UNSUPERVISED LEARNING

1. load the iris data set with the command `load 'fisheriris'`. Two data structures will appear in your workspace: `meas` and `species`. The data structure `meas` contains the flower measurements as a 150x4 matrix -- 150 samples, each with 4 variables. The data structure `species` has text labels for each iris type; these labels are not needed for the clustering exercises here.

```
load fisheriris
meas
```

```
meas = 150×4
          5.1          3.5          1.4          0.2
          4.9            3          1.4          0.2
          4.7          3.2          1.3          0.2
          4.6          3.1          1.5          0.2
            5          3.6          1.4          0.2
          5.4          3.9          1.7          0.4
          4.6          3.4          1.4          0.3
            5          3.4          1.5          0.2
          4.4          2.9          1.4          0.2
          4.9          3.1          1.5          0.1
      ⋮
```

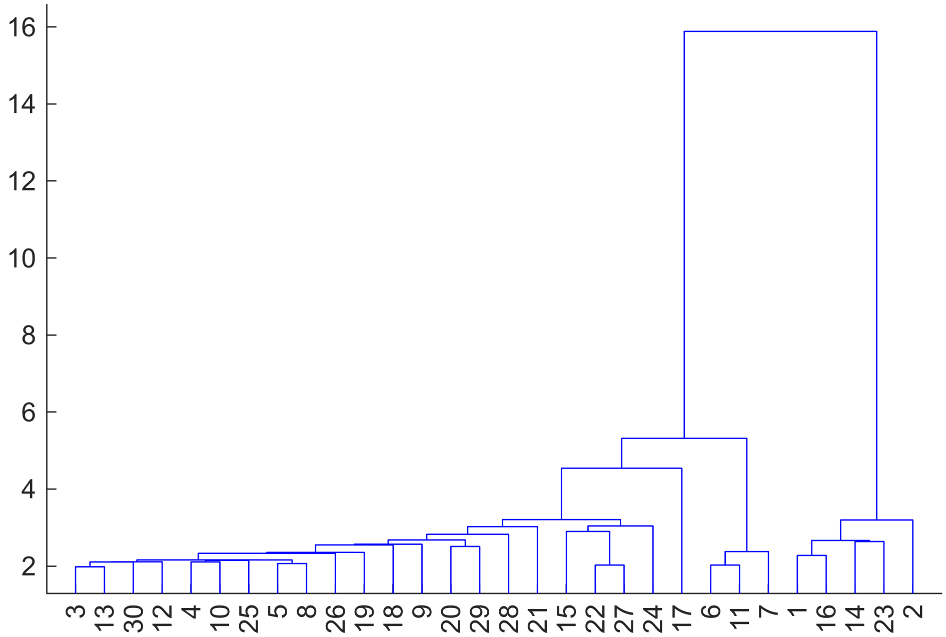
2. Cluster the iris data set using `kmeans` and create a dendrogram using using matlab's `linkage.m`. Compare the results.

```
[idx, C] = kmeans(meas,3)
```

```
idx = 150×1
     2
     2
     2
     2
     2
     2
     2
     2
     2
     2
      ⋮
C = 3×4
       6.8538       3.0769       5.7154       2.0538
        5.006        3.428        1.462        0.246
       5.8836        2.741       4.3885       1.4344
```

```

d = pdist(meas);
m = squareform(d);
ml = linkage(m);
dendrogram(ml)
```



3. Run `origbcm.m` on a dataset of 8 normalized random vectors. Comment on the result.

```
rs = 0;
p8data = .7*ones(8)+.3*eye(8);
p8data = normc(p8data);
p8data'*p8data
```

```
ans = 8×8
           1      0.97968      0.97968      0.97968      0.97968      0.97968 ···
     0.97968            1      0.97968      0.97968      0.97968      0.97968
     0.97968      0.97968            1      0.97968      0.97968      0.97968
     0.97968      0.97968      0.97968            1      0.97968      0.97968
     0.97968      0.97968      0.97968      0.97968            1      0.97968
     0.97968      0.97968      0.97968      0.97968      0.97968            1
     0.97968      0.97968      0.97968      0.97968      0.97968      0.97968
     0.97968      0.97968      0.97968      0.97968      0.97968      0.97968
```

```
b0 = initorigbcm(8,2,rs)
```

```
b0 = struct with fields:
    wts: [0.62945 0.81158 -0.74603 0.82675 0.26472 -0.80492 -0.443 0.093763]
     rb: 0
```

```
bf = origbcm(b0,p8data,100000,.005,rs)
```

```
bf = struct with fields:
    wts: [2.2045 3.2723 -2.2539 3.2704 0.57052 -2.3536 -1.5646 -0.062638]
     rb: 1.0817
```

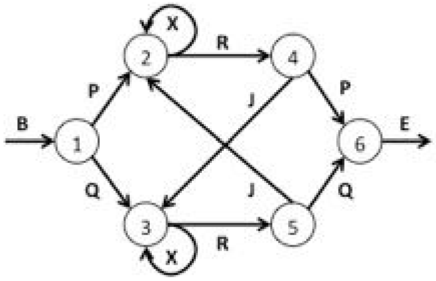
```
bf.wts*p8data
```

```
ans = 1×8
      1.3395       1.4917      0.70406       1.4915       1.1066      0.68986 ···
```

LANGUAGE

Create an SRN model of the grammar below. Generate a list of training strings.

Test the model on grammatical strings, such as BPXXRJXXXRQE



```
% setup list generation

reber.ind = [ % col->row weight
    0 1 0 0 0 0 0 ;
    0 0 2 3 0 0 0 ;
    0 0 4 0 5 0 0 ;
    0 0 0 4 0 5 0 ;
    0 0 0 6 0 0 2 ;
    0 0 6 0 0 0 3 ;
    7 0 0 0 0 0 0 ;];
reber.prob = [ % 0.5 for two output, 1 for one output
    0    1.0  0    0    0    0    0    ;
    0    0    0.5  0.5  0    0    0    ;
    0    0    0.5  0    0.5  0    0    ;
    0    0    0    0.5  0    0.5  0    ;
    0    0    0    0.5  0    0    0.5  ;
    0    0    0.5  0    0    0    0.5  ;
    1    0    0    0    0    0    0    ;];
reber.labels = 'BPQXRJE';

% make training list
list = makestringlist(reber,10)
```

```
list = struct with fields:
      list: [1 3 4 4 4 4 5 3 7 1 2 4 5 2 7 1 3 4 4 5 6 5 2 7 1 2 4 4 4 5 6 4 4 5 3 7 1 3 5 3 7 1 2 5 6 4 5 6 5 6 4
    states: [1 2 4 4 4 4 4 6 1 2 3 3 5 1 2 4 4 4 6 3 5 1 2 3 3 3 3 5 4 4 4 6 1 2 4 6 1 2 3 5 4 4 6 3 5 4 4 4 6 1 2
       ind: [1 10 16 25 37 42 56 61 72 77]
```

```
% init net
n0=initnet3srnx(5,3,5,2,2,rs)
```

```
n0 = struct with fields:
        wih: [3×5 double]
         hh: [3×3 double]
      hbias: [0.35747 0.51548 0.48626]
      whout: [5×3 double]
      obias: [0.53103 0.5904 -0.62625 -0.020471 -0.10883]
    context: [0 0 0]
```

```
% train net
nf=bp3srn(n0,list,30000,.02,0)
```

```
Error using  *
Incorrect dimensions for matrix multiplication. Check that the number of columns in the
first matrix matches the number of rows in the second matrix. To operate on each element of
the matrix individually, use TIMES (.*) for elementwise multiplication.
Error in Assignment8>hidlayersrn (line 178)
lll=b'+win(:,pin)+wctx*ctx; %combine input from single input and ctx layer
Error in Assignment8>forw1p3srn (line 130)
netact.hid=hidlayersrn(p,netwk.context,netwk.wih,netwk.hh,netwk.hbias,nois);
Error in Assignment8>cyc3srn (line 136)
activity=forw1p3srn(nstruct,pin,noi) ;
Error in Assignment8>bp3srn (line 115)
        netk=cyc3srn(netk,ts(j),ts(j+1),eta,nlev) ;
Related documentation
```

```
% BPXXRJXXXRQE = 124456444537
stringprocv4X(n0,[1 2 4 4 5 6 4 4 4 5 3 7],reber)
```

Attachments

```
function babynet = initorigbcm( nin,range,rs )
%initialize bcm cell
rng(rs);
babynet.wts=range*(rand(1,nin)-0.5) ;
babynet.rb = 0 ;
end

function finalcell = origbcm( initcell, pset, niter, dt, rs )
%iterates iterbcm
cell=initcell;
avgpat=sum(pset,2)/size(pset,2);
rng(rs) ;
for i=1:niter
    apat = pset(:,irand(size(pset,2),1)) ;
    r=cell.wts*apat ;
    cell.rb = cell.wts*avgpat ;
    cell.wts = cell.wts + dt*r*(r-cell.rb*cell.rb)*apat' ;
end
finalcell=cell;
end




function netstruct=initnet3srnx(n1,n2,n3,uamp,vamp,rs)
rng(rs);
netstruct.wih=uamp*(rand(n2,n1)-0.5) ;
netstruct.hh=uamp*(rand(n2,n2)-0.5) ;
netstruct.hbias=uamp*(rand(1,n2)-0.5) ;
netstruct.whout=vamp*(rand(n3,n2)-0.5) ;
netstruct.obias=vamp*(rand(1,n3)-0.5);
netstruct.context=zeros(1,n2);
end

function strings = makestringlist(tgram,nstrings)
jj=1; % initial state
strings.list=[];
strings.states=[];
nstates=size(tgram.prob,2);
for ii=1:nstrings
    strings.ind(ii)=jj ; %index into superstring
    seq=[]; %initialize one string
    st=1;
    stlist=[] ; %initial state list
    while (st<nstates)
        rr=rand();
        cumu=0; i=0;
        while (cumu<rr)
            i=i+1;
            cumu=cumu+tgram.prob(st,i);
        end
        letter=tgram.ind(st,i) ;
        seq=[seq letter];
        stlist=[stlist st];
        st=i;
    end
    seq=[seq nstates] ; % append end character to seq
    strings.list=[strings.list seq];
    jj=jj+size(seq,2);
    strings.states=[strings.states stlist];
end
end


function finalnet=bp3srn(net0,strlist,niter,eta,nlev)
netk=net0;
for i=1:niter
    ts=selectstring(strlist) ; % new training string
    netk.context=zeros(size(netk.wih,1),1); % resets context
    for j=1:size(ts,2)-1 % this loop trains a single string
        netk=cyc3srn(netk,ts(j),ts(j+1),eta,nlev) ;
    end
end
finalnet=netk;
end


function sg = selectstring(sdata)
j=randi(size(sdata.ind,2)) ;
if (j<size(sdata.ind,2)) sg=sdata.list(sdata.ind(j):sdata.ind(j+1)-1);
else sg=sdata.list(sdata.ind(j):size(sdata.list,2)) ;
```

```
end
end

function netact=forw1p3srn(netwk,p,nois)
netact.hid=hidlayersrn(p,netwk.context,netwk.wih,netwk.hh,netwk.hbias,nois);
netact.out=layersig01(netact.hid,netwk.whout,netwk.obias) ;
end

function newstruct=cyc3srn(nstruct,pin,pout,dt,noi)
newstruct=nstruct;
activity=forw1p3srn(nstruct,pin,noi) ;
tvec=zeros(size(nstruct.obias)) ;
tvec(pout)=1;
odelt=tvec-activity.out; %output deltas
hdelt=0.5*(nstruct.whout'*odelt').*(1+activity.hid').*(1-activity.hid');%hid deltas
%adjust weights and biases
newstruct.whout=newstruct.whout+dt*odelt'*activity.hid ;
newstruct.obias=newstruct.obias+dt*odelt ;
newstruct.wih(:,pin)=newstruct.wih(:,pin)+dt*hdelt; %just update weights from active input
newstruct.hbias=newstruct.hbias+dt*hdelt' ;
newstruct.hh=newstruct.hh+dt*hdelt*nstruct.context ;
newstruct.context=activity.hid ;
end

function [sout,hlist,slist] = stringprocv4X(netwk,strg,gramm)
hlist=[] ;
ctxinp=zeros(1,size(netwk.wih,1));
slist=[] ;
lets=gramm.labels(strg)

%STRINGS!!!
s1=[] ;
sout=[];

for j=1:size(strg,2)-1
    hhh=hidlayersrn(strg(j),ctxinp,netwk.wih,netwk.hh,netwk.hbias,0.0);
    ou=layersig01(hhh,netwk.whout,netwk.obias);
    hlist=[hlist;hhh] ;
    s1=[s1,lets(j)];
    scell=cellstr(s1) ;
    slist=[slist;scell] ;
    sout=[sout, sprintf('%c %c',gramm.labels(strg(j)), gramm.labels(strg(j+1)))] ;
    for kk=1:size(netwk.whout,1)
        sout=[sout sprintf('%6.3f',ou(kk))];
    end
    sout=[sout, sprintf('\n')];

    ctxinp=hhh;
end
end
```

```
function lout=hidlayersrn(pin,ctx,win,wctx,b,noise)
lll=b'+win(:,pin)+wctx*ctx; %combine input from single input and ctx layer
lout=sigpn(lll)'+noise*(rand(size(lll))'-0.5);
end
```