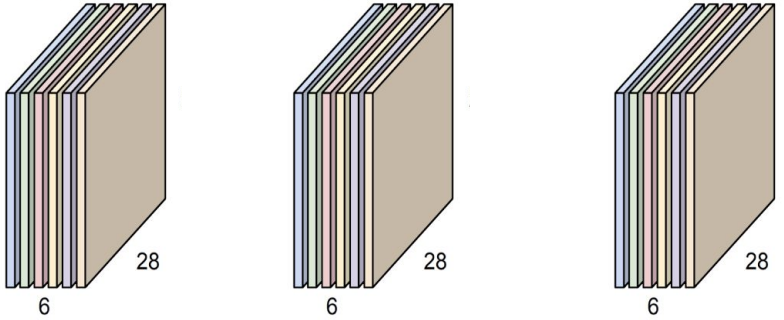
$$\widehat{x}_i \leftarrow \frac{x_i - \mu_{\mathcal{B}}}{\sqrt{\sigma^2_{\mathcal{B}} + \epsilon}} \qquad \text{// normalize}$$

$$y_i \leftarrow \gamma \widehat{x}_i + \beta \equiv \mathrm{BN}_{\gamma,\beta}(x_i) \qquad \text{// scale and shift}$$



그 외의 Normalization들





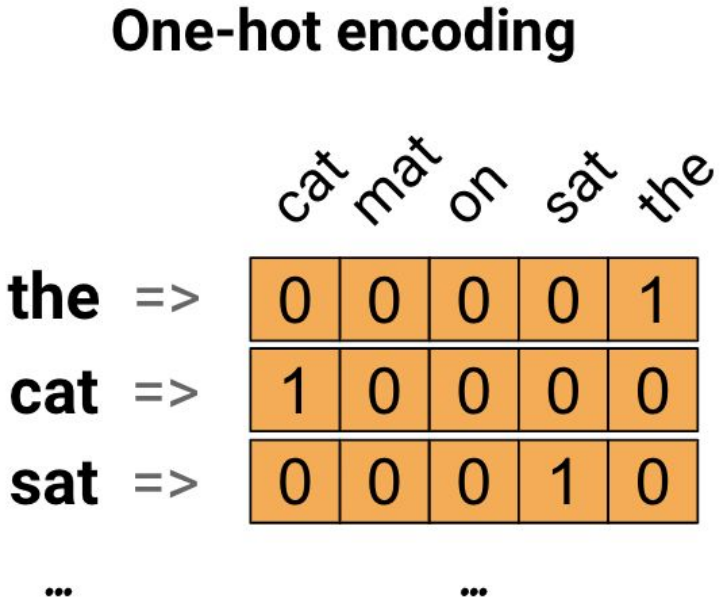
(batch: 3, channel: 6, width, height: 28, 28)

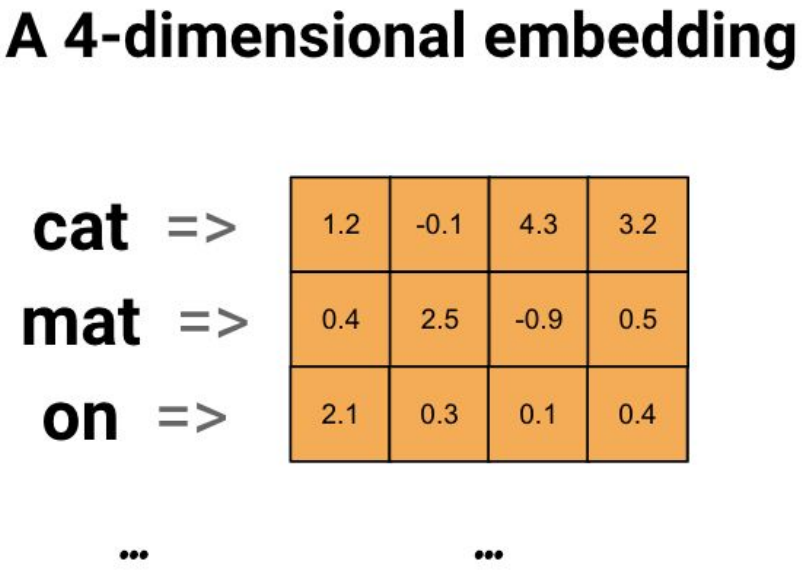
- batchNorm: batch 내의 같은 색 channel을 모아서 Norm
- LayerNorm: 각 batch 별로 channel을 모아서 Norm
- InstanceNorm: batch 내의 channel 별로 Norm
- groupNorm: 각 batch 별로 channel을 그룹지어서 Norm

Embedding

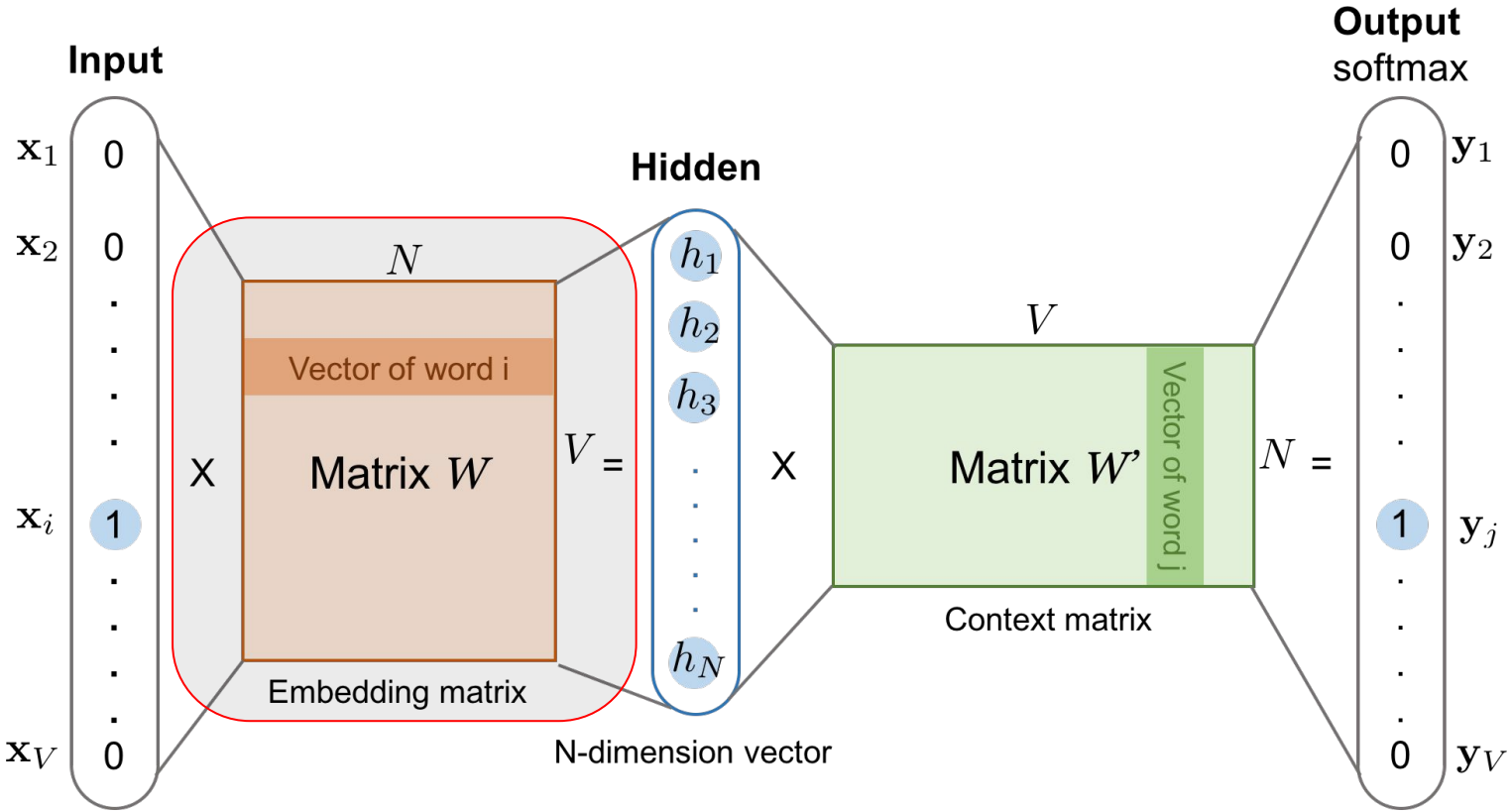
https://www.tensorflow.org/text/guide/word_embeddings

One-hot encoding VS Embedding

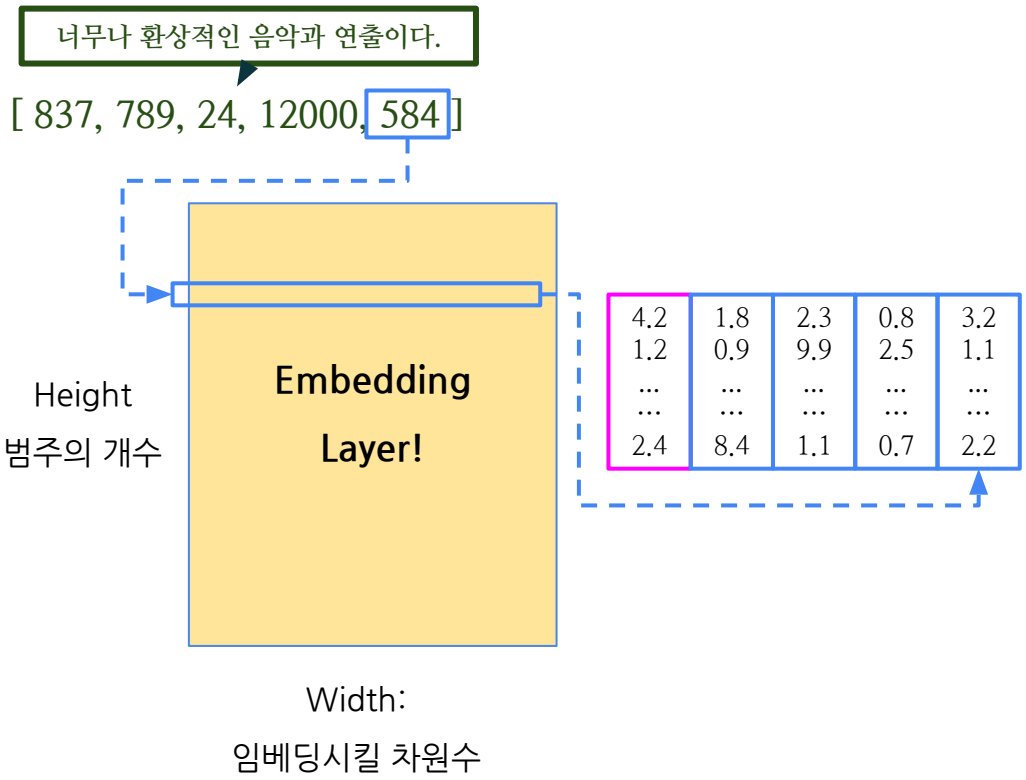




Embedding layer



Embedding layer



	living being	feline	human	gender	royalty	verb	plural
cat →	0.6	0.9	0.1	0.4	−0.7	−0.3	−0.2
kitten →	0.5	0.8	−0.1	0.2	−0.6	−0.5	−0.1
dog →	0.7	−0.1	0.4	0.3	−0.4	−0.1	−0.3
houses →	−0.8	−0.4	−0.5	0.1	−0.9	0.3	0.8
man →	0.6	−0.2	0.8	0.9	−0.1	−0.9	−0.7
woman →	0.7	0.3	0.9	−0.7	0.1	−0.5	−0.4
king →	0.5	−0.4	0.7	0.8	0.9	−0.7	−0.6
queen →	0.8	−0.1	0.8	−0.9	0.8	−0.5	−0.9

Embedding Example – IMDB

```
import tensorflow as tf

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.imdb.load_data(num_words=10000)
print(x_train.shape, x_test.shape)

x_train = tf.keras.preprocessing.sequence.pad_sequences(x_train, maxlen=32)
x_test = tf.keras.preprocessing.sequence.pad_sequences(x_test, maxlen=32)

print(x_train.shape, x_test.shape)
```

- x_train: imdb 영화 댓글
- y_train: 호감, 비호감 평가
- 각 문장의 길이가 다르기 때문에 최대 길이 32 단어로 자름

Embedding Example – IMDB

```
word_index = tf.keras.datasets.imdb.get_word_index()
inverted_word_index = dict((i, word) for (word, i) in word_index.items())
list(inverted_word_index.items())[:10]
```

```
[(34701, 'fawn'),
 (52006, 'tsukino'),
 (52007, 'nunnery'),
 (16816, 'sonja'),
 (63951, 'vani'),
 (1408, 'woods'),
 (16115, 'spiders'),
 (2345, 'hanging'),
 (2289, 'woody'),
 (52008, 'trawling')]
```

```
print(" ".join([inverted_word_index[w] for w in x_train[0]]))
```

- x_train는 단어를 word index로 변환해 놓은 데이터
- 다시 영어 문장으로 바꾸어서 출력하는 코드

Embedding Example – IMDB

```
X = tf.keras.Input(shape=[32])
H = tf.keras.layers.Embedding(10000, 20)(X)
H = tf.keras.layers.SimpleRNN(32)(H)
Y = tf.keras.layers.Dense(1, activation="sigmoid")(H)

model = tf.keras.Model(X, Y)
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
model.summary()
```

```
history = model.fit(x_train, y_train, epochs=10, batch_size=32)
```

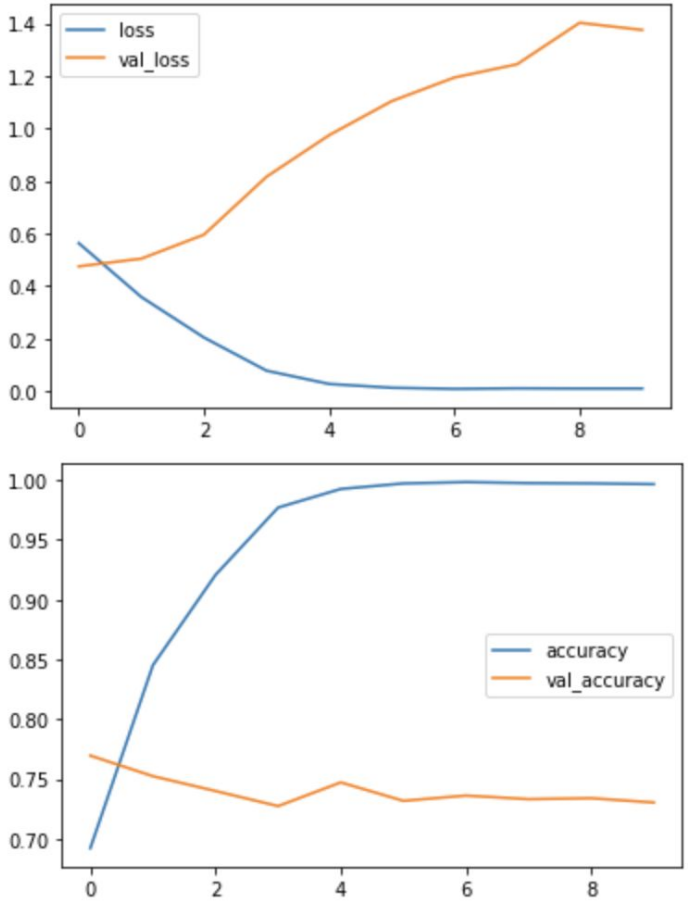
- Embedding layer를 이용하여 20개의 feature로 embedding
- RNN을 사용

Embedding Example – IMDB

```
import matplotlib.pyplot as plt

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.legend(['loss', 'val_loss'])
plt.show()

plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.legend(['accuracy', 'val_accuracy'])
plt.show()
```



Model Save & Load

방법 1.
가중치와 모델을 한꺼번에
저장했다가 꺼내는 방법

```
model.save('model.h5', include_optimizer=True)
```

```
model = tf.keras.models.load_model('my_model.h5')
```

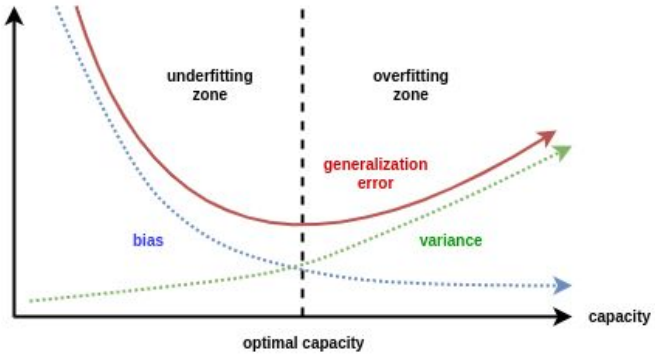
방법 2.
가중치와 모델을 따로
저장했다가 꺼내는 방법

```
model.save_weights('model_weights.h5')
with open('model.json', 'w') as f:
    f.write(model.to_json())
```

```
with open('model.json', 'r') as f:
    model = tf.keras.models.model_from_json(f.read())
model.load_weights('model_weights.h5')
```

Early Stopping

- overfitting이 발생하면 멈추고 멈추기 전 최적의 모델을 적용한다.




```python
es = tf.keras.callbacks.EarlyStopping(
    monitor = 'val_loss',
    min_delta = 0, # 개선되고 있다고 판단하기 위한 최소 변화량
    patience = 10, # 개선 없는 epoch 얼마나 기달려 줄거야?
    verbose = 1
)

# 학습
result = model.fit(
    x_train, y_train,
    epochs=20000, batch_size=128, validation_split=0.2,
    callbacks=[es]
)

model.evaluate(x_test, y_test)
```