

1 Implementation in Streamlit

```
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
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()
```

```

50     }
51
52     # Execute selected source
53     sources[chosen_id].load_source(
54         classifier_id, scale_factor, min_neighbors, min_size,
55         show_results)
56
57 if __name__ == "__main__":
58     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:
9      str, scale_factor: float = 1.1, min_neighbors: int = 4,
10     min_size: int = 10) -> Mat:
11     """
12     Detects objects in an image using Haar Cascades classifiers.
13     It can use a preset of trained classifiers in resources/
14     haarcascades/*.
15     The found objects get highlighted by a rectangle around it.
16
17     Parameters
18     -----
19     np_input_image : npt.ArrayLike
20         The input image
21     classifier_id : str
22         the classifier name. E.g. when you set it to "
23         frontalface_default", the configuration file
24         "haarcascade_frontalface_default.xml" will be loaded
25     scale_factor : float, optional, by default 1.1
26         determines the factor by which the detection window of
27         the classifier is scaled down per detection pass. A factor of
28         1.1
29         corresponds to an increase of 10%. Hence, increasing the
30         scale factor increases performance, as the number of
31         detection
32         passes is reduced. However, as a consequence the
33         reliability by which a face is detected is reduced. See:
34         https://hackaday.io/project/12384-autofan-automated-
35         control-of-air-flow/log/41956-face-detection-using-a-haar-
36         cascade-classifier
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

```

```

29         faces in the image. The argument seems to have no
        influence on the performance of the algorithm. See:
30         https://hackaday.io/project/12384-autofan-automated-
        control-of-air-flow/log/41956-face-detection-using-a-haar-
        cascade-classifier
31
32     Returns
33     -----
34     cv2.Mat
35         The image in Mat representation
36     list
37         A list of found objects in the image
38     """
39
40     classifier = cv2.CascadeClassifier(
41         f"resources/haarcascades/haarcascade_{classifier_id}.xml"
42     )
43
44     img = cv2.cvtColor(np_input_image, 1)
45     gray = cv2.cvtColor(np_input_image, cv2.COLOR_BGR2GRAY)
46     objects = classifier.detectMultiScale(
47         gray, scaleFactor=scale_factor, minNeighbors=
48         min_neighbors, minSize=(min_size, min_size))
49     # pylint: disable=invalid-name
50     for (x, y, w, h) in objects:
51         cv2.rectangle(img, (x, y), (x + w, y + h), (255, 0, 0),
52             4)
53     return img, objects

```

Listing 2: app.py

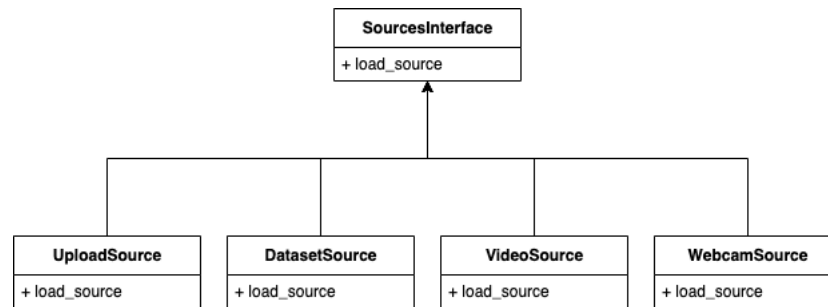


Abbildung 1: UML Diagramm für unterschiedliche Source-Typen

```

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: app.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: app.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: app.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
6  import av
7  import streamlit as st
8  from streamlit_webrtc import MediaPlayerFactory, WebRtcMode,
9     webrtc_streamer
10
11  from pki_a22_app.dashboard.sources import SourcesInterface
12  from pki_a22_app.haarcascades.haarcascades import detect_objects
13  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: app.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
:19302"]}]}
61     }
62     webrtc_streamer(key="example", video_frame_callback=
callback,
                    rtc_configuration=rtc_configuration)

```

Listing 7: app.py

```

1  """This modules contains helper methods to get information from
   local file system"""
2  import os
3  import pathlib
4  from typing import List
5
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/
haarcascades/")
21     classifiers = [item.replace("haarcascade_", "")
22                    for item in classifier_files]
23     classifiers = [item.replace(".xml", "") for item in
24                    classifiers]
25     classifiers.sort()
26     return classifiers
27
28  def get_datasets() -> List[str]:
29      """
30      Returns the folders found under /resources/datasets/
31
32      Returns
33      -----
34      List[str]
35          List of available dataset
36      """
37     datasets = os.listdir(os.getcwd() + "/resources/datasets/")
38     datasets = [item for item in datasets if not item.startswith(
39     ".")]
40     datasets.sort()
41     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: app.py