DeepImageSearch_v1.43

September 16, 2024

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Python Version Executing this notebook: Python 3.11 (Anaconda 2024.02)

1 Malware Classification using DeepImageSearch

The purpose of this notebook is to introduce the methodology of using Convolutional Neural Networks (CNN) for malware classification. This notebook selects a few CNNs loaded in DeepImageSearch to analyze malware and assess performance of each CNN.

2 DeepImageSearch References

- Deep Image Search GitHub: https://github.com/TechyNilesh/DeepImageSearch/blob/main/Documents/Do
- DeepImageSearch: https://github.com/TechyNilesh/DeepImageSearch
- Tutorial: "How to Easily!! Find Similar Images in Python using Machine Learning with Deep Image Search" "https://www.youtube.com/watch?v=znM_Z_jYT8E

3 Code Version

```
[1]: CODE_VERSION = 1.43
```

4 Imports

```
[2]: import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import sys
import random
import pickle
import zipfile
import os
import pandas as pd
```

```
import time
import shutil
import inspect
```

[3]:
```
################################################################################
# Configure Deep Image Search
################################################################################
configure_machine = True # change this to true if this is your first working␣
 ↪with DeepImageSearch

if configure_machine:
    # you can try !pip install DeepImageSearch or !pip install deepimagesearch
    # I'm including both. If one fails to install, try the other one
    !pip install DeepImageSearch
    !pip install DeepImageSearch --upgrade
    print('\n', '#'*80, '\n # DeepImageSearch\n', '#'*80)
    !pip show DeepImageSearch
    print('\n')

    # try this configuration as well - some python installations prefer the␣
 ↪above, others work with the below install
    !pip install deepimagesearch
    !pip install deepimagesearch  --upgrade

    !pip install timm
    !pip install py7zr
    #!pip uninstall -y torch torchvision
    #!pip install torch torchvision

    print('\n', '*'*90, '\n', '* If this is your first time configuring your␣
 ↪machine for DeepImageSearch, \n * please RESTART JUPYTER NOTEBOOK KERNEL to␣
 ↪ensure kernel updates correctly.\n', '*'*90, '\n')

print('configuration complete')
```

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##
 # DeepImageSearch
##
Name: DeepImageSearch
Version: 2.5
Summary: DeepImageSearch is a Python library for fast and accurate image search.
It offers seamless integration with Python, GPU support, and advanced
capabilities for identifying complex image patterns using the Vision Transformer
models.
Home-page: https://github.com/TechyNilesh/DeepImageSearch
Author: Nilesh Verma

Author-email: me@nileshverma.com
License: MIT
Location: /home/ssonya/.local/lib/python3.11/site-packages
Requires: faiss-cpu, matplotlib, numpy, pandas, Pillow, timm, torch,
torchvision, tqdm
Required-by:

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/apps/cent7/anaconda/2024.02/lib/python3.11/site-packages (from py7zr) (5.9.0)

 ****
 ****
 * If this is your first time configuring your machine for DeepImageSearch,
 * please RESTART JUPYTER NOTEBOOK KERNEL to ensure kernel updates correctly.
 ****
 ****

configuration complete

```
[4]: import timm
     import py7zr
     from pprint import pprint
     import torch
     import torchvision
```

```
[5]: from DeepImageSearch import Load_Data, Search_Setup
     # depending on your pythong environment, try this line if the above import␣
      ↪DeepImageSearch fails
     #from deepimagesearch import Load_Data, Search_Setup
     print('\nimport complete!')
```

import complete!

5 Configure environment

```python
os.makedirs('output', exist_ok=True)
```

6 Specify to load previously trained models

```python
LOAD_PRETRAINED_MODELS = False
path_to_pretrained_models = './trained_models'
```

7 Set Options

```python
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
```

8 Set input file path

```python
zip_file = './grayscale_pw_infected.7z'
extract_to = './grayscale'
zip_password = 'infected'
```

9 Extract Archive

```python
# Extract .7z archive
with py7zr.SevenZipFile(zip_file, mode='r', password=zip_password) as archive:
    archive.extractall(path=extract_to)

print(f"Extraction complete! Files extracted to {extract_to}")
```

```
Extraction complete! Files extracted to ./grayscale
```

10 Rescale images to 224 x 224

```python
rescale = True

if rescale:
    from PIL import Image
    import os

    # Path to the root folder containing images
    root_folder = extract_to

    # Set dimensions
```

```python
    new_width = 224
    new_height = 224

    # Function to resize and convert images to grayscale

    def process_image(image_path, width, height):
        # Open the image
        img = Image.open(image_path)
        # Get the original dimensions
        original_width, original_height = img.size
        # Resize the image to specified dimensions
        img = img.resize((width, height), resample=Image.Resampling.LANCZOS)
        # Convert the image to grayscale
        img = img.convert("L")  # "L" mode for grayscale
        # Save the resized and converted image, overwriting the original image
        img.save(image_path)
        # Get the new dimensions
        new_width, new_height = img.size
        # Print the dimensions
        print(f"Resized {os.path.basename(image_path)} from
→{original_width}x{original_height} to {new_width}x{new_height} pixels.")

    # Recursively iterate over files in the root folder and its subfolders
    for root, dirs, files in os.walk(root_folder):
        for file in files:
            # Check if the file is an image (you can add more image extensions
→if needed)
            if file.lower().endswith(('.png', '.jpg', '.jpeg', '.gif', '.bmp')):
                # Construct the full path to the image file
                image_path = os.path.join(root, file)
                # Process the image (resize and convert to grayscale)
                process_image(image_path, new_width, new_height)

    print(f'\nComplete! All images resized to {new_width}x{new_height} pixels
→and converted to grayscale.')
```

```
Resized grayscale_square_d6fb956ada8728768d0bfeb98402cbb4db0358fa2c0a28966669e77
0d72b75a5.png from 417x417 to 224x224 pixels.
Resized grayscale_square_d1e0164c68c9ee348c437127c3a037d08767e9be5aded7a304bb130
0a4a1aa35.png from 439x439 to 224x224 pixels.
Resized grayscale_square_2452cf5c6fccf361fa27131d9b261a60253eef8b96e6e2f524c85be
ea6488bd0.png from 321x321 to 224x224 pixels.
Resized grayscale_square_a5751a46768149c5ddf318fd75afc66b3db28a5b76254ee0d6ae27b
21712e266.png from 441x441 to 224x224 pixels.
Resized grayscale_square_5c278c04bb19196dc8559d45b9728b3ba0c1bc5cdd20a766f56248e
561c6f5a6.png from 484x484 to 224x224 pixels.
Resized grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43
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d421bb42d.png from 321x321 to 224x224 pixels.
Resized grayscale_square_f7b83f07f6fec1df0fa73c935c96dc2ec8fbe0de3b17bb56f9963c9
2c22715c3.png from 443x443 to 224x224 pixels.
Resized grayscale_square_c67ba4c6e872dbcd2b1281c33fb033f886d8472ea021cf3974a445c
4b804fec2.png from 441x441 to 224x224 pixels.
Resized grayscale_square_DD8652E2DCFE3F1A72631B3A9585736FBE77FFABEE4098F6B3C48E1
469BF27AA.png from 528x528 to 224x224 pixels.
Resized grayscale_square_3AD53495851BAFC48CAF6D2227A434CA2E0BEF9AB3BD40ABFE4EA8F
318D37BBE.png from 506x506 to 224x224 pixels.
Resized grayscale_square_973F573CAB683636D9A70B8891263F59E2F02201FFB4DD2E9D7ECBB
1521DA03E.png from 528x528 to 224x224 pixels.
Resized grayscale_square_3ED21A4BFCF9838E06AD3058D13D5C28026C17DC996953A22A00F06
09B0DF3B9.png from 542x542 to 224x224 pixels.
Resized grayscale_square_31ACF37D180AB9AFBCF6A4EC5D29C3E19C947641A2D9CE3CE56D71C
1F576C069.png from 540x540 to 224x224 pixels.
Resized grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png from 876x876 to
224x224 pixels.
Resized grayscale_square_dce4b1e6a5f9b6d836913013606371ce.png from 831x831 to
224x224 pixels.
Resized grayscale_square_2fa9185ceeb1d25e8bde77a4cf3f70d4.png from 876x876 to
224x224 pixels.
Resized grayscale_square_deb1c7b83dfe3a38de11c81c355b862c.png from 825x825 to
224x224 pixels.
