Нейроинформатика. Лабораторная работа №5

Сети с обратными связями

Целью работы является исследование свойств сети Элмана, алогритмов обучения, а также применения сетей в задачах распознавания статических и динамических образов.

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In [1]:
```
import matplotlib.pyplot as plt
import numpy as np
import torch
from torch import nn
from torch.utils.data import DataLoader
import tqdm
```

2 класса сигналов

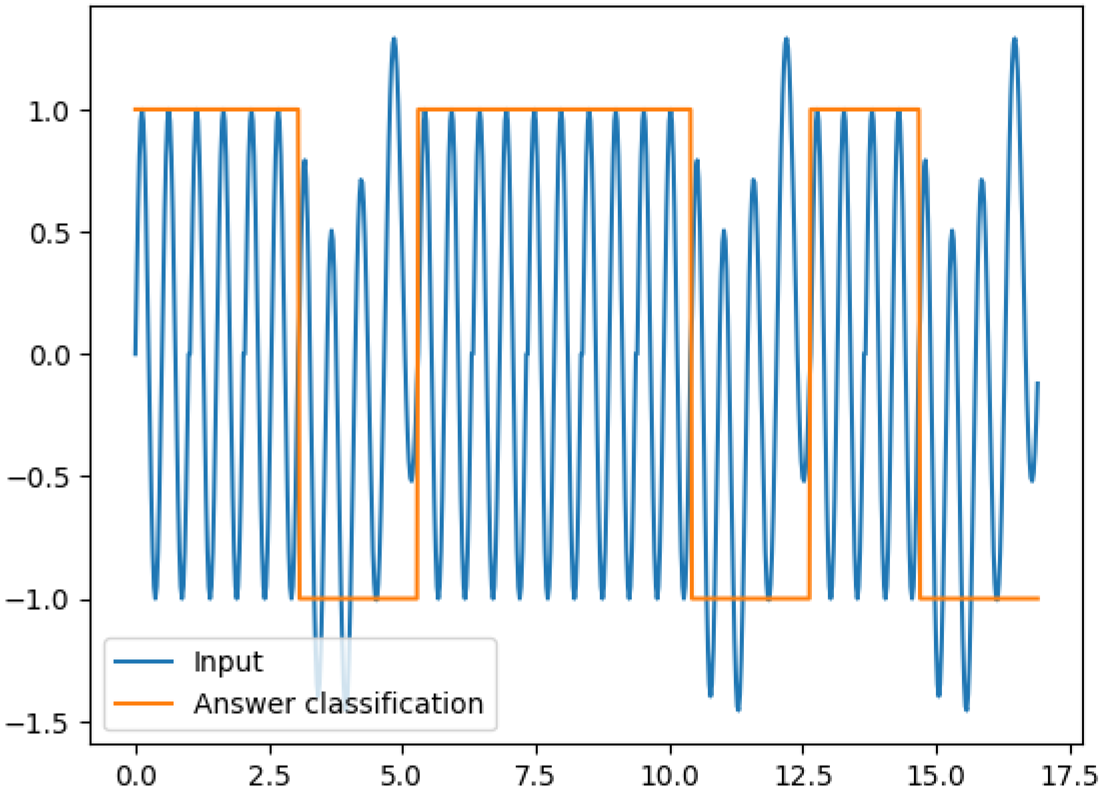
In [2]:
```
def f1(k: float):
    return np.sin(4*np.pi*k)

def f2(k: float):
    return np.sin(k**2 - 15*k + 3) - np.sin(k)**2 + 0.5
```

Входная функция и ее класстфикация

In [3]:
```
h = 0.025
k1 = np.arange(0, 1+h,h)
k2 = np.arange(0.9, 3.1+h,h)
p1 = f1(k1)
p2 = f2(k2)
r = [3,5,2]
p = np.concatenate((np.tile(p1,r[0]),
                    p2,
                    np.tile(p1,r[1]),
                    p2,
                    np.tile(p1,r[2]),
                    p2))
t = np.concatenate((np.ones(len(p1)*r[0]),
                    -1*np.ones(len(p2)),
                    np.ones(len(p1)*r[1]),
                    -1*np.ones(len(p2)),
                    np.ones(len(p1)*r[2]),
                    -1*np.ones(len(p2))))
x = np.arange(len(p))*h
```

In [4]:
```
plt.plot(x, p, label='Input')
plt.plot(x, t, label='Answer classification')
plt.legend()
```

Out[4]:
```
<matplotlib.legend.Legend at 0x7f87e3c5e190>
```



Создаем датасет

In [5]:

```python
w = 5
X = [p[i:i+w].astype('float32') for i in range(0, len(p) - w)]
y = [t[i:i+w].astype('float32') for i in range(0, len(p) - w)]
data = [(x,y) for x, y in zip(X,y)]
train_dataloader = DataLoader(data, batch_size=1, shuffle=False)
```

Класс слоя Элмана

In [6]:

```python
class ElmanLayer(nn.Module):
    def __init__(self, size_in, size_out):
        super().__init__()
        w1 = torch.randn(size_in, size_out)
        w2 = torch.randn(size_out, size_out)
        b = torch.randn(size_out)
        self.w1 = nn.Parameter(w1)
        self.w2 = nn.Parameter(w2)
        self.b = nn.Parameter(b)

    def forward(self, x):
        out = torch.matmul(x, self.w1)
        out = torch.add(out, self.b)
        if hasattr(self, "prev"):
            d = torch.matmul(self.prev, self.w2)
            out = torch.add(out, d)
        out = torch.tanh(out)
        self.prev = torch.tensor(out)
        return out

    def del_prev(self):
        if hasattr(self, "prev"):
            delattr(self, "prev")
```

Модель

In [14]:

```
vectoriz = 8
elman = ElmanLayer(w,vectoriz)
linear = nn.Linear(vectoriz, w)
model = nn.Sequential(elman,linear)
```

Тренеруем модель

In [15]:

```
optimizer = torch.optim.Adam(model.parameters(), lr=1e-3)
loss_fn = nn.MSELoss()

epoch = 300
model.train()

loses = []
for ep in tqdm.tqdm(range(epoch)):
    model[0].del_prev()
    epoch_loss = []
    for (inp, out) in train_dataloader:
        pred = model(inp)

        loss = loss_fn(pred, out)
        loss = torch.sqrt_(loss)
        epoch_loss.append(loss.item())
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()
    loses.append(np.mean(epoch_loss))
```

```
  0%|          | 0/300 [00:00<?, ?it/s]/tmp/ipykernel_684/370478990.py:18: UserWarning:
To copy construct from a tensor, it is recommended to use sourceTensor.clone().detach()
or sourceTensor.clone().detach().requires_grad_(True), rather than torch.tensor(sourceTe
nsor).
  self.prev = torch.tensor(out)
100%|██████████| 300/300 [01:43<00:00,  2.89it/s]
```

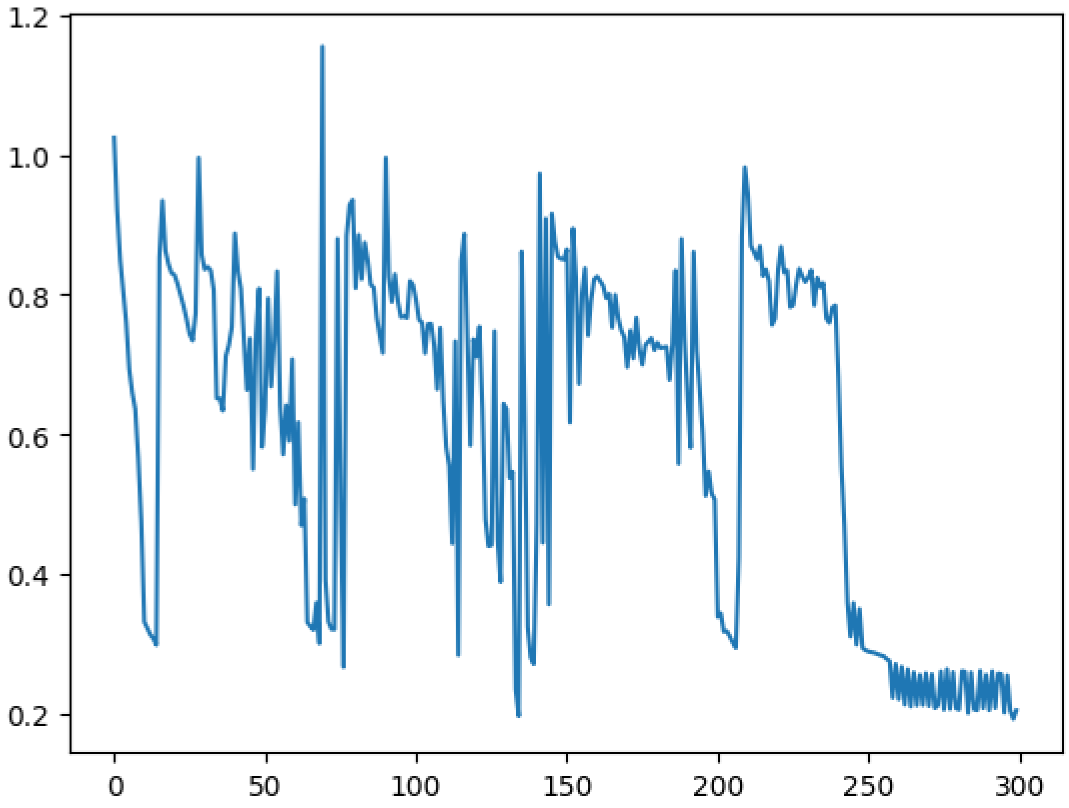
График ошибки

In [16]:

```
plt.plot(np.arange(epoch), loses)
```

Out[16]:

```
[<matplotlib.lines.Line2D at 0x7f87d371c880>]
```



Делаем предсказание

In [17]:

```
model.eval()
model[0].del_prev()
pred = []
for (inp, out) in tqdm.tqdm(train_dataloader):
    pred.append(model(inp).detach().numpy())
```

```
  0%|          | 0/672 [00:00<?, ?it/s]/tmp/ipykernel_684/370478990.py:18: UserWarning:
To copy construct from a tensor, it is recommended to use sourceTensor.clone().detach()
or sourceTensor.clone().detach().requires_grad_(True), rather than torch.tensor(sourceTe
nsor).
  self.prev = torch.tensor(out)
100%|██████████| 672/672 [00:00<00:00, 8307.68it/s]
```

Обрабатываем предсказание

In [18]:

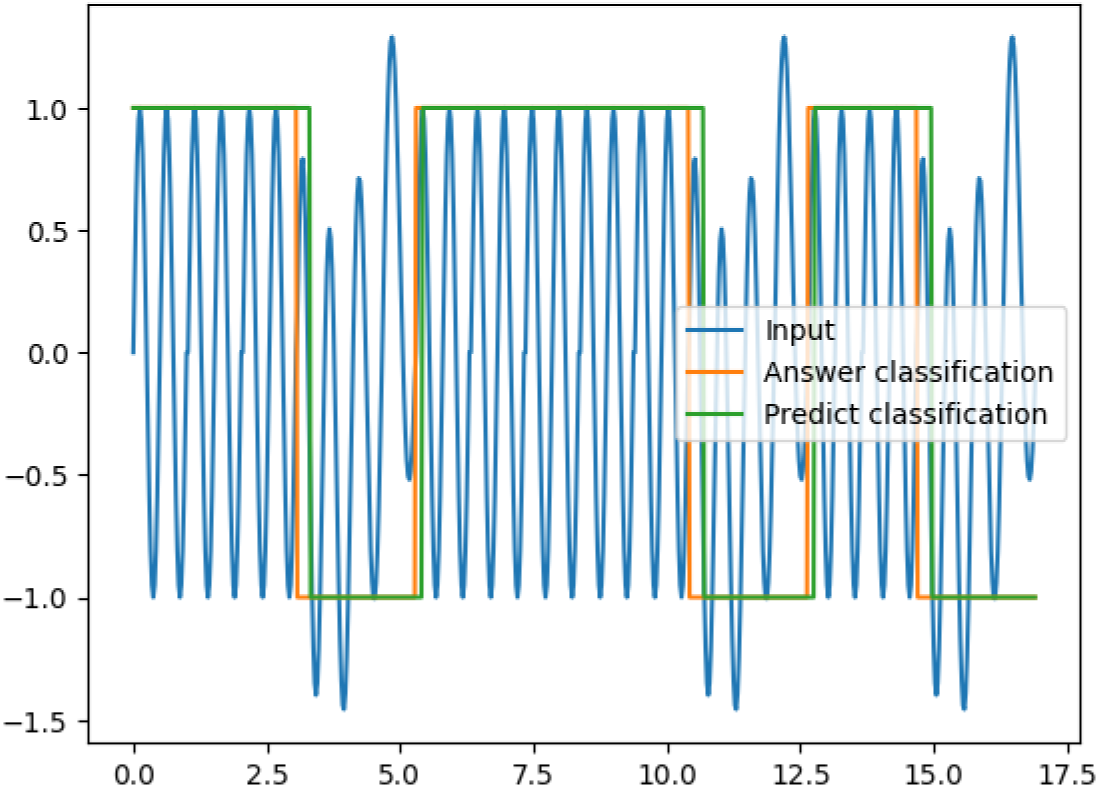
```
sum_ped = [0]*len(p)
for i, window in enumerate(pred):
    for j, item in enumerate(window[0]):
        sum_ped[i+j] = item

ans = [1 if elem > 0 else -1 for elem in sum_ped]
```

In [19]:

```
plt.plot(x, p, label='Input')
plt.plot(x, t, label='Answer classification')
plt.plot(x, ans, label='Predict classification')
plt.legend()
```

Out[19]:

```
<matplotlib.legend.Legend at 0x7f87d36e45b0>
```


1.0
0.5
0.0
−0.5
−1.0
−1.5
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Input
Answer classification
Predict classification