UNSUPERVISED LEARNING

1. Ioad 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
```

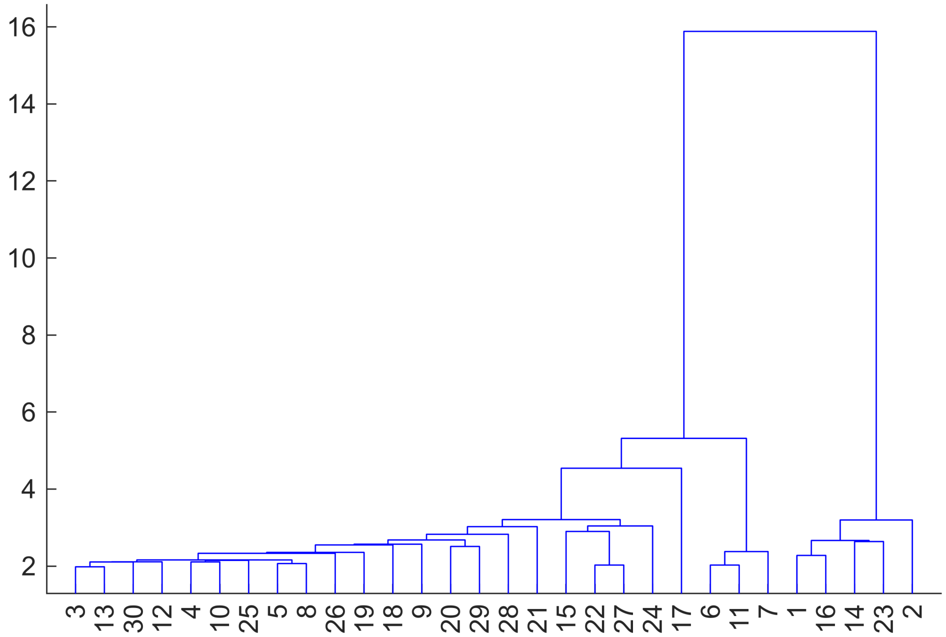
```
meas = 150×4
          5.1          3.5          1.4          0.2
          4.9            3          1.4          0.2
          4.7          3.2          1.3          0.2
          4.6          3.1          1.5          0.2
            5          3.6          1.4          0.2
          5.4          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
     1
     1
     1
     1
     1
     1
     1
     1
     1
     1
     ⋮
C = 3×4
        5.006        3.428        1.462        0.246
       6.8538       3.0769       5.7154       2.0538
       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
```

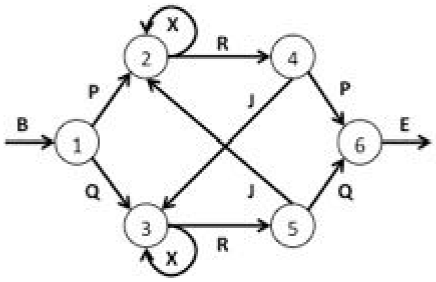
```
bf.wts*p8data
```

```
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.labels = 'BPQXRJE'
```

```
reber = struct with fields:
    labels: 'BPQXRJE'
       ind: [8×8 double]
      prob: [8×8 double]
```

```
reber.ind = [ % col->row weight
    0 1 0 0 0 0 0 0;
    0 0 2 3 0 0 0 0;
    0 0 4 0 5 0 0 0;
    0 0 0 4 0 5 0 0;
    0 0 0 6 0 0 2 0;
    0 0 6 0 0 0 3 0;
    0 0 0 0 0 0 0 7;
    0 0 0 0 0 0 0 0;]
```

```
reber = struct with fields:
    labels: 'BPQXRJE'
       ind: [8×8 double]
      prob: [8×8 double]
```

```
reber.prob = [ % 0.5 for two output, 1 for one output
    0    1.0  0    0    0    0    0    0;
    0    0    0.5  0.5  0    0    0    0;
    0    0    0.5  0    0.5  0    0    0;
    0    0    0    0.5  0    0.5  0    0;
    0    0    0    0.5  0    0    0.5  0;
    0    0    0.5  0    0    0    0.5  0;
    0    0    0    0    0    0    0    1;
    0    0    0    0    0    0    0    0;]
```

```
reber = struct with fields:
    labels: 'BPQXRJE'
       ind: [8×8 double]
      prob: [8×8 double]
```

```


% make training list
```

```
list = makestringlist(reber,1000)
```

```
list = struct with fields:
      list: [1 3 4 5 3 7 8 1 2 5 6 5 6 5 6 5 3 7 8 1 3 4 4 4 5 6 5 6 5 6 4 4 5 6 4 5 3 7 8 1 2 5 2 7 8 1 2 4 5 2 7
    states: [1 2 4 4 6 7 1 2 3 5 4 6 3 5 4 6 7 1 2 4 4 4 4 6 3 5 4 6 3 3 3 5 4 4 6 7 1 2 3 5 7 1 2 3 3 5 7 1 2 4 4
       ind: [1 8 20 40 46 53 69 78 87 101 118 133 144 156 166 173 179 197 206 219 226 232 239 252 261 267 278 289
```

```
% init net
n0=initnet3srnx(5,3,5,1,3,rs)
```

```
n0 = struct with fields:
        wih: [3×5 double]
         hh: [3×3 double]
      hbias: [0.17874 0.25774 0.24313]
      whout: [5×3 double]
      obias: [0.79655 0.8856 -0.93938 -0.030707 -0.16324]
    context: [0 0 0]
```

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

```
Unrecognized function or variable 'hidlayersrn'.
Error in Assignment8>forw1p3srn (line 129)
netact.hid=hidlayersrn(p,netwk.context,netwk.wih,netwk.hh,netwk.hbias,nois);
Error in Assignment8>cyc3srn (line 135)
activity=forw1p3srn(nstruct,pin,noi) ;
Error in Assignment8>bp3srn (line 114)
        netk=cyc3srn(netk,ts(j),ts(j+1),eta,nlev) ;
```

```
% BPXXRJXXXRQE = 124456444537
stringprocv4X(nf,[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
```