Certificate

This is to certify that this report is submitted by Digvijay Singh,N Naga Sai Krishna, Samanway Dey,Abhinav Srihari.R students of Computer Science and Engineering, Indian School of Mines, Dhanbad and they have successfully completed a project on Facial Expression Recognition in 4th Semester of Academic year 2015-2016.

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Contents

1. Introduction…………………………………………………………………4
2. Theory………………………………………………………………………5
3. Approach……………………………………………………………………6
   1. Correlation coefficient………………………………………………..7
   2. Discrete Cosine Transform………………………………………….8
   3. HU Moments………………………………………………………….9
4. Code and Analysis………………………………………………………10
5. Conclusion and Reference…………..…………………………………15

INTRODUCTION

A facial expression is one or more motions or positions of the muscles beneath the skin of the face. Facialrecognition is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database.

The human face plays an important role in our social interaction, conveying people’s identity. Using the human face as a key to security, biometric face recognition technology has received significant attention in the past several years due to its potential for a wide variety of applications in both law enforcement and non-law enforcement.

As compared with other biometrics systems using fingerprint/palm-print and iris, face recognition has distinct advantages because of its non-contact process. Face images can be captured from a distance without touching the person being identified, and the identification does not require interacting with the person. In addition, face recognition serves the crime deterrent purpose because face images that have been recorded and archived can later help identify a person.

Most current facial recognition systems work with numeric codes called faceprints. Such systems identify 80 nodal points on a human face. In this context, nodal points are end points used to measure variables of a person’s face, such as the length or width of the nose, the depth of the eye sockets and the shape of the cheekbones. Now, facial expression recognition is identifying the actual expression or emotion of the face in the sample image.

THEORY

Among the different biometric techniques, facial recognition may not be most reliable and efficient. However, one key advantage is that it does not require the cooperation of the test subject to work. Properly designed systems installed in airports, multiplexes, and other public places can identify individuals among the crowd, without passers-by even being aware of the system.

**Weaknesses**

Face recognition is not perfect and struggles to perform under certain conditions.

* Face recognition has been getting pretty good at full frontal faces and 20 degrees off, but as soon as you go towards profile, there've been problems.
* Other conditions where face recognition does not work well include poor lighting, sunglasses, long hair, or other objects partially covering the subject’s face, and low resolution images.
* Another serious disadvantage is that many systems are less effective if facial expressions vary. Even a big smile can render the system less effective.

**Effectiveness**

* Facial recognition can be a crime-fighting tool that law enforcement agencies can use to recognize people based on their eyes and face. There has been a flurry of activity in biometric solutions being employed by the security industry and law enforcement recently, facial recognition in particular.
* States like New York are now using facial recognition to catch identity thieves and other criminals committing fraud.
* Underage drinkers can now be outed easily using facial recognition technology. In fact, a supermarket chain is using face recognition cameras to prevent staff from selling alcohol to minors.

Approach

**1. Correlation Coefficient**

A correlation coefficient is a coefficient that illustrates a quantitative measure of some type of correlation and dependence, meaning statistical relationships between two or more random variables or observed data values.

Correlation coefficient formula is used to find how strong a relationship is between data. The formula returns a value between -1 and 1, where: 1 indicates a strong positive relationship & -1 indicates a strong negative relationship.

The correlation coefficient is used for security applications such as surveillance, treaty verification, tamper detection using security seals, and tagging. In theory, we would obtain an r value of 1 if the object is intact, and a value of less than 1 if alteration or movement has occurred.

Despite its advantages, the correlation coefficient has many problems and limitations. The most widely recognized disadvantage is that it is computationally intensive. This often limits its usefulness for image registration (that is, orienting and positioning two images so they overlap). The correlation coefficient is also extremely sensitive to the image skewing and pin cushioning that inevitably occur in imaging systems.

**2. Discrete Cosine Transform (DCT)**

The discrete cosine transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality).

The basic operation of the DCT is as follows:

* + The input image is N by M;
  + f(i,j) is the intensity of the pixel in row i and column j.
  + F(u,v) is the DCT coefficient in row k1 and column k2 of the DCT matrix.
  + For most images, much of the signal energy lies at low frequencies; these appear in the upper left corner of the DCT.
  + Compression is achieved since the lower right values represent higher frequencies, and are often small - small enough to be neglected with little visible distortion.
  + The DCT input is an 8 by 8 array of integers. This array contains each pixel's gray scale level;
  + 8 bit pixels have levels from 0 to 255.Therefore an 8 point DCT would be:



where,



**3. HU Moments**

An image moment is a certain particular weighted average (moment) of the image pixels' intensities, or a function of such moments, usually chosen to have some attractive property or interpretation.

