# CNN Moneymaker

In [1]:
```
import torch
import torch.optim
import torch.nn as nn
import torch.nn.functional as F
from torch.utils.data import DataLoader

import time
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
X_train, X_val, y_train, y_val, train_mean, val_mean, train_std, val_std
= torch.load("assets/all.pt")
```

In [3]:
```
print("X_train shape: \t\t", X_train.shape)
print("X_val shape: \t\t", X_val.shape)
print("y_train shape: \t\t", y_train.shape)
print("y_val shape: \t\t", y_val.shape)
```

```
X_train shape:           torch.Size([2567487, 122, 4])
X_val shape:             torch.Size([299507, 122, 4])
y_train shape:           torch.Size([2567487, 1])
y_val shape:             torch.Size([299507, 1])
```

In [4]:
```
N, S, D = X_train.shape
```

## Training a CNN

In [5]:
```
class Dataset(torch.utils.data.Dataset):
    def __init__(self, X, y):
        self.X = X
        self.y = y

    def __len__(self):
        return len(self.X)

    def __getitem__(self, index):
        return self.X[index], self.y[index]
```

In [6]:
```
batch_size = 32
dataset = Dataset(X_train, y_train)
loader = DataLoader(dataset, batch_size, shuffle=True)
```

In [7]:
```
class CNNClassifier(nn.Module):
    def __init__(self, input_dim, hidden_dim, output_dim):
        super(CNNClassifier, self).__init__()
        self.lstm = nn.LSTM(input_dim, hidden_dim, batch_first=True)
        self.drop = nn.Dropout()
        self.conv1 = nn.Conv1d(input_dim, hidden_dim, 7)
        self.pool = nn.MaxPool1d(3)
        self.flattened_dim = int((S - 7) / 3) * hidden_dim

        self.fc = nn.Linear(self.flattened_dim + hidden_dim, output_dim)

    def forward(self, x, h=None):
        # LSTM
        if type(h) == type(None):
            x1, hn = self.lstm(x)
        else:
            x1, hn = self.lstm(x, h.detach())
        x1 = x1[:, -1, :]
        x1 = self.drop(x1)

        # Conv
        x2 = torch.transpose(x, 1, 2)
        x2 = self.pool(F.relu(self.conv1(x2)))
        x2 = x2.view(-1, self.flattened_dim)

        x = torch.cat([x1, x2], dim=1)
        out = self.fc(x)
        return out
```

In [8]:
```
input_dim = 4
hidden_dim = 32
output_dim = 1
```

In [9]:
```
model = CNNClassifier(input_dim, hidden_dim, output_dim)
if torch.cuda.is_available():
    model = model.to("cuda")

criterion = nn.MSELoss()
optimizer = torch.optim.Adam(model.parameters())
```

In [10]:
```
train_accs = []
val_accs = []
train_losses = []
val_losses = []
epoch = 0
```

## Train the model

In [11]:

```
def pred_val(X_val, model):
    val_batch_size = 1000
    val_set_size = X_val.shape[0]
    preds = []
    with torch.no_grad():
        for i in range(0, val_set_size, val_batch_size):
            start = i
            end = min(i+val_batch_size, val_set_size)
            preds.append(model(X_val[start:end]))
    pred = torch.cat(preds, dim=0)
    return pred
```

