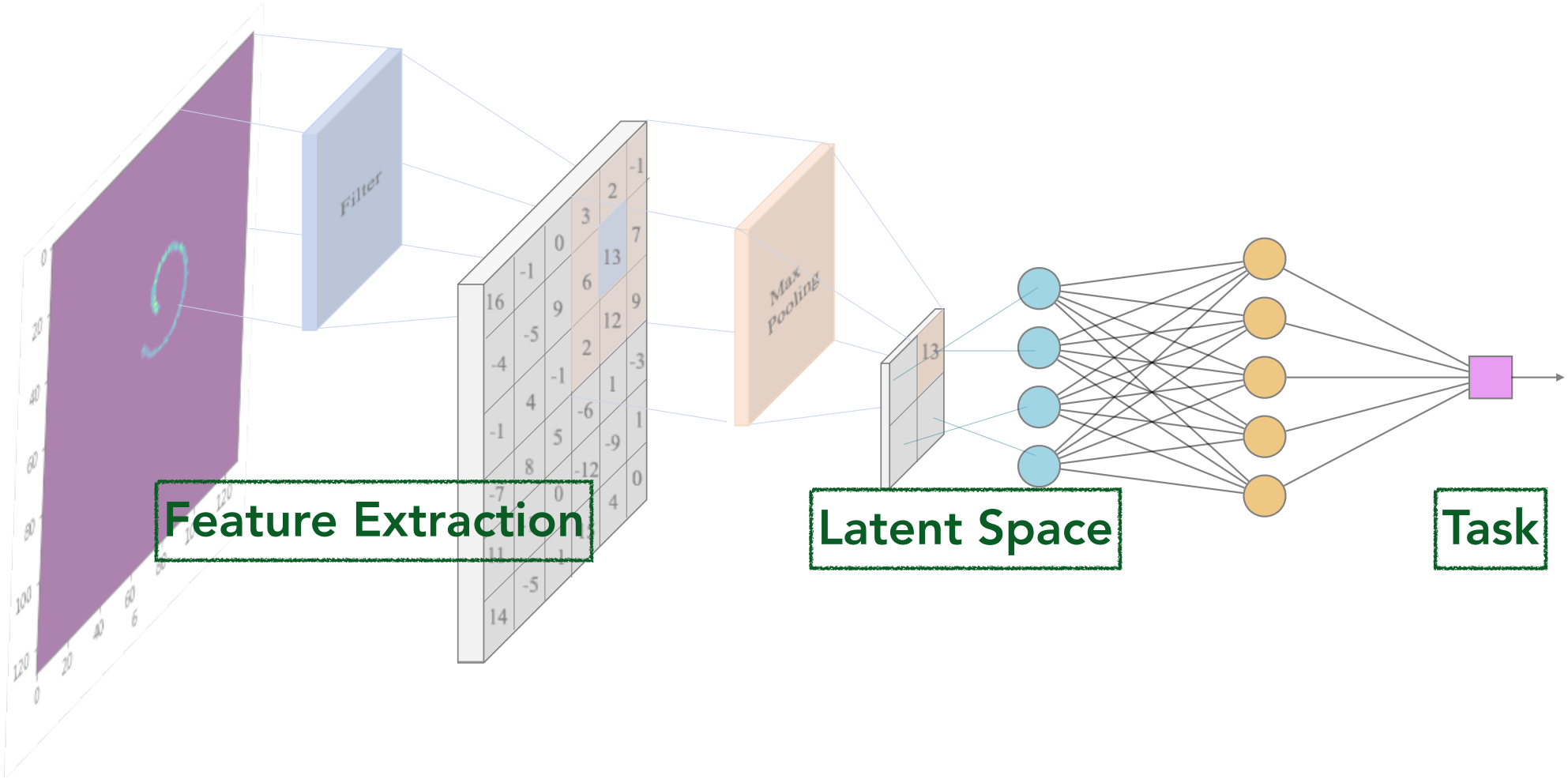
UNSUPERVISED LEARNING

MICHELLE KUCHERA
DAVIDSON COLLEGE

ECT* TALENT SUMMER SCHOOL
02 JULY 2020

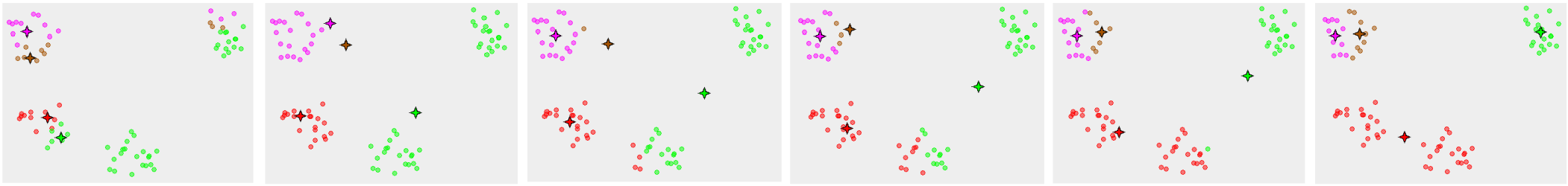
CONVOLUTIONAL NEURAL NETWORKS



CLUSTERING — KMEANS

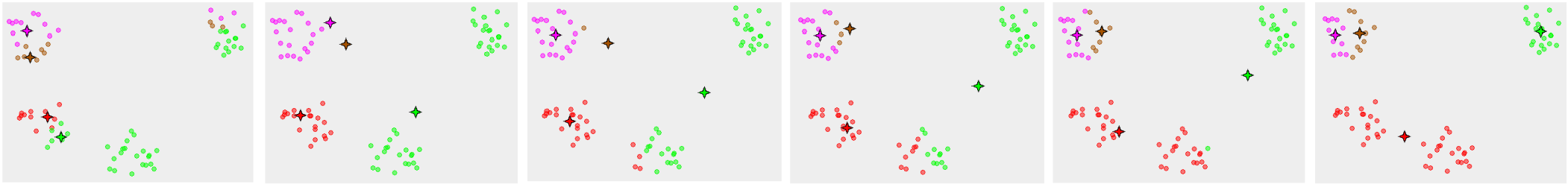
Goal: minimize pairwise distances between points in *same* cluster