Image moments are useful to describe objects after segmentation. Simple properties of the image which are found *via* image moments include area (or total intensity), its centroid, and information about its orientation.

Central moments are defines as,



where

 

are the components of centroid.

The normalized central moments,



Hu moment Invariants,



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The first one, *I*1, is analogous to the moment of inertia around the image's centroid, where the pixels' intensities are analogous to physical density. The last one, *I*7, is skew invariant, which enables it to distinguish mirror images of otherwise identical images.

Matlab code for calculating correlation coefficient of two images

%co-relation co-efficient for 2 images

%This function divides image into 16 parts And calculates r for each part

%Saves r for each part into a vector

%function returns r for parts

function r=rparts1(img1,img2)

p1=parts(img1);

p2=parts(img2);

cnt=1;

for i=1:4

for j=1:4

r(i,j)=add\_gray(p1(:,:,cnt),p2(:,:,cnt));

cnt=cnt+1;

end

end

end

%function for calculating r

function ccr=add\_gray(i1,i2)

c=covar\_gray(i1,i2);

s1=standard\_deviation\_gray(i1);

s2=standard\_deviation\_gray(i2);

ccr=c/(s1\*s2);

end

%function for covariance

function [m1 m2]=covar\_gray(i1,i2)

v1=sum(i1);

v1=sum(v1);

v2=sum(i2);

v2=sum(v2);

[m,o]=size(i1);

n=m\*o;

v1=v1/n;

v2=v2/n;

i1=uint32(i1);

i2=uint32(i2);

for j=1:m

for k=1:o

i1(j,k)=i1(j,k)\*i2(j,k);

end

end

V1=sum(i1);

V1=sum(V1);

V1=V1/n;

c=V1-v1\*v2;

m1=v1;

m2=v2;

end

%function for standard deviation

function s=standard\_deviation\_gray(i)

[m n]=size(i);

v=sum(i);

v=sum(v);

i=uint32(i);

i=power(i,2);

V=sum(i);

V=sum(V);

n=n\*m;

s=sqrt(V/n-((v/n)\*(v/n)));

end

%function for dividng image into 16 parts

function p=parts(img)

[M N]=size(img);

m=ceil(M/4);

n=ceil(N/4);

cnt=1;

i=1;

while(i<=M)

j=1;

while(j<=N)

a=1;

for k=i:i+m-1

b=1;

for l=j:j+n-1

p(a,b,cnt)=img(k,l);

b=b+1;

end

a=a+1;

end

cnt=cnt+1;

j=j+n;

end

i=i+m;

end;

end

**Analysis:**

1. r for normal face and angry face





0.8312 0.8069 0.8721 0.8055

0.8614 0.9071 0.8756 0.9039

0.7739 0.8130 0.8019 0.4855

0.7439 0.6975 **0.3316** 0.6874

1. r for normal face and happy face

 

0.9137 0.9621 0.9651 0.8280

0.9447 0.9296 0.9344 0.9128

0.8704 0.8334 0.5390 0.5227

0.6176 0.6776 0.5107 0.7914

1. r for normal face and fear face

 

0.7970 0.8536 0.9300 0.7554

0.8296 0.9270 0.9224 0.8955

0.7173 0.9288 0.8877 0.4692

0.7047 0.6930 0.4075 0.7275

1. r for normal face and surprise face

 

0.8743 0.9290 0.9672 0.7856

0.9289 0.9512 0.8837 0.8683

0.7888 0.9077 0.8727 0.3219

0.5308 0.5570 **0.1901** 0.6914

1. r for normal face and disgust face

 

0.8197 0.8293 0.8228 0.7955

0.9112 0.8807 0.8438 0.9344

0.8228 0.8000 0.6165 0.6634

0.7648 0.7052 **0.4643** 0.6712

1. r for normal face and sad face

 

0.8521 0.8899 0.8732 0.8339

0.9406 0.9468 0.8957 0.9392

0.8020 0.9308 0.8525 0.6858

0.6492 0.6655 **0.3708** 0.7117

Note:

1. r stands for co-relation co-efficient between 2 images.
2. Underlined numbers are the corresponding places where a change is occurring during the change in expression.
3. Underlined bold numbers are the place where a major change occurs during expression change.

Matlab code for calculation of Hu Moment Invariants

% Hu Moments of order 2 and 3

% This function calculates hu moments acording to the formulas given

% First of all the central moments(mu(i,j)) and center of mass(x\_bar,y\_bar)

% of the image are calculated according to the formulas given

% then hu moments are calculated and saved in a vector as an output

function hu\_moments\_vector = hu\_moments( image )

[height, width] = size(image);

% defining a co-ordinate system for image

xgrid = repmat((-floor(height/2):1:ceil(height/2)-1)',1,width);

ygrid = repmat(-floor(width/2):1:ceil(width/2)-1,height,1);

[x\_bar, y\_bar] = centerOfMass(image,xgrid,ygrid);

% normalize coordinate system by subtracting mean

xnorm = x\_bar - xgrid;

ynorm = y\_bar - ygrid;

% central moments

mu\_11 = central\_moments( image ,xnorm,ynorm,1,1);

mu\_20 = central\_moments( image ,xnorm,ynorm,2,0);

mu\_02 = central\_moments( image ,xnorm,ynorm,0,2);

mu\_21 = central\_moments( image ,xnorm,ynorm,2,1);

mu\_12 = central\_moments( image ,xnorm,ynorm,1,2);

mu\_03 = central\_moments( image ,xnorm,ynorm,0,3);

mu\_30 = central\_moments( image ,xnorm,ynorm,3,0);

%calculating the first 8 hu moments of order 2 and 3

I\_one = mu\_20 + mu\_02;

I\_two = (mu\_20 - mu\_02)^2 + 4\*mu\_11\*mu\_11;

I\_three = (mu\_30 - 3\*mu\_12)^2 + (mu\_03 - 3\*mu\_21)^2;

I\_four = (mu\_30 + mu\_12)^2 + (mu\_03 + mu\_21)^2;

I\_five = (mu\_30 - 3\*mu\_12)\*(mu\_30 + mu\_12)\*((mu\_30 + mu\_12)^2 - 3\*(mu\_21 + mu\_03)^2) + (3\*mu\_21 - mu\_03)\*(mu\_21 + mu\_03)\*(3\*(mu\_30 + mu\_12)^2 - (mu\_03 + mu\_21)^2);

I\_six = (mu\_20 - mu\_02)\*((mu\_30 + mu\_12)^2 - (mu\_21 + mu\_03)^2) + 4\*(mu\_30 + mu\_12)\*(mu\_21 + mu\_03)\*mu\_11;

I\_seven = (3\*mu\_21 - mu\_03)\*(mu\_30 + mu\_12)\*((mu\_30 + mu\_12)^2 - 3\*(mu\_21 + mu\_03)^2) + (3\*mu\_12 - mu\_30)\*(mu\_21 + mu\_03)\*(3\*(mu\_30 + mu\_12)^2 - (mu\_21 + mu\_03)^2);

I\_eight = mu\_11\*(mu\_30 + mu\_12)^2 - (mu\_03 + mu\_21)^2 - (mu\_20 - mu\_02)\*(mu\_30 + mu\_12)\*(mu\_21 + mu\_03);

hu\_moments\_vector = [I\_one, I\_two, I\_three,I\_four,I\_five,I\_six,I\_seven,I\_eight];

end

% calculating the scale invariant central moments

function cm = central\_moments( image ,xnorm,ynorm,p,q)

cm = sum(sum((xnorm.^p).\*(ynorm.^q).\*image));

cm\_00 = sum(sum(image));

% normalise moments for scale invariance

cm = cm/(cm\_00^(1+(p+q)/2));

end

% calculating center of mass

function [x\_bar, y\_bar] = centerOfMass(image,xgrid,ygrid)

eps = 10^(-6); % very small constant

x\_bar = sum(sum((xgrid.\*image)))/(sum(image(:))+eps);

y\_bar = sum(sum((ygrid.\*image)))/(sum(image(:))+eps);

end

Analysis:

HU’s 7 invariant moment for a sad face and a normal face

 

Normal face: 0.0141 1.9948e-04 1.2305e-07 1.2305e-07 1.5141e-14 1.7379e-09 0

Sad face : 0.0140 1.9471e-04 1.2441e-07 1.2441e-07 1.5477e-14 1.7359e-09 0

Note: The above result shows that the HU’s moment are invariant of expression of the person.

Conclusion

We have successfully implemented the correlation coefficient and HU moments and verified them over the images of the sample database and realized where the major changes occurs in nodal points of a face for particular facial expression.

Reference

* We have used Jaffe Database for all the analysis of the codes.
* https://en.wikipedia.org/wiki/Discrete\_cosine\_transform
* https://en.wikipedia.org/wiki/Facial\_expression
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* http://www.academia.edu/5307215/Facial\_Recognition\_using\_digital\_image\_processing