best_classifiers

September 10, 2025

[73]:
```
%load_ext autoreload
%autoreload 2

import ipynbname
import torch
import os
import warnings
import numpy as np
from xgboost import XGBClassifier
from libraries.classifier_utils import *
from libraries.embeddings_utils import *
from libraries.EmbeddingNet import *
from libraries.retrieval_utils import *


project_dir = f"{os.getcwd().
  ↪split('SIDS_revelation_project')[0]}SIDS_revelation_project/"
image_dataset_path = f"{project_dir}datasets/onback_onstomach_v3"
model_path_fd = f"{project_dir}/models/4.fd_weights/best.pt"
model_path_pe = f"{project_dir}/models/2.pe_weights/best.pt"

if torch.cuda.is_available():
    device = torch.device("cuda")
elif torch.backends.mps.is_available():
    device = torch.device("mps")
else:
    device = torch.device("cpu")
print(f"Using device: {device}")
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
Using device: cpu
```

[74]:
```
emb_builder = EmbeddingBuilder(model_path_fd, image_dataset_path,␣
  ↪"load",weights_path_pe=model_path_pe)
```

```
Extracting dataset info from .coco.json
```

```
file:--------------------------------------------------
Dataset contains 4158 valid samples, and labels are {'baby_on_back': 1,
'baby_on_stomach': 2}
--------------------------------------------------------------------------------
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Loading features from
.csv----------------------------------------------------------------
Features loaded succesfully, in particular there are 4158 files in the dataset
--------------------------------------------------------------------------------
----------

Embedding builder initialized
successfully--------------------------------------------------
Face detection model: 4 (YOLOv8)
Dataset: /home/terra/Desktop/unimore/AI_engineering/SIDS_revelation_project/data
sets/onback_onstomach_v3
Dataset dimension: 4158
Dataset labels: {'baby_safe': 0, 'baby_unsafe': 1}
--------------------------------------------------------------------------------
----------
```

0.1 Best model with approach Features selection: xgbc

Best parameters: {'colsample_bytree': np.float64(0.9942601816442402), 'gamma': np.float64(0.1210276357557502), 'learning_rate': np.float64(0.21164066422176356), 'max_depth': 5, 'n_estimators': 283, 'subsample': np.float64(0.6950550175969599)} - Best embeddings: orginal - {'face_vertical_length_norm', 'flag_mouth', 'flag_eye1', 'face_angle_horizontal', 'flag_nose', 'y_eye2', 'x_left_elbow', 'x_left_hip', 'x_eye2', 'nose_hip_right', 'flag_eye2'} - Performance: 0.90 with all feature, 0.89 with 25_top_features, 0.84 with top_10_features

[75]:
```
embeddings = emb_builder.create_embedding(flags=True,positions=True,␣
↪positions_normalized=True, geometric_info=True,k_positions_normalized=True␣
↪,k_geometric_info=True)
```

```
Embedding
creation------------------------------------------------------------------
Features: ['flag_eye1', 'flag_eye2', 'flag_nose', 'flag_mouth', 'x_eye1',
'y_eye1', 'x_eye2', 'y_eye2', 'x_nose', 'y_nose', 'x_mouth', 'y_mouth',
'x_eye1_norm', 'y_eye1_norm', 'x_eye2_norm', 'y_eye2_norm', 'x_nose_norm',
'y_nose_norm', 'x_mouth_norm', 'y_mouth_norm', 'eye_distance',
'eye_distance_norm', 'face_vertical_length', 'face_vertical_length_norm',
'face_angle_vertical', 'face_angle_horizontal', 'symmetry_diff', 'head_ration',
'x_nose_k', 'y_nose_k', 'x_left_eye_k', 'y_left_eye_k', 'x_right_eye_k',
'y_right_eye_k', 'x_left_ear', 'y_left_ear', 'x_right_ear', 'y_right_ear',
'x_left_shoulder', 'y_left_shoulder', 'x_right_shoulder', 'y_right_shoulder',
'x_left_elbow', 'y_left_elbow', 'x_right_elbow', 'y_right_elbow',
'x_left_wrist', 'y_left_wrist', 'x_right_wrist', 'y_right_wrist', 'x_left_hip',
'y_left_hip', 'x_right_hip', 'y_right_hip', 'x_left_knee', 'y_left_knee',
'x_right_knee', 'y_right_knee', 'x_left_ankle', 'y_left_ankle', 'x_right_ankle',
'y_right_ankle', 'shoulders_dist', 'shoulder_hip_right_dist',
'shoulder_hip_left_dist', 'nose_shoulder_right', 'nose_shoulder_left',
'shoulder_left_knee_right', 'shoulder_right_knee_left', 'knee_ankle_right',
'knee_ankle_left', 'nose_hip_right', 'nose_hip_left',
'elbow_shoulder_hip_right', 'elbow_shoulder_hip_left',
'shoulder_elbow_wrist_right', 'shoulder_elbow_wrist_left',
'shoulder_hip_knee_right', 'shoulder_hip_knee_left', 'hip_knee_ankle_right',
'hip_knee_ankle_left', 'shoulders_line_inclination', 'hips_line_inclination',
'torsion']
FINISHED: 4158 embedding created
--------------------------------------------------------------------------------
----------
```

[76]:
```python
features_to_drop = ['face_vertical_length_norm', 'flag_mouth', 'flag_eye1',␣
 ↪'face_angle_horizontal', 'flag_nose', 'y_eye2', 'x_left_elbow',␣
 ↪'x_left_hip', 'x_eye2', 'nose_hip_right', 'flag_eye2']
embeddings = embeddings.drop(columns=features_to_drop)
clf = Classifier(embeddings, emb_builder.y, emb_builder.classes_bs,␣
 ↪image_paths=emb_builder.image_paths)

best_params = {
    'colsample_bytree': np.float64(0.9942601816442402),
    'gamma': np.float64(0.1210276357557502),
    'learning_rate': np.float64(0.21164066422176356),
    'max_depth': 5,
    'n_estimators': 283,
    'subsample': np.float64(0.6950550175969599),
    'use_label_encoder': False,  # necessario con sklearn>=1.0
    'eval_metric': 'logloss'
}
model = XGBClassifier(**best_params)

with warnings.catch_warnings():
    warnings.simplefilter("ignore")
    results =clf.evaluation_pipeline_save_misclassified(model)
```

```
--------------------------------------------------------------------------------
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--------------------------------------FIRST
ANALYSIS--------------------------------------
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/home/terra/anaconda3/envs/SIDS_project/lib/python3.10/site-
packages/xgboost/core.py:377: FutureWarning: Your system has an old version of
```

```
glibc (< 2.28). We will stop supporting Linux distros with glibc older than 2.28
after **May 31, 2025**. Please upgrade to a recent Linux distro (with glibc >=
2.28) to use future versions of XGBoost.
Note: You have installed the 'manylinux2014' variant of XGBoost. Certain
features such as GPU algorithms or federated learning are not available. To use
these features, please upgrade to a recent Linux distro with glibc 2.28+, and
install the 'manylinux_2_28' variant.
  warnings.warn(
/home/terra/anaconda3/envs/SIDS_project/lib/python3.10/site-
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```

