

*Feb 2nd, 2025*

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## Calibrating the latent space representation

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Based on our conversations, Rodrigo suggested the following notes:

- To find 5 images for every phenotype and take them out of the dataset.

```
Retrain the model with more iterations (perhaps 250 epochs)
Run these images through the encoder to obtain a point z for each of these
images
Create a linear transition (presented as images) from one phenotype to the
other
```

- To run the analysis with more than 2 dimensions for the matrix z

```
Run a KNN (k-nearest neighbors) analysis on the data.
```

## Moving images

```
└─ scripts/
   └─ Wings
      ├── 00_MetaDataset
      ├── 01_cleaned_Dataset
      ├── 02_stnd_Dataset
      ├── 03_subset_stnd <---
      │   ├── phenotype_1
      │   └── phenotype_2
      ├── Autoencoder
      ├── Manifold_learning
      └── PCA_decomposition
```

The following images were chosen and transferred into **03\_subset\_stnd**:

phenotype\_1:

The distal margin of the wings is not covered in "artifacts" of chitin. The wings are hirsute giving a velvety appearance to the wing. Geometry of the wings doesn't seem to be affected as much.

```

ArmFliesPilot_20240830__055__ArmFliesPilot_20240830__055_11.png
ArmFliesPilot_20240830__056__ArmFliesPilot_20240830__056_01.png
ArmFliesPilot_20240830__056__ArmFliesPilot_20240830__056_06.png
ArmFliesPilot_20240830__057__ArmFliesPilot_20240830__057_01.png

```

### phenotype\_2:

Main diagnostic feature is the artifacts that appear at the distal edge of the wings.

```

ArmFliesPilot_20240830__058__ArmFliesPilot_20240830__058_01.png
ArmFliesPilot_20240830__058__ArmFliesPilot_20240830__058_06.png
ArmFliesPilot_20240830__058__ArmFliesPilot_20240830__058_16.png
ArmFliesPilot_20240830__059__ArmFliesPilot_20240830__059_01.png
ArmFliesPilot_20240830__059__ArmFliesPilot_20240830__059_36.png

```

## Training the network

The VAE\_train.py has now been used with the following parameters:

```

dataset_size=      133-9 images (124)
epochs =           350
batch_size =       30
dimension in z =   1

```

```

encoder.0.conv.0.weight True
encoder.0.conv.0.bias True
encoder.0.conv.2.weight True
encoder.0.conv.2.bias True
encoder.1.conv.0.weight True
encoder.1.conv.0.bias True
encoder.1.conv.2.weight True
encoder.1.conv.2.bias True
Epoch 1      Average Loss:  86856.30598958333
Epoch 2      Average Loss:  34178.89114583333
Epoch 3      Average Loss:  33734.552408854164
Epoch 4      Average Loss:  33307.7900390625
Epoch 5      Average Loss:  32719.988802083335
Epoch 6      Average Loss:  31971.3974609375
Epoch 7      Average Loss:  30901.0017578125
Epoch 8      Average Loss:  29453.848307291668
Epoch 9      Average Loss:  27644.131119791666
Epoch 10     Average Loss:  25613.796614583334
Epoch 11     Average Loss:  23653.631315104165
Epoch 12     Average Loss:  22130.4087890625
Epoch 13     Average Loss:  21058.4533203125
Epoch 14     Average Loss:  20384.860677083332

```

Epoch 15	Average Loss:	19985.692513020833
Epoch 16	Average Loss:	19669.3111328125
Epoch 17	Average Loss:	19433.321614583332
Epoch 18	Average Loss:	19271.764778645833
Epoch 19	Average Loss:	19168.444075520834
Epoch 20	Average Loss:	19088.448828125
Epoch 21	Average Loss:	19032.554231770835
Epoch 22	Average Loss:	18987.4373046875
Epoch 23	Average Loss:	18932.581510416665
Epoch 24	Average Loss:	18889.6919921875
Epoch 25	Average Loss:	18860.108333333334
Epoch 26	Average Loss:	18838.0525390625
Epoch 27	Average Loss:	18818.147135416668
Epoch 28	Average Loss:	18801.610546875
Epoch 29	Average Loss:	18786.416536458335
Epoch 30	Average Loss:	18777.539127604166
Epoch 31	Average Loss:	18764.7109375
Epoch 32	Average Loss:	18757.400716145832
Epoch 33	Average Loss:	18746.474934895832
Epoch 34	Average Loss:	18740.224348958334
Epoch 35	Average Loss:	18743.840950520833
Epoch 36	Average Loss:	18727.255013020833
Epoch 37	Average Loss:	18729.310611979166
Epoch 38	Average Loss:	18732.9197265625
Epoch 39	Average Loss:	18716.424283854165
Epoch 40	Average Loss:	18720.286588541665
Epoch 41	Average Loss:	18698.96484375
Epoch 42	Average Loss:	18701.2375
Epoch 43	Average Loss:	18695.947330729166
Epoch 44	Average Loss:	18688.604752604166
Epoch 45	Average Loss:	18691.021223958334
Epoch 46	Average Loss:	18678.991861979168
Epoch 47	Average Loss:	18677.193359375
Epoch 48	Average Loss:	18669.103645833333
Epoch 49	Average Loss:	18662.3740234375
Epoch 50	Average Loss:	18661.154036458334
Epoch 51	Average Loss:	18656.396940104165
Epoch 52	Average Loss:	18652.1099609375
Epoch 53	Average Loss:	18647.45859375
Epoch 54	Average Loss:	18644.962174479166
Epoch 55	Average Loss:	18643.315364583334
Epoch 56	Average Loss:	18644.351627604166
Epoch 57	Average Loss:	18637.744010416667
Epoch 58	Average Loss:	18646.876692708334
Epoch 59	Average Loss:	18634.537109375
Epoch 60	Average Loss:	18634.1044921875
Epoch 61	Average Loss:	18637.999544270835
Epoch 62	Average Loss:	18635.909114583334
Epoch 63	Average Loss:	18624.430989583332
Epoch 64	Average Loss:	18637.241536458332
Epoch 65	Average Loss:	18628.959049479166
Epoch 66	Average Loss:	18615.740104166667
Epoch 67	Average Loss:	18614.402018229168
Epoch 68	Average Loss:	18596.650846354165

