In [243]:
```
import numpy as np
data = np.load('mnist.npz')
import matplotlib.pyplot as plt
import pandas as pd
import gzip
import os
import sys
import struct
%matplotlib inline
```

In [244]:
```
def relu(x):
    return (x > 0) * x

def softmax(x, axis=1):
    e_x = np.exp(x - np.max(x, axis=axis, keepdims=True))
    return e_x / e_x.sum(axis=axis, keepdims=True)

def onehot(y, n_classes):
    o = np.zeros(shape=(y.shape[0], n_classes))
    for i in range(y.shape[0]):
        o[i, int(y[i])] = 1
    return o
```

Data Preparation

reading data and preparing the test, train and validation sets

In [245]:
```
def read_image(fi):
    magic, n, rows, columns = struct.unpack(">IIII", fi.read(16))
    assert magic == 0x00000803
    assert rows == 28
    assert columns == 28
    rawbuffer = fi.read()
    assert len(rawbuffer) == n * rows * columns
    rawdata = np.frombuffer(rawbuffer, dtype='>u1', count=n*rows*columns)
    return rawdata.reshape(n, rows, columns).astype(np.float32) / 255.0

def read_label(fi):
    magic, n = struct.unpack(">II", fi.read(8))
    assert magic == 0x00000801
    rawbuffer = fi.read()
    assert len(rawbuffer) == n
    return np.frombuffer(rawbuffer, dtype='>u1', count=n)


os.system('wget -N http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz')
os.system('wget -N http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz')
os.system('wget -N http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz')
os.system('wget -N http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz')

train_x=read_image(gzip.open('train-images-idx3-ubyte.gz', 'rb')),
train_y=read_label(gzip.open('train-labels-idx1-ubyte.gz', 'rb')),
test_x=read_image(gzip.open('t10k-images-idx3-ubyte.gz', 'rb')),
test_y=read_label(gzip.open('t10k-labels-idx1-ubyte.gz', 'rb'))
```

In [246]:
```
data = np.load('mnist.npz')
X_train = data['train_x'][:55000].reshape(55000, 784)
y_train = data["train_y"][:55000]
X_valid = data['train_x'][55000:].reshape(5000, 784)
y_valid = data["train_y"][55000:]

X_test = data['test_x'].reshape(10000, 784)
y_test = data['test_y']

y_train_onehot = onehot(y_train, 10)
y_valid_onehot = onehot(y_valid, 10)
y_test_onehot = onehot(y_test, 10)
```

In [255]:
```
class MLP:


    def __init__(self, init_method, input_size = 784, hidden_size = 512, output_s
                 hidden_dims=(512,512), n_hidden=2, mode='train', datapath=None,

        self.W1 = np.random.normal(0, 1, (hidden_dims[0], input_size))
        self.b1 = np.zeros(hidden_size)
        self.W2 = np.random.normal(0, 1, (hidden_dims[0], hidden_dims[1]))
        self.b2 = np.zeros(hidden_size)
        self.W3 = np.random.normal(0, 1, (output_size, hidden_dims[1]))
        self.b3 = np.zeros(output_size)

        self.parameters = [self.b1, self.W1, self.b2, self.W2, self.b3, self.W3]


    def forward(self, x):
        y_1 = np.dot(x, self.W1.T) + self.b1
        r_1 = relu(y_1)
        y_2 = np.dot(r_1, self.W2.T) + self.b2
        r_2 = relu(y_2)
        y_3 = np.dot(r_2, self.W3.T) + self.b3
        os = softmax(y_3, axis=1)
        return y_1, r_1,  y_2, r_2,  y_3, os

    def backward(self, y, x, y_1, r_1,  y_2, r_2,  y_3,  os, weight_decay=0):
        bs = x.shape[0]
        d_y_3 = os - y
        d_r_2 = np.dot(d_y_3, self.W3)
        d_y_2 = (y_2 > 0) * d_r_2
        d_r_1 = np.dot(d_y_2, self.W2)
        d_y_1 = (y_1 > 0) * d_r_1

        d_W3 = np.dot(d_y_3.T, r_2) / bs + weight_decay * self.W3
        d_b3 = d_y_3.mean(axis=0)
        d_W2 = np.dot(d_y_2.T, r_1) / bs + weight_decay * self.W2
        d_b2 = d_y_2.mean(axis=0)
        d_W1 = np.dot(d_y_1.T , x) / bs + weight_decay * self.W1
        d_b1 = d_y_1.mean(axis=0)
        return d_b1, d_W1, d_b2, d_W2, d_b3, d_W3


    def loss(self, os, y):
        return (y * (-np.log(os))).sum(axis=1).mean(axis=0)

    def train(self, data, target, mb_size=100, learning_rate=1e-1, weight_decay=(
        for i in range(data.shape[0] // mb_size):
            xi = data[i*mb_size:(i+1)*mb_size]
            yi = target[i*mb_size:(i+1)*mb_size]
            y_1, r_1,  y_2, r_2,  y_3, os = self.forward(xi)
            average_grads = self.backward(yi, xi,  y_1, r_1,  y_2, r_2,  y_3, os
            average_loss = self.loss(os, yi)
            for p, grad in zip(self.parameters, average_grads):
                p -= learning_rate * grad
        return average_loss
```

```
    def mat_predict(self, x):
        _, _, _, _, _, os = self.forward(x)
        return os.argmax(axis=1)

    def test(self, x, y):
        _, _, _, _, _, os = self.forward(x)
        return self.loss(os, y), os.argmax(axis=1)
```

In [251]:

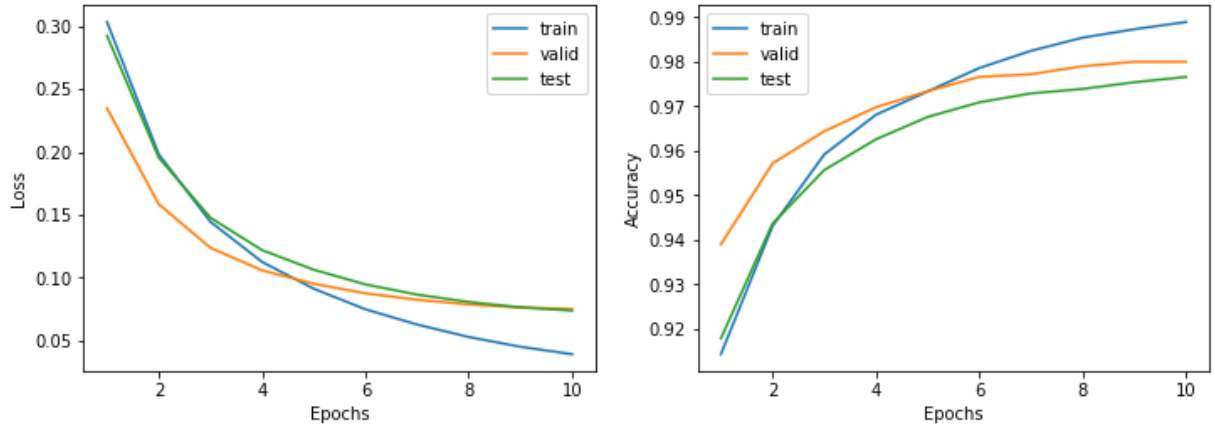
```
def run(init_method, num_epoche = 10):
    mlp = MLP(init_method = init_method)
    train_accuracies, train_losses = [], []
    valid_accuracies, valid_losses = [], []
    test_accuracies, test_losses = [], []

    for e in range(num_epoche):
        loss = mlp.train(X_train, y_train_onehot, mb_size=100, learning_rate=1e-1

        loss_train, pred_train = mlp.test(X_train, y_train_onehot)
        loss_valid, pred_valid = mlp.test(X_valid, y_valid_onehot)
        loss_test, pred_test = mlp.test(X_test, y_test_onehot)
        valid_losses.append(loss_valid)
        test_losses.append(loss_test)
        valid_accuracies.append((pred_valid == y_valid).mean())
        test_accuracies.append((pred_test == y_test).mean())
        train_losses.append(loss_train)
        train_accuracies.append((pred_train == y_train).mean())

    ### Plotting the loss and accuracy
    plt.figure(figsize=(12, 4))
    axis = plt.subplot(1, 2, 1)
    axis.plot(range(1, len(train_losses)+1), train_losses, label='train')
    axis.plot(range(1, len(valid_losses)+1), valid_losses, label='valid')
    axis.plot(range(1, len(test_losses)+1), test_losses, label='test')
    axis.legend()
    axis.set_ylabel('Loss')
    axis.set_xlabel('Epochs')
    axis = plt.subplot(1, 2, 2)
    axis.plot(range(1, len(train_accuracies)+1), train_accuracies, label='train'
    axis.plot(range(1, len(valid_accuracies)+1), valid_accuracies, label='valid'
    axis.plot(range(1, len(test_accuracies)+1), test_accuracies, label='test')
    axis.legend()
    axis.set_ylabel('Accuracy')
    axis.set_xlabel('Epochs')
```

In [252]:
```
run(init_method = "uniform")
```



In [ ]:
```

```