Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 561s 11ms/step - loss: 0.0142 - mean\_squared\_error: 0.0142 - acc: 0.9049 - val\_loss: 0.0071 - val\_mean\_squared\_error: 0.0071 - val\_acc: 0.9547

Epoch 2/15

50000/50000 [==============================] - 563s 11ms/step - loss: 0.0059 - mean\_squared\_error: 0.0059 - acc: 0.9622 - val\_loss: 0.0046 - val\_mean\_squared\_error: 0.0046 - val\_acc: 0.9697

Epoch 3/15

50000/50000 [==============================] - 560s 11ms/step - loss: 0.0041 - mean\_squared\_error: 0.0041 - acc: 0.9746 - val\_loss: 0.0043 - val\_mean\_squared\_error: 0.0043 - val\_acc: 0.9720

Epoch 4/15

50000/50000 [==============================] - 560s 11ms/step - loss: 0.0031 - mean\_squared\_error: 0.0031 - acc: 0.9805 - val\_loss: 0.0051 - val\_mean\_squared\_error: 0.0051 - val\_acc: 0.9681

Epoch 5/15

50000/50000 [==============================] - 563s 11ms/step - loss: 0.0025 - mean\_squared\_error: 0.0025 - acc: 0.9846 - val\_loss: 0.0041 - val\_mean\_squared\_error: 0.0041 - val\_acc: 0.9753

Epoch 6/15

50000/50000 [==============================] - 563s 11ms/step - loss: 0.0020 - mean\_squared\_error: 0.0020 - acc: 0.9874 - val\_loss: 0.0038 - val\_mean\_squared\_error: 0.0038 - val\_acc: 0.9756

Epoch 7/15

50000/50000 [==============================] - 562s 11ms/step - loss: 0.0017 - mean\_squared\_error: 0.0017 - acc: 0.9893 - val\_loss: 0.0032 - val\_mean\_squared\_error: 0.0032 - val\_acc: 0.9781

Epoch 8/15

50000/50000 [==============================] - 563s 11ms/step - loss: 0.0014 - mean\_squared\_error: 0.0014 - acc: 0.9915 - val\_loss: 0.0033 - val\_mean\_squared\_error: 0.0033 - val\_acc: 0.9782

Epoch 9/15

50000/50000 [==============================] - 561s 11ms/step - loss: 0.0012 - mean\_squared\_error: 0.0012 - acc: 0.9929 - val\_loss: 0.0029 - val\_mean\_squared\_error: 0.0029 - val\_acc: 0.9812

Epoch 10/15

50000/50000 [==============================] - 562s 11ms/step - loss: 9.4839e-04 - mean\_squared\_error: 9.4839e-04 - acc: 0.9945 - val\_loss: 0.0030 - val\_mean\_squared\_error: 0.0030 - val\_acc: 0.9805

Epoch 11/15

50000/50000 [==============================] - 563s 11ms/step - loss: 7.8463e-04 - mean\_squared\_error: 7.8463e-04 - acc: 0.9956 - val\_loss: 0.0030 - val\_mean\_squared\_error: 0.0030 - val\_acc: 0.9805

Epoch 12/15

50000/50000 [==============================] - 563s 11ms/step - loss: 7.0660e-04 - mean\_squared\_error: 7.0660e-04 - acc: 0.9961 - val\_loss: 0.0032 - val\_mean\_squared\_error: 0.0032 - val\_acc: 0.9801

Epoch 13/15

50000/50000 [==============================] - 560s 11ms/step - loss: 5.5590e-04 - mean\_squared\_error: 5.5590e-04 - acc: 0.9970 - val\_loss: 0.0028 - val\_mean\_squared\_error: 0.0028 - val\_acc: 0.9813

Epoch 14/15

50000/50000 [==============================] - 562s 11ms/step - loss: 5.0113e-04 - mean\_squared\_error: 5.0113e-04 - acc: 0.9972 - val\_loss: 0.0031 - val\_mean\_squared\_error: 0.0031 - val\_acc: 0.9792

Epoch 15/15

50000/50000 [==============================] - 564s 11ms/step - loss: 4.1664e-04 - mean\_squared\_error: 4.1664e-04 - acc: 0.9978 - val\_loss: 0.0029 - val\_mean\_squared\_error: 0.0029 - val\_acc: 0.9823

10000/10000 [==============================] - 1s 120us/step

The testing accuracy metric for lr 0.05 and batch\_size 1 is [0.0026572770610719066, 0.0026572770610719066, 0.9839]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 564s 11ms/step - loss: 0.0127 - mean\_squared\_error: 0.0127 - acc: 0.9139 - val\_loss: 0.0069 - val\_mean\_squared\_error: 0.0069 - val\_acc: 0.9548

Epoch 2/15

50000/50000 [==============================] - 563s 11ms/step - loss: 0.0055 - mean\_squared\_error: 0.0055 - acc: 0.9637 - val\_loss: 0.0057 - val\_mean\_squared\_error: 0.0057 - val\_acc: 0.9635

Epoch 3/15

50000/50000 [==============================] - 564s 11ms/step - loss: 0.0040 - mean\_squared\_error: 0.0040 - acc: 0.9739 - val\_loss: 0.0039 - val\_mean\_squared\_error: 0.0039 - val\_acc: 0.9753

Epoch 4/15

50000/50000 [==============================] - 562s 11ms/step - loss: 0.0033 - mean\_squared\_error: 0.0033 - acc: 0.9788 - val\_loss: 0.0042 - val\_mean\_squared\_error: 0.0042 - val\_acc: 0.9734

Epoch 5/15

50000/50000 [==============================] - 560s 11ms/step - loss: 0.0026 - mean\_squared\_error: 0.0026 - acc: 0.9836 - val\_loss: 0.0033 - val\_mean\_squared\_error: 0.0033 - val\_acc: 0.9791

Epoch 6/15

50000/50000 [==============================] - 565s 11ms/step - loss: 0.0024 - mean\_squared\_error: 0.0024 - acc: 0.9852 - val\_loss: 0.0037 - val\_mean\_squared\_error: 0.0037 - val\_acc: 0.9758

Epoch 7/15

50000/50000 [==============================] - 559s 11ms/step - loss: 0.0019 - mean\_squared\_error: 0.0019 - acc: 0.9883 - val\_loss: 0.0040 - val\_mean\_squared\_error: 0.0040 - val\_acc: 0.9733

Epoch 8/15

50000/50000 [==============================] - 571s 11ms/step - loss: 0.0017 - mean\_squared\_error: 0.0017 - acc: 0.9895 - val\_loss: 0.0044 - val\_mean\_squared\_error: 0.0044 - val\_acc: 0.9723

Epoch 9/15

50000/50000 [==============================] - 491s 10ms/step - loss: 0.0014 - mean\_squared\_error: 0.0014 - acc: 0.9913 - val\_loss: 0.0032 - val\_mean\_squared\_error: 0.0032 - val\_acc: 0.9799

Epoch 10/15

50000/50000 [==============================] - 474s 9ms/step - loss: 0.0013 - mean\_squared\_error: 0.0013 - acc: 0.9917 - val\_loss: 0.0034 - val\_mean\_squared\_error: 0.0034 - val\_acc: 0.9792