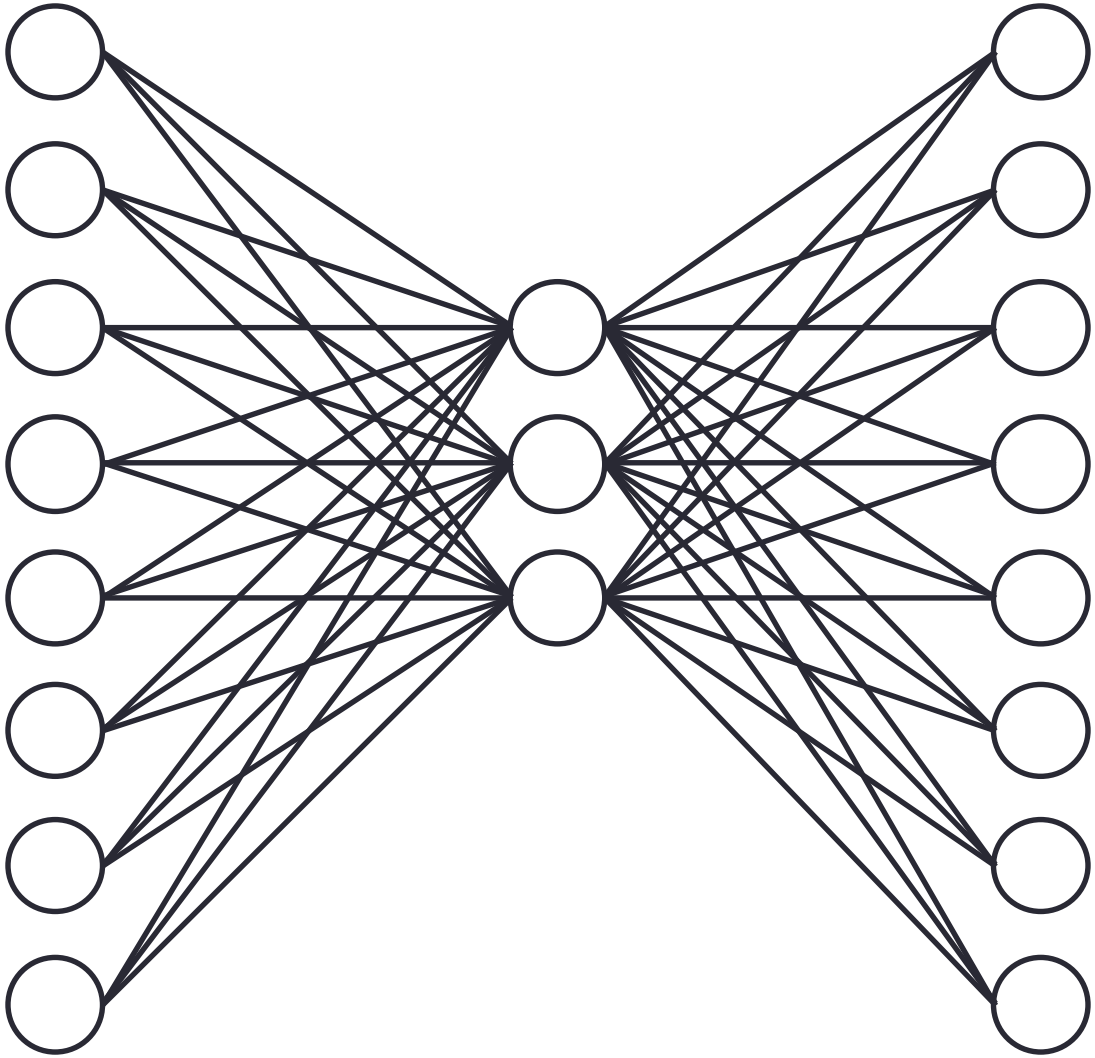
$$\min \sum_{i=1}^{k} \frac{1}{2N} \sum_{x,y,x \neq y}^{N} (\vec{x} - \vec{y})^2$$



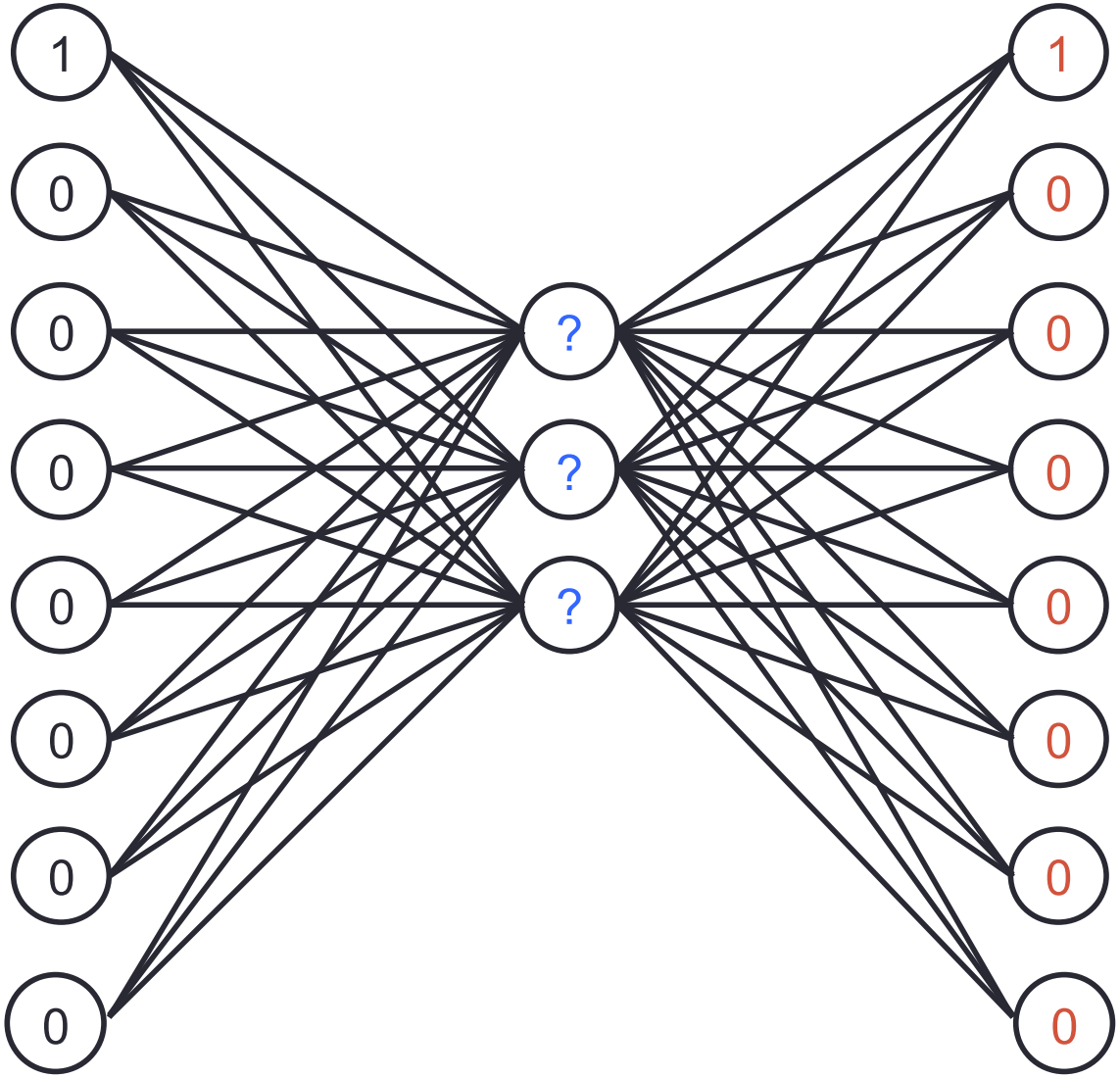
Goal: maximize pairwise distances between points in *different* clusters

CLUSTERING — KMEANS



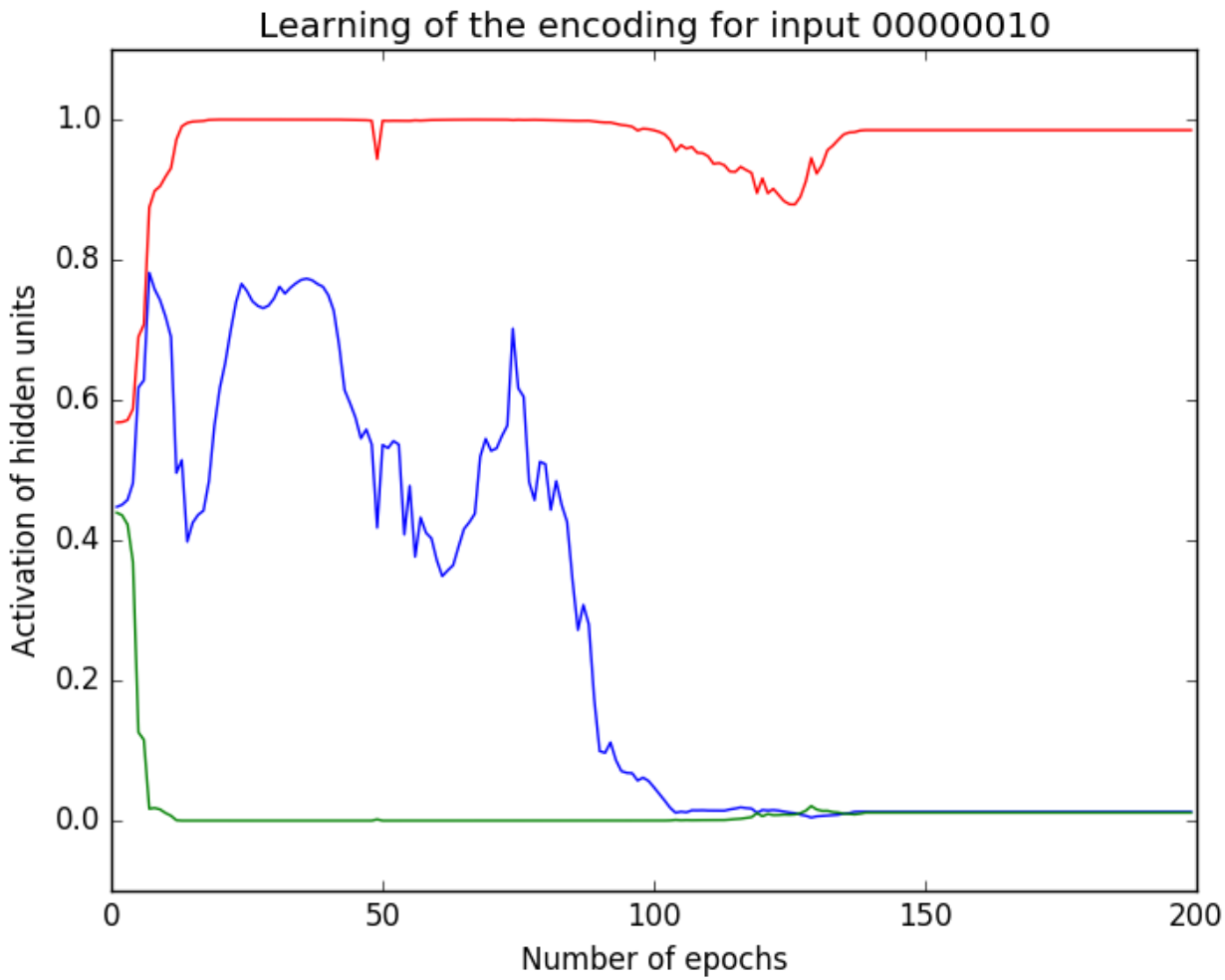


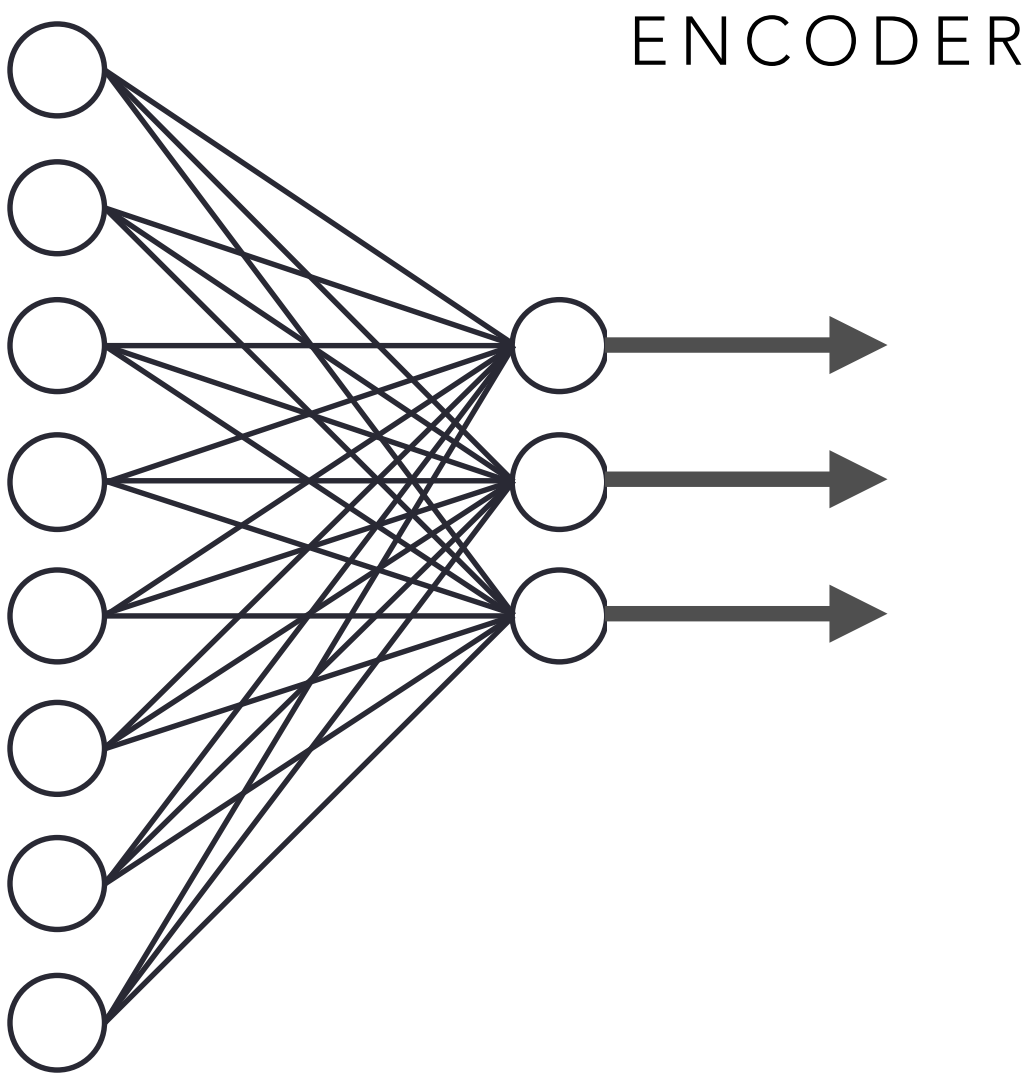
Input	Output
10000000	10000000
01000000	01000000
00100000	00100000
00010000	00010000
00001000	00001000
00000100	00000100


1
0
0
0
0
0
0
0
?
?
?
1
0
0
0
0
0
0
0

Input	Output
10000000	10000000
01000000	01000000
00100000	00100000
00010000	00010000
00001000	00001000
00000100	00000100

Input	A1	A2	A3	Output
10000000	0.9911	0.9869	0.0093	10000000
01000000	0.9892	0.0095	0.0124	01000000
00100000	0.0094	0.0283	0.0122	00100000
00010000	0.9840	0.9836	0.9900	00010000
00001000	0.0139	0.9904	0.0186	00001000
00000100	0.0128	0.9805	0.9868	00000100


Learning of the encoding for input 00000010
Activation of hidden units
Number of epochs
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200


ENCODER

GENERATIVE MODELS

MICHELLE KUCHERA
DAVIDSON COLLEGE

ECT* TALENT SUMMER SCHOOL
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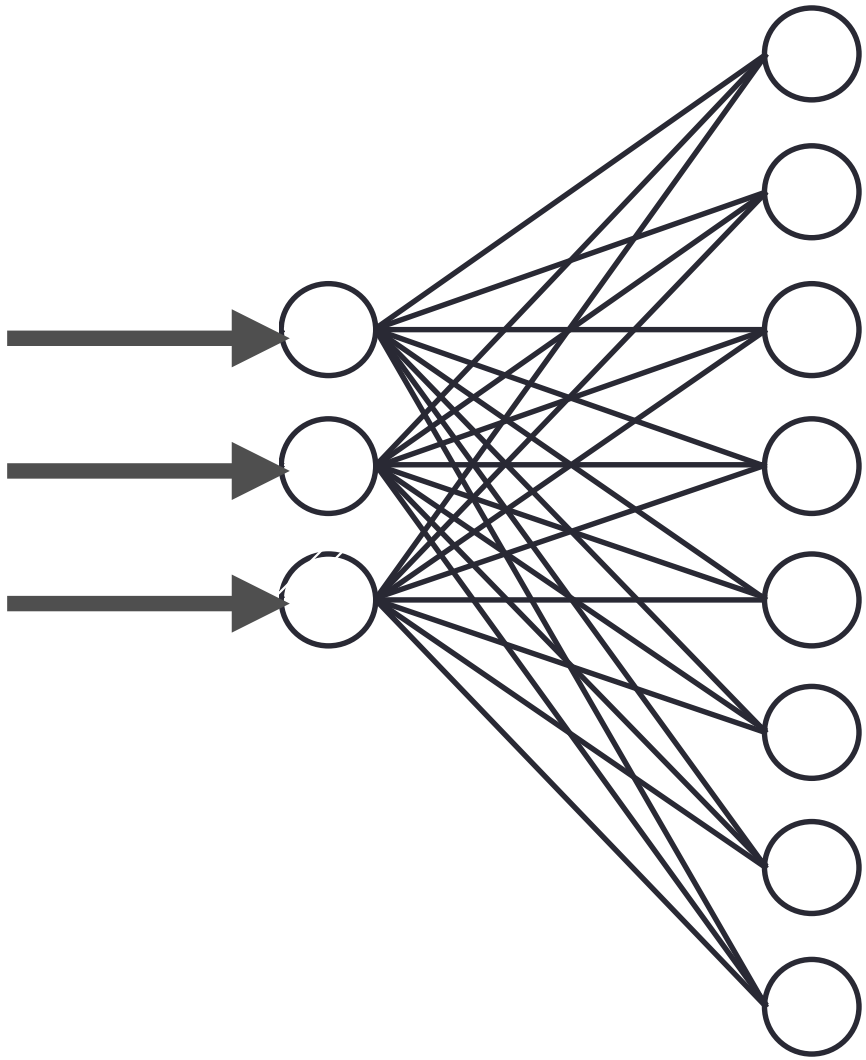
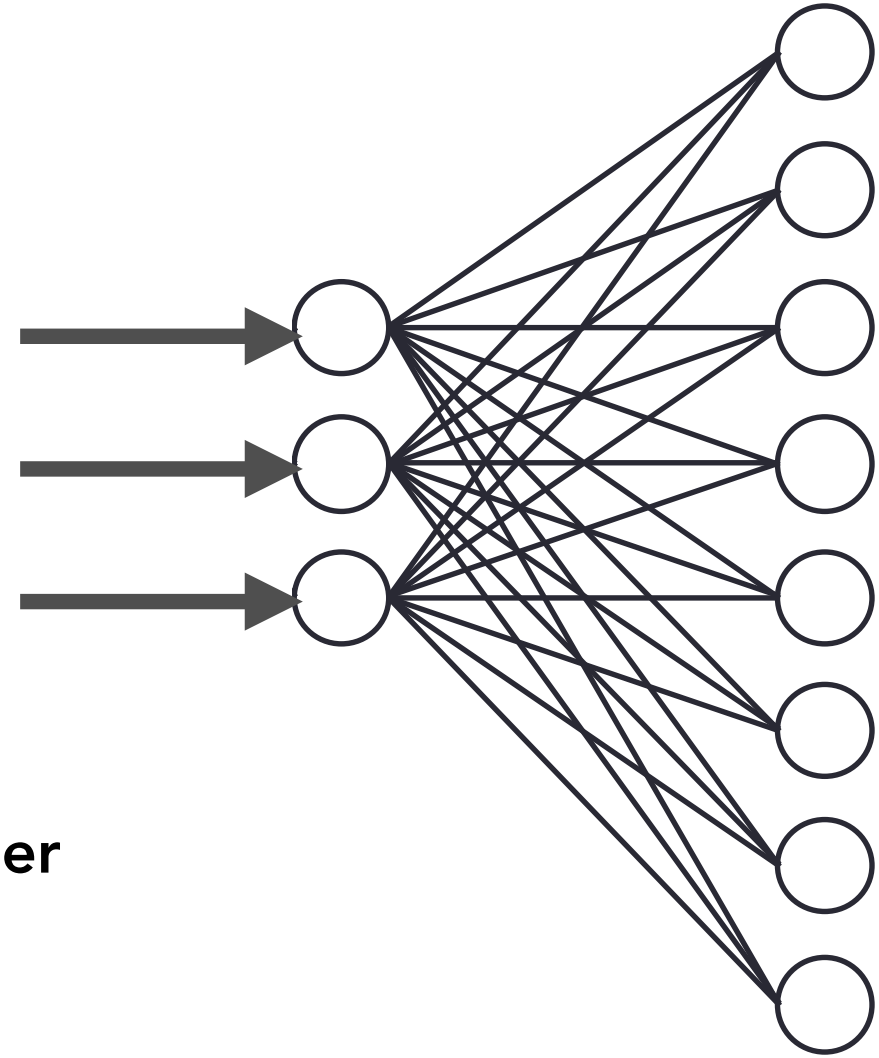
DECODER



