```
% gda10_05
% factor analysis on Atlantic Rocks dataset
% using singular value decomposition
% and the varimax procedure
% Supports Figure 10.8

% load data
D = load('../data/rocks.txt');
sio2 = D(:,1);   % SiO2
tio2 = D(:,2);   % TiO2
als03 = D(:,3);  % Al203
feot = D(:,4);   % FeO-total
mgo = D(:,5);    % MgO
cao = D(:,6);    % CaO
na20 = D(:,7);   % Na2O
k20 = D(:,8);    % K2O
Ns = size(D);
N = Ns(1);
M = Ns(2);

% compute factors and factor loadings using singular value decompostion
[U, S, V] = svd(D,0);

% keep only first five singular values
P=5;
F = V(:,1:P)';
C = U(:,1:P)*S(1:P,1:P);

% initial rotated factor matrix, FP, abd rotation matrix, MR
MR=eye(P,P);
FP=F;

% spike these factors using the varimax procedure
k = [2, 3, 4, 5]';
Nk = length(k);

% varimax is an iterative procedure, but converges very rapidly,
% so do only 3 iterations.  Within each iteration, one applies
% the procedure to every pair of factors.
for iter = [1:3] % iterations
for ii = [1:Nk]  % pairs of factors
for jj = [ii+1:Nk]

% spike factors i and j
i=k(ii);
j=k(jj);

% copy factors from matrix to vectors
fA = FP(i,:)';
fB = FP(j,:)';

% standard varimax procedure to determine rotation angle q
u = fA.^2 - fB.^2;
v = 2* fA .* fB;

A = 2*M*u'*v;
B = sum(u)*sum(v);
top = A - B;
```

```
C = M*(u'*u-v'*v);
D = (sum(u)^2)-(sum(v)^2);
bot =  C - D;

q = 0.25 * atan2(top,bot);

cq = cos(q);
sq = sin(q);

fAp =  cq*fA + sq*fB;
fBp = -sq*fA + cq*fB;

% put back into factor matrix, FP
FP(i,:) = fAp';
FP(j,:) = fBp';

% accumulate rotation
mA = MR(i,:)';
mB = MR(j,:)';
mAp =  cq*mA + sq*mB;
mBp = -sq*mA + cq*mB;
MR(i,:) = mAp';
MR(j,:) = mBp';

end
end
end

% new factor loadings
CP=C*MR';

% display first five factors
for j = [1:5]
f1=FP(j,:);
disp(sprintf('factor %d', j));
disp(sprintf('SiO2 %f', f1(1)));
disp(sprintf('TiO2 %f', f1(2)));
disp(sprintf('Al203 %f', f1(3)));
disp(sprintf('FeO-total %f', f1(4)));
disp(sprintf('MgO %f', f1(5)));
disp(sprintf('CaO %f', f1(6)));
disp(sprintf('Na2O %f', f1(7)));
disp(sprintf('K2O %f', f1(8)));
disp(sprintf(' '));
end
```

```
factor 1
SiO2 -0.908829
TiO2 -0.024638
Al203 -0.275168
FeO-total -0.177851
MgO -0.141341
CaO -0.209989
Na2O -0.044611
K2O -0.003430

factor 2
SiO2 -0.131621
```

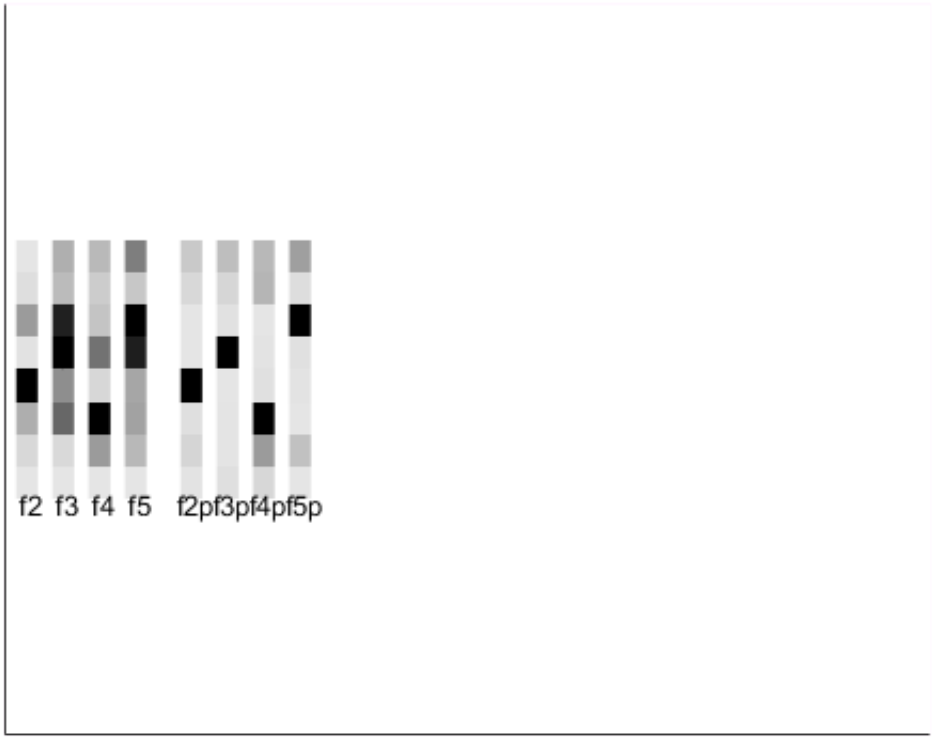
```
TiO2 -0.070685
Al203 -0.014311
FeO-total -0.011084
MgO 0.984305
CaO -0.038976
Na2O -0.080453
K2O -0.022437

factor 3
SiO2 0.178651
TiO2 -0.077399
Al203 0.029953
FeO-total -0.979373
MgO 0.010557
CaO 0.014822
Na2O 0.016830
K2O 0.037555

factor 4
SiO2 0.182928
TiO2 0.195179
Al203 0.004503
FeO-total 0.012028
MgO 0.028210
CaO -0.913888
Na2O 0.297483
K2O 0.061593

factor 5
SiO2 0.288635
TiO2 -0.035952
Al203 -0.944592
FeO-total 0.024113
MgO 0.010209
CaO -0.002672
Na2O -0.149835
K2O 0.000397
```

```
gda_draw_bw(' ', abs(F(2,:))', 'caption f2', abs(F(3,:))', 'caption f3', abs(F(4,:))', 'captio
         ' ', abs(FP(2,:))', 'caption f2p', abs(FP(3,:))', 'caption f3p', abs(FP(4,:))', 'capt
```




```
% Figure 10.8 (A) Factors f(2) through f(5) of the Atlantic Rock data set, as calculated
% by singular-value decomposition. (B) Factors f'(2) through f'(5), after application of
% the varimax procedure. MatLab script gda10_05.

% This is a test that the rotated matrices are correct
% (that is, that they reproduce the original sample matrix)
e = C*F-CP*FP;
E = sqrt(sum(sum(e.^2))) / sqrt(sum(sum((C*F).^2)));
fprintf('Fractional error in reconstruction: %.3f percent\n', 100*E );
```

```
Fractional error in reconstruction: 0.000 percent
```