Epoch 11/15

50000/50000 [==============================] - 476s 10ms/step - loss: 0.0012 - mean\_squared\_error: 0.0012 - acc: 0.9929 - val\_loss: 0.0035 - val\_mean\_squared\_error: 0.0035 - val\_acc: 0.9786

Epoch 12/15

50000/50000 [==============================] - 476s 10ms/step - loss: 0.0011 - mean\_squared\_error: 0.0011 - acc: 0.9934 - val\_loss: 0.0037 - val\_mean\_squared\_error: 0.0037 - val\_acc: 0.9770

Epoch 13/15

50000/50000 [==============================] - 478s 10ms/step - loss: 0.0011 - mean\_squared\_error: 0.0011 - acc: 0.9932 - val\_loss: 0.0033 - val\_mean\_squared\_error: 0.0033 - val\_acc: 0.9799

Epoch 14/15

50000/50000 [==============================] - 476s 10ms/step - loss: 0.0010 - mean\_squared\_error: 0.0010 - acc: 0.9939 - val\_loss: 0.0033 - val\_mean\_squared\_error: 0.0033 - val\_acc: 0.9802

Epoch 15/15

50000/50000 [==============================] - 476s 10ms/step - loss: 8.2970e-04 - mean\_squared\_error: 8.2970e-04 - acc: 0.9950 - val\_loss: 0.0033 - val\_mean\_squared\_error: 0.0033 - val\_acc: 0.9799

10000/10000 [==============================] - 1s 105us/step

The testing accuracy metric for lr 0.1 and batch\_size 1 is [0.003532880306907353, 0.003532880306907353, 0.9789]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 24s 481us/step - loss: 0.0903 - mean\_squared\_error: 0.0903 - acc: 0.1017 - val\_loss: 0.0901 - val\_mean\_squared\_error: 0.0901 - val\_acc: 0.1031

Epoch 2/15

50000/50000 [==============================] - 24s 475us/step - loss: 0.0900 - mean\_squared\_error: 0.0900 - acc: 0.1067 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1102

Epoch 3/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0896 - mean\_squared\_error: 0.0896 - acc: 0.1150 - val\_loss: 0.0895 - val\_mean\_squared\_error: 0.0895 - val\_acc: 0.1201

Epoch 4/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0893 - mean\_squared\_error: 0.0893 - acc: 0.1288 - val\_loss: 0.0891 - val\_mean\_squared\_error: 0.0891 - val\_acc: 0.1370

Epoch 5/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0890 - mean\_squared\_error: 0.0890 - acc: 0.1495 - val\_loss: 0.0888 - val\_mean\_squared\_error: 0.0888 - val\_acc: 0.1623

Epoch 6/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0887 - mean\_squared\_error: 0.0887 - acc: 0.1762 - val\_loss: 0.0885 - val\_mean\_squared\_error: 0.0885 - val\_acc: 0.1964

Epoch 7/15

50000/50000 [==============================] - 24s 487us/step - loss: 0.0883 - mean\_squared\_error: 0.0883 - acc: 0.2080 - val\_loss: 0.0881 - val\_mean\_squared\_error: 0.0881 - val\_acc: 0.2306

Epoch 8/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0880 - mean\_squared\_error: 0.0880 - acc: 0.2383 - val\_loss: 0.0877 - val\_mean\_squared\_error: 0.0877 - val\_acc: 0.2632

Epoch 9/15

50000/50000 [==============================] - 24s 478us/step - loss: 0.0876 - mean\_squared\_error: 0.0876 - acc: 0.2649 - val\_loss: 0.0873 - val\_mean\_squared\_error: 0.0873 - val\_acc: 0.2951

Epoch 10/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0872 - mean\_squared\_error: 0.0872 - acc: 0.2905 - val\_loss: 0.0869 - val\_mean\_squared\_error: 0.0869 - val\_acc: 0.3183

Epoch 11/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0867 - mean\_squared\_error: 0.0867 - acc: 0.3116 - val\_loss: 0.0864 - val\_mean\_squared\_error: 0.0864 - val\_acc: 0.3423

Epoch 12/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0863 - mean\_squared\_error: 0.0863 - acc: 0.3323 - val\_loss: 0.0860 - val\_mean\_squared\_error: 0.0860 - val\_acc: 0.3602

Epoch 13/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0858 - mean\_squared\_error: 0.0858 - acc: 0.3494 - val\_loss: 0.0854 - val\_mean\_squared\_error: 0.0854 - val\_acc: 0.3762

Epoch 14/15

50000/50000 [==============================] - 24s 478us/step - loss: 0.0853 - mean\_squared\_error: 0.0853 - acc: 0.3646 - val\_loss: 0.0849 - val\_mean\_squared\_error: 0.0849 - val\_acc: 0.3875

Epoch 15/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0847 - mean\_squared\_error: 0.0847 - acc: 0.3772 - val\_loss: 0.0843 - val\_mean\_squared\_error: 0.0843 - val\_acc: 0.3991

10000/10000 [==============================] - 1s 105us/step

The testing accuracy metric for lr 0.001 and batch\_size 32 is [0.08423589417934418, 0.08423589417934418, 0.3839]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 24s 482us/step - loss: 0.0882 - mean\_squared\_error: 0.0882 - acc: 0.2260 - val\_loss: 0.0862 - val\_mean\_squared\_error: 0.0862 - val\_acc: 0.4733

Epoch 2/15

50000/50000 [==============================] - 24s 481us/step - loss: 0.0834 - mean\_squared\_error: 0.0834 - acc: 0.5273 - val\_loss: 0.0794 - val\_mean\_squared\_error: 0.0794 - val\_acc: 0.5905

Epoch 3/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0741 - mean\_squared\_error: 0.0741 - acc: 0.6167 - val\_loss: 0.0669 - val\_mean\_squared\_error: 0.0669 - val\_acc: 0.6723

Epoch 4/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0592 - mean\_squared\_error: 0.0592 - acc: 0.6905 - val\_loss: 0.0496 - val\_mean\_squared\_error: 0.0496 - val\_acc: 0.7555

Epoch 5/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0444 - mean\_squared\_error: 0.0444 - acc: 0.7580 - val\_loss: 0.0367 - val\_mean\_squared\_error: 0.0367 - val\_acc: 0.7942

Epoch 6/15

50000/50000 [==============================] - 24s 478us/step - loss: 0.0343 - mean\_squared\_error: 0.0343 - acc: 0.8142 - val\_loss: 0.0283 - val\_mean\_squared\_error: 0.0283 - val\_acc: 0.8621

Epoch 7/15

50000/50000 [==============================] - 24s 477us/step - loss: 0.0278 - mean\_squared\_error: 0.0278 - acc: 0.8562 - val\_loss: 0.0232 - val\_mean\_squared\_error: 0.0232 - val\_acc: 0.8779

Epoch 8/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0237 - mean\_squared\_error: 0.0237 - acc: 0.8719 - val\_loss: 0.0201 - val\_mean\_squared\_error: 0.0201 - val\_acc: 0.8872

