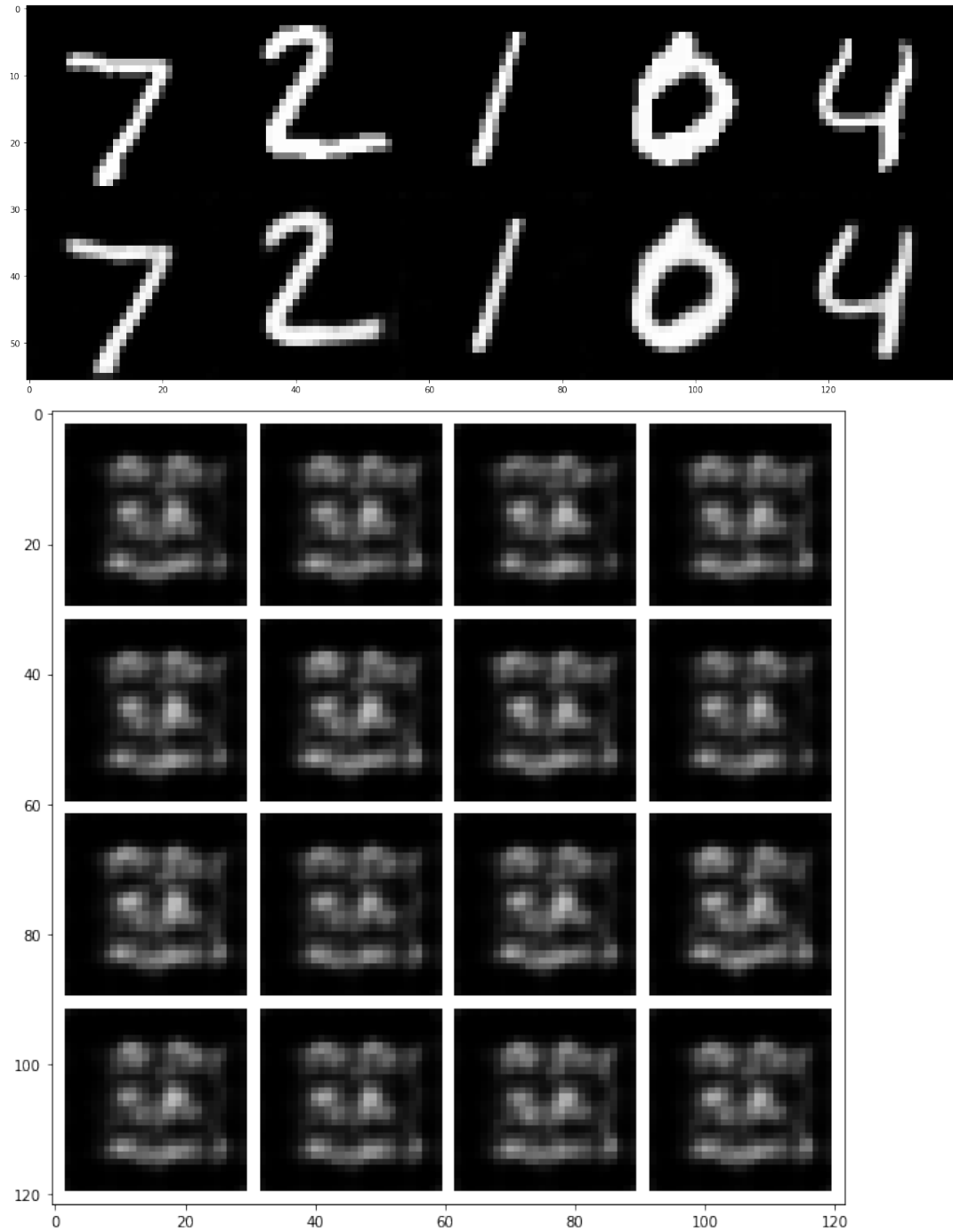


Programming Assignment #2

1. Auto-encoder samples and AE sampling inline question answer.



Inline Question: Describe your observations, why do you think they occur? [2pt]

Answer: Since we are using a normal distribution to sample the embeddings, the output will be a combination of the features of all the numbers seen in that batch, this is because the autoencoder is trained just to reconstruct the samples not to generate new samples that look similar to the batch. In other words, we will see a combination of the different numbers that our model saw during training.

2. VAE training curves, reconstructions and samples for:

2.1 $\beta=0$

Run Epoch 0

It 0: Total Loss: 0.5811722874641418,	Rec Loss: 0.2718198001384735,	KL Loss: 0.30935248732566833
It 100: Total Loss: 1.516053318977356,	Rec Loss: 0.056767672300338745,	KL Loss: 1.4592856168746948
It 200: Total Loss: 2.8029658794403076,	Rec Loss: 0.030721625313162804,	KL Loss: 2.7722442150115967
It 300: Total Loss: 3.607170820236206,	Rec Loss: 0.022127831354737282,	KL Loss: 3.585042953491211
It 400: Total Loss: 4.066409111022949,	Rec Loss: 0.01953379437327385,	KL Loss: 4.046875476837158
It 500: Total Loss: 4.416645526885986,	Rec Loss: 0.01518859900534153,	KL Loss: 4.401456832885742
It 600: Total Loss: 4.69534158706665,	Rec Loss: 0.01416174229234457,	KL Loss: 4.681180000305176
It 700: Total Loss: 4.944004058837891,	Rec Loss: 0.01455592829734087,	KL Loss: 4.929448127746582
It 800: Total Loss: 5.128725528717041,	Rec Loss: 0.012645507231354713,	KL Loss: 5.116079807281494
It 900: Total Loss: 5.389089107513428,	Rec Loss: 0.013713179156184196,	KL Loss: 5.375375747680664

Run Epoch 1

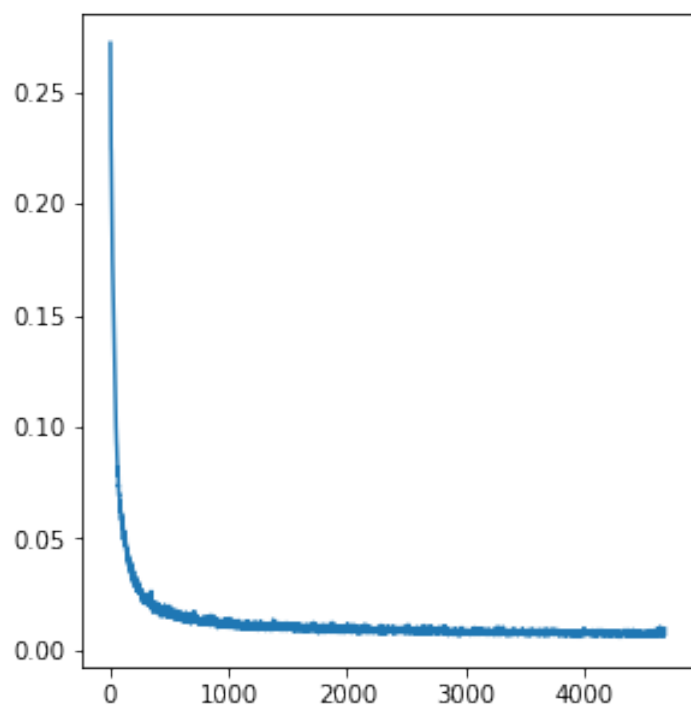
It 1000: Total Loss: 5.52078104019165,	Rec Loss: 0.01171525102108717,	KL Loss: 5.509065628051758
It 1100: Total Loss: 5.681763172149658,	Rec Loss: 0.010850450955331326,	KL Loss: 5.670912742614746
It 1200: Total Loss: 5.84111213684082,	Rec Loss: 0.010157763957977295,	KL Loss: 5.830954551696777
It 1300: Total Loss: 5.976903438568115,	Rec Loss: 0.010814030654728413,	KL Loss: 5.966089248657227
It 1400: Total Loss: 6.086448669433594,	Rec Loss: 0.012847048230469227,	KL Loss: 6.073601722717285
It 1500: Total Loss: 6.195892333984375,	Rec Loss: 0.011540630832314491,	KL Loss: 6.184351921081543
It 1600: Total Loss: 6.318881034851074,	Rec Loss: 0.011081520467996597,	KL Loss: 6.307799339294434
It 1700: Total Loss: 6.412571907043457,	Rec Loss: 0.010392441414296627,	KL Loss: 6.40217924118042
It 1800: Total Loss: 6.5517659187316895,	Rec Loss: 0.010467835702002048,	KL Loss: 6.541297912597656