Epoch 69	Average Loss:	18580.853841145832
Epoch 70	Average Loss:	18578.914908854167
Epoch 71	Average Loss:	18575.955533854165
Epoch 72	Average Loss:	18567.55390625
Epoch 73	Average Loss:	18569.208723958334
Epoch 74	Average Loss:	18558.8435546875
Epoch 75	Average Loss:	18540.283658854165
Epoch 76	Average Loss:	18532.133333333335
Epoch 77	Average Loss:	18526.290625
Epoch 78	Average Loss:	18517.0568359375
Epoch 79	Average Loss:	18515.862369791666
Epoch 80	Average Loss:	18505.031575520832
Epoch 81	Average Loss:	18496.15
Epoch 82	Average Loss:	18477.645052083335
Epoch 83	Average Loss:	18474.323372395833
Epoch 84	Average Loss:	18459.618098958334
Epoch 85	Average Loss:	18448.117838541668
Epoch 86	Average Loss:	18439.9662109375
Epoch 87	Average Loss:	18431.2267578125
Epoch 88	Average Loss:	18421.0162109375
Epoch 89	Average Loss:	18409.466861979166
Epoch 90	Average Loss:	18398.87265625
Epoch 91	Average Loss:	18390.911067708334
Epoch 92	Average Loss:	18382.7884765625
Epoch 93	Average Loss:	18367.26796875
Epoch 94	Average Loss:	18361.487434895833
Epoch 95	Average Loss:	18349.874479166665
Epoch 96	Average Loss:	18344.732096354168
Epoch 97	Average Loss:	18335.563020833335
Epoch 98	Average Loss:	18321.156640625
Epoch 99	Average Loss:	18316.738802083335
Epoch 100	Average Loss:	18308.8646484375
Epoch 101	Average Loss:	18298.855143229168
Epoch 102	Average Loss:	18297.899479166666
Epoch 103	Average Loss:	18293.484309895834
Epoch 104	Average Loss:	18288.510091145832
Epoch 105	Average Loss:	18283.8404296875
Epoch 106	Average Loss:	18274.733268229167
Epoch 107	Average Loss:	18282.342838541666
Epoch 108	Average Loss:	18304.692122395834
Epoch 109	Average Loss:	18309.290755208334
Epoch 110	Average Loss:	18266.033203125
Epoch 111	Average Loss:	18253.092513020834
Epoch 112	Average Loss:	18249.048828125
Epoch 113	Average Loss:	18241.302018229166
Epoch 114	Average Loss:	18229.277864583335
Epoch 115	Average Loss:	18236.643424479167
Epoch 116	Average Loss:	18244.921614583334
Epoch 117	Average Loss:	18248.663020833334
Epoch 118	Average Loss:	18285.1197265625
Epoch 119	Average Loss:	18305.424739583334
Epoch 120	Average Loss:	18243.8498046875
Epoch 121	Average Loss:	18205.546158854166
Epoch 122	Average Loss:	18200.9794921875

Epoch 123	Average Loss:	18198.702864583334
Epoch 124	Average Loss:	18191.561458333334
Epoch 125	Average Loss:	18187.976822916666
Epoch 126	Average Loss:	18184.361393229166
Epoch 127	Average Loss:	18179.348177083335
Epoch 128	Average Loss:	18174.891731770833
Epoch 129	Average Loss:	18174.423372395835
Epoch 130	Average Loss:	18172.420442708335
Epoch 131	Average Loss:	18177.058919270832
Epoch 132	Average Loss:	18184.284375
Epoch 133	Average Loss:	18182.831315104166
Epoch 134	Average Loss:	18180.757161458332
Epoch 135	Average Loss:	18169.422981770833
Epoch 136	Average Loss:	18164.281119791667
Epoch 137	Average Loss:	18157.99453125
Epoch 138	Average Loss:	18157.347265625
Epoch 139	Average Loss:	18145.071940104168
Epoch 140	Average Loss:	18144.346744791666
Epoch 141	Average Loss:	18144.839192708332
Epoch 142	Average Loss:	18142.574348958333
Epoch 143	Average Loss:	18140.6876953125
Epoch 144	Average Loss:	18139.076171875
Epoch 145	Average Loss:	18134.702408854166
Epoch 146	Average Loss:	18133.36796875
Epoch 147	Average Loss:	18135.098567708334
Epoch 148	Average Loss:	18139.4064453125
Epoch 149	Average Loss:	18143.664908854167
Epoch 150	Average Loss:	18174.88125
Epoch 151	Average Loss:	18190.915625
Epoch 152	Average Loss:	18200.290885416667
Epoch 153	Average Loss:	18153.7798828125
Epoch 154	Average Loss:	18137.784505208332
Epoch 155	Average Loss:	18135.867057291667
Epoch 156	Average Loss:	18120.585677083334
Epoch 157	Average Loss:	18123.639322916668
Epoch 158	Average Loss:	18120.394596354166
Epoch 159	Average Loss:	18112.89892578125
Epoch 160	Average Loss:	18111.2876953125
Epoch 161	Average Loss:	18112.6376953125
Epoch 162	Average Loss:	18109.566080729168
Epoch 163	Average Loss:	18106.735416666666
Epoch 164	Average Loss:	18111.521354166667
Epoch 165	Average Loss:	18108.775130208334
Epoch 166	Average Loss:	18104.437109375
Epoch 167	Average Loss:	18099.853776041666
Epoch 168	Average Loss:	18098.6955078125
Epoch 169	Average Loss:	18103.565950520835
Epoch 170	Average Loss:	18099.370638020835
Epoch 171	Average Loss:	18095.46015625
Epoch 172	Average Loss:	18093.431966145832
Epoch 173	Average Loss:	18090.335091145833
Epoch 174	Average Loss:	18089.931119791665
Epoch 175	Average Loss:	18087.786848958334
Epoch 176	Average Loss:	18088.88095703125

Epoch 177	Average Loss:	18086.694661458332
Epoch 178	Average Loss:	18086.349348958334
Epoch 179	Average Loss:	18090.975455729167
Epoch 180	Average Loss:	18086.788606770835
Epoch 181	Average Loss:	18089.86328125
Epoch 182	Average Loss:	18092.892708333333
Epoch 183	Average Loss:	18101.485026041668
Epoch 184	Average Loss:	18097.872005208334
Epoch 185	Average Loss:	18096.225260416668
Epoch 186	Average Loss:	18090.8216796875
Epoch 187	Average Loss:	18079.372395833332
Epoch 188	Average Loss:	18079.153450520833
Epoch 189	Average Loss:	18076.269010416665
Epoch 190	Average Loss:	18077.998274739584
Epoch 191	Average Loss:	18075.8345703125
Epoch 192	Average Loss:	18074.662109375
Epoch 193	Average Loss:	18077.490169270834
Epoch 194	Average Loss:	18072.867447916666
Epoch 195	Average Loss:	18069.007356770835
Epoch 196	Average Loss:	18069.1072265625
Epoch 197	Average Loss:	18070.437109375
Epoch 198	Average Loss:	18067.746744791668
Epoch 199	Average Loss:	18064.602994791665
Epoch 200	Average Loss:	18063.783723958335
Epoch 201	Average Loss:	18060.71875
Epoch 202	Average Loss:	18061.3619140625
Epoch 203	Average Loss:	18061.312565104166
Epoch 204	Average Loss:	18061.048763020834
Epoch 205	Average Loss:	18063.222981770832
Epoch 206	Average Loss:	18065.293098958333
Epoch 207	Average Loss:	18067.3703125
Epoch 208	Average Loss:	18072.9037109375
Epoch 209	Average Loss:	18080.6181640625
Epoch 210	Average Loss:	18098.685546875
Epoch 211	Average Loss:	18102.733658854166
Epoch 212	Average Loss:	18077.526302083334
Epoch 213	Average Loss:	18071.200455729166
Epoch 214	Average Loss:	18074.301953125
Epoch 215	Average Loss:	18078.243619791665
Epoch 216	Average Loss:	18062.753385416665
Epoch 217	Average Loss:	18060.2708984375
Epoch 218	Average Loss:	18056.439908854165
Epoch 219	Average Loss:	18054.439713541666
Epoch 220	Average Loss:	18053.662369791666
Epoch 221	Average Loss:	18051.450130208334
Epoch 222	Average Loss:	18049.860807291665
Epoch 223	Average Loss:	18045.443033854168
Epoch 224	Average Loss:	18046.503645833334
Epoch 225	Average Loss:	18047.4408203125
Epoch 226	Average Loss:	18050.463541666668
Epoch 227	Average Loss:	18052.3005859375
Epoch 228	Average Loss:	18052.7564453125
Epoch 229	Average Loss:	18050.3251953125
Epoch 230	Average Loss:	18050.217643229167



Epoch 231	Average Loss:	18047.581966145834
Epoch 232	Average Loss:	18040.901236979167
Epoch 233	Average Loss:	18042.4123046875
Epoch 234	Average Loss:	18041.729557291666
Epoch 235	Average Loss:	18039.57421875
Epoch 236	Average Loss:	18044.0546875
Epoch 237	Average Loss:	18050.750455729165
Epoch 238	Average Loss:	18043.356380208334
Epoch 239	Average Loss:	18038.5041015625
Epoch 240	Average Loss:	18041.3998046875
Epoch 241	Average Loss:	18038.901171875
Epoch 242	Average Loss:	18036.540625
Epoch 243	Average Loss:	18036.8830078125
Epoch 244	Average Loss:	18033.447981770834
Epoch 245	Average Loss:	18037.0326171875
Epoch 246	Average Loss:	18036.203450520832
Epoch 247	Average Loss:	18037.860026041668
Epoch 248	Average Loss:	18036.047591145834
Epoch 249	Average Loss:	18035.763932291666
Epoch 250	Average Loss:	18031.71953125
Epoch 251	Average Loss:	18033.680859375
Epoch 252	Average Loss:	18030.665104166666
Epoch 253	Average Loss:	18030.555729166666
Epoch 254	Average Loss:	18034.099088541665
Epoch 255	Average Loss:	18040.186979166665
Epoch 256	Average Loss:	18056.616276041666
Epoch 257	Average Loss:	18069.8060546875
Epoch 258	Average Loss:	18069.696875
Epoch 259	Average Loss:	18049.599153645835
Epoch 260	Average Loss:	18041.285611979165
Epoch 261	Average Loss:	18034.554264322916
Epoch 262	Average Loss:	18031.156575520832
Epoch 263	Average Loss:	18025.990071614582
Epoch 264	Average Loss:	18028.906119791667
Epoch 265	Average Loss:	18028.270833333332
Epoch 266	Average Loss:	18027.366861979168
Epoch 267	Average Loss:	18031.446028645834
Epoch 268	Average Loss:	18028.372526041665
Epoch 269	Average Loss:	18025.175065104166
Epoch 270	Average Loss:	18022.221419270834
Epoch 271	Average Loss:	18026.272005208335
Epoch 272	Average Loss:	18033.085807291667
Epoch 273	Average Loss:	18028.376432291665
Epoch 274	Average Loss:	18030.0322265625
Epoch 275	Average Loss:	18026.4943359375
Epoch 276	Average Loss:	18029.629166666666
Epoch 277	Average Loss:	18026.324283854166
Epoch 278	Average Loss:	18023.555403645834
Epoch 279	Average Loss:	18023.219270833335
Epoch 280	Average Loss:	18020.180729166666
Epoch 281	Average Loss:	18017.859309895834
Epoch 282	Average Loss:	18017.984635416666
Epoch 283	Average Loss:	18019.8328125
Epoch 284	Average Loss:	18019.273567708333

Epoch 285	Average Loss:	18018.184700520833
Epoch 286	Average Loss:	18019.34921875
Epoch 287	Average Loss:	18014.193098958334
Epoch 288	Average Loss:	18014.832356770832
Epoch 289	Average Loss:	18016.7216796875
Epoch 290	Average Loss:	18014.741276041666
Epoch 291	Average Loss:	18012.723567708334
Epoch 292	Average Loss:	18017.6455078125
Epoch 293	Average Loss:	18018.659635416665
Epoch 294	Average Loss:	18021.1994140625
Epoch 295	Average Loss:	18021.951497395832
Epoch 296	Average Loss:	18027.541731770834
Epoch 297	Average Loss:	18025.543424479165
Epoch 298	Average Loss:	18027.2349609375
Epoch 299	Average Loss:	18020.8708984375
Epoch 300	Average Loss:	18014.2111328125
Epoch 301	Average Loss:	18012.272135416668
Epoch 302	Average Loss:	18014.964388020835
Epoch 303	Average Loss:	18019.645182291668
Epoch 304	Average Loss:	18032.805859375
Epoch 305	Average Loss:	18039.362630208332
Epoch 306	Average Loss:	18023.405208333334
Epoch 307	Average Loss:	18017.415234375
Epoch 308	Average Loss:	18011.645052083335
Epoch 309	Average Loss:	18012.7642578125
Epoch 310	Average Loss:	18011.442708333332
Epoch 311	Average Loss:	18006.3921875
Epoch 312	Average Loss:	18007.996223958333
Epoch 313	Average Loss:	18005.698567708332
Epoch 314	Average Loss:	18004.3513671875
Epoch 315	Average Loss:	18010.1490234375
Epoch 316	Average Loss:	18007.761067708332
Epoch 317	Average Loss:	18009.033854166668
Epoch 318	Average Loss:	18004.971940104166
Epoch 319	Average Loss:	18004.994075520834
Epoch 320	Average Loss:	18008.792643229168
Epoch 321	Average Loss:	18004.417838541667
Epoch 322	Average Loss:	18006.92265625
Epoch 323	Average Loss:	18002.2216796875
Epoch 324	Average Loss:	18004.173177083332
Epoch 325	Average Loss:	18008.550520833334
Epoch 326	Average Loss:	18009.239518229166
Epoch 327	Average Loss:	18011.016471354167
Epoch 328	Average Loss:	18006.9396484375
Epoch 329	Average Loss:	18003.367122395834
Epoch 330	Average Loss:	18007.133528645834
Epoch 331	Average Loss:	18013.135546875
Epoch 332	Average Loss:	18012.379947916666
Epoch 333	Average Loss:	18010.069986979168
Epoch 334	Average Loss:	18001.312044270835
Epoch 335	Average Loss:	18006.6541015625
Epoch 336	Average Loss:	18011.599088541665
Epoch 337	Average Loss:	18015.217578125
Epoch 338	Average Loss:	18002.3255859375



```

Epoch 339   Average Loss:  18002.940169270834
Epoch 340   Average Loss:  17997.297200520832
Epoch 341   Average Loss:  17999.463020833333
Epoch 342   Average Loss:  17996.109375
Epoch 343   Average Loss:  17997.535481770832
Epoch 344   Average Loss:  17994.8701171875
Epoch 345   Average Loss:  17999.761328125
Epoch 346   Average Loss:  17999.8560546875
Epoch 347   Average Loss:  18005.083463541665
Epoch 348   Average Loss:  18005.572005208334
Epoch 349   Average Loss:  18007.6244140625
Epoch 350   Average Loss:  18005.866471354166

```

## Feeding the testing set of images into the encoder

A new script `encode_validation.py` was created to iterate over the different images, and extracting their Z values. The script is located in the same folder where the VAE model was created:

```

└─ scripts/
  └─ wings
    └─ 03_subset_std
      └─ phenotype_1
        └─ phenotype_2
          └─ Autoencoder
            ├── constants.py
            ├── encode_validation.py      <---- encoder for phenotype_1
            and phenotype_2
            ├── mosaic_VAE_visualization.py
            ├── output.pth
            ├── VAE.py
            ├── VAE_train.py
            ├── VAE_validate.py
            ├── vgg19-dcbb9e9d.pth      <--- trained model weights
            └─ VGG19.py
          └─ Manifold_learning
          └─ PCA_decomposition

```

For images belonging to phenotype\_1, the following values of latent space were recovered:

```

encodings for phenotype_1
tensor([[ -2.8056],
        [ -2.6430],
        [ -2.5537],
        [ -2.7457]], device='cuda:0', grad_fn=<AddBackward0>)

```

For images belonging to phenotype\_2, the following values of the latent space were recovered:

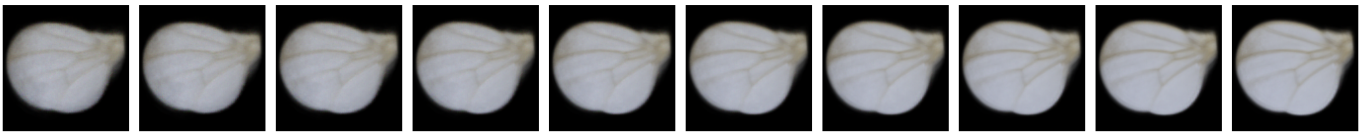
```
encodings for phenotype_2
tensor([[ -3.7645],
        [ -4.2681],
        [ -4.5377],
        [ -4.4112],
        [ -3.7510]], device='cuda:0', grad_fn=<AddBackward0>)
```

## Visualizing a gradient

With the images encoded in latent space, a new script `latent_grad_vis_1D.py` was generated which:

- Takes two sets of image values, represented as a list of latent space
- Takes the average for each list, returning two real numbers  $l_1$  and  $l_2$
- Creates a gradient visualization by generating  $n$  images, where the value fed into the encoder is given by the position  $n_i$  in a linear space from  $l_1$  to  $l_2$

This enabled us to visualize the sense that our model developed on the data.



The figure represents the linear space interpolation in latent space between phenotype 1 and 2. The elements on the left represent the recovered

## KNN analysis

A new python script called `knn.py` was made to attempt running a KNN (K-Nearest Neighbors) analysis on the data from latent space. To achieve this, a new model was trained with more than 1D latent space sized vector  $z$ . The model was trained using the following parameters:

```
dataset_size=      133-9 images (124)
epochs =           350
batch_size =        30
dimension in z =     8
```

The number for the dimensions of  $z$  was picked almost arbitrarily, picking the even number 8 as a multiple of 2, as it's often the standard for other types of hyperparameter tuning values when it comes to neural networks.

Epoch 1	Average Loss: 151551.62786458334
Epoch 2	Average Loss: 37593.43359375
Epoch 3	Average Loss: 33107.192122395834
Epoch 4	Average Loss: 31885.396028645835
Epoch 5	Average Loss: 30064.202734375
Epoch 6	Average Loss: 27775.0265625
Epoch 7	Average Loss: 25010.707421875
Epoch 8	Average Loss: 22636.848307291668
Epoch 9	Average Loss: 21405.393489583334
Epoch 10	Average Loss: 20625.387434895834
Epoch 11	Average Loss: 20134.231510416666
Epoch 12	Average Loss: 19809.745052083334
Epoch 13	Average Loss: 19591.230859375
Epoch 14	Average Loss: 19459.0470703125
Epoch 15	Average Loss: 19360.098567708334
Epoch 16	Average Loss: 19282.537369791666
Epoch 17	Average Loss: 19215.1236328125
Epoch 18	Average Loss: 19158.495572916665
Epoch 19	Average Loss: 19091.476171875
Epoch 20	Average Loss: 19040.390950520832
Epoch 21	Average Loss: 18996.391536458334
Epoch 22	Average Loss: 18970.251432291665
Epoch 23	Average Loss: 18938.444791666665
Epoch 24	Average Loss: 18913.9400390625
Epoch 25	Average Loss: 18886.198502604166
Epoch 26	Average Loss: 18858.3619140625
Epoch 27	Average Loss: 18826.4490234375
Epoch 28	Average Loss: 18785.228059895835
Epoch 29	Average Loss: 18735.654752604165
Epoch 30	Average Loss: 18668.781315104166
Epoch 31	Average Loss: 18609.461002604166
Epoch 32	Average Loss: 18519.4146484375
Epoch 33	Average Loss: 18452.31875
Epoch 34	Average Loss: 18387.058463541667
Epoch 35	Average Loss: 18326.114713541665
Epoch 36	Average Loss: 18276.486783854165
Epoch 37	Average Loss: 18240.3087890625
Epoch 38	Average Loss: 18190.961197916666
Epoch 39	Average Loss: 18149.309635416666
Epoch 40	Average Loss: 18113.890559895834
Epoch 41	Average Loss: 18087.942903645835
Epoch 42	Average Loss: 18066.9462890625
Epoch 43	Average Loss: 18058.356770833332
Epoch 44	Average Loss: 18020.221484375
Epoch 45	Average Loss: 17969.3662109375
Epoch 46	Average Loss: 17929.257682291667
Epoch 47	Average Loss: 17909.591731770834
Epoch 48	Average Loss: 17880.3189453125
Epoch 49	Average Loss: 17858.110546875
Epoch 50	Average Loss: 17828.6296875
Epoch 51	Average Loss: 17802.654817708335
Epoch 52	Average Loss: 17767.509765625
Epoch 53	Average Loss: 17741.163346354166

Epoch 54	Average Loss:	17718.957682291668
Epoch 55	Average Loss:	17702.2908203125
Epoch 56	Average Loss:	17686.289518229165
Epoch 57	Average Loss:	17695.95625
Epoch 58	Average Loss:	17705.365494791666
Epoch 59	Average Loss:	17698.668098958333
Epoch 60	Average Loss:	17669.0111328125
Epoch 61	Average Loss:	17611.529296875
Epoch 62	Average Loss:	17608.20703125
Epoch 63	Average Loss:	17575.164192708333
Epoch 64	Average Loss:	17558.429166666665
Epoch 65	Average Loss:	17528.95390625
Epoch 66	Average Loss:	17514.790234375
Epoch 67	Average Loss:	17499.8
Epoch 68	Average Loss:	17482.4748046875
Epoch 69	Average Loss:	17481.410286458333
Epoch 70	Average Loss:	17484.213411458335
Epoch 71	Average Loss:	17494.800520833334
Epoch 72	Average Loss:	17461.405598958332
Epoch 73	Average Loss:	17426.30166015625
Epoch 74	Average Loss:	17413.0841796875
Epoch 75	Average Loss:	17400.88125
Epoch 76	Average Loss:	17390.9115234375
Epoch 77	Average Loss:	17375.408268229166
Epoch 78	Average Loss:	17364.203971354167
Epoch 79	Average Loss:	17350.769401041667
Epoch 80	Average Loss:	17337.64921875
Epoch 81	Average Loss:	17323.447526041666
Epoch 82	Average Loss:	17313.540559895835
Epoch 83	Average Loss:	17306.488671875
Epoch 84	Average Loss:	17295.754720052082
Epoch 85	Average Loss:	17289.054427083334
Epoch 86	Average Loss:	17283.301822916666
Epoch 87	Average Loss:	17276.519466145834
Epoch 88	Average Loss:	17280.4607421875
Epoch 89	Average Loss:	17289.670572916668
Epoch 90	Average Loss:	17305.669596354168
Epoch 91	Average Loss:	17309.910807291668
Epoch 92	Average Loss:	17269.615983072916
Epoch 93	Average Loss:	17255.626692708334
Epoch 94	Average Loss:	17252.214713541667
Epoch 95	Average Loss:	17238.076953125
Epoch 96	Average Loss:	17222.234635416666
Epoch 97	Average Loss:	17219.690787760417
Epoch 98	Average Loss:	17201.214973958333
Epoch 99	Average Loss:	17195.395768229166
Epoch 100	Average Loss:	17186.933984375
Epoch 101	Average Loss:	17185.39638671875
Epoch 102	Average Loss:	17181.823307291666
Epoch 103	Average Loss:	17171.7255859375
Epoch 104	Average Loss:	17167.8240234375
Epoch 105	Average Loss:	17163.5310546875
Epoch 106	Average Loss:	17161.3146484375
Epoch 107	Average Loss:	17156.0185546875

Epoch 108	Average Loss:	17152.143033854165
Epoch 109	Average Loss:	17150.81279296875
Epoch 110	Average Loss:	17145.546744791667
Epoch 111	Average Loss:	17143.5974609375
Epoch 112	Average Loss:	17140.564908854165
Epoch 113	Average Loss:	17150.476822916666
Epoch 114	Average Loss:	17172.7568359375
Epoch 115	Average Loss:	17185.881184895832
Epoch 116	Average Loss:	17148.800846354166
Epoch 117	Average Loss:	17118.8806640625
Epoch 118	Average Loss:	17119.407486979166
Epoch 119	Average Loss:	17109.49794921875
Epoch 120	Average Loss:	17108.5408203125
Epoch 121	Average Loss:	17107.445345052085
Epoch 122	Average Loss:	17091.098893229166
Epoch 123	Average Loss:	17088.017252604168
Epoch 124	Average Loss:	17079.496223958333
Epoch 125	Average Loss:	17074.88125
Epoch 126	Average Loss:	17072.4044921875
Epoch 127	Average Loss:	17073.179134114584
Epoch 128	Average Loss:	17066.233333333334
Epoch 129	Average Loss:	17067.881640625
Epoch 130	Average Loss:	17062.980989583335
Epoch 131	Average Loss:	17060.769466145834
Epoch 132	Average Loss:	17055.726302083334
Epoch 133	Average Loss:	17052.821744791665
Epoch 134	Average Loss:	17055.7478515625
Epoch 135	Average Loss:	17053.713606770834
Epoch 136	Average Loss:	17053.153580729166
Epoch 137	Average Loss:	17048.292447916665
Epoch 138	Average Loss:	17046.33681640625
Epoch 139	Average Loss:	17044.698372395833
Epoch 140	Average Loss:	17038.354622395833
Epoch 141	Average Loss:	17038.558072916665
Epoch 142	Average Loss:	17030.653059895834
Epoch 143	Average Loss:	17030.4701171875
Epoch 144	Average Loss:	17030.158528645832
Epoch 145	Average Loss:	17036.097623697915
Epoch 146	Average Loss:	17034.832161458333
Epoch 147	Average Loss:	17048.058919270832
Epoch 148	Average Loss:	17070.552734375
Epoch 149	Average Loss:	17074.049153645832
Epoch 150	Average Loss:	17037.847102864584
Epoch 151	Average Loss:	17025.519759114584
Epoch 152	Average Loss:	17031.241015625
Epoch 153	Average Loss:	17017.806640625
Epoch 154	Average Loss:	17010.691536458333
Epoch 155	Average Loss:	17009.994270833333
Epoch 156	Average Loss:	17001.411002604167
Epoch 157	Average Loss:	17002.2818359375
Epoch 158	Average Loss:	16997.5080078125
Epoch 159	Average Loss:	16994.147721354166
Epoch 160	Average Loss:	16993.758333333335
Epoch 161	Average Loss:	16994.4412109375

Epoch 162	Average Loss:	17005.466861979166
Epoch 163	Average Loss:	17024.099609375
Epoch 164	Average Loss:	17013.813639322918
Epoch 165	Average Loss:	17015.155826822916
Epoch 166	Average Loss:	16996.471419270834
Epoch 167	Average Loss:	17001.819401041666
Epoch 168	Average Loss:	16986.6712890625
Epoch 169	Average Loss:	16992.984602864584
Epoch 170	Average Loss:	17002.49228515625
Epoch 171	Average Loss:	17017.26015625
Epoch 172	Average Loss:	17018.030729166665
Epoch 173	Average Loss:	16990.465104166666
Epoch 174	Average Loss:	16984.313802083332
Epoch 175	Average Loss:	16975.3376953125
Epoch 176	Average Loss:	16970.492578125
Epoch 177	Average Loss:	16969.421354166665
Epoch 178	Average Loss:	16960.698990885416
Epoch 179	Average Loss:	16958.3533203125
Epoch 180	Average Loss:	16956.853776041666
Epoch 181	Average Loss:	16953.608528645833
Epoch 182	Average Loss:	16947.443424479166
Epoch 183	Average Loss:	16945.452669270835
Epoch 184	Average Loss:	16944.499869791667
Epoch 185	Average Loss:	16942.584505208335
Epoch 186	Average Loss:	16939.373567708335
Epoch 187	Average Loss:	16941.011458333334
Epoch 188	Average Loss:	16939.453059895834
Epoch 189	Average Loss:	16936.051692708334
Epoch 190	Average Loss:	16936.046419270835
Epoch 191	Average Loss:	16933.97734375
Epoch 192	Average Loss:	16935.722200520835
Epoch 193	Average Loss:	16934.733626302084
Epoch 194	Average Loss:	16933.7337890625
Epoch 195	Average Loss:	16932.977864583332
Epoch 196	Average Loss:	16930.025162760416
Epoch 197	Average Loss:	16934.84140625
Epoch 198	Average Loss:	16936.675455729168
Epoch 199	Average Loss:	16937.679915364584
Epoch 200	Average Loss:	16940.596061197917
Epoch 201	Average Loss:	16941.4814453125
Epoch 202	Average Loss:	16942.933463541667
Epoch 203	Average Loss:	16951.7568359375
Epoch 204	Average Loss:	16957.093619791667
Epoch 205	Average Loss:	16958.371354166666
Epoch 206	Average Loss:	16976.222786458333
Epoch 207	Average Loss:	16985.330240885418
Epoch 208	Average Loss:	16977.897819010417
Epoch 209	Average Loss:	17014.727799479166
Epoch 210	Average Loss:	16963.127766927082
Epoch 211	Average Loss:	16951.534244791666
Epoch 212	Average Loss:	16933.6177734375
Epoch 213	Average Loss:	16932.713606770834
Epoch 214	Average Loss:	16922.231575520833
Epoch 215	Average Loss:	16927.258528645834



Epoch 216	Average Loss:	16915.104036458335
Epoch 217	Average Loss:	16912.133072916666
Epoch 218	Average Loss:	16913.150325520834
Epoch 219	Average Loss:	16916.08310546875
Epoch 220	Average Loss:	16916.740559895832
Epoch 221	Average Loss:	16914.244401041666
Epoch 222	Average Loss:	16911.324869791668
Epoch 223	Average Loss:	16910.059765625
Epoch 224	Average Loss:	16907.106640625
Epoch 225	Average Loss:	16906.71591796875
Epoch 226	Average Loss:	16905.439225260416
Epoch 227	Average Loss:	16901.696451822918
Epoch 228	Average Loss:	16903.41875
Epoch 229	Average Loss:	16901.061067708335
Epoch 230	Average Loss:	16901.3638671875
Epoch 231	Average Loss:	16899.0458984375
Epoch 232	Average Loss:	16902.604752604166
Epoch 233	Average Loss:	16903.432747395833
Epoch 234	Average Loss:	16895.425651041667
Epoch 235	Average Loss:	16898.17265625
Epoch 236	Average Loss:	16897.187955729165
Epoch 237	Average Loss:	16894.739908854168
Epoch 238	Average Loss:	16899.915104166666
Epoch 239	Average Loss:	16893.12265625
Epoch 240	Average Loss:	16890.093359375
Epoch 241	Average Loss:	16885.58564453125
Epoch 242	Average Loss:	16885.3396484375
Epoch 243	Average Loss:	16880.545703125
Epoch 244	Average Loss:	16878.690690104166
Epoch 245	Average Loss:	16877.129459635416
Epoch 246	Average Loss:	16878.09375
Epoch 247	Average Loss:	16875.626432291665
Epoch 248	Average Loss:	16876.320963541668
Epoch 249	Average Loss:	16872.9365234375
Epoch 250	Average Loss:	16874.33310546875
Epoch 251	Average Loss:	16871.229134114583
Epoch 252	Average Loss:	16869.475716145833
Epoch 253	Average Loss:	16868.981380208334
Epoch 254	Average Loss:	16867.788932291667
Epoch 255	Average Loss:	16867.643359375
Epoch 256	Average Loss:	16866.511067708332
Epoch 257	Average Loss:	16867.077311197918
Epoch 258	Average Loss:	16866.703515625
Epoch 259	Average Loss:	16866.79453125
Epoch 260	Average Loss:	16867.288802083334
Epoch 261	Average Loss:	16866.843098958332
Epoch 262	Average Loss:	16872.083268229166
Epoch 263	Average Loss:	16872.97548828125
Epoch 264	Average Loss:	16873.016959635417
Epoch 265	Average Loss:	16869.961100260418
Epoch 266	Average Loss:	16868.6689453125
Epoch 267	Average Loss:	16871.232096354168
Epoch 268	Average Loss:	16871.853971354165
Epoch 269	Average Loss:	16872.234147135416

Epoch 270	Average Loss:	16882.731184895834
Epoch 271	Average Loss:	16878.029427083333
Epoch 272	Average Loss:	16880.425260416665
Epoch 273	Average Loss:	16878.763151041665
Epoch 274	Average Loss:	16875.222395833334
Epoch 275	Average Loss:	16868.104752604166
Epoch 276	Average Loss:	16861.17470703125
Epoch 277	Average Loss:	16863.660514322917
Epoch 278	Average Loss:	16865.293684895834
Epoch 279	Average Loss:	16854.927897135418
Epoch 280	Average Loss:	16857.115690104165
Epoch 281	Average Loss:	16856.776236979167
Epoch 282	Average Loss:	16855.265755208333
Epoch 283	Average Loss:	16854.7384765625
Epoch 284	Average Loss:	16850.778450520833
Epoch 285	Average Loss:	16849.185481770834
Epoch 286	Average Loss:	16849.449348958333
Epoch 287	Average Loss:	16853.428580729167
Epoch 288	Average Loss:	16858.661588541665
Epoch 289	Average Loss:	16860.22421875
Epoch 290	Average Loss:	16868.224739583333
Epoch 291	Average Loss:	16873.354752604166
Epoch 292	Average Loss:	16898.685481770834
Epoch 293	Average Loss:	16894.820768229165
Epoch 294	Average Loss:	16937.44306640625
Epoch 295	Average Loss:	16937.717122395832
Epoch 296	Average Loss:	16916.361263020834
Epoch 297	Average Loss:	16909.5486328125
Epoch 298	Average Loss:	16874.013899739584
Epoch 299	Average Loss:	16878.220865885418
Epoch 300	Average Loss:	16859.013020833332
Epoch 301	Average Loss:	16847.37587890625
Epoch 302	Average Loss:	16847.178059895832
Epoch 303	Average Loss:	16842.302734375
Epoch 304	Average Loss:	16836.652018229168
Epoch 305	Average Loss:	16833.0892578125
Epoch 306	Average Loss:	16833.011588541667
Epoch 307	Average Loss:	16831.526595052084
Epoch 308	Average Loss:	16830.740852864583
Epoch 309	Average Loss:	16829.369401041666
Epoch 310	Average Loss:	16828.273046875
Epoch 311	Average Loss:	16828.281119791667
Epoch 312	Average Loss:	16827.4328125
Epoch 313	Average Loss:	16826.325846354168
Epoch 314	Average Loss:	16825.158072916667
Epoch 315	Average Loss:	16825.3759765625
Epoch 316	Average Loss:	16824.634147135417
Epoch 317	Average Loss:	16823.8830078125
Epoch 318	Average Loss:	16823.6015625
Epoch 319	Average Loss:	16823.999837239582
Epoch 320	Average Loss:	16820.353287760416
Epoch 321	Average Loss:	16821.997037760415
Epoch 322	Average Loss:	16821.777408854166
Epoch 323	Average Loss:	16820.104264322916

Epoch 324	Average Loss:	16820.025944010416
Epoch 325	Average Loss:	16819.3802734375
Epoch 326	Average Loss:	16820.053841145833
Epoch 327	Average Loss:	16818.188020833335
Epoch 328	Average Loss:	16821.850032552084
Epoch 329	Average Loss:	16821.378645833334
Epoch 330	Average Loss:	16820.729654947918
Epoch 331	Average Loss:	16822.35625
Epoch 332	Average Loss:	16818.541373697917
Epoch 333	Average Loss:	16819.444010416668
Epoch 334	Average Loss:	16817.657747395835
Epoch 335	Average Loss:	16818.221223958335
Epoch 336	Average Loss:	16817.628580729168
Epoch 337	Average Loss:	16817.359830729165
Epoch 338	Average Loss:	16815.9044921875
Epoch 339	Average Loss:	16814.96298828125
Epoch 340	Average Loss:	16815.302213541665
Epoch 341	Average Loss:	16815.84619140625
Epoch 343	Average Loss:	16821.915950520834
Epoch 344	Average Loss:	16814.1224609375
Epoch 345	Average Loss:	16813.166015625
Epoch 346	Average Loss:	16812.379361979165
Epoch 347	Average Loss:	16811.94052734375
Epoch 348	Average Loss:	16816.612174479167
Epoch 349	Average Loss:	16822.912955729167
Epoch 350	Average Loss:	16818.7396484375

The resulting model `output_VAE_VGG_Feb6_10z.pth` has been saved in the same directory as the other python scripts:

```

├── scripts/
│   ├── Wings
│   │   ├── 00_MetaDataset
│   │   ├── 01_cleaned_Dataset
│   │   ├── 02_stdn_Dataset
│   │   ├── 03_subset_stdn
│   │   │   ├── phenotype_1
│   │   │   └── phenotype_2
│   │   └── Autoencoder
│   │       ├── constants.py
│   │       ├── encode_validation.py
│   │       ├── knn.py
│   │       ├── latent_grad_vis_1D.py
│   │       ├── mosaic_VAE_visualization.py
│   │       ├── output.pth
│   │       ├── output_VAE_VGG_Feb6_10z.pth
│   │       ├── VAE.py
│   │       ├── VAE_train.py
│   │       ├── VAE_validate.py
│   │       ├── vgg19-dcbb9e9d.pth
│   │       └── VGG19.py

```

```

├──Manifold_learning
├──PCA_decomposition

```

## Encoding the latent space representation for model output\_VAE\_VGG\_Feb6\_10z.pth

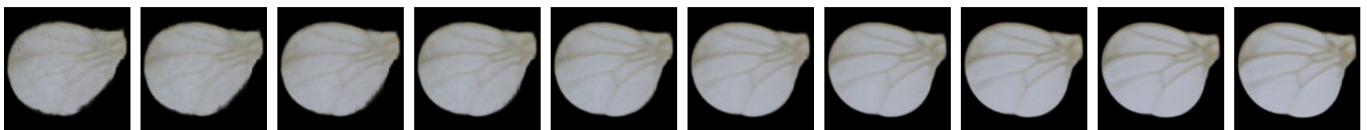
The resulting values of the encoding with 8 dimensions of a latent space with the phenotype 1 and 2 was obtained via the `encode_validation.py` file to obtain a set of  $k * 8$  float values, where  $k$  is the number of total images across all phenotypes.

```

[tensor([[ -1.2315,  2.0817,  0.3527, -0.6426, -2.8064,  0.4664, -1.7412, -1.1686],
         [ -1.0638, -0.3491, -1.8067,  1.2116, -3.8767, -1.8967,  0.4423, -0.5907],
         [ -2.1857,  2.8967, -1.0262,  0.5235, -1.8676, -0.0312,  1.5228, -0.7799],
         [  0.1656,  4.2359, -0.0438,  1.3187, -0.8061,  2.3772,  0.5196,
1.1527]]),
      device='cuda:0', grad_fn=<AddBackward0>),
 tensor([[ -1.3023,  0.8225, -2.0528,  2.9128, -1.9699,  1.7855,  0.2844, -0.9383],
         [ -2.5380,  2.4622, -1.6950,  0.9799, -1.4210,  2.3617,  0.6099, -1.8234],
         [ -1.6521,  1.1868, -1.6417,  1.4208,  0.0425,  2.3097, -0.6533, -3.2517],
         [ -2.7555,  2.4555, -1.1511,  1.4526,  0.1689,  1.6614,  1.0278, -1.2549],
         [ -2.9286,  1.4928, -1.3507,  2.5353, -1.0033,  1.4764, -1.0380,
-2.4542]]),
      device='cuda:0', grad_fn=<AddBackward0>)]

```

Feeding these elements into the visualization function `latent_grad_vis_1D` required a small adjustment in the handling of the and calculation of the mean for each of the two phenotypes. The name of the function was changed given the expansion in the domain of values the program can take. The name has been replaced to `latent_grad_vis`. The name of the script was also based on the constraint of 1D, and was therefore renamed to `latent_grad_vis.py`



These elements were then fed into the `analyze_latent_knn` function, which was imported from `knn.py` into `encode_validation.py` to generate the following matrices:

```

>>> phenotype 1:

distances
[0.      4.14957817  5.1779758   5.34708124]
[0.      4.5452232   5.1779758   7.53847741]
[0.      4.14957817  4.5452232   4.69965341]

```

```
[0.          4.69965341  5.34708124  7.53847741]
```

```
Indices
```

```
[0 2 1 3]
```

```
[1 2 0 3]
```

```
[2 0 1 3]
```

```
[3 2 0 1]
```

```
>>> phenotype 2:
```

```
distances
```

```
[0.          2.87673079  3.0187643   3.50417409]
```

```
[0.          1.76409104  2.81218626  2.82807829]
```

```
[0.          2.47919316  2.82807829  3.20681752]
```

```
[0.          1.76409104  3.20681752  3.21537143]
```

```
[0.          2.47919316  2.81218626  2.87673079]
```

```
indices
```

```
[0 4 1 3]
```

```
[1 3 4 2]
```

```
[2 4 1 3]
```

```
[3 1 2 4]
```

```
[4 2 1 0]
```