

```
% 读取原图并分割左右眼
```

```
I = imread('./Data/eye3.jpg');
```

```
figure(1);
```

```
imshow(I);
```

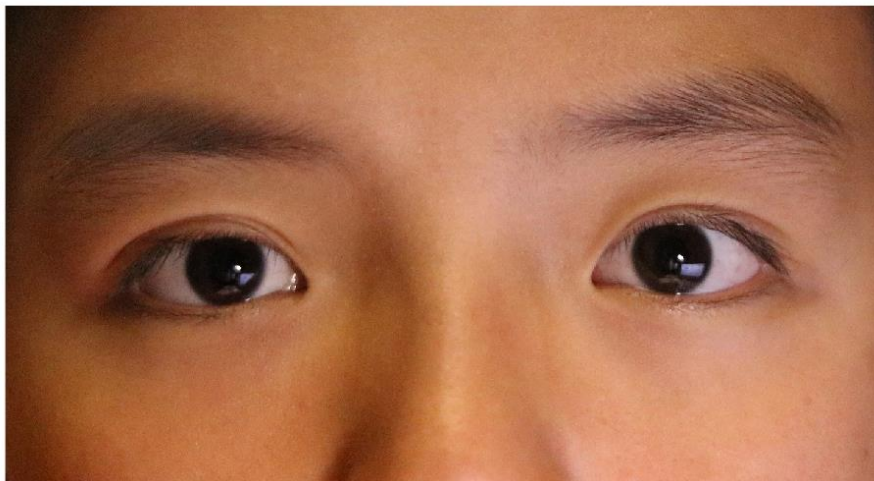
```
suptitle('原图');
```

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

```
Eye_R = I(228:689,88:552);
```

```
Eye_L = I(180:658,910:1426);
```

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(50:400,100:end) = true;
```

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

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

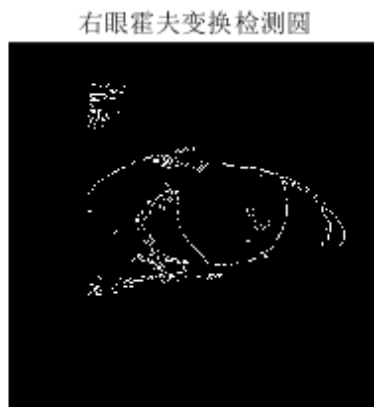
```
Eye_R_edge = edge(Eye_R_bw, 'canny');
```

```
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;

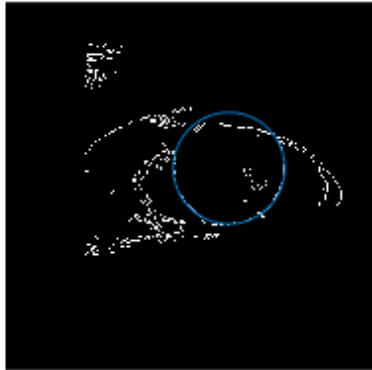
r1 = r1 + rmin;

