セットアップ

```
from google.colab import drive
drive.mount('/content/drive')
%cd "drive/Shareddrives/doradora-JPHacks2021/"
```

```
Mounted at /content/drive
/content/drive/Shareddrives/doradora-JPHacks2021
```

```
!pip install nbconvert
```

```
Requirement already satisfied: nbconvert in /usr/local/lib/python3.7/dist-packages (5.6.1)
Requirement already satisfied: defusedxml in /usr/local/lib/python3.7/dist-packages (from nbc
Requirement already satisfied: jupyter-core in /usr/local/lib/python3.7/dist-packages (from n
Requirement already satisfied: nbformat>=4.4 in /usr/local/lib/python3.7/dist-packages (from
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.7/dist-packages (from
Requirement already satisfied: pygments in /usr/local/lib/python3.7/dist-packages (from nbcon
Requirement already satisfied: testpath in /usr/local/lib/python3.7/dist-packages (from nbcon
Requirement already satisfied: pandocfilters>=1.4.1 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: mistune<2,>=0.8.1 in /usr/local/lib/python3.7/dist-packages (f
Requirement already satisfied: bleach in /usr/local/lib/python3.7/dist-packages (from nbconve
Requirement already satisfied: jinja2>=2.4 in /usr/local/lib/python3.7/dist-packages (from nb
Requirement already satisfied: entrypoints>=0.2.2 in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/python3.7/dist-packages (fr
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: ipython-genutils in /usr/local/lib/python3.7/dist-packages (fr
Requirement already satisfied: packaging in /usr/local/lib/python3.7/dist-packages (from blea
Requirement already satisfied: webencodings in /usr/local/lib/python3.7/dist-packages (from b
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.7/dist-packages (from ble
Requirement already satisfied: pyparsing>=2.0.2 in /usr/local/lib/python3.7/dist-packages (fr
```

```
!!jupyter nbconvert --to=html './notebook/board_proc'
```

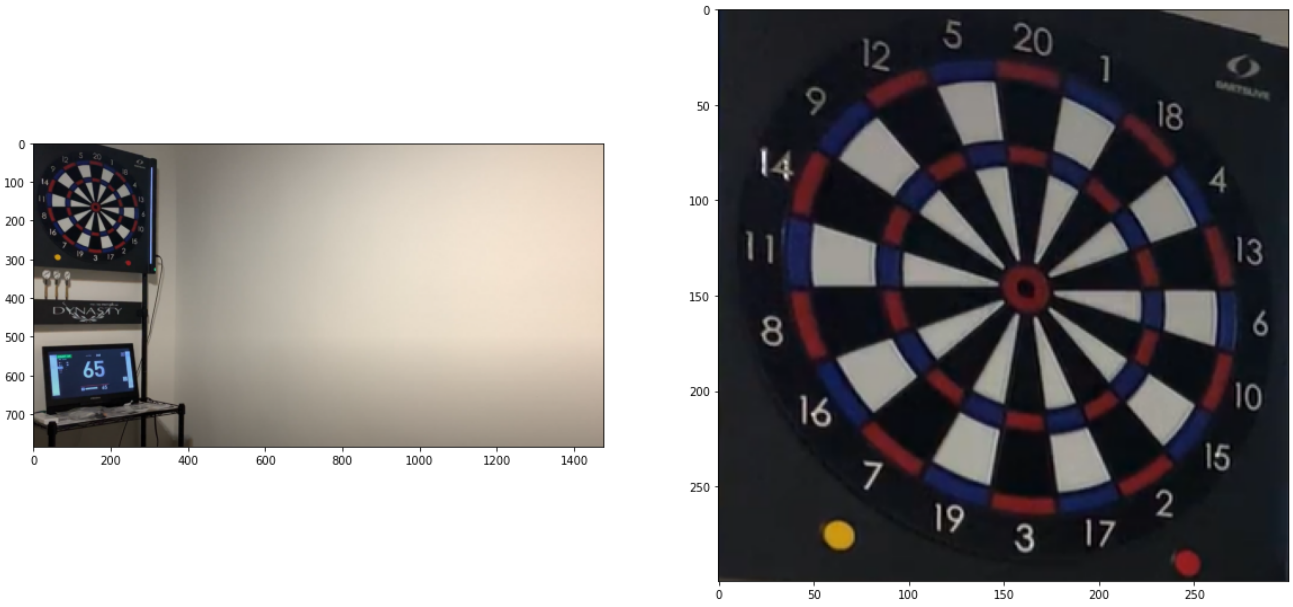
```
['[NbConvertApp] Converting notebook ./notebook/board_proc to html',
 "/usr/local/lib/python2.7/dist-packages/nbconvert/filters/datatypefilter.py:41: UserWarning:
 '  mimetypes=output.keys())',
 '[NbConvertApp] Writing 78118105 bytes to ./notebook/board_pro.html']
```

```
import cv2
import numpy as np
import matplotlib.pyplot as plt
from google.colab.patches import cv2_imshow
from scipy.ndimage import minimum_filter
from scipy.stats import gaussian_kde
from PIL import Image, ImageDraw
from scipy import interpolate
from sklearn.decomposition import PCA
```

```
# img = cv2.imread('video/IMG_0144_crop.png')
```

```
img_org = cv2.imread('video/IMG_0144.png')
img = img_org[20:320,:300]
img_center = img.shape[1]/2, img.shape[0]/2

plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(cv2.cvtColor(img_org, cv2.COLOR_BGR2RGB))
plt.subplot(1,2,2)
plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))
```

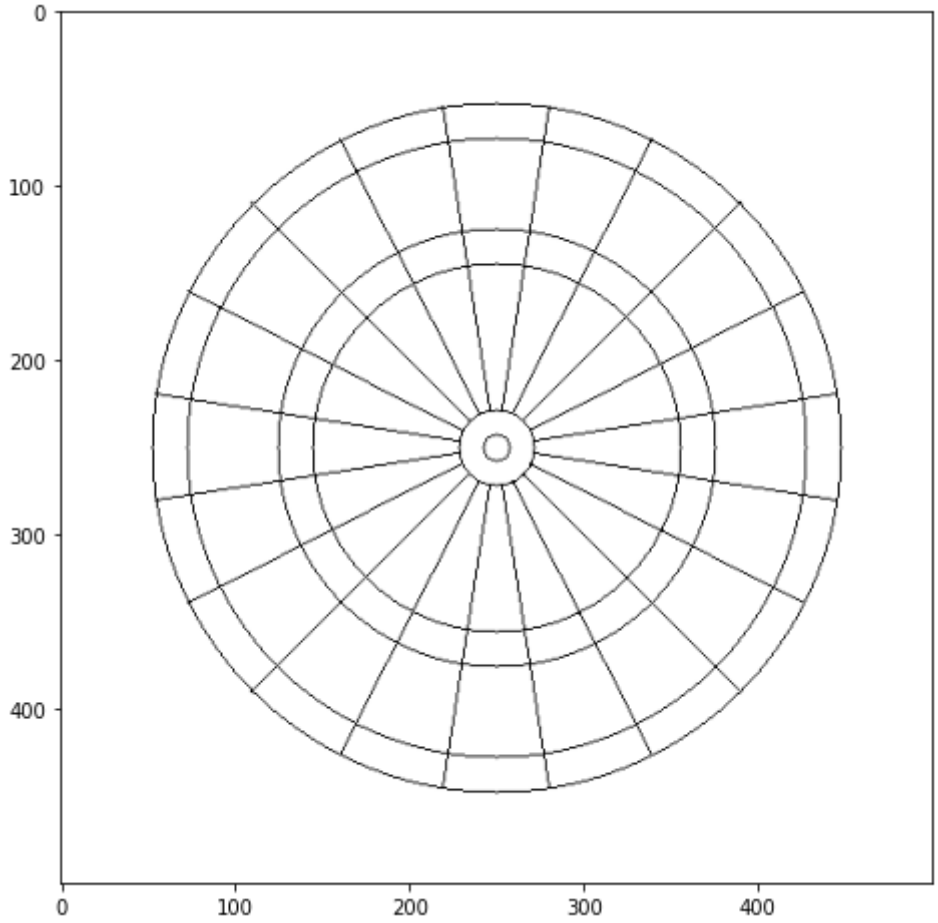
```
<matplotlib.image.AxesImage at 0x7fbdd9c11790>
```



```
coordinate_size = 500
coordinate_center = (250, 250)
coordinate_r2 = 198
coordinate_r = 178
coordinate_margine = coordinate_r/(coordinate_size/2)

img_coordinate = np.ones((coordinate_size,coordinate_size,3), np.float32)*255

cv2.circle(img_coordinate,coordinate_center,radius=8,color=(0,0,0),thickness=1)
cv2.circle(img_coordinate,coordinate_center,radius=22,color=(0,0,0),thickness=1)
cv2.circle(img_coordinate,coordinate_center,radius=106,color=(0,0,0),thickness=1)
cv2.circle(img_coordinate,coordinate_center,radius=106,color=(0,0,0),thickness=1)
cv2.circle(img_coordinate,coordinate_center,radius=126,color=(0,0,0),thickness=1)
```

```
cv2.circle(img_coordinate,coordinate_center,radius=coordinate_r,color=(0,0,0),thickness=1)
cv2.circle(img_coordinate,coordinate_center,radius=coordinate_r2,color=(0,0,0),thickness=1)

for i in range(20):
  cv2.line(img_coordinate,(int(coordinate_center[0]+22*np.cos(2*np.pi/20*i+2*np.pi/40)),int(coordin

plt.figure(figsize=(8,8))
plt.imshow(img_coordinate)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255
<matplotlib.image.AxesImage at 0x7fb1ecc55cd0>
```



正面化

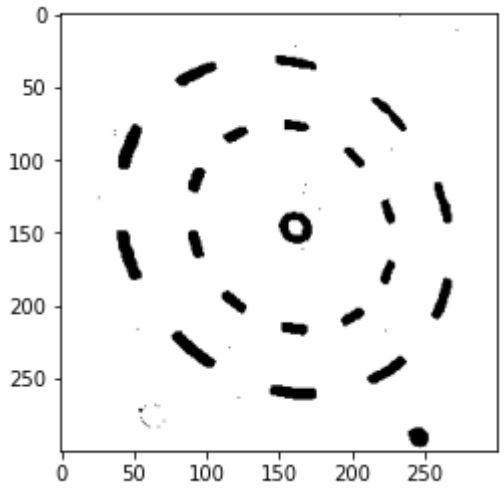
楕円近似案 (不採用)

近似楕円検出

```
img_filltered = img.copy()
# img2[:,:,0] = np.where(img2[:,:,0]<100, 255, 0)
# img2[:,:,2] = np.where(img2[:,:,2]<130, 255, 0)
# img2[:,:,1] = np.ones(img2.shape[:2])*0
```

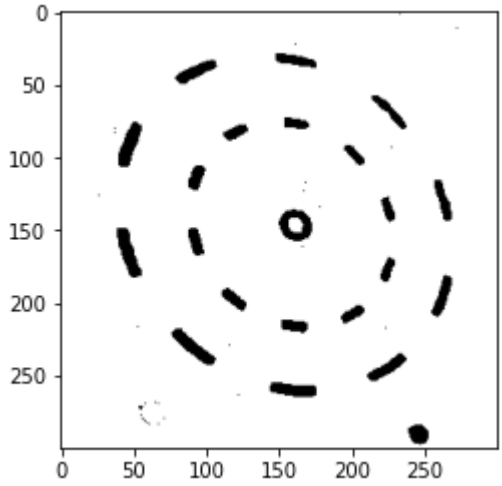
```
cond_red = (img_filltered[:,:,0]<70)&(img_filltered[:,:,1]<70)&(img_filltered[:,:,2]>70)
# cond_blue = (img_filltered[:,:,0]>90)&(img_filltered[:,:,1]<100)&(img_filltered[:,:,2]<100)
cond_blue = False
cond_red_blue = cond_red | cond_blue
# cond_black = (img_filltered[:,:,0]>120)&(img_filltered[:,:,1]>120)&(img_filltered[:,:,2]>120)

img_filltered[:,:,0] = np.where(cond_red_blue, 0, 255)
img_filltered[:,:,1] = np.where(cond_red_blue, 0, 255)
img_filltered[:,:,2] = np.where(cond_red_blue, 0, 255)

plt.imshow(cv2.cvtColor(img_filltered, cv2.COLOR_BGR2RGB))
```

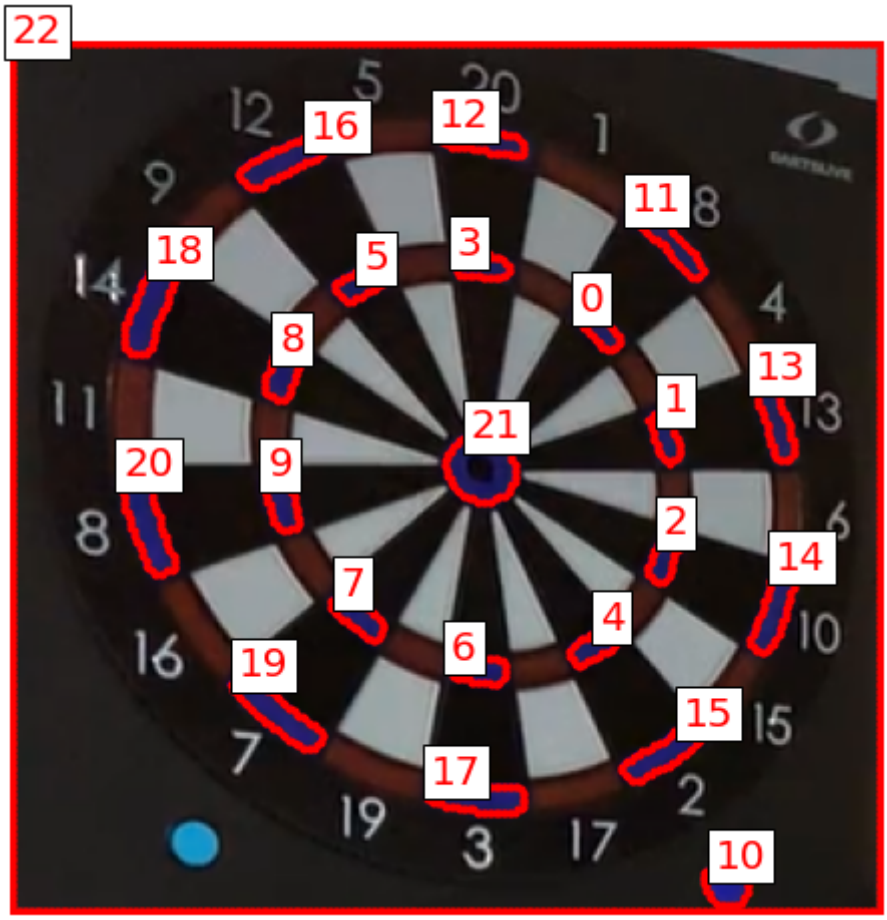
```
<matplotlib.image.AxesImage at 0x7f144020bed0>
```




```
def draw_contours(ax, img, contours):
    ax.imshow(img)
    ax.set_axis_off()

    for i, cnt in enumerate(contours):
        # 形状を変更する。(NumPoints, 1, 2) -> (NumPoints, 2)
        cnt = cnt.squeeze(axis=1)
        # 輪郭の点同士を結ぶ線を描画する。
        ax.add_patch(plt.Polygon(cnt, color="b", fill=None, lw=2))
        # 輪郭の点を描画する。
        ax.plot(cnt[:, 0], cnt[:, 1], "ro", mew=0, ms=4)
        # 輪郭の番号を描画する。
        ax.text(cnt[0][0], cnt[0][1], i, color="r", size="20", bbox=dict(fc="w"))


img_filltered_gray = cv2.bitwise_and(img_filltered[:,:,0], img_filltered[:,:,1])
img_filltered_gray = cv2.bitwise_and(img_filltered_gray, img_filltered[:,:,2])

contours, hierarchy =  cv2.findContours(img_filltered_gray, cv2.RETR_LIST, cv2.CHAIN_APPROX_NONE )
contours = list(filter(lambda x: 1e2 < cv2.contourArea(x) , contours))
contours = np.array(contours)[np.argsort([cv2.contourArea(x) for x in contours])]

plt.imshow(cv2.cvtColor(img_filltered_gray, cv2.COLOR_GRAY2RGB))
fig, ax = plt.subplots(figsize=(8, 8))
draw_contours(ax, img, contours)
plt.show()
```

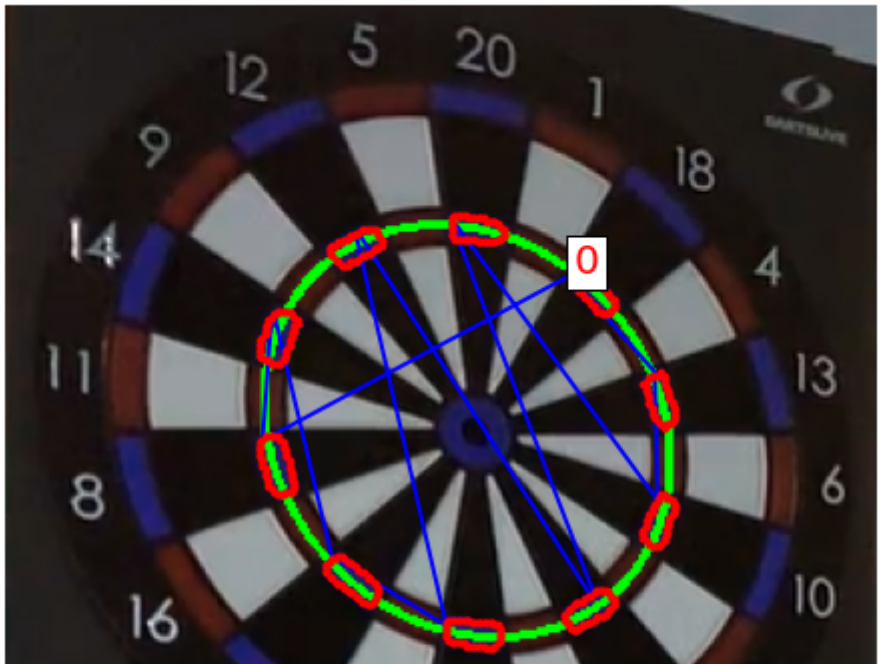
```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:21: VisibleDeprecationWarning: C
```






```
merged_contours = np.vstack(contours[0:10])
ellipse = cv2.fitEllipse(merged_contours)

fig, ax = plt.subplots(figsize=(8, 8))
_ = draw_contours(ax, img, [merged_contours])
img_with_ellipse = cv2.ellipse(img.copy(), ellipse,(0,255,0),2)
plt.imshow(img_with_ellipse)
```

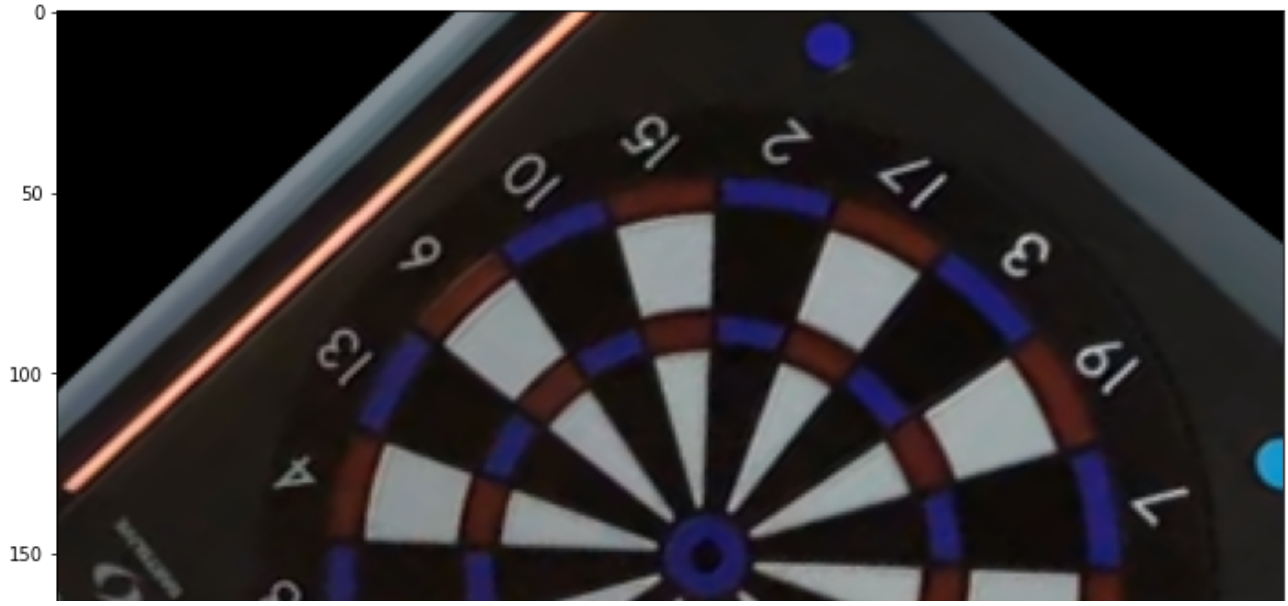
```
<matplotlib.image.AxesImage at 0x7f14400554d0>
```



正面画像に変換

```
angle = ellipse[2]
scale = ellipse[1]
scale = scale[0]/scale[1]

M = cv2.getRotationMatrix2D((img.shape[0]/2, img.shape[1]/2), angle, 1)
M[:,0:2] = np.array([[1,0],[0,scale]]) @ M[:,0:2]
M[1,2] = M[1,2] * scale
img_front = cv2.warpAffine(img, M, dsize=img.shape[:2])

fig = plt.figure(figsize=(12,12))
plt.imshow(img_front)
```

```
<matplotlib.image.AxesImage at 0x7f144ff15210>
```

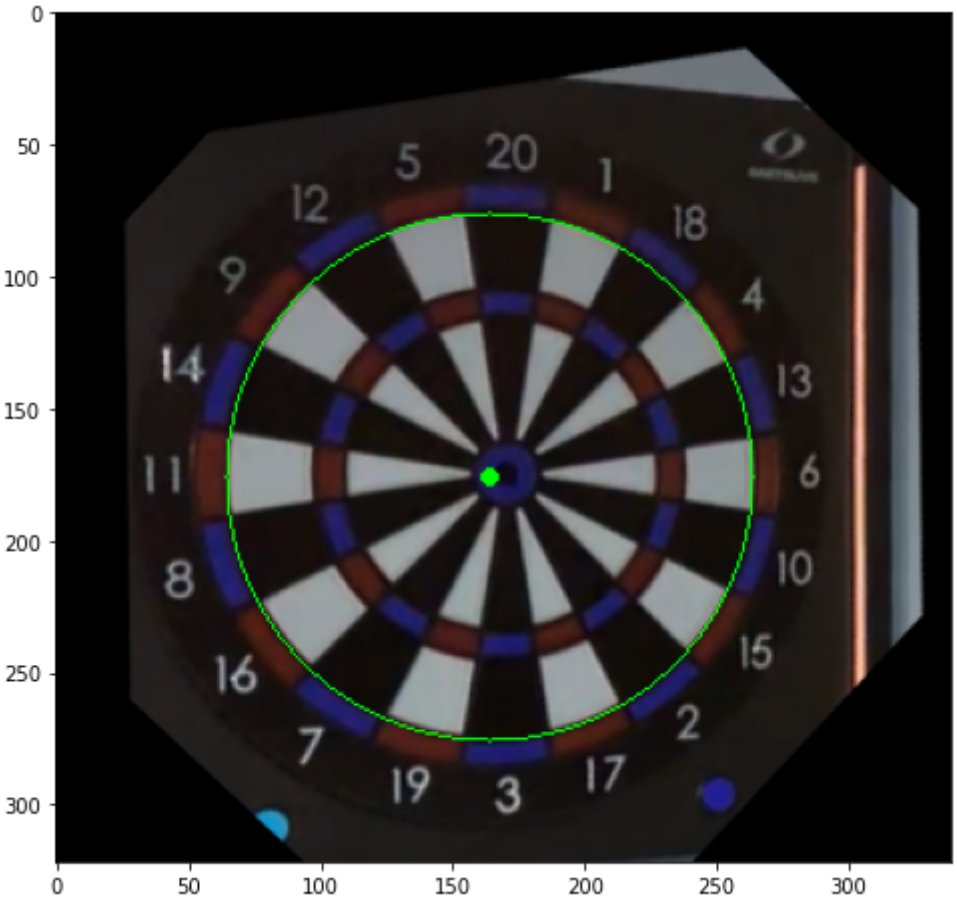



```
M = cv2.getRotationMatrix2D(center=(img.shape[0]/2, img.shape[1]/2), angle=227, scale=1)
img_front2 = cv2.warpAffine(img_front, M, img.shape[:2])

fig = plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(img)
plt.subplot(1,2,2)
plt.imshow(img_front2)
```

```
<matplotlib.image.AxesImage at 0x7f14506fe550>
```

```
img_front2_gray = cv2.cvtColor(img_front2, cv2.COLOR_BGR2GRAY)
circles = cv2.HoughCircles(img_front2_gray , cv2.HOUGH_GRADIENT, dp=1.05, minDist=200, param1=100,

img_front3 = img_front2.copy()
for circle in circles:
  cv2.circle(img_front3, (circle[0], circle[1]), circle[2], (0, 255, 0), 1)
  cv2.circle(img_front3, (circle[0], circle[1]), 2, (0, 255, 0), 2)
plt.figure(figsize=(8,8))
plt.imshow(img_front3)
```

```
<matplotlib.image.AxesImage at 0x7f144f184810>
```

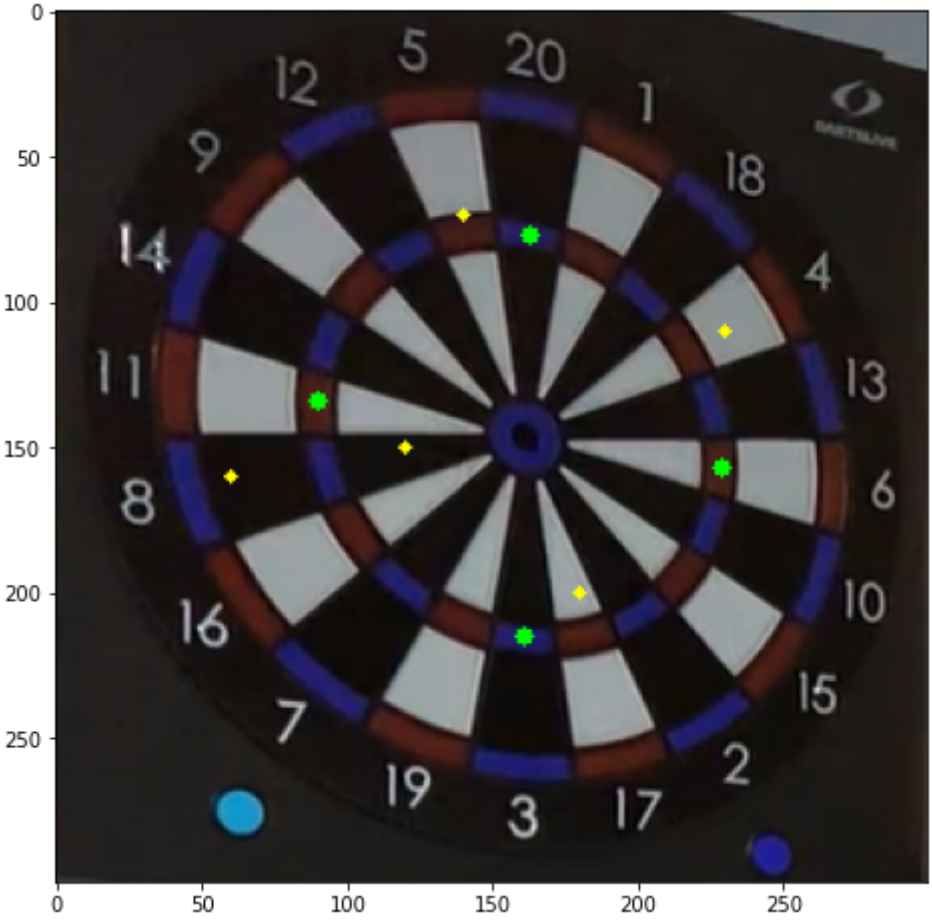


タップでマーキング案 (保留)

```
img_marked = img.copy()
marked_points = [[163, 77],[161, 215],[90, 134],[229, 157]]
for mp in marked_points:
  cv2.circle(img_marked, tuple(mp), 3, (0, 255, 0), -1)

test_points = [[180, 200], [120, 150], [60, 160], [230, 110], [140, 70]]
for tp in test_points:
  cv2.circle(img_marked, tuple(tp), 2, (255, 255, 0), -1)
```

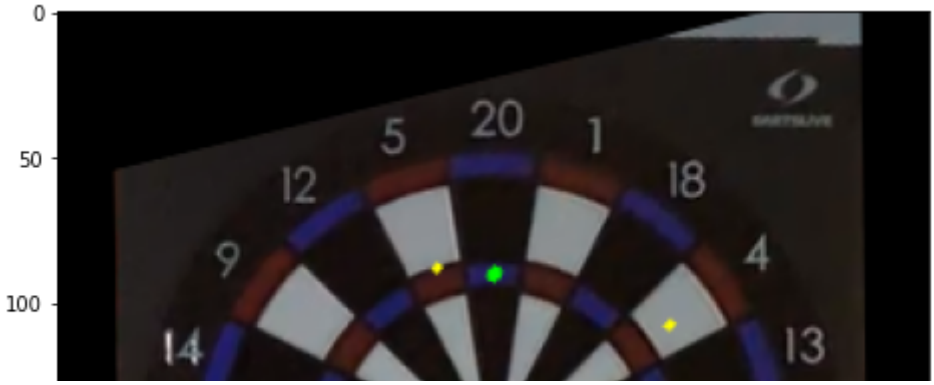
```
plt.figure(figsize=(8,8))
plt.imshow(img_marked)
```

```
<matplotlib.image.AxesImage at 0x7f333e094c10>
```




```
# 変換前後の対応点を設定
p_original = np.float32(marked_points)
p_trans = np.float32([[150,90], [150,210], [90,150], [210,150]])

# 変換マトリクスと射影変換
M1 = cv2.getPerspectiveTransform(p_original, p_trans)
img_marked_front = cv2.warpPerspective(img_marked, M1, img.shape[:2])

plt.figure(figsize=(8,8))
plt.imshow(img_marked_front)
```

```
<matplotlib.image.AxesImage at 0x7f751b24a650>
```



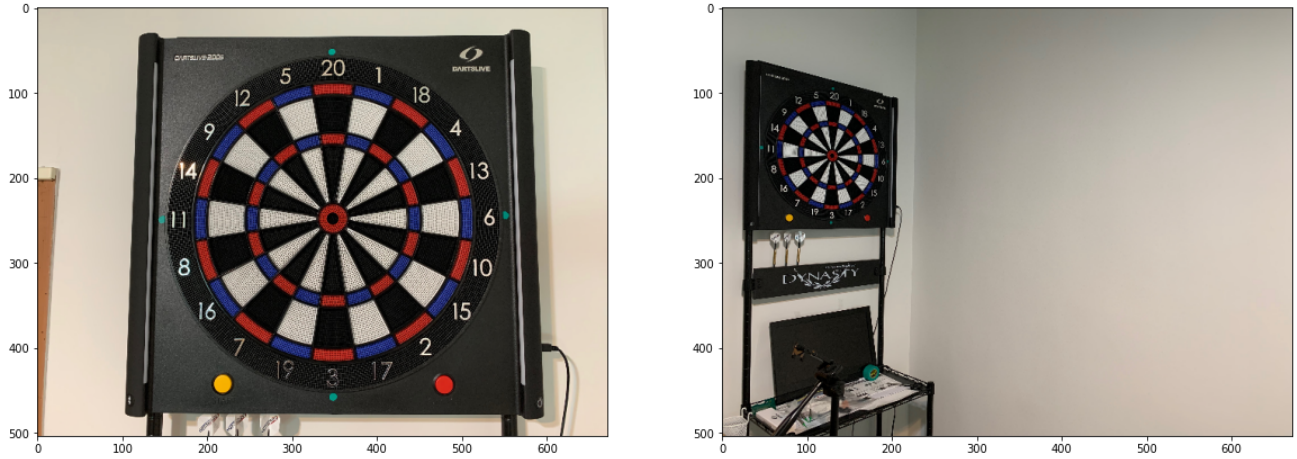

```
img_marked_front_gray = cv2.cvtColor(img_marked_front, cv2.COLOR_BGR2GRAY)
circles = cv2.HoughCircles(img_marked_front_gray , cv2.HOUGH_GRADIENT, dp=1.13, minDist=300, param1

img_marked_front2 = img_marked_front.copy()
for circle in circles:
  cv2.circle(img_marked_front2, (circle[0], circle[1]), circle[2], (0, 255, 0), 1)
  cv2.circle(img_marked_front2, (circle[0], circle[1]), 2, (0, 255, 0), 2)
plt.figure(figsize=(12,12))
plt.imshow(img_marked_front2)
```

```
<matplotlib.image.AxesImage at 0x7f751b1b5790>
```

マーキング画像案 (採用)

```
img1 = cv2.imread('video/IMG_0155.jpeg')
# img1 = cv2.imread('video/IMG_0153.png')
img2 = cv2.imread('video/IMG_0158.jpeg')
# img_center = img.shape[1]/2, img.shape[0]/2

n = 6
img1 = cv2.resize(img1, (int(img1.shape[1]/n),int(img1.shape[0]/n)))
img2 = cv2.resize(img2, (int(img2.shape[1]/n),int(img2.shape[0]/n)))

plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(cv2.cvtColor(img1, cv2.COLOR_BGR2RGB))
plt.subplot(1,2,2)
plt.imshow(cv2.cvtColor(img2, cv2.COLOR_BGR2RGB))
```

```
<matplotlib.image.AxesImage at 0x7f0d3b4ec6d0>
```

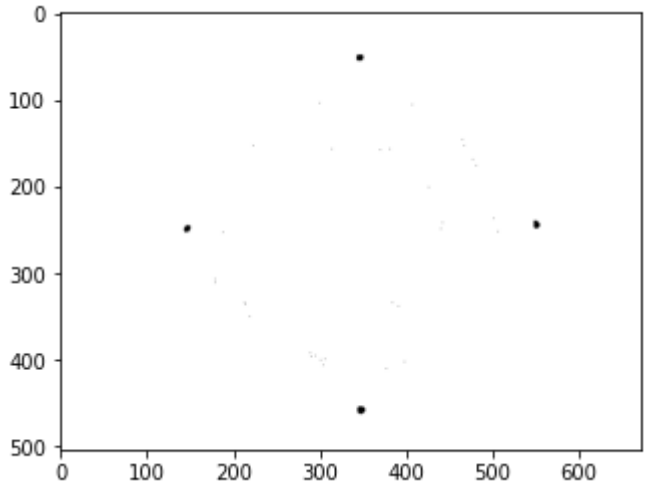


img1

```
img = img1.copy()
```

```
img_filltered = img.copy()

cond_green = (img_filltered[:,:,0]>60)&(img_filltered[:,:,1]>80)&(img_filltered[:,:,2]<60)
# cond_green = True

img_filltered[:,:,0] = np.where(cond_green, 0, 255)
img_filltered[:,:,1] = np.where(cond_green, 0, 255)
img_filltered[:,:,2] = np.where(cond_green, 0, 255)

plt.imshow(cv2.cvtColor(img_filltered, cv2.COLOR_BGR2RGB))
```

```
<matplotlib.image.AxesImage at 0x7f333df4a310>
```

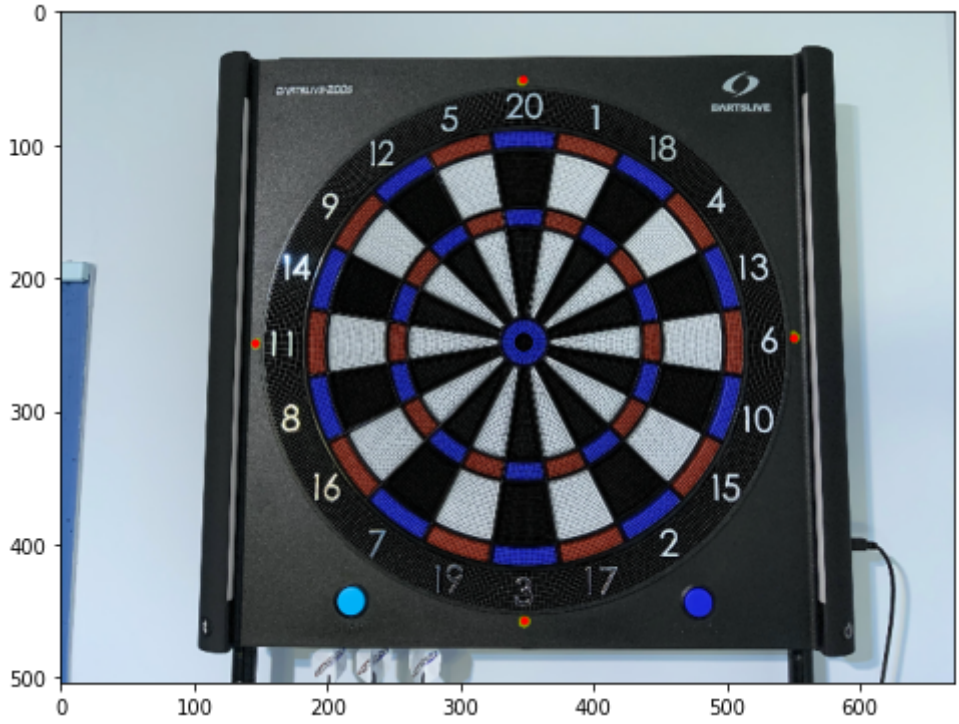



```
img_filltered_gray = cv2.cvtColor(img_filltered, cv2.COLOR_BGR2GRAY)
circles = cv2.HoughCircles(img_filltered_gray , cv2.HOUGH_GRADIENT, dp=0.4, minDist=50, param1=100,
circles = [circle for circle in circles if circle[2] < 10]

img_filltered_circle = img_filltered.copy()
for circle in circles:
  cv2.circle(img_filltered_circle, (circle[0], circle[1]), circle[2], (0, 255, 0), 1)
  cv2.circle(img_filltered_circle, (circle[0], circle[1]), 2, (0, 255, 0), 2)

plt.figure(figsize=(8,8))
plt.imshow(img_filltered_circle)
```

```
<matplotlib.image.AxesImage at 0x7f333df30790>
```

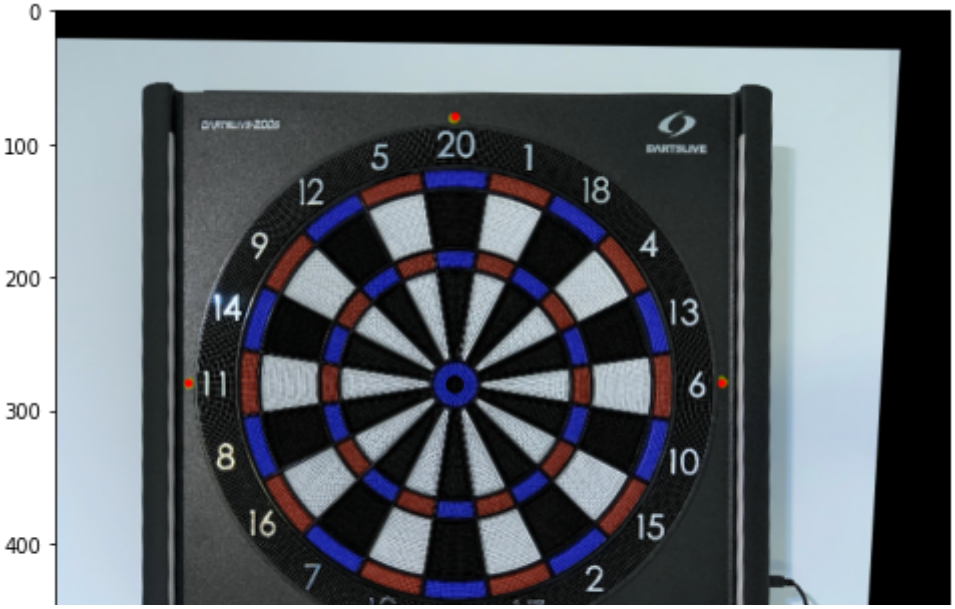
```
img_marked = img.copy()
marked_points = [circle[:2] for circle in circles]
for mp in marked_points:
  cv2.circle(img_marked, tuple(mp), 3, (255, 0, 0), -1)

# test_points = [[180, 200], [120, 150], [60, 160], [230, 110], [140, 70]]
# for tp in test_points:
#   cv2.circle(img_marked, tuple(tp), 2, (255, 255, 0), -1)

plt.figure(figsize=(8,8))
plt.imshow(img_marked)
```

```
<matplotlib.image.AxesImage at 0x7f333de9f410>
```




```
# 変換前後の対応点を設定
p_original = np.float32(marked_points)
p_trans = np.float32([[100,280], [300,480], [300,80], [500,280]])

# 変換マトリクスと射影変換
M1 = cv2.getPerspectiveTransform(p_original, p_trans)
img_marked_front = cv2.warpPerspective(img_marked, M1, (img.shape[1],img.shape[0]))

plt.figure(figsize=(8,8))
plt.imshow(img_marked_front)
```

```
<matplotlib.image.AxesImage at 0x7f333de06710>
```



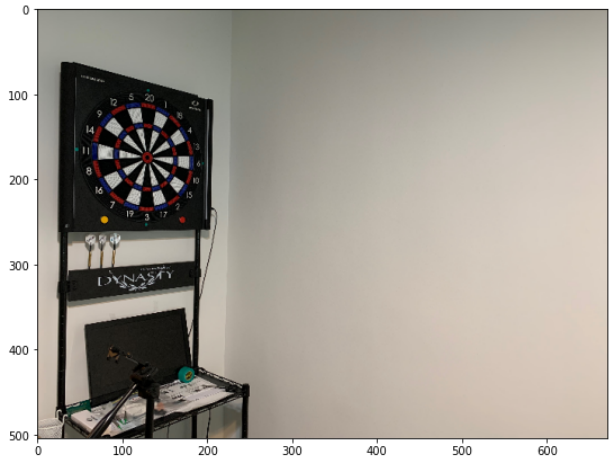

```
img_marked_front_gray = cv2.cvtColor(img_marked_front, cv2.COLOR_BGR2GRAY)
circles = cv2.HoughCircles(img_marked_front_gray , cv2.HOUGH_GRADIENT, dp=1.13, minDist=300, param1

img_marked_front2 = img_marked_front.copy()
for circle in circles:
  cv2.circle(img_marked_front2, (circle[0], circle[1]), circle[2], (0, 255, 0), 1)
  cv2.circle(img_marked_front2, (circle[0], circle[1]), 2, (0, 255, 0), 2)
plt.figure(figsize=(12,12))
plt.imshow(img_marked_front2)
```

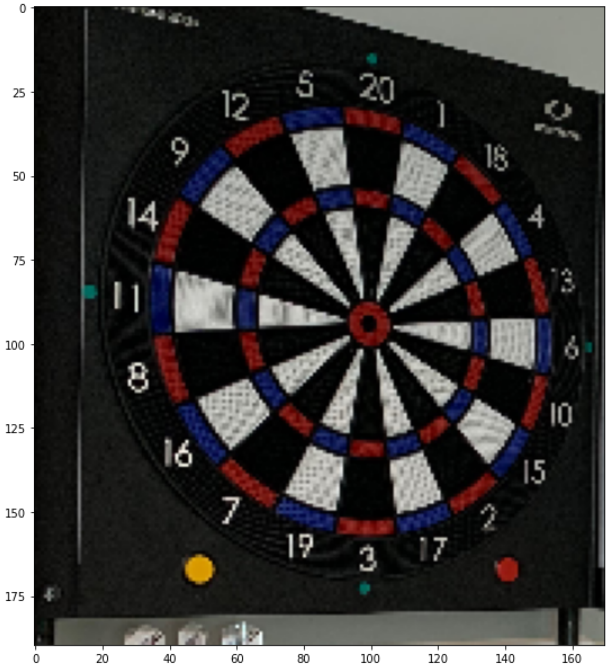
```
<matplotlib.image.AxesImage at 0x7f333ddf0f50>
```

img2

```
img = img2.copy()[80:270,30:200,:]
# img = cv2.imread('video/IMG_0158_crop.png')

plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(cv2.cvtColor(img2, cv2.COLOR_BGR2RGB))
plt.subplot(1,2,2)
plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))
```

```
<matplotlib.image.AxesImage at 0x7f333dda0090>
```

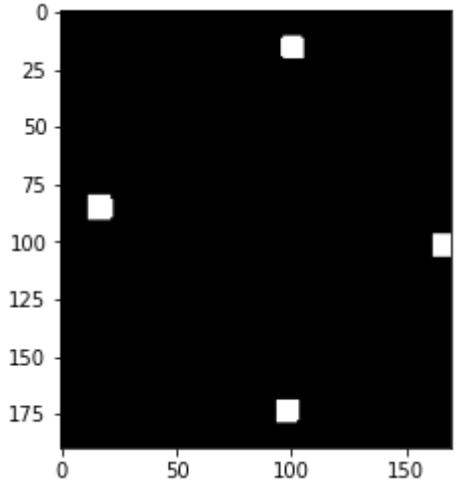




```
img_filltered = img.copy()

cond_green = (img_filltered[:,:,0]>30)&(img_filltered[:,:,1]>70)&(img_filltered[:,:,2]<60)
# cond_green = True
```

```
img_filltered[:,:,0] = np.where(cond_green, 255, 0)
img_filltered[:,:,1] = np.where(cond_green, 255, 0)
img_filltered[:,:,2] = np.where(cond_green, 255, 0)

img_filltered = cv2.blur(img_filltered, (8,8))

img_filltered[:,:,0] = np.where(img_filltered[:,:,0]>0, 255, 0)
img_filltered[:,:,1] = np.where(img_filltered[:,:,1]>0, 255, 0)
img_filltered[:,:,2] = np.where(img_filltered[:,:,2]>0, 255, 0)

plt.imshow(cv2.cvtColor(img_filltered, cv2.COLOR_BGR2RGB))
```

```
<matplotlib.image.AxesImage at 0x7f333e0a0a90>
```

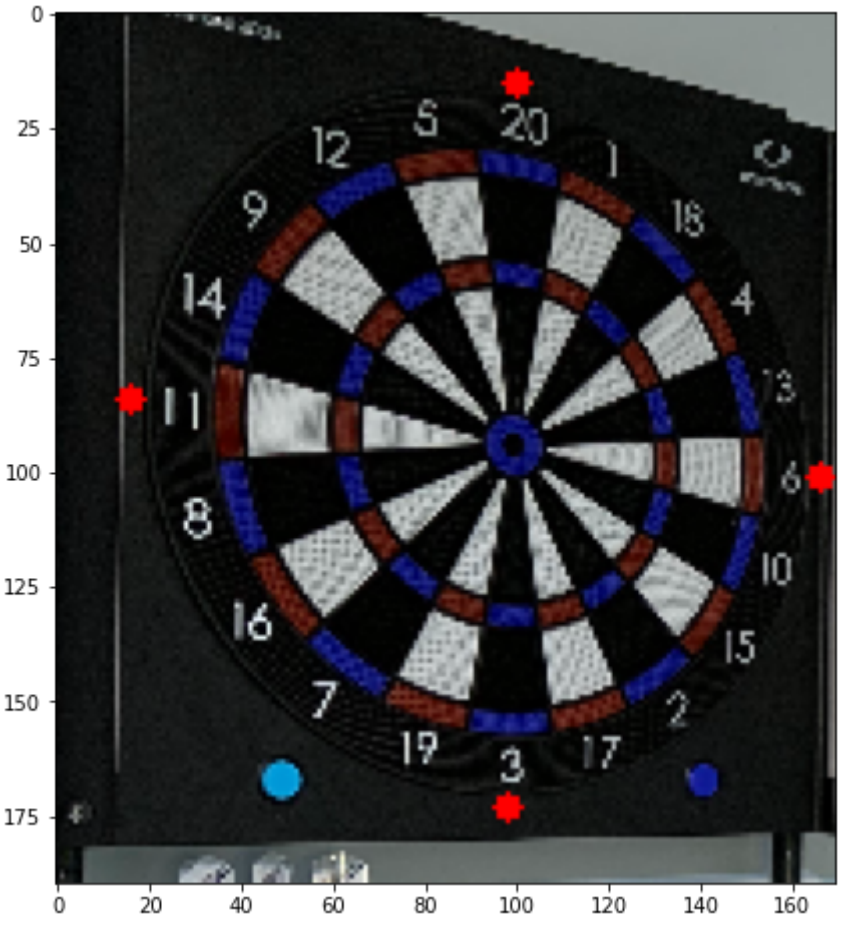



```
img_filltered_gray = cv2.cvtColor(img_filltered, cv2.COLOR_BGR2GRAY)
circles = cv2.HoughCircles(img_filltered_gray , cv2.HOUGH_GRADIENT, dp=0.3, minDist=50, param1=100,
circles = [circle for circle in circles if circle[2] < 10]

img_filltered_circle = img_filltered.copy()
for circle in circles:
  cv2.circle(img_filltered_circle, (circle[0], circle[1]), circle[2], (0, 255, 0), 1)
  cv2.circle(img_filltered_circle, (circle[0], circle[1]), 2, (0, 255, 0), 2)

plt.figure(figsize=(8,8))
plt.imshow(img_filltered_circle)
```

```
<matplotlib.image.AxesImage at 0x7f333de7d190>
```

```
img_marked = img.copy()
marked_points = [circle[:2] for circle in circles]
for mp in marked_points:
  cv2.circle(img_marked, tuple(mp), 3, (255, 0, 0), -1)

# test_points = [[180, 200], [120, 150], [60, 160], [230, 110], [140, 70]]
# for tp in test_points:
#   cv2.circle(img_marked, tuple(tp), 2, (255, 255, 0), -1)

plt.figure(figsize=(8,8))
plt.imshow(img_marked)
```

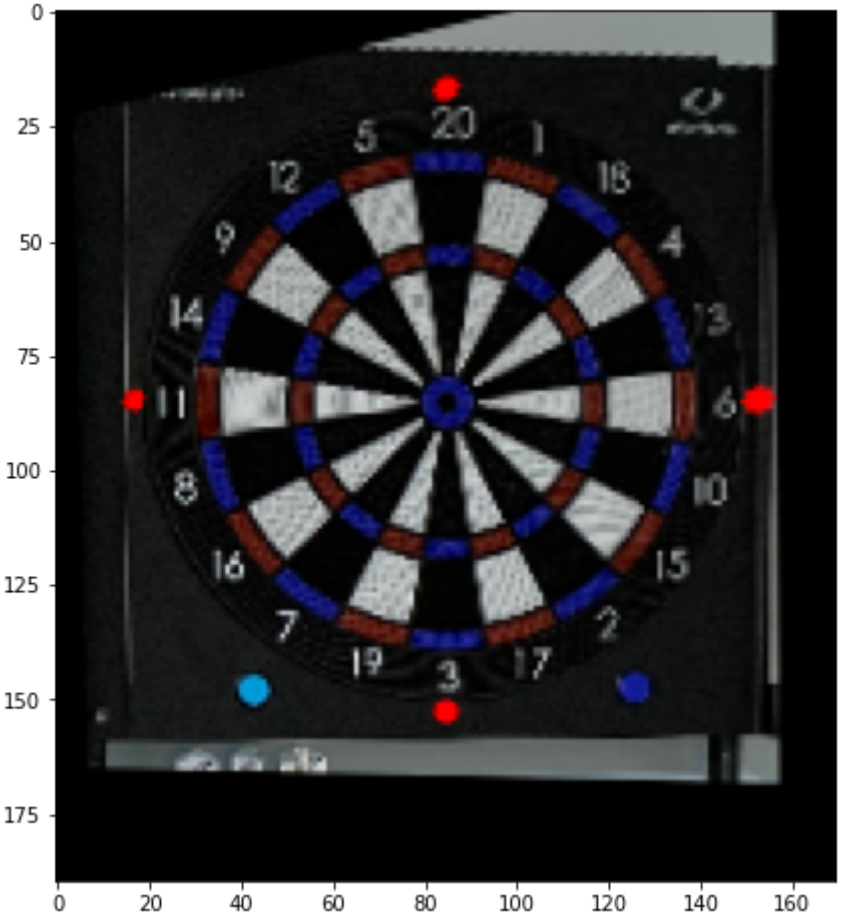
```
<matplotlib.image.AxesImage at 0x7f333dbf8090>
```




```
# 変換前後の対応点を設定
idx_mp = np.argsort([mp[0] for mp in marked_points], axis=0)
marked_points = np.array(marked_points)[idx_mp]
```

```
p_trans = np.array([[0.5,0.1], [0.5,0.9], [0.9,0.5], [0.1,0.5]])
idx = np.argsort(p_trans[:,0], axis=0)
if ((marked_points[1,1] > marked_points[2,1]) & (idx[1] < idx[2])) or ((marked_points[1,1] < marked
  tmp = idx[1]
  idx[1] = idx[2]
  idx[2] = tmp
p_trans = p_trans[idx]

p_original = np.float32(marked_points)
p_trans = p_trans.astype(np.float32)*min(img.shape[:2])

# 変換マトリクスと射影変換
M1 = cv2.getPerspectiveTransform(p_original, p_trans)
img_marked_front = cv2.warpPerspective(img_marked, M1, (img.shape[1],img.shape[0]))

plt.figure(figsize=(8,8))
plt.imshow(img_marked_front)
```

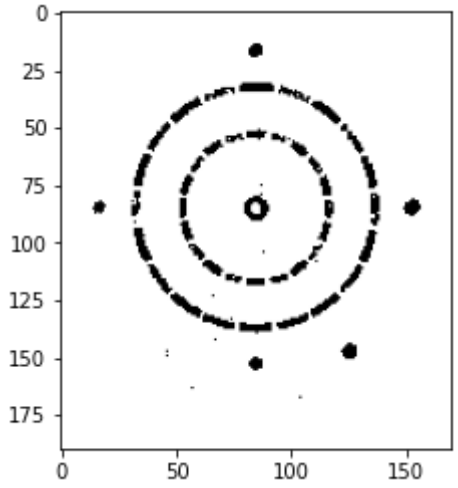
```
<matplotlib.image.AxesImage at 0x7f333db68bd0>
```




```
img_marked_front2 = img_marked_front.copy()
# img2[:,:,0] = np.where(img2[:,:,0]<100, 255, 0)
# img2[:,:,2] = np.where(img2[:,:,2]<130, 255, 0)
# img2[:,:,1] = np.ones(img2.shape[:2])*0


cond_red = (img_marked_front2[:,:,0]<70)&(img_marked_front2[:,:,1]<70)&(img_marked_front2[:,:,2]>70
cond_blue = (img_marked_front2[:,:,0]>70)&(img_marked_front2[:,:,1]<70)&(img_marked_front2[:,:,2]<7
```

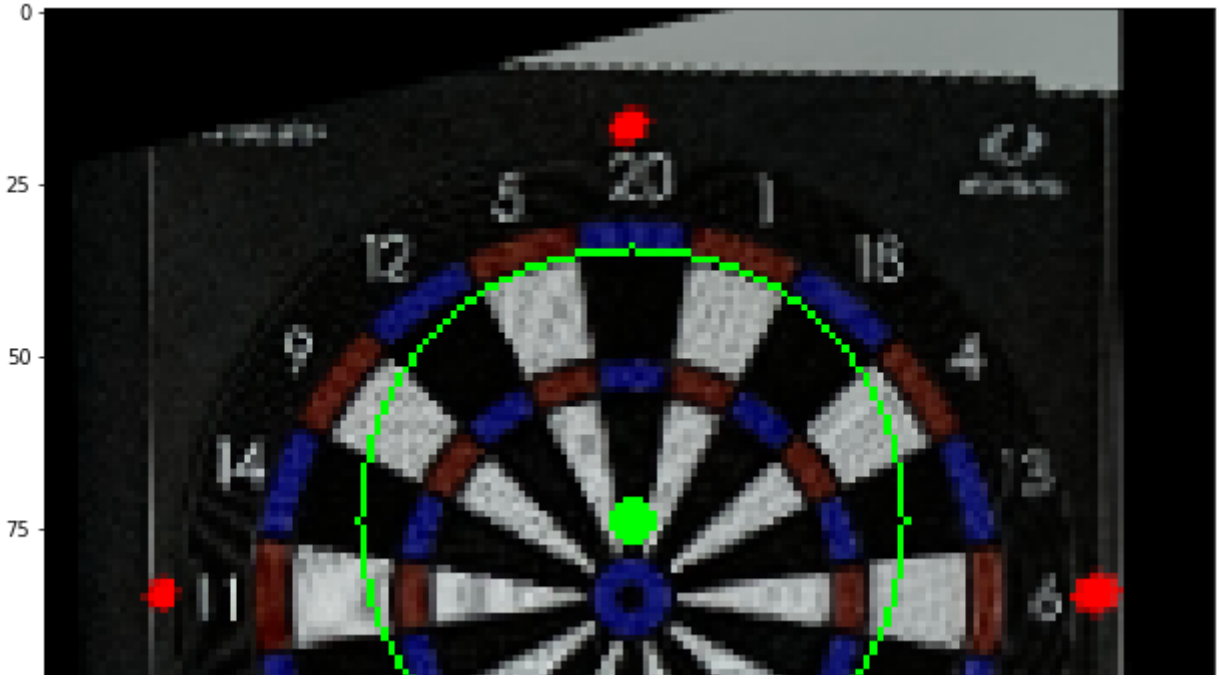
```
# cond_blue = False
cond_red_blue = cond_red | cond_blue
# cond_black = (img_filltered[:,:,0]>120)&(img_filltered[:,:,1]>120)&(img_filltered[:,:,2]>120)

img_marked_front2[:,:,0] = np.where(cond_red_blue, 0, 255)
img_marked_front2[:,:,1] = np.where(cond_red_blue, 0, 255)
img_marked_front2[:,:,2] = np.where(cond_red_blue, 0, 255)

plt.imshow(cv2.cvtColor(img_marked_front2, cv2.COLOR_BGR2RGB))
```

```
<matplotlib.image.AxesImage at 0x7f333daed7d0>
```




```
img_marked_front_gray = cv2.cvtColor(img_marked_front2, cv2.COLOR_BGR2GRAY)
circles = cv2.HoughCircles(img_marked_front_gray , cv2.HOUGH_GRADIENT, dp=0.4, minDist=400, param1=

img_marked_front2 = img_marked_front.copy()
for circle in circles:
  cv2.circle(img_marked_front2, (circle[0], circle[1]), circle[2], (0, 255, 0), 1)
  cv2.circle(img_marked_front2, (circle[0], circle[1]), 2, (0, 255, 0), 2)
plt.figure(figsize=(12,12))
plt.imshow(img_marked_front2)
```

```
<matplotlib.image.AxesImage at 0x7f333da73590>
```

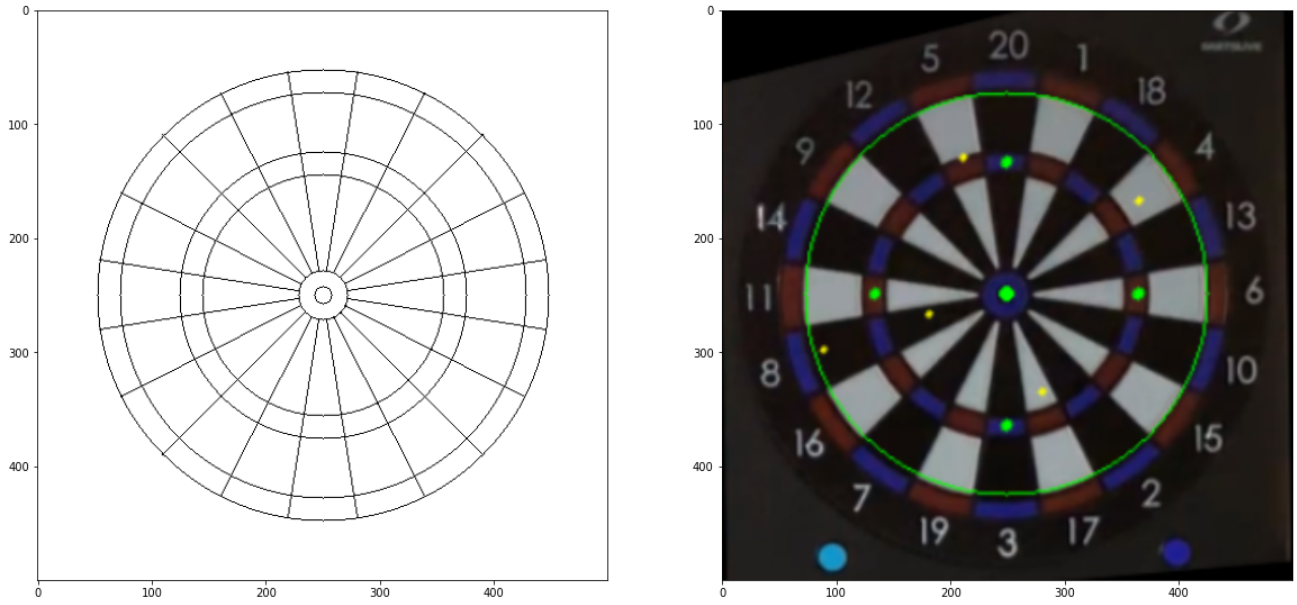


19.5：中心から店の外側 24：マークまで

既知の盤面にマッピング (Done)

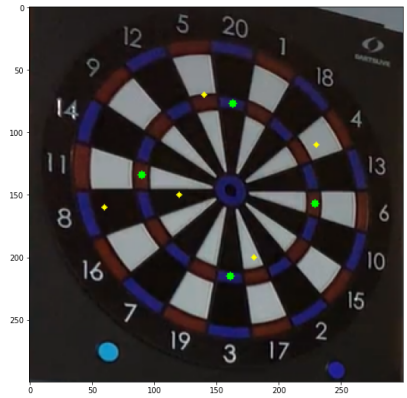
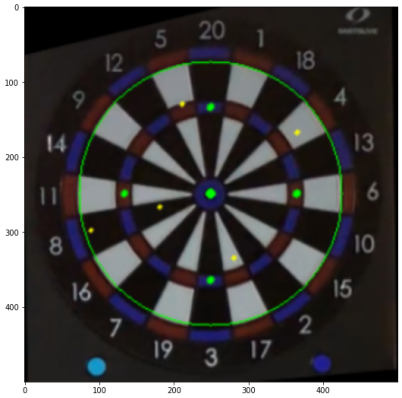
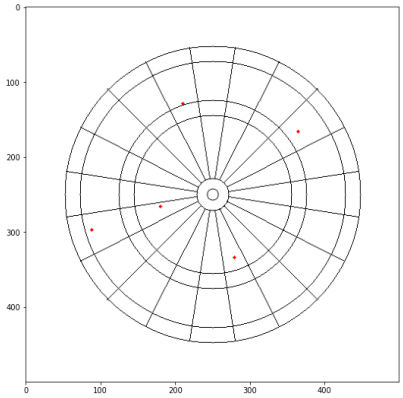
```
detected_board_circle = circles[0]
detected_center = detected_board_circle[:2]
detected_r = detected_board_circle[2]
detected_margine = detected_r/(img.shape[0]/2)

img_warped = img_marked_front2.copy()

dx = img_center[0] - detected_center[0]
dy = img_center[1] - detected_center[1]
M2 = np.float32([[1,0,dx],[0,1,dy]])
img_warped = cv2.warpAffine(img_warped, M2, img.shape[:2])

zoom_rate = coordinate_margine/detected_margine
M3 = np.float32([[zoom_rate,0,-(zoom_rate-1)*img_center[0]],[0,zoom_rate,-(zoom_rate-1)*img_center[
img_warped = cv2.warpAffine(img_warped, M3, img.shape[:2])

img_warped = cv2.resize(img_warped, img_coordinate.shape[:2], interpolation = cv2.INTER_LINEAR)

plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(img_coordinate)
plt.subplot(1,2,2)
plt.imshow(img_warped)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255
<matplotlib.image.AxesImage at 0x7f751b16d1d0>
```




```
img_result = img_coordinate.copy()

for tp in test_points:
  a = np.array([[tp]], dtype=np.float32)
  b = cv2.perspectiveTransform(a, M1)[0][0]
  c = M2@np.array([b[0],b[1],1], np.float32).T
  d = M3@np.array([c[0],c[1],1], np.float32).T
  res_x, res_y = d[0]/(img.shape[1]/coordinate_size), d[1]/(img.shape[0]/coordinate_size)
  print(res_x, res_y)
  cv2.circle(img_result, (int(res_x), int(res_y)), 2, (255, 0, 0), -1)

plt.figure(figsize=(30,12))
plt.subplot(1,3,1)
plt.imshow(img_marked)
plt.subplot(1,3,2)
plt.imshow(img_warped)
plt.subplot(1,3,3)
plt.imshow(img_result)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255
279.73210652669275 334.23423767089844
180.40420532226562 266.3451639811198
88.33202362060547 297.3236338297526
364.2227681477865 166.89114888509116
210.51302591959637 129.25448099772137
<matplotlib.image.AxesImage at 0x7f751b07d050>
```

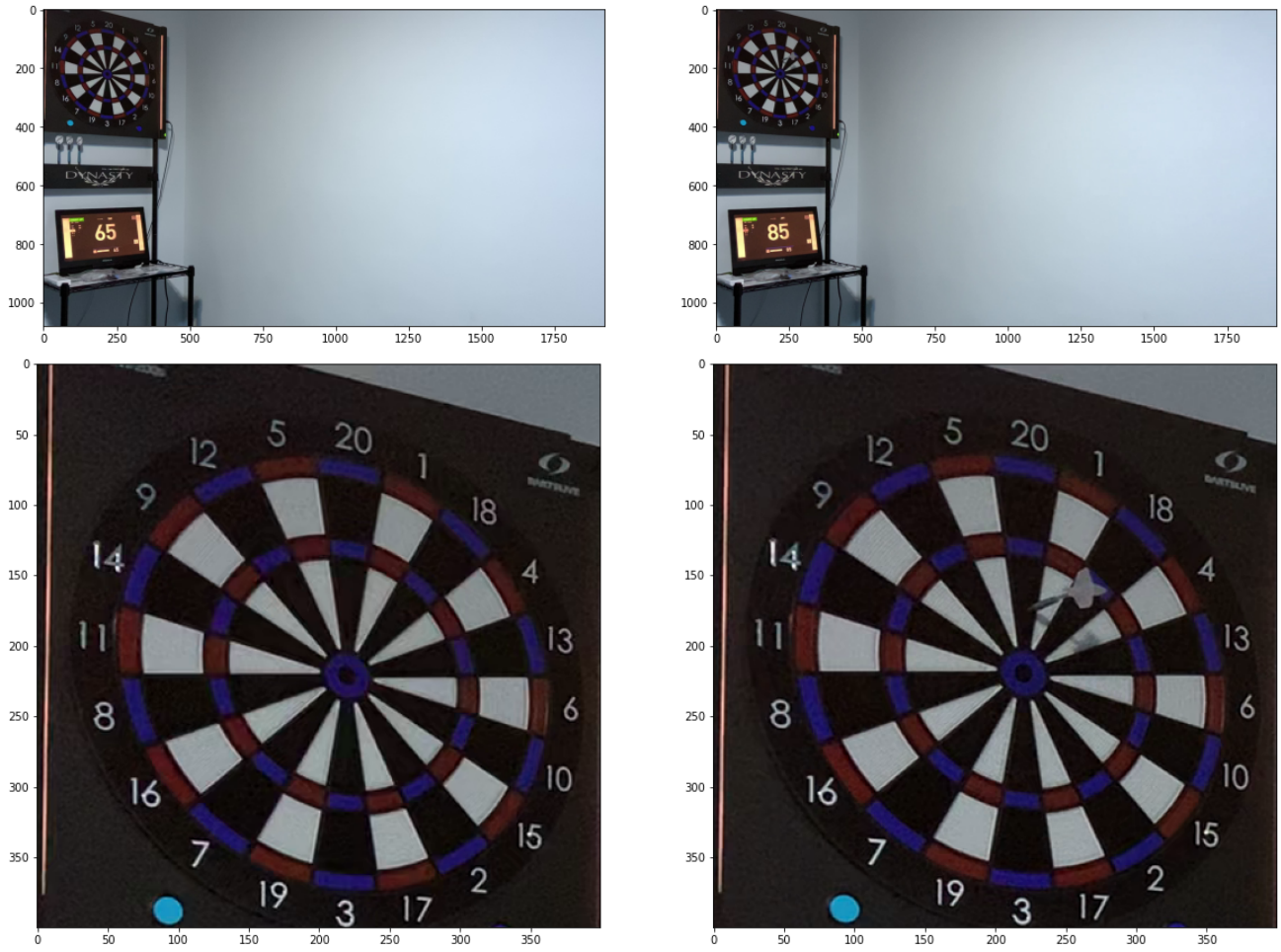
投擲位置検出

色なし案 (無理)

```
cap = cv2.VideoCapture('video/IMG_0144.MOV')
crop_width = 400
crop_height = 400
idx_frame0 = 0
idx_frame1 = 440

cap.set(cv2.CAP_PROP_POS_FRAMES, idx_frame0)
ret, frame0 = cap.read()
frame0_crop = frame0[:crop_height,:crop_width,:]
cap.set(cv2.CAP_PROP_POS_FRAMES, idx_frame1)
ret, frame1 = cap.read()
frame1_crop = frame1[:crop_height,:crop_width,:]


plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(frame0)
plt.subplot(1,2,2)
plt.imshow(frame1)
```

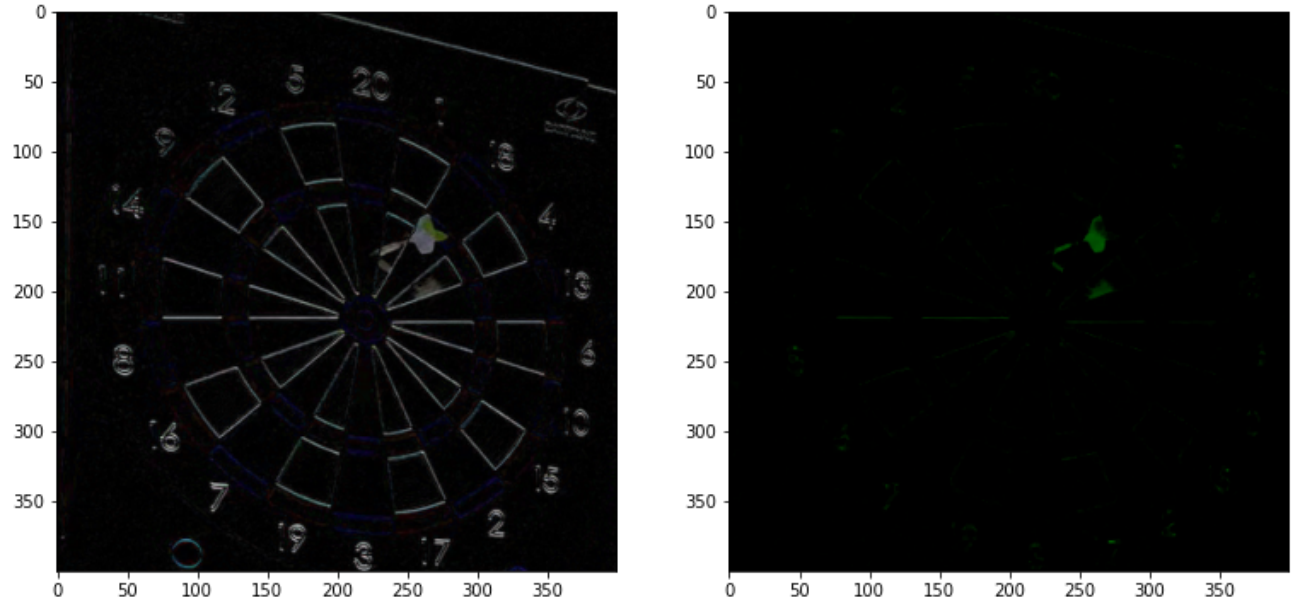
```
plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.imshow(frame0_crop)
plt.subplot(1,2,2)
plt.imshow(frame1_crop)
```

```
<matplotlib.image.AxesImage at 0x7f75063dc990>
```



```
def drop_color(img):
  cond_drop_red = img[:,:,2]<100
  cond_drop_blue = img[:,:,0]<50
  cond_drop_blue = False
  cond_drop_red_blue = cond_drop_red | cond_drop_blue
  img2 = frame0_crop.copy()
  img2[:,:,0] = np.where(cond_drop_red_blue,0,1)
  img2[:,:,1] = np.where(cond_drop_red_blue,0,1)
  img2[:,:,2] = np.where(cond_drop_red_blue,0,1)
  img2 = img2 * img
  return img


a = drop_color(frame0_crop)
b = drop_color(frame1_crop)
c = cv2.absdiff(a, b)
d = minimum_filter(c,size=3,mode='constant')

plt.figure(figsize=(20,8))
plt.subplot(1,3,1)
plt.imshow(c)
plt.subplot(1,3,2)
plt.imshow(d)
```

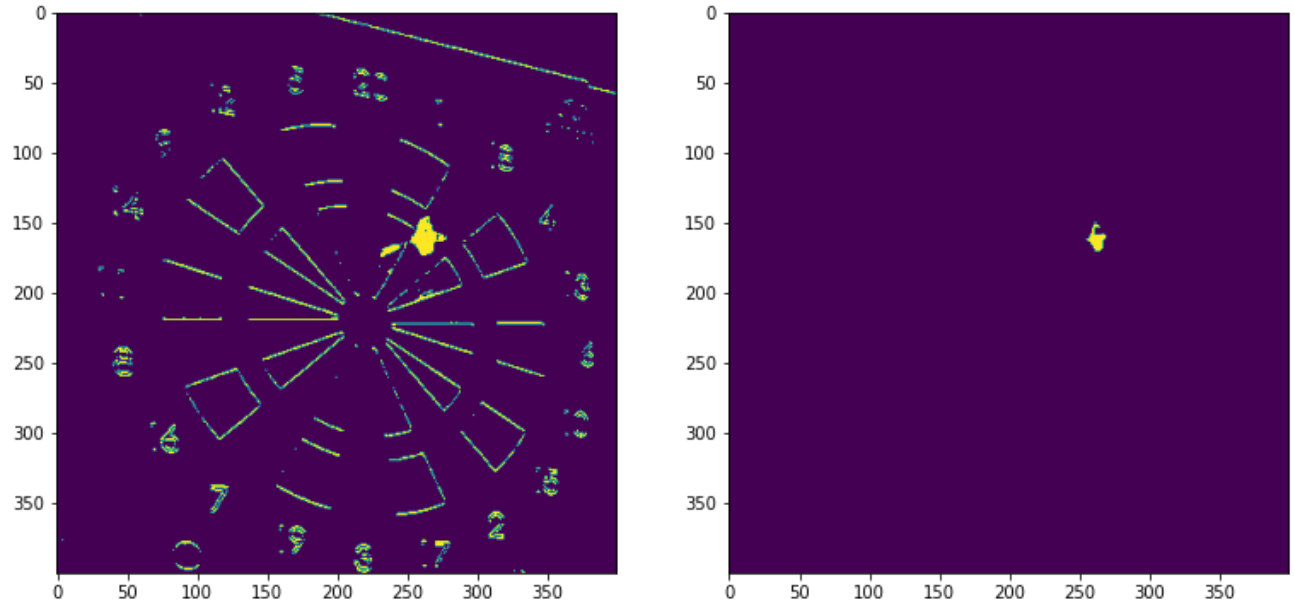
```
<matplotlib.image.AxesImage at 0x7f750b496350>
```



```
c2 = c.copy()
color_drop = (c2[:,:,0]<70) & (c2[:,:,1]<70) & (c2[:,:,2]<70)
c2[:,:,0] = np.where(color_drop,0,255)
c2[:,:,1] = np.where(color_drop,0,255)
c2[:,:,2] = np.where(color_drop,0,255)

c2 = cv2.cvtColor(c2, cv2.COLOR_BGR2GRAY)
d2 = minimum_filter(c2,size=5,mode='constant')
```

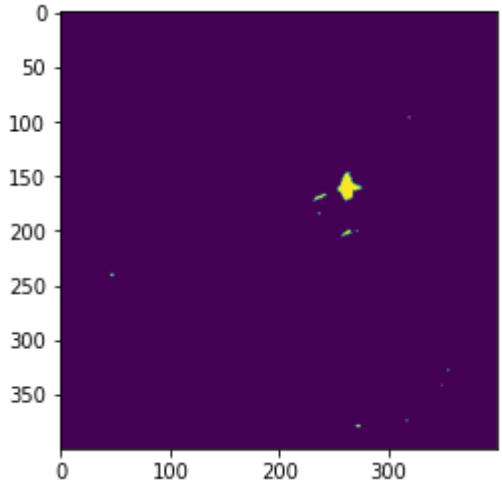
```
plt.figure(figsize=(20,8))
plt.subplot(1,3,1)
plt.imshow(c2)
plt.subplot(1,3,2)
plt.imshow(d2)
```

```
<matplotlib.image.AxesImage at 0x7f75085a24d0>
```



```
lines = cv2.HoughLinesP(minimum_filter(d2,size=3,mode='constant'), rho=1, theta=np.pi/360, threshol

img_line = d2.copy()
# for line in lines:
#   line = line[0]
#   cv2.line(img_line, tuple(line[:2]), tuple(line[2:]), (255, 255, 255), thickness=1, lineType=cv2

# plt.figure(figsize=(8,8))
plt.imshow(img_line)
```

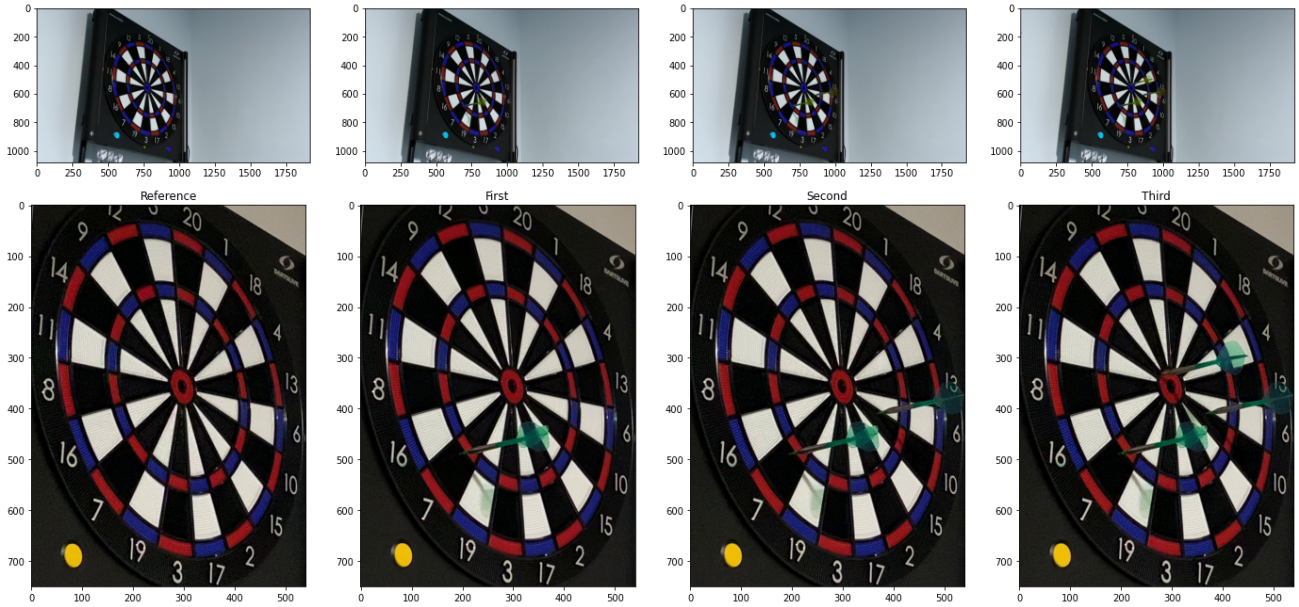
```
<matplotlib.image.AxesImage at 0x7f7508c234d0>
```



色あり案

```
cap = cv2.VideoCapture('video/IMG_0164.MOV')
img_arrow = cv2.imread('video/arrow.png')

idx_frame0 = 0
idx_frame1 = 550
idx_frame2 = 800
idx_frame3 = 1000

cap.set(cv2.CAP_PROP_POS_FRAMES, idx_frame0)
ret, frame0 = cap.read()
frame0_crop = frame0[200:950,480:1020,:]
cap.set(cv2.CAP_PROP_POS_FRAMES, idx_frame1)
ret, frame1 = cap.read()
frame1_crop = frame1[200:950,480:1020,:]
cap.set(cv2.CAP_PROP_POS_FRAMES, idx_frame2)
ret, frame2 = cap.read()
frame2_crop = frame2[200:950,480:1020,:]
cap.set(cv2.CAP_PROP_POS_FRAMES, idx_frame3)
ret, frame3 = cap.read()
frame3_crop = frame3[200:950,480:1020,:]


plt.figure(figsize=(24,12))
plt.subplot(1,4,1)
plt.imshow(frame0)
plt.subplot(1,4,2)
plt.imshow(frame1)
plt.subplot(1,4,3)
plt.imshow(frame2)
plt.subplot(1,4,4)
plt.imshow(frame3)

plt.figure(figsize=(24,8))
plt.subplot(1,4,1)
plt.title("Reference")
plt.imshow(cv2.cvtColor(frame0_crop, cv2.COLOR_BGR2RGB))
plt.subplot(1,4,2)
plt.title("First")
plt.imshow(cv2.cvtColor(frame1_crop, cv2.COLOR_BGR2RGB))
plt.subplot(1,4,3)
plt.title("Second")
plt.imshow(cv2.cvtColor(frame2_crop, cv2.COLOR_BGR2RGB))
plt.subplot(1,4,4)
plt.title("Third")
plt.imshow(cv2.cvtColor(frame3_crop, cv2.COLOR_BGR2RGB))
```

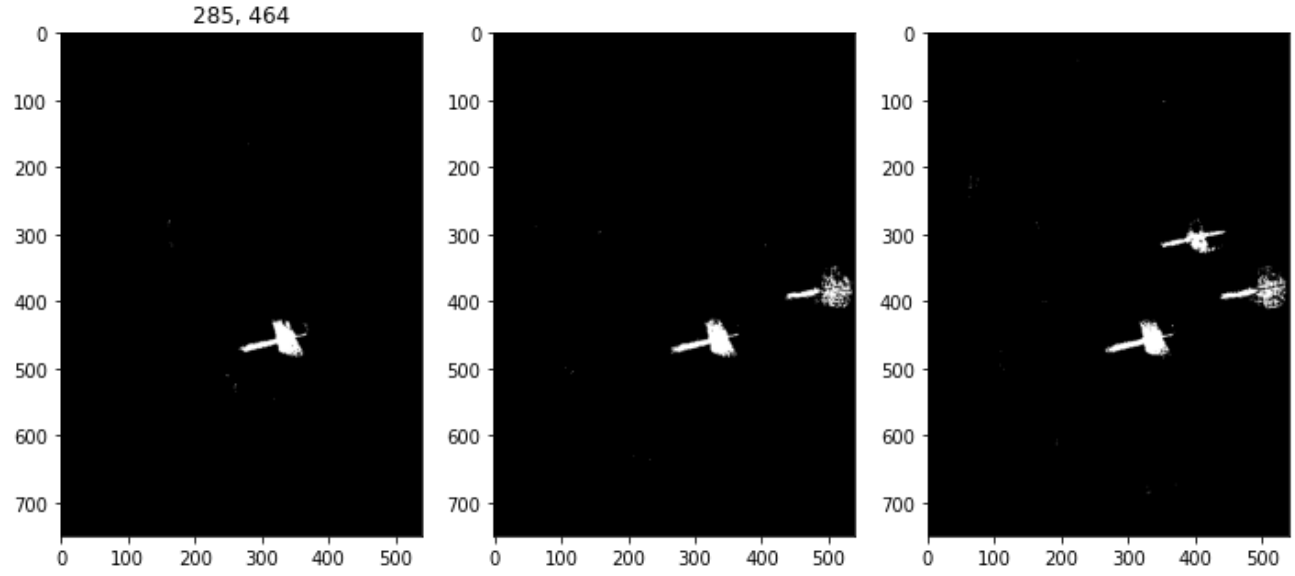
```
<matplotlib.image.AxesImage at 0x7fb1e473e050>
```




```
def is_ignore_pixel(img, idx, column, kernel_size, p):
  img_crop = img[max(0,idx-int(kernel_size/2)):idx+int(kernel_size/2), max(0,column-int(kernel_size
  if np.percentile(img_crop, p) == 255:
    # print(idx,column)
    # print(img_crop)
    return False
  else:
    return True


def extract_arrow(img, diff_image = False, ignore_kernel_size = 3, p = 50):
  img_arrow = img.copy()

  if not diff_image:
    cond_green = (img[:,:,0]>40) & (img[:,:,1]>40) & (img[:,:,2]<30)
    img_arrow[:,:,0] = np.where(cond_green, 255, 0)
    img_arrow[:,:,1] = np.where(cond_green, 255, 0)
    img_arrow[:,:,2] = np.where(cond_green, 255, 0)

  for c in range(0,img.shape[1]):
    i = np.argmax(img_arrow[:,c,1])
    if is_ignore_pixel(img_arrow,i,c,ignore_kernel_size,p):
      continue
    est_xtip = c
    est_ytip = i
```

```
        break

    return img_arrow, est_xtip, est_ytip


img_arrow1, est_xtip1, est_ytip1 = extract_arrow(frame1_crop, ignore_kernel_size = 3)
img_arrow2, _, _ = extract_arrow(frame2_crop)
img_arrow3, _, _ = extract_arrow(frame3_crop)

plt.figure(figsize=(12,6))
plt.subplot(1,3,1)
plt.title(f'{est_xtip1}, {est_ytip1}')
plt.imshow(img_arrow1)
plt.subplot(1,3,2)
plt.imshow(img_arrow2)
plt.subplot(1,3,3)
plt.imshow(img_arrow3)
```

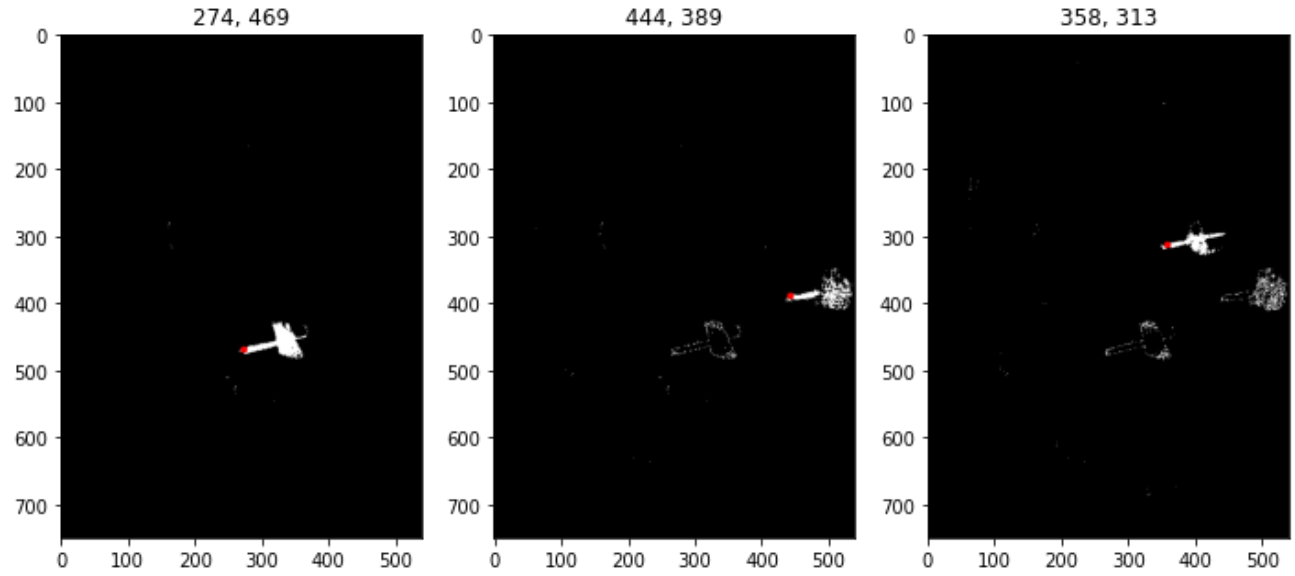
```
<matplotlib.image.AxesImage at 0x7fb1e459c790>
```




```
img_arrow1, est_xtip1, est_ytip1 = extract_arrow(frame1_crop, ignore_kernel_size = 8, p = 50)

img_arrow2_diff = cv2.absdiff(img_arrow2, img_arrow1)
img_arrow2_diff, est_xtip2, est_ytip2 = extract_arrow(img_arrow2_diff, diff_image = True, ignore_ke

img_arrow3_diff = cv2.absdiff(img_arrow3, img_arrow2)
img_arrow3_diff, est_xtip3, est_ytip3 = extract_arrow(img_arrow3_diff, diff_image = True, ignore_ke


plt.figure(figsize=(12,6))
plt.subplot(1,3,1)
plt.title(f'{est_xtip1}, {est_ytip1}')
cv2.circle(img_arrow1, (est_xtip1, est_ytip1), 5, (255, 0, 0), -1)
plt.imshow(img_arrow1)
plt.subplot(1,3,2)
plt.title(f'{est_xtip2}, {est_ytip2}')
cv2.circle(img_arrow2_diff, (est_xtip2, est_ytip2), 5, (255, 0, 0), -1)
```

```
plt.imshow(img_arrow2_diff)
plt.subplot(1,3,3)
plt.title(f'{est_xtip3}, {est_ytip3}')
cv2.circle(img_arrow3_diff, (est_xtip3, est_ytip3), 5, (255, 0, 0), -1)
plt.imshow(img_arrow3_diff)
```

```
<matplotlib.image.AxesImage at 0x7fb1e4a68e10>
```




```
given_xtip, given_ytip = (199, 488)

tuned_dx = given_xtip - est_xtip1
tuned_dy = given_ytip - est_ytip1


plt.figure(figsize=(16,8))
plt.subplot(1,3,1)
plt.title("First")
img_marked = frame1_crop.copy()
cv2.circle(img_marked, (given_xtip, given_ytip), 4, (0, 255, 0), -1)
cv2.circle(img_marked, (est_xtip1, est_ytip1), 4, (255, 0, 0), -1)
plt.imshow(img_marked)

plt.subplot(1,3,2)
plt.title("Second")
img_marked = frame2_crop.copy()
cv2.circle(img_marked, (est_xtip2 + tuned_dx, est_ytip2 + tuned_dy), 4, (255, 255, 0), -1)
cv2.circle(img_marked, (est_xtip2, est_ytip2), 4, (255, 0, 0), -1)
plt.imshow(img_marked)

plt.subplot(1,3,3)
plt.title("Third")
img_marked = frame3_crop.copy()
cv2.circle(img_marked, (est_xtip3 + tuned_dx, est_ytip3 + tuned_dy), 4, (255, 255, 0), -1)
cv2.circle(img_marked, (est_xtip3, est_ytip3), 4, (255, 0, 0), -1)
plt.imshow(img_marked)
```

```
<matplotlib.image.AxesImage at 0x7fe736063190>
```

投擲軌道検出

セットアップ

```
def is_ignore_pixel(img, idx, column, kernel_size, p):
  img_crop = img[max(0,idx-int(kernel_size/2)):idx+int(kernel_size/2), max(0,column-int(kernel_size
  # print(img_crop.shape)
  if np.percentile(img_crop, p) == 255:
    # print(idx,column)
    # print(img_crop)
    return False, img_crop
  else:
    return True, img_crop


def extract_arrow(img, condition, diff_image = False, ignore_kernel_size = 3, p = 50):
  img_arrow = img.copy()

  if not diff_image:
    img_arrow[:,:,0] = np.where(condition, 255, 0)
    img_arrow[:,:,1] = np.where(condition, 255, 0)
    img_arrow[:,:,2] = np.where(condition, 255, 0)


  est_xtip, est_ytip = np.nan, np.nan
  for c in range(0,img.shape[1]):
    i = np.argmax(img_arrow[:,c,1])
```

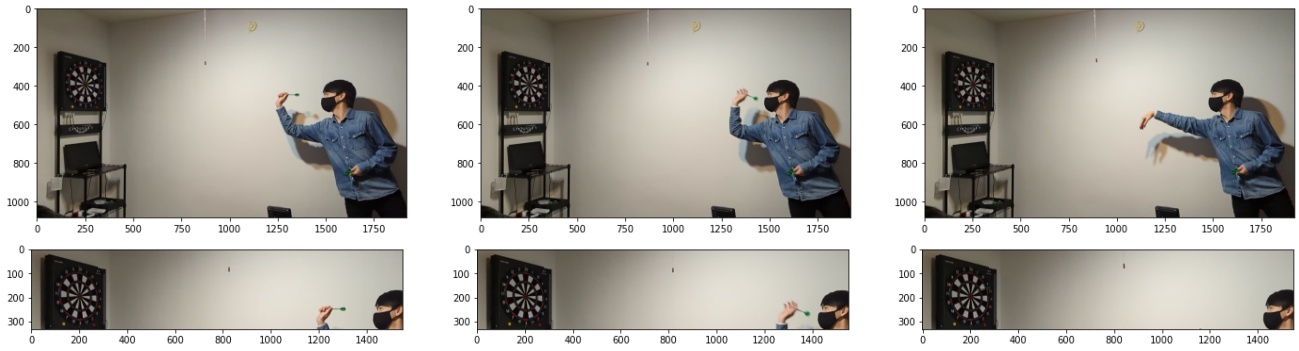
```
        state, img_crop = is_ignore_pixel(img_arrow,i,c,ignore_kernel_size,p)
        if state:
          continue
        est_xtip = c
        est_ytip = i
        # print(img_crop)
        break

      return img_arrow, est_xtip, est_ytip

    from sklearn import preprocessing

    def estimate_axis(img, est_xtip, est_ytip, kernel, rate=20):
      # print(img)
      # print(max(0,est_ytip-kernel),est_ytip+kernel, max(0,est_xtip-kernel),est_xtip+kernel)
      img = img[max(0,est_ytip-kernel):est_ytip+kernel, max(0,est_xtip-kernel):est_xtip+kernel, 1].copy
      # print(img)
      x, y = np.where(img > 10)
      samples = np.array([x,y]).T
      mm = preprocessing.MinMaxScaler()
      samples = mm.fit_transform(samples)
      # samples = scipy.stats.zscore(samples)

      pcamodel = PCA()
      pcamodel.fit(samples)
      pca_cor = pcamodel.transform(samples)
      # print(pca_cor)
      dx, dy = pcamodel.components_[0]
      if dx > 0:
        axis = np.array([[est_xtip-rate*dx, est_ytip-rate*dy], [est_xtip, est_ytip]], dtype=int)
      else:
        axis = np.array([[est_xtip, est_ytip], [est_xtip+rate*dx, est_ytip+rate*dy]], dtype=int)

      return axis


    def lineList(x1, y1, x2, y2):
        line_lst = []
        step = 0
        dx = abs(x2 - x1)
        dy = abs(y2 - y1)
        if dx > dy:
            if x1 > x2 :
                step = 0
                if y1 > y2:
                    step = 1
                else:
                    step = -1
                x1, x2 = x2, x1 # swap
                y1 = y2;
            else:
                if y1 < y2:
                    step = 1
                else:
                    step = -1
```

```
            line_lst.append((x1, y1))
            s = dx >> 1
            x1 += 1
            while (x1 <= x2):
                s -= dy
                if s < 0:
                    s += dx
                    y1 += step
                line_lst.append((x1, y1))
                x1 += 1
        else:
            if y1 > y2:
                if x1 > x2:
                    step = 1
                else:
                    step = -1

                y1, y2 = y2, y1 # swap
                x1 = x2
            else:
                if x1 < x2:
                    step = 1
                else:
                    step = -1
            line_lst.append((x1, y1))
            s = dy >> 1
            y1 += 1
            while y1 <= y2:
                s -= dx
                if s < 0:
                    s += dy
                    x1 += step
                line_lst.append((x1, y1))
                y1 += 1
        return  line_lst

    #   img         イメージ
    #   start_point 始点
    #   end_point   終点
    #   gap         点線ギャップ（間隔）
    #   linewidth   線幅
    #   color       色
    #
    def drawDashedLine(img, start_point, end_point, gap, linewidth, color):
        li = lineList(start_point[0], start_point[1], end_point[0], end_point[1])
        fwd = start_point
        bwd = start_point
        j = 0
        for i, pt in enumerate(li):
            if i % gap == 0:
                bwd = pt

                if(j % 2):
                    cv2.line(img, fwd, bwd, color, linewidth, lineType=cv2.LINE_AA)
                fwd = bwd
```

```
            j += 1
    return img



def detect_release(img_arrow, img_hand, axis, kernel=5):
  p_grasp = axis[np.argmin(axis[:,0])]
  pg_minw, pg_maxw = p_grasp[0]-kernel, p_grasp[0]+kernel
  pg_minh, pg_maxh = p_grasp[1]-kernel, p_grasp[1]+kernel
  grasp_area = np.sum(img_hand[pg_minh:pg_maxh,pg_minw:pg_maxw,:])
  if grasp_area == 0:
    return True
  else:
    return False


# movie_path = 'video/u4-t.mp4'
# movie_path = 'IMG_5308.mov'
movie_path = 'video/u5-1.mp4'

cap = cv2.VideoCapture(movie_path)

# start_idx = 1910
# end_idx = 1990
start_idx = 315
end_idx = 450

hmin = 200
hmax = 530
wmin = 50
wmax = 1600

cap.set(cv2.CAP_PROP_POS_FRAMES, 0)
ret, frame0 = cap.read()
frame0_crop = frame0[hmin:hmax,wmin:wmax,:]
cap.set(cv2.CAP_PROP_POS_FRAMES, start_idx)
ret, frame1 = cap.read()
frame1_crop = frame1[hmin:hmax,wmin:wmax,:]
cap.set(cv2.CAP_PROP_POS_FRAMES, end_idx)
ret, frame2 = cap.read()
frame2_crop = frame2[hmin:hmax,wmin:wmax,:]


plt.figure(figsize=(24,12))
plt.subplot(1,3,1)
plt.imshow(cv2.cvtColor(frame0, cv2.COLOR_BGR2RGB))
plt.subplot(1,3,2)
plt.imshow(cv2.cvtColor(frame1, cv2.COLOR_BGR2RGB))
plt.subplot(1,3,3)
plt.imshow(cv2.cvtColor(frame2, cv2.COLOR_BGR2RGB))

plt.figure(figsize=(24,24))
plt.subplot(1,3,1)
plt.imshow(cv2.cvtColor(frame0_crop, cv2.COLOR_BGR2RGB))
plt.subplot(1,3,2)
```

```
plt.imshow(cv2.cvtColor(frame1_crop, cv2.COLOR_BGR2RGB))
plt.subplot(1,3,3)
plt.imshow(cv2.cvtColor(frame2_crop, cv2.COLOR_BGR2RGB))
```

```
<matplotlib.image.AxesImage at 0x7fbda93409d0>
```



```
cap = cv2.VideoCapture(movie_path)

frames = []
for idx in range(start_idx,end_idx,1):
  cap.set(cv2.CAP_PROP_POS_FRAMES, idx)
  _, frame = cap.read()
  frames.append(frame)
```

射出検出

```
for i in range(0,20):
  tmp_img = frames[i][hmin:hmax,wmin:wmax,:].copy()

  # 手の検出
  cond_blue = (130<tmp_img[:,:,0]) & (tmp_img[:,:,0]<180)
  cond_green = (150<tmp_img[:,:,1]) & (tmp_img[:,:,1]<190)
  cond_red = (200<tmp_img[:,:,2]) & (tmp_img[:,:,2]<230)
  condition = cond_blue & cond_green & cond_red
  img_hand, _, _ = extract_arrow(tmp_img, condition, ignore_kernel_size = 8, p = 60)

  # 矢の検出
  cond_blue = (30<tmp_img[:,:,0]) & (tmp_img[:,:,0]<90)
  cond_green = 70<tmp_img[:,:,1]
  cond_red = (30<tmp_img[:,:,2]) & (tmp_img[:,:,2]<90)
  condition = cond_blue & cond_green & cond_red
```

```
  cond_blue = (100<tmp_img[:,:,0]) & (tmp_img[:,:,0]<150)
  cond_green = 150<tmp_img[:,:,1]
  cond_red = (100<tmp_img[:,:,2]) & (tmp_img[:,:,2]<150)
  condition = (cond_blue & cond_green & cond_red) | condition

  img_arrow, est_xtip, est_ytip = extract_arrow(tmp_img, condition, ignore_kernel_size = 16, p = 70

  if est_xtip == est_xtip:
    # 先端の検出
    axis = estimate_axis(img_arrow, est_xtip, est_ytip, kernel=30, rate=55)
    img_axis = np.zeros(tmp_img.shape)
    cv2.line(img_axis,tuple(axis[0]),tuple(axis[1]),(255,0,0),6)

    # 把持位置の検出
    print(detect_release(img_arrow, img_hand, axis, kernel=5))

    plt.figure(figsize=(24,24))
    plt.subplot(1,2,1)
    plt.imshow(cv2.cvtColor(img_arrow, cv2.COLOR_BGR2RGB))
    plt.subplot(1,2,2)
    cv2.line(tmp_img,tuple(axis[0]),tuple(axis[1]),(255,0,0),6)
    cv2.circle(tmp_img, (int(est_xtip), int(est_ytip)), 3, (0, 0, 255), -1)
    plt.imshow(cv2.cvtColor(tmp_img, cv2.COLOR_BGR2RGB))
```

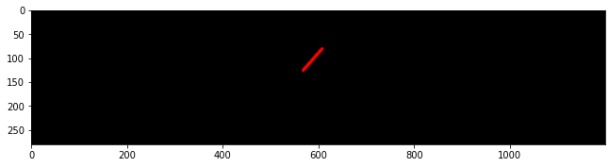
```
    False
    False
    False
    False
    False
    False
    False
    False
    False
    True
    True
    True
    True
    True
    True
    True
    True
    True
    True
```

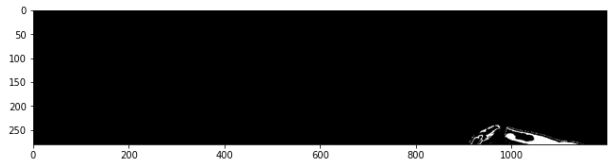
```
axis
```

```
    array([[1090,  163],
           [1129,  118]])
```

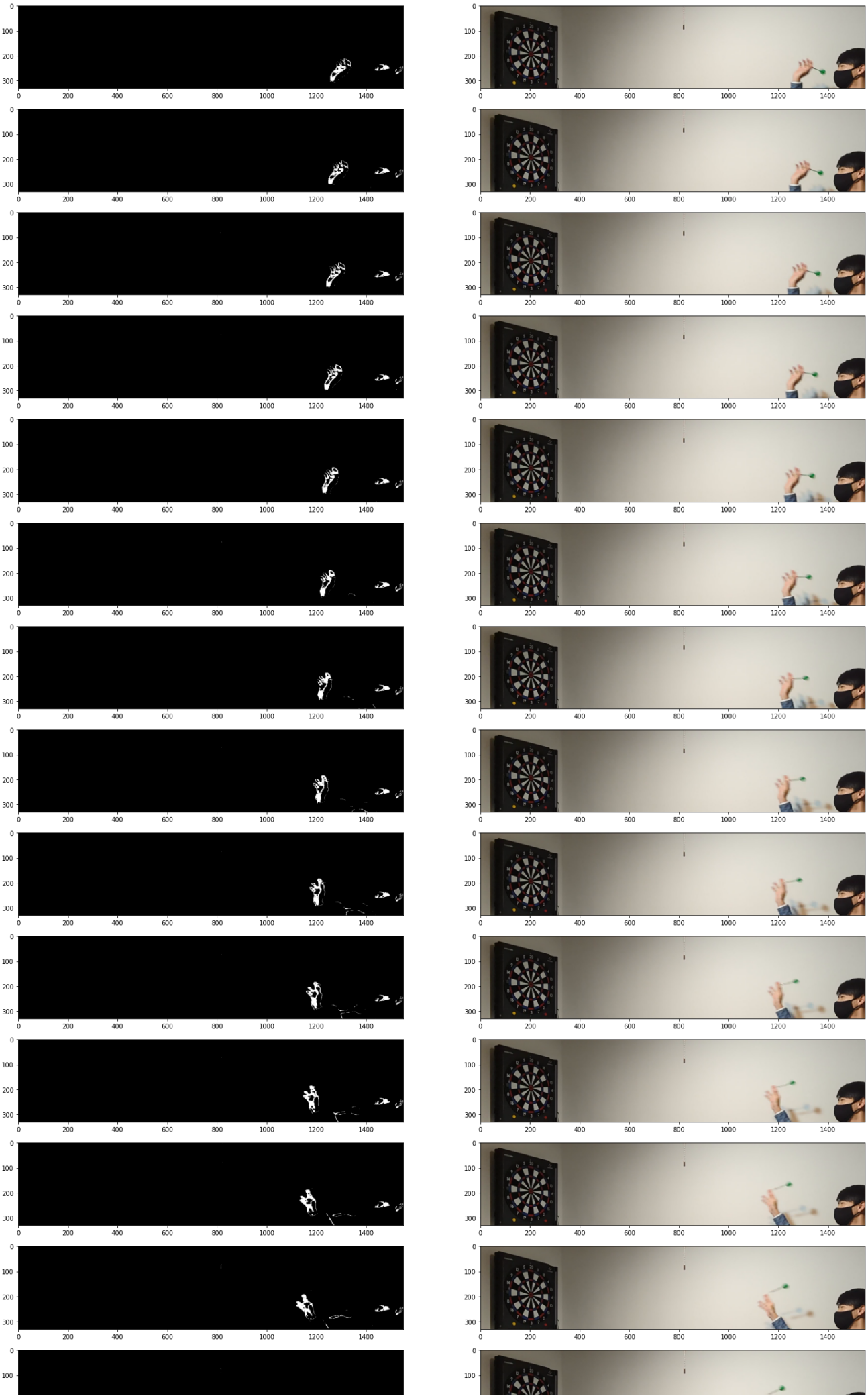
```
plt.figure(figsize=(24,24))
plt.subplot(1,2,1)
plt.imshow(img_axis)
plt.subplot(1,2,2)
plt.imshow(img_hand)
```

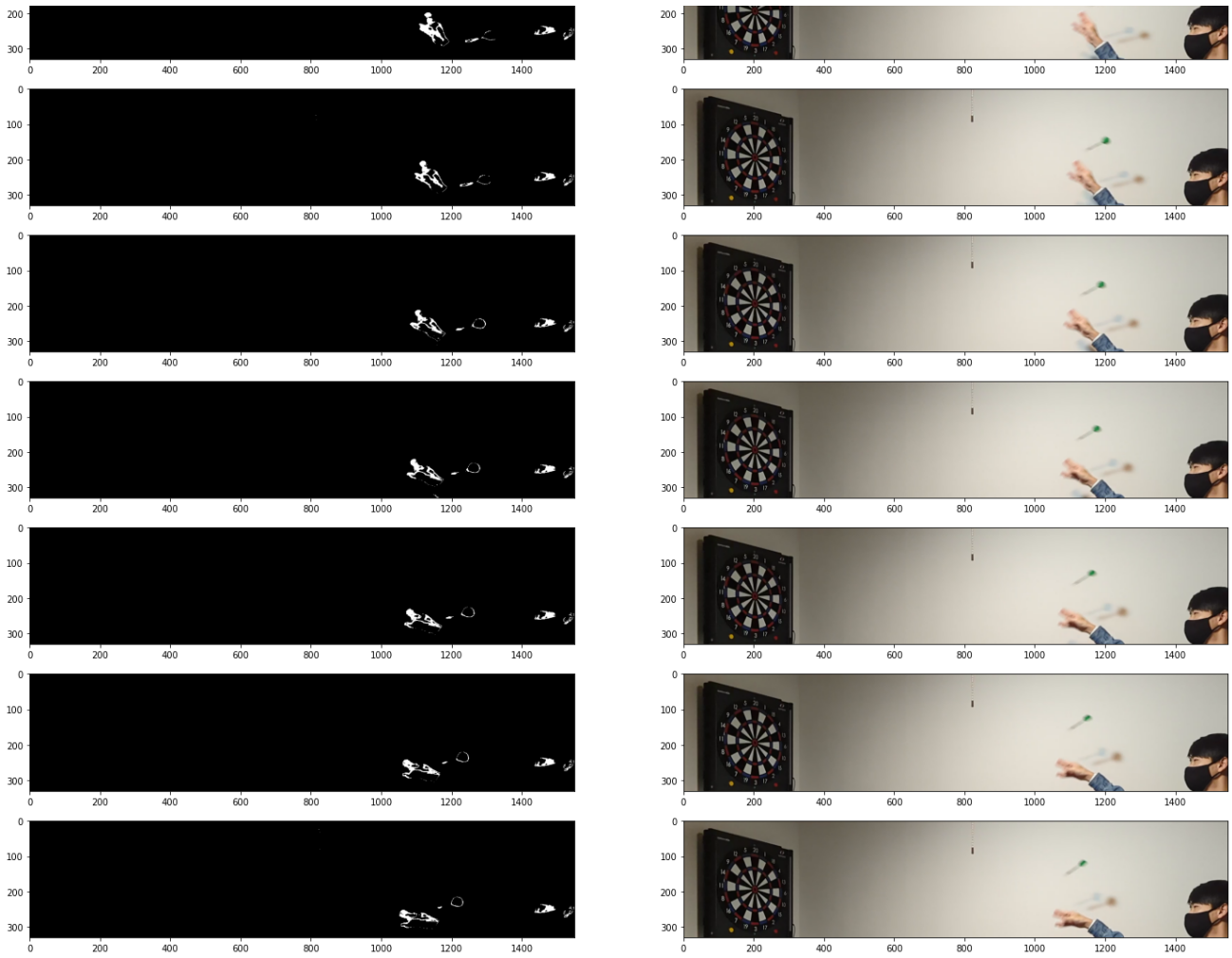
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255
<matplotlib.image.AxesImage at 0x7f1480155550>
```






```
gif_imgs = []
cv2_imgs = []
diff_imgs = []
for idx in range(0, 20, 1):
  # print(idx)
  tmp_img = frames[idx][hmin:hmax,wmin:wmax,:].copy()

  cond_blue = (130<tmp_img[:,:,0]) & (tmp_img[:,:,0]<180)
  cond_green = (150<tmp_img[:,:,1]) & (tmp_img[:,:,1]<200)
  cond_red = (200<tmp_img[:,:,2]) & (tmp_img[:,:,2]<230)
  condition = cond_blue & cond_green & cond_red

  img_arrow, est_xtip, est_ytip = extract_arrow(tmp_img, condition, ignore_kernel_size = 8, p = 60)
  gif_imgs.append(img_arrow)

  plt.figure(figsize=(24,24))
  plt.subplot(1,2,1)
  plt.imshow(cv2.cvtColor(img_arrow, cv2.COLOR_BGR2RGB))
  plt.subplot(1,2,2)
  plt.imshow(cv2.cvtColor(tmp_img, cv2.COLOR_BGR2RGB))
```



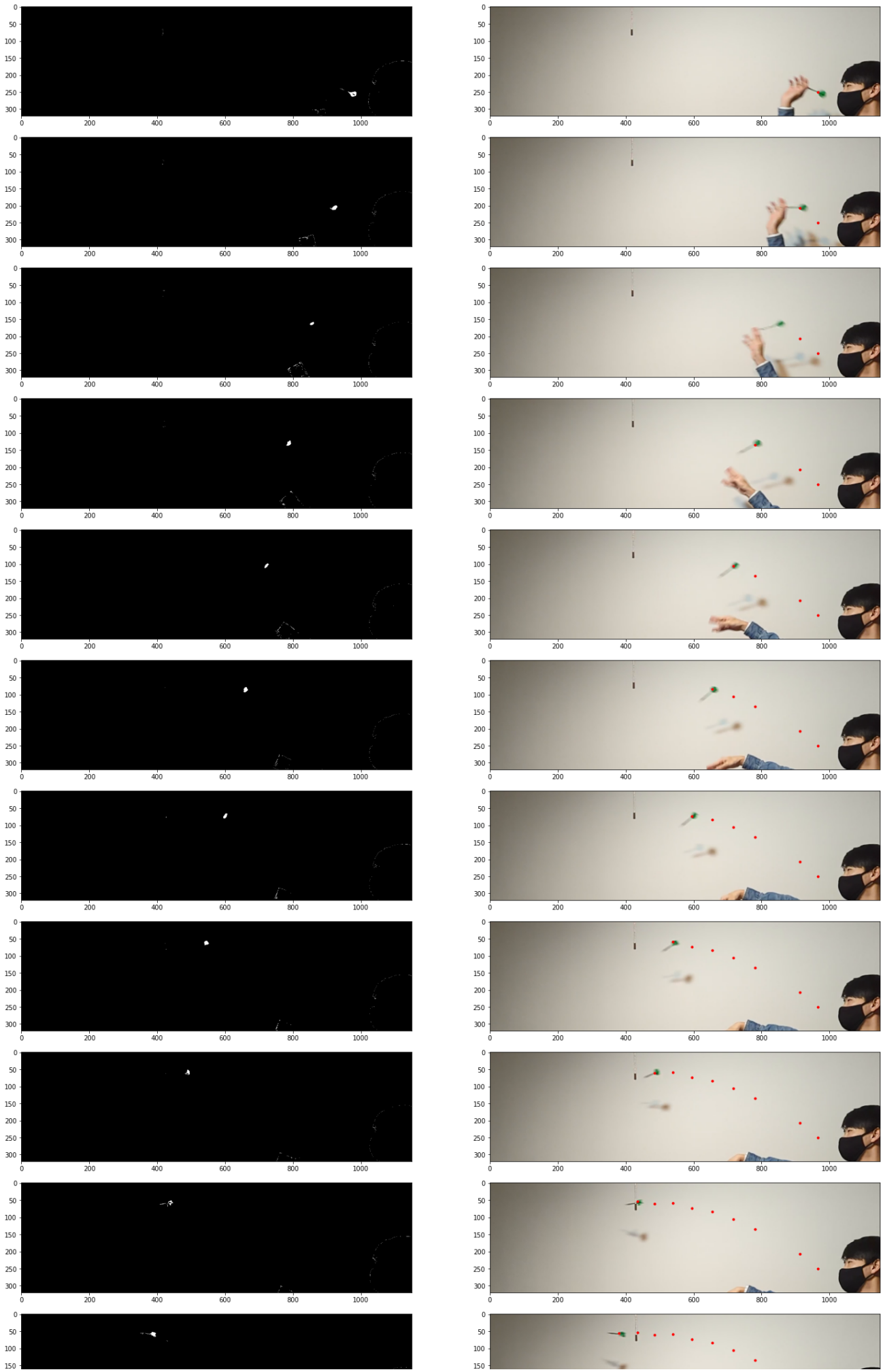


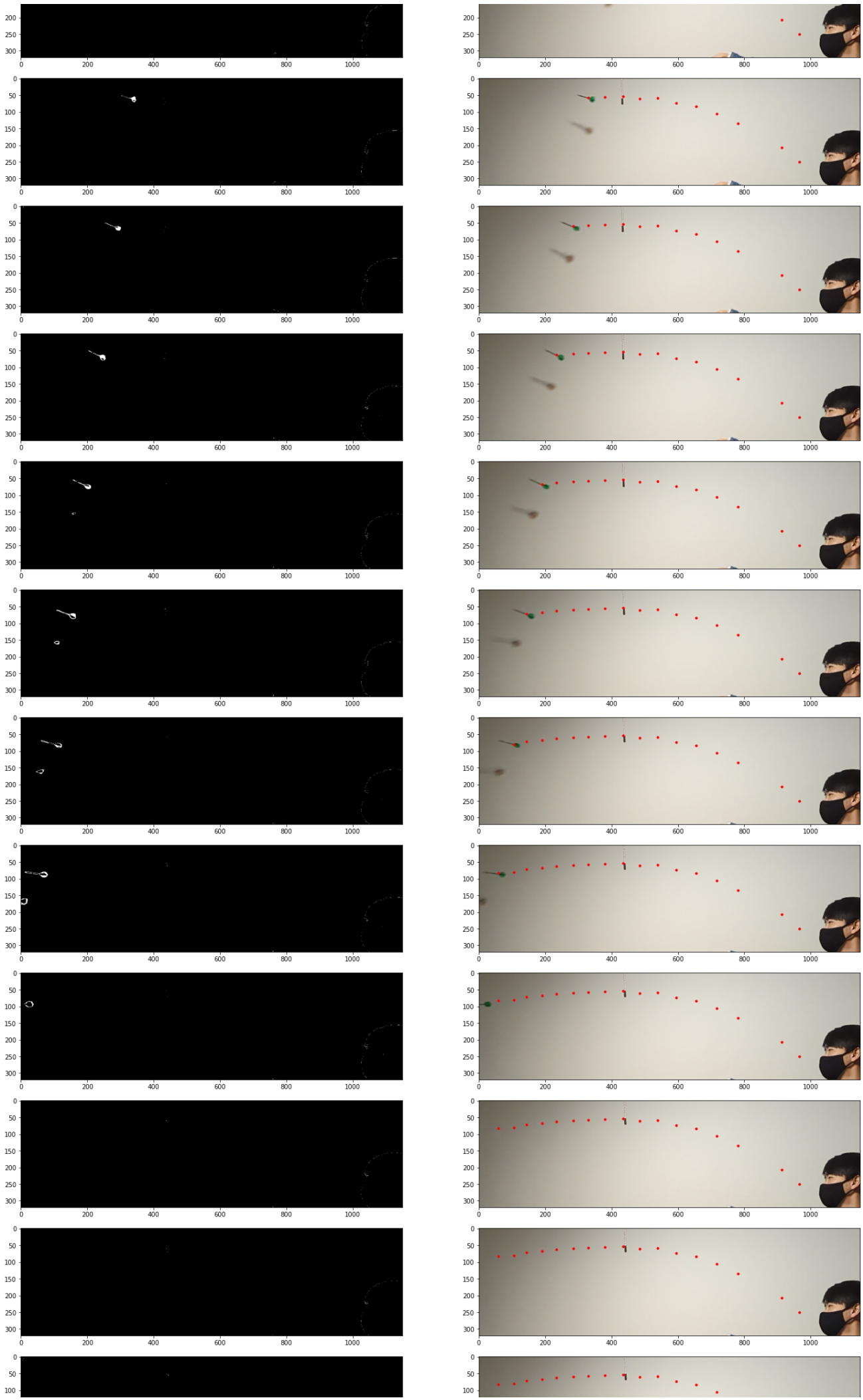
羽検出

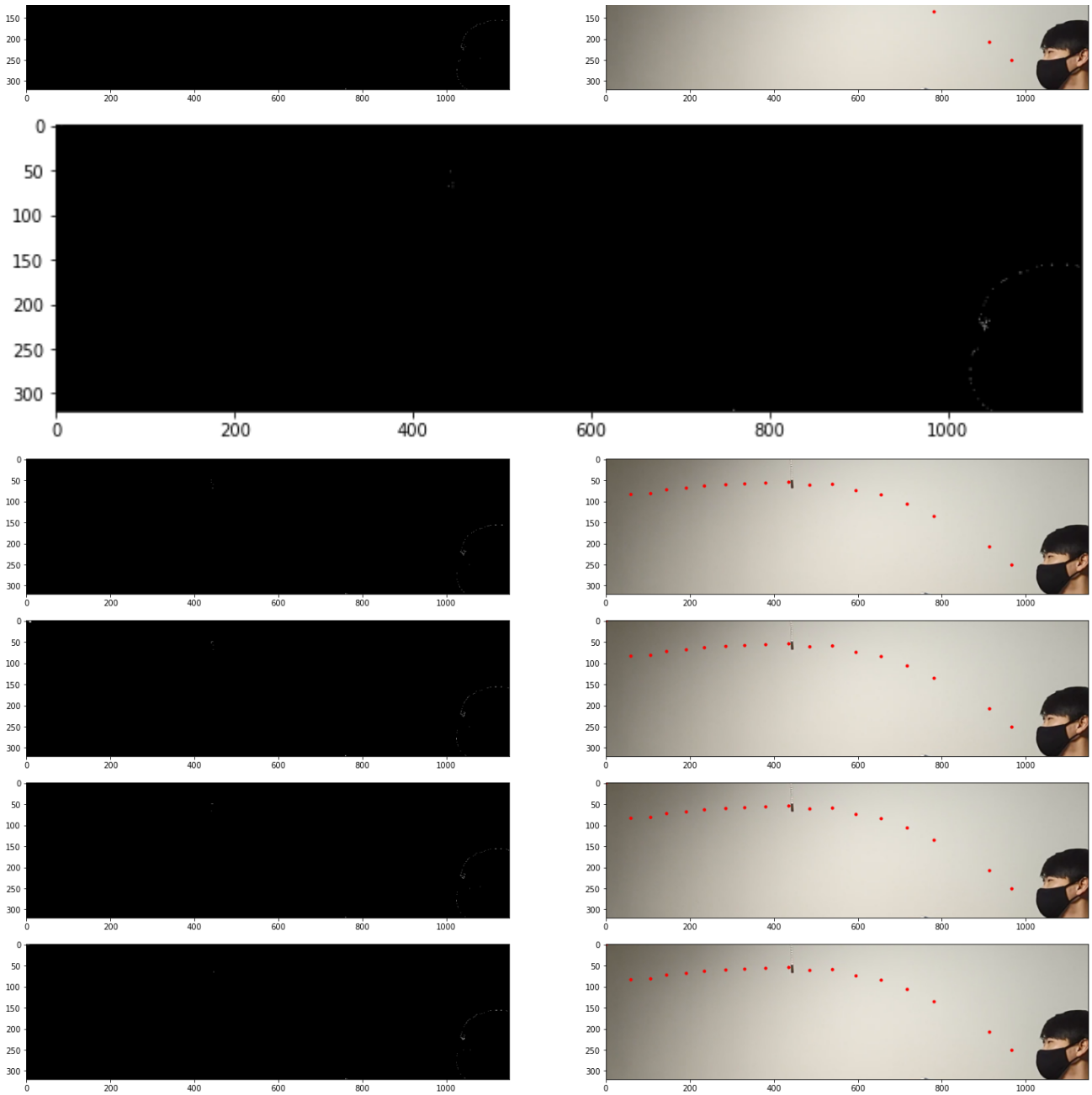
```
trajectory = []
cv2_imgs = []
for idx in range(0, len(frames), 5):
  # print(idx)
  tmp_img = frames[idx][hmin:hmax,wmin:wmax,:][10:,400:,:].copy()

  cond_blue = (0<tmp_img[:,:,0]) & (tmp_img[:,:,0]<100)
  cond_green = 80<tmp_img[:,:,1]
```

```
    cond_red = (0<tmp_img[:,:,2]) & (tmp_img[:,:,2]<100)
    condition = cond_blue & cond_green & cond_red

    img_arrow, est_xtip, est_ytip = extract_arrow(tmp_img, condition, ignore_kernel_size = 20, p = 80
    trajectory.append([est_xtip, est_ytip])

    plt.figure(figsize=(24,24))
    plt.subplot(1,2,1)
    plt.imshow(cv2.cvtColor(img_arrow, cv2.COLOR_BGR2RGB))
    plt.subplot(1,2,2)

    for est_xtip, est_ytip in trajectory:
      if est_xtip==est_xtip:
        cv2.circle(tmp_img, (int(est_xtip), int(est_ytip)), 4, (0, 0, 255), -1)
    cv2_imgs.append(tmp_img)
    tmp_img = cv2.cvtColor(tmp_img, cv2.COLOR_BGR2RGB)
    plt.imshow(tmp_img)

    gif_imgs.append(Image.fromarray(tmp_img))

# gif_imgs[0].save('./video/output.gif', save_all=True, append_images=gif_imgs[1:], optimize=False,
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:15: RuntimeWarning: More than 20
  from ipykernel import kernelapp as app
```







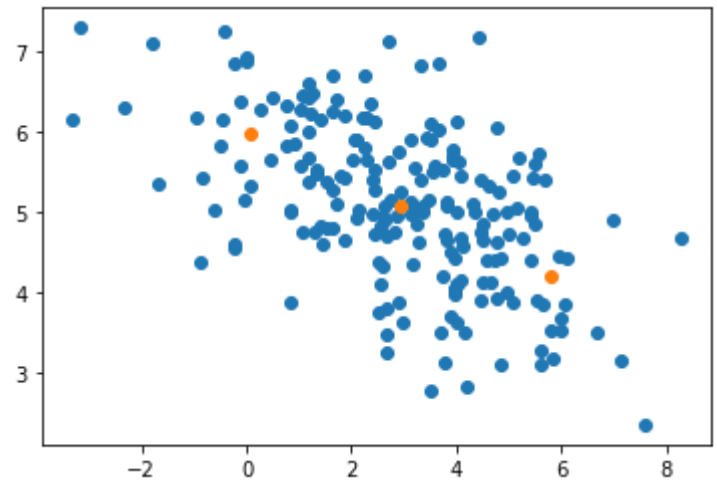
```
# max_idx = np.argmin(np.nan_to_num(np.array(trajectory)[:,1]/5,nan = 1000))
# max_height_x = int(trajectory[max_idx][0])
# max_height_y = int(trajectory[max_idx][1])

# gif_imgs = []
# # for i, img in enumerate(cv2_imgs):
# for i in range(0,len(frames),5):
#   img = cv2_imgs[i].copy()
#   if i >= max_idx:
#     cv2.circle(img, (max_height_x, max_height_y), 36, (255, 255, 255), 1)
#     cv2.circle(img, (max_height_x, max_height_y), 32, (0, 0, 0), 2)
#     cv2.circle(img, (max_height_x, max_height_y), 28, (255, 255, 255), 1)
#     cv2.putText(img,
```

```
#             text='Max Height',
#             org=(max_height_x+40, max_height_y-20),
#             fontFace=cv2.FONT_HERSHEY_SIMPLEX,
#             fontScale=1.0,
#             color=(0, 0, 0),
#             thickness=2,
#             lineType=cv2.LINE_4)
#     drawDashedLine(img, (max_height_x, max_height_y), (max_height_x, img.shape[0]), 8, 2, (255,0,
#   img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
#   plt.figure(figsize=(24,6))
#   plt.imshow(img)
#   gif_imgs.append(Image.fromarray(img))
# # gif_imgs[0].save('./video/output.gif', save_all=True, append_images=gif_imgs[1:], optimize=Fals
```

先端検出

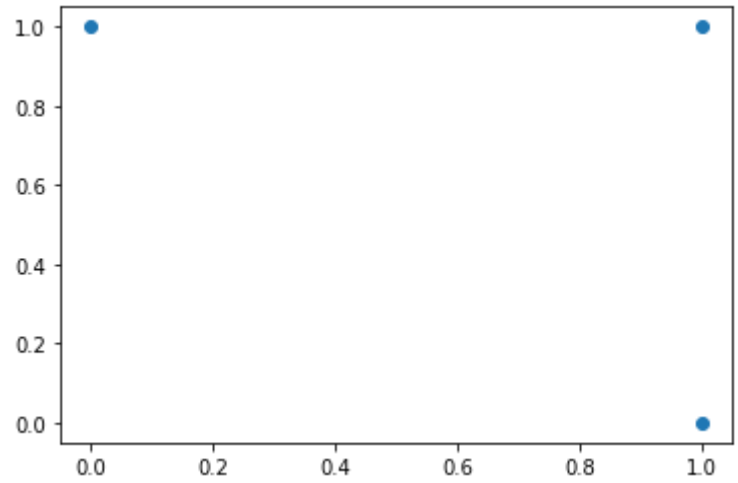
```
from scipy.stats import multivariate_normal
import scipy

mean = np.array([3, 5])
cov = np.array([[4, -1.2], [-1.2, 1]])

# numpy を用いた生成
data = np.random.multivariate_normal(mean, cov, size=200)

plt.scatter(data[:,0], data[:,1])

pcamodel = PCA()
pcamodel.fit(data)
pca_cor = pcamodel.transform(data)
dx, dy = pcamodel.components_[0]

x_mean = np.mean(data[:,0])
y_mean = np.mean(data[:,1])

plt.scatter(x=[x_mean-3*dx, x_mean, x_mean+3*dx], y = [y_mean-3*dy, y_mean, y_mean+3*dy])
```

```
<matplotlib.collections.PathCollection at 0x7f1486086fd0>
```



```
data = np.array([[0,255],[255,255]])
x, y = np.where(data>10)
plt.scatter(x, y)
```

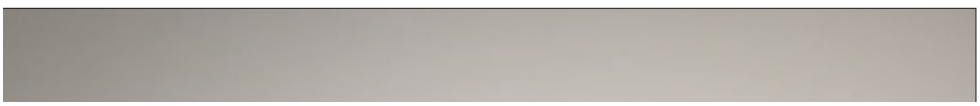
```
<matplotlib.collections.PathCollection at 0x7f199ccf4950>
```

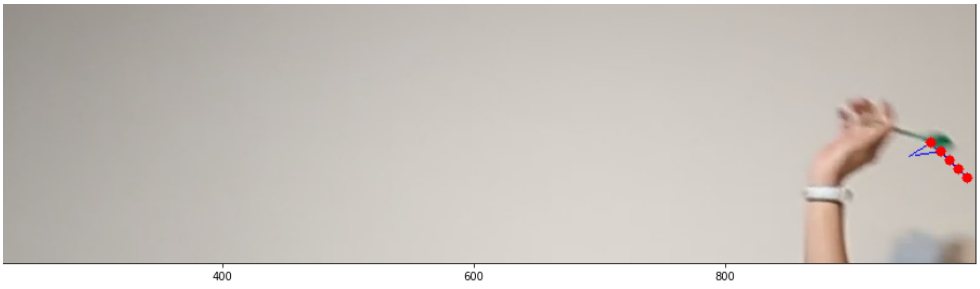



```
x_offset = 200


# cv2_imgs = []
# trajectory = []
# axis_list = []
# gif_imgs = []
# for idx in range(0, len(frames), 1):
#   # print(idx)
#   tmp_img = frames[idx][hmin:hmax,wmin+x_offset:wmax,:].copy()

#   cond_blue = (0<tmp_img[:,:,0]) & (tmp_img[:,:,0]<90)
#   cond_green = 70<tmp_img[:,:,1]
#   cond_red = (0<tmp_img[:,:,2]) & (tmp_img[:,:,2]<90)
#   condition = cond_blue & cond_green & cond_red

#   img_arrow, est_xtip, est_ytip = extract_arrow(tmp_img, condition, ignore_kernel_size = 8, p = 8
#   trajectory.append([est_xtip, est_ytip])

#   if est_xtip == est_xtip:
#     axis = estimate_axis(img_arrow, est_xtip, est_ytip, kernel=10)
#     axis_list.append(axis)
#   else:
#     axis_list.append([[None, None], [None,None]])

#   plt.figure(figsize=(24,24))
#   plt.subplot(1,2,1)
#   plt.imshow(cv2.cvtColor(img_arrow, cv2.COLOR_BGR2RGB))
#   plt.subplot(1,2,2)

#   for (est_xtip, est_ytip), axis in zip(trajectory, axis_list):
#     if est_xtip==est_xtip:
#       cv2.line(tmp_img,tuple(axis[0]),tuple(axis[1]),(255,0,0),1)
#       cv2.circle(tmp_img, (int(est_xtip), int(est_ytip)), 4, (0, 0, 255), -1)

#   cv2_imgs.append(tmp_img)
```

```
#   tmp_img = cv2.cvtColor(tmp_img, cv2.COLOR_BGR2RGB)
#   plt.imshow(tmp_img)

#   gif_imgs.append(Image.fromarray(tmp_img))

# gif_imgs[0].save('./video/output2.gif', save_all=True, append_images=gif_imgs[1:], optimize=False


max_idx = np.argmin(np.nan_to_num(np.array(trajectory)[:,1],nan = 1000))
max_height_x = int(trajectory[max_idx][0])
max_height_y = int(trajectory[max_idx][1])

gif_imgs = []
for i, img in enumerate(cv2_imgs):
  tmp_img = img.copy()
  if i >= max_idx:
    cv2.circle(img, (max_height_x, max_height_y), 36, (255, 255, 255), 1)
    cv2.circle(img, (max_height_x, max_height_y), 32, (0, 0, 0), 2)
    cv2.circle(img, (max_height_x, max_height_y), 28, (255, 255, 255), 1)
    cv2.putText(img,
            text='Max Height',
            org=(max_height_x+40, max_height_y-20),
            fontFace=cv2.FONT_HERSHEY_SIMPLEX,
            fontScale=1.0,
            color=(0, 0, 0),
            thickness=2,
            lineType=cv2.LINE_4)
    drawDashedLine(img, (max_height_x, max_height_y), (max_height_x, img.shape[0]), 8, 2, (255,0,25
  img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
  plt.figure(figsize=(24,6))
  plt.imshow(img)
  gif_imgs.append(Image.fromarray(img))
gif_imgs[0].save('./video/output2.gif', save_all=True, append_images=gif_imgs[1:], optimize=False,
```

```
7/dist-packages/ipykernel_launcher.py:22: RuntimeWarning: More than 20 figures have been opene
```

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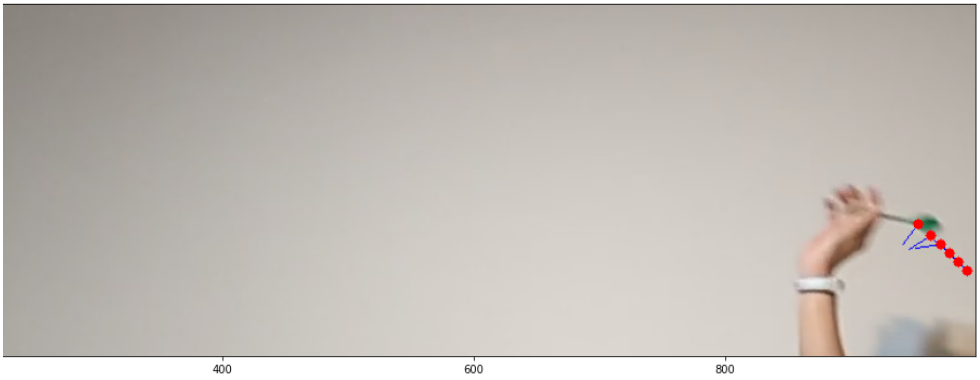
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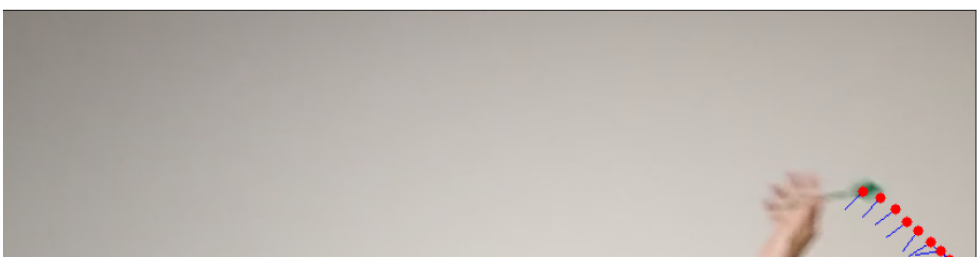


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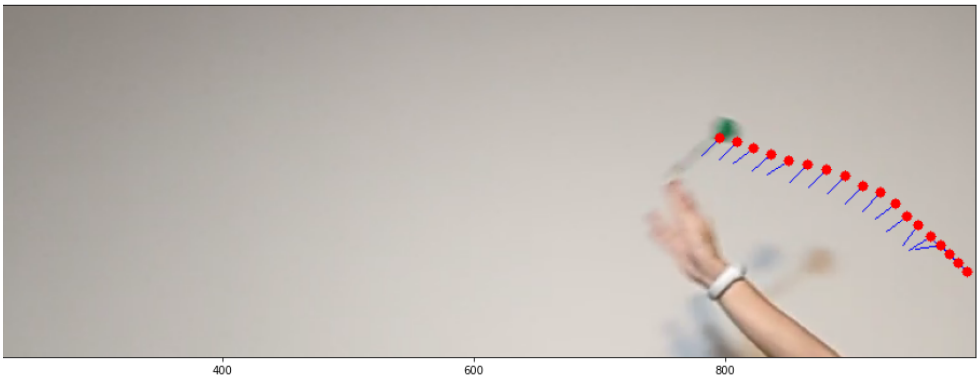
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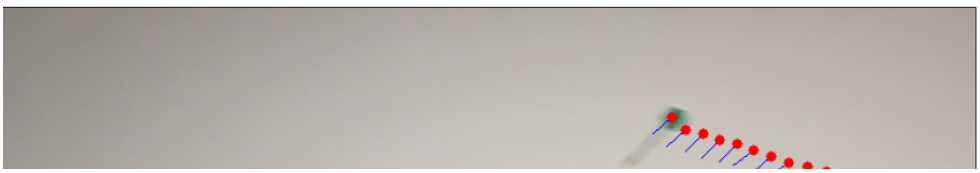

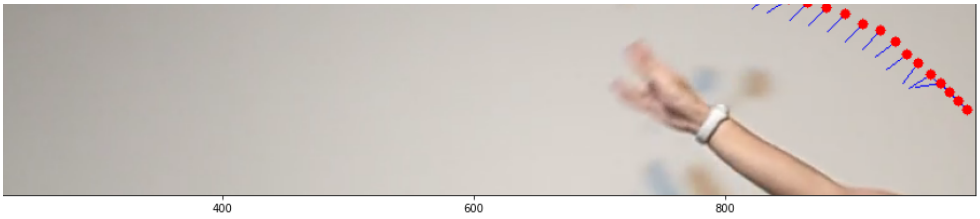
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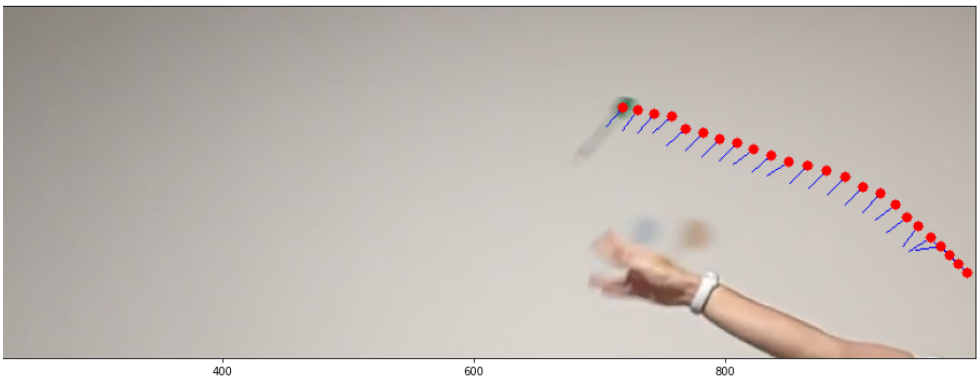
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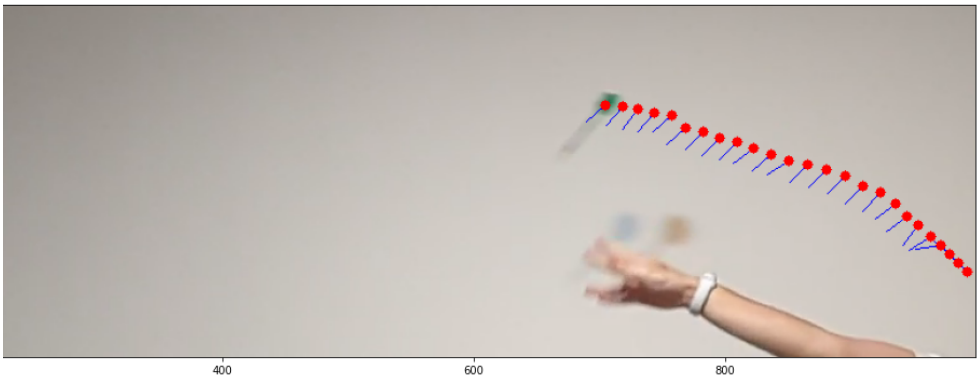
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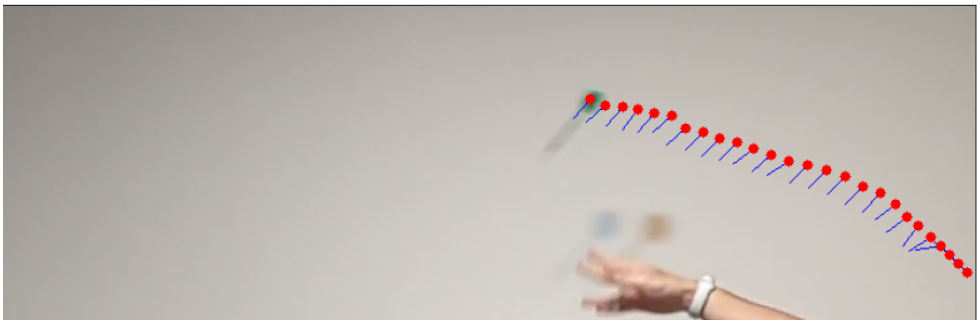

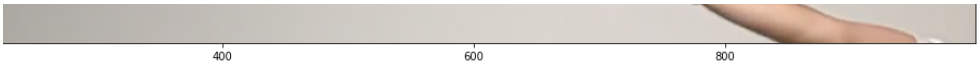
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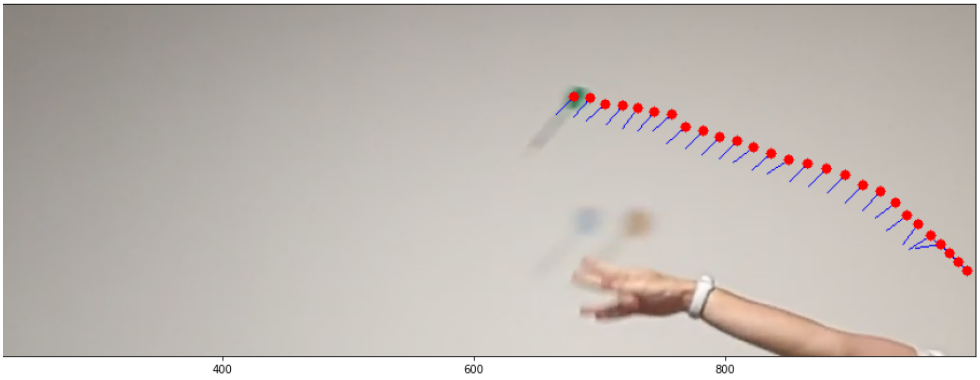
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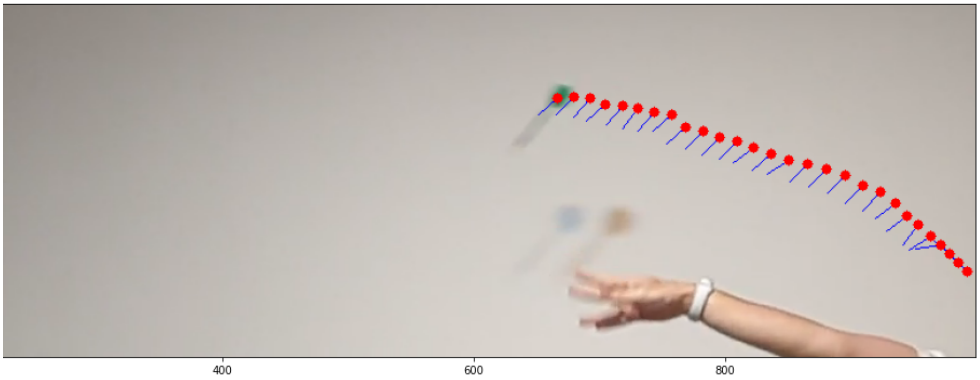
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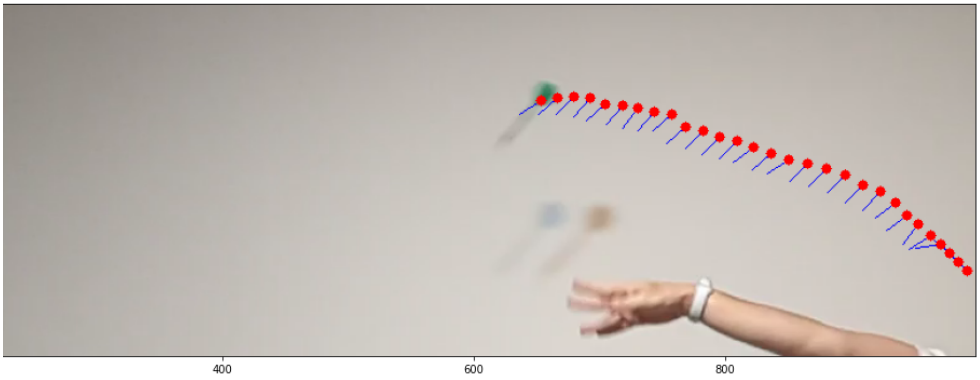
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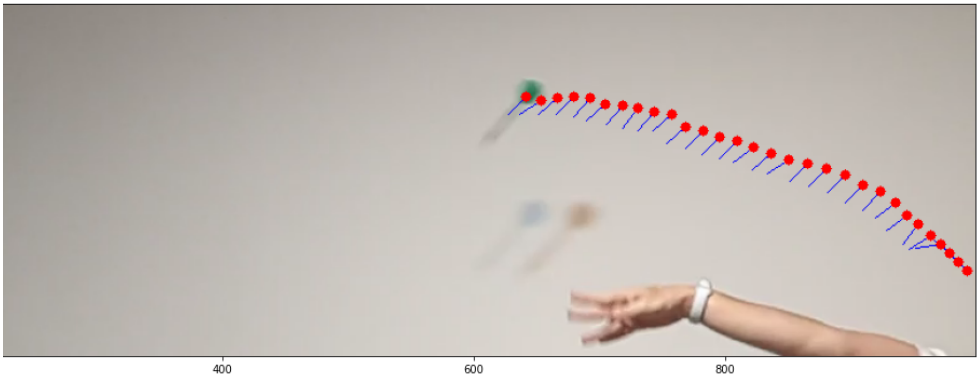
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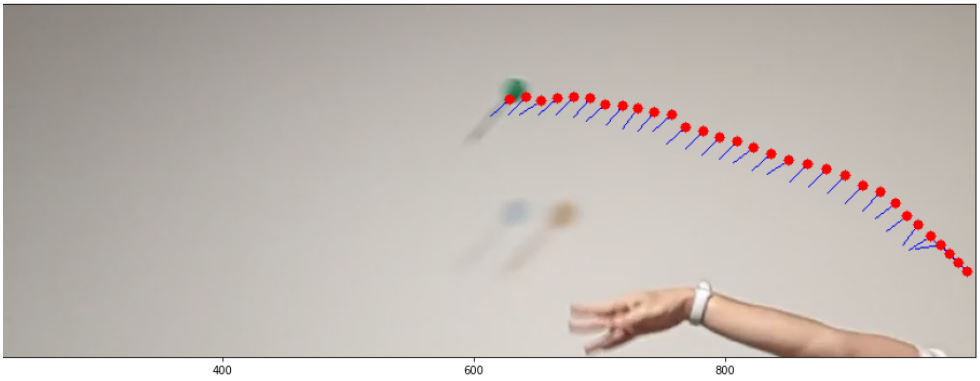
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