MAX POOLING

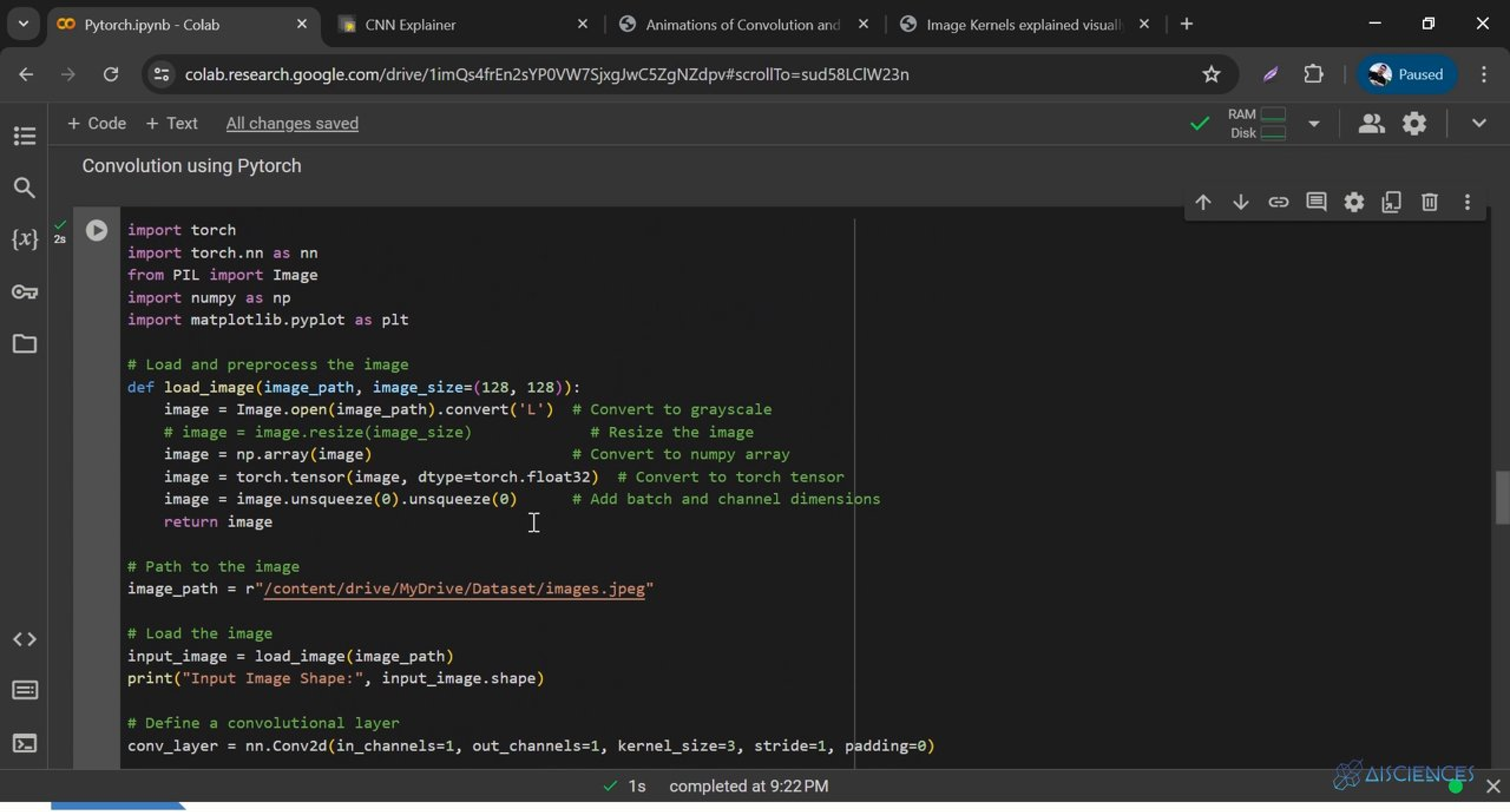
Input

$$\begin{bmatrix}6 & 3 & 2\\ 5 & 2 & 1\\ 4 & 1 & 0\end{bmatrix}$$

Pooling matrix
2x2

Output

$$\begin{bmatrix}6 & 2\\ 4 & 0\end{bmatrix}$$


Pytorch.ipynb - Colab
CNN Explainer
Animations of Convolution and
Image Kernels explained visuall
colab.research.google.com/drive/1imQs4frEn2sYP0VW7SjxgJwC5ZgNZdpv#scrollTo=sud58LClW23n
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AISCIENCES

Convolution using Pytorch

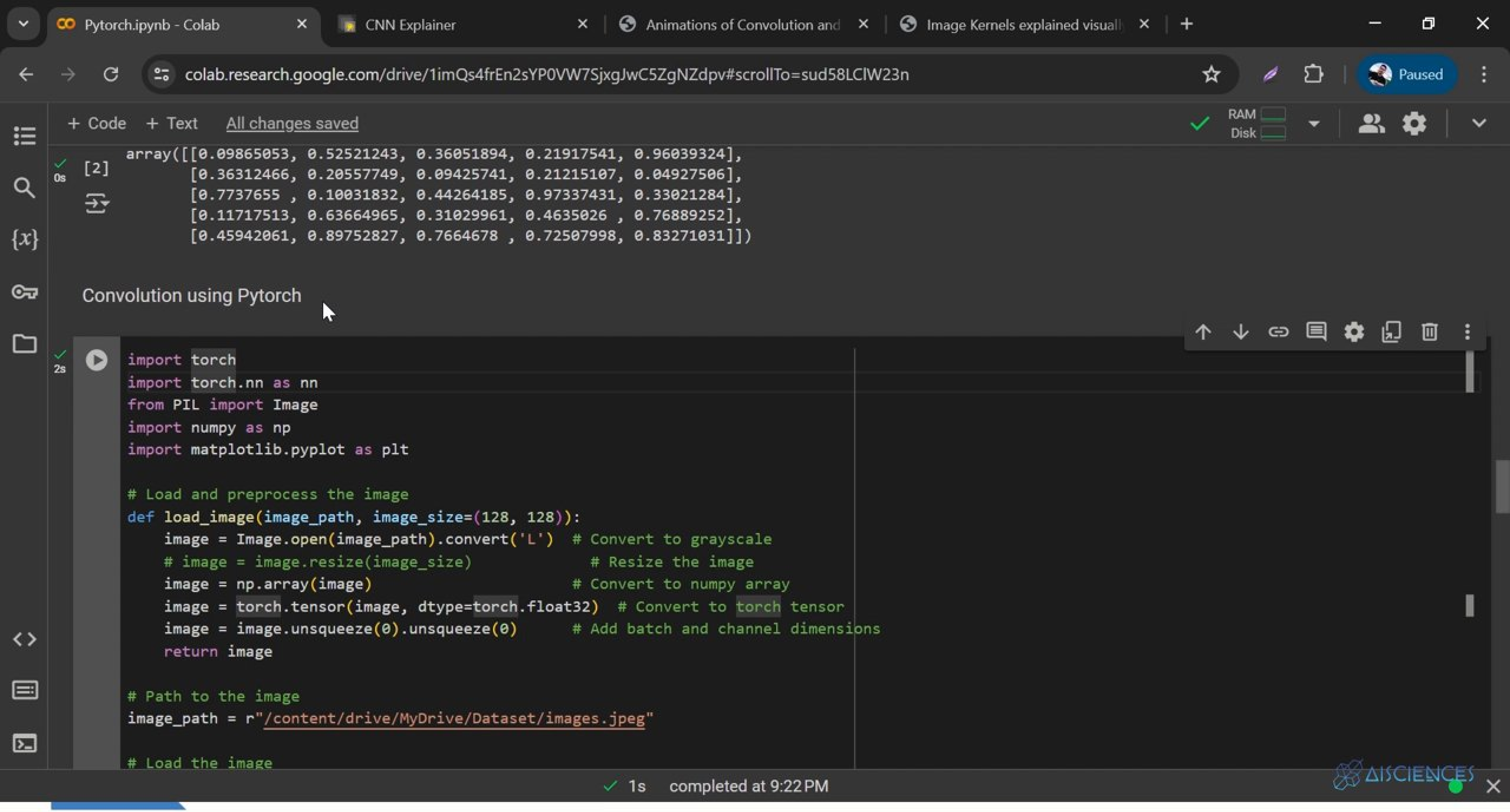
```python
import torch
import torch.nn as nn
from PIL import Image
import numpy as np
import matplotlib.pyplot as plt

# Load and preprocess the image
def load_image(image_path, image_size=(128, 128)):
    image = Image.open(image_path).convert('L')  # Convert to grayscale
    # image = image.resize(image_size)            # Resize the image
    image = np.array(image)                      # Convert to numpy array
    image = torch.tensor(image, dtype=torch.float32)  # Convert to torch tensor
    image = image.unsqueeze(0).unsqueeze(0)      # Add batch and channel dimensions
    return image

# Path to the image
image_path = r"/content/drive/MyDrive/Dataset/images.jpeg"

# Load the image
input_image = load_image(image_path)
print("Input Image Shape:", input_image.shape)

# Define a convolutional layer
conv_layer = nn.Conv2d(in_channels=1, out_channels=1, kernel_size=3, stride=1, padding=0)
```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colab.research.google.com/drive/1imQs4frEn2sYP0VW7SjxgJwC5ZgNZdpv#scrollTo=sud58LClW23n
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All changes saved
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AISCIENCES

```
array([[0.09865053, 0.52521243, 0.36051894, 0.21917541, 0.96039324],
       [0.36312466, 0.20557749, 0.09425741, 0.21215107, 0.04927506],
       [0.7737655 , 0.10031832, 0.44264185, 0.97337431, 0.33021284],
       [0.11717513, 0.63664965, 0.31029961, 0.4635026 , 0.76889252],
       [0.45942061, 0.89752827, 0.7664678 , 0.72507998, 0.83271031]])
```

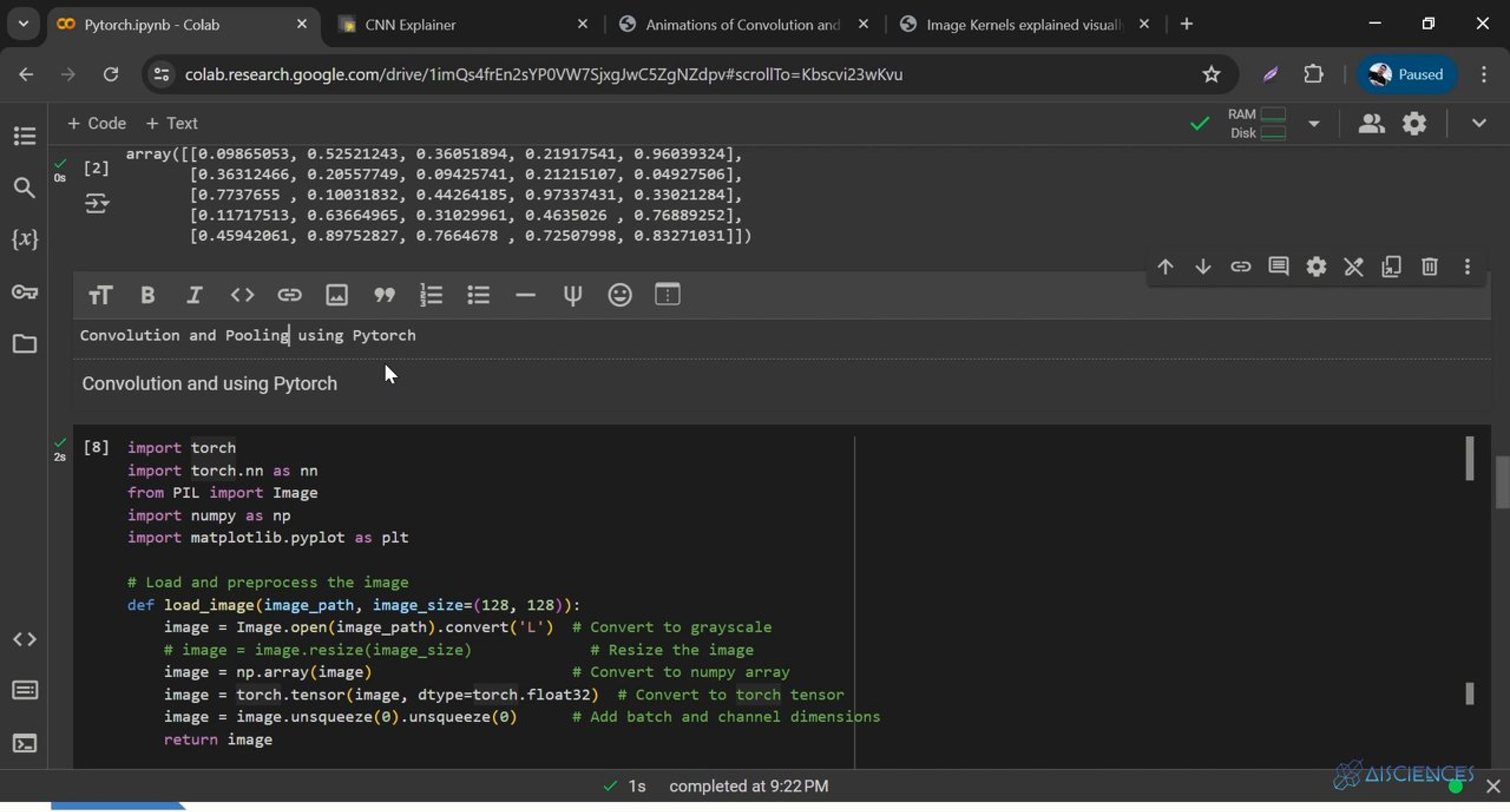
Convolution using Pytorch

```python
import torch
import torch.nn as nn
from PIL import Image
import numpy as np
import matplotlib.pyplot as plt

# Load and preprocess the image
def load_image(image_path, image_size=(128, 128)):
    image = Image.open(image_path).convert('L')  # Convert to grayscale
    # image = image.resize(image_size)             # Resize the image
    image = np.array(image)                      # Convert to numpy array
    image = torch.tensor(image, dtype=torch.float32)  # Convert to torch tensor
    image = image.unsqueeze(0).unsqueeze(0)      # Add batch and channel dimensions
    return image

# Path to the image
image_path = r"/content/drive/MyDrive/Dataset/images.jpeg"

# Load the image
```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[8]
2s
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AISCIENCES

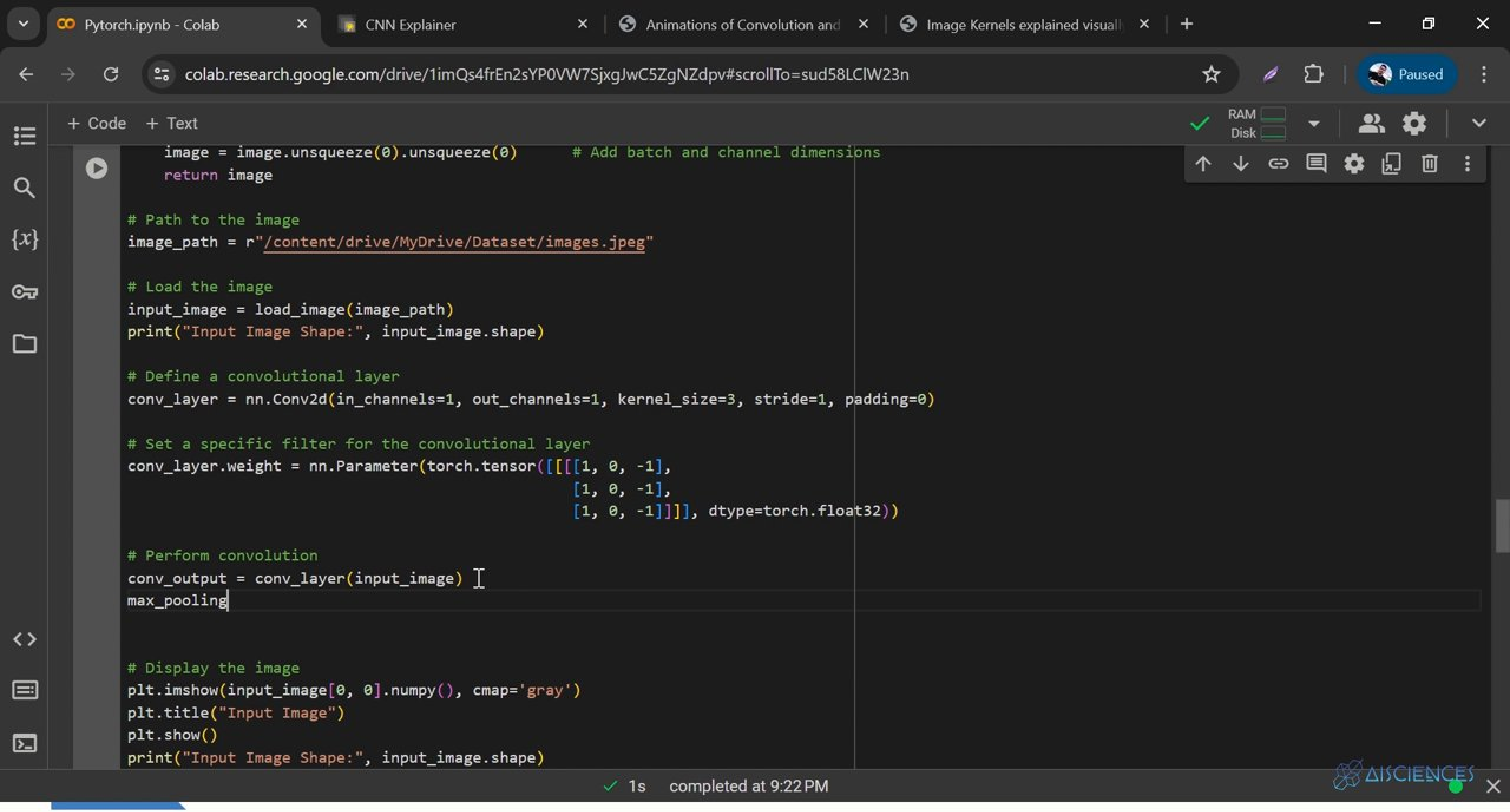
```
array([[0.09865053, 0.52521243, 0.36051894, 0.21917541, 0.96039324],
       [0.36312466, 0.20557749, 0.09425741, 0.21215107, 0.04927506],
       [0.7737655 , 0.10031832, 0.44264185, 0.97337431, 0.33021284],
       [0.11717513, 0.63664965, 0.31029961, 0.4635026 , 0.76889252],
       [0.45942061, 0.89752827, 0.7664678 , 0.72507998, 0.83271031]])
```

```
Convolution and Pooling using Pytorch
```

Convolution and using Pytorch

```python
import torch
import torch.nn as nn
from PIL import Image
import numpy as np
import matplotlib.pyplot as plt

# Load and preprocess the image
def load_image(image_path, image_size=(128, 128)):
    image = Image.open(image_path).convert('L')  # Convert to grayscale
    # image = image.resize(image_size)            # Resize the image
    image = np.array(image)                      # Convert to numpy array
    image = torch.tensor(image, dtype=torch.float32)  # Convert to torch tensor
    image = image.unsqueeze(0).unsqueeze(0)      # Add batch and channel dimensions
    return image
```



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```
    image = image.unsqueeze(0).unsqueeze(0)      # Add batch and channel dimensions
    return image

# Path to the image
image_path = r"/content/drive/MyDrive/Dataset/images.jpeg"

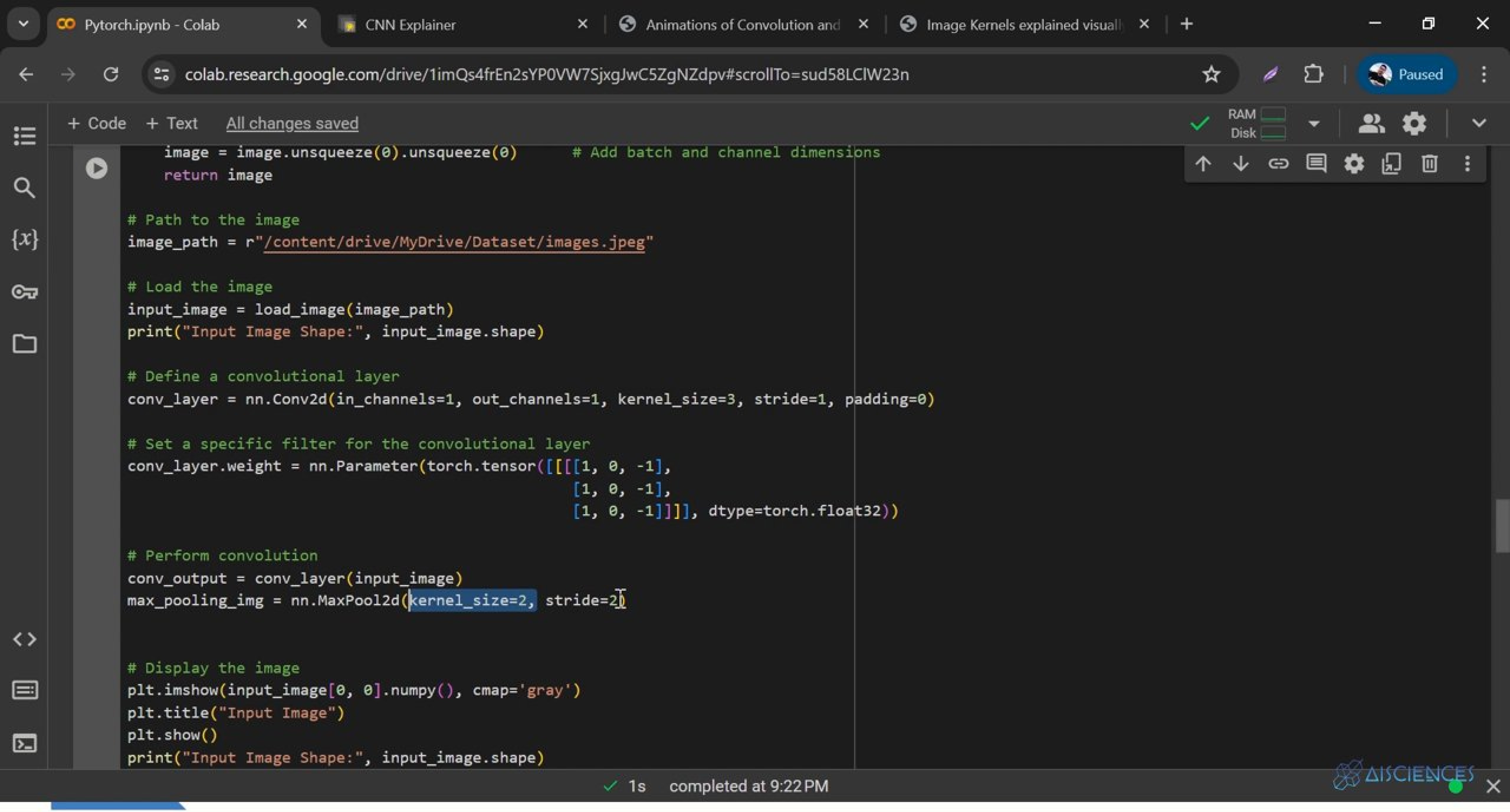
# Load the image
input_image = load_image(image_path)
print("Input Image Shape:", input_image.shape)

# Define a convolutional layer
conv_layer = nn.Conv2d(in_channels=1, out_channels=1, kernel_size=3, stride=1, padding=0)

# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                 [1, 0, -1],
                                                 [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)
```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```
    image = image.unsqueeze(0).unsqueeze(0)      # Add batch and channel dimensions
    return image

# Path to the image
image_path = r"/content/drive/MyDrive/Dataset/images.jpeg"

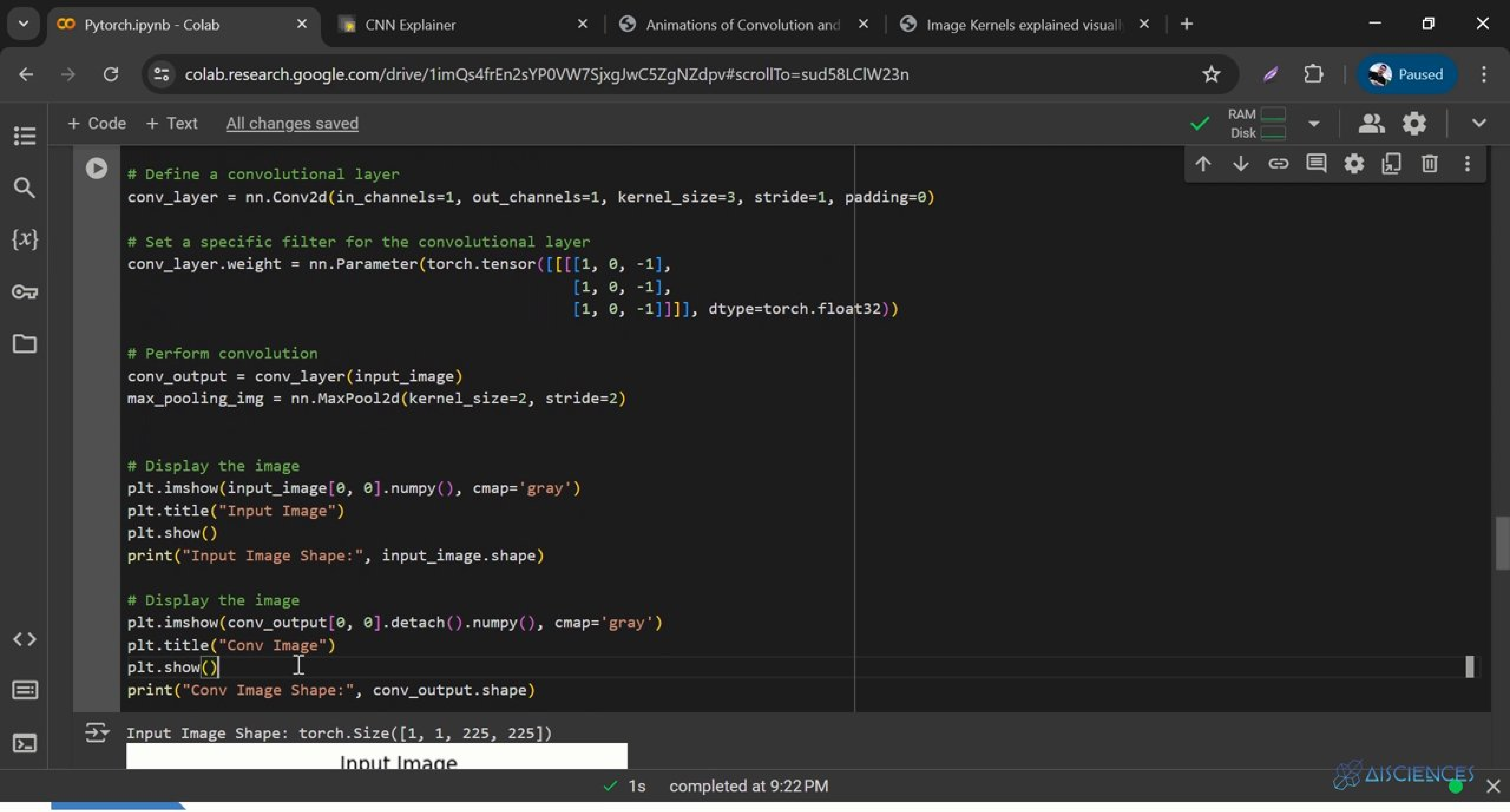
# Load the image
input_image = load_image(image_path)
print("Input Image Shape:", input_image.shape)

# Define a convolutional layer
conv_layer = nn.Conv2d(in_channels=1, out_channels=1, kernel_size=3, stride=1, padding=0)

# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                 [1, 0, -1],
                                                 [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_img = nn.MaxPool2d(kernel_size=2, stride=2)


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)
```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```
# Define a convolutional layer
conv_layer = nn.Conv2d(in_channels=1, out_channels=1, kernel_size=3, stride=1, padding=0)

# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                [1, 0, -1],
                                                [1, 0, -1]]]], dtype=torch.float32))

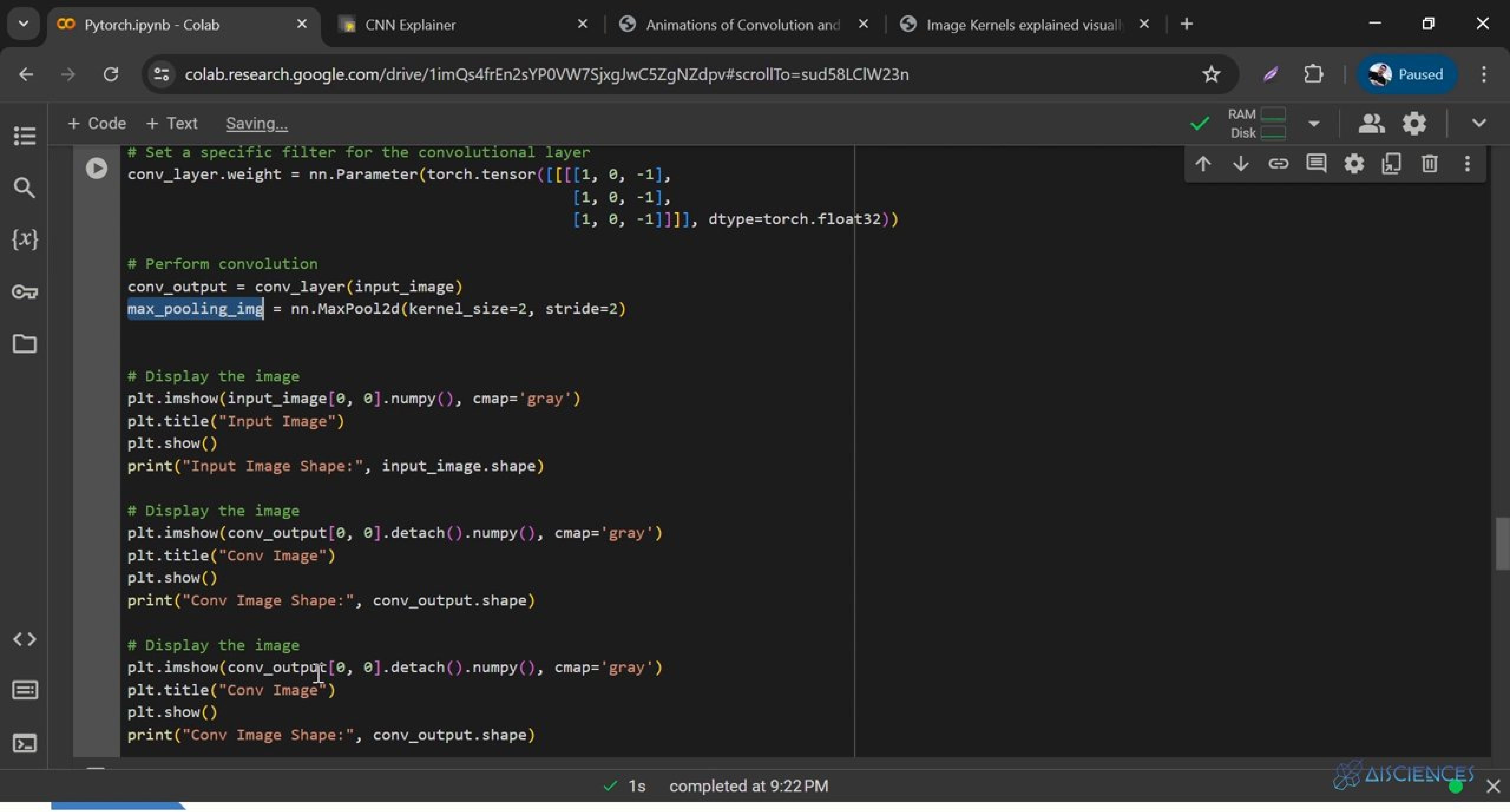
# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_img = nn.MaxPool2d(kernel_size=2, stride=2)


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)

# Display the image
plt.imshow(conv_output[0, 0].detach().numpy(), cmap='gray')
plt.title("Conv Image")
plt.show()
print("Conv Image Shape:", conv_output.shape)
```

```
Input Image Shape: torch.Size([1, 1, 225, 225])
```

Input Image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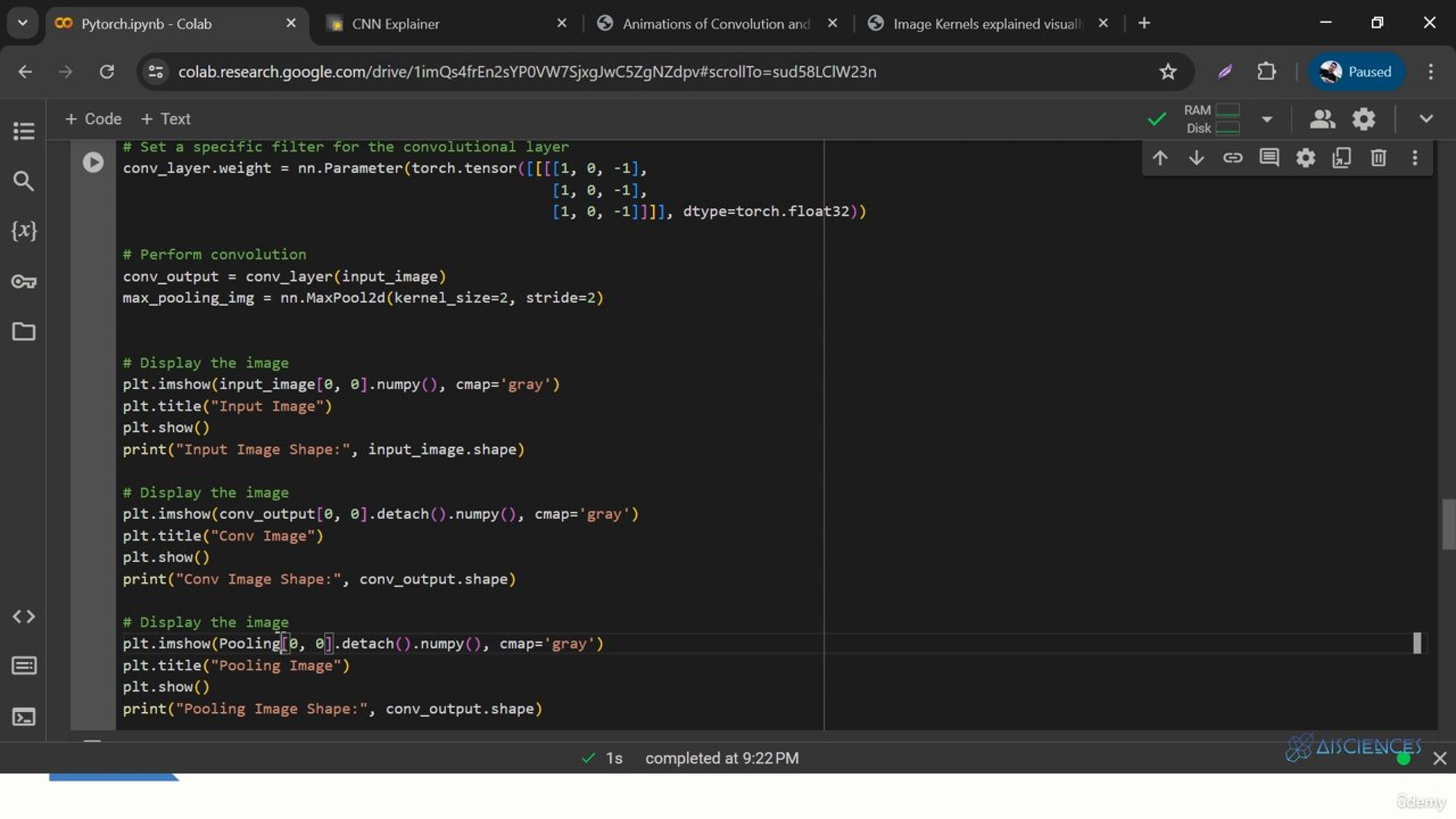
```
# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                  [1, 0, -1],
                                                  [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_img = nn.MaxPool2d(kernel_size=2, stride=2)


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)

# Display the image
plt.imshow(conv_output[0, 0].detach().numpy(), cmap='gray')
plt.title("Conv Image")
plt.show()
print("Conv Image Shape:", conv_output.shape)

# Display the image
plt.imshow(conv_output[0, 0].detach().numpy(), cmap='gray')
plt.title("Conv Image")
plt.show()
print("Conv Image Shape:", conv_output.shape)
```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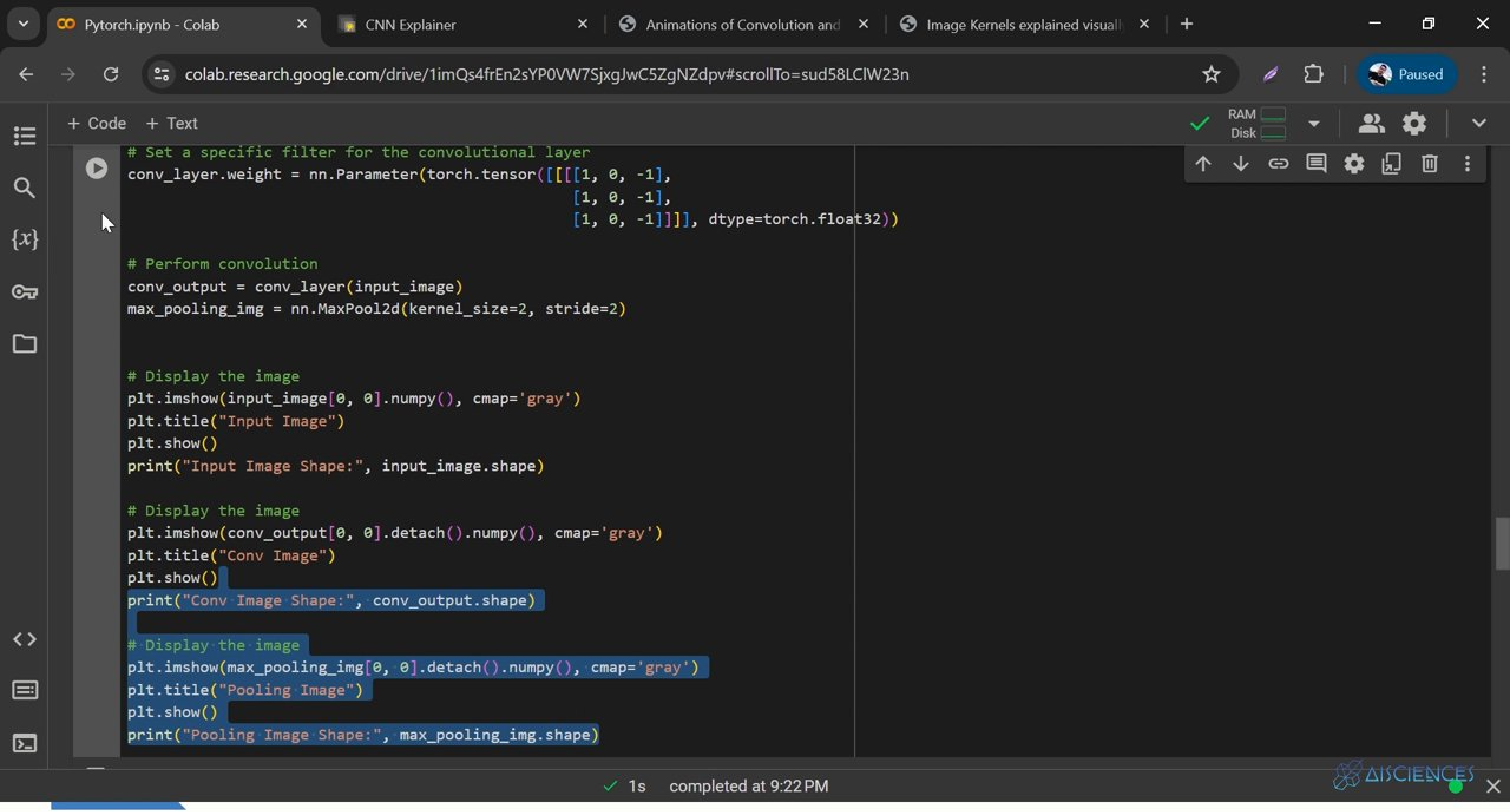
```
# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                 [1, 0, -1],
                                                 [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_img = nn.MaxPool2d(kernel_size=2, stride=2)


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)

# Display the image
plt.imshow(conv_output[0, 0].detach().numpy(), cmap='gray')
plt.title("Conv Image")
plt.show()
print("Conv Image Shape:", conv_output.shape)

# Display the image
plt.imshow(Pooling[0, 0].detach().numpy(), cmap='gray')
plt.title("Pooling Image")
plt.show()
print("Pooling Image Shape:", conv_output.shape)
```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```
# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                 [1, 0, -1],
                                                 [1, 0, -1]]]], dtype=torch.float32))

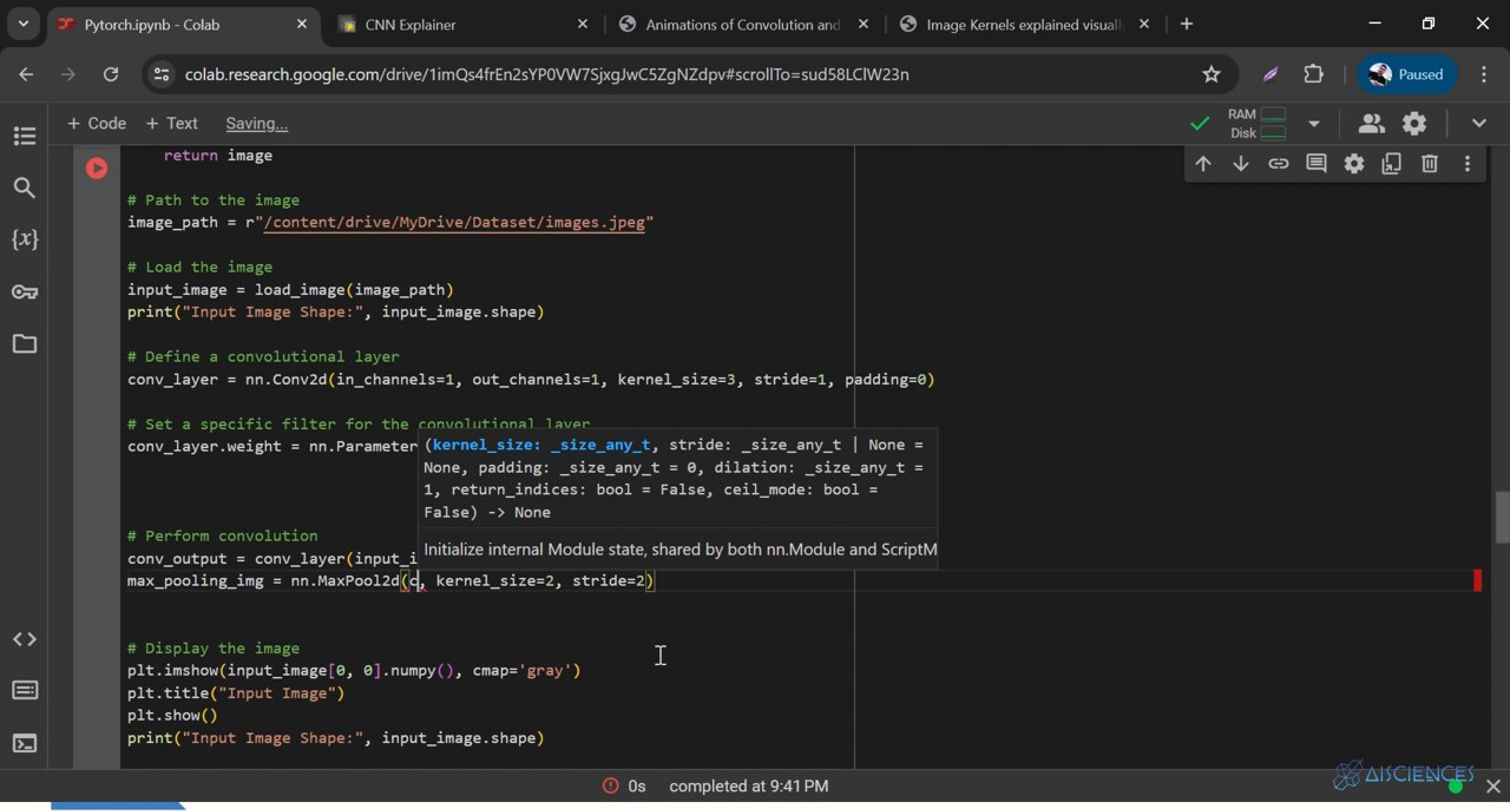

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_img = nn.MaxPool2d(kernel_size=2, stride=2)



# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)

# Display the image
plt.imshow(conv_output[0, 0].detach().numpy(), cmap='gray')
plt.title("Conv Image")
plt.show()
print("Conv Image Shape:", conv_output.shape)

# Display the image
plt.imshow(max_pooling_img[0, 0].detach().numpy(), cmap='gray')
plt.title("Pooling Image")
plt.show()
print("Pooling Image Shape:", max_pooling_img.shape)
```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colab.research.google.com/drive/1imQs4frEn2sYP0VW7SjxgJwC5ZgNZdpv#scrollTo=sud58LClW23n
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AISCIENCES

```
    return image

# Path to the image
image_path = r"/content/drive/MyDrive/Dataset/images.jpeg"

# Load the image
input_image = load_image(image_path)
print("Input Image Shape:", input_image.shape)

# Define a convolutional layer
conv_layer = nn.Conv2d(in_channels=1, out_channels=1, kernel_size=3, stride=1, padding=0)

# Set a specific filter for the convolutional layer
conv_layer.weight = nn.Parameter



# Perform convolution
conv_output = conv_layer(input_i
max_pooling_img = nn.MaxPool2d(c, kernel_size=2, stride=2)


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)
```

```
(kernel_size: _size_any_t, stride: _size_any_t | None =
None, padding: _size_any_t = 0, dilation: _size_any_t =
1, return_indices: bool = False, ceil_mode: bool =
False) -> None

Initialize internal Module state, shared by both nn.Module and ScriptM
```

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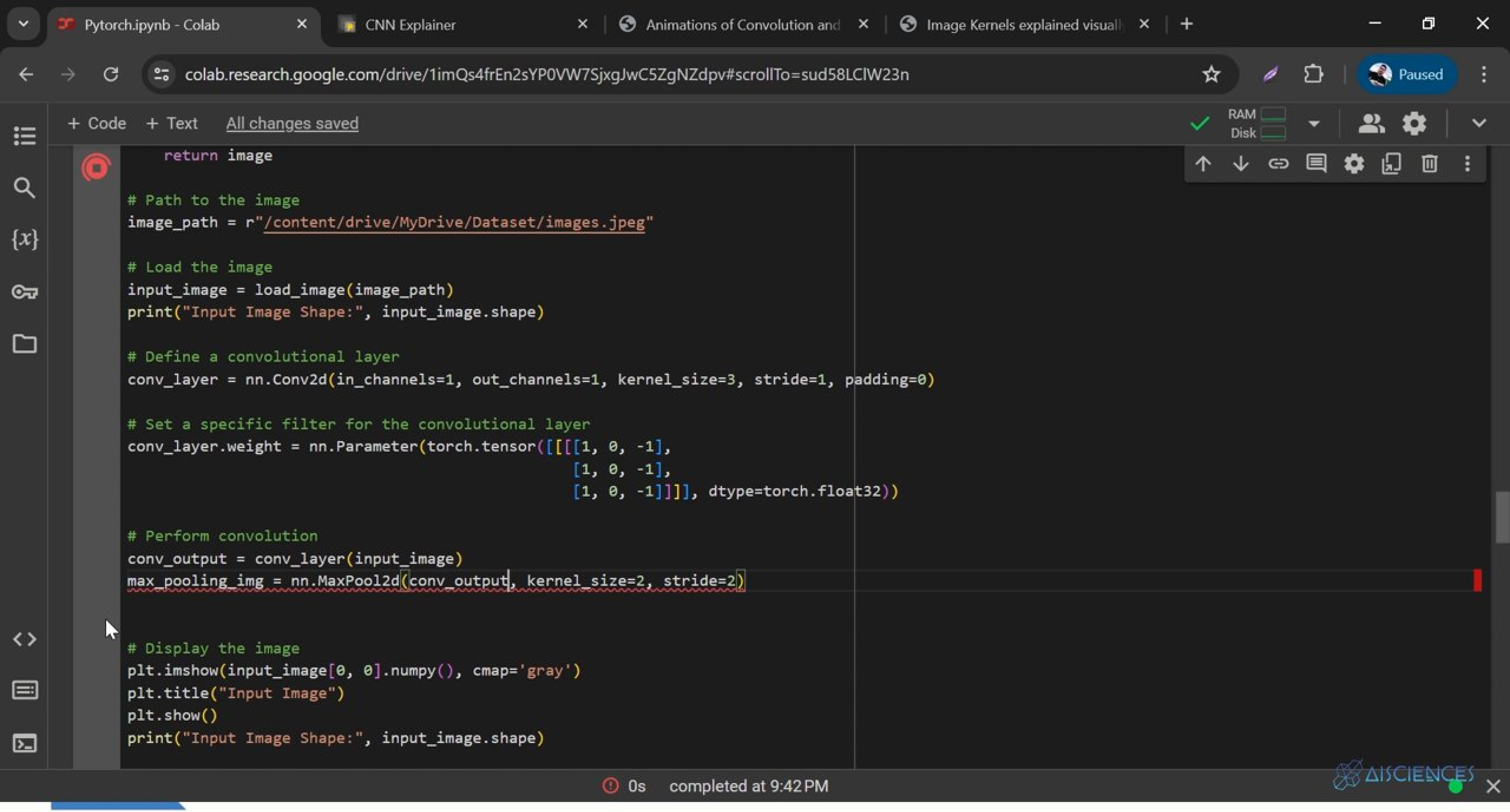
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All changes saved
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```
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# Path to the image
image_path = r"/content/drive/MyDrive/Dataset/images.jpeg"

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input_image = load_image(image_path)
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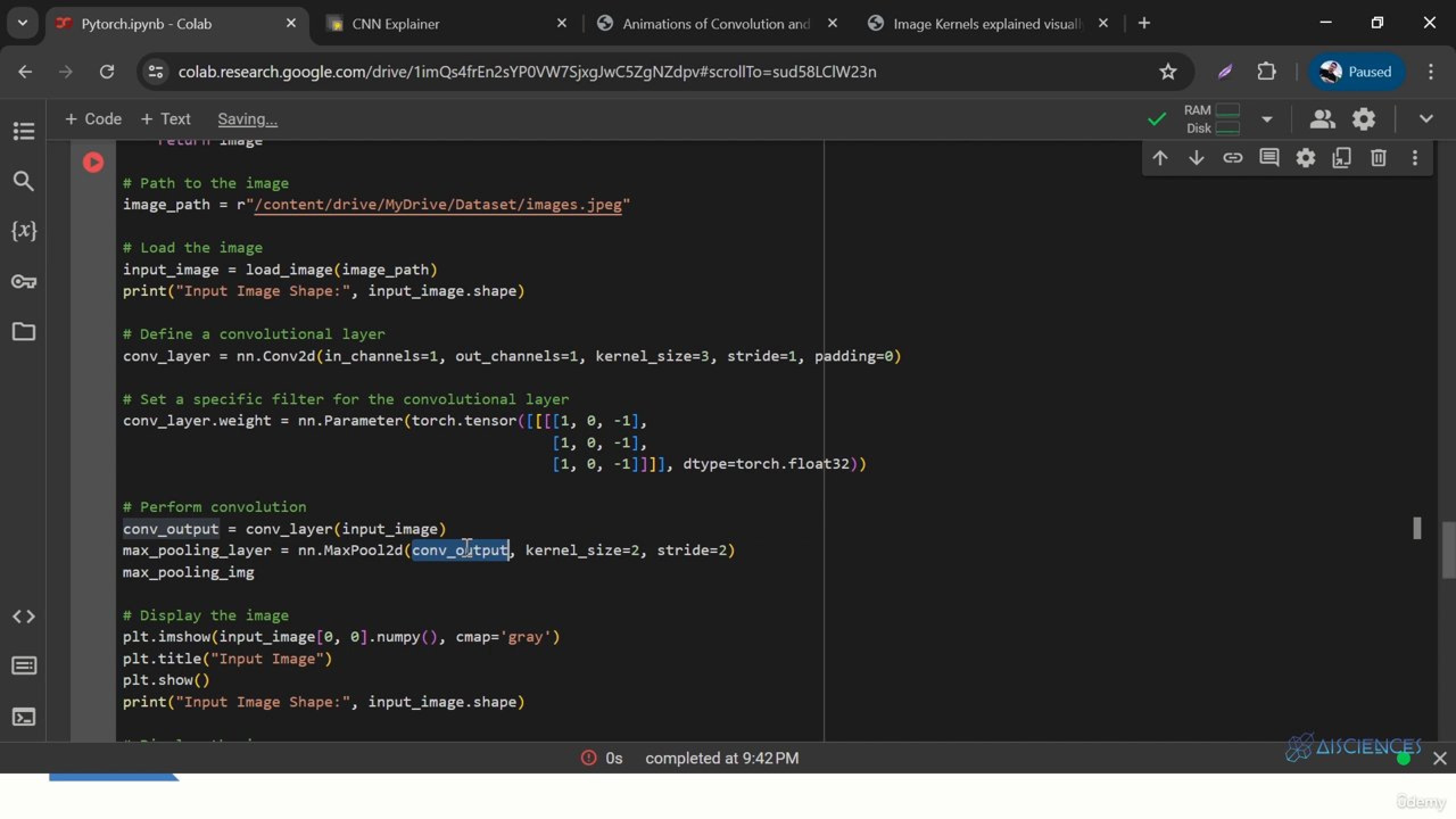
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                 [1, 0, -1],
                                                 [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_img = nn.MaxPool2d(conv_output, kernel_size=2, stride=2)


# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)
```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AISCIENCES

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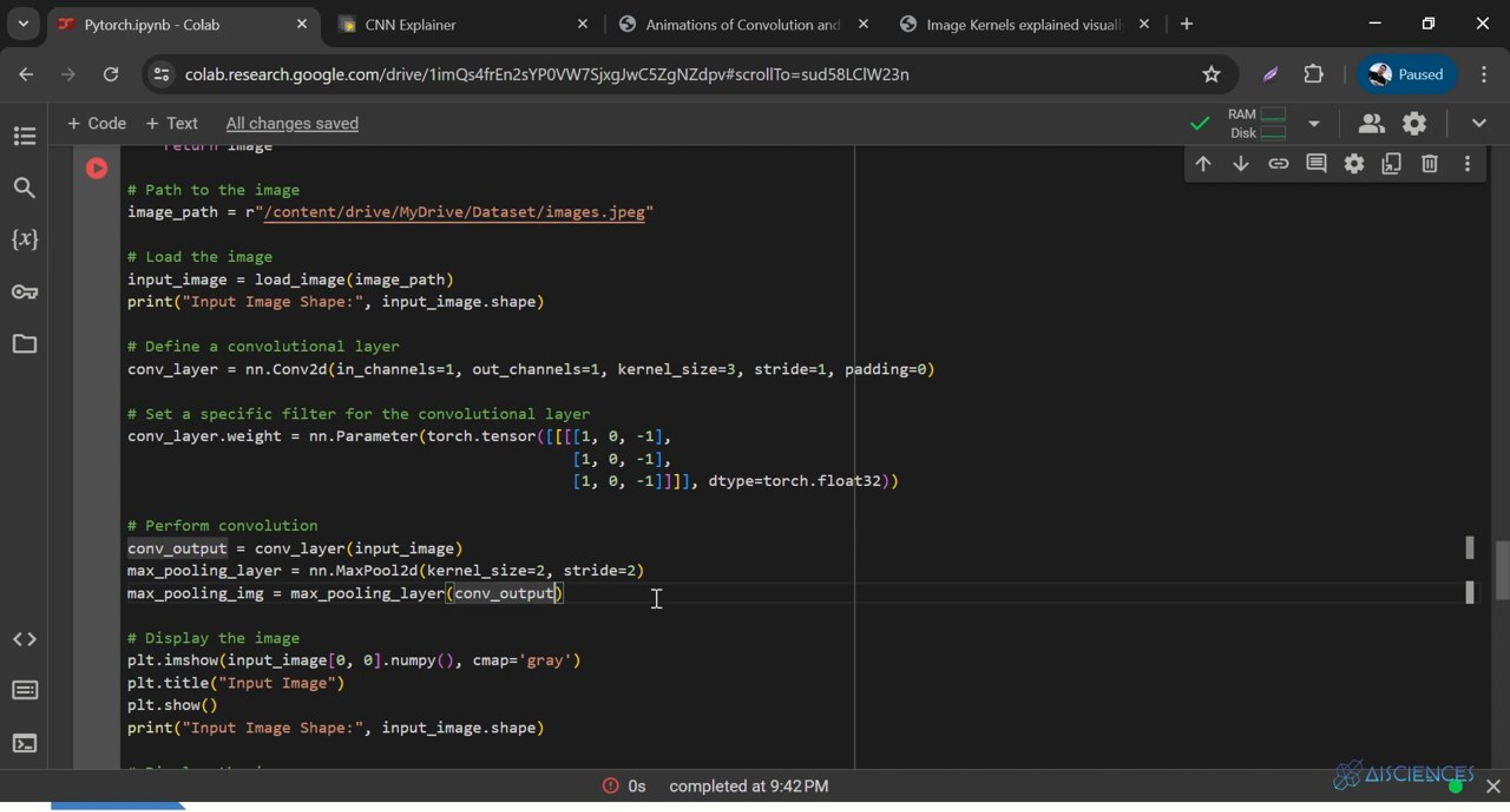
conv_layer.weight = nn.Parameter(torch.tensor([[[[1, 0, -1],
                                                  [1, 0, -1],
                                                  [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_layer = nn.MaxPool2d(conv_output, kernel_size=2, stride=2)
max_pooling_img

# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)
```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```python
    return image

# Path to the image
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                                                 [1, 0, -1],
                                                 [1, 0, -1]]]], dtype=torch.float32))

# Perform convolution
conv_output = conv_layer(input_image)
max_pooling_layer = nn.MaxPool2d(kernel_size=2, stride=2)
max_pooling_img = max_pooling_layer(conv_output)

# Display the image
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)

# Display the image
```
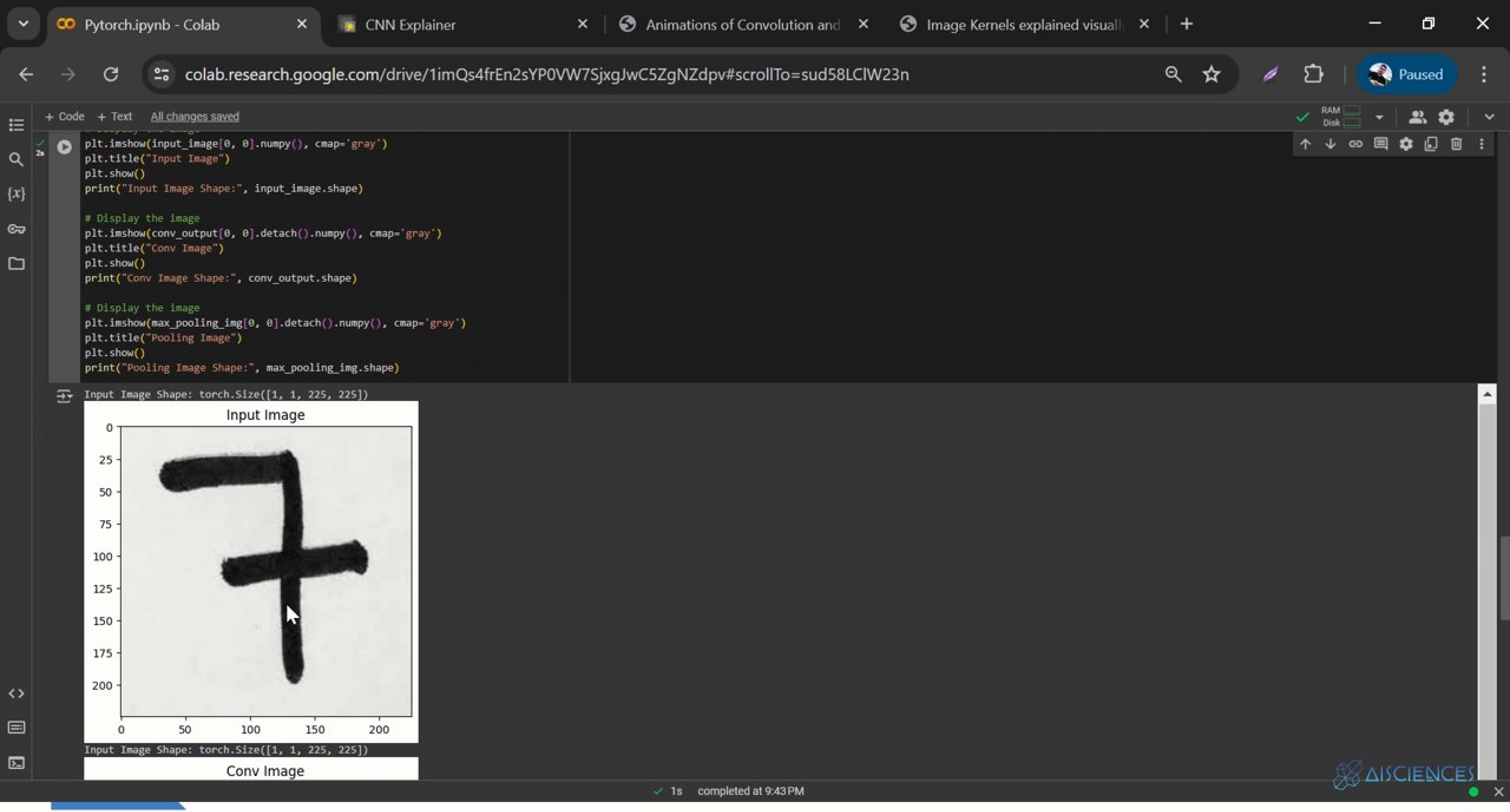
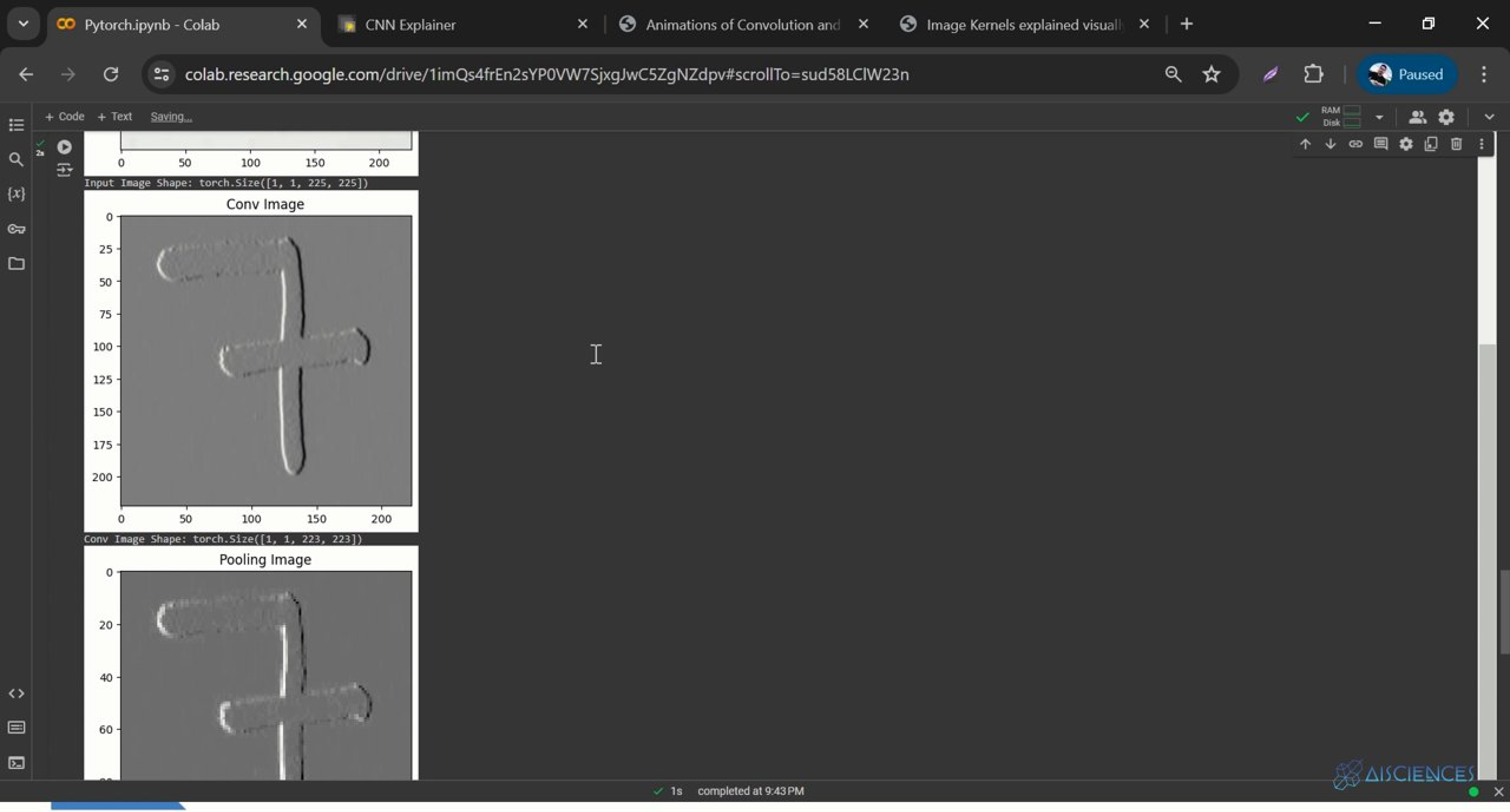



```
plt.imshow(input_image[0, 0].numpy(), cmap='gray')
plt.title("Input Image")
plt.show()
print("Input Image Shape:", input_image.shape)

# Display the image
plt.imshow(conv_output[0, 0].detach().numpy(), cmap='gray')
plt.title("Conv Image")
plt.show()
print("Conv Image Shape:", conv_output.shape)

# Display the image
plt.imshow(max_pooling_img[0, 0].detach().numpy(), cmap='gray')
plt.title("Pooling Image")
plt.show()
print("Pooling Image Shape:", max_pooling_img.shape)
```

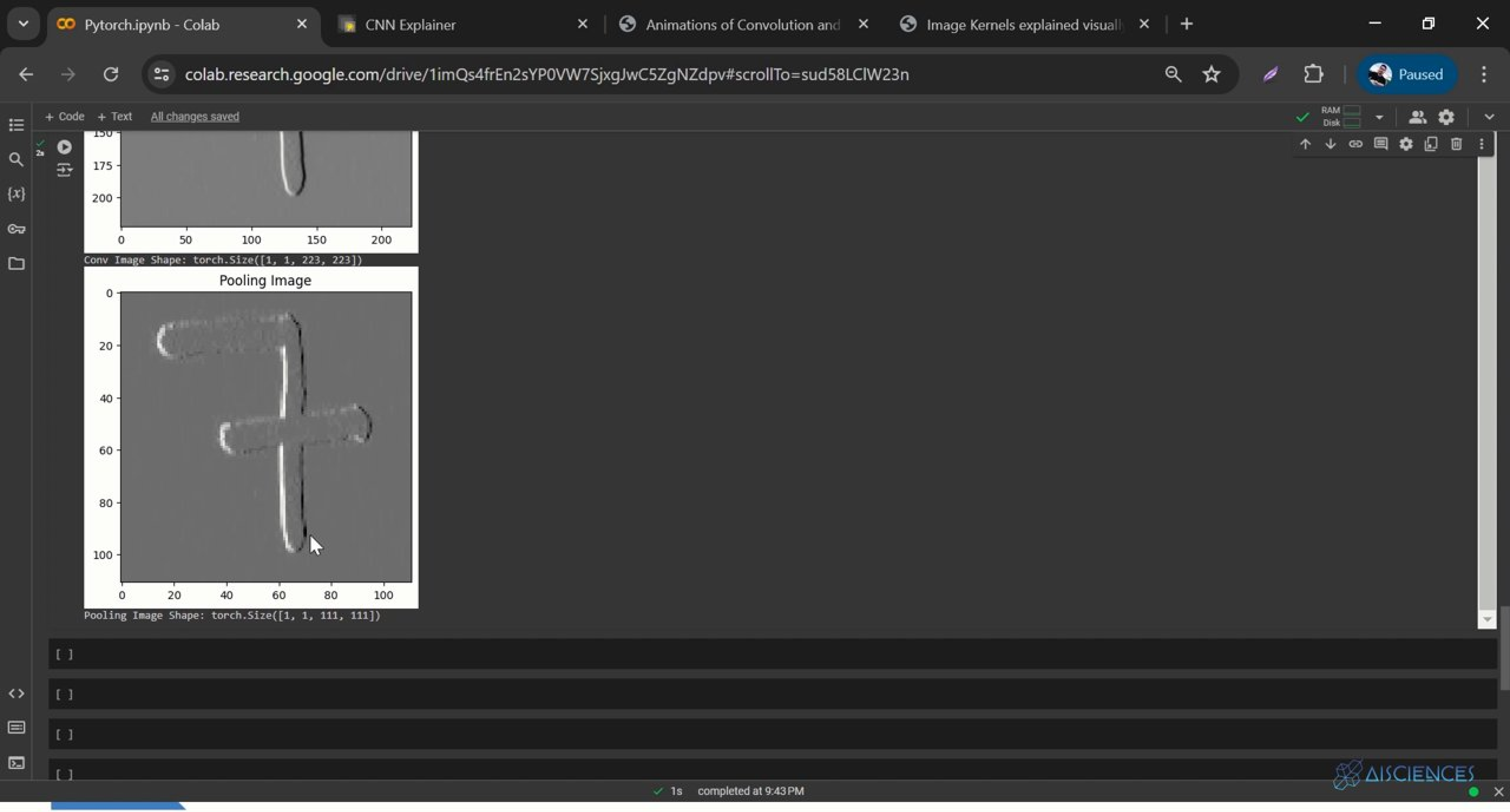
```
Input Image Shape: torch.Size([1, 1, 225, 225])
```

```
Input Image Shape: torch.Size([1, 1, 225, 225])
```



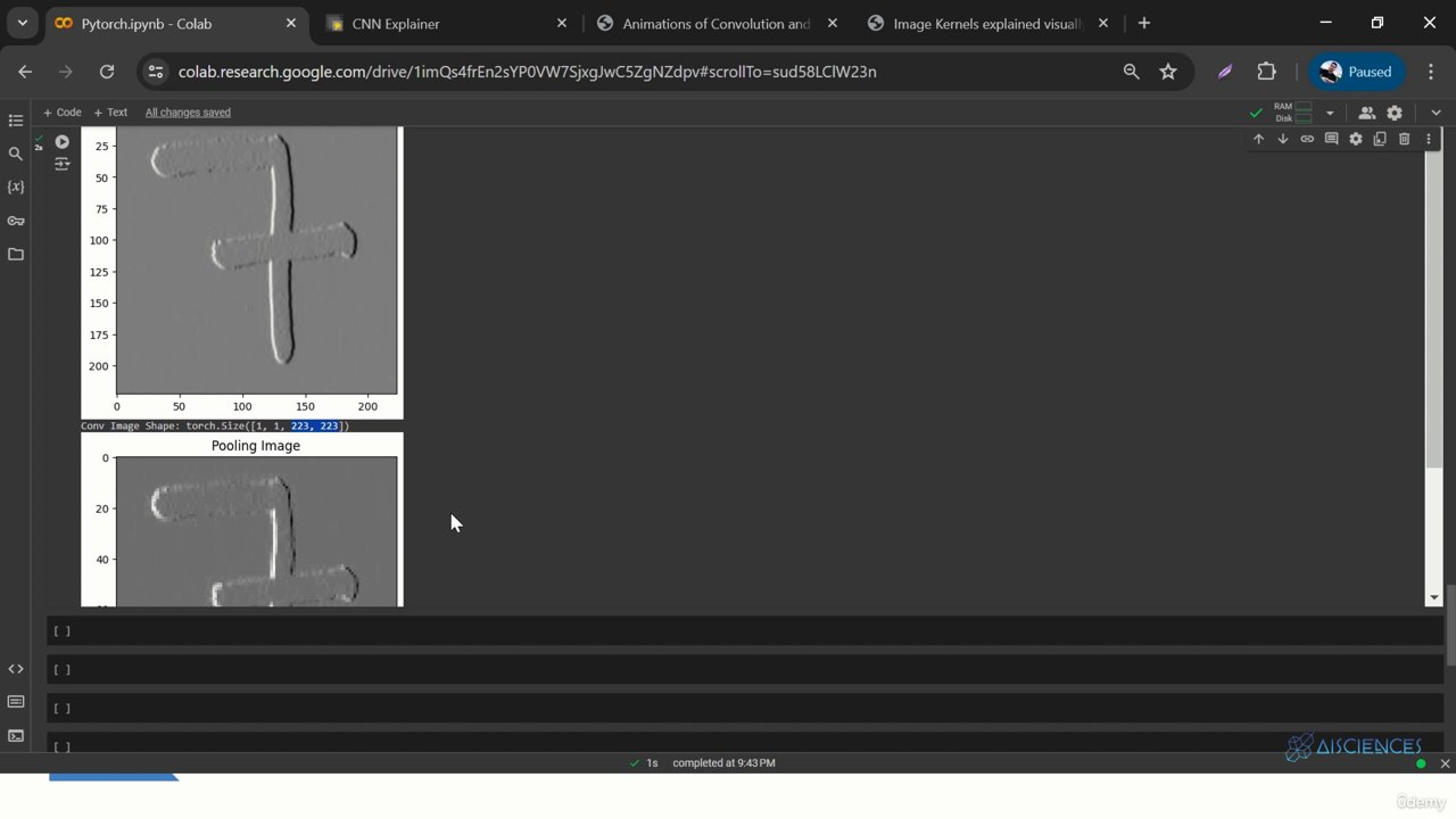
```
Input Image Shape: torch.Size([1, 1, 225, 225])
```

```
Conv Image Shape: torch.Size([1, 1, 223, 223])
```

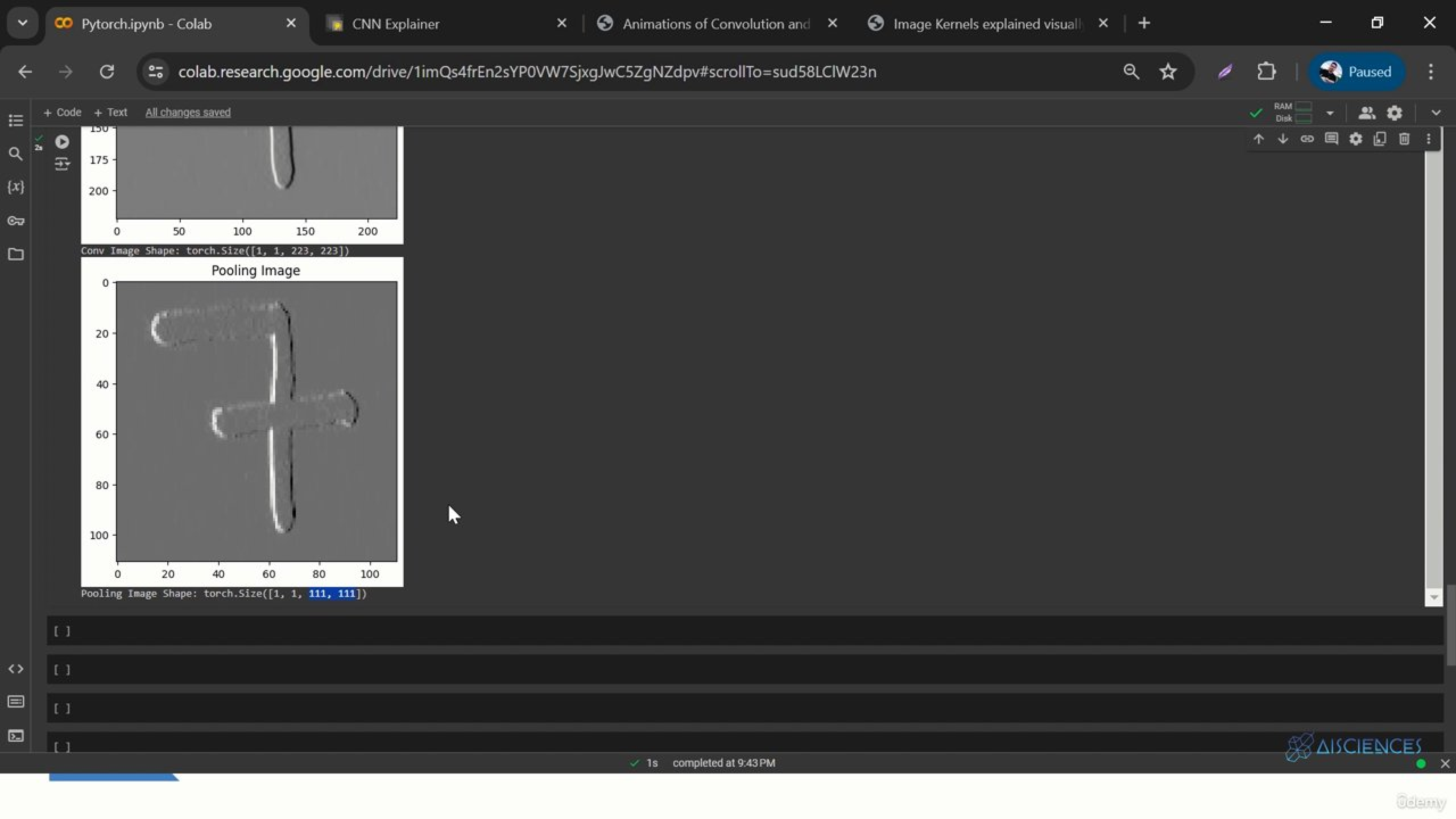


```
Conv Image Shape: torch.Size([1, 1, 223, 223])
```

```
Pooling Image Shape: torch.Size([1, 1, 111, 111])
```



```
Conv Image Shape: torch.Size([1, 1, 223, 223])
```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colab.research.google.com/drive/1imQs4frEn2sYP0VW7SjxgJwC5ZgNZdpv#scrollTo=sud58LClW23n
Paused
+ Code
+ Text
All changes saved
RAM
Disk
150
175
200
0
50
100
150
200
Pooling Image
0
20
40
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80
100
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100
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```
Conv Image Shape: torch.Size([1, 1, 223, 223])
```

```
Pooling Image Shape: torch.Size([1, 1, 111, 111])
```

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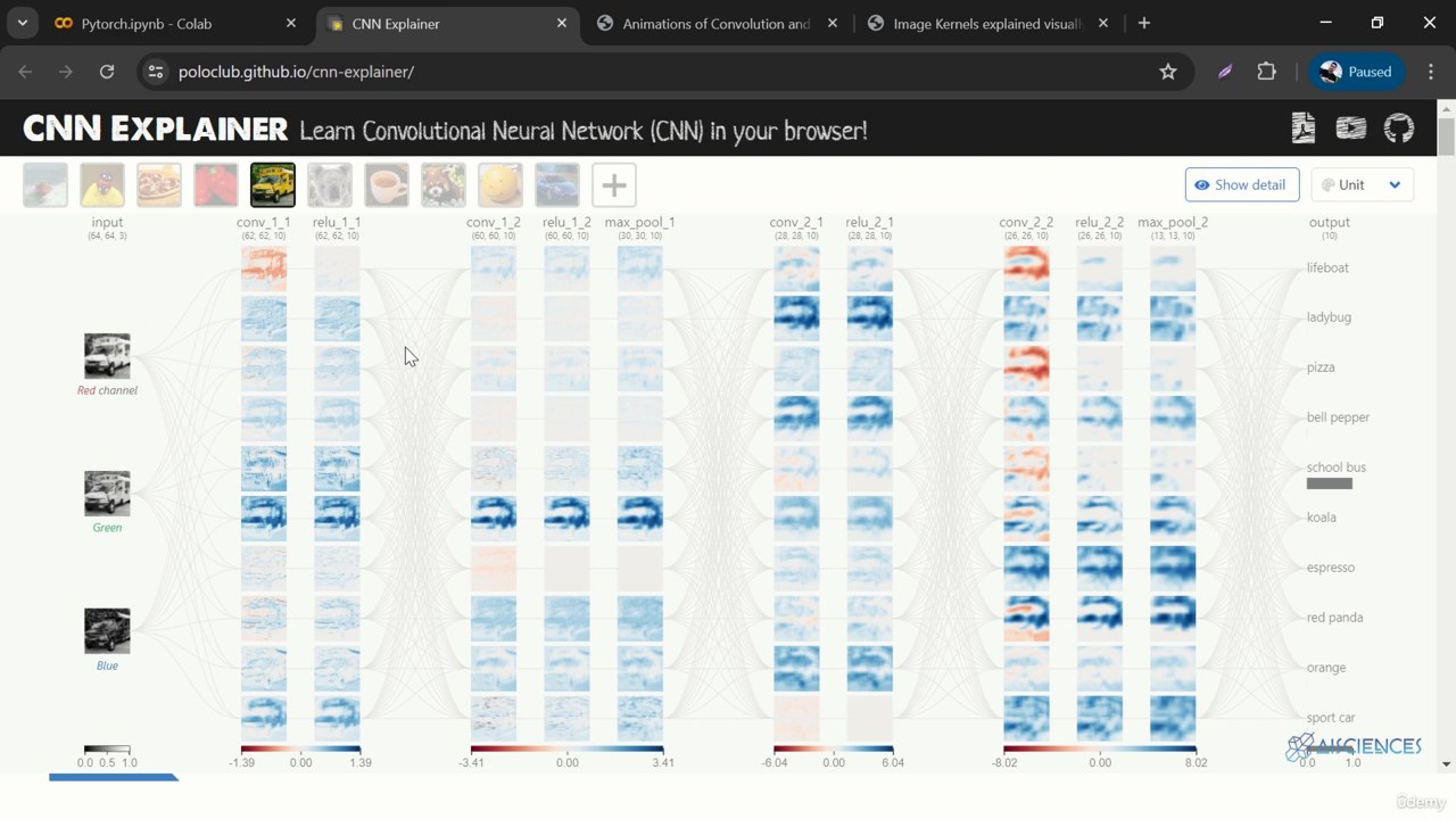

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Show detail
Unit
input (64, 64, 3)
conv_1_1 (62, 62, 10)
relu_1_1 (62, 62, 10)
conv_1_2 (60, 60, 10)
relu_1_2 (60, 60, 10)
max_pool_1 (30, 30, 10)
conv_2_1 (28, 28, 10)
relu_2_1 (28, 28, 10)
conv_2_2 (26, 26, 10)
relu_2_2 (26, 26, 10)
max_pool_2 (13, 13, 10)
output (10)
Red channel
Green
Blue
lifeboat
ladybug
pizza
bell pepper
school bus
koala
espresso
red panda
orange
sport car
0.0 0.5 1.0
-1.39 0.00 1.39
-3.41 0.00 3.41
-6.04 0.00 6.04
-8.02 0.00 8.02
0.0 1.0
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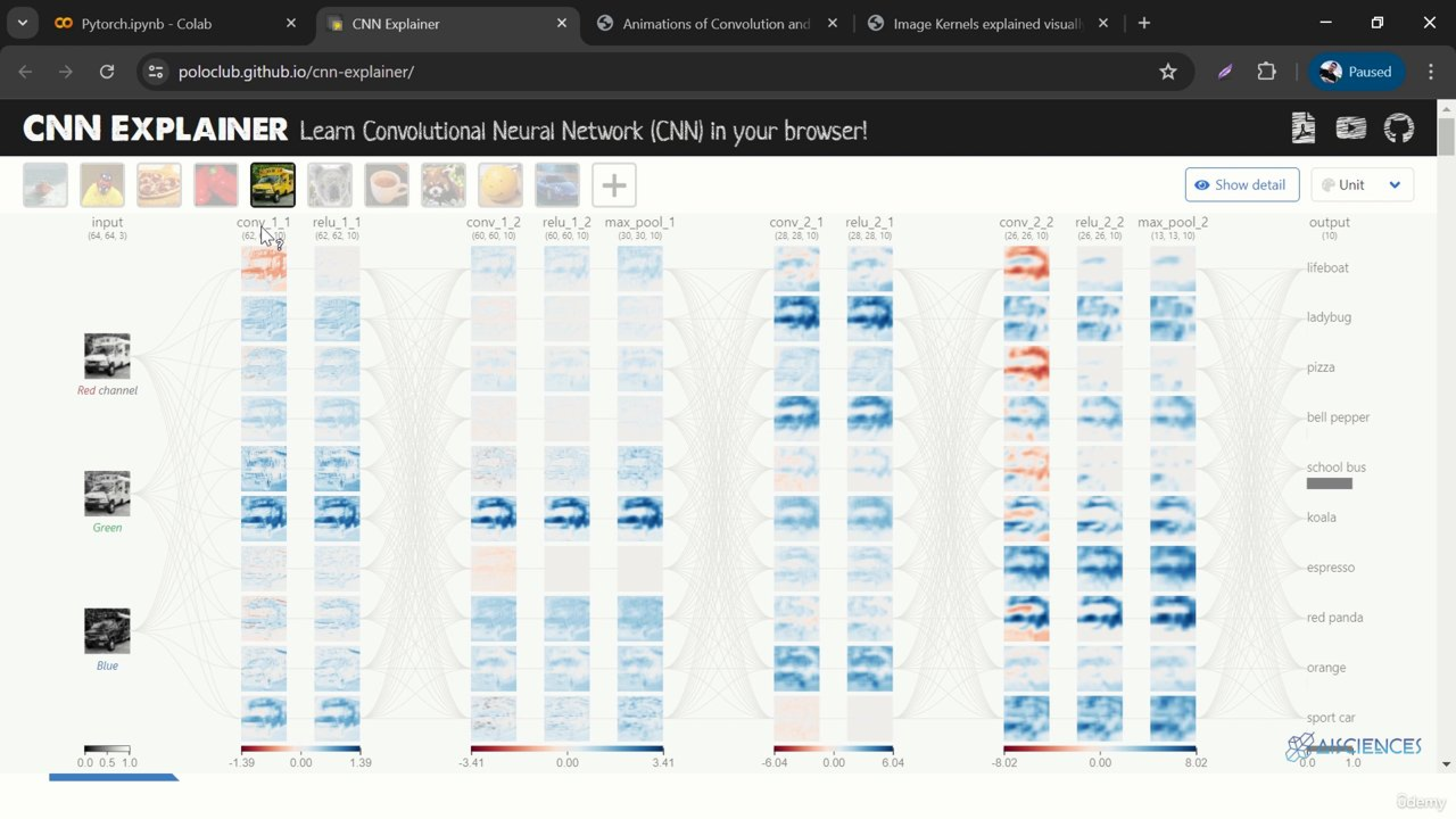

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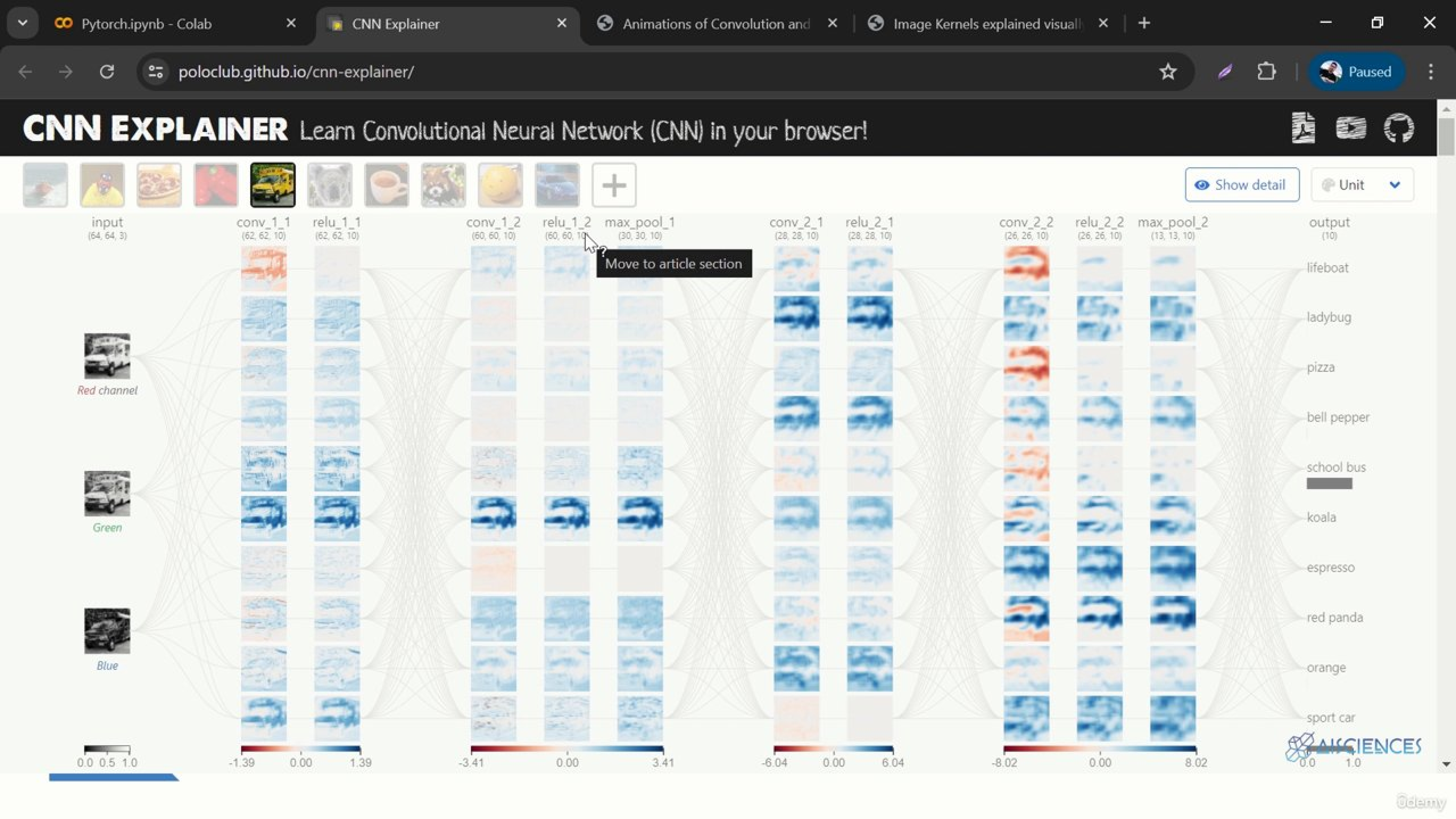

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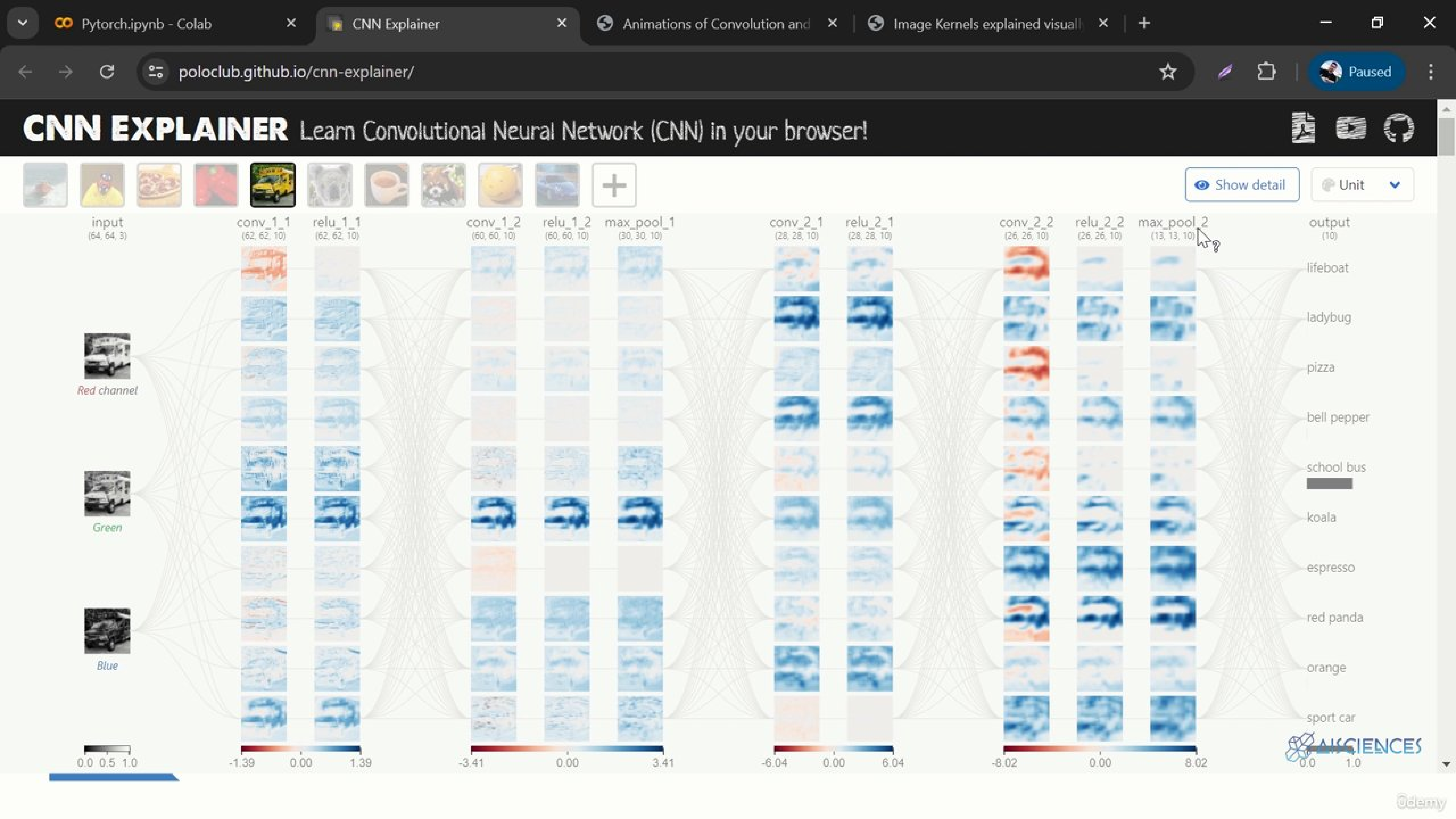
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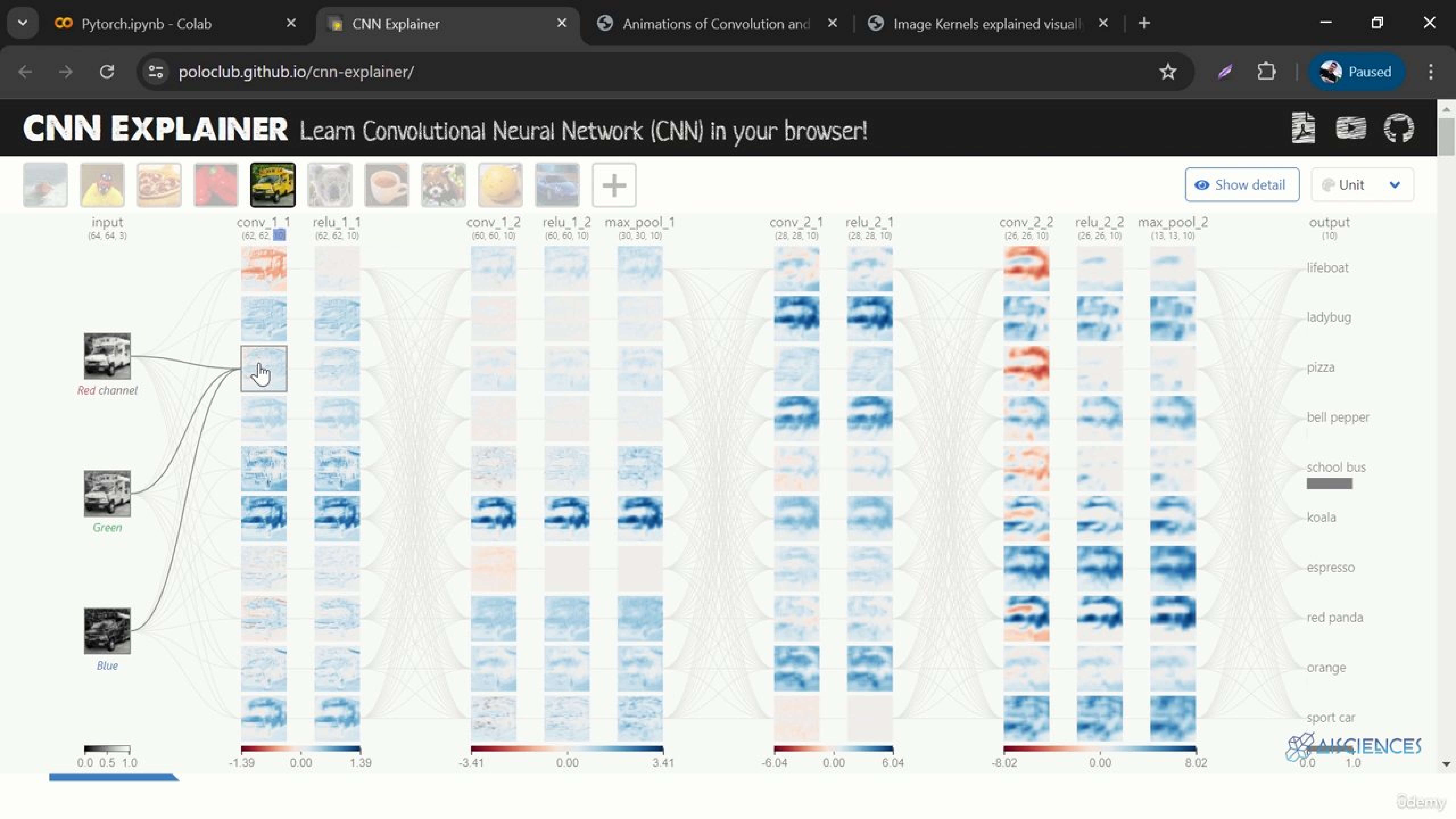

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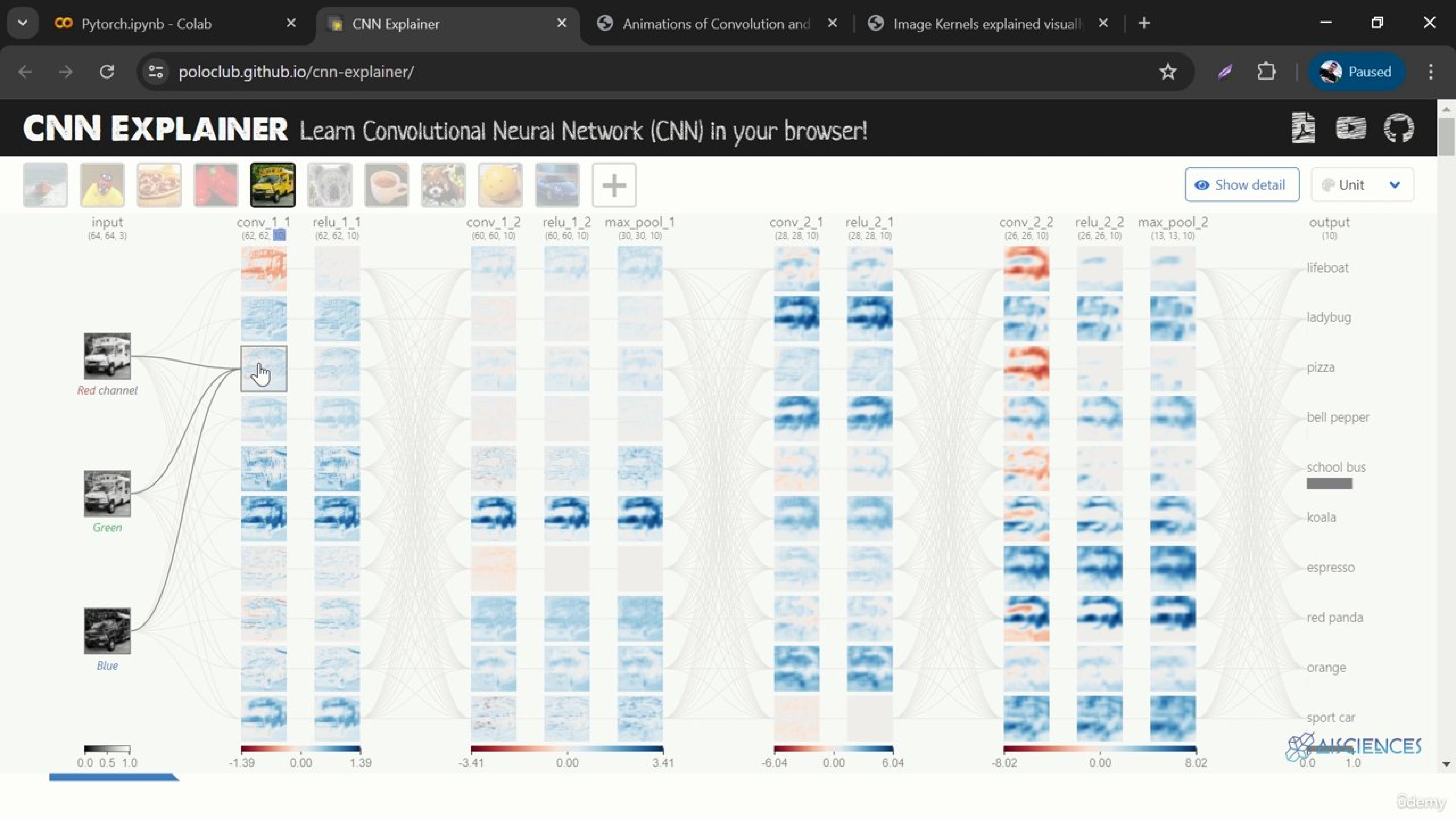

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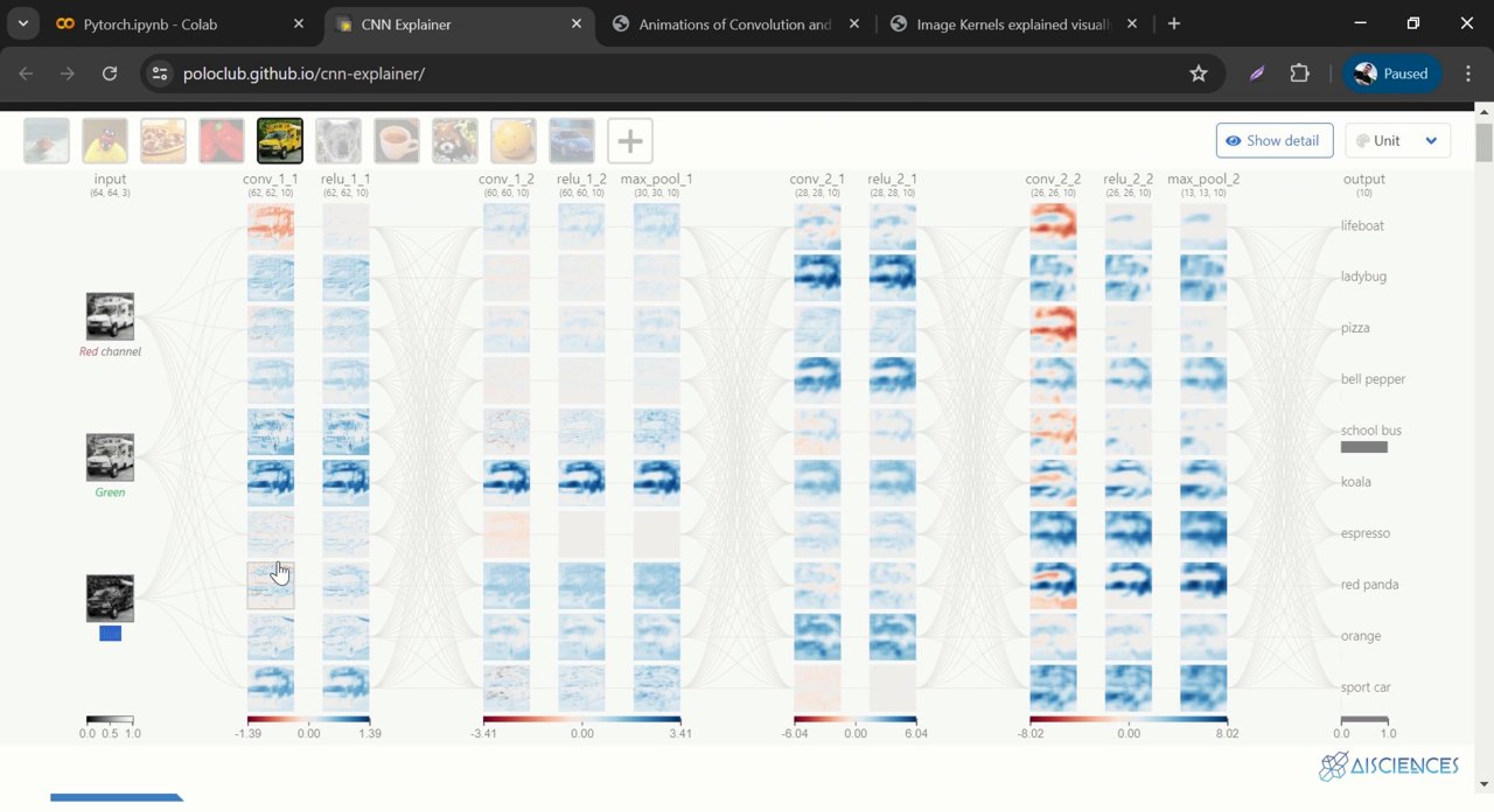
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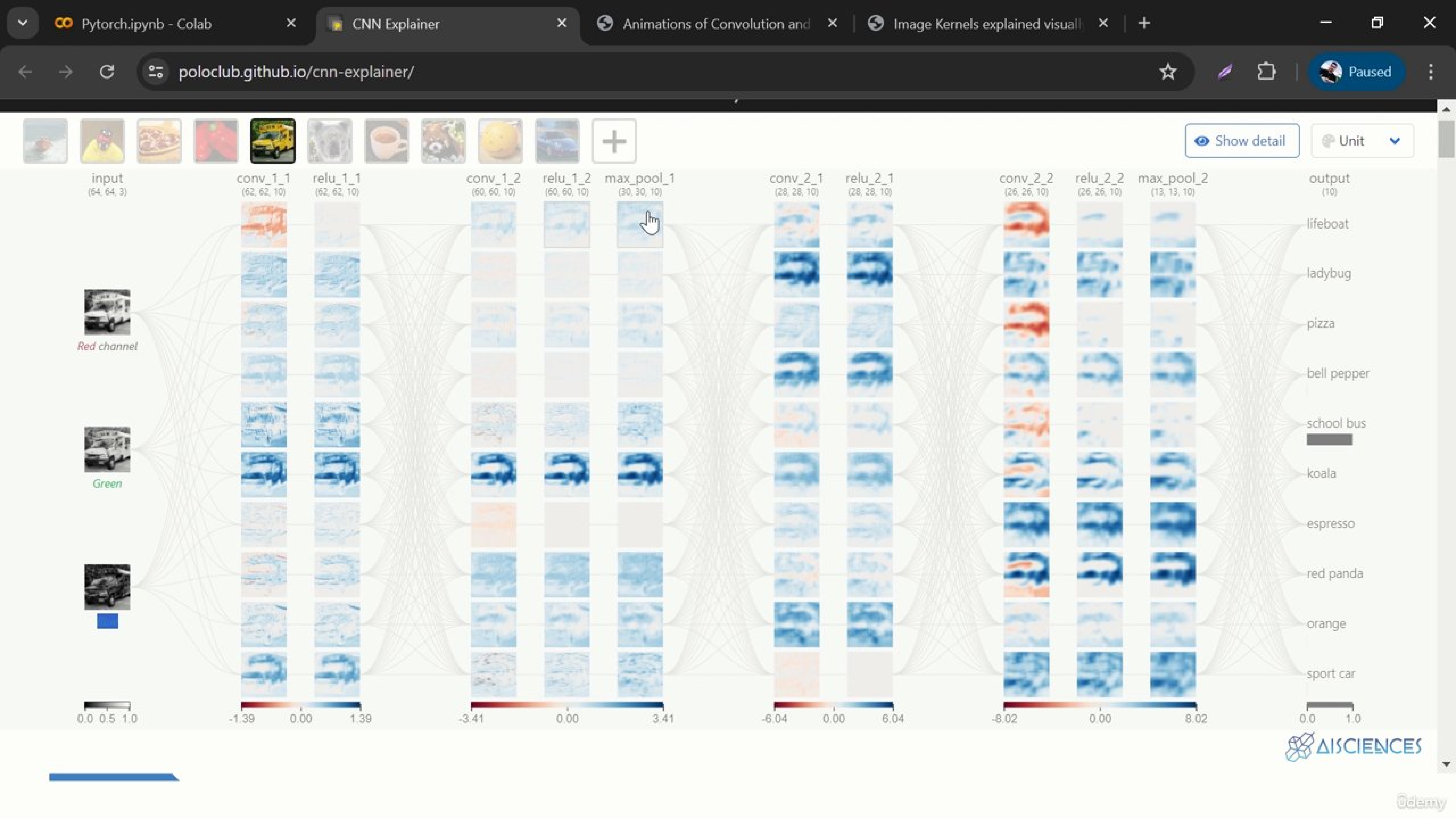
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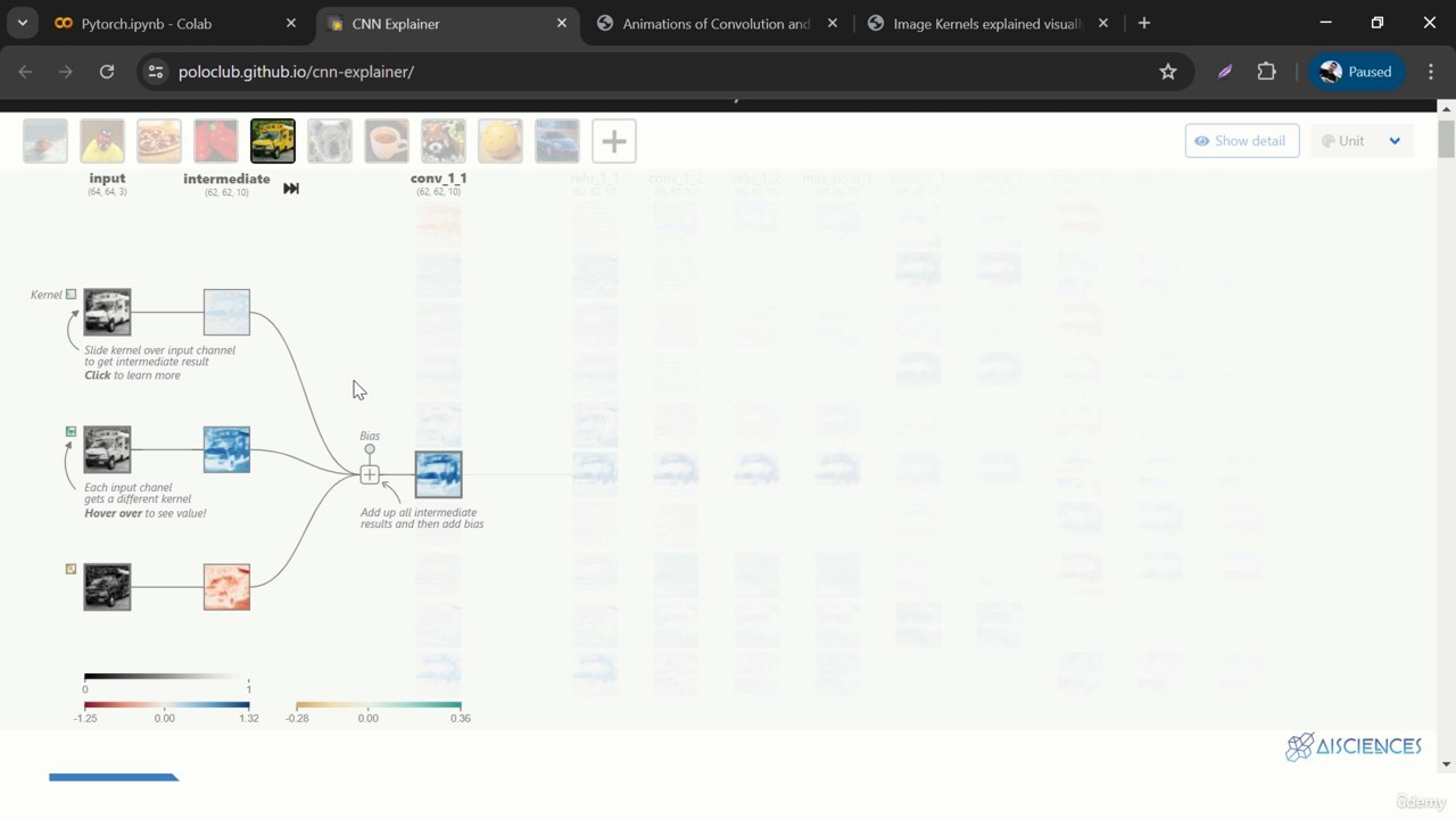
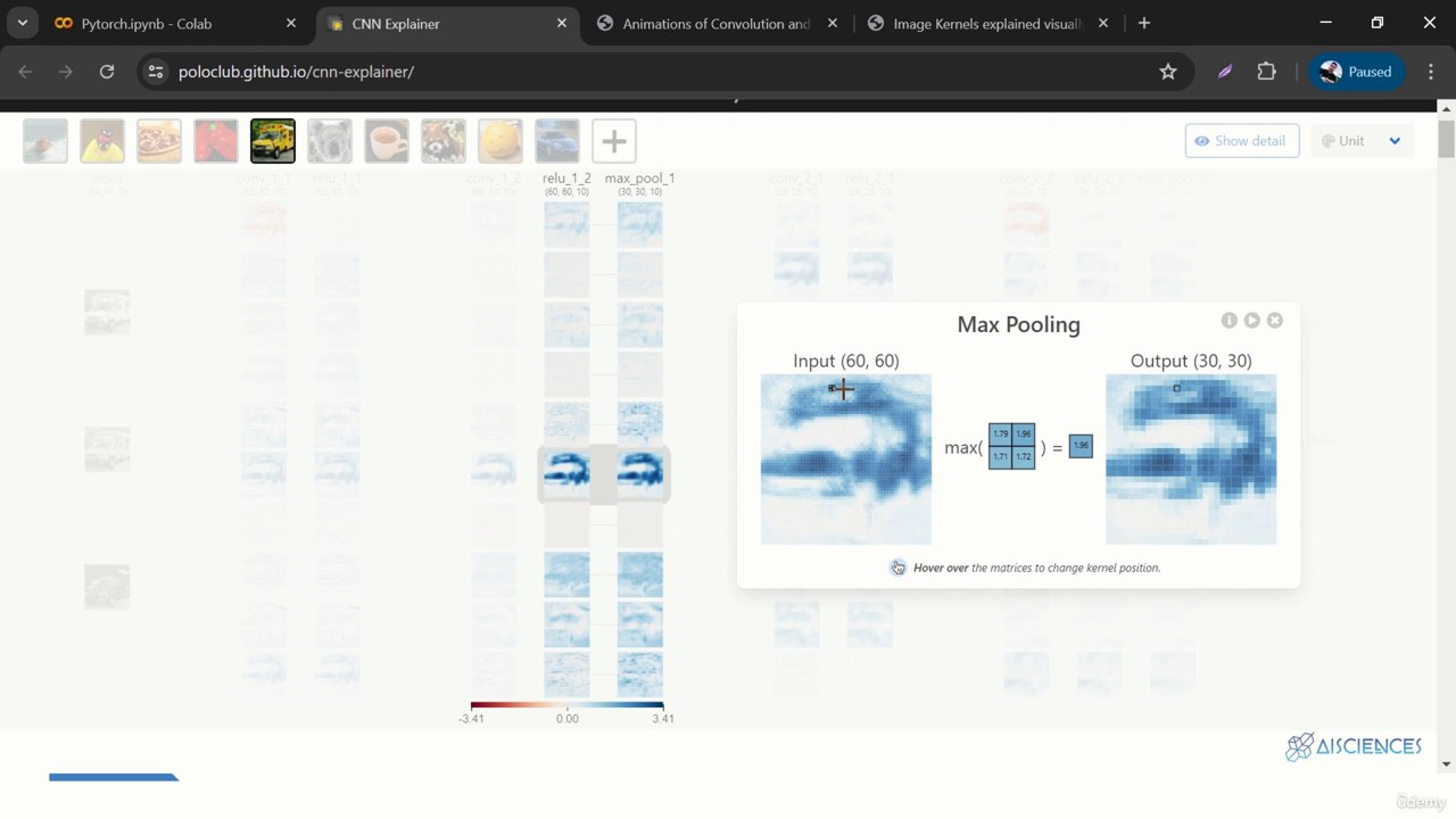


Slide kernel over input channel to get intermediate result
Click to learn more

Each input chanel gets a different kernel
Hover over to see value!

Add up all intermediate results and then add bias



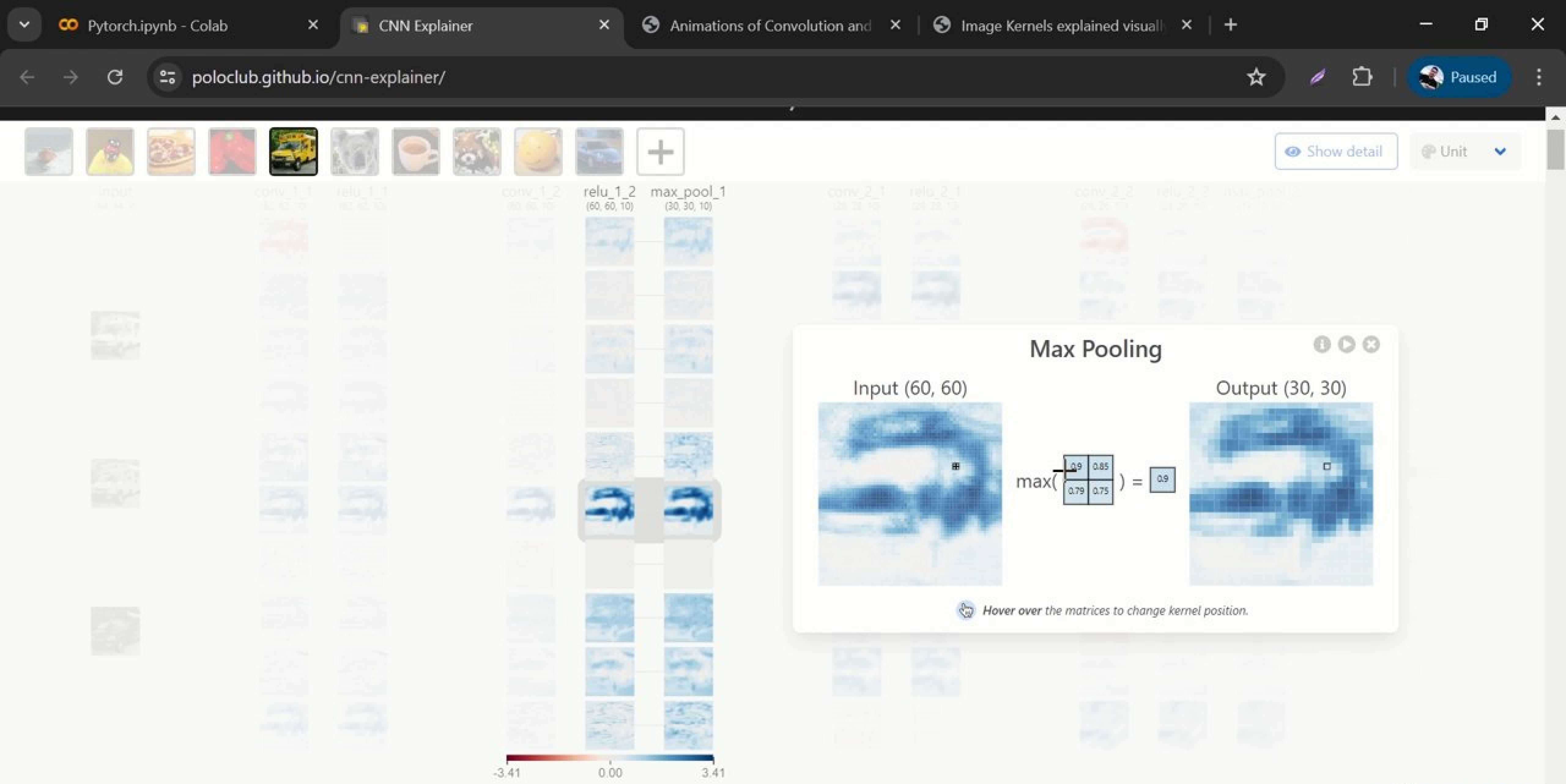
Max Pooling

Input (60, 60)

Output (30, 30)

$$\max\left(\begin{array}{|c|c|}\hline 1.79 & 1.96 \\ \hline 1.71 & 1.72 \\ \hline\end{array}\right) = \boxed{1.96}$$

Hover over *the matrices to change kernel position.*



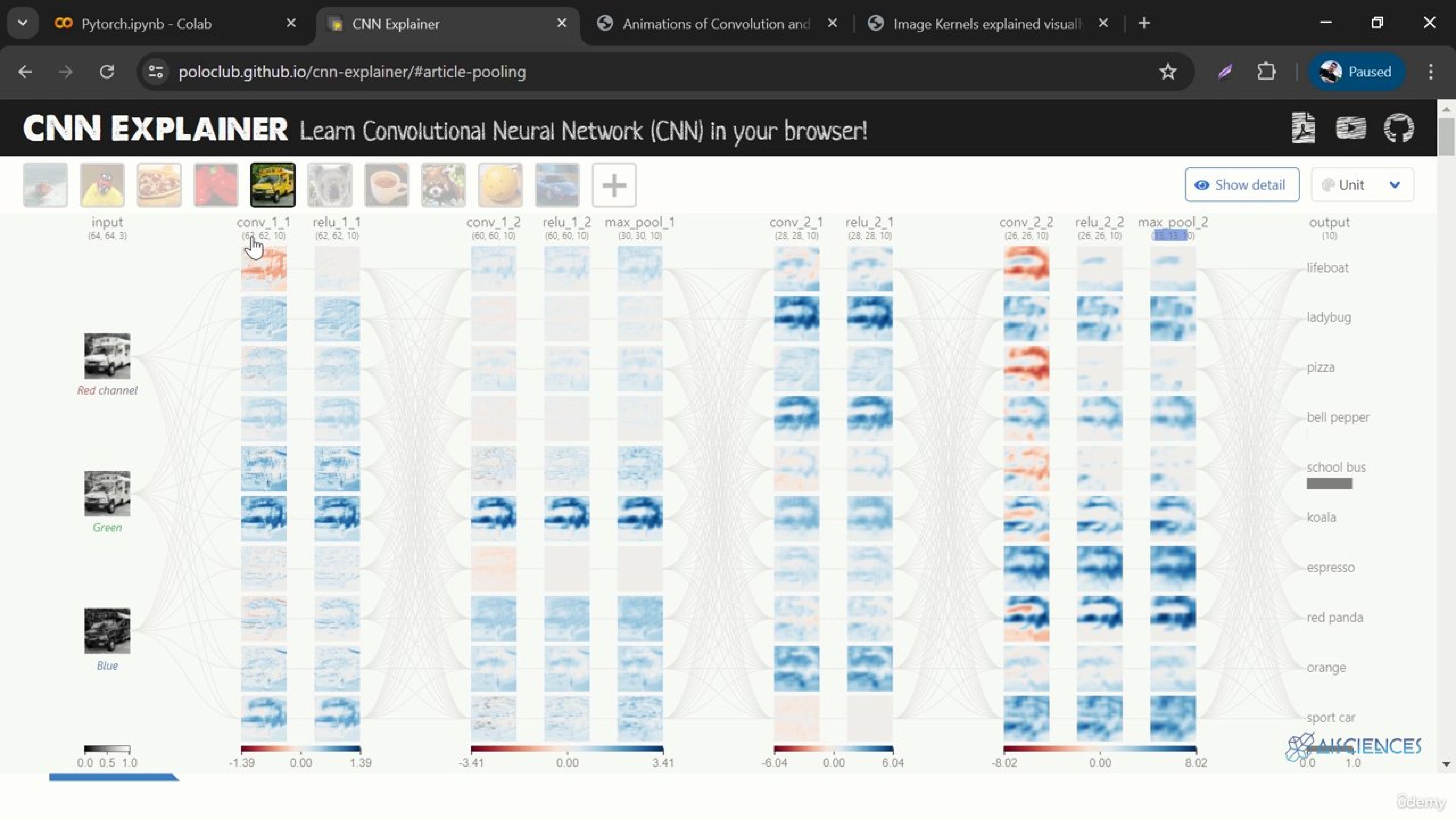
Max Pooling

Input (60, 60)

Output (30, 30)

$$\max\left(\begin{bmatrix} 0.9 & 0.85 \\ 0.79 & 0.75 \end{bmatrix}\right) = \boxed{0.9}$$

Hover over *the matrices to change kernel position.*



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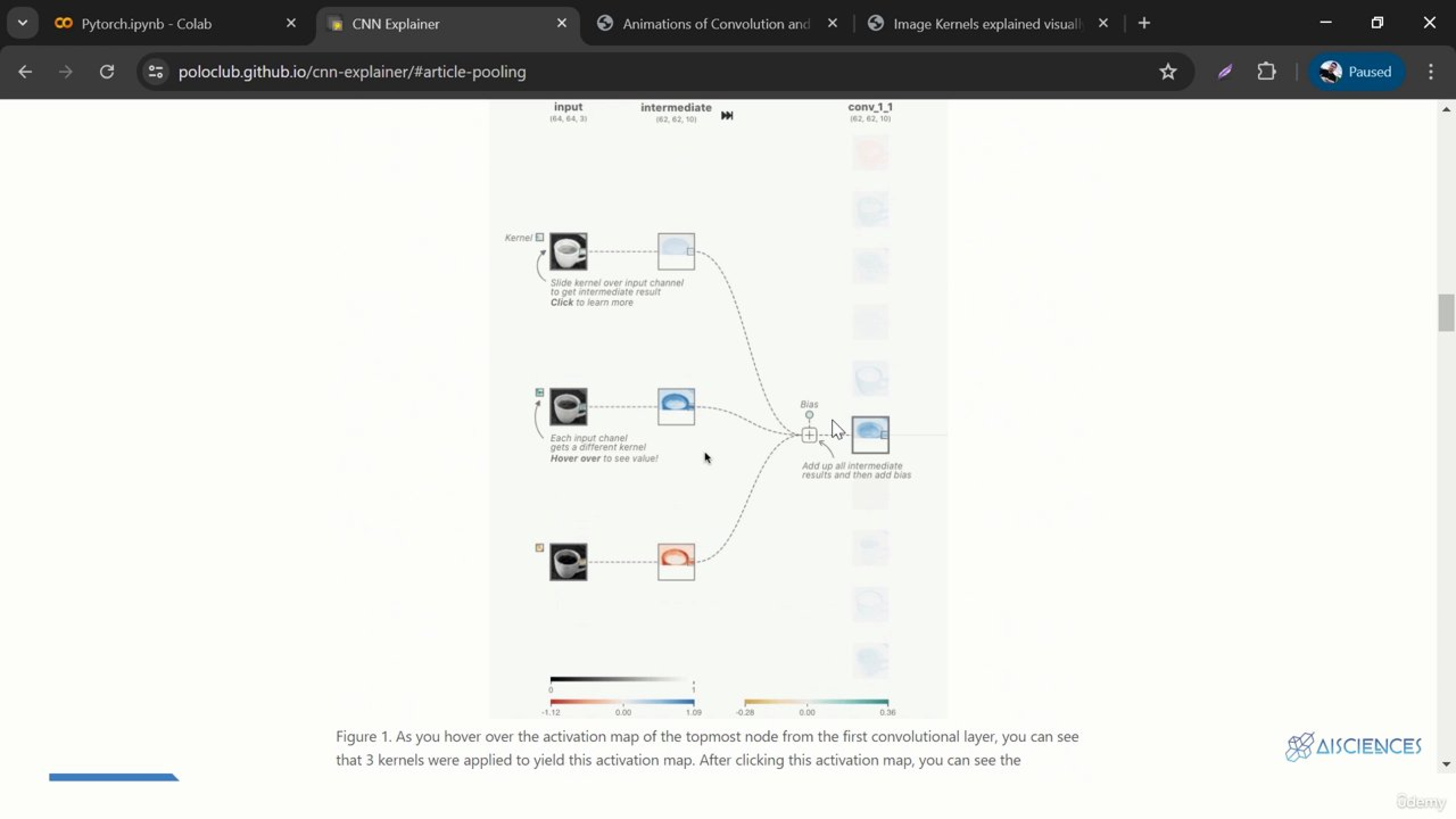

Figure 1. As you hover over the activation map of the topmost node from the first convolutional layer, you can see that 3 kernels were applied to yield this activation map. After clicking this activation map, you can see the

MAX POOLING

Input

$$\begin{bmatrix} 6 & 3 & 2 \\ 5 & 2 & 1 \\ 4 & 1 & 0 \end{bmatrix}$$

Pooling matrix
2x2

Output

$$\begin{bmatrix} 6 & 2 \\ 4 & 0 \end{bmatrix}$$

CONVOLUTION

Input

$$\begin{bmatrix} 1 & 2 & 0 & 1 & 3 \\ 4 & 1 & 0 & 2 & 1 \\ 2 & 3 & 1 & 0 & 1 \\ 1 & 2 & 0 & 1 & 3 \\ 3 & 1 & 2 & 3 & 0 \end{bmatrix}$$

Kernal

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

Output

$$\begin{bmatrix} 6 & 3 & 2 \\ 5 & 2 & 1 \\ 4 & 1 & 0 \end{bmatrix}$$

Output(1,2) = (2×1)+(0×0)+(1×−1)+(1×1)+(0×0)+(2×−1)+(3×1)+(1×0)+(0×−1)

=2+0−1+1+0−2+3+0−0

=3