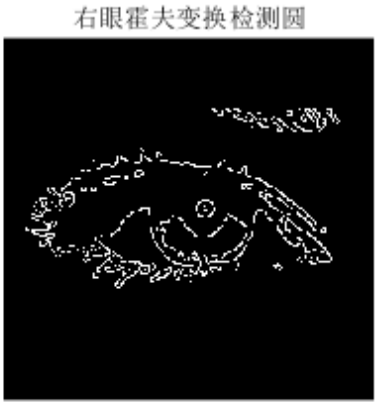
```
% 读取原图并分割左右眼

I = imread('./Data/eye2.jpg');

figure(1);

imshow(I);

suptitle('原图');

I_gray = rgb2gray(I);

Eye_R = I(58:313,65:326);

Eye_L = I(84:298,463:747);
```

原图

对右眼进行二值化和边缘检测

```
Eye_R_bw = imbinarize(Eye_R,0.4);

mask = false(size(Eye_R_bw));

mask(50:250,:) = 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);
```

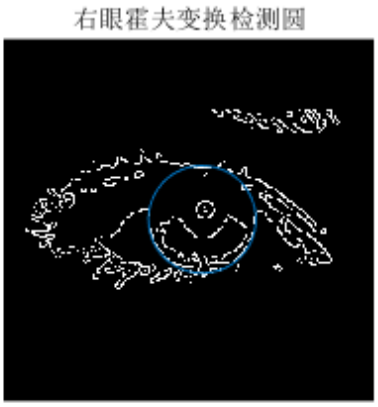
```
subplot(1,2,1);imshow(Eye_R_edge);hold on;

title("右眼霍夫变换检测圆");
```



检测右眼瞳孔外圆

```
rmin = 30;

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);
```

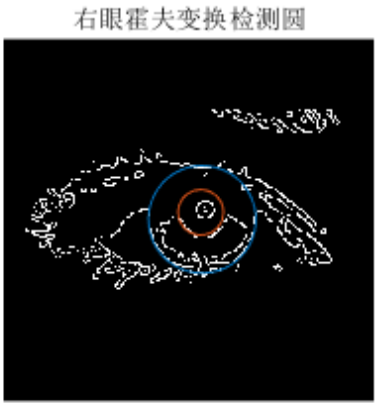
```
plot(y,x,'-');
```



检测右眼瞳孔内圆

```
rmin = 10;

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

houghspace_size = size(houghspace_eye_R(a1-20:a1+10,b1-20:b1+10,:));

max_hough = max(max(max(houghspace_eye_R(a1-20:a1+10,b1-20:b1+10,:))));

index = find(houghspace_eye_R(a1-20:a1+10,b1-20:b1+10,:) == max_hough);

[a2,b2,r2] = ind2sub([30,20,houghspace_size(3)],index);

a2 = a2 + a1 - 20;

b2 = b2 + b1 - 20;

r2 = r2+rmin;

x = a2 + r2*cos(alpha);

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

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

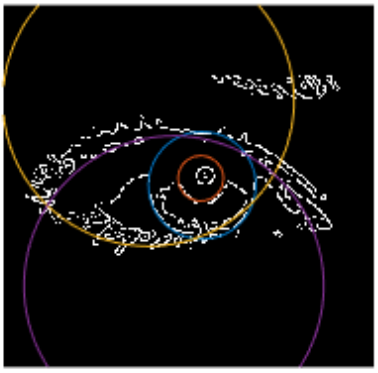


检测右眼上下眼睑

```
rmin = 100;

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);

a3 = a3(1);

b3 = b3(1);

r3 = r3(1)+rmin;

x = a3 + r3*cos(alpha);

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

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

rmin = 100;

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

b4 = b4(1);

r4 = r4(1) + rmin;

x = a4 + r4*cos(alpha);

y = b4 + r4*sin(alpha);

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

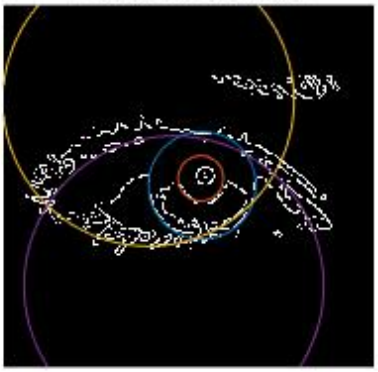
右眼霍夫变换检测圆



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,0.4);

mask = false(size(Eye_L_bw));

mask(90:200,:) = 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

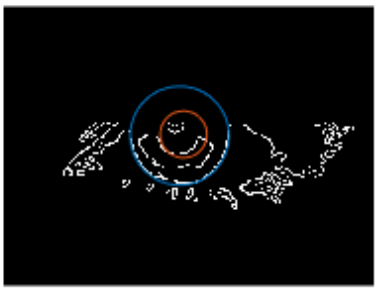
```
rmin = 30;

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 = 10;

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

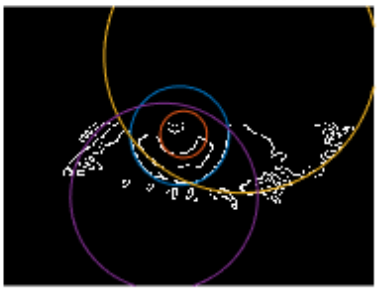


检测左眼上下眼睑

```
rmin = 100;

houghspace_eye_L = Hough(Eye_L_edge,rmin,rmin+10,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 = 65;

houghspace_eye_L = Hough(Eye_L_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(1) + floor(houghspace_size(1)/2);

b4 = b4(1);

r4 = r4(1) + rmin;

x = a4 + r4*cos(alpha);

y = b4 + r4*sin(alpha);

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

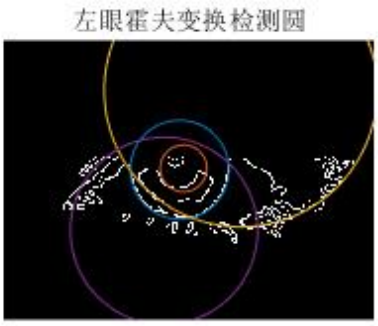
左眼霍夫变换检测圆



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);
```

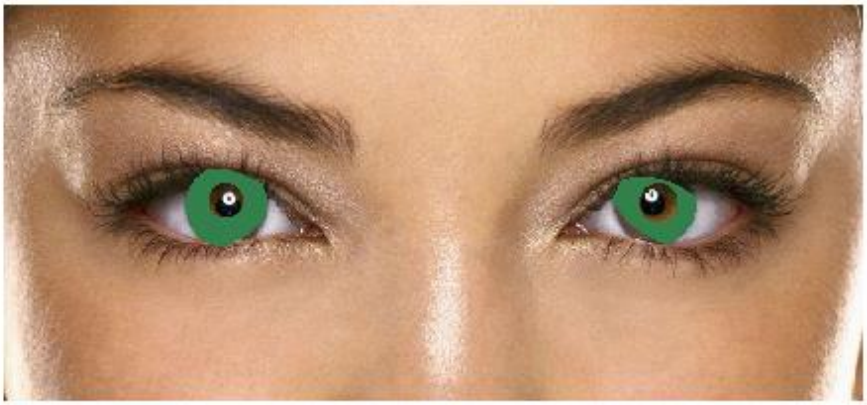
```
for i = 1:m
    for j = 1:n
        D1 = sqrt((i-a1)^2+(j-b1)^2);
        D2 = sqrt((i-a2)^2+(j-b2)^2);
        D3 = sqrt((i-a3)^2+(j-b3)^2);
        D4 = sqrt((i-a4)^2+(j-b4)^2);
        if (D1<=r1&&D2>=r2&&D3<=r3&&D4<=r4)
            eye_L_mask(i,j) = 0;
        end
    end
end
subplot(1,2,2);imshow(im2double(Eye_L) .* eye_L_mask);
title('左眼去除瞳孔');
```



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(58:313,65:326) = eye_R_mask;

total_mask(84:298,463:747) = 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



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