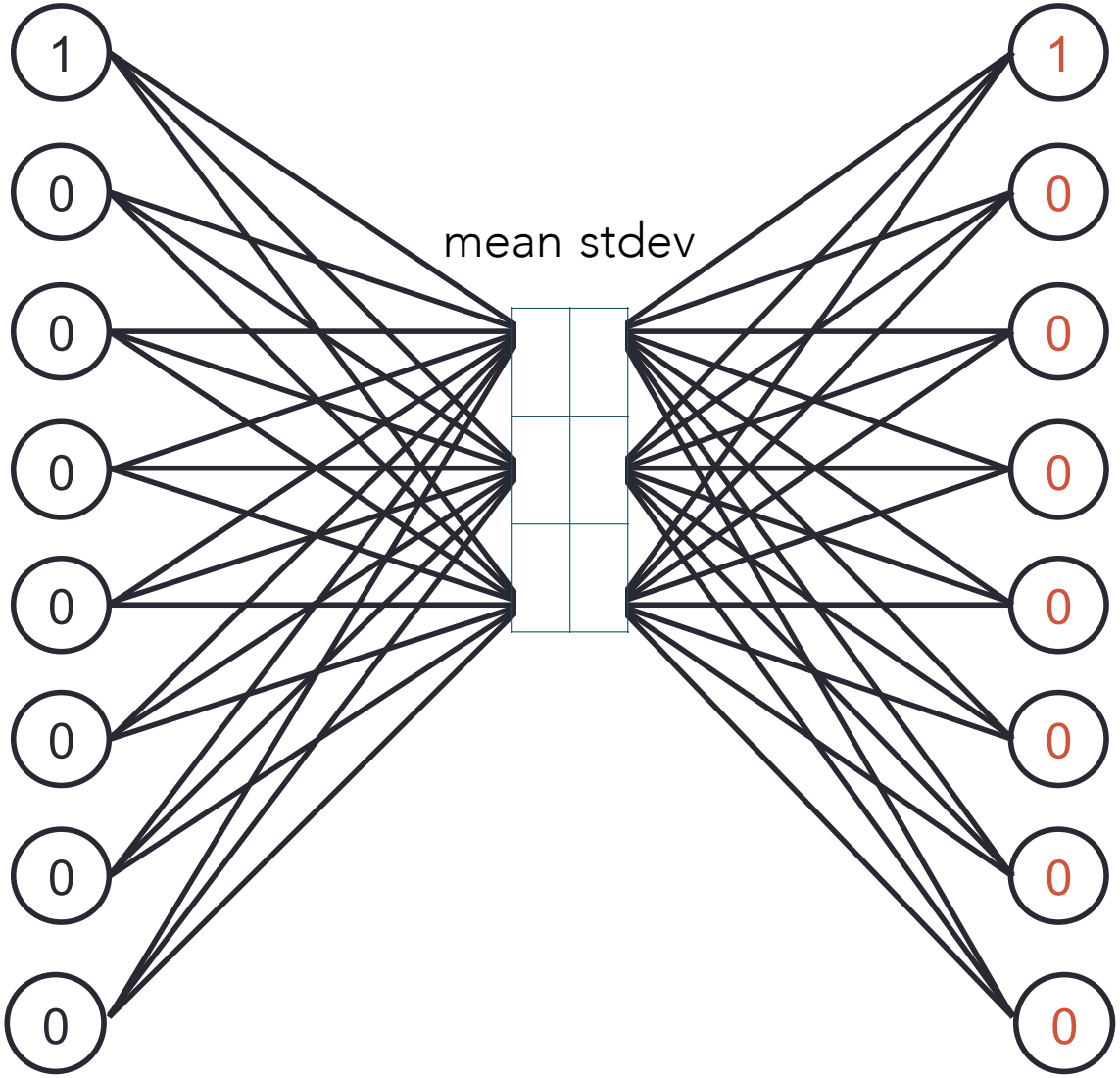
DECODER

How do we know that we are providing a latent vector that represents those seen in training?

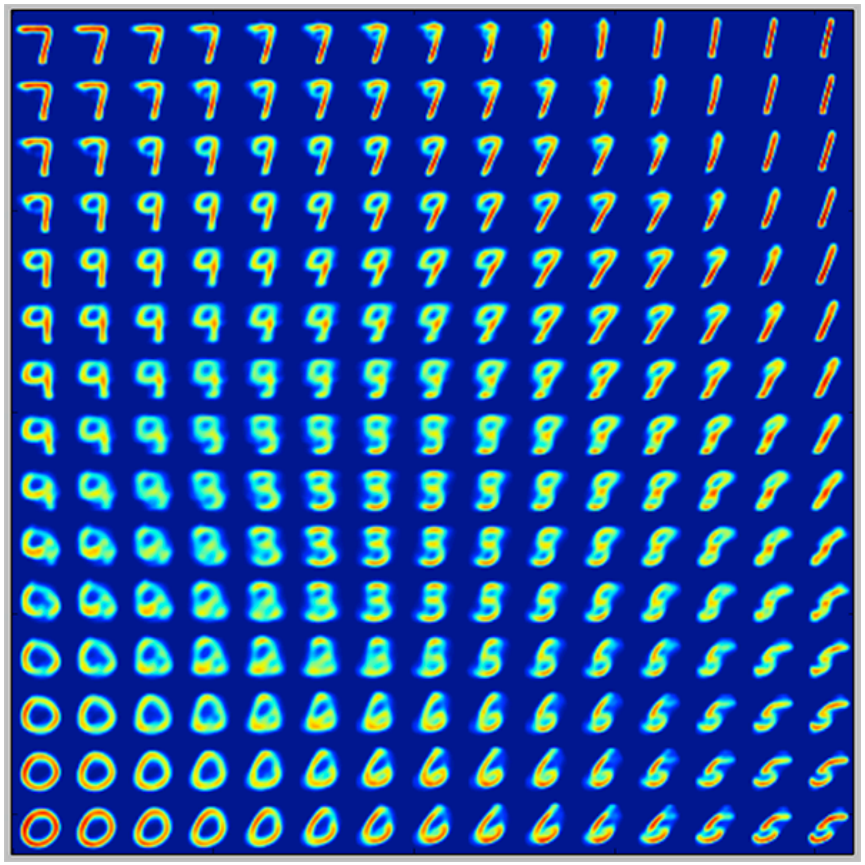


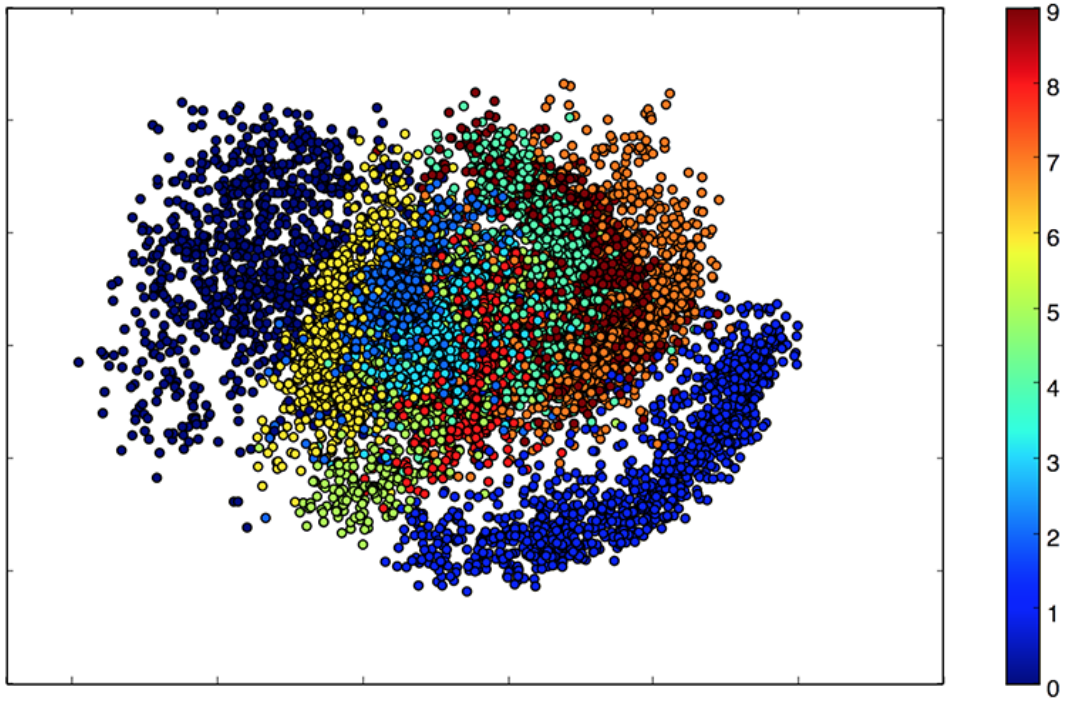
Variational Autoencoder

Encode to two outputs for each latent dimension: mean and stdev



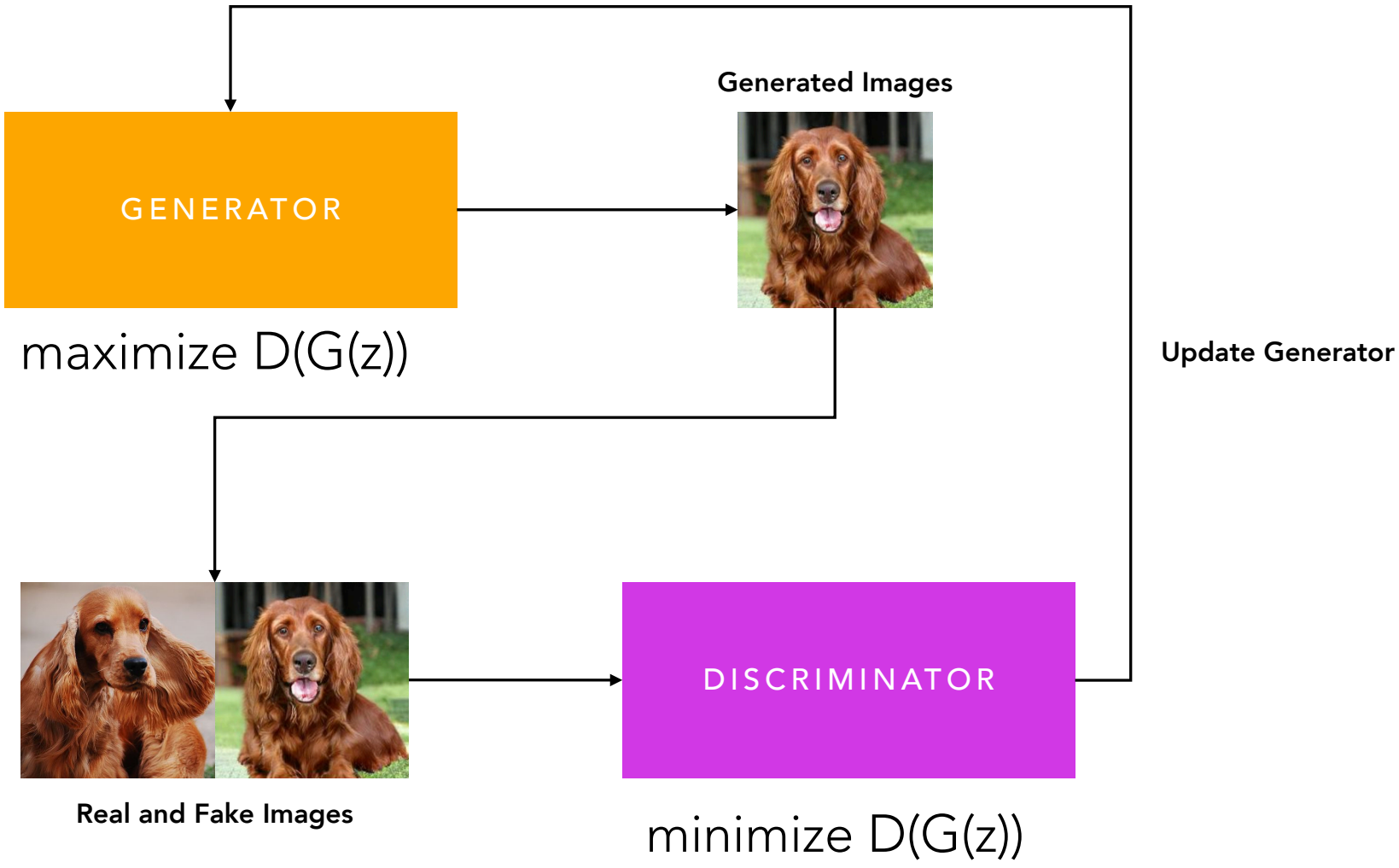
Sample similar points in latent space, decode, and compare with regularization





https://blog.keras.io/building-autoencoders-in-keras.html

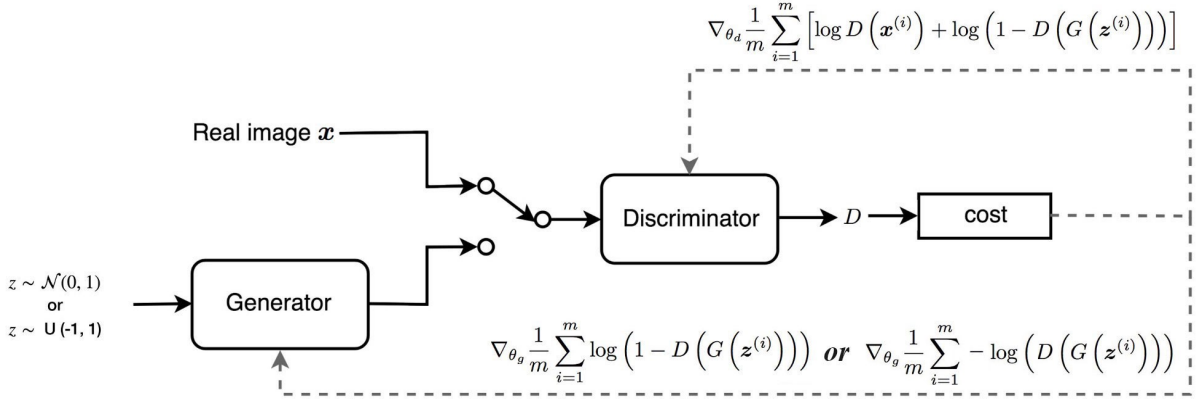
GENERATIVE ADVERSARIAL NETWORKS (GANS)



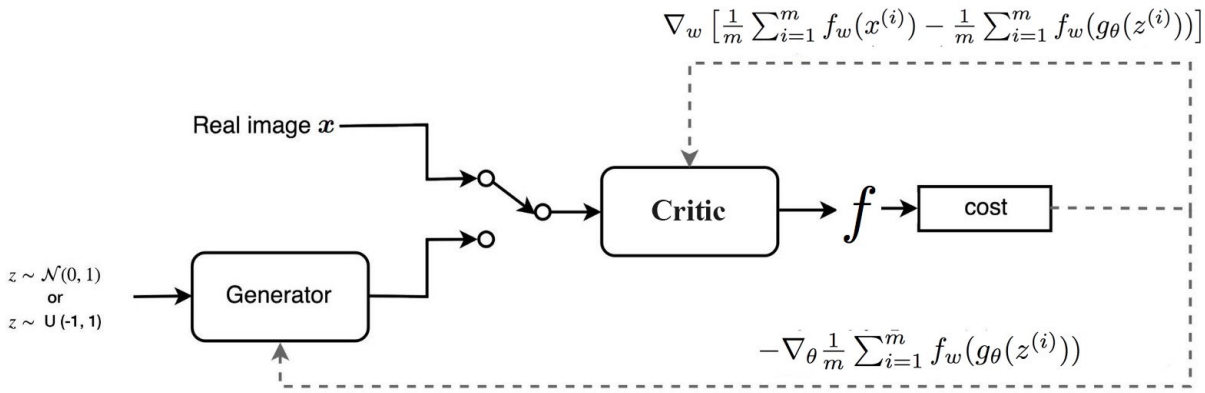
PHOTOS FROM KATRINA S; ANDREW B ET. AL., *BIGGAN*.

