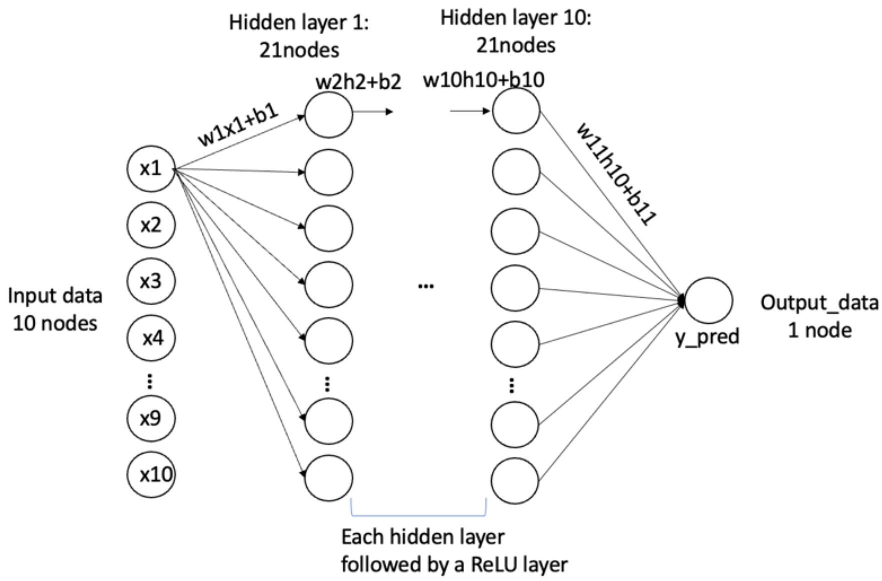
Question #1

1. Implement this neural network in pytorch
   Overview of the neural network



2. Generate the input data (x1,x2,..xd) \in [0,1] drawn from a uniform random distribution.
   Using uniform distribution to generate random value with interval [0,1].

```
runif = torch.distributions.Uniform(0,1) #[0,1]
x=runif.sample((batch_size,input_data))
```

3. Generate the labels y = (x1*x1+x2*x2+…+xd*xd)/d

```
y = x.pow(2).sum()/2
```

4. Implement a loss function L = (predict-y)^2

```
#Loss Function
loss = (y_auto_pred-y).pow(2).sum()
```

```
batch_size = 1
```

```
x=runif.sample((batch_size,input_data))
```

5. Use batch size of 1, that means feed data one point at a time into network and compute the loss. Do one-time forward propagation with one data point.

6. Compute the gradients using pytorch autograd:
   a. dL/dw, dL/db
   b. Print these values into a text file: torch_autograd.dat
7. Implement the forward propagation and backpropagation algorithm from scratch, without using pytorch autograd, compute the gradients using your implementation.

a. dL/dw, dL/db

b. Print these values into a text file: my_autograd.dat

Backpropagation algorithm:

loss = (y_pred-y)**2/2

grad_y_pred = loss’ = 2*(y_pred - y)

y_pred = relu(h10 * w11 + b11)

b11’ = relu’(x) * x’ = 1*1* grad_y_pred = grad_b11

w11’ = 1*1*h10* grad_y_pred

w11’= h10.T* grad_b11 = grad_w11

y_pred = relu(relu(h9*w10 + b10) * w11 + b11)

b10’ = w11.T* grad_b11

w10’ = grad_w11 * h9.T

```python
#Back-propagation
grad_y_pred = 2*(y_pred - y)
w_grad = [0]*11
b_grad = [0]*11

for i in range(11):
    if i == 0:
        b_grad[10 - i] = grad_y_pred
        w_grad[10 - i] = (b_grad[10-i] * h_list[9-i].T )
    elif i == 10:
        b_grad[10 - i] = torch.mm(b_grad[11-i],w_list[11 - i].T)
        b_grad[10 - i][h_list[10 - i]<=0] = 0
        w_grad[10 - i] = torch.mm(x.T,b_grad[10-i])
    else:
        b_grad[10 - i] = torch.mm(b_grad[11-i],w_list[11 - i].T)
        b_grad[10 - i][h_list[10 - i]<=0] = 0
        w_grad[10 - i] = torch.mm(h_list[9-i].T,b_grad[10-i])
```

8. Compare the two files torch_autograd.dat and my_autograd.dat and show that they give the same values up to 5 significant numbers

I exported w and b in different files, so I got four files.

My_grad_w vs. torch_grad_w

my_grad_w.txt

```
tensor([[-5.53375e+08,  0.00000e+00,  7.07888e+08,  1.68588e+08, -4.91744e+08,
          0.00000e+00,  0.00000e+00,  0.00000e+00,  4.88407e+08,  3.73732e+05,
          1.09556e+09,  0.00000e+00,  0.00000e+00, -1.30155e+08,  1.18425e+09,
          0.00000e+00, -2.17313e+08, -3.46116e+08,  0.00000e+00,  0.00000e+00,
          6.44276e+06],
```

torch_grad_w.txt

```
tensor([[-5.53375e+08,  0.00000e+00,  7.07888e+08,  1.68588e+08, -4.91744e+08,
          0.00000e+00,  0.00000e+00,  0.00000e+00,  4.88407e+08,  3.73732e+05,
          1.09556e+09,  0.00000e+00,  0.00000e+00, -1.30155e+08,  1.18425e+09,
          0.00000e+00, -2.17313e+08, -3.46116e+08,  0.00000e+00,  0.00000e+00,
          6.44276e+06],
```

y_grad_b vs. torch_grad_b

torch_grad_b.txt

```
tensor([[-9.28489e+08,  0.00000e+00,  1.18774e+09,  2.82868e+08, -8.25080e+08,
          0.00000e+00,  0.00000e+00,  0.00000e+00,  8.19480e+08,  6.27072e+05,
          1.83820e+09,  0.00000e+00,  0.00000e+00, -2.18382e+08,  1.98701e+09,
          0.00000e+00, -3.64622e+08, -5.80736e+08,  0.00000e+00,  0.00000e+00,
          1.08101e+07]])
```

my_grad_b.txt

```
tensor([-9.28489e+08,  0.00000e+00,  1.18774e+09,  2.82868e+08, -8.25080e+08,
         0.00000e+00,  0.00000e+00,  0.00000e+00,  8.19480e+08,  6.27072e+05,
         1.83820e+09,  0.00000e+00,  0.00000e+00, -2.18382e+08,  1.98701e+09,
         0.00000e+00, -3.64622e+08, -5.80736e+08,  0.00000e+00,  0.00000e+00,
         1.08101e+07])
```

These files show the result of my grad and torch grad are all same. It means that the implementation of my algorithm is correct.

9. Use K=10,d=10

Question #2

Run the following code, generate the computational graph, label and explain **all** nodes (all nodes mean not just the leave nodes, all intermediate nodes should be explained):

This graph shows a tree that implementing pytorch operation. It builds during **forward propagation** and showing which operations will be called on **backward.** It didn't mention the subgraph which **do not require gradient.**

Blue boxes:
These correspond to the tensors we use as parameters, the ones we want use PyTorch to compute gradients.
Gray boxes:
A Python operation that involves a gradient-computing tensor or its dependencies.
Green box:
It is the starting point for the computation of gradients (assuming the backward () method is called from the variable used to visualize the graph) — they are computed from the **bottom-up** in a graph. (https://towardsdatascience.com/understanding-pytorch-with-an-example-a-step-by-step-tutorial-81fc5f8c4e8e)

The attached pdf shows the label of all nodes.