Epoch 9/15

50000/50000 [==============================] - 24s 486us/step - loss: 0.0212 - mean\_squared\_error: 0.0212 - acc: 0.8807 - val\_loss: 0.0182 - val\_mean\_squared\_error: 0.0182 - val\_acc: 0.8942

Epoch 10/15

50000/50000 [==============================] - 24s 483us/step - loss: 0.0195 - mean\_squared\_error: 0.0195 - acc: 0.8874 - val\_loss: 0.0168 - val\_mean\_squared\_error: 0.0168 - val\_acc: 0.9004

Epoch 11/15

50000/50000 [==============================] - 25s 500us/step - loss: 0.0182 - mean\_squared\_error: 0.0182 - acc: 0.8929 - val\_loss: 0.0158 - val\_mean\_squared\_error: 0.0158 - val\_acc: 0.9056

Epoch 12/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0172 - mean\_squared\_error: 0.0172 - acc: 0.8969 - val\_loss: 0.0151 - val\_mean\_squared\_error: 0.0151 - val\_acc: 0.9092

Epoch 13/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0165 - mean\_squared\_error: 0.0165 - acc: 0.8999 - val\_loss: 0.0144 - val\_mean\_squared\_error: 0.0144 - val\_acc: 0.9115

Epoch 14/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0159 - mean\_squared\_error: 0.0159 - acc: 0.9031 - val\_loss: 0.0140 - val\_mean\_squared\_error: 0.0140 - val\_acc: 0.9141

Epoch 15/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0153 - mean\_squared\_error: 0.0153 - acc: 0.9054 - val\_loss: 0.0135 - val\_mean\_squared\_error: 0.0135 - val\_acc: 0.9159

10000/10000 [==============================] - 1s 111us/step

The testing accuracy metric for lr 0.01 and batch\_size 32 is [0.0140970636124257, 0.0140970636124257, 0.9134]

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Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0716 - mean\_squared\_error: 0.0716 - acc: 0.5298 - val\_loss: 0.0373 - val\_mean\_squared\_error: 0.0373 - val\_acc: 0.8328

Epoch 2/15

50000/50000 [==============================] - 24s 488us/step - loss: 0.0257 - mean\_squared\_error: 0.0257 - acc: 0.8607 - val\_loss: 0.0170 - val\_mean\_squared\_error: 0.0170 - val\_acc: 0.9026

Epoch 3/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0170 - mean\_squared\_error: 0.0170 - acc: 0.8970 - val\_loss: 0.0138 - val\_mean\_squared\_error: 0.0138 - val\_acc: 0.9171

Epoch 4/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0145 - mean\_squared\_error: 0.0145 - acc: 0.9094 - val\_loss: 0.0123 - val\_mean\_squared\_error: 0.0123 - val\_acc: 0.9225

Epoch 5/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0131 - mean\_squared\_error: 0.0131 - acc: 0.9180 - val\_loss: 0.0113 - val\_mean\_squared\_error: 0.0113 - val\_acc: 0.9265

Epoch 6/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0120 - mean\_squared\_error: 0.0120 - acc: 0.9246 - val\_loss: 0.0109 - val\_mean\_squared\_error: 0.0109 - val\_acc: 0.9302

Epoch 7/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0113 - mean\_squared\_error: 0.0113 - acc: 0.9289 - val\_loss: 0.0102 - val\_mean\_squared\_error: 0.0102 - val\_acc: 0.9333

Epoch 8/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0107 - mean\_squared\_error: 0.0107 - acc: 0.9333 - val\_loss: 0.0097 - val\_mean\_squared\_error: 0.0097 - val\_acc: 0.9371

Epoch 9/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0101 - mean\_squared\_error: 0.0101 - acc: 0.9362 - val\_loss: 0.0092 - val\_mean\_squared\_error: 0.0092 - val\_acc: 0.9420

Epoch 10/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0097 - mean\_squared\_error: 0.0097 - acc: 0.9397 - val\_loss: 0.0091 - val\_mean\_squared\_error: 0.0091 - val\_acc: 0.9415

Epoch 11/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0093 - mean\_squared\_error: 0.0093 - acc: 0.9419 - val\_loss: 0.0088 - val\_mean\_squared\_error: 0.0088 - val\_acc: 0.9430

Epoch 12/15

50000/50000 [==============================] - 24s 481us/step - loss: 0.0089 - mean\_squared\_error: 0.0089 - acc: 0.9449 - val\_loss: 0.0084 - val\_mean\_squared\_error: 0.0084 - val\_acc: 0.9461

Epoch 13/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0085 - mean\_squared\_error: 0.0085 - acc: 0.9473 - val\_loss: 0.0082 - val\_mean\_squared\_error: 0.0082 - val\_acc: 0.9485

Epoch 14/15

50000/50000 [==============================] - 24s 486us/step - loss: 0.0081 - mean\_squared\_error: 0.0081 - acc: 0.9501 - val\_loss: 0.0078 - val\_mean\_squared\_error: 0.0078 - val\_acc: 0.9496

Epoch 15/15

50000/50000 [==============================] - 24s 490us/step - loss: 0.0078 - mean\_squared\_error: 0.0078 - acc: 0.9517 - val\_loss: 0.0075 - val\_mean\_squared\_error: 0.0075 - val\_acc: 0.9519

10000/10000 [==============================] - 1s 106us/step

The testing accuracy metric for lr 0.05 and batch\_size 32 is [0.007876876812247793, 0.007876876812247793, 0.9483]

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Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 24s 484us/step - loss: 0.0500 - mean\_squared\_error: 0.0500 - acc: 0.6698 - val\_loss: 0.0183 - val\_mean\_squared\_error: 0.0183 - val\_acc: 0.8947

Epoch 2/15

50000/50000 [==============================] - 24s 487us/step - loss: 0.0163 - mean\_squared\_error: 0.0163 - acc: 0.8992 - val\_loss: 0.0131 - val\_mean\_squared\_error: 0.0131 - val\_acc: 0.9166

Epoch 3/15

50000/50000 [==============================] - 25s 494us/step - loss: 0.0129 - mean\_squared\_error: 0.0129 - acc: 0.9187 - val\_loss: 0.0113 - val\_mean\_squared\_error: 0.0113 - val\_acc: 0.9268

Epoch 4/15

50000/50000 [==============================] - 24s 477us/step - loss: 0.0112 - mean\_squared\_error: 0.0112 - acc: 0.9288 - val\_loss: 0.0099 - val\_mean\_squared\_error: 0.0099 - val\_acc: 0.9360

Epoch 5/15

50000/50000 [==============================] - 24s 475us/step - loss: 0.0100 - mean\_squared\_error: 0.0100 - acc: 0.9369 - val\_loss: 0.0088 - val\_mean\_squared\_error: 0.0088 - val\_acc: 0.9444

Epoch 6/15

50000/50000 [==============================] - 24s 475us/step - loss: 0.0091 - mean\_squared\_error: 0.0091 - acc: 0.9433 - val\_loss: 0.0083 - val\_mean\_squared\_error: 0.0083 - val\_acc: 0.9475

Epoch 7/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0083 - mean\_squared\_error: 0.0083 - acc: 0.9477 - val\_loss: 0.0077 - val\_mean\_squared\_error: 0.0077 - val\_acc: 0.9514