```
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/home/terra/anaconda3/envs/SIDS_project/lib/python3.10/site-
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features such as GPU algorithms or federated learning are not available. To use
these features, please upgrade to a recent Linux distro with glibc 2.28+, and
install the 'manylinux_2_28' variant.
  warnings.warn(
```
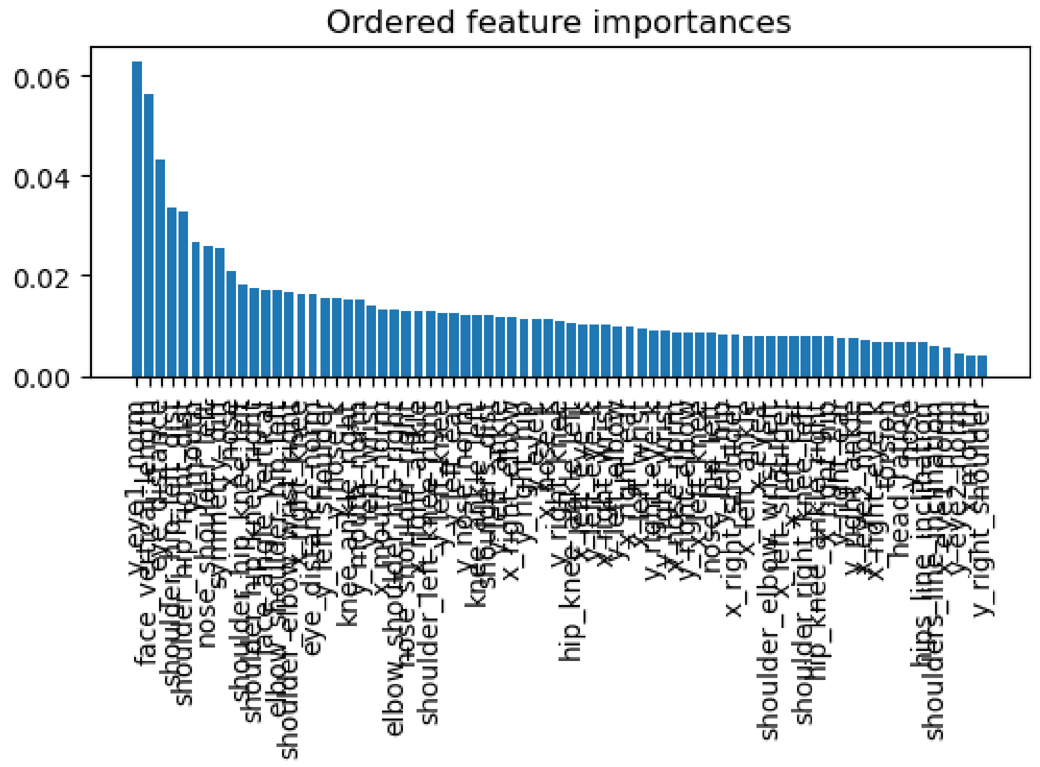
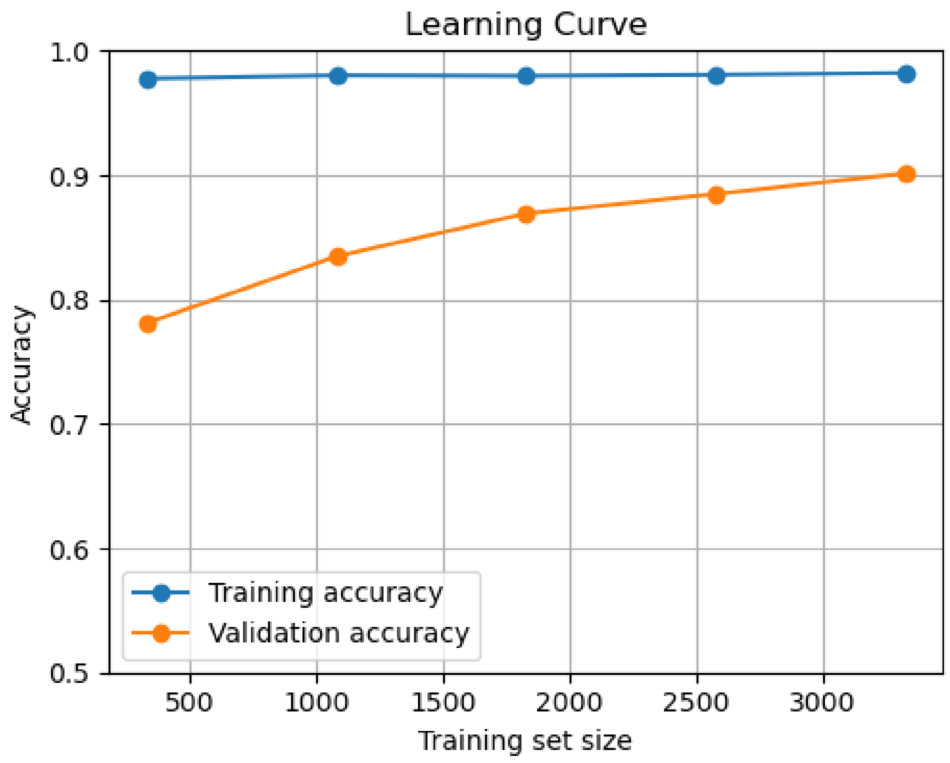
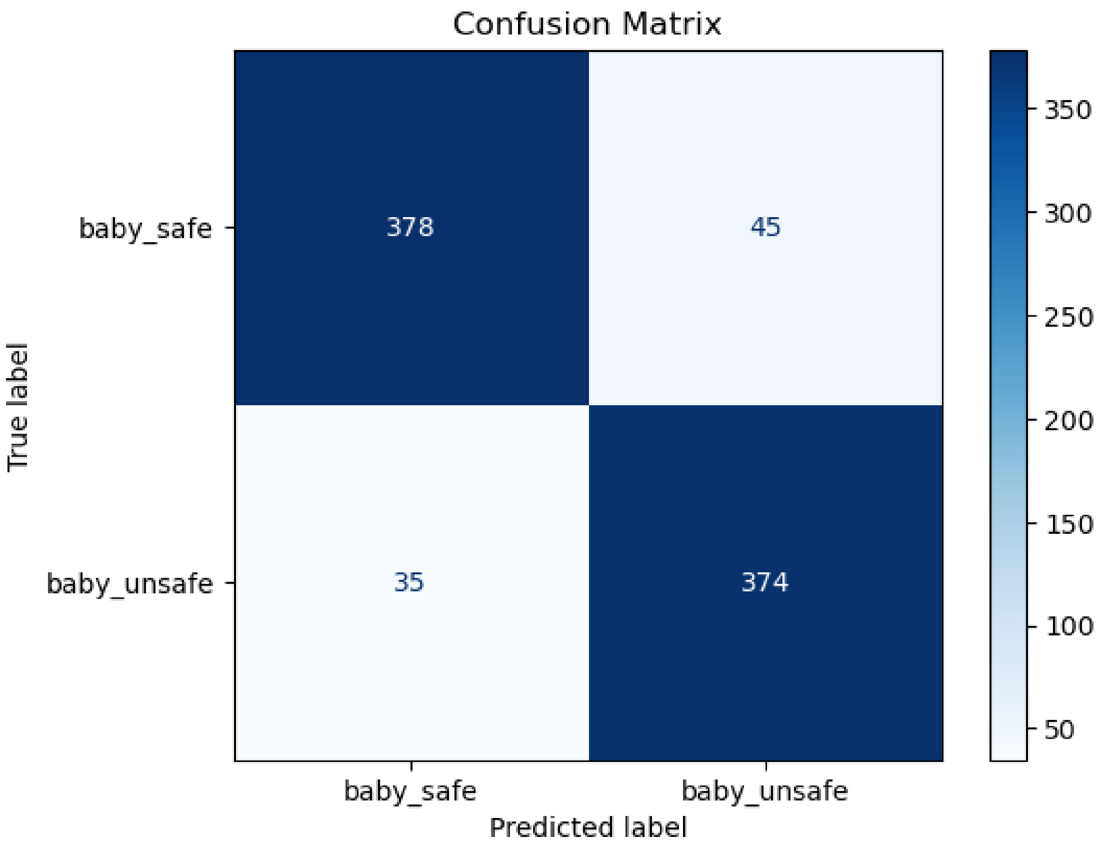





```
Dataset labels:---------------------------------------
{'baby_safe': 0, 'baby_unsafe': 1}

Report------------------------------------------------
              precision    recall  f1-score   support

   baby_safe       0.92      0.89      0.90       423
 baby_unsafe       0.89      0.91      0.90       409

    accuracy                           0.90       832
   macro avg       0.90      0.90      0.90       832
weighted avg       0.90      0.90      0.90       832

Confusion matrix---------------------------------------
```



```
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---------------------------------TOP 25 FEATURES
ANALYSIS---------------------------------
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```
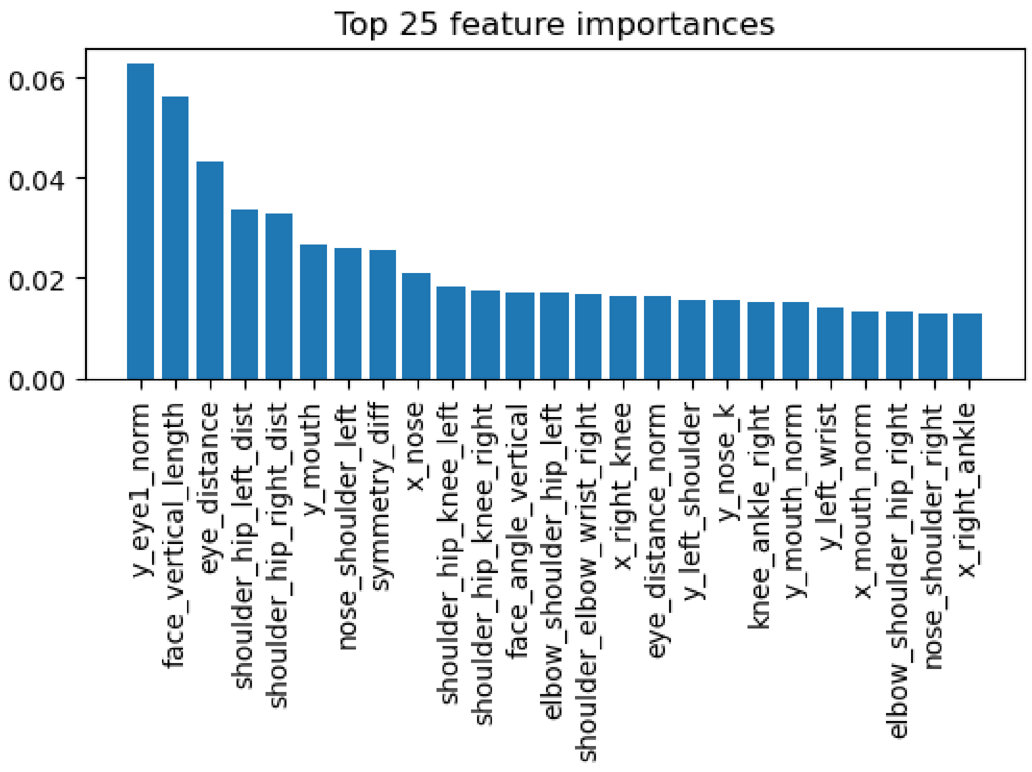
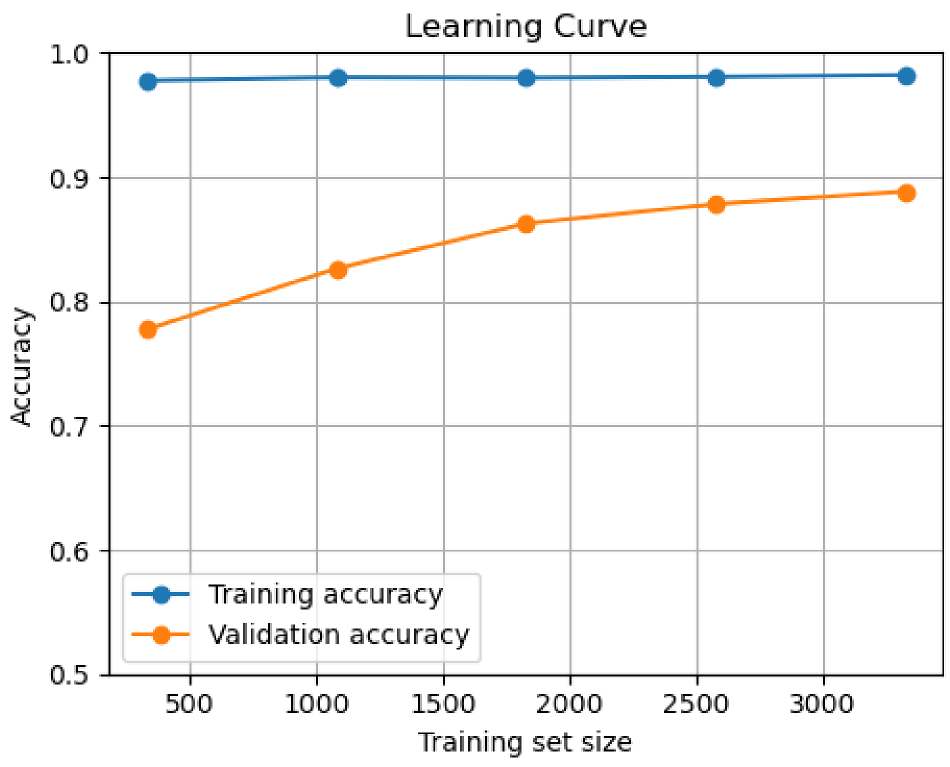
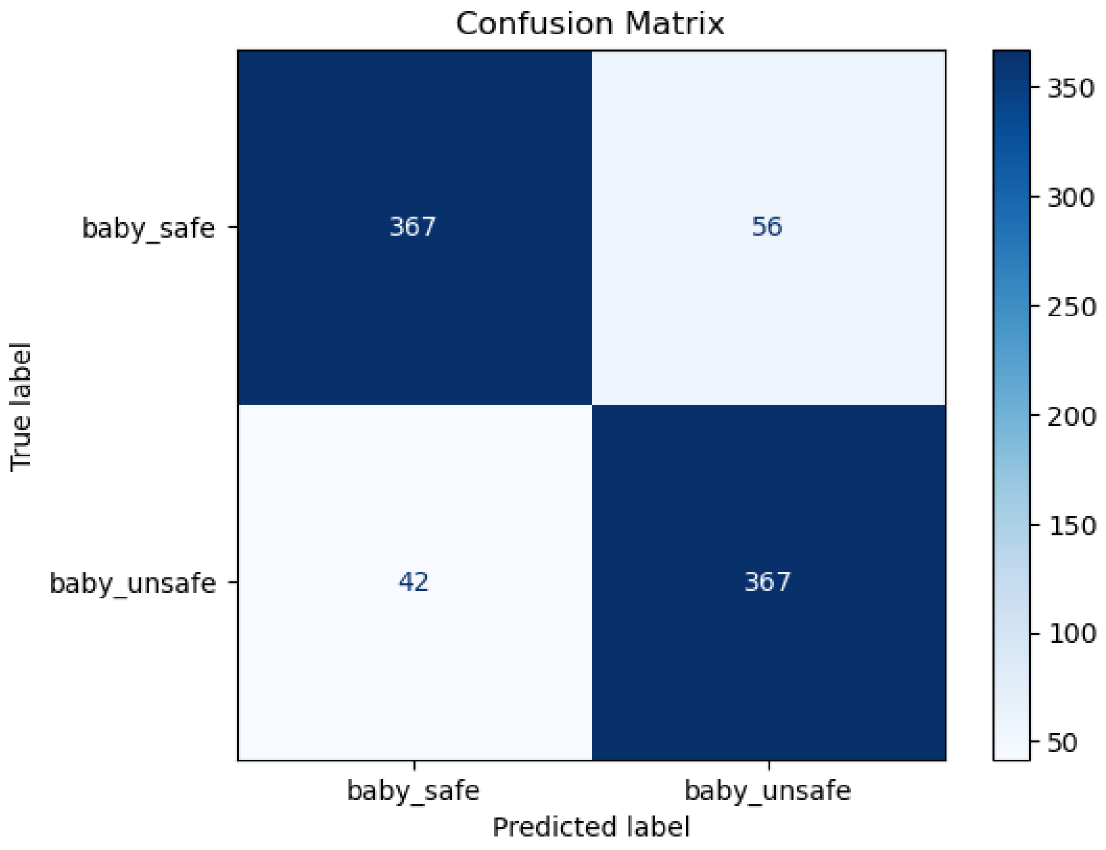