minimax / binary cross entropy

GAN

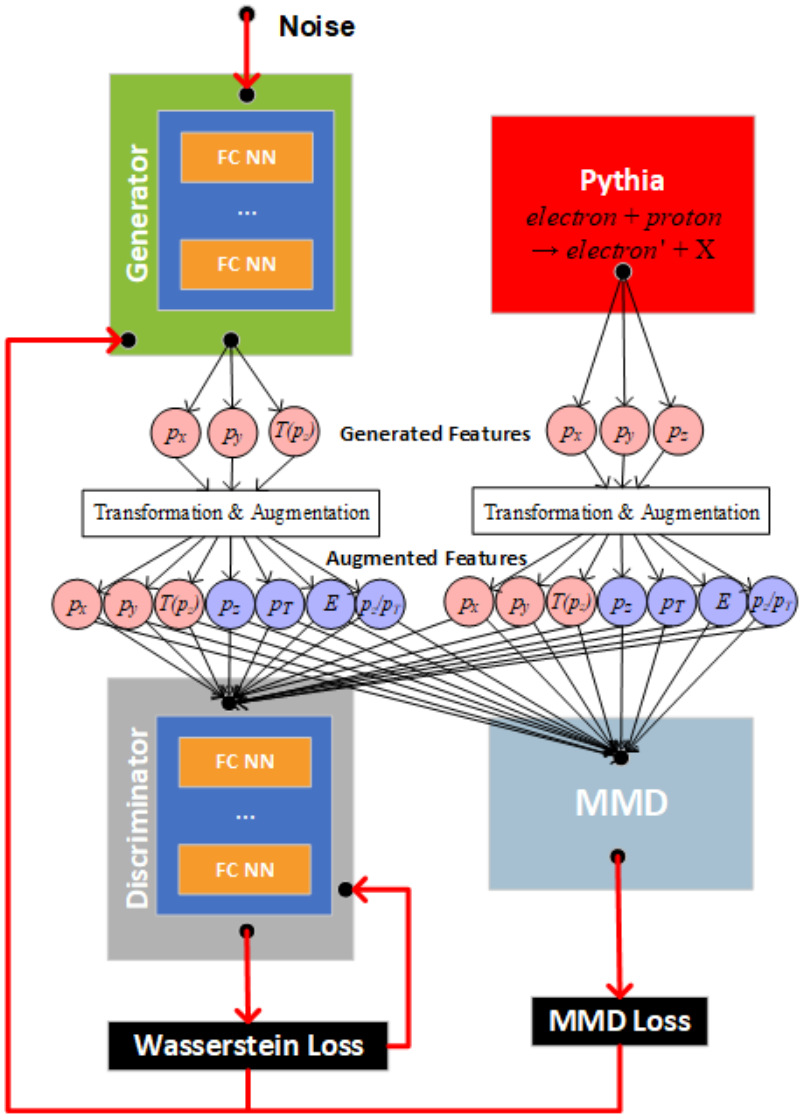


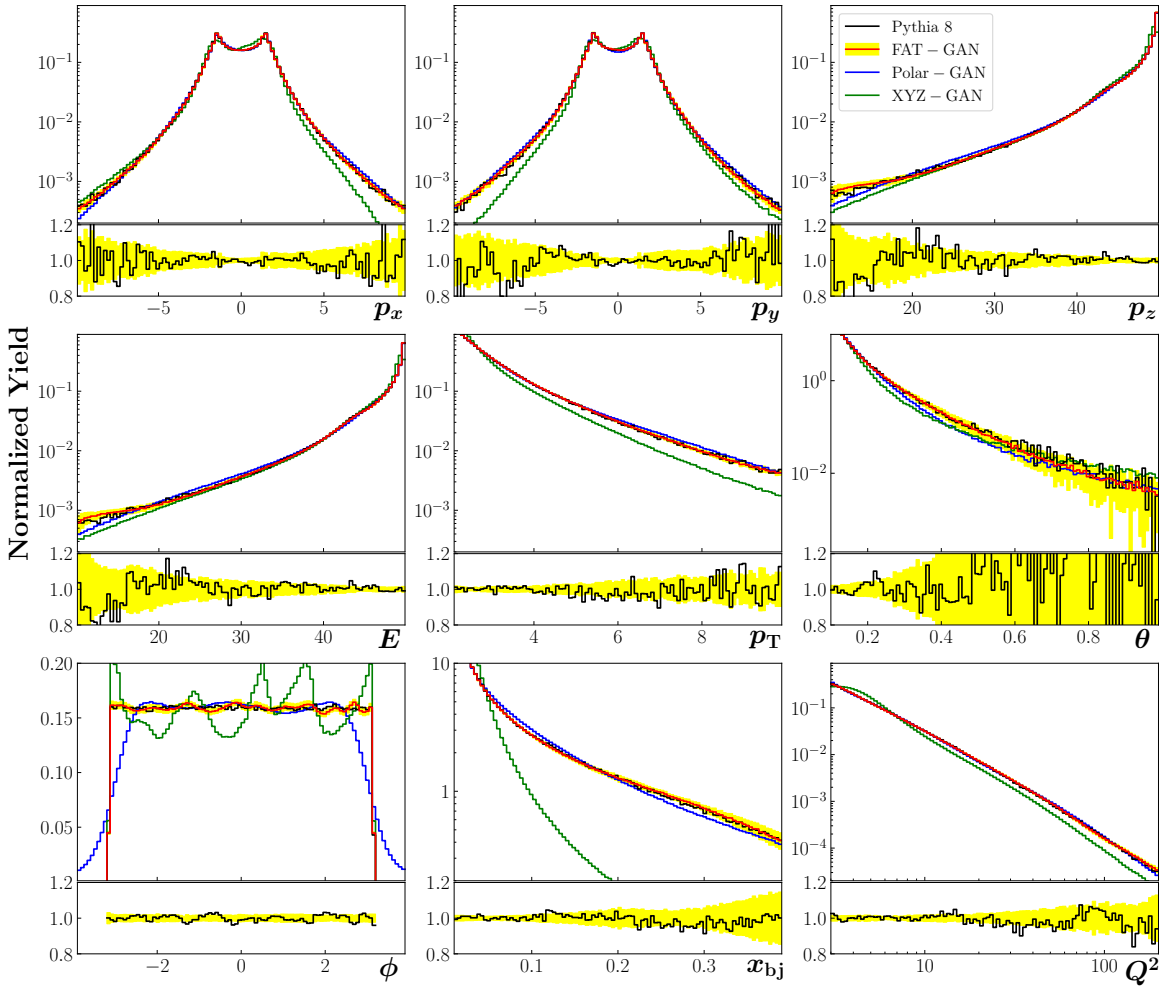
WGAN

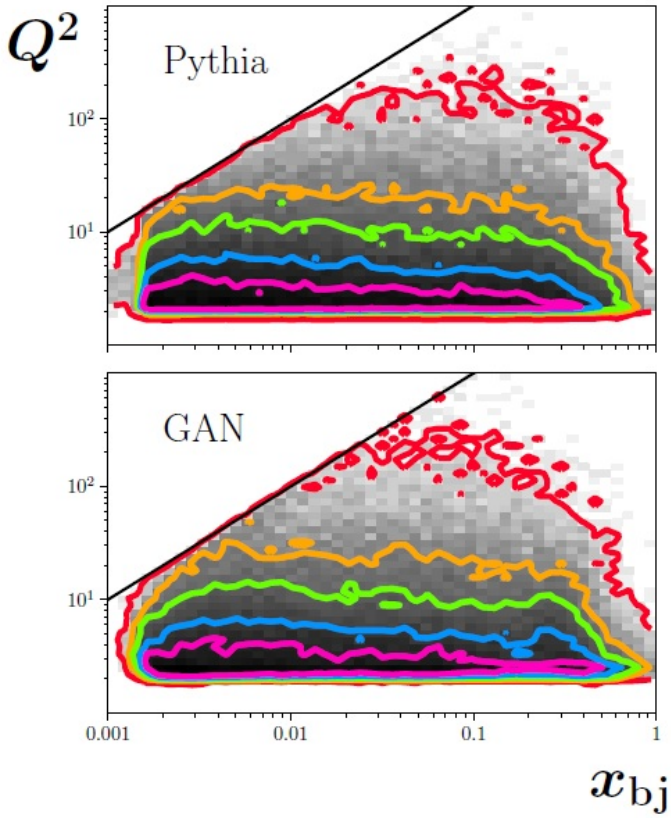


MAXIMUM MEAN DISCREPANCY (MMD) GAN

MMD: Critic loss: batch distribution matching




Normalized Yield
Pythia 8
FAT – GAN
Polar – GAN
XYZ – GAN
p_x
p_y
p_z
E
p_T
θ
ϕ
x_{bj}
Q^2


Q^2
Pythia
GAN
0.001
0.01
0.1
1
x_{bj}

RECENT WORK

Physics Letters B
Volume 813, 10 February 2021, 136041

Bayesian neural networks for fast SUSY predictions

B.S. Kronheim [a], M.P. Kuchera [a], H.B. Prosper [b], A. Karbo [a]

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https://doi.org/10.1016/j.physletb.2020.136041

Abstract

One of the goals of current particle physics research is to obtain evidence for new physics, that is, physics beyond the Standard Model (BSM), at accelerators such as the Large Hadron Collider (LHC) at CERN. The searches for new physics are often guided by BSM theories that depend on many unknown parameters, which, in some cases, makes testing their predictions difficult. In this paper, machine learning is used to model the mapping from the parameter space of the phenomenological Minimal Supersymmetric Standard

Unsupervised Learning for Identifying Events in Active Target Experiments

R. Solli
...ics AS, Tordenskiolds gate 6, 0160, Oslo, Norway
...f Physics, University of Oslo, POB 1048 Oslo, N-0316 Oslo, Norway
D. Bazin
Department of Physics and Astronomy and Facility for Rare Ion Beams and National Superconducting Cyclotron Facility, Michigan State University, East Lansing, MI 48824, USA

COMING SOON!

cFAT-GAN: Conditional Simulation of Electron-Proton Scattering Events with Variate Beam Energies by a Feature Augmented and Transformed Generative Adversarial Network *accepted for publication, ICMLA, 2020.*

Department of Physics and Center for Computing in Science Education, University of Oslo, POB 1048 Oslo, N-0316 Oslo, Norway

COMING SOON!

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment
Volume 940, 1 October 2019, Pages 156-167

Machine learning methods for track classification in the AT-TPC

M.P. Kuchera [a], R. Ramanujan [b], J.Z. Taylor [a], R.R. Strauss [b], D. Bazin [c], J. Bradt [c], Ruiming Chen [a]

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https://doi.org/10.1016/j.nima.2019.05.097

Abstract

...classification in the ...at the National ... Michigan State ...ed via cuts in the ...plicit classification ...uld result in more ...process. We tested

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