Epoch 8/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0076 - mean\_squared\_error: 0.0076 - acc: 0.9526 - val\_loss: 0.0070 - val\_mean\_squared\_error: 0.0070 - val\_acc: 0.9551

Epoch 9/15

50000/50000 [==============================] - 24s 475us/step - loss: 0.0071 - mean\_squared\_error: 0.0071 - acc: 0.9567 - val\_loss: 0.0069 - val\_mean\_squared\_error: 0.0069 - val\_acc: 0.9568

Epoch 10/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0066 - mean\_squared\_error: 0.0066 - acc: 0.9601 - val\_loss: 0.0063 - val\_mean\_squared\_error: 0.0063 - val\_acc: 0.9592

Epoch 11/15

50000/50000 [==============================] - 24s 475us/step - loss: 0.0061 - mean\_squared\_error: 0.0061 - acc: 0.9624 - val\_loss: 0.0062 - val\_mean\_squared\_error: 0.0062 - val\_acc: 0.9617

Epoch 12/15

50000/50000 [==============================] - 24s 476us/step - loss: 0.0057 - mean\_squared\_error: 0.0057 - acc: 0.9657 - val\_loss: 0.0059 - val\_mean\_squared\_error: 0.0059 - val\_acc: 0.9635

Epoch 13/15

50000/50000 [==============================] - 24s 485us/step - loss: 0.0054 - mean\_squared\_error: 0.0054 - acc: 0.9676 - val\_loss: 0.0055 - val\_mean\_squared\_error: 0.0055 - val\_acc: 0.9652

Epoch 14/15

50000/50000 [==============================] - 24s 479us/step - loss: 0.0050 - mean\_squared\_error: 0.0050 - acc: 0.9704 - val\_loss: 0.0052 - val\_mean\_squared\_error: 0.0052 - val\_acc: 0.9666

Epoch 15/15

50000/50000 [==============================] - 24s 480us/step - loss: 0.0047 - mean\_squared\_error: 0.0047 - acc: 0.9728 - val\_loss: 0.0053 - val\_mean\_squared\_error: 0.0053 - val\_acc: 0.9668

10000/10000 [==============================] - 1s 106us/step

The testing accuracy metric for lr 0.1 and batch\_size 32 is [0.005621543229324743, 0.005621543229324743, 0.965]

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Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 11s 211us/step - loss: 0.0900 - mean\_squared\_error: 0.0900 - acc: 0.0987 - val\_loss: 0.0899 - val\_mean\_squared\_error: 0.0899 - val\_acc: 0.1063

Epoch 2/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1018 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1097

Epoch 3/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1055 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1133

Epoch 4/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1091 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1172

Epoch 5/15

50000/50000 [==============================] - 10s 205us/step - loss: 0.0897 - mean\_squared\_error: 0.0897 - acc: 0.1127 - val\_loss: 0.0896 - val\_mean\_squared\_error: 0.0896 - val\_acc: 0.1220

Epoch 6/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0897 - mean\_squared\_error: 0.0897 - acc: 0.1172 - val\_loss: 0.0895 - val\_mean\_squared\_error: 0.0895 - val\_acc: 0.1272

Epoch 7/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0896 - mean\_squared\_error: 0.0896 - acc: 0.1225 - val\_loss: 0.0895 - val\_mean\_squared\_error: 0.0895 - val\_acc: 0.1335

Epoch 8/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0895 - mean\_squared\_error: 0.0895 - acc: 0.1282 - val\_loss: 0.0894 - val\_mean\_squared\_error: 0.0894 - val\_acc: 0.1395

Epoch 9/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0894 - mean\_squared\_error: 0.0894 - acc: 0.1347 - val\_loss: 0.0893 - val\_mean\_squared\_error: 0.0893 - val\_acc: 0.1458

Epoch 10/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0894 - mean\_squared\_error: 0.0894 - acc: 0.1421 - val\_loss: 0.0892 - val\_mean\_squared\_error: 0.0892 - val\_acc: 0.1528

Epoch 11/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0893 - mean\_squared\_error: 0.0893 - acc: 0.1492 - val\_loss: 0.0892 - val\_mean\_squared\_error: 0.0892 - val\_acc: 0.1606

Epoch 12/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0892 - mean\_squared\_error: 0.0892 - acc: 0.1571 - val\_loss: 0.0891 - val\_mean\_squared\_error: 0.0891 - val\_acc: 0.1685

Epoch 13/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0891 - mean\_squared\_error: 0.0891 - acc: 0.1656 - val\_loss: 0.0890 - val\_mean\_squared\_error: 0.0890 - val\_acc: 0.1780

Epoch 14/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0891 - mean\_squared\_error: 0.0891 - acc: 0.1737 - val\_loss: 0.0889 - val\_mean\_squared\_error: 0.0889 - val\_acc: 0.1884

Epoch 15/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0890 - mean\_squared\_error: 0.0890 - acc: 0.1824 - val\_loss: 0.0889 - val\_mean\_squared\_error: 0.0889 - val\_acc: 0.1995

10000/10000 [==============================] - 1s 106us/step

The testing accuracy metric for lr 0.001 and batch\_size 128 is [0.08885503696203231, 0.08885503696203231, 0.1926]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 11s 212us/step - loss: 0.0897 - mean\_squared\_error: 0.0897 - acc: 0.1282 - val\_loss: 0.0894 - val\_mean\_squared\_error: 0.0894 - val\_acc: 0.1598

Epoch 2/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0891 - mean\_squared\_error: 0.0891 - acc: 0.1743 - val\_loss: 0.0887 - val\_mean\_squared\_error: 0.0887 - val\_acc: 0.2074

Epoch 3/15

50000/50000 [==============================] - 10s 202us/step - loss: 0.0884 - mean\_squared\_error: 0.0884 - acc: 0.2152 - val\_loss: 0.0880 - val\_mean\_squared\_error: 0.0880 - val\_acc: 0.2405

Epoch 4/15

50000/50000 [==============================] - 10s 202us/step - loss: 0.0877 - mean\_squared\_error: 0.0877 - acc: 0.2513 - val\_loss: 0.0872 - val\_mean\_squared\_error: 0.0872 - val\_acc: 0.2728

Epoch 5/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0868 - mean\_squared\_error: 0.0868 - acc: 0.2874 - val\_loss: 0.0862 - val\_mean\_squared\_error: 0.0862 - val\_acc: 0.3155

Epoch 6/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0858 - mean\_squared\_error: 0.0858 - acc: 0.3282 - val\_loss: 0.0851 - val\_mean\_squared\_error: 0.0851 - val\_acc: 0.3598

Epoch 7/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0846 - mean\_squared\_error: 0.0846 - acc: 0.3679 - val\_loss: 0.0838 - val\_mean\_squared\_error: 0.0838 - val\_acc: 0.4037

Epoch 8/15

50000/50000 [==============================] - 10s 205us/step - loss: 0.0832 - mean\_squared\_error: 0.0832 - acc: 0.4147 - val\_loss: 0.0823 - val\_mean\_squared\_error: 0.0823 - val\_acc: 0.4476

Epoch 9/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0816 - mean\_squared\_error: 0.0816 - acc: 0.4589 - val\_loss: 0.0805 - val\_mean\_squared\_error: 0.0805 - val\_acc: 0.4977

Epoch 10/15

50000/50000 [==============================] - 11s 210us/step - loss: 0.0799 - mean\_squared\_error: 0.0799 - acc: 0.5054 - val\_loss: 0.0786 - val\_mean\_squared\_error: 0.0786 - val\_acc: 0.5349

Epoch 11/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0778 - mean\_squared\_error: 0.0778 - acc: 0.5407 - val\_loss: 0.0764 - val\_mean\_squared\_error: 0.0764 - val\_acc: 0.5673

Epoch 12/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0756 - mean\_squared\_error: 0.0756 - acc: 0.5637 - val\_loss: 0.0739 - val\_mean\_squared\_error: 0.0739 - val\_acc: 0.5877

Epoch 13/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0730 - mean\_squared\_error: 0.0730 - acc: 0.5785 - val\_loss: 0.0710 - val\_mean\_squared\_error: 0.0710 - val\_acc: 0.5990

Epoch 14/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0700 - mean\_squared\_error: 0.0700 - acc: 0.5889 - val\_loss: 0.0677 - val\_mean\_squared\_error: 0.0677 - val\_acc: 0.6109

Epoch 15/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0667 - mean\_squared\_error: 0.0667 - acc: 0.6001 - val\_loss: 0.0641 - val\_mean\_squared\_error: 0.0641 - val\_acc: 0.6299

10000/10000 [==============================] - 1s 106us/step

The testing accuracy metric for lr 0.01 and batch\_size 128 is [0.0643465113043785, 0.0643465113043785, 0.6232]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 11s 210us/step - loss: 0.0881 - mean\_squared\_error: 0.0881 - acc: 0.2410 - val\_loss: 0.0856 - val\_mean\_squared\_error: 0.0856 - val\_acc: 0.4110

Epoch 2/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0818 - mean\_squared\_error: 0.0818 - acc: 0.4940 - val\_loss: 0.0761 - val\_mean\_squared\_error: 0.0761 - val\_acc: 0.5935

Epoch 3/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0685 - mean\_squared\_error: 0.0685 - acc: 0.6144 - val\_loss: 0.0579 - val\_mean\_squared\_error: 0.0579 - val\_acc: 0.6657

Epoch 4/15

50000/50000 [==============================] - 10s 204us/step - loss: 0.0499 - mean\_squared\_error: 0.0499 - acc: 0.7166 - val\_loss: 0.0397 - val\_mean\_squared\_error: 0.0397 - val\_acc: 0.8115

Epoch 5/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0356 - mean\_squared\_error: 0.0356 - acc: 0.8170 - val\_loss: 0.0284 - val\_mean\_squared\_error: 0.0284 - val\_acc: 0.8577

Epoch 6/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0275 - mean\_squared\_error: 0.0275 - acc: 0.8499 - val\_loss: 0.0227 - val\_mean\_squared\_error: 0.0227 - val\_acc: 0.8763

Epoch 7/15

50000/50000 [==============================] - 10s 204us/step - loss: 0.0231 - mean\_squared\_error: 0.0231 - acc: 0.8693 - val\_loss: 0.0195 - val\_mean\_squared\_error: 0.0195 - val\_acc: 0.8879

Epoch 8/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0204 - mean\_squared\_error: 0.0204 - acc: 0.8815 - val\_loss: 0.0175 - val\_mean\_squared\_error: 0.0175 - val\_acc: 0.8964

Epoch 9/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0187 - mean\_squared\_error: 0.0187 - acc: 0.8898 - val\_loss: 0.0162 - val\_mean\_squared\_error: 0.0162 - val\_acc: 0.9002

Epoch 10/15

50000/50000 [==============================] - 10s 204us/step - loss: 0.0174 - mean\_squared\_error: 0.0174 - acc: 0.8953 - val\_loss: 0.0152 - val\_mean\_squared\_error: 0.0152 - val\_acc: 0.9047

Epoch 11/15

50000/50000 [==============================] - 10s 205us/step - loss: 0.0164 - mean\_squared\_error: 0.0164 - acc: 0.8993 - val\_loss: 0.0144 - val\_mean\_squared\_error: 0.0144 - val\_acc: 0.9087

Epoch 12/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0157 - mean\_squared\_error: 0.0157 - acc: 0.9043 - val\_loss: 0.0139 - val\_mean\_squared\_error: 0.0139 - val\_acc: 0.9117

Epoch 13/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0150 - mean\_squared\_error: 0.0150 - acc: 0.9074 - val\_loss: 0.0134 - val\_mean\_squared\_error: 0.0134 - val\_acc: 0.9138

Epoch 14/15

50000/50000 [==============================] - 10s 203us/step - loss: 0.0145 - mean\_squared\_error: 0.0145 - acc: 0.9099 - val\_loss: 0.0130 - val\_mean\_squared\_error: 0.0130 - val\_acc: 0.9175

Epoch 15/15

50000/50000 [==============================] - 10s 204us/step - loss: 0.0140 - mean\_squared\_error: 0.0140 - acc: 0.9127 - val\_loss: 0.0126 - val\_mean\_squared\_error: 0.0126 - val\_acc: 0.9201

10000/10000 [==============================] - 1s 107us/step

The testing accuracy metric for lr 0.05 and batch\_size 128 is [0.012921269045351073, 0.012921269045351073, 0.9191]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 10s 209us/step - loss: 0.0852 - mean\_squared\_error: 0.0852 - acc: 0.3498 - val\_loss: 0.0768 - val\_mean\_squared\_error: 0.0768 - val\_acc: 0.5937

Epoch 2/15

50000/50000 [==============================] - 13s 251us/step - loss: 0.0602 - mean\_squared\_error: 0.0602 - acc: 0.6791 - val\_loss: 0.0411 - val\_mean\_squared\_error: 0.0411 - val\_acc: 0.7837

Epoch 3/15

50000/50000 [==============================] - 12s 243us/step - loss: 0.0332 - mean\_squared\_error: 0.0332 - acc: 0.8164 - val\_loss: 0.0237 - val\_mean\_squared\_error: 0.0237 - val\_acc: 0.8796

Epoch 4/15

50000/50000 [==============================] - 11s 227us/step - loss: 0.0223 - mean\_squared\_error: 0.0223 - acc: 0.8780 - val\_loss: 0.0177 - val\_mean\_squared\_error: 0.0177 - val\_acc: 0.8999

Epoch 5/15

50000/50000 [==============================] - 12s 236us/step - loss: 0.0182 - mean\_squared\_error: 0.0182 - acc: 0.8932 - val\_loss: 0.0153 - val\_mean\_squared\_error: 0.0153 - val\_acc: 0.9109

Epoch 6/15

50000/50000 [==============================] - 12s 234us/step - loss: 0.0162 - mean\_squared\_error: 0.0162 - acc: 0.9021 - val\_loss: 0.0139 - val\_mean\_squared\_error: 0.0139 - val\_acc: 0.9147

Epoch 7/15

50000/50000 [==============================] - 11s 226us/step - loss: 0.0149 - mean\_squared\_error: 0.0149 - acc: 0.9088 - val\_loss: 0.0132 - val\_mean\_squared\_error: 0.0132 - val\_acc: 0.9182

Epoch 8/15

50000/50000 [==============================] - 11s 229us/step - loss: 0.0140 - mean\_squared\_error: 0.0140 - acc: 0.9132 - val\_loss: 0.0123 - val\_mean\_squared\_error: 0.0123 - val\_acc: 0.9237

Epoch 9/15

50000/50000 [==============================] - 12s 241us/step - loss: 0.0133 - mean\_squared\_error: 0.0133 - acc: 0.9169 - val\_loss: 0.0118 - val\_mean\_squared\_error: 0.0118 - val\_acc: 0.9252

Epoch 10/15

50000/50000 [==============================] - 11s 230us/step - loss: 0.0127 - mean\_squared\_error: 0.0127 - acc: 0.9207 - val\_loss: 0.0114 - val\_mean\_squared\_error: 0.0114 - val\_acc: 0.9266

Epoch 11/15

50000/50000 [==============================] - 11s 230us/step - loss: 0.0122 - mean\_squared\_error: 0.0122 - acc: 0.9238 - val\_loss: 0.0109 - val\_mean\_squared\_error: 0.0109 - val\_acc: 0.9309

Epoch 12/15

50000/50000 [==============================] - 12s 234us/step - loss: 0.0117 - mean\_squared\_error: 0.0117 - acc: 0.9263 - val\_loss: 0.0109 - val\_mean\_squared\_error: 0.0109 - val\_acc: 0.9292

Epoch 13/15

50000/50000 [==============================] - 12s 240us/step - loss: 0.0114 - mean\_squared\_error: 0.0114 - acc: 0.9287 - val\_loss: 0.0103 - val\_mean\_squared\_error: 0.0103 - val\_acc: 0.9345

Epoch 14/15

50000/50000 [==============================] - 12s 237us/step - loss: 0.0110 - mean\_squared\_error: 0.0110 - acc: 0.9310 - val\_loss: 0.0100 - val\_mean\_squared\_error: 0.0100 - val\_acc: 0.9372

Epoch 15/15

50000/50000 [==============================] - 12s 232us/step - loss: 0.0106 - mean\_squared\_error: 0.0106 - acc: 0.9332 - val\_loss: 0.0098 - val\_mean\_squared\_error: 0.0098 - val\_acc: 0.9381

10000/10000 [==============================] - 1s 125us/step

The testing accuracy metric for lr 0.1 and batch\_size 128 is [0.010260066588164772, 0.010260066588164772, 0.9346]

---------------------------------------------------

Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 8s 151us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1106 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1146

Epoch 2/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1114 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1152

Epoch 3/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1121 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1159

Epoch 4/15

50000/50000 [==============================] - 7s 143us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1126 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1167

Epoch 5/15

50000/50000 [==============================] - 7s 143us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1132 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1170

Epoch 6/15

50000/50000 [==============================] - 7s 143us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1138 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1177

Epoch 7/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1144 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1188

Epoch 8/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1150 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1195

Epoch 9/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1155 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1201

Epoch 10/15

50000/50000 [==============================] - 7s 143us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1162 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1206

Epoch 11/15

50000/50000 [==============================] - 7s 146us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1167 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1219

Epoch 12/15

50000/50000 [==============================] - 7s 146us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1173 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1228

Epoch 13/15

50000/50000 [==============================] - 7s 146us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1180 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1235

Epoch 14/15

50000/50000 [==============================] - 7s 143us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1187 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1240

Epoch 15/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1193 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1247

10000/10000 [==============================] - 1s 127us/step

The testing accuracy metric for lr 0.001 and batch\_size 1024 is [0.08979297177791595, 0.08979297177791595, 0.1173]

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Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 8s 150us/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1632 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1732

Epoch 2/15

50000/50000 [==============================] - 7s 149us/step - loss: 0.0897 - mean\_squared\_error: 0.0897 - acc: 0.1724 - val\_loss: 0.0896 - val\_mean\_squared\_error: 0.0896 - val\_acc: 0.1831

Epoch 3/15

50000/50000 [==============================] - 7s 146us/step - loss: 0.0896 - mean\_squared\_error: 0.0896 - acc: 0.1806 - val\_loss: 0.0895 - val\_mean\_squared\_error: 0.0895 - val\_acc: 0.1908

Epoch 4/15

50000/50000 [==============================] - 8s 154us/step - loss: 0.0895 - mean\_squared\_error: 0.0895 - acc: 0.1902 - val\_loss: 0.0894 - val\_mean\_squared\_error: 0.0894 - val\_acc: 0.1997

Epoch 5/15

50000/50000 [==============================] - 7s 146us/step - loss: 0.0894 - mean\_squared\_error: 0.0894 - acc: 0.1987 - val\_loss: 0.0894 - val\_mean\_squared\_error: 0.0894 - val\_acc: 0.2092

Epoch 6/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0893 - mean\_squared\_error: 0.0893 - acc: 0.2078 - val\_loss: 0.0893 - val\_mean\_squared\_error: 0.0893 - val\_acc: 0.2168

Epoch 7/15

50000/50000 [==============================] - 7s 144us/step - loss: 0.0892 - mean\_squared\_error: 0.0892 - acc: 0.2156 - val\_loss: 0.0892 - val\_mean\_squared\_error: 0.0892 - val\_acc: 0.2249

Epoch 8/15

50000/50000 [==============================] - 7s 145us/step - loss: 0.0891 - mean\_squared\_error: 0.0891 - acc: 0.2237 - val\_loss: 0.0891 - val\_mean\_squared\_error: 0.0891 - val\_acc: 0.2342

Epoch 9/15

50000/50000 [==============================] - 13s 255us/step - loss: 0.0890 - mean\_squared\_error: 0.0890 - acc: 0.2320 - val\_loss: 0.0890 - val\_mean\_squared\_error: 0.0890 - val\_acc: 0.2426

Epoch 10/15

50000/50000 [==============================] - 11s 215us/step - loss: 0.0889 - mean\_squared\_error: 0.0889 - acc: 0.2399 - val\_loss: 0.0889 - val\_mean\_squared\_error: 0.0889 - val\_acc: 0.2518

Epoch 11/15

50000/50000 [==============================] - 9s 185us/step - loss: 0.0888 - mean\_squared\_error: 0.0888 - acc: 0.2480 - val\_loss: 0.0888 - val\_mean\_squared\_error: 0.0888 - val\_acc: 0.2605

Epoch 12/15

50000/50000 [==============================] - 9s 171us/step - loss: 0.0887 - mean\_squared\_error: 0.0887 - acc: 0.2564 - val\_loss: 0.0887 - val\_mean\_squared\_error: 0.0887 - val\_acc: 0.2693

Epoch 13/15

50000/50000 [==============================] - 8s 167us/step - loss: 0.0887 - mean\_squared\_error: 0.0887 - acc: 0.2647 - val\_loss: 0.0886 - val\_mean\_squared\_error: 0.0886 - val\_acc: 0.2772

Epoch 14/15

50000/50000 [==============================] - 8s 163us/step - loss: 0.0886 - mean\_squared\_error: 0.0886 - acc: 0.2723 - val\_loss: 0.0885 - val\_mean\_squared\_error: 0.0885 - val\_acc: 0.2855

Epoch 15/15

50000/50000 [==============================] - 8s 165us/step - loss: 0.0885 - mean\_squared\_error: 0.0885 - acc: 0.2810 - val\_loss: 0.0884 - val\_mean\_squared\_error: 0.0884 - val\_acc: 0.2955

10000/10000 [==============================] - 2s 186us/step

The testing accuracy metric for lr 0.01 and batch\_size 1024 is [0.08831514716148377, 0.08831514716148377, 0.2969]

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Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 10s 194us/step - loss: 0.0903 - mean\_squared\_error: 0.0903 - acc: 0.0879 - val\_loss: 0.0901 - val\_mean\_squared\_error: 0.0901 - val\_acc: 0.0996

Epoch 2/15

50000/50000 [==============================] - 9s 178us/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1029 - val\_loss: 0.0897 - val\_mean\_squared\_error: 0.0897 - val\_acc: 0.1152

Epoch 3/15

50000/50000 [==============================] - 8s 154us/step - loss: 0.0895 - mean\_squared\_error: 0.0895 - acc: 0.1242 - val\_loss: 0.0893 - val\_mean\_squared\_error: 0.0893 - val\_acc: 0.1424

Epoch 4/15

50000/50000 [==============================] - 8s 154us/step - loss: 0.0892 - mean\_squared\_error: 0.0892 - acc: 0.1592 - val\_loss: 0.0889 - val\_mean\_squared\_error: 0.0889 - val\_acc: 0.1886

Epoch 5/15

50000/50000 [==============================] - 8s 153us/step - loss: 0.0888 - mean\_squared\_error: 0.0888 - acc: 0.2151 - val\_loss: 0.0885 - val\_mean\_squared\_error: 0.0885 - val\_acc: 0.2570

Epoch 6/15

50000/50000 [==============================] - 8s 158us/step - loss: 0.0883 - mean\_squared\_error: 0.0883 - acc: 0.2817 - val\_loss: 0.0881 - val\_mean\_squared\_error: 0.0881 - val\_acc: 0.3245

Epoch 7/15

50000/50000 [==============================] - 8s 158us/step - loss: 0.0879 - mean\_squared\_error: 0.0879 - acc: 0.3444 - val\_loss: 0.0876 - val\_mean\_squared\_error: 0.0876 - val\_acc: 0.3884

Epoch 8/15

50000/50000 [==============================] - 8s 156us/step - loss: 0.0874 - mean\_squared\_error: 0.0874 - acc: 0.4012 - val\_loss: 0.0871 - val\_mean\_squared\_error: 0.0871 - val\_acc: 0.4360

Epoch 9/15

50000/50000 [==============================] - 8s 156us/step - loss: 0.0869 - mean\_squared\_error: 0.0869 - acc: 0.4424 - val\_loss: 0.0866 - val\_mean\_squared\_error: 0.0866 - val\_acc: 0.4678

Epoch 10/15

50000/50000 [==============================] - 8s 153us/step - loss: 0.0864 - mean\_squared\_error: 0.0864 - acc: 0.4715 - val\_loss: 0.0860 - val\_mean\_squared\_error: 0.0860 - val\_acc: 0.4892

Epoch 11/15

50000/50000 [==============================] - 8s 152us/step - loss: 0.0858 - mean\_squared\_error: 0.0858 - acc: 0.4885 - val\_loss: 0.0853 - val\_mean\_squared\_error: 0.0853 - val\_acc: 0.4984

Epoch 12/15

50000/50000 [==============================] - 8s 152us/step - loss: 0.0851 - mean\_squared\_error: 0.0851 - acc: 0.4972 - val\_loss: 0.0846 - val\_mean\_squared\_error: 0.0846 - val\_acc: 0.5067

Epoch 13/15

50000/50000 [==============================] - 8s 153us/step - loss: 0.0843 - mean\_squared\_error: 0.0843 - acc: 0.5006 - val\_loss: 0.0838 - val\_mean\_squared\_error: 0.0838 - val\_acc: 0.5110

Epoch 14/15

50000/50000 [==============================] - 8s 156us/step - loss: 0.0835 - mean\_squared\_error: 0.0835 - acc: 0.5022 - val\_loss: 0.0829 - val\_mean\_squared\_error: 0.0829 - val\_acc: 0.5123

Epoch 15/15

50000/50000 [==============================] - 8s 152us/step - loss: 0.0825 - mean\_squared\_error: 0.0825 - acc: 0.5045 - val\_loss: 0.0819 - val\_mean\_squared\_error: 0.0819 - val\_acc: 0.5178

10000/10000 [==============================] - 1s 139us/step

The testing accuracy metric for lr 0.05 and batch\_size 1024 is [0.08174470328092576, 0.08174470328092576, 0.5156]

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Train on 50000 samples, validate on 10000 samples

Epoch 1/15

50000/50000 [==============================] - 9s 173us/step - loss: 0.0901 - mean\_squared\_error: 0.0901 - acc: 0.1694 - val\_loss: 0.0896 - val\_mean\_squared\_error: 0.0896 - val\_acc: 0.2259

Epoch 2/15

50000/50000 [==============================] - 8s 154us/step - loss: 0.0890 - mean\_squared\_error: 0.0890 - acc: 0.2750 - val\_loss: 0.0884 - val\_mean\_squared\_error: 0.0884 - val\_acc: 0.3033

Epoch 3/15

50000/50000 [==============================] - 8s 151us/step - loss: 0.0878 - mean\_squared\_error: 0.0878 - acc: 0.3278 - val\_loss: 0.0871 - val\_mean\_squared\_error: 0.0871 - val\_acc: 0.3376

Epoch 4/15

50000/50000 [==============================] - 8s 152us/step - loss: 0.0864 - mean\_squared\_error: 0.0864 - acc: 0.3527 - val\_loss: 0.0856 - val\_mean\_squared\_error: 0.0856 - val\_acc: 0.3629

Epoch 5/15

50000/50000 [==============================] - 8s 156us/step - loss: 0.0847 - mean\_squared\_error: 0.0847 - acc: 0.3729 - val\_loss: 0.0837 - val\_mean\_squared\_error: 0.0837 - val\_acc: 0.3847

Epoch 6/15

50000/50000 [==============================] - 8s 151us/step - loss: 0.0827 - mean\_squared\_error: 0.0827 - acc: 0.3936 - val\_loss: 0.0814 - val\_mean\_squared\_error: 0.0814 - val\_acc: 0.4100

Epoch 7/15

50000/50000 [==============================] - 8s 152us/step - loss: 0.0802 - mean\_squared\_error: 0.0802 - acc: 0.4217 - val\_loss: 0.0787 - val\_mean\_squared\_error: 0.0787 - val\_acc: 0.4493

Epoch 8/15

50000/50000 [==============================] - 8s 151us/step - loss: 0.0773 - mean\_squared\_error: 0.0773 - acc: 0.4621 - val\_loss: 0.0754 - val\_mean\_squared\_error: 0.0754 - val\_acc: 0.5049

Epoch 9/15

50000/50000 [==============================] - 8s 157us/step - loss: 0.0739 - mean\_squared\_error: 0.0739 - acc: 0.5182 - val\_loss: 0.0717 - val\_mean\_squared\_error: 0.0717 - val\_acc: 0.5642

Epoch 10/15

50000/50000 [==============================] - 8s 153us/step - loss: 0.0700 - mean\_squared\_error: 0.0700 - acc: 0.5732 - val\_loss: 0.0676 - val\_mean\_squared\_error: 0.0676 - val\_acc: 0.6129

Epoch 11/15

50000/50000 [==============================] - 8s 159us/step - loss: 0.0659 - mean\_squared\_error: 0.0659 - acc: 0.6195 - val\_loss: 0.0631 - val\_mean\_squared\_error: 0.0631 - val\_acc: 0.6608

Epoch 12/15

50000/50000 [==============================] - 8s 155us/step - loss: 0.0615 - mean\_squared\_error: 0.0615 - acc: 0.6655 - val\_loss: 0.0583 - val\_mean\_squared\_error: 0.0583 - val\_acc: 0.7016

Epoch 13/15

50000/50000 [==============================] - 8s 152us/step - loss: 0.0569 - mean\_squared\_error: 0.0569 - acc: 0.7002 - val\_loss: 0.0535 - val\_mean\_squared\_error: 0.0535 - val\_acc: 0.7369

Epoch 14/15

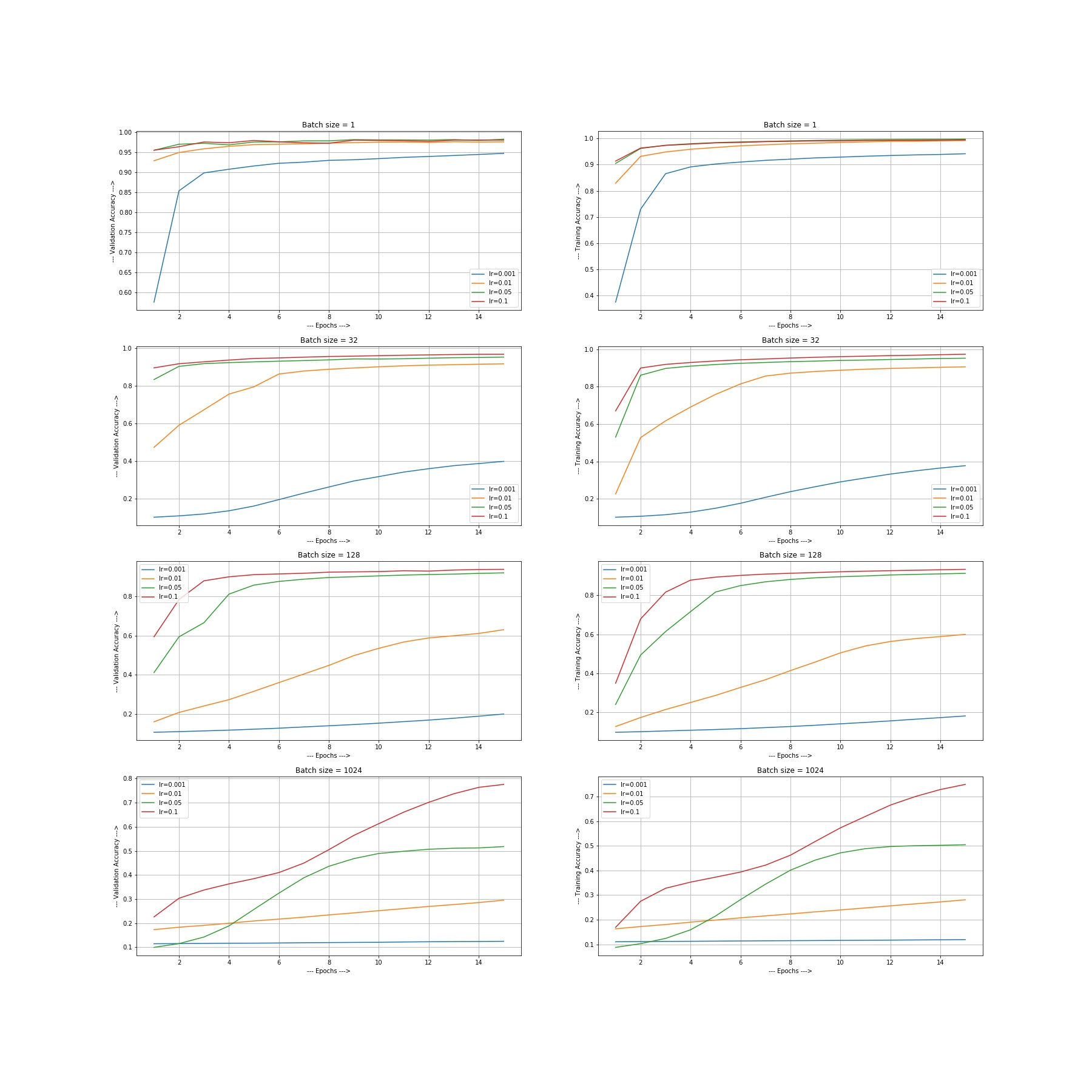
50000/50000 [==============================] - 8s 152us/step - loss: 0.0523 - mean\_squared\_error: 0.0523 - acc: 0.7287 - val\_loss: 0.0488 - val\_mean\_squared\_error: 0.0488 - val\_acc: 0.7636

Epoch 15/15

50000/50000 [==============================] - 8s 156us/step - loss: 0.0480 - mean\_squared\_error: 0.0480 - acc: 0.7494 - val\_loss: 0.0446 - val\_mean\_squared\_error: 0.0446 - val\_acc: 0.7758

10000/10000 [==============================] - 1s 139us/step

The testing accuracy metric for lr 0.1 and batch\_size 1024 is [0.04482823349833488, 0.04482823349833488, 0.7679]



**OBSERVATIONS:**

We see that more time we give to the model to train, better is the Accuracy. Specific Observation is as below:

1. **Batch Size Vs Accuracy**: More batch size means less iterations in one epoch. We observed that as we decrease the batch size, the accuracy increases and stabilizes around 98%. Both validation and training accuracy increased indicating that the model didn’t overfit. As we can see from above data, testing accuracy also increased. We can also see that when the batch size was 1, the training accuracy is almost 100% and validation accuracy and testing accuracy is 97%. Here we can conclude that the model was on the way of overfitting.
2. **Epoch Vs Accuracy**: We can see that as the no of epochs increased, the accuracy for both training and validation has increased and has come to saturation after some epochs. To save computational effort, we should regulate this growth and stop the training when the difference between the accuracy of last two epoch isn’t significant enough.
3. **Learning Rate vs Accuracy**:
4. N=0.01: When the learning rate was this small, it took time to gain significant accuracy. That’s why we see that training and validation accuracy is bit low in this case as compared to others. Its not saturated till 15 epochs.
5. N= 0.1: Being the greatest among all other, the model learned very quickly. We can also see that at batch size 32, the validation accuracy reached around 85% after one epoch only, while the one with learning rate 0.01 is at 60% and the one with 0.001 is around 20%.