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

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

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

右眼霍夫变换检测圆



估计右眼瞳孔内圆

```
rmin = 35;
```

```
a2 = a1;
```

```
b2 = b1;
```

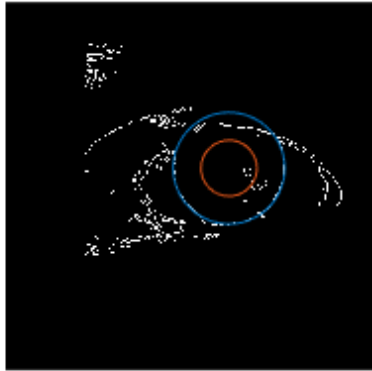
```
r2 = rmin;
```

```
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 = 200;  
  
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 = 200;

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

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

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

[a4,b4,r4] =

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

a4 = a4(1);

b4 = b4(1);

r4 = r4(1) + rmin;

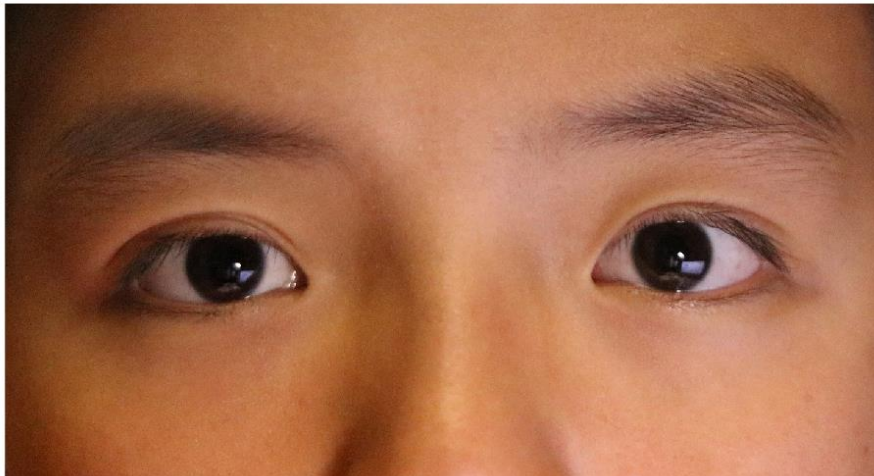
x = a4 + r4*cos(alpha);

y = b4 + r4*sin(alpha);

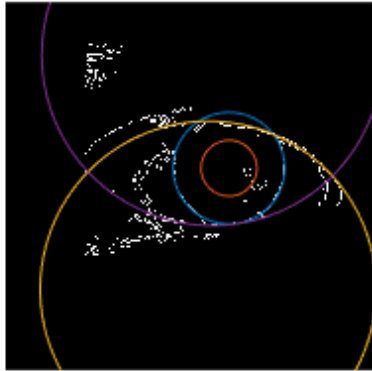
plot(y,x,'-');

```

原图



右眼霍夫变换检测圆



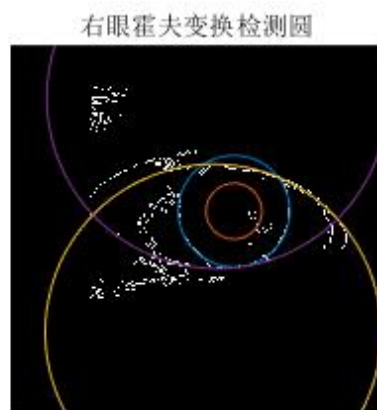
利用得到的圆心和半径制作 mask

```
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
```

```
end
```

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

```
title("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,0.6);
```

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

```
mask(90:400,:) = true;
```

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

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

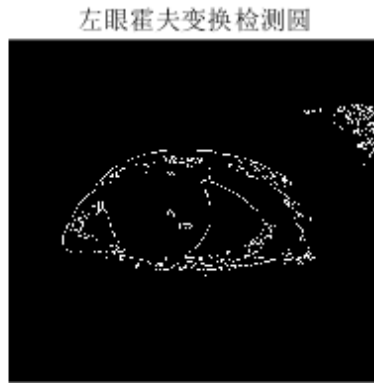
```
Eye_L_edge = edge(Eye_L_bw,'canny');
```

```
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');
```

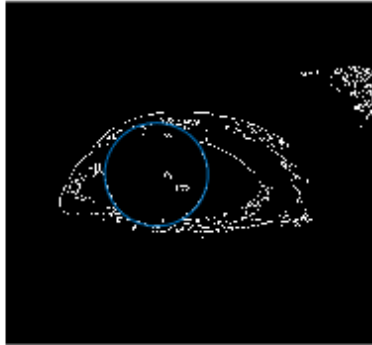


检测左眼外圆

```
rmin = 45;  
  
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,'-');
```



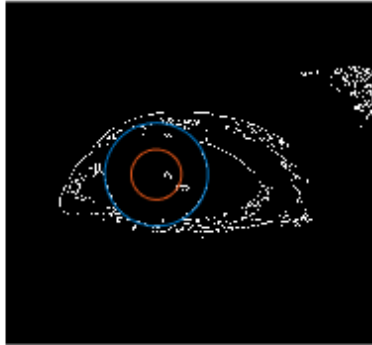
左眼霍夫变换检测圆



估计左眼内圆

```
rmin = 35;  
  
a2 = a1;  
  
b2 = b1;  
  
r2 = rmin;  
  
x = a2 + r2*cos(alpha);  
  
y = b2 + r2*sin(alpha);  
  
hold on;  
  
plot(y,x, '-');
```

左眼霍夫变换检测圆



检测左眼上下眼睑

```
rmin = 220;

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(1:floor(houghspace_size(1)*1/2),:,:))));

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

[a3,b3,r3] =

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

r3 = r3+rmin;

x = a3 + r3*cos(alpha);

y = b3 + r3*sin(alpha);

plot(y,x,'-');

rmin = 200;
```

```

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);

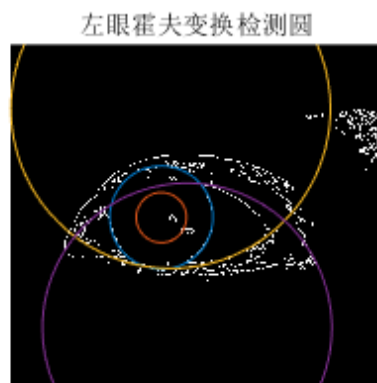
r4 = r4(1) + rmin;

x = a4 + r4*cos(alpha);

y = b4 + r4*sin(alpha);

plot(y,x, '-');

```



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

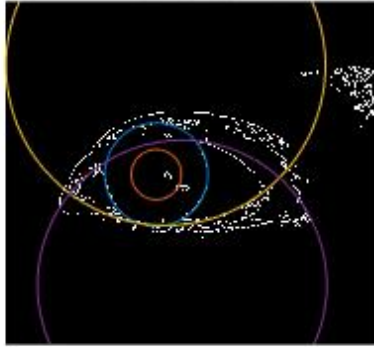
    end

end

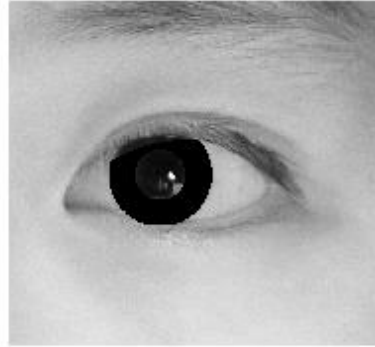
subplot(1,2,2);imshow(im2double(Eye_L) .* eye_L_mask);

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(228:689,88:552) = eye_R_mask;

total_mask(180:658,910:1426) = 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;

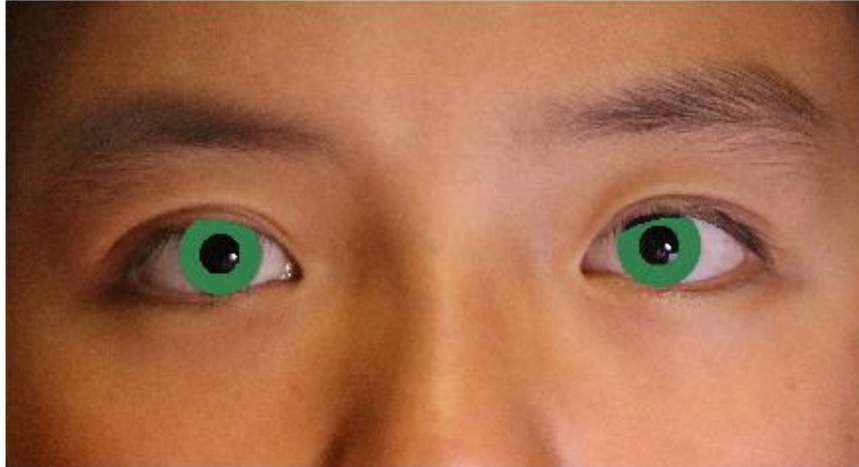
new_I(:,:,3) = new_I(:,:,3) + ~total_mask*0.3;

figure(4);

suptitle('更换瞳孔颜色');
```

```
imshow(new_I);
```

更换瞳孔颜色



*Published with MATLAB® R2018b*