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Date: 1 November 2020

CSCE 636: Deep Learning (Fall 2020)

Assignment #3

Report

1. What is the singular value decomposition of the given matrix?

Ans (1)

$$A = \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ u_{21} & u_{22} & u_{23} \\ u_{31} & u_{32} & u_{33} \end{bmatrix} \begin{bmatrix} 3 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} u_{11} & u_{21} & u_{31} \\ u_{12} & u_{22} & u_{32} \\ u_{13} & u_{23} & u_{33} \end{bmatrix}$$

$$\therefore A = U \lambda U^T$$

For SVD,

$$A = U \Sigma V^T$$

Where,
the values of Σ should be positive and diagonal elements be in decreasing order.

To get values of Σ, we change the values of U and V^T.

$$A = \begin{bmatrix} u_{11} & u_{13} & u_{12} \\ u_{21} & u_{23} & u_{22} \\ u_{31} & u_{33} & u_{32} \end{bmatrix} \begin{bmatrix} 3 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{11} & u_{21} & u_{31} \\ u_{13} & u_{23} & u_{33} \\ u_{12} & u_{22} & u_{32} \end{bmatrix}$$

(above, the columns of U are flipped: second & third)

Final SVD of A:

$$A = \begin{bmatrix} u_{11} & -u_{13} & u_{12} \\ u_{21} & -u_{23} & u_{22} \\ u_{31} & -u_{31} & u_{32} \end{bmatrix} \begin{bmatrix} 3 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{11} & u_{21} & u_{31} \\ u_{13} & u_{23} & u_{33} \\ u_{12} & u_{22} & u_{32} \end{bmatrix}$$

2. Solve using the primal equation given the kernel data.

Given : $K_1 \in \mathbb{R}^{n \times n}$ training kernel
$K_2 \in \mathbb{R}^{n \times m}$ testing kernel

Let $A \in \mathbb{R}^{n \times k}$ be the traing data
and $B \in \mathbb{R}^{m \times k}$ be the testing data.

For some number of features 'k',

$$K_1 = A \cdot A^T \quad \text{---(1)}$$

Let $K_1 = U \Sigma U^T$ be its compact SVD

$\Rightarrow \Sigma$ has all positive values in the diagonal.

$$\Rightarrow K_1 = U \Sigma^{1/2} (U \Sigma^{1/2})^T \quad \text{---(2)}$$

$$\Rightarrow \boxed{A = U \Sigma^{1/2}}$$

Thus, we can compute training data by using U and Σ which can be obtained by SVD of A.
We shall use this A with the labels for training using the primal solver.

for testing data,.

$$K_2 = A \cdot B^T$$

$$\Rightarrow K_2 = U \Sigma^{1/2} \cdot B^T$$

$$\Rightarrow U^T K_2 = U^T U \cdot \Sigma^{1/2} \cdot B^T$$

$$(U^T U = I)$$

$$\Rightarrow U^T K_2 = \Sigma^{1/2} \cdot B^T$$

$$\Rightarrow B^T = \left(\Sigma^{1/2}\right)^{-1} \cdot U^T K_2$$

$$\Rightarrow \boxed{B = \left[\left(\Sigma^{1/2}\right)^{-1} \cdot U^T K_2\right]^T}$$

Thus, we can compute the testing data using U and Σ as well, obtained by performing SVD on A.

⇒ We will use this to get the predictions.

3. Proof of Ky Fan Theorem

Applying SVD on H,

$$H = V \Sigma U^T$$

Since H is symmetric matrix, $V = U$.

$$\Rightarrow H = U \Sigma U^T$$

$$\Rightarrow \max_{A \in R^{n \times k} : A^T A = I} \text{trace}(A^T H A)$$

$$= \max_{A \in R^{n \times k} : A^T A = I} \text{trace}(A^T U \Sigma U^T A)$$

$$= \max_{A \in R^{n \times k} : A^T A = I} \text{trace}((U^T A)^T \Sigma U^T A)$$

Let $B = U^T A$, $(B \in R^{n \times k} : B^T B = I)$

~~We know that~~

$$\Rightarrow \max_{A \in R^{n \times k}, A^T A = I} \text{trace}((U^T A)^T \Sigma U^T A)$$

$$= \max_{B \in R^{n \times k} : B^T B = I} \text{trace}(B^T \Sigma B)$$

Since $\text{trace}(AB) = \text{trace}(BA)$

($\because$ associative rule),

$$= \max_{B \in R^{n \times k} : B^T B = I} \text{trace}(\Sigma B (B)^T)$$

Apply trace, take diagonal elements:

$$= \max \left(\sum_{i=1}^{n} \lambda_i b_i^T b_i \right)$$

Substituting $B^T = A^T U$.

$$= \max \left(\sum_{i=1}^{n} \lambda_i a_i^T u_i u_i^T a_i \right)$$

(dimensions of both B and A = $n \times k$)

$u_i u_i^T = 1$ (H is symmetric, U is orthogonal)

$$= \max \left(\sum_{i=1}^{n} \lambda_i a_i^T a_i \right) .$$

Here $A^T A = I_k$ (dimensions of $A^T = k \times n$, dimensions of $A = n \times k$)

$$a_i^T a_i = \begin{cases} 1 & i \leq k \\ 0 & i \geq k+1 \end{cases}$$

Like $a_i^T a_i \in [0, 1]$,
$b_i^T b_i \in [0, 1]$

$\Rightarrow \max(b_i^T b_i) = 1.$

$\Rightarrow \max\left(\sum_{i=1}^{n} b_i^T b_i\right) = k.$

and $\lambda_1 \geq \lambda_2 \geq \lambda_3 \ldots \geq \lambda_n$

for max value of trace, subsitute $b_i^T b_i = 1$,

$$= \max\left(\sum_{i=1}^{k} \lambda_i b_i^T b_i + \sum_{i=k+1}^{n} \lambda_i b_i^T b_i\right)$$

$$= \sum_{i=1}^{k} \lambda_i (1) + \sum_{i=k+1}^{n} \lambda_i (0)$$

$$= \boxed{\sum_{i=1}^{k} \lambda_i}.$$

for $1 \le i \le k$,

$$\| A^T u_i \|_2 = 1$$

$$\Rightarrow u_i = A q_i$$

where $q_i = q_1, \ldots, q_k$ → unit orthogonal vectors

Remove $(k+1)$ to n terms (neglect because they'll be multiplied with 0 since for $k+1 \le i \le n$,

$$\| A^T u_i \|_2 = 0.$$

$$\therefore \boxed{A = [u_1, \ldots u_k] \cdot Q}$$

where $Q = [q_1, \ldots q_i]^T \in R^{k \times k}$

4. Kernel vs Neural Network:

a. Implement and test kernel logistic regression model - complete the *forward()* function of the *class Kernel Layer()* and the *init ()* function of the *class Kernel LR()*, test your implementation in \main.py"

```
def forward(self, x):
    """
    Compute Gaussian kernel (radial basis function) of the input sample batch
    and self.prototypes (stored training samples or "representatives" of training samples).

    Args:
        x: A torch tensor of shape [batch_size, n_features]

    Returns:
        A torch tensor of shape [batch_size, num_of_prototypes]
    """
    assert x.shape[1] == self.prototypes.shape[1]
    ### YOUR CODE HERE
    # Basically you need to follow the equation of radial basis function
    # in the section 5 of note at http://people.tamu.edu/~sji/classes/nnkernel.pdf

    # Comments:
    # get the required size
    # set the views for input and prototype
    # compute norms using broadcasting
    # divide by sigma^2 and apply exp

    size = (x.shape[0], self.prototypes.shape[0], x.shape[1])
    x = x.unsqueeze(1).expand(size)
    p = self.prototypes.unsqueeze(0).expand(size)
    norms = (x - p).pow(2).sum(-1).pow(0.5)
    y = torch.exp(-1 * norms / (2 * (self.sigma ^ 2)))
    return y
    ### END YOUR CODE
```

Code is explained in the comments section.

```
def __init__(self, sigma, hidden_dim):
    """
    Define network structure.

    Args:
        sigma: used in the kernel layer.
        hidden_dim: the number of prototypes in the kernel layer,
                                in this model, hidden_dim has to be equal to the
                                number of training samples.
    """
    super(Kernel_LR, self).__init__()
    self.hidden_dim = hidden_dim
    ### YOUR CODE HERE
    # Use pytorch nn.Sequential object to build a network composed of a
    # kernel layer (Kernel_Layer object) and a linear layer (nn.Linear object)

    self.net = nn.Sequential(
            Kernel_Layer(sigma),
            nn.Linear(hidden_dim, 1, False))
    # Remember that kernel logistic regression model uses all training samples
    # in kernel layer, so set 'hidden_dim' argument to be None when creating
    # a Kernel_Layer object.

    # How should we set the "bias" argument of nn.Linear?
    ### END YOUR CODE
```

For this, I have kept **bias as false** because after applying kernels it is redundant. The kernel methods only capture the norm of the difference between input values.

```
13      ### YOUR CODE HERE
14      # Run your kernel logistic regression model here
15      learning_rate = [0.01]
16      max_epoch = [50]
17      batch_size = [32]
18      sigma = [1.0, 2.0, 3.0]
19
20      ans = []
21
22      for lr in learning_rate:
23          for ep in max_epoch:
24              for bs in batch_size:
25                  for sig in sigma:
26
27                      model = Model('Kernel_LR', train_X.shape[0], sig)
28                      model.train(train_X, train_y, valid_X, valid_y, ep, lr, bs)
29
30                      model = Model('Kernel_LR', train_valid_X.shape[0], sig)
31                      model.train(train_valid_X, train_valid_y, None, None, ep, lr, bs)
32                      score = model.score(test_X, test_y)
33                      print("score = {} in test set.\n".format(score))
34
35                      ans.append((lr,ep,bs,sig,score))
36
37      for a in ans:
38          print(a)
39      ### END YOUR CODE
```

Hyper-parameter tuning:

Results for kernel logistic regression model:

LR	Epoch	Batch Size	Sigma	Accuracy
0.01	10	256	0.01	0.571429
0.01	10	256	0.1	0.536797
0.01	10	256	1	0.984848
0.01	50	32	0.01	0.571429
0.01	50	32	0.1	0.569264
0.01	50	32	1	0.989177
0.01	50	128	0.01	0.571429
0.01	50	128	0.1	0.571429
0.01	50	128	1	0.987013
0.01	50	256	0.01	0.571429
0.01	50	256	0.1	0.571429
0.01	50	256	1	0.989177
0.001	10	32	0.01	0.571429
0.001	10	32	0.1	0.469697
0.001	10	32	1	0.984848
0.001	10	128	0.01	0.571429
0.001	10	128	0.1	0.510823
0.001	10	128	1	0.945887
0.001	10	256	0.01	0.571429
0.001	10	256	0.1	0.534632
0.001	10	256	1	0.87013
0.001	50	32	0.01	0.571429
0.001	50	32	0.1	0.545455
0.001	50	32	1	0.989177

Best results:

Learning rate = 0.001, Epochs = 50, Batch Size = 32, Sigma = 1

Test Accuracy = 0.989177

b. (10 points) Implement and test radial basis function network model | complete the k means() function of the class Kernel Layer() and the init () function of the class RBF(), test your implementation in \main.py".

```
34      def _k_means(self, X):
35          """
36          K-means clustering
37
38          Args:
39              X: A Numpy array of shape [n_samples, n_features].
40
41          Returns:
42              centroids: A Numpy array of shape [self.hidden_dim, n_features].
43          """
44          ### YOUR CODE HERE
45          kmeans = KMeans(n_clusters = self.hidden_dim)
46          kmeans.fit(X)
47          centroids = kmeans.cluster_centers_
48          ### END YOUR CODE
49          return centroids
```

For K-means clustering, I have used scikit learn function.

```
141     def __init__(self, sigma, hidden_dim):
142         """
143         Define network structure.
144
145         Args:
146             sigma: used in the kernel layer.
147             hidden_dim: the number of prototypes in the kernel layer,
148                                                 in this model, hidden_dim is a user-specified hyp
149         """
150         super(RBF, self).__init__()
151         ### YOUR CODE HERE
152         # Use pytorch nn.Sequential object to build a network composed of a
153         # kernel layer (Kernel_Layer object) and a linear layer (nn.Linear object)
154         # How should we set the "bias" argument of nn.Linear?
155         self.net = nn.Sequential(
156                         Kernel_Layer(sigma, hidden_dim),
157                         nn.Linear(hidden_dim, 1, False))
158         ### END CODE HERE
159
```

For this too, I will keep **bias = False** because we are applying kernel method same as question (a).

Hyper-parameter tuning:

```
### YOUR CODE HERE
# Run your radial basis function network model here
hidden_dims = [16, 32, 64]
learning_rate = [0.01]
max_epoch = [50]
batch_size = [128]
sigma = [0.1, 1.0, 3.0]

ans = []

for lr in learning_rate:
    for ep in max_epoch:
        for bs in batch_size:
            for sig in sigma:
                for hidden_dim in hidden_dims:

                    model = Model('RBF', hidden_dim, sig)
                    model.train(train_X, train_y, valid_X, valid_y, ep, lr, bs)

                    model = Model('RBF', hidden_dim, sig)
                    model.train(train_valid_X, train_valid_y, None, None, ep, lr, bs)
                    score = model.score(test_X, test_y)
                    print("score = {} in test set.\n".format(score))
                    ans.append((lr,ep,bs,sig,hidden_dim,score))

for a in ans:
    print(a)
# ### END YOUR CODE
```

Results

LR	Epoch	Batch Size	Sigma	Hidden Dim	Accuracy
0.01	50	128	0.1	16	0.47619
0.01	50	128	0.1	32	0.564935
0.01	50	128	0.1	64	0.443723
0.01	50	128	1	16	0.987013
0.01	50	128	1	32	0.97619
0.01	50	128	1	64	0.967532
0.01	50	128	3	16	0.987013
0.01	50	128	3	32	0.980519
0.01	50	128	3	64	0.978355

Best results:

Learning rate = 0.01, Epoch = 50, Batch size = 128, sigma = 1/3, Hidden dimensions = 16
Test Accuracy = 0.987013

c. Implement and test feed forward neural network model | complete the init () function of the class FFN(), test your implementation in \main.py".:

```
190     def __init__(self, input_dim, hidden_dim):
191         """
192         Define network structure.
193
194         Args:
195             input_dim: number of features of each input.
196             hidden_dim: the number of hidden units in the hidden layer, a user-spec
197         """
198         super(FFN, self).__init__()
199         ### YOUR CODE HERE
200         # Use pytorch nn.Sequential object to build a network composed of
201         # two linear layers (nn.Linear object)
202         self.net = nn.Sequential(
203                     nn.Linear(input_dim, hidden_dim, True),
204                     nn.Linear(hidden_dim, 1, True))
205
206         ### END CODE HERE
```

I have taken 2 linear layers this time with **bias = True** for the FFN network.

Results:

LR	Epoch	Batch Size	Hidden Dim	Accuracy
0.01	50	128	16	0.989177489
0.01	50	128	32	0.989177489
0.01	50	128	64	0.987012987
0.01	200	128	16	0.989177489
0.01	200	128	32	0.989177489
0.01	200	128	64	0.989177489
0.1	50	128	16	0.982683983
0.1	50	128	32	0.965367965
0.1	50	128	64	0.987012987
0.1	200	128	16	0.987012987
0.1	200	128	32	0.991341991
0.1	200	128	64	0.987012987

Best results:

Learning rate = 0.1, Epoch = 200, Batch size = 128, Hidden dimensions = 32
Test Accuracy = 0.99134

Results comparison between 3 methods:

Method	Best Accuracy
Kernel Logistic Regression	0.98917
RBF	0.9870
FNN	0.98917

Conclusion:

Even with using fewer parameters, the RBF methods performs comparable with a feed forward neural network. Thus, with data transformations using kernels, even a simple model could give good accuracy.

Still, the best accuracy was observed in a neural network (0.991). However, the difference is very less.

5. PCA vs Autoencoder

a. In the class PCA(), complete the do pca() function.

```
52      def _do_pca(self):
53          '''
54          To do PCA decomposition.
55          Returns:
56              Up: Principal components (transform matrix) of shape [n_fea
57              Xp: The reduced data matrix after PCA of shape [n_component
58          '''
59          ### YOUR CODE HERE
60          X = self.X
61          Xcentered = X  - X.mean(axis=1, keepdims=True)
62          cov = Xcentered.dot(np.transpose(Xcentered)) / X.shape[1]
63          U, sigma, V = np.linalg.svd(cov)
64          Up = U[:,:self.n_components]
65          Xp = np.transpose(Up).dot(Xcentered)
66          ### END YOUR CODE
67          return Up, Xp
68
```

For this part, I have followed the steps mentioned in the slides. I created the Xcentered my subtracting the means at the column level. Then applied SVD and used the first n_components to get the Up.

b. In the class PCA(), complete the reconstruction() function to perform data reconstruction. Please evaluate your code by testing different numbers of the principal component that p = 32, 64, 128.

```
83      def reconstruction(self, Xp):
84          '''
85          To reconstruct reduced data given principal components Up.
86
87          Args:
88          Xp: The reduced data matrix after PCA of shape [n_components, n_samples].
89
90          Return:
91          X_re: The reconstructed matrix of shape [n_features, n_samples].
92          '''
93          ### YOUR CODE HERE
94          X_re = self.Up.dot(Xp)
95          ### END YOUR CODE
96          return X_re
```

For reconstruction, take a dot product of Up and Xp.

