

Programmierung für KI  
Projektausarbeitung - Haar Cascades

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14. Januar 2023

## **Inhaltsverzeichnis**

## Einleitung

Im Rahmen der Veranstaltung - *Programmierung für KI*, haben wir das Thema **Haar Cascades**, als gemeinsam zu bearbeitendes Projekt erhalten. Haar Cascades beschreibt ein Verfahren bzw. einen Algorithmus, welches bestimmte Merkmale oder Muster in Bildern oder Videos erkennen kann.

Ziel dieses Projektes ist es nun ein solches Verfahren zu implementieren und eine passende graphische Benutzeroberfläche in Python bereitzustellen. Nach einer kurzen theoretischen Einführung in das Thema, teilt sich die Arbeit in zwei Teile auf. Der erste Teil beschäftigt sich mit der Erstellung einer graphischen Benutzeroberfläche mit Hilfe von **Tkinter** und der zweite Teil mit **steamlit**.

Schrittweise werden wir auf die einzelnen Python Codes eingehen und diese näher erläutern. Des Weiteren werden wir kennzeichnen, welche Codeblock genau, welchem Projektteilnehmer zuzuordnen sind.

## 1 Einführung - Haar Cascades

Wie bereits oben erwähnt sind Haar Cascades <sup>1</sup> ein Verfahren zur Erkennung von Objekten in Bildern und Videos. Genauer handelt es sich hierbei um einen Klassifikationsalgorithmus, welches Beispielbilder trainiert, die entweder das zu erkennende Muster oder Objekt enthalten oder nicht. Anschließend kann der Haar Cascade dann auf neue Bilder oder Videos angewendet werden und versucht, das gesuchte Muster oder Objekt darin wieder zu erkennen.

### 1.1 Funktionsweise: Haar-like Features

Aus den Bildern als Eingangsdaten werden so genannte Haar-like Features als Merkmale extrahiert. Für diese Merkmale werden rechteckige Bereiche im Bild zusammengefasst.

---

<sup>1</sup>Rapid object detection using a boosted cascade of simple features und Viola, Jones: Robust Real-time Object Detection, IJCV 2001, zurück zu führen auf *Paul Viola* und *Michael Jones*

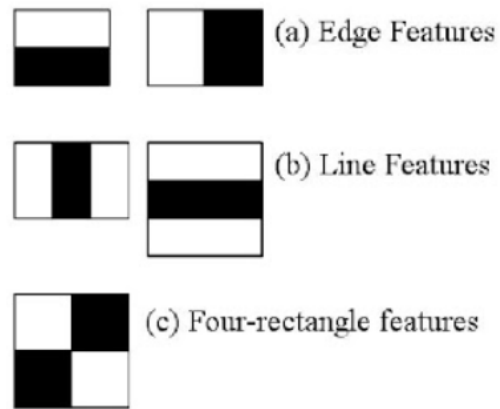


Abbildung 1: Haar-like Features

## 1.2 Umsetzung in OpenCV

Für unseren Anwendungsfall ist es mit Hilfe von OpenCV nicht notwendig einen eigenen Haar Cascade Algorithmus anzulernen. Wir laden die XML-Datei mit den zugehörigen *Haar-like-Features*, die wir verwenden möchten. Diese XML-Dateien enthalten Informationen darüber, wie die Features bzw. Merkmale aussehen und wie sie auf Bilder angewendet werden sollen.

## 2 Implementation in Tkinter

Um den Code möglichst lesbar zu gestalten, teilen wir diesen im Folgenden in mehreren kleinen Blöcke auf.

### 2.1 Packages

```
1 import tkinter as tk
2 from tkinter import ttk
3 from tkinter import filedialog
4 import numpy as np
5 import cv2
6 from PIL import Image, ImageTk
7 import random
8 import os
9
10 from pki_a22_app.utils.file_loader import get_classifiers
11
12 path_haarcascade = "resources/haarcascades/haarcascade_"
13
14
15 classifier_list = get_classifiers()
```

### 2.2 Initialisierung und Geometrie

```
1 root = tk.Tk()
2 root.title('Projekt Gruppe a2-2 - Thema: Bilderkennung Haar-
3           Cascades')
4
5 screen_width = root.winfo_screenwidth()
6 screen_height = root.winfo_screenheight()
7
8
9 if screen_width/screen_height < 1.8:
10     window_width = int(screen_width * 0.8)
11 else:
12     window_width = int(screen_height * (screen_width/2/
13     screen_height)*0.8)
14     window_height = int(screen_height * 0.8)
15
16 img_max_width = int(window_width/2-75)
17 img_max_height = int(window_height-300)
18
19 center_x = int(screen_width/2 - window_width / 2)
20 center_y = int(screen_height/2 - window_height / 2)
21
22
23
24 root.geometry(f'{window_width}x{window_height}+{center_x}+{
25     center_y}')
26 root.resizable(False, False)
```

## 2.3 Bild öffnen und Klassifizierer anwenden

```
1 def file_open():
2     global input_image
3     global output_image
4     filename = filedialog.askopenfilename(filetypes=(("jpg files",
5         "*.jpg"), ("png files", "*.png")))
6     input_image = Image.open(filename)
7     width, height = input_image.size
8     aspect_ratio = width / height
9     if aspect_ratio > 1:
10         new_width = img_max_width
11         new_height = int(new_width / aspect_ratio)
12     else:
13         new_height = img_max_height
14         new_width = int(new_height * aspect_ratio)
15     input_image = input_image.resize((new_width, new_height), Image.
16         ANTIALIAS)
17     input_image_tk = ImageTk.PhotoImage(input_image)
18     input_img_label.config(image=input_image_tk)
19     input_img_label.image = input_image_tk
20
21     output_image = Image.open(filename)
22     output_image = output_image.resize((new_width, new_height),
23         Image.ANTIALIAS)
24     output_image_tk = ImageTk.PhotoImage(output_image)
25     output_img_label.config(image=output_image_tk)
26     output_img_label.image = output_image_tk
27
28 def img_change(classifier):
29     global input_image
30     global output_image
31     cascade = cv2.CascadeClassifier(path_haarcascade + classifier +
32         ".xml")
33     output_image_cv = np.array(output_image.convert('RGB'))
34     output_image_cv_gray = cv2.cvtColor(output_image_cv, cv2.
35         COLOR_BGR2GRAY)
36     cascade_results = cascade.detectMultiScale(output_image_cv_gray,
37         scaleFactor=s1.get_val(), minNeighbors = s2.get_val(),
38         minSize=(s3.get_val(), s3.get_val()))
39     iterations = 0
40
41     if len(cascade_results) > 0:
42         color = (random.randint(0,255), random.randint(0,255), random.
43             randint(0,255))
44         for (x,y,w,h) in cascade_results:
45             cv2.rectangle(output_image_cv, (x,y), (x+w,y+h), (color), 2)
46             roi_gray = output_image_cv_gray[y:y+h, x:x+w]
47             roi_color = output_image_cv[y:y+h, x:x+w]
48             output_image = Image.fromarray(output_image_cv)
49             output_img_label.image.paste(output_image)
50     else:
51         flag = False
52         for i1 in np.arange(1.5, 0.9, -0.1):
53             for i2 in range(6, 2, -1):
54                 for i3 in range(50, 9, -10):
55                     s1.s.set(i1)
```

```

24         s2.s.set(i2)
25         s3.s.set(i3)
26         iterations = iterations + 1
27         cascade_results = cascade.detectMultiScale(
28             output_image_cv_gray, scaleFactor=s1.get_val(), minNeighbors
29             = s2.get_val(), minSize=(s3.get_val(), s3.get_val()))
30         if len(cascade_results) > 0:
31             color = (random.randint(0,255),random.randint(0,255),
32                 random.randint(0,255))
33             for (x,y,w,h) in cascade_results:
34                 cv2.rectangle(output_image_cv,(x,y),(x+w,y+h),(
35                     color),2)
36                 roi_gray = output_image_cv_gray[y:y+h, x:x+w]
37                 roi_color = output_image_cv[y:y+h, x:x+w]
38                 output_image = Image.fromarray(output_image_cv)
39                 output_img_label.image.paste(output_image)
40                 flag = True
41                 break
42             if flag: break
43             if flag: break
44             if len(cascade_results) == 0:
45                 print(f"Kein Ergebnis nach {iterations} Iterationen")

```

```

1 def output_image_restart():
2     global input_image
3     global output_image
4     output_image = input_image
5     output_img_label.image.paste(output_image)

```

## 2.4 Slider und Button

```

1 class slider:
2     def __init__(self,name,x_pos=0,y_pos=0,scale_from=0,scale_to
3         =100,typ=int):
4         self.name = name
5         self.x_pos = x_pos
6         self.y_pos = y_pos
7         self.scale_from = scale_from
8         self.scale_to = scale_to
9         if typ==int:
10             self.val = tk.IntVar()
11         else:
12             self.val = tk.DoubleVar()
13
14         self.lbl = ttk.Label(root, text=name)
15         self.lbl.place(x=self.x_pos,y=self.y_pos)
16
17         self.s = ttk.Scale(root, from_=self.scale_from, to=self.
18             scale_to, orient="horizontal",command=self.slider_change,
19             variable=self.val)
20         self.s.place(x=self.x_pos+100,y=self.y_pos)
21
22         self.v = ttk.Label(root,text=f"{self.get_val():.1f}")
23         self.v.place(x=self.x_pos+210,y=self.y_pos)
24     def get_val(self):
25         return self.val.get()

```

```

23     def slider_change(self, event):
24         self.v.configure(text=f"{self.get_val():.1f}")

1 def blur_rectangle(classifier):
2     global input_image
3     global output_image
4     cascade = cv2.CascadeClassifier(path_haarcascade + classifier +
5                                     ".xml")
6     output_image_cv = np.array(output_image.convert('RGB'))
7     output_image_cv_gray = cv2.cvtColor(output_image_cv, cv2.
8         COLOR_BGR2GRAY)
9     cascade_results = cascade.detectMultiScale(output_image_cv_gray
10        , scaleFactor=s1.get_val(), minNeighbors = s2.get_val(),
11        minSize=(s3.get_val(), s3.get_val()))
12     if len(cascade_results) > 0:
13         for (x,y,w,h) in cascade_results:
14             face = output_image_cv[y:y+h, x:x+w]
15             face = cv2.GaussianBlur(face, (23, 23), 30)
16             output_image_cv[y:y+h, x:x+w] = face
17
18     output_image = Image.fromarray(output_image_cv)
19     output_img_label.image.paste(output_image)
20
21 def save_jpg():
22     file_path = filedialog.asksaveasfilename(initialfile="
23         output_image", filetypes=(("jpg files", "*.jpg"),("png files"
24         , "*.png")), defaultextension=".jpeg")
25     if file_path:
26         output_image.save(file_path)
27
28 tk.Button(root, text="Bild aus Datei oeffnen", command=file_open)
29     .place(x=window_width/2-window_width/4,y=150)
30 tk.Button(root, text="Classifier anwenden", command=lambda:
31     img_change(dropdown.get())).place(x=window_width/2+
32     window_width/4,y=150)
33 tk.Button(root, text="==>", command=output_image_restart).place(x
34     =window_width/2-12.5,y=window_height/2)
35 tk.Button(root, text="Weichzeichnen", command=lambda:
36     blur_rectangle(dropdown.get())).place(x=window_width/2+
37     window_width/4+122,y=150)
38 tk.Button(root, text="Bild speichern", command=save_jpg).place(x=
39     window_width/2+window_width/4+220,y=150)
40
41 dropdown = tk.StringVar(root)
42 dropdown.set(classifier_list[2])
43 dropdown_label = tk.OptionMenu(root, dropdown, *classifier_list)
44 dropdown_label.place(x=window_width/2-75,y=20)
45
46 xpos_slider_window = window_width/2 -75
47 ypos_slider_window = 60
48 s1 = slider("ScaleFactor",xpos_slider_window,ypos_slider_window
49     ,1.01,1.5,float)
50 s1.s.set(1.1)
51 s2 = slider("MinNeighbors",xpos_slider_window,ypos_slider_window
52     +30,3,6)
53 s2.s.set(4)

```



```

40 s3 = slider("minSize",xpos_slider_window,ypos_slider_window
    +60,10,50)
41 s3.s.set(30)
42
43
44 input_img_label = ttk.Label(root)
45 input_img_label.place(x=25,y=200)
46
47 output_img_label = ttk.Label(root)
48 output_img_label.place(x=window_width/2+50,y=200)
49
50 fh_logo = Image.open("resources/images/Logo.jpg")
51 fh_logo = fh_logo.resize((300,100), Image.ANTIALIAS)
52 fh_logo_tk = ImageTk.PhotoImage(fh_logo)
53 ttk.Label(root, image=fh_logo_tk).place(x=0,y=0)
54
55 root.mainloop()

```

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### 3 Implementierung mit Streamlit

Eine weitere Implementierung des Haar Cascade Klassifizierers wurde mit dem Dashboard Framework **Streamlit** als **Web-Anwendung** umgesetzt. Das Dashboard enthält zum einen einen Bereich mit unterschiedlichen Parametern für den Haar Cascade Klassifizierer, und zum anderen einen Bereich, in dem verschieden Bild-Quellen ausgewählt werden können. Dazu gehört neben eigenen oder vorinstallierten Bildern auch die Möglichkeit, ein Video oder das eigene Webcam-Bild zu verwenden.

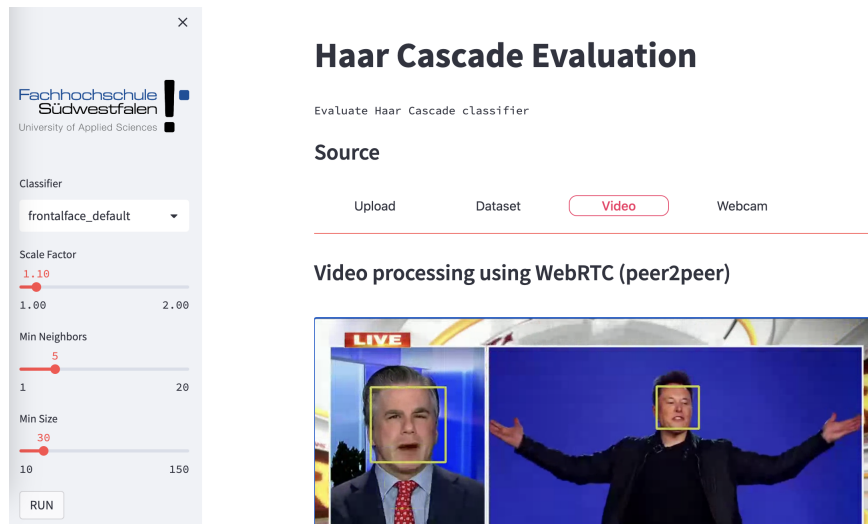


Abbildung 2: Streamlit Dashboard mit Haar Cascade Klassifizierer

Das Dashboard kann auch als <https://jk-flswf-pki-a22-app-app-codcuk.streamlit.app/Demo-Anwendung> auf der Streamlit-Cloud ausprobiert werden.

#### 3.1 Eingabequellen

Die Anwendung unterstützt diese bereits angesprochenen Eingabemöglichkeiten:

##### Upload

Hier kann ein einzelnes Bild hochgeladen und verwendet werden

##### Dataset

Unter diesem Punkt können mehrere vorkonfigurierte Bilder auf einmal verwendet werden

##### Video

Bei dieser Option wird ein vorkonfiguriertes Video abgespielt, auf dem der ausgewählte Klassifizierer angewandt wird

## Webcam

Hier besteht die Möglichkeit, den Klassifizierer auf die eigene Webcam-Bilder anzuwenden

## 3.2 Optionen

Die verwendeten Optionen zur Konfiguration des Haar Cascade Klassifizierers **Scale Factor**, **Min Neighbors** und **Min Size** wurden bereits in den vorherigen Abschnitten im Rahmen der Tkinter Anwendung beschrieben.

## 3.3 Code

Der Programmcode für die Implementierung des Streamlit-Dashboards ist auf die folgenden Quelldateien verteilt:

```
1 # Hauptanwendung und Einstiegspunkt
2 app.py
3 # Funktion zur Ausfuehrung des eigentlichen Klassifizierers
4 pki_a22_app/haarcascades/haarcascades.py
5 # Interface fuer die unterschiedlichen Eingabequellen
6 pki_a22_app/dashboard/sources.py
7 # Eingabequelle mit einem einzelnen hochladbarem Bild
8 pki_a22_app/dashboard/source_upload.py
9 # Eingabequelle mit Auswahl eines Datensatzes mit mehreren
  Bildern
10 pki_a22_app/dashboard/source_dataset.py
11 # Eingabequelle zum Abspielen eines voreingestellten Videos
12 pki_a22_app/dashboard/source_video.py
13 # Eingabequelle bei der die eigene Webcam verwendet wird
14 pki_a22_app/dashboard/source_webcam.py
15 # Utility Modul, das vor allem Funktionen fuer Datei-Operationen
  enthaelt
16 pki_a22_app/utils/file_loader.py
```

## 4 Organisation

Besonders zu Beginn war es sehr hilfreich, eine Kollaborations-Plattform für das Projekt einzurichten, über die die unterschiedlichsten Informationen organisatorischer Natur ausgetauscht werden konnten. Wir haben uns für den Einsatz eines Miro-Boardes entschieden. das wir unter anderem nutzten für:

- Terminfindung
- Pinnwand
- Brainstorming
- Zeitplanung
- Wireframes

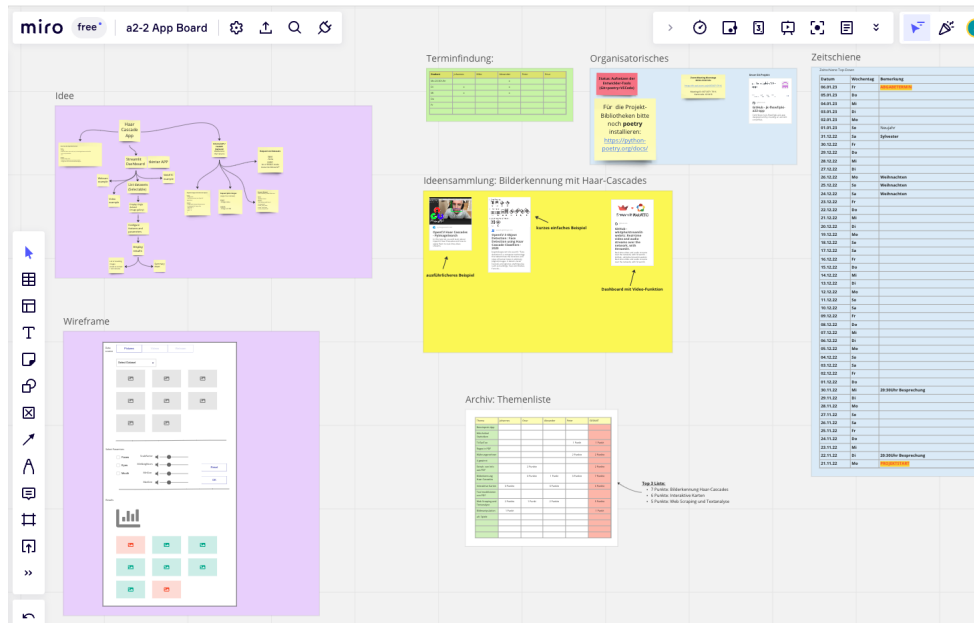


Abbildung 3: Miro-Board für organisatorische Aufgaben

## 5 Continuos Integration

Um gemeinsam am Programmcode arbeiten zu können, haben wir uns ein Git-basiertes Codeverwaltungs-Tool entschieden. Hierfür haben wir auf GitHub ein eigenes <https://github.com/jk-fhswf/pki-a22-appGit-Repository> eingerichtet.

Zur Qualitätssicherung haben wir uns dafür entschieden, für den main-Branch Pull-Requests zu verwenden und die Erfolgreiche Ausführung eines GitHub-Actions- Workflows für Unit-Tests vorauszusetzen.

## 6 Anhang Streamlit Code

```
1 """Start a streamlit dashboard showing some haarcascade
   operations with Opencv"""
2
3 # Core Pkgs
4
5 import extra_streamlit_components as stx
6 import streamlit as st
7 from pki_a22_app.dashboard.source_dataset import DatasetSource
8 from pki_a22_app.dashboard.source_upload import UploadSource
9 from pki_a22_app.dashboard.source_video import VideoSource
10 from pki_a22_app.dashboard.source_webcam import WebcamSource
11
```

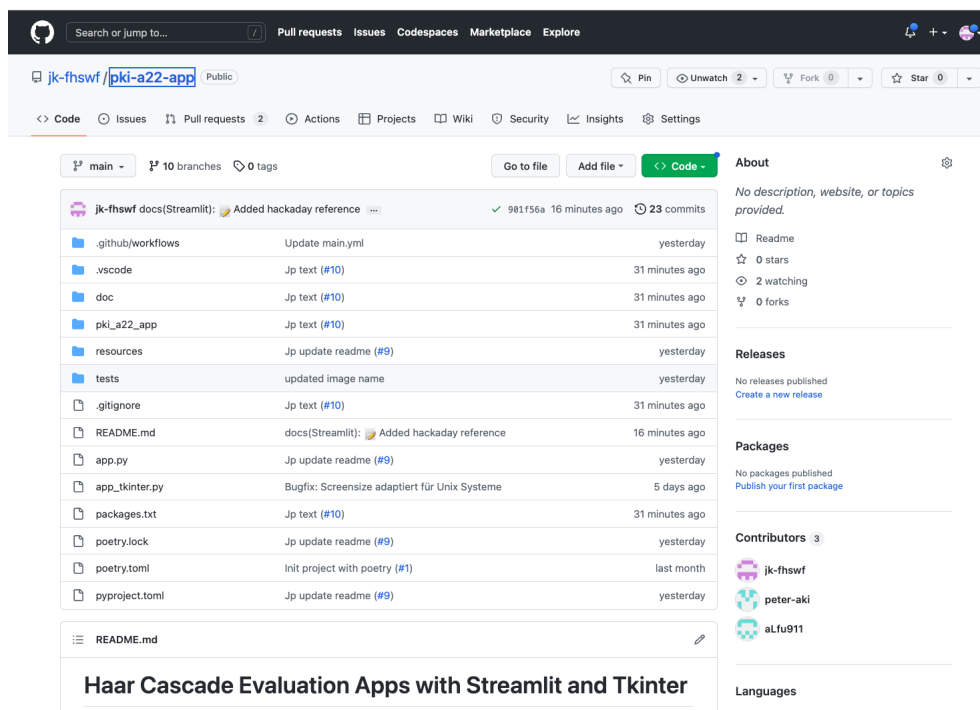


Abbildung 4: Git-Repository auf GitHub

General

Access

Collaborators

Moderation options

Code and automation

Branches

Tags

Actions

Webhooks

Environments

Codespaces

Pages

Security

Code security and analysis

Deploy keys

Secrets and variables

Integrations

GitHub apps

Email notifications

Branch protection rule

Branch name pattern \*

main

Applies to 1 branch

main

Protect matching branches

☒ **Require a pull request before merging**  
 When enabled, all commits must be made to a non-protected branch and submitted via a pull request before they can be merged into a branch that matches this rule.

☒ **Require approvals**  
 When enabled, pull requests targeting a matching branch require a number of approvals and no changes requested before they can be merged.  

Required number of approvals before merging: 1

☐ **Dismiss stale pull request approvals when new commits are pushed**  
 New reviewable commits pushed to a matching branch will dismiss pull request review approvals.

☐ **Require review from Code Owners**  
 Require an approved review in pull requests including files with a designated code owner.

☐ **Require approval of the most recent push**  
 The most recent push must be approved by someone other than the last pusher.

☒ **Require status checks to pass before merging**  
 Choose which **status checks** must pass before branches can be merged into a branch that matches this rule. When enabled, commits must first be pushed to another branch, then merged or pushed directly to a branch that matches this rule after status checks have passed.

☐ **Require branches to be up to date before merging**  
 This ensures pull requests targeting a matching branch have been tested with the latest code. This setting will not take effect unless at least one status check is enabled (see below).

Search for status checks in the last week for this repository

Status checks that are required

Abbildung 5: Konfiguration von QA-Optionen

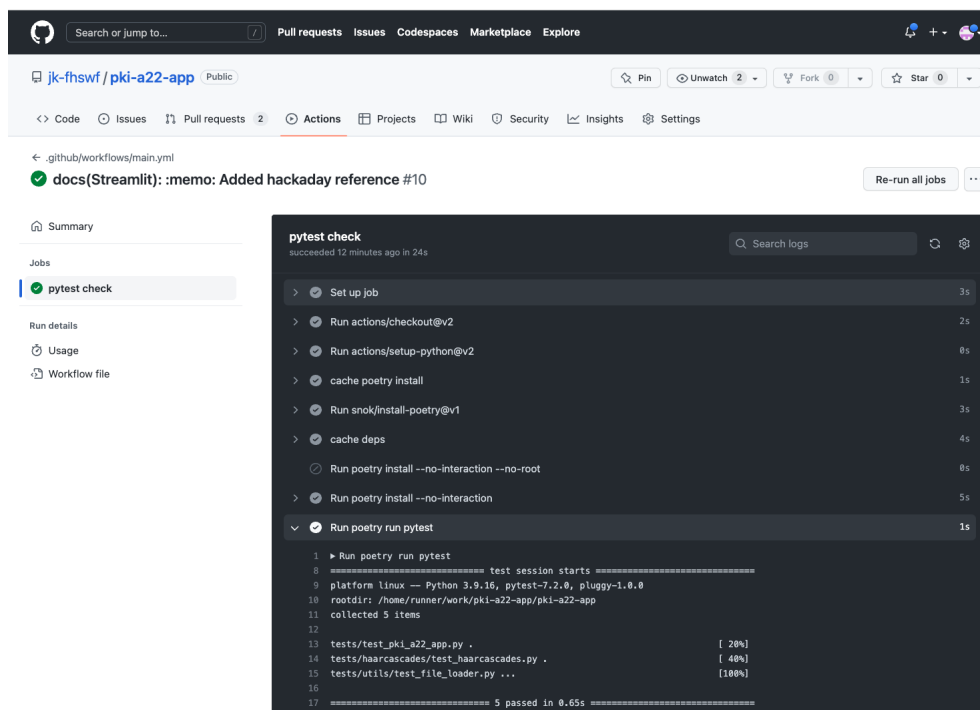


Abbildung 6: Beispiel Ausführung von Tests mit pytest



```

12 from pki_a22_app.utils.file_loader import (get_classifiers)
13
14
15 def main():
16     """
17     Main function that initiates the Streamlit dashboard
18     """
19
20     st.title("Haar Cascade Evaluation")
21     st.text("Evaluate Haar Cascade classifier")
22
23     # Configure the sources section
24     st.subheader("Source")
25     chosen_id = stx.tab_bar(data=[
26         stx.TabBarItemData(id=1, title="Upload", description=""),
27         stx.TabBarItemData(id=2, title="Dataset", description="")
28     ],
29         [
30             stx.TabBarItemData(id=3, title="Video", description=""),
31             stx.TabBarItemData(id=4, title="Webcam", description="")
32         ], default=1)
33
34     st.sidebar.image("resources/images/logo-fh-swf-300x93.png")
35     st.sidebar.markdown('#')
36
37     # Configure the algorithm controls
38     classifiers: list = get_classifiers()
39     classifier_id = st.sidebar.selectbox("Classifier",
40                                         classifiers)
41     scale_factor = st.sidebar.slider('Scale Factor', 1.0, 2.0,
42                                     1.1, 0.1)
43     min_neighbors = st.sidebar.slider('Min Neighbors', 1, 20, 5,
44                                     1)
45     min_size = st.sidebar.slider('Min Size', 10, 150, 30, 5)
46
47     show_results = st.sidebar.button("RUN")
48
49     # Define different sources that render the input and output
50     accordingly
51     sources = {
52         "1": UploadSource(),
53         "2": DatasetSource(),
54         "3": VideoSource(),
55         "4": WebcamSource()
56     }
57
58     # Execute selected source
59     sources[chosen_id].load_source(
60         classifier_id, scale_factor, min_neighbors, min_size,
61         show_results)
62
63 if __name__ == '__main__':
64     main()

```

Listing 1: app.py

```

1 """This module contains haar cascade core functionality"""
2

```

```

3 import cv2
4 from cv2 import Mat
5 import numpy.typing as npt
6
7
8 def detect_objects(np_input_image: npt.ArrayLike, classifier_id:
   str, scale_factor: float = 1.1, min_neighbors: int = 4,
   min_size: int = 10) -> Mat:
9     """
10     Detects objects in an image using Haar Cascades classifiers.
11     It can use a preset of trained classifiers in resources/
12     haarcascades/*.
13     The found objects get highlighted by a rectangle around it.
14
15     The parameter description was taken from:
16     https://hackaday.io/project/12384-autofan-automated-control-
17     of-air-flow/log/41956-face-detection-using-a-haar-cascade-
18     classifier
19
20     Parameters
21     -----
22     np_input_image : npt.ArrayLike
23         The input image
24     classifier_id : str
25         the classifier name. E.g. when you set it to "
26         frontalface_default", the configuration file
27         "haarcascade_frontalface_default.xml" will be loaded
28     scale_factor : float, optional, by default 1.1
29         determines the factor by which the detection window of
30         the classifier is scaled down per detection pass. A factor of
31         1.1
32         corresponds to an increase of 10%. Hence, increasing the
33         scale factor increases performance, as the number of
34         detection
35         passes is reduced. However, as a consequence the
36         reliability by which a face is detected is reduced. See:
37     min_neighbors : int, optional, by default 4
38         determines the minimum number of neighboring facial
39         features that need to be present to indicate the detection of
40         a face by the
41         classifier. Decreasing the factor increases the amount of
42         false positive detections. Increasing the factor might lead
43         to missing
44         faces in the image. The argument seems to have no
45         influence on the performance of the algorithm. See:
46     min_size: int
47         determines the minimum size of the detection window in
48         pixels. Increasing the minimum detection window increases
49         performance.
50         However, smaller faces are going to be missed then. In
51         the scope of this project however a relatively big detection
52         window can
53         be used, as the user is sitting directly in front of the
54         camera.
55
56     Returns
57 
```

```

38  -----
39  cv2.Mat
40      The image in Mat representation
41  list
42      A list of found objects in the image
43  """
44
45  classifier = cv2.CascadeClassifier(
46      f"resources/haarcascades/haarcascade_{classifier_id}.xml"
47  )
48
49  img = cv2.cvtColor(np_input_image, 1)
50  gray = cv2.cvtColor(np_input_image, cv2.COLOR_BGR2GRAY)
51  objects = classifier.detectMultiScale(
52      gray, scaleFactor=scale_factor, minNeighbors=
53      min_neighbors, minSize=(min_size, min_size))
54  # pylint: disable=invalid-name
55  for (x, y, w, h) in objects:
56      cv2.rectangle(img, (x, y), (x + w, y + h), (72, 209, 204)
57      , 4)
58  return img, objects

```

Listing 2: haarcascades/haarcascades.py

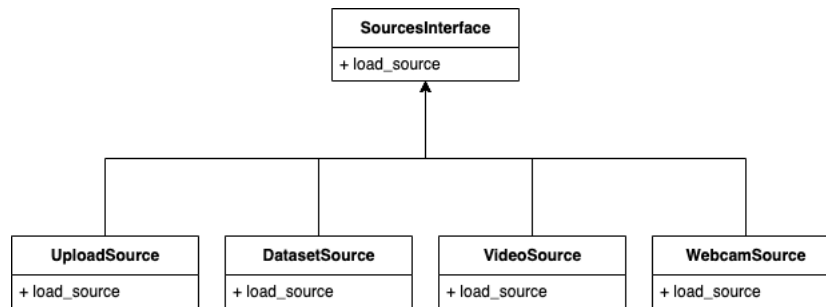


Abbildung 7: UML Diagramm für unterschiedliche Source-Typen

```

1  """
2  Contains an interface definition to use different source-types
3  in the Streamlit dashboard
4  """
5  import abc
6
7
8  class SourcesInterface(metaclass=abc.ABCMeta):
9      """
10     Interface for handling different input source types
11
12     Methods
13     -----
14     load_source(classifier_id: str, scale_factor: int,
15                 min_neighbors: int, show_results: bool = False)
16         Load the sources and outputs with respect to the given
17         parameters
18     """
19
20     @classmethod
21     def __subclasshook__(cls, subclass):
22         """
23         Ensures that needed methods are implemented in your
24         derivatives
25
26         Parameters
27         -----
28         subclass : Any
29             subclass that was created
30
31         Returns
32         -----
33         Bool
34             True if it is a valid subclass
35         """
36         return (hasattr(subclass, 'load_source') and
37                 callable(subclass.load_source) or
38                 NotImplemented)
39
40     @abc.abstractmethod

```

```

39 def load_source(self, classifier_id: str, scale_factor: int,
40 min_neighbors: int, min_size: int, show_results: bool = False
41 ):
42     """
43     This method handles the display of different Streamlit-UI
44     elements. Implement these in your
45     concrete derivatives
46
47     The parameter description was taken from:
48     https://hackaday.io/project/12384-autofan-automated-
49     control-of-air-flow/log/41956-face-detection-using-a-haar-
50     cascade-classifier
51
52     Parameters
53     -----
54     classifier_id : str
55         the classifier name. E.g. when you set it to "
56         frontalface_default", the configuration file
57         "haarcascade_frontalface_default.xml" will be loaded
58     scale_factor : float, optional, by default 1.1
59         determines the factor by which the detection window
60         of the classifier is scaled down per detection pass. A factor
61         of 1.1
62         corresponds to an increase of 10%. Hence, increasing
63         the scale factor increases performance, as the number of
64         detection
65         passes is reduced. However, as a consequence the
66         reliability by which a face is detected is reduced. See:
67     min_neighbors : int, optional, by default 4
68         determines the minimum number of neighboring facial
69         features that need to be present to indicate the detection of
70         a face by the
71         classifier. Decreasing the factor increases the
72         amount of false positive detections. Increasing the factor
73         might lead to missing
74         faces in the image. The argument seems to have no
75         influence on the performance of the algorithm. See:
76     min_size: int
77         determines the minimum size of the detection window
78         in pixels. Increasing the minimum detection window increases
79         performance.
80         However, smaller faces are going to be missed then.
81         In the scope of this project however a relatively big
82         detection window can
83         be used, as the user is sitting directly in front of
84         the camera.
85     show_results : bool, optional
86         If true we want to display the original images AND
87         the results, by default False
88
89     Raises
90     -----
91     NotImplementedError
92         Error that gets thrown if you do not implement this
93         function
94     """

```

```
72         raise NotImplementedError
```

Listing 3: dashboard/sources.py

```
1  """Implementation of a source-type to upload an image and apply
   the Haar Cascade classifier on it"""
2  # Core Pkgs
3
4  import numpy as np
5  import streamlit as st
6  from PIL import Image
7
8  from pki_a22_app.dashboard.sources import SourcesInterface
9  from pki_a22_app.haarcascades.haarcascades import detect_objects
10
11
12  class UploadSource(SourcesInterface):
13      def load_source(self, classifier_id: str, scale_factor: int,
14                     min_neighbors: int, min_size: int, show_results: bool = False
15                     ):
16          """
17          This method creates a form to upload an image that can be
18          processed by the haar cascade classifier afterwards.
19
20          The parameter description was taken from:
21          https://hackaday.io/project/12384-autofan-automated-
22          control-of-air-flow/log/41956-face-detection-using-a-haar-
23          cascade-classifier
24
25          Parameters
26          -----
27          classifier_id : str
28              the classifier name. E.g. when you set it to "
29              frontalface_default", the configuration file
30              "haarcascade_frontalface_default.xml" will be loaded
31          scale_factor : float, optional, by default 1.1
32              determines the factor by which the detection window
33              of the classifier is scaled down per detection pass. A factor
34              of 1.1
35              corresponds to an increase of 10%. Hence, increasing
36              the scale factor increases performance, as the number of
37              detection
38              passes is reduced. However, as a consequence the
39              reliability by which a face is detected is reduced. See:
40          min_neighbors : int, optional, by default 4
41              determines the minimum number of neighboring facial
42              features that need to be present to indicate the detection of
43              a face by the
44              classifier. Decreasing the factor increases the
45              amount of false positive detections. Increasing the factor
46              might lead to missing
47              faces in the image. The argument seems to have no
48              influence on the performance of the algorithm. See:
49          min_size: int
50              determines the minimum size of the detection window
51              in pixels. Increasing the minimum detection window increases
52              performance.
```

```

35         However, smaller faces are going to be missed then.
        In the scope of this project however a relatively big
        detection window can
36         be used, as the user is sitting directly in front of
        the camera.
37         show_results : bool, optional
38         If true we want to display the original images AND
        the results, by default False
39         """
40         st.subheader("Upload an image")
41
42         # Show the upload form
43         image_file = st.file_uploader(
44             "Upload Image", type=["jpg", "png", "jpeg"])
45         our_image = None
46
47         # If a image was uploaded, display it
48         if image_file is not None:
49             our_image = Image.open(image_file)
50             our_np_image = np.array(our_image.convert("RGB"))
51             st.text("Original Image")
52             st.image(our_image)
53             image_location = st.empty()
54
55         # Show processed image
56         if show_results and classifier_id:
57             # Actual object detection
58             result_img, result_faces = detect_objects(
59                 our_np_image, classifier_id, scale_factor,
        min_neighbors, min_size)
60             image_location.image(result_img)
61             st.text("Resulting Image")
62             st.success(f"Found {len(result_faces)} Objects")

```

Listing 4: dashboard/source upload.py

```

1  """Implementation of a source-type that show multiple images at
    once"""
2
3  # Core Pkgs
4  from itertools import cycle
5
6  import numpy as np
7  import streamlit as st
8  from PIL import Image
9
10 from pki_a22_app.dashboard.sources import SourcesInterface
11 from pki_a22_app.haarcascades.haarcascades import detect_objects
12 from pki_a22_app.utils.file_loader import get_datasets,
    get_images_of_dataset
13
14
15 class DatasetSource(SourcesInterface):
16     """
17     Implementation for handling multiple images, also called
    dataset here
18
19     Methods

```

```

20 -----
21 load_source(classifier_id: str, scale_factor: int,
22             min_neighbors: int, show_results: bool = False)
23     """
24     Load multiple images and display results
25     """
26
27     def load_source(self, classifier_id: str, scale_factor: int,
28                   min_neighbors: int, min_size: int, show_results: bool = False
29                   ):
30         """
31         This method shows a selectbox to select an existing
32         dataset. A dataset contains multiple images. The datasets are
33         located
34         at resource/datasets/. The Haar Cascade classifier will
35         then be applied to all images of the dataset.
36
37         The parameter description was taken from:
38         https://hackaday.io/project/12384-autofan-automated-
39         control-of-air-flow/log/41956-face-detection-using-a-haar-
40         cascade-classifier
41
42         Parameters
43         -----
44         classifier_id : str
45             the classifier name. E.g. when you set it to "
46             frontalface_default", the configuration file
47             "haarcascade_frontalface_default.xml" will be loaded
48             scale_factor : float, optional, by default 1.1
49             determines the factor by which the detection window
50             of the classifier is scaled down per detection pass. A factor
51             of 1.1
52             corresponds to an increase of 10%. Hence, increasing
53             the scale factor increases performance, as the number of
54             detection
55             passes is reduced. However, as a consequence the
56             reliability by which a face is detected is reduced. See:
57             min_neighbors : int, optional, by default 4
58             determines the minimum number of neighboring facial
59             features that need to be present to indicate the detection of
60             a face by the
61             classifier. Decreasing the factor increases the
62             amount of false positive detections. Increasing the factor
63             might lead to missing
64             faces in the image. The argument seems to have no
65             influence on the performance of the algorithm. See:
66             min_size: int
67             determines the minimum size of the detection window
68             in pixels. Increasing the minimum detection window increases
69             performance.
70             However, smaller faces are going to be missed then.
71             In the scope of this project however a relatively big
72             detection window can
73             be used, as the user is sitting directly in front of
74             the camera.
75             show_results : bool, optional
76             If true we want to display the original images AND
77             the results, by default False

```



```

52     """
53     st.subheader("Load an existing dataset")
54
55     # Setup dataset selector
56     datasets = get_datasets()
57     datasets.insert(0, "None")
58     dataset_selection = st.selectbox("Dataset", datasets)
59
60     img_width = 300
61     img_columns = 2
62
63     # When a dataset was selected start presenting it
64     if dataset_selection and dataset_selection != "None":
65         images_in_ds = get_images_of_dataset(
66             dataset_selection)
67
68         # Show images in max n columns
69         cols = cycle(st.columns(img_columns))
70         for idx, filtered_image in enumerate(images_in_ds):
71             next(cols).image(str(filtered_image), width=
72                 img_width)
73
74         # We were requested to show the results
75         if show_results and dataset_selection:
76             images_in_ds = get_images_of_dataset(
77                 dataset_selection)
78             st.write("### Results:")
79             cols = cycle(st.columns(img_columns))
80             for idx, filtered_image in enumerate(images_in_ds
81 ):
82                 ds_image = Image.open(filtered_image)
83                 ds_np_image = np.array(ds_image.convert("RGB"
84 ))
85
86                 # Actual object detection
87                 ds_res_image, ds_result_faces =
88                 detect_objects(ds_np_image, classifier_id, scale_factor,
89                     min_neighbors, min_size)
90                 col = next(cols)
91                 col.image(ds_res_image, width=img_width,
92                     caption=f"{len(ds_result_faces)} objects")

```

Listing 5: dashboard/source dataset.py

```

1  """Implementation of a source-type to select a video and apply
2     the Haar Cascade classifier on it"""
3
4  # Core Pkgs
5  import av
6  import streamlit as st
7  from streamlit_webrtc import MediaPlayerFactory, WebRtcMode,
8     webrtc_streamer
9
10 from pki_a22_app.dashboard.sources import SourcesInterface
11 from pki_a22_app.haarcascades.haarcascades import detect_objects
12 from aiortc.contrib.media import MediaPlayer

```

```

12
13
14 class VideoSource(SourcesInterface):
15     def load_source(self, classifier_id: str, scale_factor: int,
16                     min_neighbors: int, min_size: int, show_results: bool = False
17                     ):
18         """
19         This function shows a video player where the haar cascade
20         detection is applied on single frames.
21         The player uses WebRTC to stream the video.
22
23         The parameter description was taken from:
24         https://hackaday.io/project/12384-autofan-automated-
25         control-of-air-flow/log/41956-face-detection-using-a-haar-
26         cascade-classifier
27
28         Parameters
29         -----
30         classifier_id : str
31             the classifier name. E.g. when you set it to "
32             frontalface_default", the configuration file
33             "haarcascade_frontalface_default.xml" will be loaded
34         scale_factor : float, optional, by default 1.1
35             determines the factor by which the detection window
36             of the classifier is scaled down per detection pass. A factor
37             of 1.1
38             corresponds to an increase of 10%. Hence, increasing
39             the scale factor increases performance, as the number of
40             detection
41             passes is reduced. However, as a consequence the
42             reliability by which a face is detected is reduced. See:
43         min_neighbors : int, optional, by default 4
44             determines the minimum number of neighboring facial
45             features that need to be present to indicate the detection of
46             a face by the
47             classifier. Decreasing the factor increases the
48             amount of false positive detections. Increasing the factor
49             might lead to missing
50             faces in the image. The argument seems to have no
51             influence on the performance of the algorithm. See:
52         min_size: int
53             determines the minimum size of the detection window
54             in pixels. Increasing the minimum detection window increases
55             performance.
56             However, smaller faces are going to be missed then.
57             In the scope of this project however a relatively big
58             detection window can
59             be used, as the user is sitting directly in front of
60             the camera.
61         show_results : bool, optional
62             If true we want to display the original images AND
63             the results, by default False
64         """
65         st.subheader("Video processing using WebRTC (peer2peer)")
66
67         # Callback function that takes an image frame that can

```

```

47     # be processed
48     def callback(frame):
49         # convert frame to ndarray
50         img = frame.to_ndarray(format="bgr24")
51
52         # actual object detection
53         result_img, result_faces = detect_objects(
54             img, classifier_id, scale_factor, min_neighbors,
min_size)
55
56         return av.VideoFrame.from_ndarray(result_img, format=
"bgr24")
57
58         rtc_configuration = { # Add this config
59             "iceServers": [{"urls": ["stun:stun.l.google.com
:19302"]}]}
60         }
61
62         def create_player():
63             return MediaPlayer("resources/videos/musk.mp4")
64
65         # This will show the video-UI elements in Streamlit
66         # Each frame gets sent to the callback method
67         webrtc_streamer(key="videoexample",
68                         video_frame_callback=callback,
69                         rtc_configuration=rtc_configuration,
70                         mode=WebRtcMode.RECVONLY,
71                         player_factory=create_player,
72                         media_stream_constraints={
73                             "video": True
74                         }
75                     )

```

Listing 6: dashboard/source video.py

```

1  """Implementation of a source-type to display a webcam stream and
2     apply the Haar Cascade classifier on it"""
3
4  # Core Pkgs
5  import av
6  import streamlit as st
7  from streamlit_webrtc import webrtc_streamer
8
9  from pki_a22_app.dashboard.sources import SourcesInterface
10 from pki_a22_app.haarcascades.haarcascades import detect_objects
11
12
13 class WebcamSource(SourcesInterface):
14     def load_source(self, classifier_id: str, scale_factor: int,
15                   min_neighbors: int,
16                   min_size: int, show_results: bool = False) ->
17         None:
18             """
19             This method shows an UI element to display the stream of
20             a webcam. The Haar Cascade classifier will then be applied to
21             the images
22             of the webcam.

```

```

19
20     The parameter description was taken from:
21     https://hackaday.io/project/12384-autofan-automated-
control-of-air-flow/log/41956-face-detection-using-a-haar-
cascade-classifier
22
23
24     Parameters
25     -----
26     classifier_id : str
27         the classifier name. E.g. when you set it to "
frontalface_default", the configuration file
28         "haarcascade_frontalface_default.xml" will be loaded
29     scale_factor : float, optional, by default 1.1
30         determines the factor by which the detection window
of the classifier is scaled down per detection pass. A factor
of 1.1
31         corresponds to an increase of 10%. Hence, increasing
the scale factor increases performance, as the number of
detection
32         passes is reduced. However, as a consequence the
reliability by which a face is detected is reduced. See:
33     min_neighbors : int, optional, by default 4
34         determines the minimum number of neighboring facial
features that need to be present to indicate the detection of
a face by the
35         classifier. Decreasing the factor increases the
amount of false positive detections. Increasing the factor
might lead to missing
36         faces in the image. The argument seems to have no
influence on the performance of the algorithm. See:
37     min_size: int
38         determines the minimum size of the detection window
in pixels. Increasing the minimum detection window increases
performance.
39         However, smaller faces are going to be missed then.
In the scope of this project however a relatively big
detection window can
40         be used, as the user is sitting directly in front of
the camera.
41     show_results : bool, optional
42         If true we want to display the original images AND
the results, by default False
43     """
44     st.subheader("Webcam processing using WebRTC (peer2peer)"
)
45
46     def callback(frame):
47         # convert frame to ndarray
48         img = frame.to_ndarray(format="bgr24")
49
50         # actual object detection
51         result_img, result_faces = detect_objects(
52             img, classifier_id, scale_factor, min_neighbors,
min_size)
53
54         return av.VideoFrame.from_ndarray(result_img, format=

```

```

55 "bgr24")
56
57     # This will show the webcam-UI elements in streamlit
58     # Each frame gets sent to the callback method
59     rtc_configuration = { # Add this config
60         "iceServers": [{"urls": ["stun:stun.l.google.com
61         :19302"]}]}
62     }
63     webrtc_streamer(key="example", video_frame_callback=
64     callback,
65                     rtc_configuration=rtc_configuration)

```

Listing 7: dashboard/source webcam.py

```

1  """This modules contains helper methods to get information from
2     local file system"""
3  import os
4  import pathlib
5  from typing import List
6
7  def get_classifiers() -> List[str]:
8      """
9      Reads all files in /resources/haarcascades/ and returns only
10     the actual classifier
11     name without "haarcascade_" and ".xml". "E.g.
12     haarcascade_frontalface_default.xml"
13     gets to "haarcascade_frontalface_default".
14
15     Returns
16     -----
17     List[str]
18         List of found classifiers
19     """
20     classifier_files = os.listdir(os.getcwd() + "/resources/
21     haarcascades/")
22     classifiers = [item.replace("haarcascade_", "")
23     for item in classifier_files]
24     classifiers = [item.replace(".xml", "") for item in
25     classifiers]
26     classifiers.sort()
27     return classifiers
28
29  def get_datasets() -> List[str]:
30      """
31      Returns the folders found under /resources/datasets/
32
33      Returns
34      -----
35      List[str]
36         List of available dataset
37      """
38     datasets = os.listdir(os.getcwd() + "/resources/datasets/")
39     datasets = [item for item in datasets if not item.startswith(
40     ".")]
41     datasets.sort()
42     return datasets

```

```

39
40
41 def get_images_of_dataset(dataset_name: str) -> List[str]:
42     """
43     Returns the images contained in a dataset
44
45     Parameters
46     -----
47     dataset_name : str
48         Name of the dataset (folder)
49
50     Returns
51     -----
52     List[str]
53         List of found images
54     """
55     extensions = ['.jpg', '.png', '.jpeg']
56     img_list = [x for x in pathlib.Path(f"resources/datasets/{
dataset_name}").iterdir() if x.suffix.lower() in extensions]
57     img_list = [str(item) for item in img_list]
58     return list(img_list)

```

Listing 8: utils/file loader.py