

AutoEncoderBySize(alpha=3)

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1 Autoencoder Performance by Size

In this notebook, we investigate the performance of a basic autoencoder model when neighbors become random in the high-dimensional space according to the data size. We start by loading the necessary libraries.

```
[1]: # Handling arrays
import numpy as np

# Handling data frames
import pandas as pd

# neural networks in Python
import torch
from torch import nn

# plotting
import matplotlib.pyplot as plt

%matplotlib inline
```

We define our experiment parameters.

```
[2]: ntimes = 100 # number of noise replicates to investigate dimred performance
npoints = [25, 50, 100] # number of points in our ground truth data set to be
    ↪ investigated
maxdim = 10000 # maximal dimension of the data set to be investigated
dims = np.round(np.exp(np.linspace(np.log(2), np.log(maxdim), num=10))).
    ↪ astype("int") # dimensions to study
a = 1.25 # magnitude of noise: per dimension we sample noise uniformly from
    ↪ [-a, a]
alpha = 3 # factor controlling the growth rate of the ground truth diamete
```

We construct the ground truth data sets according to the various growth rates.

```
[3]: datasets = []
for idx, points in enumerate(npoints):
    t = np.linspace(0, 1, num=points)
```

```

        factor = np.ones(maxdim) if alpha == np.inf else (np.arange(maxdim) +
↪1)**(-1 / alpha)
        datasets.append(np.transpose(np.tile(t, (maxdim, 1))) * np.tile(factor,
↪(points, 1)))

```

We define an autoencoder model.

```

[4]: class autoencoder(nn.Module):

    def init_weights(self, m):
        if isinstance(m, nn.Linear):
            nn.init.xavier_uniform_(m.weight, gain=1.0)
            nn.init.zeros_(m.bias)

    def __init__(self, input_dim, encoding_dim):
        super(autoencoder, self).__init__()
        self.input_dim = input_dim
        self.encoding_dim = encoding_dim
        self.encoder = nn.Sequential(
            nn.Linear(self.input_dim, 24),
            nn.Tanh(),
            nn.Linear(24, 6),
            nn.Tanh(),
            nn.Linear(6, self.encoding_dim),
            nn.Tanh())
        self.decoder = nn.Sequential(
            nn.Linear(self.encoding_dim, 6),
            nn.Tanh(),
            nn.Tanh(),
            nn.Linear(6, 24),
            nn.Linear(24, self.input_dim))

        self.encoder.apply(self.init_weights)
        self.decoder.apply(self.init_weights)

    def forward(self, x):
        x = self.encoder(x)
        x = self.decoder(x)
        return x

def autoencode(X, encoding_dim, num_epochs=2000, learning_rate=1e-3, eps=1e-07):
    X = torch.tensor(X).type(torch.float)
    model = autoencoder(input_dim=X.shape[1], encoding_dim=encoding_dim)
    criterion = nn.MSELoss()
    optimizer = torch.optim.Adam(model.parameters(), lr=learning_rate, eps=eps)

```

```

for epoch in range(num_epochs):
    output = model(X)
    loss = criterion(output, X)
    loss.backward()
    optimizer.step()
    optimizer.zero_grad()

Y = model.encoder(X).detach().numpy()

return(Y)

```

We measure the autoencoder performance by dimensionality and data size.

```

[5]: cor_auto = np.zeros([len(dims), len(npoints)])

for idx in range(ntimes):

    print("progress: " + str(round(100 * idx / ntimes, 2)).ljust(5, "0") + "%",
    ↪end="\r")

    N = a * (2 * np.random.rand(max(npoints), maxdim) - 1)

    for np_idx, points in enumerate(npoints):

        XN = datasets[np_idx] + a * N[:datasets[np_idx].shape[0],]

        for dim_idx, dim in enumerate(dims):

            Y = autoencode(XN[:, :dim], 1)
            cor = np.max([np.corrcoef(Y[:, 0], datasets[np_idx][:, 0])[0, 1],
            ↪np.corrcoef(np.flip(Y[:, 0], axis=0),
            ↪datasets[np_idx][:, 0])[0, 1]])
            cor_auto[dim_idx, np_idx] += cor

cor_auto /= ntimes

print("progress: 100.0%", end="\r")

fig, ax = plt.subplots(figsize=(5, 5))
ax.set_xlabel("dim")
ax.set_ylabel("correlation")
ax.set_xscale("log")

for idx, points in enumerate(npoints):

    ax.plot(dims, cor_auto[:, idx], label=points)

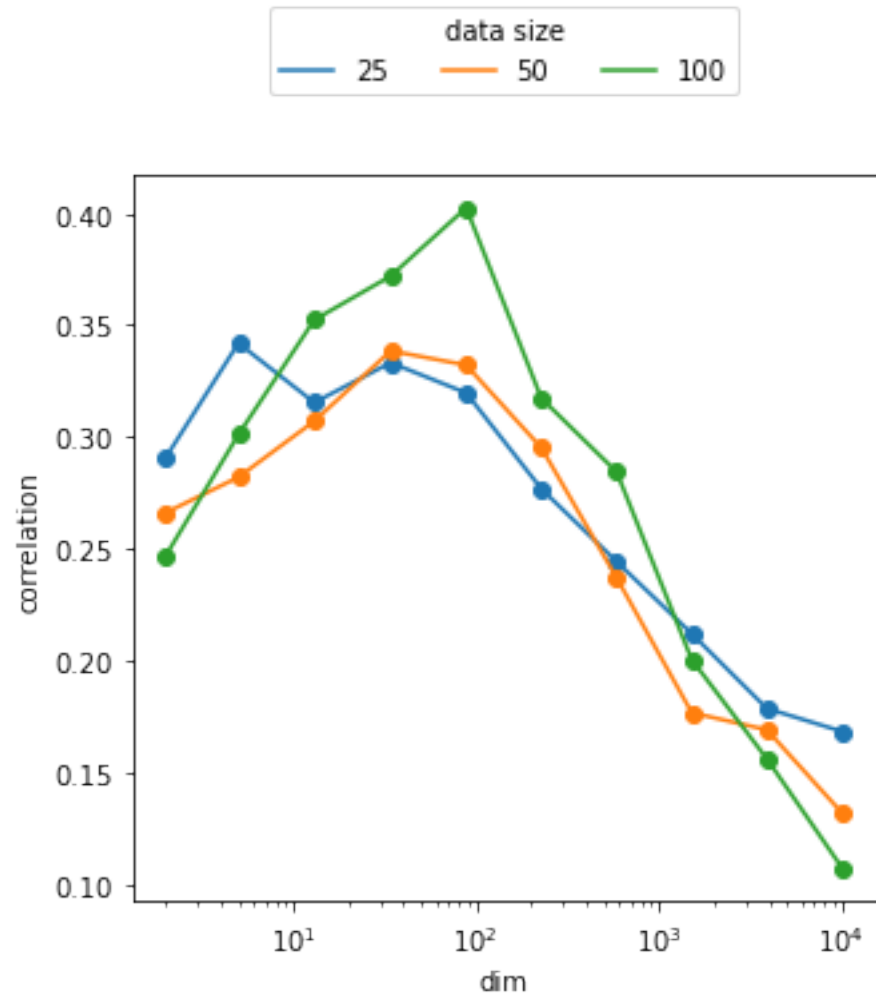
```

```
ax.scatter(dims, cor_auto[:,idx])

ax.legend(title="data size", loc="upper center", ncol=3, bbox_to_anchor=(0.5, 1.
↪25))
```

progress: 100.0%

[5]: <matplotlib.legend.Legend at 0x7f3c84338160>



We modify the style of the results and save as csv for plotting in R.

```
[6]: cor_auto_df = np.zeros([cor_auto.shape[0] * cor_auto.shape[1], 3])
idx = 0
for idx1, points in enumerate(npoints):
    for idx2, dim in enumerate(dims):
        cor_auto_df[idx,:] = [points, dim, cor_auto[idx2, idx1]]
```

```
idx += 1

cor_auto_df = pd.DataFrame(cor_auto_df)
cor_auto_df.columns = ["size", "dim", "cor"]
cor_auto_df.to_csv("../Results/Size/AUTO_alpha3.csv")
```

```
[ ]:
```