In [4]:
```
def open_images(filename):
    filename = "[redacted]/CNN_demo.ipynb"
    with gzip.open(filename, "rb") as file:
        data = file.read()
        return (np.frombuffer(data, dtype=np.uint8, offset=16)
                .reshape(-1, 28, 28)
                .astype(np.float32))

def open_labels(filename):
    filename = "[redacted]/CNN_demo.ipynb"
    with gzip.open(filename, "rb") as file:
        data = file.read()
        return np.frombuffer(data, dtype=np.uint8, offset=8)
```

In [5]:
```
from IPython.display import display, Markdown
```

In [6]:
```
# Part 1: Introduction
## Convolutional Neural Network for Fashion MNIST
## Convolutional Neural Network für Fashion MNIST


# In this presentation, I will showcase my ability to build and train a Convolutional Neural Network (CNN).
# The aim is to demonstrate my skills in data processing, model development, and result visualization.

# In dieser Präsentation zeige ich meine Fähigkeit, ein Convolutional Neural Network (CNN)
# dem Fashion MNIST-Datensatz zu erstellen und zu trainieren.
# Ziel ist es, meine Fähigkeiten in der Datenverarbeitung,Modellentwicklung und Ergebnisvisualisierung zu demonstrieren.
```

In [7]:
```
# Part 2: Description of the Task
# Task Context
# Kontext der Aufgabe

## Description of the Task
## Beschreibung der Aufgabe

# The task involves building a model to classify images of clothing items into one of 10 categories using the Fashion MNIST.
# This dataset is widely used for benchmarking machine learning algorithms.

# Die Aufgabe besteht darin, ein Modell zu erstellen, das Bilder von Kleidungsstücken in eine von 10 Kategorien einordnet,
# unter Verwendung des Fashion MNIST-Datensatzes.
# Dieser Datensatz wird häufig zum Benchmarking von maschinellen Lernalgorithmen verwendet.
```

In [8]:
```
# Part 3: Model Layers
# Methods and Tools
# Methoden und Werkzeuge

## List of Methods and Tools Used
## Liste der verwendeten Methoden und Werkzeuge

# 1. **TensorFlow and Keras**: For building and training the CNN model.
# 2. **NumPy**: For numerical operations and data manipulation.
# 3. **Matplotlib**: For data visualization.
# 4. **Gzip**: For decompressing the dataset files.

# 1. **TensorFlow und Keras**: Zum Erstellen und Trainieren des CNN-Modells.
# 2. **NumPy**: Für numerische Operationen und Datenmanipulation.
# 3. **Matplotlib**: Zur Datenvisualisierung.
# 4. **Gzip**: Zum Dekomprimieren der Datensatzdateien.
```

In [9]:

```
# Data Analysis
# Datenanalyse

## Loading Libraries
## Laden der Bibliotheken

import tensorflow as tf
from tensorflow import keras

print("TensorFlow version:", tf.__version__)
print("Keras version:", keras.__version__)
```

```
TensorFlow version: 2.1.0
Keras version: 2.2.4-tf
```

In [10]:

```
# Data Preprocessing
# Datenvorverarbeitung

## Functions to Open Images and Labels
## Funktionen zum Öffnen von Bildern und Labels

import gzip
import numpy as np
from tensorflow.keras.utils import to_categorical

def open_images(filename):
    with gzip.open(filename, "rb") as file:
        data = file.read()
        return (np.frombuffer(data, dtype=np.uint8, offset=16)
                .reshape(-1, 28, 28)
                .astype(np.float32))

def open_labels(filename):
    with gzip.open(filename, "rb") as file:
        data = file.read()
        return np.frombuffer(data, dtype=np.uint8, offset=8)

# Loading and Preprocessing Data
# Laden und Vorverarbeitung der Daten

X_train = open_images("[redacted]train-images-idx3-ubyte.gz")
y_train = open_labels("[redacted]train-labels-idx1-ubyte.gz")

X_test = open_images("[redacted]t10k-images-idx3-ubyte.gz")
y_test = open_labels("[redacted]/t10k-labels-idx1-ubyte.gz")

y_train = to_categorical(y_train)
y_test = to_categorical(y_test)
```

In [13]:

```
# Model Definition
# Modelldefinition

## Defining the Model Architecture
## Definition der Modellarchitektur

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv2D, Flatten

model = Sequential()

model.add(Conv2D(10, kernel_size=(3,3), activation="relu", input_shape=(28,28,1)))
model.add(Flatten())
model.add(Dense(10, activation="softmax"))

# Model Compilation and Training
# Modellkompilierung und -training
```

```
## Compiling and Training the Model
## Kompilieren und Trainieren des Modells

model.compile(optimizer="rmsprop", loss="categorical_crossentropy", metrics=["accuracy"])

model.fit(
    X_train.reshape(60000, 28, 28, 1),
    y_train,
    epochs=10,
    batch_size=1000)
```

```
Train on 60000 samples
Epoch 1/10
60000/60000 [==============================] - 13s 219us/sample - loss: 62.9586 - accuracy: 0.5991 - lo
Epoch 2/10
60000/60000 [==============================] - 12s 200us/sample - loss: 13.7750 - accuracy: 0.7440
Epoch 3/10
60000/60000 [==============================] - 12s 201us/sample - loss: 4.5491 - accuracy: 0.8063
Epoch 4/10
60000/60000 [==============================] - 14s 225us/sample - loss: 1.2759 - accuracy: 0.8422
Epoch 5/10
60000/60000 [==============================] - 12s 197us/sample - loss: 0.4981 - accuracy: 0.8681- loss: 0.5925 - accura - ETA: 7s
Epoch 6/10
60000/60000 [==============================] - 12s 200us/sample - loss: 0.3206 - accuracy: 0.8903
Epoch 7/10
60000/60000 [==============================] - 12s 198us/sample - loss: 0.2546 - accuracy: 0.9091
Epoch 8/10
60000/60000 [==============================] - 12s 198us/sample - loss: 0.2259 - accuracy: 0.9182- los
Epoch 9/10
60000/60000 [==============================] - 12s 196us/sample - loss: 0.1996 - accuracy: 0.9273
Epoch 10/10
60000/60000 [==============================] - 12s 196us/sample - loss: 0.1804 - accuracy: 0.9339
```

Out[13]:
```
<tensorflow.python.keras.callbacks.History at 0x1c25fd485f8>
```

In [14]:
```
# Model Structure
# Modellstruktur

## Checking the Layers of the Model
## Überprüfung der Schichten des Modells

model.layers
```

Out[14]:
```
[<tensorflow.python.keras.layers.convolutional.Conv2D at 0x1c25f9a1b70>,
 <tensorflow.python.keras.layers.core.Flatten at 0x1c25f998198>,
 <tensorflow.python.keras.layers.core.Dense at 0x1c25f998828>]
```

In [22]:
```
# Weights of the First Layer
# Gewichte der ersten Schicht

## Inspecting the Weights
## Untersuchung der Gewichte

model.layers[0].weights
```

Out[22]:
```
[<tf.Variable 'conv2d/kernel:0' shape=(3, 3, 1, 10) dtype=float32, numpy=
 array([[[[-2.85780872e-03,  1.18585318e-01, -1.30591104e-02,
           -1.64691657e-01,  4.66694590e-03, -9.25477520e-02,
            1.13602601e-01,  3.65085006e-02, -9.19569582e-02,
           -1.42988488e-01]],

         [[-2.61877291e-02, -7.83542171e-02, -1.51394054e-01,
            1.06431521e-01, -1.59644946e-01,  2.77685635e-02,
            7.39484057e-02, -9.06928815e-03,  1.30068222e-02,
           -1.18249841e-01]],

         [[ 1.76664647e-02, -1.79735273e-01, -2.19657451e-01,
           -1.64638698e-01,  5.20035066e-02, -2.08313257e-01,
           -1.93146989e-01,  1.10633448e-02,  9.16855112e-02,
```

```
           9.79717523e-02]]],


        [[[ 1.01913407e-01, -2.04257518e-01, -1.06051072e-01,
           -1.83400631e-01, -1.20637543e-01,  2.15254754e-01,
           -1.91171870e-01, -1.64253756e-01,  8.06288198e-02,
           -7.68632889e-02]],

         [[-1.10321552e-01, -8.02843347e-02,  2.37416252e-02,
           -5.15200496e-02,  1.19147226e-01, -2.33394593e-01,
            4.98690344e-02,  7.45656341e-02, -1.44482823e-02,
           -8.60762671e-02]],

         [[ 3.52349132e-03,  9.18780118e-02,  8.87966305e-02,
            1.19184837e-01,  6.48180582e-03,  2.43444324e-01,
            4.98337708e-02, -7.71581940e-03, -5.12306653e-02,
            8.54695737e-02]]],


        [[[-7.64283165e-02, -1.46812975e-01,  5.36561161e-02,
           -5.87765165e-02,  1.20308802e-01, -1.60722837e-01,
           -7.40465745e-02, -3.56295183e-02, -3.09614073e-02,
            5.41790910e-02]],

         [[-2.23894138e-04,  1.41659781e-01,  1.02988914e-01,
           -1.23163722e-01, -1.79537624e-01, -1.86944887e-01,
           -1.68770686e-01, -2.64353514e-01, -7.72091374e-03,
           -3.27663809e-01]],

         [[ 1.12962071e-02, -1.48747861e-02, -1.16374061e-01,
            4.24521975e-02, -6.72580078e-02, -1.27067164e-01,
            7.30229244e-02,  7.29208579e-03, -1.51915878e-01,
           -1.68409243e-01]]]], dtype=float32)>,
 <tf.Variable 'conv2d/bias:0' shape=(10,) dtype=float32, numpy=
 array([-0.08882507, -0.04236728, -0.01803251, -0.01378375, -0.11253818,
        -0.00202528, -0.04842331, -0.1525321 , -0.06131497,  0.00882011],
       dtype=float32)>]
```

In [15]:

```
# Visualizing Weights
# Visualisierung der Gewichte

## Displaying the Weights
## Darstellung der Gewichte

import tensorflow.keras.backend as K

data = K.eval(model.layers[0].weights[0])

data[:, :, :, 0]
```

Out[15]:

```
array([[[-0.16036654],
        [ 0.06038418],
        [ 0.09603793]],

       [[-0.03488331],
        [ 0.03705579],
        [-0.09858648]],

       [[ 0.05619534],
        [-0.11196055],
        [ 0.01476851]]], dtype=float32)
```

In [16]:

```
data[:, :, :, 0].reshape(3,3)
```

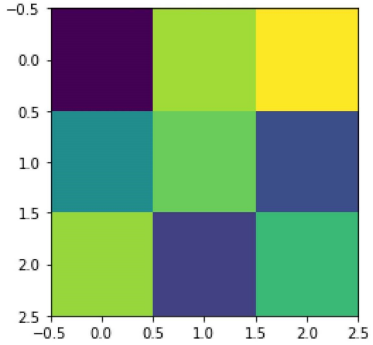
Out[16]:

```
array([[-0.16036654,  0.06038418,  0.09603793],
       [-0.03488331,  0.03705579, -0.09858648],
       [ 0.05619534, -0.11196055,  0.01476851]], dtype=float32)
```

In [17]:

```
%matplotlib inline
import matplotlib.pyplot as plt
```

```
plt.imshow(data[:, :, :, 0].reshape(3,3))
plt.show()
```



In [18]:

```
# Part 4: Visualizing Test Image
# Creating a New Model with Saved Weights
# Erstellen eines neuen Modells mit gespeicherten Gewichten

## Using Saved Weights in a New Model
## Verwendung gespeicherter Gewichte in einem neuen Modell

model12 = Sequential()

model12.add(Conv2D(10,
                   kernel_size=(3,3),
                   activation="sigmoid",
                   input_shape=(28,28,1),
                  weights=model.layers[0].get_weights()))
```

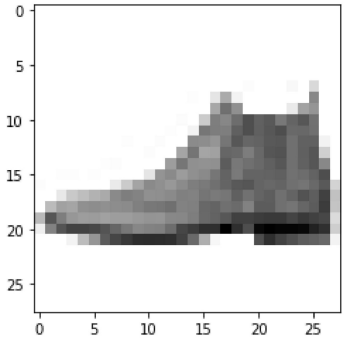
In [19]:

```
# Visualizing Test Image
# Visualisierung des Testbildes

## Displaying a Test Image
## Darstellung eines Testbildes

%matplotlib inline
import matplotlib.pyplot as plt

plt.imshow(X_test[0], cmap="gray_r")
plt.show()
```



In [20]:

```
# Prediction Using the New Model
# Vorhersage mit dem neuen Modell
```

```python
## Making Predictions
## Vorhersagen machen

result=model12.predict(X_test[0].reshape(1, 28,28, 1))
```

In [21]:

```python
result.shape
```

Out[21]:

```
(1, 26, 26, 10)
```

In [22]:

```python
result[0][:, :, 0]
```

Out[22]:

```
array([[4.99577284e-01, 4.99577284e-01, 4.99577284e-01, 4.99577284e-01,
        4.99577284e-01, 4.99577284e-01, 4.99577284e-01, 4.99577284e-01,
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        5.13622761e-01, 5.25400281e-01, 3.13154072e-01, 7.18718052e-01,
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        4.78983790e-01, 4.57746893e-01, 6.24677420e-01, 1.43801168e-01,
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```

```
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```
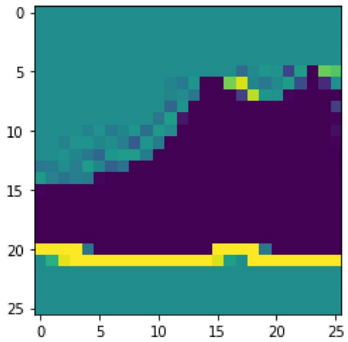

In [23]:

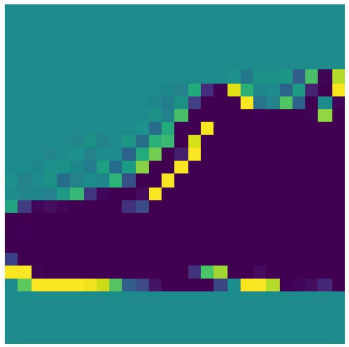
```
plt.imshow(result[0][:, :, 8])
plt.show()
```



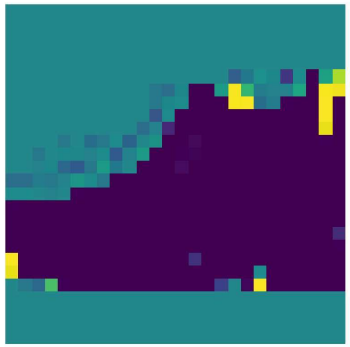
In [24]:

```
# Part 5: Visualizing All Channels

# Slide 5: Visualizing All Channels
## Visualizing All Channels
## Visualisierung aller Kanäle

## Displaying All Channels of the Convolutional Layer
## Darstellung aller Kanäle der Convolutional-Schicht


num_channels = result[0].shape[2]
height = result[0].shape[0]
width = result[0].shape[1]

num_rows = int(np.ceil(np.sqrt(num_channels)))
num_cols = int(np.ceil(num_channels / num_rows))

fig, axes = plt.subplots(num_rows, num_cols, figsize=(15, 15))

for i in range(num_channels):
    row = i // num_cols
    col = i % num_cols
    ax = axes[row, col]
    ax.imshow(result[0][:, :, i], cmap='viridis')
    ax.set_title(f'Channel {i}')
    ax.axis('off')

for j in range(i + 1, num_rows * num_cols):
    fig.delaxes(axes.flatten()[j])

plt.tight_layout()
plt.show()
```

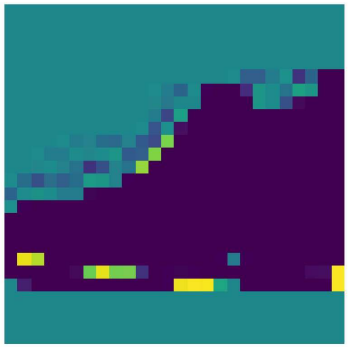
Channel 0



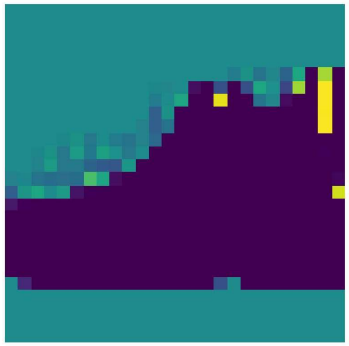
Channel 1



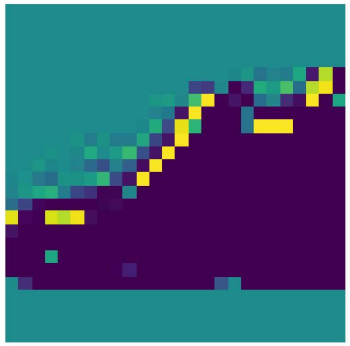
Channel 2



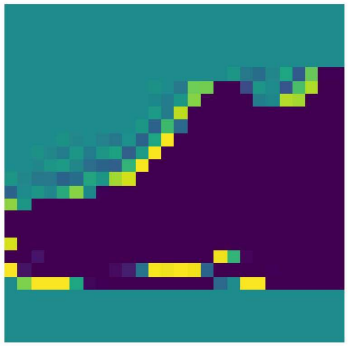
Channel 3



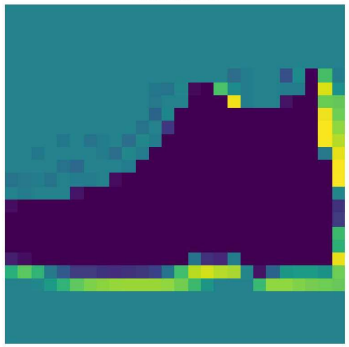
Channel 4



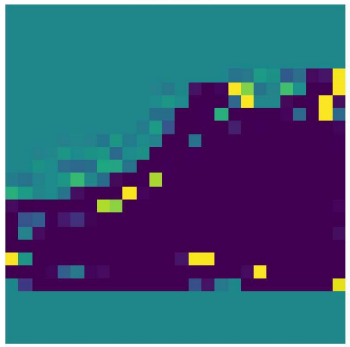
Channel 5



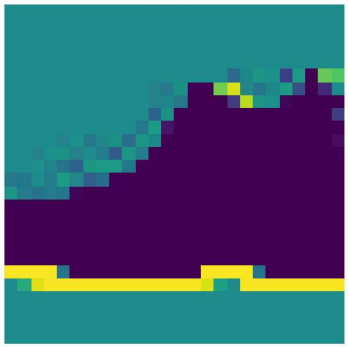
Channel 6



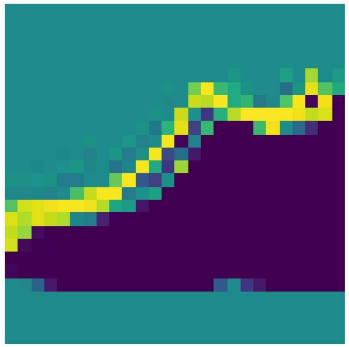
Channel 7



Channel 8



Channel 9



In [25]:

```
# Part 6: Conclusion

# Results and Conclusions
# Ergebnisse und Schlussfolgerungen

## Key Results
## Wichtige Ergebnisse


# - Successfully built and trained a CNN model to classify Fashion MNIST images.
# - Visualized the learned filters and the output of the convolutional layers.
# - Demonstrated the ability to use saved weights in a new model for predictions.

# - Erfolgreich ein CNN-Modell zur Klassifikation von Fashion MNIST-Bildern erstellt und trainiert.
# - Visualisierung der gelernten Filter und der Ausgabe der Convolutional-Schichten.
# - Fähigkeit demonstriert, gespeicherte Gewichte in einem neuen Modell für Vorhersagen zu verwenden.

# Conclusion
# Fazit

## Summary and Future Steps
## Zusammenfassung und zukünftige Schritte

# In this project, we demonstrated the process of building, training, and evaluating a CNN model for image classification.
# Future steps include experimenting with more complex architectures, tuning hyperparameters,and exploring different datasets.

# In diesem Projekt haben wir den Prozess des Erstellens, Trainings und Bewertens eines CNN-Modells zur Bildklassifikation
# demonstriert. Zukünftige Schritte umfassen Experimente mit komplexeren Architekturen, Hyperparametertuning und
# die Erforschung verschiedener Datensätze.
```

In [ ]: