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Факультет прикладной математики и физики
Кафедра вычислительной математики и программирования

Лабораторная работа № 5

по курсу «Нейроинформатика»

Тема: Сети с обратными связями.

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Постановка задачи

Исследование сетей Хопфилда, Хемминга и Элмана, алгоритмов обучения, а также применение сетей в задачах распознавания статических и динамических образов.

1. Использовать сеть Элмана для распознава ния динамических образов.
2. Использовать сеть Хопфилда для распознавания динамических образов.
3. Использовать сеть Хемминга для распознавания динамических образов.

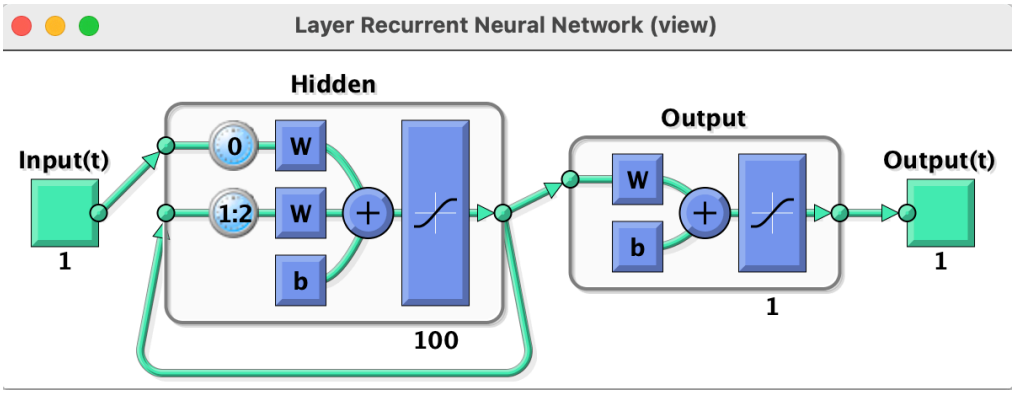
Вариант 6:

6.	$g(k) = \sin(k^2 - 5k + 6), \quad k \in [0.67, 4.98]$	$[2, 6, 5]$
6.	$[9, 2, 3]$	

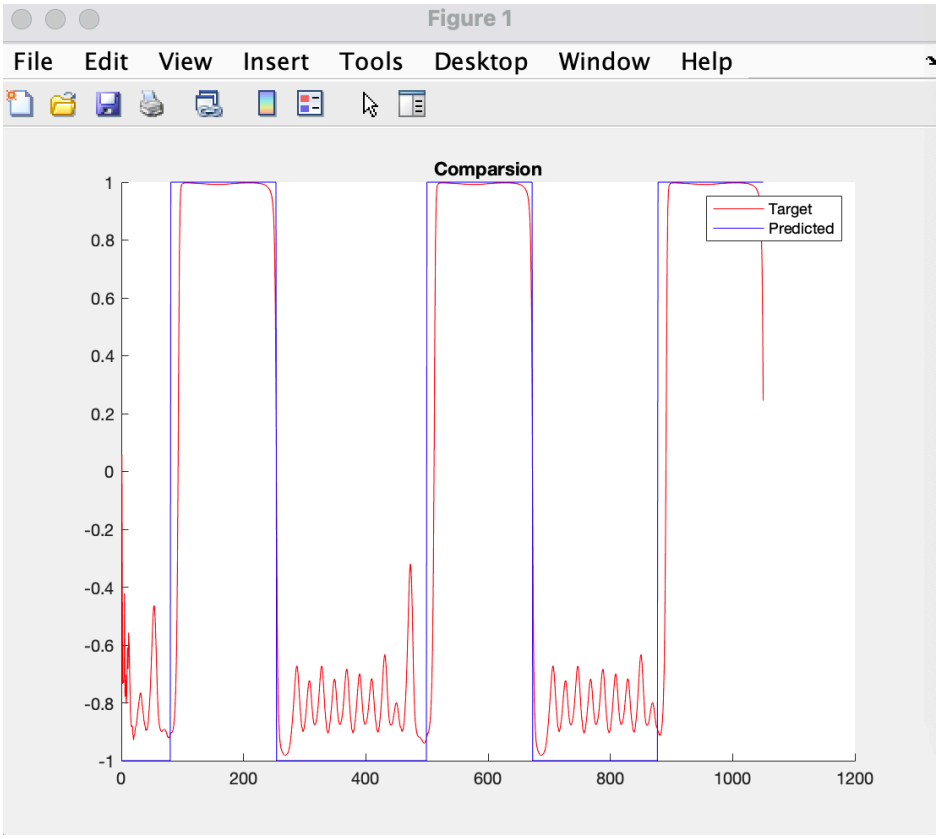
Ход работы

1.

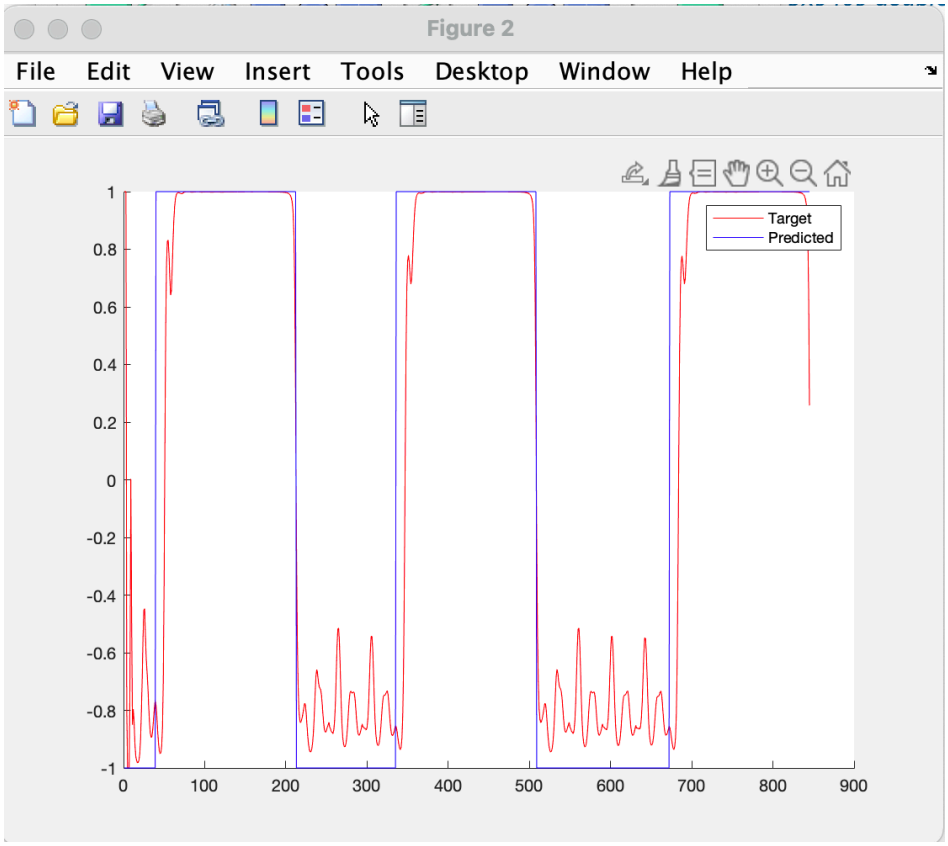
Структура сети



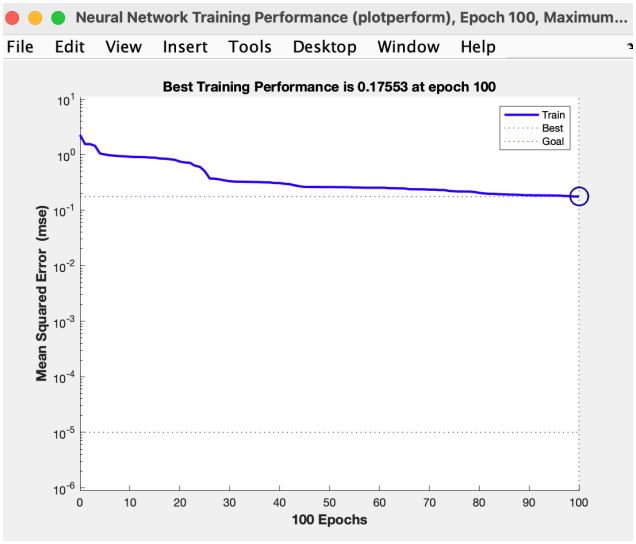
Результат работы сети для исходных сигналов

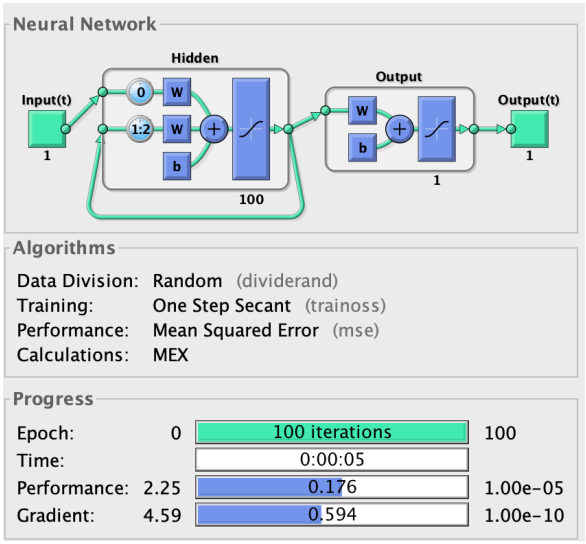


Результат рабы сети для иного набора сигналов (2, 6, 5)

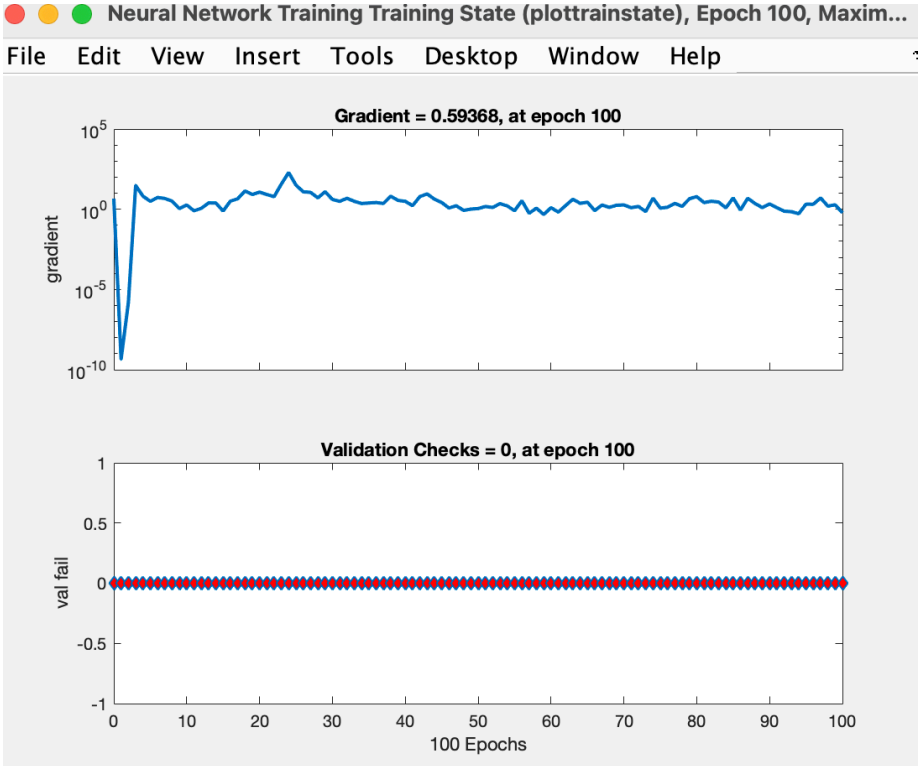


Performance





Training state



Train size: 1049

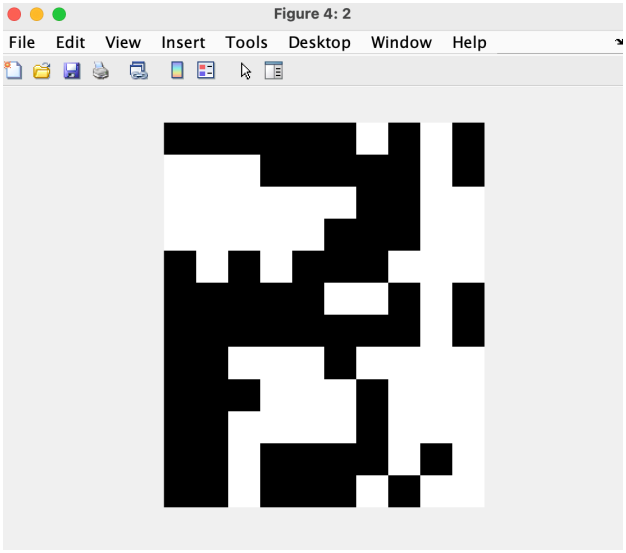
Match: 1012

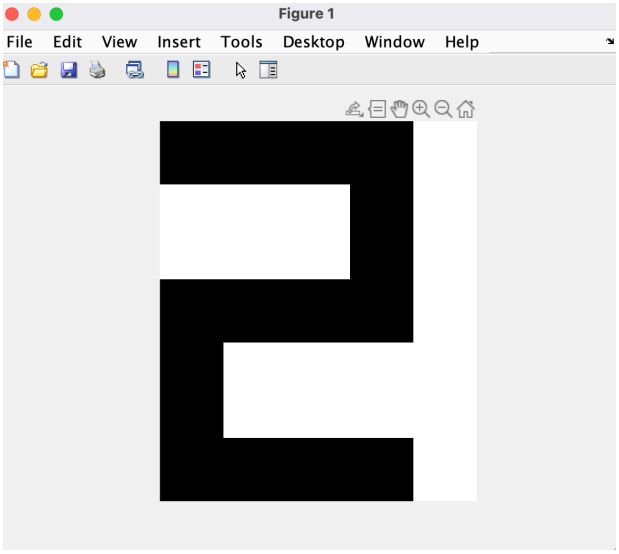
Train size: 844

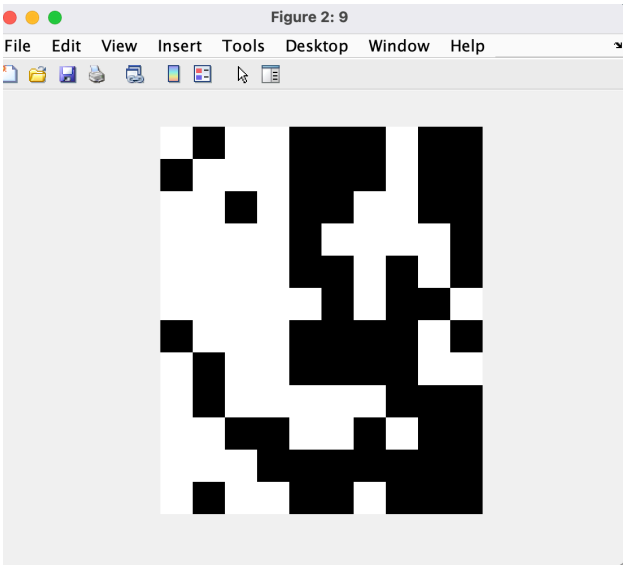
Match: 808

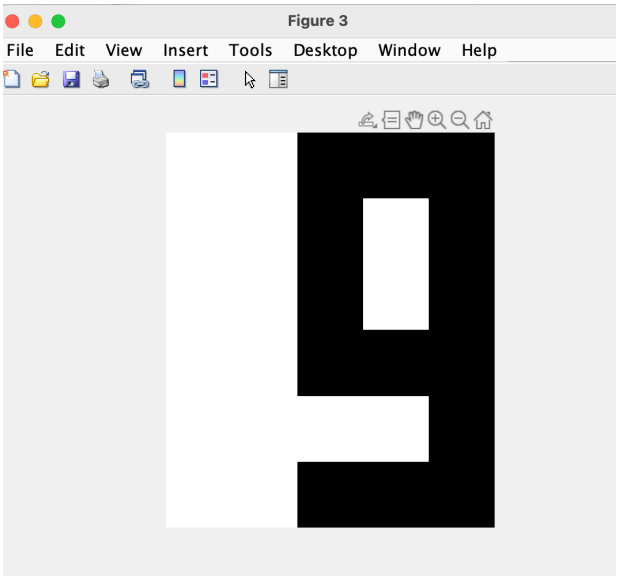
2.

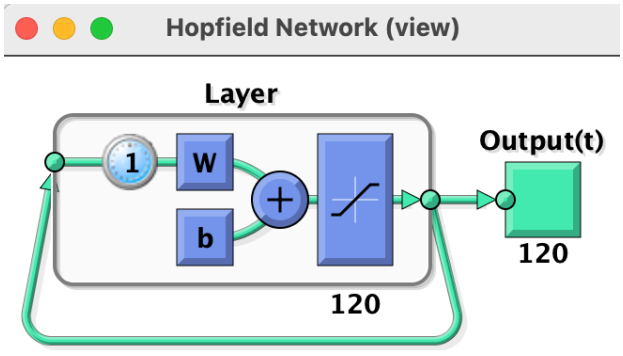
Распознавание образов сетью Хопфилда





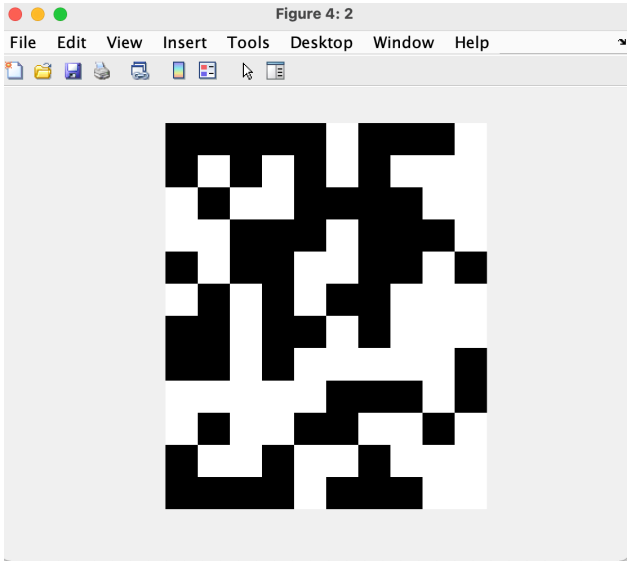


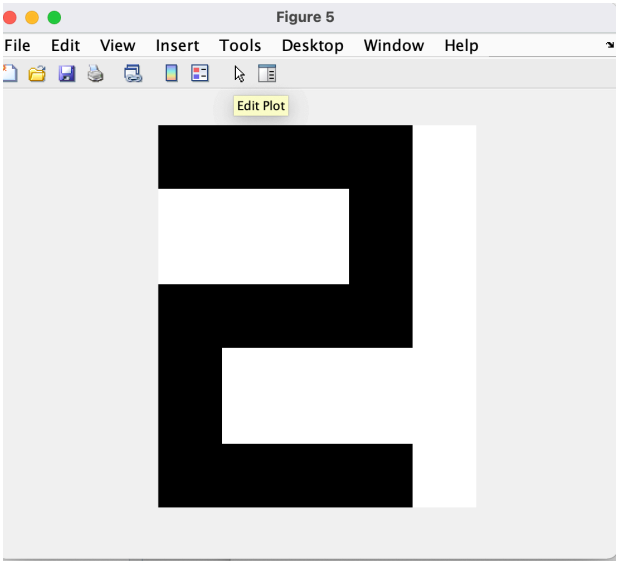


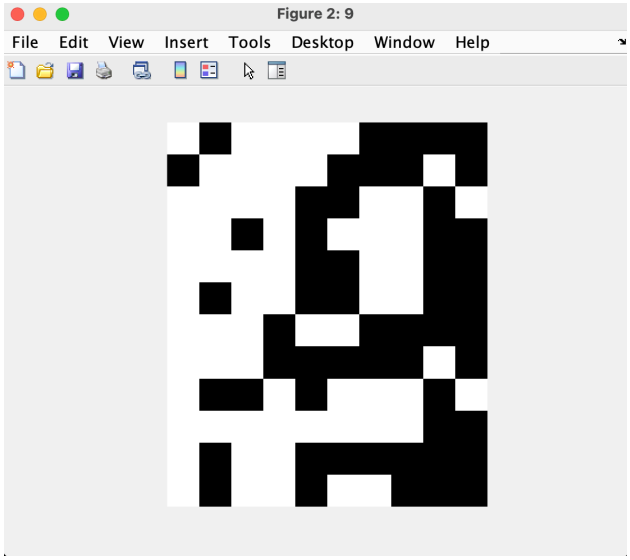


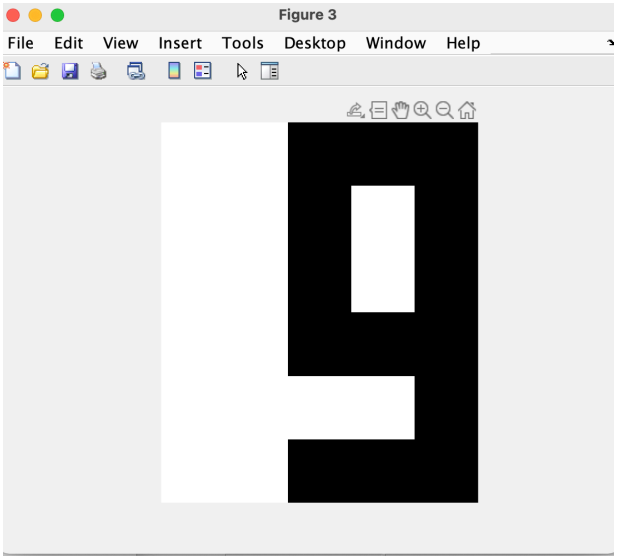
3.

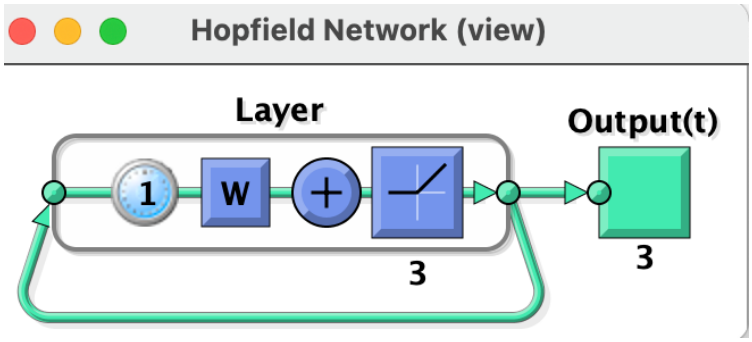
Распознавание образов сетью Хемминга











```
% 1.1
% Основной сигнал
k1 = 0:0.025:1;
p1 = sin(4 * pi * k1);

% Целевой выход основного сигнала
t1 = -ones(size(p1));

% Сигнал для распознавания
k2 = 0.67:0.025:4.98;
p2 = sin(k2.^2 - 5 * k2 + 6);
% Целевой выход
t2 = ones(size(p2));

% Длительность основного сигнала
R = {2; 6; 5};

% Входное множество
P = [repmat(p1, 1, R{1}), p2, repmat(p1, 1, R{2}), p2, repmat(p1, 1, R{3}), p2];
T = [repmat(t1, 1, R{1}), t2, repmat(t1, 1, R{2}), t2, repmat(t1, 1, R{3}), t2];
P = con2seq(P);
T = con2seq(T);

% Инициализация сети
net = layrecnet(1 : 2, 100, 'trainoss');
net.layers{1}.transferFcn = 'tansig';
net.layers{2}.transferFcn = 'tansig';
net = configure(net, P, T);

% 1.3
[p, Xi, Ai, t] = preparets(net, P, T);

% 1.4
net.trainParam.epochs = 100;
net.trainParam.goal = 1.0e-5;

% 1.5
% Обучение и вывод
net = train(net, p, t, Xi, Ai);
Y = sim(net, p, Xi, Ai);
view(net);
```

```
%1.7
figure;
hold on;

rLine = plot(cell2mat(Y), 'r');
pLine = plot(cell2mat(t), 'b');
legend([rLine,pLine],'Target', 'Predicted');
title("Comparsion");

% 1.8
tc = zeros(0, length(Y));
for i=1:length(Y)
    if Y{i} >= 0
        tc(i) = 1;
    else
        tc(i) = -1;
    end
end

fprintf('Train size: %d\n',length(T)-3);
T = [repmat(t1, 1, R{1}), t2, repmat(t1, 1, R{2}), t2, repmat(t1, 1, R{3}), t2];
fprintf('Match: %d\n',nnz(tc == T(3 : end)));

% 1.9
R = {1;3;4};
P = [repmat(p1, 1, R{1}), p2, repmat(p1, 1, R{2}), p2, repmat(p1, 1, R{3}), p2];
T = [repmat(t1, 1, R{1}), t2, repmat(t1, 1, R{2}), t2, repmat(t1, 1, R{3}), t2];
P = con2seq(P);
T = con2seq(T);

% Инициализация сети
net = layrecnet(1 : 2, 100, 'trainoss');
net.layers{1}.transferFcn = 'tansig';
net.layers{2}.transferFcn = 'tansig';
net = configure(net, P, T);

[p, Xi, Ai, t] = preparets(net, P, T);

net.trainParam.epochs = 100;
net.trainParam.goal = 1.0e-5;

%1.10
net = train(net, p, t, Xi, Ai);
Y = sim(net, p, Xi, Ai);

figure;
hold on;


rLine = plot(cell2mat(Y), 'r');
pLine = plot(cell2mat(t), 'b');
legend([rLine,pLine],'Target', 'Predicted');

%1.11
tc = zeros(0, length(Y));
for i=1:length(Y)
    if Y{i} >= 0
        tc(i) = 1;
    else
        tc(i) = -1;
    end
end


fprintf('Train size: %d\n',length(T)-3);
T = [repmat(t1, 1, R{1}), t2, repmat(t1, 1, R{2}), t2, repmat(t1, 1, R{3}), t2];
fprintf('Match: %d\n',nnz(tc == T(3 : end)));
```

```
% [9, 2, 3]
number9 = [-1 -1 -1 -1 +1 +1 +1 +1 +1 +1;
           -1 -1 -1 -1 +1 +1 +1 +1 +1 +1;
           -1 -1 -1 -1 +1 +1 -1 -1 +1 +1;
           -1 -1 -1 -1 +1 +1 -1 -1 +1 +1;
           -1 -1 -1 -1 +1 +1 -1 -1 +1 +1;
           -1 -1 -1 -1 +1 +1 -1 -1 +1 +1;
           -1 -1 -1 -1 +1 +1 +1 +1 +1 +1;
           -1 -1 -1 -1 +1 +1 +1 +1 +1 +1;
           -1 -1 -1 -1 -1 -1 -1 -1 +1 +1;
           -1 -1 -1 -1 -1 -1 -1 -1 +1 +1;
           -1 -1 -1 -1 +1 +1 +1 +1 +1 +1;
           -1 -1 -1 -1 +1 +1 +1 +1 +1 +1];

number2 = [+1 +1 +1 +1 +1 +1 +1 +1 -1 -1;
           +1 +1 +1 +1 +1 +1 +1 +1 -1 -1;
           -1 -1 -1 -1 -1 -1 +1 +1 -1 -1;
           -1 -1 -1 -1 -1 -1 +1 +1 -1 -1;
           -1 -1 -1 -1 -1 -1 +1 +1 -1 -1;
           +1 +1 +1 +1 +1 +1 +1 +1 -1 -1;
           +1 +1 +1 +1 +1 +1 +1 +1 -1 -1;
           +1 +1 -1 -1 -1 -1 -1 -1 -1 -1;
           +1 +1 -1 -1 -1 -1 -1 -1 -1 -1;
           +1 +1 -1 -1 -1 -1 -1 -1 -1 -1;
           +1 +1 +1 +1 +1 +1 +1 +1 -1 -1;
           +1 +1 +1 +1 +1 +1 +1 +1 -1 -1];

number3 = [-1 -1 +1 +1 +1 +1 +1 +1 -1 -1;
           -1 -1 +1 +1 +1 +1 +1 +1 +1 -1;
           -1 -1 -1 -1 -1 -1 -1 +1 +1 -1;
           -1 -1 -1 -1 -1 -1 -1 +1 +1 -1;
           -1 -1 -1 -1 -1 -1 -1 +1 +1 -1;
           -1 -1 -1 -1 +1 +1 +1 +1 -1 -1;
           -1 -1 -1 -1 +1 +1 +1 +1 -1 -1;
           -1 -1 -1 -1 -1 -1 -1 +1 +1 -1;
           -1 -1 -1 -1 -1 -1 -1 +1 +1 -1;
           -1 -1 -1 -1 -1 -1 -1 +1 +1 -1;
           -1 -1 -1 +1 +1 +1 +1 +1 +1 -1;
           -1 -1 -1 +1 +1 +1 +1 +1 -1 -1];

% 2.1
% Инициализация сети
P = [number9(:), number2(:), number3(:)];
net = newhop(P);
view(net);

% 2.2
% Расчет выхода и подача исходного образа
iterations = 600;
R = sim(net, {1 iterations}, {}, number2(:));
R = reshape(R{iterations}, 12, 10);
R(R >=0 ) = 2;
R(R < 0 ) = 1;

map = [1, 1, 1; 0, 0, 0];
image(R);
colormap(map)
axis off
axis image

% 2.3
% Зашумление 20%
r = rand([12, 10]);
M = 0.2;
in = number9;
for i=1:12
    for j = 1:10
        if r(i,j) < M
            in(i,j) = -in(i,j);
        end
    end
end

% Вывод образа
R = reshape(in, 12, 10);
R(R >= 0) = 2;
R(R < 0) = 1;
map = [1, 1, 1; 0, 0, 0];
figure('Name', '9');
image(R);
colormap(map)
axis off
axis image
```

```
% Распознавание
iterations = 600;
R = sim(net, {1 iterations},  {}, in(:));
R = reshape(R{iterations}, 12, 10);
R(R >=0 ) = 2;
R(R < 0 ) = 1;
map = [1, 1, 1; 0, 0, 0];
figure;
image(R);
colormap(map)
axis off
axis image

% 2.4
% Зашумление 30%
r = rand([12, 10]);
M = 0.3;
in = number2;
for i=1:12
    for j = 1:10
        if r(i,j) < M
            in(i,j) = -in(i,j);
        end
    end
end

% Вывод образа
R = reshape(in, 12, 10);
R(R >= 0) = 2;
R(R < 0) = 1;
map = [1, 1, 1; 0, 0, 0];
figure('Name', '2');
image(R);
colormap(map)
axis off
axis image


% Распознавание
iterations = 600;
R = sim(net, {1 iterations},  {}, in(:));
R = reshape(R{iterations}, 12, 10);
R(R >=0 ) = 2;
R(R < 0 ) = 1;
map = [1, 1, 1; 0, 0, 0];
figure;
image(R);
colormap(map)
axis off
axis image
```

```
P = [number9(:), number2(:), number3(:)];

% 3.1
% Реализация работы первого слоя
Q = 3;

eps = 1 / (Q - 1);

% Задаем размерность
R = 10 * 12;

IW = [number9(:)'; number2(:)'; number3(:)'];
b = ones(Q, 1) * R;

a = zeros(Q, Q);
for i = 1:Q
    a(:,i) = IW * P(:, i) + b;
end

% 3.3
% Реализация работы первого слоя

net = newhop(a);
net.biasConnect(1) = 0;
net.layers{1}.transferFcn = 'poslin';

net.LW{1, 1} = eye(Q, Q) * (1 + eps) - ones(Q, Q) * eps;
view(net);

%3.4 Расчет выхода и подача исходного образа
iterations = 600;
in = number2(:);
A = IW * in + b;
R = sim(net, {1 iterations}, {}, A);
A = R{iterations};

index = A == max(A);
A = IW(index, :)';

 R = reshape(A, 12, 10);
 R(R >= 0) = 2;
 R(R < 0) = 1;
 map = [1, 1, 1; 0, 0, 0];
 image(R);
 colormap(map)
 axis off
 axis image

 % 3.5
 % Зашумление 20%
 iterations = 600;
 r = rand([12, 10]);
 M = 0.2;
 in = number9;

 for i = 1:12
     for j = 1:10
         if r(i, j) < M
             in(i, j) = -in(i, j);
         end
     end
 end

 % Отображение
 in = in(:);
 R = reshape(in, 12, 10);
 R(R >=0) = 2;
 R(R < 0) = 1;
 map = [1, 1, 1; 0, 0, 0];
 figure('Name', '9');
 image(R);
 colormap(map)
 axis off
 axis image

 % Распознавание
 A = IW * in + b;
 R = sim(net, {1 iterations}, {}, A);
 A = R{iterations};
 index = A == max(A);
 A = IW(index, :)';
```

```
R = reshape(A, 12, 10);
R(R >=0) = 2;
R(R < 0) = 1;
map = [1, 1, 1; 0, 0, 0];
figure
image(R);
colormap(map)
axis off
axis image

% 3.6
% Зашумление 30%
iterations = 600;
r = rand([12, 10]);
M = 0.3;
in = number2;

%гЮЬСЛКЕМХЕ
for i = 1:12
    for j = 1:10
        if r(i, j) < M
            in(i, j) = -in(i, j);
        end
    end
end

% Отображение
in = in(:);
R = reshape(in, 12, 10);
R(R >=0) = 2;
R(R < 0) = 1;
map = [1, 1, 1; 0, 0, 0];
figure('Name', '2');
image(R);
colormap(map)
axis off
axis image

% Распознавание
A = IW * in + b;
R = sim(net, {1 iterations}, {}, A);
A = R{iterations};
index = find(A == max(A));
A = IW(index, :)';

R = reshape(A, 12, 10);
R(R >=0) = 2;
R(R < 0) = 1;
map = [1, 1, 1; 0, 0, 0];
figure
image(R);
colormap(map)
axis off
axis image
```