```
import torch
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import DataLoader
from torch.utils.data import sampler
import torchvision.datasets as dset
import torchvision.transforms as T
import numpy as np
import time
from datetime import datetime
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
```

```
from google.colab import drive
drive.mount('/content/gdrive/', force_remount=True)
import sys
sys.path.insert(0,'/content/gdrive/My Drive/Colab Notebooks')
```

```
Mounted at /content/gdrive/
```

```
from project_utilities import Loss
from project_utilities import efficiency
from project_utilities import ValueSet
```

```
from helper_funcs import MyDataset
from helper_funcs import get_random_indices, plot_values, plot_num_excitations, plot_non_zero_hist, plot_correlation
from helper_funcs import get_train_test_split_indices, get_params, train, validate
from helper_funcs import plot_training_graphs, plot_results
```

DEVICE

```
CUDA_DEVICE_NUM = 0
DEVICE = torch.device(f'cuda:{CUDA_DEVICE_NUM}' if torch.cuda.is_available() else 'cpu')
print('Device:', DEVICE)
```

```
Device: cuda:0
```

```
%env CUBLAS_WORKSPACE_CONFIG=:4096:8
```

```
env: CUBLAS_WORKSPACE_CONFIG=:4096:8
```

```
import os
print(os.environ["CUBLAS_WORKSPACE_CONFIG"])
```

```
:4096:8
```

```
def set_deterministic():
    if torch.cuda.is_available():
        torch.backends.cudnn.benchmark = False
        torch.backends.cudnn.deterministic = True
    torch.use_deterministic_algorithms(True)
set_deterministic()
```

Change Directory

```
%cd /content/gdrive/My Drive/dl_mid3/data
```

```
/content/gdrive/My Drive/dl_mid3/data
```

Training and Test sets

```
# Large training sample
train_set_idx_l, val_set_idx_l = get_train_test_split_indices(20)
```

```
Training set len: 59
Training set indices: [56, 28, 50, 38, 49, 79, 12, 8, 31, 65, 59, 27, 48, 33, 74, 30, 1, 37, 2, 6, 46, 64, 26, 60, 7, 76, 40
Validation set len: 20
Validation set indices: [22, 34, 73, 20, 16, 44, 17, 13, 75, 35, 23, 39, 47, 15, 42, 67, 69, 43, 68, 5]
```

```
# Medium training sample
train_set_idx_m, val_set_idx_m = get_train_test_split_indices(40)
```

```
Training set len: 39
Training set indices: [33, 23, 70, 60, 42, 69, 56, 25, 6, 47, 76, 48, 20, 34, 14, 52, 64, 53, 32, 31, 8, 79, 37, 58, 74, 15,
Validation set len: 40
Validation set indices: [45, 22, 62, 36, 11, 1, 78, 75, 30, 71, 18, 39, 26, 9, 73, 65, 44, 17, 5, 41, 13, 10, 4, 28, 38, 59,
```

```
# Small training sample
train_set_idx_s, val_set_idx_s = get_train_test_split_indices(60)
```

```
Training set len: 19
Training set indices: [15, 75, 27, 49, 3, 10, 21, 13, 53, 42, 79, 62, 36, 16, 40, 4, 61, 29, 37]
Validation set len: 60
Validation set indices: [9, 2, 51, 46, 18, 6, 35, 45, 59, 63, 70, 30, 24, 50, 66, 25, 28, 56, 14, 69, 1, 52, 12, 78, 48, 17,
```

```
# One training sample
train_set_idx_o, val_set_idx_o = get_train_test_split_indices(78)
```

```
Training set len: 1
Training set indices: [50]
Validation set len: 78
Validation set indices: [55, 51, 49, 1, 74, 62, 14, 13, 25, 63, 32, 60, 58, 23, 53, 41, 4, 9, 79, 27, 66, 72, 26, 29, 5, 2,
```

```
## Very small validation set to use while training for overfir or underfit
train_set_idx_sv, val_set_idx_sv = get_train_test_split_indices(5)
```

```
Training set len: 74
Training set indices: [53, 34, 21, 57, 24, 10, 51, 71, 28, 70, 32, 25, 55, 4, 33, 62, 17, 54, 35, 43, 76, 31, 8, 78, 14, 58,
Validation set len: 5
Validation set indices: [73, 48, 66, 59, 69]
```

```
## Debugging dataset with small train and val
train_set_idx_db, val_set_idx_db = get_train_test_split_indices(5, 11)
```

```
Training set len: 5
Training set indices: [3, 7, 8, 9, 5]
Validation set len: 5
Validation set indices: [2, 1, 6, 4, 10]
```

Architectures

Simple RNN

```
class SimpleRNN1(torch.nn.Module):
  def __init__(self, num_input_features, num_output_features):
    super(SimpleRNN1, self).__init__()
    self.flatten = torch.nn.Flatten()
    self.linear = torch.nn.Linear(num_input_features, num_output_features)
    self.rnn1 =  torch.nn.LSTM(num_output_features, 128)
    self.fc = torch.nn.Linear(128,  num_output_features)

  def forward(self, x):
    flat_x = self.linear(self.flatten(x))
    output, (hidden, cell) = self.rnn1(flat_x)
```

```
    fc_output = self.fc(output)

    return fc_output


loss_model = Loss(0.00001)
model = SimpleRNN1(4*4000, 4000)
model.to(DEVICE)
```

```
SimpleRNN1(
  (flatten): Flatten(start_dim=1, end_dim=-1)
  (linear): Linear(in_features=16000, out_features=4000, bias=True)
  (rnn1): LSTM(4000, 128)
  (fc): Linear(in_features=128, out_features=4000, bias=True)
)
```

```
print(get_params(model))
```

```
66634560
```

```
NUM_EPOCHS = 1


(cost_l,
 efficiency_train_l,
 efficiency_val_l,
 fp_rate_train_l,
 fp_rate_val_l) = train(model,
                        DEVICE=DEVICE,
                        loss_model=loss_model,
                        num_epochs=NUM_EPOCHS,
                        train_set_idx=train_set_idx_db,
                        val_set_idx=val_set_idx_db[:1],
                        learning_rate=0.001,
                        seed=123,
                        batch_size=500)
```

```
Start Time -  30/11/2022 21:01:13
Set index: 1, Set Id: 10
Epoch ID: 0   Set ID: 10  Batch ID: 1 | Loss: 7.41897
Epoch ID: 0   Set ID: 10  Batch ID: 2 | Loss: 7.42264
Epoch ID: 0   Set ID: 10  Batch ID: 3 | Loss: 7.41595
Epoch ID: 0   Set ID: 10  Batch ID: 4 | Loss: 7.41844
```

This model automatically started crashing as it was too heavy

[ ] *3 cells hidden*

RNN2 with a simple embedding layer

```
class SimpleRNN2(torch.nn.Module):
  def __init__(self, num_input_features, embedding_dim, hidden_dim, num_output_features):
    super(SimpleRNN2, self).__init__()
    self.enco1 = torch.nn.Linear(num_input_features, embedding_dim)
    # self.enco2 = torch.nn.Linear(8000, embedding_dim)
    self.rnn = torch.nn.LSTM(embedding_dim, hidden_dim)
    # self.deco1 = torch.nn.Linear(hidden_dim, 8000)
    self.deco2 = torch.nn.Linear(hidden_dim, num_output_features)

  def forward(self, x):
        # print("x", x.shape)
        # print("x", x.view(-1, 16000).shape)
        x = self.enco1(x.view(-1, 16000))
        # print("x", x.shape)
        x = torch.nn.functional.relu(x)
        # print("x", x.shape)
        # x = self.enco2(x)
        # print("x", x.shape)
        # x = torch.nn.functional.relu(x)
        # print("x", x.shape)
        output, (hidden, cell) = self.rnn(x)
```

```
        # output = self.deco1(output)
        output = self.deco2(output)
        # print("output", output.shape)
        return output


EMBEDDING_DIM = 1024
HIDDEN_DIM = 256


loss_model = Loss(0.00001)
model = SimpleRNN2(num_input_features=16000,
            embedding_dim=EMBEDDING_DIM,
            hidden_dim=HIDDEN_DIM,
            num_output_features=4000 )
model.to(DEVICE)
```

```
SimpleRNN2(
  (enco1): Linear(in_features=16000, out_features=1024, bias=True)
  (rnn): LSTM(1024, 256)
  (deco2): Linear(in_features=256, out_features=4000, bias=True)
)
```

```
print(get_params(model))
```

```
18725792
```

```
NUM_EPOCHS = 1


(cost_l,
 efficiency_train_l,
 efficiency_val_l,
 fp_rate_train_l,
 fp_rate_val_l) = train(model,
                        DEVICE=DEVICE,
                        loss_model=loss_model,
                        num_epochs=NUM_EPOCHS,
                        train_set_idx=train_set_idx_db,
                        val_set_idx=val_set_idx_db[:1],
                        learning_rate=0.001,
                        seed=123,
                        batch_size=500)
```

```
Time till now : 0.048585096995035805 minutes
Set index: 2, Set Id: 1
Epoch ID: 0   Set ID: 1  Batch ID: 11 | Loss: 6.99964
Epoch ID: 0   Set ID: 1  Batch ID: 12 | Loss: 6.99562
Epoch ID: 0   Set ID: 1  Batch ID: 13 | Loss: 6.99740
Epoch ID: 0   Set ID: 1  Batch ID: 14 | Loss: 6.99679
Epoch ID: 0   Set ID: 1  Batch ID: 15 | Loss: 6.99363
Epoch ID: 0   Set ID: 1  Batch ID: 16 | Loss: 7.05999
Epoch ID: 0   Set ID: 1  Batch ID: 17 | Loss: 7.04860
Epoch ID: 0   Set ID: 1  Batch ID: 18 | Loss: 7.05008
Epoch ID: 0   Set ID: 1  Batch ID: 19 | Loss: 7.05440
Epoch ID: 0   Set ID: 1  Batch ID: 20 | Loss: 7.05056
Set Time : 0.05004342397054037 minutes
Time till now : 0.09864335854848226 minutes
Set index: 3, Set Id: 8
Epoch ID: 0   Set ID: 8  Batch ID: 21 | Loss: 7.04982
Epoch ID: 0   Set ID: 8  Batch ID: 22 | Loss: 7.05407
Epoch ID: 0   Set ID: 8  Batch ID: 23 | Loss: 7.05339
Epoch ID: 0   Set ID: 8  Batch ID: 24 | Loss: 7.05667
Epoch ID: 0   Set ID: 8  Batch ID: 25 | Loss: 7.05567
Epoch ID: 0   Set ID: 8  Batch ID: 26 | Loss: 7.05248
Epoch ID: 0   Set ID: 8  Batch ID: 27 | Loss: 7.05836
Epoch ID: 0   Set ID: 8  Batch ID: 28 | Loss: 7.05683
```

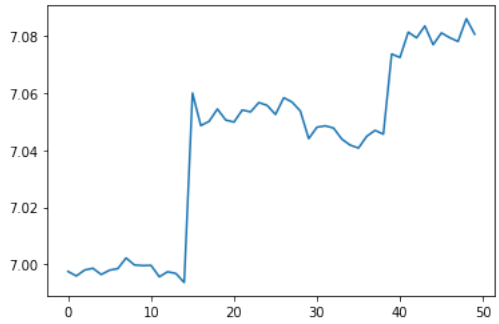
```
Epoch ID: 0   Set ID: 9  Batch ID: 39 | Loss: 7.04559
Epoch ID: 0   Set ID: 9  Batch ID: 40 | Loss: 7.07367
Set Time : 0.05051025152206421 minutes
Time till now : 0.19787110090255738 minutes
Set index: 5, Set Id: 4
Epoch ID: 0   Set ID: 4  Batch ID: 41 | Loss: 7.07247
Epoch ID: 0   Set ID: 4  Batch ID: 42 | Loss: 7.08132
Epoch ID: 0   Set ID: 4  Batch ID: 43 | Loss: 7.07935
Epoch ID: 0   Set ID: 4  Batch ID: 44 | Loss: 7.08348
Epoch ID: 0   Set ID: 4  Batch ID: 45 | Loss: 7.07693
Epoch ID: 0   Set ID: 4  Batch ID: 46 | Loss: 7.08106
Epoch ID: 0   Set ID: 4  Batch ID: 47 | Loss: 7.07939
Epoch ID: 0   Set ID: 4  Batch ID: 48 | Loss: 7.07808
Epoch ID: 0   Set ID: 4  Batch ID: 49 | Loss: 7.08605
Epoch ID: 0   Set ID: 4  Batch ID: 50 | Loss: 7.08063
Set Time : 0.048401562372843425 minutes
Time till now : 0.24628729820251466 minutes
Validating
2
Val loss: 7.079649448394775, Val efficiency: 0.10596439713708937, Val Fp rate: 39.31353729254149
Epoch Time : 0.28895164330800377 minutes
Total time : 0.2889551798502604 minutes
```

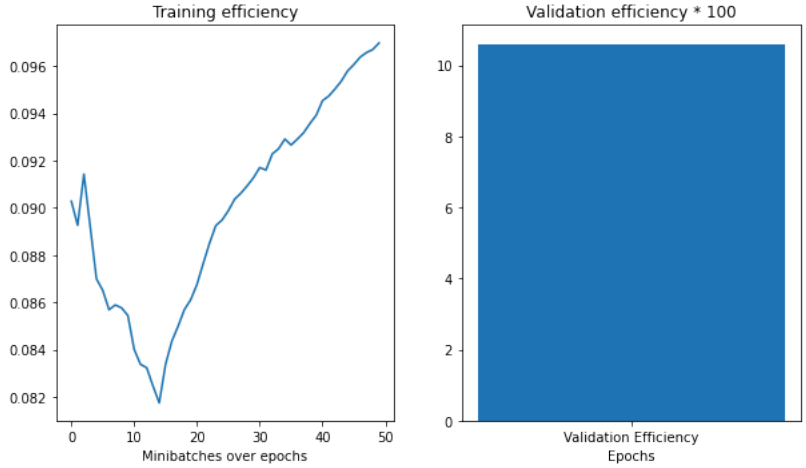
```
loss_val, eff_rate, fp_rate = validate(model, DEVICE, loss_model, val_set_idx_db)
print('Loss: %0.3f ' % loss_val, end="")
print('  Efficiency: %0.3f' % eff_rate, end="")
print('  False positive rate: %0.3f' % fp_rate)
```

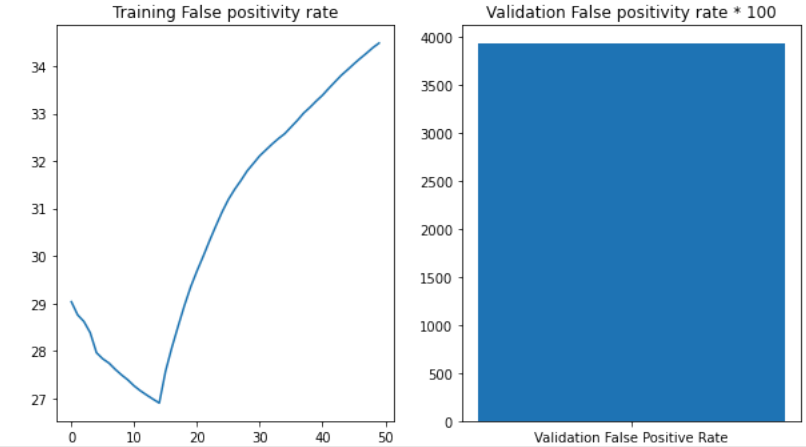
```
Validating
2
6
3
10
7
Loss: 7.079   Efficiency: 0.105  False positive rate: 39.249
```

```
plot_training_graphs(
    NUM_EPOCHS,
    cost_l,
    efficiency_train_l,
    efficiency_val_l,
    fp_rate_train_l,
    fp_rate_val_l)
```

```
1 50 50 1 50 1
```

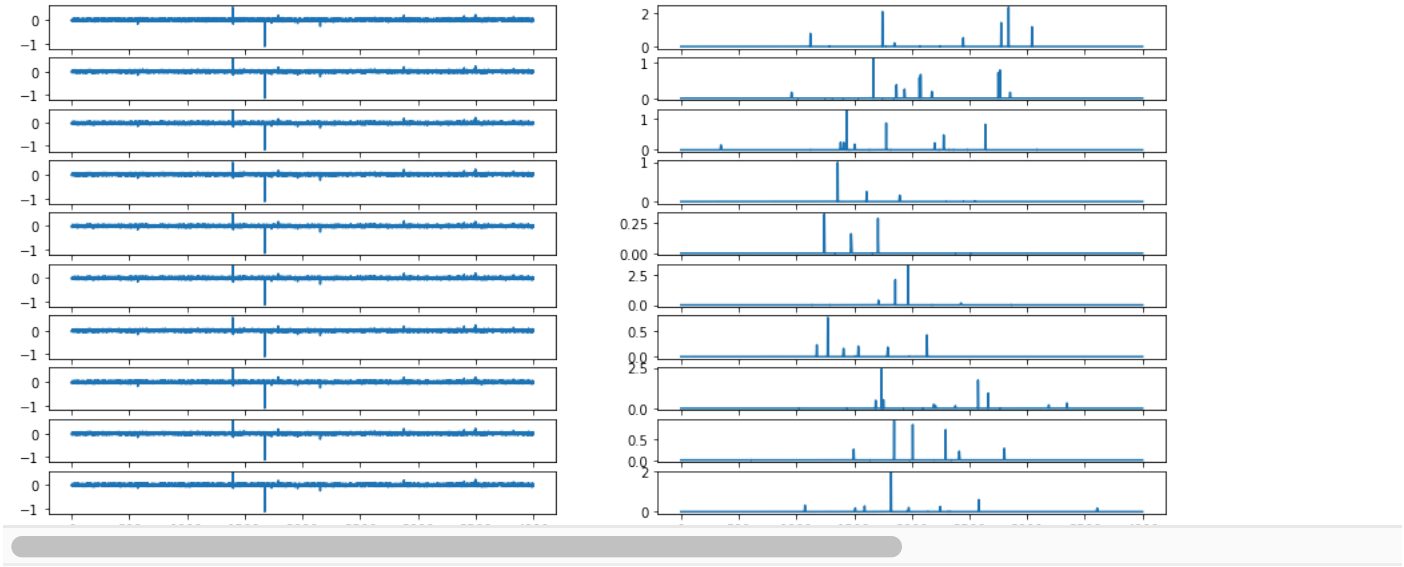







```
plot_results(model,DEVICE, 6)
```

```
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
```



Increasing the embeding dimensions

[ ] ↳ *7 cells hidden*

Reducing learning rate

[ ] ↳ *7 cells hidden*

Falling back on lr and Incresing epochs

[ ] ↳ *7 cells hidden*

The above model was crashing so changing the architecture a little

Updating architecture by adding more layers

```
class SimpleRNN4(torch.nn.Module):
  def __init__(self, num_input_features, embedding_dim, hidden_dim1, hidden_dim2, num_output_features):
    super(SimpleRNN4, self).__init__()
    self.enco1 = torch.nn.Linear(num_input_features, embedding_dim)
    # self.enco2 = torch.nn.Linear(8000, embedding_dim)
    self.rnn = torch.nn.LSTM(embedding_dim, hidden_dim1)
    # self.deco1 = torch.nn.Linear(hidden_dim, 8000)
    self.deco1 = torch.nn.Linear(hidden_dim1, hidden_dim2)
    self.deco2 = torch.nn.Linear(hidden_dim2, num_output_features)

  def forward(self, x):
        # print("x", x.shape)
        # print("x", x.view(-1, 16000).shape)
        x = self.enco1(x.view(-1, 16000))
        # print("x", x.shape)
        x = torch.nn.functional.relu(x)
        # print("x", x.shape)
        # x = self.enco2(x)
        # print("x", x.shape)
```

```
        # x = torch.nn.functional.relu(x)
        # print("x", x.shape)
        output, (hidden, cell) = self.rnn(x)

        output = self.deco1(output)
        output = self.deco2(output)
        # print("output", output.shape)
        return output


EMBEDDING_DIM = 512
HIDDEN_DIM = 128

loss_model = Loss(0.00001)
model = SimpleRNN4(num_input_features=16000,
            embedding_dim=EMBEDDING_DIM,
            hidden_dim1=HIDDEN_DIM,
            hidden_dim2=512,
            num_output_features=4000)
model.to(DEVICE)
```

```
SimpleRNN4(
  (enco1): Linear(in_features=16000, out_features=512, bias=True)
  (rnn): LSTM(512, 128)
  (deco1): Linear(in_features=128, out_features=512, bias=True)
  (deco2): Linear(in_features=512, out_features=4000, bias=True)
)
```

```
print(get_params(model))
```

```
10639264
```

```
NUM_EPOCHS = 3


(cost_l,
 efficiency_train_l,
 efficiency_val_l,
 fp_rate_train_l,
 fp_rate_val_l) = train(model,
                        DEVICE=DEVICE,
                        loss_model=loss_model,
                        num_epochs=NUM_EPOCHS,
                        train_set_idx=train_set_idx_db,
                        val_set_idx=val_set_idx_db[:1],
                        learning_rate=0.001,
                        seed=123,
                        batch_size=500)
```

```
Start Time -  30/11/2022 21:38:20
Set index: 1, Set Id: 5
Epoch ID: 0   Set ID: 5  Batch ID: 1 | Loss: 7.19023
Epoch ID: 0   Set ID: 5  Batch ID: 2 | Loss: 7.19096
Epoch ID: 0   Set ID: 5  Batch ID: 3 | Loss: 7.19260
Epoch ID: 0   Set ID: 5  Batch ID: 4 | Loss: 7.19449
Epoch ID: 0   Set ID: 5  Batch ID: 5 | Loss: 7.22853
Epoch ID: 0   Set ID: 5  Batch ID: 6 | Loss: 7.22616
Epoch ID: 0   Set ID: 5  Batch ID: 7 | Loss: 7.22820
Epoch ID: 0   Set ID: 5  Batch ID: 8 | Loss: 7.22960
Epoch ID: 0   Set ID: 5  Batch ID: 9 | Loss: 7.22538
Epoch ID: 0   Set ID: 5  Batch ID: 10 | Loss: 7.22379
Set Time : 0.04233774741490682 minutes
Time till now : 0.04233876864115397 minutes
Set index: 2, Set Id: 4
Epoch ID: 0   Set ID: 4  Batch ID: 11 | Loss: 7.22378
Epoch ID: 0   Set ID: 4  Batch ID: 12 | Loss: 7.22213
Epoch ID: 0   Set ID: 4  Batch ID: 13 | Loss: 7.22192
Epoch ID: 0   Set ID: 4  Batch ID: 14 | Loss: 7.21964
Epoch ID: 0   Set ID: 4  Batch ID: 15 | Loss: 7.23847
Epoch ID: 0   Set ID: 4  Batch ID: 16 | Loss: 7.24037
Epoch ID: 0   Set ID: 4  Batch ID: 17 | Loss: 7.24031
Epoch ID: 0   Set ID: 4  Batch ID: 18 | Loss: 7.24842
Epoch ID: 0   Set ID: 4  Batch ID: 19 | Loss: 7.24920
Epoch ID: 0   Set ID: 4  Batch ID: 20 | Loss: 7.24844
Set Time : 0.04253925085067749 minutes
Time till now : 0.08487910032272339 minutes
Set index: 3, Set Id: 8
Epoch ID: 0   Set ID: 8  Batch ID: 21 | Loss: 7.24667
Epoch ID: 0   Set ID: 8  Batch ID: 22 | Loss: 7.24697
Epoch ID: 0   Set ID: 8  Batch ID: 23 | Loss: 7.26720
```

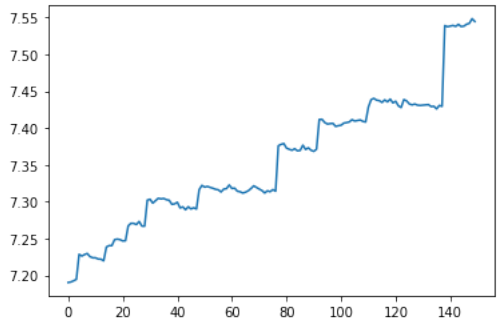
```
Epoch ID: 0   Set ID: 8  Batch ID: 24 | Loss: 7.27065
Epoch ID: 0   Set ID: 8  Batch ID: 25 | Loss: 7.27051
Epoch ID: 0   Set ID: 8  Batch ID: 26 | Loss: 7.26895
Epoch ID: 0   Set ID: 8  Batch ID: 27 | Loss: 7.27315
Epoch ID: 0   Set ID: 8  Batch ID: 28 | Loss: 7.26690
Epoch ID: 0   Set ID: 8  Batch ID: 29 | Loss: 7.26672
Epoch ID: 0   Set ID: 8  Batch ID: 30 | Loss: 7.30213
Set Time : 0.04189810355504354 minutes
Time till now : 0.12677830855051678 minutes
Set index: 4, Set Id: 3
Epoch ID: 0   Set ID: 3  Batch ID: 31 | Loss: 7.30329
Epoch ID: 0   Set ID: 3  Batch ID: 32 | Loss: 7.29802
Epoch ID: 0   Set ID: 3  Batch ID: 33 | Loss: 7.30139
Epoch ID: 0   Set ID: 3  Batch ID: 34 | Loss: 7.30461
Epoch ID: 0   Set ID: 3  Batch ID: 35 | Loss: 7.30380
Epoch ID: 0   Set ID: 3  Batch ID: 36 | Loss: 7.30435
Epoch ID: 0   Set ID: 3  Batch ID: 37 | Loss: 7.30269
Epoch ID: 0   Set ID: 3  Batch ID: 38 | Loss: 7.30195
Epoch ID: 0   Set ID: 3  Batch ID: 39 | Loss: 7.29641
Epoch ID: 0   Set ID: 3  Batch ID: 40 | Loss: 7.29705
Set Time : 0.04137629667917887 minutes
Time till now : 0.16815605163574218 minutes
Set index: 5, Set Id: 1
Epoch ID: 0   Set ID: 1  Batch ID: 41 | Loss: 7.29919
Epoch ID: 0   Set ID: 1  Batch ID: 42 | Loss: 7.29155
Epoch ID: 0   Set ID: 1  Batch ID: 43 | Loss: 7.29298
Epoch ID: 0   Set ID: 1  Batch ID: 44 | Loss: 7.28902
```

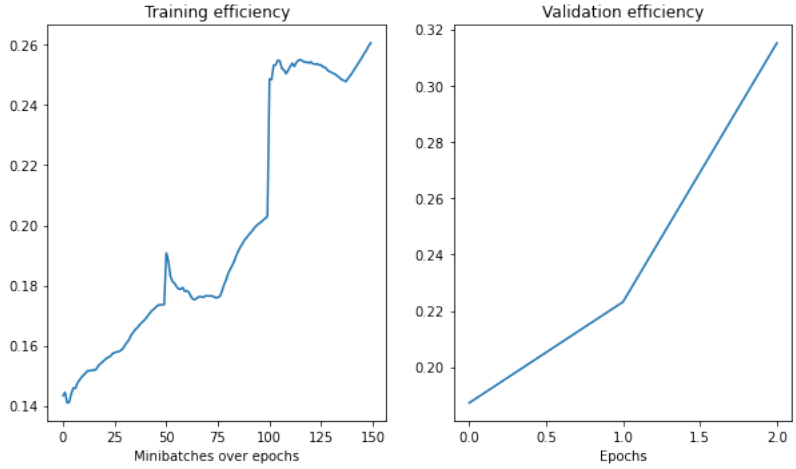
```
loss_val, eff_rate, fp_rate = validate(model, DEVICE, loss_model, val_set_idx_l)
print('Loss: %0.3f ' % loss_val, end="")
print('  Efficiency: %0.3f' % eff_rate, end="")
print('  False positive rate: %0.3f' % fp_rate)
```

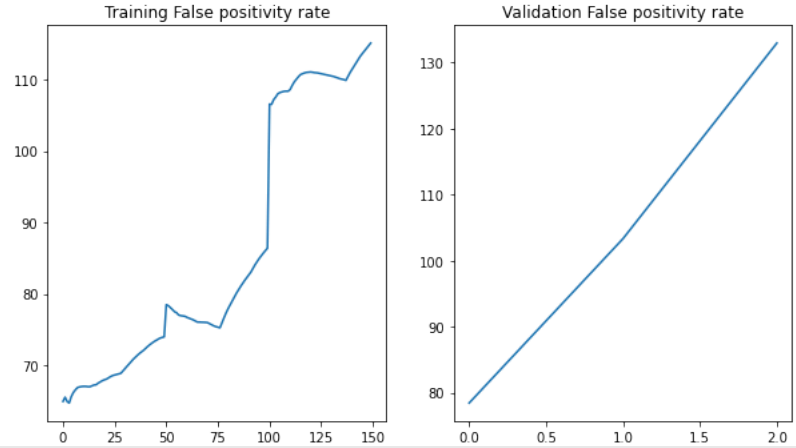
```
Validating
63
78
2
79
31
68
51
26
69
49
13
54
46
70
29
66
47
44
23
32
Loss: 7.543   Efficiency: 0.315  False positive rate: 133.017
```

```
plot_training_graphs(
    NUM_EPOCHS,
    cost_l,
    efficiency_train_l,
    efficiency_val_l,
    fp_rate_train_l,
    fp_rate_val_l)
```

```
3 150 150 3 150 3
```

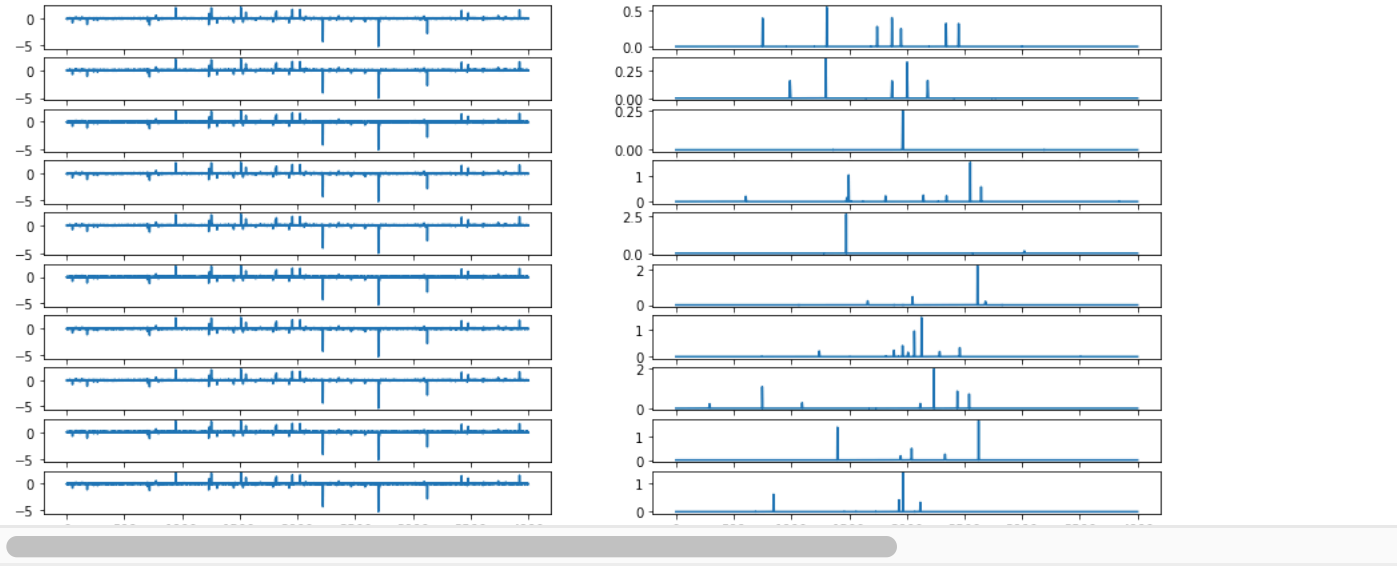







```
plot_results(model,DEVICE, 6)
```

```
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
```



Small large dataset

Reducing the dims as well because it is crashing

```
EMBEDDING_DIM = 512
HIDDEN_DIM = 128

loss_model = Loss(0.00001)
model_s = SimpleRNN4(num_input_features=16000,
            embedding_dim=128,
            hidden_dim1=64,
            hidden_dim2=128,
            num_output_features=4000)
model_s.to(DEVICE)
```

```
SimpleRNN4(
  (enco1): Linear(in_features=16000, out_features=128, bias=True)
  (rnn): LSTM(128, 64)
  (deco1): Linear(in_features=64, out_features=128, bias=True)
  (deco2): Linear(in_features=128, out_features=4000, bias=True)
)
```

```
print(get_params(model_s))
```

```
2622112
```

Session is crashing for anything more than 1 epoch so falling back to 1 epoch only and anyway we aren't seeing any improvement with more epochs.

```
NUM_EPOCHS = 1
```

```
(cost_s,
 efficiency_train_s,
 efficiency_val_s,
 fp_rate_train_s,
 fp_rate_val_s) = train(model_s,
```

```
                        DEVICE=DEVICE,
                        loss_model=loss_model,
                        num_epochs=NUM_EPOCHS,
                        train_set_idx=train_set_idx_s,
                        val_set_idx=val_set_idx_db[:1],
                        learning_rate=0.001,
                        seed=123,
                        batch_size=1000)
```

```
Start Time -  01/12/2022 14:34:04
Set index: 1, Set Id: 15
Epoch ID: 0   Set ID: 15  Batch ID: 1 | Loss: 7.48771
Epoch ID: 0   Set ID: 15  Batch ID: 2 | Loss: 7.48303
Epoch ID: 0   Set ID: 15  Batch ID: 3 | Loss: 7.48012
Epoch ID: 0   Set ID: 15  Batch ID: 4 | Loss: 7.48790
Epoch ID: 0   Set ID: 15  Batch ID: 5 | Loss: 7.48693
Set Time : 0.045254011948903404 minutes
Time till now : 0.04525519609451294 minutes
Set index: 2, Set Id: 75
Epoch ID: 0   Set ID: 75  Batch ID: 6 | Loss: 7.48533
Epoch ID: 0   Set ID: 75  Batch ID: 7 | Loss: 7.48988
Epoch ID: 0   Set ID: 75  Batch ID: 8 | Loss: 7.48488
Epoch ID: 0   Set ID: 75  Batch ID: 9 | Loss: 7.48504
Epoch ID: 0   Set ID: 75  Batch ID: 10 | Loss: 7.48467
Set Time : 0.04084610939025879 minutes
Time till now : 0.0861244797706604 minutes
Set index: 3, Set Id: 27
Epoch ID: 0   Set ID: 27  Batch ID: 11 | Loss: 7.50303
Epoch ID: 0   Set ID: 27  Batch ID: 12 | Loss: 7.49783
Epoch ID: 0   Set ID: 27  Batch ID: 13 | Loss: 7.49678
Epoch ID: 0   Set ID: 27  Batch ID: 14 | Loss: 7.53612
Epoch ID: 0   Set ID: 27  Batch ID: 15 | Loss: 7.53426
Set Time : 0.05663884083429972 minutes
Time till now : 0.1427914341290792 minutes
Set index: 4, Set Id: 49
Epoch ID: 0   Set ID: 49  Batch ID: 16 | Loss: 7.53213
Epoch ID: 0   Set ID: 49  Batch ID: 17 | Loss: 7.53448
Epoch ID: 0   Set ID: 49  Batch ID: 18 | Loss: 7.53371
Epoch ID: 0   Set ID: 49  Batch ID: 19 | Loss: 7.53075
Epoch ID: 0   Set ID: 49  Batch ID: 20 | Loss: 7.53171
Set Time : 0.03955653508504232 minutes
Time till now : 0.18236064116160075 minutes
Set index: 5, Set Id: 3
Epoch ID: 0   Set ID: 3  Batch ID: 21 | Loss: 7.53197
Epoch ID: 0   Set ID: 3  Batch ID: 22 | Loss: 7.52790
Epoch ID: 0   Set ID: 3  Batch ID: 23 | Loss: 7.53518
Epoch ID: 0   Set ID: 3  Batch ID: 24 | Loss: 7.53621
Epoch ID: 0   Set ID: 3  Batch ID: 25 | Loss: 7.53733
Set Time : 0.03902498881022135 minutes
Time till now : 0.2213870604832967 minutes
Set index: 6, Set Id: 10
Epoch ID: 0   Set ID: 10  Batch ID: 26 | Loss: 7.54094
Epoch ID: 0   Set ID: 10  Batch ID: 27 | Loss: 7.54031
Epoch ID: 0   Set ID: 10  Batch ID: 28 | Loss: 7.53795
Epoch ID: 0   Set ID: 10  Batch ID: 29 | Loss: 7.53467
Epoch ID: 0   Set ID: 10  Batch ID: 30 | Loss: 7.53263
Set Time : 0.03930117289225261 minutes
Time till now : 0.2607023596763611 minutes
Set index: 7, Set Id: 21
Epoch ID: 0   Set ID: 21  Batch ID: 31 | Loss: 7.53132
Epoch ID: 0   Set ID: 21  Batch ID: 32 | Loss: 7.53442
Epoch ID: 0   Set ID: 21  Batch ID: 33 | Loss: 7.53393
Epoch ID: 0   Set ID: 21  Batch ID: 34 | Loss: 7.53375
Epoch ID: 0   Set ID: 21  Batch ID: 35 | Loss: 7.56471
Set Time : 0.039004504680633545 minutes
Time till now : 0.2997080087661743 minutes
Set index: 8, Set Id: 13
```

