

function cool- displays letters A,B,C,D,E,J,K in 3 different fonts

```
a=[0 0 1 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 1 0 1 0 0; 0 0 1 0 1 0 0; 0 1 1 1 1 1 0; 0  
1 0 0 0 1 0; 0 1 0 0 0 1 0; 1 1 1 0 1 1 1];
```

```
for i=1:9  
    for j=1:7;  
        if a(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot (3 , 7 , 1); plot(x,y,'k.');        end  
    end  
end  
end
```

```
a2=[0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 1 0 1 0 0; 0 0 1 0 1 0 0; 0 1 0 0 0 1 0;  
0 1 1 1 1 1 0; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0];
```

```
for i=1:9  
    for j=1:7;  
        if a2(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,8); plot(x,y,'k.');        end  
    end  
end  
end
```

```
a3=[0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 1 0 1 0 0; 0 0 1 0 1 0 0; 0 1 0 0 0 1 0; 0 1 1 1 1 1 0; 1  
0 0 0 0 0 1; 1 0 0 0 0 0 1; 1 1 0 0 0 1 1];
```

```
for i=1:9  
    for j= 1:7;  
        if a3(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3 , 7 , 15); plot(x,y,'k.');        end  
    end  
end  
end
```

```
b1=[1 1 1 1 1 1 0; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 1 1 1 1 0; 0 1 0 0 0 0 1; 0 1  
0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 1 0];
```

```
for i=1:9  
    for j= 1:7;  
        if b1(i,j)==1
```

```

        x=j;
        y=-i;
        hold on;
        subplot(3 , 7, 2), plot(x,y,'k.');
```

end

```
end
end
```

```

b2=[1 1 1 1 1 1 0;1 0 0 0 0 0 1;1 0 0 0 0 0 1;1 0 0 0 0 0 1;1 1 1 1 1 1 0;1 0 0 0 0 0 1;1
0 0 0 0 0 1;1 0 0 0 0 0 1;1 1 1 1 1 1 0];
for i= 1:9
    for j=1:7;
        if b2(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,9),plot(x,y,'k.');
```

end

```
end
end
```

```

b3=[1 1 1 1 1 1 0;0 1 0 0 0 0 1;0 1 0 0 0 0 1;0 1 1 1 1 1 0;0 1 0 0 0 0 1;0 1 0 0 0 0 1;0 1
0 0 0 0 1;0 1 0 0 0 0 1;1 1 1 1 1 1 0];
for i=1:9
    for j=1:7;
        if b3(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,16), plot(x,y,'k.');
```

end

```
end
end
```

```

c1=[0 0 1 1 1 1 1 ;0 1 0 0 0 0 1;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0
;1 0 0 0 0 0 0;0 1 0 0 0 0 1;0 0 1 1 1 1 0];
for i=1:9
    for j=1:7;
        if c1(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,3), plot(x,y,'k.');
```

end

```
end
end
```

```
c2=[0 0 1 1 1 0 0 ;0 1 0 0 0 1 0; 1 0 0 0 0 0 1; 1 0 0 0 0 0 0;1 0 0 0 0 0 0;1 0 0 0 0 0 0 ; 1  
0 0 0 0 0 1 ; 0 1 0 0 0 1 0; 0 0 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if c2(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,10), plot(x,y,'k.');        end  
    end  
end  
end
```

```
c3=[0 0 1 1 1 0 1; 0 1 0 0 0 1 1; 1 0 0 0 0 0 1;1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0;1 0 0 0 0 0 0; 1  
0 0 0 0 0 1; 0 1 0 0 0 1 0; 0 0 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if c3(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,17), plot(x,y,'k.');        end  
    end  
end  
end
```

```
d1=[1 1 1 1 1 0 0 ; 0 1 0 0 0 1 0; 0 1 0 0 0 0 1;0 1 0 0 0 0 1;0 1 0 0 0 0 1;0 1 0 0 0 0 1; 0 1  
0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if d1(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,4), plot(x,y,'k.');        end  
    end  
end  
end
```

```
d2=[1 1 1 1 1 0 0;1 0 0 0 0 1 0; 1 0 0 0 0 0 1; 1 0 0 0 0 0 1; 1 0 0 0 0 0 1; 1 0 0 0 0 0 1; 1  
0 0 0 0 0 1;1 0 0 0 0 1 0; 1 1 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if d2(i,j)==1  
            x=j;
```

```

        y=-i;
        hold on;
        subplot(3,7,11), plot(x,y,'k.');
```

end

```
end
end
```

```

d3=[1 1 1 1 1 0 0; 0 1 0 0 0 1 0; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0
1 0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 1 0 0];
for i=1:9
    for j=1:7;
        if d3(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,18), plot(x,y,'k.');
```

end

```
end
end
```

```

e1=[1 1 1 1 1 1 1 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 0; 0 1 0 1 0 0 0; 0 1 1 1 0 0 0; 0 1 0 1 0 0 0; 0
1 0 0 0 0 0; 0 1 0 0 0 0 1; 1 1 1 1 1 1 1 1];
for i=1:9
    for j=1:7;
        if e1(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,5), plot(x,y,'k.');
```

end

```
end
end
```

```

e2=[1 1 1 1 1 1 1 1; 1 0 0 0 0 0 0; 1 0 0 0 0 0 0; 1 0 0 0 0 0 0; 1 1 1 1 1 0 0; 1 0 0 0 0 0 0; 1 0
0 0 0 0 0; 1 0 0 0 0 0 0; 1 1 1 1 1 1 1 1];
for i=1:9
    for j=1:7;
        if e2(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,12), plot(x,y,'k.');
```

end

```
end
end
```

```
e3=[1 1 1 1 1 1 1;0 1 0 0 0 0 1;0 1 0 0 1 0 0;0 1 1 1 1 0 0;0 1 0 0 1 0 0;0 1 0 0 0 0 0;0 1  
0 0 0 0 0;0 1 0 0 0 0 1;1 1 1 1 1 1 1];
```

```
for i=1:9  
    for j=1:7;  
        if e3(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,19), plot(x,y,'k.');        end  
    end  
end  
end
```

```
j1=[0 0 0 1 1 1 1;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 1  
0 0 0 1 0;0 1 0 0 0 1 0;0 0 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if j1(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,6), plot(x,y,'k.');        end  
    end  
end  
end
```

```
j2=[0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0  
1 0 0 0 1 0;0 1 0 0 0 1 0;0 0 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if j2(i,j)==1  
            x=j;  
            y=-i;  
            hold on;  
            subplot(3,7,13), plot(x,y,'k.');        end  
    end  
end  
end
```

```
j3=[0 0 0 0 1 1 1;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0 0 0 0 0 1 0;0  
0 0 0 0 1 0;0 1 0 0 0 1 0;0 0 1 1 1 0 0];
```

```
for i=1:9  
    for j=1:7;  
        if j3(i,j)==1  
            x=j;  
            y=-i;
```

```

        hold on;
        subplot(3,7,20), plot(x,y,'k.');
```

end

```

end
end

k1=[1 1 1 0 0 1 1 ; 0 1 0 0 1 0 0 ; 0 1 0 1 0 0 0 ; 0 1 1 0 0 0 0 ; 0 1 1 0 0 0 0 ; 0 1 0 1 0 0 0 ;
0 1 0 0 1 0 0 ; 0 1 0 0 0 1 0 ; 1 1 1 0 0 1 1];
for i=1:9
    for j=1:7;
        if k1(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,7), plot(x,y,'k.');
```

end

```

end
end

k2=[1 0 0 0 0 1 0 ; 1 0 0 0 1 0 0 ; 1 0 0 1 0 0 0 ; 1 0 1 0 0 0 0 ; 1 1 0 0 0 0 0 ; 1 0 1 0 0 0 0 ; 1
0 0 1 0 0 0 ; 1 0 0 0 1 0 0 ; 1 0 0 0 0 1 0];
for i=1:9
    for j=1:7;
        if k2(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,14), plot(x,y,'k.');
```

end

```

end
end

k3=[1 1 1 0 0 1 1 ; 0 1 0 0 0 1 0 ; 0 1 0 0 1 0 0 ; 0 1 0 1 0 0 0 ; 0 1 1 0 0 0 0 ; 0 1 0 1 0 0 0 ; 0
1 0 0 1 0 0 ; 0 1 0 0 0 1 0 ; 1 1 1 0 0 1 1];
for i=1:9
    for j=1:7;
        if k3(i,j)==1
            x=j;
            y=-i;
            hold on;
            subplot(3,7,21), plot(x,y,'k.');
```

end

```

end
end
```

function cool3- displays training pattern and corresponding matching patterns, and final weights

figure

```
tp=[0 0 1 1 1 1 1;0 1 0 0 0 0 1;1 0 0 0 0 0 0;1 0 0 0 0 0 0;1 0 0 0 0 0 0;1 0 0 0 0 0 0;1 0 0 0 0 0 0;0 1 0 0 0 0 1;0 0 1 1 1 1 0];
```

```
for i=1:9
```

```
    for j=1:7;
```

```
        if tp(i,j)==1
```

```
            x=j;
```

```
            y=-i;
```

```
            hold on;
```

```
            subplot(3,7,1),plot(x,y,'k.');
```

```
        end
```

```
    end
```

```
end
```

```
title('Training Pattern');
```

```
a=[0 0 1 1 0 0 0; 0 0 0 1 0 0 0;0 0 0 1 0 0 0; 0 0 1 0 1 0 0; 0 0 1 0 1 0 0; 0 1 1 1 1 1 0; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0; 1 1 1 0 1 1 1];
```

```
for i=1:9
```

```
    for j=1:7;
```

```
        if a(i,j)==1
```

```
            x=j;
```

```
            y=-i;
```

```
            hold on;
```

```
            subplot (3 , 7 , 5); plot(x,y,'k.');
```

```
        end
```

```
    end
```

```
end
```

```
b1=[1 1 1 1 1 1 0;0 1 0 0 0 0 1;0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 1 1 1 1 0; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 1 0];
```

```
for i=1:9
```

```
    for j= 1:7;
```

```
        if b1(i,j)==1
```

```
            x=j;
```

```
            y=-i;
```

```
            hold on;
```

```
            subplot(3 , 7 , 12), plot(x,y,'k.');
```

```
        end
```

```
end
end
```

```
c1=[0 0 1 1 1 1 1 ; 0 1 0 0 0 0 1; 1 0 0 0 0 0 0; 1 0 0 0 0 0 0; 1 0 0 0 0 0 0; 1 0 0 0 0 0 0
; 1 0 0 0 0 0 0; 0 1 0 0 0 0 1; 0 0 1 1 1 1 0];
```

```
for i=1:9
```

```
    for j=1:7;
```

```
        if c1(i,j)==1
```

```
            x=j;
```

```
            y=-i;
```

```
            hold on;
```

```
            subplot(3,7,19), plot(x,y,'k.');
```

```
        end
```

```
    end
```

```
end
```

```
d1=[1 1 1 1 1 0 0 ; 0 1 0 0 0 1 0; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1
0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 0 0];
```

```
for i=1:9
```

```
    for j=1:7;
```

```
        if d1(i,j)==1
```

```
            x=j;
```

```
            y=-i;
```

```
            hold on;
```

```
            subplot(3,7,20), plot(x,y,'k.');
```

```
        end
```

```
    end
```

```
end
```

```
e1=[1 1 1 1 1 1 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 0; 0 1 0 1 0 0 0; 0 1 1 1 0 0 0; 0 1 0 1 0 0 0; 0
1 0 0 0 0 0; 0 1 0 0 0 0 1; 1 1 1 1 1 1 1];
```

```
for i=1:9
```

```
    for j=1:7;
```

```
        if e1(i,j)==1
```

```
            x=j;
```

```
            y=-i;
```

```
            hold on;
```

```
            subplot(3,7,21), plot(x,y,'k.');
```

```
        end
```

```
    end
```

```
end
```



```

function [V,W] = art1s(p,rho,flag,V,W)
%ART1S  ART1 simulation function.
%
%      [V,W] = ART1S(P,rho,flag)
%      P - F1xQ matrix of input vectors.
%      rho - the vigilance parameter, 0<= rho <=1.
%      flag - (Optional) Printing flag. Any value of flag
%             enables printing of events.
%      Returns:
%      V - the new top-down (T-D) weight matrix F1xF2.
%      W - the new bottom-up (B-U) weight matrix F2xF1.
%           F2 is the number of nodes in layer F2 (max # of categories)
%      Example:   P = letno;
%                 art1s(P,0.7);
%
%           See also LETNO

%      Author: Val Ninov, e-mail: valninov@total.net
%              Grad. Student, Dept. of Electrical Engineering
%              Concordia University, Montreal, Canada
%              (c) April, 1997
%      References:
%      [1]  Carpenter, G. A. and S. Grossberg, "ART2: self-organization
%           of stable category recognition codes for analog input patterns."
%           Applied Optics, vol. 26, no. 23, Dec. 1987, pp. 4919-4930.
%      [2]  J. Freeman and D. Skapura, Neural Networks: Algorithms,
%           Applications, and Programming Techniques. Addison Wesley

if nargin<2 | nargin>5 error('Wrong number of input arguments. '); end

% NETWORK PARAMETERS
[R,Q] = size(p);
F1 = R;
F2 = Q;
L = 2;
categ = zeros(F2,F2); % category table
count = ones(1,F2); % counter for patterns in one category

% INITIALIZE WEIGHTS
if nargin < 4
W = ones(F2,F1)*(L/(L-1+F1));
V = ones(F1,F2);
fprintf('INITIAL TOP-DOWN MATRIX :'); V
fprintf('INITIAL BOTTOM-UP MATRIX :'); W
end

```

```

% INITIALIZE RETURN VARIABLES
a1 = zeros(F1,Q); % output of F1
i = zeros(1,Q); % winner index
win = 1; % First time node 1 in F2 is the winner
nActive = 1; % The number of active neurons in F2

% PRESENT EACH INPUT VECTOR
for q=1:Q
    Reset = 0;
    B2 = zeros(F2,1);
    resonance = 0;
    while ~resonance % REPEAT UNTIL: LAYERS F1 & F2 RESONATE
        % Initially a1 = p;
        % Calculate the winning node in F2 (among the active nodes)
        A2 = compet(W(1:nActive,:)*p(:,q)+B2(1:nActive,1));
        i(q) = find(A2 == 1);
        win = i(q);
        % RECALCULATE a1 WITH FEEDBACK FROM A2
        a1(:,q) = (p(:,q) & V(:,win));

        % RESET if the new a1 is too different from p
        S= sum(a1(:,q));
        X= sum(p(:,q));
        Reset = (S/X) < rho;

        % IF RESET: TAKE WINNING NEURON IN F2 OUT OF COMPETITION
        if Reset
            B2(win) = -100;
            if nargin == 3
                fprintf(' RESET: Pattern %0.f resets F2 neuron %0.f\n',q,win);
            end

            % IF ALL NEURONS IN A2 OUT OF COMPETITION ADD NEURON TO
            LAYER 2
            if all(B2(1:nActive,1) == -100)
                nActive = nActive + 1;
                if nargin == 3
                    fprintf(' A new category %d created\n',nActive);
                end
                win = nActive;
            end

            % ELSE RESET NEURON DOES NOT FIRE: LAYERS 1 & 2 RESONATE
            else
                if nargin == 3

```

```

        fprintf('Pattern %d classified in %d category.\n',q,win);
    end
    resonance = 1;
end

end % end of WHILE loop

    % Update B-U LTM and T-D LTM
    V(:,win) = a1(:,q)&V(:,win);
    W(win,:) = (a1(:,q)*L/(L-1+sum(a1(:,q))))';
    V(:,win) = V(:,win).*p(:,q);
    W(win,:) = (V(:,win).*p(:,q))/(0.5 + sum(V(:,win).*p(:,q)));
    categ(win, count(win)) = q;
    count(win) = count(win)+1;
end % end of FOR loop

% Display final classification
fprintf('\n Category   Pattern\n -----\n');
for i = 1:nActive
    fprintf('   %d       ',i);
    for j= 1:F2
        if categ(i,j)
            fprintf('%s, ',(categ(i,j)+64));
        end
    end
end

    fprintf('\n -----\n');

end

end

```