Run Epoch 2

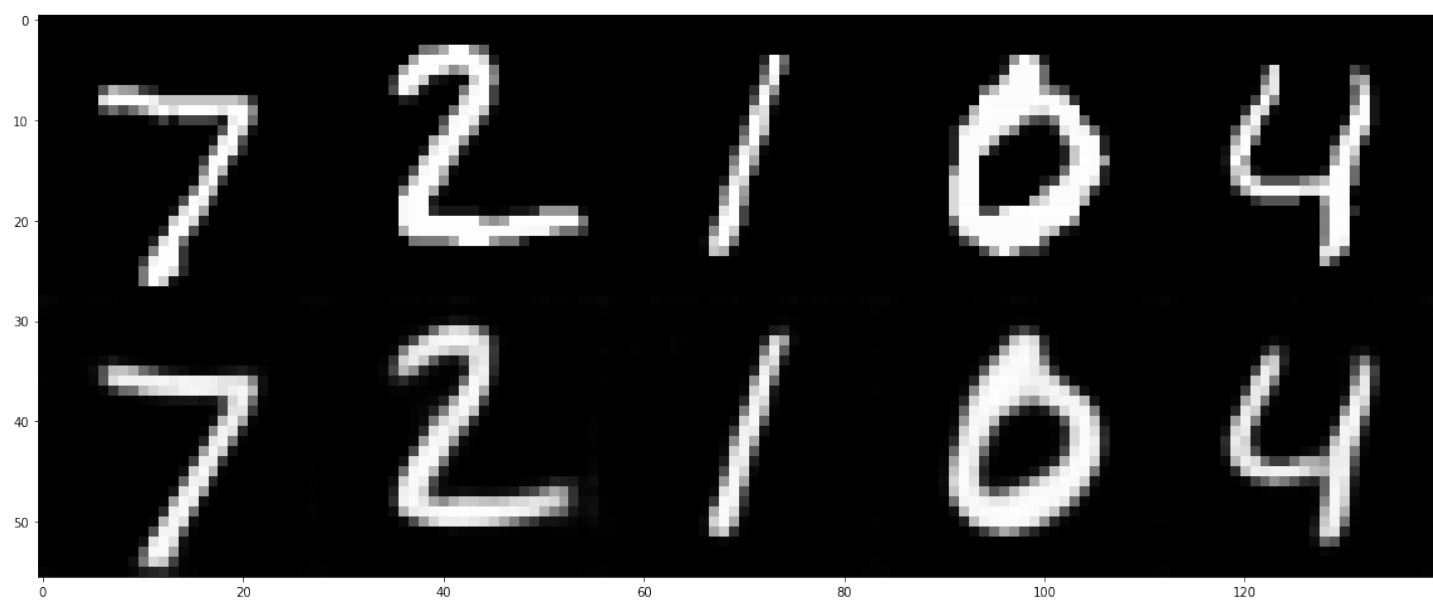
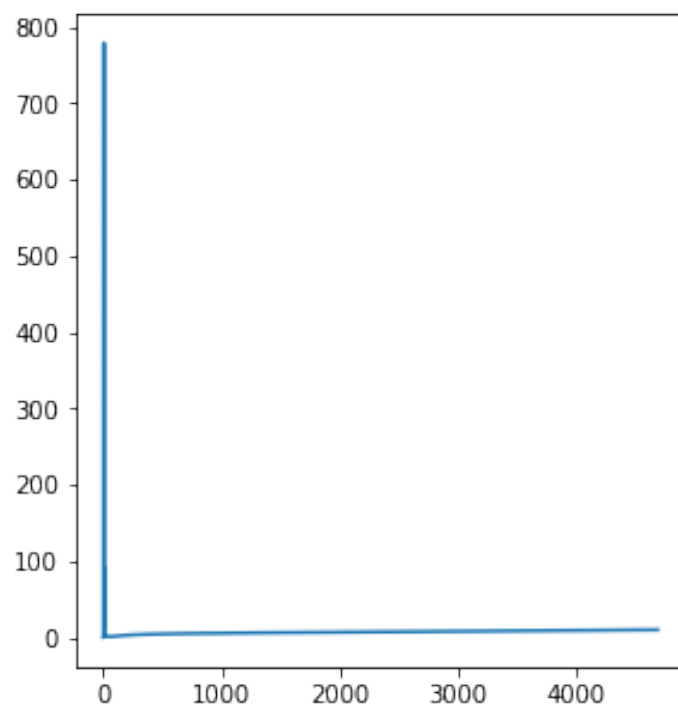
It 1900: Total Loss: 6.616015911102295,	Rec Loss: 0.009488444775342941,	KL Loss: 6.606527328491211
It 2000: Total Loss: 6.736297130584717,	Rec Loss: 0.009365268051624298,	KL Loss: 6.726932048797607
It 2100: Total Loss: 6.907715797424316,	Rec Loss: 0.009482208639383316,	KL Loss: 6.898233413696289

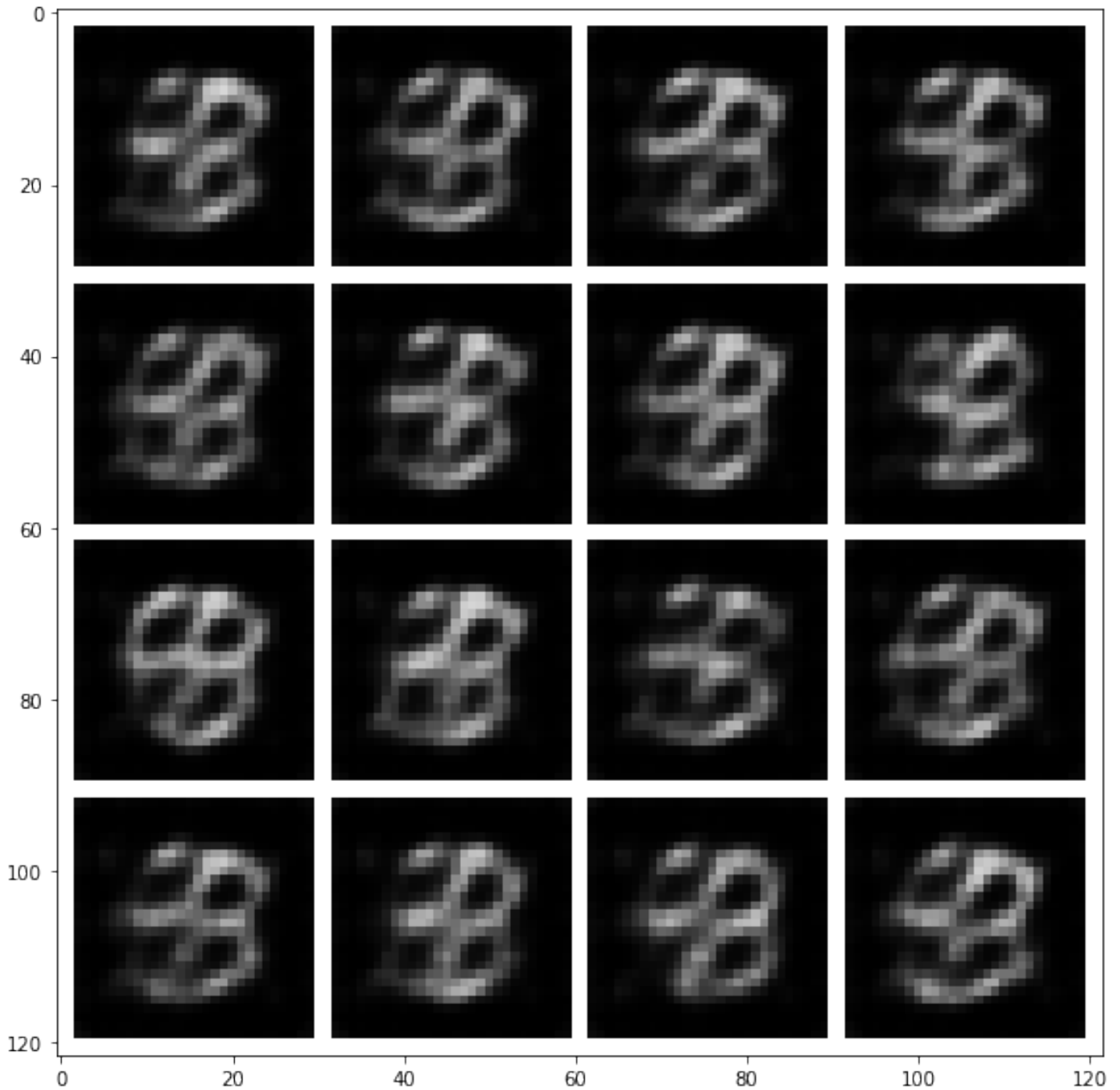
It 2200: Total Loss: 7.023165225982666, Loss: 7.014705657958984	Rec Loss: 0.008459783159196377,	KL
It 2300: Total Loss: 7.145569801330566, Loss: 7.137986660003662	Rec Loss: 0.00758309755474329,	KL
It 2400: Total Loss: 7.247585773468018, Loss: 7.239235877990723	Rec Loss: 0.008349666371941566,	KL
It 2500: Total Loss: 7.3315935134887695, Loss: 7.323578834533691	Rec Loss: 0.008014536462724209,	KL
It 2600: Total Loss: 7.436214447021484, Loss: 7.428121566772461	Rec Loss: 0.008092999458312988,	KL
It 2700: Total Loss: 7.621686935424805, Loss: 7.61117696762085	Rec Loss: 0.010510138235986233,	KL
It 2800: Total Loss: 7.754864692687988, Loss: 7.744864463806152	Rec Loss: 0.010000085458159447,	KL
Run Epoch 3		
It 2900: Total Loss: 7.845767498016357, Loss: 7.836698532104492	Rec Loss: 0.009068971499800682,	KL
It 3000: Total Loss: 7.919299602508545, Loss: 7.911481857299805	Rec Loss: 0.007817593403160572,	KL
It 3100: Total Loss: 8.125051498413086, Loss: 8.116226196289062	Rec Loss: 0.00882492121309042,	KL
It 3200: Total Loss: 8.139623641967773, Loss: 8.132619857788086	Rec Loss: 0.007003596518188715,	KL
It 3300: Total Loss: 8.249198913574219, Loss: 8.242109298706055	Rec Loss: 0.007089537568390369,	KL
It 3400: Total Loss: 8.401388168334961, Loss: 8.393697738647461	Rec Loss: 0.007690700236707926,	KL
It 3500: Total Loss: 8.512272834777832, Loss: 8.50529670715332	Rec Loss: 0.006976139731705189,	KL
It 3600: Total Loss: 8.672998428344727, Loss: 8.663816452026367	Rec Loss: 0.009181894361972809,	KL
It 3700: Total Loss: 8.759498596191406, Loss: 8.752159118652344	Rec Loss: 0.00733931502327323,	KL
Run Epoch 4		
It 3800: Total Loss: 8.867029190063477, Loss: 8.85927963256836	Rec Loss: 0.007749943062663078,	KL
It 3900: Total Loss: 9.022603988647461, Loss: 9.01461410522461	Rec Loss: 0.007990092970430851,	KL
It 4000: Total Loss: 9.09693431854248, Loss: 9.089611053466797	Rec Loss: 0.0073231481947004795,	KL
It 4100: Total Loss: 9.148226737976074, Loss: 9.141036987304688	Rec Loss: 0.007189847994595766,	KL
It 4200: Total Loss: 9.3771390914917, 9.368734359741211	Rec Loss: 0.008405025117099285,	KL Loss:
It 4300: Total Loss: 9.463607788085938, Loss: 9.456148147583008	Rec Loss: 0.007459585554897785,	KL
It 4400: Total Loss: 9.609740257263184, Loss: 9.602951049804688	Rec Loss: 0.006788900587707758,	KL
It 4500: Total Loss: 9.702607154846191, Loss: 9.695363998413086	Rec Loss: 0.007243385538458824,	KL
It 4600: Total Loss: 9.820686340332031, Loss: 9.813151359558105	Rec Loss: 0.007535073906183243,	KL
Done!		

Reconstruction Loss



KL Loss





2.2 $\beta=10$

Run Epoch 0

It 0: Total Loss: 0.5315370559692383, Rec Loss: 0.26101958751678467, KL Loss: 0.270517498254776

It 100: Total Loss: 0.07499094307422638, Rec Loss: 0.0734420046210289, KL Loss: 0.0015489384531974792

It 200: Total Loss: 0.07035774737596512, Rec Loss: 0.06977185606956482, KL Loss: 0.0005858943914063275

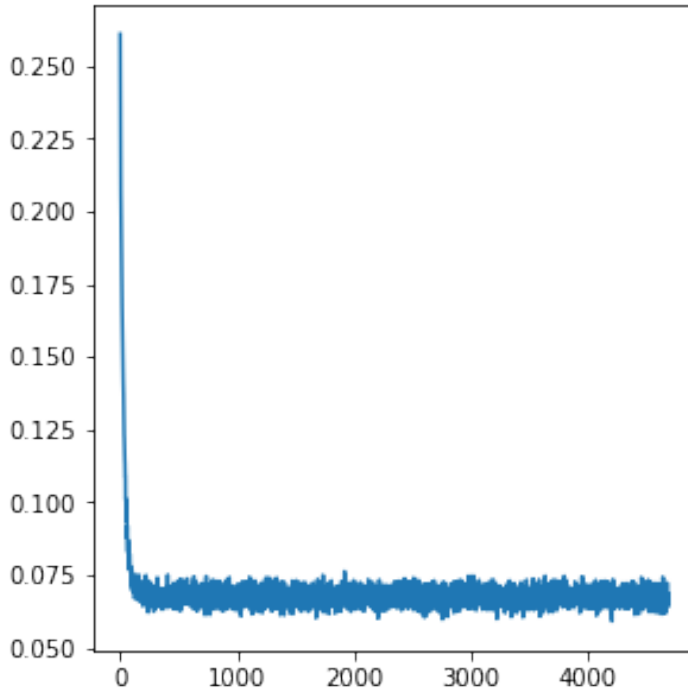
It 300: Total Loss: 0.06754367798566818, Rec Loss: 0.067195363342762, KL Loss: 0.0003483120526652783

It 400: Total Loss: 0.06557648628950119, 0.00017998757539317012	Rec Loss: 0.0653964951634407, KL Loss:
It 500: Total Loss: 0.0680609792470932, Loss: 0.00016558390052523464	Rec Loss: 0.06789539754390717, KL
It 600: Total Loss: 0.06962273269891739, Loss: 8.878029620973393e-05	Rec Loss: 0.06953395158052444, KL
It 700: Total Loss: 0.06970930844545364, 8.587774209445342e-05	Rec Loss: 0.0696234330534935, KL Loss:
It 800: Total Loss: 0.06701688468456268, Loss: 6.503189069917426e-05	Rec Loss: 0.06695185601711273, KL
It 900: Total Loss: 0.06768175214529037, Loss: 5.9093501477036625e-05	Rec Loss: 0.06762266159057617, KL
Run Epoch 1	
It 1000: Total Loss: 0.06644164025783539, Loss: 7.034578447928652e-05	Rec Loss: 0.06637129187583923, KL
It 1100: Total Loss: 0.06440179795026779, Loss: 5.197362042963505e-05	Rec Loss: 0.06434982270002365, KL
It 1200: Total Loss: 0.06689245998859406, Loss: 3.9764920074958354e-05	Rec Loss: 0.06685269623994827, KL
It 1300: Total Loss: 0.06562933325767517, Loss: 2.6048277504742146e-05	Rec Loss: 0.06560328602790833, KL
It 1400: Total Loss: 0.06771208345890045, Loss: 3.1211056921165437e-05	Rec Loss: 0.06768087297677994, KL
It 1500: Total Loss: 0.06585680693387985, Loss: 3.236871998524293e-05	Rec Loss: 0.06582444161176682, KL
It 1600: Total Loss: 0.0675949677824974, Loss: 2.6888519641943276e-05	Rec Loss: 0.06756807863712311, KL
It 1700: Total Loss: 0.07138138264417648, Loss: 3.3399446692783386e-05	Rec Loss: 0.07134798169136047, KL
It 1800: Total Loss: 0.06786135584115982, Loss: 3.181204374413937e-05	Rec Loss: 0.06782954186201096, KL
Run Epoch 2	
It 1900: Total Loss: 0.06559540331363678, Loss: 2.8244496206752956e-05	Rec Loss: 0.06556715816259384, KL
It 2000: Total Loss: 0.0689873918890953, Loss: 2.4151377147063613e-05	Rec Loss: 0.06896323710680008, KL
It 2100: Total Loss: 0.065380431711167374, Loss: 1.918385532917455e-05	Rec Loss: 0.06536124646663666, KL
It 2200: Total Loss: 0.06495604664087296, Loss: 2.187139034504071e-05	Rec Loss: 0.06493417173624039, KL
It 2300: Total Loss: 0.06925695389509201, Loss: 1.904946839204058e-05	Rec Loss: 0.06923790276050568, KL
It 2400: Total Loss: 0.06923459470272064, Loss: 2.2976091713644564e-05	Rec Loss: 0.06921161711215973, KL
It 2500: Total Loss: 0.06989689916372299, Loss: 2.3477077775169164e-05	Rec Loss: 0.06987342238426208, KL
It 2600: Total Loss: 0.06828882545232773, 2.2216881916392595e-05	Rec Loss: 0.0682666078209877, KL Loss:
It 2700: Total Loss: 0.06907301396131516, Loss: 1.737098500598222e-05	Rec Loss: 0.06905564665794373, KL
It 2800: Total Loss: 0.06880224496126175, Loss: 1.359314046567306e-05	Rec Loss: 0.06878865510225296, KL
Run Epoch 3	
It 2900: Total Loss: 0.06645859032869339, Loss: 1.7994279915001243e-05	Rec Loss: 0.06644059717655182, KL
It 3000: Total Loss: 0.06692427396774292, 1.7624784959480166e-05	Rec Loss: 0.0669066458940506, KL Loss:
It 3100: Total Loss: 0.07085005939006805, Loss: 1.837815943872556e-05	Rec Loss: 0.07083167880773544, KL
It 3200: Total Loss: 0.06759805977344513, Loss: 2.1329607989173383e-05	Rec Loss: 0.06757672876119614, KL
It 3300: Total Loss: 0.06839524209499359, Loss: 1.5626246749889106e-05	Rec Loss: 0.06837961822748184, KL

