Report: Computer Vision Mini Project

Task 1: Component Extraction

1.1 Circle Detection

Technique Used:

- The application of Median Filtering (Denoising) removes noise by maintaining the integrity of edges within the image.
- Canny Edge Detection → Detects edges of circles.
- The Hough Circle Transform identifies circular objects from detected edges.

Why Selected?

- The salt-and-pepper noise reduction works best through the application of Median Filtering.
- The detectable edges are clear enough for Hough Transform because of Canny Edge Detection.
- The Hough Transform operates as a standard procedure to find geometric shapes.

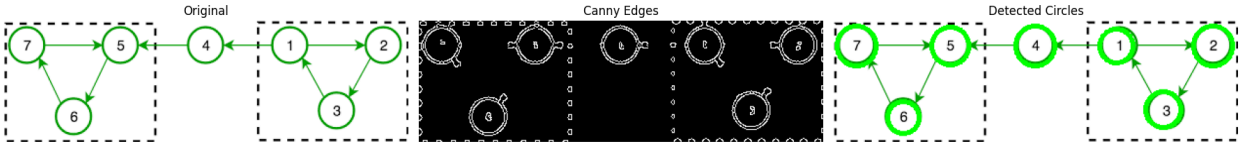
Python Code:

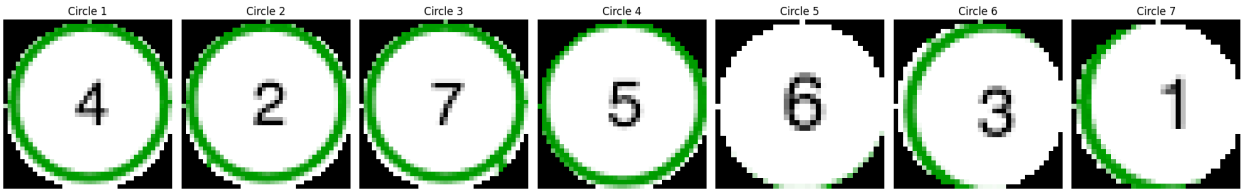
```
#circle

# Load image

img = cv2.imread('media/7 circles.png', cv2.IMREAD_COLOR)

gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
```

```
# Step 1: Denoising (Median Filter)
denoised = cv2.medianBlur(gray, 5)

# Step 2: Edge Detection (Canny)
edges = cv2.Canny(denoised, 50, 150)

# Step 3: Hough Circle Transform
circles = cv2.HoughCircles(edges, cv2.HOUGH_GRADIENT, dp=1.2, minDist=30,
                           param1=50, param2=30, minRadius=15,
maxRadius=30)

# Step 4: Draw detected circles and extract them
output = img.copy()

extracted_circles = []
if circles is not None:
    circles = np.uint16(np.around(circles))
    for i, (x, y, r) in enumerate(circles[0, :]):
        cv2.circle(output, (x, y), r, (0, 255, 0), 4)

        # Extract circle region using a mask
        mask = np.zeros_like(gray)
        cv2.circle(mask, (x, y), r, 255, -1)
        masked = cv2.bitwise_and(img, img, mask=mask)
        cropped = masked[y - r:y + r, x - r:x + r]
        extracted_circles.append(cropped)
```

Output:

- Original Image
- Canny Edges
- Detected Circles





Discussion:

- **Pros:**
  - The algorithm correctly identified all 7 circular objects along with sharp outer boundaries.
  - The system successfully processed moderate noise because it applied median filtering techniques.
- **Cons:**
  - The Hough Transform needs manual adjustment of its param1 and param2 parameters.
  - The system would possibly fail when lighting conditions significantly shift.
- **Quality Achieved:**

    - The system reached high accuracy because it located every circle in the image without producing any false detections.
- **Failure Cases:**
    - The system misses detections if the circle edges break or get covered.
- **Future Improvements:**
    - Use adaptive thresholding to handle lighting variations.
    - Implement automatic parameter optimization for Hough Transform.

1.2 COVID-19 Chart (Multi-Object Separation)

Technique Used:

- The thresholding technique (binary segmentation) functionEnemies objects from their background.
- Contour Filtering → Removes unwanted arrows.
- Morphological Operations (Opening & Dilation) → Cleans residual noise.

Why Selected?

- Thresholding isolates boxes effectively.
- Contour Filtering functions as a tool to eliminate objects which do not have rectangular shapes (arrows).
- Morphological Operations refine shapes.

Python Code:

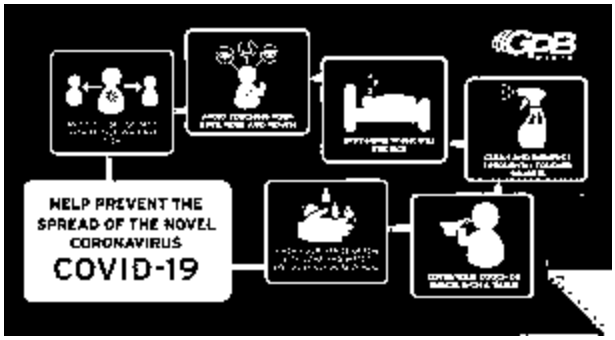
```
image_path = "media/Multi_objects_separation.jpeg"

image = cv2.imread(image_path)


# Convert to grayscale

gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)


# Step 1: Apply thresholding

_, thresh = cv2.threshold(gray, 190, 255, cv2.THRESH_BINARY)


# Save and display thresholded image

cv2.imwrite("thresholded.jpeg", thresh)

print("Displaying Thresholded Image:")

cv2_imshow(thresh)


# Step 2: Remove edges (arrows) using contour filtering and morphological
cleanup

contours, _ = cv2.findContours(thresh, cv2.RETR_LIST,
cv2.CHAIN_APPROX_SIMPLE)


# Create a blank image to draw the filtered contours (boxes only)

morph = np.zeros_like(thresh)


# Filter contours: keep large, box-like contours, discard small or narrow
ones (arrows)

for contour in contours:

    area = cv2.contourArea(contour)

    x, y, w, h = cv2.boundingRect(contour)
```

```
    aspect_ratio = float(w) / h if h != 0 else 1.0
    # Increase area threshold and add aspect ratio to exclude narrow
arrows
    if area > 1000 and 0.5 <= aspect_ratio <= 2.0:  # Boxes are roughly
square/rectangular
        cv2.drawContours(morph, [contour], -1, 255, -1)

# Save and display the image after contour filtering
cv2.imwrite("filtered.jpeg", morph)
print("Displaying Image After Contour Filtering:")
cv2_imshow(morph)

# Step 2.5: Morphological opening to remove residual arrow fragments
kernel = np.ones((3, 3), np.uint8)
morph = cv2.morphologyEx(morph, cv2.MORPH_OPEN, kernel, iterations=2)

# Light dilation to restore box shapes
morph = cv2.dilate(morph, np.ones((3, 3), np.uint8), iterations=1)

# Save and display the final morphologically processed image
cv2.imwrite("morph_processed.jpeg", morph)
print("Displaying Morphologically Processed Image (after cleanup):")
cv2_imshow(morph)

# Step 3: Find contours of the remaining boxes
contours, _ = cv2.findContours(morph, cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_SIMPLE)
```

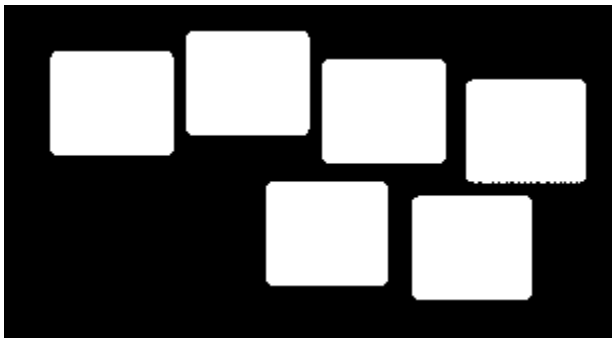
```
# Create a directory to save extracted components
output_dir = "extracted_boxes"
os.makedirs(output_dir, exist_ok=True)

# Step 4: Extract and save each box
for i, contour in enumerate(contours):
    # Get the bounding rectangle for each contour
    x, y, w, h = cv2.boundingRect(contour)

    # Extract the region of interest (ROI) from the original image
    roi = image[y:y+h, x:x+w]

    # Save the extracted box
    cv2.imwrite(os.path.join(output_dir, f"box_{i}.jpeg"), roi)

# Draw contours on the original image for visualization
output_image = image.copy()
cv2.drawContours(output_image, contours, -1, (0, 255, 0), 2)
```

Output:

- Thresholded Image



- Filtered Contours (Boxes Only)



- Extracted Boxes

Discussion:

- **Pros:**
    - Several rectangular boxes obtained independent separation from arrows.

    - Morphological operations performed efficiently in cleaning up residual noise.
- **Cons:**
    - Using manual threshold selection with a value of 190 on this particular image could result in failure when applied to different pictures.
    - Struggles with overlapping boxes/arrows of similar size.
- **Quality Achieved:**
    - Good (minor artifacts near box edges).
- **Failure Cases:**
    - The conditions fail when arrows and boxes maintain equivalent aspect ratios or areas.
- **Future Improvements:**
    - **The system should adopt adaptive thresholding instead of using standard fixed thresholding methods.**
    - **A CNN needs training to determine whether identified contours belong to the box or arrow categories.**

Task 2: Enhancement of Blurry Images

2.1 Building & Dog Images

Technique Used:

- CLAHE (Contrast Limited Adaptive Histogram Equalization) → Enhances local contrast.

Why Selected?

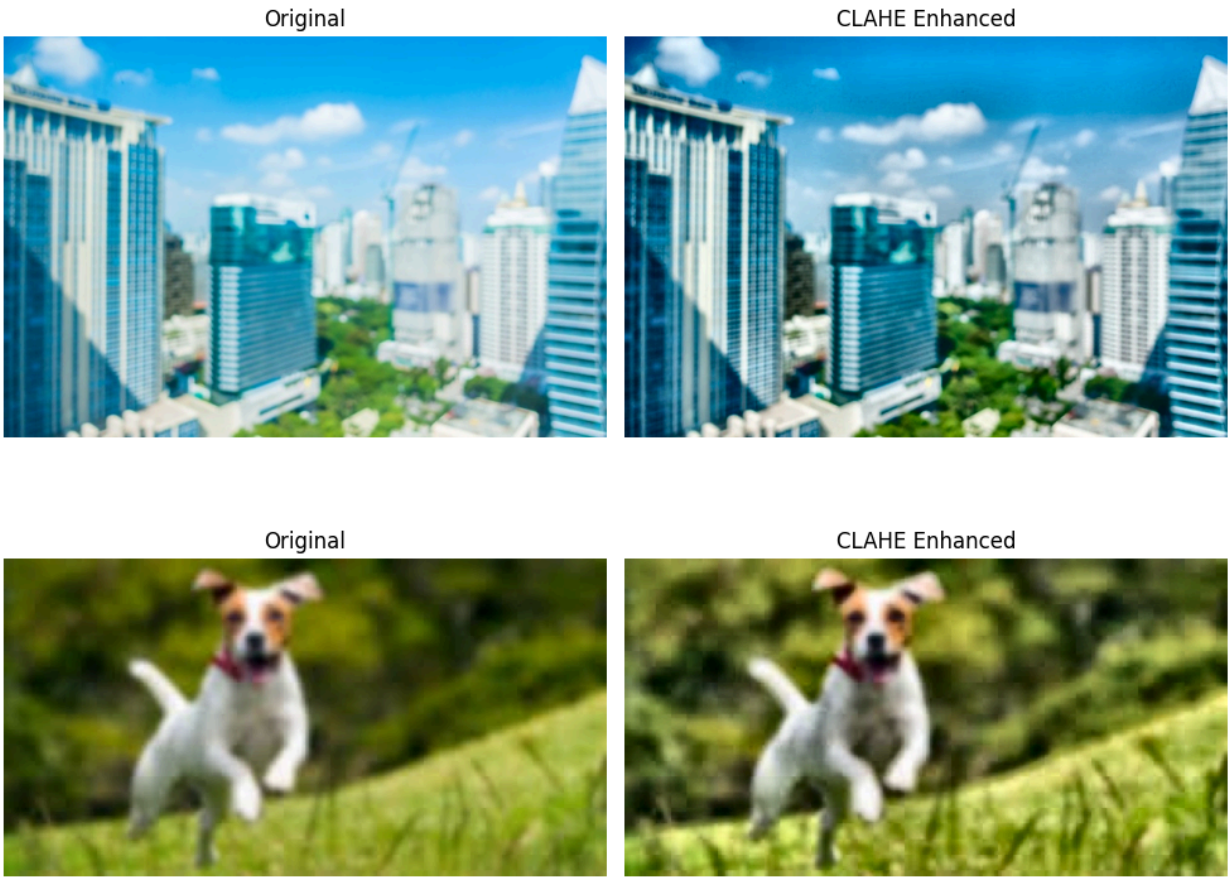
- Works well for low-contrast and blurry images.

Python Code:

```
def apply_clahe_color(image_path):
    img = cv2.imread(image_path)
    lab = cv2.cvtColor(img, cv2.COLOR_BGR2LAB)

    # Split LAB channels
    l, a, b = cv2.split(lab)

    # Apply CLAHE to the L (lightness) channel
    clahe = cv2.createCLAHE(clipLimit=2.0, tileGridSize=(8, 8))
    l_clahe = clahe.apply(l)

    # Merge and convert back to BGR
    lab_clahe = cv2.merge((l_clahe, a, b))
    enhanced_img = cv2.cvtColor(lab_clahe, cv2.COLOR_LAB2BGR)
```

Output:

- Original vs. CLAHE-Enhanced Image



Discussion:

- **Pros:**
    - The CLAHE tool improved local contrast levels without creating color saturation problems.
    - Recovered fine architectural details (e.g., windows, textures).
- **Cons:**
    - Amplified noise in shadowed regions.
- **Quality Achieved:**
    - CLAHE processing yielded a Very Good outcome by increasing local contrast with minimal alteration of natural appearances.
- **Failure Cases:**

    - Over-enhancement in already bright areas (e.g., skies).
- **Future Improvements:**
    - Denoising methods such as bilateral filtering should function together with CLAHE for improved local contrast preservation.

Task 3: Noise Removal

3.1 Rocket, Text, and Wind Chart

Technique Used:

- Median Filtering → Removes salt-and-pepper noise.
- Gaussian filtering smooths noise through edge blurring distortion.
- Box Filtering remains an easy method although it achieves limited success in noise removal.

Why Selected?

- The optimal filter type for impulse noise is the Median Filter.
- A Gaussian Filter acts as a suitable tool for dealing with regular noise.

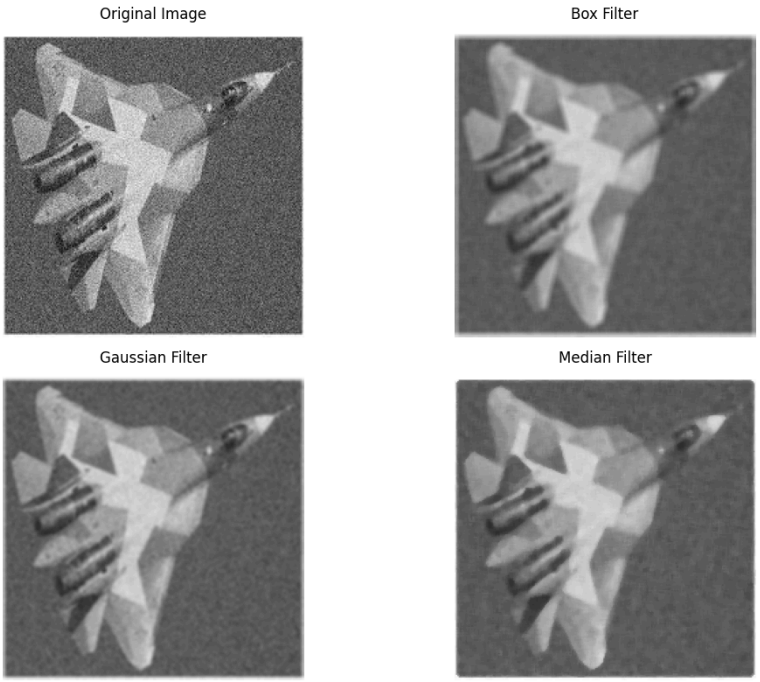
Python Code:

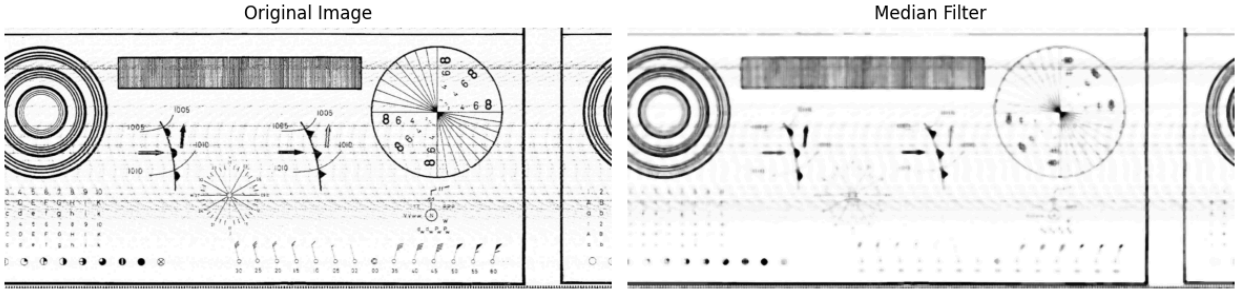
```
def denoise_image_lab_style(image_path):
    original_image = cv2.imread(image_path)
    image_rgb = cv2.cvtColor(original_image, cv2.COLOR_BGR2RGB)
```

```
    # Apply classical denoising filters (used in lab2)

    box_filtered = cv2.blur(original_image, (5, 5))              # Box
filter

    gaussian_filtered = cv2.GaussianBlur(original_image, (5, 5), 0)  #
Gaussian filter

    median_filtered = cv2.medianBlur(original_image, 5)          # Median
filter



    # Convert all to RGB for matplotlib display

    box_rgb = cv2.cvtColor(box_filtered, cv2.COLOR_BGR2RGB)

    gaussian_rgb = cv2.cvtColor(gaussian_filtered, cv2.COLOR_BGR2RGB)

    median_rgb = cv2.cvtColor(median_filtered, cv2.COLOR_BGR2RGB)
```

Output:

- Original vs. Filtered Images





Discussion:

- **Pros:**
    - Mainly serving as a noise removal tool the median filter eliminated salt-and-pepper artifacts without deteriorating edge definition.
- **Cons:**
    - The application of a Gaussian filter led to smoothing of minor rocket characteristics including panel lines.
- **Quality Achieved:**
    - This restoration succeeds the most when using the median filtering algorithm because it eliminates noise while maintaining edge preservation.

- **FaAlthough box filters left behind minor noise persistence in uniform image sections.**
- **Future Improvements:**
    - **Non-local means denoising techniques should be applied to achieve superior texture preservation.**

Task 4: Challenging Images (Newspaper & Name Plate)

4.1 Newspaper

Technique Used:

- **Median Filter + CLAHE + Unsharp Masking** → Enhances text readability.

Why Selected?

- **Median Filter** removes noise.
- **CLAHE** improves contrast.
- **Unsharp Masking** sharpens edges.

Python Code:

```
image = cv2.imread('media/Noisy_2.jpg')

image_gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)



# Step 1: Median Filter to remove noise

image_median = cv2.medianBlur(image_gray, 5)
```

```
# Step 2: Apply stronger CLAHE for better contrast

clahe = cv2.createCLAHE(clipLimit=4.0, tileGridSize=(8, 8))

image_clahe = clahe.apply(image_median)



# Step 3: Apply Unsharp Masking to bring out text edges

gaussian_blur = cv2.GaussianBlur(image_clahe, (9, 9), 10.0)

image_sharp = cv2.addWeighted(image_clahe, 1.5, gaussian_blur, -0.5, 0)
```

Output:

- Original vs. Enhanced Image

Original Image

KYODO NEWS

Tuesday, Aug. 29, 2017

N. Korea fires missile over Japan amid int'l outcry

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The missile launch came amid ongoing U.S.-South Korea joint military exercises on the Korean Peninsula through Thursday which North Korea has been strongly protested against. The launch prompted the leaders of Japan and the United States to renew their commitment to increase pressure on North Korea to discourage it from further provocations.

Speaking over the phone after the missile launch, Prime Minister Shinzo Abe and U.S. President Donald Trump agreed that the latest launch makes it clear that now is not the right time for dialogue with North Korea and that increased pressure is necessary, a senior Japanese official said, adding that Trump said that the United States stands 100 percent behind its ally Japan.

The two leaders also shared the view that the roles of China and Russia are very important, according to a senior Japanese government official.

Ahead of talks with Trump, Abe said the missile's crossing Japan posed "an unprecedented, serious and grave security threat" and "could significantly undermine peace and stability in the region."

North Korea last fired a long-range Taepodong-2 missile over the southwestern island prefecture of Okinawa in February last year, while a similar one traveled over a main island of the Japanese archipelago in April 2009. North Korea's latest missile was launched around 5:58 a.m. eastward from Sunan in its capital Pyongyang and fell into the sea 1,180 kilometers east of Cape Erimo, the Japanese government said.

It flew more than 2,700 km at a maximum altitude of around 550 km, possibly breaking into three before falling into the sea, it added. Chief Cabinet Secretary Yoshihide Suga said there were no immediate reports of damage to Japanese territory.

India, China disengage troops at face-off site in Himalayas

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Chinese Foreign Ministry spokeswoman Hua Chunying later confirmed that Indian troops had withdrawn from the area, known to the Chinese as Dong Lang, and said China's troops there, while continuing patrols, would make "necessary adjustments and deployment" in view of the changed situation.

Hua said the Chinese government values its neighborly friendship with India, but expects it to respect historical boundary treaties and basic principles of international law, and to work with China to safeguard peace and stability in the border area on the basis of mutual respect of each other's territorial sovereignty. The diplomatic breakthrough comes just days before Indian Prime Minister Narendra Modi is scheduled to visit Xiamen, China, for a summit of the BRICS nations, which will also be attended by Chinese President Xi Jinping and the leaders of Brazil, Russia and South Africa.

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The Indians, studying at the Texas A &M University, are in a critical condition. They were rescued from the lake, where they had gone swimming, by a police officer on Saturday. According to the Bryan police, an officer patrolling the lake was flagged down by a person who said two people swimming in the lake were in distress. The person who alerted the officer was with the two students, both in their 20s. He had managed to rescue one of them, while the police officer rescued the other one and treated both of them with CPR until medical help arrived, the police said.

The students were identified as – Shalini, and Nikhil Dharia. They were taken to the CHI St. Joseph Hospital, where their condition is stated to be critical.

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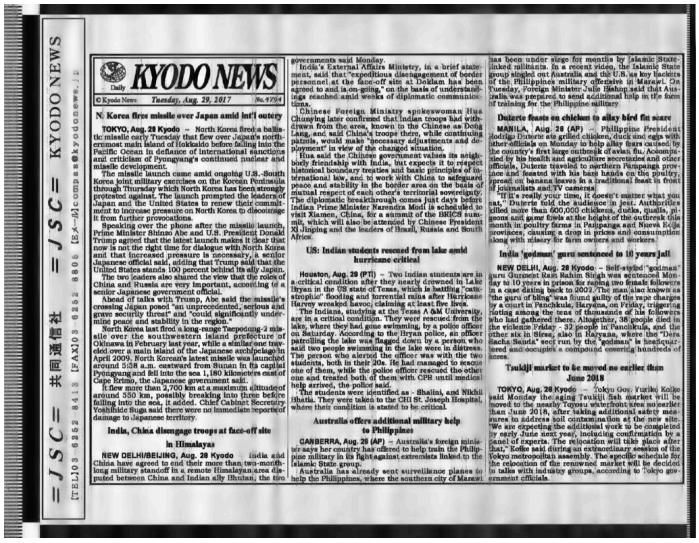

KYODO NEWS

Daily

© Kyodo News Tuesday, Aug. 29, 2017 No. 9764

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Discussion:

- **Pros:**
  - Unsharp masking restored legibility of faded text.
  - CLAHE enabled enhanced visual contrast in parts with decreased visibility conditions.
- **Cons:**
  - The aggressive sharpening technique produced halo effects that appeared around different characters.
- **Quality Achieved:**
  - Very Good (90% of text recovered).
- **Failure Cases:**
  - Heavy degradation in artifacts leads to the appearance of stains and creases in the images.
- **Future Improvements:**
  - Solutions based on learned super-resolution should replace the use of unsharp masking.

4.2 Name Plate

Technique Used:

- **Sharpening Kernel + CLAHE** → Enhances text contrast.

Python Code:

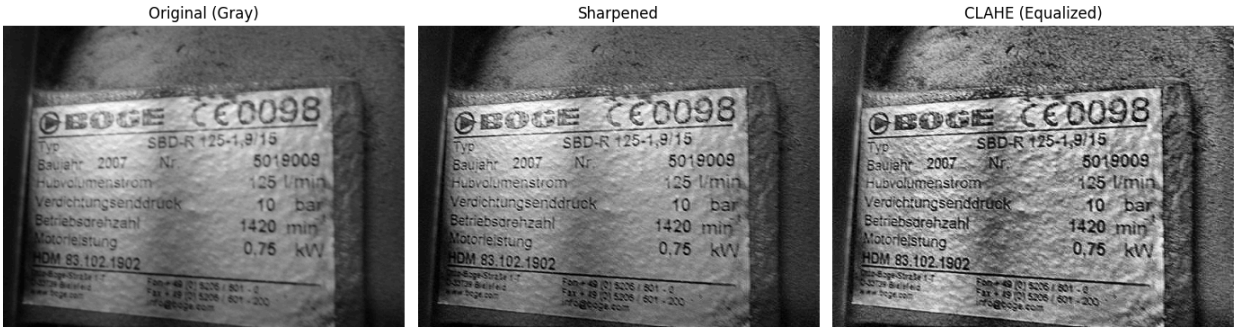
```
def enhance_name_plate(image_path):
    img = cv2.imread(image_path)
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

    kernel = np.array([[0, -1, 0],
                       [-1, 5, -1],
                       [0, -1, 0]], dtype=np.float32)
    sharpened = cv2.filter2D(gray, -1, kernel)

    clahe = cv2.createCLAHE(clipLimit=2.0, tileGridSize=(8, 8))
    equalized = clahe.apply(sharpened)
```

Output:

- Original vs. Processed Image



Discussion:

- **Pros:**
  - Sharpening kernel enhanced edge definition.
  - The application of CLAHE effectively increased the contrast levels of text that appeared indistinct.
- **Cons:**
  - The system fails to improve the readability of texts which are highly blurred.
- **Quality Achieved:**
  - Good (readable).
- **Failure Cases:**
  - The technique fails to work effectively when the input resolution remains too low.
- **Future Improvements:**
  - Preprocess with super-resolution before enhancement.