Update

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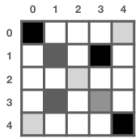
SPRACE

Sparse Data Generation

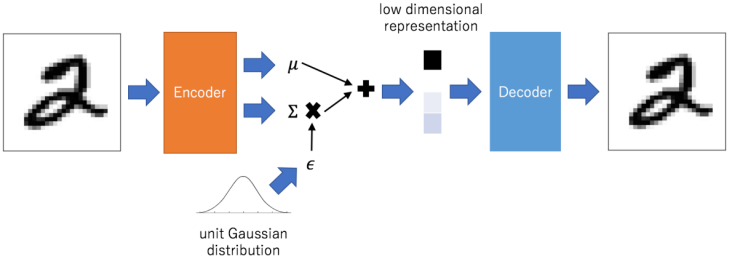
- Image with sparse pixels
  - Each pixel has 3 features:
    - A pair of position coordinates (x and y)
    - An intensity-like variable (pixel intensity)
- Separate only intense pixels
  - List the pixels with non-zero intensity
    - Less time consuming



0	0	1	1	2	3	3	4	4
0	4	1	3	2	1	3	0	4
1.00	0.25	0.75	1.00	0.25	0.75	0.50	0.25	1.00

Variational Autoencoder (VAE)

- A VAE is a neural network that has the following structure:



- Its main feature is the capability of generating new outputs through the encoding of the training inputs into a low dimensional representation
- Custom reconstruction loss term in loss function

Reconstruction Loss Term in VAE Loss Function

- Two different approaches
  - Use the pixel intensity as the third axis of a 3D space:

$$\sum_i \ min\ [d_E(p_i,\ \hat{p})]^2 + \sum_i \ min\ [d_E(p,\ \hat{p}_i)]^2 \tag{1}$$

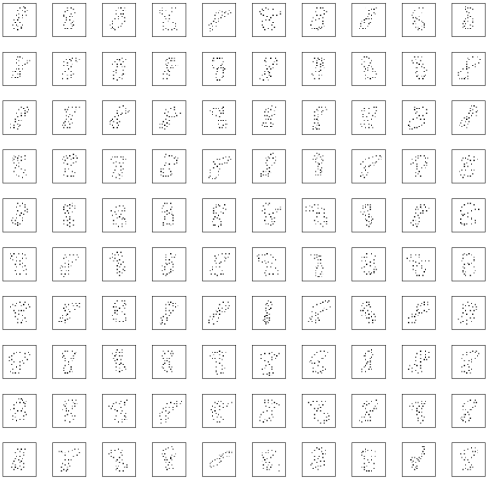
    - $p = (x,\ y,\ I)$ and $\hat{p} = (\hat{x},\ \hat{y},\ \hat{I})$ are input and output pixels features respectively;
  - Find the closest pixel and then compare their intensity:

$$\sum_i \ min\ [d_E(x_i,\ \hat{x})]^2 + \sum_i \ min\ [d_E(x,\ \hat{x}_i)]^2 + \sum_i (I_i - \hat{I}_{\hat{k}})^2 + \sum_i (I_k - \hat{I}_i)^2 \tag{2}$$

    - $x = (x,\ y)$ and $\hat{x} = (\hat{x},\ \hat{y})$ are the positions of input and output pixels respectively;
    - d_E is the euclidean distance;
    - I and $\hat{I}$ are the intensities of input and output pixels respectively;
    - $\hat{k} = \ argmin\ [d_E(x_i,\ \hat{x})]^2$ and $k = \ argmin\ [d_E(x,\ \hat{x}_i)]^2$;
- Optimizing the KL divergence intensity: $L = L_{rec} + \beta D_{KL}$

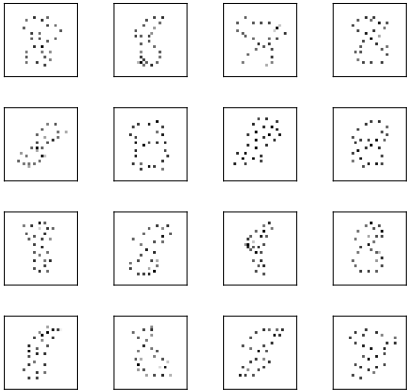
MNIST Superpixels Dataset

- Only 25 pixels with intensities greater than 0
- Very sparse
- Using only one type of digit
  - Train other networks for other digits

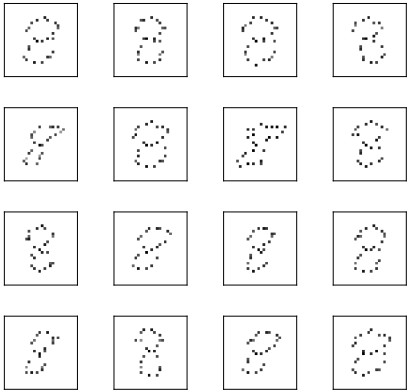


MNIST Superpixels Results

MNIST image

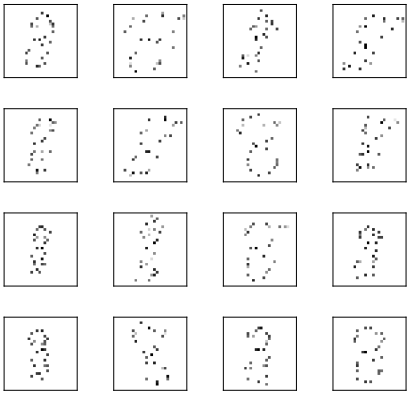


VAE reconstruction

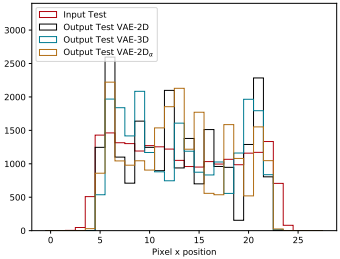


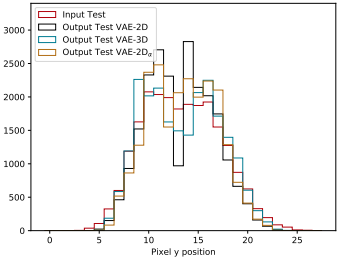
MNIST Superpixels Results

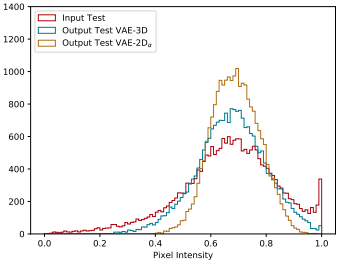
VAE generated

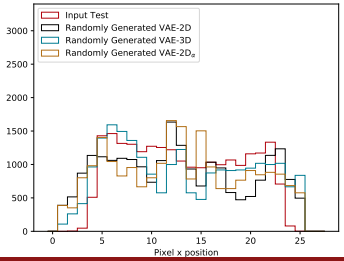


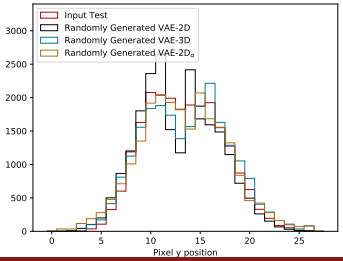
MNIST Superpixels Results

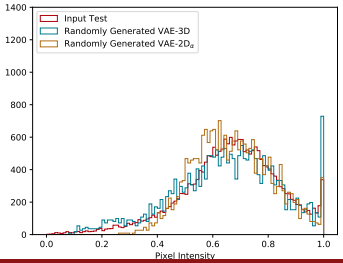








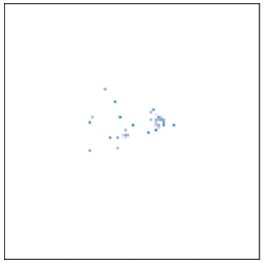




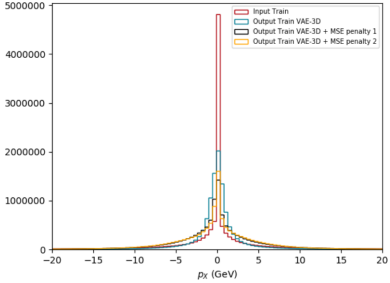
Hadronic Jets Generation

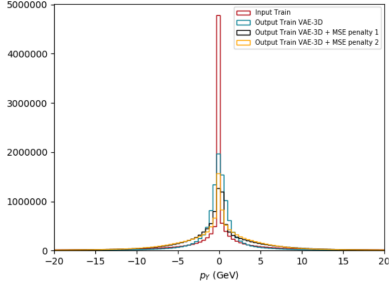
- Hadronic jets are composed of tens or hundreds of particles (such as the pixels of an image)
  - Two distinct ways to characterize the particles:
    - p_T, η and ϕ
    - p_x, p_y and p_z
- Loss function as:

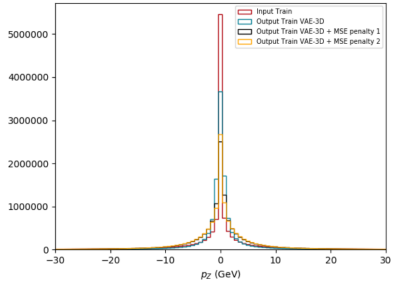
$$L = L_{rec} + \beta D_{KL} + MSE \text{ (jet features)}$$