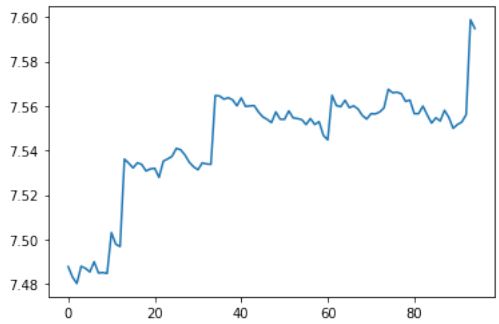
```
loss_val, eff_rate, fp_rate = validate(model_s, DEVICE, loss_model, val_set_idx_l)
print('Loss: %0.3f ' % loss_val, end="")
print('  Efficiency: %0.3f' % eff_rate, end="")
print('  False positive rate: %0.3f' % fp_rate)
```

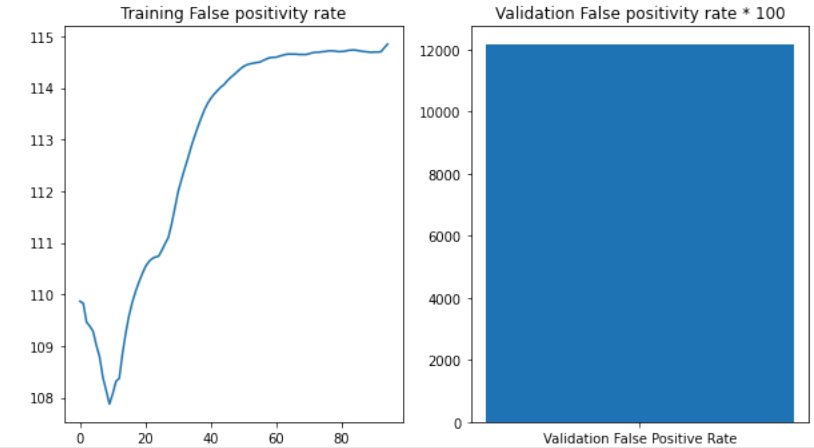
```
Validating
22
34
73
20
16
44
17
13
75
```

```
35
23
39
47
15
42
67
69
43
68
5
Loss: 7.594   Efficiency: 0.266  False positive rate: 121.573
```

```
plot_training_graphs(
    NUM_EPOCHS,
    cost_s,
    efficiency_train_s,
    efficiency_val_s,
    fp_rate_train_s,
    fp_rate_val_s)
```

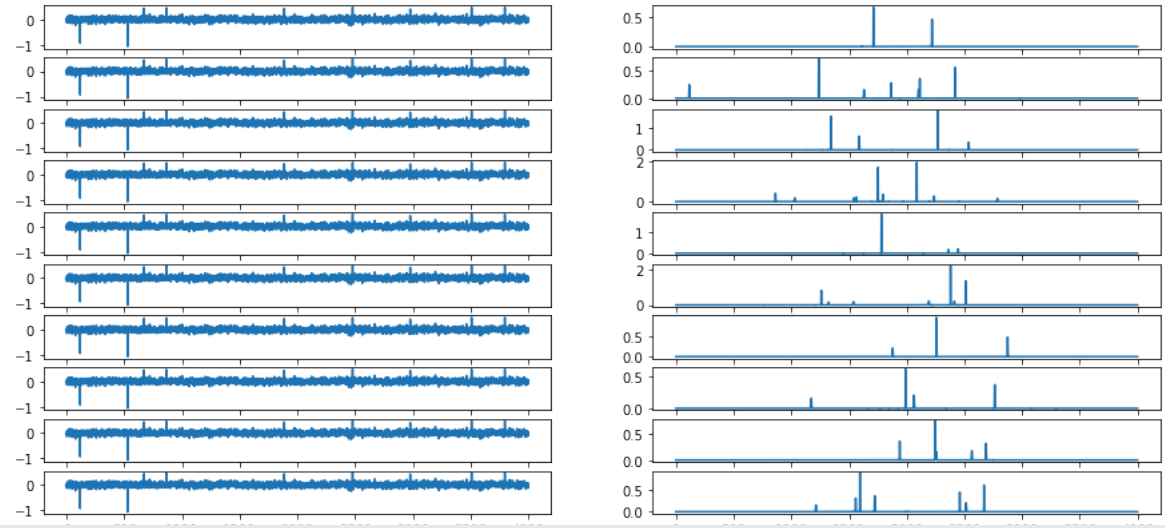
```
1 95 95 1 95 1
```






```
plot_results(model_s,DEVICE, 6)
```

```
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
```



Medium dataset

```
EMBEDDING_DIM = 512
HIDDEN_DIM = 128

loss_model = Loss(0.00001)
model_m = SimpleRNN4(num_input_features=16000,
            embedding_dim=EMBEDDING_DIM,
            hidden_dim1=HIDDEN_DIM,
            hidden_dim2=512,
            num_output_features=4000)
model_m.to(DEVICE)
```

```
SimpleRNN4(
  (enco1): Linear(in_features=16000, out_features=512, bias=True)
  (rnn): LSTM(512, 128)
  (deco1): Linear(in_features=128, out_features=512, bias=True)
  (deco2): Linear(in_features=512, out_features=4000, bias=True)
)
```

```
print(get_params(model_m))
```

```
10639264
```

```
NUM_EPOCHS = 2

(cost_m,
 efficiency_train_m,
 efficiency_val_m,
 fp_rate_train_m,
 fp_rate_val_m) = train(model_m,
                        DEVICE=DEVICE,
                        loss_model=loss_model,
                        num_epochs=NUM_EPOCHS,
                        train_set_idx=train_set_idx_m,
                        val_set_idx=val_set_idx_db[:1],
                        learning_rate=0.001,
                        seed=123,
                        batch_size=1000)
```

```
Set Time : 0.041666885217030845 minutes
Time till now : 1.243246030807495 minutes
Set index: 29, Set Id: 27
Epoch ID: 0   Set ID: 27  Batch ID: 141 | Loss: 7.22877
Epoch ID: 0   Set ID: 27  Batch ID: 142 | Loss: 7.23031
Epoch ID: 0   Set ID: 27  Batch ID: 143 | Loss: 7.23024
Epoch ID: 0   Set ID: 27  Batch ID: 144 | Loss: 7.23277
Epoch ID: 0   Set ID: 27  Batch ID: 145 | Loss: 7.22967
Set Time : 0.04162616729736328 minutes
Time till now : 1.2848897178967793 minutes
Set index: 30, Set Id: 63
Epoch ID: 0   Set ID: 63  Batch ID: 146 | Loss: 7.22964
Epoch ID: 0   Set ID: 63  Batch ID: 147 | Loss: 7.23051
Epoch ID: 0   Set ID: 63  Batch ID: 148 | Loss: 7.23435
Epoch ID: 0   Set ID: 63  Batch ID: 149 | Loss: 7.22932
Epoch ID: 0   Set ID: 63  Batch ID: 150 | Loss: 7.23096
Set Time : 0.060890289147694905 minutes
Time till now : 1.3457813143730164 minutes
Set index: 31, Set Id: 35
Epoch ID: 0   Set ID: 35  Batch ID: 151 | Loss: 7.22907
Epoch ID: 0   Set ID: 35  Batch ID: 152 | Loss: 7.23452
Epoch ID: 0   Set ID: 35  Batch ID: 153 | Loss: 7.23491
Epoch ID: 0   Set ID: 35  Batch ID: 154 | Loss: 7.23715
Epoch ID: 0   Set ID: 35  Batch ID: 155 | Loss: 7.23700
Set Time : 0.04030138651529948 minutes
Time till now : 1.3860841592152913 minutes
Set index: 32, Set Id: 3
Epoch ID: 0   Set ID: 3  Batch ID: 156 | Loss: 7.23800
Epoch ID: 0   Set ID: 3  Batch ID: 157 | Loss: 7.24193
Epoch ID: 0   Set ID: 3  Batch ID: 158 | Loss: 7.24625
Epoch ID: 0   Set ID: 3  Batch ID: 159 | Loss: 7.24936
Epoch ID: 0   Set ID: 3  Batch ID: 160 | Loss: 7.24478
Set Time : 0.04160443147023519 minutes
Time till now : 1.4276901284853618 minutes
Set index: 33, Set Id: 46
Epoch ID: 0   Set ID: 46  Batch ID: 161 | Loss: 7.24463
Epoch ID: 0   Set ID: 46  Batch ID: 162 | Loss: 7.24487
Epoch ID: 0   Set ID: 46  Batch ID: 163 | Loss: 7.24154
Epoch ID: 0   Set ID: 46  Batch ID: 164 | Loss: 7.24151
Epoch ID: 0   Set ID: 46  Batch ID: 165 | Loss: 7.24052
Set Time : 0.04025114774703979 minutes
Time till now : 1.4679561813672384 minutes
Set index: 34, Set Id: 29
Epoch ID: 0   Set ID: 29  Batch ID: 166 | Loss: 7.24417
Epoch ID: 0   Set ID: 29  Batch ID: 167 | Loss: 7.24335
Epoch ID: 0   Set ID: 29  Batch ID: 168 | Loss: 7.24599
Epoch ID: 0   Set ID: 29  Batch ID: 169 | Loss: 7.24874
Epoch ID: 0   Set ID: 29  Batch ID: 170 | Loss: 7.25583
Set Time : 0.04164001941680908 minutes
Time till now : 1.5095975438753764 minutes
Set index: 35, Set Id: 61
Epoch ID: 0   Set ID: 61  Batch ID: 171 | Loss: 7.26231
Epoch ID: 0   Set ID: 61  Batch ID: 172 | Loss: 7.25848
Epoch ID: 0   Set ID: 61  Batch ID: 173 | Loss: 7.26062
Epoch ID: 0   Set ID: 61  Batch ID: 174 | Loss: 7.26146
Epoch ID: 0   Set ID: 61  Batch ID: 175 | Loss: 7.27154
Set Time : 0.04064406951268514 minutes
Time till now : 1.5502434531847635 minutes
Set index: 36. Set Id: 68
```

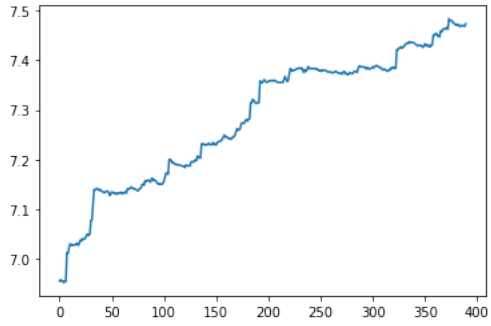
```
loss_val, eff_rate, fp_rate = validate(model_m, DEVICE, loss_model, val_set_idx_l)
print('Loss: %0.3f ' % loss_val, end="")
print('  Efficiency: %0.3f' % eff_rate, end="")
print('  False positive rate: %0.3f' % fp_rate)
```

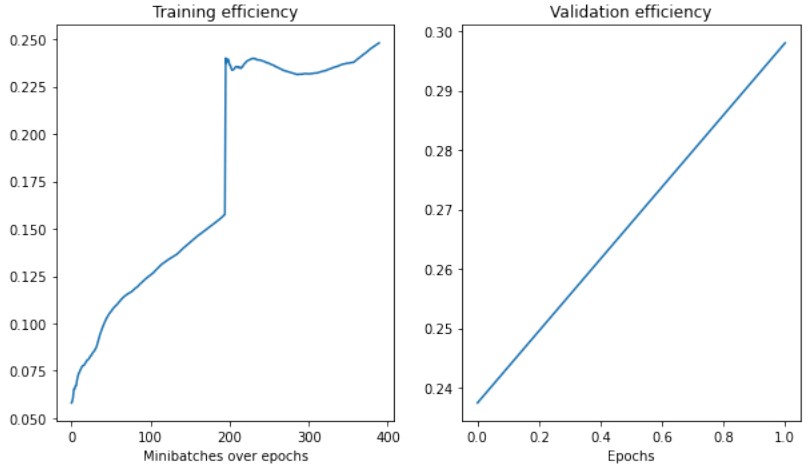
```
Validating
22
34
73
20
16
44
17
13
75
35
23
39
47
15
42
67
69
43
```

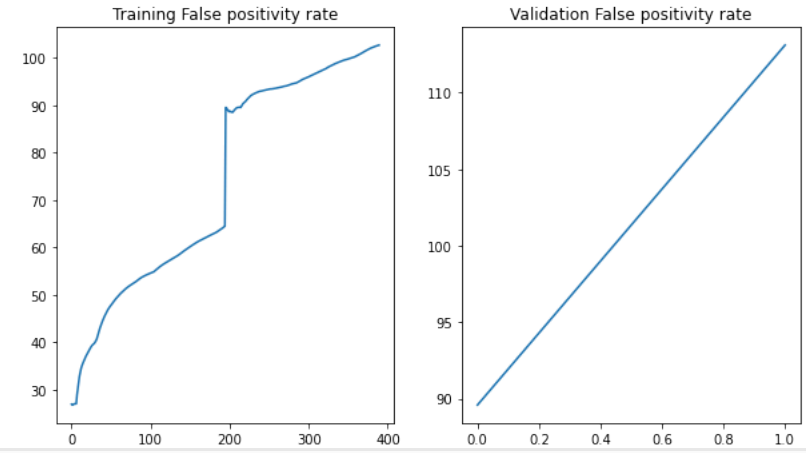
```
68
5
Loss: 7.472   Efficiency: 0.296  False positive rate: 112.992
```

```
plot_training_graphs(
    NUM_EPOCHS,
    cost_m,
    efficiency_train_m,
    efficiency_val_m,
    fp_rate_train_m,
    fp_rate_val_m)
```

```
2 390 390 2 390 2
```

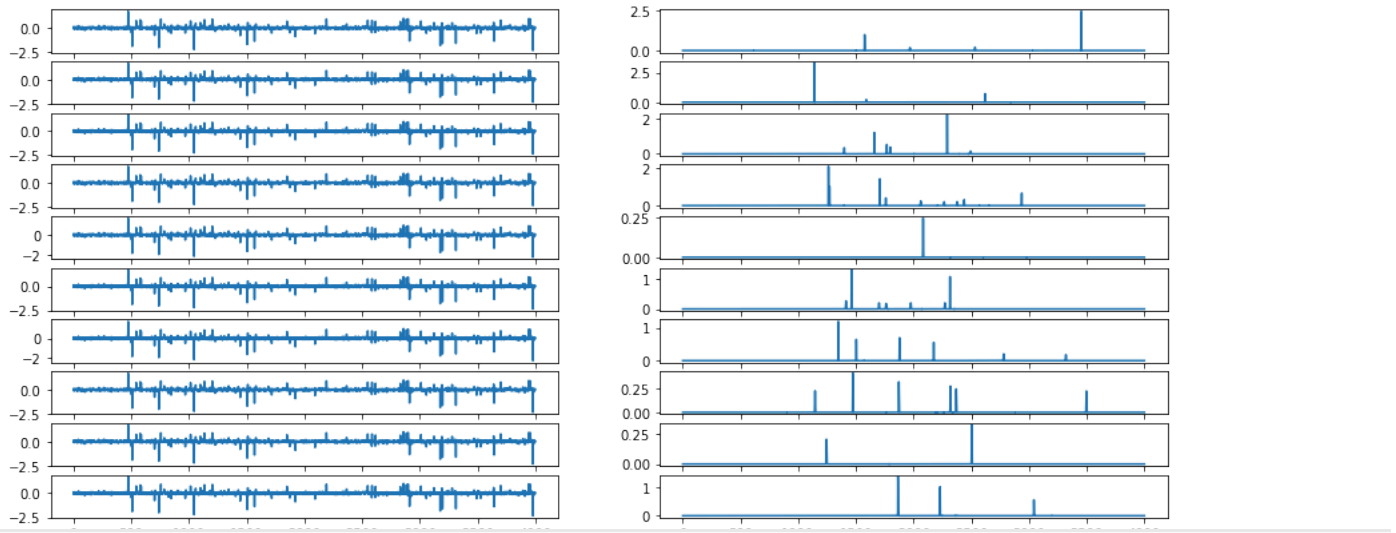







```
plot_results(model_m,DEVICE, 6)
```

```
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
Total correct 0 4000
```



Large dataset

```
EMBEDDING_DIM = 512
HIDDEN_DIM = 128

loss_model = Loss(0.00001)
model_l = SimpleRNN4(num_input_features=16000,
            embedding_dim=EMBEDDING_DIM,
            hidden_dim1=HIDDEN_DIM,
            hidden_dim2=512,
            num_output_features=4000)
model_l.to(DEVICE)
```

```
SimpleRNN4(
  (enco1): Linear(in_features=16000, out_features=512, bias=True)
  (rnn): LSTM(512, 128)
  (deco1): Linear(in_features=128, out_features=512, bias=True)
  (deco2): Linear(in_features=512, out_features=4000, bias=True)
)
```

```
print(get_params(model_l))
```

```
10639264
```

```
NUM_EPOCHS = 1


(cost_l,
 efficiency_train_l,
 efficiency_val_l,
 fp_rate_train_l,
 fp_rate_val_l) = train(model_l,
                        DEVICE=DEVICE,
                        loss_model=loss_model,
                        num_epochs=NUM_EPOCHS,
                        train_set_idx=train_set_idx_l,
                        val_set_idx=val_set_idx_db[:1],
                        learning_rate=0.000001,
                        seed=123,
                        batch_size=1000)
```

```
Start Time -  01/12/2022 14:42:35
Set index: 1, Set Id: 56
Epoch ID: 0   Set ID: 56  Batch ID: 1 | Loss: 6.95370
Epoch ID: 0   Set ID: 56  Batch ID: 2 | Loss: 6.95472
Epoch ID: 0   Set ID: 56  Batch ID: 3 | Loss: 6.95490
Epoch ID: 0   Set ID: 56  Batch ID: 4 | Loss: 6.95382
Epoch ID: 0   Set ID: 56  Batch ID: 5 | Loss: 6.95580
Set Time : 0.04509572188059489 minutes
Time till now : 0.045097068945566816 minutes
Set index: 2, Set Id: 28
Epoch ID: 0   Set ID: 28  Batch ID: 6 | Loss: 6.95525
Epoch ID: 0   Set ID: 28  Batch ID: 7 | Loss: 6.95292
Epoch ID: 0   Set ID: 28  Batch ID: 8 | Loss: 6.95469
Epoch ID: 0   Set ID: 28  Batch ID: 9 | Loss: 6.95522
Epoch ID: 0   Set ID: 28  Batch ID: 10 | Loss: 6.95455
Set Time : 0.059081315994262695 minutes
Time till now : 0.10419180393218994 minutes
Set index: 3, Set Id: 50
Epoch ID: 0   Set ID: 50  Batch ID: 11 | Loss: 6.95528
Epoch ID: 0   Set ID: 50  Batch ID: 12 | Loss: 6.95443
Epoch ID: 0   Set ID: 50  Batch ID: 13 | Loss: 6.95444
Epoch ID: 0   Set ID: 50  Batch ID: 14 | Loss: 6.95428
Epoch ID: 0   Set ID: 50  Batch ID: 15 | Loss: 6.95397
Set Time : 0.041890966892242434 minutes
Time till now : 0.14608410199483235 minutes
Set index: 4, Set Id: 38
Epoch ID: 0   Set ID: 38  Batch ID: 16 | Loss: 6.95267
Epoch ID: 0   Set ID: 38  Batch ID: 17 | Loss: 6.95455
Epoch ID: 0   Set ID: 38  Batch ID: 18 | Loss: 6.95392
Epoch ID: 0   Set ID: 38  Batch ID: 19 | Loss: 6.95376
Epoch ID: 0   Set ID: 38  Batch ID: 20 | Loss: 6.95260
Set Time : 0.05736340284347534 minutes
Time till now : 0.20344926516215006 minutes
Set index: 5, Set Id: 49
Epoch ID: 0   Set ID: 49  Batch ID: 21 | Loss: 6.95397
Epoch ID: 0   Set ID: 49  Batch ID: 22 | Loss: 6.95377
Epoch ID: 0   Set ID: 49  Batch ID: 23 | Loss: 6.95521
Epoch ID: 0   Set ID: 49  Batch ID: 24 | Loss: 6.95335
Epoch ID: 0   Set ID: 49  Batch ID: 25 | Loss: 6.95416
Set Time : 0.039481496810913085 minutes
Time till now : 0.24294437170028688 minutes
Set index: 6, Set Id: 79
Epoch ID: 0   Set ID: 79  Batch ID: 26 | Loss: 6.95529
Epoch ID: 0   Set ID: 79  Batch ID: 27 | Loss: 6.95688
Epoch ID: 0   Set ID: 79  Batch ID: 28 | Loss: 6.95472
Epoch ID: 0   Set ID: 79  Batch ID: 29 | Loss: 6.95370
Epoch ID: 0   Set ID: 79  Batch ID: 30 | Loss: 6.95526
Set Time : 0.04029147624969483 minutes
Time till now : 0.28325215975443524 minutes
Set index: 7, Set Id: 12
Epoch ID: 0   Set ID: 12  Batch ID: 31 | Loss: 6.95448
Epoch ID: 0   Set ID: 12  Batch ID: 32 | Loss: 6.95371
Epoch ID: 0   Set ID: 12  Batch ID: 33 | Loss: 6.95505
Epoch ID: 0   Set ID: 12  Batch ID: 34 | Loss: 6.95463
Epoch ID: 0   Set ID: 12  Batch ID: 35 | Loss: 6.95533
Set Time : 0.04120314915974935 minutes
Time till now : 0.3244566241900126 minutes
Set index: 8, Set Id: 8
```

```
loss_val, eff_rate, fp_rate = validate(model_l, DEVICE, loss_model, val_set_idx_l)
print('Loss: %0.3f ' % loss_val, end="")
print('  Efficiency: %0.3f' % eff_rate, end="")
print('  False positive rate: %0.3f' % fp_rate)
```

```
Validating
22
34
73
20
16
44
17
13
75
35
23
39
47
15
42
67
69
43
```

```
        68
        5
        Loss: 6.954   Efficiency: 0.083  False positive rate: 29.514

plot_training_graphs(
    NUM_EPOCHS,
```