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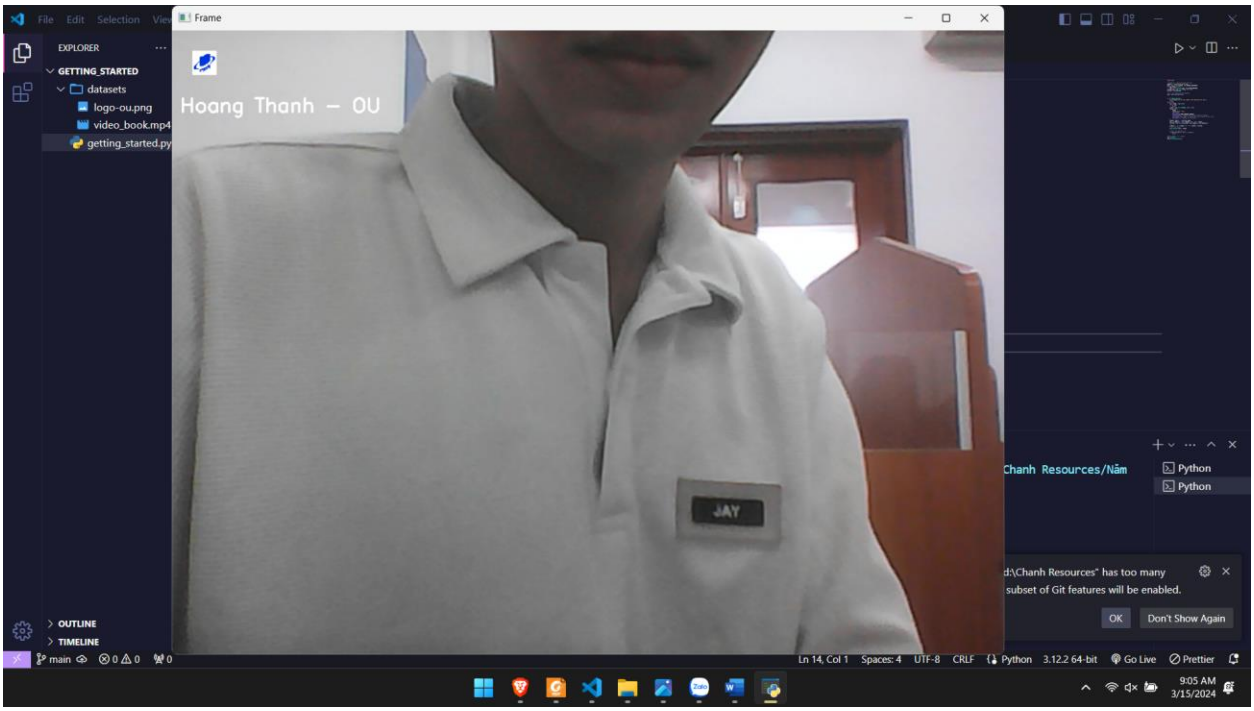
Part 1: Getting started

Code:

```
import cv2

# videoPath = "datasets/video_book.mp4"
imgPath = "datasets/logo-ou.png"
img = cv2.imread(imgPath, cv2.IMREAD_UNCHANGED)
if img.shape[2] == 4:
    img = cv2.cvtColor(img, cv2.COLOR_RGBA2RGB)
resized_img = cv2.resize(img, (30, 30))
overlay = resized_img

# cap = cv2.VideoCapture(videoPath)
cap = cv2.VideoCapture(0)


if not cap.isOpened():
    print("Không thể kết nối camera. Vui lòng kiểm tra
lại.")
    exit()
while True:
    ret, frame = cap.read()
    if not ret:
        break
    frame = cv2.resize(frame, (1024, 768))
    cv2.putText(
        frame,
        "Hoang Thanh - OU",
        (10, 100),
        fontFace=cv2.FONT_HERSHEY_SIMPLEX,
        fontScale=0.8,  # Adding the missing fontScale
argument
```

```
        color=(255, 255, 255),  # Adding font color
(white in this case)
        thickness=2,  # Adding text thickness
    )
    height, width, _ = overlay.shape
    roi = frame[100 : 100 + height, 150 : 150 + width]
    overlay = cv2.resize(overlay, (roi.shape[1],
roi.shape[0]))

    frame[25 : 25 + height, 25 : 25 + width] = overlay
    # Hiển thị frame
    cv2.imshow("Frame", frame)

    # Thoát nếu nhấn phím 'q'
    if cv2.waitKey(1) & 0xFF == ord("q"):
        break

# Giải phóng các tài nguyên
cap.release()
cv2.destroyAllWindows()
```

Result:



Part 2: Candel in pinhole

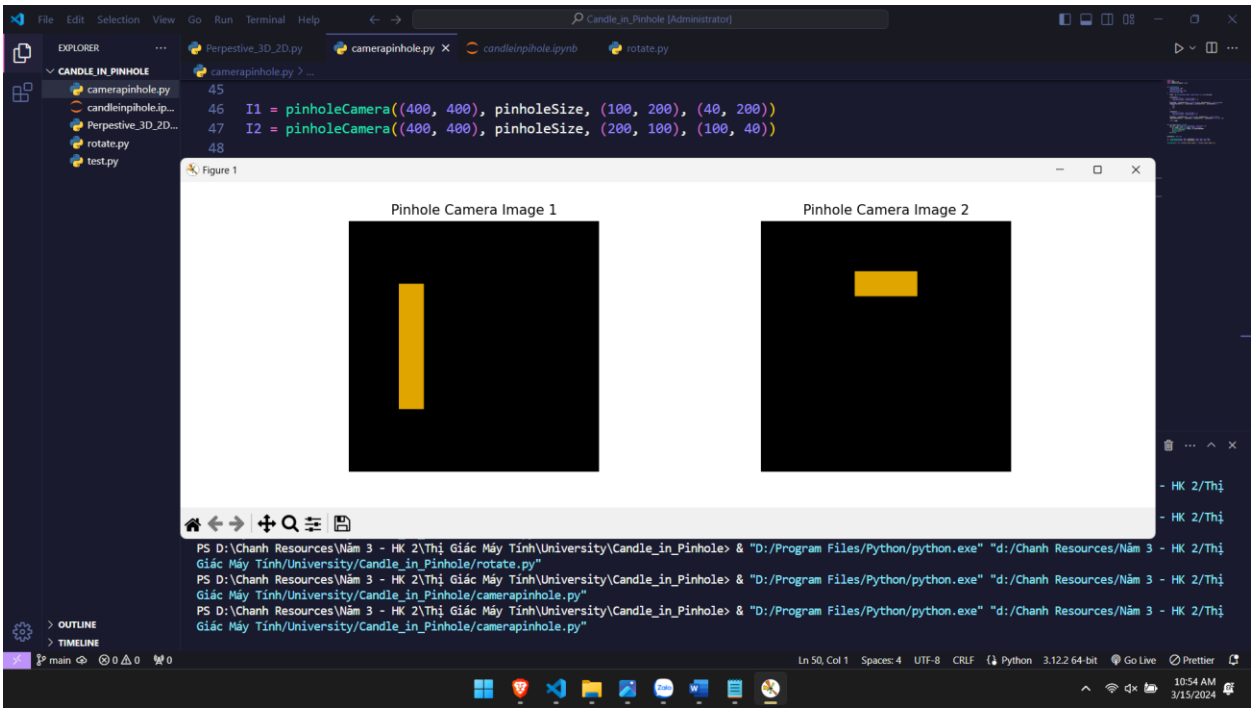
Code:

```
import cv2
import numpy as np
import matplotlib.pyplot as plt


def pinholeCamera(
    imageSize=(400, 400),
    pinholeSize=(3, 3),
    objectPosition=(200, 200),
    objectSize=(20, 100),
):
    image = np.zeros((imageSize[0], imageSize[1], 3),
dtype=np.uint8)

    pinholeStart = (
        objectPosition[0] - pinholeSize[0] // 2,
        objectPosition[1] - pinholeSize[1] // 2,
    )
```

```
    pinholeEnd = (pinholeStart[0] + pinholeSize[0],
pinholeStart[1] + pinholeSize[1])
    image[pinholeStart[1] : pinholeEnd[1],
pinholeStart[0] : pinholeEnd[0]] = [
        225,
        225,
        225,
    ]

    candleStart = (
        objectPosition[0] - objectSize[0] // 2,
        objectPosition[1] - objectSize[1] // 2,
    )
    candleEnd = (candleStart[0] + objectSize[0],
candleStart[1] + objectSize[1])
    image[candleStart[1] : candleEnd[1], candleStart[0] :
candleEnd[0]] = [0, 165, 225]

    return image


def plotImages(images, titles):
    fig, axe = plt.subplots(1, len(images), figsize=(12,
4))
    for ax, image, title in zip(axe, images, titles):
        ax.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
        ax.set_title(title)
        ax.axis("off")
    plt.show()


pinholeSize = (10, 10)

I1 = pinholeCamera((400, 400), pinholeSize, (100, 200),
(40, 200))
```

```
I2 = pinholeCamera((400, 400), pinholeSize, (200, 100),
(100, 40))

plotImages([I1, I2], ["Pinhole Camera Image 1", "Pinhole
Camera Image 2"])
```

Result:



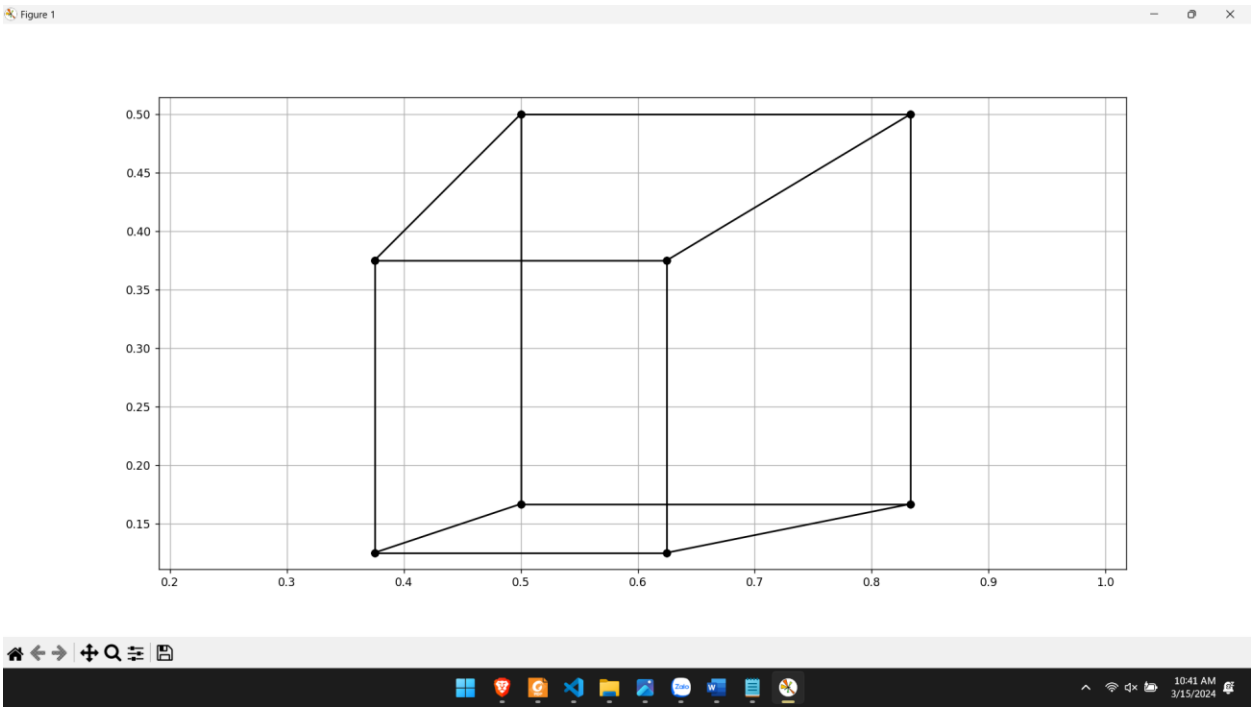
Part 3: Perpestive cube 3D →2D

Code:

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

A = np.array([1, 1, 1])
B = np.array([-1, 1, 1])
C = np.array([1, -1, 1])
D = np.array([-1, -1, 1])
E = np.array([1, 1, -1])
```

```
F = np.array([-1, 1, -1])
G = np.array([1, -1, -1])
H = np.array([-1, -1, -1])

camera = np.array([4, 2, 7])

Points = dict(zip("ABCDEFGH", [A, B, C, D, E, F, G, H]))

edges = ["AB", "CD", "EF", "GH", "AC", "BD", "EG", "FH",
"AE", "CG", "BF", "DH"]
points = {k: v - camera for k, v in Points.items()}


def pinhole(v):
    x, y, z = v
    if z == 0:
        return np.array([float("inf"), float("inf")])
    return np.array([x / z, y / z])


uvs = {k: pinhole(p) for k, p in points.items()}

plt.figure(figsize=(10, 10))
for a, b in edges:
    ua, va = uvs[a]
    ub, vb = uvs[b]
    plt.plot([ua, ub], [va, vb], "ko-")

plt.axis("equal")
plt.grid()

plt.show()
```

Result:



Part 4: Rotate cube 3D → 2D

Code:

```python
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Define points
A = np.array([1, 1, 1])
B = np.array([-1, 1, 1])
C = np.array([1, -1, 1])
D = np.array([-1, -1, 1])
E = np.array([1, 1, -1])
F = np.array([-1, 1, -1])
G = np.array([1, -1, -1])
H = np.array([-1, -1, -1])

camera = np.array([2, 3, 5])
```

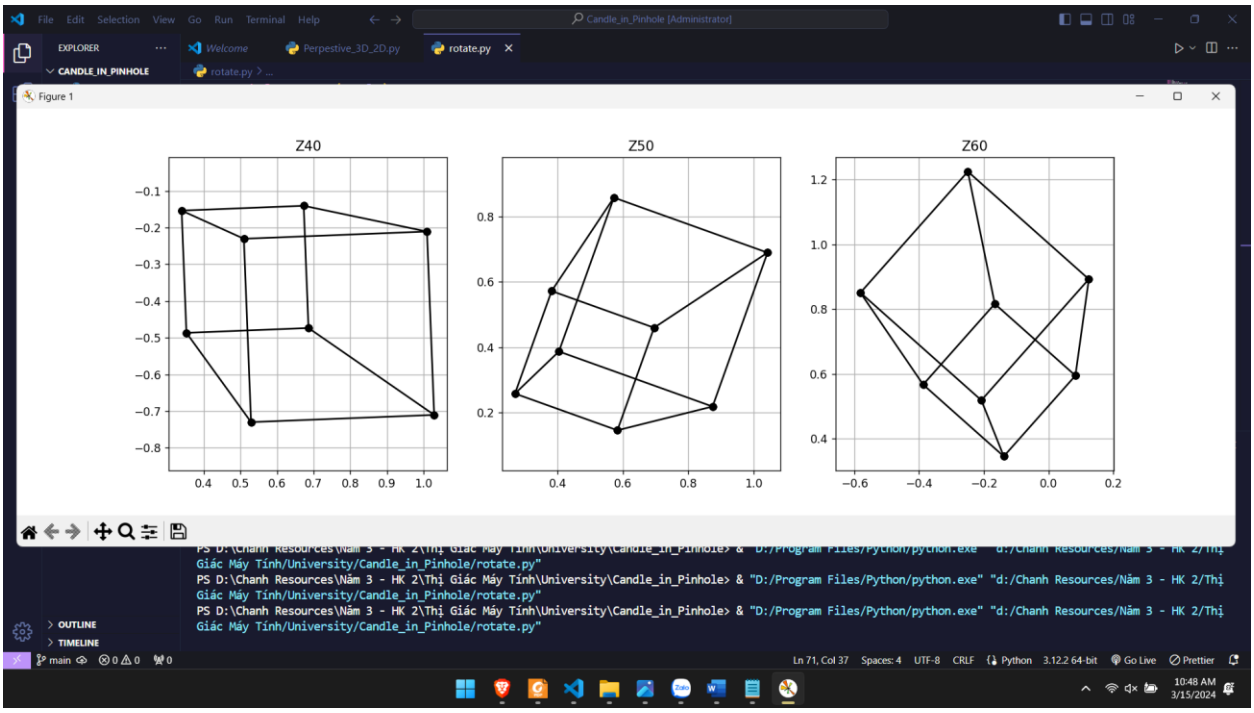
```
Points = dict(zip("ABCDEFGH", [A, B, C, D, E, F, G, H]))

edges = ["AB", "CD", "EF", "GH", "AC", "BD", "EG", "FH",
"AE", "CG", "BF", "DH"]
points = {k: v - camera for k, v in Points.items()}


def pinhole(v):
    x, y, z = v
    if z == 0:
        return np.array([float("inf"), float("inf")])
    return np.array([x / z, y / z])


def rotate(R, v):
    return np.dot(R, v)


def getRotX(angle):
    Rx = np.zeros((3, 3))
    Rx[0, 0] = 1
    Rx[1, 1] = np.cos(angle)
    Rx[1, 2] = -np.sin(angle)
    Rx[2, 1] = np.sin(angle)
    Rx[2, 2] = np.cos(angle)

    return Rx


def getRotY(angle):
    Ry = np.zeros((3, 3))
    Ry[0, 0] = np.cos(angle)
    Ry[0, 2] = -np.sin(angle)
    Ry[2, 0] = np.sin(angle)
    Ry[2, 2] = np.cos(angle)
    Ry[1, 1] = 1
```

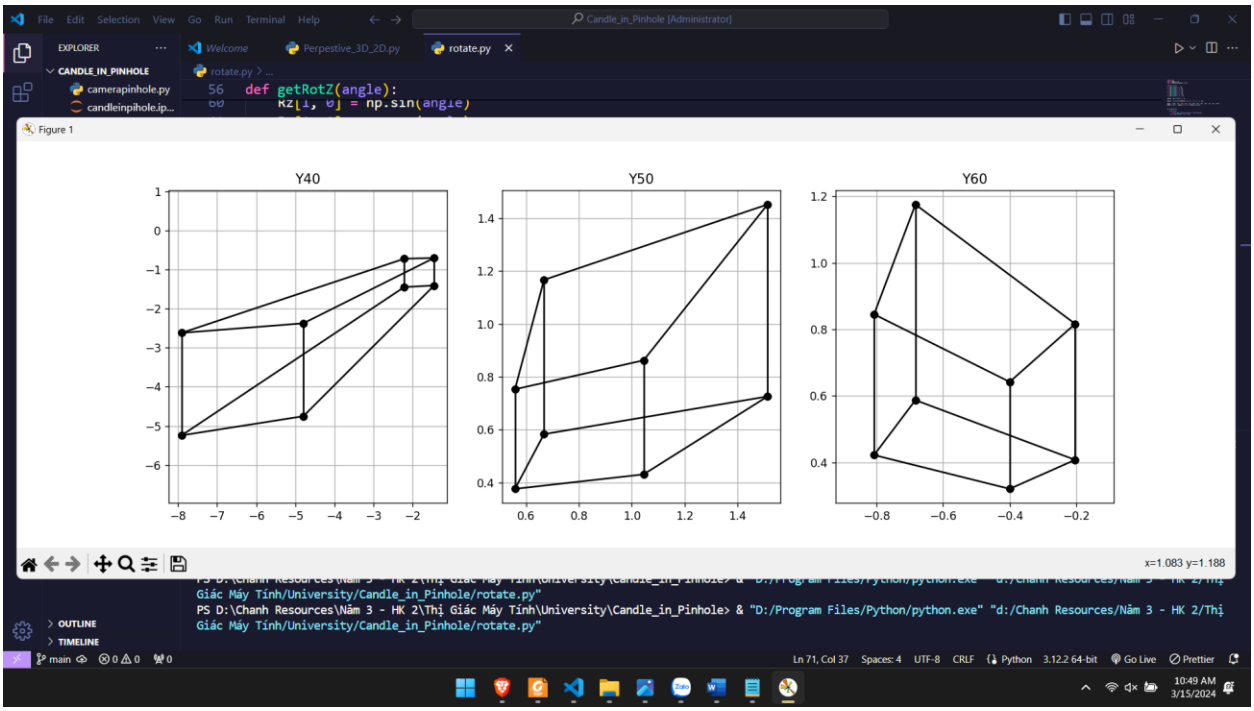
```
    return Ry


def getRotZ(angle):
    Rz = np.zeros((3, 3))
    Rz[0, 0] = np.cos(angle)
    Rz[0, 1] = -np.sin(angle)
    Rz[1, 0] = np.sin(angle)
    Rz[1, 1] = np.cos(angle)
    Rz[2, 2] = 1

    return Rz


angles = [40, 50, 60]

# Plot for Z rotations
fig, ax = plt.subplots(1, 3, figsize=(15, 5))
for i, angle_z in enumerate(angles):
    Rz = getRotZ(np.degrees(angle_z))

    # Apply rotation to points
    ps = {key: rotate(Rz, value) for key, value in
points.items()}
    uvs = {key: pinhole(value) for key, value in
ps.items()}

    # Plot edges
    for a, b in edges:
        ua, va = uvs[a]
        ub, vb = uvs[b]
        ax[i].plot([ua, ub], [va, vb], "ko-")

    ax[i].set_title(f"Z{angle_z}")
    ax[i].axis("equal")
    ax[i].grid()
```

```
plt.show()

# Plot for Y rotations
fig, ax = plt.subplots(1, 3, figsize=(15, 5))
for i, angle_y in enumerate(angles):
    Ry = getRotY(np.degrees(angle_y))

    # Apply rotation to points
    ps = {key: rotate(Ry, value) for key, value in
points.items()}
    uvs = {key: pinhole(value) for key, value in
ps.items()}

    # Plot edges
    for a, b in edges:
        ua, va = uvs[a]
        ub, vb = uvs[b]
        ax[i].plot([ua, ub], [va, vb], "ko-")

    ax[i].set_title(f"Y{angle_y}")
    ax[i].axis("equal")
    ax[i].grid()

plt.show()

# Plot for X rotations
fig, ax = plt.subplots(1, 3, figsize=(15, 5))
for i, angle_x in enumerate(angles):
    Rx = getRotX(np.degrees(angle_x))

    # Apply rotation to points
    ps = {key: rotate(Rx, value) for key, value in
points.items()}
    uvs = {key: pinhole(value) for key, value in
ps.items()}
```

```
    # Plot edges
    for a, b in edges:
        ua, va = uvs[a]
        ub, vb = uvs[b]
        ax[i].plot([ua, ub], [va, vb], "ko-")

    ax[i].set_title(f"X{angle_x}")
    ax[i].axis("equal")
    ax[i].grid()

plt.show()
```

Result:






```
def getRotZ(angle):
    Rz[1, 0] = np.sin(angle)
```

```
Giác Máy Tính\University\Candle_in_Pinhole\rotate.py"
PS D:\Chanh Resources\Năm 3 - HK 2\Thị Giác Máy Tính\University\Candle_in_Pinhole> & "D:/Program Files/Python/python.exe" "d:/Chanh Resources/Năm 3 - HK 2/Thị Giác Máy Tính/University/Candle_in_Pinhole/rotate.py"
```