Top 25 feature importances
0.06
0.04
0.02
0.00
y_eye1_norm
face_vertical_length
eye_distance
shoulder_hip_left_dist
shoulder_hip_right_dist
y_mouth
nose_shoulder_left
symmetry_diff
x_nose
shoulder_hip_knee_left
shoulder_hip_knee_right
face_angle_vertical
elbow_shoulder_hip_left
shoulder_elbow_wrist_right
x_right_knee
eye_distance_norm
y_left_shoulder
y_nose_k
knee_ankle_right
y_mouth_norm
y_left_wrist
x_mouth_norm
elbow_shoulder_hip_right
nose_shoulder_right
x_right_ankle


Learning Curve
1.0
0.9
0.8
0.7
0.6
0.5
Accuracy
500
1000
1500
2000
2500
3000
Training set size
Training accuracy
Validation accuracy

```
Dataset labels:----------------------------------------
{'baby_safe': 0, 'baby_unsafe': 1}

Report-------------------------------------------------
              precision    recall  f1-score   support

   baby_safe       0.90      0.87      0.88       423
 baby_unsafe       0.87      0.90      0.88       409

    accuracy                           0.88       832
   macro avg       0.88      0.88      0.88       832
weighted avg       0.88      0.88      0.88       832

Confusion matrix---------------------------------------
```



```
--------------------------------------------------------------------------------
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```
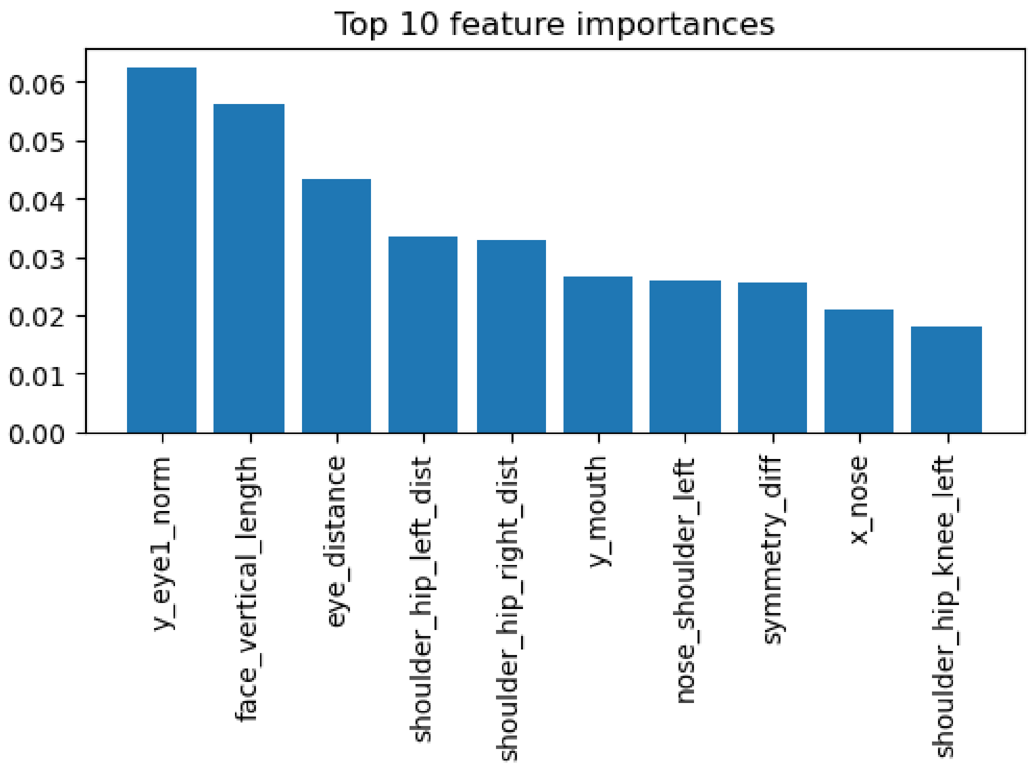
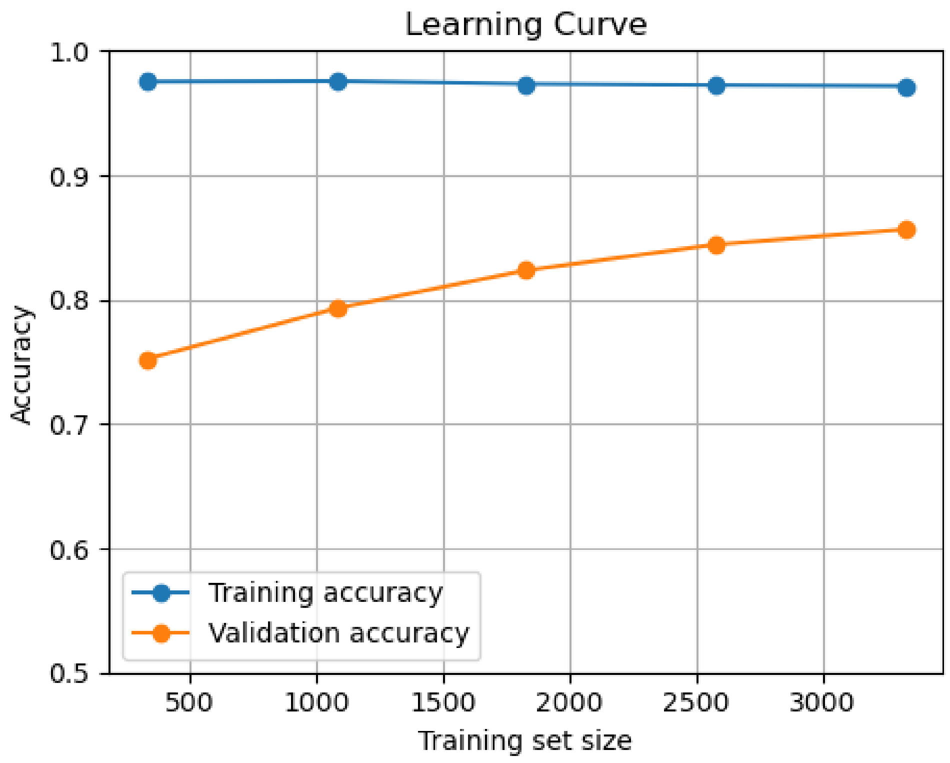
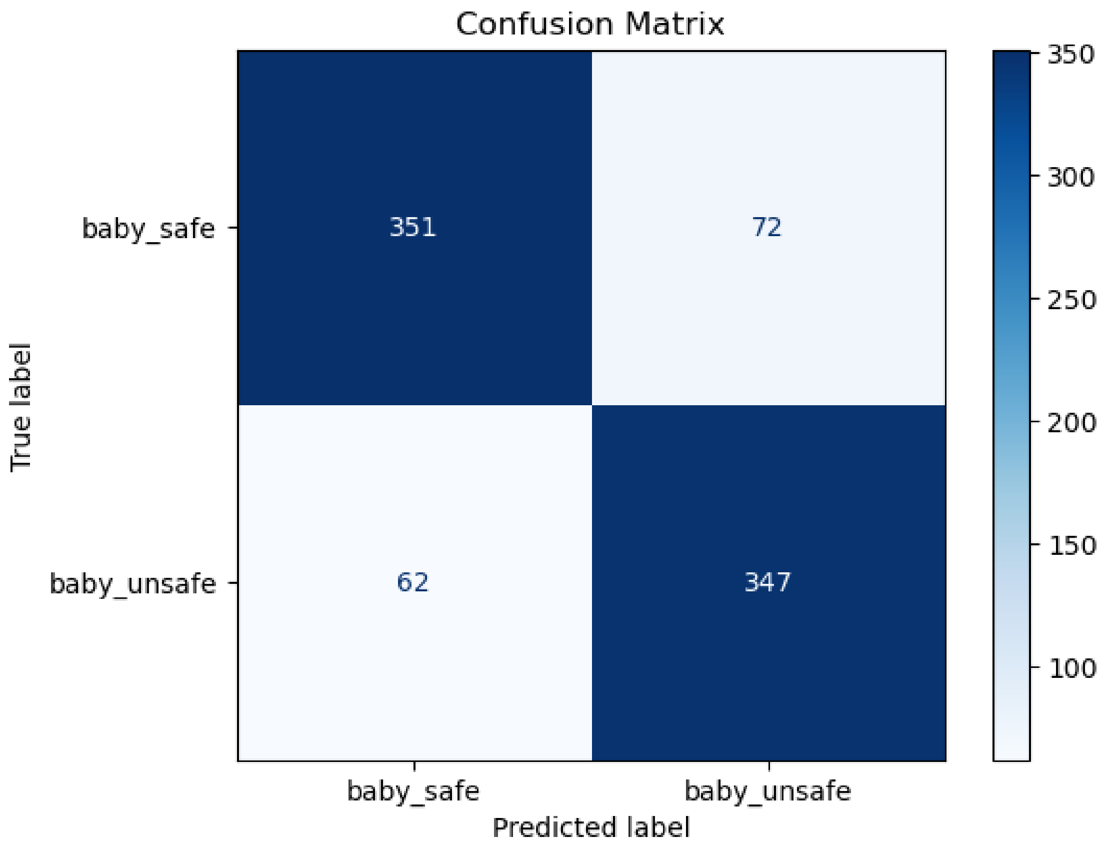

```
---------------------------------TOP 10 FEATURES
ANALYSIS---------------------------------
--------------------------------------------------------------------------------
----------
```





```
Dataset labels:---------------------------------------
{'baby_safe': 0, 'baby_unsafe': 1}

Report---------------------------------------------
              precision    recall  f1-score   support

   baby_safe       0.85      0.83      0.84       423
 baby_unsafe       0.83      0.85      0.84       409

    accuracy                           0.84       832
   macro avg       0.84      0.84      0.84       832
weighted avg       0.84      0.84      0.84       832

Confusion matrix---------------------------------------
```



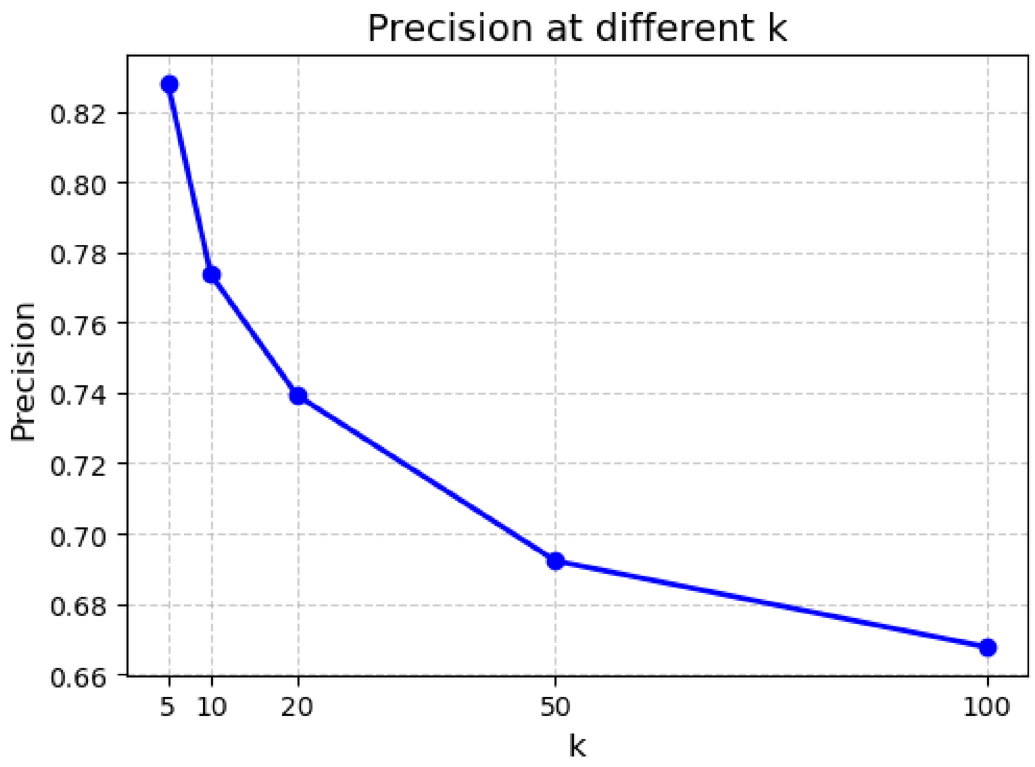
[77]:
```
prediction = results["all_features"]["y_predicted"]
true_y= clf.y_test
misclassified = np.where(true_y != prediction)[0]

misclassified_images = [clf.images_paths_test[i] for i in misclassified]
image_dataset_path=emb_builder.dataset

folder_path = f"{project_dir}image_prediction/approach_features_selection/"
if not os.path.exists(folder_path):
    os.makedirs(folder_path)

from PIL import Image, ImageDraw, ImageFont

for img_path, prediction in zip(misclassified_images, prediction):
        img = Image.open(f"{image_dataset_path}/{img_path}")
        draw = ImageDraw.Draw(img)

        try:
            font = ImageFont.truetype("DejaVuSans-Bold.ttf", size=34)  #␣
 ↪Imposta la dimensione del font
```

```
        except IOError:
            font = ImageFont.load_default()  # Usa il font di default se il␣
 ↪file ttf non è trovato

        predicted_class = [key for key, value in emb_builder.classes_bs.items()␣
 ↪if value == prediction][0]
        text = f"{predicted_class}"
        text_position = (50, 50)
        text_color = (255, 0, 0)
        draw.text(text_position, text, fill=text_color, font=font)

        new_image_path = f"{folder_path}{img_path}"
        img.save(new_image_path)

print(f"Misclassified images successfully saved in {folder_path}")
```

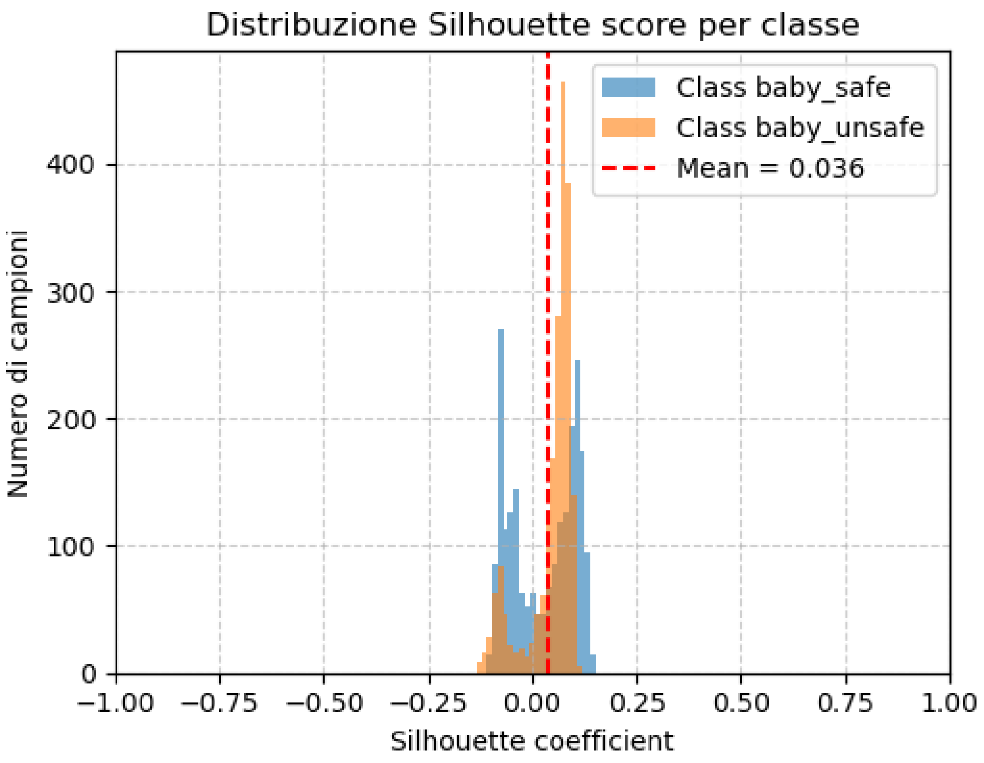
```
Misclassified images successfully saved in /home/terra/Desktop/unimore/AI_engine
ering/SIDS_revelation_project/image_prediction/approach_features_selection/
```

[78]:
```
ret = ImageRetrieval(embeddings, emb_builder.y, emb_builder.image_paths,␣
 ↪emb_builder.dataset, emb_builder.classes_bs)
ret.report('euclidean')
```

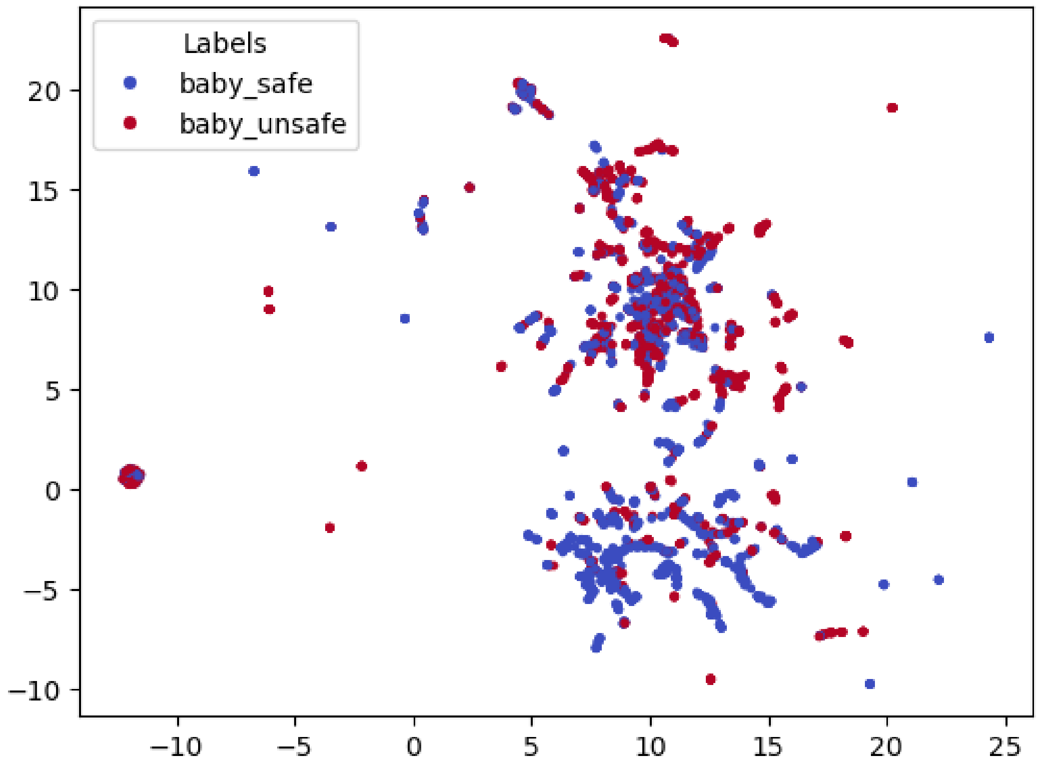
```
Precision at different
k:-----------------------------------------------------------------
```



```
Recall at
R----------------------------------------------------------------------
0.5437276847656125

Silhouette
score---------------------------------------------------------------------
```

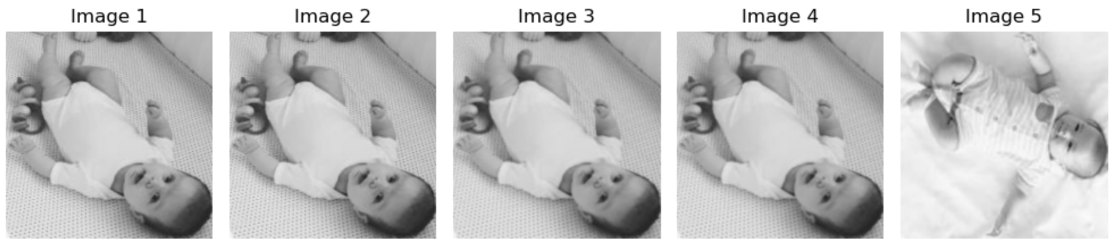


```
Silhouette score (euclidean): 0.036

Embeddings
distributions----------------------------------------------------------
```



[79]:
```python
image_paths = emb_builder.image_paths
idx_query = 99
image_to_retrieve = f"{emb_builder.dataset}/{image_paths[idx_query]}"

print("Image to retrieve")
img = mpimg.imread(image_to_retrieve)
plt.figure(figsize=(3, 3))
plt.imshow(img)
plt.axis('off')
plt.show()

distances_all, image_paths_similar_all = ret.
 ↪retrieve_similar(idx_query=idx_query,k=5,verbose=False)
ret.show_images(image_paths_similar_all)
```

```
Image to retrieve
```



0.2 Best model with approach Supervised Learning Metric

XGBC with no optimization

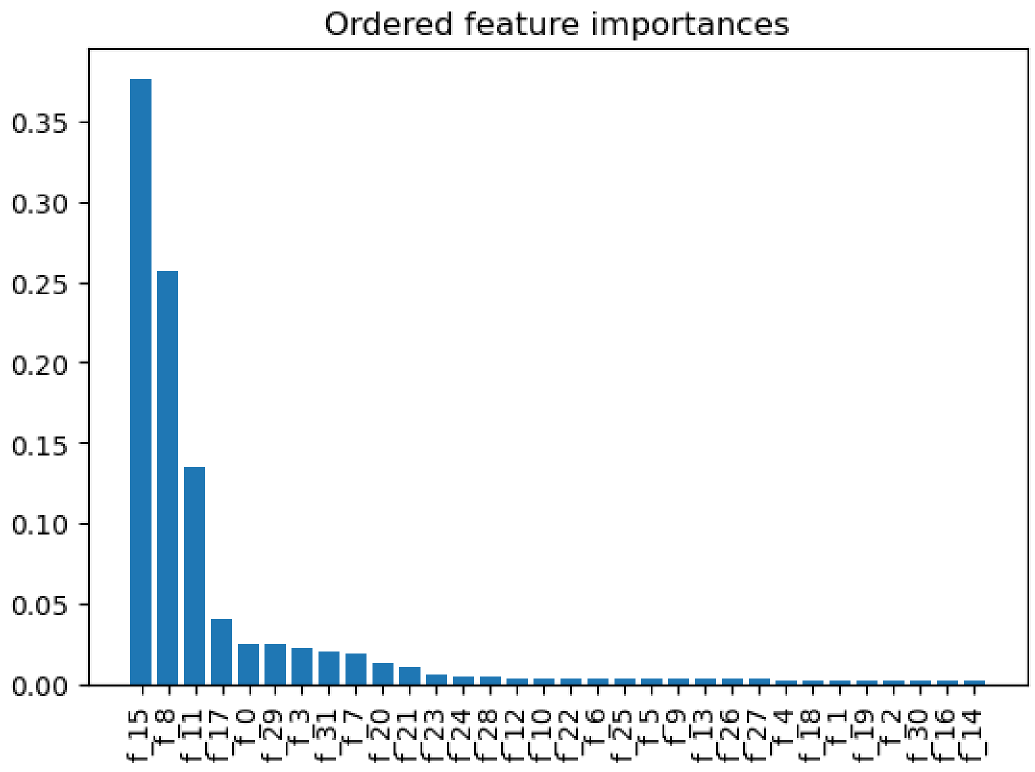
[80]:
```
embeddings = emb_builder.create_embedding(flags=True,positions=True,␣
↪positions_normalized=True, geometric_info=True,k_positions_normalized=True␣
↪,k_geometric_info=True)
```

```
Embedding
creation------------------------------------------------------------------------
Features: ['flag_eye1', 'flag_eye2', 'flag_nose', 'flag_mouth', 'x_eye1',
'y_eye1', 'x_eye2', 'y_eye2', 'x_nose', 'y_nose', 'x_mouth', 'y_mouth',
'x_eye1_norm', 'y_eye1_norm', 'x_eye2_norm', 'y_eye2_norm', 'x_nose_norm',
'y_nose_norm', 'x_mouth_norm', 'y_mouth_norm', 'eye_distance',
'eye_distance_norm', 'face_vertical_length', 'face_vertical_length_norm',
'face_angle_vertical', 'face_angle_horizontal', 'symmetry_diff', 'head_ration',
'x_nose_k', 'y_nose_k', 'x_left_eye_k', 'y_left_eye_k', 'x_right_eye_k',
'y_right_eye_k', 'x_left_ear', 'y_left_ear', 'x_right_ear', 'y_right_ear',
'x_left_shoulder', 'y_left_shoulder', 'x_right_shoulder', 'y_right_shoulder',
'x_left_elbow', 'y_left_elbow', 'x_right_elbow', 'y_right_elbow',
'x_left_wrist', 'y_left_wrist', 'x_right_wrist', 'y_right_wrist', 'x_left_hip',
'y_left_hip', 'x_right_hip', 'y_right_hip', 'x_left_knee', 'y_left_knee',
'x_right_knee', 'y_right_knee', 'x_left_ankle', 'y_left_ankle', 'x_right_ankle',
'y_right_ankle', 'shoulders_dist', 'shoulder_hip_right_dist',
'shoulder_hip_left_dist', 'nose_shoulder_right', 'nose_shoulder_left',
'shoulder_left_knee_right', 'shoulder_right_knee_left', 'knee_ankle_right',
'knee_ankle_left', 'nose_hip_right', 'nose_hip_left',
'elbow_shoulder_hip_right', 'elbow_shoulder_hip_left',
'shoulder_elbow_wrist_right', 'shoulder_elbow_wrist_left',
'shoulder_hip_knee_right', 'shoulder_hip_knee_left', 'hip_knee_ankle_right',
'hip_knee_ankle_left', 'shoulders_line_inclination', 'hips_line_inclination',
'torsion']
FINISHED: 4158 embedding created
--------------------------------------------------------------------------------
----------
```

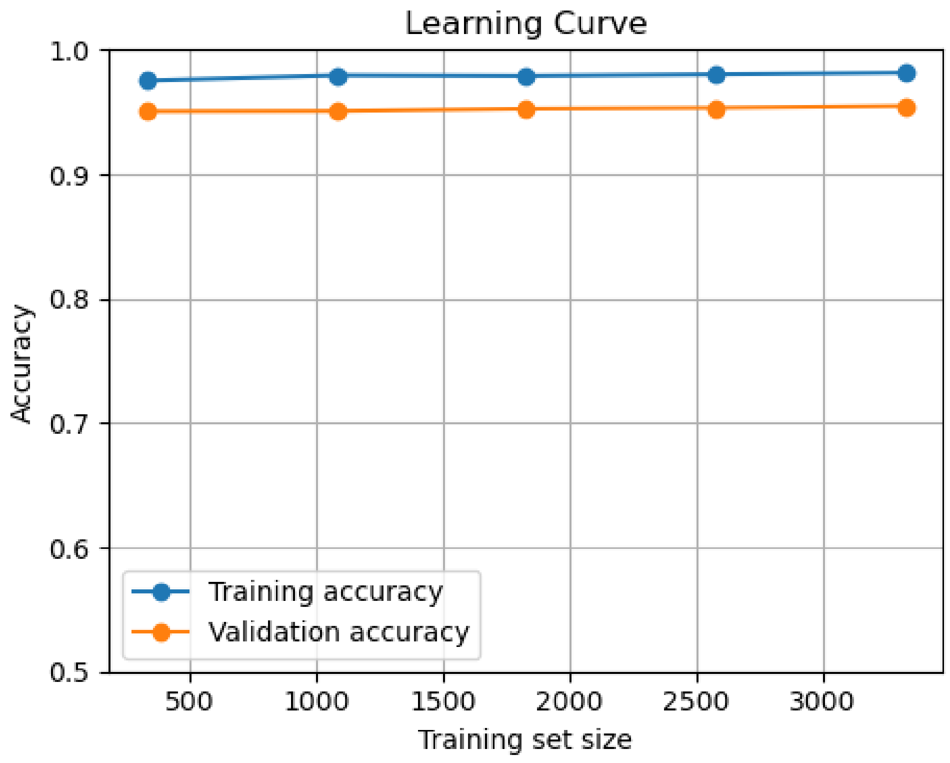
[87]:
```
dataset = EmbeddingDataset(embeddings.to_numpy(),emb_builder.y,device=device)
model = dataset.train_embeddings(embed_dim=32, epochs=50, batch_size=128,␣
 ↪lr=1e-3,verbose=False,weight_decay=1e-7,dropout_rate=0.05)

embeddings_new = dataset.extract_embeddings(model)
embeddings_new= pd.DataFrame(embeddings_new.to_numpy(), columns=[f"f_{i}" for i␣
 ↪in range(embeddings_new.shape[1])])
clf = Classifier(embeddings_new, emb_builder.y, emb_builder.classes_bs,␣
 ↪image_paths=emb_builder.image_paths)
```

[88]:
```
params = {
    'n_estimators': 300,
    'max_depth': 5,
    'learning_rate': 0.05,
    'subsample': 0.8,
    'colsample_bytree': 0.8,
    'reg_lambda': 1,
    'reg_alpha': 0.5,
    'random_state': None
}
model = XGBClassifier(**params)

with warnings.catch_warnings():
    warnings.simplefilter("ignore")
    results =clf.evaluation_pipeline_save_misclassified(model)
```

```
--------------------------------------------------------------------------------
----------
--------------------------------------FIRST
ANALYSIS---------------------------------------
--------------------------------------------------------------------------------
----------
```

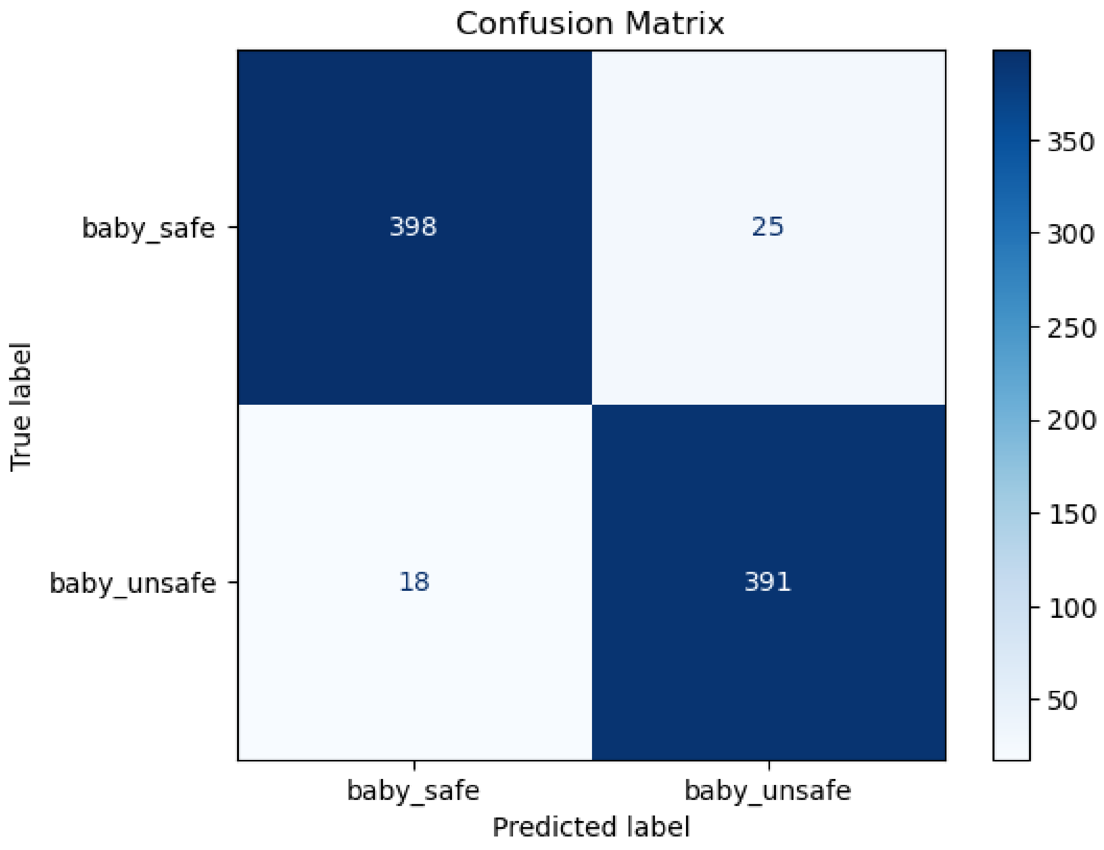


Ordered feature importances
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
f_15
f_8
f_11
f_17
f_0
f_29
f_3
f_31
f_7
f_20
f_21
f_23
f_24
f_28
f_12
f_10
f_22
f_6
f_25
f_5
f_9
f_13
f_26
f_27
f_4
f_18
f_1
f_19
f_2
f_30
f_16
f_14



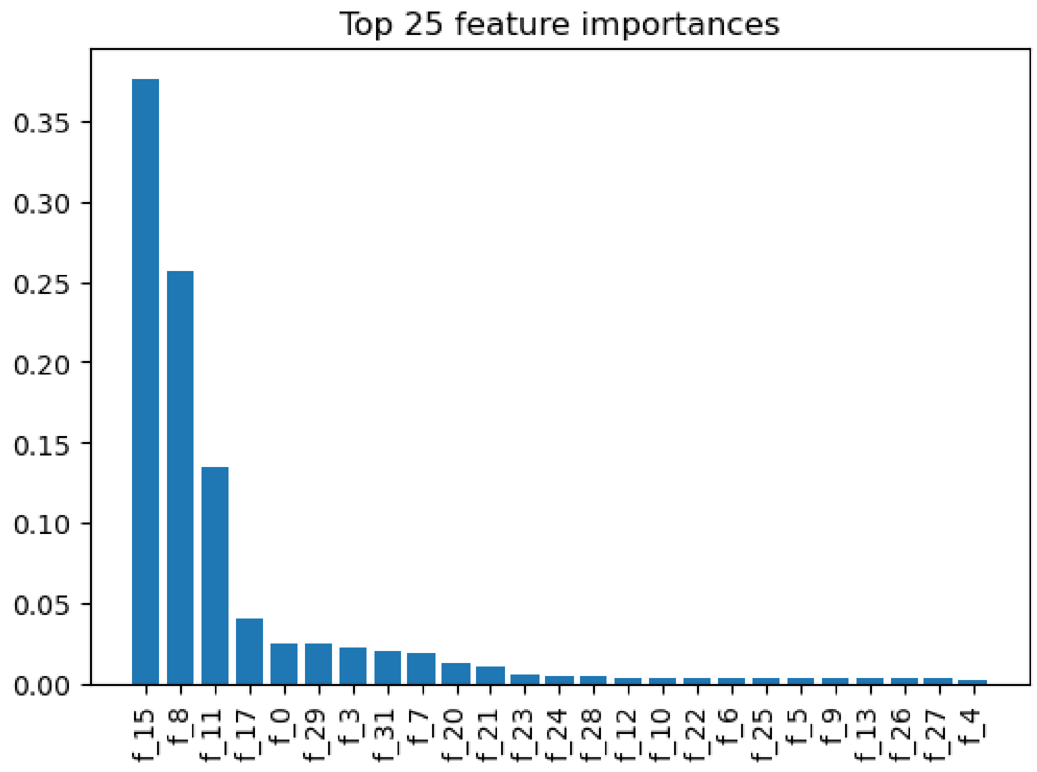
Learning Curve
Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
500
1000
1500
2000
2500
3000
Training set size
Training accuracy
Validation accuracy

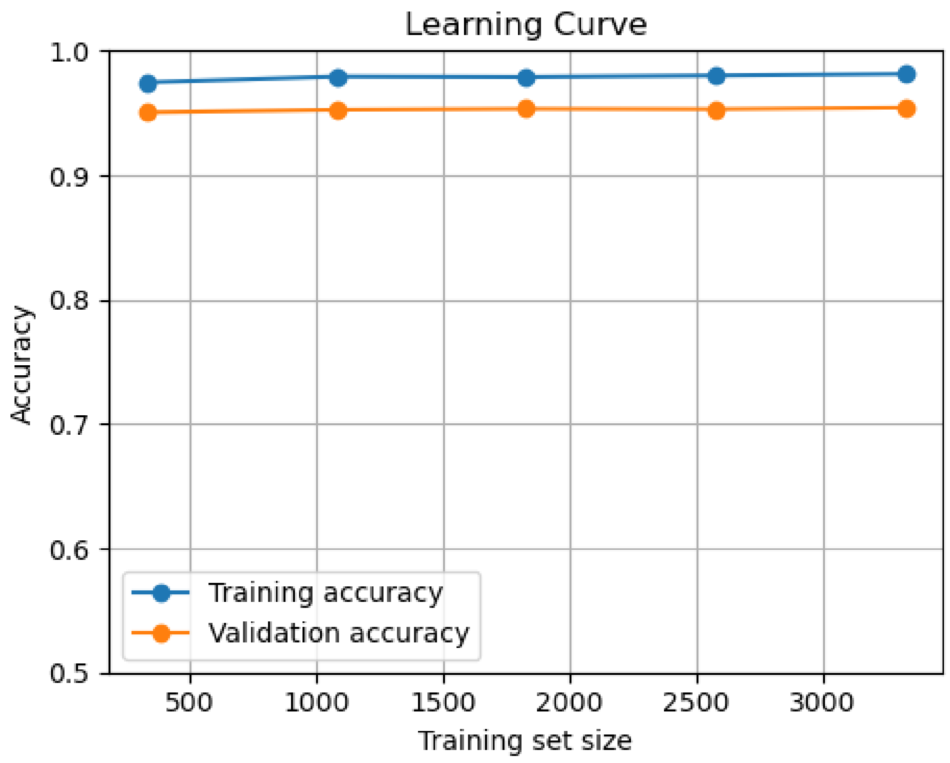
```
Dataset labels:----------------------------------------
{'baby_safe': 0, 'baby_unsafe': 1}

Report------------------------------------------------
              precision    recall  f1-score   support

   baby_safe       0.96      0.94      0.95       423
 baby_unsafe       0.94      0.96      0.95       409

    accuracy                           0.95       832
   macro avg       0.95      0.95      0.95       832
weighted avg       0.95      0.95      0.95       832

Confusion matrix--------------------------------------
```



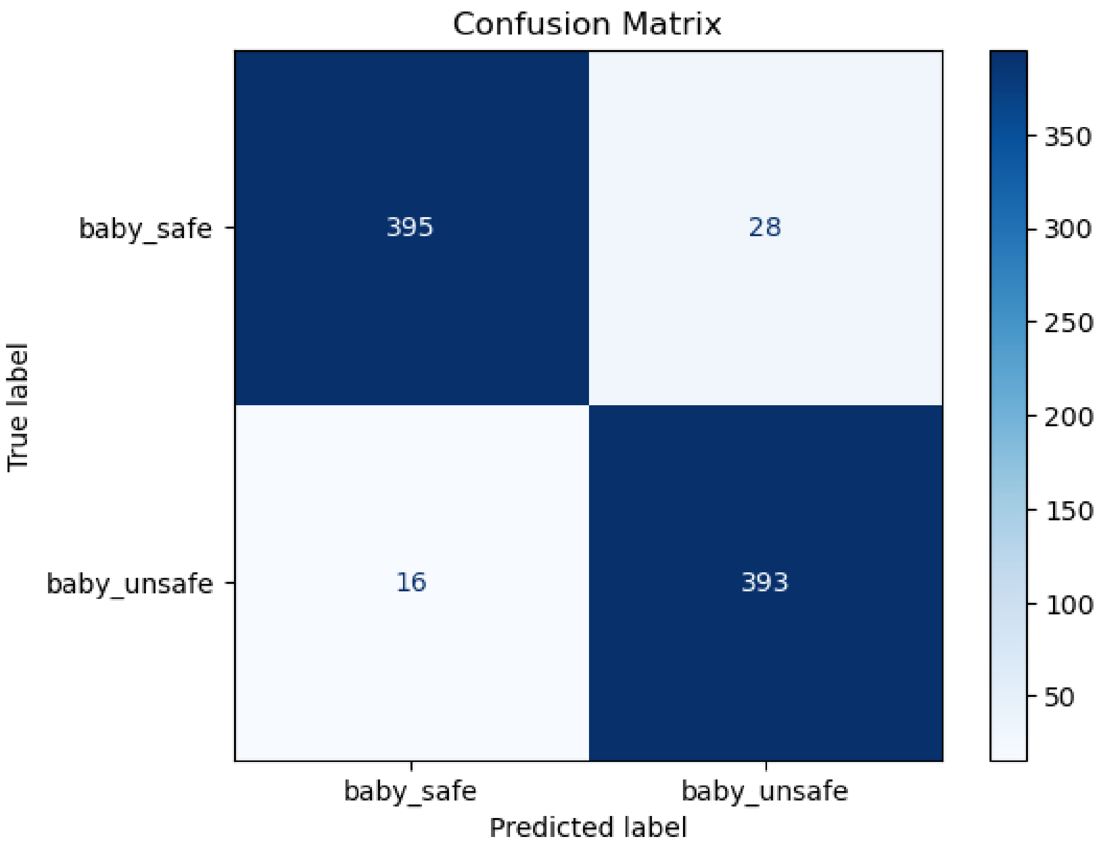
```
--------------------------------------------------------------------------------
----------
```

```
---------------------------------TOP 25 FEATURES
ANALYSIS---------------------------------
--------------------------------------------------------------------------------
----------
```

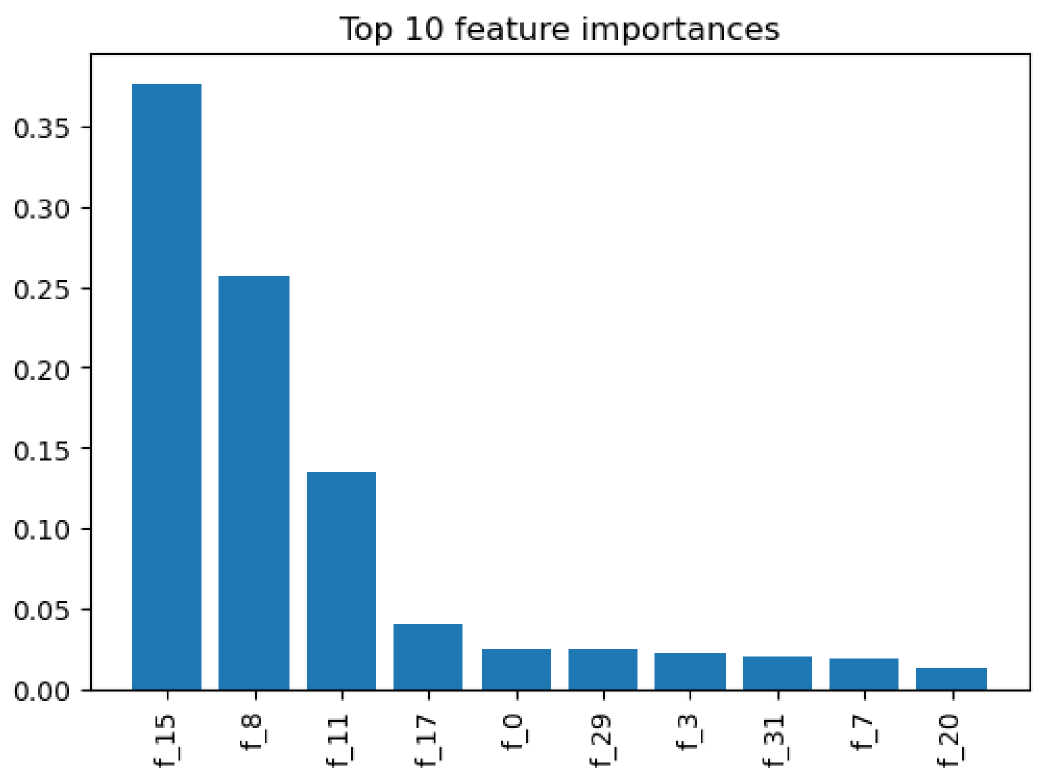


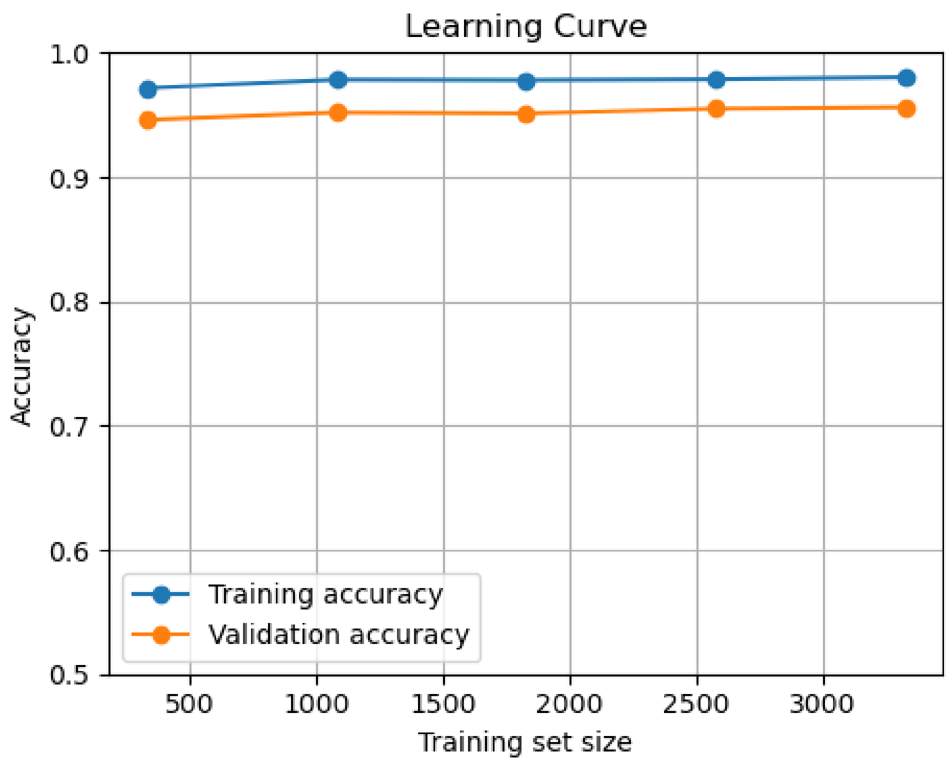


```
Dataset labels:---------------------------------------
{'baby_safe': 0, 'baby_unsafe': 1}

Report------------------------------------------------
              precision    recall  f1-score   support

   baby_safe       0.96      0.93      0.95       423
 baby_unsafe       0.93      0.96      0.95       409

    accuracy                           0.95       832
   macro avg       0.95      0.95      0.95       832
weighted avg       0.95      0.95      0.95       832

Confusion matrix---------------------------------------
```

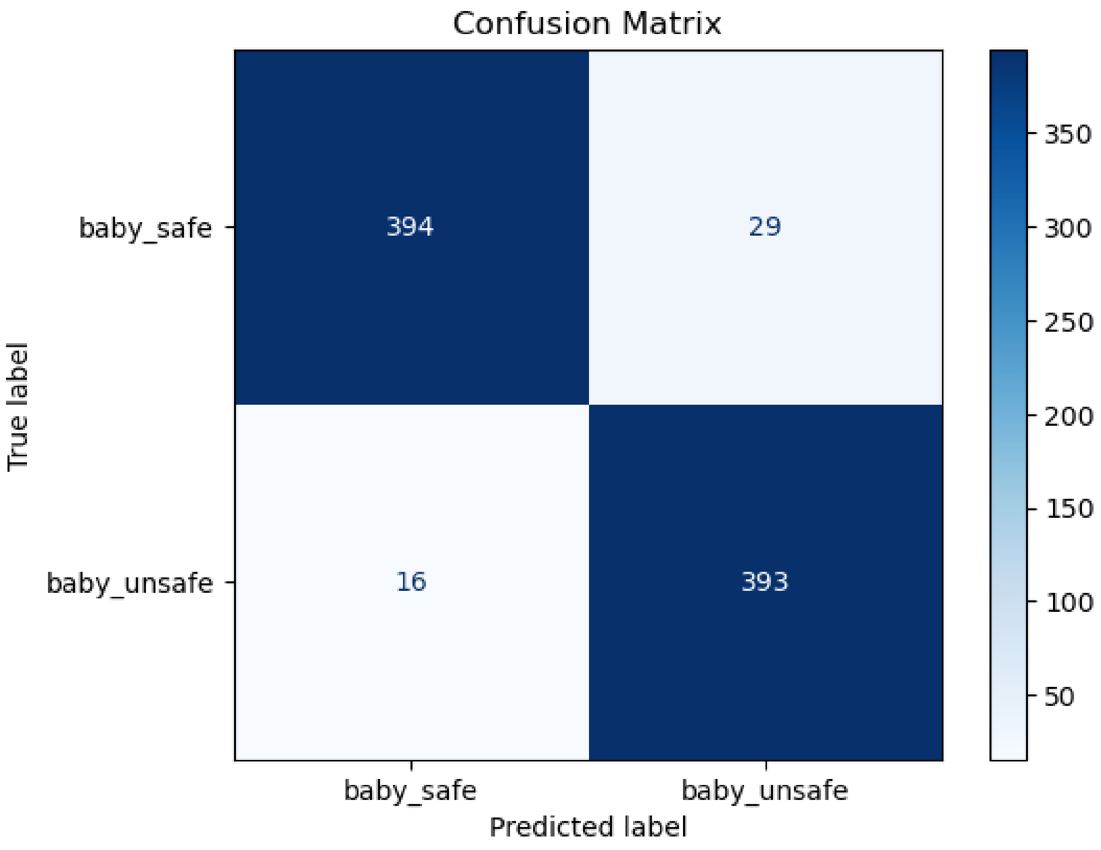


```
--------------------------------------------------------------------------------
----------
---------------------------------TOP 10 FEATURES
ANALYSIS---------------------------------
--------------------------------------------------------------------------------
----------
```


Top 10 feature importances
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
f_15
f_8
f_11
f_17
f_0
f_29
f_3
f_31
f_7
f_20


Learning Curve
1.0
0.9
0.8
0.7
0.6
0.5
Accuracy
500
1000
1500
2000
2500
3000
Training set size
Training accuracy
Validation accuracy

```
Dataset labels:----------------------------------------
{'baby_safe': 0, 'baby_unsafe': 1}

Report------------------------------------------------
              precision    recall  f1-score   support

   baby_safe       0.96      0.93      0.95       423
 baby_unsafe       0.93      0.96      0.95       409

    accuracy                           0.95       832
   macro avg       0.95      0.95      0.95       832
weighted avg       0.95      0.95      0.95       832

Confusion matrix--------------------------------------
```



[89]:
```
prediction = results["all_features"]["y_predicted"]
true_y= clf.y_test
misclassified = np.where(true_y != prediction)[0]

misclassified_images = [clf.images_paths_test[i] for i in misclassified]
image_dataset_path=emb_builder.dataset

folder_path = f"{project_dir}image_prediction/
 ↪approach_supervised_learning_metric/"
if not os.path.exists(folder_path):
    os.makedirs(folder_path)

from PIL import Image, ImageDraw, ImageFont

for img_path, prediction in zip(misclassified_images, prediction):
        img = Image.open(f"{image_dataset_path}/{img_path}")
        draw = ImageDraw.Draw(img)

        try:
            font = ImageFont.truetype("DejaVuSans-Bold.ttf", size=34)  #␣
 ↪Imposta la dimensione del font
        except IOError:
            font = ImageFont.load_default()  # Usa il font di default se il␣
 ↪file ttf non è trovato

        predicted_class = [key for key, value in emb_builder.classes_bs.items()␣
 ↪if value == prediction][0]
        text = f"{predicted_class}"
        text_position = (50, 50)
        text_color = (255, 0, 0)
        draw.text(text_position, text, fill=text_color, font=font)

        new_image_path = f"{folder_path}{img_path}"
        img.save(new_image_path)

print(f"Misclassified images successfully saved in {folder_path}")
```

```
Misclassified images successfully saved in /home/terra/Desktop/unimore/AI_engine
ering/SIDS_revelation_project/image_prediction/approach_supervised_learning_metr
ic/
```

[ ]:
```
ret = ImageRetrieval(embeddings_new, emb_builder.y, emb_builder.image_paths,␣
 ↪emb_builder.dataset, emb_builder.classes_bs)
ret.report('euclidean')
```

```
Precision at different
k:-----------------------------------------------------------------
```

[ ]:
```
image_paths = emb_builder.image_paths
idx_query = 99
image_to_retrieve = f"{emb_builder.dataset}/{image_paths[idx_query]}"

print("Image to retrieve")
img = mpimg.imread(image_to_retrieve)
plt.figure(figsize=(3, 3))
plt.imshow(img)
plt.axis('off')
plt.show()

distances_all, image_paths_similar_all = ret.
 ↪retrieve_similar(idx_query=idx_query,k=5,verbose=False)
ret.show_images(image_paths_similar_all)
```

0.3 Best model with approach Supervised Learning Metric

XGBC with optimization

Best parameters : {‘colsample_bytree’: np.float64(0.6547542520275229), ‘gamma’: np.float64(0.45000932092405255), ‘learning_rate’: np.float64(0.2721670232687546), ‘max_depth’: 4, ‘n_estimators’: 367, ‘subsample’: np.float64(0.853239225342979)} Best mean cross-validation accuracy: 0.9735415114362482

[ ]:
```
embeddings = emb_builder.create_embedding(flags=True,positions=True,␣
 ↪positions_normalized=True, geometric_info=True,k_positions_normalized=True␣
 ↪,k_geometric_info=True)
```

[ ]:
```
dataset = EmbeddingDataset(embeddings.to_numpy(),emb_builder.y,device=device)
model = dataset.train_embeddings(embed_dim=32, epochs=50, batch_size=128,␣
 ↪lr=1e-3,verbose=False,weight_decay=1e-7,dropout_rate=0.05)

embeddings_new = dataset.extract_embeddings(model)
embeddings_new= pd.DataFrame(embeddings_new.to_numpy(), columns=[f"f_{i}" for i␣
 ↪in range(embeddings_new.shape[1])])
clf = Classifier(embeddings_new, emb_builder.y, emb_builder.classes_bs)
```

[ ]:
```
best_params =  {
    'colsample_bytree': np.float64(0.6547542520275229),
    'gamma': np.float64(0.45000932092405255),
    'learning_rate': np.float64(0.2721670232687546),
    'max_depth': 4,
    'n_estimators': 367,
    'subsample': np.float64(0.853239225342979)
}
model = XGBClassifier(**best_params)
```

```
with warnings.catch_warnings():
    warnings.simplefilter("ignore")
    results =clf.evaluation_pipeline_save_misclassified(model)
```

```
[ ]: prediction = results["all_features"]["y_predicted"]
true_y= clf.y_test
misclassified = np.where(true_y != prediction)[0]

misclassified_images = [clf.images_paths_test[i] for i in misclassified]
image_dataset_path=emb_builder.dataset

folder_path = f"{project_dir}image_prediction/
 ↪approach_supervised_learning_metric_optimized/"
if not os.path.exists(folder_path):
    os.makedirs(folder_path)

from PIL import Image, ImageDraw, ImageFont

for img_path, prediction in zip(misclassified_images, prediction):
        img = Image.open(f"{image_dataset_path}/{img_path}")
        draw = ImageDraw.Draw(img)

        try:
            font = ImageFont.truetype("DejaVuSans-Bold.ttf", size=34)  #␣
 ↪Imposta la dimensione del font
        except IOError:
            font = ImageFont.load_default()  # Usa il font di default se il␣
 ↪file ttf non è trovato

        predicted_class = [key for key, value in emb_builder.classes_bs.items()␣
 ↪if value == prediction][0]
        text = f"{predicted_class}"
        text_position = (50, 50)
        text_color = (255, 0, 0)
        draw.text(text_position, text, fill=text_color, font=font)

        new_image_path = f"{folder_path}{img_path}"
        img.save(new_image_path)

print(f"Misclassified images successfully saved in {folder_path}")
```

Retrieval is invariant, same embeddings as previous point

```
[ ]: ret = ImageRetrieval(embeddings_new, emb_builder.y, emb_builder.image_paths,␣
 ↪emb_builder.dataset, emb_builder.classes_bs)
ret.report('euclidean')
```

```
[ ]: image_paths = emb_builder.image_paths
     idx_query = 99
     image_to_retrieve = f"{emb_builder.dataset}/{image_paths[idx_query]}"

     print("Image to retrieve")
     img = mpimg.imread(image_to_retrieve)
     plt.figure(figsize=(3, 3))
     plt.imshow(img)
     plt.axis('off')
     plt.show()

     distances_all, image_paths_similar_all = ret.
      ↪retrieve_similar(idx_query=idx_query,k=5,verbose=False)
     ret.show_images(image_paths_similar_all)
```

```
[ ]: import ipynbname
     from libraries.file_manager_utils import *

     save_as_pdf(ipynbname.path())
```