**CECS 551**
**Assignment 5**
**Total: 40 Points**

General Instruction

- Submit uncompressed file(s) in the Dropbox folder via BeachBoard (Not email).

1. Design neural networks to classify hand written numbers using `keras` library, however, **do not** include convolutional layers.
   (a) Design neural networks and implement them.
      - Find `Assignment_5_mnist.ipynb` and `mnist.zip`.
      - `train_X` and `test_X` are list of intensities in 8-bit gray scale of 28 × 28 images.
      - `train_y` and `test_y` are list of integers which are the classes of the corresponding images.
      - The objective of the networks is classifying images into 0 to 9.

   (b) Split the training dataset into sub_training and validation sets randomly. Use $\frac{1}{6}$ of training dataset as validation set. Use the 'accuracy' as metric. Please repeat 10 times of random split for each hyper-parameters and architecture, and aggregate (average) the accuracy.

   (c) (20 points) Optimizer evaluation
      - Implement a neural network which has single hidden layer with 32 units. Using the network, find best hyper-parameters of the following optimizers; SGD, RMSprop, Adam, Adagrad.
      - You have 10 different sub_training and validation sets.
      - Tune hyper-parameters of SGD, RMSprop, Adam, and Adagrad with those sets.
      - Choose the best hyper-parameters by averaging the accuracy.
      - With the best hyper-parameters of each optimizer, train the network with the training dataset (not sub training).
      - For each optimizer, report **test accuracy** using the test dataset.

   (d) (20 points) Architecture evaluation
      - Pick the best optimizer and it's hyper-parameters from the previous part.
      - Using sub_training and validation datasets, find the best architecture in terms of the number of layers, the number of units, and activation functions.
      - Report 3 best architectures in terms of **test accuracy**. Please include architecture diagram as shown in Figure 1.

   (e) Submit `ipynb` files which include your source codes and `pdf` file which includes your report.

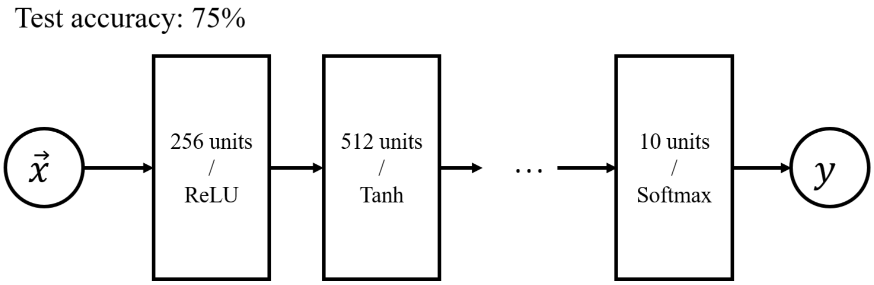

Figure 1: A network architecture example