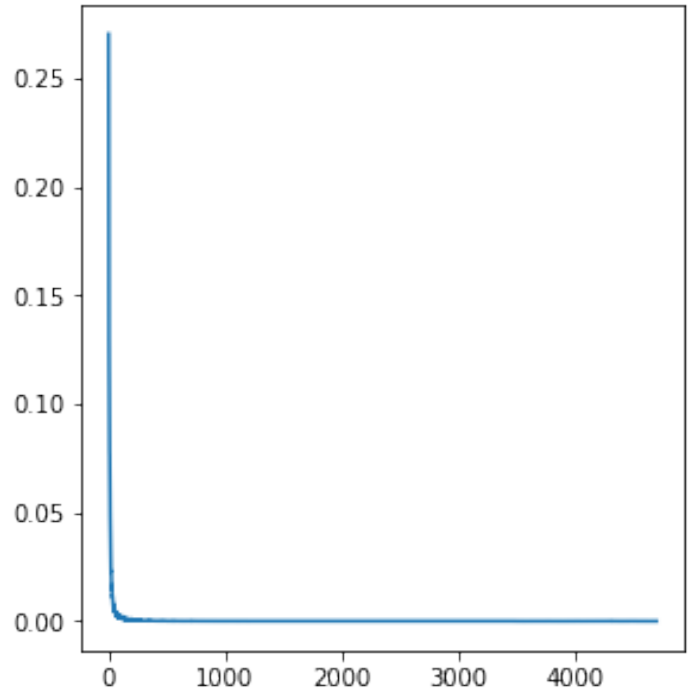
It 3400: Total Loss: 0.06604082882404327,
 Loss: 2.035526995314285e-05
 It 3500: Total Loss: 0.06749716401100159,
 Loss: 2.263557689730078e-05
 It 3600: Total Loss: 0.06545525044202805,
 Loss: 2.060249971691519e-05
 It 3700: Total Loss: 0.06541132926940918,
 Loss: 1.668676850385964e-05
 Run Epoch 4
 It 3800: Total Loss: 0.07463168352842331,
 Loss: 1.754104596329853e-05
 It 3900: Total Loss: 0.06806988269090652,
 Loss: 2.2262291167862713e-05
 It 4000: Total Loss: 0.06871496886014938,
 Loss: 1.9666571461129934e-05
 It 4100: Total Loss: 0.07178859412670135,
 Loss: 1.1077936505898833e-05
 It 4200: Total Loss: 0.06827454268932343,
 Loss: 1.1378884664736688e-05
 It 4300: Total Loss: 0.06659327447414398,
 Loss: 1.907206024043262e-05
 It 4400: Total Loss: 0.07229256629943848,
 Loss: 2.3221968149300665e-05
 It 4500: Total Loss: 0.06461280584335327,
 Loss: 2.176097041228786e-05
 It 4600: Total Loss: 0.06748780608177185,
 Loss: 8.919458196032792e-06
 Done!

Rec Loss: 0.06602047383785248, KL
 Rec Loss: 0.06747452914714813, KL
 Rec Loss: 0.06543464958667755, KL
 Rec Loss: 0.06539463996887207, KL
 Rec Loss: 0.07461414486169815, KL
 Rec Loss: 0.06804762035608292, KL
 Rec Loss: 0.0686952993273735, KL Loss:
 Rec Loss: 0.07177751511335373, KL
 Rec Loss: 0.06826316565275192, KL
 Rec Loss: 0.06657420098781586, KL
 Rec Loss: 0.07226934283971786, KL
 Rec Loss: 0.06459104269742966, KL
 Rec Loss: 0.06747888773679733, KL

Reconstruction Loss



KL Loss



2.3 Tuned $\beta = 0.1$

Run Epoch 0

It 0: Total Loss: 0.5394340753555298,	Rec Loss: 0.27188438177108765,	KL Loss:
0.26754969358444214		
It 100: Total Loss: 0.08542830497026443,	Rec Loss: 0.07369745522737503,	KL
Loss: 0.011730852536857128		
It 200: Total Loss: 0.10158344358205795,	Rec Loss: 0.0614016056060791,	KL Loss:
0.04018183797597885		
It 300: Total Loss: 0.11978854238986969,	Rec Loss: 0.05648331716656685,	KL
Loss: 0.06330522894859314		
It 400: Total Loss: 0.12733577191829681,	Rec Loss: 0.05149164795875549,	KL
Loss: 0.07584412395954132		
It 500: Total Loss: 0.13786864280700684,	Rec Loss: 0.048836104571819305,	KL
Loss: 0.08903254568576813		
It 600: Total Loss: 0.13504263758659363,	Rec Loss: 0.0460640974342823,	KL Loss:
0.08897854387760162		
It 700: Total Loss: 0.15043796598911285,	Rec Loss: 0.043450500816106796,	KL
Loss: 0.10698746144771576		
It 800: Total Loss: 0.13939017057418823,	Rec Loss: 0.04153541475534439,	KL
Loss: 0.09785474836826324		
It 900: Total Loss: 0.14072419703006744,	Rec Loss: 0.03535039350390434,	KL
Loss: 0.1053738072514534		

Run Epoch 1

It 1000: Total Loss: 0.1514614224433899,	Rec Loss: 0.03867146745324135,	KL
Loss: 0.11278995871543884		
It 1100: Total Loss: 0.15002012252807617,	Rec Loss: 0.03655519708991051,	KL
Loss: 0.11346492916345596		
It 1200: Total Loss: 0.14602212607860565,	Rec Loss: 0.03349098190665245,	KL
Loss: 0.1125311478972435		
It 1300: Total Loss: 0.15432214736938477,	Rec Loss: 0.03410022705793381,	KL
Loss: 0.12022191286087036		
It 1400: Total Loss: 0.154240682721138,	Rec Loss: 0.03425806388258934,	KL
Loss: 0.11998261511325836		
It 1500: Total Loss: 0.15318261086940765,	Rec Loss: 0.032994043081998825,	KL
Loss: 0.12018857151269913		
It 1600: Total Loss: 0.1526852697134018,	Rec Loss: 0.03332074359059334,	KL
Loss: 0.11936452984809875		
It 1700: Total Loss: 0.1503327339887619,	Rec Loss: 0.03409504145383835,	KL
Loss: 0.11623769253492355		
It 1800: Total Loss: 0.14940650761127472,	Rec Loss: 0.02889540232717991,	KL
Loss: 0.12051110714673996		

Run Epoch 2

It 1900: Total Loss: 0.15365570783615112,	Rec Loss: 0.030154291540384293,	KL
Loss: 0.12350141257047653		
It 2000: Total Loss: 0.15195220708847046,	Rec Loss: 0.032182104885578156,	KL
Loss: 0.1197700947523117		
It 2100: Total Loss: 0.1557057797908783,	Rec Loss: 0.02902023121714592,	KL
Loss: 0.12668554484844208		
It 2200: Total Loss: 0.17054133117198944,	Rec Loss: 0.03469749912619591,	KL
Loss: 0.13584382832050323		
It 2300: Total Loss: 0.15715113282203674,	Rec Loss: 0.031727854162454605,	KL
Loss: 0.12542328238487244		
It 2400: Total Loss: 0.15935249626636505,	Rec Loss: 0.031887684017419815,	KL
Loss: 0.12746481597423553		
It 2500: Total Loss: 0.15868635475635529,	Rec Loss: 0.03167085349559784,	KL
Loss: 0.12701550126075745		
It 2600: Total Loss: 0.16003815829753876,	Rec Loss: 0.032027263194322586,	KL
Loss: 0.12801089882850647		
It 2700: Total Loss: 0.16664768755435944,	Rec Loss: 0.033098671585321426,	KL
Loss: 0.1335490196943283		

It 2800: Total Loss: 0.15951913595199585, Loss: 0.1286083161830902 Run Epoch 3	Rec Loss: 0.03091081976890564,	KL
It 2900: Total Loss: 0.16476309299468994, Loss: 0.12990963459014893	Rec Loss: 0.034853458404541016,	KL
It 3000: Total Loss: 0.1625693440437317, Loss: 0.12935882806777954	Rec Loss: 0.03321051225066185,	KL
It 3100: Total Loss: 0.16078314185142517, Loss: 0.13175880908966064	Rec Loss: 0.029024332761764526,	KL
It 3200: Total Loss: 0.15673887729644775, Loss: 0.12766747176647186	Rec Loss: 0.029071398079395294,	KL
It 3300: Total Loss: 0.1594734489917755, Loss: 0.13270840048789978	Rec Loss: 0.026765048503875732,	KL
It 3400: Total Loss: 0.1655503213405609, Loss: 0.13493984937667847	Rec Loss: 0.030610473826527596,	KL
It 3500: Total Loss: 0.16162575781345367, Loss: 0.1317412555217743	Rec Loss: 0.029884500429034233,	KL
It 3600: Total Loss: 0.16183075308799744, Loss: 0.13342566788196564	Rec Loss: 0.028405090793967247,	KL
It 3700: Total Loss: 0.16199080646038055, 0.1321740448474884 Run Epoch 4	Rec Loss: 0.0298167672008276, KL Loss:	
It 3800: Total Loss: 0.1605018675327301, Loss: 0.13372117280960083	Rec Loss: 0.02678070031106472,	KL
It 3900: Total Loss: 0.16256216168403625, Loss: 0.13436788320541382	Rec Loss: 0.02819427102804184,	KL
It 4000: Total Loss: 0.16549594700336456, Loss: 0.13715989887714386	Rec Loss: 0.028336048126220703,	KL
It 4100: Total Loss: 0.16036774218082428, Loss: 0.13207626342773438	Rec Loss: 0.028291478753089905,	KL
It 4200: Total Loss: 0.16088859736919403, Loss: 0.13419026136398315	Rec Loss: 0.02669833041727543,	KL
It 4300: Total Loss: 0.16088947653770447, Loss: 0.13160181045532227	Rec Loss: 0.029287666082382202,	KL
It 4400: Total Loss: 0.16023749113082886, Loss: 0.1344892978668213	Rec Loss: 0.025748196989297867,	KL
It 4500: Total Loss: 0.1657552719116211, Loss: 0.13718070089817047	Rec Loss: 0.028574563562870026,	KL
It 4600: Total Loss: 0.16601449251174927, Loss: 0.13846582174301147 Run Epoch 5	Rec Loss: 0.02754867821931839,	KL
It 4700: Total Loss: 0.15900102257728577, Loss: 0.13038712739944458	Rec Loss: 0.028613895177841187,	KL
It 4800: Total Loss: 0.16311481595039368, Loss: 0.13447585701942444	Rec Loss: 0.02863895334303379,	KL
It 4900: Total Loss: 0.16489529609680176, Loss: 0.13458821177482605	Rec Loss: 0.03030708059668541,	KL
It 5000: Total Loss: 0.1686810702085495, Loss: 0.1379760354757309	Rec Loss: 0.030705038458108902,	KL
It 5100: Total Loss: 0.16819629073143005, Loss: 0.13825568556785583	Rec Loss: 0.029940597712993622,	KL
It 5200: Total Loss: 0.16597886383533478, Loss: 0.13837921619415283	Rec Loss: 0.027599645778536797,	KL
It 5300: Total Loss: 0.1626291275024414, Loss: 0.13179221749305725	Rec Loss: 0.03083690255880356,	KL
It 5400: Total Loss: 0.16044571995735168, Loss: 0.13634219765663147	Rec Loss: 0.024103518575429916,	KL
It 5500: Total Loss: 0.1616751253604889, Loss: 0.13405741751194	Rec Loss: 0.02761770784854889,	KL
It 5600: Total Loss: 0.15976740419864655, Loss: 0.13309913873672485 Run Epoch 6	Rec Loss: 0.026668265461921692,	KL

