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disp("PicA")
picA = double(imread('picA.jpg'));
[pic, pich] = comp(picA,160);
figure(1); imshow(uint8(pic)); axis equal;
figure(2); imshow(uint8(pich)); axis equal;

[~, pich] = comp(picA,320);
figure(3); imshow(uint8(pich)); axis equal;

disp("PicB")
picB = double(imread('picB.jpg'));
[pic, pich] = comp(picB,160);
figure(4); imshow(uint8(pic)); axis equal;
figure(5); imshow(uint8(pich)); axis equal;

[~, pich] = comp(picB,320);
figure(6); imshow(uint8(pich)); axis equal;

% disp("PicC")
% picC = double(imread('picC.jpg'));
% comp(picC,160)
% comp(picC,320)
%
% disp("PicD")
% picD = double(imread('picD.jpg'));
% comp(picD,160)
% comp(picD,320)
%
% disp("PicE")
% picE = double(imread('picE.jpg'));
% comp(picE,160)
% comp(picE,320)
%
% disp("PicF")
% picF = double(imread('picF.jpg'));
% comp(picF,160)
% comp(picF,320)
%
% disp("PicG")
% picG = double(imread('picG.jpg'));
% comp(picG,160)
% comp(picG,320)

function [pic, pich] = comp(pic,rk)
tic; [Us1,Ss1,Vs1] = HW6_GKLsvds(pic(:,:,1),rk); toc;
tic; [Us2,Ss2,Vs2] = HW6_GKLsvds(pic(:,:,2),rk); toc;
tic; [Us3,Ss3,Vs3] = HW6_GKLsvds(pic(:,:,3),rk); toc;
tic; [U1,S1,V1] = svd(pic(:,:,1),0); toc;
tic; [U2,S2,V2] = svd(pic(:,:,2),0); toc;
tic; [U3,S3,V3] = svd(pic(:,:,3),0); toc;

whos pic
whos Us1 Vs1 Us2 Vs2 Us3 Vs3
whos U1 V1 U2 V2 U3 V3

pich = zeros(size(pic));
pich(:,:,1) = Us1*Ss1*Vs1';
pich(:,:,2) = Us2*Ss2*Vs2';
pich(:,:,3) = Us3*Ss3*Vs3';

disp([norm(pich(:,:,1)-pic(:,:,1),'fro')/norm(pic(:,:,1),'fro') ...
norm(pich(:,:,2)-pic(:,:,2),'fro')/norm(pic(:,:,2),'fro') ...
norm(pich(:,:,3)-pic(:,:,3),'fro')/norm(pic(:,:,3),'fro')]);
end

function [U,S,V] = HW6_GKLsvds(A,k)

% The Golub-Kahan-Lanczos bidiagonalization
%
% Input:
% A      The matrix for which we are computing largest singular values
%        should be large to show the competitiveness of iterative method
% k      The number of singular values wanted
%
% Output:
% S      The k by k diagonal matrix of approximate dominant singular values
% U,V   The k approximate left and right singular vectors
%
% Copyright (c) F. Xue 10/21/2017

[m,n] = size(A);
v_k = randn(n,1);
v_k = v_k/norm(v_k);
maxiter = min([m n max([ceil(1.2*k) k+5])]);
beta_km1 = 0;

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u_km1 = zeros(m,1);
alpha_all = zeros(maxiter,1);
beta_all = zeros(maxiter+1,1);
U = zeros(m,maxiter);
V = zeros(n,maxiter+1);
V(:,1) = v_k;

for iter = 1 : maxiter
    u_k = A*v_k-beta_km1*u_km1;

    for jj = 1 : iter-1
        u_k = u_k - U(:,jj)*(U(:,jj))'*u_k;
    end
    %u_k = u_k - U(:,1:iter-1)*(U(:,1:iter-1))'*u_k;

    alpha_k = norm(u_k);
    u_k = u_k/alpha_k;
    v_kp1 = (u_k'*A)'-alpha_k*v_k;

    for jj = 1 : iter
        v_kp1 = v_kp1 - V(:,jj)*(V(:,jj))'*v_kp1;
    end
    %v_kp1 = v_kp1 - V(:,1:iter)*(V(:,1:iter))'*v_kp1;

    beta_k = norm(v_kp1);
    v_kp1 = v_kp1/beta_k;

    alpha_all(iter) = alpha_k;
    beta_all(iter+1) = beta_k;

    U(:,iter) = u_k;
    V(:,iter+1) = v_kp1;

    u_km1 = u_k;
    v_k = v_kp1;
    beta_km1 = beta_k;
end

B = spdiags([alpha_all beta_all(1:end-1)],0:1,maxiter,maxiter);
[Us,S,Vs] = svd(full(B));
U = U*Us(:,1:k);
V = V(:,1:maxiter)*Vs(:,1:k);
S = S(1:k,1:k);

end

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PicA
Elapsed time is 0.896455 seconds.
Elapsed time is 0.741844 seconds.
Elapsed time is 0.789864 seconds.
Elapsed time is 3.810750 seconds.
Elapsed time is 3.505444 seconds.
Elapsed time is 3.950762 seconds.

Name      Size          Bytes  Class     Attributes
pic      2304x2092x3      115679232  double

Name      Size          Bytes  Class     Attributes
Us1      2304x160       2949120  double
Us2      2304x160       2949120  double
Us3      2304x160       2949120  double
Vs1      2092x160       2677760  double
Vs2      2092x160       2677760  double
Vs3      2092x160       2677760  double

Name      Size          Bytes  Class     Attributes
U1      2304x2092       38559744  double
U2      2304x2092       38559744  double
U3      2304x2092       38559744  double
V1      2092x2092       35011712  double
V2      2092x2092       35011712  double
V3      2092x2092       35011712  double

0.0978   0.0955   0.0968

Elapsed time is 1.847161 seconds.
Elapsed time is 1.938489 seconds.
Elapsed time is 1.868728 seconds.
Elapsed time is 3.466685 seconds.
Elapsed time is 3.451249 seconds.
Elapsed time is 3.810249 seconds.

Name      Size          Bytes  Class     Attributes
pic      2304x2092x3      115679232  double

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Name	Size	Bytes	Class	Attributes
Us1	2304x320	5898240	double	
Us2	2304x320	5898240	double	
Us3	2304x320	5898240	double	
Vs1	2092x320	5355520	double	
Vs2	2092x320	5355520	double	
Vs3	2092x320	5355520	double	

Name	Size	Bytes	Class	Attributes
U1	2304x2092	38559744	double	
U2	2304x2092	38559744	double	
U3	2304x2092	38559744	double	
V1	2092x2092	35011712	double	
V2	2092x2092	35011712	double	
V3	2092x2092	35011712	double	

0.0675 0.0674 0.0675

PicB
Elapsed time is 1.577584 seconds.
Elapsed time is 1.463842 seconds.
Elapsed time is 1.531912 seconds.
Elapsed time is 7.317038 seconds.
Elapsed time is 7.259443 seconds.
Elapsed time is 7.367266 seconds.

Name	Size	Bytes	Class	Attributes
pic	2304x4089x3	226105344	double	

Name	Size	Bytes	Class	Attributes
Us1	2304x160	2949120	double	
Us2	2304x160	2949120	double	
Us3	2304x160	2949120	double	
Vs1	4089x160	5233920	double	
Vs2	4089x160	5233920	double	
Vs3	4089x160	5233920	double	

Name	Size	Bytes	Class	Attributes
U1	2304x2304	42467328	double	
U2	2304x2304	42467328	double	
U3	2304x2304	42467328	double	
V1	4089x4089	133759368	double	
V2	4089x4089	133759368	double	
V3	4089x4089	133759368	double	

0.0997 0.1122 0.1243

Elapsed time is 4.344866 seconds.
Elapsed time is 3.547297 seconds.
Elapsed time is 3.368739 seconds.
Elapsed time is 6.759537 seconds.
Elapsed time is 7.600708 seconds.
Elapsed time is 7.328449 seconds.

Name	Size	Bytes	Class	Attributes
pic	2304x4089x3	226105344	double	

Name	Size	Bytes	Class	Attributes
Us1	2304x320	5898240	double	
Us2	2304x320	5898240	double	
Us3	2304x320	5898240	double	
Vs1	4089x320	10467840	double	
Vs2	4089x320	10467840	double	
Vs3	4089x320	10467840	double	

Name	Size	Bytes	Class	Attributes
U1	2304x2304	42467328	double	
U2	2304x2304	42467328	double	
U3	2304x2304	42467328	double	
V1	4089x4089	133759368	double	
V2	4089x4089	133759368	double	
V3	4089x4089	133759368	double	

0.0878 0.0994 0.1103