Results:

```
PCA-Reconstruction error for 32 components is 129.37250450846798
PCA-Reconstruction error for 64 components is 85.81758325733647
PCA-Reconstruction error for 128 components is 45.633694294093935
```

c. In the class AE(), complete the network() and forward() function. Please follow the note (http://people.tamu.edu/~sji/classes/PCA.pdf) to implement your network. Note that for problems (c), (e), and (f), the weights need to be shared between the encoder and the decoder with weight matrices transposed to each other.

```
145     def _network(self):
146         '''
147 
148         You are free to use the listed functions and APIs from torch or torch.nn:
149             torch.empty
150             nn.Parameter
151             nn.init.kaiming_normal_
152 
153         You need to define and initialize weights here.
154 
155         '''
156 
157         ### YOUR CODE HERE
158 
159         '''
160         Note: you should include all the three variants of the networks here.
161         You can comment the other two when you running one, but please include
162         and uncomment all the three in you final submissions.
163         '''
164 
165         # Note: here for the network with weights sharing. Basically you need to follo
166         weights = torch.empty(self.n_features, self.d_hidden_rep)
167         init_weights = nn.init.kaiming_normal_(weights)
168         self.weights = nn.Parameter(init_weights)
169         self.w = self.weights
170 
```

For the shared weights, we use a placeholder for empty weights. Then we initialize it and pass them as parameters of our network.

```
203     def _forward(self, X):
204         '''
205 
206         You are free to use the listed functions and APIs from torch and torch.nn:
207             torch.mm
208             torch.transpose
209             nn.Tanh
210             nn.ReLU
211             nn.Sigmoid
212 
213         Args:
214             X: A torch tensor of shape [n_features, batch_size].
215                 for input images.
216 
217         Returns:
218             out: A torch tensor of shape [n_features, batch_size].
219 
220         '''
221 
222         ### YOUR CODE HERE
223 
224         '''
225         Note: you should include all the three variants of the networks here.
226         You can comment the other two when you running one, but please include
227         and uncomment all the three in you final submissions.
228         '''
229 
230         # Note: here for the network with weights sharing. Basically you need to follow t
231         # formula (WW^TX) in the note at http://people.tamu.edu/~sji/classes/PCA.pdf .
232         hidden = torch.mm(self.weights.t(), X)
233         output = torch.mm(self.weights, hidden)
234         return output
```

As the weights are to be shared, we use the weight's transpose for getting the output from the hidden representation. (*self.weights* is to be transposed twice, hence cancelled)

d. (5 points) In the class AE(), complete the reconstruction() function to perform data reconstruction. Please test your function using three different dimensions for the hidden representation d that d = 32, 64, 128.

```
336     def reconstruction(self, X):
337         '''
338         To reconstruct data. You're required to reconstruct one by one here,
339         that is to say, for one loop, input to the network is of the shape [n_feat
340         Args:
341             X: The data matrix with shape [n_features, n_any], a numpy array.
342         Returns:
343             X_re: The reconstructed data matrix, which has the same shape as X, a
344         '''
345         _, n_samples = X.shape
346         X_re = []
347         with torch.no_grad():
348             for i in range(n_samples):
349                 ### YOUR CODE HERE
350                 curr_X = X[:,i].reshape(X.shape[0],1)
351                 # Note: Format input curr_X to the shape [n_features, 1]
352 
353                 ### END YOUR CODE
354                 curr_X_tensor = torch.tensor(curr_X).float()
355                 curr_X_re_tensor = self._forward(curr_X_tensor)
356                 ### YOUR CODE HERE
357                 X_re.append(curr_X_re_tensor.numpy())
358                 # Note: To achieve final reconstructed data matrix with the shape
359 
360             X_re = np.asarray(X_re).T
361             ### END YOUR CODE
362         return X_re
```

e. (10 points) Compare the reconstruction errors from PCA and AE. Note that you need to set p = d for comparisons. Please evaluate the errors using p = d = 32; 64; 128. Report the reconstruction errors and provide a brief analysis.

	32	**64**	**128**
PCA	129.37	85.81	45.63
AutoEncoder	132.29	86.51	46.67

PCA gives slightly better results than an Autoencoder. However, the differences are very small indicating that the neural network does indeed reduces dimensions in a similar fashion like PCA.

f. (10 points) Experimentally justify the relations between the projection matrix G in PCA and the optimized weight matrix W in AE. Note that you need to set p = d for valid comparisons. lease explore three different cases that p = d = 32; 64; 128. We recommend to use frobeniu norm error() to verify if W and G are the same. If not, please follow the note (http://people.tamu.edu/~sji/classes/PCA. pdf) to implement necessary transformations for two matrices G and W and explore the relations. You need to modify the code in \main.py".

Part A: Comparison of G and W

Following are the frobeniu norm between G and W:

P=d	**frobeniu norm**
32	7.942
64	11.353
128	16.005

Ideally, the matrices should have given similar results but because of the computation of the neural network, there is a slight difference in the values.

However, these matrices are orthonormal and the values for G^TG and W^TW should be much closer. For that, we take the transpose of these matrices and multiply it with the matrices. On taking frobeniu norm after that, we get the following results:

P=d	**frobeniu norm**
32	0.183
64	0.039
128	0.024

As expected, the value goes significantly down and is almost close to 0.

g. (10 points) Please modify the network() and forward() function so that the weights are not shared between the encoder and the decoder. Report the reconstructions errors for d = 32; 64; 128. Please compare with the sharing weights case and briefly analyze you results.

Forward()

```
236         # Note: here for the network without weights sharing
237         hidden = torch.mm(self.weights_in.t(), X)
238         output = torch.mm(self.weights_out.t(), hidden)
239         return output
```

I take the matrix multiplication of weights of the first layer and input to get the hidden state. Then multiplying the hidden state with the weights of the output layer gives us the output.

Note that the weights are not shared here.

Network()

```
171         # Note: here for the network without weights sharing
172         weights_in = torch.empty(self.n_features, self.d_hidden_rep)
173         init_weights_in = nn.init.kaiming_normal_(weights_in)
174         self.weights_in = nn.Parameter(init_weights_in)
175         self.w = self.weights_in
176
177         weights_out = torch.empty(self.d_hidden_rep, self.n_features)
178         init_weights_out = nn.init.kaiming_normal_(weights_out)
179         self.weights_out = nn.Parameter(init_weights_out)
```

The layers are set by first creating empty weights, initializing them using the kaiming normal initialization method and then assigning them as the weights.

Results:

	32	**64**	**128**
Shared Weights	132.29	86.51	46.67
Not Shared Weights	130.42	86.57	47.10

The results are similar to the results we get from the shared weights as essentially the network learns to mirror them on its own.

h. (10 points) Please modify the network() and forward() function to include more network layers and nonlinear functions. Please set d = 64 and explore different hyper-parameters. Report the hyperparameters of the best model and its reconstruction error. Please analyze and report your conclusions.

Forward()

```
241         # Note: here for the network with more layers and nonlinear functions
242         hidden1_in = torch.relu(torch.mm(self.weights_in_1.t(), X))
243         hidden2_in = torch.mm(self.weights_in_2.t(), hidden1_in)
244         hidden2_out = torch.mm(self.weights_out_2.t(), hidden2_in)
245         hidden1_out = torch.sigmoid(torch.mm(self.weights_out_1.t(), hidden2_out))
246 
247         return hidden1_out
```

I have used 4 layers for this network. I take the first layer as twice that of the hidden representation so that the network becomes gradually smaller. Same thing is done for the output layer.

I tried different activation functions for different layers and the best results were obtained with these combination (relu->linear->linear->sigmoid).

Network()

```
181         # Note: here for the network with more layers and nonlinear functions
182         scaling = 2
183 
184         weights_in_1 = torch.empty(self.n_features, scaling * self.d_hidden_rep)
185         init_weights_in_1 = nn.init.kaiming_normal_(weights_in_1)
186         self.weights_in_1 = nn.Parameter(init_weights_in_1)
187 
188         weights_in_2 = torch.empty(scaling * self.d_hidden_rep, self.d_hidden_rep)
189         init_weights_in_2 = nn.init.kaiming_normal_(weights_in_2)
190         self.weights_in_2 = nn.Parameter(init_weights_in_2)
191         self.w = self.weights_in_2
192 
193         weights_out_2 = torch.empty(self.d_hidden_rep, scaling * self.d_hidden_rep)
194         init_weights_out_2 = nn.init.kaiming_normal_(weights_out_2)
195         self.weights_out_2 = nn.Parameter(init_weights_out_2)
196 
197         weights_out_1 = torch.empty(scaling * self.d_hidden_rep, self.n_features)
198         init_weights_out_1 = nn.init.kaiming_normal_(weights_out_1)
199         self.weights_out_1 = nn.Parameter(init_weights_out_1)
200 
201         ### END YOUR CODE
```

For the network, I design the network with 4 layers with the output from the second layer being my hidden representation. Same initialization method has been used.

Results:

Batch Size	Epochs	Reconstruction Error
32	1000	48.33207138
32	2500	45.50556132
64	1000	46.82855888
64	2500	44.66214642
128	1000	46.42822365
128	2500	44.69153236

Best results:

Batch Size = 64, Epochs = 2500

Reconstruction error = 44.662

Method	**Reconstruction error for p=64**
PCA	85.81
AE shared weights	86.51
AE not shared weights	86.57
Non-linear functions and more layers	44.66

The best reconstruction error for p=64 here beats the reconstruction error from the PCA and autoencoding methods.

Thus, on using more layers and non-linear activations, the network learns more complex interactions and hence could recreate the data more accurately.

Appendix (logs)

a. Kernel logistic regression log

```
100% 43/43 [00:04<00:00,  9.35it/s]
score = 0.9841269841269841 in validation set.

100% 43/43 [00:00<00:00, 825.84it/s]
score = 0.9973544973544973 in validation set.

100% 43/43 [00:00<00:00, 819.67it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 768.18it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 828.61it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 810.45it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 820.16it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 822.61it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 781.05it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 798.17it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 818.01it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 782.25it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 812.19it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 829.68it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 721.21it/s]
```

```
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 831.13it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 797.21it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 824.53it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 833.04it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 774.04it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 819.48it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 796.86it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 828.68it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 838.00it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 773.08it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 837.22it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 756.94it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 772.29it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 834.03it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 778.39it/s]
score = 1.0 in validation set.

100% 43/43 [00:00<00:00, 800.73it/s]
score = 1.0 in validation set.

```

```
100% 43/43 [00:00<00:00, 739.01it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 821.28it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 810.84it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 768.68it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 789.31it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 762.45it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 820.61it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 821.97it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 784.85it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 797.75it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 783.75it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 818.26it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 767.95it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 832.66it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 751.06it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 766.29it/s]
    score = 1.0 in validation set.

    100% 43/43 [00:00<00:00, 813.47it/s]
    score = 1.0 in validation set.
```

```
149.
150.      100% 43/43 [00:00<00:00, 790.72it/s]
151.      score = 1.0 in validation set.
152.
153.      100% 43/43 [00:00<00:00, 797.42it/s]
154.      score = 1.0 in validation set.
155.
156.      100% 55/55 [00:00<00:00, 762.69it/s]
157.      100% 55/55 [00:00<00:00, 794.43it/s]
158.      100% 55/55 [00:00<00:00, 775.93it/s]
159.      100% 55/55 [00:00<00:00, 825.13it/s]
160.      100% 55/55 [00:00<00:00, 788.27it/s]
161.      100% 55/55 [00:00<00:00, 766.47it/s]
162.      100% 55/55 [00:00<00:00, 764.90it/s]
163.      100% 55/55 [00:00<00:00, 819.25it/s]
164.      100% 55/55 [00:00<00:00, 769.15it/s]
165.      100% 55/55 [00:00<00:00, 807.82it/s]
166.      100% 55/55 [00:00<00:00, 792.44it/s]
167.      100% 55/55 [00:00<00:00, 796.58it/s]
168.      100% 55/55 [00:00<00:00, 834.20it/s]
169.      100% 55/55 [00:00<00:00, 768.47it/s]
170.      100% 55/55 [00:00<00:00, 770.52it/s]
171.      100% 55/55 [00:00<00:00, 833.35it/s]
172.      100% 55/55 [00:00<00:00, 832.61it/s]
173.      100% 55/55 [00:00<00:00, 776.84it/s]
174.      100% 55/55 [00:00<00:00, 799.83it/s]
175.      100% 55/55 [00:00<00:00, 833.24it/s]
176.      100% 55/55 [00:00<00:00, 835.70it/s]
177.      100% 55/55 [00:00<00:00, 813.26it/s]
178.      100% 55/55 [00:00<00:00, 814.94it/s]
179.      100% 55/55 [00:00<00:00, 796.54it/s]
180.      100% 55/55 [00:00<00:00, 833.37it/s]
181.      100% 55/55 [00:00<00:00, 834.74it/s]
182.      100% 55/55 [00:00<00:00, 777.09it/s]
183.      100% 55/55 [00:00<00:00, 799.57it/s]
184.      100% 55/55 [00:00<00:00, 786.62it/s]
185.      100% 55/55 [00:00<00:00, 796.01it/s]
186.      100% 55/55 [00:00<00:00, 821.99it/s]
187.      100% 55/55 [00:00<00:00, 779.14it/s]
188.      100% 55/55 [00:00<00:00, 752.08it/s]
189.      100% 55/55 [00:00<00:00, 806.33it/s]
190.      100% 55/55 [00:00<00:00, 833.21it/s]
191.      100% 55/55 [00:00<00:00, 821.60it/s]
192.      100% 55/55 [00:00<00:00, 746.44it/s]
193.      100% 55/55 [00:00<00:00, 797.08it/s]
194.      100% 55/55 [00:00<00:00, 817.58it/s]
195.      100% 55/55 [00:00<00:00, 763.09it/s]
196.      100% 55/55 [00:00<00:00, 771.65it/s]
197.      100% 55/55 [00:00<00:00, 812.05it/s]
198.      100% 55/55 [00:00<00:00, 735.74it/s]
```

```
100% 55/55 [00:00<00:00, 807.64it/s]
100% 55/55 [00:00<00:00, 767.96it/s]
100% 55/55 [00:00<00:00, 814.63it/s]
100% 55/55 [00:00<00:00, 760.06it/s]
100% 55/55 [00:00<00:00, 809.27it/s]
100% 55/55 [00:00<00:00, 797.82it/s]
100% 55/55 [00:00<00:00, 760.04it/s]
score = 0.9848484848484849 in test set.
```

b. RBF log

```
100% 11/11 [00:00<00:00, 661.52it/s]
score = 0.8492063492063492 in validation set.

100% 11/11 [00:00<00:00, 756.68it/s]
score = 0.9312169312169312 in validation set.

100% 11/11 [00:00<00:00, 766.34it/s]
score = 0.9708994708994709 in validation set.

100% 11/11 [00:00<00:00, 760.87it/s]
score = 0.9708994708994709 in validation set.

100% 11/11 [00:00<00:00, 723.65it/s]
score = 0.9788359788359788 in validation set.

100% 11/11 [00:00<00:00, 754.78it/s]
score = 0.9814814814814815 in validation set.

100% 11/11 [00:00<00:00, 760.29it/s]
score = 0.9814814814814815 in validation set.

100% 11/11 [00:00<00:00, 762.60it/s]
score = 0.9814814814814815 in validation set.

100% 11/11 [00:00<00:00, 759.50it/s]
score = 0.9814814814814815 in validation set.

100% 11/11 [00:00<00:00, 756.56it/s]
score = 0.9814814814814815 in validation set.

100% 11/11 [00:00<00:00, 757.26it/s]
score = 0.9841269841269841 in validation set.

100% 11/11 [00:00<00:00, 734.03it/s]
score = 0.9841269841269841 in validation set.

100% 11/11 [00:00<00:00, 760.90it/s]
score = 0.9841269841269841 in validation set.

100% 11/11 [00:00<00:00, 760.70it/s]
score = 0.9867724867724867 in validation set.
```

```
100% 11/11 [00:00<00:00, 761.41it/s]
score = 0.9867724867724867 in validation set.

100% 11/11 [00:00<00:00, 757.59it/s]
score = 0.9867724867724867 in validation set.

100% 11/11 [00:00<00:00, 761.38it/s]
score = 0.9894179894179894 in validation set.

100% 11/11 [00:00<00:00, 602.09it/s]
score = 0.9894179894179894 in validation set.

100% 11/11 [00:00<00:00, 507.21it/s]
score = 0.9894179894179894 in validation set.

100% 11/11 [00:00<00:00, 623.60it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 633.69it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 647.69it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 591.78it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 684.36it/s]
score = 0.9894179894179894 in validation set.

100% 11/11 [00:00<00:00, 730.59it/s]
score = 0.9894179894179894 in validation set.

100% 11/11 [00:00<00:00, 747.33it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 761.98it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 752.44it/s]
score = 0.9894179894179894 in validation set.

100% 11/11 [00:00<00:00, 724.61it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 583.60it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 748.16it/s]
score = 0.9947089947089947 in validation set.

100% 11/11 [00:00<00:00, 759.18it/s]
score = 0.9920634920634921 in validation set.
```

```
100% 11/11 [00:00<00:00, 546.03it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 584.00it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 631.50it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 743.07it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 742.39it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 740.00it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 741.53it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 618.47it/s]
score = 0.9947089947089947 in validation set.

100% 11/11 [00:00<00:00, 728.65it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 720.22it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 747.12it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 742.34it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 752.77it/s]
score = 0.9947089947089947 in validation set.

100% 11/11 [00:00<00:00, 396.81it/s]
score = 0.9867724867724867 in validation set.

100% 11/11 [00:00<00:00, 749.96it/s]
score = 0.9947089947089947 in validation set.

100% 11/11 [00:00<00:00, 746.41it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 740.65it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 753.37it/s]
score = 0.9920634920634921 in validation set.
```

```
100% 14/14 [00:00<00:00, 662.53it/s]
100% 14/14 [00:00<00:00, 711.46it/s]
100% 14/14 [00:00<00:00, 730.76it/s]
100% 14/14 [00:00<00:00, 742.82it/s]
100% 14/14 [00:00<00:00, 745.11it/s]
100% 14/14 [00:00<00:00, 740.75it/s]
100% 14/14 [00:00<00:00, 739.00it/s]
100% 14/14 [00:00<00:00, 676.14it/s]
100% 14/14 [00:00<00:00, 733.83it/s]
100% 14/14 [00:00<00:00, 733.91it/s]
100% 14/14 [00:00<00:00, 739.00it/s]
100% 14/14 [00:00<00:00, 734.55it/s]
100% 14/14 [00:00<00:00, 672.56it/s]
100% 14/14 [00:00<00:00, 731.46it/s]
100% 14/14 [00:00<00:00, 724.06it/s]
100% 14/14 [00:00<00:00, 732.83it/s]
100% 14/14 [00:00<00:00, 731.28it/s]
100% 14/14 [00:00<00:00, 719.89it/s]
100% 14/14 [00:00<00:00, 737.52it/s]
100% 14/14 [00:00<00:00, 736.64it/s]
100% 14/14 [00:00<00:00, 739.75it/s]
100% 14/14 [00:00<00:00, 728.78it/s]
100% 14/14 [00:00<00:00, 615.55it/s]
100% 14/14 [00:00<00:00, 723.40it/s]
100% 14/14 [00:00<00:00, 740.21it/s]
100% 14/14 [00:00<00:00, 738.54it/s]
100% 14/14 [00:00<00:00, 735.39it/s]
100% 14/14 [00:00<00:00, 717.98it/s]
100% 14/14 [00:00<00:00, 744.14it/s]
100% 14/14 [00:00<00:00, 634.44it/s]
100% 14/14 [00:00<00:00, 704.85it/s]
100% 14/14 [00:00<00:00, 668.56it/s]
100% 14/14 [00:00<00:00, 715.26it/s]
100% 14/14 [00:00<00:00, 746.37it/s]
100% 14/14 [00:00<00:00, 747.51it/s]
100% 14/14 [00:00<00:00, 750.08it/s]
100% 14/14 [00:00<00:00, 734.80it/s]
100% 14/14 [00:00<00:00, 663.83it/s]
100% 14/14 [00:00<00:00, 720.37it/s]
100% 14/14 [00:00<00:00, 738.39it/s]
100% 14/14 [00:00<00:00, 739.70it/s]
100% 14/14 [00:00<00:00, 739.90it/s]
100% 14/14 [00:00<00:00, 740.12it/s]
100% 14/14 [00:00<00:00, 745.72it/s]
100% 14/14 [00:00<00:00, 697.02it/s]
100% 14/14 [00:00<00:00, 743.77it/s]
100% 14/14 [00:00<00:00, 669.31it/s]
100% 14/14 [00:00<00:00, 674.53it/s]
100% 14/14 [00:00<00:00, 605.20it/s]
100% 14/14 [00:00<00:00, 556.60it/s]
score = 0.9783549783549783 in test set.
```

c. FNN training log

```
100% 11/11 [00:04<00:00,  2.38it/s]
score = 0.9920634920634921 in validation set.

100% 11/11 [00:00<00:00, 563.01it/s]
score = 1.0 in validation set.

100% 11/11 [00:00<00:00, 564.84it/s]
score = 0.9947089947089947 in validation set.

100% 11/11 [00:00<00:00, 563.63it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 567.23it/s]
score = 1.0 in validation set.

100% 11/11 [00:00<00:00, 556.12it/s]
score = 1.0 in validation set.

100% 11/11 [00:00<00:00, 573.20it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 587.77it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 558.39it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 575.28it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 458.57it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 560.86it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 586.96it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 585.65it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 589.82it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 578.16it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 577.92it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 586.38it/s]
score = 1.0 in validation set.
```

```
100% 11/11 [00:00<00:00, 583.17it/s]
score = 1.0 in validation set.

100% 11/11 [00:00<00:00, 583.50it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 515.47it/s]
score = 0.9973544973544973 in validation set.


100% 11/11 [00:00<00:00, 540.81it/s]
score = 0.9973544973544973 in validation set.

100% 11/11 [00:00<00:00, 575.33it/s]
score = 0.9973544973544973 in validation set.

100% 14/14 [00:00<00:00, 580.32it/s]
100% 14/14 [00:00<00:00, 571.15it/s]
100% 14/14 [00:00<00:00, 518.81it/s]
100% 14/14 [00:00<00:00, 570.06it/s]
100% 14/14 [00:00<00:00, 589.93it/s]
100% 14/14 [00:00<00:00, 556.19it/s]
100% 14/14 [00:00<00:00, 577.42it/s]
100% 14/14 [00:00<00:00, 569.37it/s]
100% 14/14 [00:00<00:00, 582.90it/s]
100% 14/14 [00:00<00:00, 500.48it/s]
100% 14/14 [00:00<00:00, 531.70it/s]
100% 14/14 [00:00<00:00, 572.38it/s]
100% 14/14 [00:00<00:00, 587.11it/s]
100% 14/14 [00:00<00:00, 571.56it/s]
100% 14/14 [00:00<00:00, 477.12it/s]
100% 14/14 [00:00<00:00, 576.30it/s]
100% 14/14 [00:00<00:00, 575.85it/s]
100% 14/14 [00:00<00:00, 563.93it/s]
100% 14/14 [00:00<00:00, 552.01it/s]
100% 14/14 [00:00<00:00, 585.97it/s]
100% 14/14 [00:00<00:00, 587.56it/s]
100% 14/14 [00:00<00:00, 514.99it/s]
100% 14/14 [00:00<00:00, 577.55it/s]
100% 14/14 [00:00<00:00, 577.89it/s]
100% 14/14 [00:00<00:00, 583.39it/s]
100% 14/14 [00:00<00:00, 535.55it/s]
100% 14/14 [00:00<00:00, 539.21it/s]
100% 14/14 [00:00<00:00, 585.31it/s]
100% 14/14 [00:00<00:00, 515.85it/s]
100% 14/14 [00:00<00:00, 548.78it/s]
100% 14/14 [00:00<00:00, 573.93it/s]
100% 14/14 [00:00<00:00, 591.21it/s]
100% 14/14 [00:00<00:00, 567.46it/s]
100% 14/14 [00:00<00:00, 503.28it/s]
100% 14/14 [00:00<00:00, 575.31it/s]
100% 14/14 [00:00<00:00, 490.34it/s]
100% 14/14 [00:00<00:00, 519.77it/s]
100% 14/14 [00:00<00:00, 494.76it/s]
```

```
100% 14/14 [00:00<00:00, 525.18it/s]
100% 14/14 [00:00<00:00, 582.73it/s]
100% 14/14 [00:00<00:00, 562.71it/s]
100% 14/14 [00:00<00:00, 575.89it/s]
100% 14/14 [00:00<00:00, 577.89it/s]
100% 14/14 [00:00<00:00, 568.70it/s]
100% 14/14 [00:00<00:00, 588.62it/s]
100% 14/14 [00:00<00:00, 486.90it/s]
100% 14/14 [00:00<00:00, 591.68it/s]
100% 14/14 [00:00<00:00, 443.79it/s]
100% 14/14 [00:00<00:00, 456.59it/s]
100% 14/14 [00:00<00:00, 583.75it/s]
100% 14/14 [00:00<00:00, 570.23it/s]
100% 14/14 [00:00<00:00, 511.16it/s]
100% 14/14 [00:00<00:00, 584.41it/s]
100% 14/14 [00:00<00:00, 580.83it/s]
100% 14/14 [00:00<00:00, 577.48it/s]
score = 0.9891774891774892 in test set

(0.01, 200, 128, 32, 0.9891774891774892)
```

d. AE shared weights training

```
PCA-Reconstruction error for 32 components is 129.37250450846798
---Run...
Epoch 1 Loss 2.925075: 100% 23/23 [00:00<00:00, 175.64it/s]
Doing validation... Validation Loss 2.429030
Epoch 2 Loss 2.314254: 100% 23/23 [00:00<00:00, 1292.61it/s]
Doing validation... Validation Loss 1.729535
Epoch 3 Loss 1.693006: 100% 23/23 [00:00<00:00, 1210.95it/s]
Doing validation... Validation Loss 1.393158
Epoch 4 Loss 1.439806: 100% 23/23 [00:00<00:00, 965.64it/s]
Doing validation... Validation Loss 1.166162
Epoch 5 Loss 1.277668: 100% 23/23 [00:00<00:00, 1300.68it/s]
Doing validation... Validation Loss 1.002837
Epoch 6 Loss 1.104677: 100% 23/23 [00:00<00:00, 1201.93it/s]
Doing validation... Validation Loss 0.879136
Epoch 7 Loss 0.913193: 100% 23/23 [00:00<00:00, 887.72it/s]
Doing validation... Validation Loss 0.783645
Epoch 8 Loss 0.884548: 100% 23/23 [00:00<00:00, 851.15it/s]
Doing validation... Validation Loss 0.704858
Epoch 9 Loss 0.793524: 100% 23/23 [00:00<00:00, 1265.30it/s]
Doing validation... Validation Loss 0.640991
Epoch 10 Loss 0.697006: 100% 23/23 [00:00<00:00, 1112.03it/s]
Doing validation... Validation Loss 0.588449
Epoch 11 Loss 0.644082: 100% 23/23 [00:00<00:00, 1299.60it/s]
Doing validation... Validation Loss 0.543568
Epoch 12 Loss 0.638227: 100% 23/23 [00:00<00:00, 1308.23it/s]
Doing validation... Validation Loss 0.507189
Epoch 13 Loss 0.597845: 100% 23/23 [00:00<00:00, 1299.67it/s]
Doing validation... Validation Loss 0.474363
Epoch 14 Loss 0.538512: 100% 23/23 [00:00<00:00, 1298.51it/s]
Doing validation... Validation Loss 0.446598
Epoch 15 Loss 0.510171: 100% 23/23 [00:00<00:00, 1282.34it/s]
```

```
Doing validation... Validation Loss 0.423059
Epoch 16 Loss 0.495520: 100% 23/23 [00:00<00:00, 1271.77it/s]
Doing validation... Validation Loss 0.401913
Epoch 17 Loss 0.460600: 100% 23/23 [00:00<00:00, 1141.96it/s]
Doing validation... Validation Loss 0.383667
Epoch 18 Loss 0.432372: 100% 23/23 [00:00<00:00, 1303.95it/s]
Doing validation... Validation Loss 0.367151
Epoch 19 Loss 0.427827: 100% 23/23 [00:00<00:00, 1266.31it/s]
Doing validation... Validation Loss 0.352627
Epoch 20 Loss 0.397610: 100% 23/23 [00:00<00:00, 1183.93it/s]
Doing validation... Validation Loss 0.339875
Epoch 21 Loss 0.386505: 100% 23/23 [00:00<00:00, 1230.61it/s]
Doing validation... Validation Loss 0.328198
Epoch 22 Loss 0.377175: 100% 23/23 [00:00<00:00, 1107.90it/s]
Doing validation... Validation Loss 0.317569
Epoch 23 Loss 0.359339: 100% 23/23 [00:00<00:00, 1244.39it/s]
Doing validation... Validation Loss 0.308021
Epoch 24 Loss 0.361776: 100% 23/23 [00:00<00:00, 1282.08it/s]
Doing validation... Validation Loss 0.299210
Epoch 25 Loss 0.348365: 100% 23/23 [00:00<00:00, 1275.49it/s]
Doing validation... Validation Loss 0.291477
Epoch 26 Loss 0.359061: 100% 23/23 [00:00<00:00, 1287.42it/s]
Doing validation... Validation Loss 0.284468
Epoch 27 Loss 0.332429: 100% 23/23 [00:00<00:00, 1086.89it/s]
Doing validation... Validation Loss 0.277735
Epoch 28 Loss 0.319250: 100% 23/23 [00:00<00:00, 1152.13it/s]
Doing validation... Validation Loss 0.271754
Epoch 29 Loss 0.306081: 100% 23/23 [00:00<00:00, 1160.92it/s]
Doing validation... Validation Loss 0.266332
Epoch 30 Loss 0.321057: 100% 23/23 [00:00<00:00, 1170.78it/s]
Doing validation... Validation Loss 0.261085
Epoch 31 Loss 0.301153: 100% 23/23 [00:00<00:00, 1269.40it/s]
Doing validation... Validation Loss 0.256423
Epoch 32 Loss 0.289704: 100% 23/23 [00:00<00:00, 1301.91it/s]
Doing validation... Validation Loss 0.252178
Epoch 33 Loss 0.290947: 100% 23/23 [00:00<00:00, 1293.01it/s]
Doing validation... Validation Loss 0.247936
Epoch 34 Loss 0.289965: 100% 23/23 [00:00<00:00, 1297.86it/s]
Doing validation... Validation Loss 0.244212
Epoch 35 Loss 0.296509: 100% 23/23 [00:00<00:00, 1264.16it/s]
Doing validation... Validation Loss 0.240632
Epoch 36 Loss 0.275905: 100% 23/23 [00:00<00:00, 1300.26it/s]
Doing validation... Validation Loss 0.237399
Epoch 37 Loss 0.282917: 100% 23/23 [00:00<00:00, 1259.37it/s]
Doing validation... Validation Loss 0.234316
Epoch 38 Loss 0.278845: 100% 23/23 [00:00<00:00, 1301.95it/s]
Doing validation... Validation Loss 0.231571
Epoch 39 Loss 0.267399: 100% 23/23 [00:00<00:00, 1314.99it/s]
Doing validation... Validation Loss 0.228825
Epoch 40 Loss 0.278420: 100% 23/23 [00:00<00:00, 1271.84it/s]
Doing validation... Validation Loss 0.226246
Epoch 41 Loss 0.273366: 100% 23/23 [00:00<00:00, 749.02it/s]
Doing validation... Validation Loss 0.223908
Epoch 42 Loss 0.267133: 100% 23/23 [00:00<00:00, 1291.87it/s]
```

```
Doing validation... Validation Loss 0.221747
Epoch 43 Loss 0.253921: 100% 23/23 [00:00<00:00, 1310.58it/s]
Doing validation... Validation Loss 0.219635
Epoch 44 Loss 0.251701: 100% 23/23 [00:00<00:00, 1118.12it/s]
Doing validation... Validation Loss 0.217609
Epoch 45 Loss 0.263318: 100% 23/23 [00:00<00:00, 1299.14it/s]
Doing validation... Validation Loss 0.215773
Epoch 46 Loss 0.241862: 100% 23/23 [00:00<00:00, 1269.20it/s]
Doing validation... Validation Loss 0.213939
Epoch 47 Loss 0.259177: 100% 23/23 [00:00<00:00, 1291.68it/s]
Doing validation... Validation Loss 0.212294
Epoch 48 Loss 0.245741: 100% 23/23 [00:00<00:00, 1254.05it/s]
Doing validation... Validation Loss 0.210587
Epoch 49 Loss 0.252214: 100% 23/23 [00:00<00:00, 1257.29it/s]
Doing validation... Validation Loss 0.208865
Epoch 50 Loss 0.251574: 100% 23/23 [00:00<00:00, 1233.84it/s]
Doing validation... Validation Loss 0.206696
Epoch 51 Loss 0.244025: 100% 23/23 [00:00<00:00, 1037.81it/s]
Doing validation... Validation Loss 0.202138
Epoch 52 Loss 0.218641: 100% 23/23 [00:00<00:00, 1325.58it/s]
Doing validation... Validation Loss 0.181303
Epoch 53 Loss 0.160530: 100% 23/23 [00:00<00:00, 1329.54it/s]
Doing validation... Validation Loss 0.128137
Epoch 54 Loss 0.139997: 100% 23/23 [00:00<00:00, 1283.62it/s]
Doing validation... Validation Loss 0.116251
Epoch 55 Loss 0.133741: 100% 23/23 [00:00<00:00, 1229.77it/s]
Doing validation... Validation Loss 0.114394
Epoch 56 Loss 0.135834: 100% 23/23 [00:00<00:00, 1219.80it/s]
Doing validation... Validation Loss 0.113460
Epoch 57 Loss 0.137774: 100% 23/23 [00:00<00:00, 1306.90it/s]
Doing validation... Validation Loss 0.112337
Epoch 58 Loss 0.132250: 100% 23/23 [00:00<00:00, 1286.12it/s]
Doing validation... Validation Loss 0.111599
Epoch 59 Loss 0.133936: 100% 23/23 [00:00<00:00, 1288.37it/s]
Doing validation... Validation Loss 0.110564
Epoch 60 Loss 0.127455: 100% 23/23 [00:00<00:00, 1325.41it/s]
Doing validation... Validation Loss 0.109277
Epoch 61 Loss 0.126753: 100% 23/23 [00:00<00:00, 1307.13it/s]
Doing validation... Validation Loss 0.109252
Epoch 62 Loss 0.125764: 100% 23/23 [00:00<00:00, 1065.84it/s]
Doing validation... Validation Loss 0.108296
Epoch 63 Loss 0.128517: 100% 23/23 [00:00<00:00, 1202.78it/s]
Doing validation... Validation Loss 0.107202
Epoch 64 Loss 0.122981: 100% 23/23 [00:00<00:00, 1344.72it/s]
Doing validation... Validation Loss 0.106216
Epoch 65 Loss 0.116884: 100% 23/23 [00:00<00:00, 1085.23it/s]
Doing validation... Validation Loss 0.106106
Epoch 66 Loss 0.124822: 100% 23/23 [00:00<00:00, 1271.92it/s]
Doing validation... Validation Loss 0.104903
Epoch 67 Loss 0.123267: 100% 23/23 [00:00<00:00, 1313.18it/s]
Doing validation... Validation Loss 0.104470
Epoch 68 Loss 0.123984: 100% 23/23 [00:00<00:00, 1296.10it/s]
Doing validation... Validation Loss 0.103849
Epoch 69 Loss 0.121293: 100% 23/23 [00:00<00:00, 1297.81it/s]
```

```
Doing validation... Validation Loss 0.102895
Epoch 70 Loss 0.127060: 100% 23/23 [00:00<00:00, 1337.27it/s]
Doing validation... Validation Loss 0.102496
Epoch 71 Loss 0.126166: 100% 23/23 [00:00<00:00, 1314.20it/s]
Doing validation... Validation Loss 0.102045
Epoch 72 Loss 0.120085: 100% 23/23 [00:00<00:00, 1229.72it/s]
Doing validation... Validation Loss 0.101153
Epoch 73 Loss 0.113682: 100% 23/23 [00:00<00:00, 1239.82it/s]
Doing validation... Validation Loss 0.100745
Epoch 74 Loss 0.117043: 100% 23/23 [00:00<00:00, 1311.47it/s]
Doing validation... Validation Loss 0.100155
Epoch 75 Loss 0.125576: 100% 23/23 [00:00<00:00, 1265.30it/s]
Doing validation... Validation Loss 0.099003
Epoch 76 Loss 0.112864: 100% 23/23 [00:00<00:00, 1274.51it/s]
Doing validation... Validation Loss 0.098585
Epoch 77 Loss 0.114525: 100% 23/23 [00:00<00:00, 1047.63it/s]
Doing validation... Validation Loss 0.096880
Epoch 78 Loss 0.119116: 100% 23/23 [00:00<00:00, 1311.91it/s]
Doing validation... Validation Loss 0.095792
Epoch 79 Loss 0.111269: 100% 23/23 [00:00<00:00, 1276.53it/s]
Doing validation... Validation Loss 0.093192
Epoch 80 Loss 0.106147: 100% 23/23 [00:00<00:00, 1313.49it/s]
Doing validation... Validation Loss 0.090648
Epoch 81 Loss 0.105571: 100% 23/23 [00:00<00:00, 1304.59it/s]
Doing validation... Validation Loss 0.086927
Epoch 82 Loss 0.098242: 100% 23/23 [00:00<00:00, 1293.97it/s]
Doing validation... Validation Loss 0.083268
Epoch 83 Loss 0.098403: 100% 23/23 [00:00<00:00, 960.44it/s]
Doing validation... Validation Loss 0.080402
Epoch 84 Loss 0.099764: 100% 23/23 [00:00<00:00, 1214.81it/s]
Doing validation... Validation Loss 0.077219
Epoch 85 Loss 0.093147: 100% 23/23 [00:00<00:00, 1252.18it/s]
Doing validation... Validation Loss 0.075258
Epoch 86 Loss 0.095923: 100% 23/23 [00:00<00:00, 1266.80it/s]
Doing validation... Validation Loss 0.073217
Epoch 87 Loss 0.095306: 100% 23/23 [00:00<00:00, 1305.13it/s]
Doing validation... Validation Loss 0.071394
Epoch 88 Loss 0.091790: 100% 23/23 [00:00<00:00, 1132.85it/s]
Doing validation... Validation Loss 0.070055
Epoch 89 Loss 0.096193: 100% 23/23 [00:00<00:00, 1126.08it/s]
Doing validation... Validation Loss 0.068957
Epoch 90 Loss 0.085380: 100% 23/23 [00:00<00:00, 1201.36it/s]
Doing validation... Validation Loss 0.067758
Epoch 91 Loss 0.083885: 100% 23/23 [00:00<00:00, 1313.83it/s]
Doing validation... Validation Loss 0.067348
Epoch 92 Loss 0.092559: 100% 23/23 [00:00<00:00, 1211.66it/s]
Doing validation... Validation Loss 0.066014
Epoch 93 Loss 0.083927: 100% 23/23 [00:00<00:00, 797.01it/s]
Doing validation... Validation Loss 0.065685
Epoch 94 Loss 0.083830: 100% 23/23 [00:00<00:00, 1288.18it/s]
Doing validation... Validation Loss 0.065057
Epoch 95 Loss 0.087497: 100% 23/23 [00:00<00:00, 1304.20it/s]
Doing validation... Validation Loss 0.064528
Epoch 96 Loss 0.081870: 100% 23/23 [00:00<00:00, 1269.13it/s]
```

```
Doing validation... Validation Loss 0.064168
Epoch 97 Loss 0.084025: 100% 23/23 [00:00<00:00, 1315.94it/s]
Doing validation... Validation Loss 0.063709
Epoch 98 Loss 0.084656: 100% 23/23 [00:00<00:00, 1315.87it/s]
Doing validation... Validation Loss 0.062955
Epoch 99 Loss 0.080985: 100% 23/23 [00:00<00:00, 1283.69it/s]
Doing validation... Validation Loss 0.062891
AE-Reconstruction error for 32-dimensional hidden representation is
132.2893243504881

PCA-Reconstruction error for 64 components is 85.81758325733647
---Run...
Epoch 1 Loss 1.524242: 100% 23/23 [00:00<00:00, 705.32it/s]
Doing validation... Validation Loss 1.165136
Epoch 2 Loss 0.989330: 100% 23/23 [00:00<00:00, 729.32it/s]
Doing validation... Validation Loss 0.798269
Epoch 3 Loss 0.796109: 100% 23/23 [00:00<00:00, 765.66it/s]
Doing validation... Validation Loss 0.621911
Epoch 4 Loss 0.596961: 100% 23/23 [00:00<00:00, 997.62it/s]
Doing validation... Validation Loss 0.512923
Epoch 5 Loss 0.524759: 100% 23/23 [00:00<00:00, 1103.07it/s]
Doing validation... Validation Loss 0.437145
Epoch 6 Loss 0.432237: 100% 23/23 [00:00<00:00, 1091.76it/s]
Doing validation... Validation Loss 0.360853
Epoch 7 Loss 0.334559: 100% 23/23 [00:00<00:00, 738.91it/s]
Doing validation... Validation Loss 0.281817
Epoch 8 Loss 0.285978: 100% 23/23 [00:00<00:00, 964.66it/s]
Doing validation... Validation Loss 0.239301
Epoch 9 Loss 0.245097: 100% 23/23 [00:00<00:00, 793.49it/s]
Doing validation... Validation Loss 0.213599
Epoch 10 Loss 0.229266: 100% 23/23 [00:00<00:00, 1090.85it/s]
Doing validation... Validation Loss 0.192069
Epoch 11 Loss 0.205357: 100% 23/23 [00:00<00:00, 1069.58it/s]
Doing validation... Validation Loss 0.173661
Epoch 12 Loss 0.184447: 100% 23/23 [00:00<00:00, 1085.97it/s]
Doing validation... Validation Loss 0.158494
Epoch 13 Loss 0.177085: 100% 23/23 [00:00<00:00, 1106.16it/s]
Doing validation... Validation Loss 0.144871
Epoch 14 Loss 0.160349: 100% 23/23 [00:00<00:00, 1109.62it/s]
Doing validation... Validation Loss 0.133042
Epoch 15 Loss 0.154497: 100% 23/23 [00:00<00:00, 1065.39it/s]
Doing validation... Validation Loss 0.122448
Epoch 16 Loss 0.143790: 100% 23/23 [00:00<00:00, 903.39it/s]
Doing validation... Validation Loss 0.113776
Epoch 17 Loss 0.132214: 100% 23/23 [00:00<00:00, 942.30it/s]
Doing validation... Validation Loss 0.105817
Epoch 18 Loss 0.128932: 100% 23/23 [00:00<00:00, 1087.87it/s]
Doing validation... Validation Loss 0.099264
Epoch 19 Loss 0.114140: 100% 23/23 [00:00<00:00, 1118.97it/s]
Doing validation... Validation Loss 0.093741
Epoch 20 Loss 0.117155: 100% 23/23 [00:00<00:00, 1093.90it/s]
Doing validation... Validation Loss 0.088991
Epoch 21 Loss 0.106738: 100% 23/23 [00:00<00:00, 1086.74it/s]
Doing validation... Validation Loss 0.084422
```

```
Epoch 22 Loss 0.108903: 100% 23/23 [00:00<00:00, 1089.64it/s]
Doing validation... Validation Loss 0.080823
Epoch 23 Loss 0.094323: 100% 23/23 [00:00<00:00, 1090.43it/s]
Doing validation... Validation Loss 0.077138
Epoch 24 Loss 0.095942: 100% 23/23 [00:00<00:00, 1047.46it/s]
Doing validation... Validation Loss 0.073810
Epoch 25 Loss 0.092268: 100% 23/23 [00:00<00:00, 1087.13it/s]
Doing validation... Validation Loss 0.071018
Epoch 26 Loss 0.086484: 100% 23/23 [00:00<00:00, 1108.49it/s]
Doing validation... Validation Loss 0.068269
Epoch 27 Loss 0.082379: 100% 23/23 [00:00<00:00, 1096.61it/s]
Doing validation... Validation Loss 0.065789
Epoch 28 Loss 0.080899: 100% 23/23 [00:00<00:00, 1104.24it/s]
Doing validation... Validation Loss 0.063519
Epoch 29 Loss 0.076101: 100% 23/23 [00:00<00:00, 1031.93it/s]
Doing validation... Validation Loss 0.061327
Epoch 30 Loss 0.075499: 100% 23/23 [00:00<00:00, 1092.80it/s]
Doing validation... Validation Loss 0.059156
Epoch 31 Loss 0.073082: 100% 23/23 [00:00<00:00, 987.29it/s]
Doing validation... Validation Loss 0.057214
Epoch 32 Loss 0.067839: 100% 23/23 [00:00<00:00, 1126.11it/s]
Doing validation... Validation Loss 0.055315
Epoch 33 Loss 0.065424: 100% 23/23 [00:00<00:00, 994.33it/s]
Doing validation... Validation Loss 0.053633
Epoch 34 Loss 0.064008: 100% 23/23 [00:00<00:00, 927.36it/s]
Doing validation... Validation Loss 0.051973
Epoch 35 Loss 0.062366: 100% 23/23 [00:00<00:00, 1096.80it/s]
Doing validation... Validation Loss 0.050462
Epoch 36 Loss 0.057462: 100% 23/23 [00:00<00:00, 1111.64it/s]
Doing validation... Validation Loss 0.048854
Epoch 37 Loss 0.053228: 100% 23/23 [00:00<00:00, 1111.38it/s]
Doing validation... Validation Loss 0.047349
Epoch 38 Loss 0.057285: 100% 23/23 [00:00<00:00, 1088.35it/s]
Doing validation... Validation Loss 0.046008
Epoch 39 Loss 0.054786: 100% 23/23 [00:00<00:00, 936.44it/s]
Doing validation... Validation Loss 0.044834
Epoch 40 Loss 0.056405: 100% 23/23 [00:00<00:00, 1021.78it/s]
Doing validation... Validation Loss 0.043498
Epoch 41 Loss 0.052545: 100% 23/23 [00:00<00:00, 1078.24it/s]
Doing validation... Validation Loss 0.042417
Epoch 42 Loss 0.052924: 100% 23/23 [00:00<00:00, 1081.95it/s]
Doing validation... Validation Loss 0.041326
Epoch 43 Loss 0.051659: 100% 23/23 [00:00<00:00, 1065.99it/s]
Doing validation... Validation Loss 0.040351
Epoch 44 Loss 0.047918: 100% 23/23 [00:00<00:00, 1096.49it/s]
Doing validation... Validation Loss 0.039474
Epoch 45 Loss 0.052137: 100% 23/23 [00:00<00:00, 1104.31it/s]
Doing validation... Validation Loss 0.038607
Epoch 46 Loss 0.048629: 100% 23/23 [00:00<00:00, 840.37it/s]
Doing validation... Validation Loss 0.037729
Epoch 47 Loss 0.045450: 100% 23/23 [00:00<00:00, 903.26it/s]
Doing validation... Validation Loss 0.036961
Epoch 48 Loss 0.044297: 100% 23/23 [00:00<00:00, 846.05it/s]
Doing validation... Validation Loss 0.036236
```

```
Epoch 49 Loss 0.043171: 100% 23/23 [00:00<00:00, 1109.07it/s]
Doing validation... Validation Loss 0.035600
Epoch 50 Loss 0.042988: 100% 23/23 [00:00<00:00, 1116.63it/s]
Doing validation... Validation Loss 0.034914
Epoch 51 Loss 0.044014: 100% 23/23 [00:00<00:00, 816.01it/s]
Doing validation... Validation Loss 0.034272
Epoch 52 Loss 0.041549: 100% 23/23 [00:00<00:00, 1058.87it/s]
Doing validation... Validation Loss 0.033683
Epoch 53 Loss 0.041673: 100% 23/23 [00:00<00:00, 1086.96it/s]
Doing validation... Validation Loss 0.033135
Epoch 54 Loss 0.038442: 100% 23/23 [00:00<00:00, 1073.70it/s]
Doing validation... Validation Loss 0.032520
Epoch 55 Loss 0.041333: 100% 23/23 [00:00<00:00, 1110.98it/s]
Doing validation... Validation Loss 0.032029
Epoch 56 Loss 0.040825: 100% 23/23 [00:00<00:00, 1033.39it/s]
Doing validation... Validation Loss 0.031571
Epoch 57 Loss 0.038317: 100% 23/23 [00:00<00:00, 1044.01it/s]
Doing validation... Validation Loss 0.031009
Epoch 58 Loss 0.038242: 100% 23/23 [00:00<00:00, 941.97it/s]
Doing validation... Validation Loss 0.030534
Epoch 59 Loss 0.033791: 100% 23/23 [00:00<00:00, 959.59it/s]
Doing validation... Validation Loss 0.030164
Epoch 60 Loss 0.037922: 100% 23/23 [00:00<00:00, 778.25it/s]
Doing validation... Validation Loss 0.029690
Epoch 61 Loss 0.039511: 100% 23/23 [00:00<00:00, 958.14it/s]
Doing validation... Validation Loss 0.029182
Epoch 62 Loss 0.034924: 100% 23/23 [00:00<00:00, 952.48it/s]
Doing validation... Validation Loss 0.028814
Epoch 63 Loss 0.037737: 100% 23/23 [00:00<00:00, 1083.11it/s]
Doing validation... Validation Loss 0.028317
Epoch 64 Loss 0.035108: 100% 23/23 [00:00<00:00, 1104.23it/s]
Doing validation... Validation Loss 0.028003
Epoch 65 Loss 0.033309: 100% 23/23 [00:00<00:00, 1114.91it/s]
Doing validation... Validation Loss 0.027611
Epoch 66 Loss 0.032623: 100% 23/23 [00:00<00:00, 1054.44it/s]
Doing validation... Validation Loss 0.027174
Epoch 67 Loss 0.033861: 100% 23/23 [00:00<00:00, 1091.64it/s]
Doing validation... Validation Loss 0.026849
Epoch 68 Loss 0.034423: 100% 23/23 [00:00<00:00, 1100.39it/s]
Doing validation... Validation Loss 0.026478
Epoch 69 Loss 0.033848: 100% 23/23 [00:00<00:00, 610.93it/s]
Doing validation... Validation Loss 0.026108
Epoch 70 Loss 0.030546: 100% 23/23 [00:00<00:00, 1058.63it/s]
Doing validation... Validation Loss 0.025670
Epoch 71 Loss 0.032998: 100% 23/23 [00:00<00:00, 1096.54it/s]
Doing validation... Validation Loss 0.025382
Epoch 72 Loss 0.034571: 100% 23/23 [00:00<00:00, 1114.90it/s]
Doing validation... Validation Loss 0.025066
Epoch 73 Loss 0.032317: 100% 23/23 [00:00<00:00, 1115.92it/s]
Doing validation... Validation Loss 0.024696
Epoch 74 Loss 0.031070: 100% 23/23 [00:00<00:00, 1082.18it/s]
Doing validation... Validation Loss 0.024367
Epoch 75 Loss 0.030318: 100% 23/23 [00:00<00:00, 975.67it/s]
Doing validation... Validation Loss 0.023997
```

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Epoch 76 Loss 0.032786: 100% 23/23 [00:00<00:00, 1073.12it/s]
Doing validation... Validation Loss 0.023697
Epoch 77 Loss 0.031093: 100% 23/23 [00:00<00:00, 1124.03it/s]
Doing validation... Validation Loss 0.023453
Epoch 78 Loss 0.032787: 100% 23/23 [00:00<00:00, 842.73it/s]
Doing validation... Validation Loss 0.023096
Epoch 79 Loss 0.030495: 100% 23/23 [00:00<00:00, 1129.75it/s]
Doing validation... Validation Loss 0.022837
Epoch 80 Loss 0.028931: 100% 23/23 [00:00<00:00, 1128.15it/s]
Doing validation... Validation Loss 0.022519
Epoch 81 Loss 0.029598: 100% 23/23 [00:00<00:00, 1080.72it/s]
Doing validation... Validation Loss 0.022236
Epoch 82 Loss 0.029511: 100% 23/23 [00:00<00:00, 1100.33it/s]
Doing validation... Validation Loss 0.021951
Epoch 83 Loss 0.030211: 100% 23/23 [00:00<00:00, 1114.15it/s]
Doing validation... Validation Loss 0.021656
Epoch 84 Loss 0.027370: 100% 23/23 [00:00<00:00, 1006.25it/s]
Doing validation... Validation Loss 0.021383
Epoch 85 Loss 0.027697: 100% 23/23 [00:00<00:00, 1076.51it/s]
Doing validation... Validation Loss 0.021142
Epoch 86 Loss 0.026310: 100% 23/23 [00:00<00:00, 1080.45it/s]
Doing validation... Validation Loss 0.020849
Epoch 87 Loss 0.025385: 100% 23/23 [00:00<00:00, 1070.76it/s]
Doing validation... Validation Loss 0.020659
Epoch 88 Loss 0.026908: 100% 23/23 [00:00<00:00, 1115.27it/s]
Doing validation... Validation Loss 0.020392
Epoch 89 Loss 0.025064: 100% 23/23 [00:00<00:00, 1097.36it/s]
Doing validation... Validation Loss 0.020193
Epoch 90 Loss 0.025404: 100% 23/23 [00:00<00:00, 897.94it/s]
Doing validation... Validation Loss 0.019945
Epoch 91 Loss 0.024905: 100% 23/23 [00:00<00:00, 1094.60it/s]
Doing validation... Validation Loss 0.019687
Epoch 92 Loss 0.025448: 100% 23/23 [00:00<00:00, 1105.85it/s]
Doing validation... Validation Loss 0.019462
Epoch 93 Loss 0.022660: 100% 23/23 [00:00<00:00, 1025.33it/s]
Doing validation... Validation Loss 0.019339
Epoch 94 Loss 0.022778: 100% 23/23 [00:00<00:00, 1077.02it/s]
Doing validation... Validation Loss 0.019063
Epoch 95 Loss 0.024910: 100% 23/23 [00:00<00:00, 1117.54it/s]
Doing validation... Validation Loss 0.018877
Epoch 96 Loss 0.023643: 100% 23/23 [00:00<00:00, 1108.99it/s]
Doing validation... Validation Loss 0.018669
Epoch 97 Loss 0.023793: 100% 23/23 [00:00<00:00, 1111.30it/s]
Doing validation... Validation Loss 0.018413
Epoch 98 Loss 0.021768: 100% 23/23 [00:00<00:00, 1108.09it/s]
Doing validation... Validation Loss 0.018333
Epoch 99 Loss 0.023700: 100% 23/23 [00:00<00:00, 990.81it/s]
Doing validation... Validation Loss 0.018077
Epoch 100 Loss 0.022512: 100% 23/23 [00:00<00:00, 641.18it/s]
Doing validation... Validation Loss 0.017903
Epoch 101 Loss 0.021909: 100% 23/23 [00:00<00:00, 1117.77it/s]
Doing validation... Validation Loss 0.017733
Epoch 102 Loss 0.020836: 100% 23/23 [00:00<00:00, 1087.51it/s]
Doing validation... Validation Loss 0.017613
```

```
Epoch 103 Loss 0.023722: 100% 23/23 [00:00<00:00, 1090.06it/s]
Doing validation... Validation Loss 0.017378
Epoch 104 Loss 0.022220: 100% 23/23 [00:00<00:00, 1081.44it/s]
Doing validation... Validation Loss 0.017277
Epoch 105 Loss 0.020001: 100% 23/23 [00:00<00:00, 989.11it/s]
Doing validation... Validation Loss 0.017105
Epoch 106 Loss 0.021056: 100% 23/23 [00:00<00:00, 939.93it/s]
Doing validation... Validation Loss 0.016960
Epoch 107 Loss 0.021236: 100% 23/23 [00:00<00:00, 969.35it/s]
Doing validation... Validation Loss 0.016820
Epoch 108 Loss 0.019363: 100% 23/23 [00:00<00:00, 1090.17it/s]
Doing validation... Validation Loss 0.016612
Epoch 109 Loss 0.021653: 100% 23/23 [00:00<00:00, 1071.21it/s]
Doing validation... Validation Loss 0.016473
Epoch 110 Loss 0.020716: 100% 23/23 [00:00<00:00, 1112.01it/s]
Doing validation... Validation Loss 0.016353
Epoch 111 Loss 0.020723: 100% 23/23 [00:00<00:00, 1108.65it/s]
Doing validation... Validation Loss 0.016203
Epoch 112 Loss 0.020389: 100% 23/23 [00:00<00:00, 1095.94it/s]
Doing validation... Validation Loss 0.016034
Epoch 113 Loss 0.022531: 100% 23/23 [00:00<00:00, 1086.55it/s]
Doing validation... Validation Loss 0.015891
Epoch 114 Loss 0.019648: 100% 23/23 [00:00<00:00, 991.37it/s]
Doing validation... Validation Loss 0.015793
Epoch 115 Loss 0.021520: 100% 23/23 [00:00<00:00, 1115.88it/s]
Doing validation... Validation Loss 0.015604
Epoch 116 Loss 0.020839: 100% 23/23 [00:00<00:00, 1112.24it/s]
Doing validation... Validation Loss 0.015438
Epoch 117 Loss 0.018552: 100% 23/23 [00:00<00:00, 961.34it/s]
Doing validation... Validation Loss 0.015307
Epoch 118 Loss 0.018713: 100% 23/23 [00:00<00:00, 926.77it/s]
Doing validation... Validation Loss 0.015198
Epoch 119 Loss 0.019522: 100% 23/23 [00:00<00:00, 1102.83it/s]
Doing validation... Validation Loss 0.015041
Epoch 120 Loss 0.018081: 100% 23/23 [00:00<00:00, 1088.93it/s]
Doing validation... Validation Loss 0.014914
Epoch 121 Loss 0.018607: 100% 23/23 [00:00<00:00, 1021.28it/s]
Doing validation... Validation Loss 0.014736
Epoch 122 Loss 0.018068: 100% 23/23 [00:00<00:00, 1098.91it/s]
Doing validation... Validation Loss 0.014612
Epoch 123 Loss 0.019016: 100% 23/23 [00:00<00:00, 831.08it/s]
Doing validation... Validation Loss 0.014466
Epoch 124 Loss 0.018241: 100% 23/23 [00:00<00:00, 965.83it/s]
Doing validation... Validation Loss 0.014371
Epoch 125 Loss 0.018960: 100% 23/23 [00:00<00:00, 961.19it/s]
Doing validation... Validation Loss 0.014218
Epoch 126 Loss 0.018209: 100% 23/23 [00:00<00:00, 1082.64it/s]
Doing validation... Validation Loss 0.014097
Epoch 127 Loss 0.017730: 100% 23/23 [00:00<00:00, 1086.15it/s]
Doing validation... Validation Loss 0.013965
Epoch 128 Loss 0.017840: 100% 23/23 [00:00<00:00, 1090.91it/s]
Doing validation... Validation Loss 0.013885
Epoch 129 Loss 0.018010: 100% 23/23 [00:00<00:00, 1082.49it/s]
Doing validation... Validation Loss 0.013716
```

```
Epoch 130 Loss 0.015925: 100% 23/23 [00:00<00:00, 818.88it/s]
Doing validation... Validation Loss 0.013645
Epoch 131 Loss 0.017160: 100% 23/23 [00:00<00:00, 1091.70it/s]
Doing validation... Validation Loss 0.013565
Epoch 132 Loss 0.016099: 100% 23/23 [00:00<00:00, 1070.27it/s]
Doing validation... Validation Loss 0.013419
Epoch 133 Loss 0.018912: 100% 23/23 [00:00<00:00, 1098.81it/s]
Doing validation... Validation Loss 0.013334
Epoch 134 Loss 0.018077: 100% 23/23 [00:00<00:00, 1100.42it/s]
Doing validation... Validation Loss 0.013244
Epoch 135 Loss 0.015943: 100% 23/23 [00:00<00:00, 1024.78it/s]
Doing validation... Validation Loss 0.013146
Epoch 136 Loss 0.017033: 100% 23/23 [00:00<00:00, 1054.44it/s]
Doing validation... Validation Loss 0.013048
Epoch 137 Loss 0.015109: 100% 23/23 [00:00<00:00, 1088.81it/s]
Doing validation... Validation Loss 0.012963
Epoch 138 Loss 0.015423: 100% 23/23 [00:00<00:00, 967.56it/s]
Doing validation... Validation Loss 0.012857
Epoch 139 Loss 0.017685: 100% 23/23 [00:00<00:00, 1096.43it/s]
Doing validation... Validation Loss 0.012756
Epoch 140 Loss 0.016126: 100% 23/23 [00:00<00:00, 1106.35it/s]
Doing validation... Validation Loss 0.012678
Epoch 141 Loss 0.016596: 100% 23/23 [00:00<00:00, 979.14it/s]
Doing validation... Validation Loss 0.012593
Epoch 142 Loss 0.017117: 100% 23/23 [00:00<00:00, 1062.63it/s]
Doing validation... Validation Loss 0.012490
Epoch 143 Loss 0.015591: 100% 23/23 [00:00<00:00, 1085.54it/s]
Doing validation... Validation Loss 0.012384
Epoch 144 Loss 0.014259: 100% 23/23 [00:00<00:00, 1083.98it/s]
Doing validation... Validation Loss 0.012359
Epoch 145 Loss 0.015267: 100% 23/23 [00:00<00:00, 908.36it/s]
Doing validation... Validation Loss 0.012243
Epoch 146 Loss 0.015935: 100% 23/23 [00:00<00:00, 914.04it/s]
Doing validation... Validation Loss 0.012181
Epoch 147 Loss 0.015155: 100% 23/23 [00:00<00:00, 931.69it/s]
Doing validation... Validation Loss 0.012085
Epoch 148 Loss 0.015042: 100% 23/23 [00:00<00:00, 966.97it/s]
Doing validation... Validation Loss 0.012031
Epoch 149 Loss 0.015264: 100% 23/23 [00:00<00:00, 1102.48it/s]
Doing validation... Validation Loss 0.011980
Epoch 150 Loss 0.015332: 100% 23/23 [00:00<00:00, 1099.61it/s]
Doing validation... Validation Loss 0.011861
Epoch 151 Loss 0.015031: 100% 23/23 [00:00<00:00, 1106.51it/s]
Doing validation... Validation Loss 0.011767
Epoch 152 Loss 0.014386: 100% 23/23 [00:00<00:00, 979.08it/s]
Doing validation... Validation Loss 0.011696
Epoch 153 Loss 0.014046: 100% 23/23 [00:00<00:00, 838.82it/s]
Doing validation... Validation Loss 0.011616
Epoch 154 Loss 0.016293: 100% 23/23 [00:00<00:00, 1098.62it/s]
Doing validation... Validation Loss 0.011550
Epoch 155 Loss 0.013996: 100% 23/23 [00:00<00:00, 1095.49it/s]
Doing validation... Validation Loss 0.011514
Epoch 156 Loss 0.013737: 100% 23/23 [00:00<00:00, 1061.80it/s]
Doing validation... Validation Loss 0.011424
```

```
Epoch 157 Loss 0.012540: 100% 23/23 [00:00<00:00, 1102.59it/s]
Doing validation... Validation Loss 0.011320
Epoch 158 Loss 0.014300: 100% 23/23 [00:00<00:00, 1078.61it/s]
Doing validation... Validation Loss 0.011285
Epoch 159 Loss 0.014682: 100% 23/23 [00:00<00:00, 1087.91it/s]
Doing validation... Validation Loss 0.011199
Epoch 160 Loss 0.013768: 100% 23/23 [00:00<00:00, 948.38it/s]
Doing validation... Validation Loss 0.011124
Epoch 161 Loss 0.015230: 100% 23/23 [00:00<00:00, 949.31it/s]
Doing validation... Validation Loss 0.011081
Epoch 162 Loss 0.014196: 100% 23/23 [00:00<00:00, 818.65it/s]
Doing validation... Validation Loss 0.010986
Epoch 163 Loss 0.013677: 100% 23/23 [00:00<00:00, 1109.37it/s]
Doing validation... Validation Loss 0.010941
Epoch 164 Loss 0.013447: 100% 23/23 [00:00<00:00, 1064.79it/s]
Doing validation... Validation Loss 0.010853
Epoch 165 Loss 0.014230: 100% 23/23 [00:00<00:00, 1050.35it/s]
Doing validation... Validation Loss 0.010804
Epoch 166 Loss 0.013147: 100% 23/23 [00:00<00:00, 1113.88it/s]
Doing validation... Validation Loss 0.010725
Epoch 167 Loss 0.012201: 100% 23/23 [00:00<00:00, 1101.80it/s]
Doing validation... Validation Loss 0.010646
Epoch 168 Loss 0.013549: 100% 23/23 [00:00<00:00, 1045.64it/s]
Doing validation... Validation Loss 0.010615
Epoch 169 Loss 0.013366: 100% 23/23 [00:00<00:00, 1119.14it/s]
Doing validation... Validation Loss 0.010553
Epoch 170 Loss 0.013018: 100% 23/23 [00:00<00:00, 962.66it/s]
Doing validation... Validation Loss 0.010505
Epoch 171 Loss 0.013178: 100% 23/23 [00:00<00:00, 912.05it/s]
Doing validation... Validation Loss 0.010411
Epoch 172 Loss 0.013878: 100% 23/23 [00:00<00:00, 1085.84it/s]
Doing validation... Validation Loss 0.010375
Epoch 173 Loss 0.013399: 100% 23/23 [00:00<00:00, 1107.32it/s]
Doing validation... Validation Loss 0.010353
Epoch 174 Loss 0.013255: 100% 23/23 [00:00<00:00, 1089.15it/s]
Doing validation... Validation Loss 0.010297
Epoch 175 Loss 0.014297: 100% 23/23 [00:00<00:00, 1022.10it/s]
Doing validation... Validation Loss 0.010226
Epoch 176 Loss 0.012913: 100% 23/23 [00:00<00:00, 867.51it/s]
Doing validation... Validation Loss 0.010167
Epoch 177 Loss 0.012569: 100% 23/23 [00:00<00:00, 1094.66it/s]
Doing validation... Validation Loss 0.010103
Epoch 178 Loss 0.013032: 100% 23/23 [00:00<00:00, 1116.49it/s]
Doing validation... Validation Loss 0.010062
Epoch 179 Loss 0.012775: 100% 23/23 [00:00<00:00, 1041.16it/s]
Doing validation... Validation Loss 0.009993
Epoch 180 Loss 0.013214: 100% 23/23 [00:00<00:00, 821.24it/s]
Doing validation... Validation Loss 0.009967
Epoch 181 Loss 0.011560: 100% 23/23 [00:00<00:00, 940.12it/s]
Doing validation... Validation Loss 0.009922
Epoch 182 Loss 0.012915: 100% 23/23 [00:00<00:00, 932.36it/s]
Doing validation... Validation Loss 0.009879
Epoch 183 Loss 0.011706: 100% 23/23 [00:00<00:00, 1091.53it/s]
Doing validation... Validation Loss 0.009831
```

```
Epoch 184 Loss 0.011459: 100% 23/23 [00:00<00:00, 1130.38it/s]
Doing validation... Validation Loss 0.009792
Epoch 185 Loss 0.012879: 100% 23/23 [00:00<00:00, 1070.91it/s]
Doing validation... Validation Loss 0.009734
Epoch 186 Loss 0.012579: 100% 23/23 [00:00<00:00, 1089.31it/s]
Doing validation... Validation Loss 0.009687
Epoch 187 Loss 0.012592: 100% 23/23 [00:00<00:00, 1118.05it/s]
Doing validation... Validation Loss 0.009633
Epoch 188 Loss 0.011817: 100% 23/23 [00:00<00:00, 1073.01it/s]
Doing validation... Validation Loss 0.009568
Epoch 189 Loss 0.011908: 100% 23/23 [00:00<00:00, 1128.64it/s]
Doing validation... Validation Loss 0.009553
Epoch 190 Loss 0.012431: 100% 23/23 [00:00<00:00, 824.06it/s]
Doing validation... Validation Loss 0.009543
Epoch 191 Loss 0.012769: 100% 23/23 [00:00<00:00, 740.32it/s]
Doing validation... Validation Loss 0.009484
Epoch 192 Loss 0.012704: 100% 23/23 [00:00<00:00, 930.62it/s]
Doing validation... Validation Loss 0.009408
Epoch 193 Loss 0.011636: 100% 23/23 [00:00<00:00, 988.38it/s]
Doing validation... Validation Loss 0.009361
Epoch 194 Loss 0.012270: 100% 23/23 [00:00<00:00, 1092.58it/s]
Doing validation... Validation Loss 0.009349
Epoch 195 Loss 0.011769: 100% 23/23 [00:00<00:00, 1054.54it/s]
Doing validation... Validation Loss 0.009301
Epoch 196 Loss 0.012344: 100% 23/23 [00:00<00:00, 1086.57it/s]
Doing validation... Validation Loss 0.009292
Epoch 197 Loss 0.011629: 100% 23/23 [00:00<00:00, 1086.15it/s]
Doing validation... Validation Loss 0.009242
Epoch 198 Loss 0.012544: 100% 23/23 [00:00<00:00, 832.76it/s]
Doing validation... Validation Loss 0.009212
Epoch 199 Loss 0.011892: 100% 23/23 [00:00<00:00, 1099.31it/s]
Doing validation... Validation Loss 0.009145
Epoch 200 Loss 0.011572: 100% 23/23 [00:00<00:00, 1097.45it/s]
Doing validation... Validation Loss 0.009091
Epoch 201 Loss 0.012621: 100% 23/23 [00:00<00:00, 1066.53it/s]
Doing validation... Validation Loss 0.009103
Epoch 202 Loss 0.011587: 100% 23/23 [00:00<00:00, 1114.45it/s]
Doing validation... Validation Loss 0.009047
Epoch 203 Loss 0.011258: 100% 23/23 [00:00<00:00, 1082.09it/s]
Doing validation... Validation Loss 0.009032
Epoch 204 Loss 0.011867: 100% 23/23 [00:00<00:00, 891.21it/s]
Doing validation... Validation Loss 0.008975
Epoch 205 Loss 0.012157: 100% 23/23 [00:00<00:00, 1119.13it/s]
Doing validation... Validation Loss 0.008931
Epoch 206 Loss 0.010480: 100% 23/23 [00:00<00:00, 1102.92it/s]
Doing validation... Validation Loss 0.008915
Epoch 207 Loss 0.011830: 100% 23/23 [00:00<00:00, 1086.11it/s]
Doing validation... Validation Loss 0.008859
Epoch 208 Loss 0.010958: 100% 23/23 [00:00<00:00, 1128.87it/s]
Doing validation... Validation Loss 0.008809
Epoch 209 Loss 0.010946: 100% 23/23 [00:00<00:00, 995.80it/s]
Doing validation... Validation Loss 0.008802
Epoch 210 Loss 0.010882: 100% 23/23 [00:00<00:00, 1110.24it/s]
Doing validation... Validation Loss 0.008764
```

```
Epoch 211 Loss 0.010794: 100% 23/23 [00:00<00:00, 852.05it/s]
Doing validation... Validation Loss 0.008749
Epoch 212 Loss 0.011050: 100% 23/23 [00:00<00:00, 927.76it/s]
Doing validation... Validation Loss 0.008729
Epoch 213 Loss 0.011626: 100% 23/23 [00:00<00:00, 1078.99it/s]
Doing validation... Validation Loss 0.008682
Epoch 214 Loss 0.011075: 100% 23/23 [00:00<00:00, 1103.15it/s]
Doing validation... Validation Loss 0.008662
Epoch 215 Loss 0.010426: 100% 23/23 [00:00<00:00, 1090.82it/s]
Doing validation... Validation Loss 0.008643
Epoch 216 Loss 0.010870: 100% 23/23 [00:00<00:00, 1118.40it/s]
Doing validation... Validation Loss 0.008591
Epoch 217 Loss 0.010590: 100% 23/23 [00:00<00:00, 1120.47it/s]
Doing validation... Validation Loss 0.008545
Epoch 218 Loss 0.010350: 100% 23/23 [00:00<00:00, 910.18it/s]
Doing validation... Validation Loss 0.008564
Epoch 219 Loss 0.010159: 100% 23/23 [00:00<00:00, 1130.79it/s]
Doing validation... Validation Loss 0.008542
Epoch 220 Loss 0.009246: 100% 23/23 [00:00<00:00, 903.93it/s]
Doing validation... Validation Loss 0.008505
Epoch 221 Loss 0.009840: 100% 23/23 [00:00<00:00, 766.11it/s]
Doing validation... Validation Loss 0.008465
Epoch 222 Loss 0.010848: 100% 23/23 [00:00<00:00, 942.72it/s]
Doing validation... Validation Loss 0.008434
Epoch 223 Loss 0.010801: 100% 23/23 [00:00<00:00, 981.65it/s]
Doing validation... Validation Loss 0.008437
Epoch 224 Loss 0.009908: 100% 23/23 [00:00<00:00, 1105.73it/s]
Doing validation... Validation Loss 0.008404
Epoch 225 Loss 0.009985: 100% 23/23 [00:00<00:00, 967.70it/s]
Doing validation... Validation Loss 0.008408
Epoch 226 Loss 0.010596: 100% 23/23 [00:00<00:00, 1107.85it/s]
Doing validation... Validation Loss 0.008366
Epoch 227 Loss 0.010424: 100% 23/23 [00:00<00:00, 852.11it/s]
Doing validation... Validation Loss 0.008366
Epoch 228 Loss 0.010934: 100% 23/23 [00:00<00:00, 769.69it/s]
Doing validation... Validation Loss 0.008321
Epoch 229 Loss 0.010233: 100% 23/23 [00:00<00:00, 966.70it/s]
Doing validation... Validation Loss 0.008294
Epoch 230 Loss 0.010761: 100% 23/23 [00:00<00:00, 1082.56it/s]
Doing validation... Validation Loss 0.008298
Epoch 231 Loss 0.011002: 100% 23/23 [00:00<00:00, 971.23it/s]
Doing validation... Validation Loss 0.008298
Epoch 232 Loss 0.011318: 100% 23/23 [00:00<00:00, 1032.46it/s]
Doing validation... Validation Loss 0.008252
Epoch 233 Loss 0.010554: 100% 23/23 [00:00<00:00, 1096.75it/s]
Doing validation... Validation Loss 0.008270
Epoch 234 Loss 0.010377: 100% 23/23 [00:00<00:00, 816.28it/s]
Doing validation... Validation Loss 0.008258
Epoch 235 Loss 0.009812: 100% 23/23 [00:00<00:00, 1054.52it/s]
Doing validation... Validation Loss 0.008208
Epoch 236 Loss 0.010221: 100% 23/23 [00:00<00:00, 1099.45it/s]
Doing validation... Validation Loss 0.008205
Epoch 237 Loss 0.009546: 100% 23/23 [00:00<00:00, 1064.64it/s]
Doing validation... Validation Loss 0.008203
```

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Epoch 238 Loss 0.010746: 100% 23/23 [00:00<00:00, 963.98it/s]
Doing validation... Validation Loss 0.008188
Epoch 239 Loss 0.010331: 100% 23/23 [00:00<00:00, 1105.09it/s]
Doing validation... Validation Loss 0.008185
Epoch 240 Loss 0.010660: 100% 23/23 [00:00<00:00, 800.81it/s]
Doing validation... Validation Loss 0.008177
Epoch 241 Loss 0.009698: 100% 23/23 [00:00<00:00, 1028.56it/s]
Doing validation... Validation Loss 0.008180
Epoch 242 Loss 0.010034: 100% 23/23 [00:00<00:00, 1075.40it/s]
Doing validation... Validation Loss 0.008154
Epoch 243 Loss 0.009285: 100% 23/23 [00:00<00:00, 1035.79it/s]
Doing validation... Validation Loss 0.008153
Epoch 244 Loss 0.011378: 100% 23/23 [00:00<00:00, 1081.15it/s]
Doing validation... Validation Loss 0.008158
Epoch 245 Loss 0.009272: 100% 23/23 [00:00<00:00, 1095.55it/s]
Doing validation... Validation Loss 0.008130
Epoch 246 Loss 0.009930: 100% 23/23 [00:00<00:00, 1075.81it/s]
Doing validation... Validation Loss 0.008114
Epoch 247 Loss 0.010625: 100% 23/23 [00:00<00:00, 965.75it/s]
Doing validation... Validation Loss 0.008088
Epoch 248 Loss 0.010052: 100% 23/23 [00:00<00:00, 1109.14it/s]
Doing validation... Validation Loss 0.008148
Epoch 249 Loss 0.009516: 100% 23/23 [00:00<00:00, 807.59it/s]
Doing validation... Validation Loss 0.008128
Epoch 250 Loss 0.010979: 100% 23/23 [00:00<00:00, 957.99it/s]
Doing validation... Validation Loss 0.008083
Epoch 251 Loss 0.010502: 100% 23/23 [00:00<00:00, 764.54it/s]
Doing validation... Validation Loss 0.008100
Epoch 252 Loss 0.009928: 100% 23/23 [00:00<00:00, 970.87it/s]
Doing validation... Validation Loss 0.008072
Epoch 253 Loss 0.010095: 100% 23/23 [00:00<00:00, 1095.06it/s]
Doing validation... Validation Loss 0.008101
Epoch 254 Loss 0.010001: 100% 23/23 [00:00<00:00, 1062.75it/s]
Doing validation... Validation Loss 0.008087
Epoch 255 Loss 0.008767: 100% 23/23 [00:00<00:00, 1060.31it/s]
Doing validation... Validation Loss 0.008059
Epoch 256 Loss 0.010091: 100% 23/23 [00:00<00:00, 1107.01it/s]
Doing validation... Validation Loss 0.008071
Epoch 257 Loss 0.009204: 100% 23/23 [00:00<00:00, 1051.34it/s]
Doing validation... Validation Loss 0.008079
Epoch 258 Loss 0.010577: 100% 23/23 [00:00<00:00, 1102.60it/s]
Doing validation... Validation Loss 0.008090
Epoch 259 Loss 0.009754: 100% 23/23 [00:00<00:00, 1082.75it/s]
Doing validation... Validation Loss 0.008067
Epoch 260 Loss 0.008829: 100% 23/23 [00:00<00:00, 1111.13it/s]
Doing validation... Validation Loss 0.008054
Epoch 261 Loss 0.009804: 100% 23/23 [00:00<00:00, 1108.79it/s]
Doing validation... Validation Loss 0.008069
Epoch 262 Loss 0.009964: 100% 23/23 [00:00<00:00, 1101.99it/s]
Doing validation... Validation Loss 0.008061
Epoch 263 Loss 0.009272: 100% 23/23 [00:00<00:00, 1112.93it/s]
Doing validation... Validation Loss 0.007999
Epoch 264 Loss 0.010085: 100% 23/23 [00:00<00:00, 781.57it/s]
Doing validation... Validation Loss 0.008072
```

```
Epoch 265 Loss 0.009486: 100% 23/23 [00:00<00:00, 973.91it/s]
Doing validation... Validation Loss 0.008053
Epoch 266 Loss 0.010427: 100% 23/23 [00:00<00:00, 944.33it/s]
Doing validation... Validation Loss 0.008042
Epoch 267 Loss 0.009990: 100% 23/23 [00:00<00:00, 1095.78it/s]
Doing validation... Validation Loss 0.008046
Epoch 268 Loss 0.009893: 100% 23/23 [00:00<00:00, 1110.46it/s]
Doing validation... Validation Loss 0.008064
Epoch 269 Loss 0.009913: 100% 23/23 [00:00<00:00, 1072.18it/s]
Doing validation... Validation Loss 0.008063
Epoch 270 Loss 0.009402: 100% 23/23 [00:00<00:00, 1094.81it/s]
Doing validation... Validation Loss 0.008035
Epoch 271 Loss 0.009274: 100% 23/23 [00:00<00:00, 1003.81it/s]
Doing validation... Validation Loss 0.008017
Epoch 272 Loss 0.009753: 100% 23/23 [00:00<00:00, 1008.02it/s]
Doing validation... Validation Loss 0.007999
Epoch 273 Loss 0.010197: 100% 23/23 [00:00<00:00, 954.77it/s]
Doing validation... Validation Loss 0.008024
Epoch 274 Loss 0.009617: 100% 23/23 [00:00<00:00, 1117.37it/s]
Doing validation... Validation Loss 0.007995
Epoch 275 Loss 0.009918: 100% 23/23 [00:00<00:00, 1083.98it/s]
Doing validation... Validation Loss 0.008052
Epoch 276 Loss 0.009759: 100% 23/23 [00:00<00:00, 1109.18it/s]
Doing validation... Validation Loss 0.008049
Epoch 277 Loss 0.009526: 100% 23/23 [00:00<00:00, 1107.32it/s]
Doing validation... Validation Loss 0.008058
Epoch 278 Loss 0.010172: 100% 23/23 [00:00<00:00, 1101.71it/s]
Doing validation... Validation Loss 0.008023
Epoch 279 Loss 0.009772: 100% 23/23 [00:00<00:00, 788.24it/s]
Doing validation... Validation Loss 0.007986
Epoch 280 Loss 0.009594: 100% 23/23 [00:00<00:00, 908.76it/s]
Doing validation... Validation Loss 0.008023
Epoch 281 Loss 0.009389: 100% 23/23 [00:00<00:00, 836.46it/s]
Doing validation... Validation Loss 0.007998
Epoch 282 Loss 0.009512: 100% 23/23 [00:00<00:00, 897.65it/s]
Doing validation... Validation Loss 0.008034
Epoch 283 Loss 0.009641: 100% 23/23 [00:00<00:00, 1060.86it/s]
Doing validation... Validation Loss 0.008010
Epoch 284 Loss 0.010511: 100% 23/23 [00:00<00:00, 774.19it/s]
Doing validation... Validation Loss 0.008038
Epoch 285 Loss 0.010023: 100% 23/23 [00:00<00:00, 1052.89it/s]
Doing validation... Validation Loss 0.008022
Epoch 286 Loss 0.009881: 100% 23/23 [00:00<00:00, 1078.76it/s]
Doing validation... Validation Loss 0.008002
Epoch 287 Loss 0.009909: 100% 23/23 [00:00<00:00, 1060.39it/s]
Doing validation... Validation Loss 0.008019
Epoch 288 Loss 0.010255: 100% 23/23 [00:00<00:00, 1056.79it/s]
Doing validation... Validation Loss 0.007976
Epoch 289 Loss 0.009956: 100% 23/23 [00:00<00:00, 1085.43it/s]
Doing validation... Validation Loss 0.008008
Epoch 290 Loss 0.010093: 100% 23/23 [00:00<00:00, 1073.42it/s]
Doing validation... Validation Loss 0.007991
Epoch 291 Loss 0.009152: 100% 23/23 [00:00<00:00, 1053.59it/s]
Doing validation... Validation Loss 0.008004
```

```
Epoch 292 Loss 0.009327: 100% 23/23 [00:00<00:00, 1083.19it/s]
Doing validation... Validation Loss 0.008012
Epoch 293 Loss 0.009857: 100% 23/23 [00:00<00:00, 698.13it/s]
Doing validation... Validation Loss 0.008011
Epoch 294 Loss 0.010070: 100% 23/23 [00:00<00:00, 1078.67it/s]
Doing validation... Validation Loss 0.008013
Epoch 295 Loss 0.009990: 100% 23/23 [00:00<00:00, 1095.29it/s]
Doing validation... Validation Loss 0.007992
Epoch 296 Loss 0.010474: 100% 23/23 [00:00<00:00, 1085.06it/s]
Doing validation... Validation Loss 0.008004
Epoch 297 Loss 0.009583: 100% 23/23 [00:00<00:00, 1057.52it/s]
Doing validation... Validation Loss 0.008006
Epoch 298 Loss 0.010928: 100% 23/23 [00:00<00:00, 1091.99it/s]
Doing validation... Validation Loss 0.007995
Epoch 299 Loss 0.009208: 100% 23/23 [00:00<00:00, 1084.59it/s]
Doing validation... Validation Loss 0.008004
Epoch 300 Loss 0.009850: 100% 23/23 [00:00<00:00, 1005.41it/s]
Doing validation... Validation Loss 0.008029
AE-Reconstruction error for 64-dimensional hidden representation is
86.51452433283427
PCA-Reconstruction error for 128 components is 45.633694294093935
---Run...
Epoch 1 Loss 0.635747: 100% 23/23 [00:00<00:00, 520.95it/s]
Doing validation... Validation Loss 0.423463
Epoch 2 Loss 0.362582: 100% 23/23 [00:00<00:00, 406.73it/s]
Doing validation... Validation Loss 0.258786
Epoch 3 Loss 0.249942: 100% 23/23 [00:00<00:00, 735.26it/s]
Doing validation... Validation Loss 0.187720
Epoch 4 Loss 0.204972: 100% 23/23 [00:00<00:00, 838.26it/s]
Doing validation... Validation Loss 0.148576
Epoch 5 Loss 0.156397: 100% 23/23 [00:00<00:00, 651.02it/s]
Doing validation... Validation Loss 0.120886
Epoch 6 Loss 0.124525: 100% 23/23 [00:00<00:00, 857.56it/s]
Doing validation... Validation Loss 0.101432
Epoch 7 Loss 0.111682: 100% 23/23 [00:00<00:00, 753.66it/s]
Doing validation... Validation Loss 0.086428
Epoch 8 Loss 0.098293: 100% 23/23 [00:00<00:00, 874.94it/s]
Doing validation... Validation Loss 0.075365
Epoch 9 Loss 0.087556: 100% 23/23 [00:00<00:00, 867.32it/s]
Doing validation... Validation Loss 0.066619
Epoch 10 Loss 0.077389: 100% 23/23 [00:00<00:00, 816.02it/s]
Doing validation... Validation Loss 0.059249
Epoch 11 Loss 0.064271: 100% 23/23 [00:00<00:00, 862.41it/s]
Doing validation... Validation Loss 0.053095
Epoch 12 Loss 0.060568: 100% 23/23 [00:00<00:00, 647.88it/s]
Doing validation... Validation Loss 0.048139
Epoch 13 Loss 0.055333: 100% 23/23 [00:00<00:00, 856.47it/s]
Doing validation... Validation Loss 0.043762
Epoch 14 Loss 0.052747: 100% 23/23 [00:00<00:00, 859.37it/s]
Doing validation... Validation Loss 0.040183
Epoch 15 Loss 0.047506: 100% 23/23 [00:00<00:00, 863.54it/s]
Doing validation... Validation Loss 0.036966
Epoch 16 Loss 0.041161: 100% 23/23 [00:00<00:00, 839.58it/s]
Doing validation... Validation Loss 0.034273
```

```
Epoch 17 Loss 0.041202: 100% 23/23 [00:00<00:00, 729.86it/s]
Doing validation... Validation Loss 0.032044
Epoch 18 Loss 0.036571: 100% 23/23 [00:00<00:00, 855.78it/s]
Doing validation... Validation Loss 0.029824
Epoch 19 Loss 0.036356: 100% 23/23 [00:00<00:00, 847.42it/s]
Doing validation... Validation Loss 0.027942
Epoch 20 Loss 0.032511: 100% 23/23 [00:00<00:00, 806.54it/s]
Doing validation... Validation Loss 0.026277
Epoch 21 Loss 0.031263: 100% 23/23 [00:00<00:00, 791.89it/s]
Doing validation... Validation Loss 0.024793
Epoch 22 Loss 0.029518: 100% 23/23 [00:00<00:00, 756.88it/s]
Doing validation... Validation Loss 0.023468
Epoch 23 Loss 0.028550: 100% 23/23 [00:00<00:00, 854.77it/s]
Doing validation... Validation Loss 0.022119
Epoch 24 Loss 0.027908: 100% 23/23 [00:00<00:00, 831.90it/s]
Doing validation... Validation Loss 0.021110
Epoch 25 Loss 0.024156: 100% 23/23 [00:00<00:00, 872.79it/s]
Doing validation... Validation Loss 0.020083
Epoch 26 Loss 0.025657: 100% 23/23 [00:00<00:00, 802.74it/s]
Doing validation... Validation Loss 0.019157
Epoch 27 Loss 0.022701: 100% 23/23 [00:00<00:00, 605.01it/s]
Doing validation... Validation Loss 0.018275
Epoch 28 Loss 0.022190: 100% 23/23 [00:00<00:00, 776.92it/s]
Doing validation... Validation Loss 0.017487
Epoch 29 Loss 0.021464: 100% 23/23 [00:00<00:00, 757.93it/s]
Doing validation... Validation Loss 0.016814
Epoch 30 Loss 0.022370: 100% 23/23 [00:00<00:00, 773.65it/s]
Doing validation... Validation Loss 0.016106
Epoch 31 Loss 0.019258: 100% 23/23 [00:00<00:00, 835.29it/s]
Doing validation... Validation Loss 0.015512
Epoch 32 Loss 0.018533: 100% 23/23 [00:00<00:00, 863.85it/s]
Doing validation... Validation Loss 0.014918
Epoch 33 Loss 0.017598: 100% 23/23 [00:00<00:00, 861.88it/s]
Doing validation... Validation Loss 0.014390
Epoch 34 Loss 0.018196: 100% 23/23 [00:00<00:00, 742.50it/s]
Doing validation... Validation Loss 0.013856
Epoch 35 Loss 0.017293: 100% 23/23 [00:00<00:00, 599.80it/s]
Doing validation... Validation Loss 0.013385
Epoch 36 Loss 0.015165: 100% 23/23 [00:00<00:00, 741.77it/s]
Doing validation... Validation Loss 0.012957
Epoch 37 Loss 0.015268: 100% 23/23 [00:00<00:00, 786.37it/s]
Doing validation... Validation Loss 0.012537
Epoch 38 Loss 0.015011: 100% 23/23 [00:00<00:00, 657.24it/s]
Doing validation... Validation Loss 0.012172
Epoch 39 Loss 0.013222: 100% 23/23 [00:00<00:00, 716.49it/s]
Doing validation... Validation Loss 0.011811
Epoch 40 Loss 0.014646: 100% 23/23 [00:00<00:00, 798.66it/s]
Doing validation... Validation Loss 0.011483
Epoch 41 Loss 0.012897: 100% 23/23 [00:00<00:00, 859.21it/s]
Doing validation... Validation Loss 0.011124
Epoch 42 Loss 0.012417: 100% 23/23 [00:00<00:00, 827.46it/s]
Doing validation... Validation Loss 0.010804
Epoch 43 Loss 0.013012: 100% 23/23 [00:00<00:00, 862.56it/s]
Doing validation... Validation Loss 0.010546
```

```
Epoch 44 Loss 0.012610: 100% 23/23 [00:00<00:00, 847.27it/s]
Doing validation... Validation Loss 0.010262
Epoch 45 Loss 0.011863: 100% 23/23 [00:00<00:00, 560.13it/s]
Doing validation... Validation Loss 0.009995
Epoch 46 Loss 0.012145: 100% 23/23 [00:00<00:00, 750.57it/s]
Doing validation... Validation Loss 0.009758
Epoch 47 Loss 0.011334: 100% 23/23 [00:00<00:00, 760.77it/s]
Doing validation... Validation Loss 0.009482
Epoch 48 Loss 0.012296: 100% 23/23 [00:00<00:00, 759.41it/s]
Doing validation... Validation Loss 0.009293
Epoch 49 Loss 0.011673: 100% 23/23 [00:00<00:00, 641.61it/s]
Doing validation... Validation Loss 0.009053
Epoch 50 Loss 0.010024: 100% 23/23 [00:00<00:00, 856.47it/s]
Doing validation... Validation Loss 0.008857
Epoch 51 Loss 0.010867: 100% 23/23 [00:00<00:00, 690.14it/s]
Doing validation... Validation Loss 0.008678
Epoch 52 Loss 0.010551: 100% 23/23 [00:00<00:00, 846.95it/s]
Doing validation... Validation Loss 0.008466
Epoch 53 Loss 0.010226: 100% 23/23 [00:00<00:00, 851.79it/s]
Doing validation... Validation Loss 0.008292
Epoch 54 Loss 0.010361: 100% 23/23 [00:00<00:00, 839.26it/s]
Doing validation... Validation Loss 0.008131
Epoch 55 Loss 0.009252: 100% 23/23 [00:00<00:00, 751.02it/s]
Doing validation... Validation Loss 0.007974
Epoch 56 Loss 0.009486: 100% 23/23 [00:00<00:00, 836.27it/s]
Doing validation... Validation Loss 0.007813
Epoch 57 Loss 0.009718: 100% 23/23 [00:00<00:00, 876.73it/s]
Doing validation... Validation Loss 0.007638
Epoch 58 Loss 0.008219: 100% 23/23 [00:00<00:00, 507.19it/s]
Doing validation... Validation Loss 0.007523
Epoch 59 Loss 0.009628: 100% 23/23 [00:00<00:00, 734.02it/s]
Doing validation... Validation Loss 0.007369
Epoch 60 Loss 0.008650: 100% 23/23 [00:00<00:00, 821.75it/s]
Doing validation... Validation Loss 0.007223
Epoch 61 Loss 0.008909: 100% 23/23 [00:00<00:00, 868.55it/s]
Doing validation... Validation Loss 0.007107
Epoch 62 Loss 0.008995: 100% 23/23 [00:00<00:00, 806.99it/s]
Doing validation... Validation Loss 0.006997
Epoch 63 Loss 0.009713: 100% 23/23 [00:00<00:00, 876.98it/s]
Doing validation... Validation Loss 0.006861
Epoch 64 Loss 0.008568: 100% 23/23 [00:00<00:00, 840.86it/s]
Doing validation... Validation Loss 0.006757
Epoch 65 Loss 0.007824: 100% 23/23 [00:00<00:00, 606.34it/s]
Doing validation... Validation Loss 0.006642
Epoch 66 Loss 0.008032: 100% 23/23 [00:00<00:00, 772.88it/s]
Doing validation... Validation Loss 0.006549
Epoch 67 Loss 0.007704: 100% 23/23 [00:00<00:00, 584.11it/s]
Doing validation... Validation Loss 0.006429
Epoch 68 Loss 0.007230: 100% 23/23 [00:00<00:00, 746.20it/s]
Doing validation... Validation Loss 0.006335
Epoch 69 Loss 0.007204: 100% 23/23 [00:00<00:00, 796.82it/s]
Doing validation... Validation Loss 0.006239
Epoch 70 Loss 0.007816: 100% 23/23 [00:00<00:00, 790.55it/s]
Doing validation... Validation Loss 0.006141
```