It 5700: Total Loss: 0.1636517494916916, Loss: 0.13608065247535706	Rec Loss: 0.02757110260426998,	KL
It 5800: Total Loss: 0.16341905295848846, 0.13682177662849426	Rec Loss: 0.0265972800552845,	KL Loss:
It 5900: Total Loss: 0.16806471347808838, Loss: 0.13889101147651672	Rec Loss: 0.029173702001571655,	KL
It 6000: Total Loss: 0.1627732515335083, Loss: 0.13465555012226105	Rec Loss: 0.028117699548602104,	KL
It 6100: Total Loss: 0.16609428822994232, Loss: 0.1393442153930664	Rec Loss: 0.026750072836875916,	KL
It 6200: Total Loss: 0.16455167531967163, Loss: 0.13768330216407776	Rec Loss: 0.02686837688088417,	KL
It 6300: Total Loss: 0.16661164164543152, Loss: 0.13872204720973969	Rec Loss: 0.027889586985111237,	KL
It 6400: Total Loss: 0.169089213013649, Loss: 0.14047813415527344	Rec Loss: 0.028611084446310997,	KL
It 6500: Total Loss: 0.16224567592144012, Loss: 0.13518548011779785	Rec Loss: 0.027060197666287422,	KL
Run Epoch 7		
It 6600: Total Loss: 0.16699832677841187, Loss: 0.13731321692466736	Rec Loss: 0.02968510426580906,	KL
It 6700: Total Loss: 0.16339775919914246, Loss: 0.1394408494234085	Rec Loss: 0.02395690605044365,	KL
It 6800: Total Loss: 0.16310428082942963, Loss: 0.13443130254745483	Rec Loss: 0.028672976419329643,	KL
It 6900: Total Loss: 0.17064113914966583, Loss: 0.13980022072792053	Rec Loss: 0.030840914696455002,	KL
It 7000: Total Loss: 0.16342414915561676, Loss: 0.13595861196517944	Rec Loss: 0.027465542778372765,	KL
It 7100: Total Loss: 0.165237158536911, Loss: 0.13839738070964813	Rec Loss: 0.026839783415198326,	KL
It 7200: Total Loss: 0.16318738460540771, Loss: 0.13738355040550232	Rec Loss: 0.025803837925195694,	KL
It 7300: Total Loss: 0.17049796879291534, Loss: 0.1441524177789688	Rec Loss: 0.026345547288656235,	KL
It 7400: Total Loss: 0.16368529200553894, Loss: 0.1353757679462433	Rec Loss: 0.028309520334005356,	KL
It 7500: Total Loss: 0.16418075561523438, Loss: 0.13801775872707367	Rec Loss: 0.02616298943758011,	KL
Run Epoch 8		
It 7600: Total Loss: 0.16310711205005646, Loss: 0.13745631277561188	Rec Loss: 0.02565080299973488,	KL
It 7700: Total Loss: 0.16559815406799316, Loss: 0.14098405838012695	Rec Loss: 0.02461409941315651,	KL
It 7800: Total Loss: 0.17077818512916565, Loss: 0.14142662286758423	Rec Loss: 0.02935156784951687,	KL
It 7900: Total Loss: 0.16617058217525482, Loss: 0.13854804635047913	Rec Loss: 0.027622532099485397,	KL
It 8000: Total Loss: 0.16598811745643616, Loss: 0.14032481610774994	Rec Loss: 0.025663303211331367,	KL
It 8100: Total Loss: 0.16581404209136963, Loss: 0.13961127400398254	Rec Loss: 0.026202766224741936,	KL
It 8200: Total Loss: 0.16370297968387604, Loss: 0.1380109339952469	Rec Loss: 0.02569204568862915,	KL
It 8300: Total Loss: 0.1818353235721588, Loss: 0.14802950620651245	Rec Loss: 0.03380582109093666,	KL
It 8400: Total Loss: 0.1647453010082245, Loss: 0.138529971241951	Rec Loss: 0.026215335354208946,	KL
Run Epoch 9		
It 8500: Total Loss: 0.16652898490428925, Loss: 0.13890063762664795	Rec Loss: 0.027628343552350998,	KL
It 8600: Total Loss: 0.1628025472164154, Loss: 0.13633054494857788	Rec Loss: 0.026472004130482674,	KL