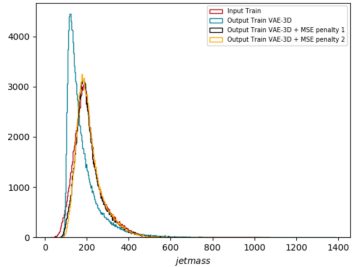
Jets Results

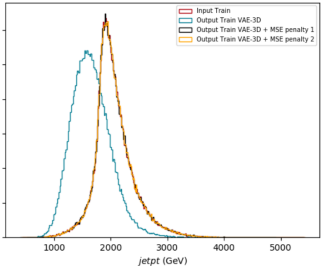


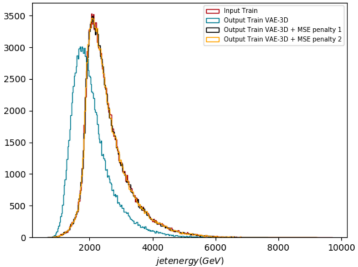


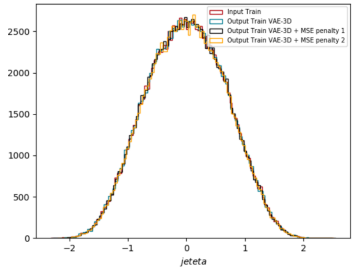


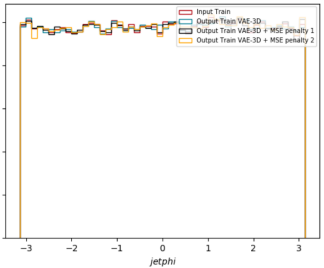
Jets Results











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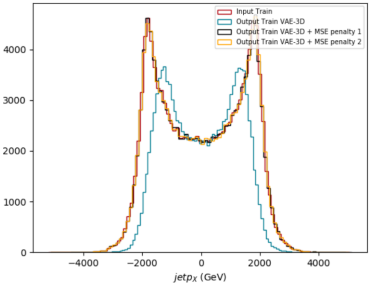

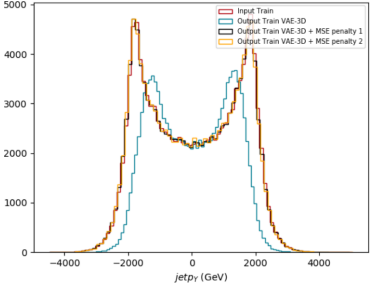

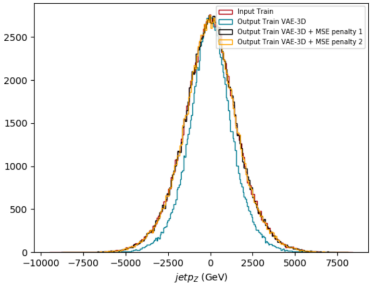

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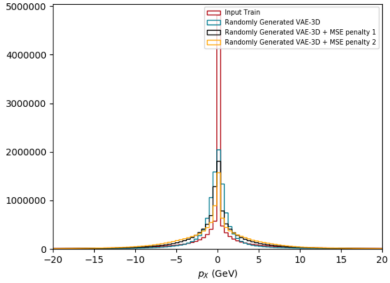

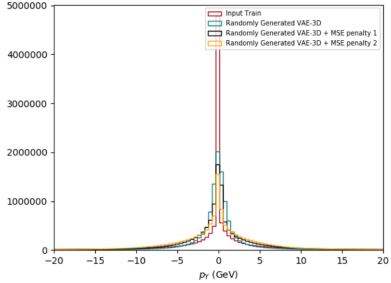

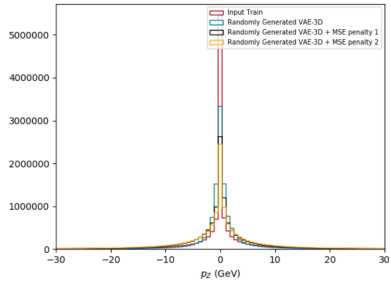

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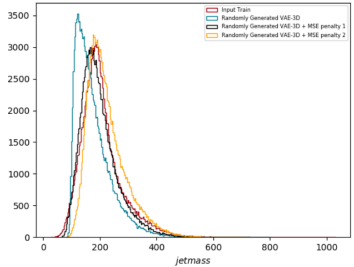

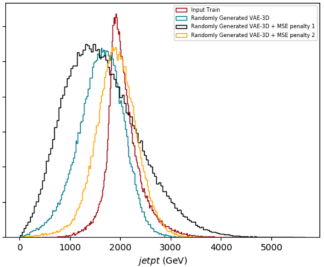

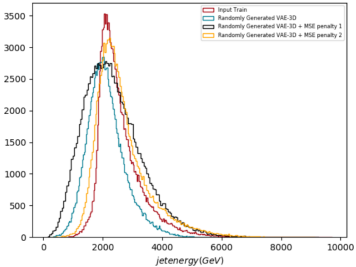

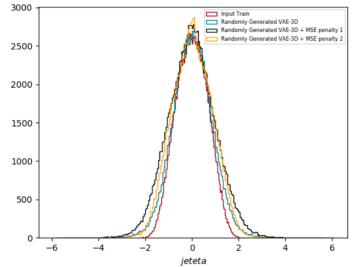

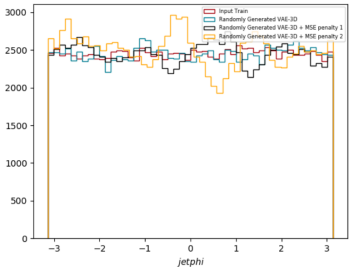

Jets Results