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Epoch 71 Loss 0.007687: 100% 23/23 [00:00<00:00, 813.01it/s]
Doing validation... Validation Loss 0.006045
Epoch 72 Loss 0.007605: 100% 23/23 [00:00<00:00, 736.28it/s]
Doing validation... Validation Loss 0.005948
Epoch 73 Loss 0.006976: 100% 23/23 [00:00<00:00, 857.98it/s]
Doing validation... Validation Loss 0.005886
Epoch 74 Loss 0.007128: 100% 23/23 [00:00<00:00, 874.47it/s]
Doing validation... Validation Loss 0.005812
Epoch 75 Loss 0.006779: 100% 23/23 [00:00<00:00, 858.49it/s]
Doing validation... Validation Loss 0.005725
Epoch 76 Loss 0.006873: 100% 23/23 [00:00<00:00, 853.92it/s]
Doing validation... Validation Loss 0.005643
Epoch 77 Loss 0.006801: 100% 23/23 [00:00<00:00, 840.86it/s]
Doing validation... Validation Loss 0.005574
Epoch 78 Loss 0.006383: 100% 23/23 [00:00<00:00, 846.32it/s]
Doing validation... Validation Loss 0.005504
Epoch 79 Loss 0.006559: 100% 23/23 [00:00<00:00, 695.13it/s]
Doing validation... Validation Loss 0.005430
Epoch 80 Loss 0.006379: 100% 23/23 [00:00<00:00, 869.18it/s]
Doing validation... Validation Loss 0.005366
Epoch 81 Loss 0.006116: 100% 23/23 [00:00<00:00, 861.38it/s]
Doing validation... Validation Loss 0.005277
Epoch 82 Loss 0.006332: 100% 23/23 [00:00<00:00, 891.52it/s]
Doing validation... Validation Loss 0.005233
Epoch 83 Loss 0.006906: 100% 23/23 [00:00<00:00, 893.40it/s]
Doing validation... Validation Loss 0.005184
Epoch 84 Loss 0.006502: 100% 23/23 [00:00<00:00, 857.92it/s]
Doing validation... Validation Loss 0.005126
Epoch 85 Loss 0.006270: 100% 23/23 [00:00<00:00, 827.73it/s]
Doing validation... Validation Loss 0.005067
Epoch 86 Loss 0.006122: 100% 23/23 [00:00<00:00, 604.98it/s]
Doing validation... Validation Loss 0.004994
Epoch 87 Loss 0.005590: 100% 23/23 [00:00<00:00, 711.85it/s]
Doing validation... Validation Loss 0.004948
Epoch 88 Loss 0.005881: 100% 23/23 [00:00<00:00, 709.38it/s]
Doing validation... Validation Loss 0.004883
Epoch 89 Loss 0.005800: 100% 23/23 [00:00<00:00, 858.27it/s]
Doing validation... Validation Loss 0.004838
Epoch 90 Loss 0.005391: 100% 23/23 [00:00<00:00, 872.71it/s]
Doing validation... Validation Loss 0.004782
Epoch 91 Loss 0.005998: 100% 23/23 [00:00<00:00, 739.07it/s]
Doing validation... Validation Loss 0.004733
Epoch 92 Loss 0.005664: 100% 23/23 [00:00<00:00, 799.40it/s]
Doing validation... Validation Loss 0.004679
Epoch 93 Loss 0.005323: 100% 23/23 [00:00<00:00, 870.48it/s]
Doing validation... Validation Loss 0.004626
Epoch 94 Loss 0.005408: 100% 23/23 [00:00<00:00, 842.86it/s]
Doing validation... Validation Loss 0.004588
Epoch 95 Loss 0.005654: 100% 23/23 [00:00<00:00, 857.92it/s]
Doing validation... Validation Loss 0.004545
Epoch 96 Loss 0.005613: 100% 23/23 [00:00<00:00, 769.76it/s]
Doing validation... Validation Loss 0.004483
Epoch 97 Loss 0.005824: 100% 23/23 [00:00<00:00, 832.67it/s]
Doing validation... Validation Loss 0.004472
```

```
Epoch 98 Loss 0.005618: 100% 23/23 [00:00<00:00, 783.42it/s]
Doing validation... Validation Loss 0.004415
Epoch 99 Loss 0.005376: 100% 23/23 [00:00<00:00, 782.02it/s]
Doing validation... Validation Loss 0.004373
Epoch 100 Loss 0.005559: 100% 23/23 [00:00<00:00, 865.12it/s]
Doing validation... Validation Loss 0.004332
Epoch 101 Loss 0.005229: 100% 23/23 [00:00<00:00, 874.96it/s]
Doing validation... Validation Loss 0.004304
Epoch 102 Loss 0.004963: 100% 23/23 [00:00<00:00, 869.40it/s]
Doing validation... Validation Loss 0.004241
Epoch 103 Loss 0.005227: 100% 23/23 [00:00<00:00, 879.23it/s]
Doing validation... Validation Loss 0.004220
Epoch 104 Loss 0.005213: 100% 23/23 [00:00<00:00, 825.05it/s]
Doing validation... Validation Loss 0.004172
Epoch 105 Loss 0.004414: 100% 23/23 [00:00<00:00, 622.02it/s]
Doing validation... Validation Loss 0.004127
Epoch 106 Loss 0.004863: 100% 23/23 [00:00<00:00, 792.22it/s]
Doing validation... Validation Loss 0.004098
Epoch 107 Loss 0.005049: 100% 23/23 [00:00<00:00, 763.77it/s]
Doing validation... Validation Loss 0.004061
Epoch 108 Loss 0.004691: 100% 23/23 [00:00<00:00, 802.64it/s]
Doing validation... Validation Loss 0.004029
Epoch 109 Loss 0.005194: 100% 23/23 [00:00<00:00, 795.17it/s]
Doing validation... Validation Loss 0.004012
Epoch 110 Loss 0.004700: 100% 23/23 [00:00<00:00, 857.09it/s]
Doing validation... Validation Loss 0.003960
Epoch 111 Loss 0.004426: 100% 23/23 [00:00<00:00, 859.70it/s]
Doing validation... Validation Loss 0.003925
Epoch 112 Loss 0.004961: 100% 23/23 [00:00<00:00, 629.57it/s]
Doing validation... Validation Loss 0.003906
Epoch 113 Loss 0.004936: 100% 23/23 [00:00<00:00, 784.00it/s]
Doing validation... Validation Loss 0.003857
Epoch 114 Loss 0.004811: 100% 23/23 [00:00<00:00, 855.91it/s]
Doing validation... Validation Loss 0.003830
Epoch 115 Loss 0.004846: 100% 23/23 [00:00<00:00, 849.31it/s]
Doing validation... Validation Loss 0.003798
Epoch 116 Loss 0.005025: 100% 23/23 [00:00<00:00, 872.15it/s]
Doing validation... Validation Loss 0.003754
Epoch 117 Loss 0.004805: 100% 23/23 [00:00<00:00, 857.16it/s]
Doing validation... Validation Loss 0.003736
Epoch 118 Loss 0.004754: 100% 23/23 [00:00<00:00, 850.48it/s]
Doing validation... Validation Loss 0.003709
Epoch 119 Loss 0.004162: 100% 23/23 [00:00<00:00, 739.24it/s]
Doing validation... Validation Loss 0.003680
Epoch 120 Loss 0.004706: 100% 23/23 [00:00<00:00, 630.25it/s]
Doing validation... Validation Loss 0.003658
Epoch 121 Loss 0.004757: 100% 23/23 [00:00<00:00, 864.81it/s]
Doing validation... Validation Loss 0.003623
Epoch 122 Loss 0.004288: 100% 23/23 [00:00<00:00, 877.68it/s]
Doing validation... Validation Loss 0.003583
Epoch 123 Loss 0.004200: 100% 23/23 [00:00<00:00, 843.14it/s]
Doing validation... Validation Loss 0.003569
Epoch 124 Loss 0.004638: 100% 23/23 [00:00<00:00, 859.50it/s]
Doing validation... Validation Loss 0.003537
```

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Epoch 125 Loss 0.004252: 100% 23/23 [00:00<00:00, 879.20it/s]
Doing validation... Validation Loss 0.003527
Epoch 126 Loss 0.004749: 100% 23/23 [00:00<00:00, 894.34it/s]
Doing validation... Validation Loss 0.003488
Epoch 127 Loss 0.004329: 100% 23/23 [00:00<00:00, 665.32it/s]
Doing validation... Validation Loss 0.003466
Epoch 128 Loss 0.004658: 100% 23/23 [00:00<00:00, 711.53it/s]
Doing validation... Validation Loss 0.003458
Epoch 129 Loss 0.004381: 100% 23/23 [00:00<00:00, 763.52it/s]
Doing validation... Validation Loss 0.003415
Epoch 130 Loss 0.004590: 100% 23/23 [00:00<00:00, 754.16it/s]
Doing validation... Validation Loss 0.003393
Epoch 131 Loss 0.003926: 100% 23/23 [00:00<00:00, 767.57it/s]
Doing validation... Validation Loss 0.003380
Epoch 132 Loss 0.004065: 100% 23/23 [00:00<00:00, 840.45it/s]
Doing validation... Validation Loss 0.003345
Epoch 133 Loss 0.004158: 100% 23/23 [00:00<00:00, 694.56it/s]
Doing validation... Validation Loss 0.003321
Epoch 134 Loss 0.004123: 100% 23/23 [00:00<00:00, 874.63it/s]
Doing validation... Validation Loss 0.003315
Epoch 135 Loss 0.004409: 100% 23/23 [00:00<00:00, 887.07it/s]
Doing validation... Validation Loss 0.003275
Epoch 136 Loss 0.004203: 100% 23/23 [00:00<00:00, 887.41it/s]
Doing validation... Validation Loss 0.003268
Epoch 137 Loss 0.004050: 100% 23/23 [00:00<00:00, 863.83it/s]
Doing validation... Validation Loss 0.003250
Epoch 138 Loss 0.004149: 100% 23/23 [00:00<00:00, 860.38it/s]
Doing validation... Validation Loss 0.003228
Epoch 139 Loss 0.003882: 100% 23/23 [00:00<00:00, 826.73it/s]
Doing validation... Validation Loss 0.003211
Epoch 140 Loss 0.003764: 100% 23/23 [00:00<00:00, 861.94it/s]
Doing validation... Validation Loss 0.003183
Epoch 141 Loss 0.004281: 100% 23/23 [00:00<00:00, 743.38it/s]
Doing validation... Validation Loss 0.003157
Epoch 142 Loss 0.004160: 100% 23/23 [00:00<00:00, 762.91it/s]
Doing validation... Validation Loss 0.003144
Epoch 143 Loss 0.003979: 100% 23/23 [00:00<00:00, 803.31it/s]
Doing validation... Validation Loss 0.003121
Epoch 144 Loss 0.003876: 100% 23/23 [00:00<00:00, 648.08it/s]
Doing validation... Validation Loss 0.003101
Epoch 145 Loss 0.004156: 100% 23/23 [00:00<00:00, 837.43it/s]
Doing validation... Validation Loss 0.003084
Epoch 146 Loss 0.003735: 100% 23/23 [00:00<00:00, 872.41it/s]
Doing validation... Validation Loss 0.003060
Epoch 147 Loss 0.004093: 100% 23/23 [00:00<00:00, 869.51it/s]
Doing validation... Validation Loss 0.003056
Epoch 148 Loss 0.003766: 100% 23/23 [00:00<00:00, 655.09it/s]
Doing validation... Validation Loss 0.003040
Epoch 149 Loss 0.004303: 100% 23/23 [00:00<00:00, 735.34it/s]
Doing validation... Validation Loss 0.003019
Epoch 150 Loss 0.004040: 100% 23/23 [00:00<00:00, 772.27it/s]
Doing validation... Validation Loss 0.002999
Epoch 151 Loss 0.004122: 100% 23/23 [00:00<00:00, 715.37it/s]
Doing validation... Validation Loss 0.002995
```

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Epoch 152 Loss 0.004067: 100% 23/23 [00:00<00:00, 858.07it/s]
Doing validation... Validation Loss 0.002954
Epoch 153 Loss 0.004032: 100% 23/23 [00:00<00:00, 863.00it/s]
Doing validation... Validation Loss 0.002952
Epoch 154 Loss 0.003792: 100% 23/23 [00:00<00:00, 873.56it/s]
Doing validation... Validation Loss 0.002936
Epoch 155 Loss 0.003561: 100% 23/23 [00:00<00:00, 741.11it/s]
Doing validation... Validation Loss 0.002914
Epoch 156 Loss 0.003486: 100% 23/23 [00:00<00:00, 817.46it/s]
Doing validation... Validation Loss 0.002889
Epoch 157 Loss 0.003436: 100% 23/23 [00:00<00:00, 851.66it/s]
Doing validation... Validation Loss 0.002883
Epoch 158 Loss 0.004024: 100% 23/23 [00:00<00:00, 853.88it/s]
Doing validation... Validation Loss 0.002869
Epoch 159 Loss 0.003866: 100% 23/23 [00:00<00:00, 850.37it/s]
Doing validation... Validation Loss 0.002858
Epoch 160 Loss 0.003812: 100% 23/23 [00:00<00:00, 865.93it/s]
Doing validation... Validation Loss 0.002851
Epoch 161 Loss 0.003617: 100% 23/23 [00:00<00:00, 877.95it/s]
Doing validation... Validation Loss 0.002831
Epoch 162 Loss 0.003465: 100% 23/23 [00:00<00:00, 615.38it/s]
Doing validation... Validation Loss 0.002802
Epoch 163 Loss 0.003294: 100% 23/23 [00:00<00:00, 769.01it/s]
Doing validation... Validation Loss 0.002810
Epoch 164 Loss 0.003767: 100% 23/23 [00:00<00:00, 874.13it/s]
Doing validation... Validation Loss 0.002798
Epoch 165 Loss 0.003528: 100% 23/23 [00:00<00:00, 848.25it/s]
Doing validation... Validation Loss 0.002780
Epoch 166 Loss 0.003682: 100% 23/23 [00:00<00:00, 846.02it/s]
Doing validation... Validation Loss 0.002748
Epoch 167 Loss 0.003570: 100% 23/23 [00:00<00:00, 569.15it/s]
Doing validation... Validation Loss 0.002766
Epoch 168 Loss 0.003668: 100% 23/23 [00:00<00:00, 607.28it/s]
Doing validation... Validation Loss 0.002727
Epoch 169 Loss 0.003639: 100% 23/23 [00:00<00:00, 728.72it/s]
Doing validation... Validation Loss 0.002720
Epoch 170 Loss 0.003445: 100% 23/23 [00:00<00:00, 872.23it/s]
Doing validation... Validation Loss 0.002701
Epoch 171 Loss 0.003795: 100% 23/23 [00:00<00:00, 883.38it/s]
Doing validation... Validation Loss 0.002705
Epoch 172 Loss 0.003523: 100% 23/23 [00:00<00:00, 855.89it/s]
Doing validation... Validation Loss 0.002678
Epoch 173 Loss 0.003730: 100% 23/23 [00:00<00:00, 719.85it/s]
Doing validation... Validation Loss 0.002669
Epoch 174 Loss 0.003655: 100% 23/23 [00:00<00:00, 763.84it/s]
Doing validation... Validation Loss 0.002654
Epoch 175 Loss 0.003485: 100% 23/23 [00:00<00:00, 878.48it/s]
Doing validation... Validation Loss 0.002648
Epoch 176 Loss 0.003476: 100% 23/23 [00:00<00:00, 878.68it/s]
Doing validation... Validation Loss 0.002631
Epoch 177 Loss 0.003642: 100% 23/23 [00:00<00:00, 875.73it/s]
Doing validation... Validation Loss 0.002625
Epoch 178 Loss 0.003545: 100% 23/23 [00:00<00:00, 715.70it/s]
Doing validation... Validation Loss 0.002608
```

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Epoch 179 Loss 0.003906: 100% 23/23 [00:00<00:00, 771.02it/s]
Doing validation... Validation Loss 0.002600
Epoch 180 Loss 0.003494: 100% 23/23 [00:00<00:00, 751.74it/s]
Doing validation... Validation Loss 0.002575
Epoch 181 Loss 0.003499: 100% 23/23 [00:00<00:00, 751.74it/s]
Doing validation... Validation Loss 0.002574
Epoch 182 Loss 0.003300: 100% 23/23 [00:00<00:00, 882.86it/s]
Doing validation... Validation Loss 0.002567
Epoch 183 Loss 0.003445: 100% 23/23 [00:00<00:00, 887.18it/s]
Doing validation... Validation Loss 0.002559
Epoch 184 Loss 0.003398: 100% 23/23 [00:00<00:00, 883.94it/s]
Doing validation... Validation Loss 0.002551
Epoch 185 Loss 0.003417: 100% 23/23 [00:00<00:00, 674.96it/s]
Doing validation... Validation Loss 0.002545
Epoch 186 Loss 0.003676: 100% 23/23 [00:00<00:00, 876.17it/s]
Doing validation... Validation Loss 0.002523
Epoch 187 Loss 0.003437: 100% 23/23 [00:00<00:00, 822.67it/s]
Doing validation... Validation Loss 0.002507
Epoch 188 Loss 0.003380: 100% 23/23 [00:00<00:00, 862.97it/s]
Doing validation... Validation Loss 0.002512
Epoch 189 Loss 0.003509: 100% 23/23 [00:00<00:00, 868.25it/s]
Doing validation... Validation Loss 0.002495
Epoch 190 Loss 0.003390: 100% 23/23 [00:00<00:00, 845.31it/s]
Doing validation... Validation Loss 0.002484
Epoch 191 Loss 0.003408: 100% 23/23 [00:00<00:00, 876.43it/s]
Doing validation... Validation Loss 0.002479
Epoch 192 Loss 0.003377: 100% 23/23 [00:00<00:00, 712.55it/s]
Doing validation... Validation Loss 0.002496
Epoch 193 Loss 0.003045: 100% 23/23 [00:00<00:00, 794.36it/s]
Doing validation... Validation Loss 0.002476
Epoch 194 Loss 0.003516: 100% 23/23 [00:00<00:00, 881.07it/s]
Doing validation... Validation Loss 0.002452
Epoch 195 Loss 0.003367: 100% 23/23 [00:00<00:00, 785.44it/s]
Doing validation... Validation Loss 0.002448
Epoch 196 Loss 0.003469: 100% 23/23 [00:00<00:00, 842.59it/s]
Doing validation... Validation Loss 0.002431
Epoch 197 Loss 0.003257: 100% 23/23 [00:00<00:00, 862.08it/s]
Doing validation... Validation Loss 0.002437
Epoch 198 Loss 0.003471: 100% 23/23 [00:00<00:00, 855.24it/s]
Doing validation... Validation Loss 0.002426
Epoch 199 Loss 0.003437: 100% 23/23 [00:00<00:00, 884.91it/s]
Doing validation... Validation Loss 0.002402
Epoch 200 Loss 0.003381: 100% 23/23 [00:00<00:00, 566.89it/s]
Doing validation... Validation Loss 0.002423
Epoch 201 Loss 0.003244: 100% 23/23 [00:00<00:00, 764.23it/s]
Doing validation... Validation Loss 0.002404
Epoch 202 Loss 0.003251: 100% 23/23 [00:00<00:00, 735.43it/s]
Doing validation... Validation Loss 0.002381
Epoch 203 Loss 0.003303: 100% 23/23 [00:00<00:00, 844.40it/s]
Doing validation... Validation Loss 0.002370
Epoch 204 Loss 0.003209: 100% 23/23 [00:00<00:00, 861.42it/s]
Doing validation... Validation Loss 0.002375
Epoch 205 Loss 0.003385: 100% 23/23 [00:00<00:00, 850.60it/s]
Doing validation... Validation Loss 0.002365
```

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Epoch 206 Loss 0.003196: 100% 23/23 [00:00<00:00, 857.56it/s]
Doing validation... Validation Loss 0.002354
Epoch 207 Loss 0.003285: 100% 23/23 [00:00<00:00, 585.64it/s]
Doing validation... Validation Loss 0.002347
Epoch 208 Loss 0.003066: 100% 23/23 [00:00<00:00, 871.84it/s]
Doing validation... Validation Loss 0.002338
Epoch 209 Loss 0.003319: 100% 23/23 [00:00<00:00, 861.78it/s]
Doing validation... Validation Loss 0.002343
Epoch 210 Loss 0.003144: 100% 23/23 [00:00<00:00, 850.58it/s]
Doing validation... Validation Loss 0.002338
Epoch 211 Loss 0.003105: 100% 23/23 [00:00<00:00, 877.76it/s]
Doing validation... Validation Loss 0.002331
Epoch 212 Loss 0.003080: 100% 23/23 [00:00<00:00, 605.78it/s]
Doing validation... Validation Loss 0.002324
Epoch 213 Loss 0.003154: 100% 23/23 [00:00<00:00, 759.66it/s]
Doing validation... Validation Loss 0.002301
Epoch 214 Loss 0.003193: 100% 23/23 [00:00<00:00, 721.06it/s]
Doing validation... Validation Loss 0.002307
Epoch 215 Loss 0.002909: 100% 23/23 [00:00<00:00, 651.83it/s]
Doing validation... Validation Loss 0.002293
Epoch 216 Loss 0.003300: 100% 23/23 [00:00<00:00, 759.10it/s]
Doing validation... Validation Loss 0.002286
Epoch 217 Loss 0.003118: 100% 23/23 [00:00<00:00, 861.76it/s]
Doing validation... Validation Loss 0.002282
Epoch 218 Loss 0.002930: 100% 23/23 [00:00<00:00, 679.70it/s]
Doing validation... Validation Loss 0.002294
Epoch 219 Loss 0.003329: 100% 23/23 [00:00<00:00, 853.35it/s]
Doing validation... Validation Loss 0.002267
Epoch 220 Loss 0.003420: 100% 23/23 [00:00<00:00, 865.29it/s]
Doing validation... Validation Loss 0.002260
Epoch 221 Loss 0.003086: 100% 23/23 [00:00<00:00, 842.86it/s]
Doing validation... Validation Loss 0.002247
Epoch 222 Loss 0.003036: 100% 23/23 [00:00<00:00, 878.36it/s]
Doing validation... Validation Loss 0.002251
Epoch 223 Loss 0.003073: 100% 23/23 [00:00<00:00, 842.52it/s]
Doing validation... Validation Loss 0.002248
Epoch 224 Loss 0.003131: 100% 23/23 [00:00<00:00, 853.74it/s]
Doing validation... Validation Loss 0.002244
Epoch 225 Loss 0.003278: 100% 23/23 [00:00<00:00, 875.75it/s]
Doing validation... Validation Loss 0.002226
Epoch 226 Loss 0.003076: 100% 23/23 [00:00<00:00, 796.55it/s]
Doing validation... Validation Loss 0.002219
Epoch 227 Loss 0.003465: 100% 23/23 [00:00<00:00, 825.47it/s]
Doing validation... Validation Loss 0.002223
Epoch 228 Loss 0.003000: 100% 23/23 [00:00<00:00, 853.99it/s]
Doing validation... Validation Loss 0.002232
Epoch 229 Loss 0.002878: 100% 23/23 [00:00<00:00, 867.27it/s]
Doing validation... Validation Loss 0.002206
Epoch 230 Loss 0.003193: 100% 23/23 [00:00<00:00, 863.95it/s]
Doing validation... Validation Loss 0.002218
Epoch 231 Loss 0.002977: 100% 23/23 [00:00<00:00, 778.10it/s]
Doing validation... Validation Loss 0.002203
Epoch 232 Loss 0.002688: 100% 23/23 [00:00<00:00, 853.75it/s]
Doing validation... Validation Loss 0.002188
```

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Epoch 233 Loss 0.002684: 100% 23/23 [00:00<00:00, 596.80it/s]
Doing validation... Validation Loss 0.002204
Epoch 234 Loss 0.003095: 100% 23/23 [00:00<00:00, 753.32it/s]
Doing validation... Validation Loss 0.002181
Epoch 235 Loss 0.003105: 100% 23/23 [00:00<00:00, 754.68it/s]
Doing validation... Validation Loss 0.002205
Epoch 236 Loss 0.002977: 100% 23/23 [00:00<00:00, 817.54it/s]
Doing validation... Validation Loss 0.002189
Epoch 237 Loss 0.003009: 100% 23/23 [00:00<00:00, 839.57it/s]
Doing validation... Validation Loss 0.002191
Epoch 238 Loss 0.002886: 100% 23/23 [00:00<00:00, 780.00it/s]
Doing validation... Validation Loss 0.002165
Epoch 239 Loss 0.003201: 100% 23/23 [00:00<00:00, 814.76it/s]
Doing validation... Validation Loss 0.002155
Epoch 240 Loss 0.003298: 100% 23/23 [00:00<00:00, 755.27it/s]
Doing validation... Validation Loss 0.002200
Epoch 241 Loss 0.003018: 100% 23/23 [00:00<00:00, 854.40it/s]
Doing validation... Validation Loss 0.002180
Epoch 242 Loss 0.003142: 100% 23/23 [00:00<00:00, 838.08it/s]
Doing validation... Validation Loss 0.002172
Epoch 243 Loss 0.003143: 100% 23/23 [00:00<00:00, 866.91it/s]
Doing validation... Validation Loss 0.002140
Epoch 244 Loss 0.002845: 100% 23/23 [00:00<00:00, 840.77it/s]
Doing validation... Validation Loss 0.002146
Epoch 245 Loss 0.002837: 100% 23/23 [00:00<00:00, 844.18it/s]
Doing validation... Validation Loss 0.002138
Epoch 246 Loss 0.002985: 100% 23/23 [00:00<00:00, 866.20it/s]
Doing validation... Validation Loss 0.002141
Epoch 247 Loss 0.003268: 100% 23/23 [00:00<00:00, 594.18it/s]
Doing validation... Validation Loss 0.002130
Epoch 248 Loss 0.003008: 100% 23/23 [00:00<00:00, 833.03it/s]
Doing validation... Validation Loss 0.002132
Epoch 249 Loss 0.003167: 100% 23/23 [00:00<00:00, 843.97it/s]
Doing validation... Validation Loss 0.002134
Epoch 250 Loss 0.002939: 100% 23/23 [00:00<00:00, 869.71it/s]
Doing validation... Validation Loss 0.002130
Epoch 251 Loss 0.002682: 100% 23/23 [00:00<00:00, 851.01it/s]
Doing validation... Validation Loss 0.002131
Epoch 252 Loss 0.002806: 100% 23/23 [00:00<00:00, 860.02it/s]
Doing validation... Validation Loss 0.002124
Epoch 253 Loss 0.002949: 100% 23/23 [00:00<00:00, 799.43it/s]
Doing validation... Validation Loss 0.002117
Epoch 254 Loss 0.003146: 100% 23/23 [00:00<00:00, 691.17it/s]
Doing validation... Validation Loss 0.002118
Epoch 255 Loss 0.002972: 100% 23/23 [00:00<00:00, 737.96it/s]
Doing validation... Validation Loss 0.002112
Epoch 256 Loss 0.002675: 100% 23/23 [00:00<00:00, 725.41it/s]
Doing validation... Validation Loss 0.002093
Epoch 257 Loss 0.002933: 100% 23/23 [00:00<00:00, 773.45it/s]
Doing validation... Validation Loss 0.002103
Epoch 258 Loss 0.002835: 100% 23/23 [00:00<00:00, 864.84it/s]
Doing validation... Validation Loss 0.002084
Epoch 259 Loss 0.002980: 100% 23/23 [00:00<00:00, 850.77it/s]
Doing validation... Validation Loss 0.002113
```

```
Epoch 260 Loss 0.003013: 100% 23/23 [00:00<00:00, 818.54it/s]
Doing validation... Validation Loss 0.002109
Epoch 261 Loss 0.002877: 100% 23/23 [00:00<00:00, 656.64it/s]
Doing validation... Validation Loss 0.002086
Epoch 262 Loss 0.002756: 100% 23/23 [00:00<00:00, 866.81it/s]
Doing validation... Validation Loss 0.002098
Epoch 263 Loss 0.002777: 100% 23/23 [00:00<00:00, 855.50it/s]
Doing validation... Validation Loss 0.002103
Epoch 264 Loss 0.002715: 100% 23/23 [00:00<00:00, 801.69it/s]
Doing validation... Validation Loss 0.002099
Epoch 265 Loss 0.003428: 100% 23/23 [00:00<00:00, 846.49it/s]
Doing validation... Validation Loss 0.002084
Epoch 266 Loss 0.003069: 100% 23/23 [00:00<00:00, 864.13it/s]
Doing validation... Validation Loss 0.002064
Epoch 267 Loss 0.002951: 100% 23/23 [00:00<00:00, 876.56it/s]
Doing validation... Validation Loss 0.002081
Epoch 268 Loss 0.003176: 100% 23/23 [00:00<00:00, 722.84it/s]
Doing validation... Validation Loss 0.002077
Epoch 269 Loss 0.002951: 100% 23/23 [00:00<00:00, 705.62it/s]
Doing validation... Validation Loss 0.002074
Epoch 270 Loss 0.002952: 100% 23/23 [00:00<00:00, 756.72it/s]
Doing validation... Validation Loss 0.002084
Epoch 271 Loss 0.003046: 100% 23/23 [00:00<00:00, 699.26it/s]
Doing validation... Validation Loss 0.002064
Epoch 272 Loss 0.003092: 100% 23/23 [00:00<00:00, 771.64it/s]
Doing validation... Validation Loss 0.002087
Epoch 273 Loss 0.003230: 100% 23/23 [00:00<00:00, 857.13it/s]
Doing validation... Validation Loss 0.002073
Epoch 274 Loss 0.002670: 100% 23/23 [00:00<00:00, 830.18it/s]
Doing validation... Validation Loss 0.002069
Epoch 275 Loss 0.002883: 100% 23/23 [00:00<00:00, 647.82it/s]
Doing validation... Validation Loss 0.002069
Epoch 276 Loss 0.003016: 100% 23/23 [00:00<00:00, 883.78it/s]
Doing validation... Validation Loss 0.002056
Epoch 277 Loss 0.003244: 100% 23/23 [00:00<00:00, 775.46it/s]
Doing validation... Validation Loss 0.002069
Epoch 278 Loss 0.003061: 100% 23/23 [00:00<00:00, 867.60it/s]
Doing validation... Validation Loss 0.002064
Epoch 279 Loss 0.002686: 100% 23/23 [00:00<00:00, 680.19it/s]
Doing validation... Validation Loss 0.002060
Epoch 280 Loss 0.002948: 100% 23/23 [00:00<00:00, 638.13it/s]
Doing validation... Validation Loss 0.002044
Epoch 281 Loss 0.002847: 100% 23/23 [00:00<00:00, 869.18it/s]
Doing validation... Validation Loss 0.002069
Epoch 282 Loss 0.003039: 100% 23/23 [00:00<00:00, 590.09it/s]
Doing validation... Validation Loss 0.002046
Epoch 283 Loss 0.003074: 100% 23/23 [00:00<00:00, 763.07it/s]
Doing validation... Validation Loss 0.002058
Epoch 284 Loss 0.003003: 100% 23/23 [00:00<00:00, 738.49it/s]
Doing validation... Validation Loss 0.002039
Epoch 285 Loss 0.002851: 100% 23/23 [00:00<00:00, 843.95it/s]
Doing validation... Validation Loss 0.002036
Epoch 286 Loss 0.002896: 100% 23/23 [00:00<00:00, 874.67it/s]
Doing validation... Validation Loss 0.002042
```

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Epoch 287 Loss 0.002954: 100% 23/23 [00:00<00:00, 616.84it/s]
Doing validation... Validation Loss 0.002042
Epoch 288 Loss 0.003050: 100% 23/23 [00:00<00:00, 868.81it/s]
Doing validation... Validation Loss 0.002061
Epoch 289 Loss 0.002713: 100% 23/23 [00:00<00:00, 882.41it/s]
Doing validation... Validation Loss 0.002033
Epoch 290 Loss 0.002851: 100% 23/23 [00:00<00:00, 879.69it/s]
Doing validation... Validation Loss 0.002038
Epoch 291 Loss 0.003098: 100% 23/23 [00:00<00:00, 848.77it/s]
Doing validation... Validation Loss 0.002057
Epoch 292 Loss 0.002709: 100% 23/23 [00:00<00:00, 867.02it/s]
Doing validation... Validation Loss 0.002034
Epoch 293 Loss 0.003134: 100% 23/23 [00:00<00:00, 866.85it/s]
Doing validation... Validation Loss 0.002042
Epoch 294 Loss 0.003022: 100% 23/23 [00:00<00:00, 574.72it/s]
Doing validation... Validation Loss 0.002047
Epoch 295 Loss 0.002962: 100% 23/23 [00:00<00:00, 755.64it/s]
Doing validation... Validation Loss 0.002019
Epoch 296 Loss 0.002905: 100% 23/23 [00:00<00:00, 721.16it/s]
Doing validation... Validation Loss 0.002035
Epoch 297 Loss 0.002619: 100% 23/23 [00:00<00:00, 790.74it/s]
Doing validation... Validation Loss 0.002014
Epoch 298 Loss 0.002886: 100% 23/23 [00:00<00:00, 698.60it/s]
Doing validation... Validation Loss 0.002056
Epoch 299 Loss 0.003339: 100% 23/23 [00:00<00:00, 851.39it/s]
Doing validation... Validation Loss 0.002031
Epoch 300 Loss 0.003041: 100% 23/23 [00:00<00:00, 850.88it/s]
Doing validation... Validation Loss 0.002036
AE-Reconstruction error for 128-dimensional hidden representation is
46.67702827362694
[7.9426074400467925, 11.353129163337364, 16.00567540078353]
```