In [12]:
```
t0 = time.time()
num_epochs = 2
for ep in range(num_epochs):
    tstart = time.time()
    for i, data in enumerate(loader):
        model.train()
        print("{}/{}".format(i, int(X_train.shape[0] / batch_size)), end
='\r')
        optimizer.zero_grad()
        outputs = model(data[0])
        loss = criterion(outputs, data[1])
        loss.backward()
        optimizer.step()

        if i % 2500 == 0:
            with torch.no_grad():
                model.eval()
                train_losses.append(loss.item())
                pXval = pred_val(X_val, model)
                vloss = criterion(pXval, y_val)
                val_losses.append(vloss.item())
                torch.save({
                    'epoch': epoch,
                    'model_state_dict': model.state_dict(),
                    'optimizer_state_dict': optimizer.state_dict(),
                    'loss': loss,
                }, 'assets/partial_model.pt')
                print("training loss: {:<3.3f} \t val loss: {:<3.3f}".fo
rmat(loss, vloss))

    with torch.no_grad():
        model.eval()
        pXval = pred_val(X_val, model)
        vloss = criterion(pXval, y_val)
        val_losses.append(vloss.item())
        epoch += 1
        tend = time.time()
        print('epoch: {:<3d} \t time: {:<3.2f} \t val loss: {:<3.3f}'.fo
rmat(epoch,
                tend - tstart, vloss.item()))
time_total = time.time() - t0
print('Total time: {:4.3f}, average time per epoch: {:4.3f}'.format(time
_total, time_total / num_epochs))
```

```
training loss: 1.517     val loss: 1.984
training loss: 0.046     val loss: 0.148
training loss: 0.108     val loss: 0.136
training loss: 0.090     val loss: 0.128
training loss: 0.055     val loss: 0.139
training loss: 0.177     val loss: 0.106
training loss: 0.124     val loss: 0.110
training loss: 0.053     val loss: 0.106
training loss: 0.128     val loss: 0.124
training loss: 0.164     val loss: 0.103
training loss: 0.087     val loss: 0.105
training loss: 0.073     val loss: 0.096
training loss: 0.196     val loss: 0.097
training loss: 0.097     val loss: 0.100
training loss: 0.076     val loss: 0.090
training loss: 0.136     val loss: 0.099
training loss: 0.074     val loss: 0.113
training loss: 0.103     val loss: 0.091
training loss: 0.122     val loss: 0.088
training loss: 0.164     val loss: 0.151
training loss: 0.054     val loss: 0.099
training loss: 0.054     val loss: 0.091
training loss: 0.057     val loss: 0.082
training loss: 0.081     val loss: 0.087
training loss: 0.063     val loss: 0.079
training loss: 0.038     val loss: 0.086
training loss: 0.054     val loss: 0.082
training loss: 0.075     val loss: 0.080
training loss: 0.074     val loss: 0.078
training loss: 0.048     val loss: 0.075
training loss: 0.033     val loss: 0.075
training loss: 0.071     val loss: 0.086
training loss: 0.070     val loss: 0.139
epoch: 1         time: 2676.33   val loss: 0.080
training loss: 0.259     val loss: 0.098
training loss: 0.032     val loss: 0.075
training loss: 0.035     val loss: 0.075
training loss: 0.035     val loss: 0.072
training loss: 0.074     val loss: 0.083
10282/80233
```

```
---------------------------------------------------------------------------
----
KeyboardInterrupt                         Traceback (most recent call l
ast)
<ipython-input-12-5e59645d8335> in <module>
     10         loss = criterion(outputs, data[1])
     11         loss.backward()
---> 12         optimizer.step()
     13 
     14         if i % 2500 == 0:

/opt/anaconda3/lib/python3.7/site-packages/torch/optim/adam.py in step
(self, closure)
    105                 step_size = group['lr'] / bias_correction1
    106 
--> 107                 p.data.addcdiv_(-step_size, exp_avg, denom)
    108 
    109         return loss

KeyboardInterrupt:
```

In [13]:
```
# ignore the Use rWarning
torch.save(model, 'assets/RNN-CNN-model.pt')
```

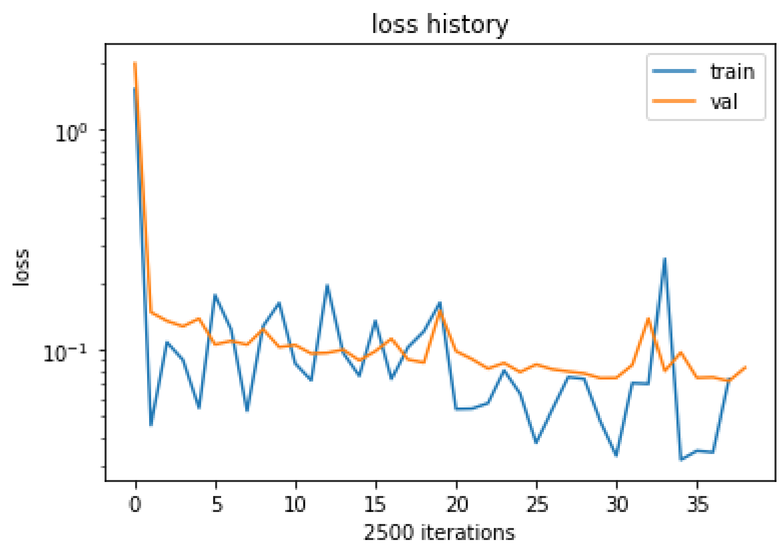
```
/opt/anaconda3/lib/python3.7/site-packages/torch/serialization.py:360:
UserWarning: Couldn't retrieve source code for container of type CNNCla
ssifier. It won't be checked for correctness upon loading.
  "type " + obj.__name__ + ". It won't be checked "
```

## Training loss vs. validation loss

In [ ]:
```
model = torch.load('assets/RNN-CNN-model.pt')
```

In [14]:
```
t_losses = [i for i in train_losses if i < 4000]
plt.plot(t_losses)
plt.plot(val_losses)
plt.title('loss history')
plt.xlabel('2500 iterations')
plt.ylabel('loss')
plt.yscale('log')
plt.legend(['train', 'val'])
```

Out[14]:
```
<matplotlib.legend.Legend at 0x7fdff9eccdd0>
```




## Evaluate the model

In [15]:
```
X_train = X_train.cuda()
y_train = y_train.cuda()
X_val = X_val.cuda()
y_val = y_val.cuda()
```

In [16]:
```
model.eval()

# predict in batches and aggregate to save space
pred = pred_val(X_val, model)
val_loss = criterion(pred, y_val).item()

print("\nFinal model evaluation: ", val_loss)
```

```
Final model evaluation:  0.07875216007232666
```

## One-step lag predictor

The one-step lag predictor simply outputs the last timestep in the input sequence. Our model should outperform the one-step lag predictor.

In [17]:

```
def one_step_lag_predictor(X):
    return X[:, -1, 3].unsqueeze(1)

p_val_naive = one_step_lag_predictor(X_val.cpu())
loss_naive = criterion(p_val_naive, y_val.cpu())

print("Loss from 1-step lag predictor:\t{}\nLoss from our model:\t\t{}".
format(loss_naive, val_loss))
```

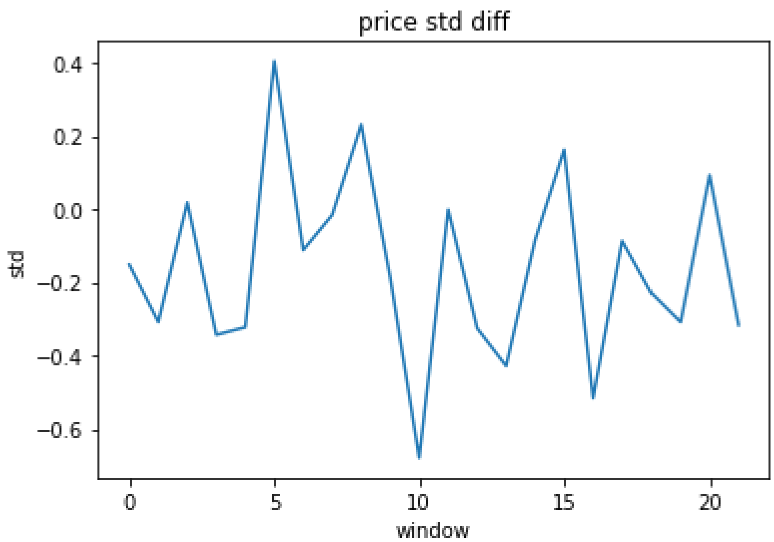
```
Loss from 1-step lag predictor: 0.15000315010547638
Loss from our model:            0.07875216007232666
```

### Standard deviation difference

In [18]:

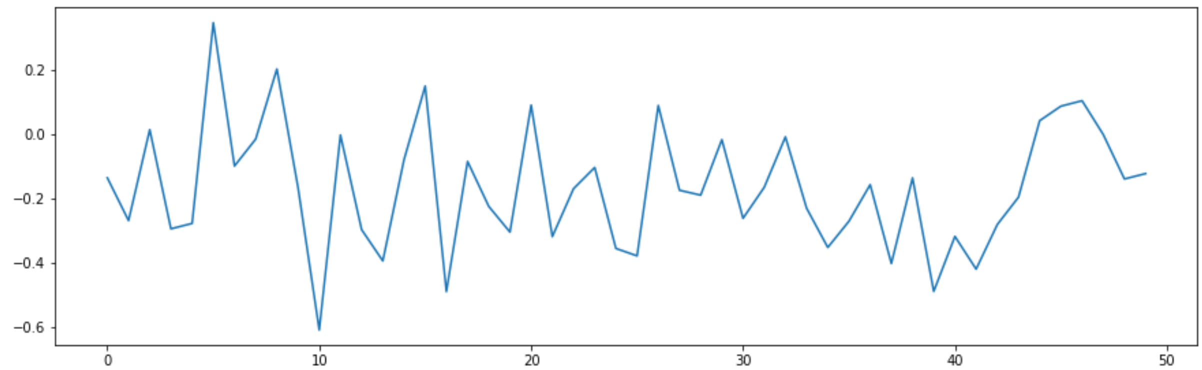
```
# switch back to cpu for plotting
X_train = X_train.cpu()
y_train = y_train.cpu()
X_val = X_val.cpu()
y_val = y_val.cpu()
pred = pred.cpu()

# backprop components no longer needed
X_train = X_train.detach()
y_train = y_train.detach()
X_val = X_val.detach()
y_val = y_val.detach()
pred = pred.detach()
```

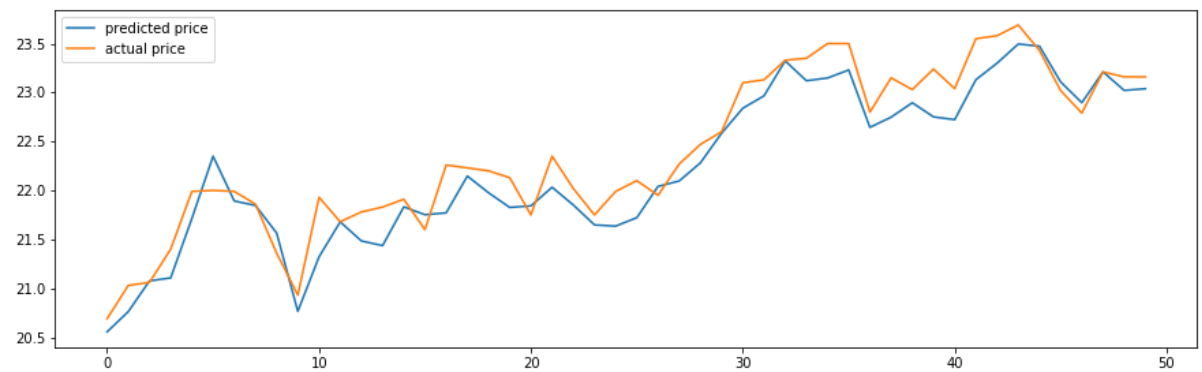
In [19]:
```
f1 = plt.figure()

ax1 = f1.add_subplot()
ax1.plot((pred - y_val)[500:522])
ax1.set_title('price std diff')
ax1.set(xlabel='window', ylabel='std')

plt.show()

# plt.plot((pred[:,3] - y_val.cpu()[:,3]).detach())
# plt.title('std difference')
# plt.plot([1, 2, 3])
```



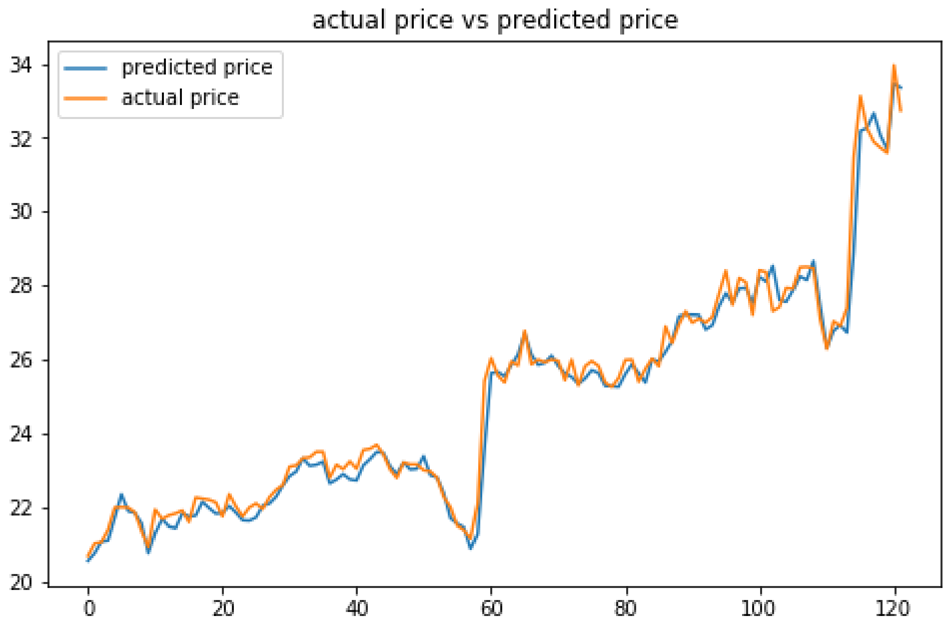

In [20]:
```
# denormalize the data
pred_abs = pred * val_std[:,3].unsqueeze(1) + val_mean[:,3].unsqueeze(1)
y_val_abs = y_val.cpu() * val_std[:,3].unsqueeze(1) + val_mean[:,3].unsq
ueeze(1)
```

In [21]:
```
fig, (ax1, ax2) = plt.subplots(2, figsize=(15, 10))
ax1.plot((pred_abs - y_val_abs)[500:550])
l1, = ax2.plot(pred_abs[500:550])
l1.set_label("predicted price")
l2, = ax2.plot(y_val_abs[500:550])
l2.set_label("actual price")

plt.legend()
plt.show()
```





In [22]:
```
fig, ax = plt.subplots(1, figsize=(8, 5))
ax.set_title("actual price vs predicted price")
l1, = ax.plot(pred_abs[500:622])
l1.set_label("predicted price")
l2, = ax.plot(y_val_abs[500:622])
l2.set_label("actual price")

plt.legend()
plt.show()
```




In [ ]: