Neural Network Models for Time Series Forecasting

```
from numpy import array

# split a univariate sequence into samples
def split_sequence(sequence, n_steps):
    X, y = list(), list()
    for i in range(len(sequence)):
        # find the end of this pattern
        end_ix = i + n_steps
        # check if we are beyond the sequence
        if end_ix > len(sequence)-1:
            break
        # gather input and output parts of the pattern
        seq_x, seq_y = sequence[i:end_ix], sequence[end_ix]
        X.append(seq_x)
        y.append(seq_y)
    return array(X), array(y)

# define input sequence
raw_seq = [10, 20, 30, 40, 50, 60, 70, 80, 90]
# choose a number of time steps
n_steps = 3
# split into samples
X, y = split_sequence(raw_seq, n_steps)
# summarize the data
for i in range(len(X)):
    print(X[i], y[i])
```

```
[10 20 30] 40
[20 30 40] 50
[30 40 50] 60
[40 50 60] 70
[50 60 70] 80
[60 70 80] 90
```

CNN Model

```
# univariate cnn example
from numpy import array
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import Flatten
from keras.layers.convolutional import Conv1D
from keras.layers.convolutional import MaxPooling1D

# split a univariate sequence into samples
def split_sequence(sequence, n_steps):
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    # check if we are beyond the sequence
    if end_ix > len(sequence)-1:
      break
    # gather input and output parts of the pattern
    seq_x, seq_y = sequence[i:end_ix], sequence[end_ix]
    X.append(seq_x)
    y.append(seq_y)
  return array(X), array(y)

# define input sequence
raw_seq = [10, 20, 30, 40, 50, 60, 70, 80, 90]
# choose a number of time steps
n_steps = 3
# split into samples
X, y = split_sequence(raw_seq, n_steps)
# reshape from [samples, timesteps] into [samples, timesteps, features]
n_features = 1
X = X.reshape((X.shape[0], X.shape[1], n_features))
# define model
model = Sequential()
model.add(Conv1D(filters=64, kernel_size=2, activation='relu', input_shape=(n_steps, n_features)))
model.add(MaxPooling1D(pool_size=2))
model.add(Flatten())
model.add(Dense(50, activation='relu'))
model.add(Dense(1))
model.compile(optimizer='adam', loss='mse')
# fit model
model.fit(X, y, epochs=1000, verbose=0)
# demonstrate prediction
x_input = array([70, 80, 90])
x_input = x_input.reshape((1, n_steps, n_features))
yhat = model.predict(x_input, verbose=0)
print(yhat)
```

```
[[101.41586]]
```

```
# multivariate data preparation
from numpy import array
from numpy import hstack
# define input sequence
in_seq1 = array([10, 20, 30, 40, 50, 60, 70, 80, 90])
in_seq2 = array([15, 25, 35, 45, 55, 65, 75, 85, 95])
out_seq = array([in_seq1[i]+in_seq2[i] for i in range(len(in_seq1))])
# convert to [rows, columns] structure
in_seq1 = in_seq1.reshape((len(in_seq1), 1))
in_seq2 = in_seq2.reshape((len(in_seq2), 1))
out_seq = out_seq.reshape((len(out_seq), 1))
# horizontally stack columns
dataset = hstack((in_seq1, in_seq2, out_seq))
print(dataset)
```

```
[[ 10  15  25]
 [ 20  25  45]
 [ 30  35  65]
 [ 40  45  85]
 [ 50  55 105]
 [ 60  65 125]
 [ 70  75 145]
 [ 80  85 165]
 [ 90  95 185]]
```

```
# split a multivariate sequence into samples
def split_sequences(sequences, n_steps):
    X, y = list(), list()
    for i in range(len(sequences)):
        # find the end of this pattern
        end_ix = i + n_steps
        # check if we are beyond the dataset
        if end_ix > len(sequences):
            break
        # gather input and output parts of the pattern
        seq_x, seq_y = sequences[i:end_ix, :-1], sequences[end_ix-1, -1]
        X.append(seq_x)
        y.append(seq_y)
    return array(X), array(y)
```

```
# multivariate data preparation
from numpy import array
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# split a multivariate sequence into samples
def split_sequences(sequences, n_steps):
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    for i in range(len(sequences)):
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        seq_x, seq_y = sequences[i:end_ix, :-1], sequences[end_ix-1, -1]
        X.append(seq_x)
        y.append(seq_y)
    return array(X), array(y)

# define input sequence
in_seq1 = array([10, 20, 30, 40, 50, 60, 70, 80, 90])
```

```
in_seq2 = array([15, 25, 35, 45, 55, 65, 75, 85, 95])
out_seq = array([in_seq1[i]+in_seq2[i] for i in range(len(in_seq1))])
# convert to [rows, columns] structure
in_seq1 = in_seq1.reshape((len(in_seq1), 1))
in_seq2 = in_seq2.reshape((len(in_seq2), 1))
out_seq = out_seq.reshape((len(out_seq), 1))
# horizontally stack columns
dataset = hstack((in_seq1, in_seq2, out_seq))
# choose a number of time steps
n_steps = 3
# convert into input/output
X, y = split_sequences(dataset, n_steps)
print(X.shape, y.shape)
# summarize the data
for i in range(len(X)):
    print(X[i], y[i])
```

```
(7, 3, 2) (7,)
[[10 15]
 [20 25]
 [30 35]] 65
[[20 25]
 [30 35]
 [40 45]] 85
[[30 35]
 [40 45]
 [50 55]] 105
[[40 45]
 [50 55]
 [60 65]] 125
[[50 55]
 [60 65]
 [70 75]] 145
[[60 65]
 [70 75]
 [80 85]] 165
[[70 75]
 [80 85]
 [90 95]] 185
```

```
# multivariate cnn example
from numpy import array
from numpy import hstack
from keras.models import Sequential
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# split a multivariate sequence into samples
def split_sequences(sequences, n_steps):
  X, y = list(), list()
  for i in range(len(sequences)):
    # find the end of this pattern
    end_ix = i + n_steps
    # check if we are beyond the dataset
    if end_ix > len(sequences):
      break
    # gather input and output parts of the pattern
    seq_x, seq_y = sequences[i:end_ix, :-1], sequences[end_ix-1, -1]
    X.append(seq_x)
    y.append(seq_y)
  return array(X), array(y)

# define input sequence
in_seq1 = array([10, 20, 30, 40, 50, 60, 70, 80, 90])
in_seq2 = array([15, 25, 35, 45, 55, 65, 75, 85, 95])
out_seq = array([in_seq1[i]+in_seq2[i] for i in range(len(in_seq1))])
# convert to [rows, columns] structure
in_seq1 = in_seq1.reshape((len(in_seq1), 1))
in_seq2 = in_seq2.reshape((len(in_seq2), 1))
out_seq = out_seq.reshape((len(out_seq), 1))
# horizontally stack columns
dataset = hstack((in_seq1, in_seq2, out_seq))
# choose a number of time steps
n_steps = 3
# convert into input/output
X, y = split_sequences(dataset, n_steps)
# the dataset knows the number of features, e.g. 2
# the dataset knows the number of features, e.g. 2
n_features = X.shape[2]
# define model
model = Sequential()
model.add(Conv1D(filters=64, kernel_size=2, activation='relu', input_shape=(n_steps, n_features)))
model.add(MaxPooling1D(pool_size=2))
model.add(Flatten())
model.add(Dense(50, activation='relu'))
model.add(Dense(1))
model.compile(optimizer='adam', loss='mse')
# fit model
model.fit(X, y, epochs=1000, verbose=0)
# demonstrate prediction
x_input = array([[80, 85], [90, 95], [100, 105]])
x_input = x_input.reshape((1, n_steps, n_features))
yhat = model.predict(x_input, verbose=0)
print(yhat)
```

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    [[209.04935]]
```

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