**DSC 275/475: Time Series Analysis and Forecasting (Fall 2021)**

**Project 3.2 – LSTM-based Auto-encoders**

1. A critical hyper-parameter when using auto-encoders is the threshold applied to the reconstructed time-series to classify between normal and abnormal. The default *threshold* in the code is set to 45. Run the code for 50 epochs.
2. For the normal and abnormal test set defined in the code as “test\_normal\_dataset” and “anomaly\_dataset”, vary the *threshold* value from 15 to 75 (both included) in increments of 10 and report (as a graph or a table) the proportion of normal and abnormal time-series that were correctly classified, i.e. *recall*. **(10 points)**

15: Correct normal predictions: 20/145

Correct anomaly predictions: 145/145

25: Correct normal predictions: 93/145

Correct anomaly predictions: 144/145

35: Correct normal predictions: 126/145

Correct anomaly predictions: 144/145

45: Correct normal predictions: 137/145

Correct anomaly predictions: 141/145

55: Correct normal predictions: 142/145

Correct anomaly predictions: 137/145

65: Correct normal predictions: 143/145

Correct anomaly predictions: 122/145

75: Correct normal predictions: 144/145

Correct anomaly predictions: 86/145

1. Briefly explain the trend you see in the *recall* values as you increase the threshold. **(5 points)**

Normal: increase

Anomaly: decreases slowly

1. In the above example, the embedding dimension (i.e. output length of encoder and input length of decoder) was set constant at 8.
2. Embedding dimension length is typically an important hyperparameter that can affect the performance of the technique. Vary the embedding dimension from 2 to 8 in increments of 2 and report the training and validation loss after 25 epochs. **(15 points)**

loss is dec

2:

Epoch 1: train loss 93.39219722109713 val loss 89.22614918471196

Epoch 2: train loss 72.21536462607763 val loss 69.20408738432484

Epoch 3: train loss 69.09479859585437 val loss 69.16084885841343

Epoch 4: train loss 68.18510655807133 val loss 69.04959373343927

Epoch 5: train loss 67.77751113541036 val loss 69.43994087245277

Epoch 6: train loss 67.5608835477879 val loss 68.83003871514121

Epoch 7: train loss 67.33883801990342 val loss 68.5559858380731

Epoch 8: train loss 67.17371953143943 val loss 69.2486509511902

Epoch 9: train loss 67.05962928731996 val loss 69.47446774948172

Epoch 10: train loss 66.94861704569966 val loss 67.13078323728803

Epoch 11: train loss 66.865299463176 val loss 67.64426626524421

Epoch 12: train loss 66.77557195150675 val loss 67.33101053856339

Epoch 13: train loss 66.67294270777981 val loss 66.71250351785393

Epoch 14: train loss 66.5670166323138 val loss 65.98274314281477

Epoch 15: train loss 66.474985626233 val loss 65.83253025927235

Epoch 16: train loss 66.37999043739501 val loss 65.67455341221937

Epoch 17: train loss 66.2934709323697 val loss 65.68787087189867

Epoch 18: train loss 66.19744093194214 val loss 65.58256953893668

Epoch 19: train loss 66.10536922499423 val loss 65.58581195349579

Epoch 20: train loss 66.0083883732185 val loss 65.61144299555964

Epoch 21: train loss 65.91017580166886 val loss 66.34333632016751

Epoch 22: train loss 65.8071834528845 val loss 65.39897183102552

Epoch 23: train loss 65.67730103400099 val loss 65.63082954745244

Epoch 24: train loss 65.5995669981877 val loss 65.49223063341994

Epoch 25: train loss 65.72224271590554 val loss 65.47300521017341

4:

Epoch 1: train loss 76.05348295052654 val loss 68.78366678648028

Epoch 2: train loss 68.61608979741396 val loss 67.8486641112448

Epoch 3: train loss 67.27787250302002 val loss 65.57934731753613

Epoch 4: train loss 63.67052447262525 val loss 60.12977374861265

Epoch 5: train loss 58.526093637880805 val loss 57.00443115494764

Epoch 6: train loss 56.23850602038874 val loss 55.97072424253913

Epoch 7: train loss 55.37592037220916 val loss 55.61173797711577

Epoch 8: train loss 54.819661157739496 val loss 54.93232777826615

Epoch 9: train loss 54.37590660178243 val loss 54.41800176731149

Epoch 10: train loss 54.04712911096132 val loss 54.29681902940769

Epoch 11: train loss 53.80483066569601 val loss 53.78971063399071

Epoch 12: train loss 53.6244226891588 val loss 53.658245321019926

Epoch 13: train loss 53.467352434686475 val loss 53.57962266576982

Epoch 14: train loss 52.967149378550914 val loss 52.51261199456433

Epoch 15: train loss 52.6869724247543 val loss 51.966614576736816

Epoch 16: train loss 52.615496487446435 val loss 51.96996011831654

Epoch 17: train loss 52.63021866345973 val loss 52.04321184906943

Epoch 18: train loss 52.512324940913246 val loss 51.892307190358025

Epoch 19: train loss 52.449550196606516 val loss 52.20075419819803

Epoch 20: train loss 52.428400756946644 val loss 51.8075308230143

Epoch 21: train loss 52.35766860795857 val loss 52.1553160045741

Epoch 22: train loss 52.276864130619025 val loss 52.735691278867755

Epoch 23: train loss 52.2459045534699 val loss 51.72398635551791

Epoch 24: train loss 52.152069689909425 val loss 52.15049616712759

Epoch 25: train loss 52.19243639123771 val loss 51.705735287975536

6:

Epoch 1: train loss 75.91648677163238 val loss 68.03929847743323

Epoch 2: train loss 68.19707075255093 val loss 68.89112984198353

Epoch 3: train loss 61.04383442796848 val loss 52.85693464832501

Epoch 4: train loss 52.18316219795716 val loss 52.156850860387394

Epoch 5: train loss 50.44942009713274 val loss 49.844851510109756

Epoch 6: train loss 48.38650738102253 val loss 45.45742271215029

Epoch 7: train loss 43.64992303629164 val loss 42.65399504521601

Epoch 8: train loss 41.11311687744706 val loss 41.280514674788854

Epoch 9: train loss 40.08824743680635 val loss 43.07958148526657

Epoch 10: train loss 39.79684500673133 val loss 38.587074943776834

Epoch 11: train loss 39.48111359220702 val loss 40.92828573545905

Epoch 12: train loss 38.868607759764004 val loss 40.167034058033806

Epoch 13: train loss 38.4352135233512 val loss 39.987267972666245

Epoch 14: train loss 38.4112941937214 val loss 37.87443972773112

Epoch 15: train loss 38.13644500126622 val loss 38.61944772114933

Epoch 16: train loss 37.30082215075049 val loss 37.73682549382232

Epoch 17: train loss 37.1523637875392 val loss 36.29700684791539

Epoch 18: train loss 36.80494636587922 val loss 37.03032223437833

Epoch 19: train loss 36.25894777604718 val loss 36.67974078858672

Epoch 20: train loss 36.203264068086895 val loss 36.526251275384794

Epoch 21: train loss 35.73182432442987 val loss 35.05489372800235

Epoch 22: train loss 35.37565809754968 val loss 35.80422351303361

Epoch 23: train loss 35.10982454308383 val loss 34.75400961788034

Epoch 24: train loss 34.886907615184974 val loss 35.23704788546513

Epoch 25: train loss 34.63201972526295 val loss 34.115558813049525

8:

Epoch 1: train loss 81.46175270126693 val loss 69.26715357393128

Epoch 2: train loss 62.26415878935525 val loss 54.303966170691794

Epoch 3: train loss 53.80281008313328 val loss 52.82068906139595

Epoch 4: train loss 53.01474976068733 val loss 52.025579862627154

Epoch 5: train loss 52.234363552064295 val loss 51.4637268118484

Epoch 6: train loss 51.15839935127452 val loss 48.91057608802978

Epoch 7: train loss 49.136260262904074 val loss 48.15237188501976

Epoch 8: train loss 46.852542535089185 val loss 45.93002436510939

Epoch 9: train loss 41.32340400308335 val loss 37.71958553587617

Epoch 10: train loss 37.97750520379444 val loss 36.26988830175823

Epoch 11: train loss 36.883777440050736 val loss 36.70854476694361

Epoch 12: train loss 35.48325261643028 val loss 34.6429040309919

Epoch 13: train loss 34.54264998022754 val loss 35.52432995688793

Epoch 14: train loss 33.55635155597458 val loss 34.038527628667524

Epoch 15: train loss 33.318421965787024 val loss 32.60291074811395

Epoch 16: train loss 32.30537081975602 val loss 32.89450958238934

Epoch 17: train loss 31.878025350528397 val loss 31.54593509049139

Epoch 18: train loss 31.59834638616338 val loss 30.81201110358124

Epoch 19: train loss 30.901500407460716 val loss 32.360906272211174

Epoch 20: train loss 30.61092894714429 val loss 30.931442986576222

Epoch 21: train loss 30.42513664265594 val loss 30.858628383675534

Epoch 22: train loss 29.991131774075136 val loss 30.473819446238235

Epoch 23: train loss 29.70262764173859 val loss 30.41454834010414

Epoch 24: train loss 29.393754101529904 val loss 29.62413584412975

Epoch 25: train loss 29.0246623660806 val loss 29.741375913392154

1. Briefly explain the trend you see in the training and validation loss **(5 points)**

2: Epoch 25: train loss 65.72224271590554 val loss 65.47300521017341

4: Epoch 25: train loss 52.19243639123771 val loss 51.705735287975536

6: Epoch 25: train loss 34.63201972526295 val loss 34.115558813049525

8: Epoch 25: train loss 29.0246623660806 val loss 29.741375913392154

They are both decreasing.

1. Compute the proportion of normal and abnormal time-series correctly classified (i.e. *Recall*) for the same test set in Q.1 above for each of the embedding dimension values from (a). You can set the threshold to 45.

2: Correct normal predictions: 2/145

Correct anomaly predictions: 144/145

4: Correct normal predictions: 41/145

Correct anomaly predictions: 143/145

6: Correct normal predictions: 128/145

Correct anomaly predictions: 143/145

8: Correct normal predictions: 127/145

Correct anomaly predictions: 143/145

1. Briefly explain the trend you see in the *Recall* in part (c) above **(5 points)**

Correct normal predictions increased from 2 to 6 and then went down for 8 while anomaly predictions are decreasing.