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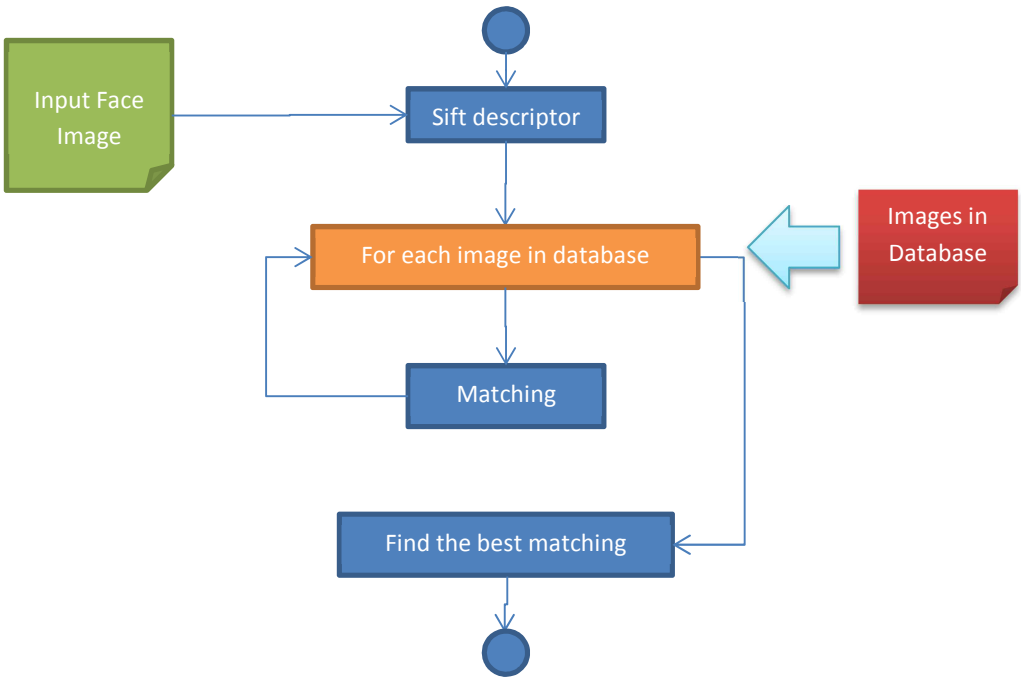
Class: Advance in Pattern Recognition

FACE RECOGNITION USING SIFT FEATURE

1. Flowchart



2. Implementation

2.1. Reference

- **Source code: SIFT Keypoint Detector** by **David Lowe**: **http://www.cs.ubc.ca/~lowe/keypoints/**
  - The demo software uses PGM format for image input. It can output keypoints and all information needed for matching them to a file in a simple ASCII format.
  - Features are extracted from each of the two images, and lines are drawn between features that have close matches.
- Paper: David G. Lowe, **"Distinctive image features from scale-invariant keypoints,"** *International Journal of Computer Vision,* 60, 2 (2004), pp. 91-110.

2.2. Wrapper source code for face recognition

- Database: face images which are closed on face region.
- Run demo_faceReg.m for running a testing of face recognition.

```
function demo_faceReg

    % indicate test images
    tDir = 'test/';
    listTest = dir(strcat(tDir,'*.*p*'));
    mT = size(listTest,1);

    % indicate database
    dbDir = 'database/';
    listDB = dir(strcat(dbDir,'*.*p*'));
    mDB = size(listDB,1);

    for i=1:mT
        tFile = strcat(tDir,listTest(i).name);
        for j=1:mDB
            dbFile = strcat(dbDir,listDB(j).name);
            num(j) = match(tFile,dbFile,0);
        end
        % find the best matching
        [vmax,nmax] = max(num);
        dbFile = strcat(dbDir,listDB(nmax).name);
        match(tFile,dbFile,1);
    end
end
```

- More detail about data and experimental result, please refer to experimental result part.
- Sift descriptor:
    - The "sift" command calls the appropriate binary to extract SIFT features (under Linux or Windows) and returns them in matrix form.

```
function [image, descriptors, locs] = sift(imageFile)

% Load image
image = imread(imageFile);
% If you have the Image Processing Toolbox, you can uncomment the following
%   lines to allow input of color images, which will be converted to grayscale.
%if isrgb(image)
    image = rgb2gray(image);
%end

[rows, cols] = size(image);

% Convert into PGM imagefile, readable by "keypoints" executable
f = fopen('tmp.pgm', 'w');
if f == -1
    error('Could not create file tmp.pgm.');
end
fprintf(f, 'P5\n%d\n%d\n255\n', cols, rows);
fwrite(f, image', 'uint8');
fclose(f);

% Call keypoints executable
if isunix
    command = '!./sift ';
else
    command = '!siftWin32 ';
end
command = [command ' <tmp.pgm >tmp.key'];
eval(command);

% Open tmp.key and check its header
g = fopen('tmp.key', 'r');
if g == -1
    error('Could not open file tmp.key.');
end
[header, count] = fscanf(g, '%d %d', [1 2]);
if count ~= 2
    error('Invalid keypoint file beginning.');
end
num = header(1);
len = header(2);
if len ~= 128
    error('Keypoint descriptor length invalid (should be 128).');
end

% Creates the two output matrices (use known size for efficiency)
locs = double(zeros(num, 4));
descriptors = double(zeros(num, 128));

% Parse tmp.key
for i = 1:num
    [vector, count] = fscanf(g, '%f %f %f %f', [1 4]); %row col scale ori
    if count ~= 4
        error('Invalid keypoint file format');
    end
    locs(i, :) = vector(1, :);

    [descrip, count] = fscanf(g, '%d', [1 len]);
    if (count ~= 128)
        error('Invalid keypoint file value.');
    end
    % Normalize each input vector to unit length
    descrip = descrip / sqrt(sum(descrip.^2));
    descriptors(i, :) = descrip(1, :);
end

fclose(g);
```

- Matching
  - The "match" function is given two image file names. It extracts SIFT features from each image, matches the features between the two images, and displays the results.

```
function num = match(image1, image2, show)

% Find SIFT keypoints for each image
[im1, des1, loc1] = sift(image1);
[im2, des2, loc2] = sift(image2);

% For efficiency in Matlab, it is cheaper to compute dot products between
%  unit vectors rather than Euclidean distances.  Note that the ratio of
%  angles (acos of dot products of unit vectors) is a close approximation
%  to the ratio of Euclidean distances for small angles.
%
% distRatio: Only keep matches in which the ratio of vector angles from the
%   nearest to second nearest neighbor is less than distRatio.
distRatio = 0.6;

% For each descriptor in the first image, select its match to second image.
des2t = des2';                          % Precompute matrix transpose
for i = 1 : size(des1,1)
   dotprods = des1(i,:) * des2t;        % Computes vector of dot products
   [vals,indx] = sort(acos(dotprods));  % Take inverse cosine and sort results

   % Check if nearest neighbor has angle less than distRatio times 2nd.
   if (vals(1) < distRatio * vals(2))
      m_match(i) = indx(1);
   else
      m_match(i) = 0;
   end
end

if (show == 1)
    % Create a new image showing the two images side by side.
    im3 = appendimages(im1,im2);

    % Show a figure with lines joining the accepted matches.
    figure('Position', [100 100 size(im3,2) size(im3,1)]);
    colormap('gray');
    imagesc(im3);
    hold on;
    cols1 = size(im1,2);
    for i = 1: size(des1,1)
      if (m_match(i) > 0)
        line([loc1(i,2) loc2(m_match(i),2)+cols1], ...
             [loc1(i,1) loc2(m_match(i),1)], 'Color', 'c');
      end
    end
    hold off;
end
num = sum(m_match > 0);
fprintf('Found %d matches.\n', num);
```

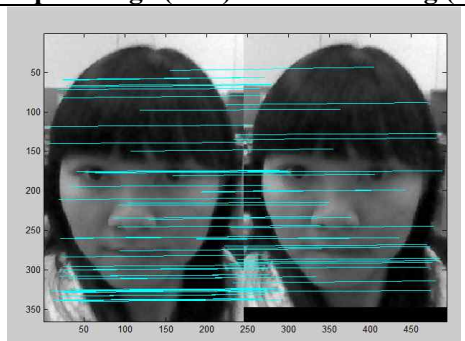
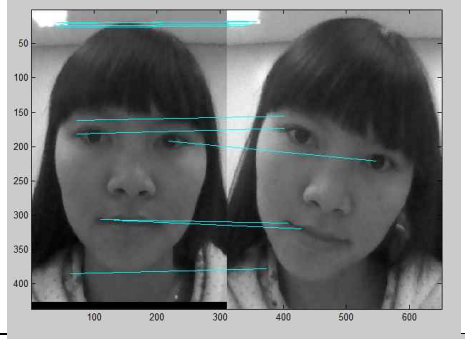
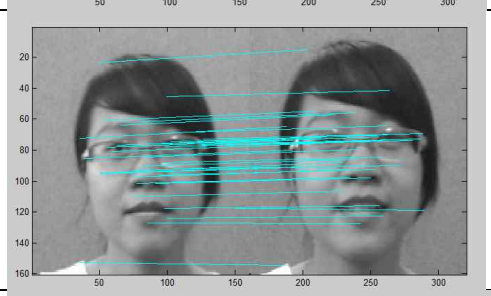
3. Experimental result

Table 1: Face database

Table 2: Test Images

- Look at the experimental result below:
  - For scaled image, sift descriptor can describe matching features very well.
  - For rotated image, 2 images have a little matching points.
  - So, sift descriptor is not good to applying for face recognition because there are a little sift feature on face

Table 3: Result of face recognition. Lines connect matching points between 2 images

Test case	Input image (Left) – Best Matching (Right)
Scaled Input Image	
Rotated Input Image	
Scaled Input Image	
Scaled Input Image	
Rotated Input Image