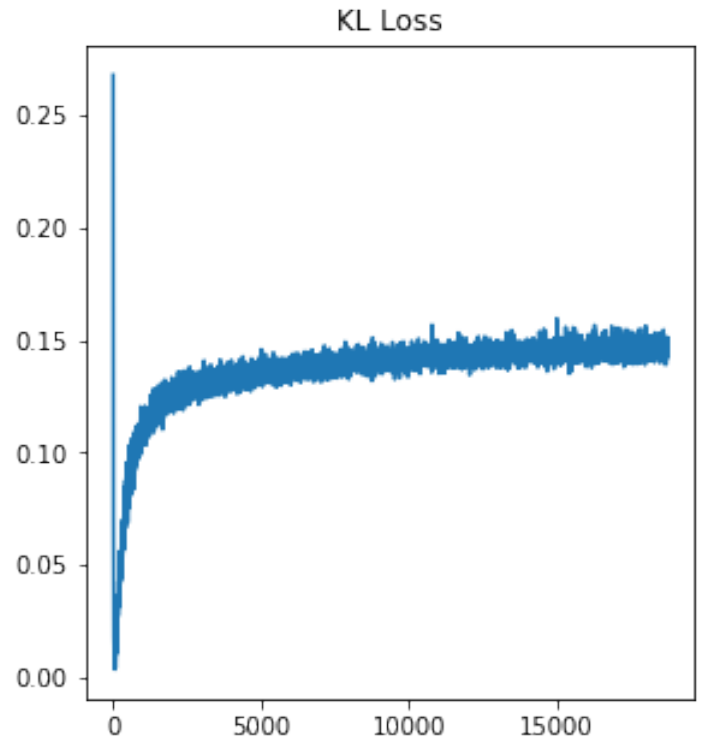
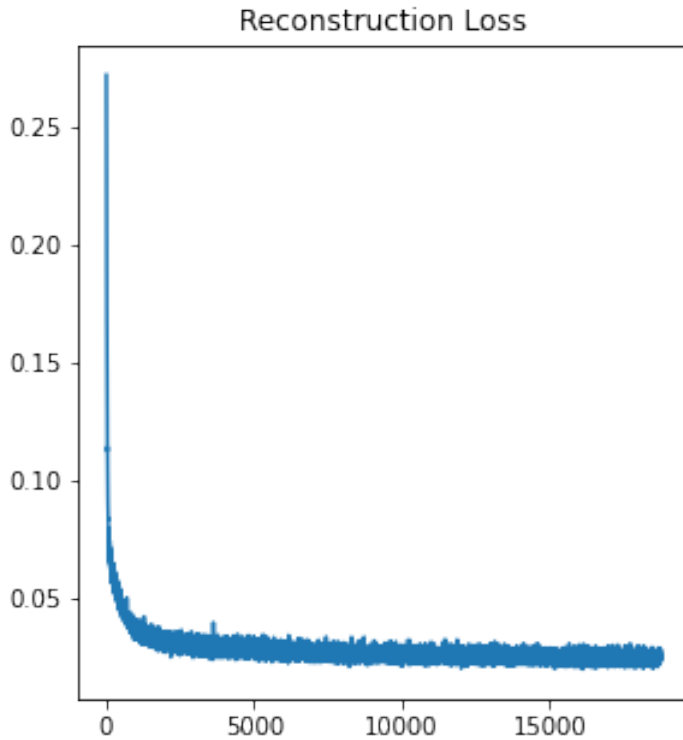
It 8700: Total Loss: 0.16679343581199646, Loss: 0.1406896710395813	Rec Loss: 0.02610376849770546,	KL
It 8800: Total Loss: 0.1692206710577011, Loss: 0.1421610713005066	Rec Loss: 0.027059603482484818,	KL
It 8900: Total Loss: 0.16745567321777344, Loss: 0.14085522294044495	Rec Loss: 0.026600457727909088,	KL
It 9000: Total Loss: 0.1693890541791916, Loss: 0.14180228114128113	Rec Loss: 0.027586771175265312,	KL
It 9100: Total Loss: 0.168310284614563, 0.13927897810935974	Rec Loss: 0.0290313009172678,	KL Loss:
It 9200: Total Loss: 0.166184201836586, Loss: 0.14033633470535278	Rec Loss: 0.025847867131233215,	KL
It 9300: Total Loss: 0.16604328155517578, Loss: 0.13939684629440308	Rec Loss: 0.026646438986063004,	KL
Run Epoch 10		
It 9400: Total Loss: 0.16808918118476868, Loss: 0.14256297051906586	Rec Loss: 0.025526218116283417,	KL
It 9500: Total Loss: 0.16580714285373688, Loss: 0.14088387787342072	Rec Loss: 0.024923261255025864,	KL
It 9600: Total Loss: 0.17054426670074463, Loss: 0.14076250791549683	Rec Loss: 0.029781758785247803,	KL
It 9700: Total Loss: 0.1639970988035202, Loss: 0.13931059837341309	Rec Loss: 0.024686502292752266,	KL
It 9800: Total Loss: 0.16613660752773285, Loss: 0.14042747020721436	Rec Loss: 0.025709131732583046,	KL
It 9900: Total Loss: 0.16161426901817322, 0.13741201162338257	Rec Loss: 0.0242022592574358,	KL Loss:
It 10000: Total Loss: 0.17131707072257996, Loss: 0.14593937993049622	Rec Loss: 0.025377698242664337,	KL
It 10100: Total Loss: 0.1658206284046173, Loss: 0.14206740260124207	Rec Loss: 0.023753229528665543,	KL
It 10200: Total Loss: 0.16853362321853638, Loss: 0.14341382682323456	Rec Loss: 0.02511979267001152,	KL
It 10300: Total Loss: 0.16878636181354523, Loss: 0.14237050712108612	Rec Loss: 0.026415858417749405,	KL
Run Epoch 11		
It 10400: Total Loss: 0.16851529479026794, Loss: 0.14254124462604523	Rec Loss: 0.025974052026867867,	KL
It 10500: Total Loss: 0.1663368046283722, Loss: 0.14166703820228577	Rec Loss: 0.024669773876667023,	KL
It 10600: Total Loss: 0.16637250781059265, Loss: 0.14092855155467987	Rec Loss: 0.025443952530622482,	KL
It 10700: Total Loss: 0.1693234145641327, Loss: 0.14399206638336182	Rec Loss: 0.025331346318125725,	KL
It 10800: Total Loss: 0.17428307235240936, Loss: 0.14809131622314453	Rec Loss: 0.02619175985455513,	KL
It 10900: Total Loss: 0.16858842968940735, Loss: 0.1422918438911438	Rec Loss: 0.026296580210328102,	KL
It 11000: Total Loss: 0.1667054295539856, Loss: 0.1418764442205429	Rec Loss: 0.02482897788286209,	KL
It 11100: Total Loss: 0.16599062085151672, Loss: 0.140252485871315	Rec Loss: 0.02573814056813717,	KL
It 11200: Total Loss: 0.16117359697818756, Loss: 0.13790422677993774	Rec Loss: 0.023269375786185265,	KL
Run Epoch 12		
It 11300: Total Loss: 0.1656436175107956, Loss: 0.13798947632312775	Rec Loss: 0.027654143050312996,	KL
It 11400: Total Loss: 0.1676175892353058, Loss: 0.14261621236801147	Rec Loss: 0.02500138431787491,	KL
It 11500: Total Loss: 0.17572030425071716, Loss: 0.14756792783737183	Rec Loss: 0.028152378275990486,	KL
It 11600: Total Loss: 0.16883979737758636, Loss: 0.14379404485225677	Rec Loss: 0.02504574880003929,	KL

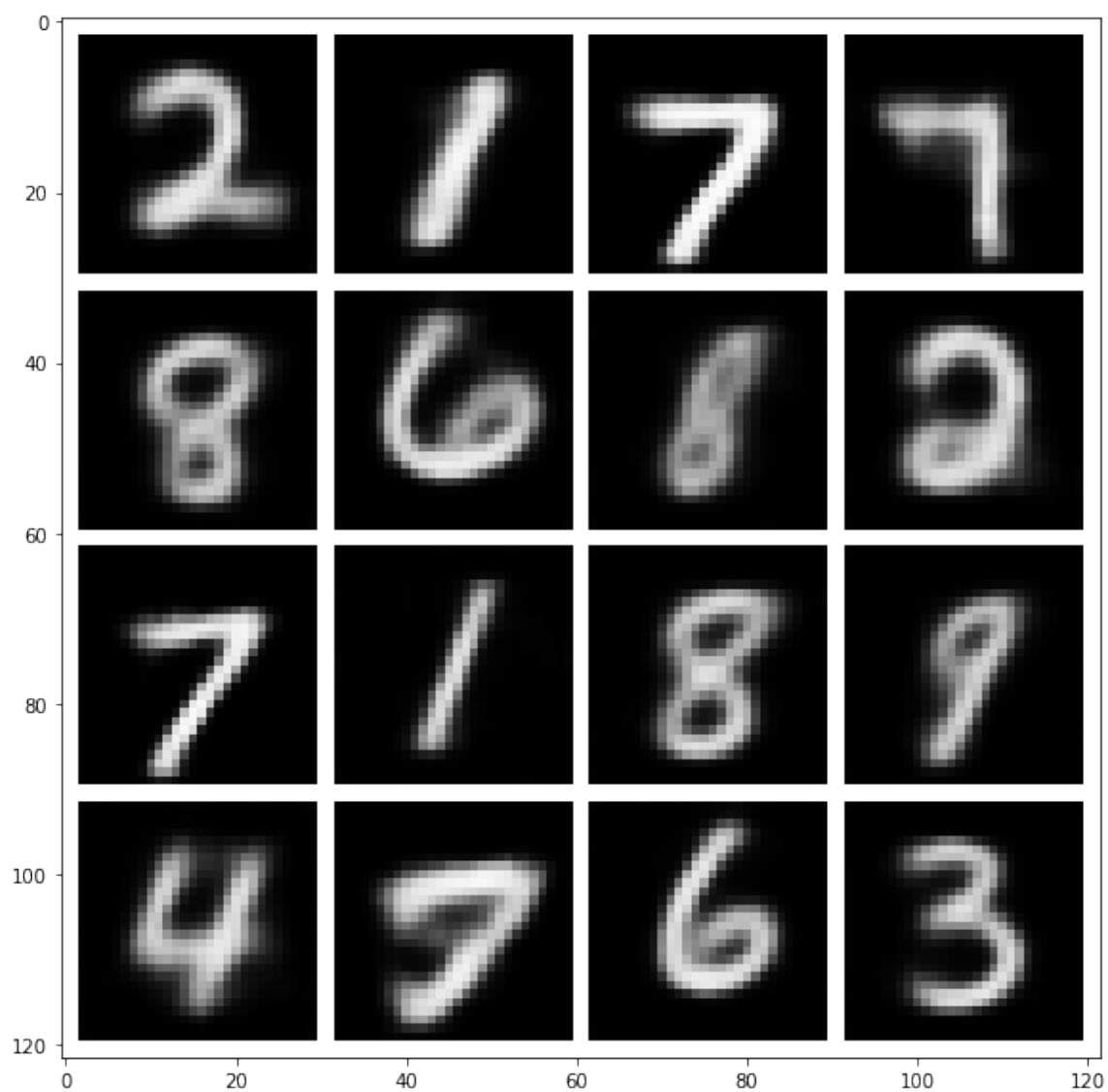
It 11700: Total Loss: 0.1674850583076477, Loss: 0.14086079597473145	Rec Loss: 0.026624254882335663,	KL
It 11800: Total Loss: 0.17027606070041656, Loss: 0.14315974712371826	Rec Loss: 0.0271163173019886,	KL Loss:
It 11900: Total Loss: 0.16262030601501465, Loss: 0.13941100239753723	Rec Loss: 0.02320929802954197,	KL
It 12000: Total Loss: 0.17084068059921265, Loss: 0.14578565955162048	Rec Loss: 0.02505502663552761,	KL
It 12100: Total Loss: 0.17014780640602112, Loss: 0.14214836061000824	Rec Loss: 0.027999449521303177,	KL
Run Epoch 13		
It 12200: Total Loss: 0.1698126643896103, Loss: 0.1445363312959671	Rec Loss: 0.02527632750570774,	KL
It 12300: Total Loss: 0.17251068353652954, Loss: 0.14634159207344055	Rec Loss: 0.02616908587515354,	KL
It 12400: Total Loss: 0.16987252235412598, Loss: 0.14273814857006073	Rec Loss: 0.027134370058774948,	KL
It 12500: Total Loss: 0.16143538057804108, Loss: 0.13771262764930725	Rec Loss: 0.023722747340798378,	KL
It 12600: Total Loss: 0.1674191653728485, Loss: 0.1441725790500641	Rec Loss: 0.023246578872203827,	KL
It 12700: Total Loss: 0.1752426028251648, Loss: 0.14853417873382568	Rec Loss: 0.026708416640758514,	KL
It 12800: Total Loss: 0.16752982139587402, Loss: 0.14287790656089783	Rec Loss: 0.024651911109685898,	KL
It 12900: Total Loss: 0.16873934864997864, Loss: 0.14508318901062012	Rec Loss: 0.02365616336464882,	KL
It 13000: Total Loss: 0.16887901723384857, Loss: 0.14517900347709656	Rec Loss: 0.023700010031461716,	KL
It 13100: Total Loss: 0.16950970888137817, Loss: 0.14417919516563416	Rec Loss: 0.02533051371574402,	KL
Run Epoch 14		
It 13200: Total Loss: 0.17148520052433014, Loss: 0.14412882924079895	Rec Loss: 0.02735636569559574,	KL
It 13300: Total Loss: 0.17290160059928894, Loss: 0.14536215364933014	Rec Loss: 0.027539454400539398,	KL
It 13400: Total Loss: 0.1692623645067215, Loss: 0.14363086223602295	Rec Loss: 0.025631505995988846,	KL
It 13500: Total Loss: 0.16519173979759216, Loss: 0.14114853739738464	Rec Loss: 0.024043209850788116,	KL
It 13600: Total Loss: 0.17282871901988983, Loss: 0.14684990048408508	Rec Loss: 0.025978822261095047,	KL
It 13700: Total Loss: 0.17224107682704926, Loss: 0.14582613110542297	Rec Loss: 0.02641494944691658,	KL
It 13800: Total Loss: 0.17446944117546082, Loss: 0.14597976207733154	Rec Loss: 0.02848968096077442,	KL
It 13900: Total Loss: 0.16674791276454926, Loss: 0.14280132949352264	Rec Loss: 0.02394658885896206,	KL
It 14000: Total Loss: 0.17023436725139618, Loss: 0.14480064809322357	Rec Loss: 0.025433719158172607,	KL
Run Epoch 15		
It 14100: Total Loss: 0.17257340252399445, Loss: 0.14754408597946167	Rec Loss: 0.025029320269823074,	KL
It 14200: Total Loss: 0.16954383254051208, Loss: 0.1440163403749466	Rec Loss: 0.02552749589085579,	KL
It 14300: Total Loss: 0.16919225454330444, Loss: 0.14467428624629974	Rec Loss: 0.024517973884940147,	KL
It 14400: Total Loss: 0.16692978143692017, Loss: 0.14222988486289978	Rec Loss: 0.024699898436665535,	KL
It 14500: Total Loss: 0.16731780767440796, Loss: 0.14168399572372437	Rec Loss: 0.025633813813328743,	KL
It 14600: Total Loss: 0.16986435651779175, Loss: 0.14364030957221985	Rec Loss: 0.02622404880821705,	KL

It 14700: Total Loss: 0.1710101217031479, 0.1464352309703827	Rec Loss: 0.0245748870074749, KL Loss:	
It 14800: Total Loss: 0.16778427362442017, Loss: 0.14258727431297302	Rec Loss: 0.025197001174092293,	KL
It 14900: Total Loss: 0.16822093725204468, Loss: 0.14389505982398987	Rec Loss: 0.024325881153345108,	KL
It 15000: Total Loss: 0.16874532401561737, Loss: 0.14548306167125702	Rec Loss: 0.023262256756424904,	KL
Run Epoch 16		
It 15100: Total Loss: 0.16547521948814392, Loss: 0.14008653163909912	Rec Loss: 0.025388693436980247,	KL
It 15200: Total Loss: 0.16959208250045776, Loss: 0.14591056108474731	Rec Loss: 0.023681528866291046,	KL
It 15300: Total Loss: 0.17599830031394958, Loss: 0.1492164433002472	Rec Loss: 0.026781849563121796,	KL
It 15400: Total Loss: 0.17074930667877197, Loss: 0.1462239921092987	Rec Loss: 0.024525318294763565,	KL
It 15500: Total Loss: 0.1720876544713974, Loss: 0.14768648147583008	Rec Loss: 0.024401167407631874,	KL
It 15600: Total Loss: 0.16450296342372894, Loss: 0.14260724186897278	Rec Loss: 0.021895725280046463,	KL
It 15700: Total Loss: 0.16881351172924042, Loss: 0.1441483497619629	Rec Loss: 0.02466515637934208,	KL
It 15800: Total Loss: 0.16519881784915924, Loss: 0.14206670224666595	Rec Loss: 0.023132119327783585,	KL
It 15900: Total Loss: 0.17141689360141754, Loss: 0.1472405344247818	Rec Loss: 0.02417636290192604,	KL
Run Epoch 17		
It 16000: Total Loss: 0.1658809334039688, Loss: 0.14181703329086304	Rec Loss: 0.024063900113105774,	KL
It 16100: Total Loss: 0.16873379051685333, Loss: 0.14404001832008362	Rec Loss: 0.024693766608834267,	KL
It 16200: Total Loss: 0.16911351680755615, Loss: 0.1411609947681427	Rec Loss: 0.027952520176768303,	KL
It 16300: Total Loss: 0.16846850514411926, Loss: 0.14425034821033478	Rec Loss: 0.024218156933784485,	KL
It 16400: Total Loss: 0.16936594247817993, 0.14464318752288818	Rec Loss: 0.0247227530926466, KL Loss:	
It 16500: Total Loss: 0.17099489271640778, Loss: 0.14623498916625977	Rec Loss: 0.024759909138083458,	KL
It 16600: Total Loss: 0.17038866877555847, Loss: 0.14409488439559937	Rec Loss: 0.026293788105249405,	KL
It 16700: Total Loss: 0.17297698557376862, Loss: 0.145856112241745	Rec Loss: 0.02712087705731392,	KL
It 16800: Total Loss: 0.17292045056819916, Loss: 0.14871332049369812	Rec Loss: 0.02420712448656559,	KL
Run Epoch 18		
It 16900: Total Loss: 0.1686878204345703, 0.1457109898328781	Rec Loss: 0.0229768268764019, KL Loss:	
It 17000: Total Loss: 0.1669345200061798, Loss: 0.1443723440170288	Rec Loss: 0.02256218157708645,	KL
It 17100: Total Loss: 0.1758710741996765, Loss: 0.1476278454065323	Rec Loss: 0.028243225067853928,	KL
It 17200: Total Loss: 0.17098121345043182, Loss: 0.14393073320388794	Rec Loss: 0.027050482109189034,	KL
It 17300: Total Loss: 0.16753149032592773, Loss: 0.14256183803081512	Rec Loss: 0.02496965602040291,	KL
It 17400: Total Loss: 0.16909034550189972, Loss: 0.14253085851669312	Rec Loss: 0.026559488847851753,	KL
It 17500: Total Loss: 0.16895925998687744, Loss: 0.14467661082744598	Rec Loss: 0.024282652884721756,	KL
It 17600: Total Loss: 0.16948123276233673, Loss: 0.14364245533943176	Rec Loss: 0.025838781148195267,	KL

It 17700: Total Loss: 0.16719461977481842,
Loss: 0.14388427138328552
It 17800: Total Loss: 0.17408759891986847,
Loss: 0.14809730648994446
Run Epoch 19
It 17900: Total Loss: 0.16269198060035706,
Loss: 0.14212355017662048
It 18000: Total Loss: 0.17180727422237396,
Loss: 0.14665071666240692
It 18100: Total Loss: 0.17011567950248718,
Loss: 0.1474342793226242
It 18200: Total Loss: 0.173336923122406,
Loss: 0.14706653356552124
It 18300: Total Loss: 0.16807502508163452,
Loss: 0.1445389837026596
It 18400: Total Loss: 0.17035295069217682,
Loss: 0.14385688304901123
It 18500: Total Loss: 0.17134183645248413,
Loss: 0.14725348353385925
It 18600: Total Loss: 0.1714237630367279,
Loss: 0.14680691063404083
It 18700: Total Loss: 0.168397918343544,
Loss: 0.1436673402786255
Done!

Rec Loss: 0.023310350254178047,	KL
Rec Loss: 0.025990286841988564,	KL
Rec Loss: 0.020568430423736572,	KL
Rec Loss: 0.025156555697321892,	KL
Rec Loss: 0.022681398317217827,	KL
Rec Loss: 0.02627038210630417,	KL
Rec Loss: 0.02353604882955551,	KL
Rec Loss: 0.02649606764316559,	KL
Rec Loss: 0.024088358506560326,	KL
Rec Loss: 0.024616844952106476,	KL
Rec Loss: 0.024730583652853966,	KL





3. Answers to all inline questions in VAE section

Inline Question: What can you observe when setting $\beta=0$? Explain your observations! [3pt]

Answer: The construction is good since only the reconstruction loss is taken into account, but there is no possible to generate good samples since the model has not learned anything about the latent space.

