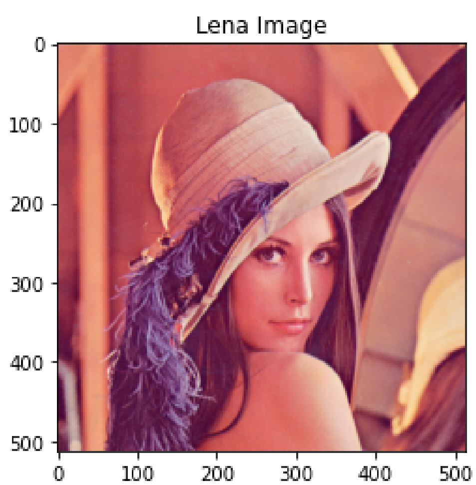
Edge Detection in OpenCV

In [152]:

```python
# imports the OpenCV (Open Source Computer Vision Library) module in Python.
# OpenCV is a powerful library used for image processing, computer vision, and
import cv2
import numpy as np
# NumPy (Numerical Python) is a powerful Python library for:
    #Working with large multi-dimensional arrays and matrices.
    #Performing mathematical and statistical operations efficiently.
    #Supporting linear algebra, Fourier transforms, and random number generati
import matplotlib.pyplot as plt
# Matplotlib is a popular Python library for data visualization,
```

In [153]:

```python
# Load the manually downloaded image
image = cv2.imread("lena.jpg") ## OpenCV loads images in BGR format
# The BGR format refers to the way OpenCV stores and processes color images.
# Instead of using the more common RGB (Red, Green, Blue) format,
# OpenCV by default loads images in BGR (Blue, Green, Red) order.

# Check if the image loaded successfully
if image is None:
    print("Error: Image not found. Please check the file path.")
else:
    # Convert BGR to RGB
    image_rgb = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)

    # Display the image
    plt.imshow(image_rgb)
    plt.title("Lena Image")
    #plt.axis("off")  # Hides the axes
    plt.show()
```



In [154]:

```python
image_rgb.shape
```

Out[154]: (512, 512, 3)

In [155]:
```
imageR = image_rgb[:,:,0]
imageG = image_rgb[:,:,1]
imageB = image_rgb[:,:,2]
imageR.shape
```

Out[155]: (512, 512)

In [156]:
```
# Pandas is a Python library for data manipulation and analysis.
# It provides powerful tools for:
  #Handling structured data (tables, spreadsheets, databases)
  #Reading and writing data from CSV, Excel, JSON, SQL, etc.
import pandas as pd
# Convert to a Pandas DataFrame for better visualization
df = pd.DataFrame(imageR)
```

In [157]:
```
df
```

Out[157]:

	0	1	2	3	4	5	6	7	8	9	...	502	503	504	505	506	507	508	509	510
0	226	226	223	223	226	226	228	227	227	225	...	185	196	211	224	229	231	234	230	221
1	226	226	223	223	226	226	228	227	227	225	...	185	196	211	224	229	231	234	230	221
2	226	226	223	223	226	226	228	227	227	225	...	185	196	211	224	229	231	234	230	221
3	226	226	223	223	226	226	228	227	227	225	...	185	196	211	224	229	231	234	230	221
4	226	226	223	223	226	226	228	227	227	225	...	185	196	211	224	229	231	234	230	221
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
507	93	93	86	89	95	96	94	98	99	102	...	104	113	120	129	141	147	160	165	162
508	86	86	91	91	93	96	95	94	103	97	...	110	120	128	135	147	154	170	172	166
509	84	84	92	93	97	92	96	90	99	96	...	116	122	132	142	151	162	174	173	172
510	82	82	96	93	97	94	92	93	98	94	...	120	132	147	152	162	173	177	179	181
511	82	82	96	93	97	94	92	93	98	94	...	120	132	147	152	162	173	177	179	181

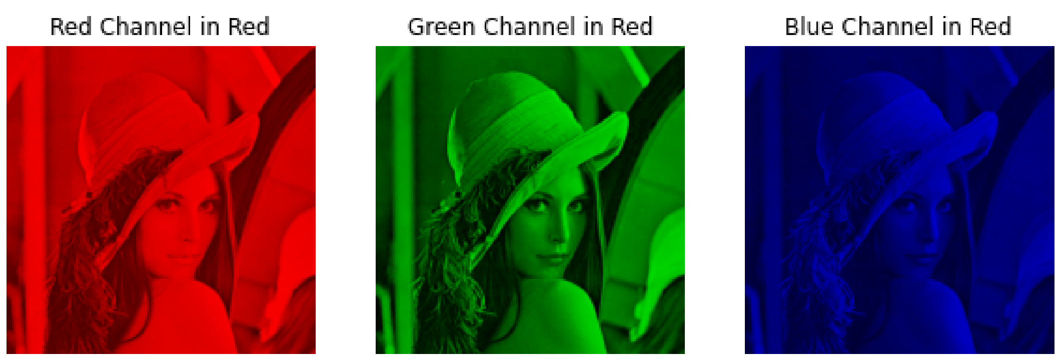
512 rows × 512 columns

In [158]:
```
imageR.max().max()
type(imageR[0,0])
```

Out[158]: numpy.uint8

In [159]:

```
# Display the Red channel, Green channel, Blue channel
# Create an empty image with 3 channels (same shape as original)
red_only = np.zeros_like(image_rgb)
green_only = np.zeros_like(image_rgb)
blue_only = np.zeros_like(image_rgb)

# Set only the Red channel, keep Green and Blue as zero
red_only[:, :, 0] = imageR  # Assign Red channel
green_only[:, :, 1] = imageG  # Assign Red channel
blue_only[:, :, 2] = imageB # Assign Red channel

# Display R , G, B
plt.figure(figsize=(10,5))

# Display the red-only image
plt.subplot(1, 3, 1)
plt.imshow(red_only)
plt.title("Red Channel in Red")
plt.axis("off")  # Hide axes


plt.subplot(1, 3, 2)
plt.imshow(green_only)
plt.title("Green Channel in Red")
plt.axis("off")  # Hide axes


plt.subplot(1, 3, 3)
plt.imshow(blue_only)
plt.title("Blue Channel in Red")
plt.axis("off")  # Hide axes
plt.show()
```



In [160]:
```
# Define a 3×3 edge detection kernel (Laplace filter)
# This 3×3 kernel (convolution filter) is specifically designed for edge detec
kernel = np.array([
    [ 0, -1,  0],
    [-1,  4, -1],
    [ 0, -1,  0]
])

# Apply the convolution filter
filtered_laplace = cv2.filter2D(cv2.cvtColor(image, cv2.COLOR_RGB2GRAY), -1, k
# This applies the Laplace filter to an image using convolution.
# In OpenCV's cv2.filter2D() function, the second argument represents the desi
# -1 means "same depth as the input image".
# Bit-depth refers to the number of bits used to represent each pixel in an im
# It determines the range of colors or intensity levels a pixel can have.
# For example:
 # -1   Same as input image (recommended for most cases)
 # cv2.CV_8U    8-bit unsigned int (0 to 255)
 # cv2.CV_16U   16-bit unsigned int (0 to 65535)
 # cv2.CV_16S   16-bit signed int (-32768 to 32767)
 # cv2.CV_32F   32-bit floating point
 # cv2.CV_64F   64-bit floating point
```

In [ ]:

In [161]:
```
# Apply Canny Edge Detection (optimal thresholds: 100, 200)
filtered_canny = cv2.Canny(cv2.cvtColor(image, cv2.COLOR_RGB2GRAY), 100, 200)

# 1️⃣ Pixels with intensity gradients above T_high (200) are considered STRONG
# 2️⃣ Pixels with intensity gradients below T_low (100) are considered WEAK edg
# 3️⃣ Pixels between T_low (100) and T_high (200) are kept ONLY if they are con

# cv2.Canny() does not directly accept a colored image as input.
# It only works with grayscale images because edge detection relies on intensi
```

2. How the Laplace Kernel Works

The Laplace kernel:

The **Laplace filter (3×3 Kernel)** is a convolution matrix used for **edge detection** in an image.

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Explanation:

- The **center value (4)** emphasizes the **current pixel's intensity**.
- The **surrounding -1 values** subtract neighboring pixels.
- This highlights **sharp intensity changes** (edges) while suppressing uniform regions.

Effect:

- **Regions with high contrast (edges) produce large values**.

- **Flat regions (uniform areas) remain close to zero**.
- This is useful for **edge detection** in **object recognition, medical imaging, and AI preprocessing**.

---

3. How Convolution Works

The filter moves across the image one pixel at a time, and at each position, the **center pixel** is replaced with a new value obtained by performing **element-wise multiplication** between the kernel and the corresponding image region, followed by summation.

Example Image Patch (Grayscale)

Consider a **3×3 grayscale image patch**:

$$\begin{bmatrix} 10 & 20 & 30 \\ 40 & 50 & 60 \\ 70 & 80 & 90 \end{bmatrix}$$

Applying Kernel Convolution:

Using the **Laplace Kernel**:

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

The **center pixel 50** is replaced with a new pixel value, which is calculated by performing **element-wise multiplication** between the kernel and the corresponding image region, followed by summation:

$$(0 \times 10) + (-1 \times 20) + (0 \times 30) + (-1 \times 40) + (4 \times 50) + (-1 \times 60) + (0 \times 70) + (-1 \times 80) + (0$$

$$= 0 - 20 + 0 - 40 + 200 - 60 + 0 - 80 + 0$$

$$= 0$$

Interpretation:

- **If the region has a sharp intensity change**, the result is **high** → **edge detected**.
- **If the region is uniform**, the result is **small** → **no edge detected**.

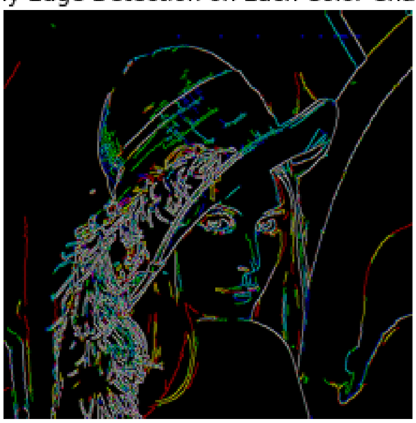
This process is applied **to every pixel in the image** to highlight edges, making it a crucial step in **image processing, AI, and object recognition**.

In [149]:
```
# Load grayscale image
imageGray = cv2.imread("lena.jpg", cv2.IMREAD_GRAYSCALE)
```

In [163]:
```
# Display the original and processed images
plt.figure(figsize=(10,5))
plt.subplot(1, 3, 1)
plt.title("Original Image")
plt.axis("off")  # Hide axes
plt.imshow(image_rgb)

plt.subplot(1, 3, 2)
plt.title("Laplace filter")
plt.axis("off")  # Hide axes
plt.imshow(filtered_laplace, cmap='gray')

plt.subplot(1, 3, 3)
plt.title("Canny Edge Detection")
plt.axis("off")  # Hide axes
plt.imshow(filtered_canny, cmap='gray')

plt.show()
```

In [164]:
```
# Extract individual color channels
r, g, b = cv2.split(image_rgb)

# Apply Canny Edge Detection to each channel
edges_r = cv2.Canny(r, 100, 200)
edges_g = cv2.Canny(g, 100, 200)
edges_b = cv2.Canny(b, 100, 200)

# Merge edges back into a color image
edges_colored = cv2.merge([edges_r, edges_g, edges_b])

# Show the colored edge detection result
plt.imshow(edges_colored)
plt.title("Canny Edge Detection on Each Color Channel")
plt.axis("off")
plt.show()
```

Canny Edge Detection on Each Color Channel



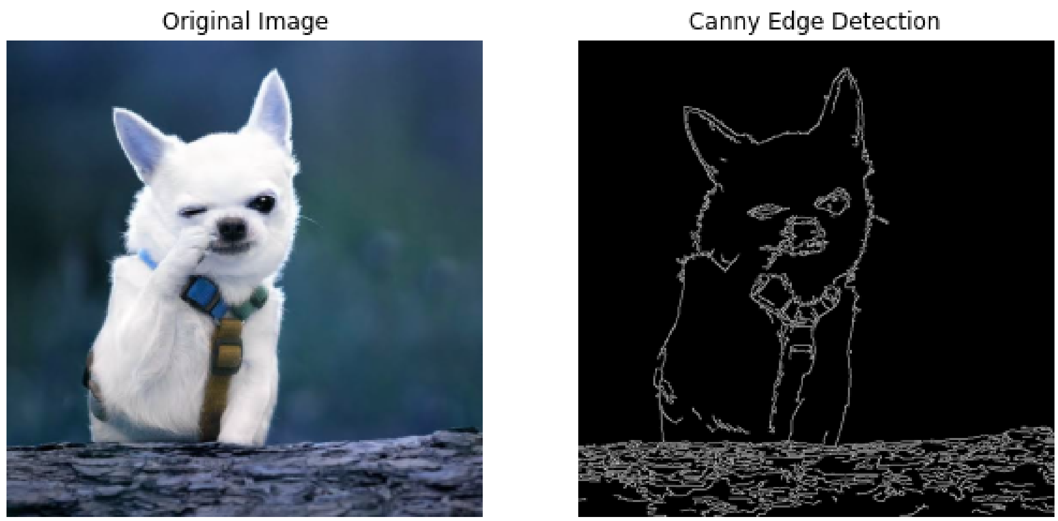
In [165]:
```
dog_color = cv2.imread("dog.jpeg")
```

In [166]:
```
plt.imshow(dog_color)
plt.title("Dog Image")
plt.axis("off")  # Hides the axes
plt.show()
```

Dog Image

In [167]:
```
# Apply Canny Edge Detection (optimal thresholds: 100, 200)
dog_edges_color = cv2.Canny(cv2.cvtColor(dog_color, cv2.COLOR_RGB2GRAY), 100, 
```

In [168]:
```
# Display the original and processed images
plt.figure(figsize=(10,5))
plt.subplot(1, 2, 1)
plt.title("Original Image")
plt.axis("off")  # Hide axes
plt.imshow(dog_color)

plt.subplot(1, 2, 2)
plt.title("Canny Edge Detection")
plt.axis("off")  # Hide axes
plt.imshow(dog_edges_color, cmap='gray')

plt.show()
```



In [ ]:

In [ ]: