model_training

May 1, 2019

1 Follow-Me Project

Congratulations on reaching the final project of the Robotics Nanodegree!

Previously, you worked on the Semantic Segmentation lab where you built a deep learning network that locates a particular human target within an image. For this project, you will utilize what you implemented and learned from that lab and extend it to train a deep learning model that will allow a simulated quadcopter to follow around the person that it detects!

Most of the code below is similar to the lab with some minor modifications. You can start with your existing solution, and modify and improve upon it to train the best possible model for this task.

You can click on any of the following to quickly jump to that part of this notebook: 1. Section **??** 2. Section **??** 3. Section **??** 4. Section 1.4 5. Section 1.5 6. Section 1.6

1.1 Data Collection

We have provided you with a starting dataset for this project. Download instructions can be found in the README for this project's repo. Alternatively, you can collect additional data of your own to improve your model. Check out the "Collecting Data" section in the Project Lesson in the Classroom for more details!

In [36]:
```
import os
import glob
import sys
import tensorflow as tf

from scipy import misc
import numpy as np

from tensorflow.contrib.keras.python import keras
from tensorflow.contrib.keras.python.keras import layers, models

from tensorflow import image

from utils import scoring_utils
from utils.separable_conv2d import SeparableConv2DKeras, BilinearUpSampling2D
from utils import data_iterator
from utils import plotting_tools
from utils import model_tools
```

1.2 FCN Layers

In the Classroom, we discussed the different layers that constitute a fully convolutional network (FCN). The following code will introduce you to the functions that you need to build your semantic segmentation model.

1.2.1 Separable Convolutions

The Encoder for your FCN will essentially require separable convolution layers, due to their advantages as explained in the classroom. The 1x1 convolution layer in the FCN, however, is a regular convolution. Implementations for both are provided below for your use. Each includes batch normalization with the ReLU activation function applied to the layers.

```
In [2]: def separable_conv2d_batchnorm(input_layer, filters, strides=1):
            output_layer = SeparableConv2DKeras(filters=filters,kernel_size=3, strides=strides,
                                        padding='same', activation='relu')(input_layer)

            output_layer = layers.BatchNormalization()(output_layer)
            return output_layer

        def conv2d_batchnorm(input_layer, filters, kernel_size=3, strides=1):
            output_layer = layers.Conv2D(filters=filters, kernel_size=kernel_size, strides=strid
                               padding='same', activation='relu')(input_layer)

            output_layer = layers.BatchNormalization()(output_layer)
            return output_layer
```

1.2.2 Bilinear Upsampling

The following helper function implements the bilinear upsampling layer. Upsampling by a factor of 2 is generally recommended, but you can try out different factors as well. Upsampling is used in the decoder block of the FCN.

```
In [3]: def bilinear_upsample(input_layer):
            output_layer = BilinearUpSampling2D((2,2))(input_layer)
            return output_layer
```

1.3 Build the Model

In the following cells, you will build an FCN to train a model to detect and locate the hero target within an image. The steps are: - Create an `encoder_block` - Create a `decoder_block` - Build the FCN consisting of encoder block(s), a 1x1 convolution, and decoder block(s). This step requires experimentation with different numbers of layers and filter sizes to build your model.

1.3.1 Encoder Block

Create an encoder block that includes a separable convolution layer using the `separable_conv2d_batchnorm()` function. The `filters` parameter defines the size or depth of the output layer. For example, 32 or 64.

```
In [115]: def encoder_block(input_layer, filters, strides=1):

              # TODO Create a separable convolution layer using the separable_conv2d_batchnorm()
              output_layer = separable_conv2d_batchnorm(input_layer, filters=filters, strides=st
              return output_layer

          image_hw = 160
          image_shape = (image_hw, image_hw, 3)
          inputs = layers.Input(image_shape)
          print(inputs.get_shape())
          test_out_layer = encoder_block(inputs,32,)
          print(test_out_layer.get_shape())
```

```
(?, 160, 160, 3)
(?, 23, 23, 32)
```

1.3.2 Decoder Block

The decoder block is comprised of three parts: - A bilinear upsampling layer using the upsample_bilinear() function. The current recommended factor for upsampling is set to 2. - A layer concatenation step. This step is similar to skip connections. You will concatenate the upsampled small_ip_layer and the large_ip_layer. - Some (one or two) additional separable convolution layers to extract some more spatial information from prior layers.

```
In [5]: def decoder_block(small_ip_layer, large_ip_layer, filters):

            # TODO Upsample the small input layer using the bilinear_upsample() function.
            Upsampled_small_ip_layer = bilinear_upsample(small_ip_layer)
            # TODO Concatenate the upsampled and large input layers using layers.concatenate
            concatenated_layers = layers.concatenate([Upsampled_small_ip_layer,large_ip_layer])
            # TODO Add some number of separable convolution layers
            output_layer = encoder_block(concatenated_layers,filters=filters, strides=1)
            return output_layer
```

1.3.3 Model

Now that you have the encoder and decoder blocks ready, go ahead and build your FCN architecture!

There are three steps: - Add encoder blocks to build the encoder layers. This is similar to how you added regular convolutional layers in your CNN lab. - Add a 1x1 Convolution layer using the conv2d_batchnorm() function. Remember that 1x1 Convolutions require a kernel and stride of 1. - Add decoder blocks for the decoder layers.

```
In [92]: def fcn_model(inputs, num_classes):

             # TODO Add Encoder Blocks.
             # Remember that with each encoder layer, the depth of your model (the number of fil
             print(inputs.get_shape())
```

```
    #Layer 1
    layer_1 = encoder_block(inputs, filters=32, strides=3)
    print(layer_1.get_shape())
    #Layer 2
    layer_2 = encoder_block(layer_1, filters=64, strides=2)
    print(layer_2.get_shape())
    layer_3 = encoder_block(layer_2, filters=128, strides=2)
    print(layer_3.get_shape())
    layer_4 = encoder_block(layer_3, filters=256, strides=2)
    print(layer_4.get_shape())
    # TODO Add 1x1 Convolution layer using conv2d_batchnorm().
    layer_1x1 = conv2d_batchnorm(layer_4, filters=1024, kernel_size=1, strides=1)
    print(layer_1x1.get_shape())
    # TODO: Add the same number of Decoder Blocks as the number of Encoder Blocks
    decoder_1 = decoder_block(layer_1x1, layer_3, filters=128)
    print(decoder_1.get_shape())
    decoder_2 = decoder_block(decoder_1, layer_2, filters=64)
    print(decoder_2.get_shape())
    decoder_3 = decoder_block(decoder_2, layer_1, filters=32)
    print(decoder_3.get_shape())
    x         = decoder_block(decoder_3, inputs, filters=num_classes)
    print(x.get_shape())
    # The function returns the output layer of your model. "x" is the final layer obtai
    return layers.Conv2D(num_classes, 3, activation='softmax', padding='same')(x)
```

1.4 Training

The following cells will use the FCN you created and define an ouput layer based on the size of the processed image and the number of classes recognized. You will define the hyperparameters to compile and train your model.

Please Note: For this project, the helper code in `data_iterator.py` will resize the copter images to 160x160x3 to speed up training.

In [116]:
```
"""
DON'T MODIFY ANYTHING IN THIS CELL THAT IS BELOW THIS LINE
"""

image_hw = 160
image_shape = (image_hw, image_hw, 3)
inputs = layers.Input(image_shape)
num_classes = 3

# Call fcn_model()
output_layer = fcn_model(inputs, num_classes)
#print(output_layer.get_shape())
```

```
(?, 160, 160, 3)
(?, 80, 80, 32)
```

```
(?, 40, 40, 64)
(?, 20, 20, 128)
(?, 10, 10, 256)
(?, 10, 10, 1024)
(?, 20, 20, 128)
(?, 40, 40, 64)
(?, 80, 80, 32)
(?, 160, 160, 3)
```

1.4.1 Hyperparameters

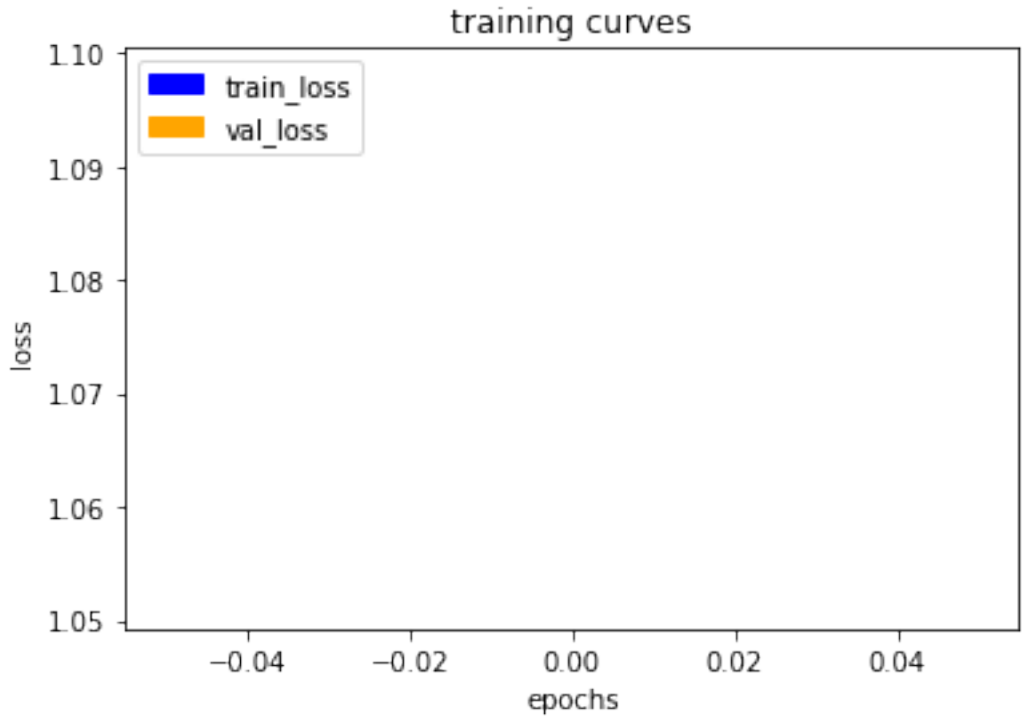
Define and tune your hyperparameters. - **batch_size**: number of training samples/images that get propagated through the network in a single pass. - **num_epochs**: number of times the entire training dataset gets propagated through the network. - **steps_per_epoch**: number of batches of training images that go through the network in 1 epoch. We have provided you with a default value. One recommended value to try would be based on the total number of images in training dataset divided by the batch_size. - **validation_steps**: number of batches of validation images that go through the network in 1 epoch. This is similar to steps_per_epoch, except validation_steps is for the validation dataset. We have provided you with a default value for this as well. - **workers**: maximum number of processes to spin up. This can affect your training speed and is dependent on your hardware. We have provided a recommended value to work with.

In [117]:
```
learning_rate = 0.001
batch_size = 50
num_epochs = 200
steps_per_epoch = 30
validation_steps = 50
workers = 2
```

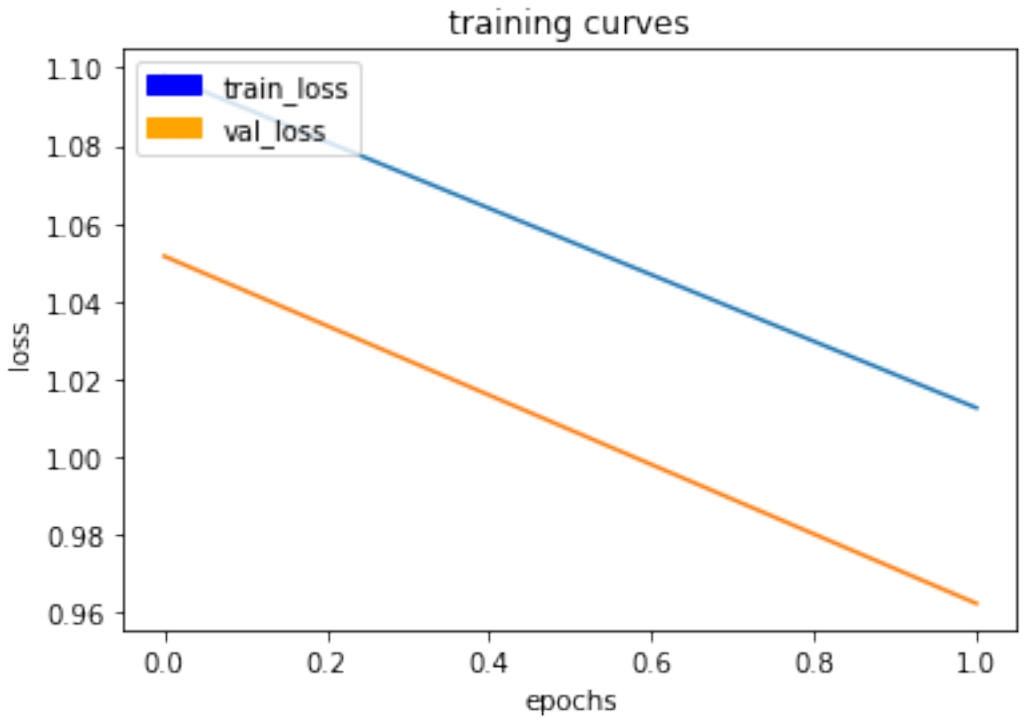
In [118]:
```
"""
DON'T MODIFY ANYTHING IN THIS CELL THAT IS BELOW THIS LINE
"""
# Define the Keras model and compile it for training
model = models.Model(inputs=inputs, outputs=output_layer)

model.compile(optimizer=keras.optimizers.Adam(learning_rate), loss='categorical_crosse

# Data iterators for loading the training and validation data
train_iter = data_iterator.BatchIteratorSimple(batch_size=batch_size,
                                               data_folder=os.path.join('..', 'data',
                                               image_shape=image_shape,
                                               shift_aug=True)

val_iter = data_iterator.BatchIteratorSimple(batch_size=batch_size,
                                             data_folder=os.path.join('..', 'data', 'v
                                             image_shape=image_shape)
```

```
        logger_cb = plotting_tools.LoggerPlotter()
        callbacks = [logger_cb]

        model.fit_generator(train_iter,
                            steps_per_epoch = steps_per_epoch, # the number of batches per epo
                            epochs = num_epochs, # the number of epochs to train for,
                            validation_data = val_iter, # validation iterator
                            validation_steps = validation_steps, # the number of batches to va
                            callbacks=callbacks,
                            workers = workers)
```

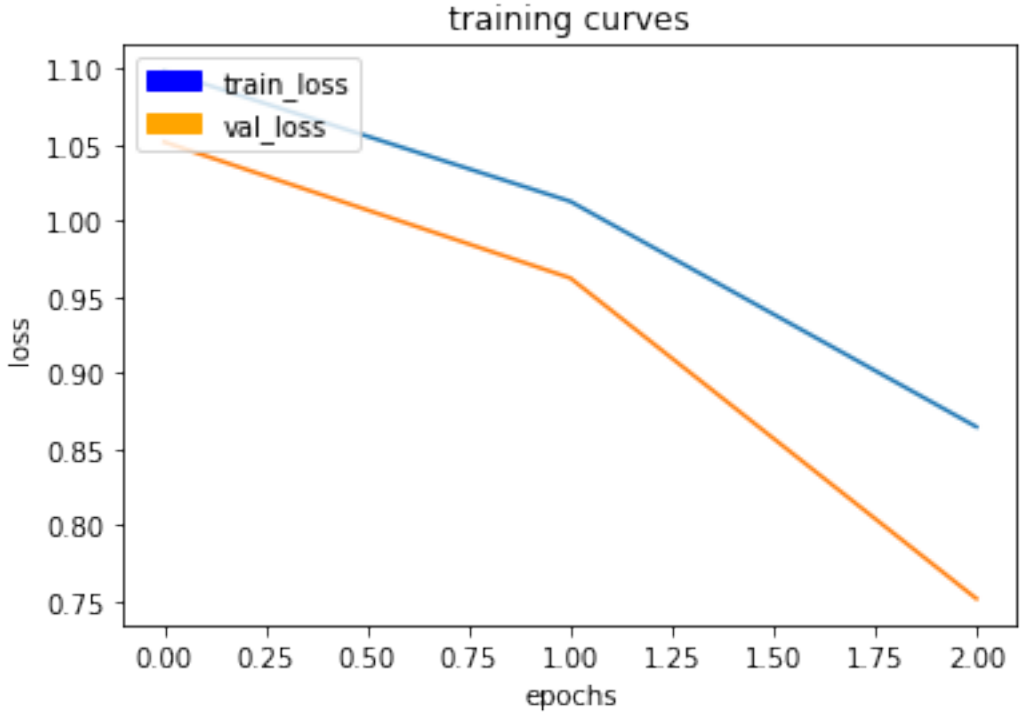
```
Epoch 1/200
29/30 [============================>.] - ETA: 0s - loss: 1.0997
```



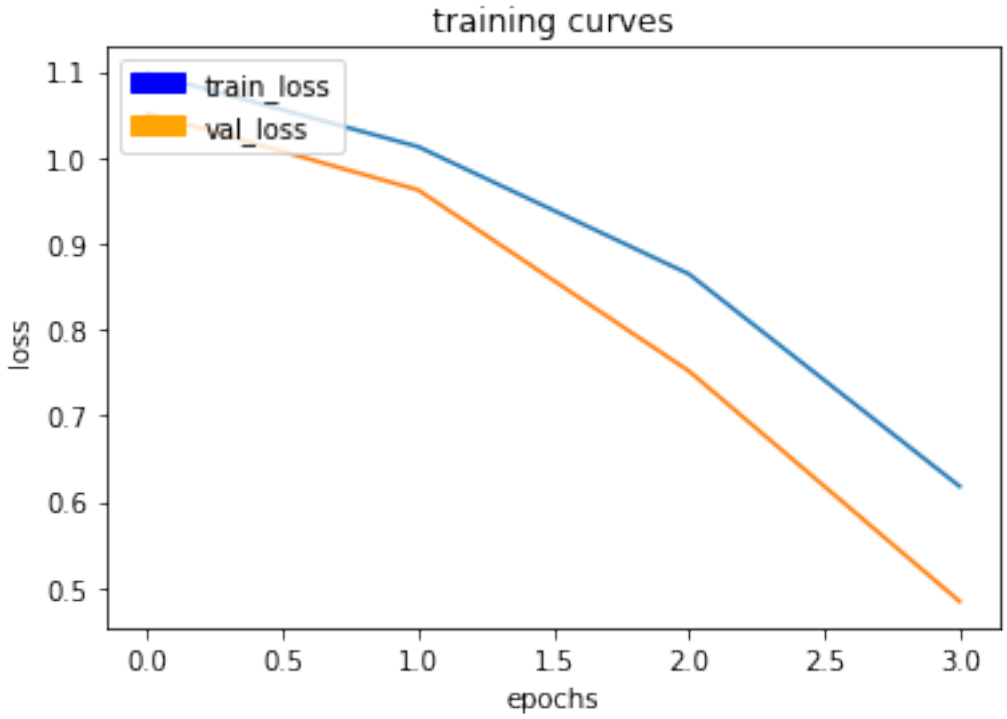

```
30/30 [==============================] - 26s - loss: 1.0981 - val_loss: 1.0516
Epoch 2/200
29/30 [============================>.] - ETA: 0s - loss: 1.0143
```



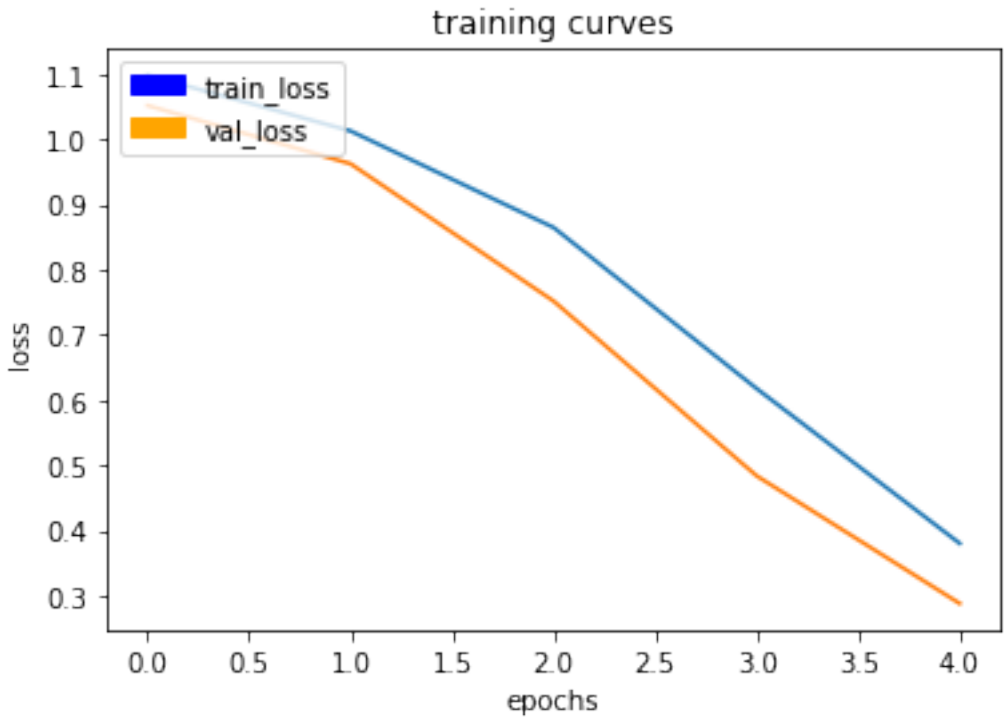

```
30/30 [==============================] - 23s - loss: 1.0126 - val_loss: 0.9622
Epoch 3/200
29/30 [============================>.] - ETA: 0s - loss: 0.8678
```



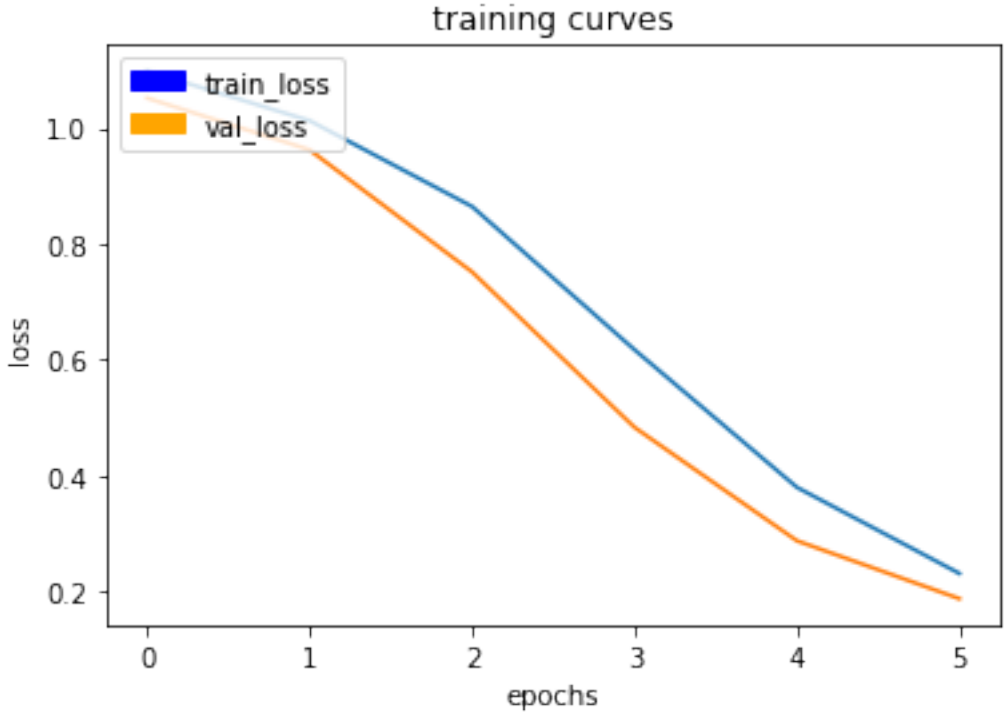
```
30/30 [==============================] - 23s - loss: 0.8638 - val_loss: 0.7517
Epoch 4/200
29/30 [============================>.] - ETA: 0s - loss: 0.6220
```



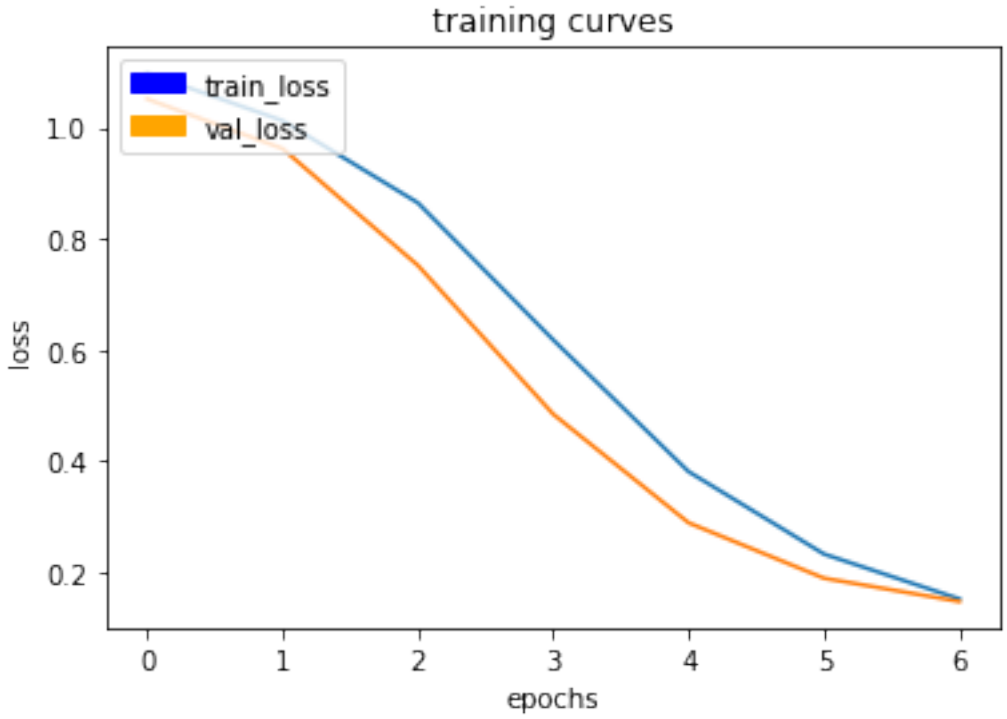

```
30/30 [==============================] - 23s - loss: 0.6175 - val_loss: 0.4837
Epoch 5/200
29/30 [============================>.] - ETA: 0s - loss: 0.3834
```



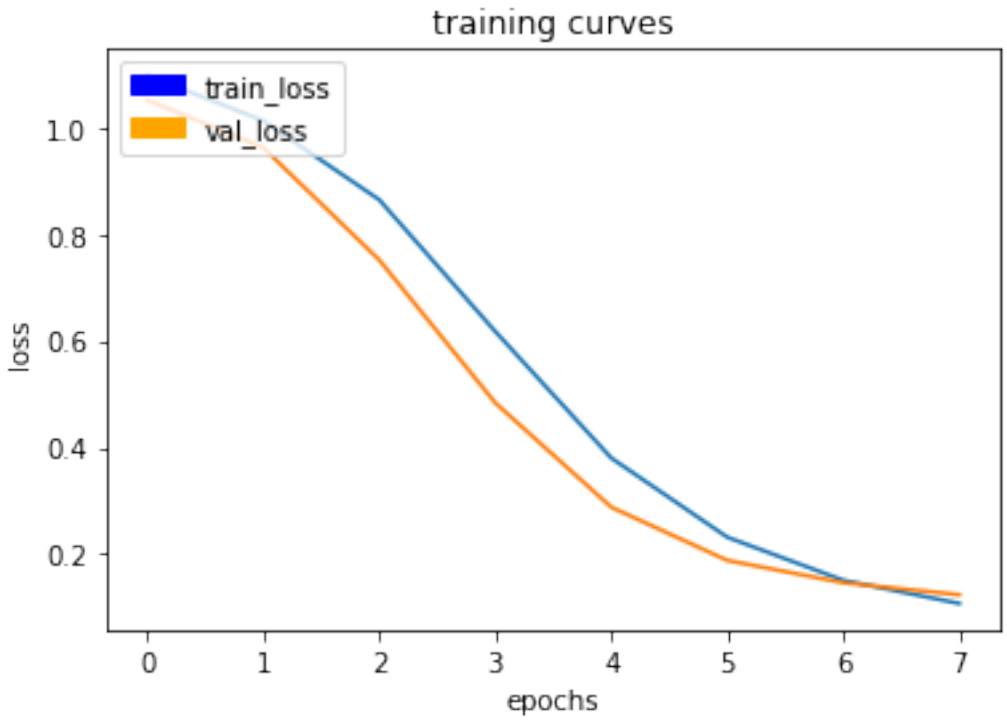

```
30/30 [==============================] - 24s - loss: 0.3802 - val_loss: 0.2880
Epoch 6/200
29/30 [============================>.] - ETA: 0s - loss: 0.2332
```



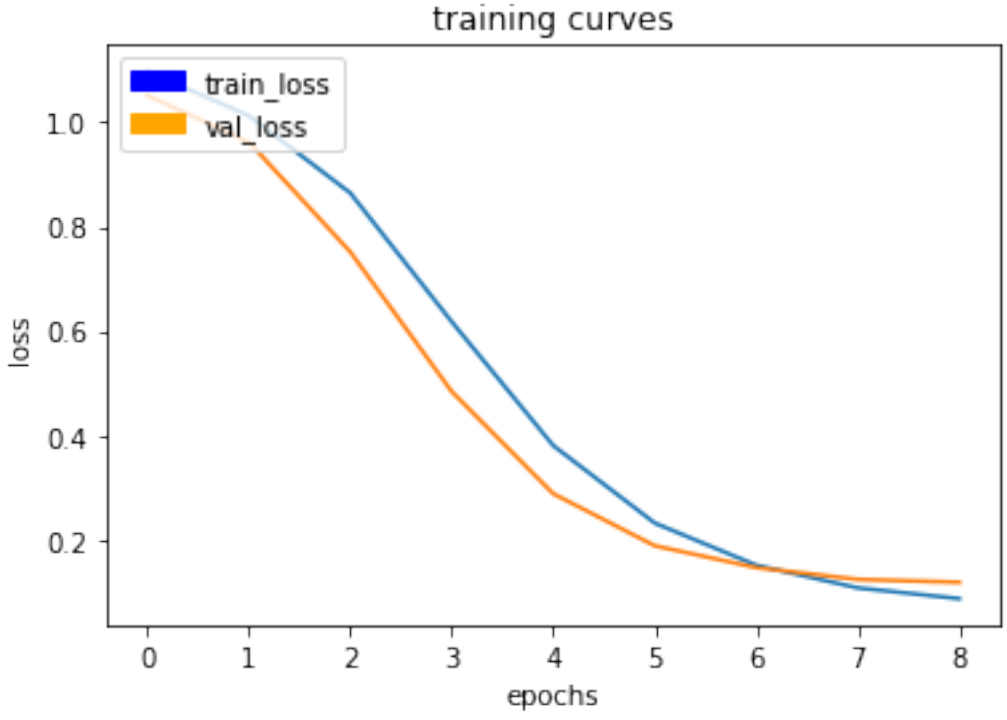
```
30/30 [==============================] - 23s - loss: 0.2316 - val_loss: 0.1882
Epoch 7/200
29/30 [============================>.] - ETA: 0s - loss: 0.1520
```



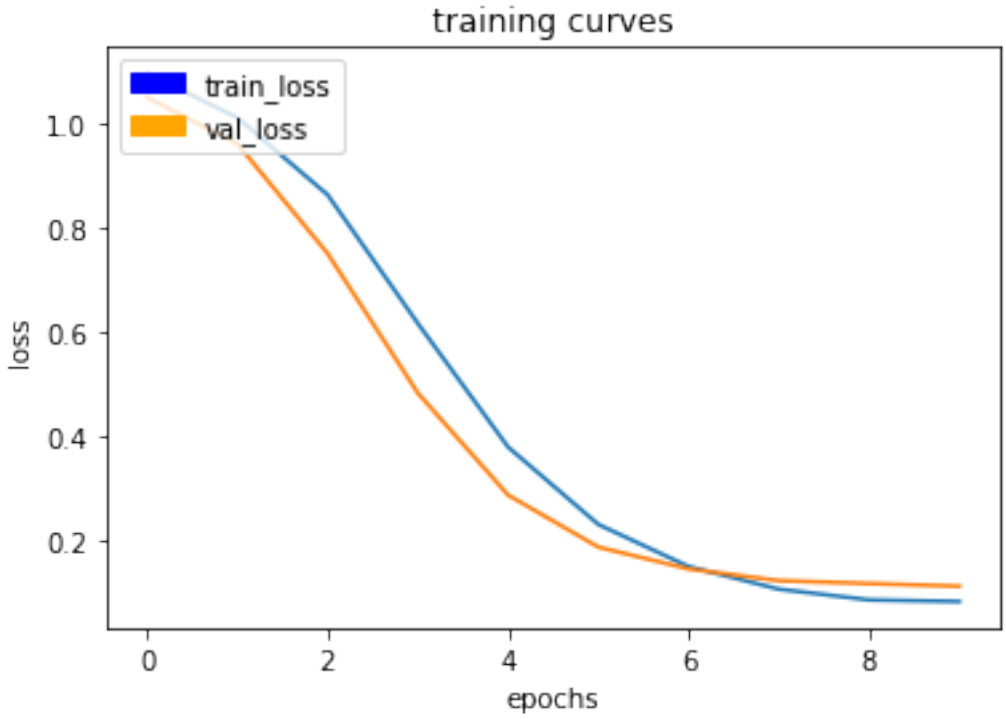

```
30/30 [==============================] - 24s - loss: 0.1509 - val_loss: 0.1463
Epoch 8/200
29/30 [============================>.] - ETA: 0s - loss: 0.1078
```



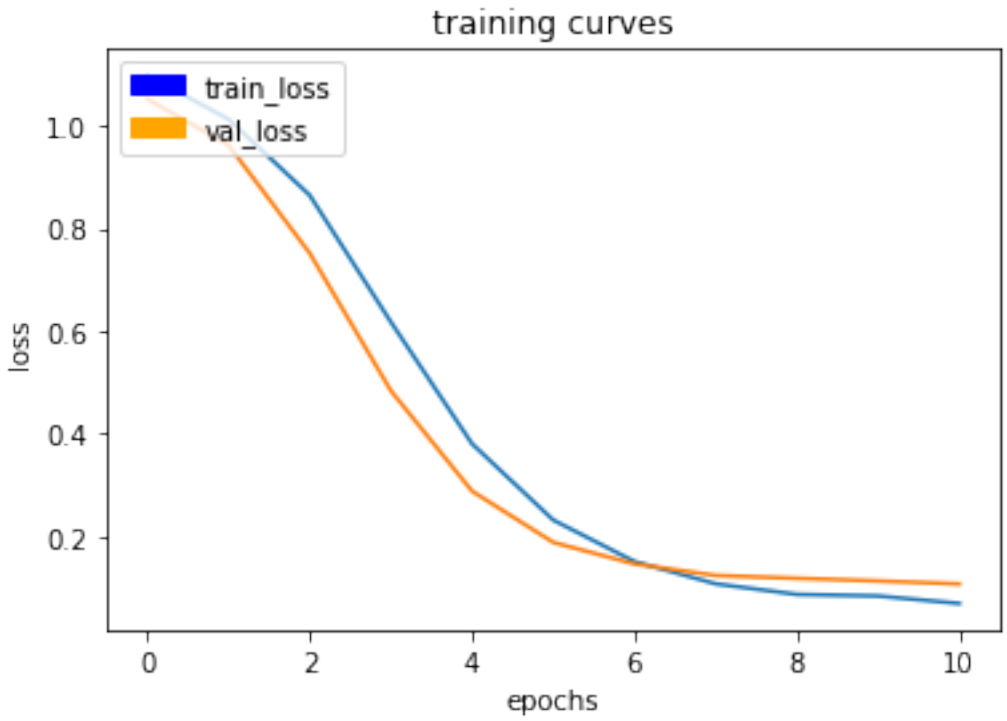

```
30/30 [==============================] - 23s - loss: 0.1075 - val_loss: 0.1238
Epoch 9/200
29/30 [============================>.] - ETA: 0s - loss: 0.0865
```



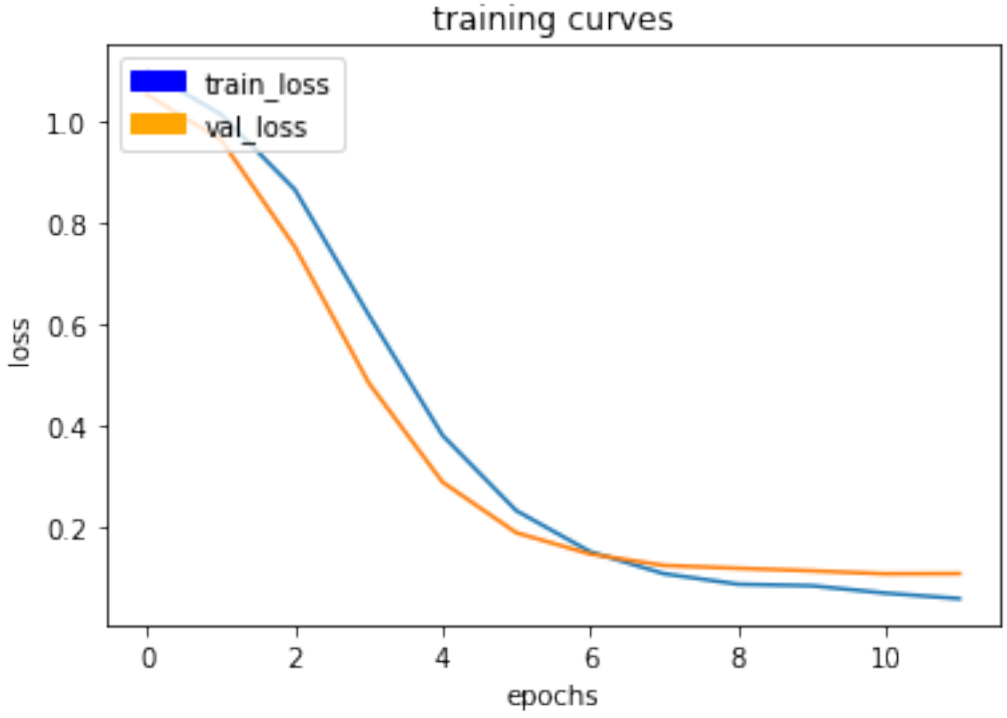
```
30/30 [==============================] - 23s - loss: 0.0868 - val_loss: 0.1183
Epoch 10/200
29/30 [============================>.] - ETA: 0s - loss: 0.0844
```



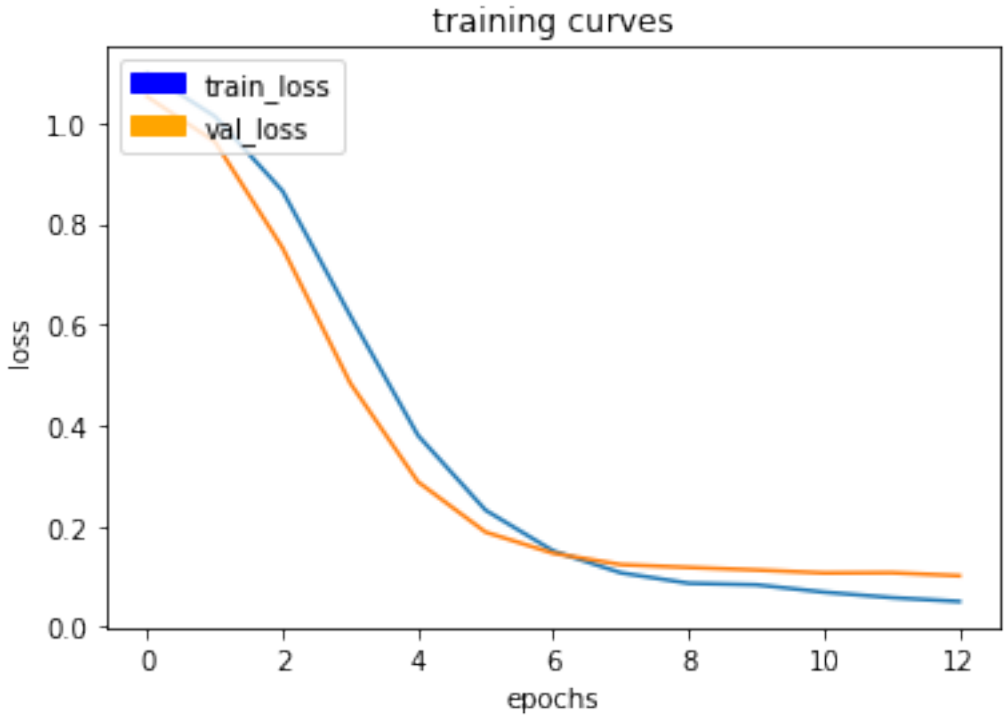

```
30/30 [==============================] - 23s - loss: 0.0839 - val_loss: 0.1132
Epoch 11/200
29/30 [============================>.] - ETA: 0s - loss: 0.0698
```



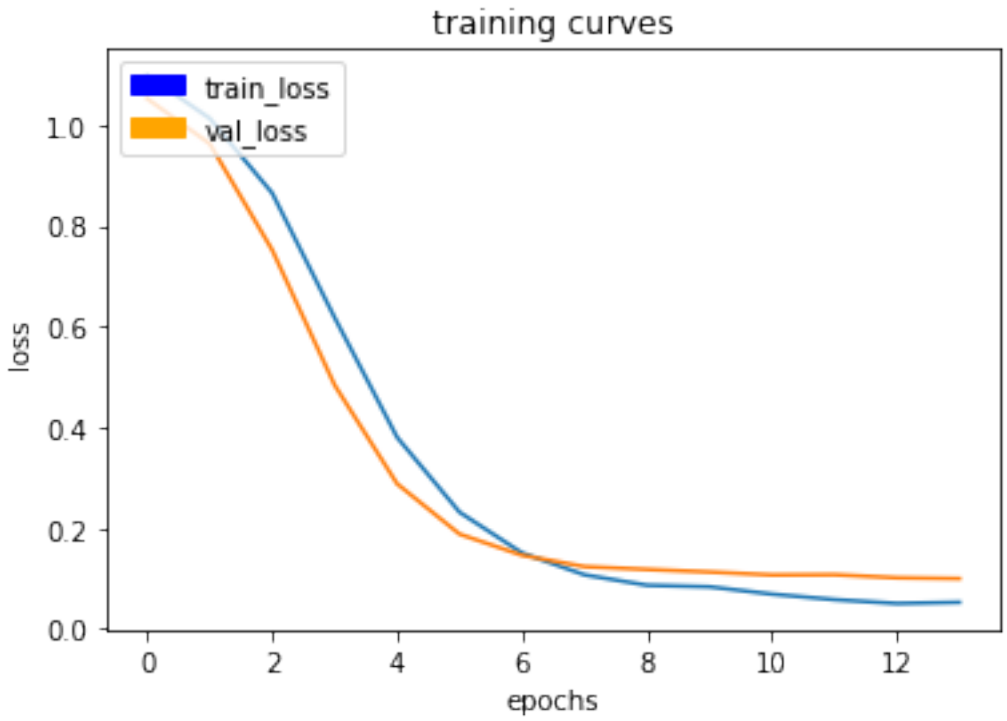

```
30/30 [==============================] - 23s - loss: 0.0693 - val_loss: 0.1073
Epoch 12/200
29/30 [============================>.] - ETA: 0s - loss: 0.0587
```



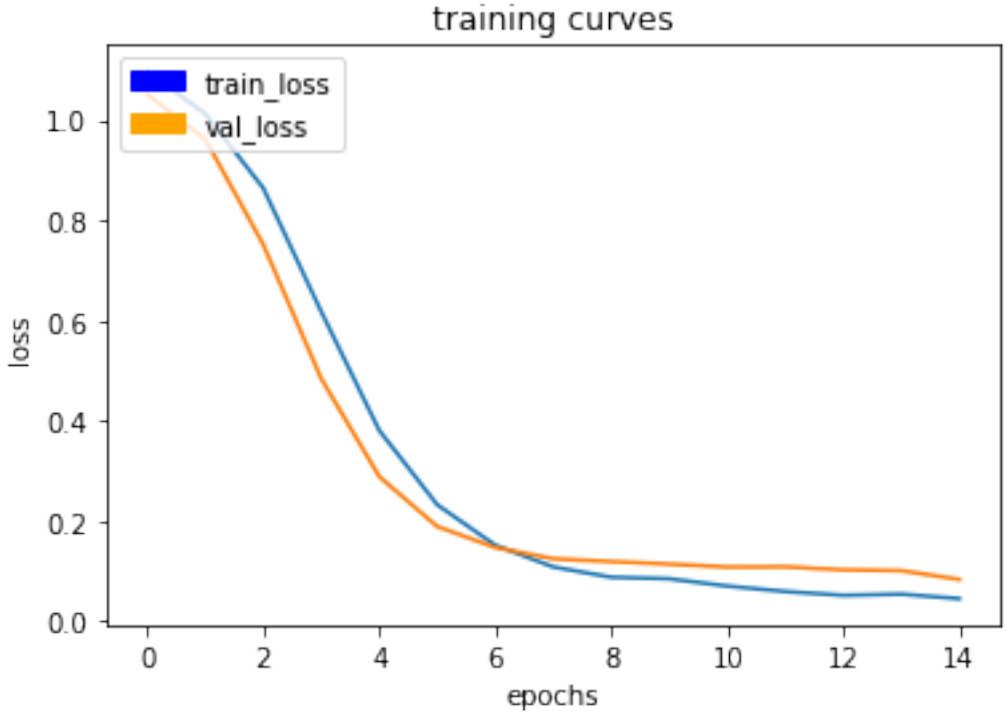
```
30/30 [==============================] - 23s - loss: 0.0584 - val_loss: 0.1078
Epoch 13/200
29/30 [============================>.] - ETA: 0s - loss: 0.0507
```



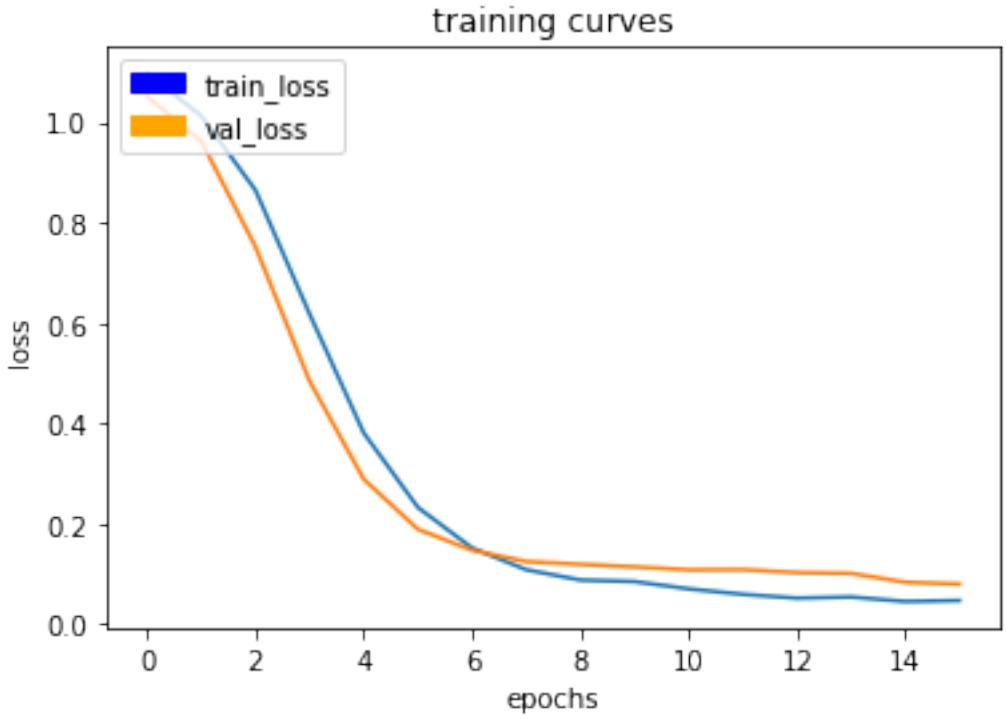

```
30/30 [==============================] - 23s - loss: 0.0508 - val_loss: 0.1017
Epoch 14/200
29/30 [============================>.] - ETA: 0s - loss: 0.0531
```



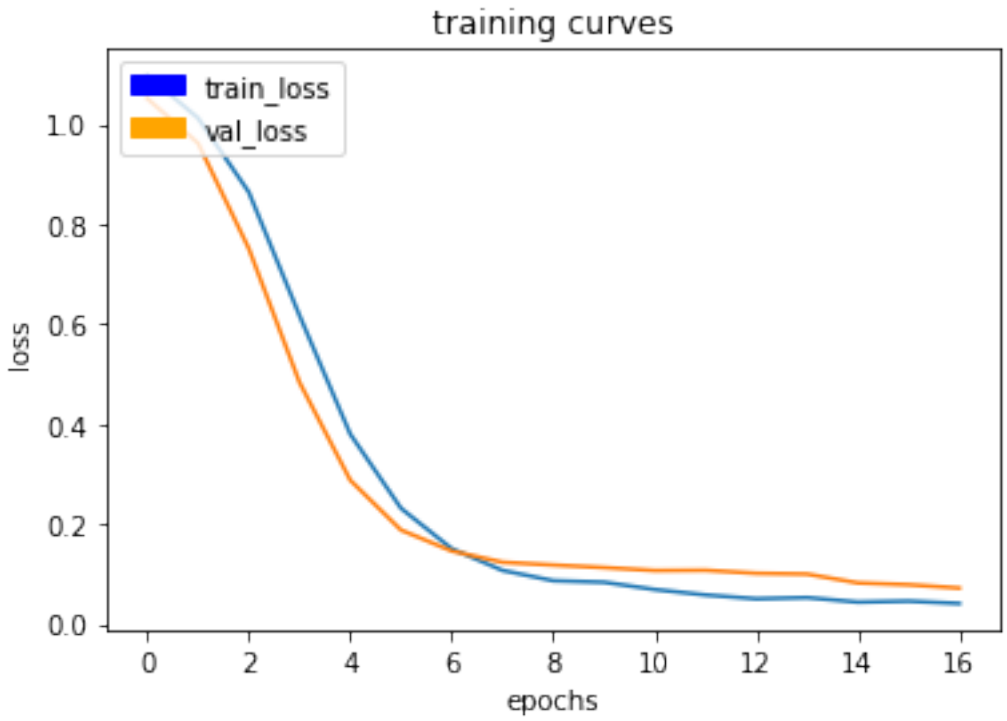

```
30/30 [==============================] - 23s - loss: 0.0529 - val_loss: 0.1001
Epoch 15/200
29/30 [============================>.] - ETA: 0s - loss: 0.0441
```



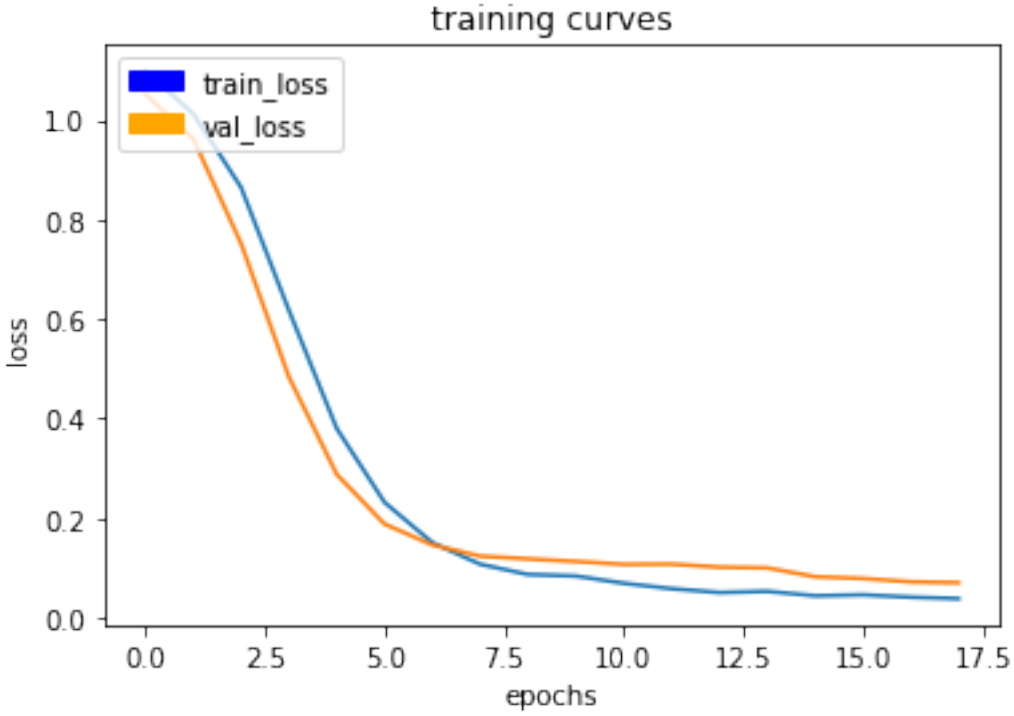
```
30/30 [==============================] - 23s - loss: 0.0441 - val_loss: 0.0825
Epoch 16/200
29/30 [============================>.] - ETA: 0s - loss: 0.0449
```



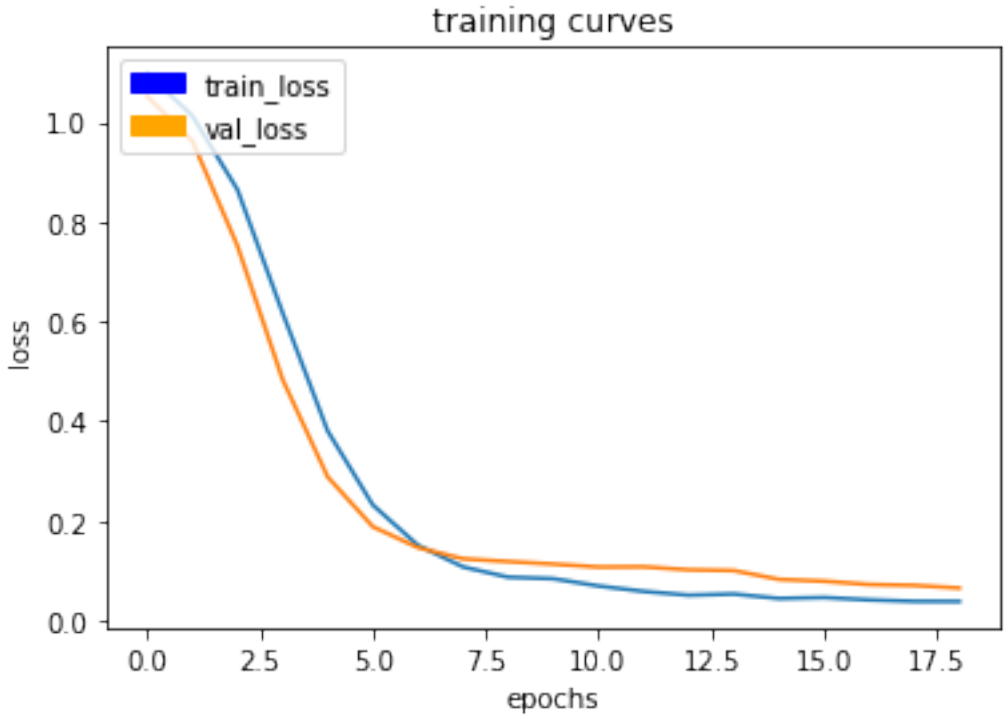

```
30/30 [==============================] - 23s - loss: 0.0460 - val_loss: 0.0789
Epoch 17/200
29/30 [============================>.] - ETA: 0s - loss: 0.0420
```



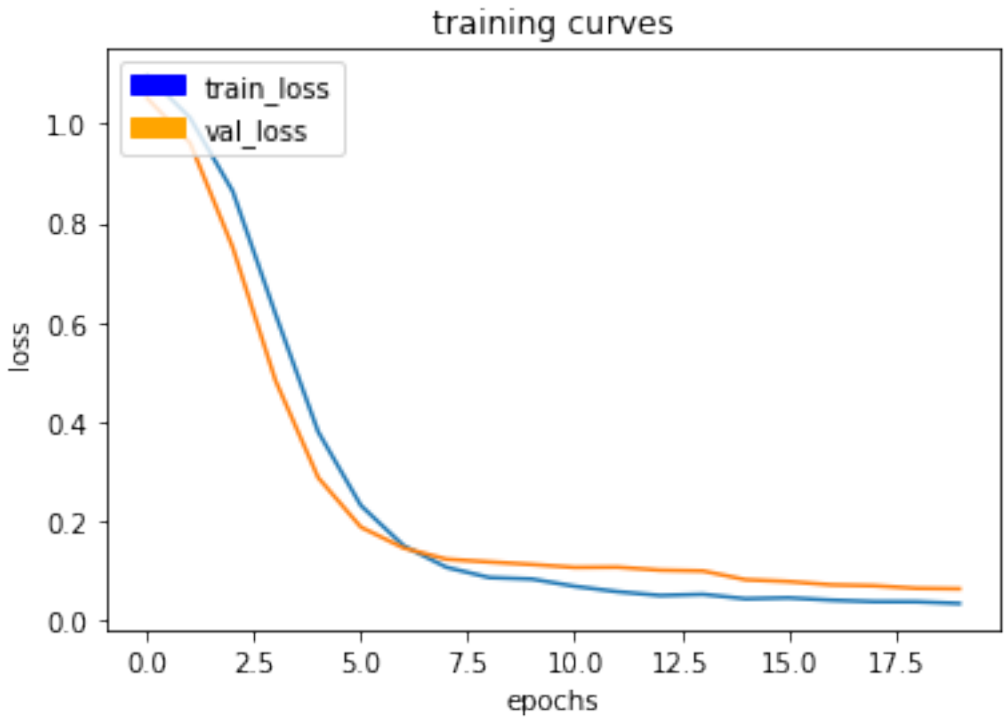

```
30/30 [==============================] - 23s - loss: 0.0419 - val_loss: 0.0722
Epoch 18/200
29/30 [============================>.] - ETA: 0s - loss: 0.0383
```



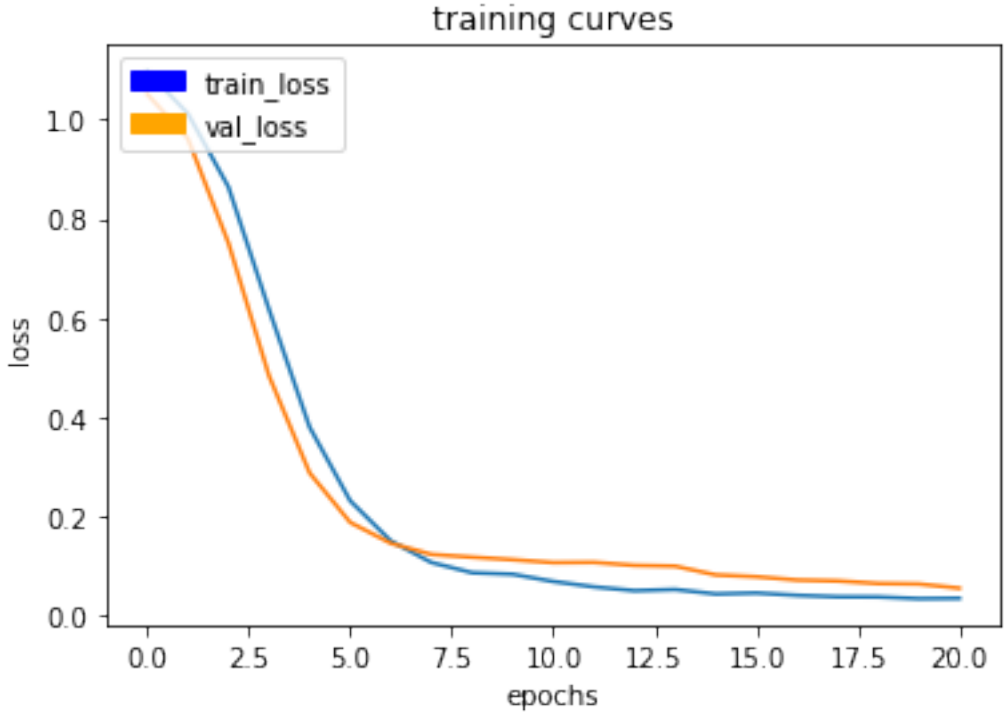
```
30/30 [==============================] - 23s - loss: 0.0384 - val_loss: 0.0704
Epoch 19/200
29/30 [============================>.] - ETA: 0s - loss: 0.0383
```



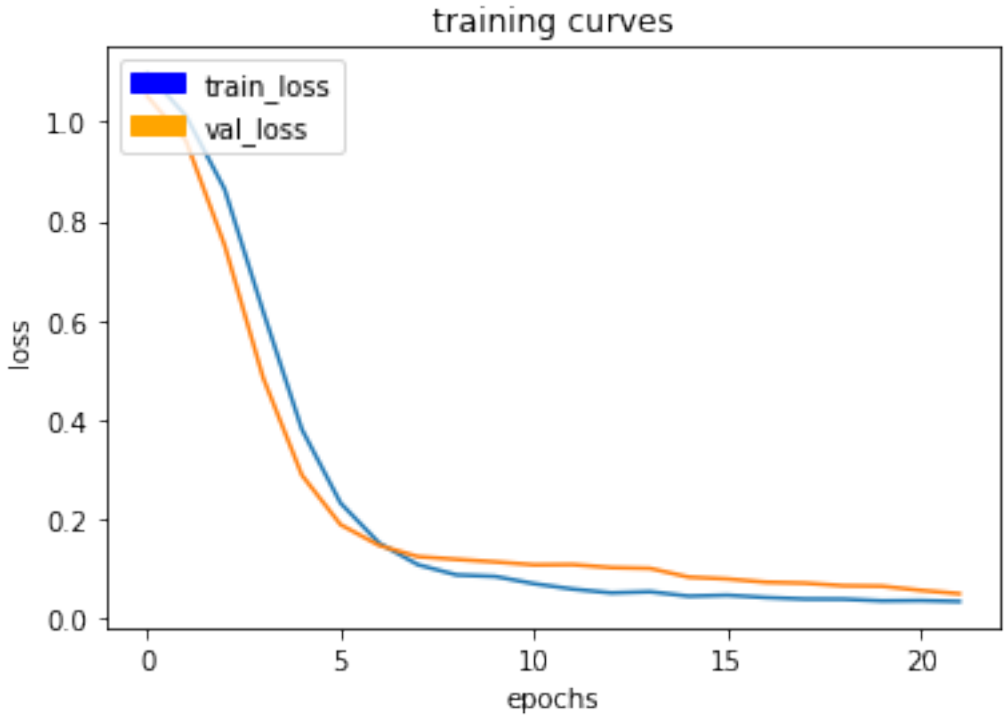

```
30/30 [==============================] - 23s - loss: 0.0381 - val_loss: 0.0652
Epoch 20/200
29/30 [============================>.] - ETA: 0s - loss: 0.0348
```



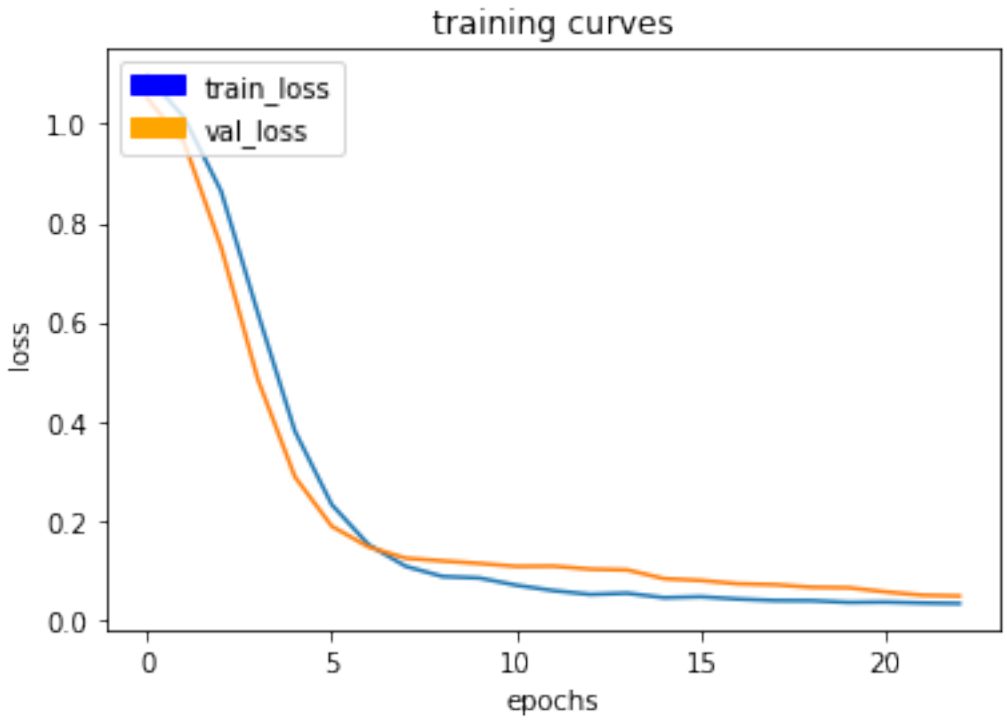

```
30/30 [==============================] - 23s - loss: 0.0347 - val_loss: 0.0642
Epoch 21/200
29/30 [============================>.] - ETA: 0s - loss: 0.0354
```



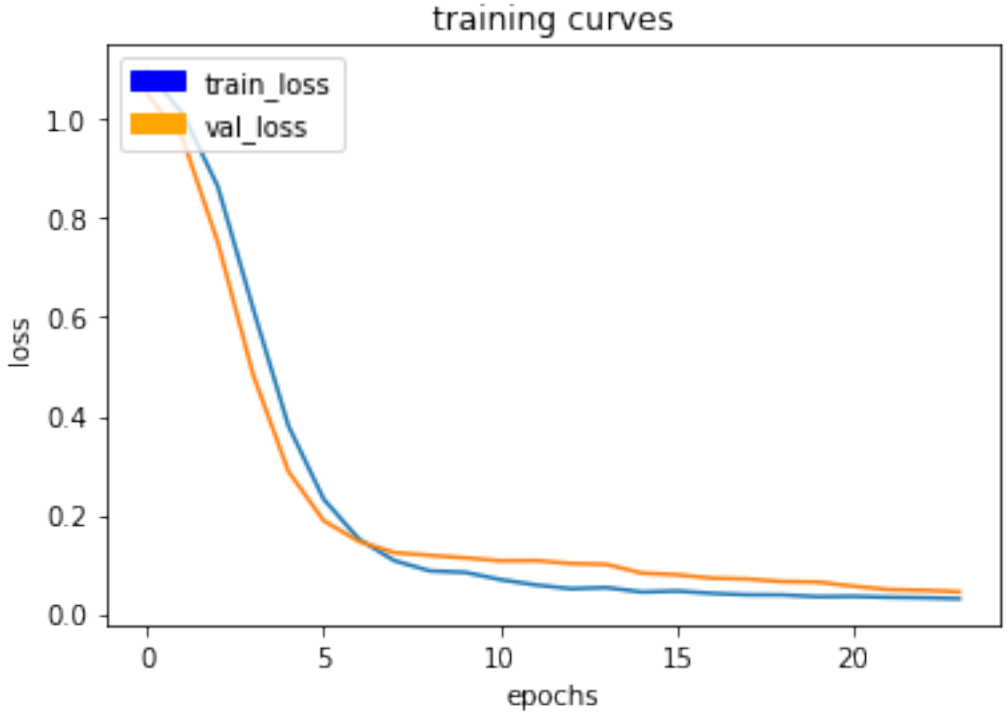
```
30/30 [==============================] - 23s - loss: 0.0353 - val_loss: 0.0558
Epoch 22/200
29/30 [============================>.] - ETA: 0s - loss: 0.0335
```



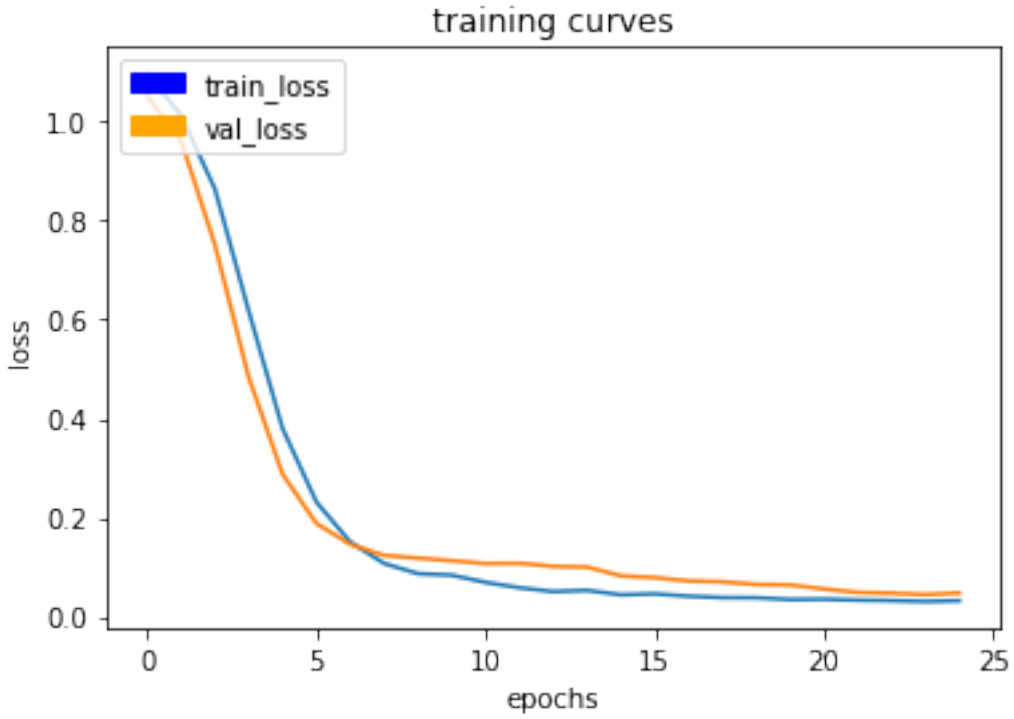

```
30/30 [==============================] - 23s - loss: 0.0334 - val_loss: 0.0491
Epoch 23/200
29/30 [============================>.] - ETA: 0s - loss: 0.0331
```



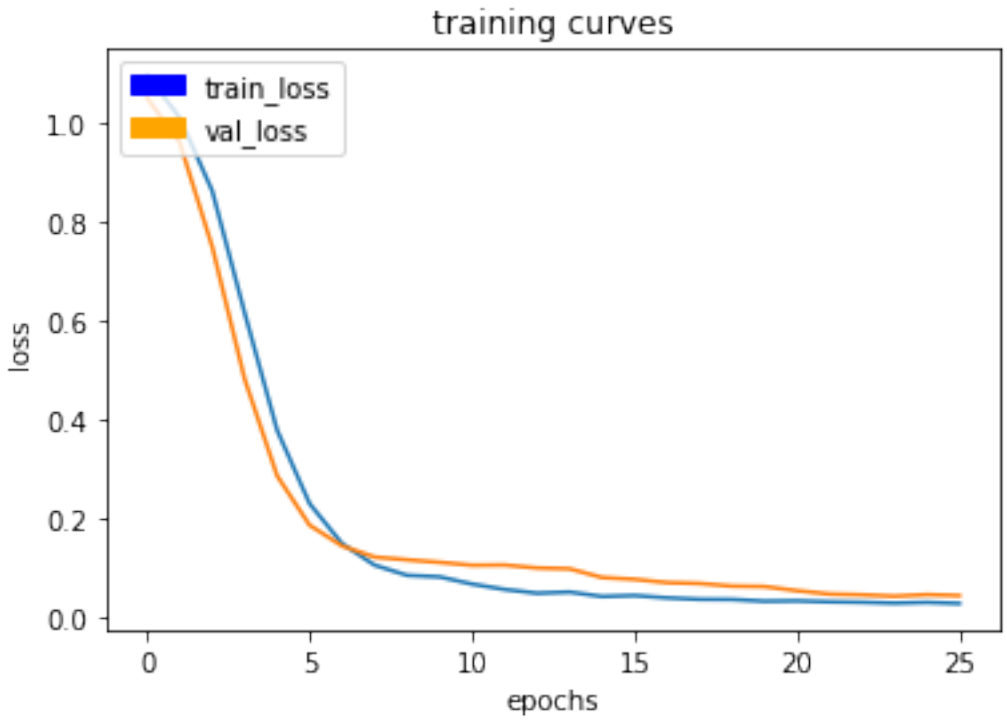

```
30/30 [==============================] - 23s - loss: 0.0329 - val_loss: 0.0475
Epoch 24/200
29/30 [============================>.] - ETA: 0s - loss: 0.0308
```



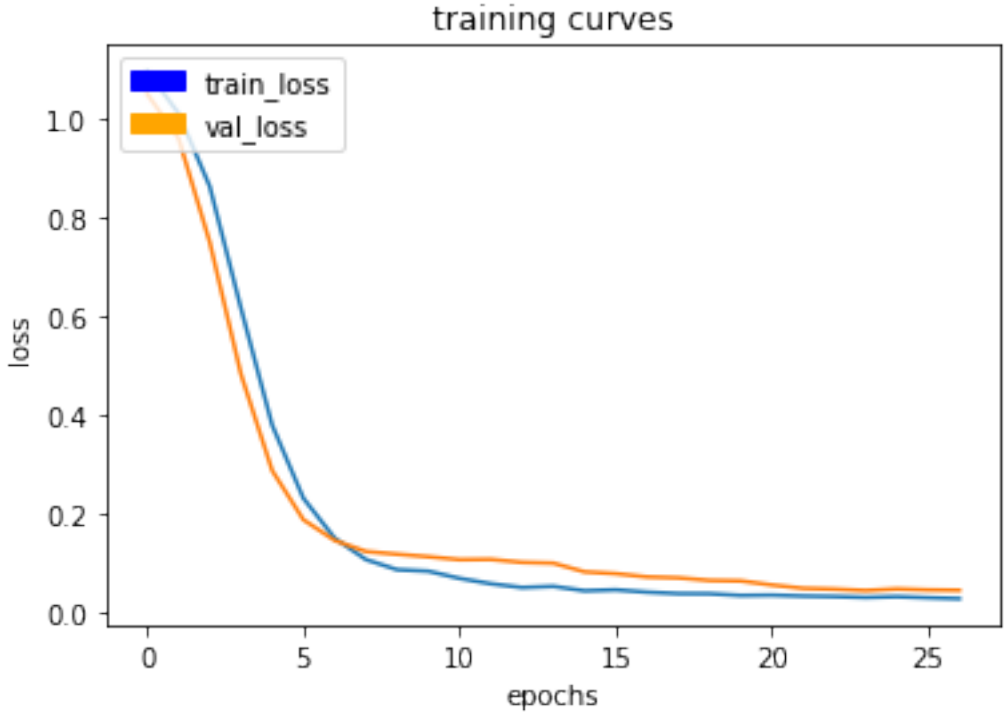
```
30/30 [==============================] - 23s - loss: 0.0307 - val_loss: 0.0446
Epoch 25/200
29/30 [============================>.] - ETA: 0s - loss: 0.0322
```



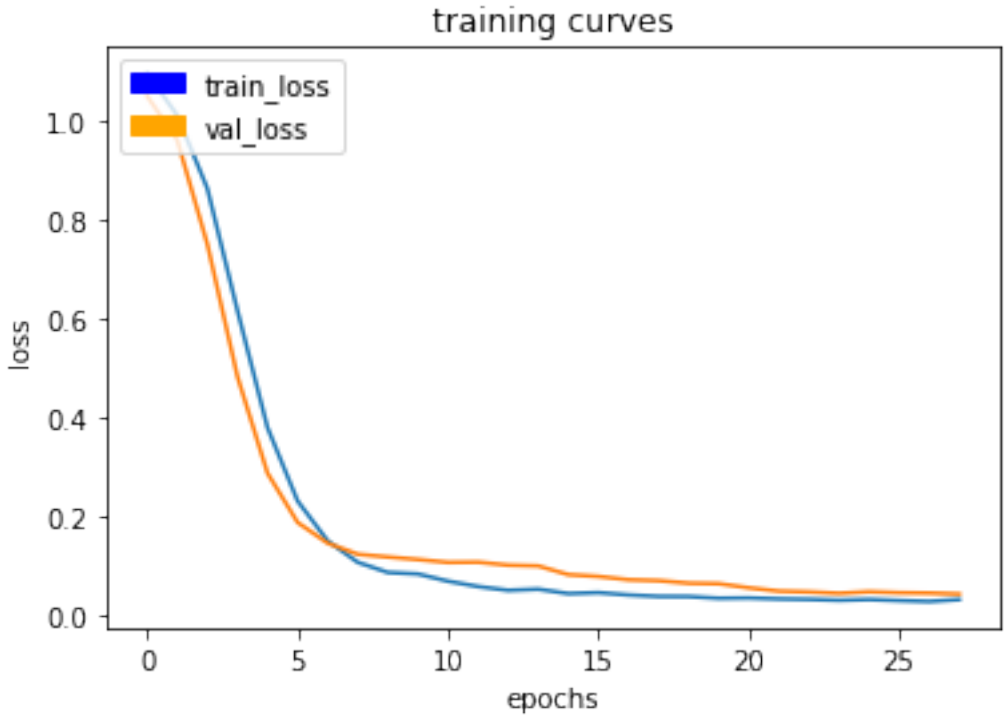

```
30/30 [==============================] - 23s - loss: 0.0321 - val_loss: 0.0479
Epoch 26/200
29/30 [============================>.] - ETA: 0s - loss: 0.0302
```



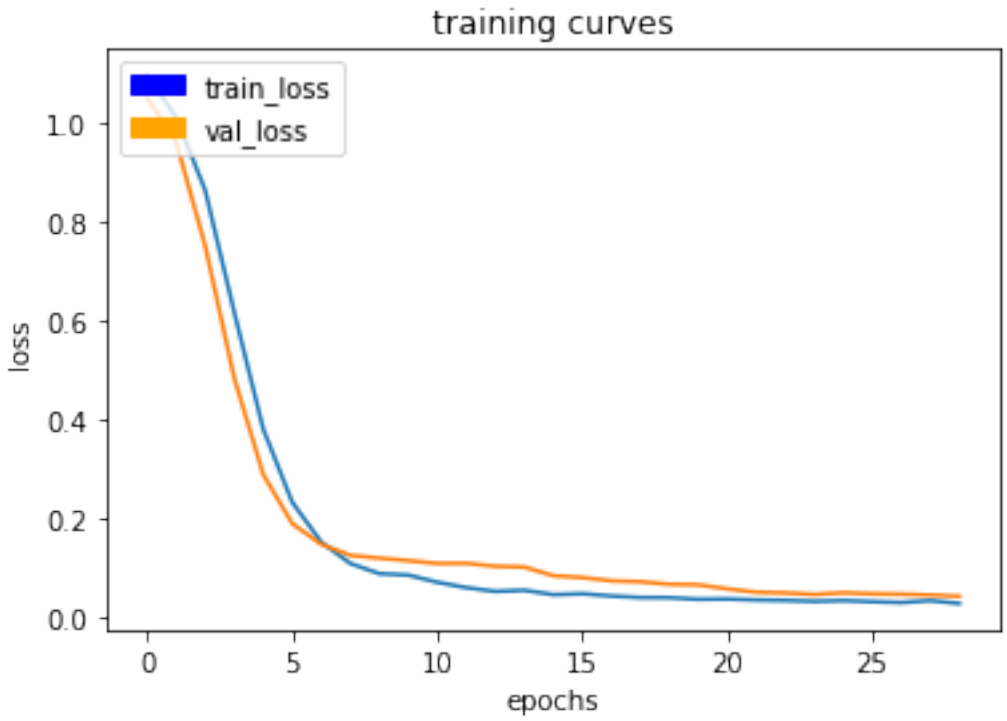

```
30/30 [==============================] - 23s - loss: 0.0300 - val_loss: 0.0459
Epoch 27/200
29/30 [============================>.] - ETA: 0s - loss: 0.0283
```



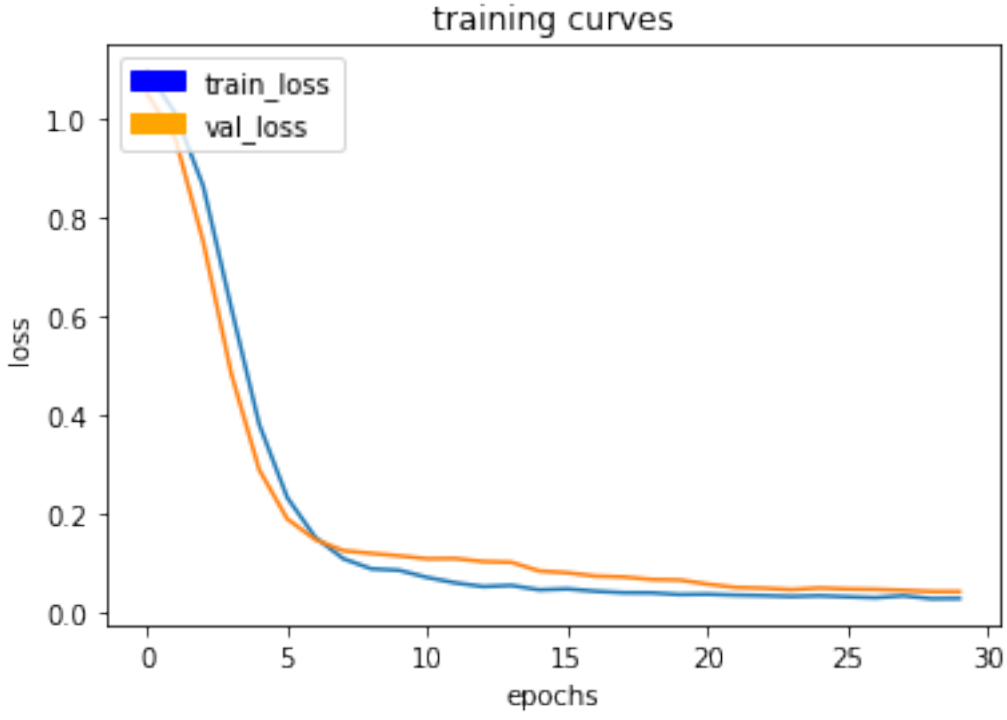
```
30/30 [==============================] - 23s - loss: 0.0282 - val_loss: 0.0452
Epoch 28/200
29/30 [============================>.] - ETA: 0s - loss: 0.0323
```



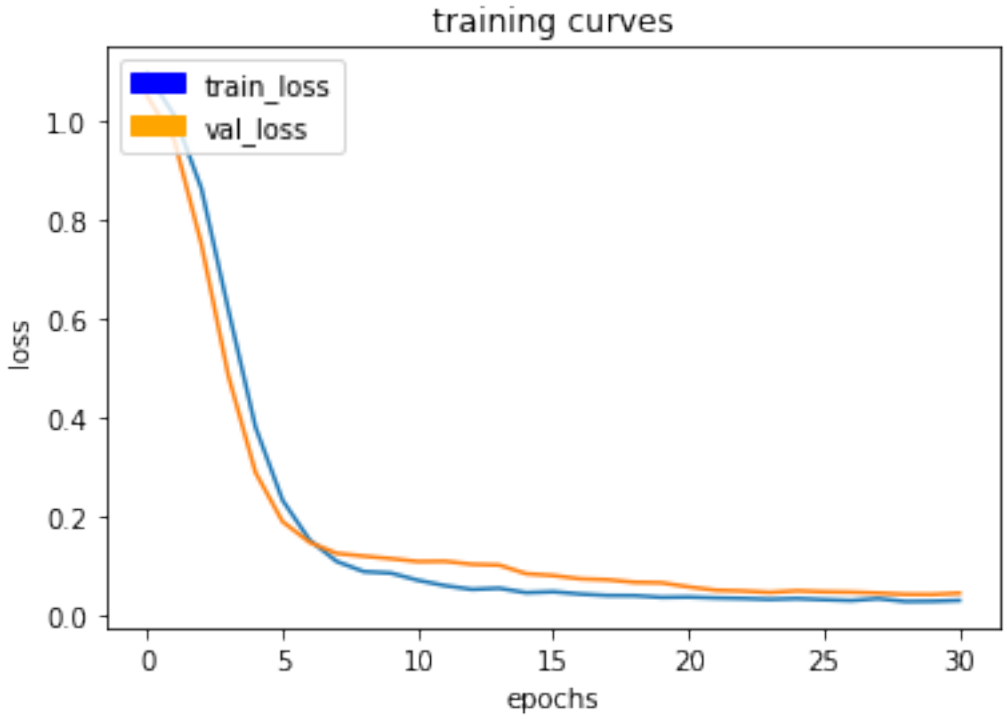

```
30/30 [==============================] - 23s - loss: 0.0321 - val_loss: 0.0433
Epoch 29/200
29/30 [============================>.] - ETA: 0s - loss: 0.0264
```



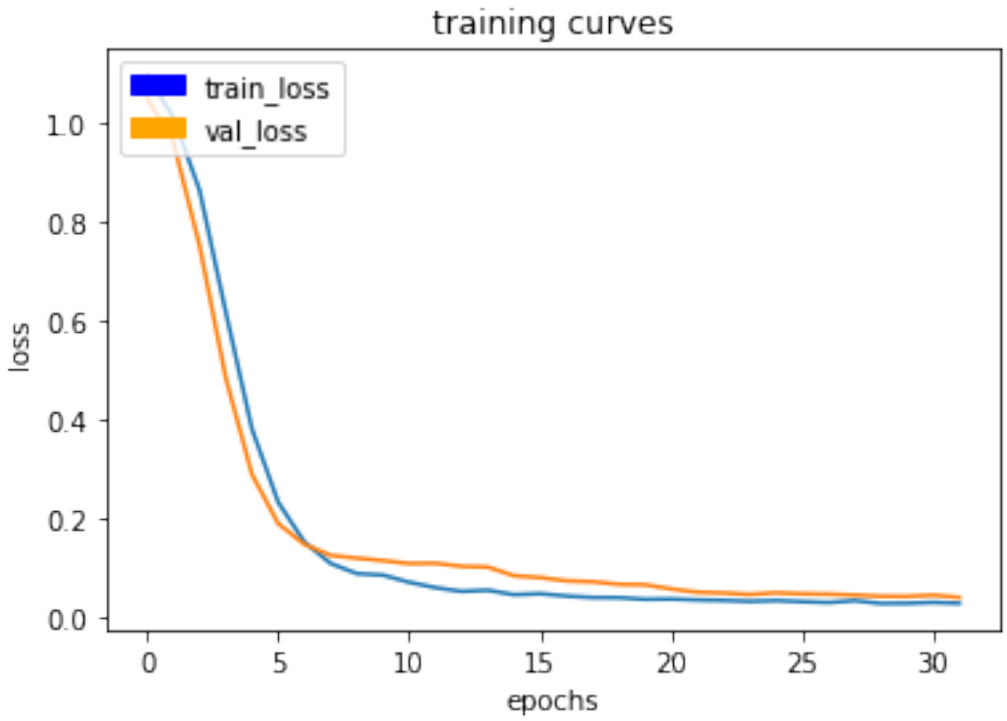

```
30/30 [==============================] - 23s - loss: 0.0263 - val_loss: 0.0408
Epoch 30/200
29/30 [============================>.] - ETA: 0s - loss: 0.0268
```



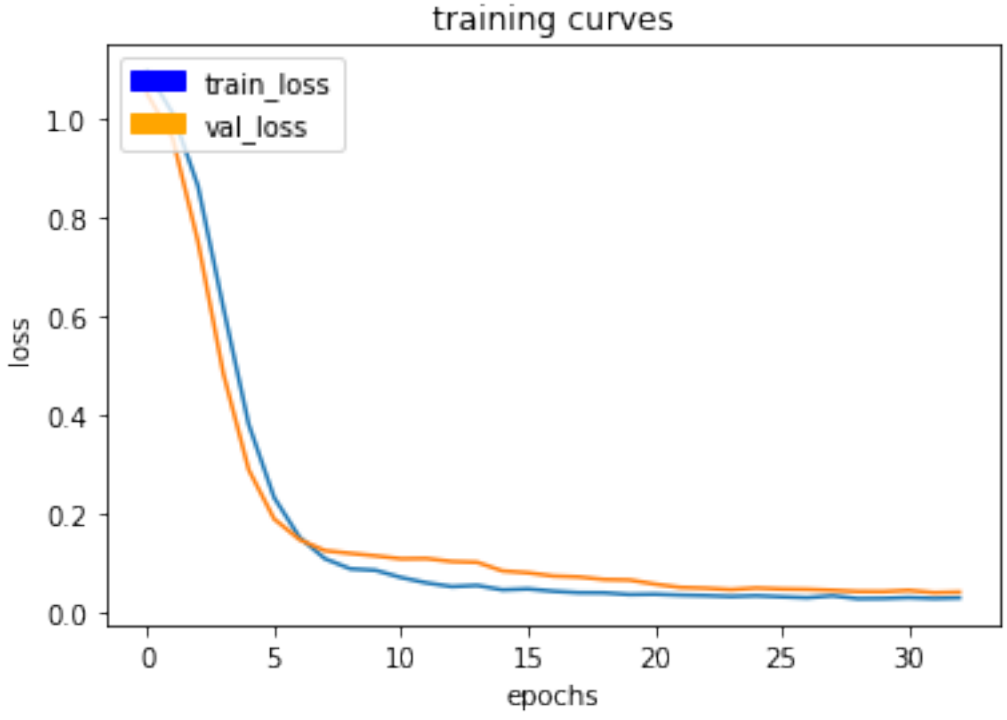
```
30/30 [==============================] - 23s - loss: 0.0266 - val_loss: 0.0405
Epoch 31/200
29/30 [============================>.] - ETA: 0s - loss: 0.0284
```



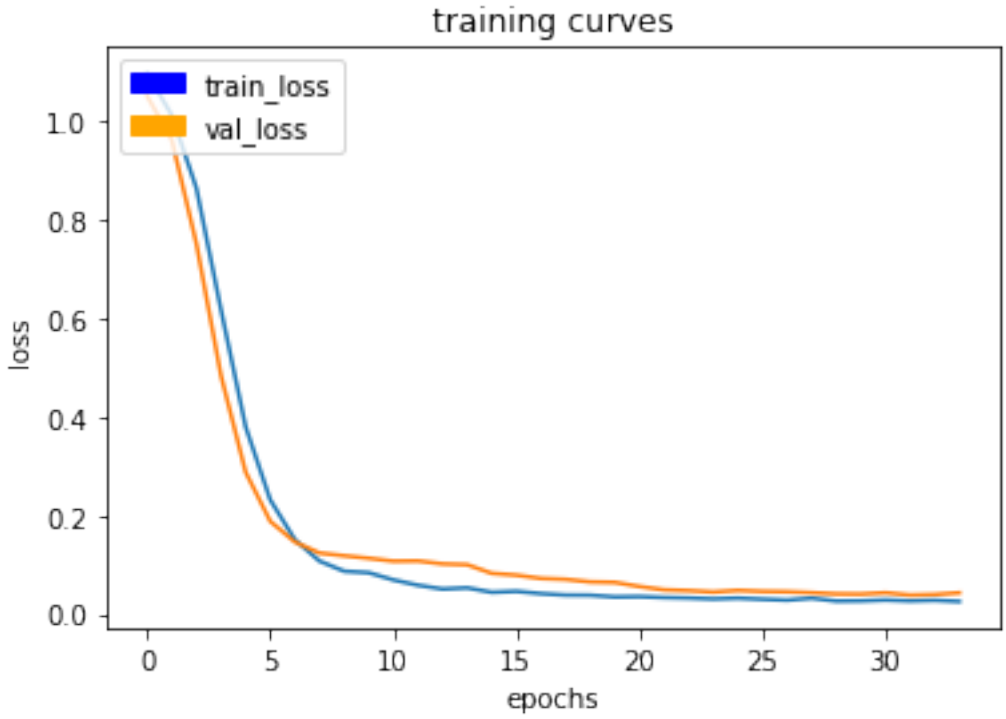

```
30/30 [==============================] - 23s - loss: 0.0283 - val_loss: 0.0431
Epoch 32/200
29/30 [============================>.] - ETA: 0s - loss: 0.0269
```



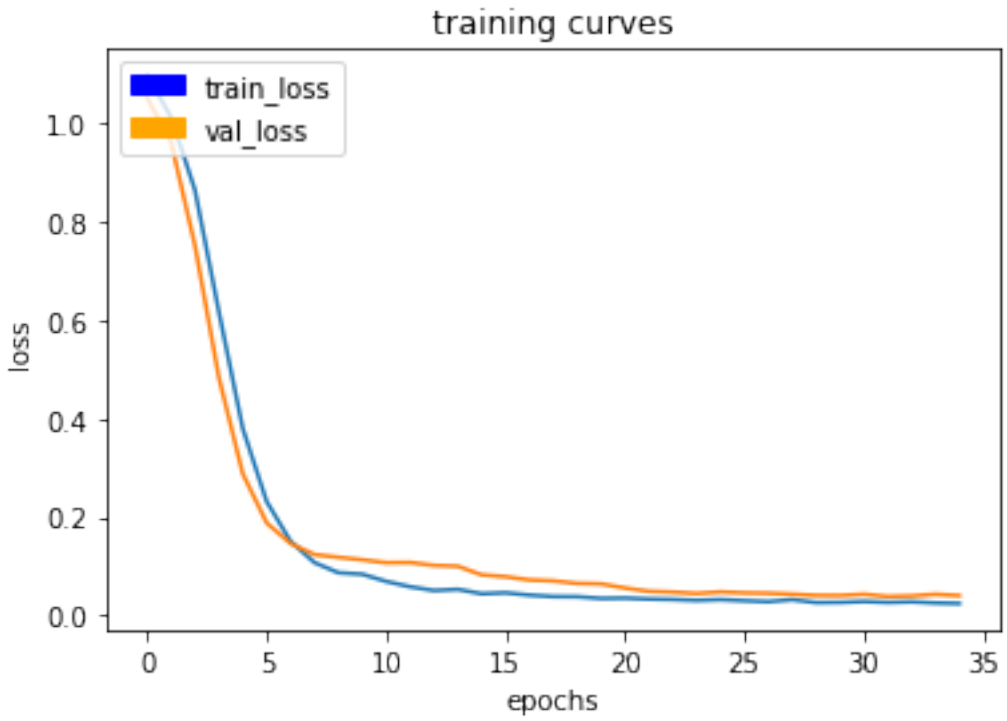

```
30/30 [==============================] - 24s - loss: 0.0266 - val_loss: 0.0385
Epoch 33/200
29/30 [============================>.] - ETA: 0s - loss: 0.0280
```



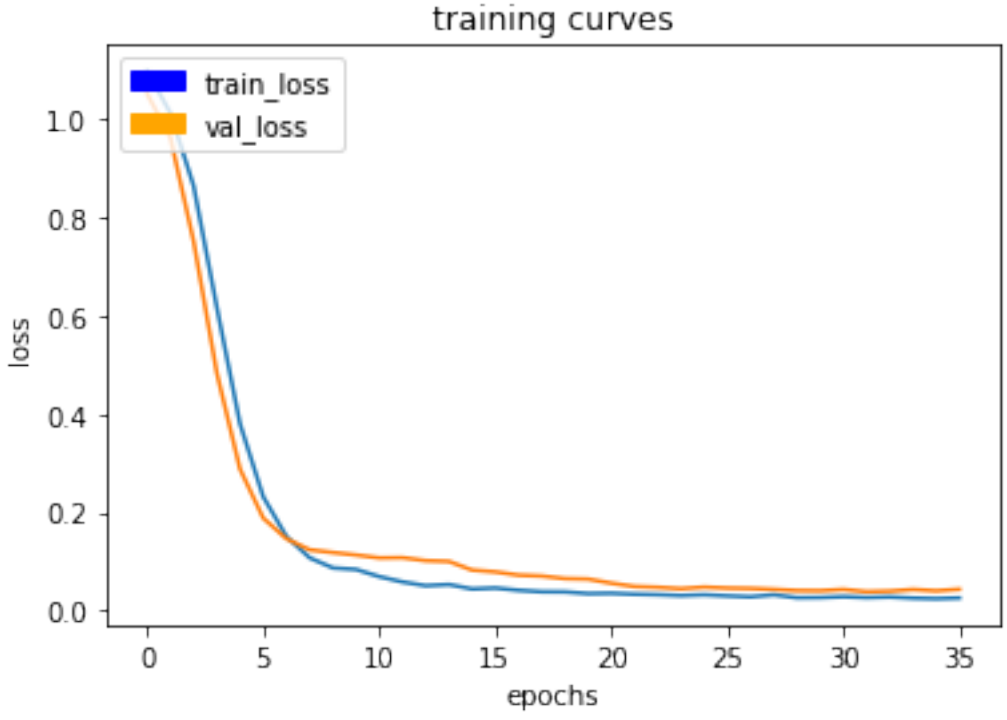
```
30/30 [==============================] - 23s - loss: 0.0278 - val_loss: 0.0396
Epoch 34/200
29/30 [============================>.] - ETA: 0s - loss: 0.0257
```



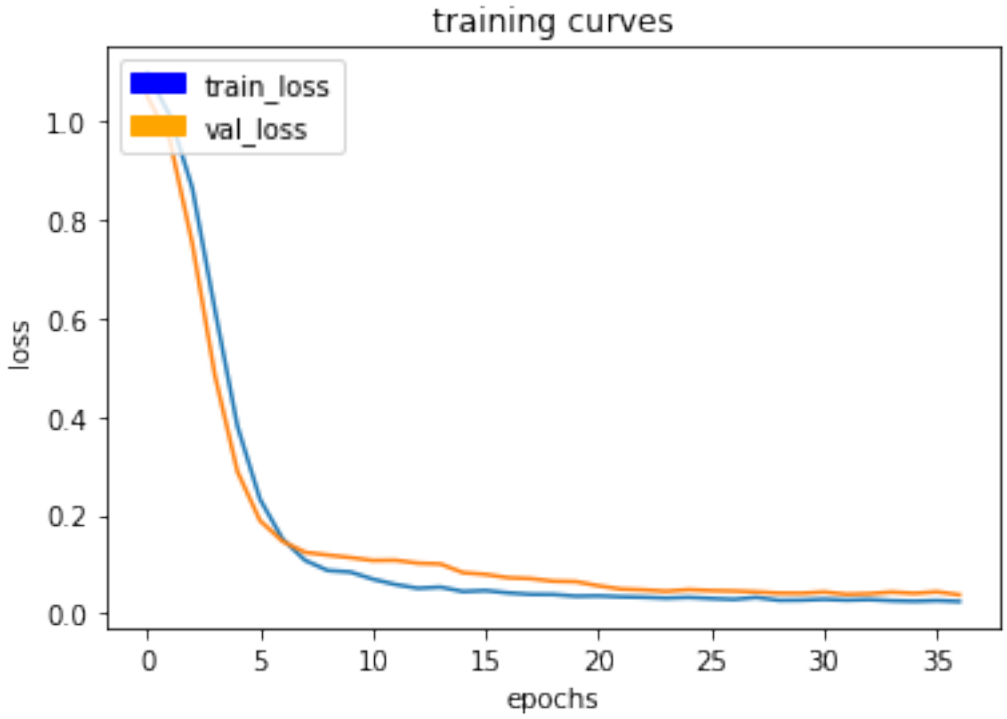

```
30/30 [==============================] - 23s - loss: 0.0255 - val_loss: 0.0430
Epoch 35/200
29/30 [============================>.] - ETA: 0s - loss: 0.0237
```



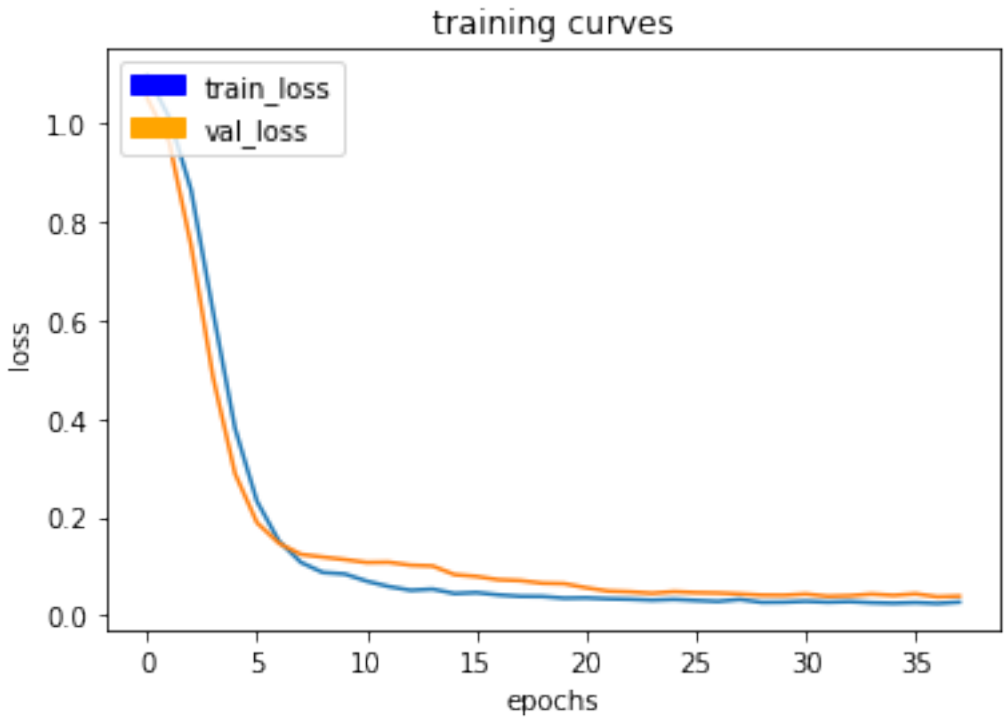

```
30/30 [==============================] - 23s - loss: 0.0244 - val_loss: 0.0403
Epoch 36/200
29/30 [============================>.] - ETA: 0s - loss: 0.0258
```



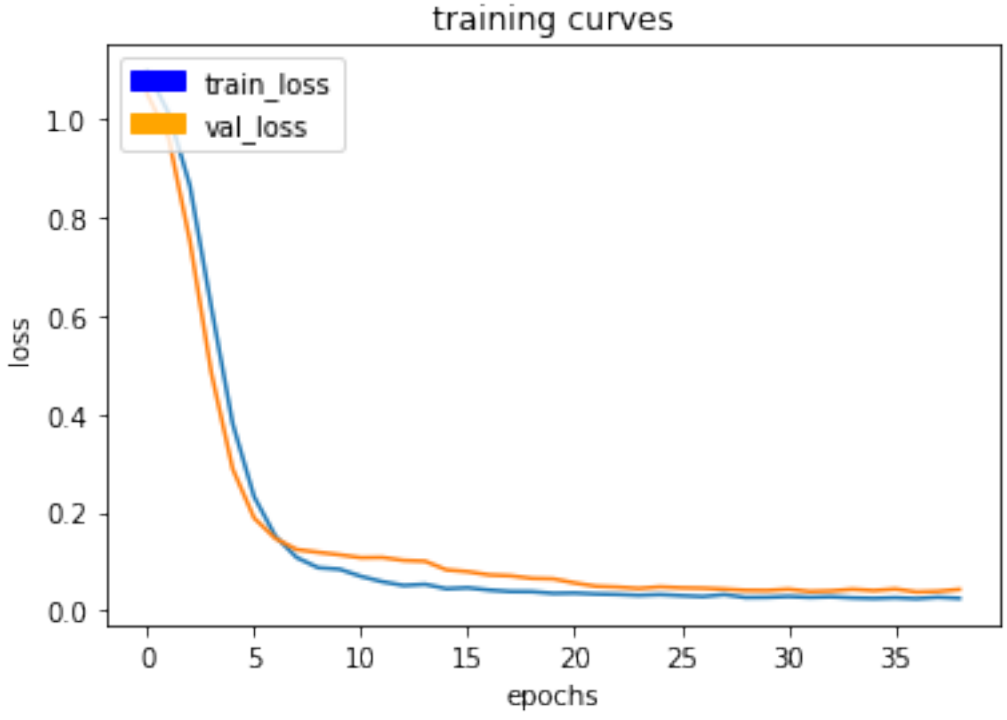
```
30/30 [==============================] - 23s - loss: 0.0257 - val_loss: 0.0435
Epoch 37/200
29/30 [============================>.] - ETA: 0s - loss: 0.0241
```



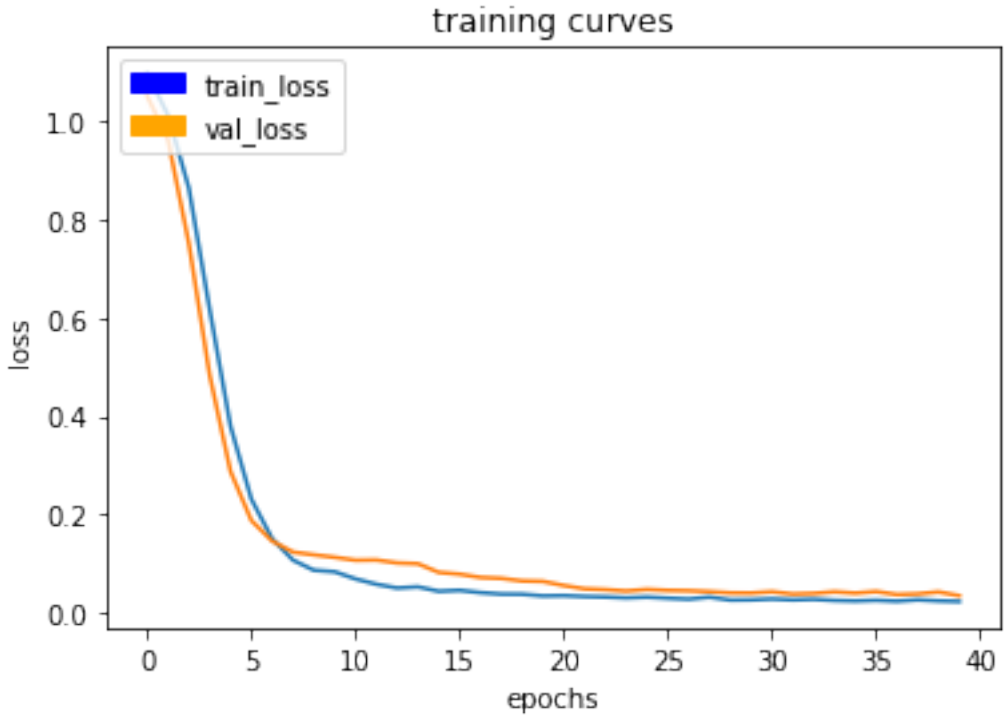

```
30/30 [==============================] - 23s - loss: 0.0239 - val_loss: 0.0374
Epoch 38/200
29/30 [============================>.] - ETA: 0s - loss: 0.0270
```



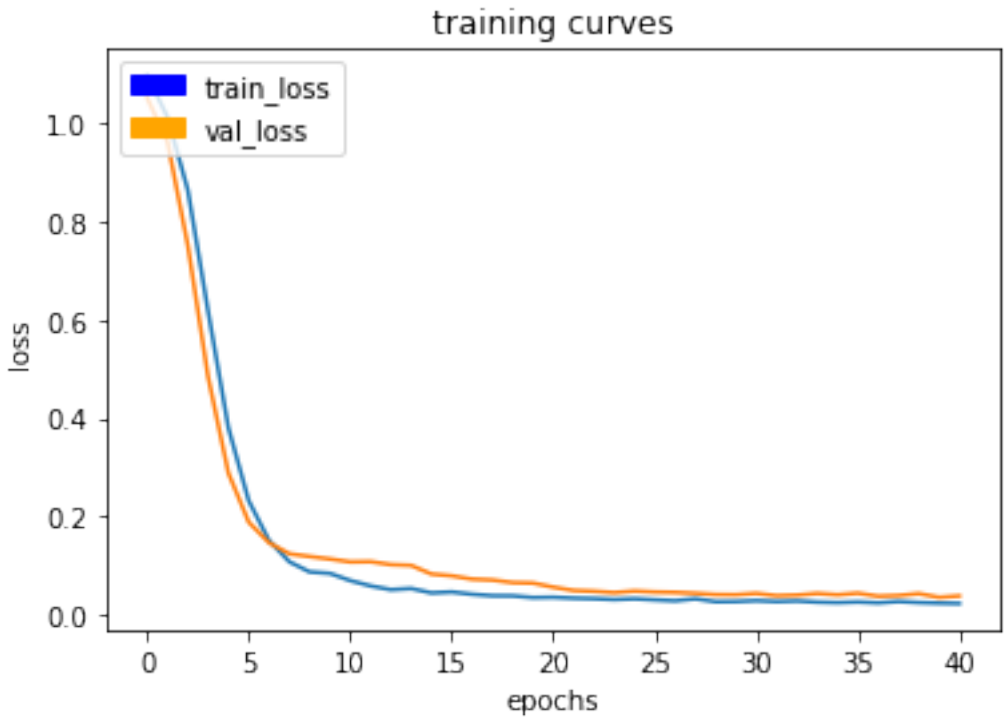

```
30/30 [==============================] - 23s - loss: 0.0267 - val_loss: 0.0388
Epoch 39/200
29/30 [============================>.] - ETA: 0s - loss: 0.0237
```



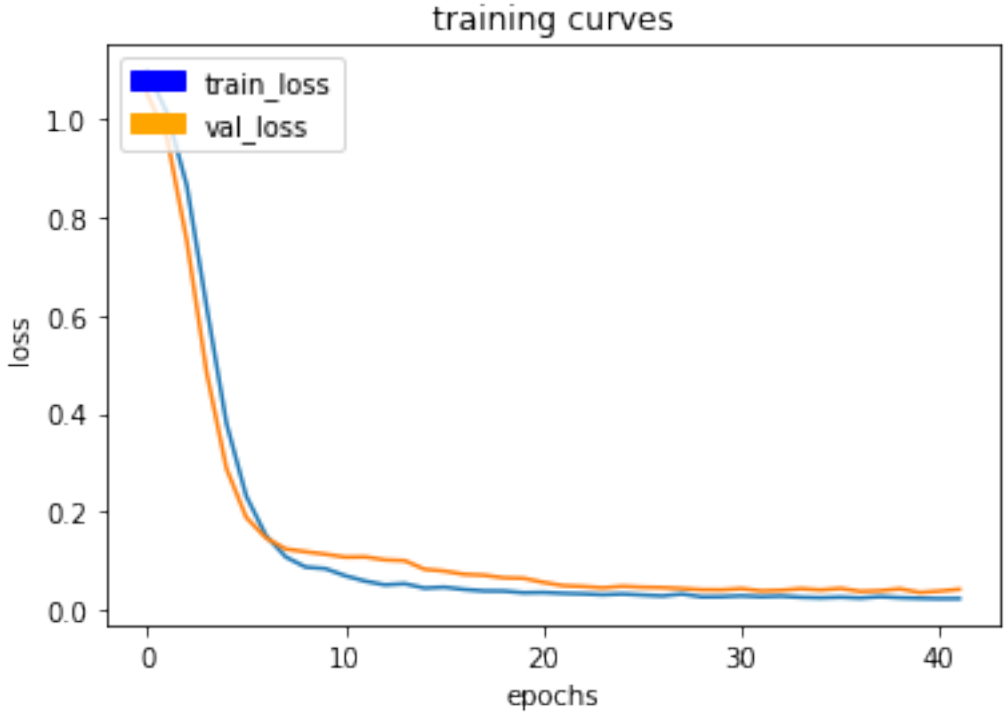
```
30/30 [==============================] - 23s - loss: 0.0245 - val_loss: 0.0427
Epoch 40/200
29/30 [============================>.] - ETA: 0s - loss: 0.0234
```



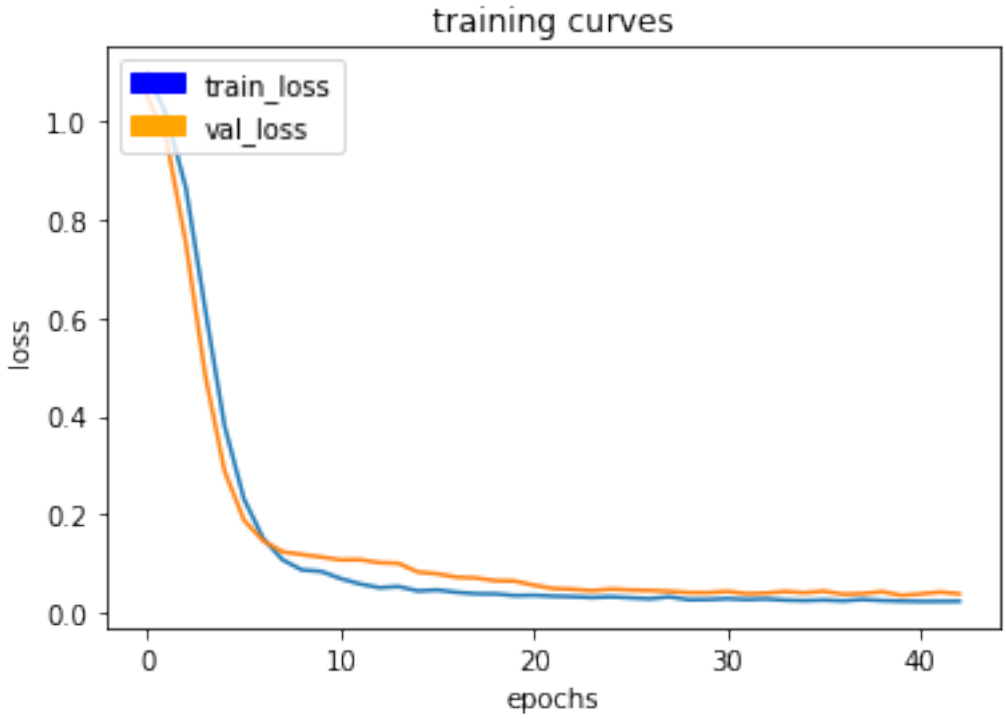

```
30/30 [==============================] - 23s - loss: 0.0233 - val_loss: 0.0351
Epoch 41/200
29/30 [============================>.] - ETA: 0s - loss: 0.0225
```



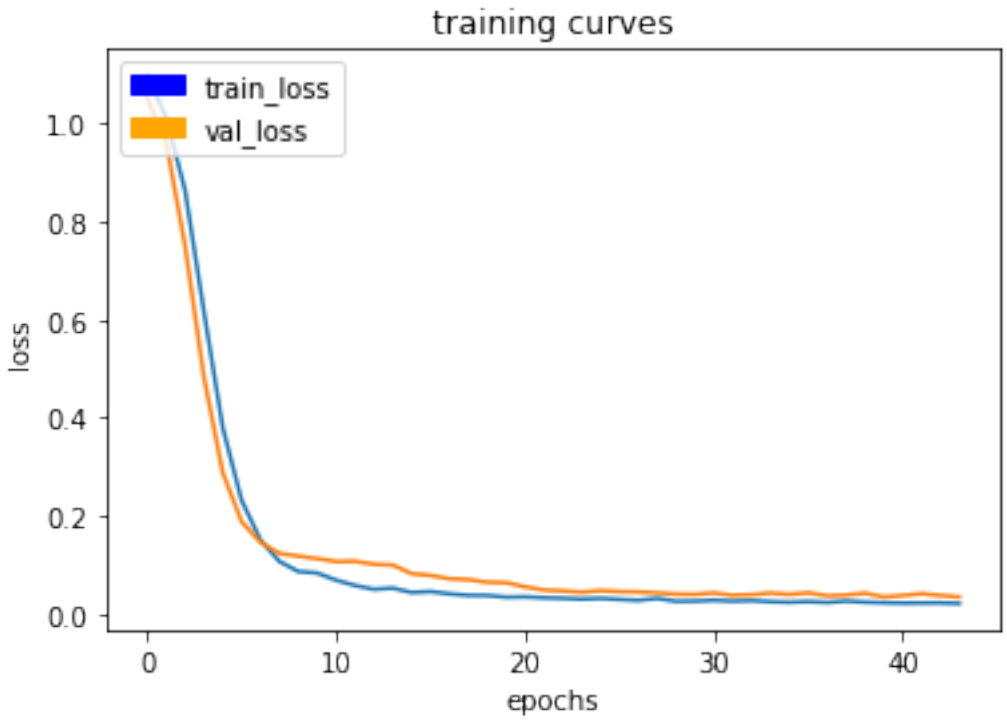

```
30/30 [==============================] - 23s - loss: 0.0226 - val_loss: 0.0380
Epoch 42/200
29/30 [============================>.] - ETA: 0s - loss: 0.0225
```



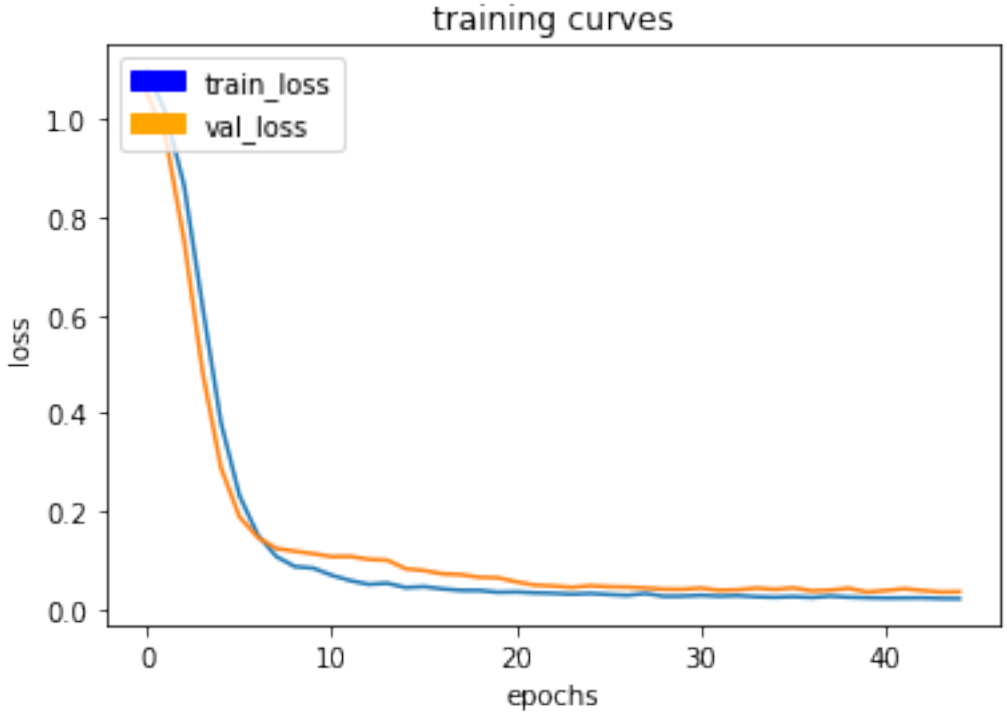
```
30/30 [==============================] - 23s - loss: 0.0227 - val_loss: 0.0418
Epoch 43/200
29/30 [============================>.] - ETA: 0s - loss: 0.0230
```



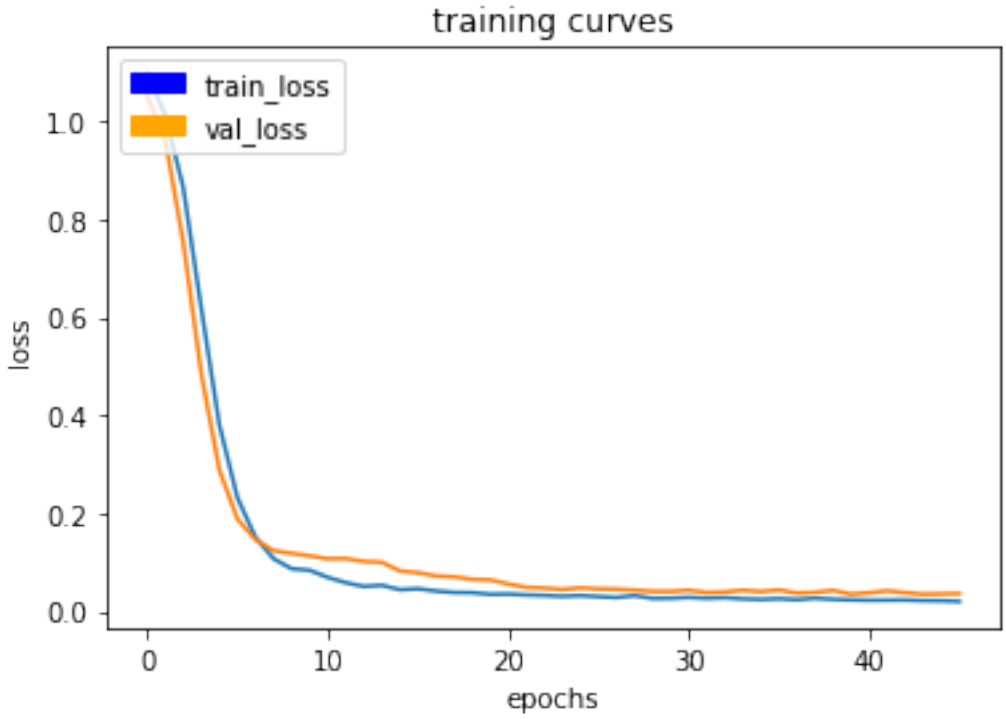

```
30/30 [==============================] - 23s - loss: 0.0231 - val_loss: 0.0382
Epoch 44/200
29/30 [============================>.] - ETA: 0s - loss: 0.0219
```



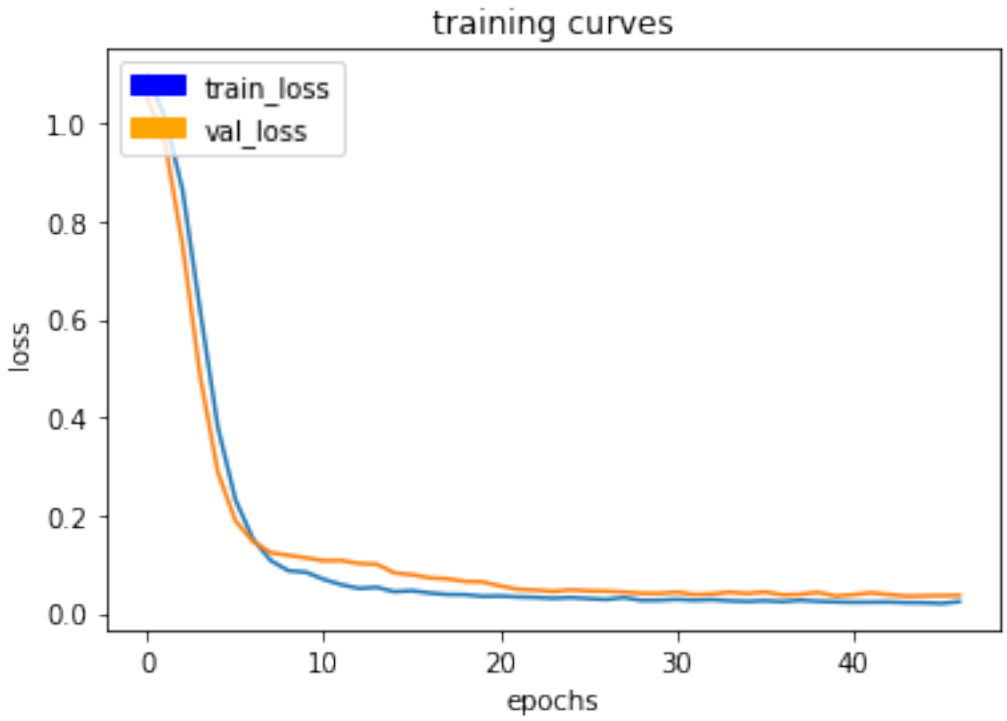

```
30/30 [==============================] - 23s - loss: 0.0218 - val_loss: 0.0350
Epoch 45/200
29/30 [============================>.] - ETA: 0s - loss: 0.0216
```



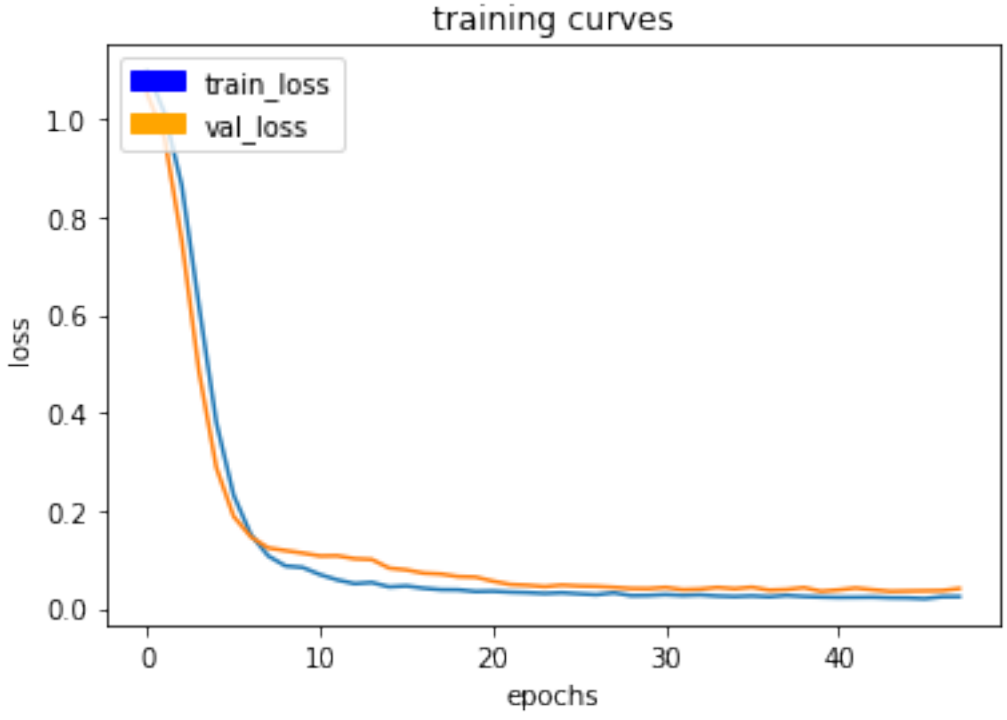
```
30/30 [==============================] - 23s - loss: 0.0215 - val_loss: 0.0356
Epoch 46/200
29/30 [============================>.] - ETA: 0s - loss: 0.0197
```



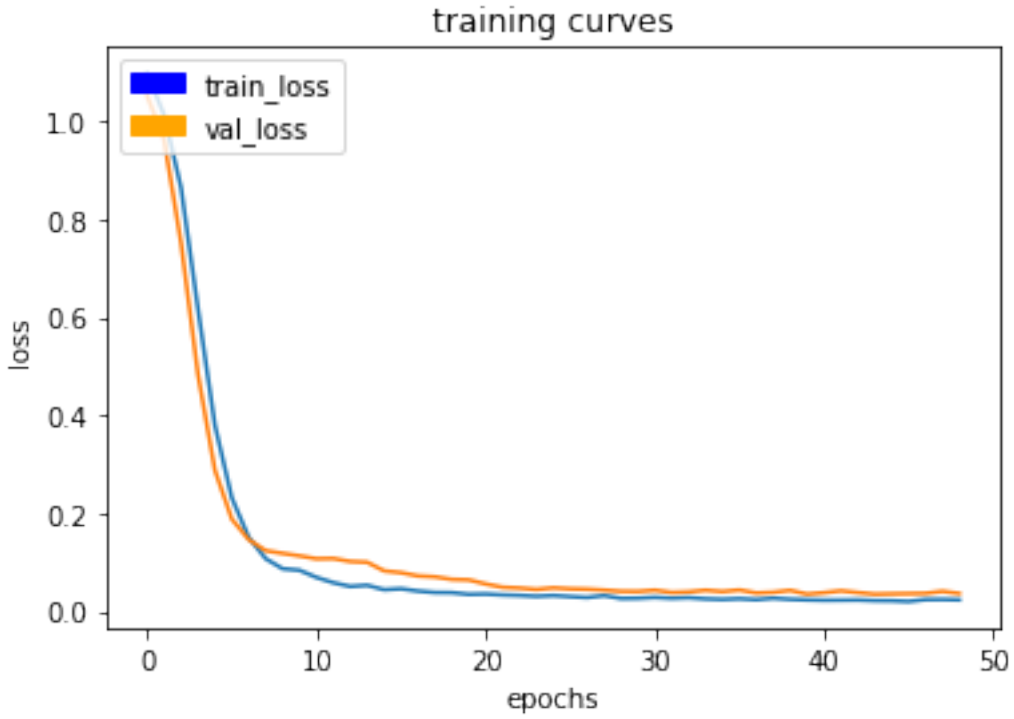

```
30/30 [==============================] - 23s - loss: 0.0201 - val_loss: 0.0361
Epoch 47/200
29/30 [============================>.] - ETA: 0s - loss: 0.0240
```



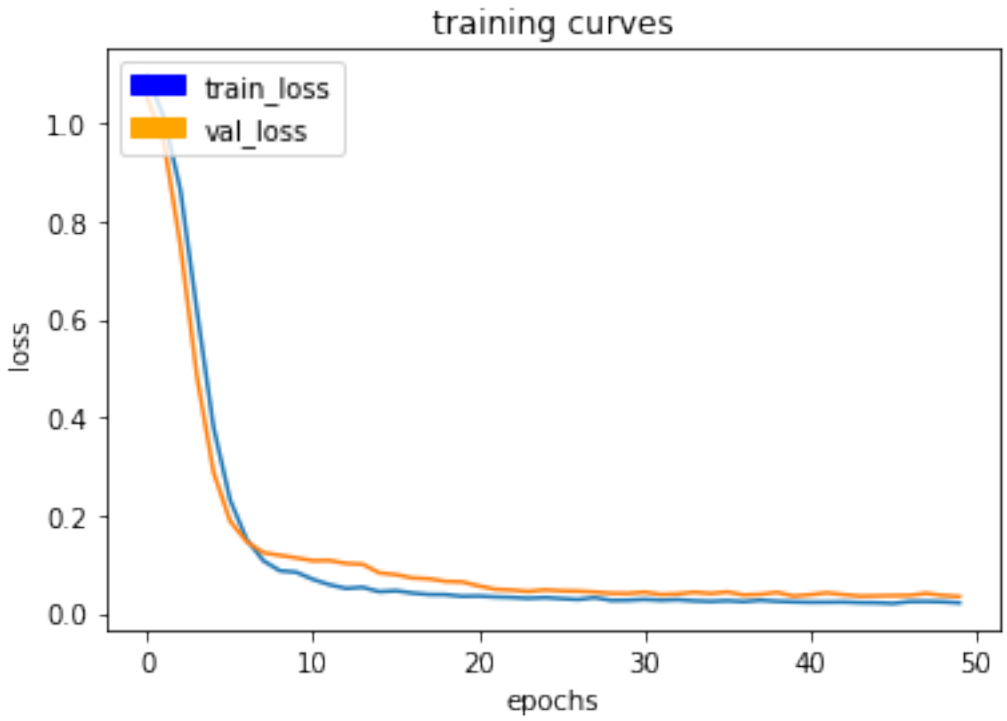

```
30/30 [==============================] - 23s - loss: 0.0240 - val_loss: 0.0366
Epoch 48/200
29/30 [============================>.] - ETA: 0s - loss: 0.0250
```



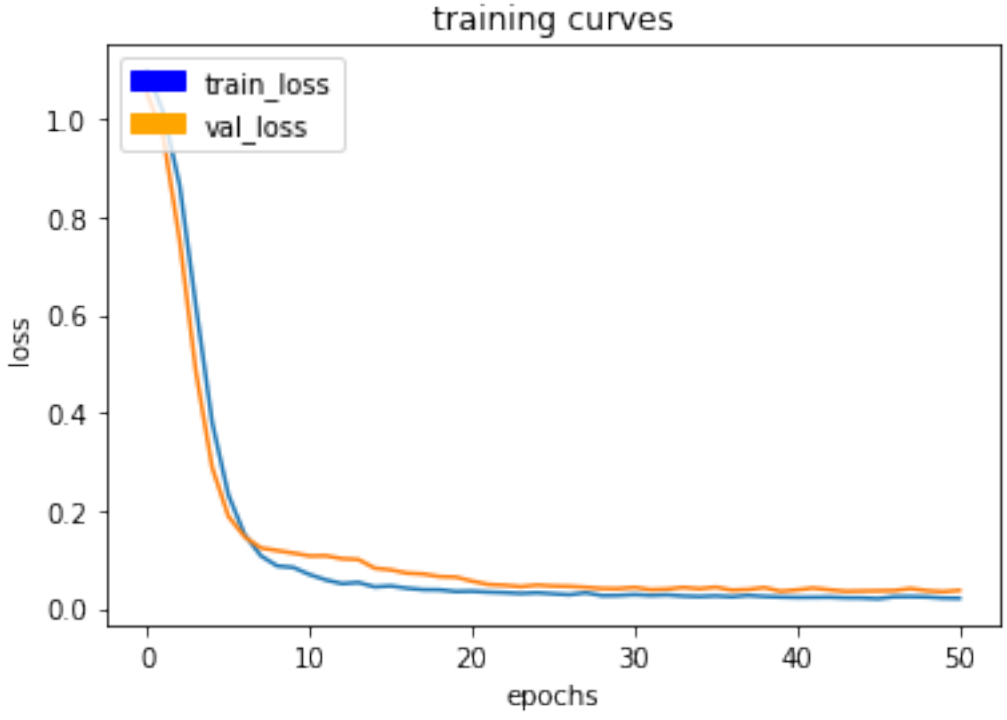
```
30/30 [==============================] - 23s - loss: 0.0248 - val_loss: 0.0408
Epoch 49/200
29/30 [============================>.] - ETA: 0s - loss: 0.0237
```



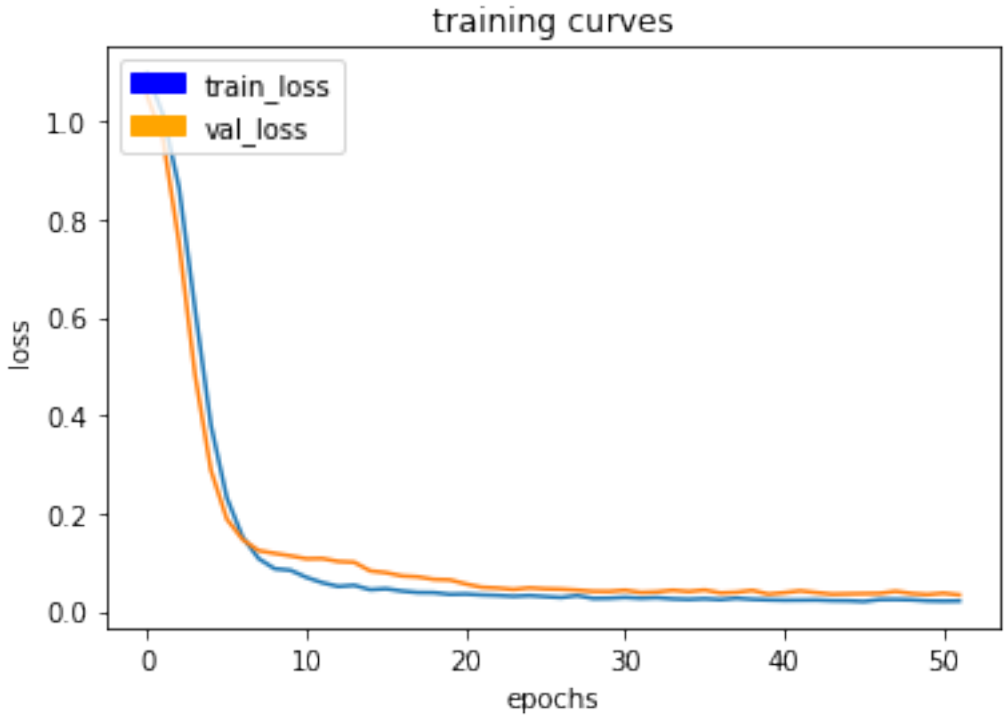

```
30/30 [==============================] - 23s - loss: 0.0235 - val_loss: 0.0363
Epoch 50/200
29/30 [============================>.] - ETA: 0s - loss: 0.0210
```



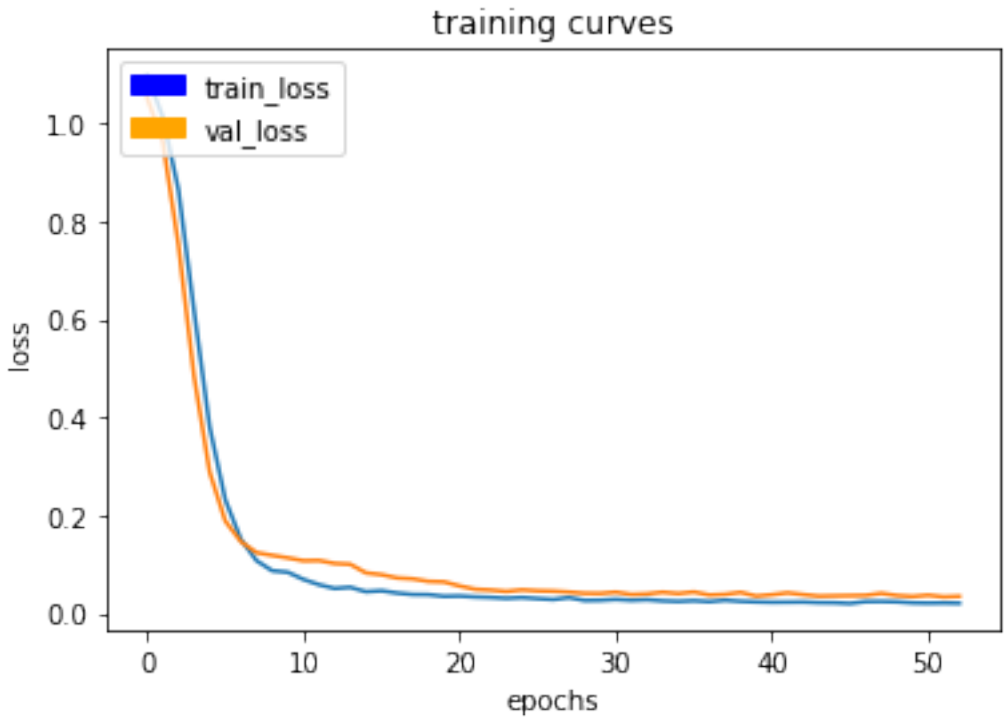

```
30/30 [==============================] - 23s - loss: 0.0213 - val_loss: 0.0343
Epoch 51/200
29/30 [============================>.] - ETA: 0s - loss: 0.0208
```



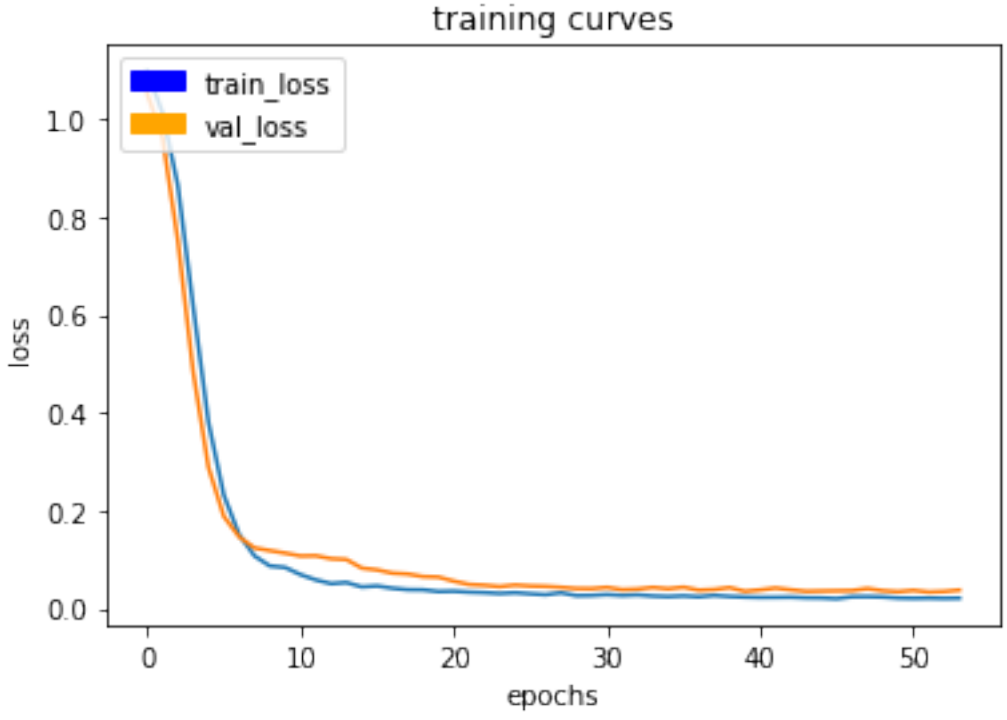
```
30/30 [==============================] - 23s - loss: 0.0208 - val_loss: 0.0369
Epoch 52/200
29/30 [============================>.] - ETA: 0s - loss: 0.0212
```



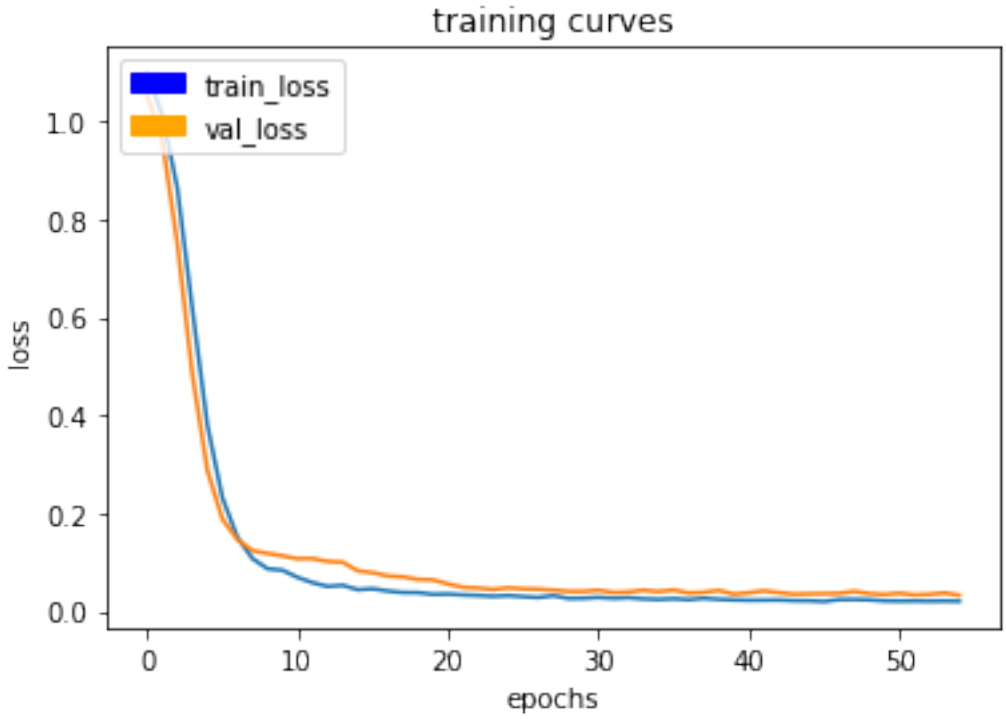

```
30/30 [==============================] - 23s - loss: 0.0212 - val_loss: 0.0336
Epoch 53/200
29/30 [============================>.] - ETA: 0s - loss: 0.0207
```



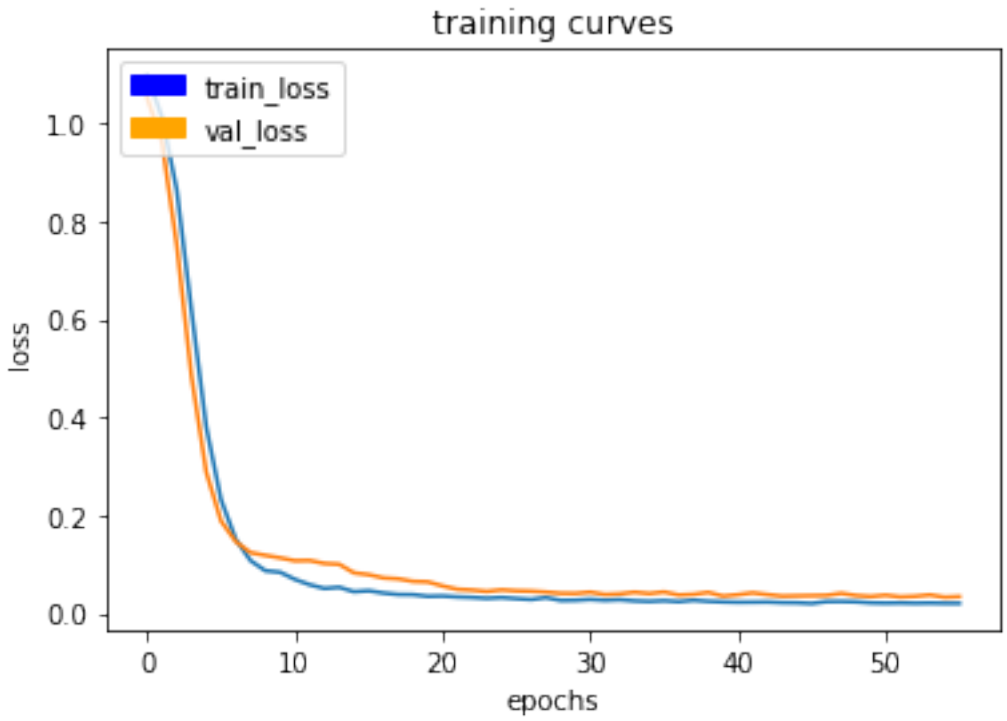

```
30/30 [==============================] - 23s - loss: 0.0206 - val_loss: 0.0347
Epoch 54/200
29/30 [============================>.] - ETA: 0s - loss: 0.0212
```



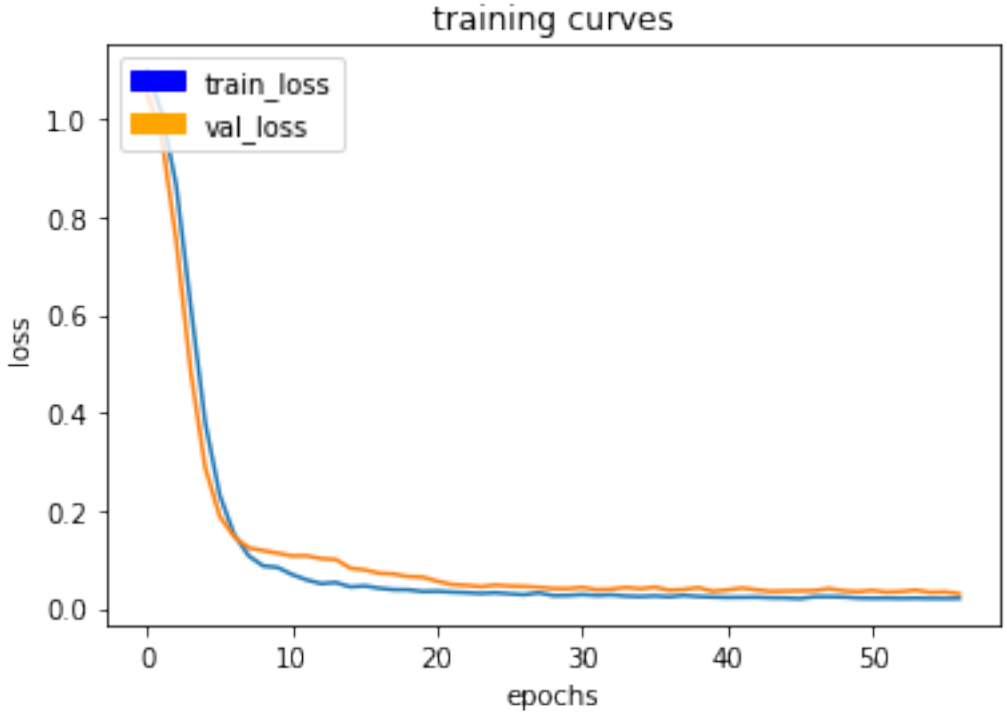
```
30/30 [==============================] - 23s - loss: 0.0210 - val_loss: 0.0376
Epoch 55/200
29/30 [============================>.] - ETA: 0s - loss: 0.0206
```



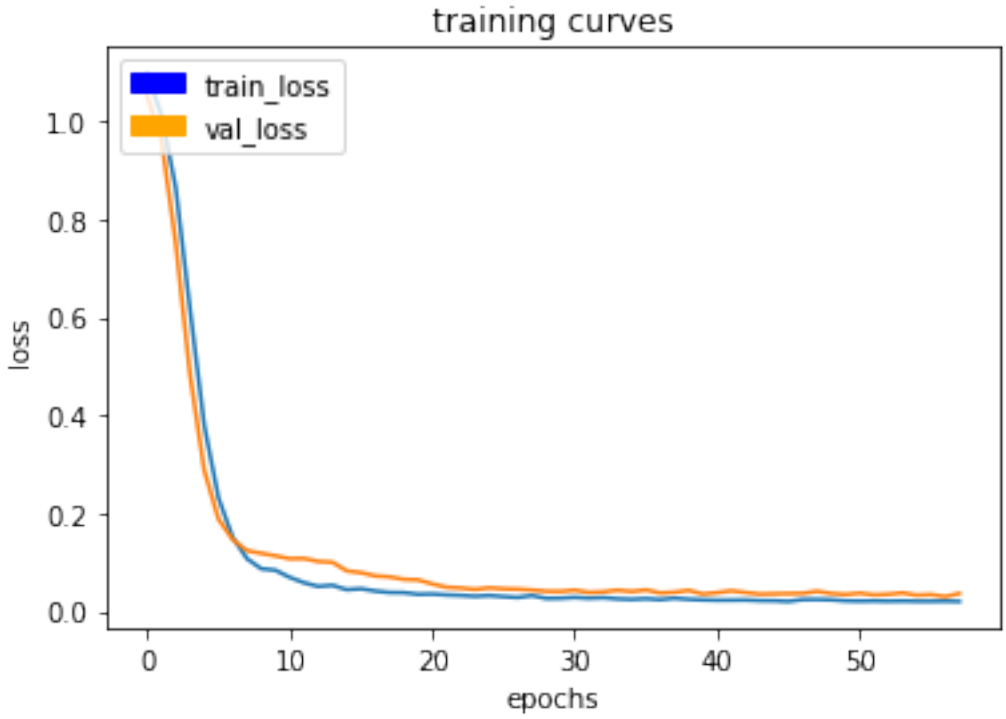

```
30/30 [==============================] - 23s - loss: 0.0205 - val_loss: 0.0329
Epoch 56/200
29/30 [============================>.] - ETA: 0s - loss: 0.0204
```



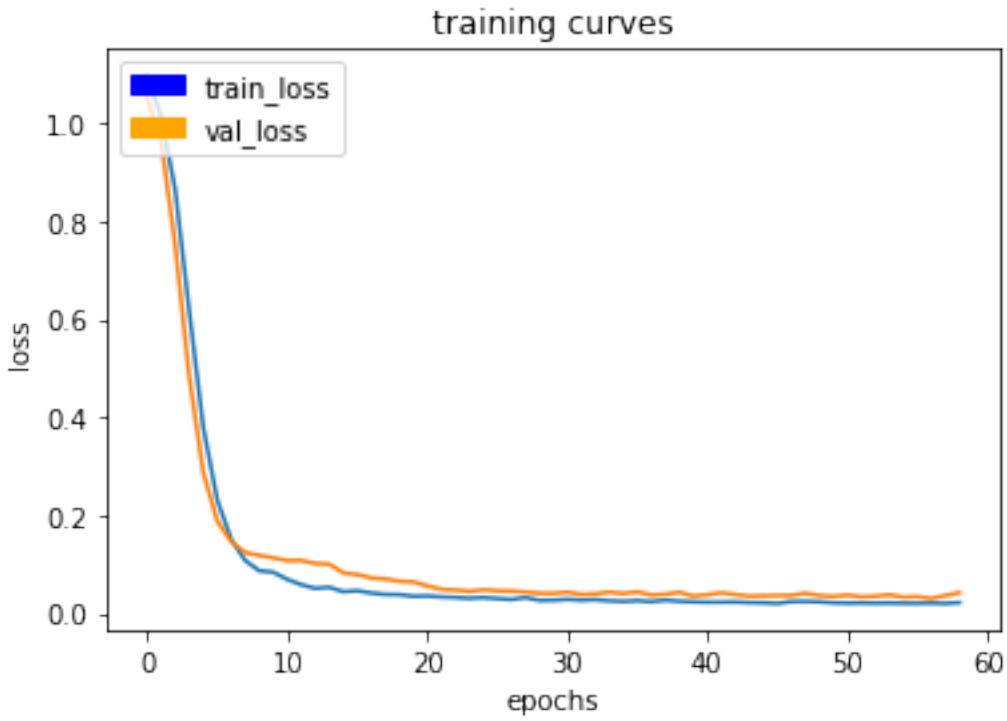

```
30/30 [==============================] - 23s - loss: 0.0204 - val_loss: 0.0341
Epoch 57/200
29/30 [============================>.] - ETA: 0s - loss: 0.0207
```



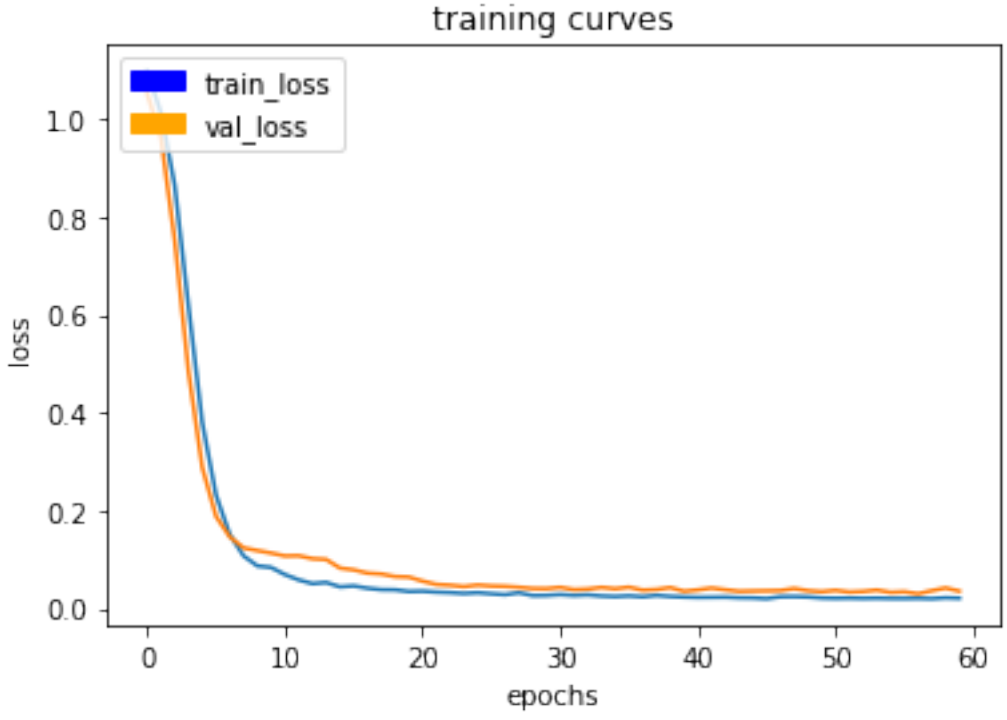
```
30/30 [==============================] - 23s - loss: 0.0207 - val_loss: 0.0300
Epoch 58/200
29/30 [============================>.] - ETA: 0s - loss: 0.0201
```



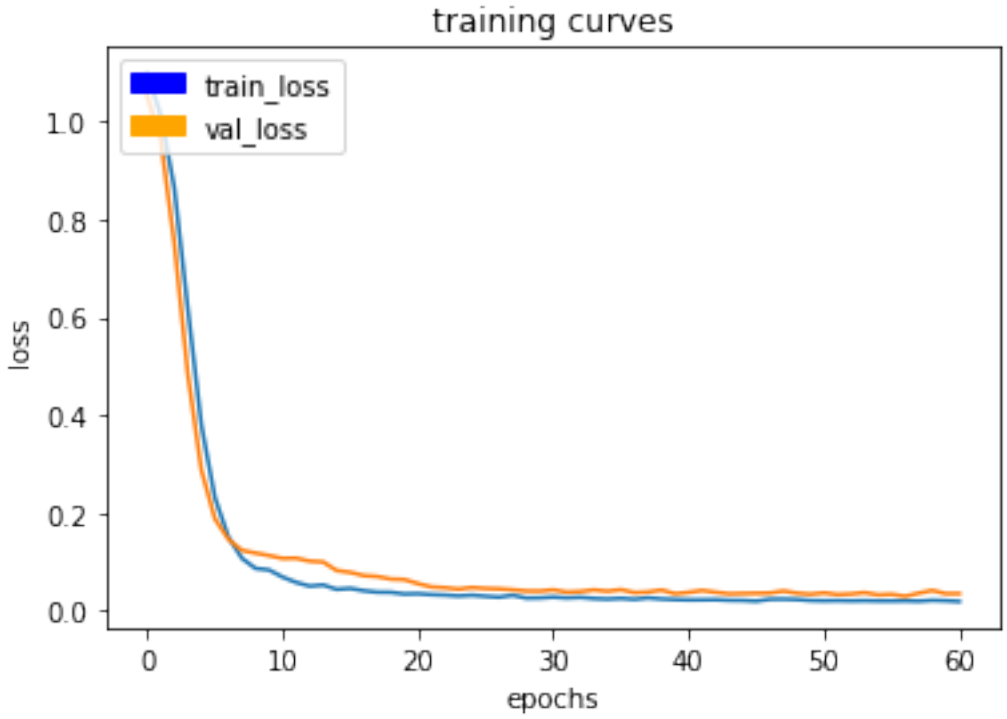

```
30/30 [==============================] - 23s - loss: 0.0200 - val_loss: 0.0363
Epoch 59/200
29/30 [============================>.] - ETA: 0s - loss: 0.0216
```



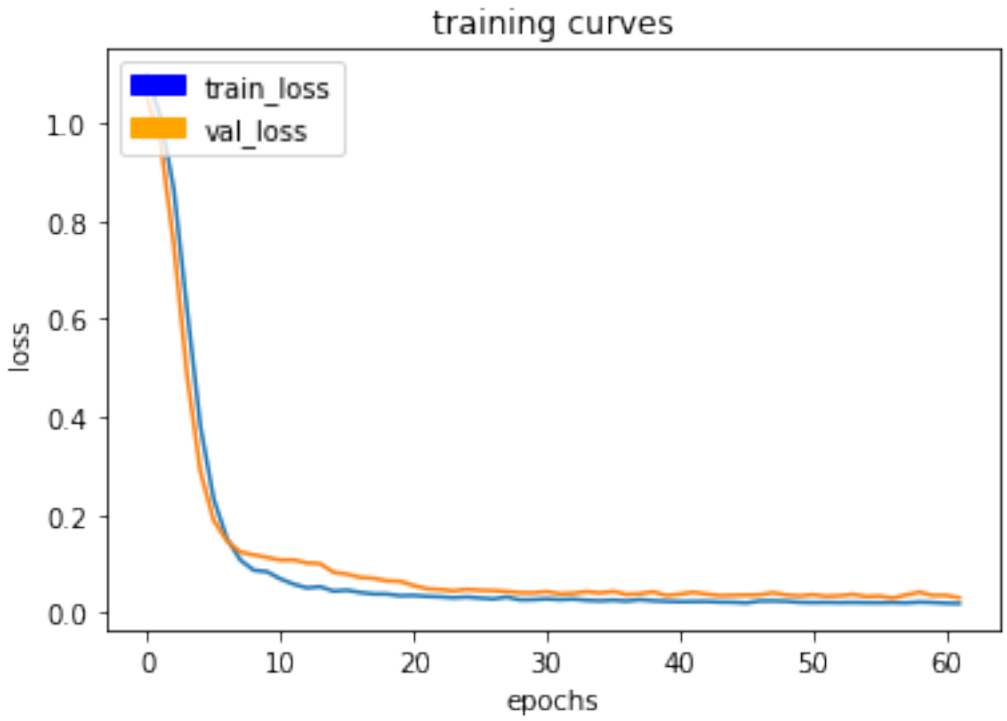

```
30/30 [==============================] - 23s - loss: 0.0217 - val_loss: 0.0419
Epoch 60/200
29/30 [============================>.] - ETA: 0s - loss: 0.0209
```



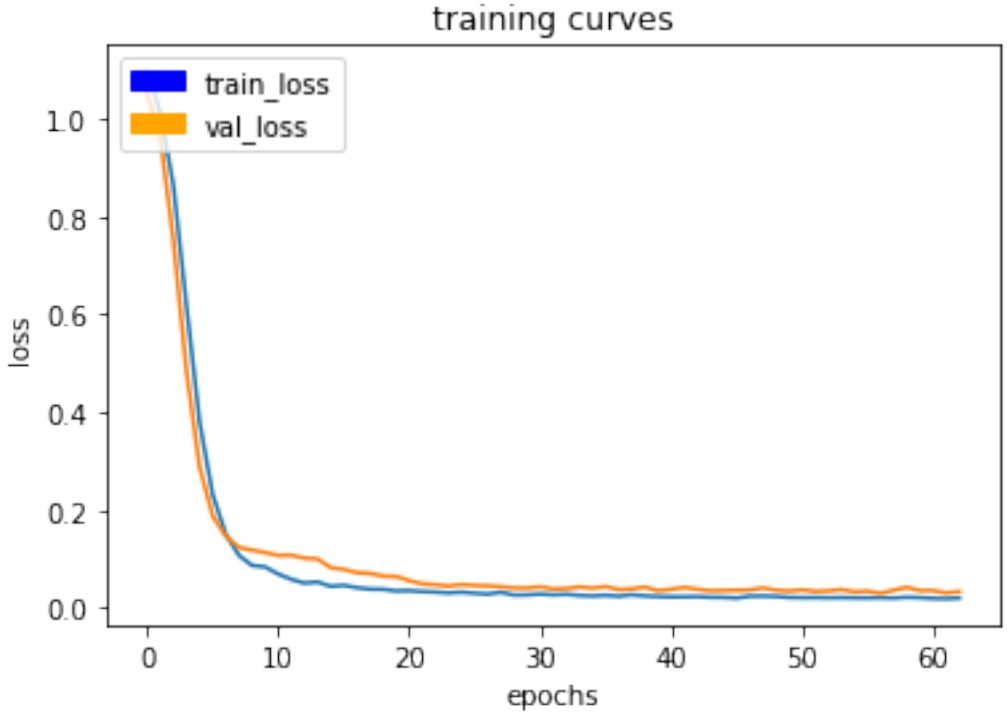
```
30/30 [==============================] - 23s - loss: 0.0209 - val_loss: 0.0354
Epoch 61/200
29/30 [============================>.] - ETA: 0s - loss: 0.0195
```



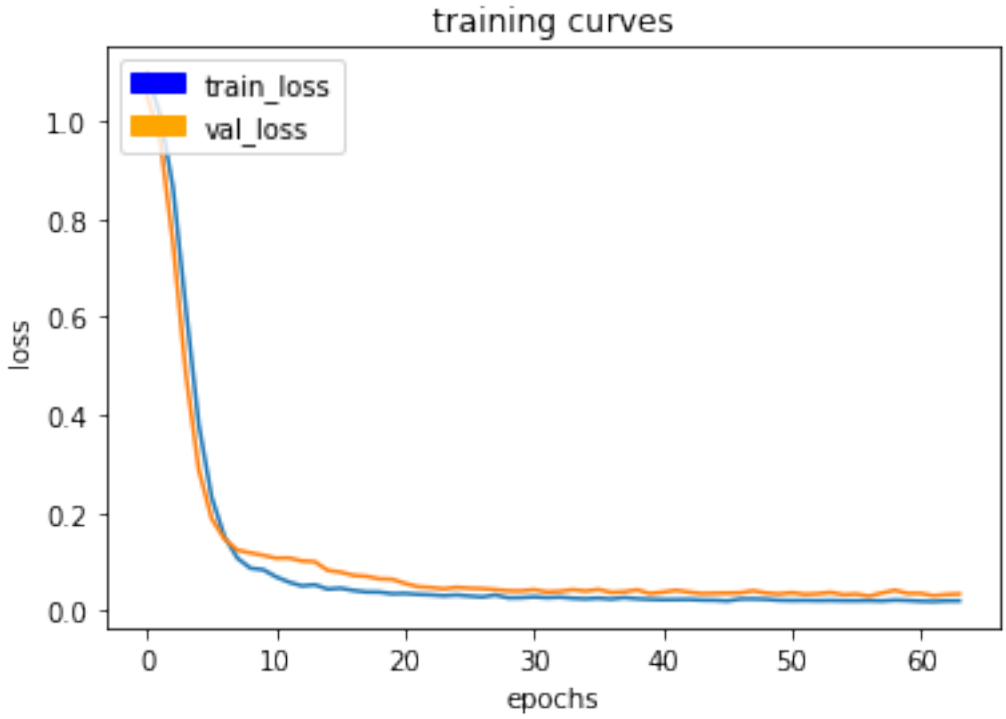

```
30/30 [==============================] - 23s - loss: 0.0194 - val_loss: 0.0354
Epoch 62/200
29/30 [============================>.] - ETA: 0s - loss: 0.0188
```



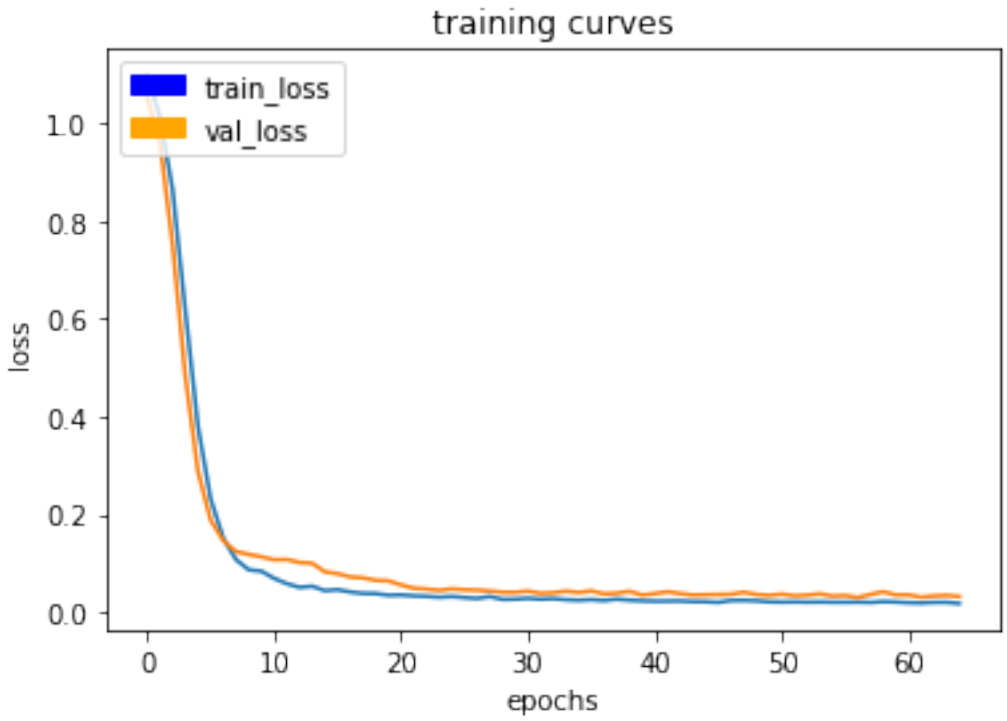

```
30/30 [==============================] - 23s - loss: 0.0189 - val_loss: 0.0306
Epoch 63/200
29/30 [============================>.] - ETA: 0s - loss: 0.0203
```



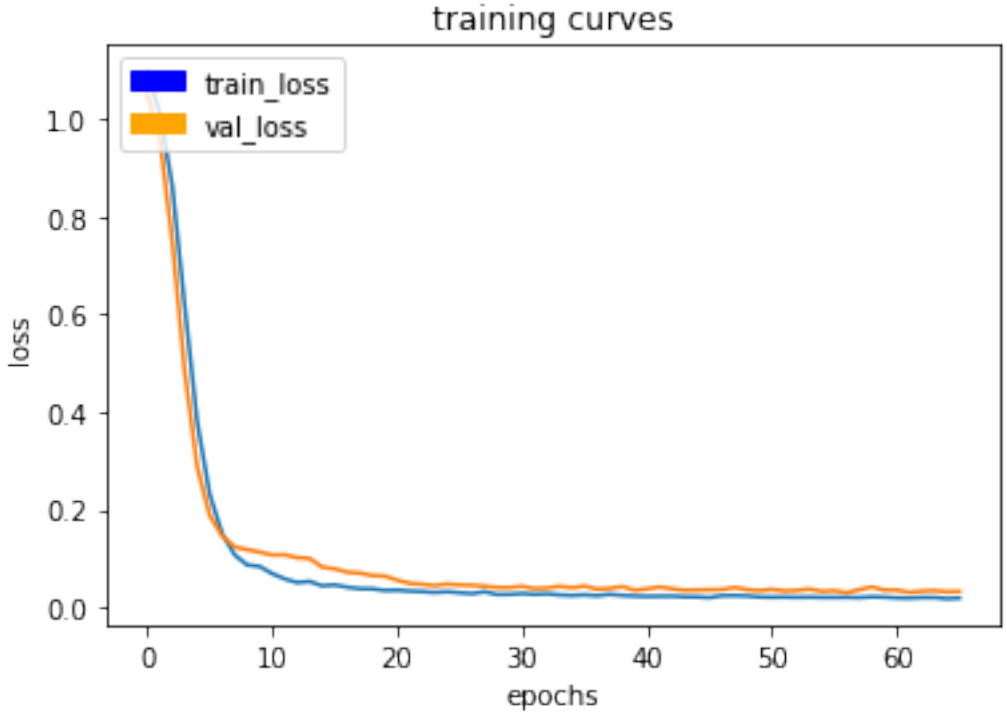
```
30/30 [==============================] - 23s - loss: 0.0201 - val_loss: 0.0331
Epoch 64/200
29/30 [============================>.] - ETA: 0s - loss: 0.0203
```



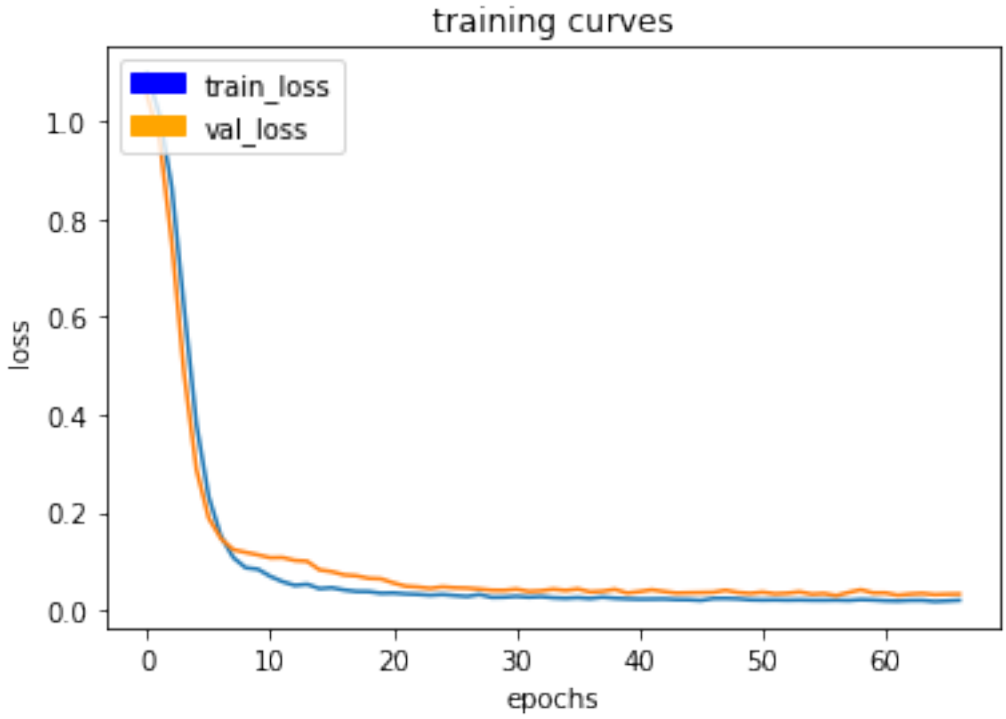

```
30/30 [==============================] - 23s - loss: 0.0201 - val_loss: 0.0344
Epoch 65/200
29/30 [============================>.] - ETA: 0s - loss: 0.0174
```



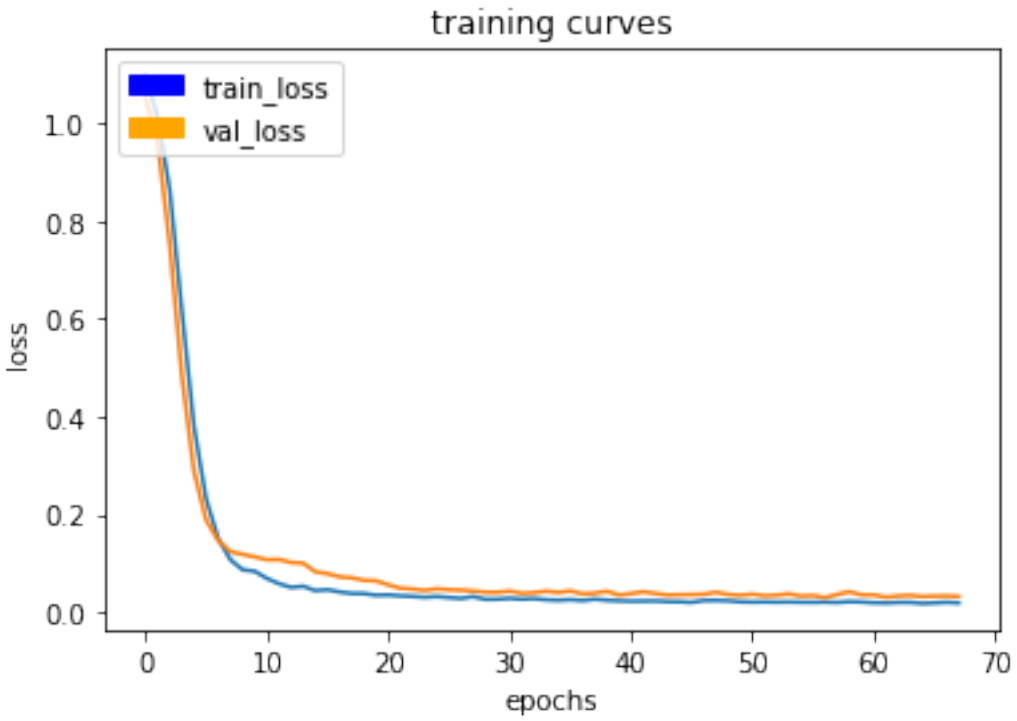

```
30/30 [==============================] - 23s - loss: 0.0179 - val_loss: 0.0319
Epoch 66/200
29/30 [============================>.] - ETA: 0s - loss: 0.0190
```



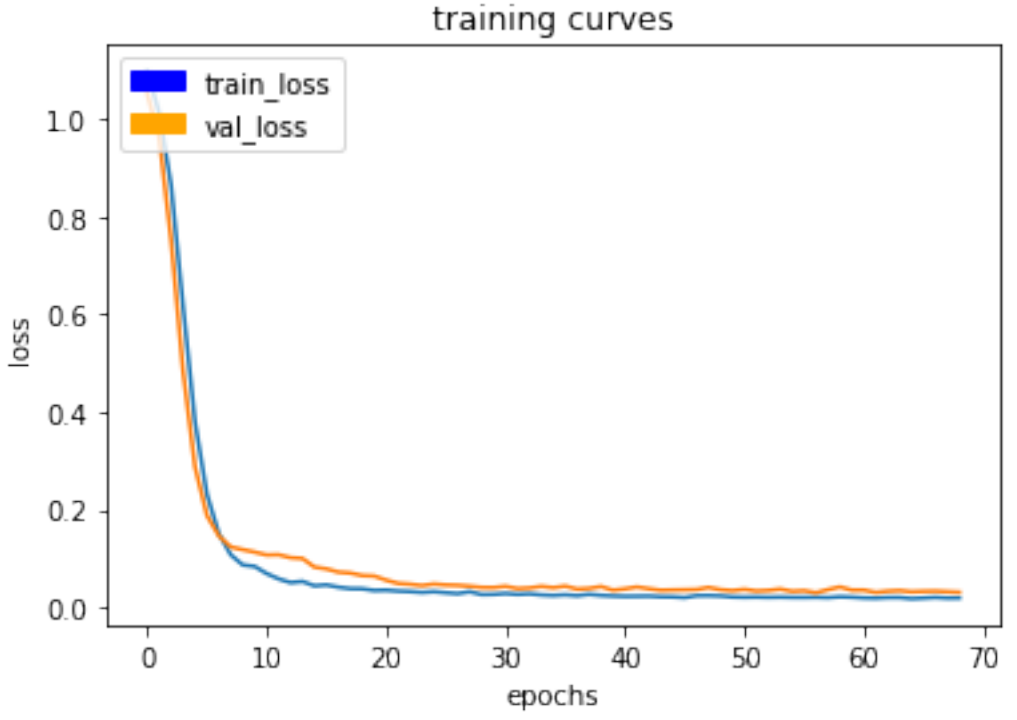
```
30/30 [==============================] - 23s - loss: 0.0190 - val_loss: 0.0328
Epoch 67/200
29/30 [============================>.] - ETA: 0s - loss: 0.0204
```



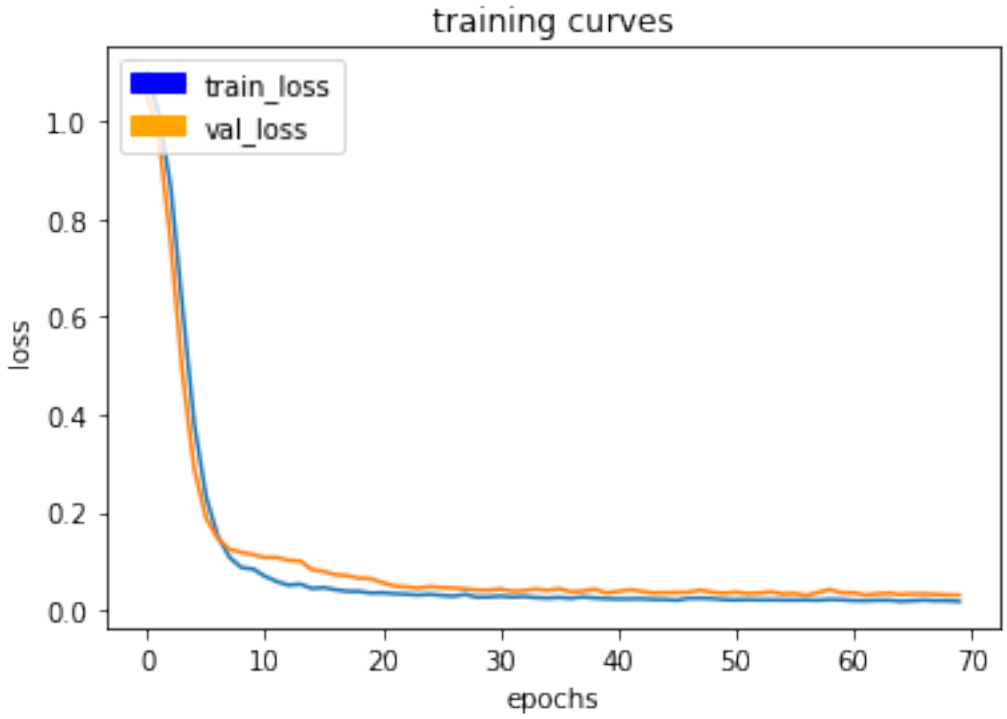

```
30/30 [==============================] - 23s - loss: 0.0204 - val_loss: 0.0332
Epoch 68/200
29/30 [============================>.] - ETA: 0s - loss: 0.0191
```



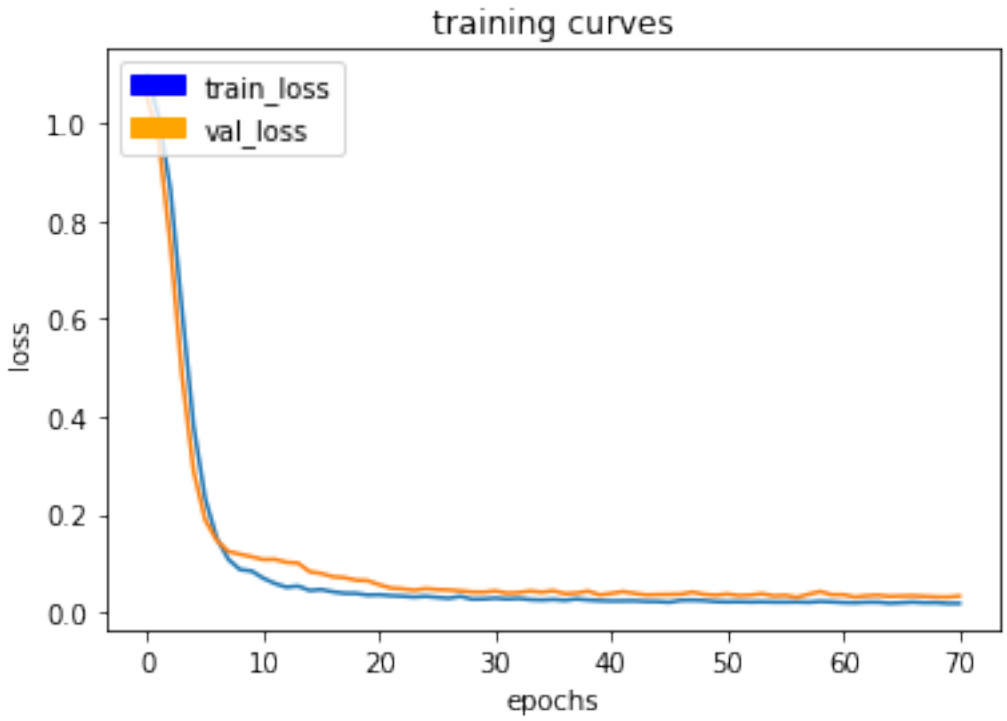

```
30/30 [==============================] - 23s - loss: 0.0189 - val_loss: 0.0320
Epoch 69/200
29/30 [============================>.] - ETA: 0s - loss: 0.0193
```



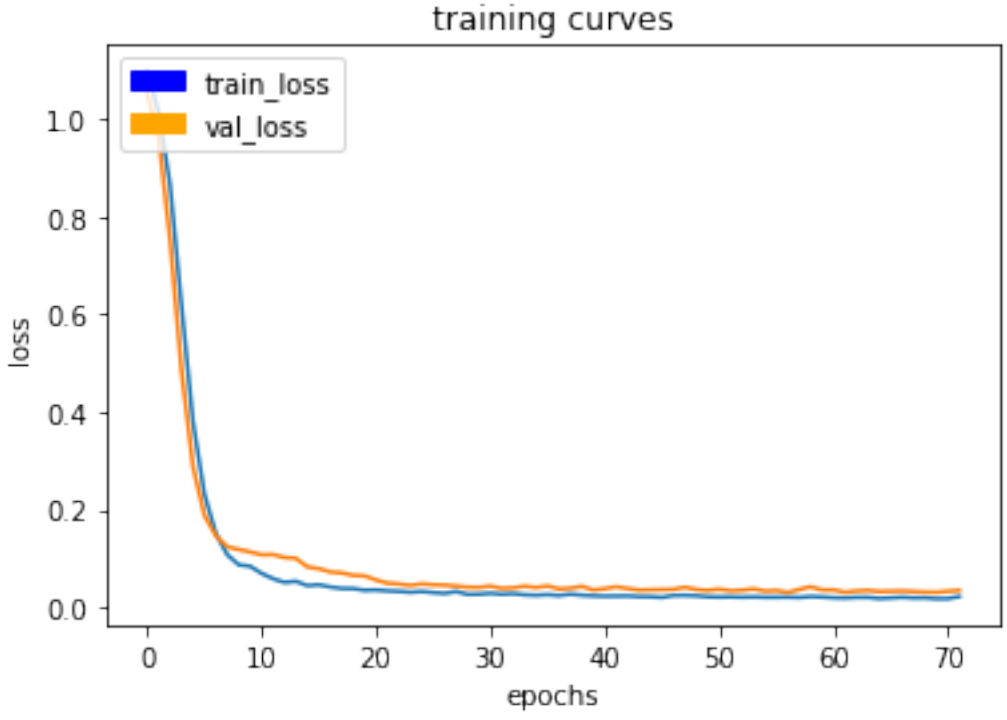
```
30/30 [==============================] - 23s - loss: 0.0192 - val_loss: 0.0309
Epoch 70/200
29/30 [============================>.] - ETA: 0s - loss: 0.0176
```



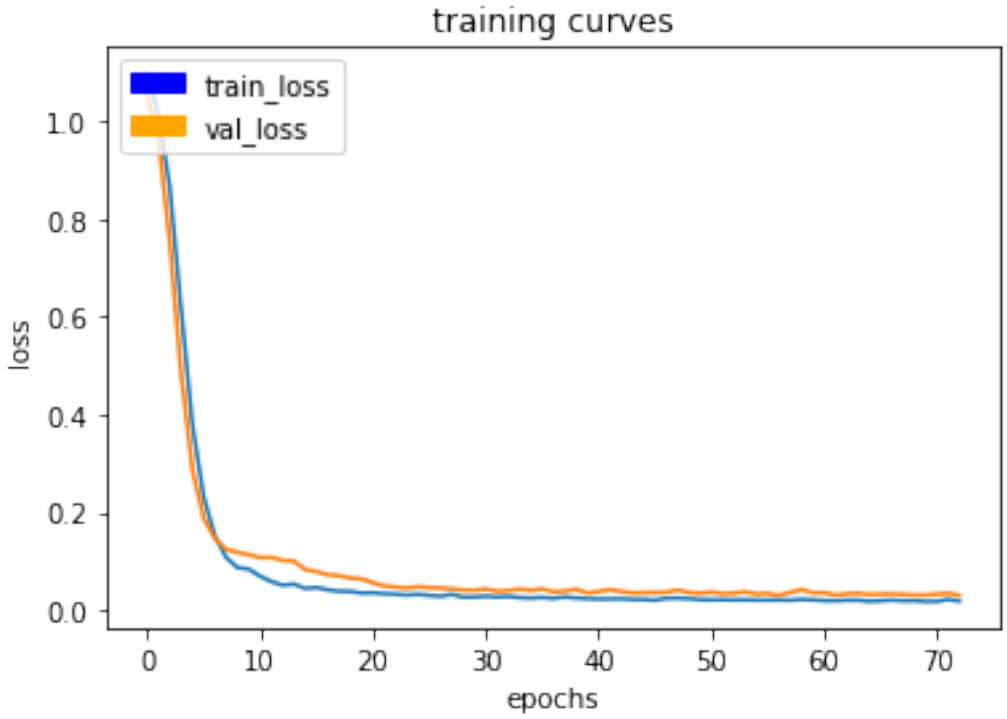

```
30/30 [==============================] - 23s - loss: 0.0175 - val_loss: 0.0306
Epoch 71/200
29/30 [============================>.] - ETA: 0s - loss: 0.0176
```



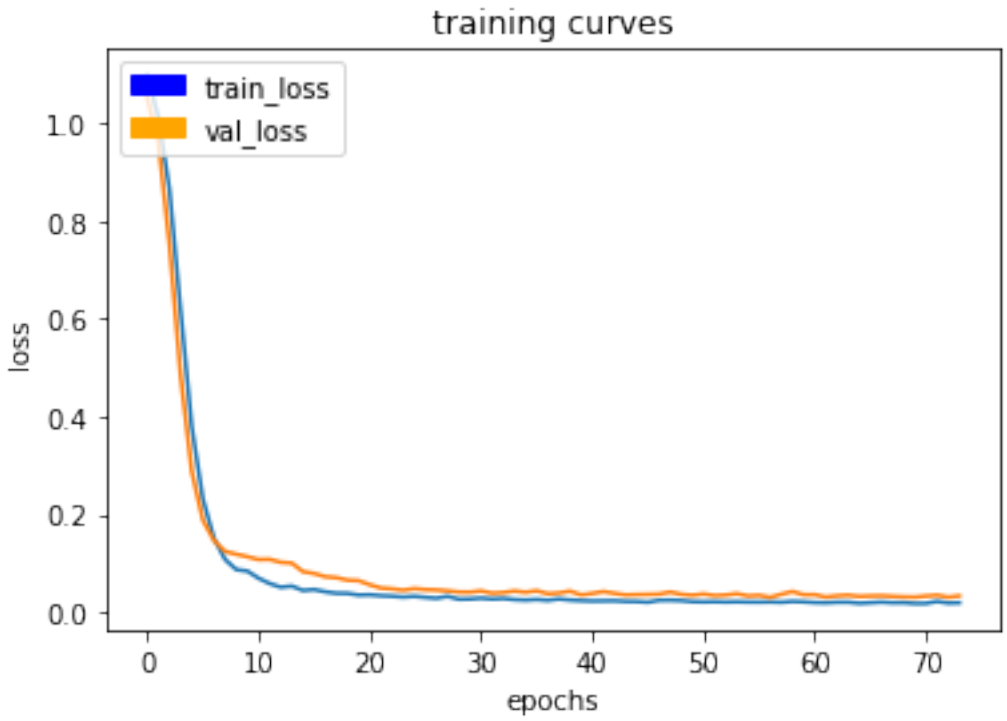

```
30/30 [==============================] - 23s - loss: 0.0176 - val_loss: 0.0326
Epoch 72/200
29/30 [============================>.] - ETA: 0s - loss: 0.0219
```



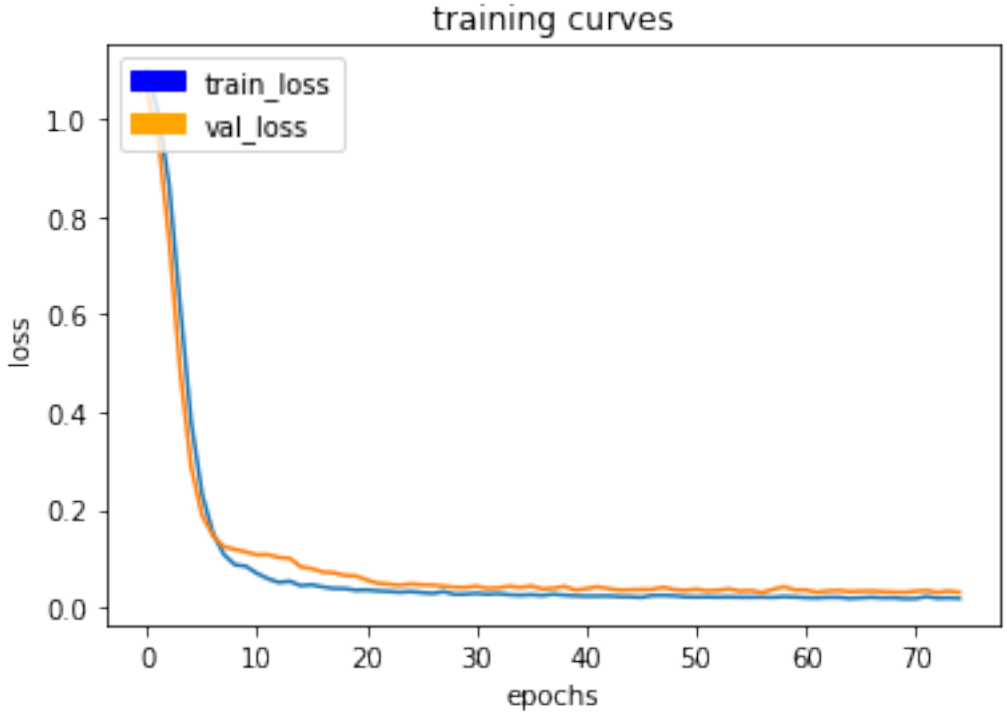
```
30/30 [==============================] - 23s - loss: 0.0218 - val_loss: 0.0343
Epoch 73/200
29/30 [============================>.] - ETA: 0s - loss: 0.0184
```



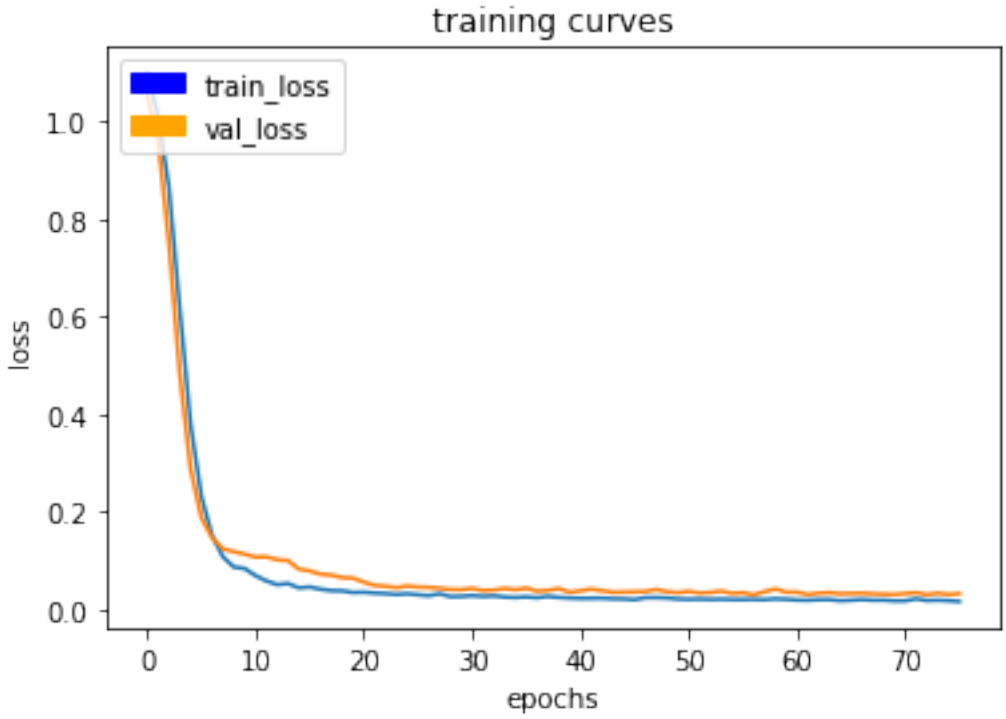

```
30/30 [==============================] - 23s - loss: 0.0183 - val_loss: 0.0303
Epoch 74/200
29/30 [============================>.] - ETA: 0s - loss: 0.0189
```



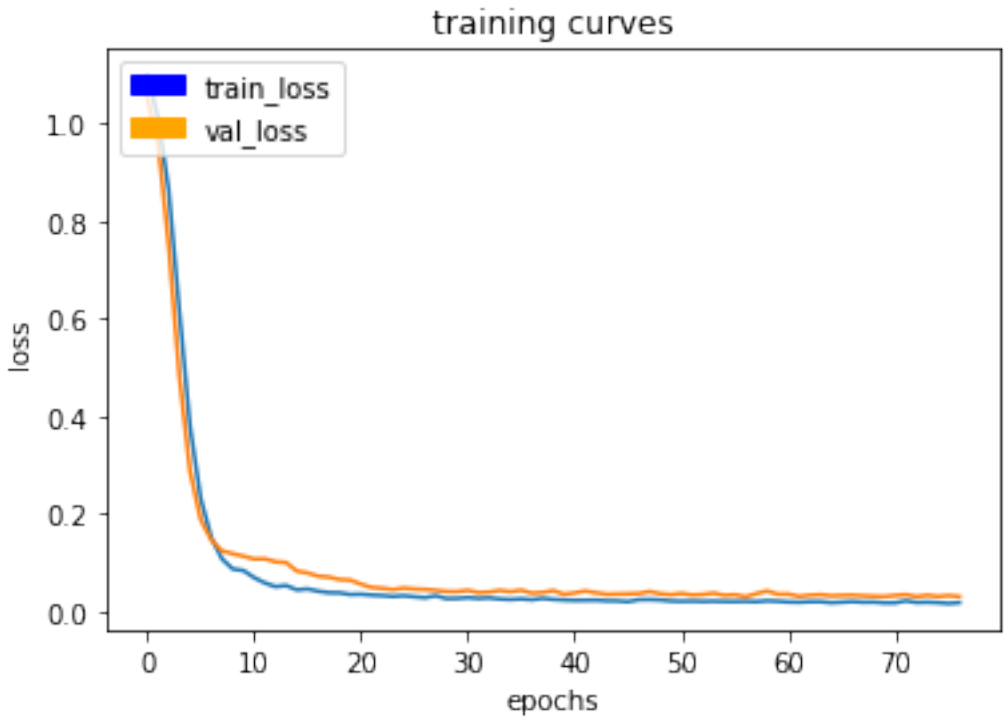

```
30/30 [==============================] - 23s - loss: 0.0189 - val_loss: 0.0331
Epoch 75/200
29/30 [============================>.] - ETA: 0s - loss: 0.0180
```



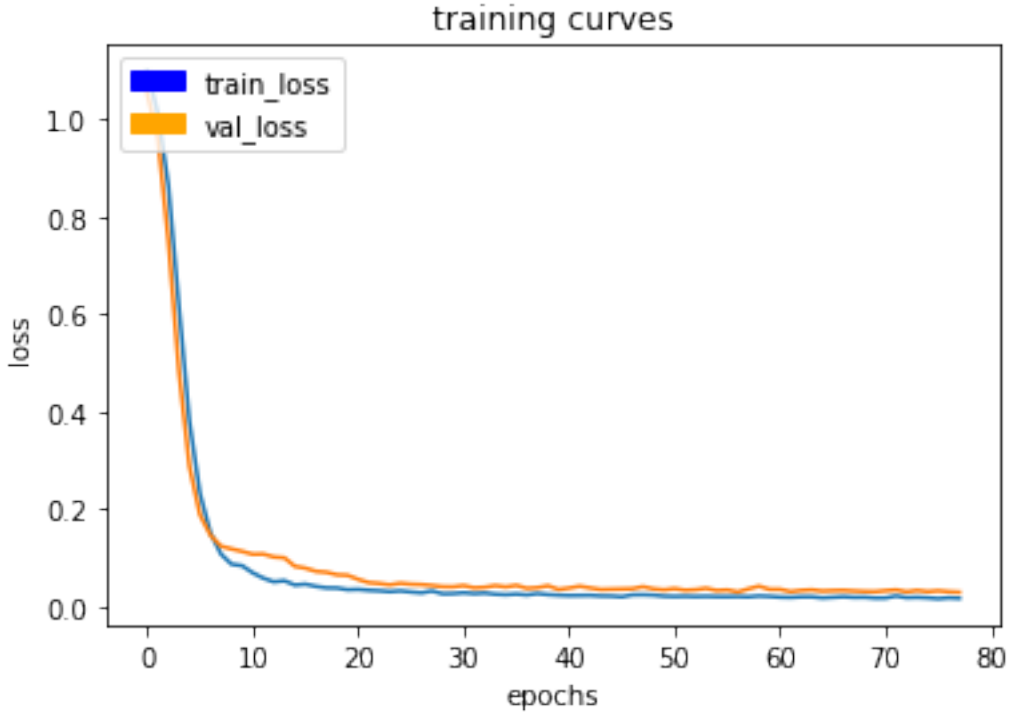
```
30/30 [==============================] - 23s - loss: 0.0180 - val_loss: 0.0307
Epoch 76/200
29/30 [============================>.] - ETA: 0s - loss: 0.0163
```



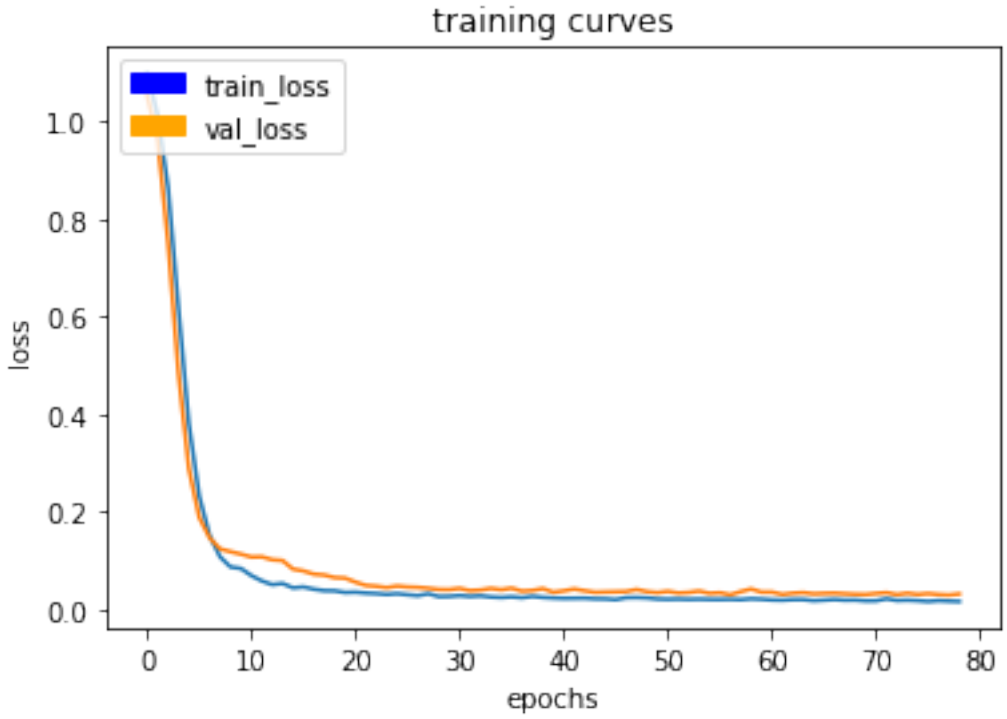

```
30/30 [==============================] - 23s - loss: 0.0163 - val_loss: 0.0324
Epoch 77/200
29/30 [============================>.] - ETA: 0s - loss: 0.0181
```



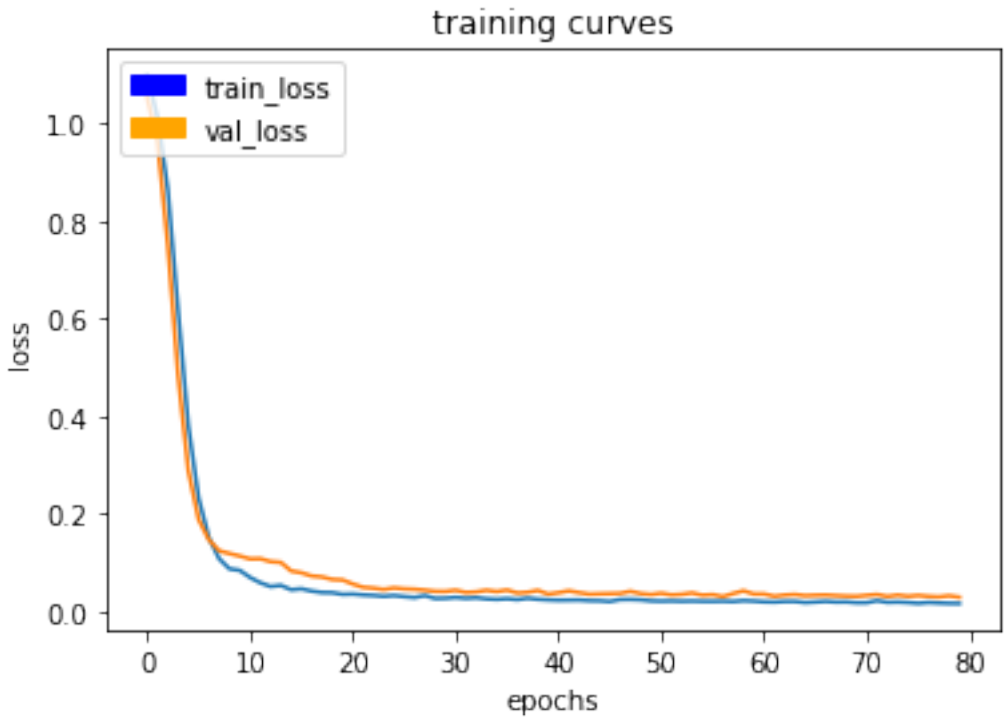

```
30/30 [==============================] - 23s - loss: 0.0180 - val_loss: 0.0305
Epoch 78/200
29/30 [============================>.] - ETA: 0s - loss: 0.0171
```



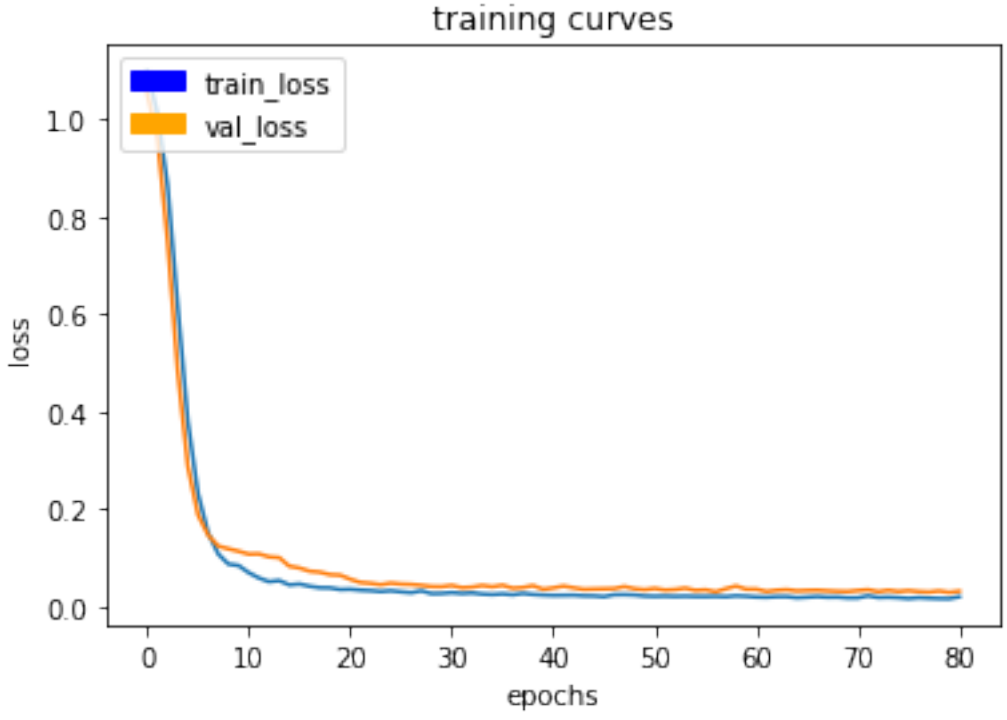
```
30/30 [==============================] - 23s - loss: 0.0169 - val_loss: 0.0294
Epoch 79/200
29/30 [============================>.] - ETA: 0s - loss: 0.0163
```



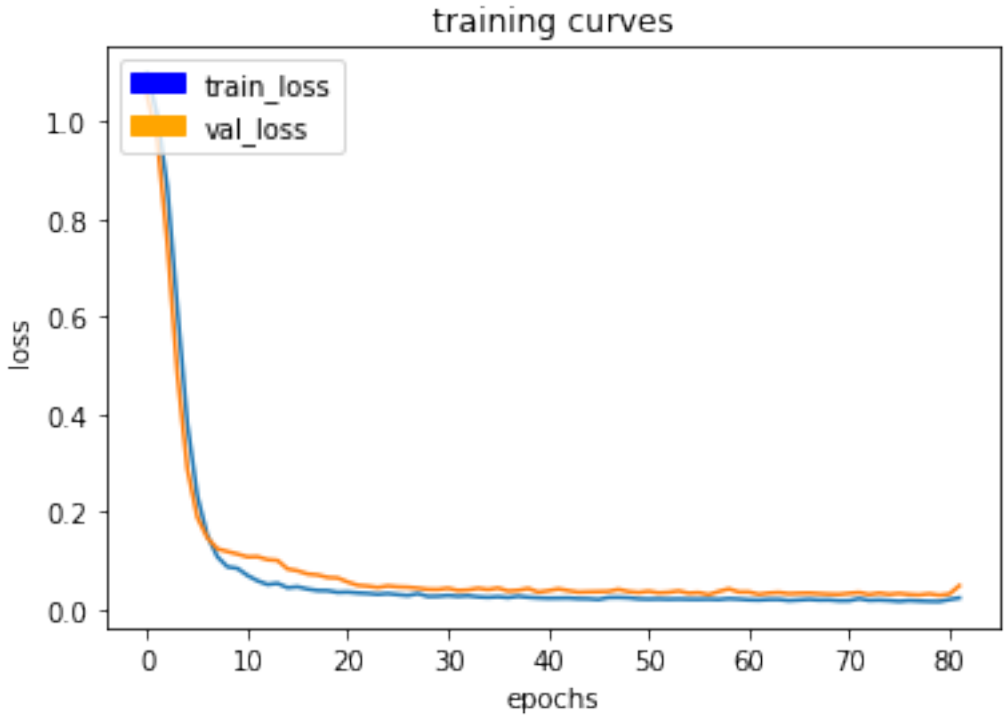

```
30/30 [==============================] - 23s - loss: 0.0162 - val_loss: 0.0317
Epoch 80/200
29/30 [============================>.] - ETA: 0s - loss: 0.0160
```



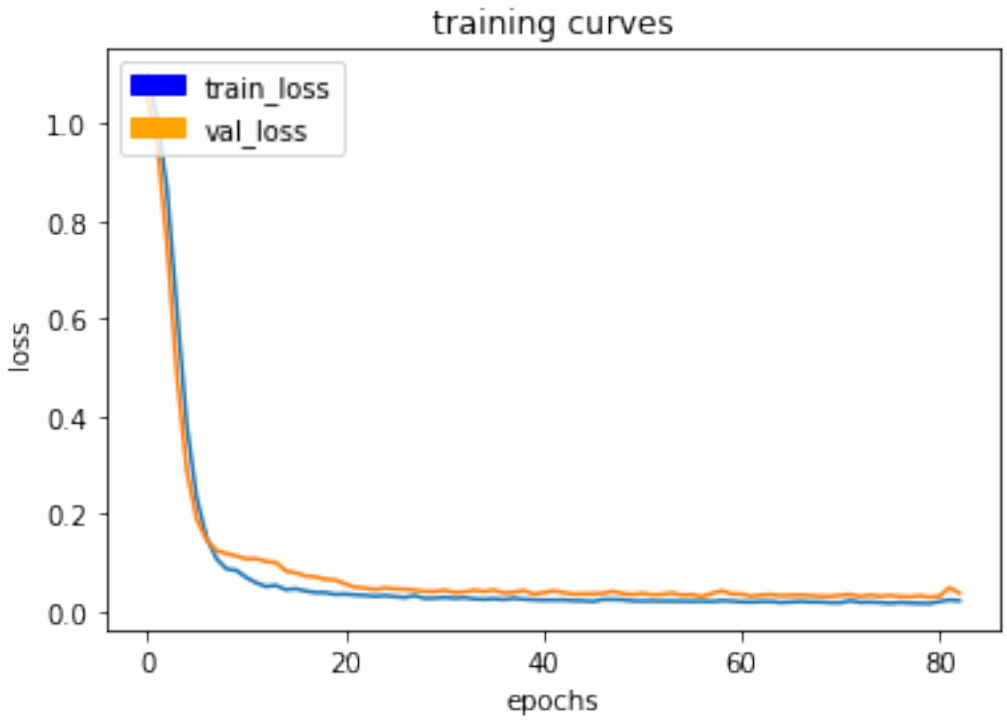

```
30/30 [==============================] - 23s - loss: 0.0160 - val_loss: 0.0288
Epoch 81/200
29/30 [============================>.] - ETA: 0s - loss: 0.0195
```



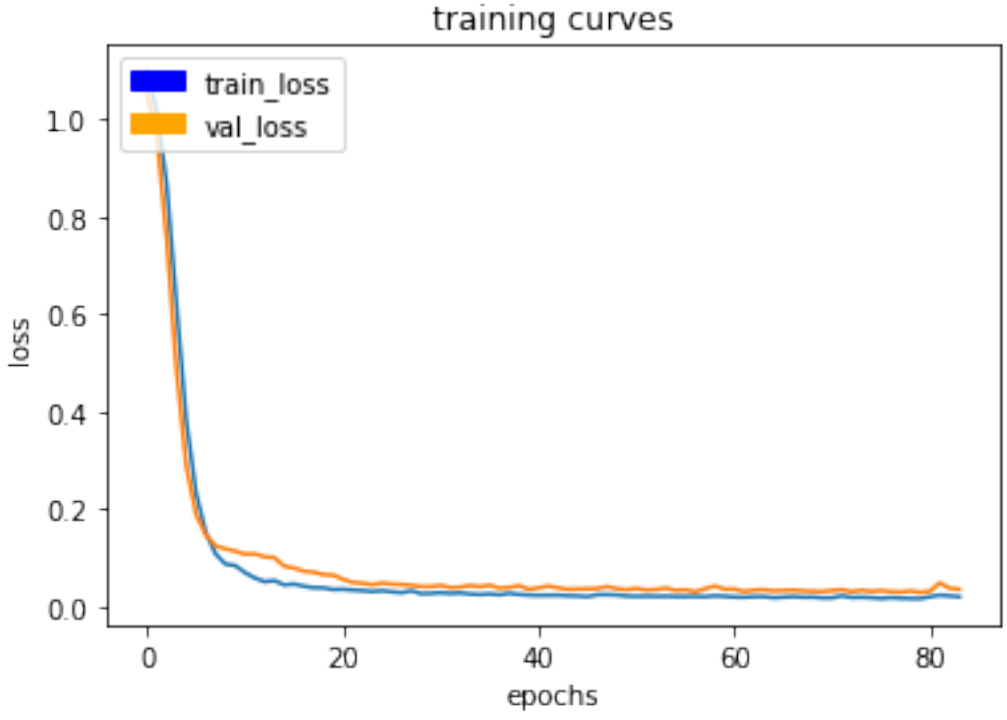
```
30/30 [==============================] - 23s - loss: 0.0199 - val_loss: 0.0313
Epoch 82/200
29/30 [============================>.] - ETA: 0s - loss: 0.0227
```



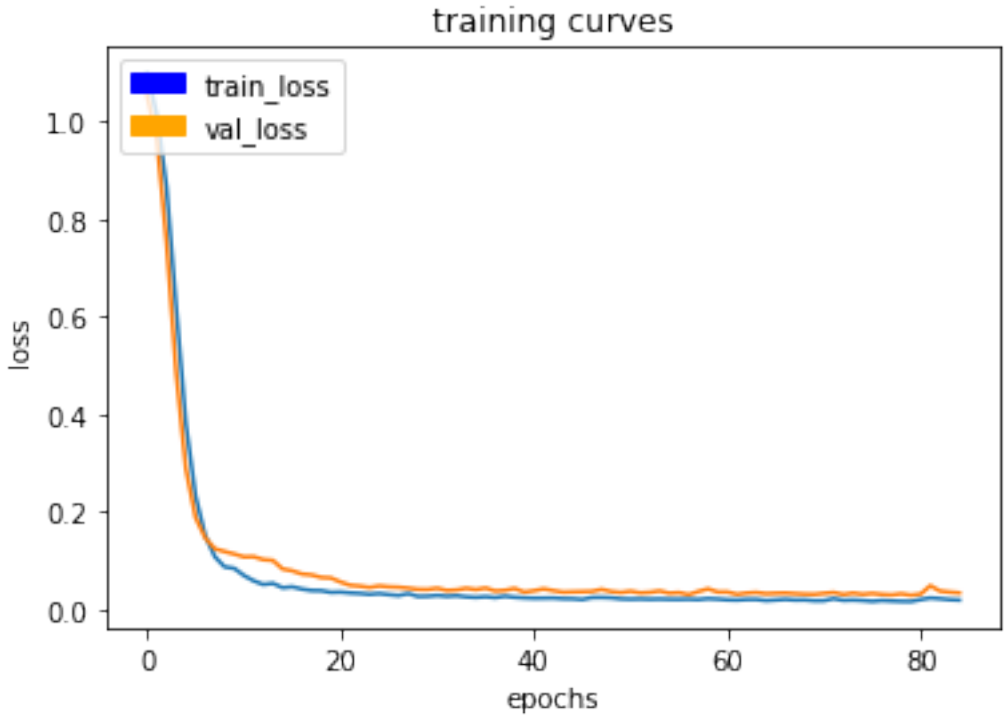

```
30/30 [==============================] - 23s - loss: 0.0232 - val_loss: 0.0483
Epoch 83/200
29/30 [============================>.] - ETA: 0s - loss: 0.0217
```



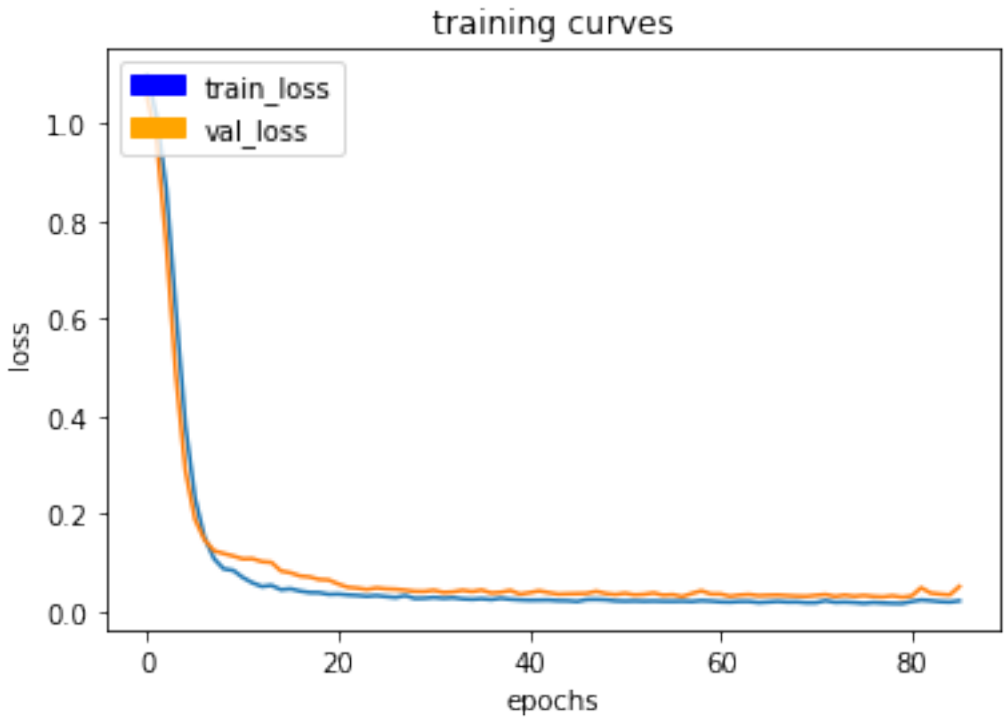

```
30/30 [==============================] - 23s - loss: 0.0217 - val_loss: 0.0372
Epoch 84/200
29/30 [============================>.] - ETA: 0s - loss: 0.0198
```



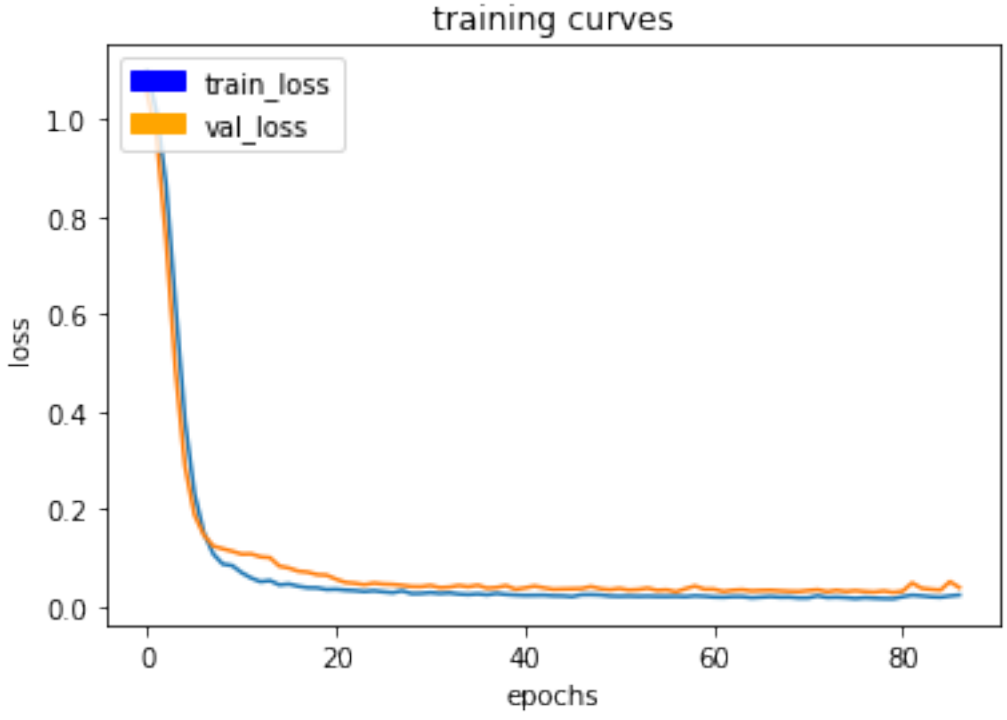
```
30/30 [==============================] - 23s - loss: 0.0198 - val_loss: 0.0351
Epoch 85/200
29/30 [============================>.] - ETA: 0s - loss: 0.0189
```



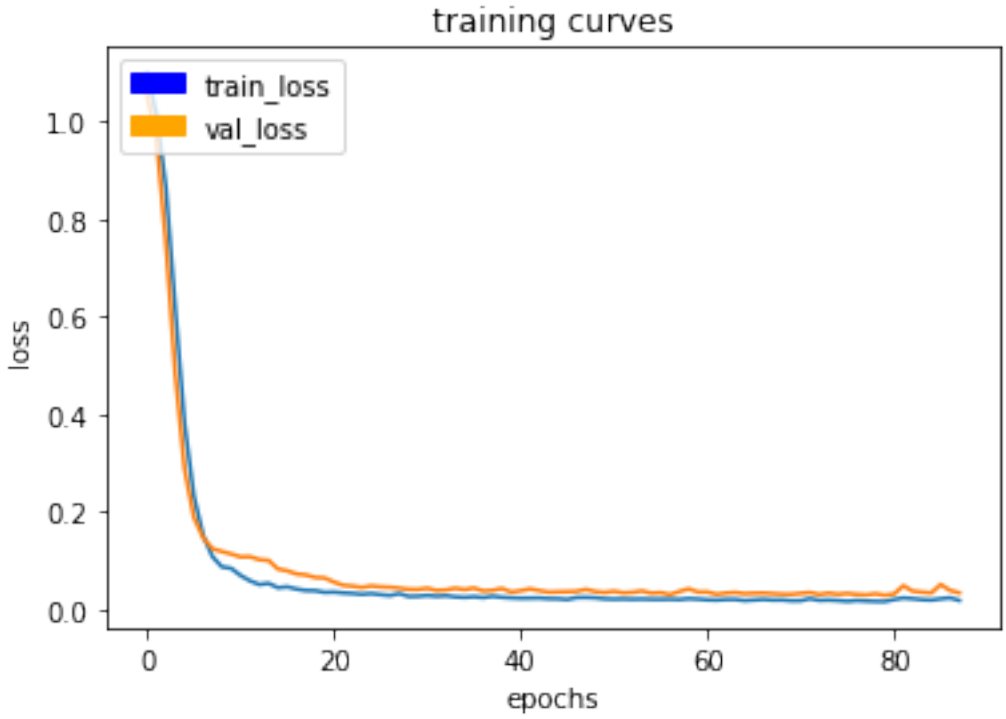

```
30/30 [==============================] - 23s - loss: 0.0189 - val_loss: 0.0335
Epoch 86/200
29/30 [============================>.] - ETA: 0s - loss: 0.0208
```



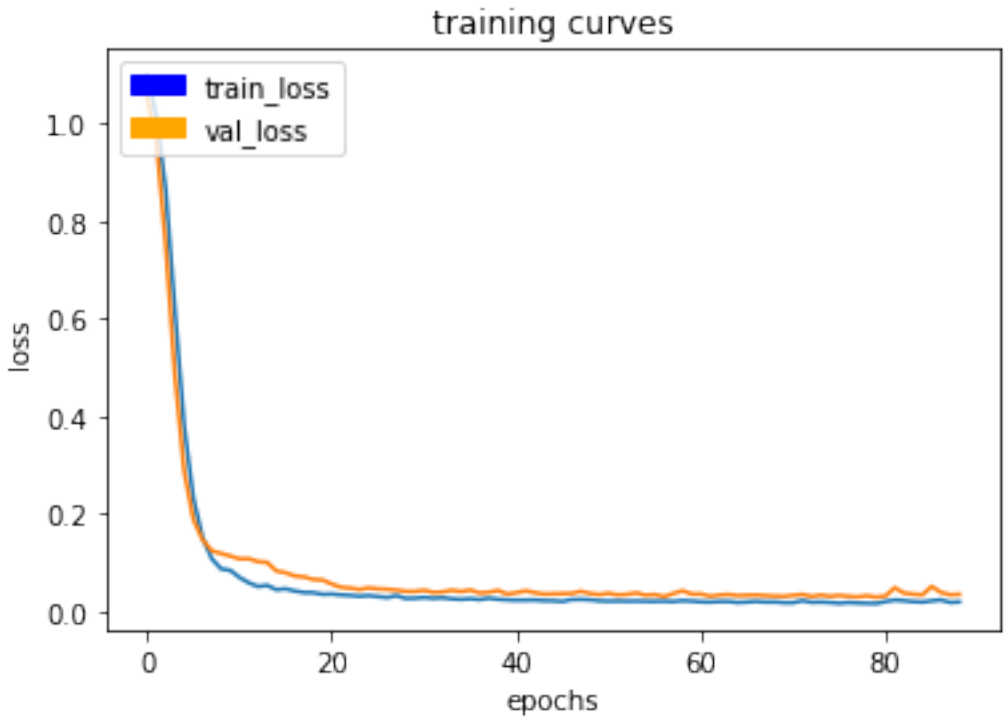

```
30/30 [==============================] - 23s - loss: 0.0215 - val_loss: 0.0508
Epoch 87/200
29/30 [============================>.] - ETA: 0s - loss: 0.0236
```



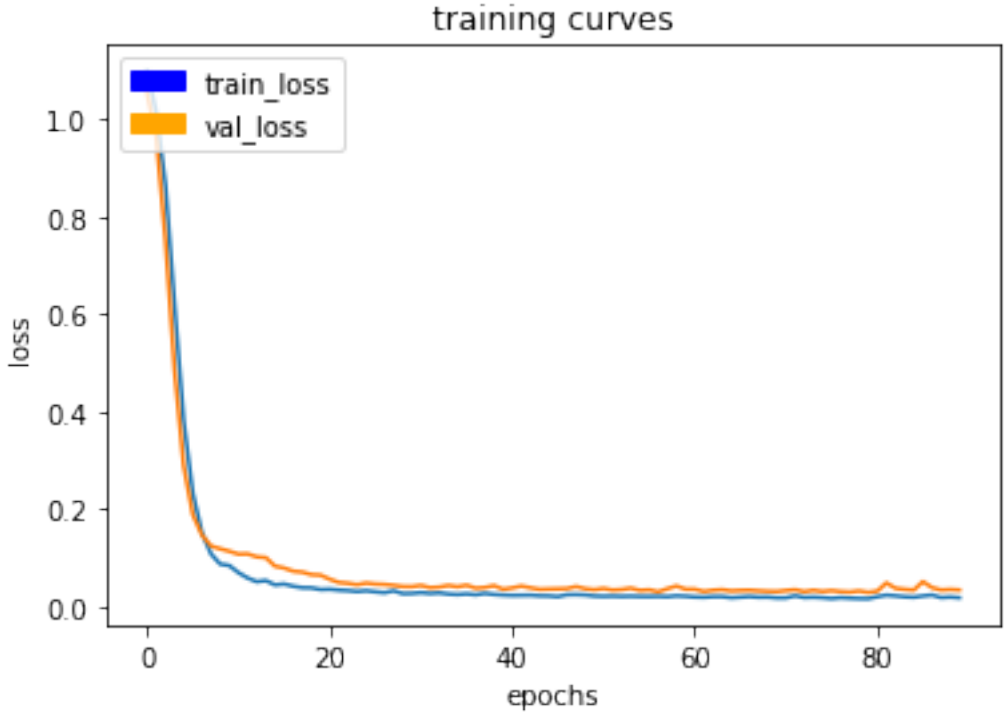
```
30/30 [==============================] - 23s - loss: 0.0234 - val_loss: 0.0386
Epoch 88/200
29/30 [============================>.] - ETA: 0s - loss: 0.0180
```



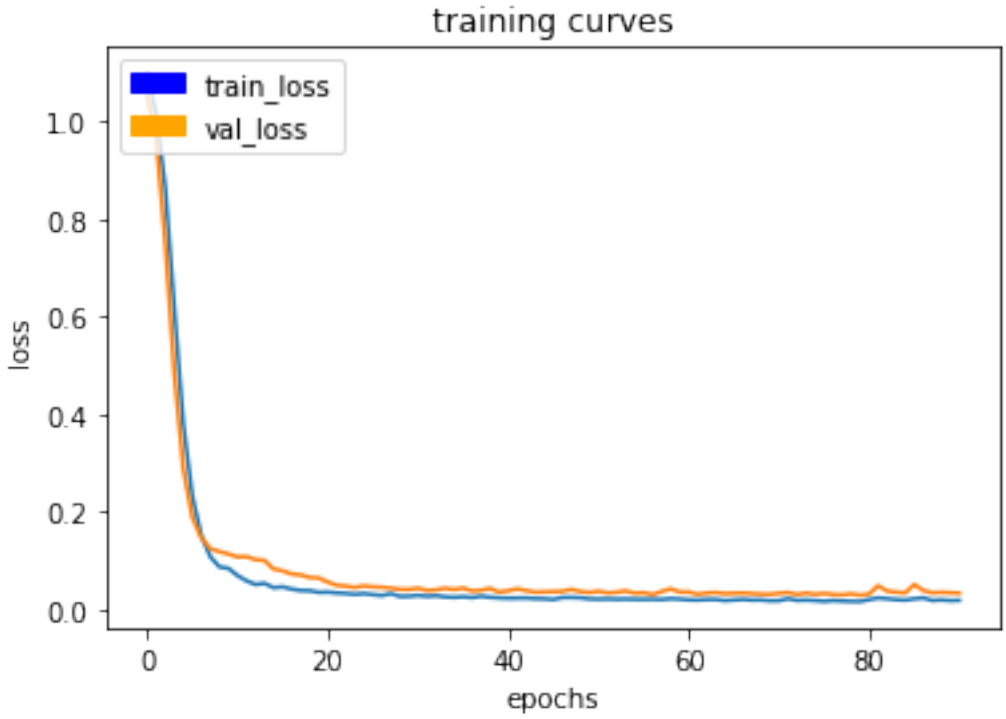

```
30/30 [==============================] - 23s - loss: 0.0181 - val_loss: 0.0337
Epoch 89/200
29/30 [============================>.] - ETA: 0s - loss: 0.0194
```



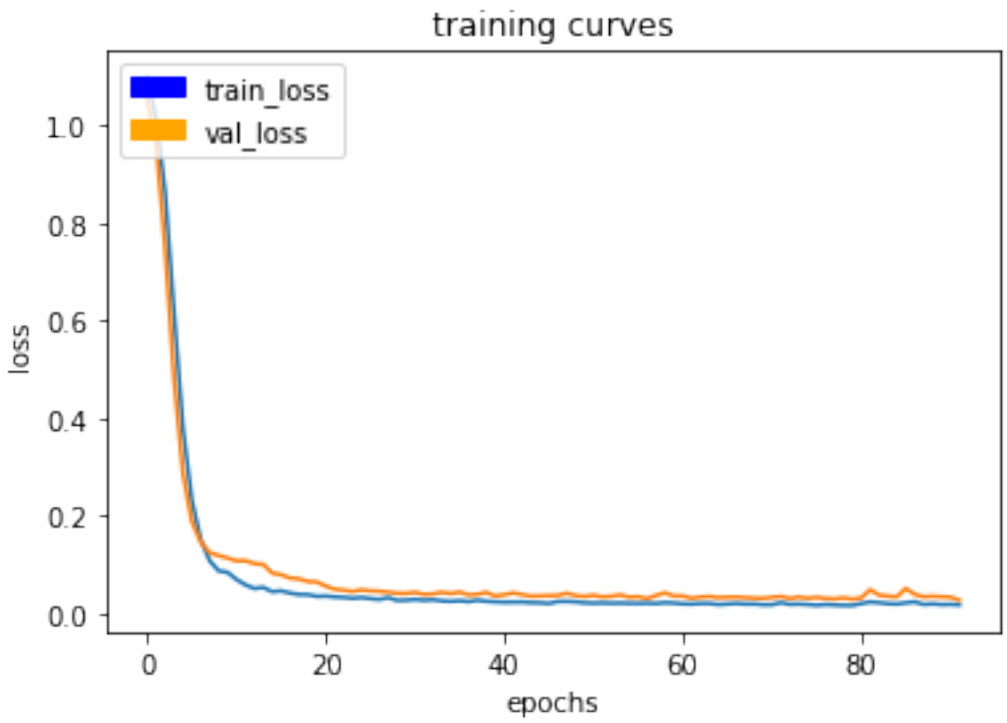

```
30/30 [==============================] - 23s - loss: 0.0193 - val_loss: 0.0348
Epoch 90/200
29/30 [============================>.] - ETA: 0s - loss: 0.0178
```



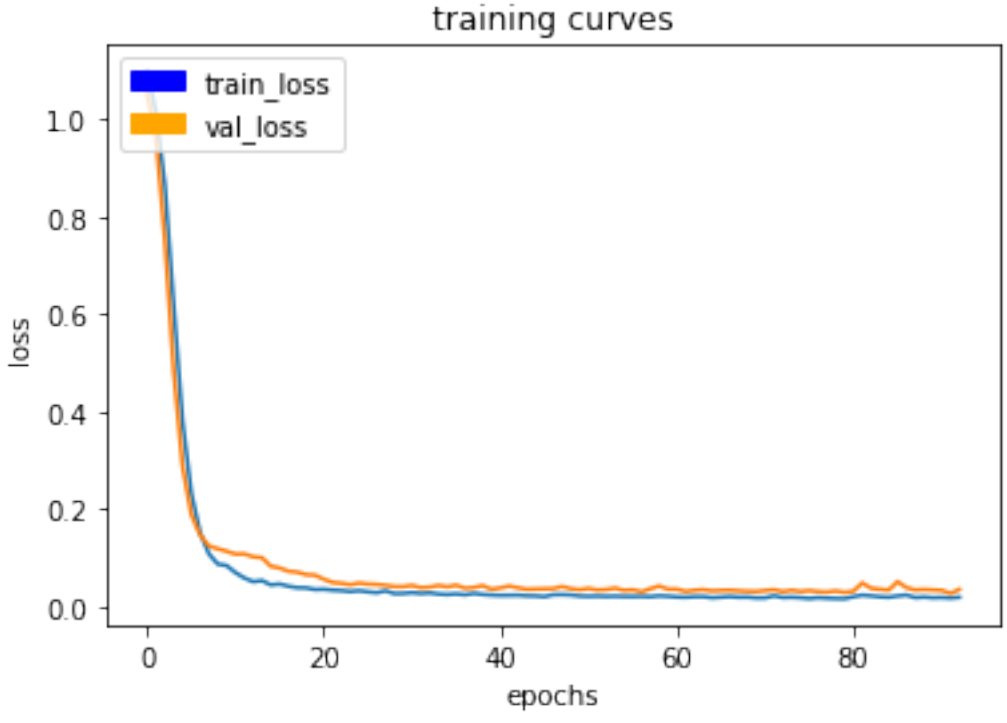
```
30/30 [==============================] - 23s - loss: 0.0178 - val_loss: 0.0338
Epoch 91/200
29/30 [============================>.] - ETA: 0s - loss: 0.0182
```



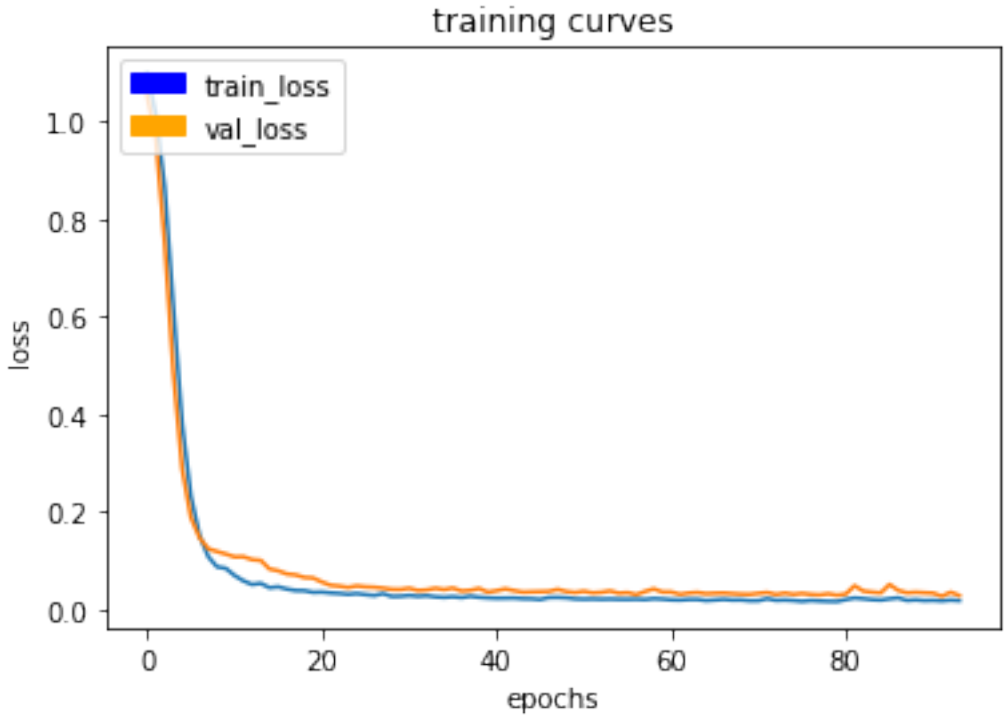

```
30/30 [==============================] - 23s - loss: 0.0183 - val_loss: 0.0331
Epoch 92/200
29/30 [============================>.] - ETA: 0s - loss: 0.0172
```



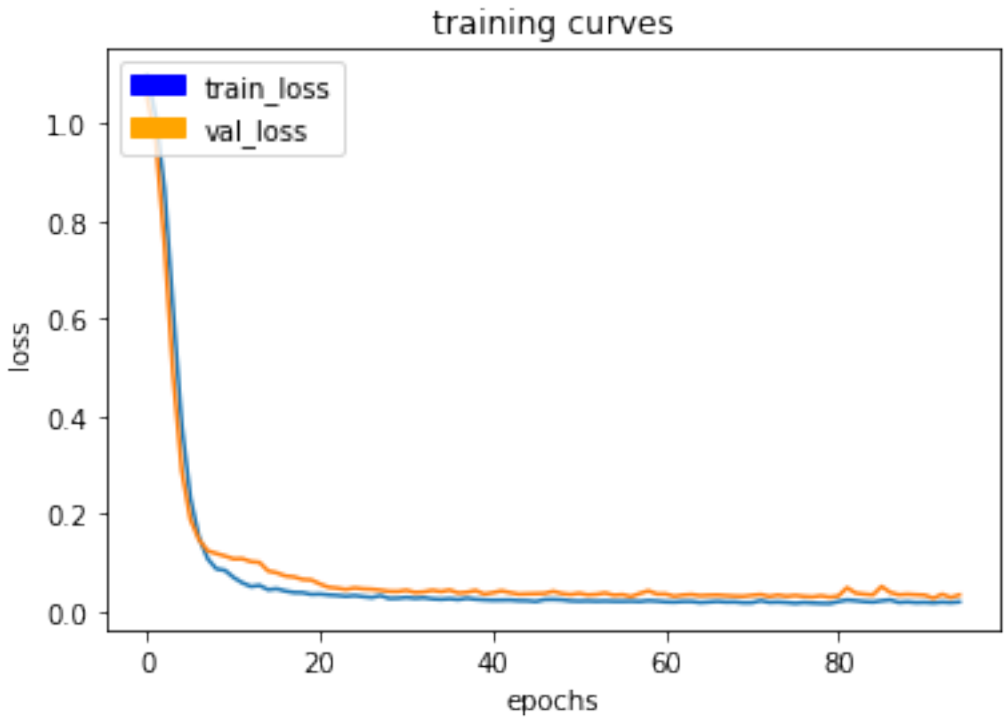

```
30/30 [==============================] - 23s - loss: 0.0172 - val_loss: 0.0267
Epoch 93/200
29/30 [============================>.] - ETA: 0s - loss: 0.0190
```



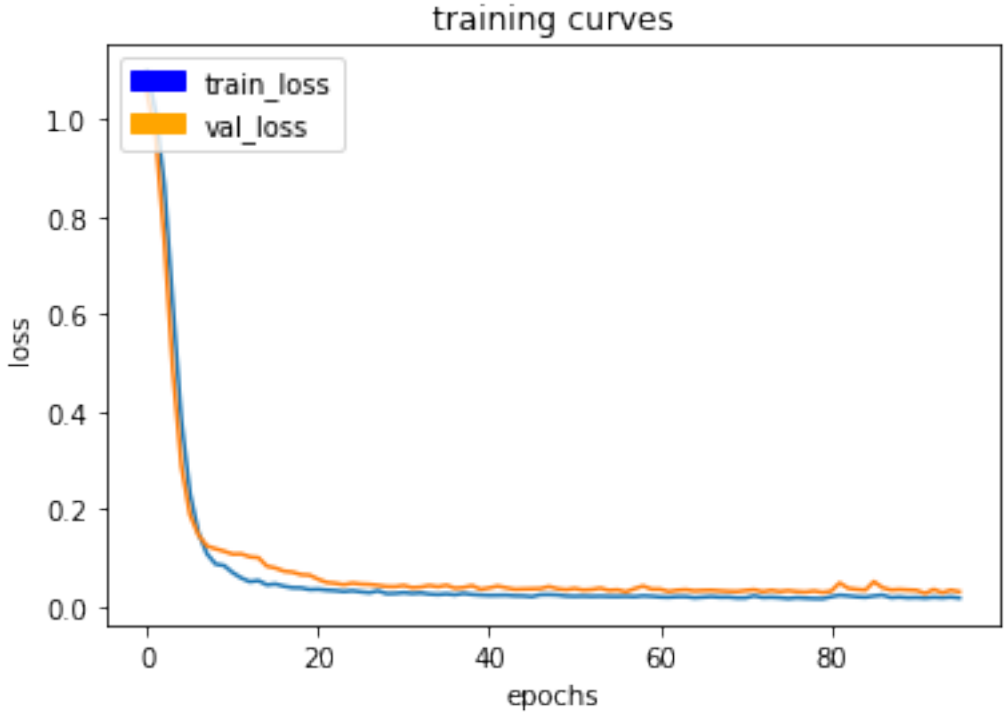
```
30/30 [==============================] - 23s - loss: 0.0189 - val_loss: 0.0349
Epoch 94/200
29/30 [============================>.] - ETA: 0s - loss: 0.0179
```



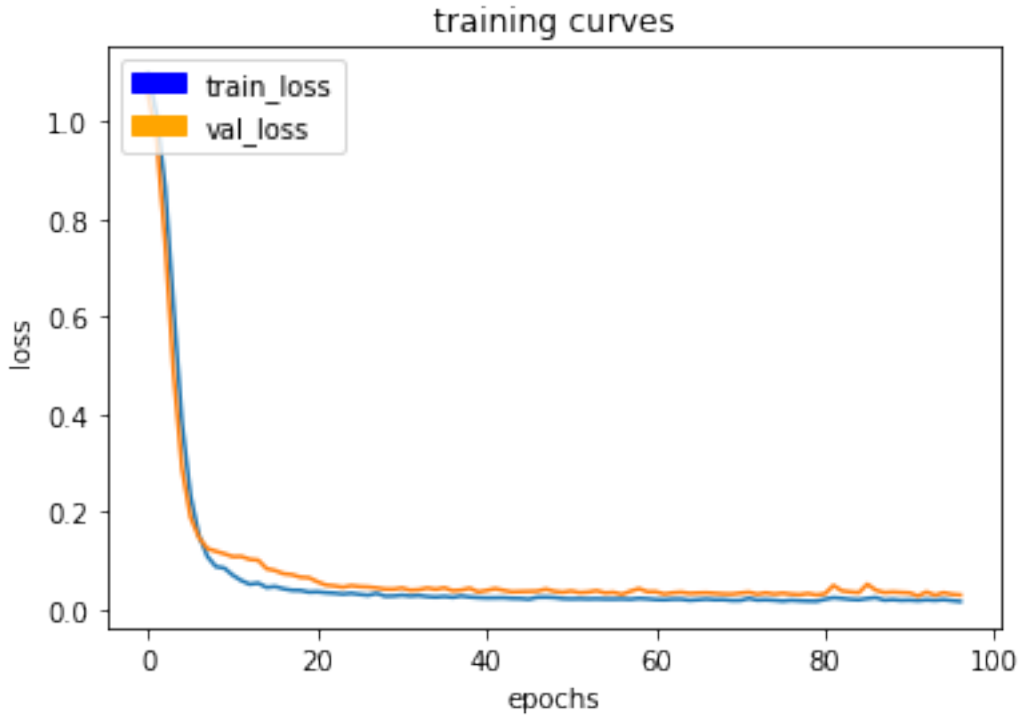

```
30/30 [==============================] - 23s - loss: 0.0178 - val_loss: 0.0282
Epoch 95/200
29/30 [============================>.] - ETA: 0s - loss: 0.0192
```



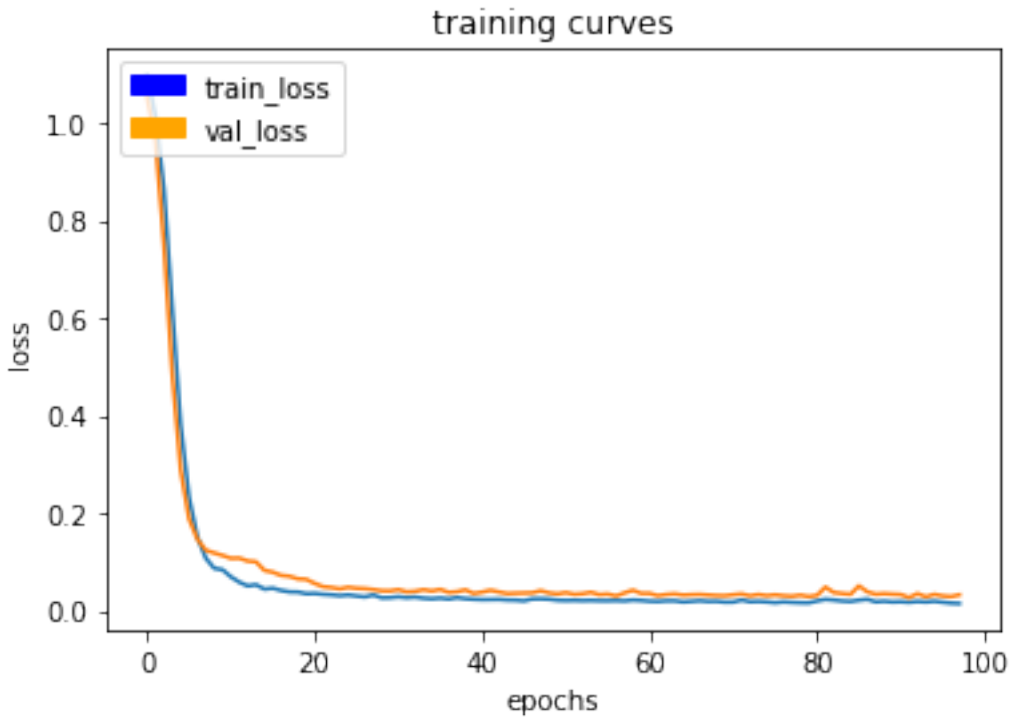

```
30/30 [==============================] - 23s - loss: 0.0193 - val_loss: 0.0334
Epoch 96/200
29/30 [============================>.] - ETA: 0s - loss: 0.0173
```



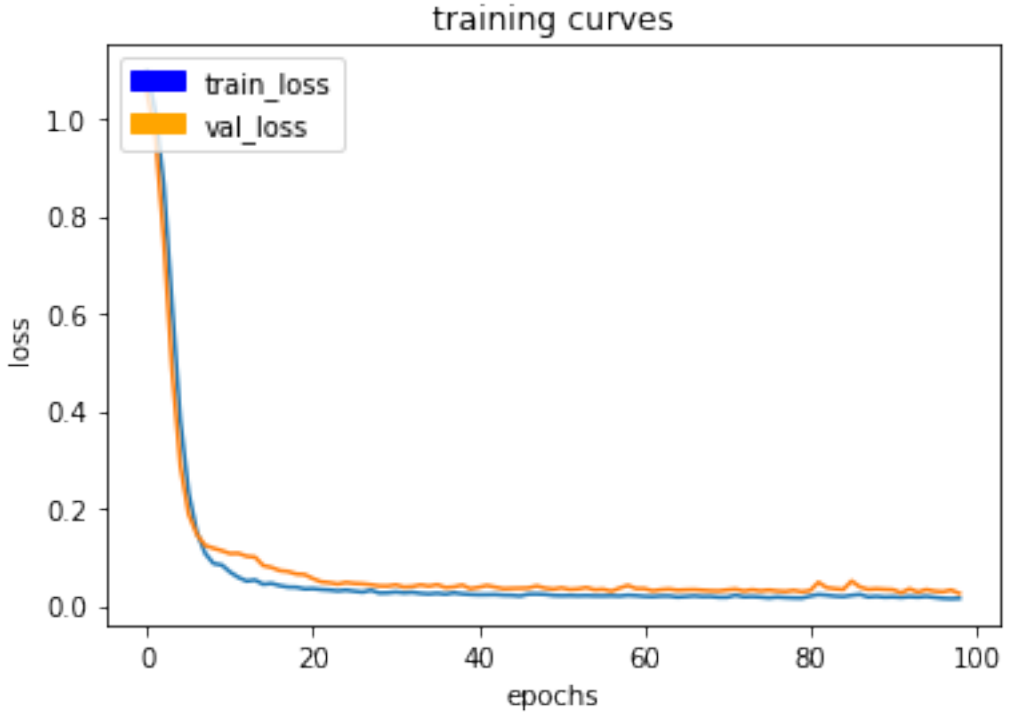
```
30/30 [==============================] - 23s - loss: 0.0173 - val_loss: 0.0302
Epoch 97/200
29/30 [============================>.] - ETA: 0s - loss: 0.0154
```



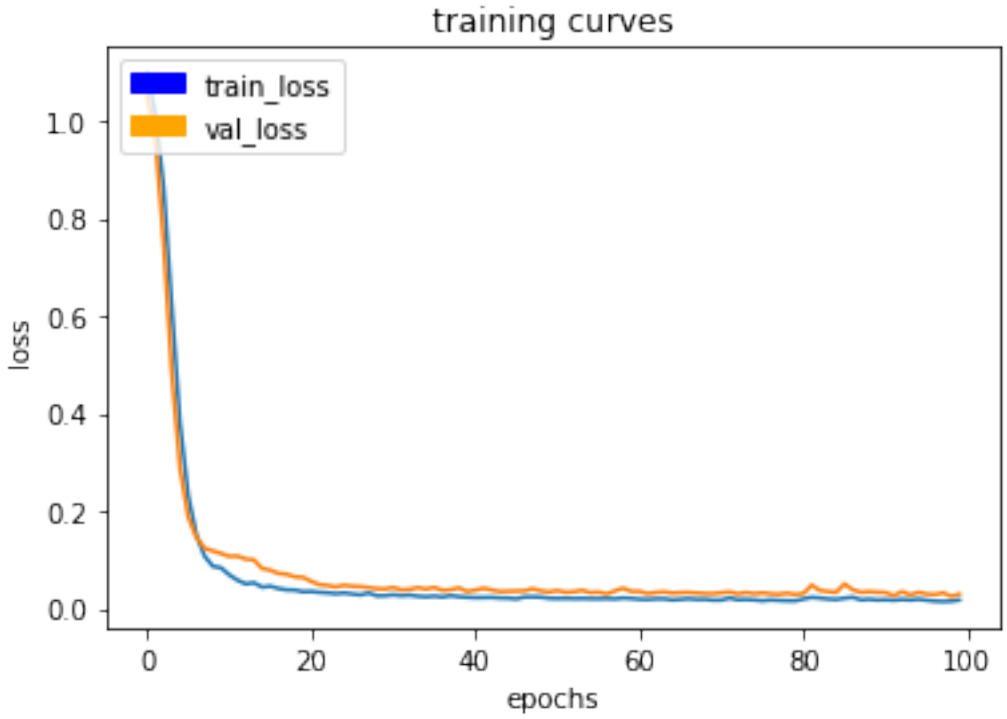

```
30/30 [==============================] - 23s - loss: 0.0154 - val_loss: 0.0287
Epoch 98/200
29/30 [============================>.] - ETA: 0s - loss: 0.0146
```



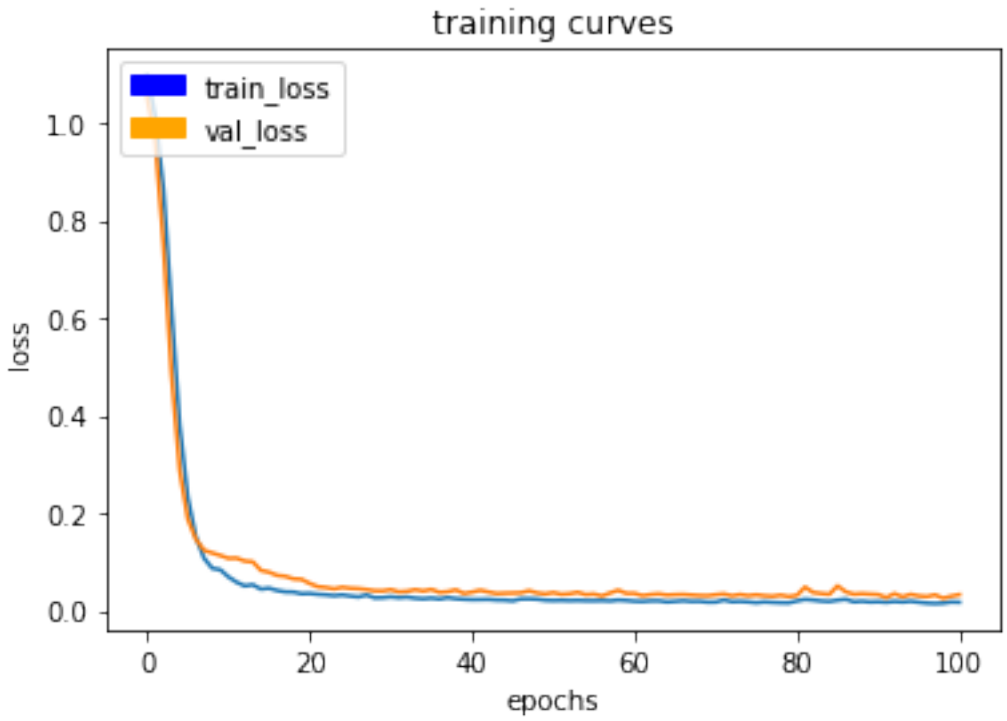

```
30/30 [==============================] - 23s - loss: 0.0147 - val_loss: 0.0324
Epoch 99/200
29/30 [============================>.] - ETA: 0s - loss: 0.0154
```



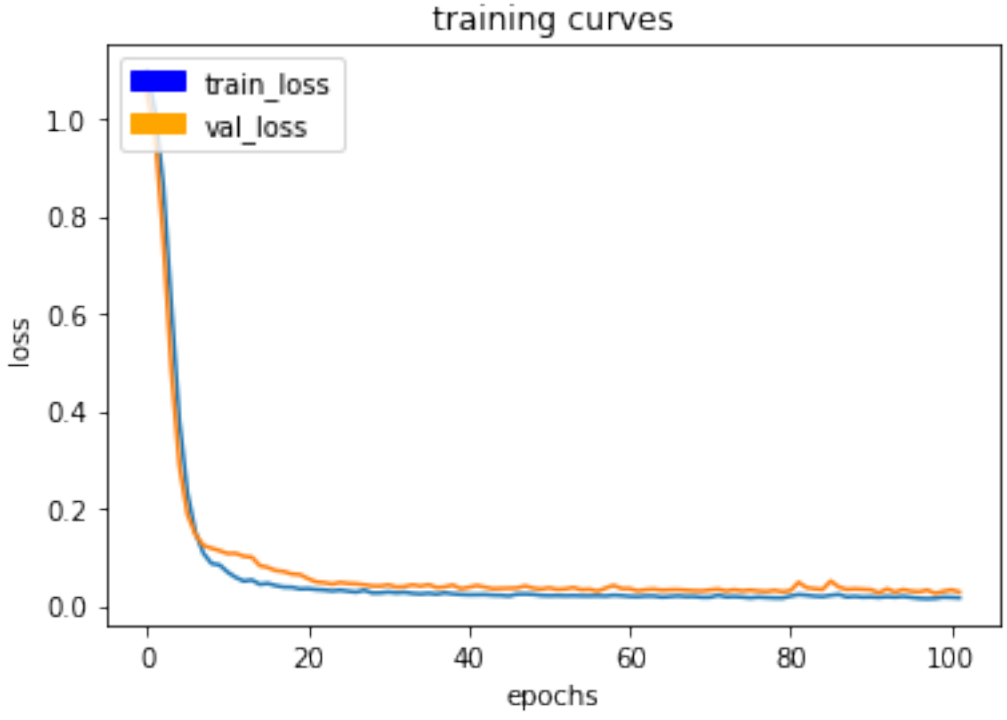
```
30/30 [==============================] - 23s - loss: 0.0154 - val_loss: 0.0254
Epoch 100/200
29/30 [============================>.] - ETA: 0s - loss: 0.0178
```



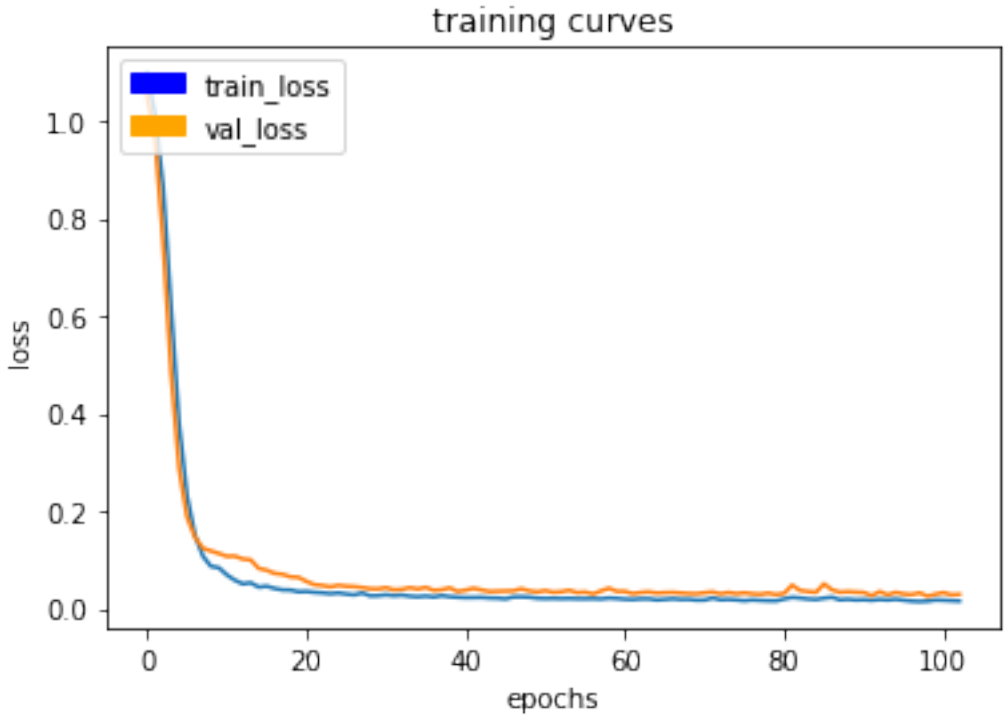

```
30/30 [==============================] - 23s - loss: 0.0178 - val_loss: 0.0296
Epoch 101/200
29/30 [============================>.] - ETA: 0s - loss: 0.0172
```



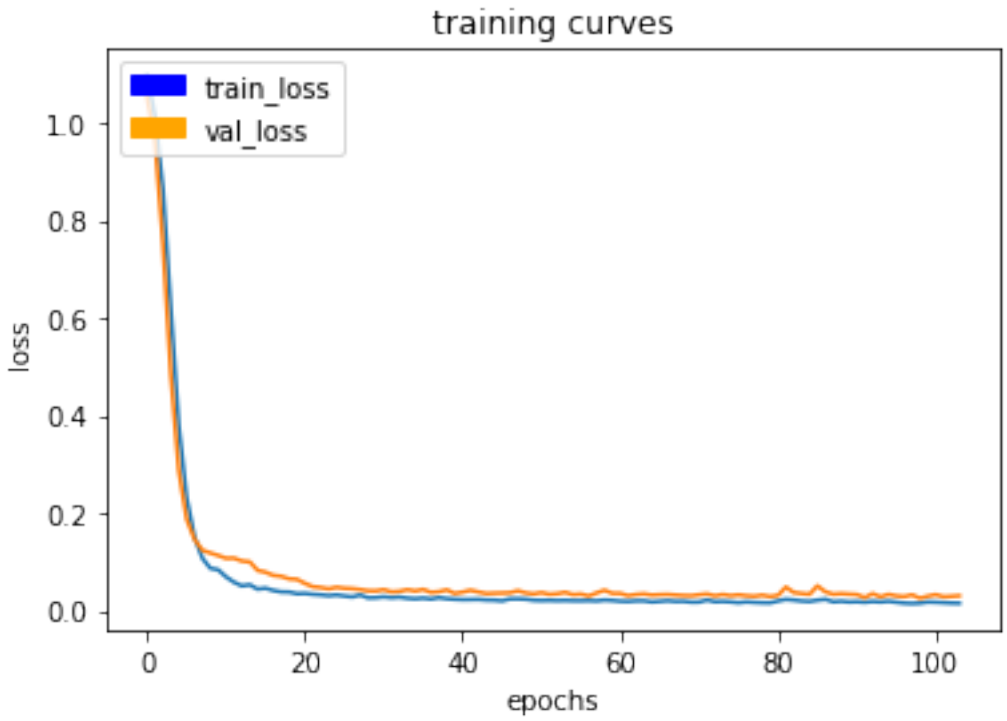

```
30/30 [==============================] - 23s - loss: 0.0172 - val_loss: 0.0328
Epoch 102/200
29/30 [============================>.] - ETA: 0s - loss: 0.0163
```



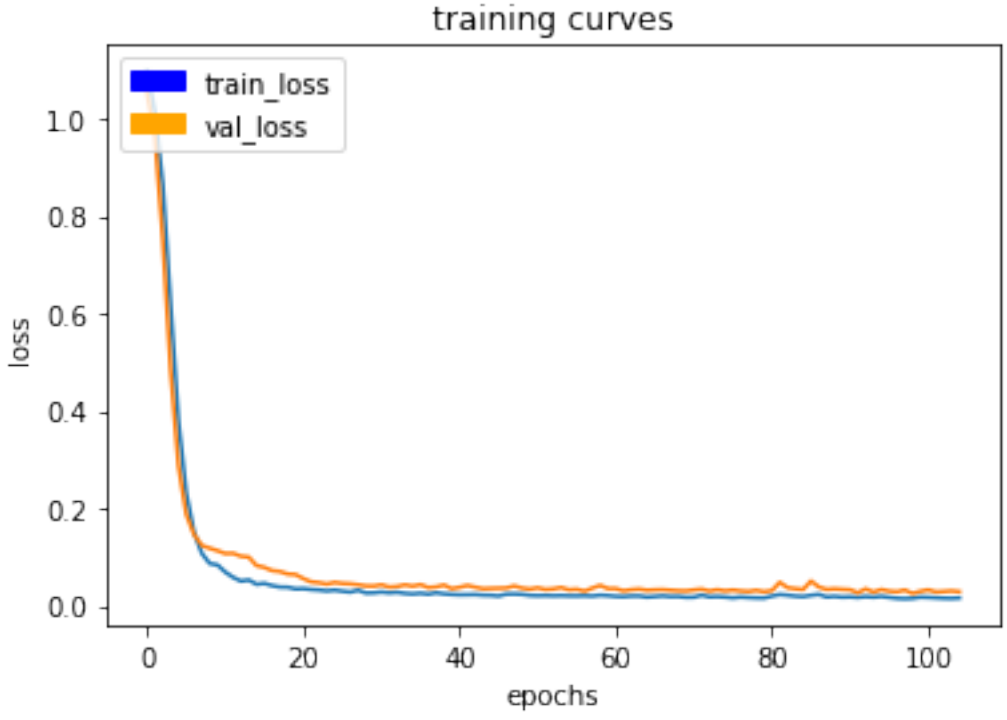
```
30/30 [==============================] - 23s - loss: 0.0163 - val_loss: 0.0284
Epoch 103/200
29/30 [============================>.] - ETA: 0s - loss: 0.0155
```



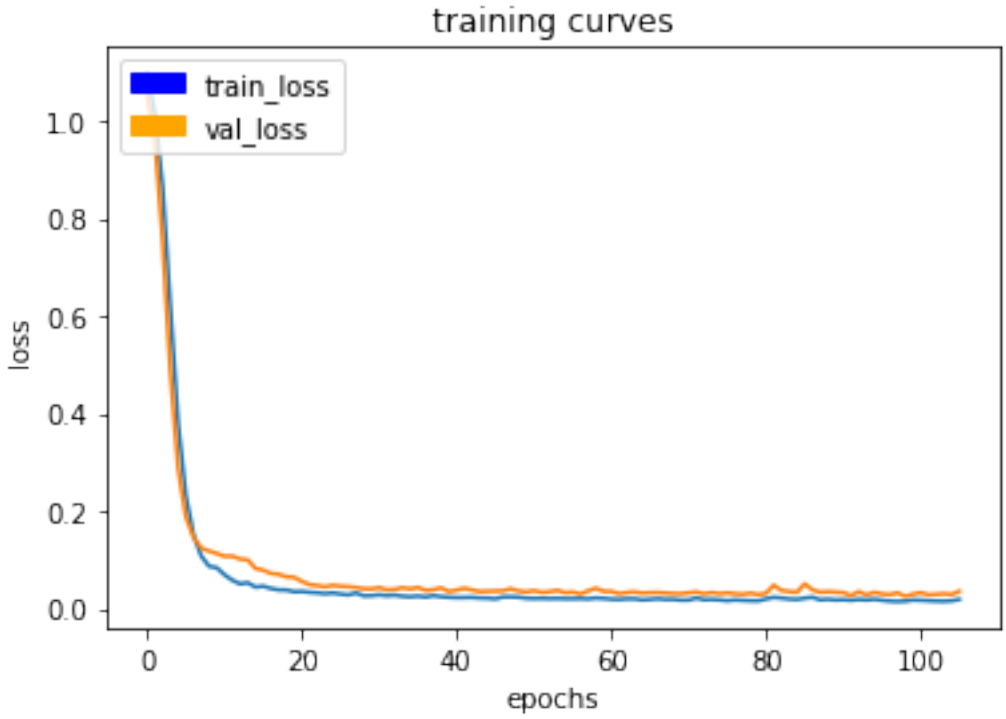

```
30/30 [==============================] - 23s - loss: 0.0155 - val_loss: 0.0293
Epoch 104/200
29/30 [============================>.] - ETA: 0s - loss: 0.0151
```



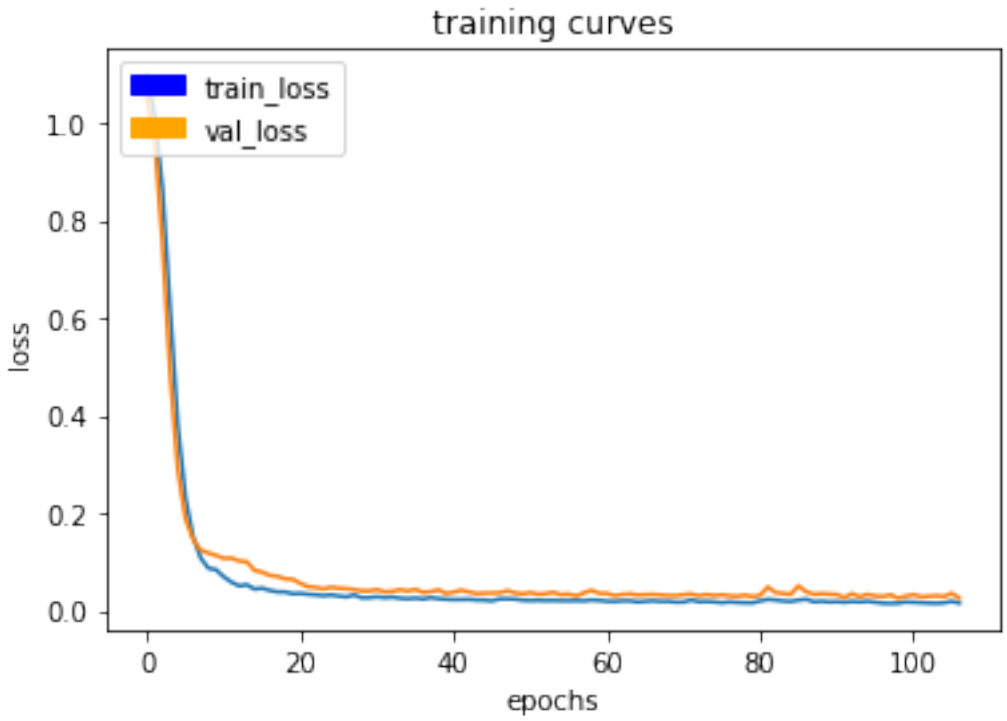

```
30/30 [==============================] - 23s - loss: 0.0152 - val_loss: 0.0305
Epoch 105/200
29/30 [============================>.] - ETA: 0s - loss: 0.0161
```



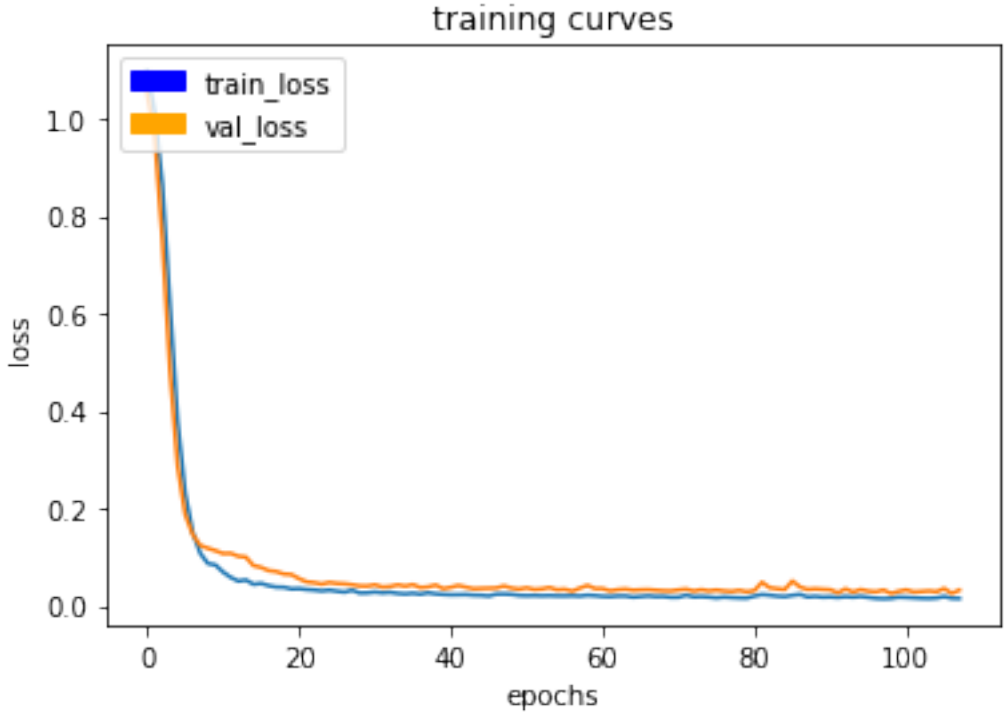
```
30/30 [==============================] - 24s - loss: 0.0160 - val_loss: 0.0289
Epoch 106/200
29/30 [============================>.] - ETA: 0s - loss: 0.0191
```



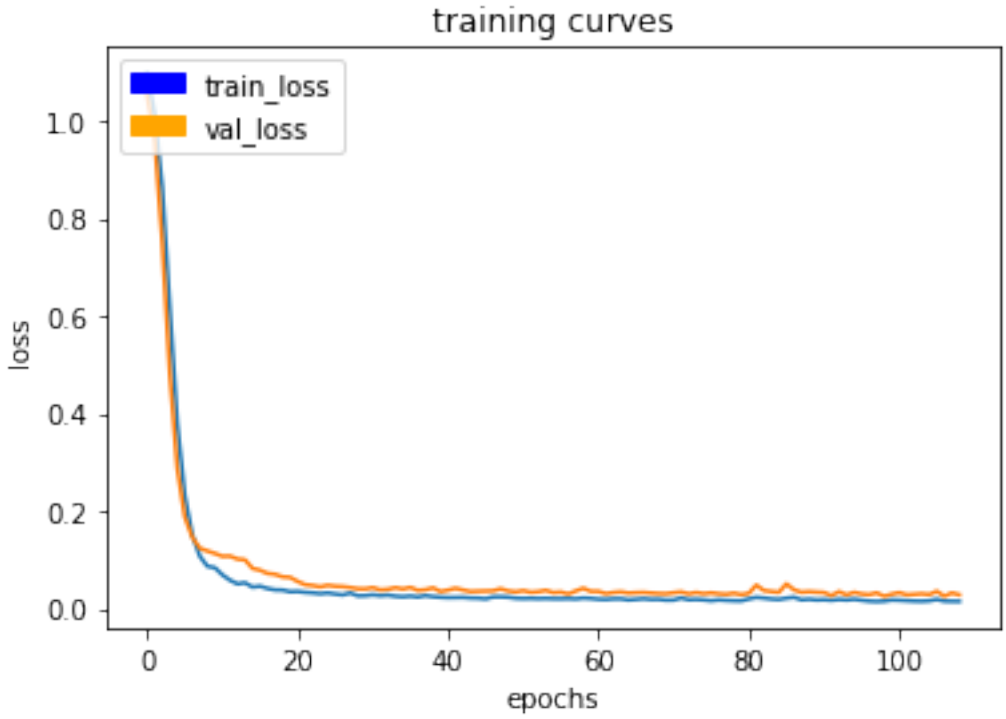

```
30/30 [==============================] - 23s - loss: 0.0191 - val_loss: 0.0357
Epoch 107/200
29/30 [============================>.] - ETA: 0s - loss: 0.0155
```



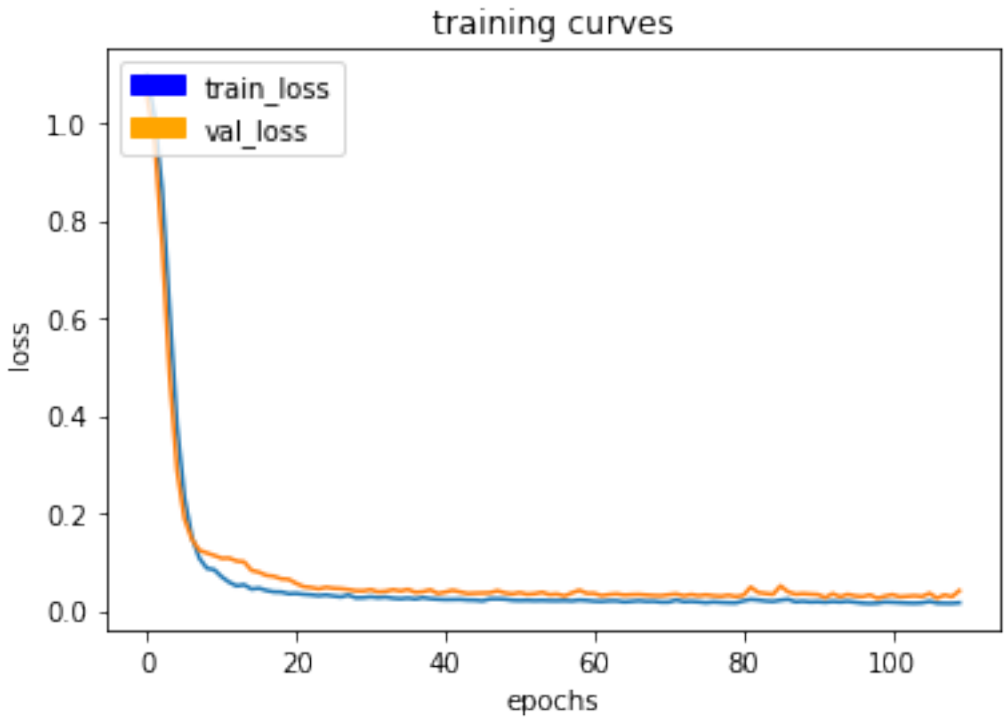

```
30/30 [==============================] - 23s - loss: 0.0154 - val_loss: 0.0254
Epoch 108/200
29/30 [============================>.] - ETA: 0s - loss: 0.0151
```



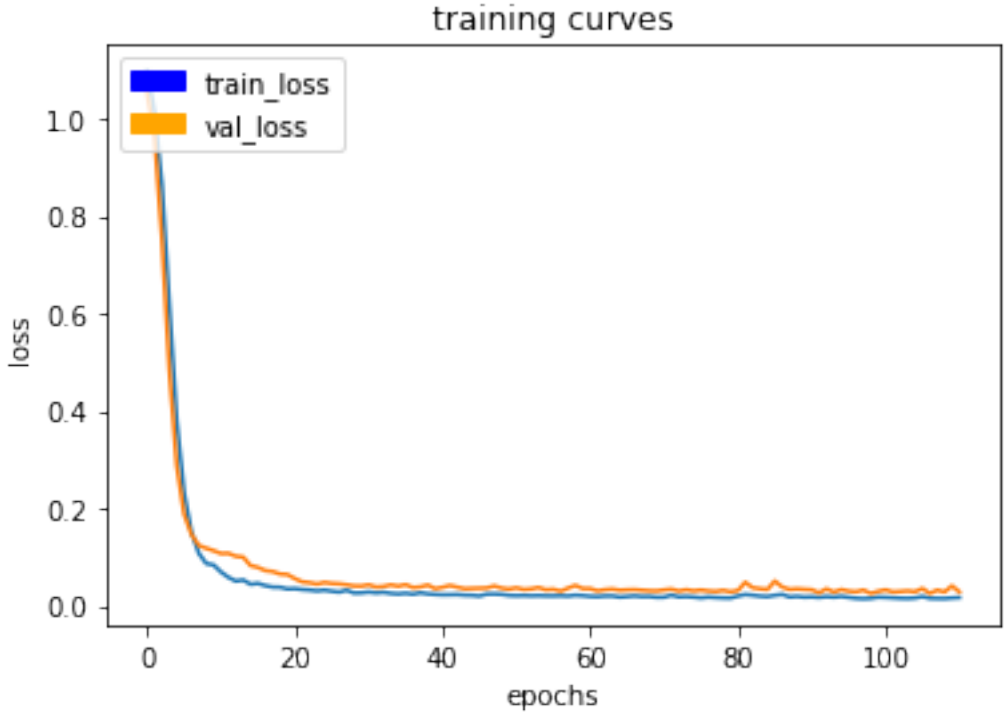
```
30/30 [==============================] - 23s - loss: 0.0151 - val_loss: 0.0322
Epoch 109/200
29/30 [============================>.] - ETA: 0s - loss: 0.0149
```



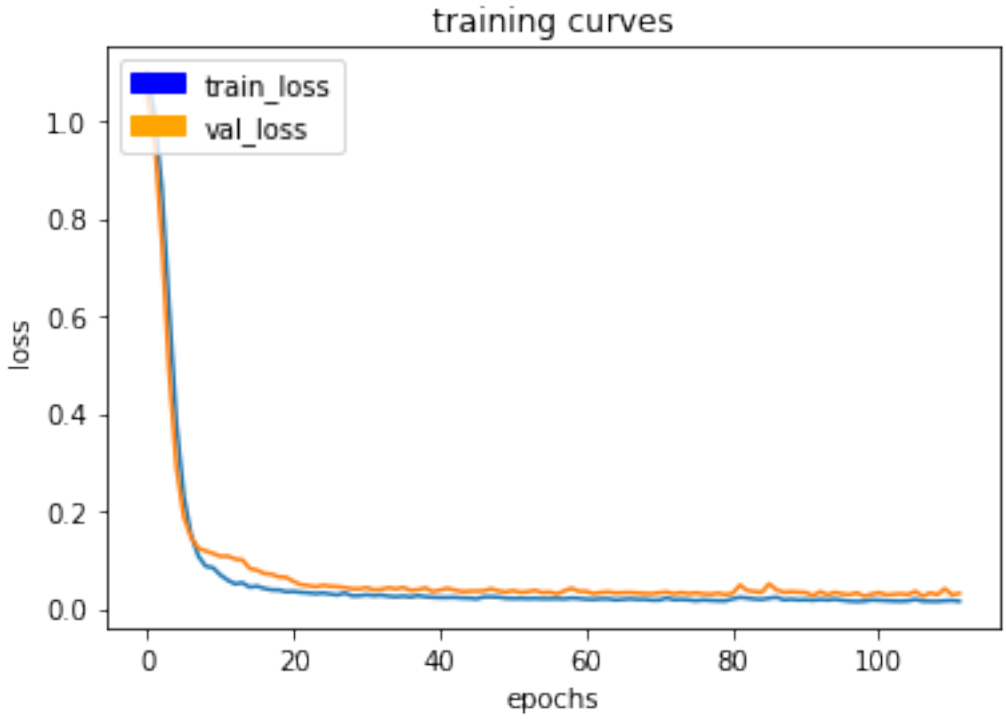

```
30/30 [==============================] - 23s - loss: 0.0149 - val_loss: 0.0284
Epoch 110/200
29/30 [============================>.] - ETA: 0s - loss: 0.0160
```



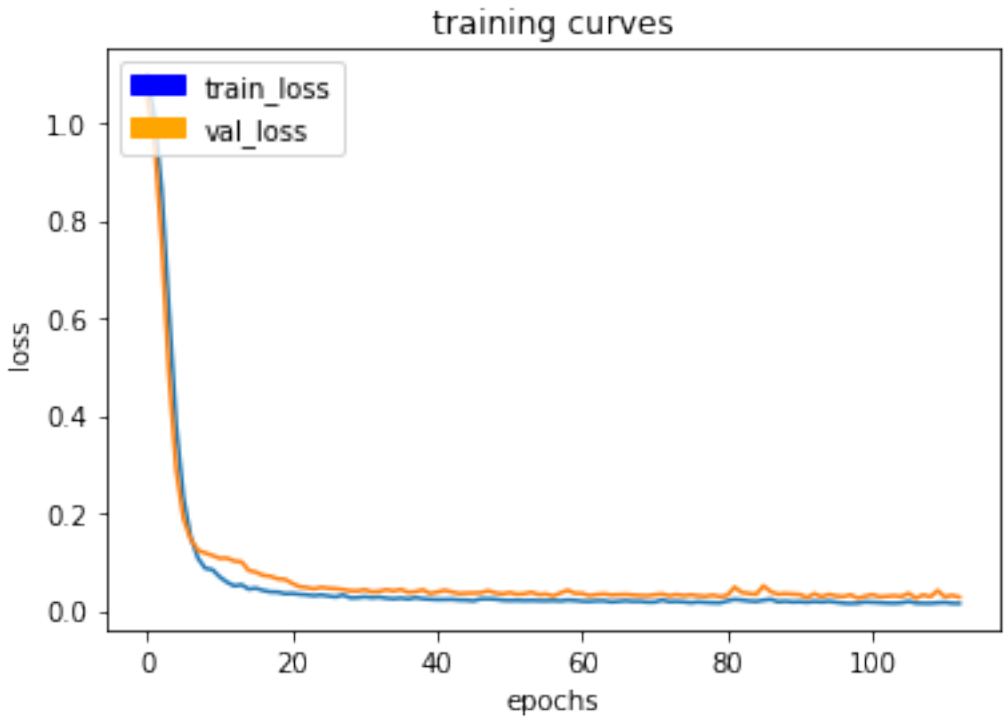

```
30/30 [==============================] - 23s - loss: 0.0161 - val_loss: 0.0410
Epoch 111/200
29/30 [============================>.] - ETA: 0s - loss: 0.0168
```



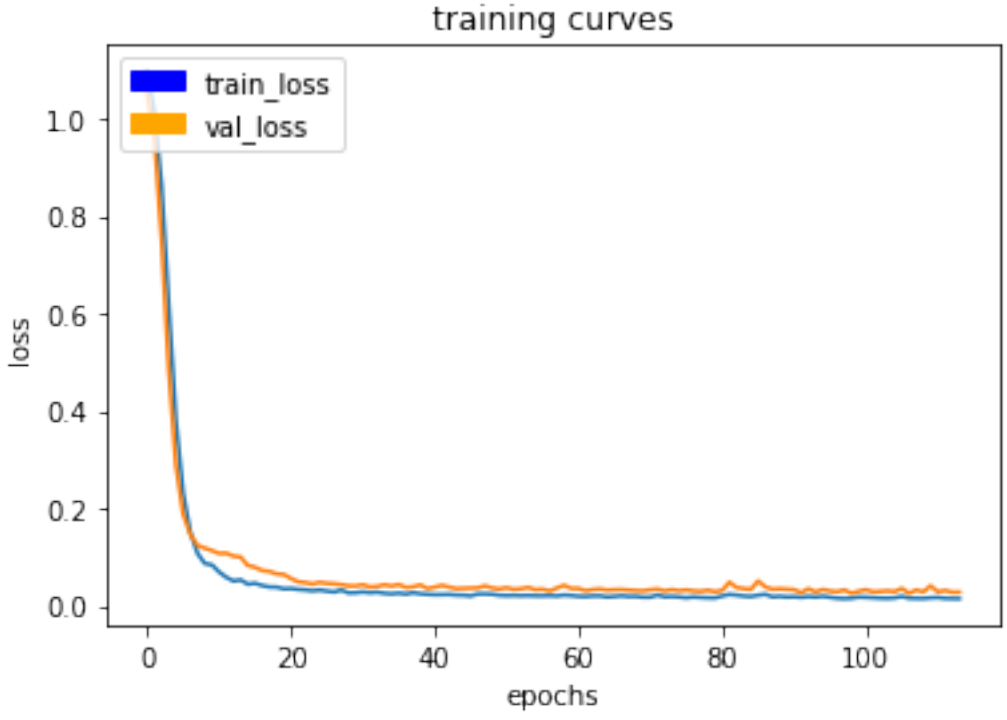
```
30/30 [==============================] - 23s - loss: 0.0169 - val_loss: 0.0285
Epoch 112/200
29/30 [============================>.] - ETA: 0s - loss: 0.0150
```



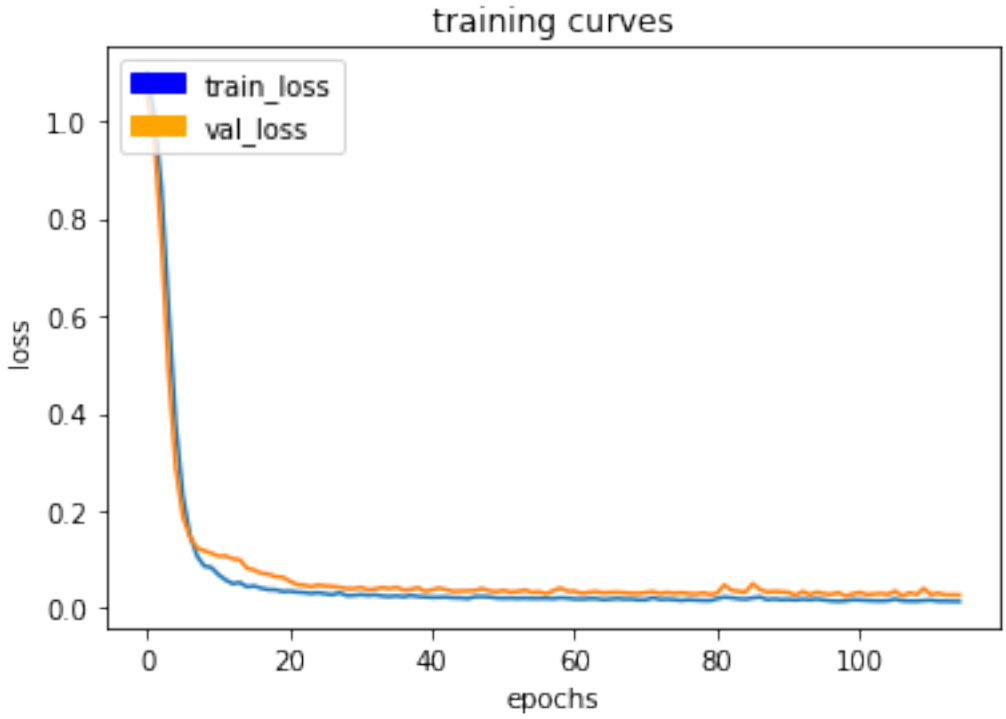

```
30/30 [==============================] - 23s - loss: 0.0150 - val_loss: 0.0313
Epoch 113/200
29/30 [============================>.] - ETA: 0s - loss: 0.0148
```



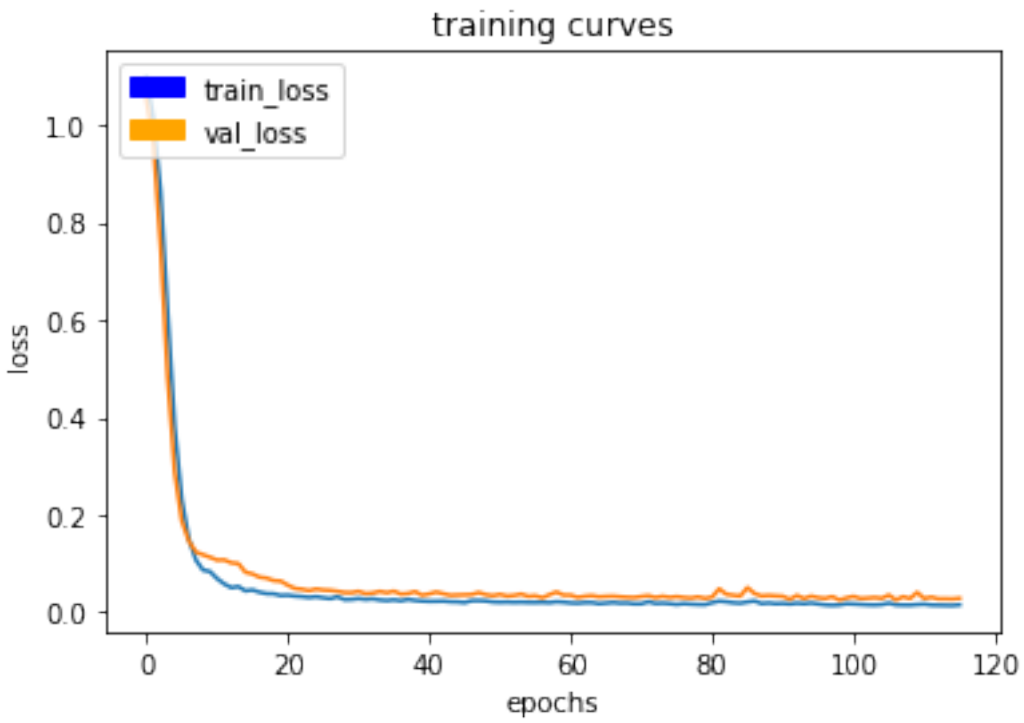

```
30/30 [==============================] - 23s - loss: 0.0147 - val_loss: 0.0278
Epoch 114/200
29/30 [============================>.] - ETA: 0s - loss: 0.0146
```



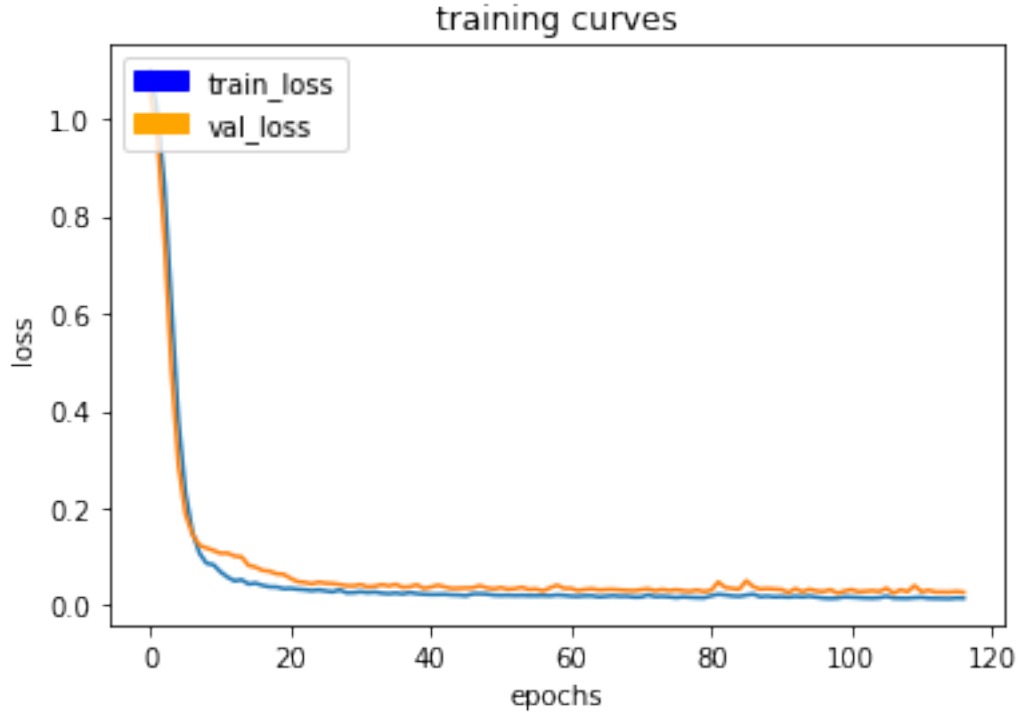
```
30/30 [==============================] - 23s - loss: 0.0145 - val_loss: 0.0279
Epoch 115/200
29/30 [============================>.] - ETA: 0s - loss: 0.0141
```



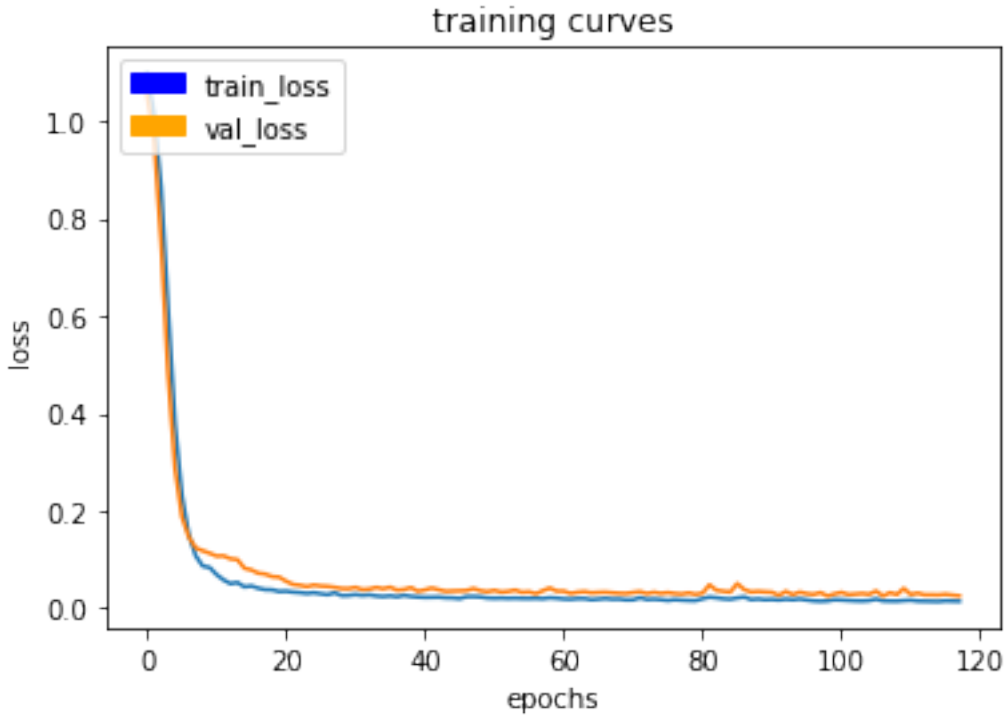

```
30/30 [==============================] - 23s - loss: 0.0142 - val_loss: 0.0275
Epoch 116/200
29/30 [============================>.] - ETA: 0s - loss: 0.0152
```



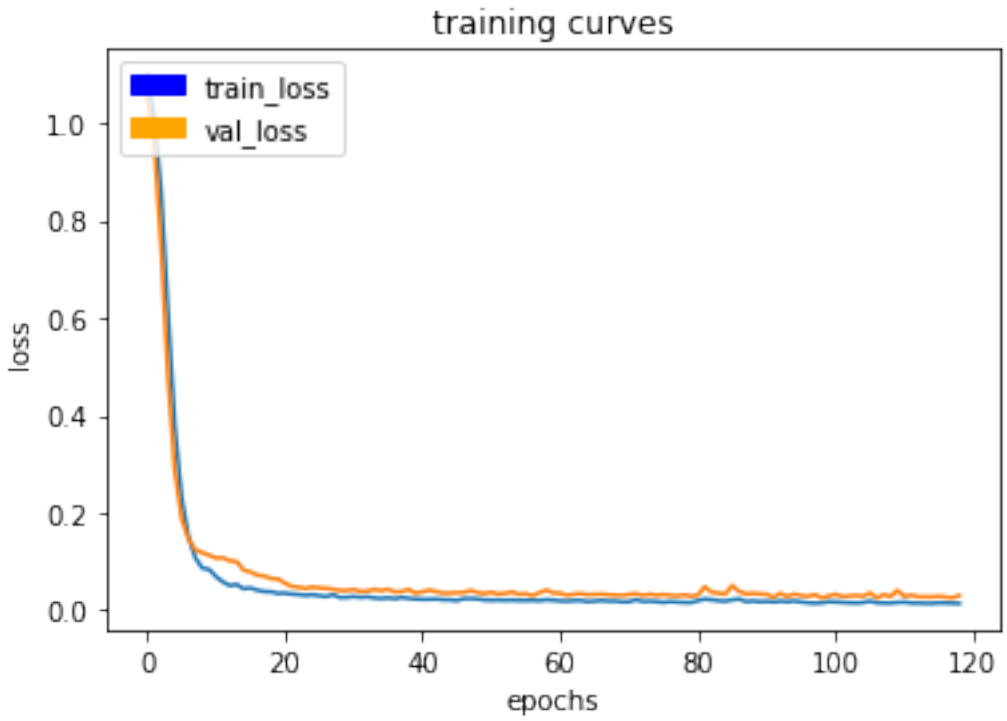

```
30/30 [==============================] - 23s - loss: 0.0155 - val_loss: 0.0289
Epoch 117/200
29/30 [============================>.] - ETA: 0s - loss: 0.0149
```



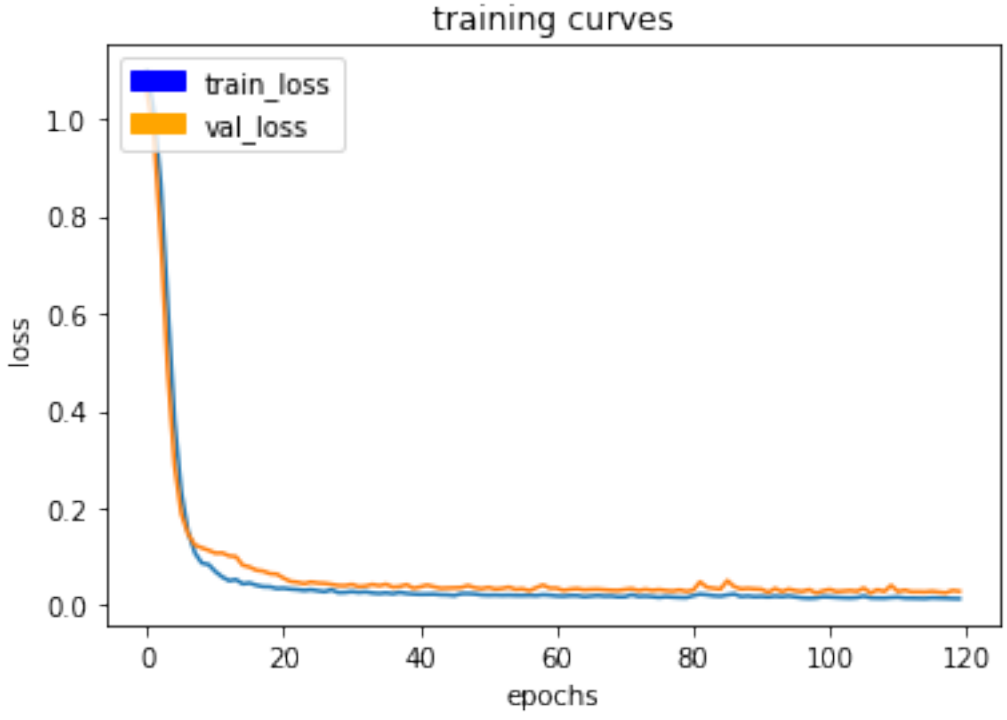
```
30/30 [==============================] - 23s - loss: 0.0150 - val_loss: 0.0272
Epoch 118/200
29/30 [============================>.] - ETA: 0s - loss: 0.0147
```



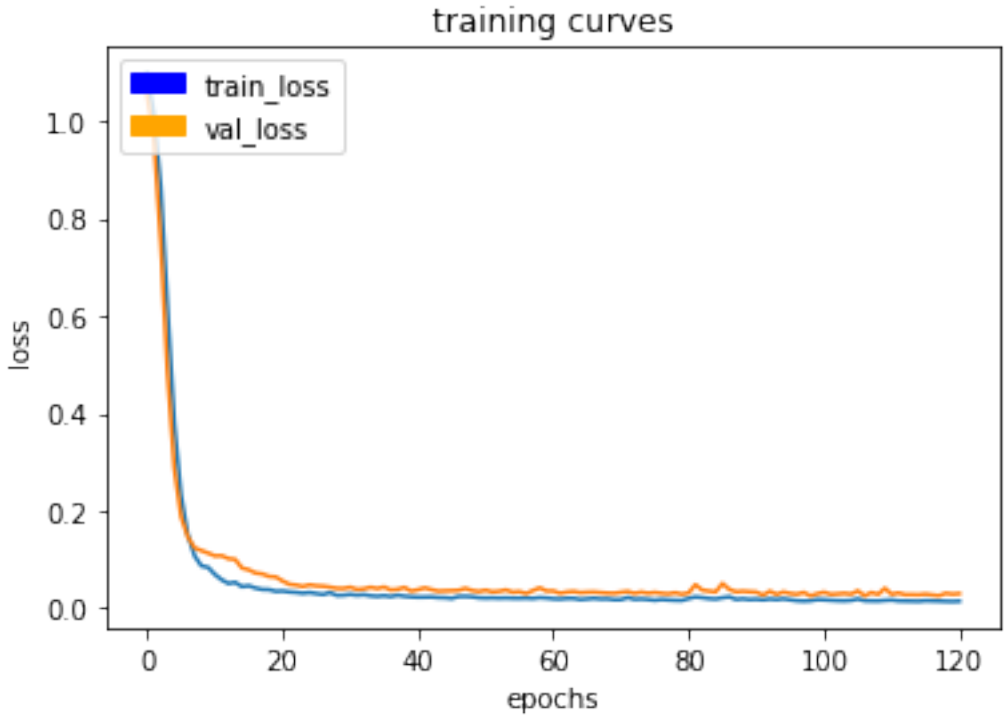

```
30/30 [==============================] - 23s - loss: 0.0147 - val_loss: 0.0257
Epoch 119/200
29/30 [============================>.] - ETA: 0s - loss: 0.0142
```



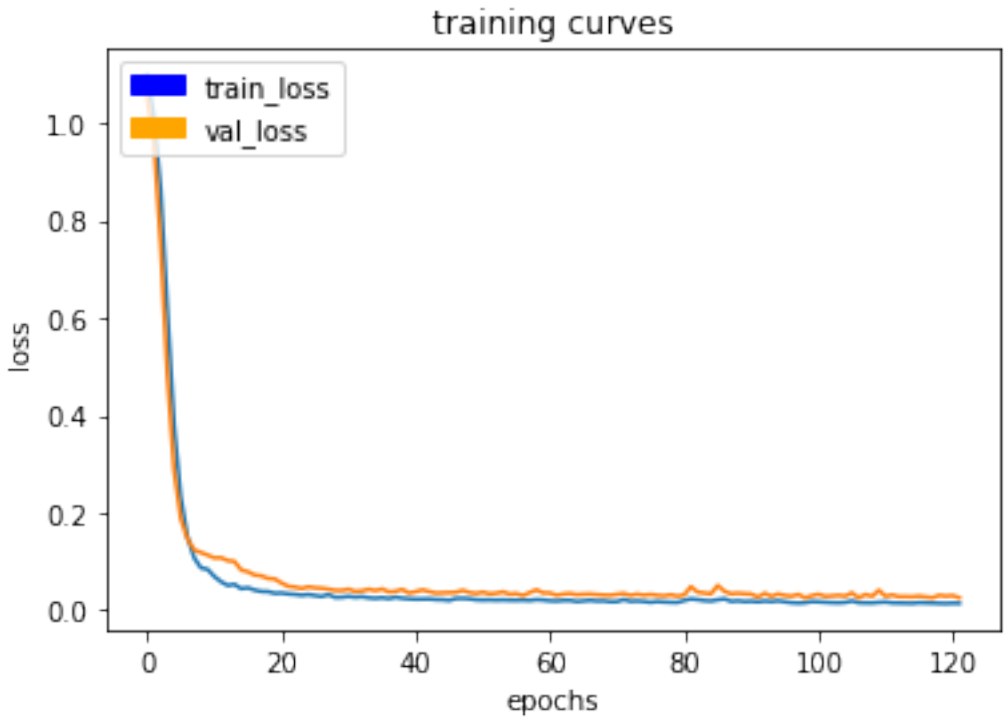

```
30/30 [==============================] - 23s - loss: 0.0141 - val_loss: 0.0306
Epoch 120/200
29/30 [============================>.] - ETA: 0s - loss: 0.0138
```



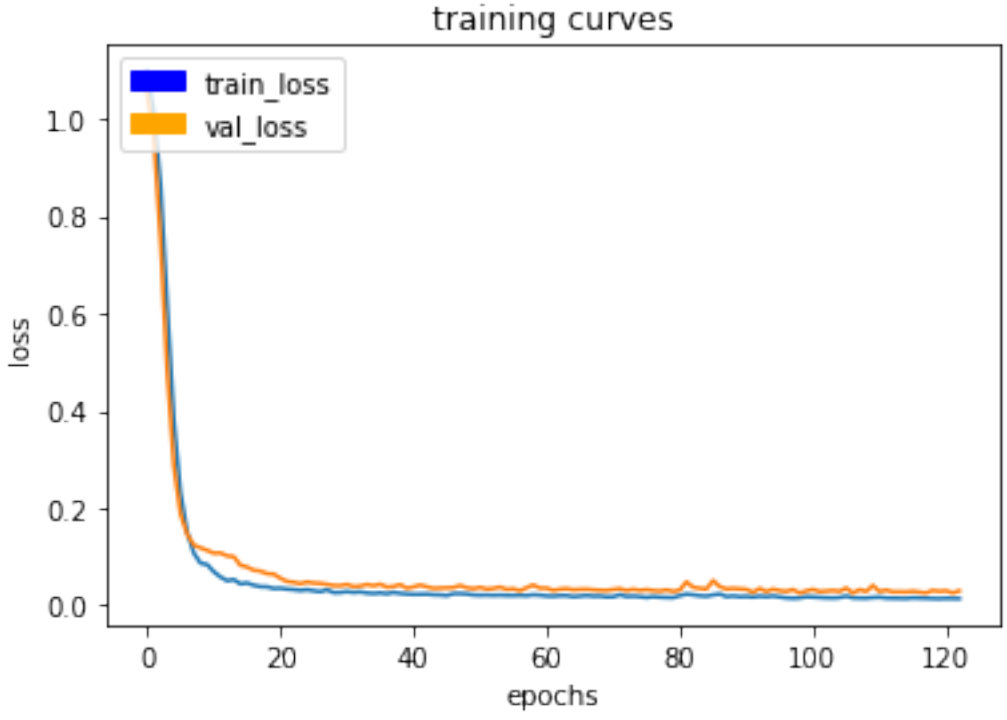
```
30/30 [==============================] - 23s - loss: 0.0138 - val_loss: 0.0289
Epoch 121/200
29/30 [============================>.] - ETA: 0s - loss: 0.0144
```



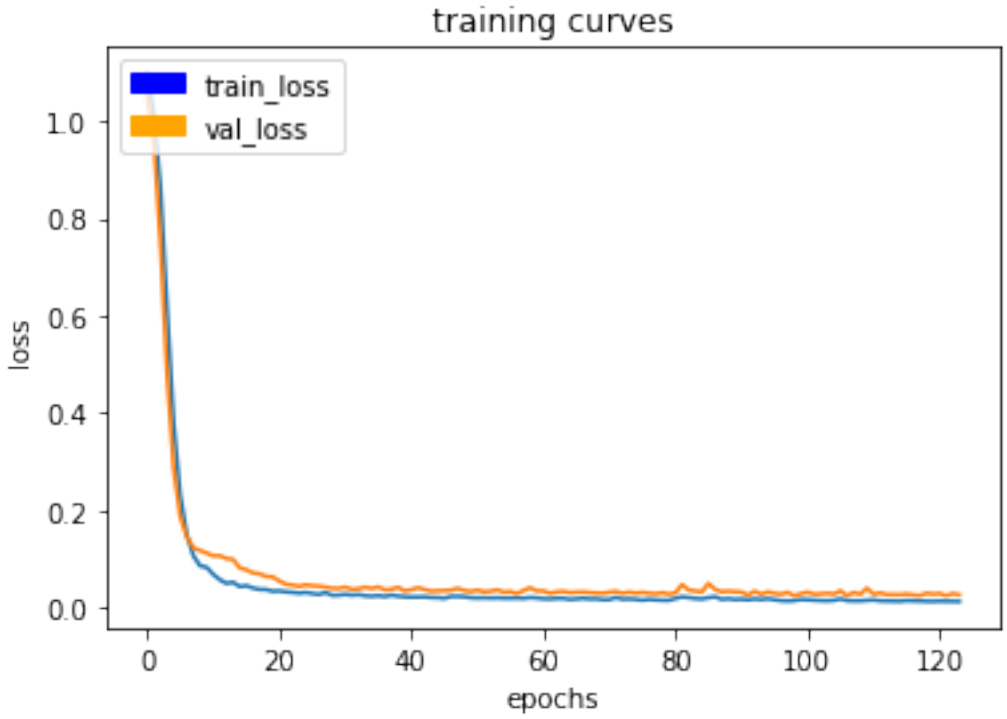

```
30/30 [==============================] - 23s - loss: 0.0144 - val_loss: 0.0300
Epoch 122/200
29/30 [============================>.] - ETA: 0s - loss: 0.0142
```



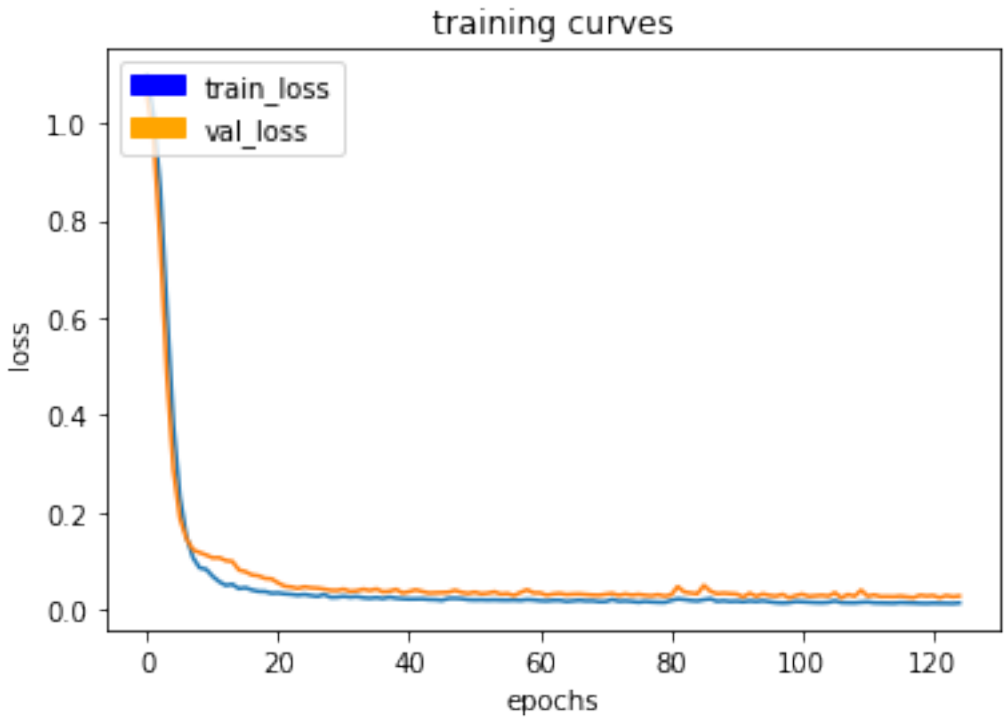

```
30/30 [==============================] - 23s - loss: 0.0141 - val_loss: 0.0255
Epoch 123/200
29/30 [============================>.] - ETA: 0s - loss: 0.0139
```



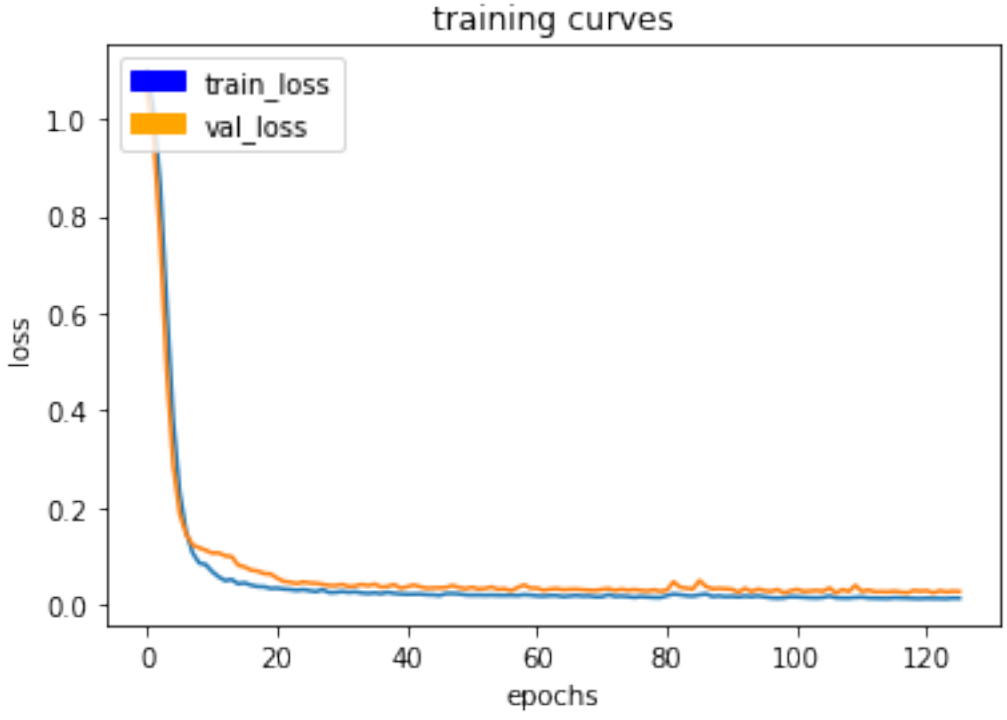
```
30/30 [==============================] - 23s - loss: 0.0140 - val_loss: 0.0299
Epoch 124/200
29/30 [============================>.] - ETA: 0s - loss: 0.0136
```



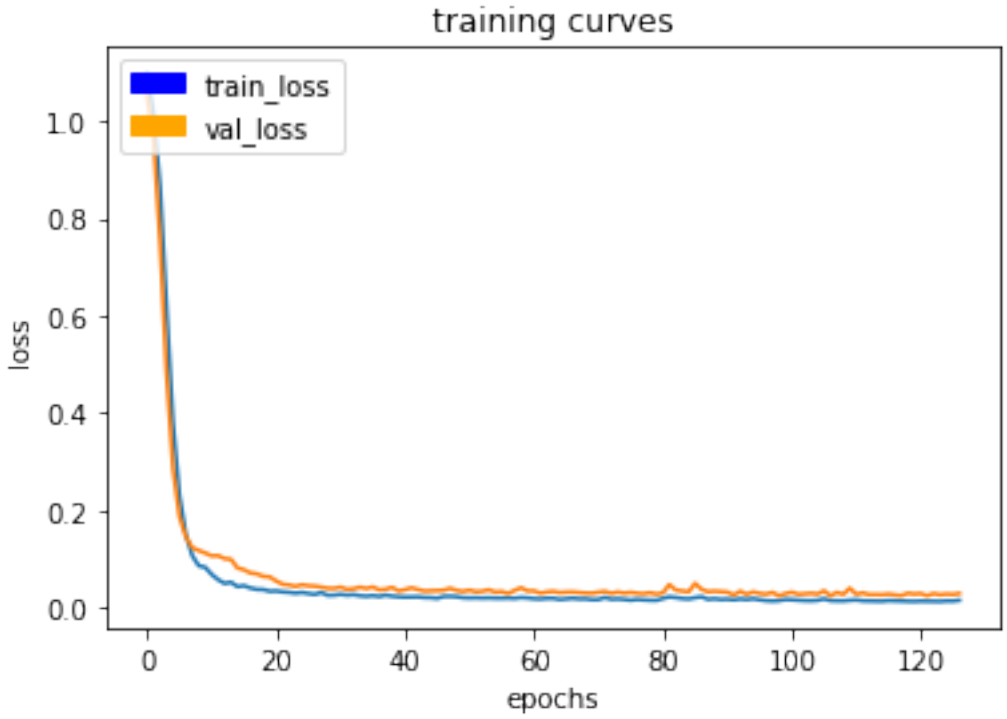

```
30/30 [==============================] - 23s - loss: 0.0136 - val_loss: 0.0275
Epoch 125/200
29/30 [============================>.] - ETA: 0s - loss: 0.0150
```



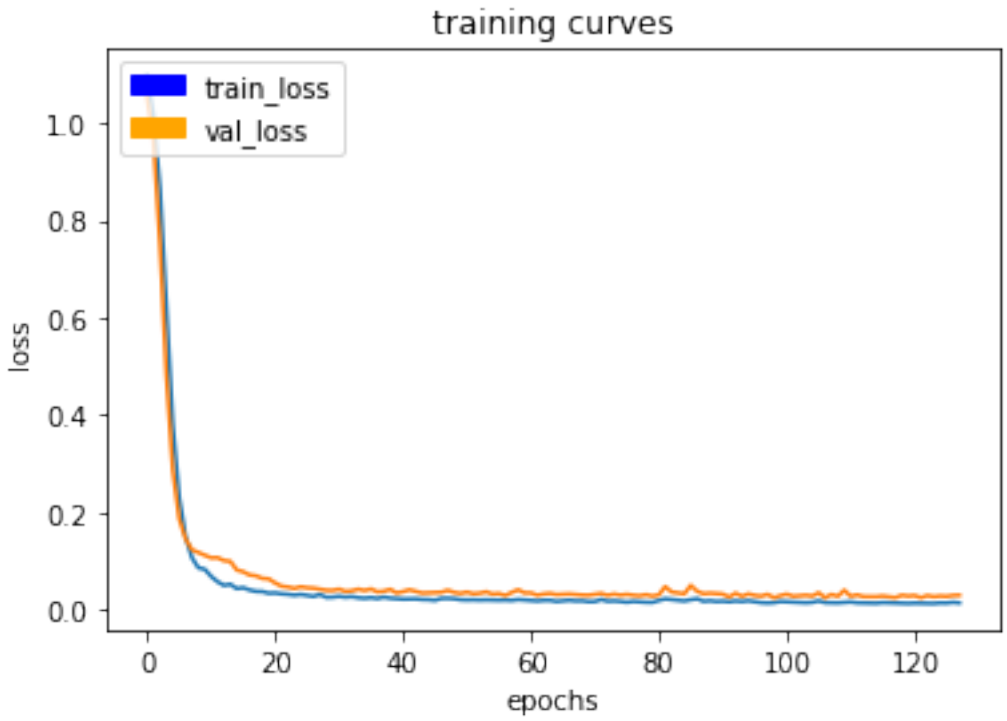

```
30/30 [==============================] - 23s - loss: 0.0148 - val_loss: 0.0290
Epoch 126/200
29/30 [============================>.] - ETA: 0s - loss: 0.0145
```



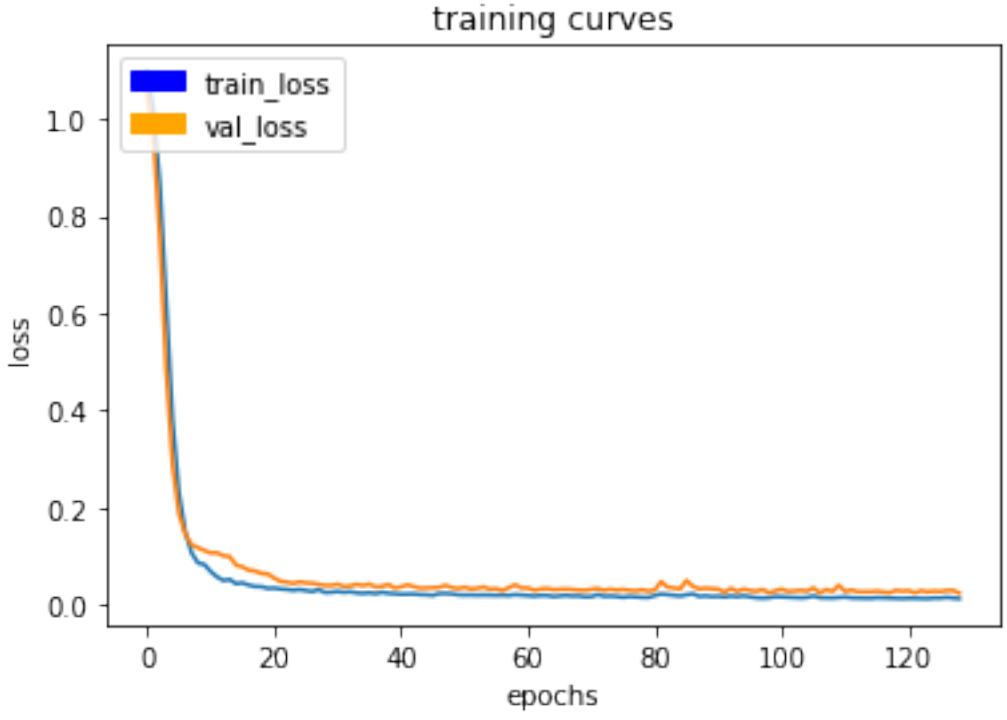
```
30/30 [==============================] - 23s - loss: 0.0145 - val_loss: 0.0282
Epoch 127/200
29/30 [============================>.] - ETA: 0s - loss: 0.0161
```



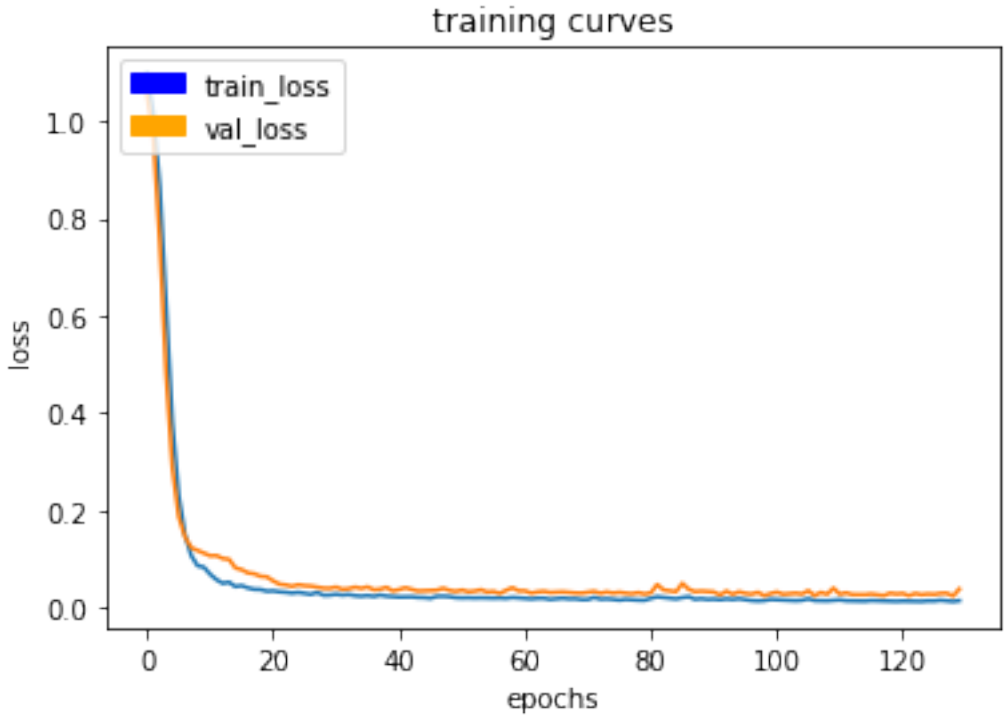

```
30/30 [==============================] - 23s - loss: 0.0161 - val_loss: 0.0301
Epoch 128/200
29/30 [============================>.] - ETA: 0s - loss: 0.0148
```



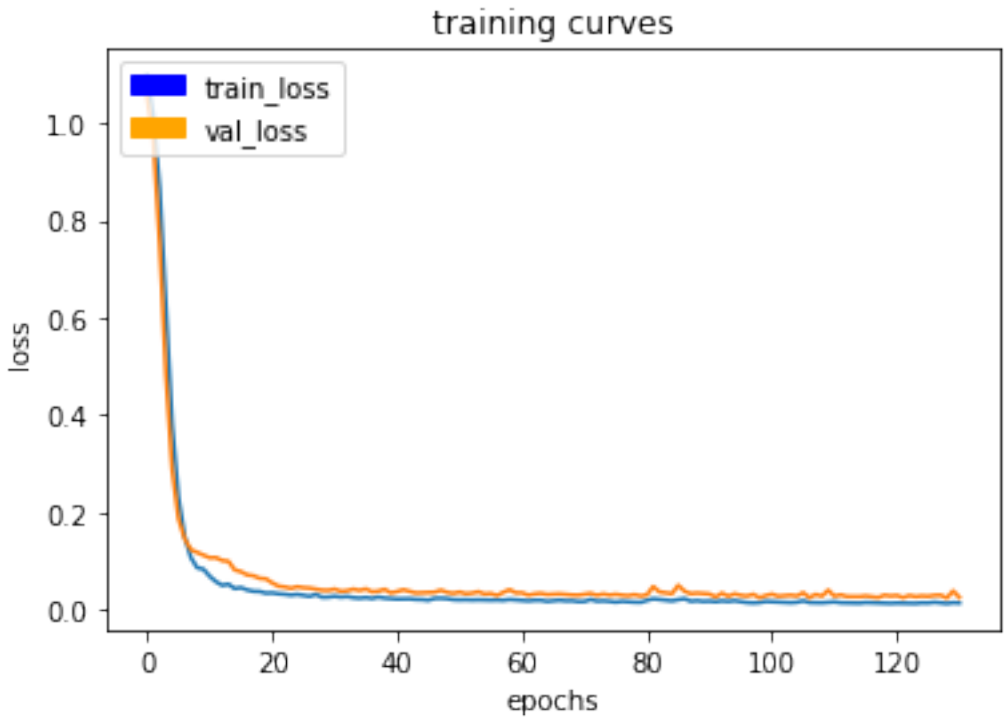

```
30/30 [==============================] - 23s - loss: 0.0148 - val_loss: 0.0305
Epoch 129/200
29/30 [============================>.] - ETA: 0s - loss: 0.0134
```



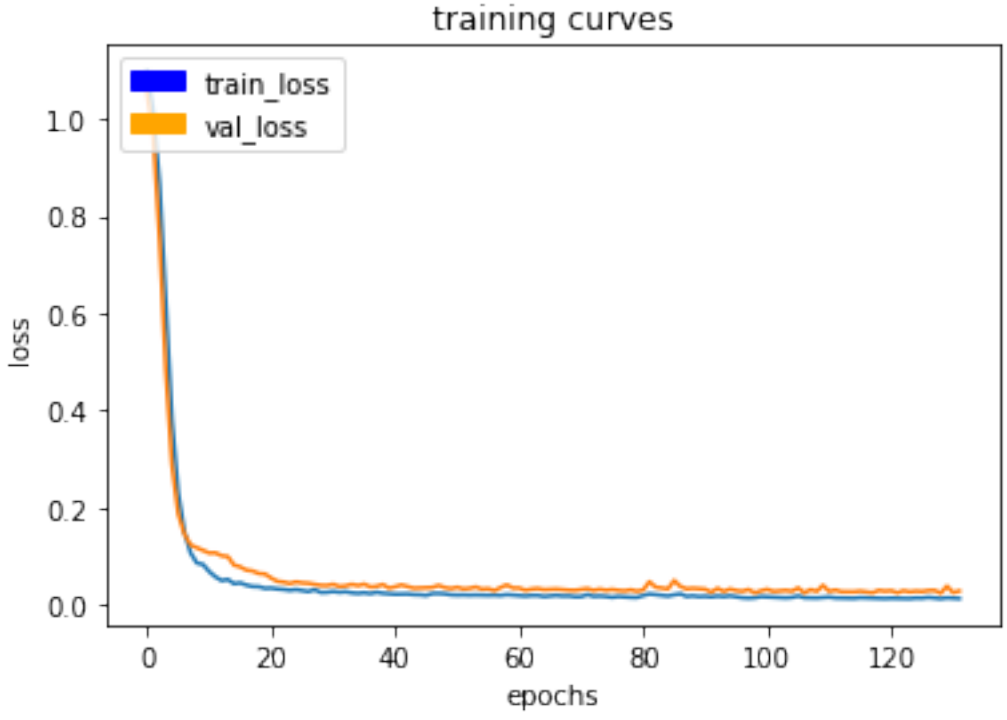
```
30/30 [==============================] - 23s - loss: 0.0135 - val_loss: 0.0247
Epoch 130/200
29/30 [============================>.] - ETA: 0s - loss: 0.0152
```



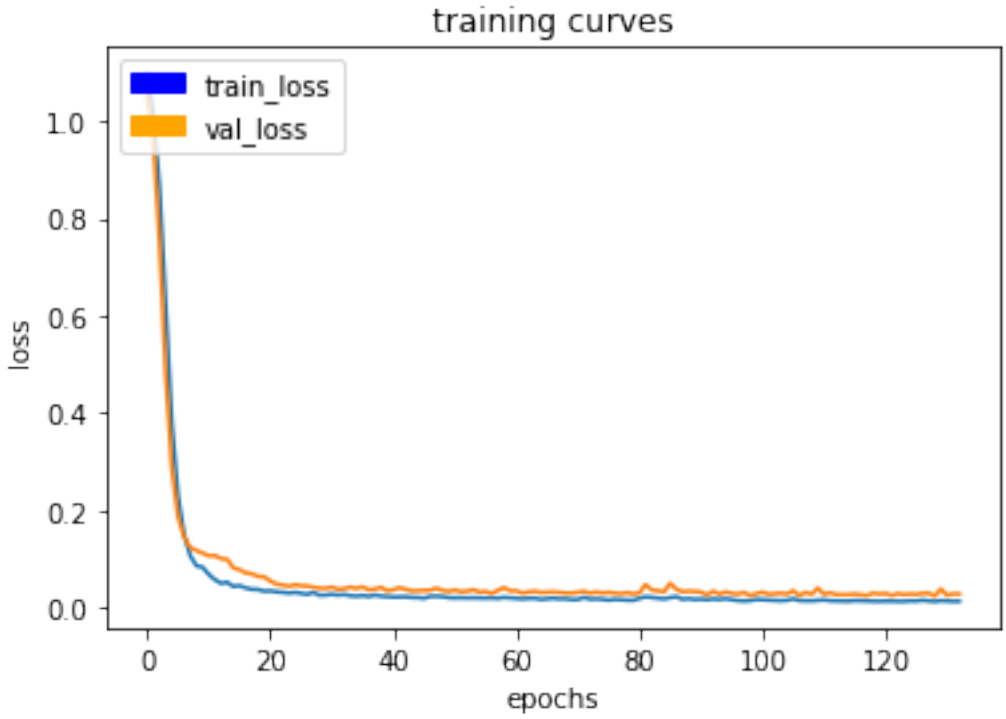

```
30/30 [==============================] - 23s - loss: 0.0152 - val_loss: 0.0393
Epoch 131/200
29/30 [============================>.] - ETA: 0s - loss: 0.0145
```



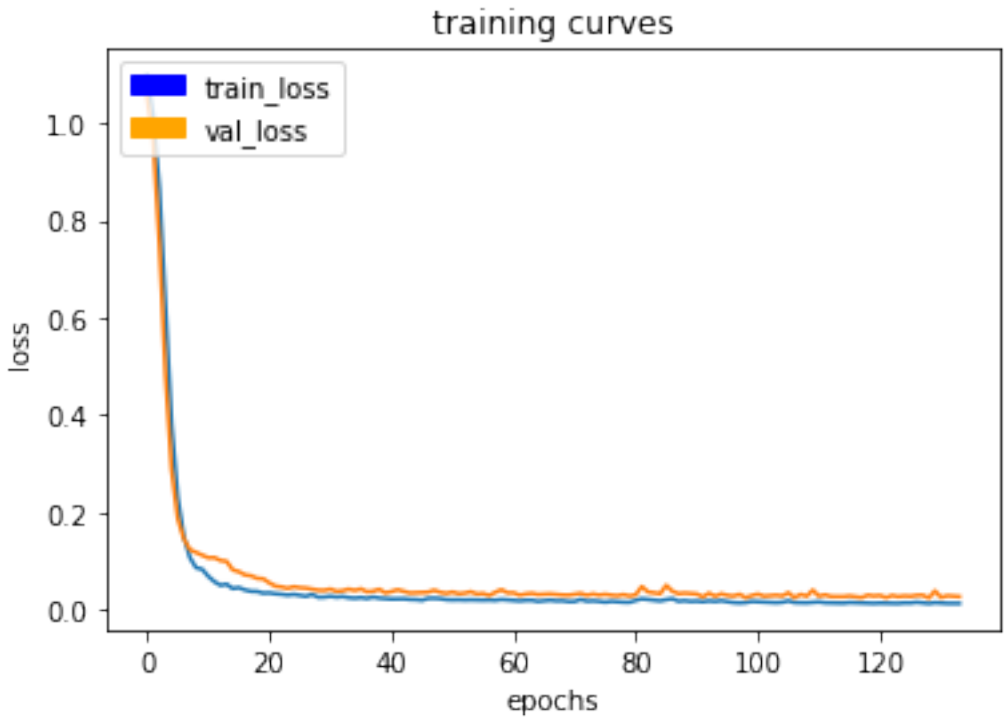

```
30/30 [==============================] - 23s - loss: 0.0145 - val_loss: 0.0259
Epoch 132/200
29/30 [============================>.] - ETA: 0s - loss: 0.0136
```



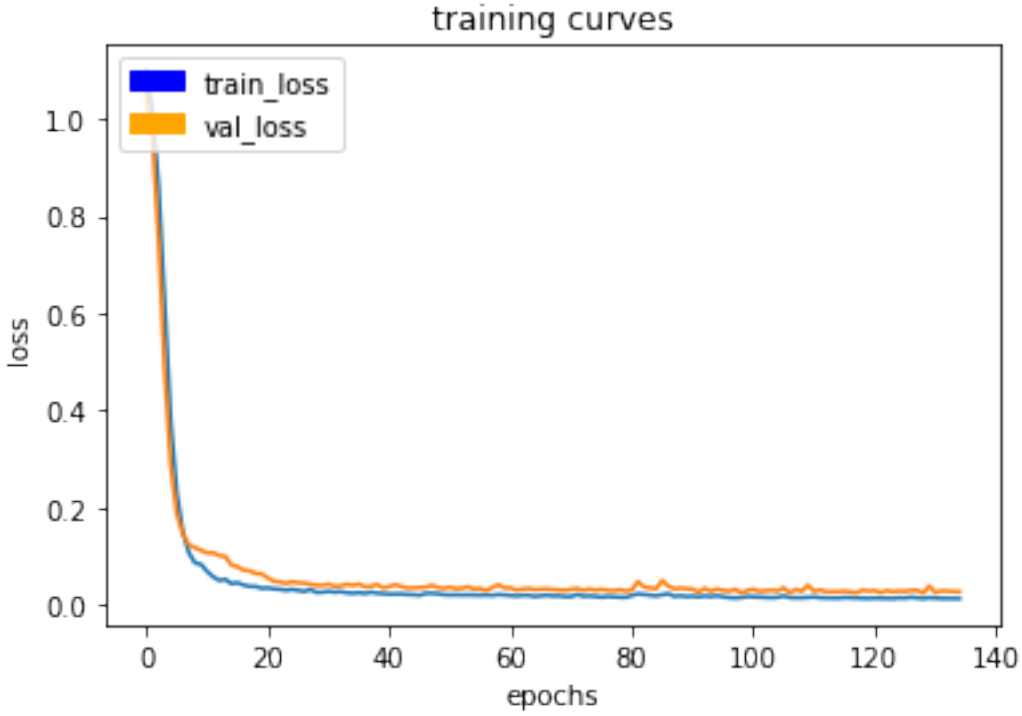
```
30/30 [==============================] - 23s - loss: 0.0138 - val_loss: 0.0293
Epoch 133/200
29/30 [============================>.] - ETA: 0s - loss: 0.0141
```



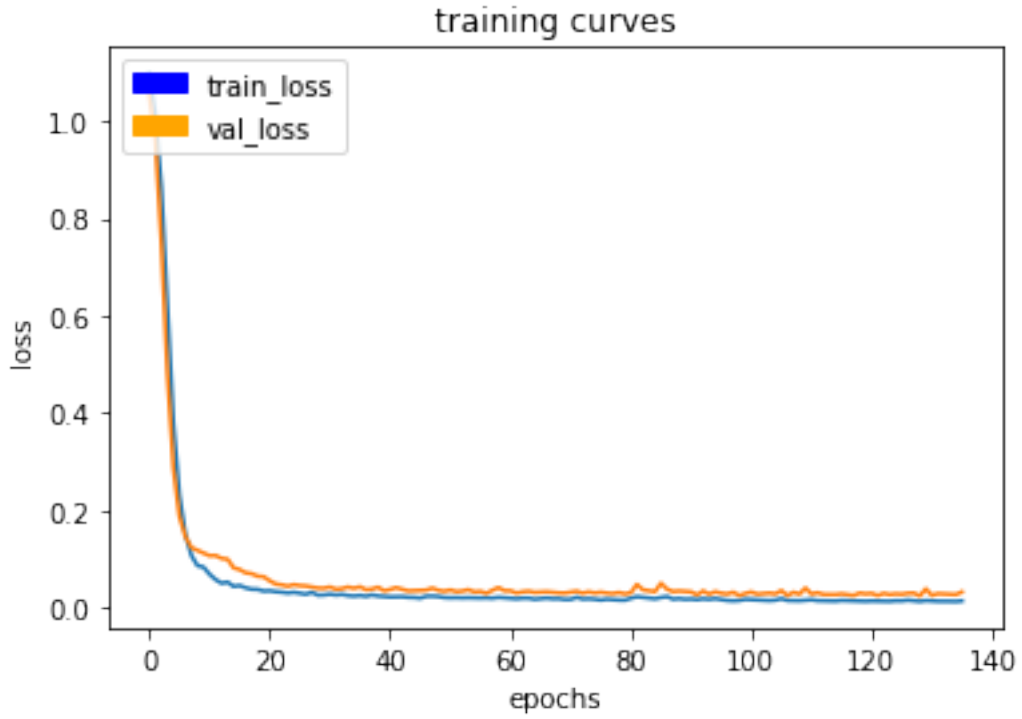

```
30/30 [==============================] - 23s - loss: 0.0140 - val_loss: 0.0288
Epoch 134/200
29/30 [============================>.] - ETA: 0s - loss: 0.0136
```



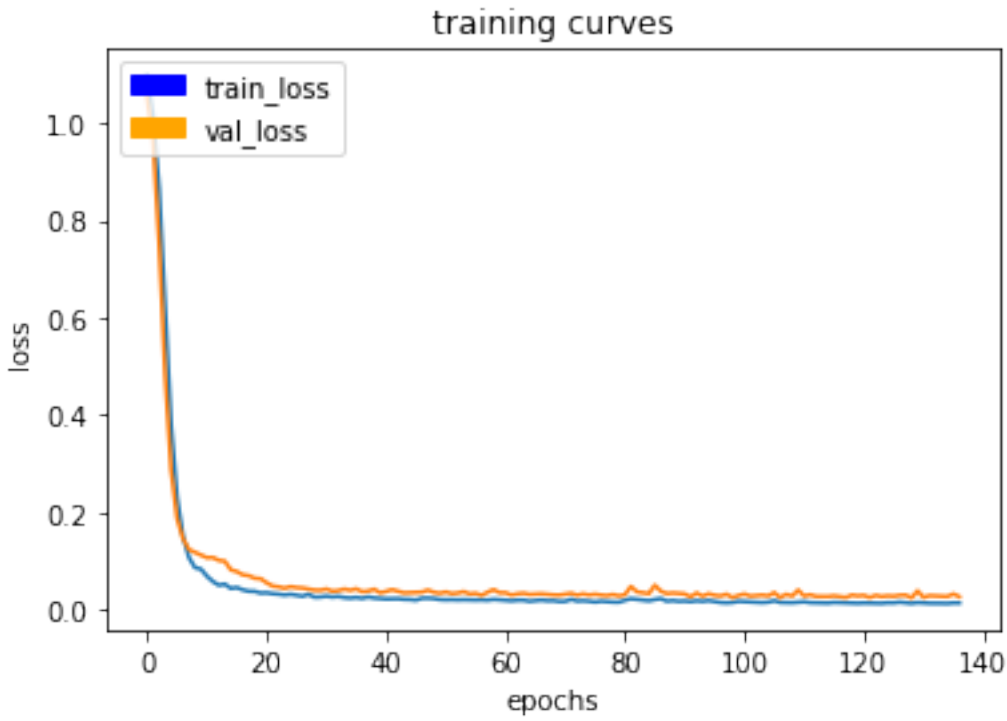

```
30/30 [==============================] - 23s - loss: 0.0136 - val_loss: 0.0276
Epoch 135/200
29/30 [============================>.] - ETA: 0s - loss: 0.0133
```



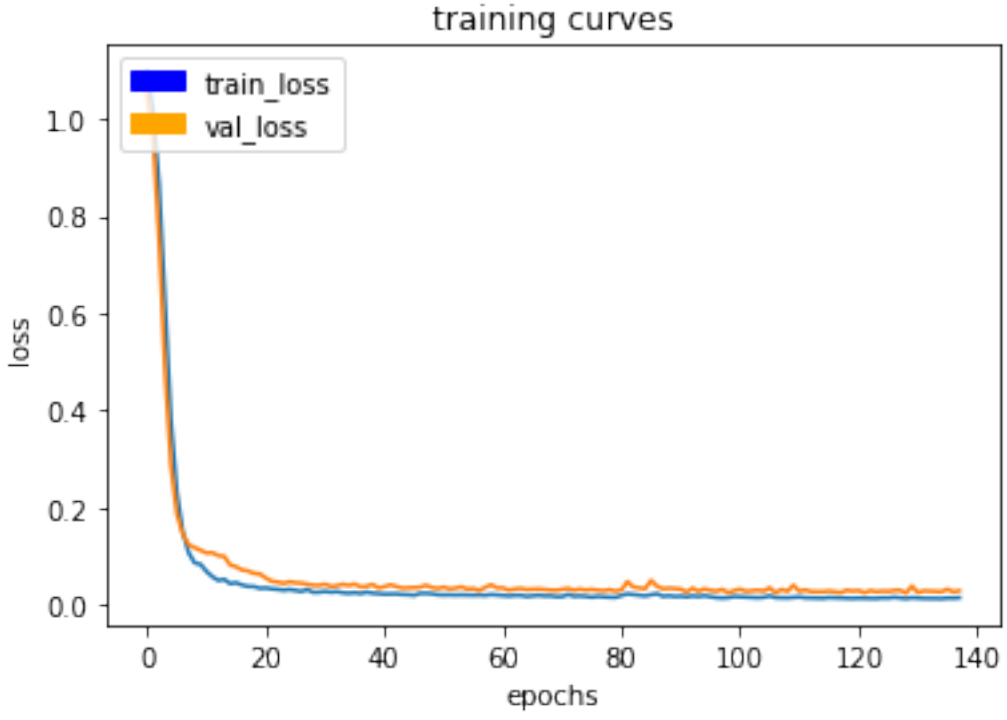
```
30/30 [==============================] - 23s - loss: 0.0133 - val_loss: 0.0275
Epoch 136/200
29/30 [============================>.] - ETA: 0s - loss: 0.0143
```



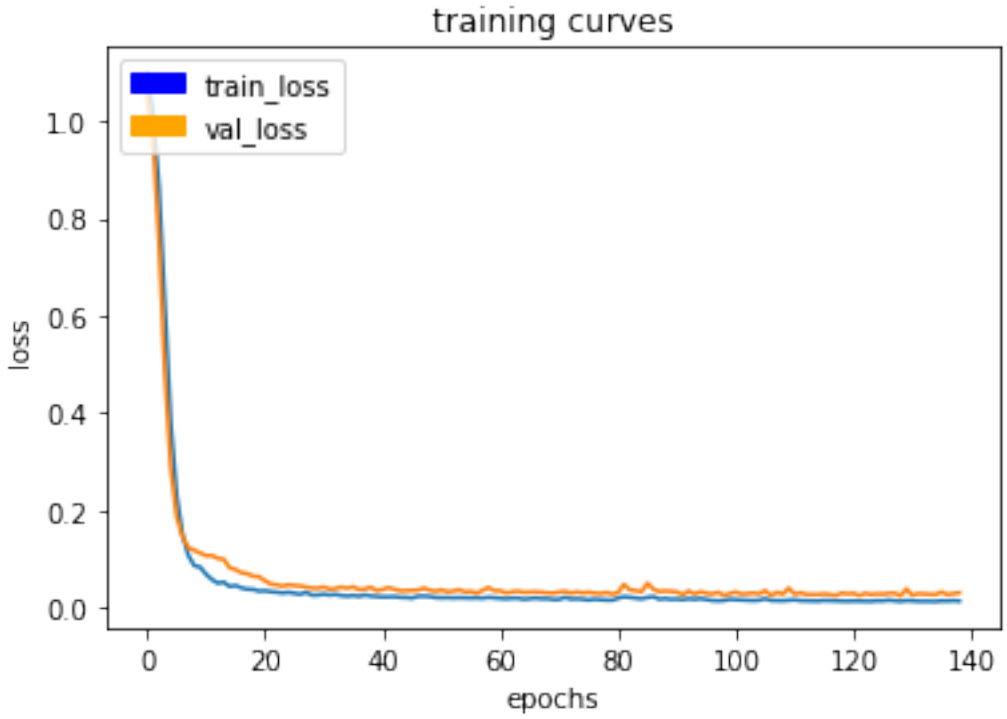

```
30/30 [==============================] - 23s - loss: 0.0145 - val_loss: 0.0329
Epoch 137/200
29/30 [============================>.] - ETA: 0s - loss: 0.0143
```



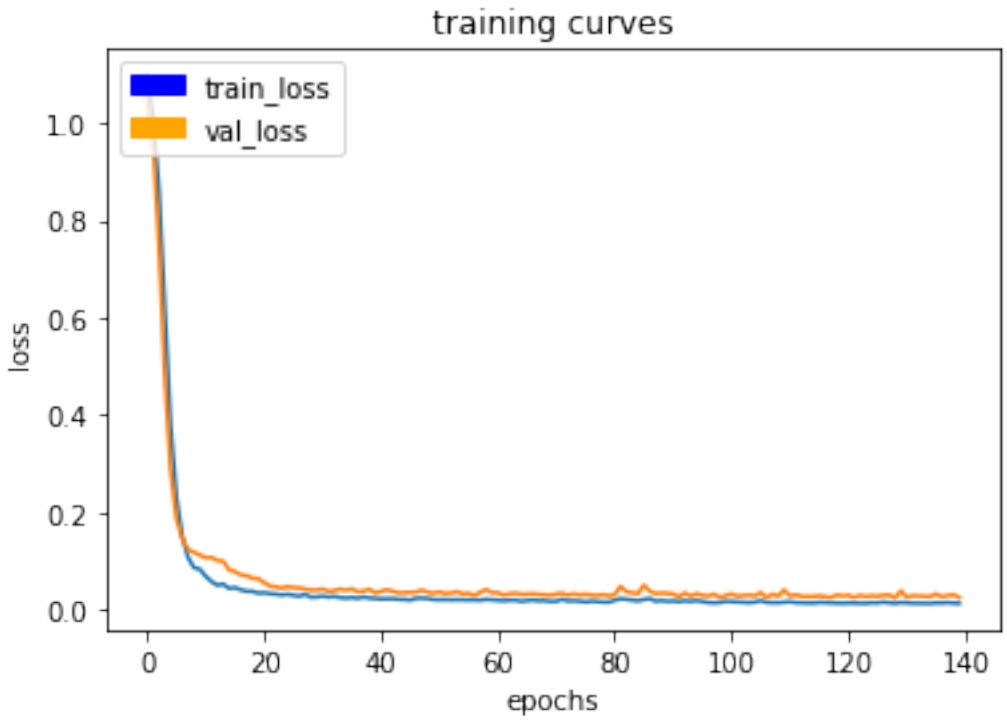

```
30/30 [==============================] - 23s - loss: 0.0143 - val_loss: 0.0271
Epoch 138/200
29/30 [============================>.] - ETA: 0s - loss: 0.0152
```



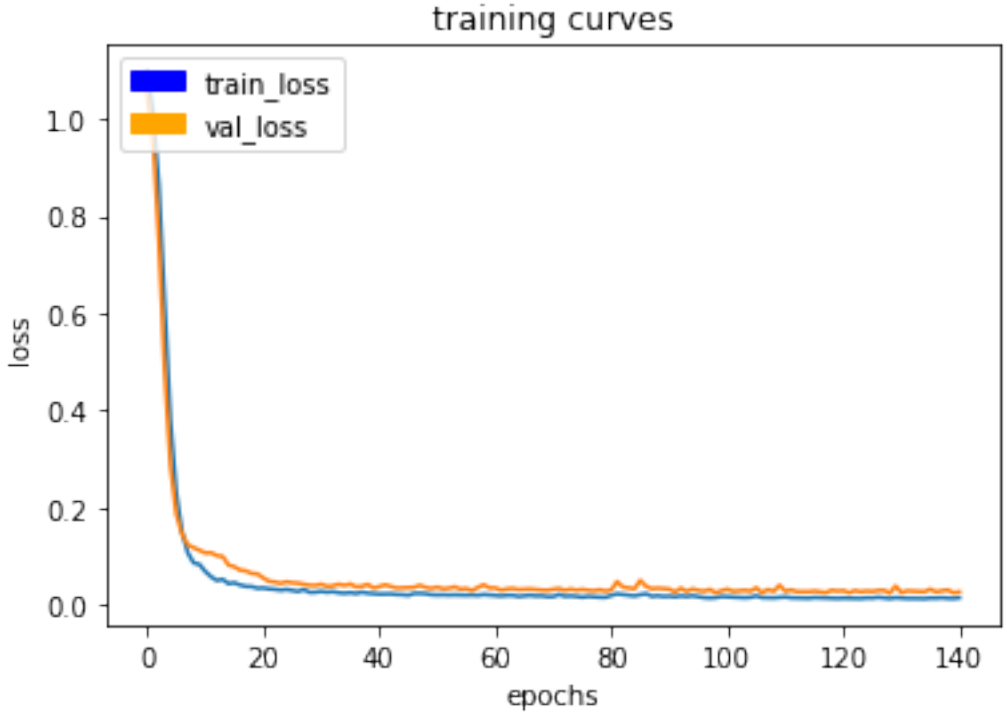
```
30/30 [==============================] - 23s - loss: 0.0151 - val_loss: 0.0296
Epoch 139/200
29/30 [============================>.] - ETA: 0s - loss: 0.0141
```



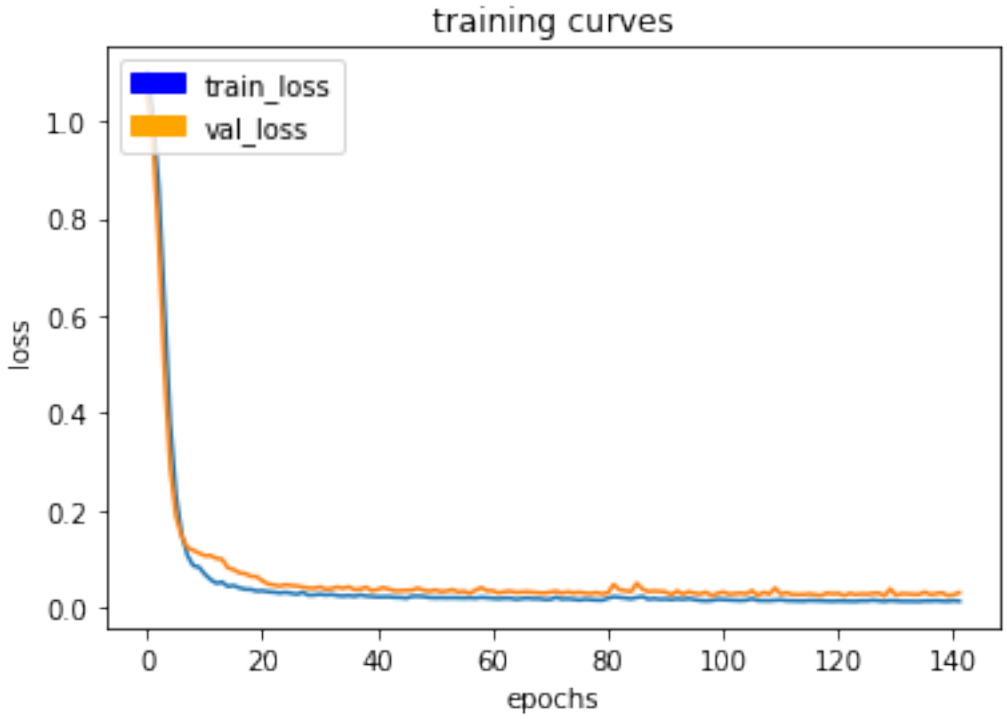

```
30/30 [==============================] - 23s - loss: 0.0141 - val_loss: 0.0312
Epoch 140/200
29/30 [============================>.] - ETA: 0s - loss: 0.0136
```



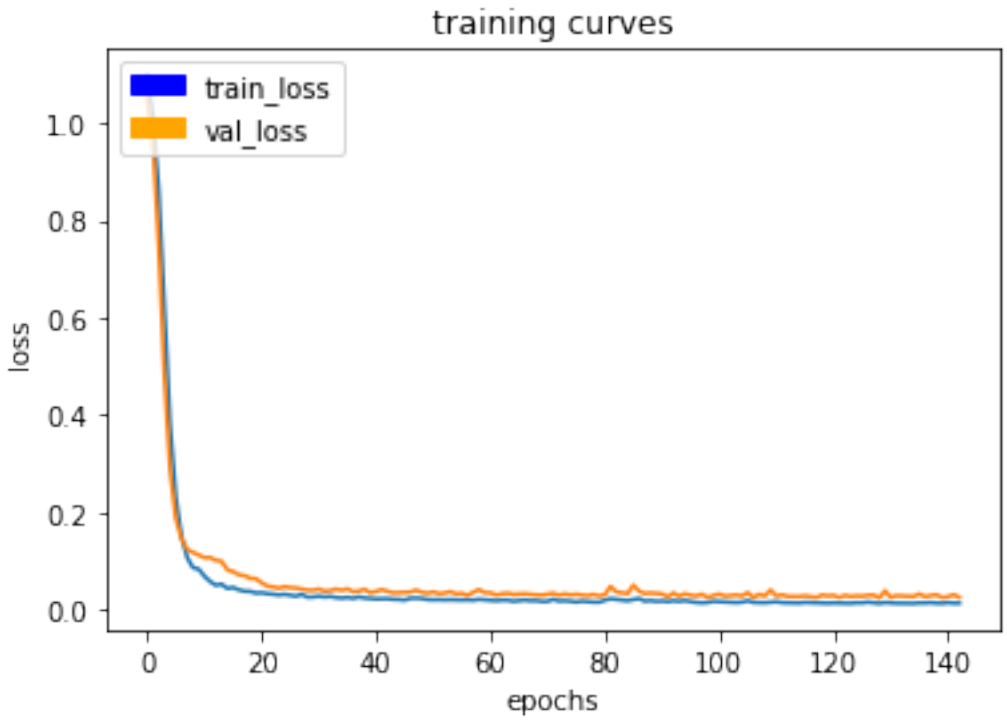

```
30/30 [==============================] - 23s - loss: 0.0137 - val_loss: 0.0254
Epoch 141/200
29/30 [============================>.] - ETA: 0s - loss: 0.0147
```



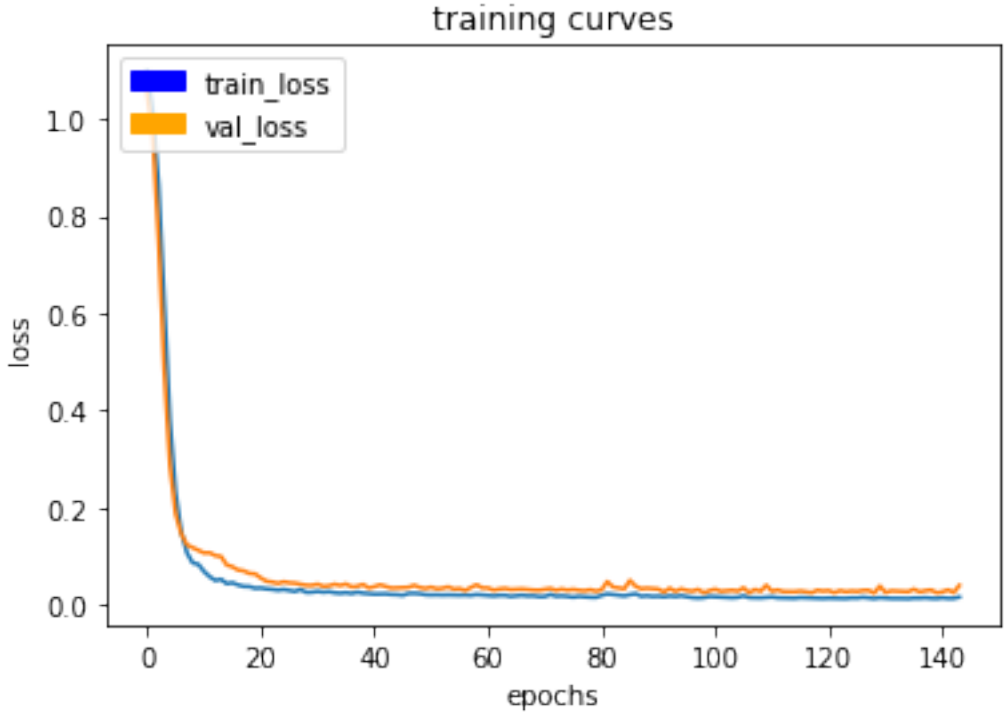
```
30/30 [==============================] - 23s - loss: 0.0150 - val_loss: 0.0272
Epoch 142/200
29/30 [============================>.] - ETA: 0s - loss: 0.0139
```



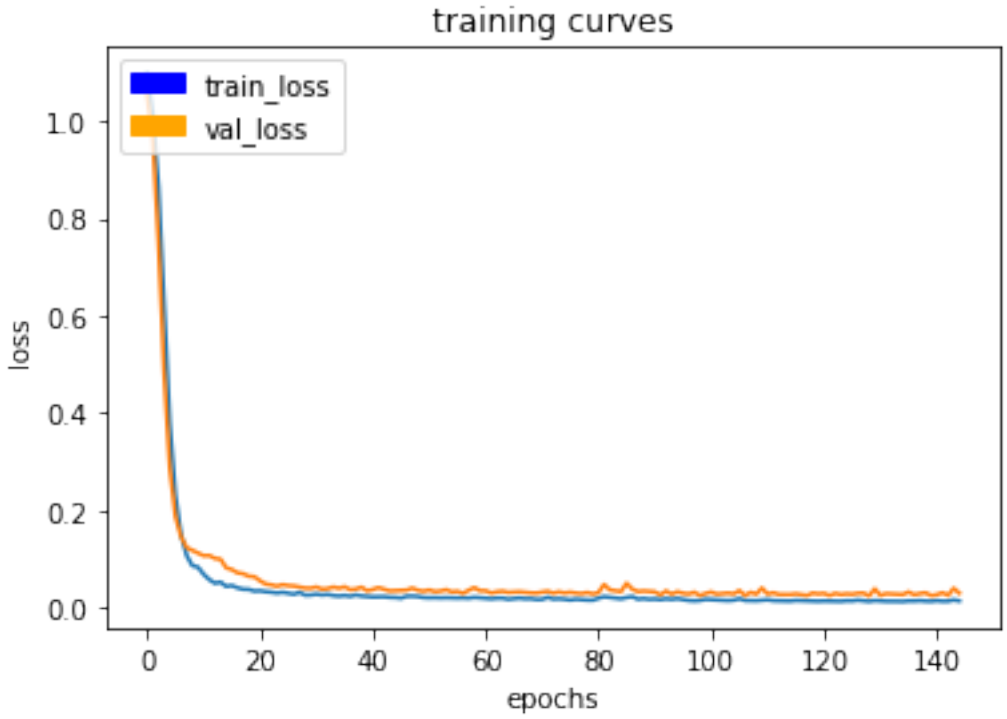

```
30/30 [==============================] - 23s - loss: 0.0139 - val_loss: 0.0313
Epoch 143/200
29/30 [============================>.] - ETA: 0s - loss: 0.0139
```



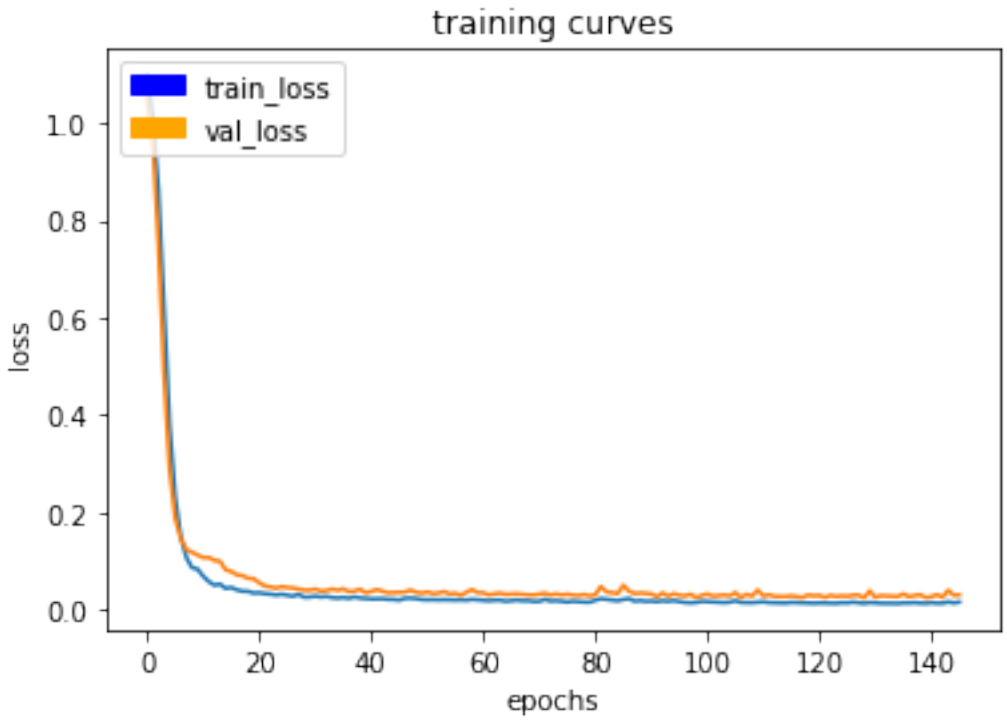

```
30/30 [==============================] - 23s - loss: 0.0139 - val_loss: 0.0259
Epoch 144/200
29/30 [============================>.] - ETA: 0s - loss: 0.0166
```



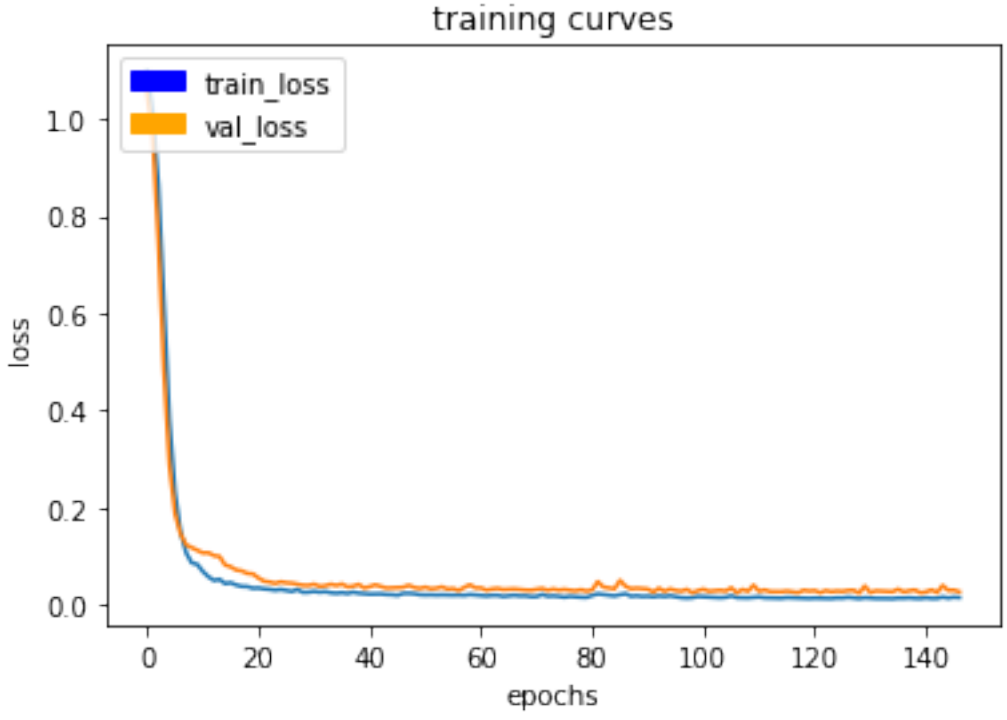
```
30/30 [==============================] - 23s - loss: 0.0166 - val_loss: 0.0404
Epoch 145/200
29/30 [============================>.] - ETA: 0s - loss: 0.0144
```



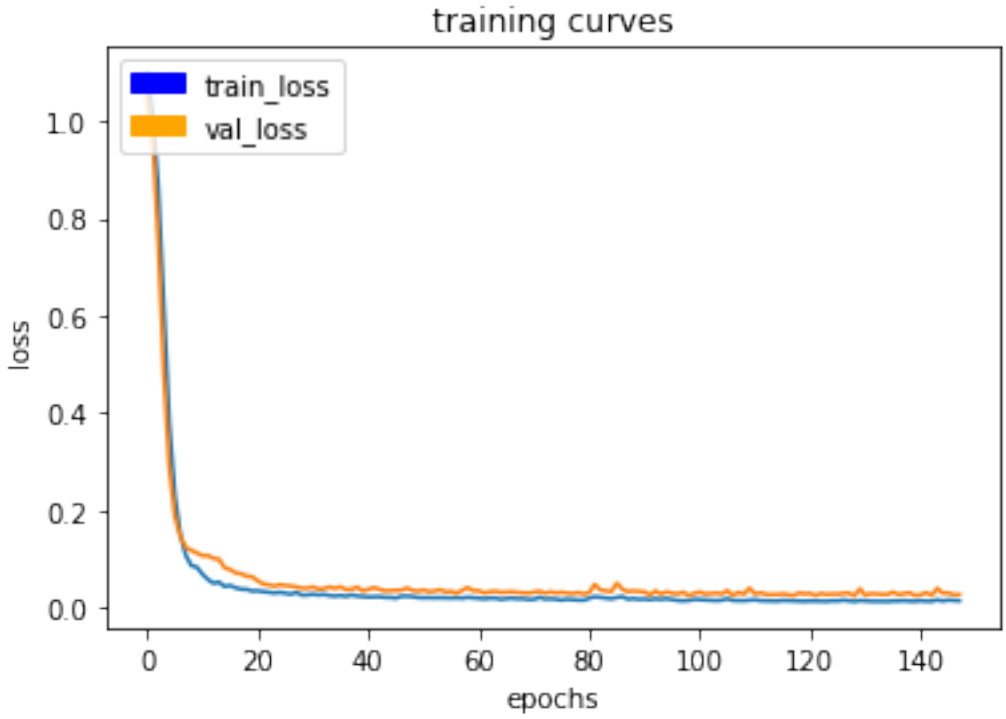

```
30/30 [==============================] - 23s - loss: 0.0144 - val_loss: 0.0303
Epoch 146/200
29/30 [============================>.] - ETA: 0s - loss: 0.0162
```



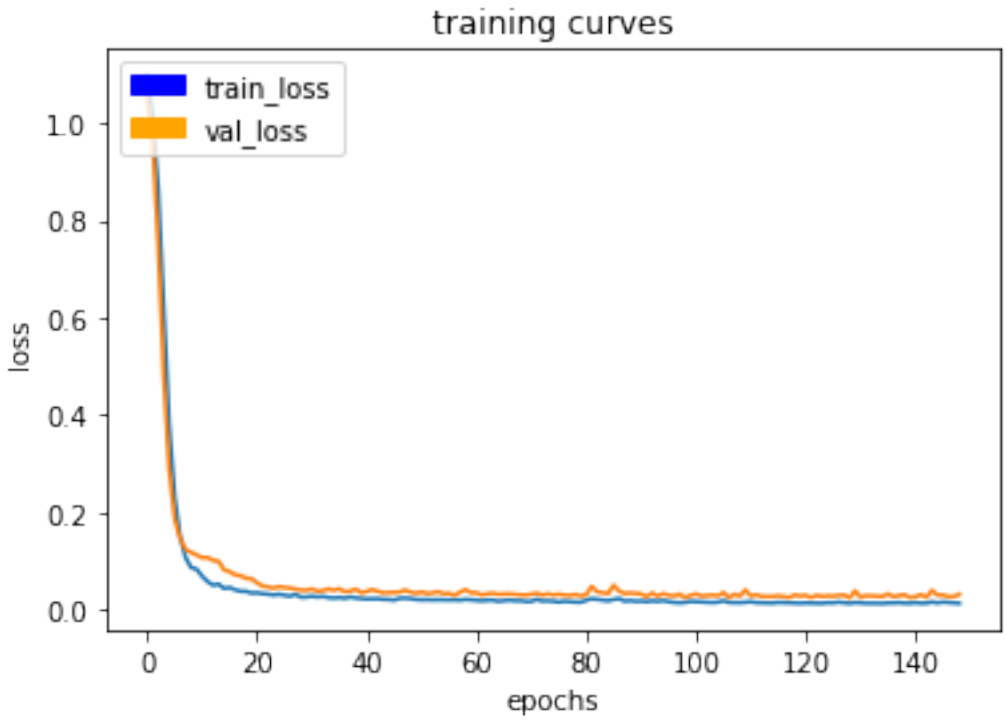

```
30/30 [==============================] - 23s - loss: 0.0162 - val_loss: 0.0308
Epoch 147/200
29/30 [============================>.] - ETA: 0s - loss: 0.0155
```



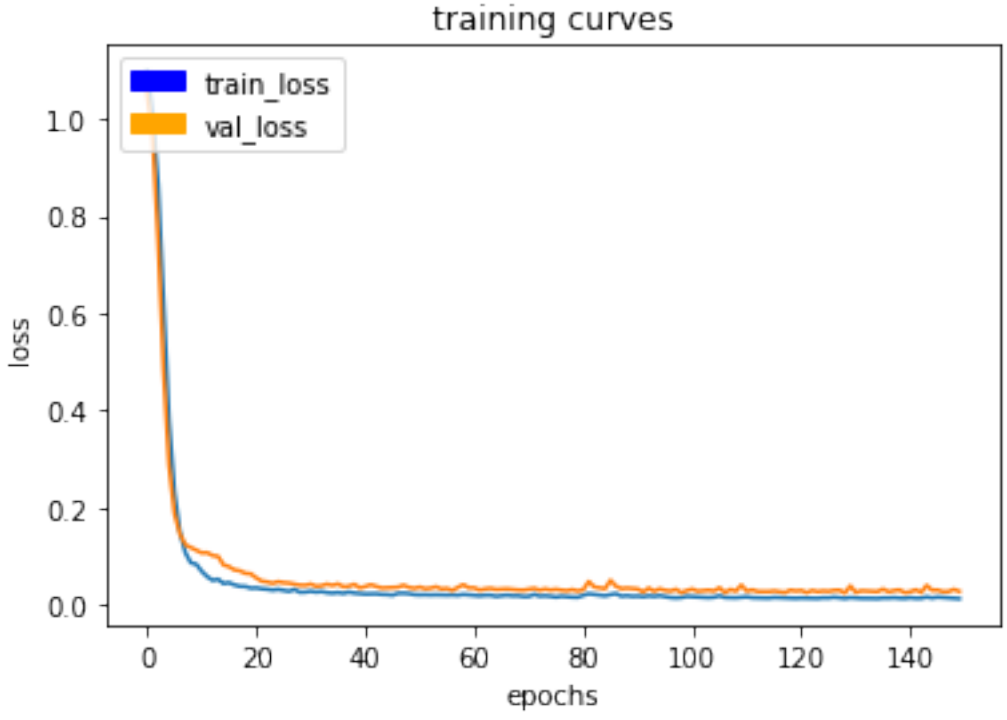
```
30/30 [==============================] - 23s - loss: 0.0154 - val_loss: 0.0273
Epoch 148/200
29/30 [============================>.] - ETA: 0s - loss: 0.0148
```



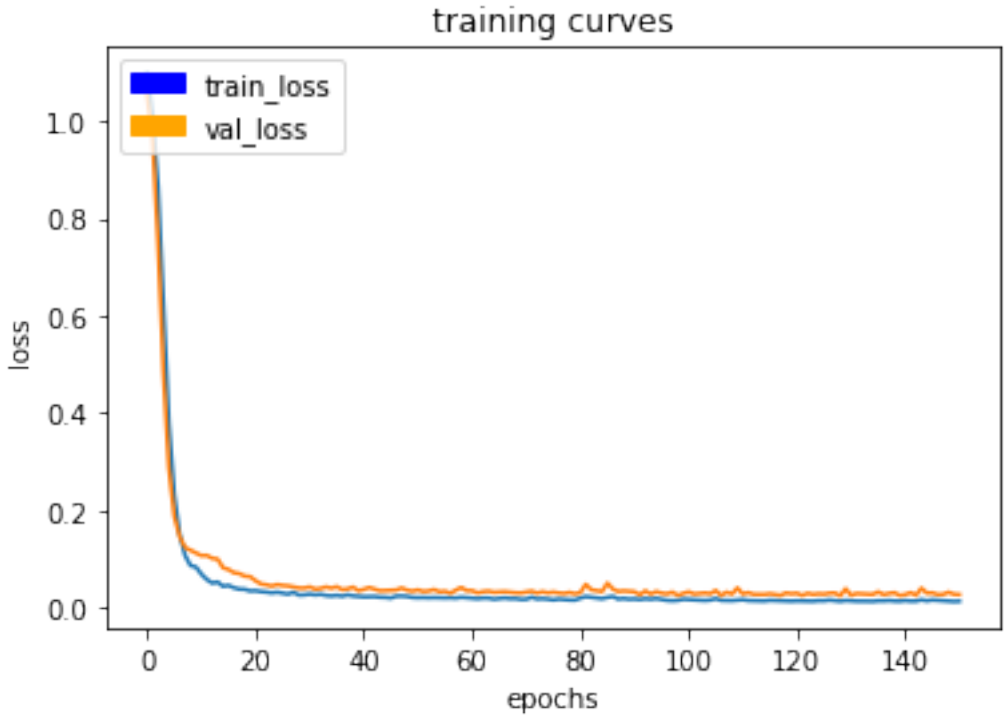

```
30/30 [==============================] - 23s - loss: 0.0147 - val_loss: 0.0276
Epoch 149/200
29/30 [============================>.] - ETA: 0s - loss: 0.0136
```



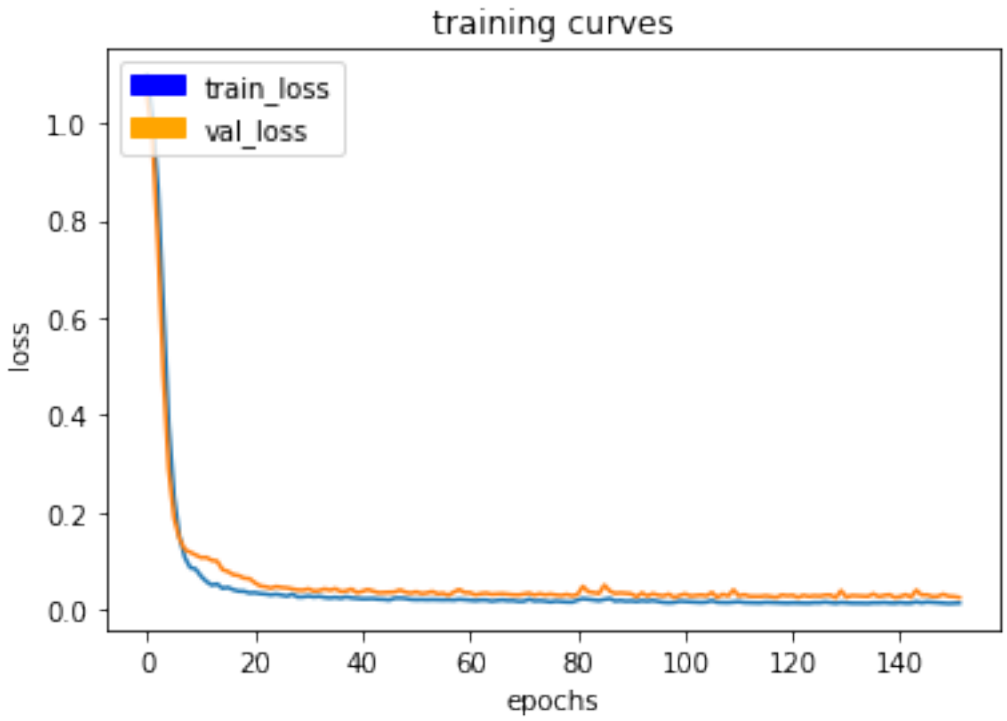

```
30/30 [==============================] - 23s - loss: 0.0136 - val_loss: 0.0321
Epoch 150/200
29/30 [============================>.] - ETA: 0s - loss: 0.0131
```



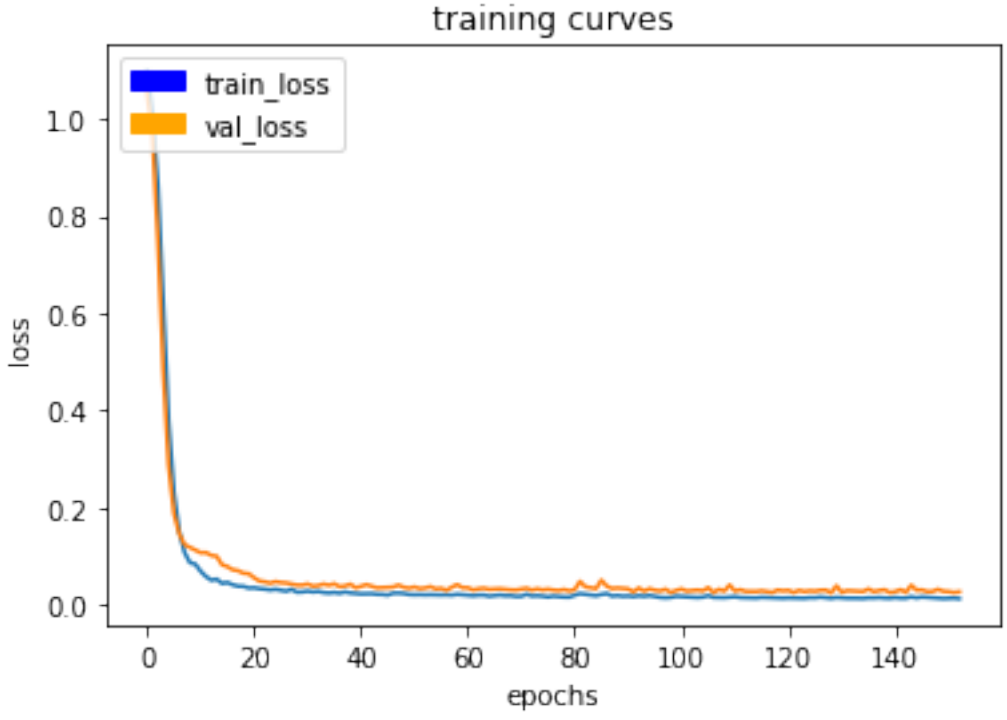
```
30/30 [==============================] - 23s - loss: 0.0131 - val_loss: 0.0279
Epoch 151/200
29/30 [============================>.] - ETA: 0s - loss: 0.0135
```



