In [17]:

```
import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)

import sys
import tensorflow as tf
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers.convolutional import Conv2D, MaxPooling2D
import numpy as np
np.random.seed(7)

print('Python version : ', sys.version)
print('TensorFlow version : ', tf.__version__)
print('Keras version : ', keras.__version__)
```

```
Python version :  3.7.4 (default, Sep 11 2019, 10:56:41)
[GCC 7.4.0]
TensorFlow version :  1.14.0
Keras version :  2.2.5
```

In [18]:

```
img_rows = 28
img_cols = 28

(x_train, y_train), (x_test, y_test) = keras.datasets.mnist.load_data()

input_shape = (img_rows, img_cols, 1)
x_train = x_train.reshape(x_train.shape[0], img_rows, img_cols, 1)
x_test = x_test.reshape(x_test.shape[0], img_rows, img_cols, 1)

x_train = x_train.astype('float32') / 255.
x_test = x_test.astype('float32') / 255.

print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')

batch_size = 128
num_classes = 10
epochs = 12

y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)
```

```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
```

In [19]:

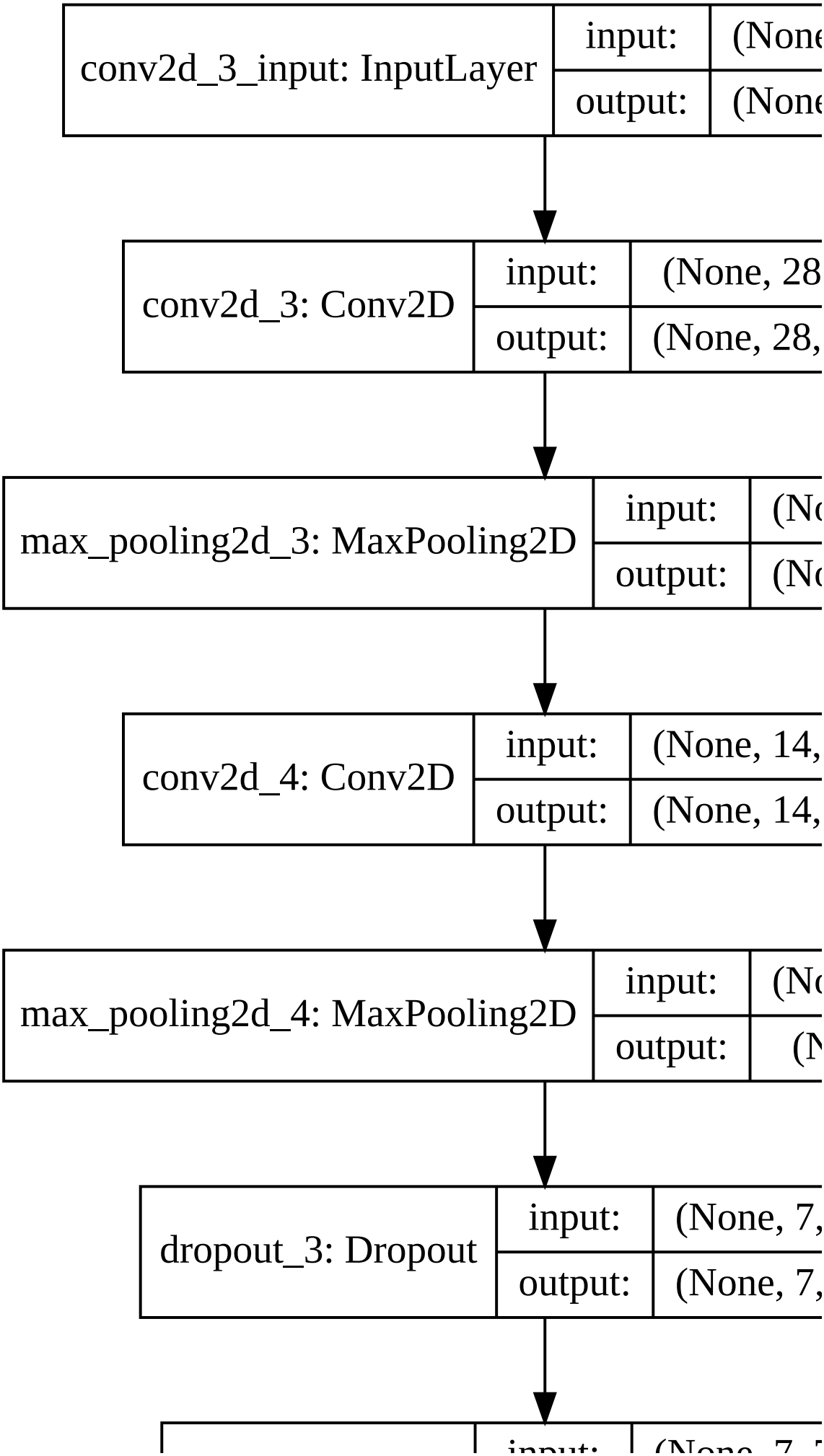
```
model = Sequential()
model.add(Conv2D(32, kernel_size=(5, 5), strides=(1, 1), padding='same',
                 activation='relu',
                 input_shape=input_shape))
model.add(MaxPooling2D(pool_size=(2, 2), strides=(2, 2)))
model.add(Conv2D(64, (2, 2), activation='relu', padding='same'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(1000, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))
model.summary()
```

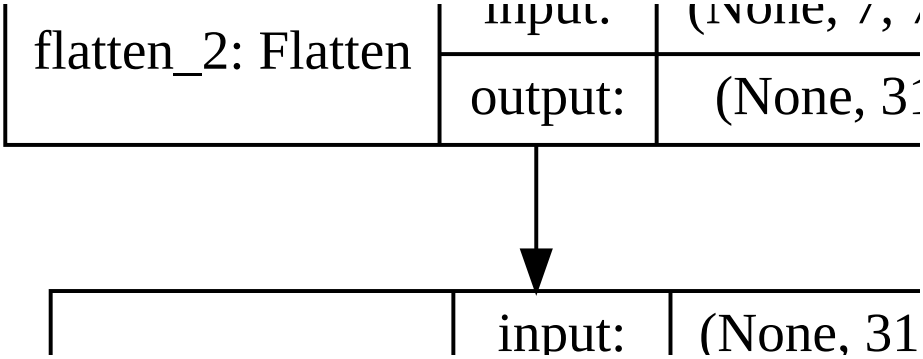
```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_3 (Conv2D)            (None, 28, 28, 32)        832
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 14, 14, 32)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 14, 14, 64)        8256
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 7, 7, 64)          0
_________________________________________________________________
dropout_3 (Dropout)          (None, 7, 7, 64)          0
_________________________________________________________________
flatten_2 (Flatten)          (None, 3136)              0
_________________________________________________________________
dense_3 (Dense)              (None, 1000)              3137000
_________________________________________________________________
dropout_4 (Dropout)          (None, 1000)              0
_________________________________________________________________
dense_4 (Dense)              (None, 10)                10010
=================================================================
Total params: 3,156,098
Trainable params: 3,156,098
Non-trainable params: 0
_________________________________________________________________
```

In [20]:

```
from IPython.display import SVG
from IPython.display import HTML
import base64
_html_template='<img width="{}" src="{}" >'

def svg_to_fixed_width_html_image(svg, width="100%"):
    text = _html_template.format(width, base64.b64encode(svg))
    return HTML(text)

from keras.utils.vis_utils import model_to_dot
%matplotlib inline

m_dot = model_to_dot(model, show_shapes=True)
m_dot.set_size('20x8')
svg = m_dot.create(prog='dot', format='svg')
SVG(svg)
```

Out[20]:


conv2d_3_input: InputLayer
input:
(None
output:
(None
conv2d_3: Conv2D
input:
(None, 28
output:
(None, 28,
max_pooling2d_3: MaxPooling2D
input:
(N
output:
(N
conv2d_4: Conv2D
input:
(None, 14,
output:
(None, 14,
max_pooling2d_4: MaxPooling2D
input:
(N
output:
(
dropout_3: Dropout
input:
(None, 7,
output:
(None, 7,


flatten_2: Flatten
input:
output:
(None, 3
input:
(None, 31

In [ ]:

```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
hist = model.fit(x_train, y_train,
                 batch_size=batch_size,
                 epochs=epochs,
                 verbose=1,
                 validation_data=(x_test, y_test))
```

```
WARNING:tensorflow:From /home/lmu/.anyenv/envs/pyenv/versions/3.7.4/envs/songpyeo
n/lib/python3.7/site-packages/keras/optimizers.py:793: The name tf.train.Optimizer
is deprecated. Please use tf.compat.v1.train.Optimizer instead.

WARNING:tensorflow:From /home/lmu/.anyenv/envs/pyenv/versions/3.7.4/envs/songpyeo
n/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:3576: The name t
f.log is deprecated. Please use tf.math.log instead.

WARNING:tensorflow:From /home/lmu/.anyenv/envs/pyenv/versions/3.7.4/envs/songpyeo
n/lib/python3.7/site-packages/tensorflow/python/ops/math_grad.py:1250: add_dispatc
h_support.<locals>.wrapper (from tensorflow.python.ops.array_ops) is deprecated an
d will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 42s 698us/step - loss: 0.1896 - ac
c: 0.9412 - val_loss: 0.0540 - val_acc: 0.9825
Epoch 2/12
60000/60000 [==============================] - 42s 697us/step - loss: 0.0621 - ac
c: 0.9810 - val_loss: 0.0349 - val_acc: 0.9874
Epoch 3/12
60000/60000 [==============================] - 45s 757us/step - loss: 0.0464 - ac
c: 0.9860 - val_loss: 0.0270 - val_acc: 0.9905
Epoch 4/12
60000/60000 [==============================] - 47s 787us/step - loss: 0.0374 - ac
c: 0.9885 - val_loss: 0.0264 - val_acc: 0.9899
Epoch 5/12
60000/60000 [==============================] - 48s 802us/step - loss: 0.0314 - ac
c: 0.9905 - val_loss: 0.0242 - val_acc: 0.9918
Epoch 6/12
60000/60000 [==============================] - 46s 760us/step - loss: 0.0273 - ac
c: 0.9911 - val_loss: 0.0238 - val_acc: 0.9923
Epoch 7/12
60000/60000 [==============================] - 45s 757us/step - loss: 0.0253 - ac
c: 0.9919 - val_loss: 0.0243 - val_acc: 0.9920
Epoch 8/12
60000/60000 [==============================] - 45s 758us/step - loss: 0.0210 - ac
c: 0.9931 - val_loss: 0.0229 - val_acc: 0.9923
Epoch 9/12
60000/60000 [==============================] - 46s 761us/step - loss: 0.0185 - ac
c: 0.9940 - val_loss: 0.0219 - val_acc: 0.9931
Epoch 10/12
60000/60000 [==============================] - 51s 852us/step - loss: 0.0172 - ac
c: 0.9942 - val_loss: 0.0213 - val_acc: 0.9931
Epoch 11/12
51456/60000 [========================>.....] - ETA: 6s - loss: 0.0172 - acc: 0.994
2
```

In [ ]:

```
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

In [ ]:

```

```