

```
% 读取原图并分割左右眼
```

```
I = imread('./Data/eye1.jpg');
```

```
figure(1);
```

```
imshow(I);
```

```
suptitle('原图');
```

```
I_gray = rgb2gray(I);
```

```
Eye_R = I(270:700,229:695);
```

```
Eye_L = I(250:600,866:1310);
```

原图



对右眼进行二值化和边缘检测

```
Eye_R_bw = imbinarize(Eye_R,0.56);
```

```
mask = false(size(Eye_R_bw));
```

```
mask(130:270,:) = true;
```

```
h=fspecial('gaussian',5);
```

```
Eye_R_bw = imfilter(Eye_R_bw,h);
```

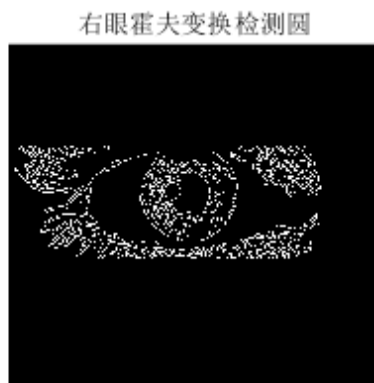
```
Eye_R_edge = edge(Eye_R_bw, 'canny');
```

```
Eye_R_edge = Eye_R_edge .* mask;
```

```
figure(2);

subplot(1,2,1);imshow(Eye_R_edge);hold on;

title("右眼霍夫变换检测圆");
```



检测右眼瞳孔外圆

```
rmin = 60;

houghspace_eye_R = Hough(Eye_R_edge,rmin,rmin+30,pi/100);

houghspace_size = size(houghspace_eye_R);

max_hough = max(max(max(houghspace_eye_R)));

index = find(houghspace_eye_R == max_hough);

[a1,b1,r1] = ind2sub(houghspace_size,index);

alpha = 0:pi/100:2*pi;

r1 = r1 + rmin;

x = a1 + r1*cos(alpha);
```

```
y = b1 + r1*sin(alpha);
```

```
plot(y,x,'-');
```

右眼霍夫变换检测圆



检测右眼瞳孔内圆

```
rmin = 15;
```

```
houghspace_eye_R = Hough(Eye_R_edge,rmin,rmin+10,pi/100);
```

```
houghspace_size = size(houghspace_eye_R(a1-5:a1+5,b1-5:b1+5,:));
```

```
max_hough = max(max(max(houghspace_eye_R(a1-5:a1+5,b1-5:b1+5,:))));
```

```
index = find(houghspace_eye_R(a1-5:a1+5,b1-5:b1+5,:) == max_hough);
```

```
[a2,b2,r2] = ind2sub([10,10,houghspace_size(3)],index);
```

```
a2 = a2 + a1 - 5;
```

```
b2 = b2 + b1 - 5;
```

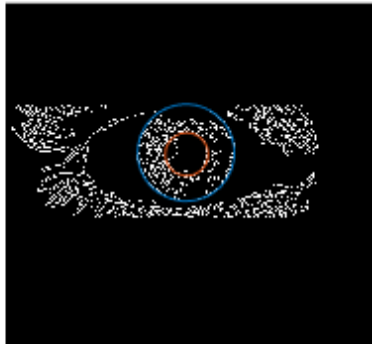
```
r2 = r2+rmin;
```

```
x = a2 + r2*cos(alpha);
```

```
y = b2 + r2*sin(alpha);
```

```
plot(y,x,'-');
```

右眼霍夫变换检测圆



检测右眼上下眼睑

```
rmin = 170;
```

```
houghspace_eye_R = Hough(Eye_R_edge,rmin,rmin+30,pi/100);
```

```
houghspace_size = size(houghspace_eye_R);
```

```
max_hough = max(max(max(houghspace_eye_R)));
```

```
index = find(houghspace_eye_R == max_hough);
```

```
[a3,b3,r3] = ind2sub(houghspace_size,index);
```

```
r3 = r3+rmin;
```

```
x = a3 + r3*cos(alpha);
```

```
y = b3 + r3*sin(alpha);
```

```
plot(y,x,'-');
```

```

rmin = 200;

houghspace_eye_R = Hough(Eye_R_edge,rmin,rmin+10,pi/100);

max_hough = max(max(max(houghspace_eye_R(floor(houghspace_size(1)/2):end,:,:),:)));

index = find(houghspace_eye_R(floor(houghspace_size(1)/2):end,:,:) == max_hough);

[a4,b4,r4] =

ind2sub([ceil(houghspace_size(1)/2),houghspace_size(2),houghspace_size(3)],index);

a4 = a4(2) + floor(houghspace_size(1)/2);

b4 = b4(2);

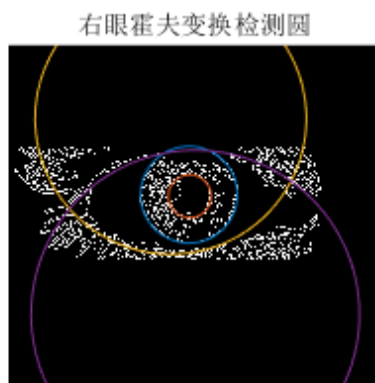
r4 = r4(2) + rmin;

x = a4 + r4*cos(alpha);

y = b4 + r4*sin(alpha);

plot(y,x,'-');

```



利用得到的圆心和半径制作 mask

```

eye_R_mask = ones(size(Eye_R_bw));

[m,n] = size(eye_R_mask);

for i = 1:m

    for j = 1:n

        D1 = sqrt((i-a1)^2+(j-b1)^2);

        D2 = sqrt((i-a2)^2+(j-b2)^2);

        D3 = sqrt((i-a3)^2+(j-b3)^2);

        D4 = sqrt((i-a4)^2+(j-b4)^2);

        if (D1<=r1&&D2>=r2&&D3<=r3&&D4<=r4)

            eye_R_mask(i,j) = 0;

        end

    end

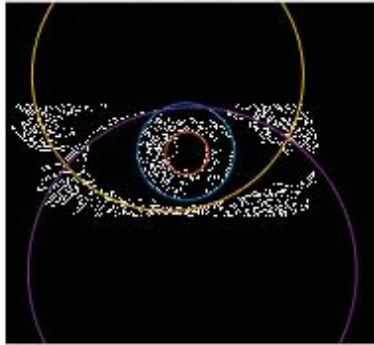
end

subplot(1,2,2);imshow(im2double(Eye_R) .* eye_R_mask);

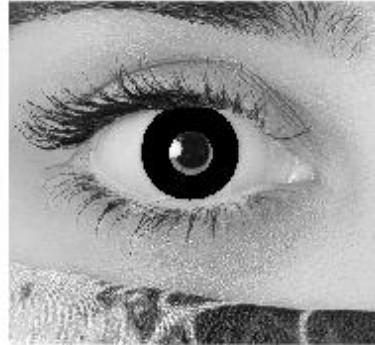
title("右眼去除瞳孔");

```

右眼霍夫变换检测圆



右眼去除瞳孔



对左眼进行二值化和边缘检测

```
Eye_L_bw = imbinarize(Eye_L,0.5);  
  
mask = false(size(Eye_L_bw));  
  
mask(100:270,:) = true;  
  
h=fspecial('gaussian',5);  
  
Eye_L_bw = imfilter(Eye_L_bw,h);  
  
Eye_L_edge = edge(Eye_L_bw,'canny');  
  
Eye_L_edge = Eye_L_edge .* mask;  
  
figure(3);  
  
subplot(1,2,1);imshow(Eye_L_edge);hold on;  
  
title('左眼霍夫变换检测圆');
```

左眼霍夫变换检测圆



检测左眼外圆

```
rmin = 60;

houghspace_eye_L = Hough(Eye_L_edge,rmin,rmin+30,pi/100);

houghspace_size = size(houghspace_eye_L);

max_hough = max(max(max(houghspace_eye_L)));

index = find(houghspace_eye_L == max_hough);

[a1,b1,r1] = ind2sub(houghspace_size,index);

alpha = 0:pi/100:2*pi;

r1 = r1 + rmin;

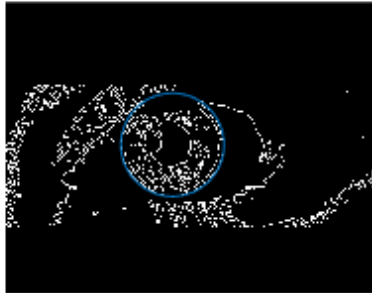
x = a1 + r1*cos(alpha);

y = b1 + r1*sin(alpha);

plot(y,x,'-');
```



左眼霍夫变换检测圆



检测左眼内圆

```
rmin = 20;

houghspace_eye_L = Hough(Eye_L_edge,rmin,rmin+10,pi/100);

houghspace_size = size(houghspace_eye_L(a1-5:a1+5,b1-5:b1+5,:));

max_hough = max(max(max(houghspace_eye_L(a1-5:a1+5,b1-5:b1+5,:))));

index = find(houghspace_eye_L(a1-5:a1+5,b1-5:b1+5,:) == max_hough);

[a2,b2,r2] = ind2sub([10,10,houghspace_size(3)],index);

a2 = a2 + a1 - 5;

b2 = b2 + b1 - 5;

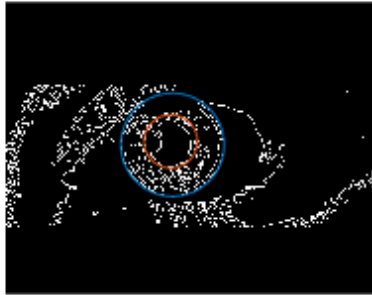
r2 = r2+rmin;

x = a2 + r2*cos(alpha);

y = b2 + r2*sin(alpha);

plot(y,x, '-');
```

左眼霍夫变换检测圆



检测左眼上下眼睑

```
rmin = 170;

houghspace_eye_L = Hough(Eye_R_edge,rmin,rmin+30,pi/100);

houghspace_size = size(houghspace_eye_L);

max_hough = max(max(max(houghspace_eye_L)));

index = find(houghspace_eye_L == max_hough);

[a3,b3,r3] = ind2sub(houghspace_size,index);

r3 = r3+rmin;

x = a3 + r3*cos(alpha);

y = b3 + r3*sin(alpha);

plot(y,x, '-');

rmin = 200;

houghspace_eye_L = Hough(Eye_R_edge,rmin,rmin+10,pi/100);
```

```

max_hough = max(max(max(houghspace_eye_L(floor(houghspace_size(1)/2):end,:,:),:));

index = find(houghspace_eye_L(floor(houghspace_size(1)/2):end,:,:) == max_hough);

[a4,b4,r4] =
ind2sub([ceil(houghspace_size(1)/2),houghspace_size(2),houghspace_size(3)],index);

a4 = a4(2) + floor(houghspace_size(1)/2);

b4 = b4(2);

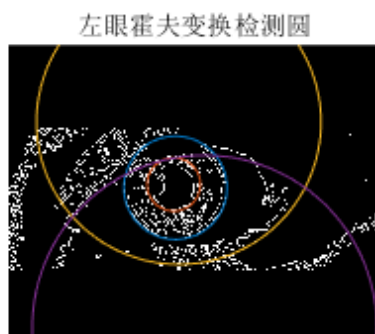
r4 = r4(2) + rmin;

x = a4 + r4*cos(alpha);

y = b4 + r4*sin(alpha);

plot(y,x,'-');

```



根据检测得到的圆心和半径制作 mask

```

eye_L_mask = ones(size(Eye_L_bw));

[m,n] = size(eye_L_mask);

```

```

for i = 1:m

    for j = 1:n

        D1 = sqrt((i-a1)^2+(j-b1)^2);

        D2 = sqrt((i-a2)^2+(j-b2)^2);

        D3 = sqrt((i-a3)^2+(j-b3)^2);

        D4 = sqrt((i-a4)^2+(j-b4)^2);

        if (D1<=r1&&D2>=r2&&D3<=r3&&D4<=r4)

            eye_L_mask(i,j) = 0;

        end

    end

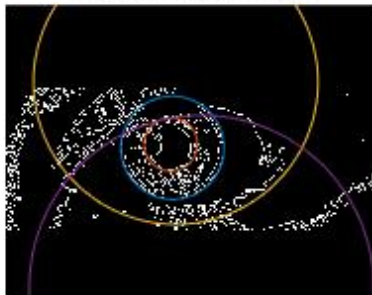
end

subplot(1,2,2);imshow(im2double(Eye_L) .* eye_L_mask);

title('左眼去除瞳孔');

```

左眼霍夫变换检测圆



左眼去除瞳孔



制作总体的 mask 并修改瞳孔颜色，以 RGB 值(0.2,0.5,0.3)为范例

```
total_mask = ones(size(I_gray));

total_mask(270:700,229:695) = eye_R_mask;

total_mask(250:600,866:1310) = eye_L_mask;

new_I = im2double(I);

new_I(:,:,1) = new_I(:,:,1) .* total_mask;

new_I(:,:,2) = new_I(:,:,2) .* total_mask;

new_I(:,:,3) = new_I(:,:,3) .* total_mask;

new_I(:,:,1) = new_I(:,:,1) + ~total_mask*0.2;

new_I(:,:,2) = new_I(:,:,2) + ~total_mask*0.5;

new_I(:,:,3) = new_I(:,:,3) + ~total_mask*0.3;

figure(4);

suptitle('更换瞳孔颜色');

imshow(new_I);
```

更换瞳孔颜色



*Published with MATLAB® R2018b*