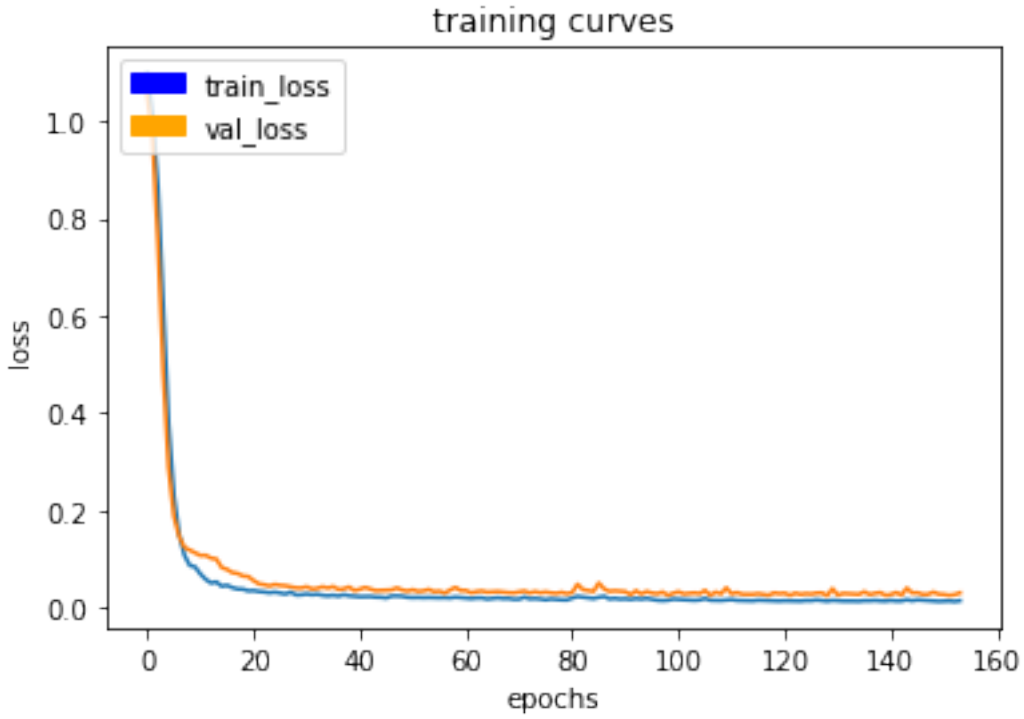

```
30/30 [==============================] - 23s - loss: 0.0136 - val_loss: 0.0273
Epoch 152/200
29/30 [============================>.] - ETA: 0s - loss: 0.0141
```



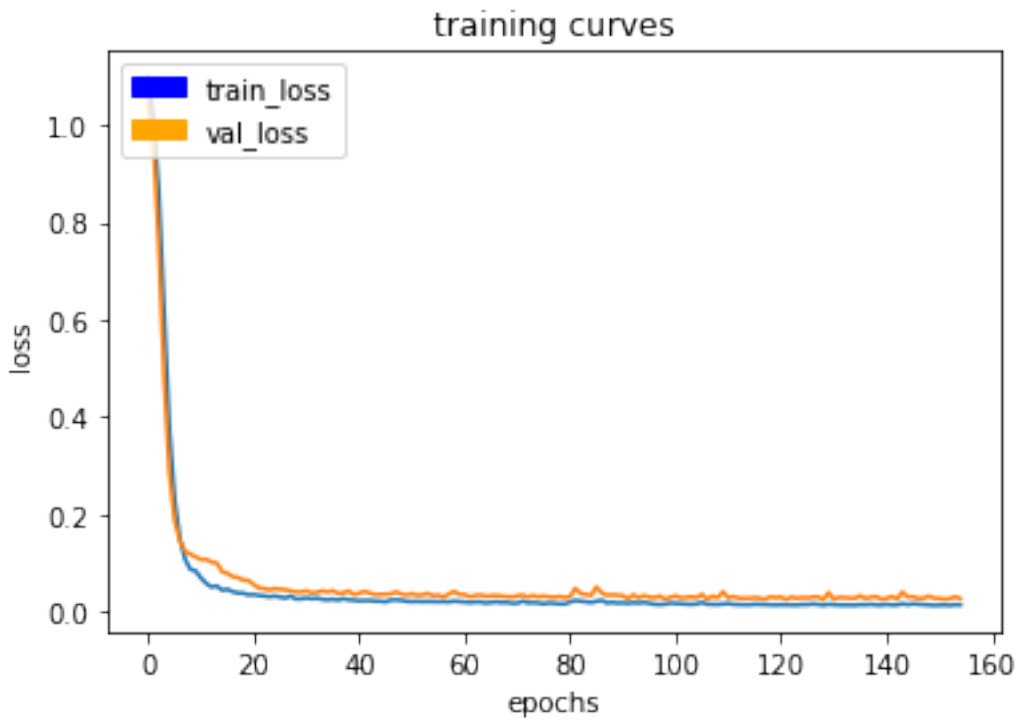

```
30/30 [==============================] - 23s - loss: 0.0140 - val_loss: 0.0254
Epoch 153/200
29/30 [============================>.] - ETA: 0s - loss: 0.0130
```



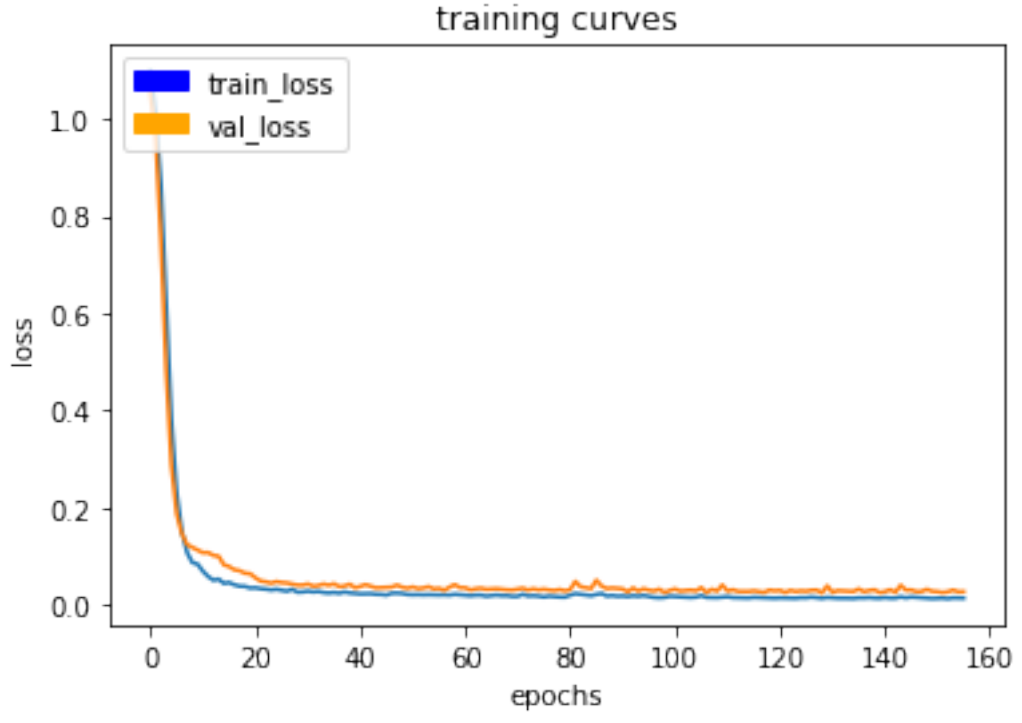
```
30/30 [==============================] - 23s - loss: 0.0129 - val_loss: 0.0269
Epoch 154/200
29/30 [============================>.] - ETA: 0s - loss: 0.0145
```



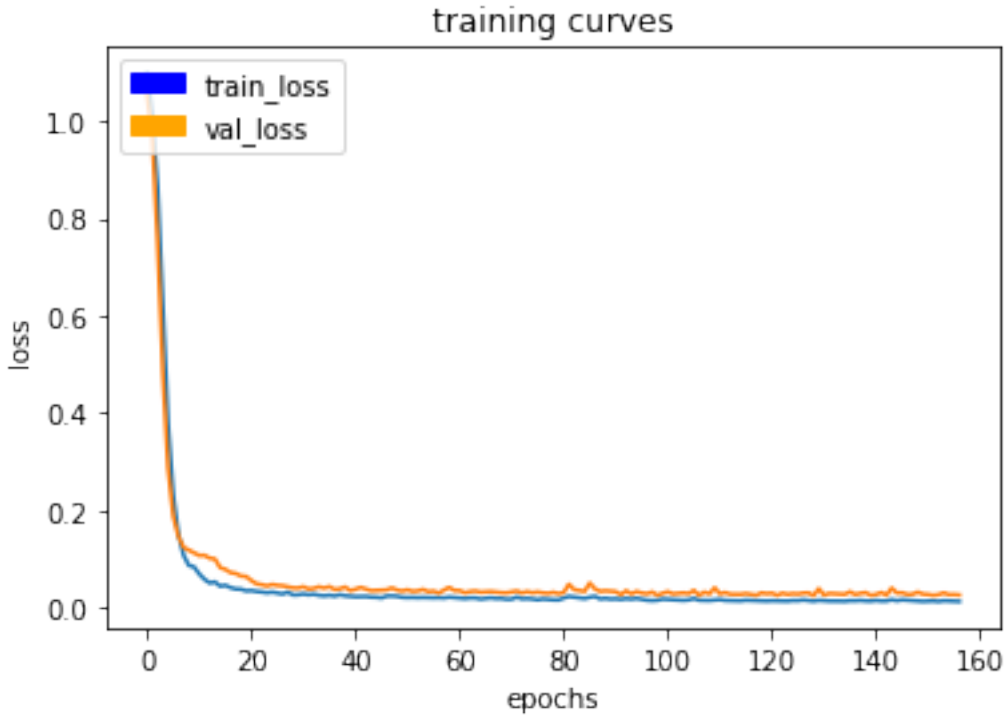

```
30/30 [==============================] - 23s - loss: 0.0144 - val_loss: 0.0305
Epoch 155/200
29/30 [============================>.] - ETA: 0s - loss: 0.0140
```



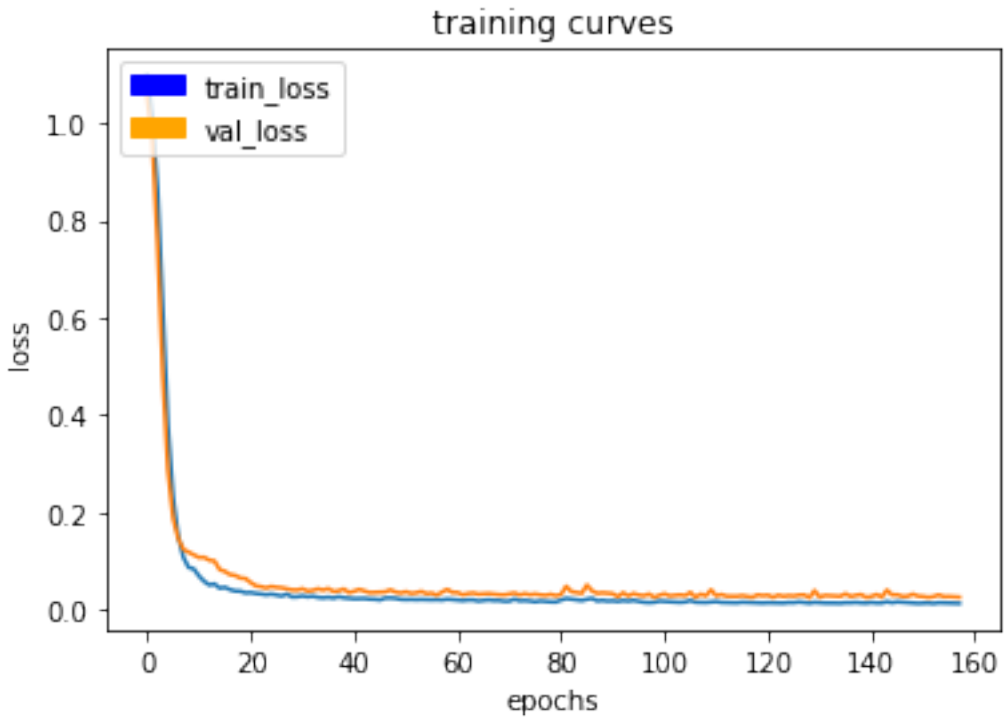

```
30/30 [==============================] - 23s - loss: 0.0139 - val_loss: 0.0269
Epoch 156/200
29/30 [============================>.] - ETA: 0s - loss: 0.0139
```



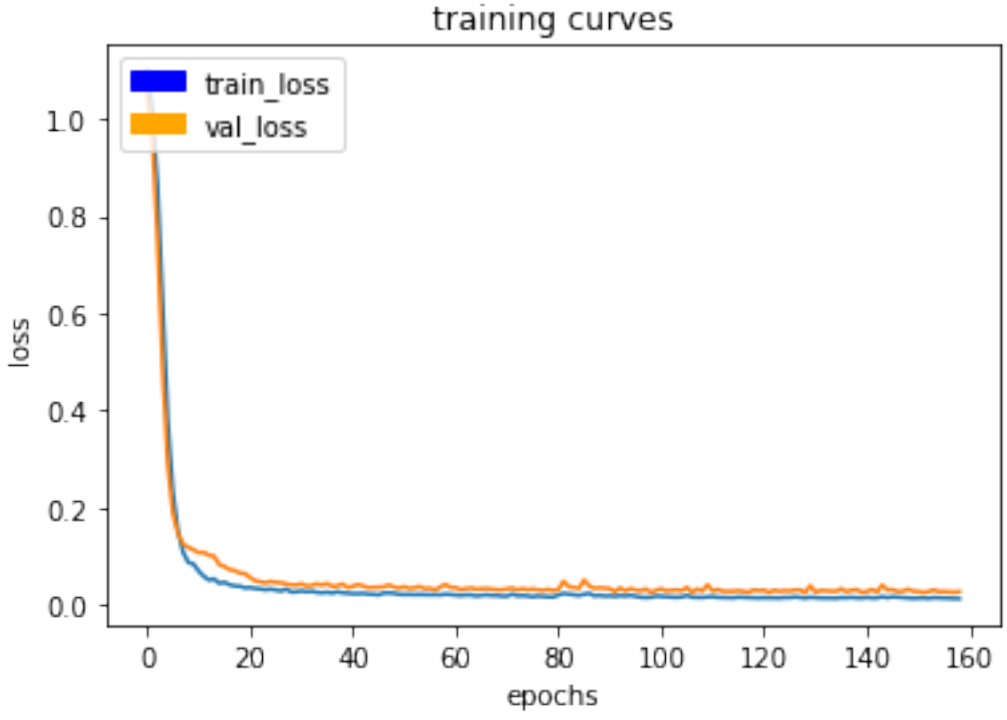
```
30/30 [==============================] - 23s - loss: 0.0138 - val_loss: 0.0271
Epoch 157/200
29/30 [============================>.] - ETA: 0s - loss: 0.0129
```



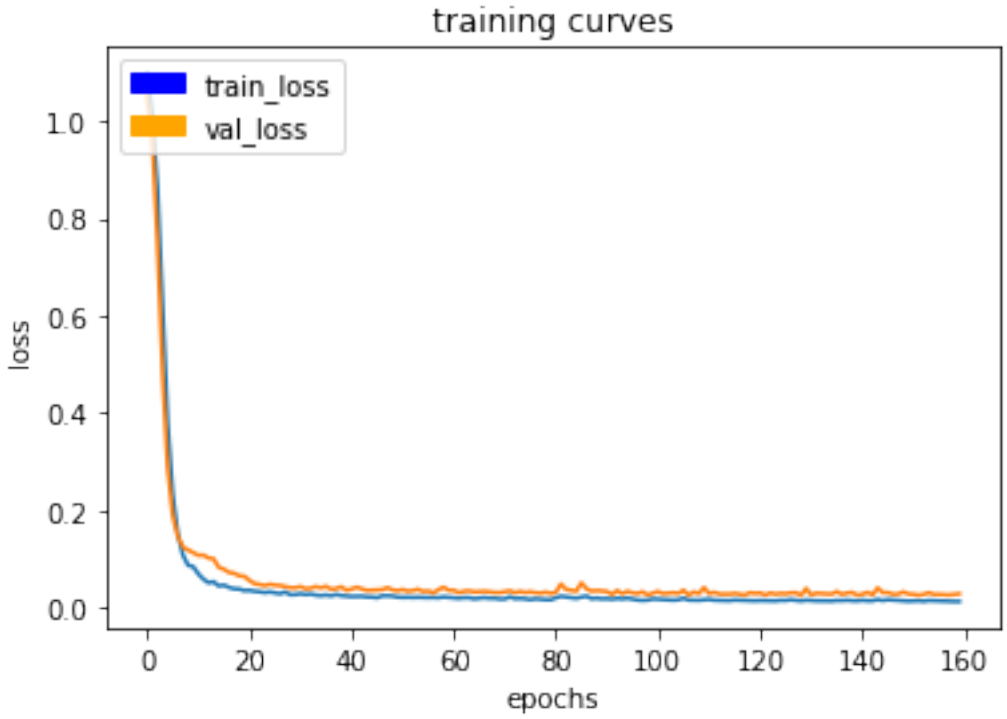

```
30/30 [==============================] - 23s - loss: 0.0129 - val_loss: 0.0262
Epoch 158/200
29/30 [============================>.] - ETA: 0s - loss: 0.0131
```



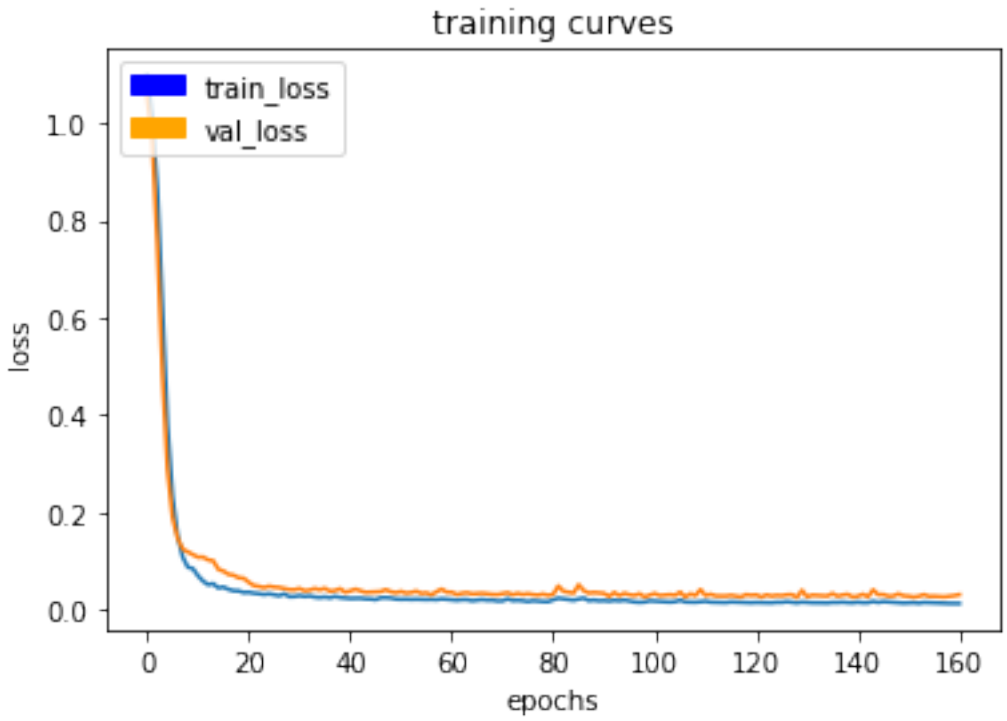

```
30/30 [==============================] - 23s - loss: 0.0131 - val_loss: 0.0258
Epoch 159/200
29/30 [============================>.] - ETA: 0s - loss: 0.0125
```



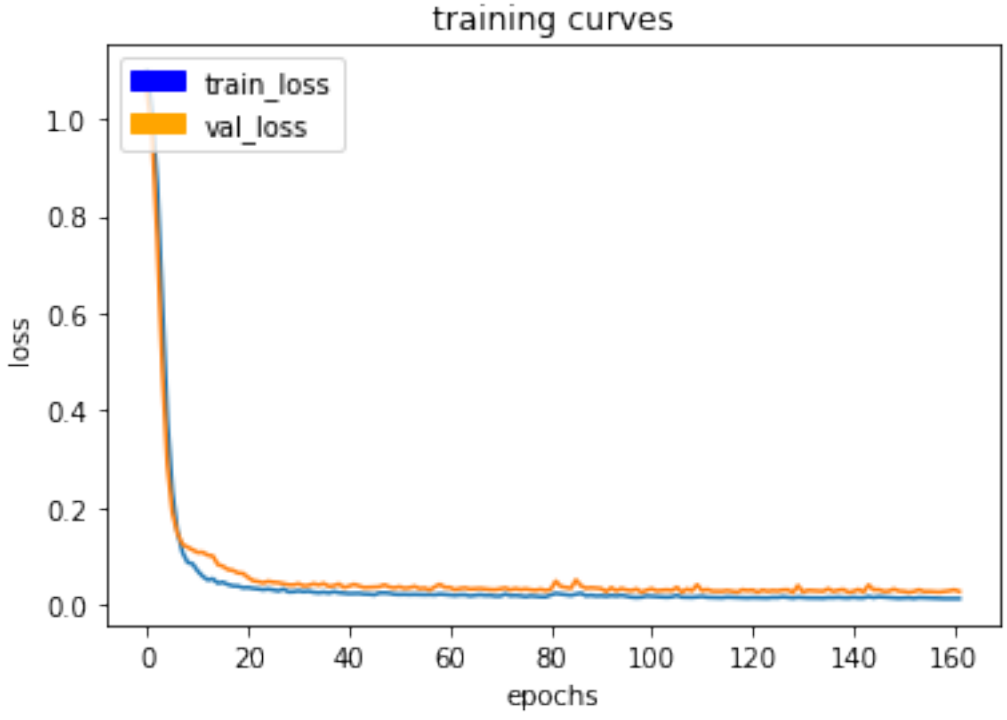
```
30/30 [==============================] - 23s - loss: 0.0124 - val_loss: 0.0269
Epoch 160/200
29/30 [============================>.] - ETA: 0s - loss: 0.0124
```



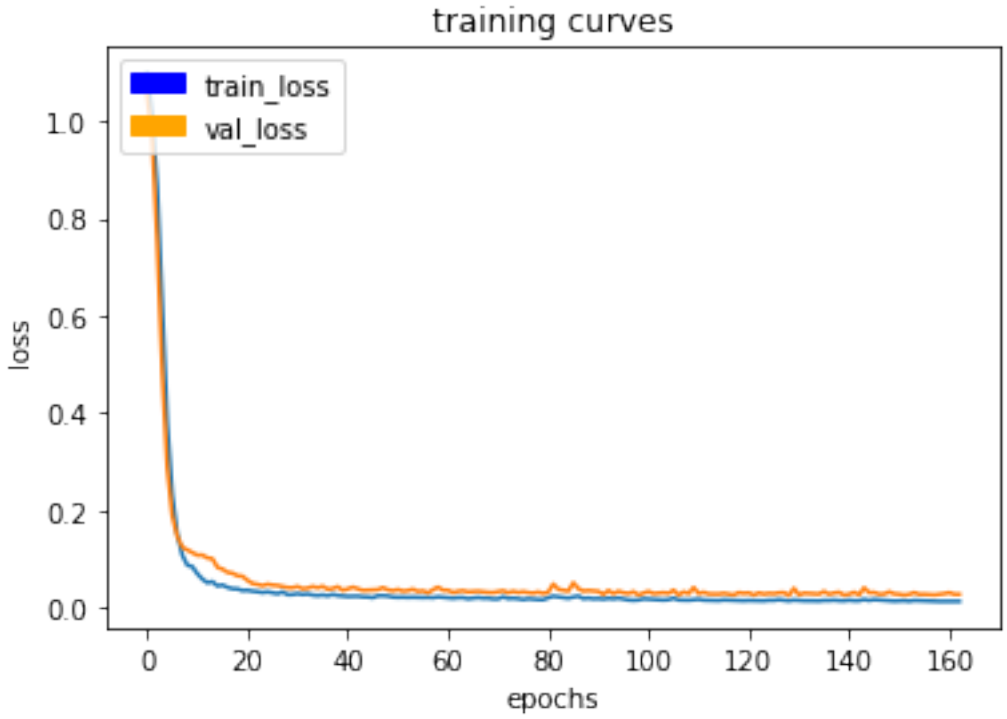

```
30/30 [==============================] - 23s - loss: 0.0124 - val_loss: 0.0283
Epoch 161/200
29/30 [============================>.] - ETA: 0s - loss: 0.0122
```



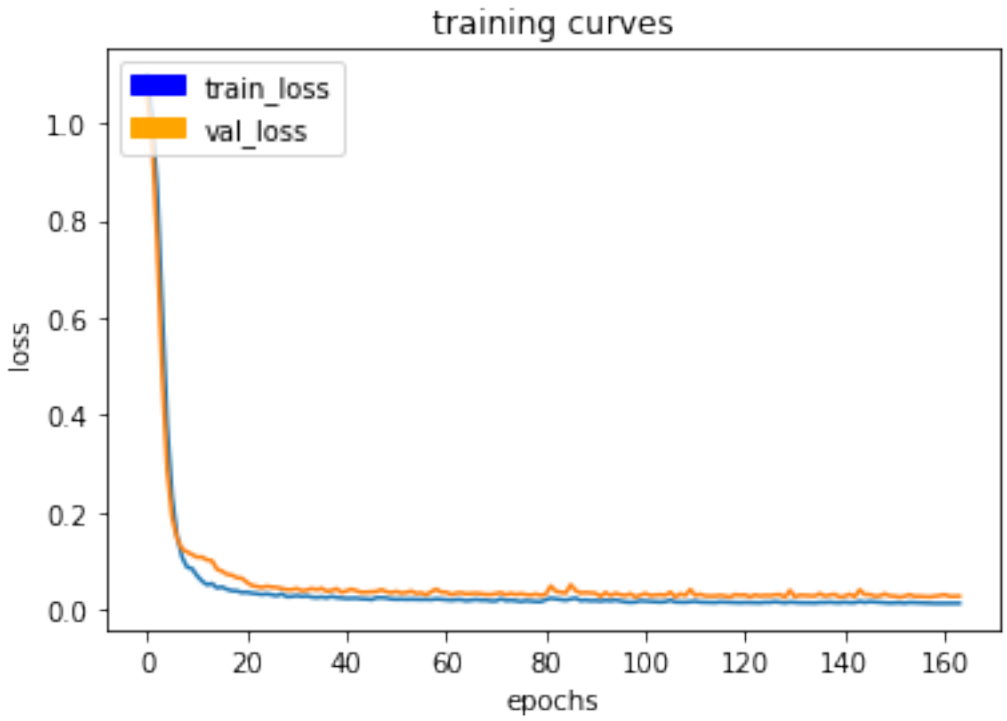

```
30/30 [==============================] - 23s - loss: 0.0122 - val_loss: 0.0304
Epoch 162/200
29/30 [============================>.] - ETA: 0s - loss: 0.0125
```



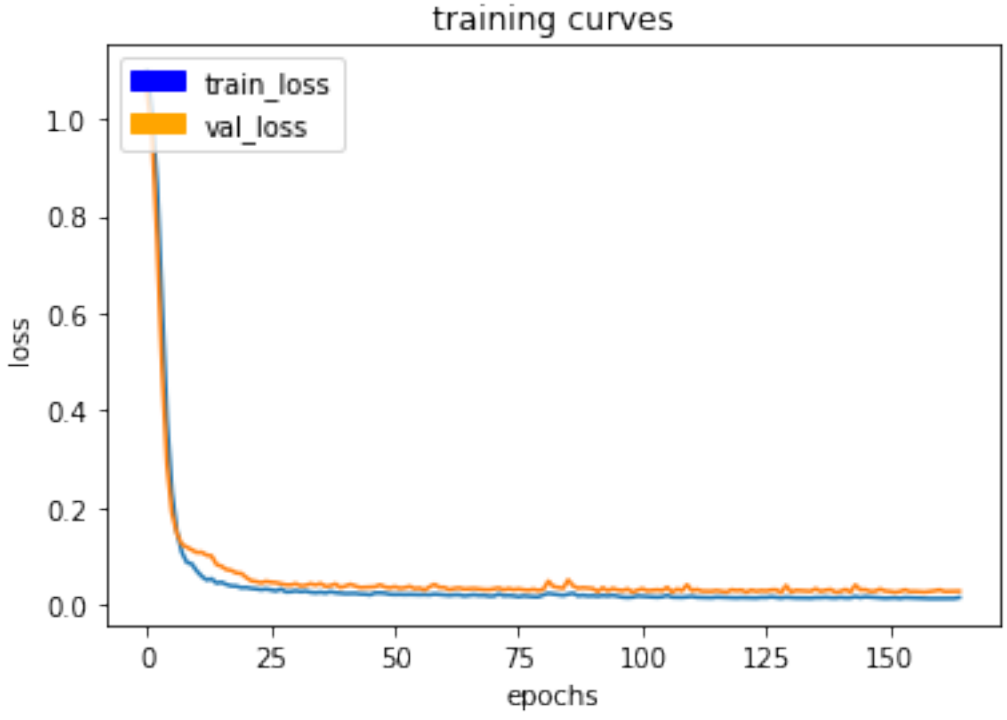
```
30/30 [==============================] - 23s - loss: 0.0124 - val_loss: 0.0270
Epoch 163/200
29/30 [============================>.] - ETA: 0s - loss: 0.0125
```



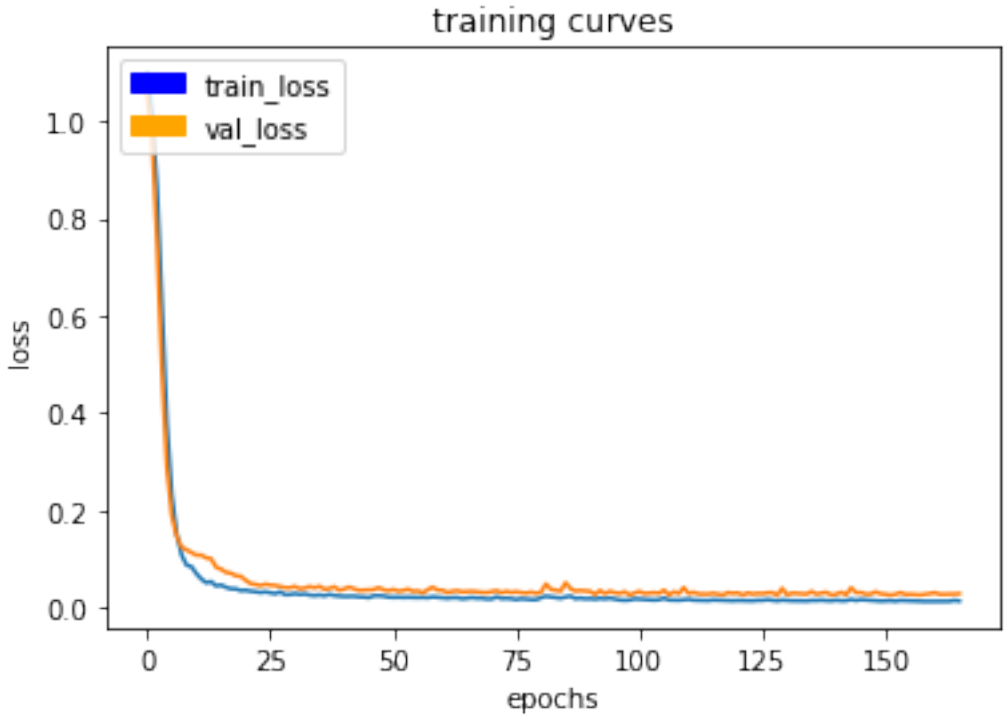

```
30/30 [==============================] - 23s - loss: 0.0125 - val_loss: 0.0270
Epoch 164/200
29/30 [============================>.] - ETA: 0s - loss: 0.0126
```



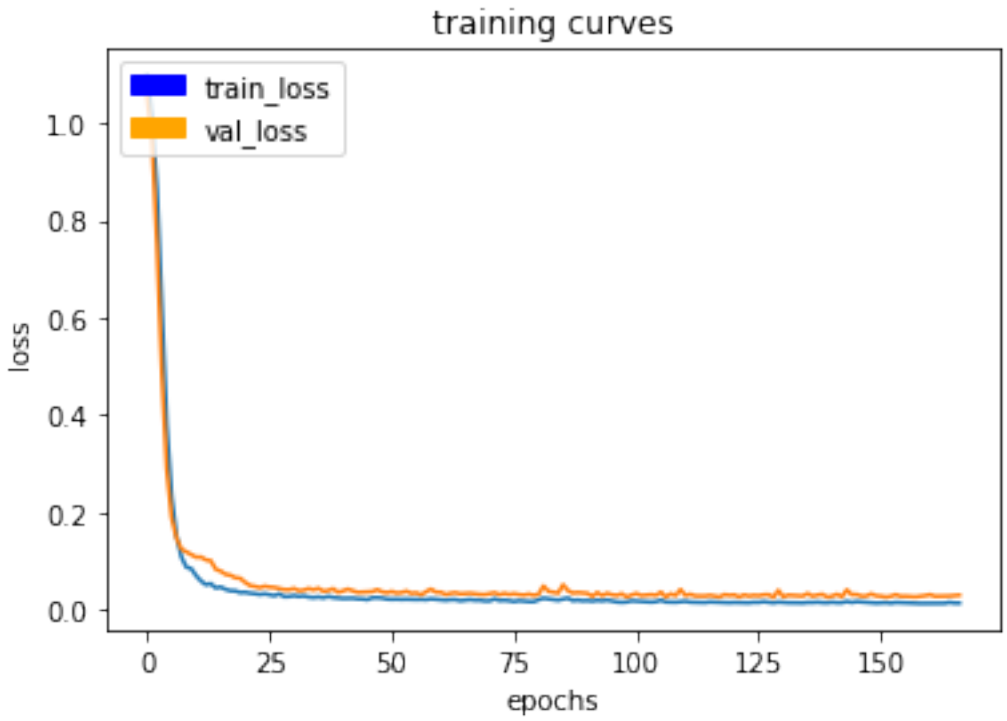

```
30/30 [==============================] - 23s - loss: 0.0126 - val_loss: 0.0272
Epoch 165/200
29/30 [============================>.] - ETA: 0s - loss: 0.0147
```



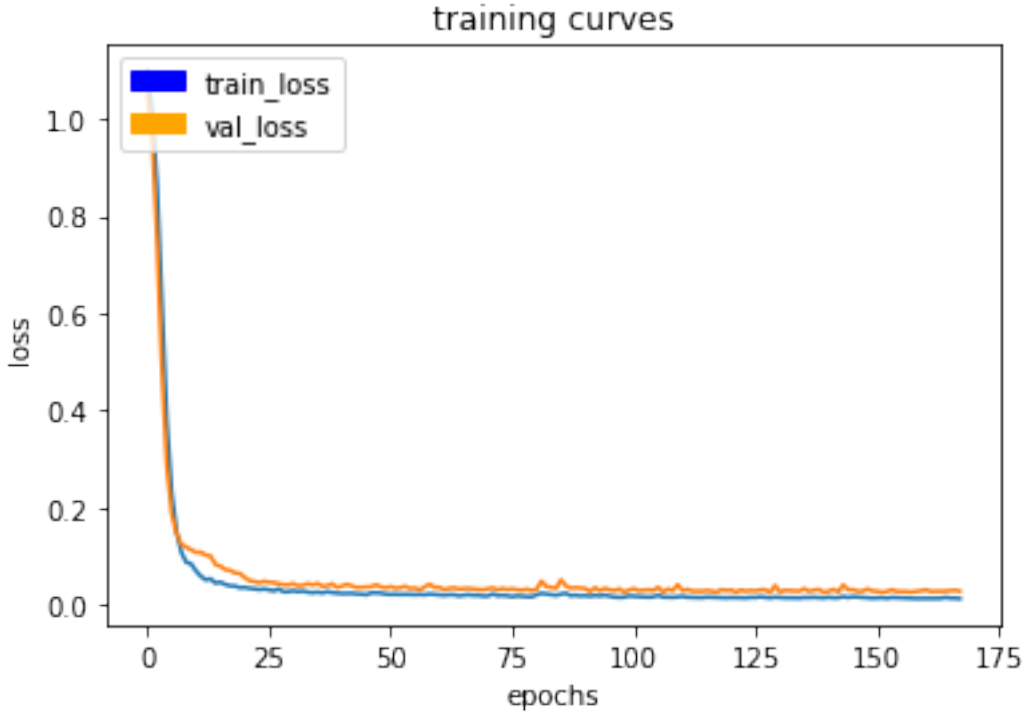
```
30/30 [==============================] - 23s - loss: 0.0146 - val_loss: 0.0276
Epoch 166/200
29/30 [============================>.] - ETA: 0s - loss: 0.0131
```



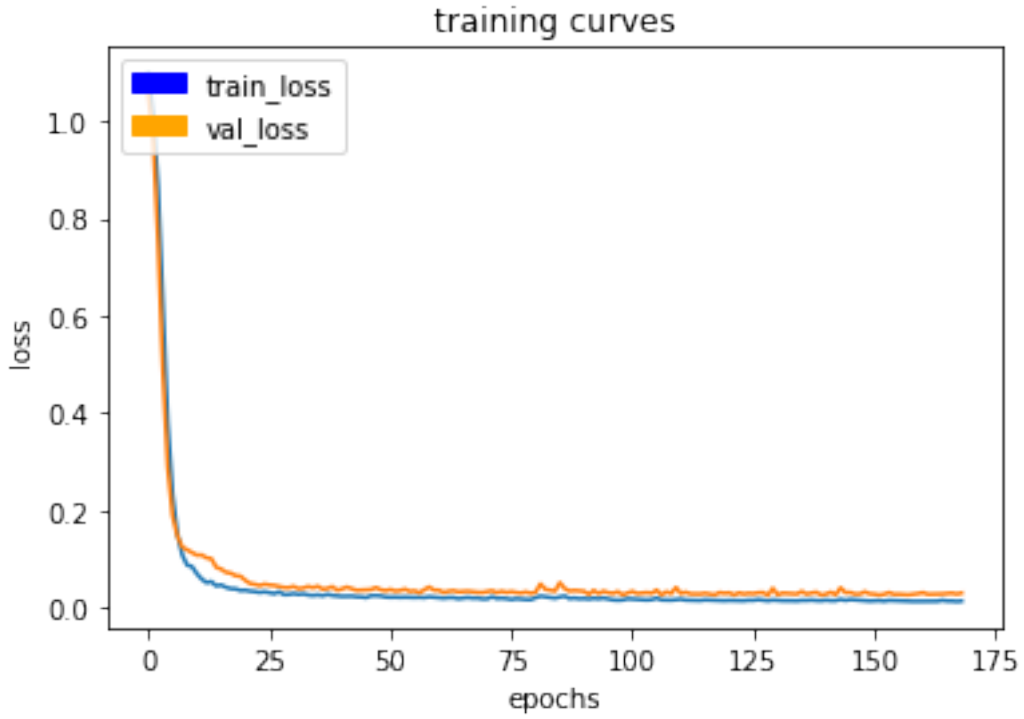

```
30/30 [==============================] - 23s - loss: 0.0131 - val_loss: 0.0284
Epoch 167/200
29/30 [============================>.] - ETA: 0s - loss: 0.0131
```



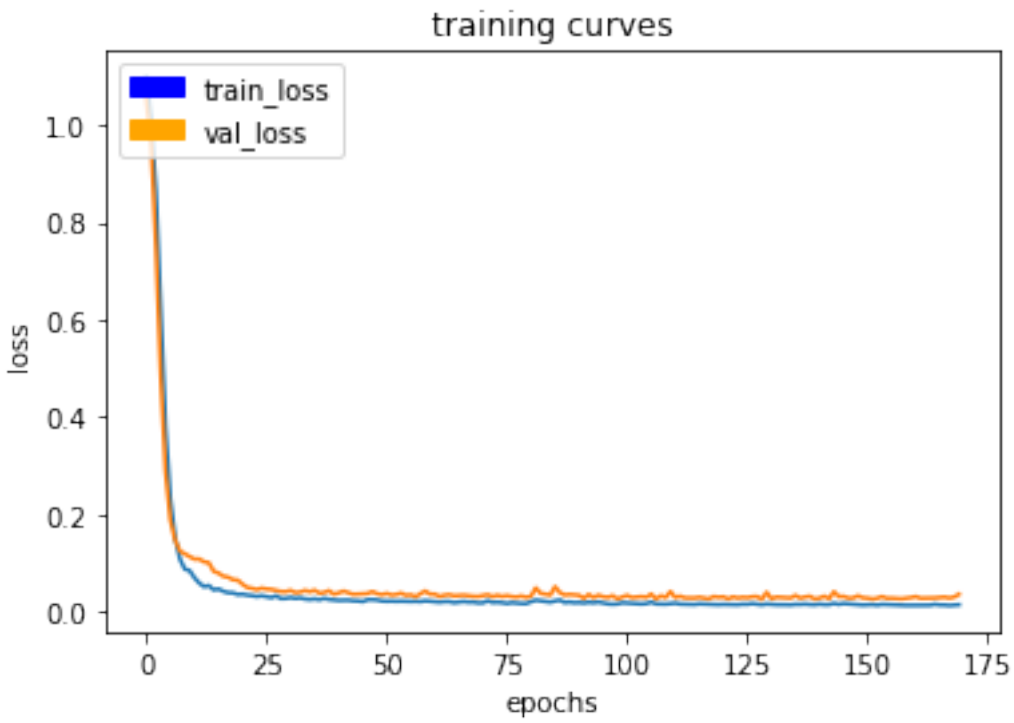

```
30/30 [==============================] - 23s - loss: 0.0131 - val_loss: 0.0293
Epoch 168/200
29/30 [============================>.] - ETA: 0s - loss: 0.0121
```



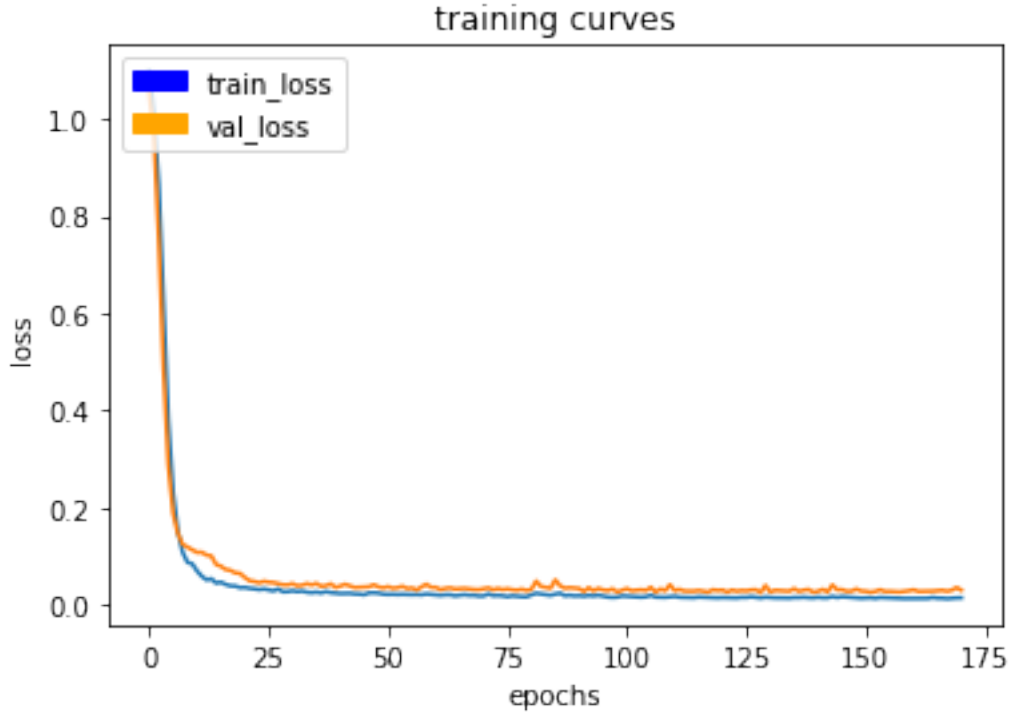
```
30/30 [==============================] - 23s - loss: 0.0121 - val_loss: 0.0274
Epoch 169/200
29/30 [============================>.] - ETA: 0s - loss: 0.0130
```



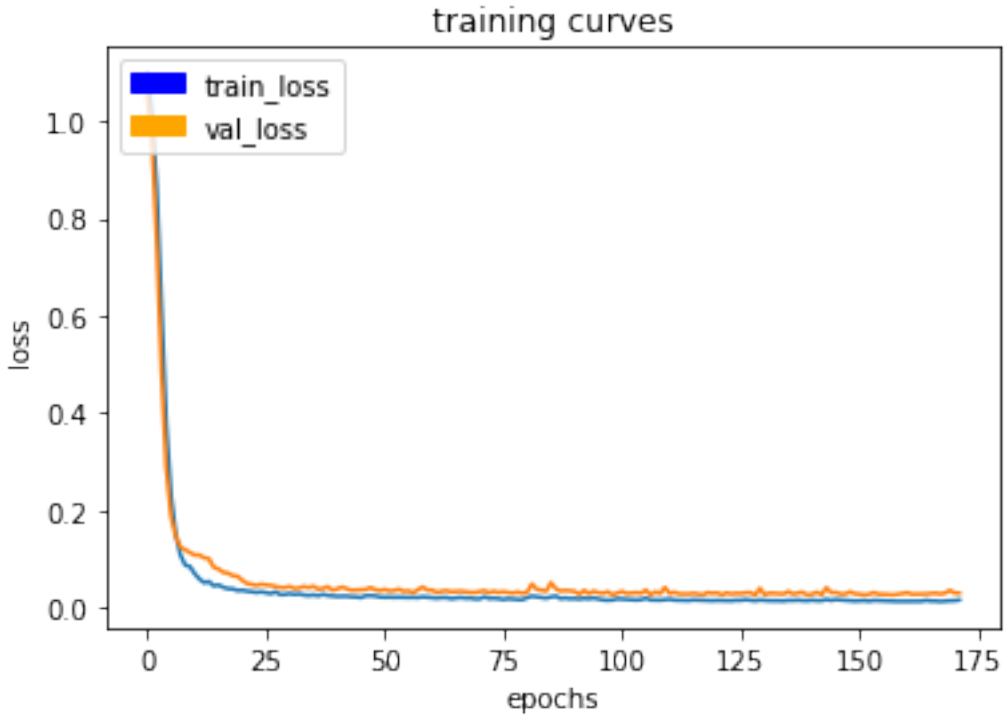

```
30/30 [==============================] - 23s - loss: 0.0130 - val_loss: 0.0295
Epoch 170/200
29/30 [============================>.] - ETA: 0s - loss: 0.0135
```



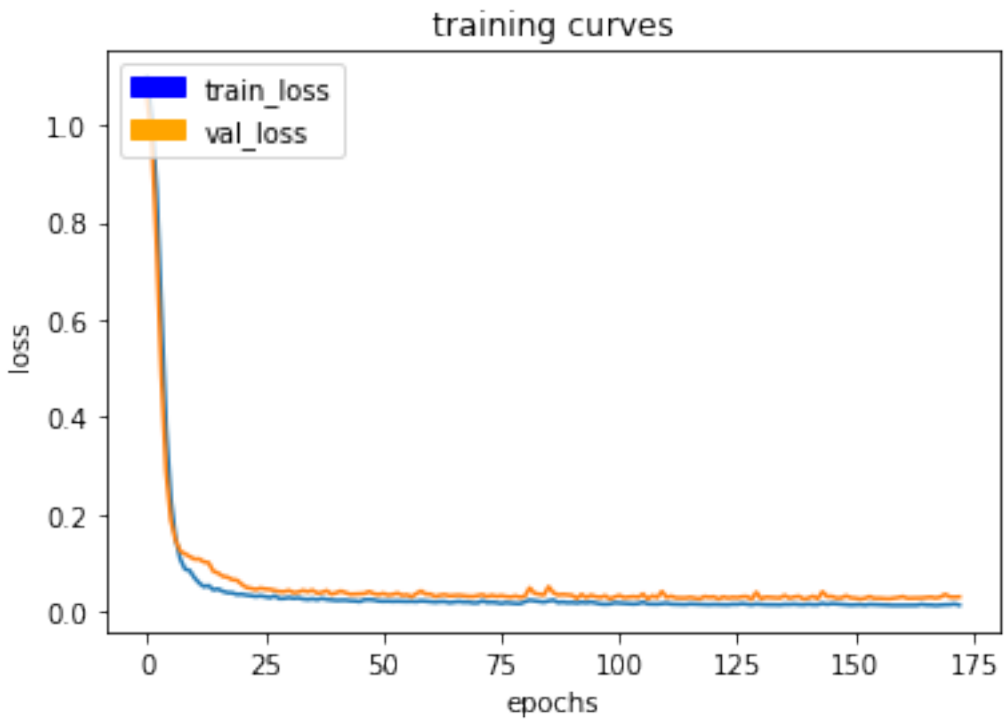

```
30/30 [==============================] - 23s - loss: 0.0136 - val_loss: 0.0351
Epoch 171/200
29/30 [============================>.] - ETA: 0s - loss: 0.0136
```



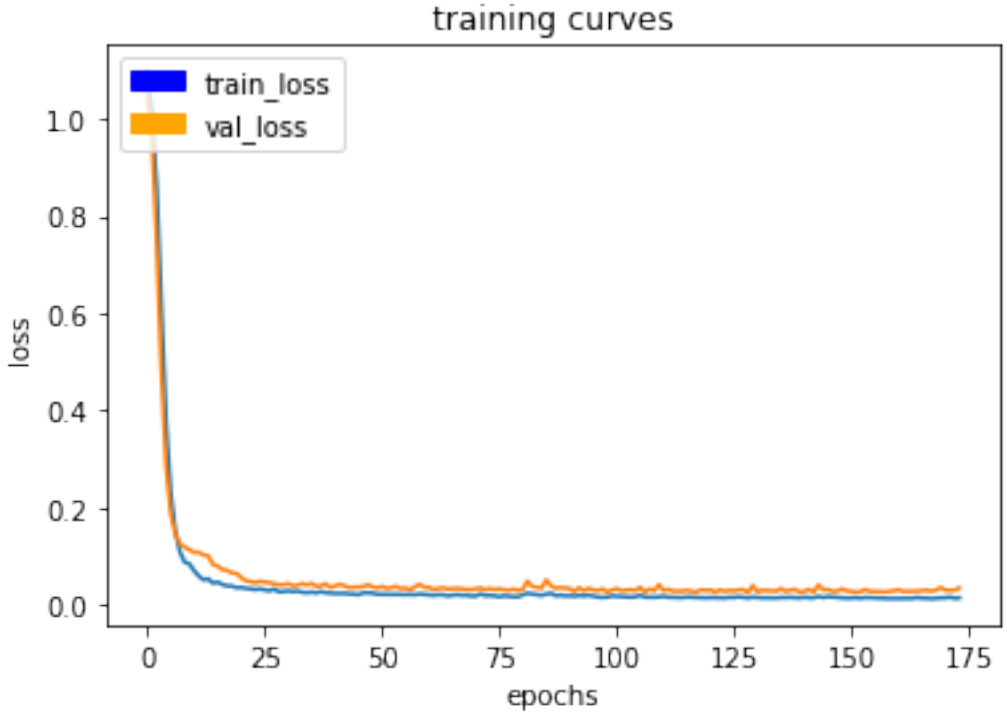
```
30/30 [==============================] - 23s - loss: 0.0138 - val_loss: 0.0295
Epoch 172/200
29/30 [============================>.] - ETA: 0s - loss: 0.0156
```



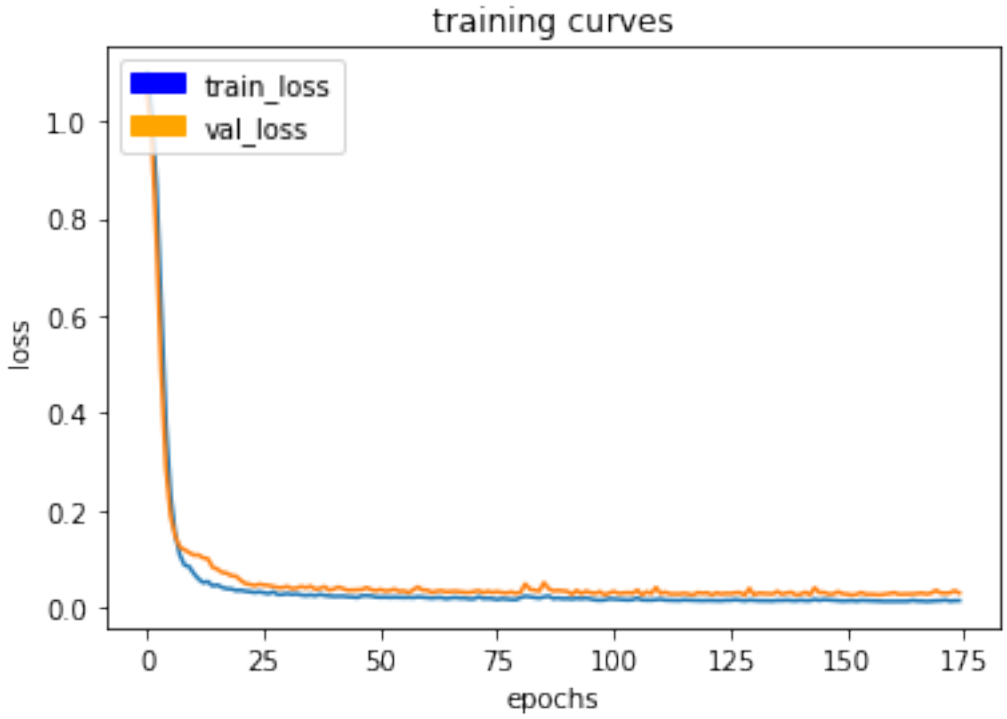

```
30/30 [==============================] - 23s - loss: 0.0155 - val_loss: 0.0292
Epoch 173/200
29/30 [============================>.] - ETA: 0s - loss: 0.0128
```



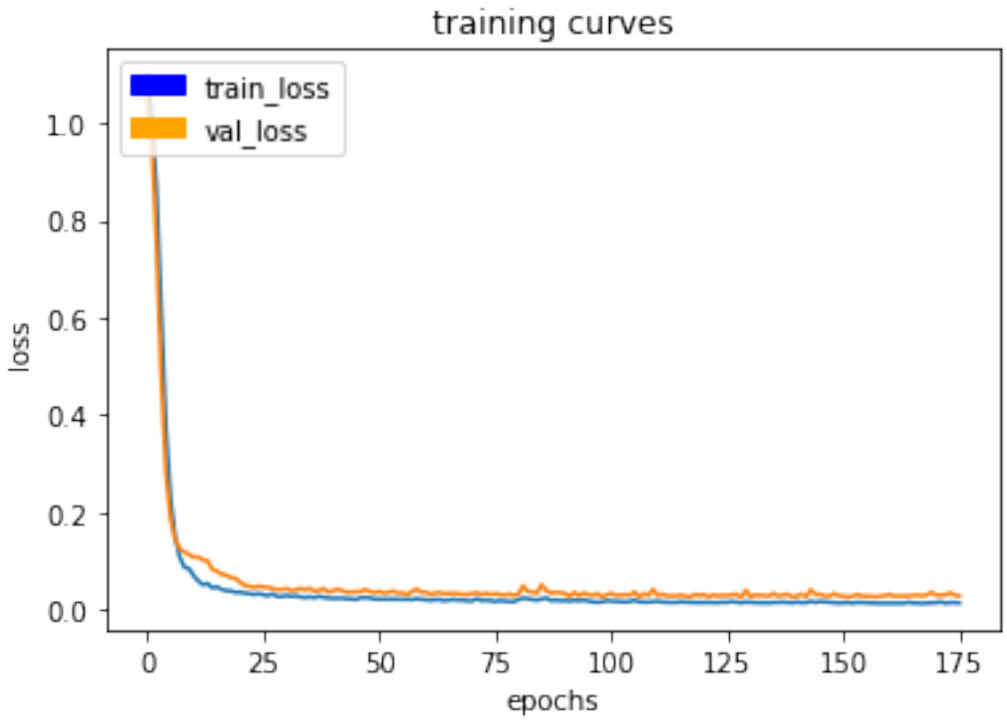

```
30/30 [==============================] - 23s - loss: 0.0127 - val_loss: 0.0298
Epoch 174/200
29/30 [============================>.] - ETA: 0s - loss: 0.0138
```



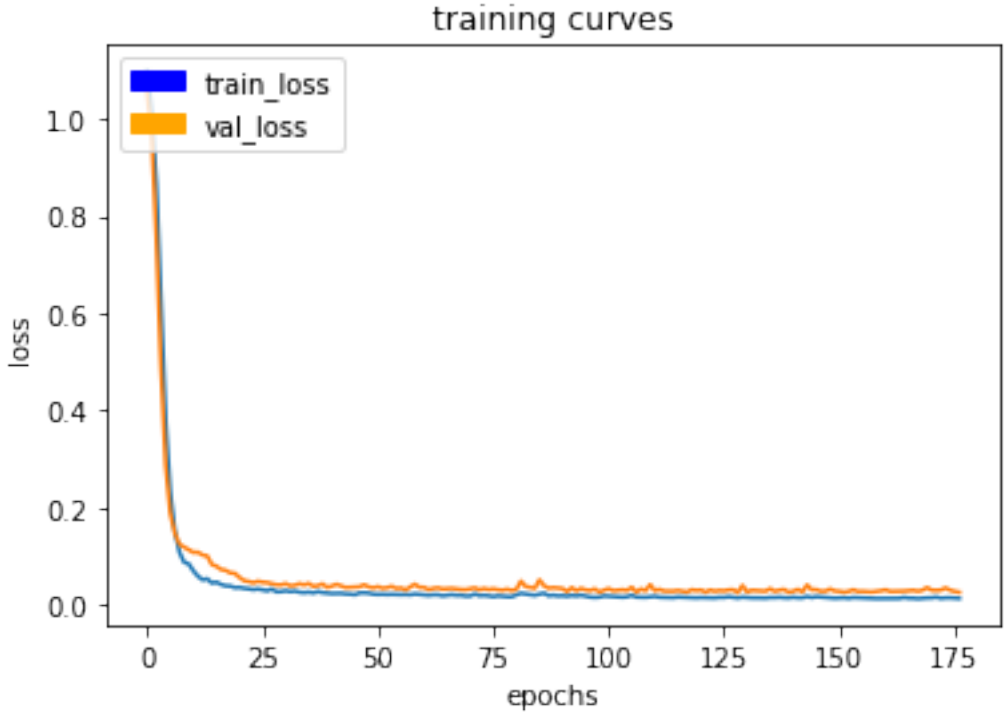
```
30/30 [==============================] - 23s - loss: 0.0138 - val_loss: 0.0343
Epoch 175/200
29/30 [============================>.] - ETA: 0s - loss: 0.0140
```



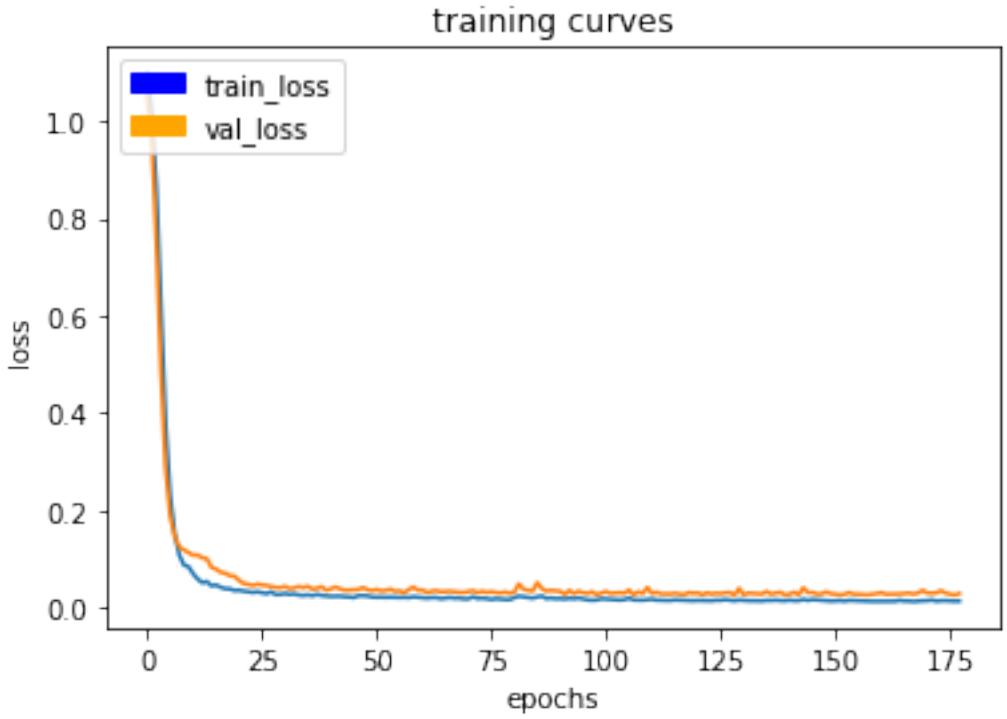

```
30/30 [==============================] - 23s - loss: 0.0139 - val_loss: 0.0295
Epoch 176/200
29/30 [============================>.] - ETA: 0s - loss: 0.0130
```



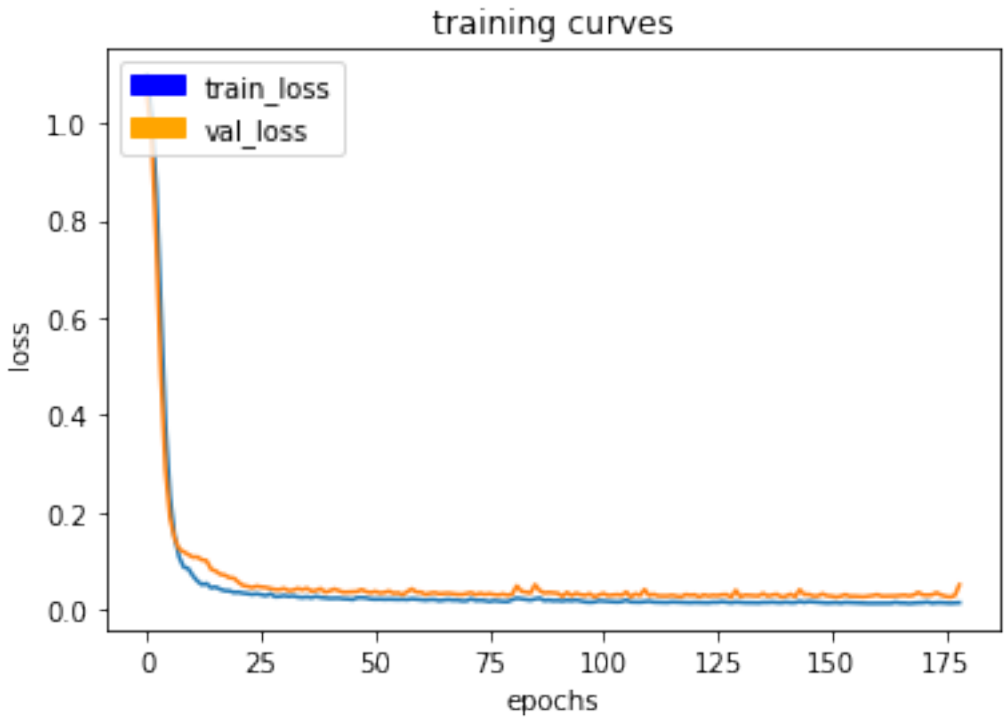

```
30/30 [==============================] - 23s - loss: 0.0130 - val_loss: 0.0269
Epoch 177/200
29/30 [============================>.] - ETA: 0s - loss: 0.0126
```



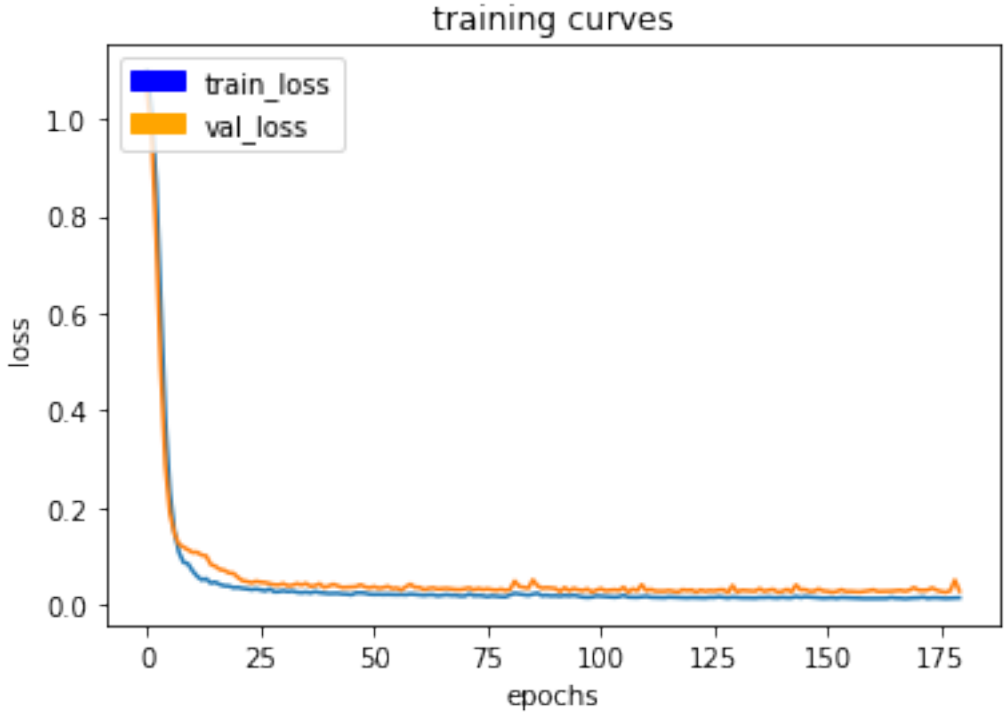
```
30/30 [==============================] - 23s - loss: 0.0126 - val_loss: 0.0252
Epoch 178/200
29/30 [============================>.] - ETA: 0s - loss: 0.0131
```



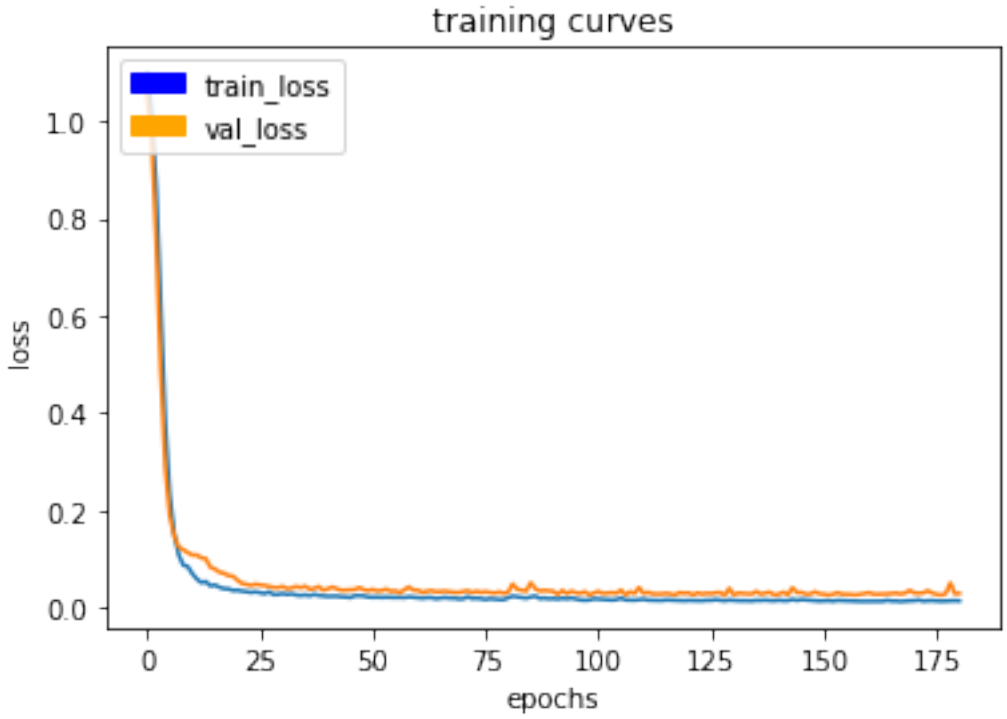

```
30/30 [==============================] - 23s - loss: 0.0131 - val_loss: 0.0284
Epoch 179/200
29/30 [============================>.] - ETA: 0s - loss: 0.0137
```



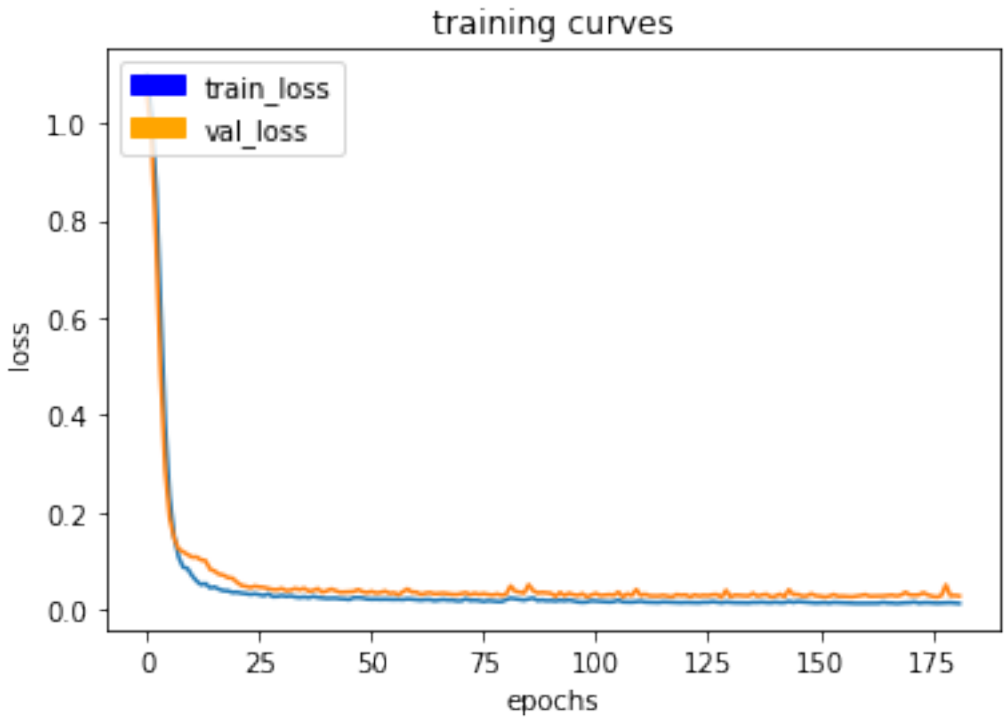

```
30/30 [==============================] - 23s - loss: 0.0137 - val_loss: 0.0503
Epoch 180/200
29/30 [============================>.] - ETA: 0s - loss: 0.0139
```



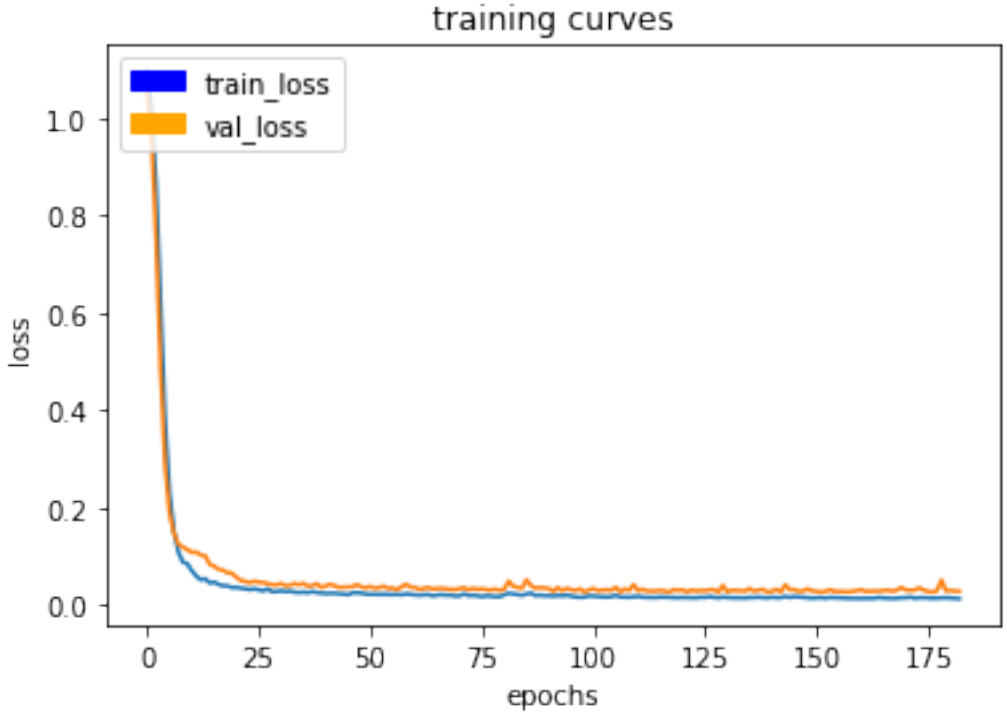
```
30/30 [==============================] - 23s - loss: 0.0139 - val_loss: 0.0280
Epoch 181/200
29/30 [============================>.] - ETA: 0s - loss: 0.0133
```



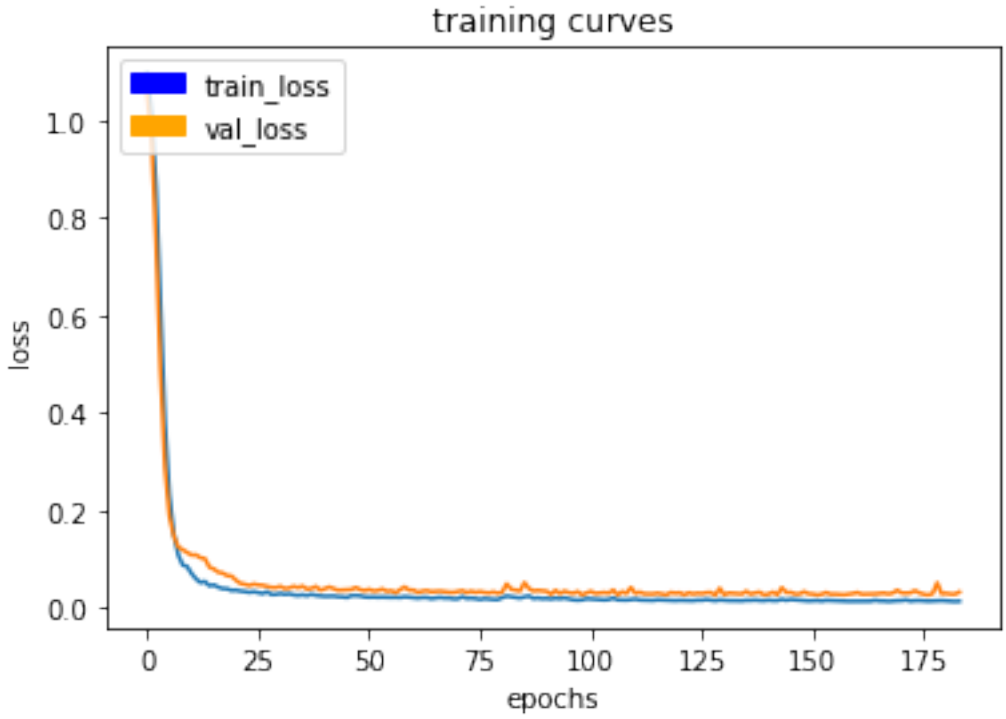

```
30/30 [==============================] - 23s - loss: 0.0133 - val_loss: 0.0287
Epoch 182/200
29/30 [============================>.] - ETA: 0s - loss: 0.0123
```



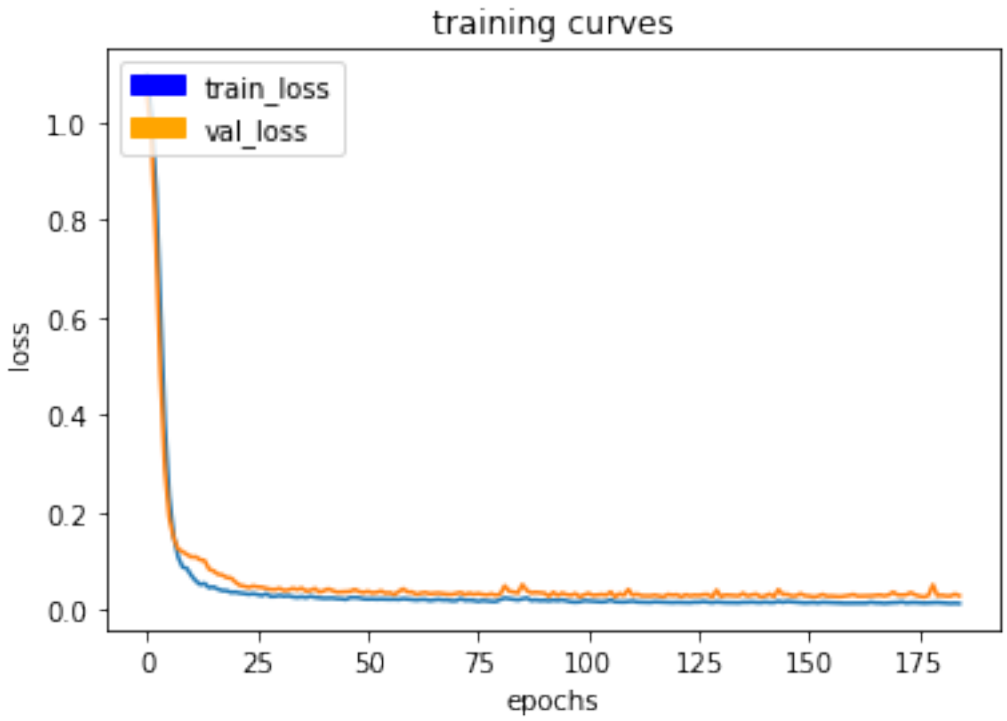

```
30/30 [==============================] - 23s - loss: 0.0123 - val_loss: 0.0273
Epoch 183/200
29/30 [============================>.] - ETA: 0s - loss: 0.0120
```



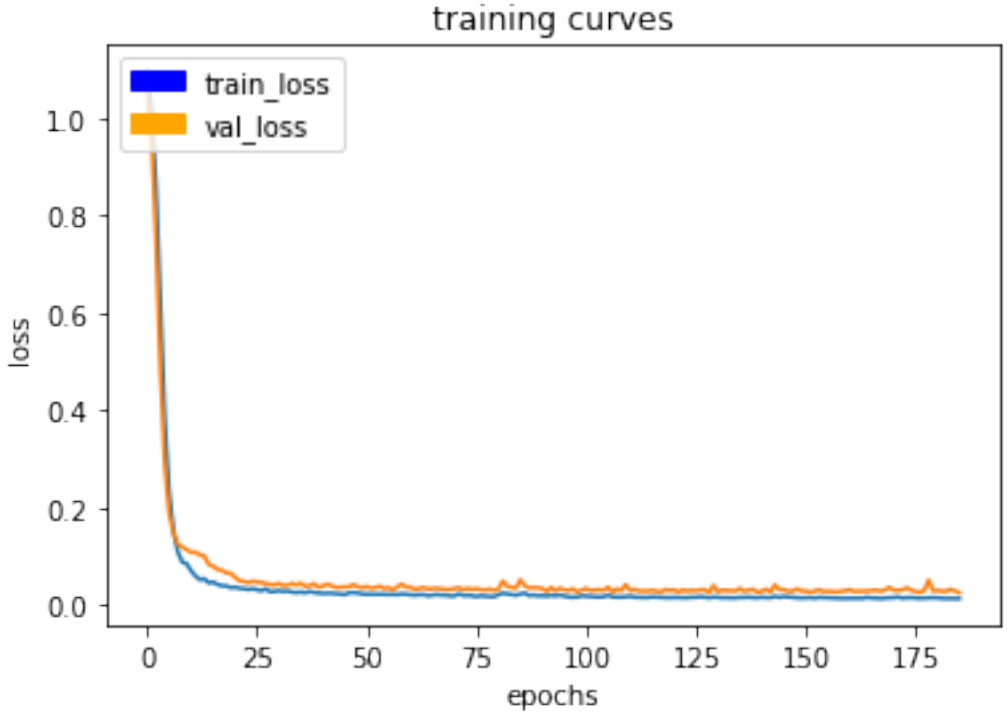
```
30/30 [==============================] - 23s - loss: 0.0120 - val_loss: 0.0271
Epoch 184/200
29/30 [============================>.] - ETA: 0s - loss: 0.0124
```



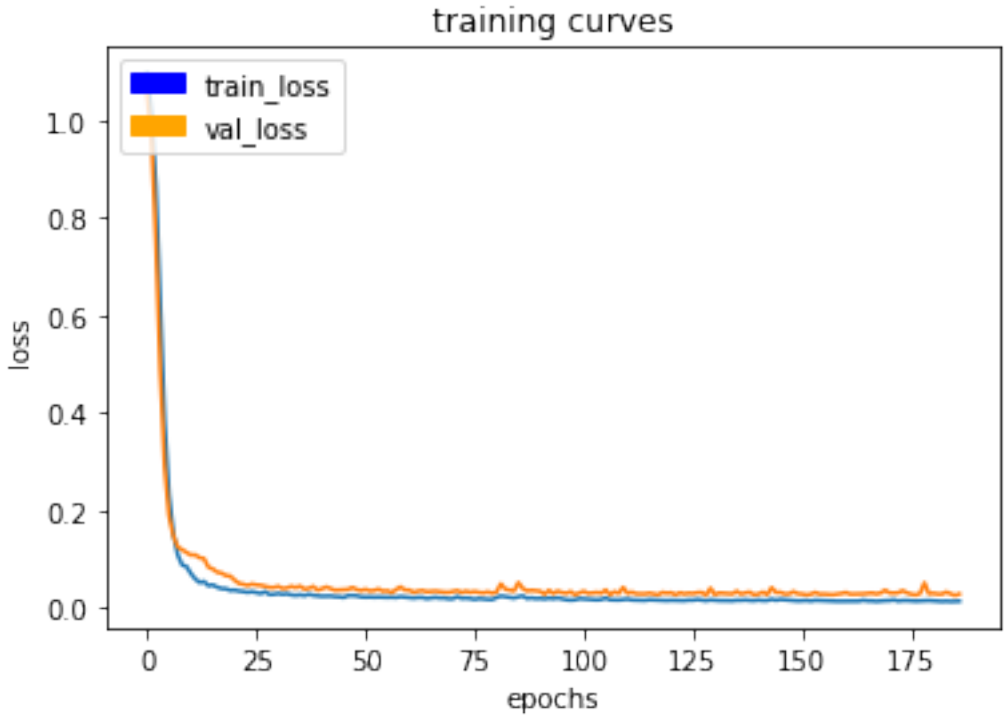

```
30/30 [==============================] - 23s - loss: 0.0125 - val_loss: 0.0313
Epoch 185/200
29/30 [============================>.] - ETA: 0s - loss: 0.0119
```



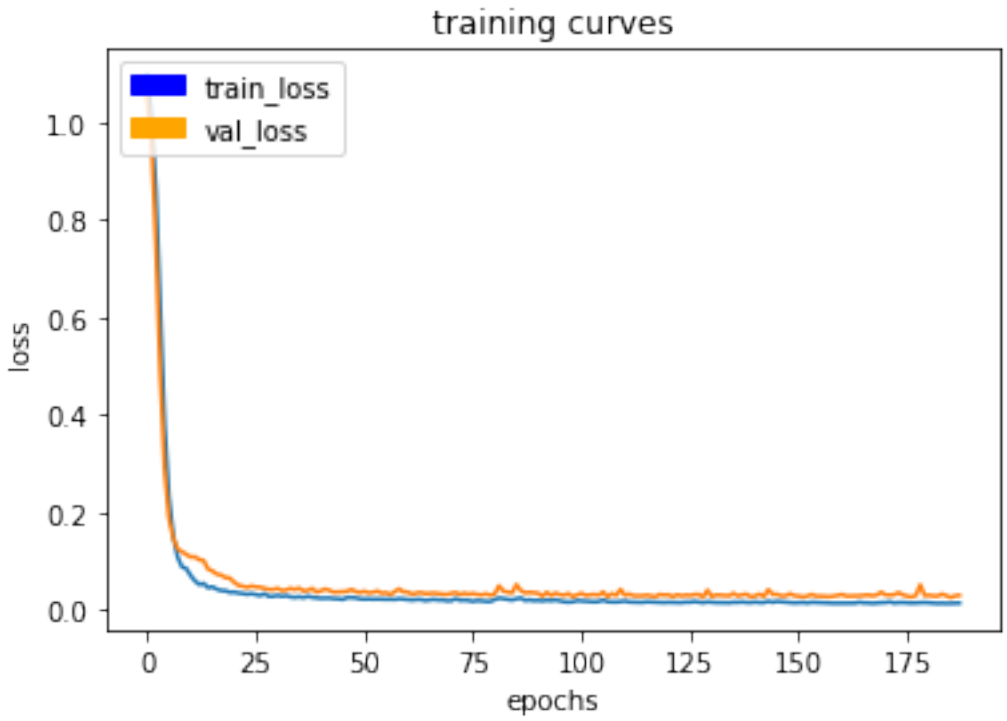

```
30/30 [==============================] - 23s - loss: 0.0119 - val_loss: 0.0275
Epoch 186/200
29/30 [============================>.] - ETA: 0s - loss: 0.0122
```



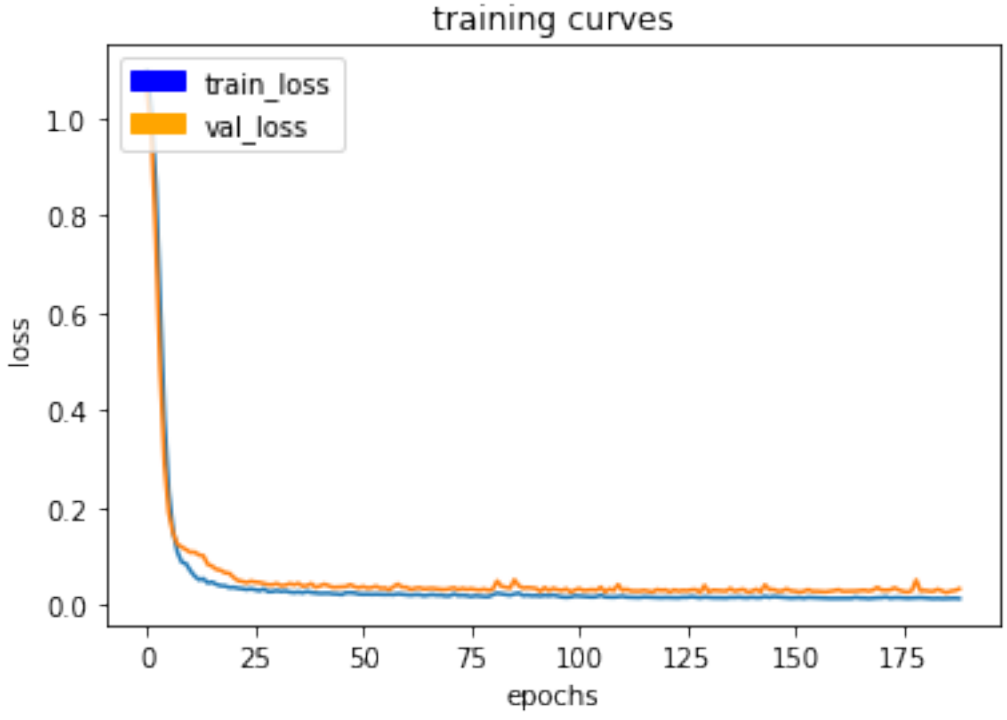
```
30/30 [==============================] - 23s - loss: 0.0122 - val_loss: 0.0242
Epoch 187/200
29/30 [============================>.] - ETA: 0s - loss: 0.0126
```



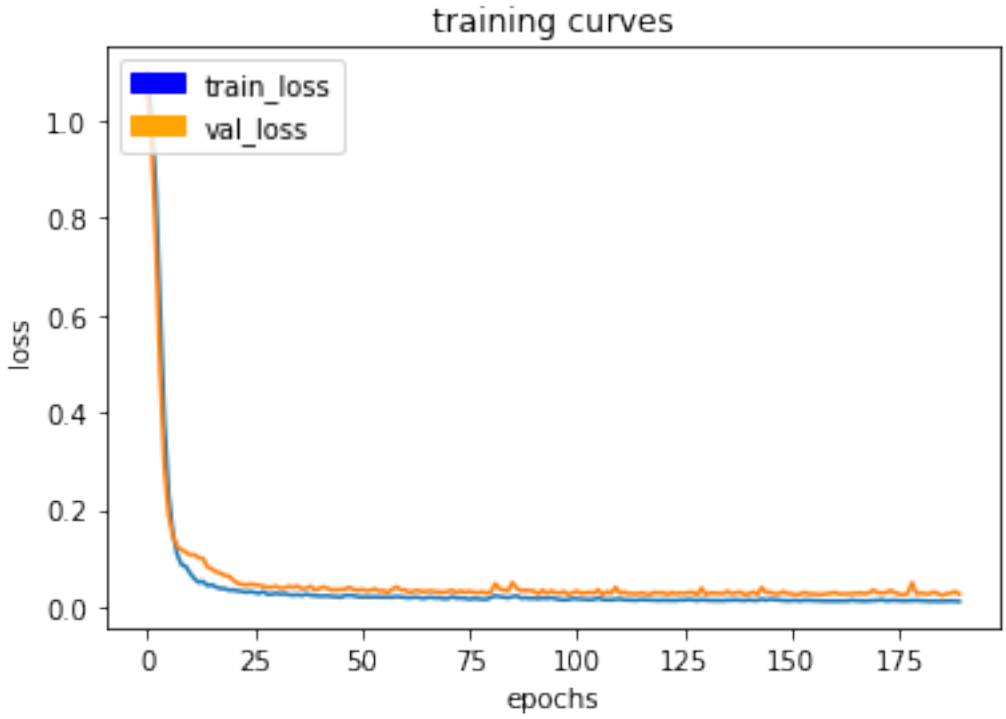

```
30/30 [==============================] - 23s - loss: 0.0125 - val_loss: 0.0274
Epoch 188/200
29/30 [============================>.] - ETA: 0s - loss: 0.0127
```



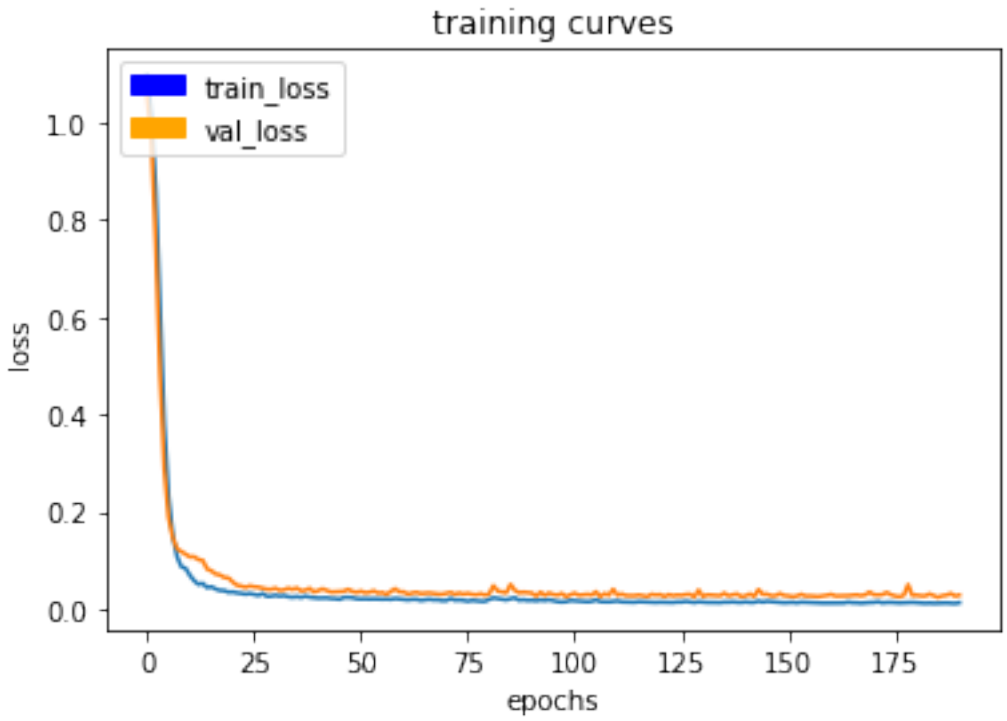

```
30/30 [==============================] - 24s - loss: 0.0127 - val_loss: 0.0287
Epoch 189/200
29/30 [============================>.] - ETA: 0s - loss: 0.0120
```



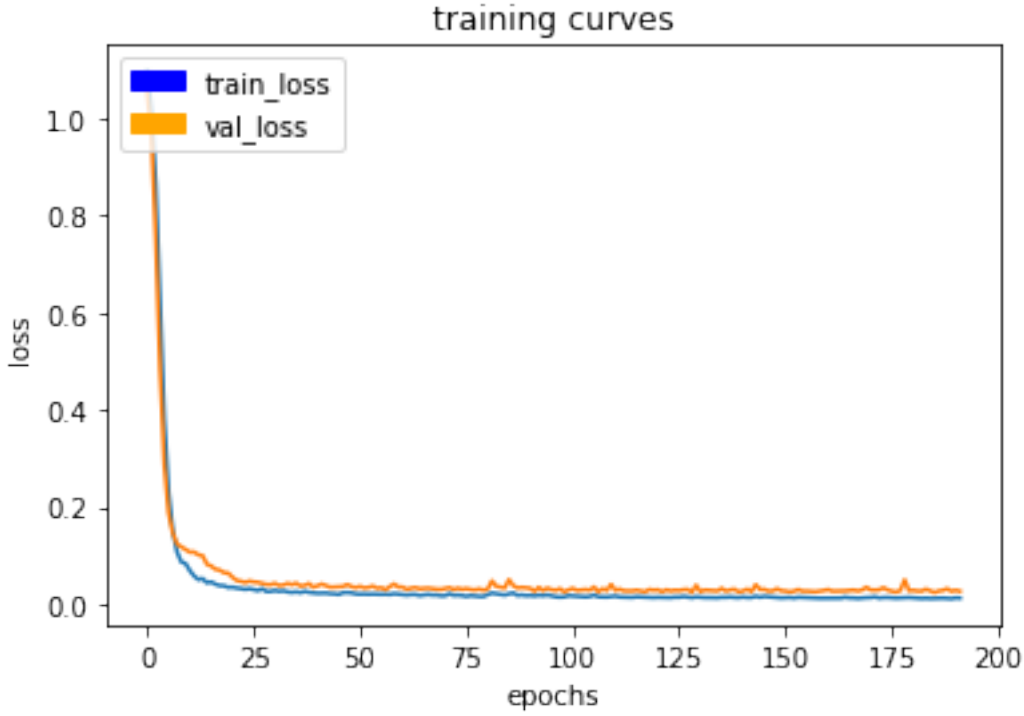
```
30/30 [==============================] - 23s - loss: 0.0121 - val_loss: 0.0322
Epoch 190/200
29/30 [============================>.] - ETA: 0s - loss: 0.0117
```



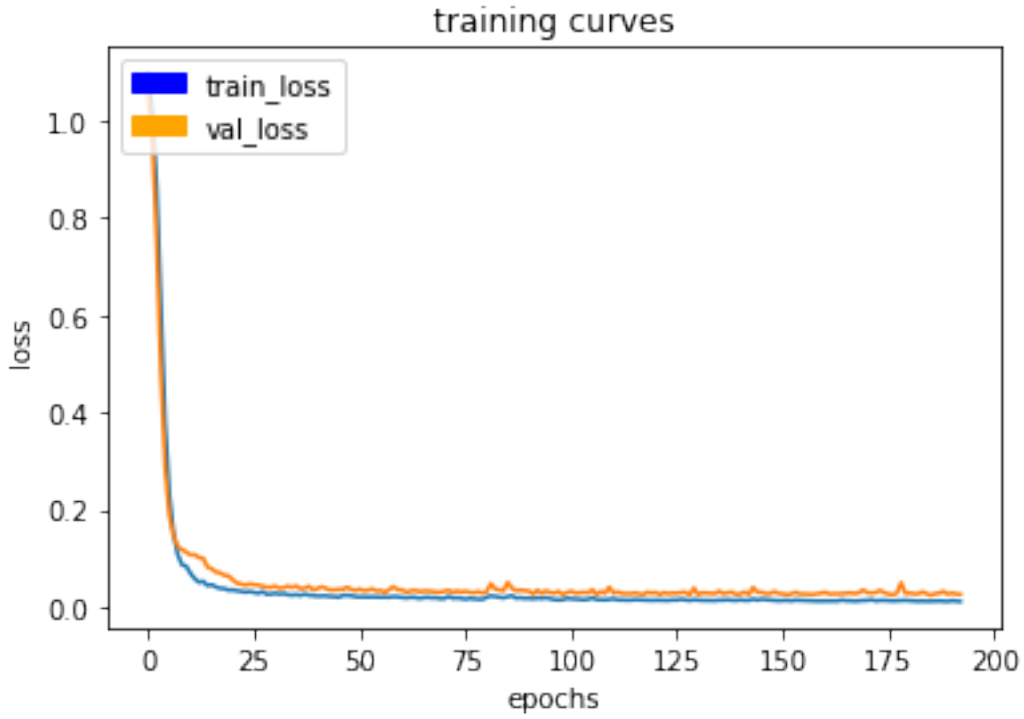

```
30/30 [==============================] - 23s - loss: 0.0116 - val_loss: 0.0267
Epoch 191/200
29/30 [============================>.] - ETA: 0s - loss: 0.0133
```



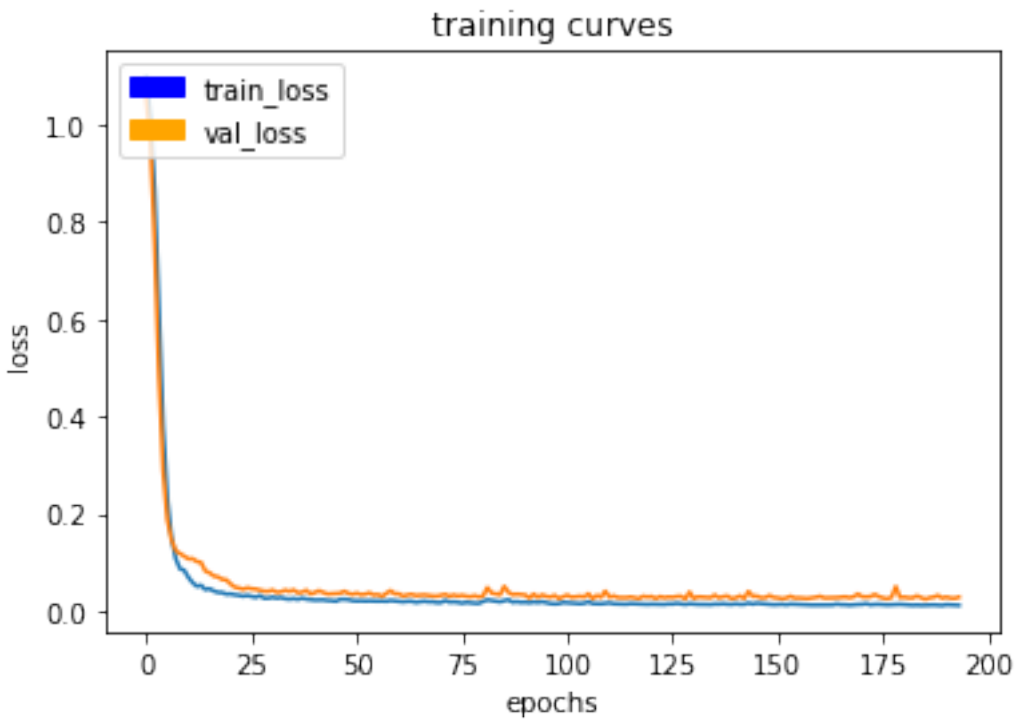

```
30/30 [==============================] - 25s - loss: 0.0132 - val_loss: 0.0288
Epoch 192/200
29/30 [============================>.] - ETA: 0s - loss: 0.0127
```



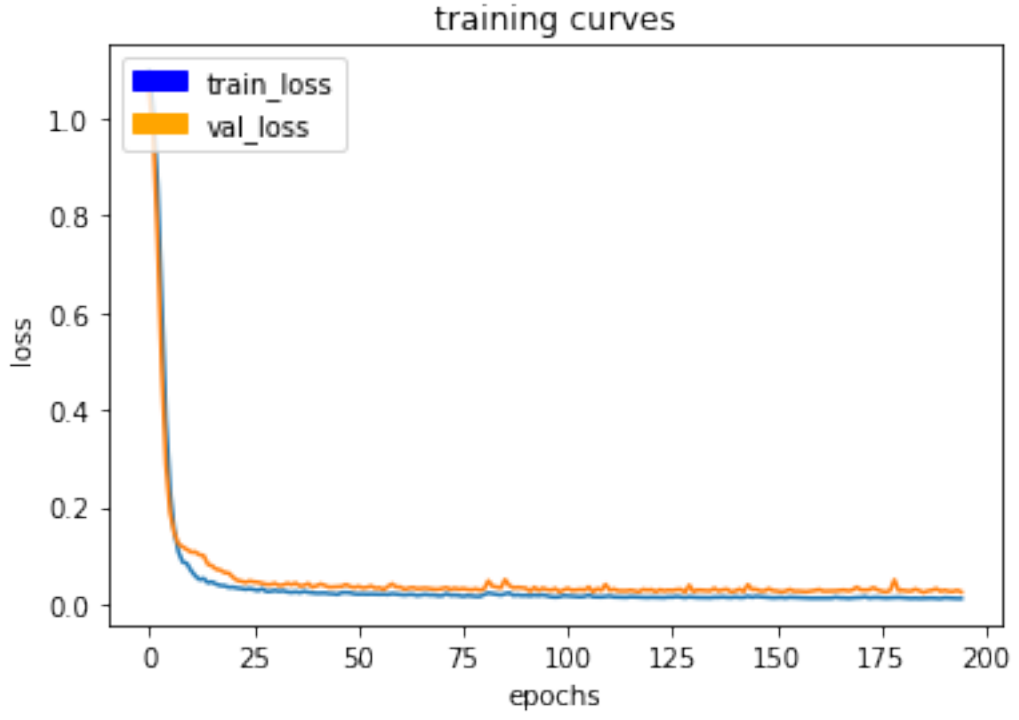
```
30/30 [==============================] - 23s - loss: 0.0126 - val_loss: 0.0267
Epoch 193/200
29/30 [============================>.] - ETA: 0s - loss: 0.0114
```



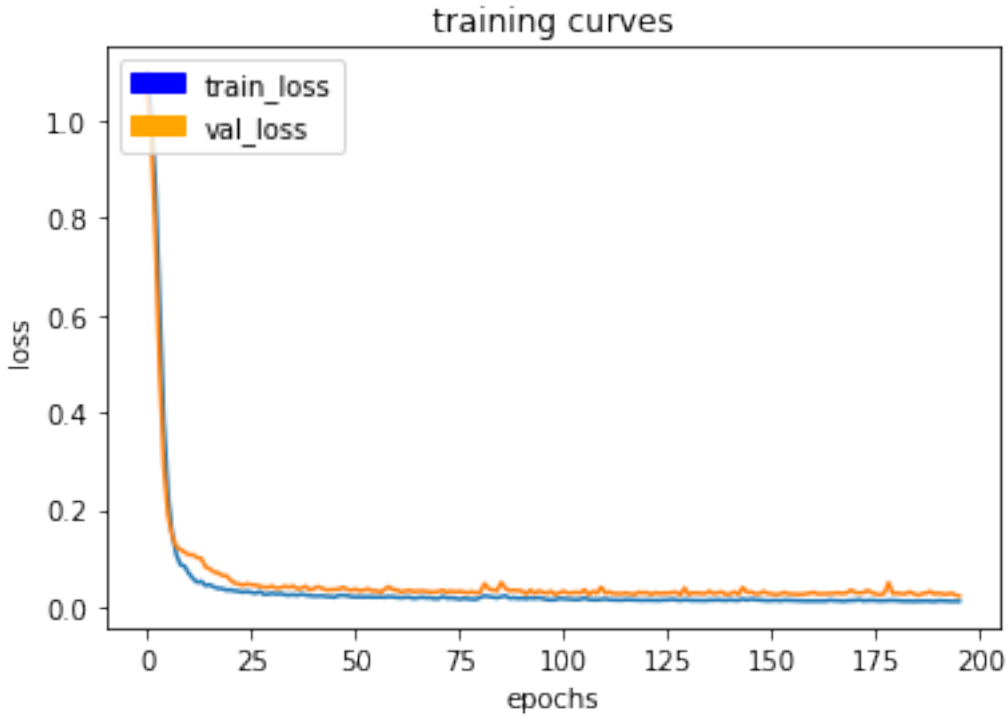

```
30/30 [==============================] - 23s - loss: 0.0115 - val_loss: 0.0262
Epoch 194/200
29/30 [============================>.] - ETA: 0s - loss: 0.0119
```



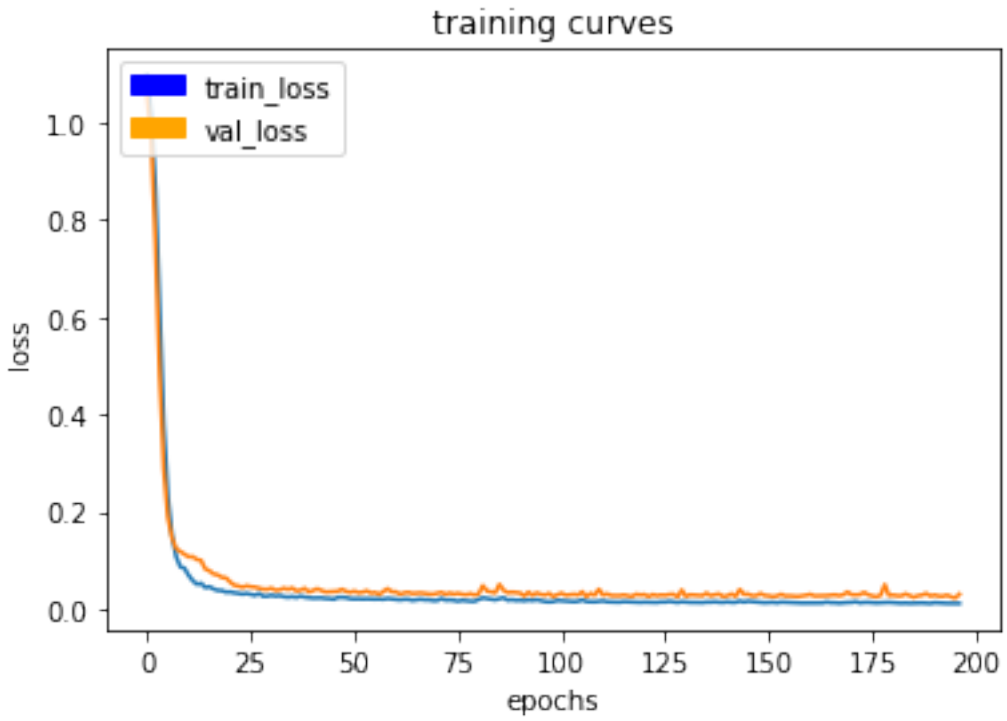

```
30/30 [==============================] - 23s - loss: 0.0118 - val_loss: 0.0286
Epoch 195/200
29/30 [============================>.] - ETA: 0s - loss: 0.0119
```



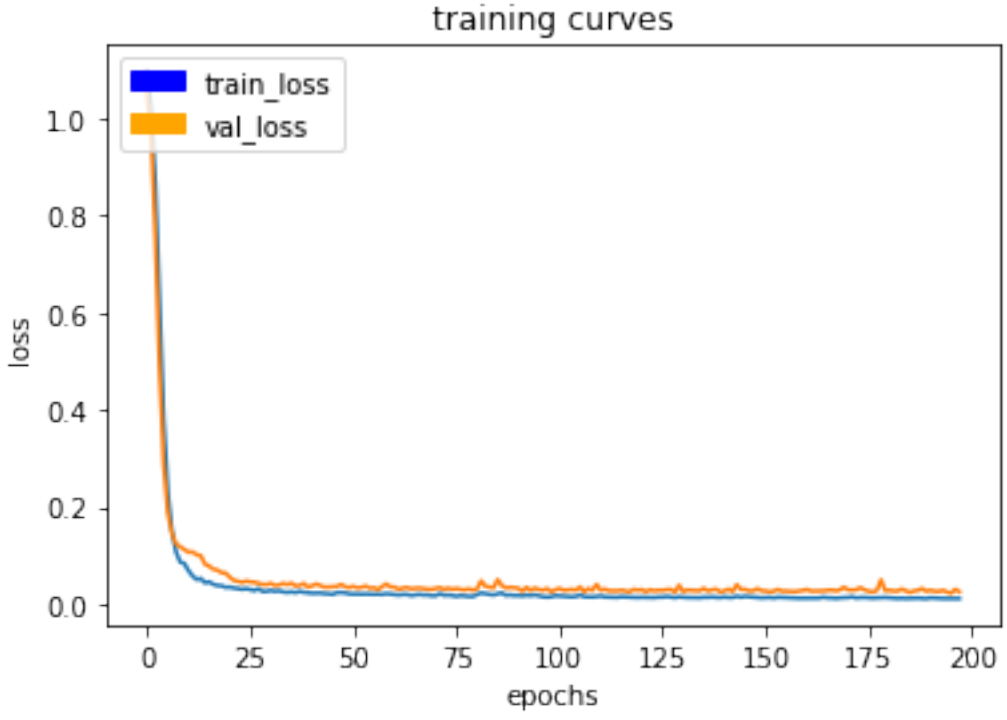
```
30/30 [==============================] - 23s - loss: 0.0119 - val_loss: 0.0252
Epoch 196/200
29/30 [============================>.] - ETA: 0s - loss: 0.0120
```



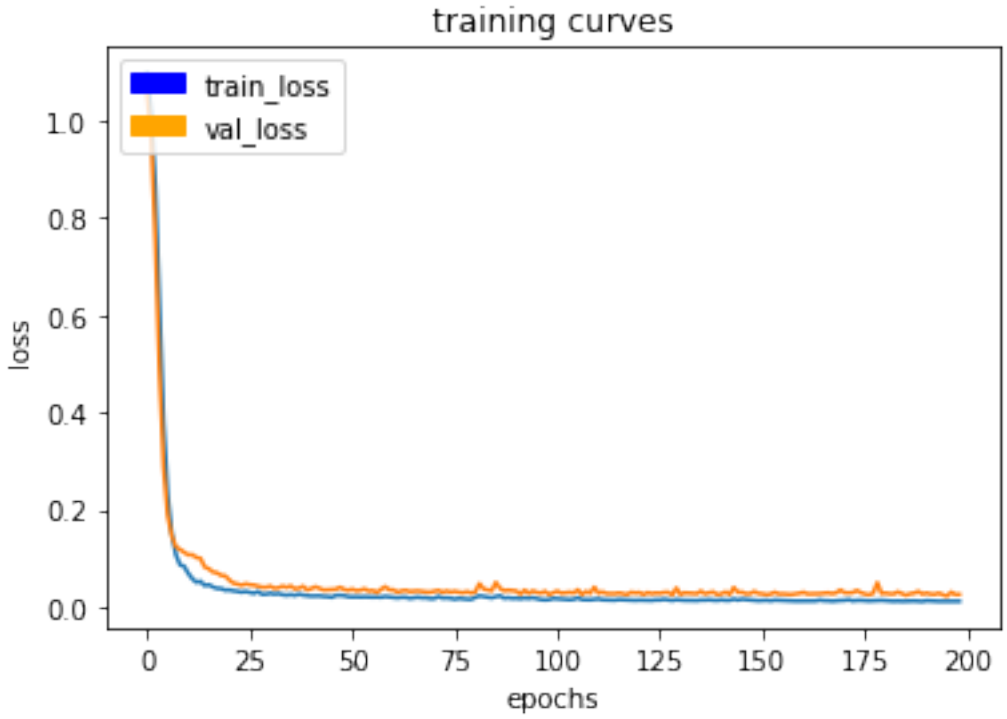

```
30/30 [==============================] - 23s - loss: 0.0120 - val_loss: 0.0225
Epoch 197/200
29/30 [============================>.] - ETA: 0s - loss: 0.0116
```



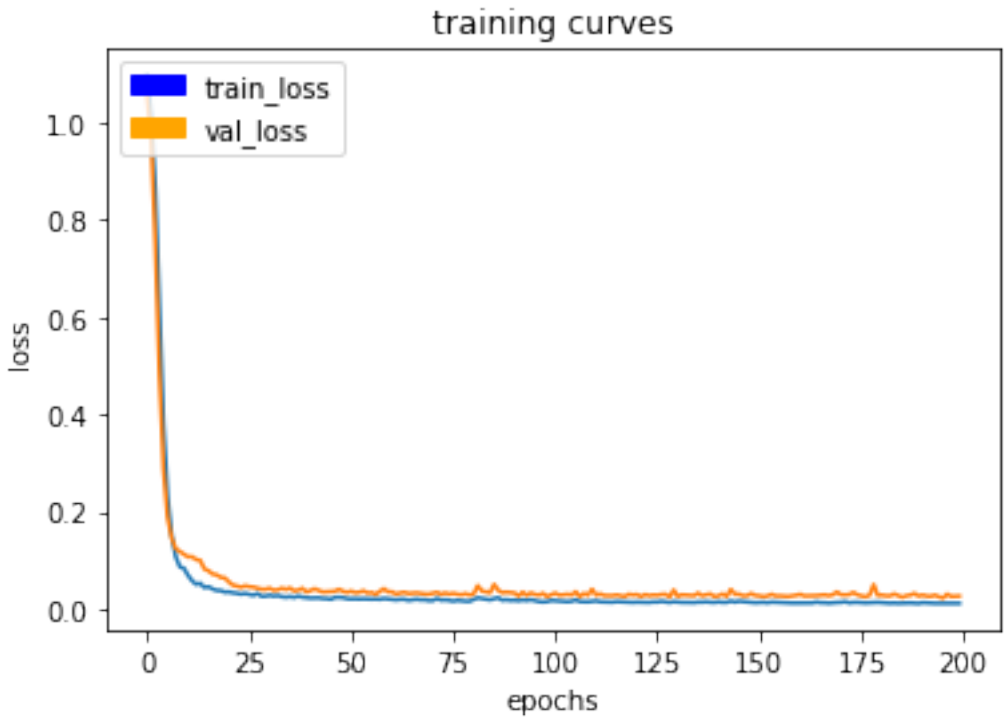

```
30/30 [==============================] - 23s - loss: 0.0116 - val_loss: 0.0308
Epoch 198/200
29/30 [============================>.] - ETA: 0s - loss: 0.0116
```



```
30/30 [==============================] - 23s - loss: 0.0117 - val_loss: 0.0258
Epoch 199/200
29/30 [============================>.] - ETA: 0s - loss: 0.0119
```




```
30/30 [==============================] - 23s - loss: 0.0119 - val_loss: 0.0260
Epoch 200/200
29/30 [============================>.] - ETA: 0s - loss: 0.0118
```




```
30/30 [==============================] - 23s - loss: 0.0118 - val_loss: 0.0267
```

```
Out[118]: <tensorflow.contrib.keras.python.keras.callbacks.History at 0x7f48525cf160>
```

```
In [119]: # Save your trained model weights
          weight_file_name = 'model_weights'
          model_tools.save_network(model, weight_file_name)
```

1.5 Prediction

Now that you have your model trained and saved, you can make predictions on your validation dataset. These predictions can be compared to the mask images, which are the ground truth labels, to evaluate how well your model is doing under different conditions.

There are three different predictions available from the helper code provided: - **patrol_with_targ**: Test how well the network can detect the hero from a distance. - **patrol_non_targ**: Test how often the network makes a mistake and identifies the wrong person as the target. - **following_images**: Test how well the network can identify the target while following them.

```
In [120]: # If you need to load a model which you previously trained you can uncomment the codel

          weight_file_name = 'model_weights'
          restored_model = model_tools.load_network(weight_file_name)
```

The following cell will write predictions to files and return paths to the appropriate directories. The `run_num` parameter is used to define or group all the data for a particular model run. You can change it for different runs. For example, 'run_1', 'run_2' etc.

```
In [121]: run_num = 'run_1'

          val_with_targ, pred_with_targ = model_tools.write_predictions_grade_set(model,
                                                  run_num,'patrol_with_targ', 'sample_evaluation

          val_no_targ, pred_no_targ = model_tools.write_predictions_grade_set(model,
                                                  run_num,'patrol_non_targ', 'sample_evaluation_

          val_following, pred_following = model_tools.write_predictions_grade_set(model,
                                                  run_num,'following_images', 'sample_evaluation


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

        TypeError                                 Traceback (most recent call last)

        <ipython-input-121-dafef4af7b78> in <module>()
          2
          3 val_with_targ, pred_with_targ = model_tools.write_predictions_grade_set(model,
    ----> 4                                       run_num,'patrol_with_targ', 'sample_evaluati
          5
          6 val_no_targ, pred_no_targ = model_tools.write_predictions_grade_set(model,


        TypeError: write_predictions_grade_set() takes 3 positional arguments but 4 were given
```

Now lets look at your predictions, and compare them to the ground truth labels and original images. Run each of the following cells to visualize some sample images from the predictions in the validation set.

```
In [ ]: # images while following the target
        im_files = plotting_tools.get_im_file_sample('sample_evaluation_data','following_images'
        for i in range(3):
            im_tuple = plotting_tools.load_images(im_files[i])
            plotting_tools.show_images(im_tuple)
```

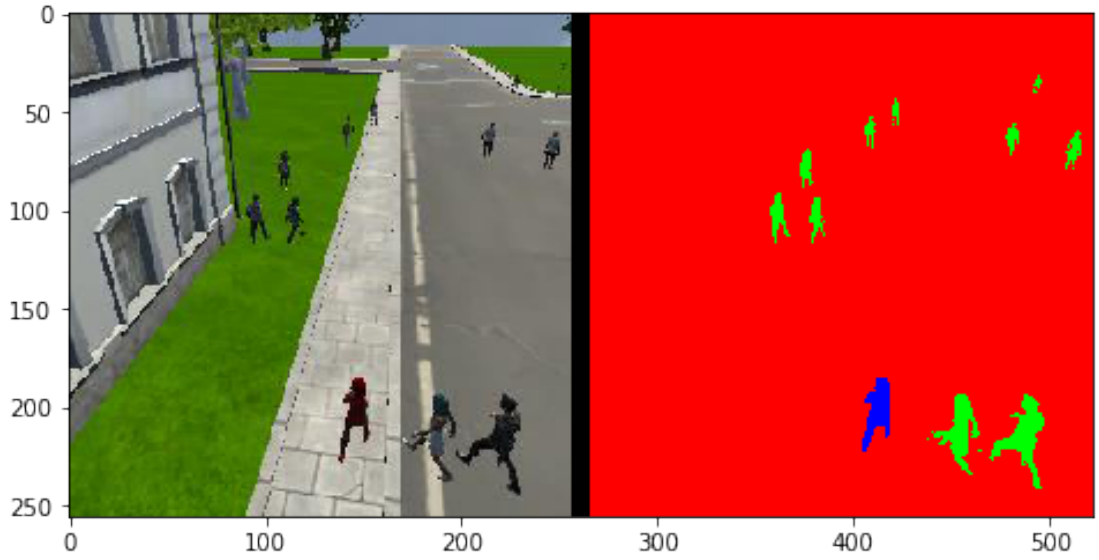
```
In [ ]: # images while at patrol without target
        im_files = plotting_tools.get_im_file_sample('sample_evaluation_data','patrol_non_targ',
        for i in range(3):
            im_tuple = plotting_tools.load_images(im_files[i])
            plotting_tools.show_images(im_tuple)
```

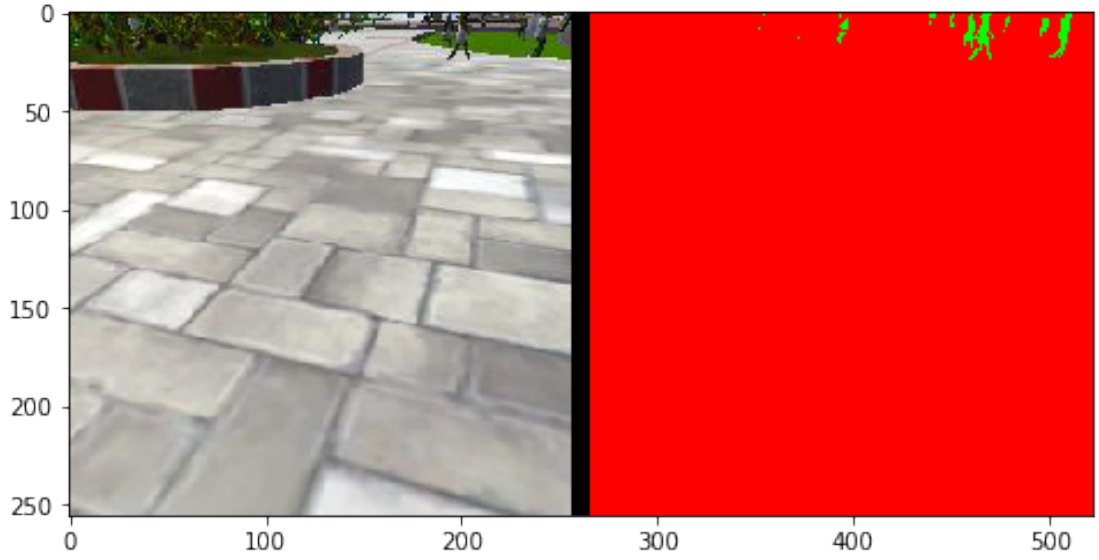
```
In [ ]:
        # images while at patrol with target
        im_files = plotting_tools.get_im_file_sample('sample_evaluation_data','patrol_with_targ'
        for i in range(3):
            im_tuple = plotting_tools.load_images(im_files[i])
            plotting_tools.show_images(im_tuple)
```

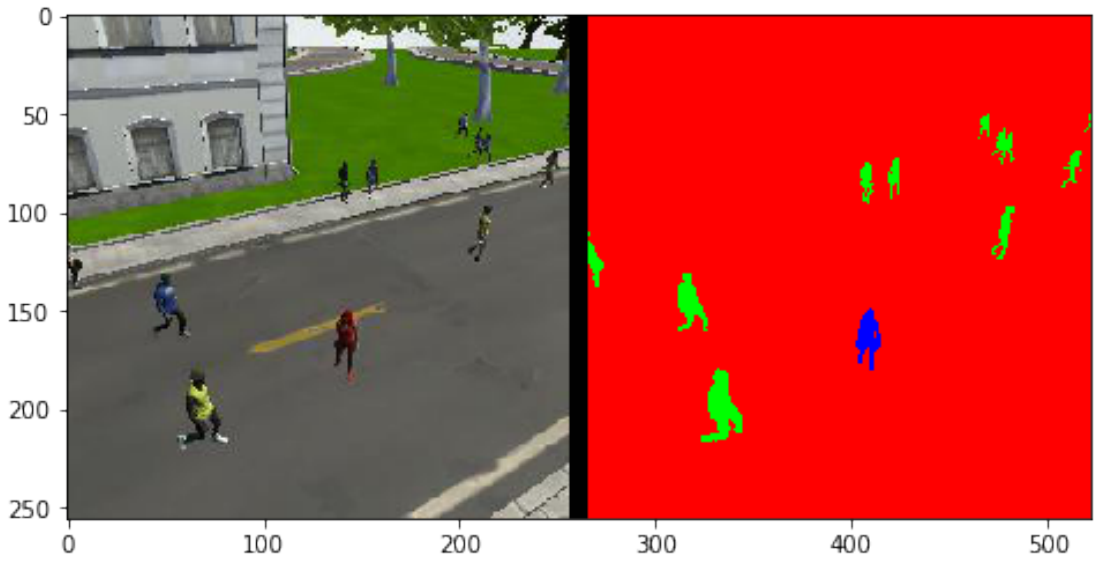
1.6 Evaluation

Evaluate your model! The following cells include several different scores to help you evaluate your model under the different conditions discussed during the Prediction step.

```
In [ ]: # Scores for while the quad is following behind the target.
        true_pos1, false_pos1, false_neg1, iou1 = scoring_utils.score_run_iou(val_following, pre

In [ ]: # Scores for images while the quad is on patrol and the target is not visable
        true_pos2, false_pos2, false_neg2, iou2 = scoring_utils.score_run_iou(val_no_targ, pred_

In [ ]: # This score measures how well the neural network can detect the target from far away
        true_pos3, false_pos3, false_neg3, iou3 = scoring_utils.score_run_iou(val_with_targ, pre

In [ ]: # Sum all the true positives, etc from the three datasets to get a weight for the score
        true_pos = true_pos1 + true_pos2 + true_pos3
        false_pos = false_pos1 + false_pos2 + false_pos3
        false_neg = false_neg1 + false_neg2 + false_neg3

        weight = true_pos/(true_pos+false_neg+false_pos)
        print(weight)

In [ ]: # The IoU for the dataset that never includes the hero is excluded from grading
        final_IoU = (iou1 + iou3)/2
        print(final_IoU)

In [ ]: # And the final grade score is
        final_score = final_IoU * weight
        print(final_score)

In [122]: #Test from segmentation lab

          run_number = 'run1'
          validation_path, output_path = model_tools.write_predictions_grade_set(model,run_numbe

In [123]: # take a look at predictions
          # validation_path = 'validation'
          im_files = plotting_tools.get_im_file_sample(run_number,validation_path)
          for i in range(3):
              im_tuple = plotting_tools.load_images(im_files[i])
              plotting_tools.show_images(im_tuple)
```


0
50
100
150
200
250
0
100
200
300
400
500


0
50
100
150
200
250
0
100
200
300
400
500



In [124]: scoring_utils.score_run(validation_path, output_path)

```
number of validation samples intersection over the union evaulated on 1184
average intersection over union for background is 0.9931917692038189
average intersection over union for other people is 0.3952889774577268
average intersection over union for hero is 0.16170155977126485
global average intersection over union is 0.5167274354776036
```