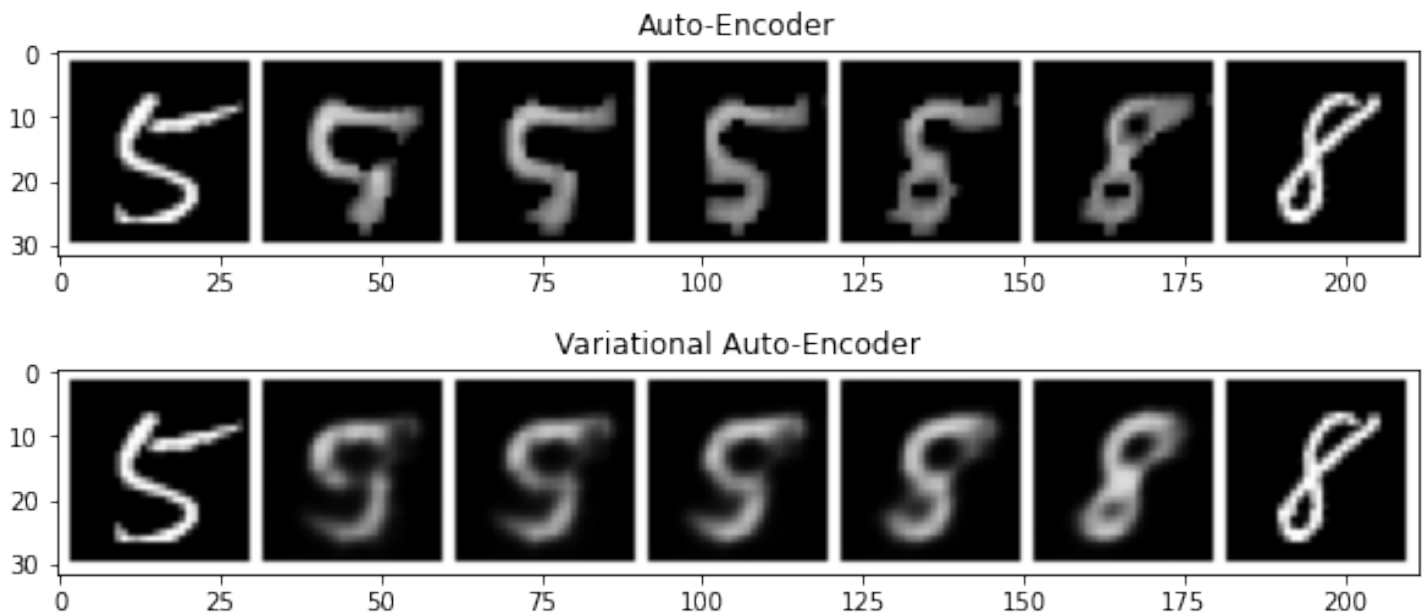
Inline Question: What can you observe when setting $\beta=10$? Explain your observations! [3pt]

Answer: A high beta is highly affecting the latent space in a way that reconstruction loss does not matter, and the latent space is sort of misrepresented, therefore reconstruction and samples looks unnatural.

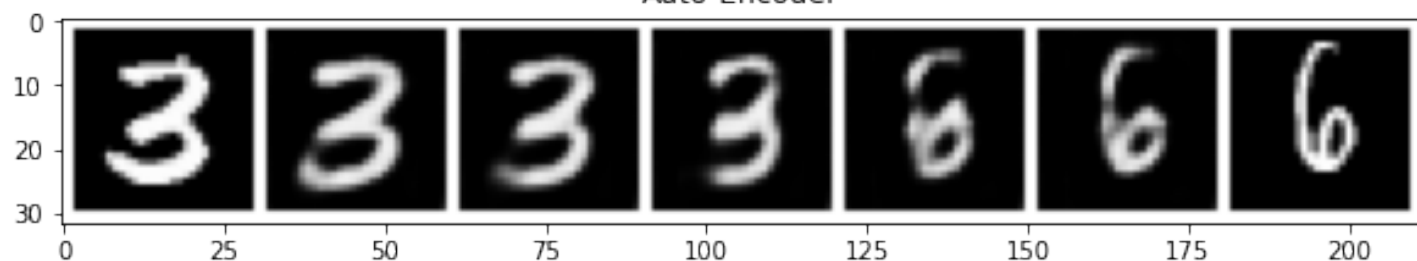
Inline Question: Characterize what properties you would expect for reconstructions (1pt) and samples (2pt) of a well-tuned VAE! [3pt]

Answer: Good result means that it approximates the input in a way that we can identify for both input and reconstruction to be the same number, doesn't matter if the reconstruction is a little bit blurry or has more or less pixels. As far as the can be recognized by humans as digit numbers it would mean a good result. Same would apply for samples as long as we can think of its representation as digits, I would say it is a good result.

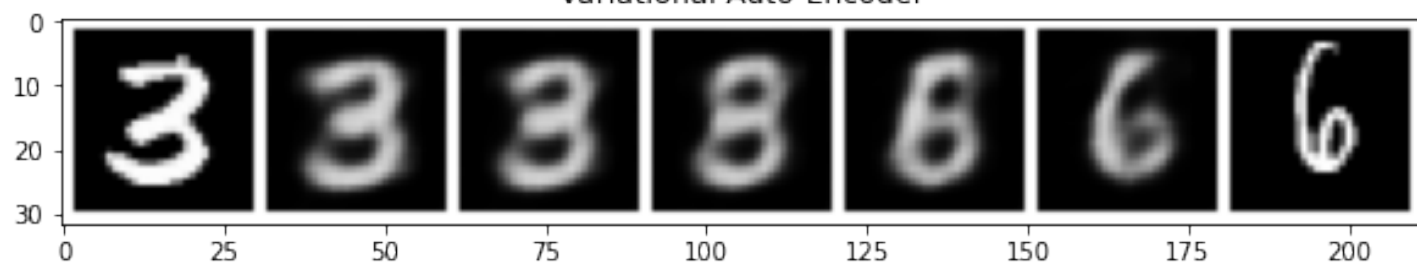
4. Three representative interpolation comparisons that show AE and VAE embedding interpolation between the same images.



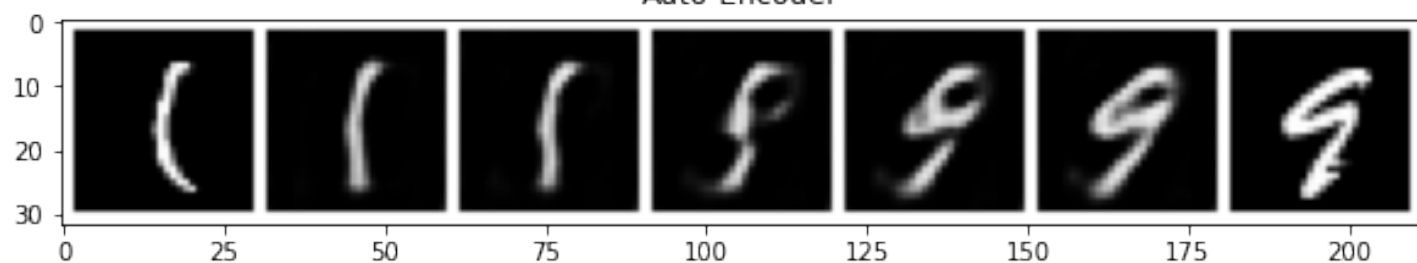
Auto-Encoder



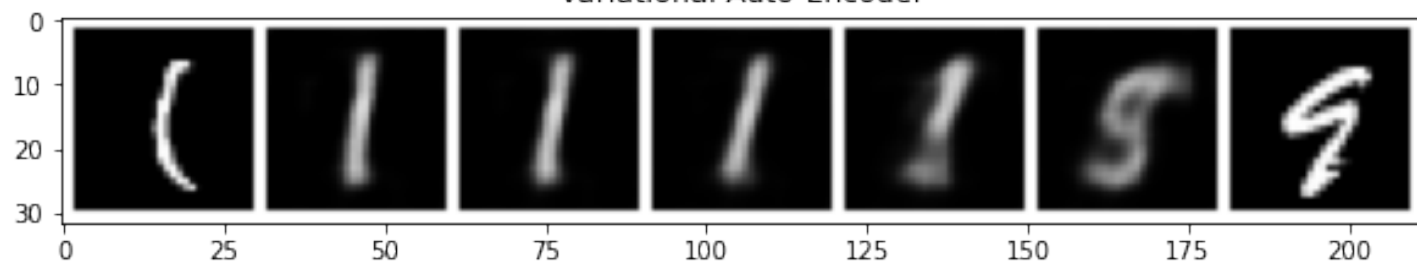
Variational Auto-Encoder



Auto-Encoder



Variational Auto-Encoder



5. Answer to interpolation inline question.

Inline Question: Repeat the interpolation experiment with different start / end labels and multiple samples. Describe your observations! Focus on:

1. How do AE and VAE embedding space interpolations differ?
2. How do you expect these differences to affect the usefulness of the learned representation for downstream learning?

Answer:

1. AE embedding space is basically a compressed representation that's why interpolated images between z_start and z_end doesn't look natural where as VAE learn the parameters of a probability distribution representing the data generating new input from a random point in the latent space that looks more like a number.
2. Similar to the previous answer. VAE learns the parameters of a probability distribution which makes generated output useful for downstream tasks like multiple predictions. Since VAE is forced to learn the representation of a world, then the data generated from a low-dimensionality vector will be meaningful for the world too. AE is limited to reproducing what is has seen, restricting it in the number of tasks where it can be useful.