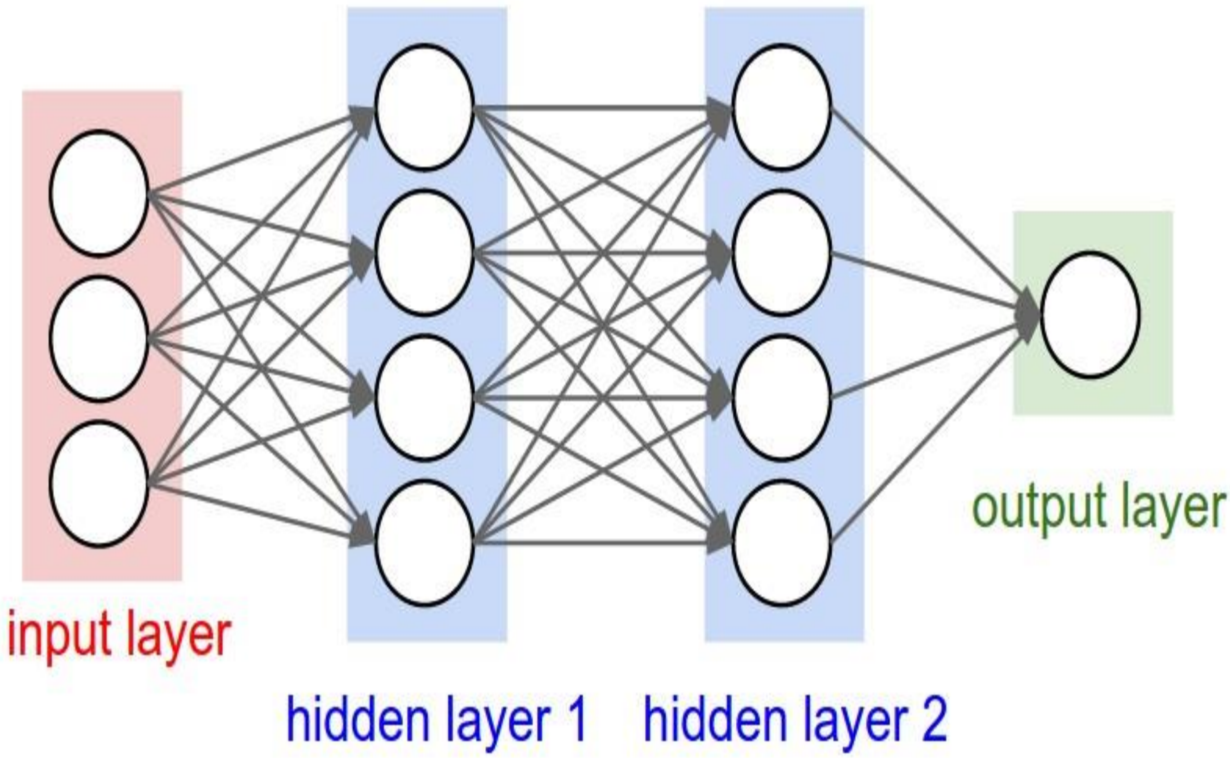
Neural Network Example

Build a 2-hidden layers fully connected neural network (a.k.a multilayer perceptron) with TensorFlow v2.

Neural Network Overview



MNIST Dataset Overview¶

This example is using MNIST handwritten digits. The dataset contains 60,000 examples for training and 10,000 examples for testing. The digits have been size-normalized and centered in a fixed-size image (28x28 pixels) with values from 0 to 255.

In [1]:

```
from __future__ import absolute_import, division, print_function

import tensorflow as tf
from tensorflow.keras import Model, layers
import numpy as np
```

In [2]:
```
# MNIST dataset parameters.
num_classes = 10 # total classes (0-9 digits).
num_features = 784 # data features (img shape: 28*28).

# Training parameters.
learning_rate = 0.1
training_steps = 75
batch_size = 256
display_step = 100

# Network parameters.
n_hidden_1 = 16 # 1st layer number of neurons.
n_hidden_2 = 32 # 2nd layer number of neurons.
```

In [3]:
```
# Prepare MNIST data.
from tensorflow.keras.datasets import mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
# Convert to float32.
x_train, x_test = np.array(x_train, np.float32), np.array(x_test, np.float3
2)
# Flatten images to 1-D vector of 784 features (28*28).
x_train, x_test = x_train.reshape([-1, num_features]), x_test.reshape([-1,
num_features])
# Normalize images value from [0, 255] to [0, 1].
x_train, x_test = x_train / 255., x_test / 255.
```

In [4]:
```
# Use tf.data API to shuffle and batch data.
train_data = tf.data.Dataset.from_tensor_slices((x_train, y_train))
train_data = train_data.repeat().shuffle(5000).batch(batch_size).prefetch(1
)
```

In [5]:
```
# Create TF Model.
class NeuralNet(Model):
    # Set layers.
    def __init__(self):
        super(NeuralNet, self).__init__()
        # First fully-connected hidden layer.
        self.fc1 = layers.Dense(n_hidden_1, activation=tf.nn.relu)
        # First fully-connected hidden layer.
        self.fc2 = layers.Dense(n_hidden_2, activation=tf.nn.relu)
        # Second fully-connecter hidden layer.
```

```
        self.out = layers.Dense(num_classes)

    # Set forward pass.
    def call(self, x, is_training=False):
        x = self.fc1(x)
        x = self.fc2(x)
        x = self.out(x)
        if not is_training:
            # tf cross entropy expect logits without softmax, so only
            # apply softmax when not training.
            x = tf.nn.softmax(x)
        return x

# Build neural network model.
neural_net = NeuralNet()
```

In [6]:

```
# Cross-Entropy Loss.
# Note that this will apply 'softmax' to the logits.
def cross_entropy_loss(x, y):
    # Convert labels to int 64 for tf cross-entropy function.
    y = tf.cast(y, tf.int64)
    # Apply softmax to logits and compute cross-entropy.
    loss = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y, logits=
x)
    # Average loss across the batch.
    return tf.reduce_mean(loss)

# Accuracy metric.
def accuracy(y_pred, y_true):
    # Predicted class is the index of highest score in prediction vector (i
.e. argmax).
    correct_prediction = tf.equal(tf.argmax(y_pred, 1), tf.cast(y_true, tf.
int64))
    return tf.reduce_mean(tf.cast(correct_prediction, tf.float32), axis=-1)

# Stochastic gradient descent optimizer.
optimizer = tf.optimizers.SGD(learning_rate)
```

In [7]:

```
# Optimization process.
def run_optimization(x, y):
    # Wrap computation inside a GradientTape for automatic differentiation.
    with tf.GradientTape() as g:
        # Forward pass.
        pred = neural_net(x, is_training=True)
```

```
        # Compute loss.
        loss = cross_entropy_loss(pred, y)

    # Variables to update, i.e. trainable variables.
    trainable_variables = neural_net.trainable_variables

    # Compute gradients.
    gradients = g.gradient(loss, trainable_variables)

    # Update W and b following gradients.
    optimizer.apply_gradients(zip(gradients, trainable_variables))
```

In [8]:

```
# Run training for the given number of steps.
for step, (batch_x, batch_y) in enumerate(train_data.take(training_steps),
1):
    # Run the optimization to update W and b values.
    run_optimization(batch_x, batch_y)

    if step % display_step == 0:
        pred = neural_net(batch_x, is_training=True)
        loss = cross_entropy_loss(pred, batch_y)
        acc = accuracy(pred, batch_y)
        print("step: %i, loss: %f, accuracy: %f" % (step, loss, acc))
```

In [9]:

```
# Test model on validation set.
pred = neural_net(x_test, is_training=False)
print("Test Accuracy: %f" % accuracy(pred, y_test))
```

In [10]:

```
# Visualize predictions.
import matplotlib.pyplot as plt
```

In [11]:

```
# Predict 12 images from validation set.
n_images = 12
test_images = x_test[:n_images]
predictions = neural_net(test_images)

# Display image and model prediction.
for i in range(n_images):
    plt.imshow(np.reshape(test_images[i], [28, 28]), cmap='gray')
    plt.show()
```

```
print("Model prediction: %i" % np.argmax(predictions.numpy()[i]))
```