Resized grayscale_square_07e1ed9c60ef84688cb35923166762cff3325e058dff59a65549efc
d22297436.png from 1834x1834 to 224x224 pixels.
Resized grayscale_square_e13fe434eb19987ee1239caae2eca96df2cd2d78dec0f8d414e04b8
56bcf2b2e.png from 1570x1570 to 224x224 pixels.
Resized grayscale_square_9e533c9f14375ca958fadc504b80dd89569a33b70275362bb1b6b6f
9f27d03b8.png from 1354x1354 to 224x224 pixels.
Resized grayscale_square_202ee8b14ac2dff31910820fed613252d813aea22b0151799759883
08c0f1c85.png from 1431x1431 to 224x224 pixels.
Resized grayscale_square_f57fc4857a76fe66cb8eb0bbc9e88d9e70f9de2135d4802c7c18f89
bd92060a9.png from 1585x1585 to 224x224 pixels.
Resized grayscale_square_8c30d08ef7a407fc32e721dd8d8f49260faf0451b41d7be5d61dd89
361fb5d03.png from 2026x2026 to 224x224 pixels.
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b82aeca21.png from 1582x1582 to 224x224 pixels.
Resized grayscale_square_684e6bdced0521344b38a3dbd0ee159a0691ca47a766a3f0ea8ca55
78ed0816d.png from 1909x1909 to 224x224 pixels.
Resized grayscale_square_540F19FF5350E08EFF2C5C4BADA1F01F.png from 181x181 to
224x224 pixels.
Resized grayscale_square_E1BDA5B01D1AD8C0F48177CD6398B15F.png from 214x214 to
224x224 pixels.
Resized grayscale_square_AB0D8F81B65E5288DD6004F2F20280FD.png from 215x215 to
224x224 pixels.
Resized grayscale_square_B2A381FBC544FE69250AD287B55F435B.png from 231x231 to
224x224 pixels.
Resized grayscale_square_9577C1B005673E1406DA41FB07E914BB.png from 295x295 to

224x224 pixels.
Resized grayscale_square_BE8C528A6BFF6668093E9AABE0634197.png from 250x250 to
224x224 pixels.
Resized grayscale_square_4E0BFF23A95E8D02800FECBAC184CD5F.png from 259x259 to
224x224 pixels.
Resized grayscale_square_0E27DF7A010338D554DBA932B94CB11E.png from 212x212 to
224x224 pixels.
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212b25cca.png from 630x630 to 224x224 pixels.
Resized grayscale_square_7cea675f189ce2987119cd5963038b24730c8d04dac36ee14c9b962
8bdd93af8.png from 630x630 to 224x224 pixels.
Resized grayscale_square_fdebe4aca409ff392986086f8eaad120499cb60738c927ec64def14
f330d3b0b.png from 630x630 to 224x224 pixels.
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4d942e53b.png from 630x630 to 224x224 pixels.
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a5438ef51.png from 630x630 to 224x224 pixels.
Resized grayscale_square_bd67c57b7b25c4a288f7253d5d9f4b371c2ec252ac495554108fa26
09fa0242d.png from 630x630 to 224x224 pixels.
Resized grayscale_square_f0eed1b99d5ea1c62d76dee2cb00b6037782a190eb9c17daaad9de0
d44a3ec85.png from 630x630 to 224x224 pixels.
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9f29e7186.png from 508x508 to 224x224 pixels.
Resized grayscale_square_7a26906506d063eb7492775688deeb52b76cffef75cb5879acf3b3c
9565e5c47.png from 381x381 to 224x224 pixels.
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224x224 pixels.
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2dad7c4c4.png from 508x508 to 224x224 pixels.
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E33F1B317.png from 694x694 to 224x224 pixels.
Resized grayscale_square_8bccd411ebd57796b3b592f7db3037eaea7bf8f335cb37925404b2e
f3305e288.png from 382x382 to 224x224 pixels.
Resized grayscale_square_3938e93ce1915e623b3cd470515bc8f0cbd0373d85ddd8992b56780
4059f804b.png from 217x217 to 224x224 pixels.
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443cfd3ca.png from 508x508 to 224x224 pixels.
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74e336914.png from 376x376 to 224x224 pixels.
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5f24cd01a.png from 394x394 to 224x224 pixels.
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1dc310e32.png from 306x306 to 224x224 pixels.
Resized grayscale_square_c4ae927e211fe408801c98892315d2f159a9ab104a2d25ede0e6b3c
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fa4c868fd.png from 1006x1006 to 224x224 pixels.
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251900ce5.png from 399x399 to 224x224 pixels.
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dd67bc23b.png from 376x376 to 224x224 pixels.
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ae7f30971.png from 375x375 to 224x224 pixels.
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22f7ca4e3.png from 267x267 to 224x224 pixels.
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e6062e538.png from 274x274 to 224x224 pixels.
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711b67561.png from 266x266 to 224x224 pixels.
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78684eaf9.png from 275x275 to 224x224 pixels.
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5a3f22a68.png from 315x315 to 224x224 pixels.
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f1c388ab1.png from 266x266 to 224x224 pixels.
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8f5aabcf4.png from 266x266 to 224x224 pixels.
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f4bc3148e.png from 1581x1581 to 224x224 pixels.
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73deb9e68.png from 336x336 to 224x224 pixels.
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ded83e7aa.png from 367x367 to 224x224 pixels.
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697994966.png from 1580x1580 to 224x224 pixels.
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F78F8955F.png from 861x861 to 224x224 pixels.
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992242E29.png from 855x855 to 224x224 pixels.
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FD66AEFA2.png from 855x855 to 224x224 pixels.
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F20C7CD2C.png from 854x854 to 224x224 pixels.
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A12AD7AD1.png from 862x862 to 224x224 pixels.
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AF1D9479B.png from 862x862 to 224x224 pixels.
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EF15A6683.png from 855x855 to 224x224 pixels.
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c43a98808.png from 607x607 to 224x224 pixels.
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b7c876de2.png from 528x528 to 224x224 pixels.
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891009d65.png from 546x546 to 224x224 pixels.
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67fc0fd2c.png from 701x701 to 224x224 pixels.
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297d81100.png from 886x886 to 224x224 pixels.
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0ef3212a9.png from 546x546 to 224x224 pixels.
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224x224 pixels.
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224x224 pixels.
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224x224 pixels.
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302c89b48.png from 252x252 to 224x224 pixels.
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e22b0ae60.png from 245x245 to 224x224 pixels.
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b2ec1e5fc.png from 1325x1325 to 224x224 pixels.
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52ff64281.png from 603x603 to 224x224 pixels.
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a30cc1846.png from 1276x1276 to 224x224 pixels.
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b19940812.png from 1585x1585 to 224x224 pixels.
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2c853f115.png from 1571x1571 to 224x224 pixels.
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5260a0911.png from 1347x1347 to 224x224 pixels.
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bd9e8601b.png from 422x422 to 224x224 pixels.
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afbc87b2e.png from 279x279 to 224x224 pixels.
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e71170efe.png from 374x374 to 224x224 pixels.
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Resized grayscale_square_fe40e5c6244c7e0a256689b6ea0881998fef897cece79a2add3ba8f
7a23f4f2b.png from 524x524 to 224x224 pixels.
Resized grayscale_square_42088f0e3e9c70b7d1d238f7e3b03a3ca177748ba2568adba9104bb
ed2827734.png from 607x607 to 224x224 pixels.
Resized grayscale_square_84d9ef8cb92d57b178cce655f3f7808c6f5cf42f15c468f741b253f
37ffc39fc.png from 528x528 to 224x224 pixels.
Resized grayscale_square_b01a96892f3efdaa6682078339b23d8954d571c27ee15a4ce9ef8ad
6c415f06d.png from 704x704 to 224x224 pixels.
Resized grayscale_square_bb382bbc0756832748b33f0d7f7ec218d570afa031937259e69237d
f4945d074.png from 566x566 to 224x224 pixels.
Resized grayscale_square_5ccee068daf8a672d0e63e334e00985aa7fe56aa26b6c036d562728
fdf968237.png from 692x692 to 224x224 pixels.
Resized grayscale_square_15d7342be36d20ce615647fac9c2277f46b6d19aa54f3cf3d99e49d
6ce0486d0.png from 697x697 to 224x224 pixels.
Resized grayscale_square_c7c04bcd56f282bc27f160cc80ccab73485dd3123f2efb35b9726a8
528b7950f.png from 642x642 to 224x224 pixels.
Resized grayscale_square_065208b037a2691eb75a14f97bdbd9914122655d42f6249d2cca419
a1e4ba6f1.png from 642x642 to 224x224 pixels.
Resized grayscale_square_567cb1d95c5b0701bc9a5b06842f9a675a592749cebcace5e7d62e6
26b2354d1.png from 638x638 to 224x224 pixels.
Resized grayscale_square_26cb76e67add724d7771d12ffc701a4806c71dc436ff7d6ed0288e8

```
99dfd0d9b.png from 637x637 to 224x224 pixels.
Resized grayscale_square_6a4ebf513f996bd7198c711bef936a989fea148c235817ea56c1e2a
fafa927f5.png from 658x658 to 224x224 pixels.
Resized grayscale_square_15a290552f9cdc38b18e6c0babe7fdd52ff8abfa73ff823220fa994
e7f023dc0.png from 637x637 to 224x224 pixels.
Resized grayscale_square_9b68f6082702082205344baf6812469cf2ef20345acb6b6a94022fe
ebb087c43.png from 638x638 to 224x224 pixels.
Resized grayscale_square_1841ca56006417e6220a857f66c8e6539502d5e9f539cf337b83a25
c15d17a50.png from 656x656 to 224x224 pixels.

Complete! All images resized to 224x224 pixels and converted to grayscale.
```

11 Import images

```python
[12]: original_image_list = Load_Data().from_folder([extract_to])

      # sort list
      image_list = sorted(original_image_list, key=lambda x: x.lower())

      # create dictionary of path to image index
      dict_path_to_image_index = dict()

      # create reverse path to family name lookup
      dict_family_from_path = dict()

      # create dictionary of unique families
      dict_unique_families = dict()

      for i in range(len(image_list)):
          print(f'[{i}]\t{image_list[i]}')
          dict_path_to_image_index[image_list[i]] = i

          # extract unique family name - list of paths for each family
          family_name = image_list[i][len(extract_to):]
          if family_name.startswith(os.sep):
              family_name = family_name[1:]
          family_name = family_name[:family_name.index(os.sep)].strip()

          if not family_name in dict_unique_families:
              dict_unique_families[family_name] = list()
          # append entry
          dict_unique_families[family_name].append(image_list[i])

          # store in reverse loopup dict as well
          dict_family_from_path[image_list[i]] = family_name
```

[0]   ./grayscale/7ev3n/grayscale_square_66e1592e69420d6046dfc44ac8d9c45e9f563
fb533cdc13d9565ae6a5438ef51.png
[1]   ./grayscale/7ev3n/grayscale_square_7cea675f189ce2987119cd5963038b24730c8
d04dac36ee14c9b9628bdd93af8.png
[2]   ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9
b1d6c3c358bf33f1e64d942e53b.png
[3]   ./grayscale/7ev3n/grayscale_square_bd67c57b7b25c4a288f7253d5d9f4b371c2ec
252ac495554108fa2609fa0242d.png
[4]   ./grayscale/7ev3n/grayscale_square_ca97d1b9ec53b7d4d860d1440802b4f8d0491
f839463325e8104993212b25cca.png
[5]   ./grayscale/7ev3n/grayscale_square_f0eed1b99d5ea1c62d76dee2cb00b6037782a
190eb9c17daaad9de0d44a3ec85.png
[6]   ./grayscale/7ev3n/grayscale_square_fdebe4aca409ff392986086f8eaad120499cb
60738c927ec64def14f330d3b0b.png
[7]   ./grayscale/9002Rat/grayscale_square_09e58c7bc6edef6dff730c06962d1815ddf
d2324412c7cade4af5f01df70dfd4.png
[8]   ./grayscale/9002Rat/grayscale_square_1442877711143210fc930295ceb55eb711c
692bd0cb7cf6ab709be2af4ef0f74.png
[9]   ./grayscale/9002Rat/grayscale_square_3124fcb79da0bdf9d0d1995e37b06f7929d
83c1c4b60e38c104743be71170efe.png
[10]   ./grayscale/9002Rat/grayscale_square_56d5fd3de23fd1aefc30dd3fa9b38767ca1
2099a62d4745859edfe0bd9e8601b.png
[11]   ./grayscale/9002Rat/grayscale_square_b5817f0a289c55f52647a2b6925578370d4
bb91dbc89056673dc07197c7e4621.png
[12]   ./grayscale/9002Rat/grayscale_square_c95d38d92f81e8d0fe6a664f6aa0cb10019
16715e51b25efd85f192afbc87b2e.png
[13]   ./grayscale/AgentTesla/grayscale_square_0e11704fcc3c36832ba98b80ea44a301
3660d1ed3fb48158b982fed9f9050391.png
[14]
./grayscale/AgentTesla/grayscale_square_1559eb5515eb732de889dcdff24662c9.png
[15]
./grayscale/AgentTesla/grayscale_square_19116e822e8178fc103e51fe18c825a4.png
[16]
./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png
[17]
./grayscale/AgentTesla/grayscale_square_5b14a7366cf5dbea3386c6afbd25f012.png
[18]
./grayscale/AgentTesla/grayscale_square_81afa08f1a1acfa3fd9f52ecadda2f55.png
[19]
./grayscale/AgentTesla/grayscale_square_bc9f0c07dfe0016049662acbafe3c96f.png
[20]
./grayscale/AgentTesla/grayscale_square_f8efaa5826c602395a6317abb2905a25.png
[21]   ./grayscale/Bankshot/grayscale_square_56a6a4a16cbe7692ab3e36fbb181c2c961
4ea06065ba2316395c6196cf3a5d1f.png
[22]   ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e89
74770258c440d398dcafe3d4ddd8a5.png
[23]   ./grayscale/Bankshot/grayscale_square_9e74ffcd50b75d36850637e0c1bca2d976
1e9c1ada63712e862db346bca68b35.png

[24]   ./grayscale/Bizarro/grayscale_square_07e1ed9c60ef84688cb35923166762cff33
25e058dff59a65549efcd22297436.png
[25]   ./grayscale/Bizarro/grayscale_square_202ee8b14ac2dff31910820fed613252d81
3aea22b015179975988308c0f1c85.png
[26]   ./grayscale/Bizarro/grayscale_square_261b9e4b576b1d2a1c4ce44a4b48cd77698
1e392615c8ee5556c066b82aeca21.png
[27]   ./grayscale/Bizarro/grayscale_square_684e6bdced0521344b38a3dbd0ee159a069
1ca47a766a3f0ea8ca5578ed0816d.png
[28]   ./grayscale/Bizarro/grayscale_square_8c30d08ef7a407fc32e721dd8d8f49260fa
f0451b41d7be5d61dd89361fb5d03.png
[29]   ./grayscale/Bizarro/grayscale_square_9e533c9f14375ca958fadc504b80dd89569
a33b70275362bb1b6b6f9f27d03b8.png
[30]   ./grayscale/Bizarro/grayscale_square_e13fe434eb19987ee1239caae2eca96df2c
d2d78dec0f8d414e04b856bcf2b2e.png
[31]   ./grayscale/Bizarro/grayscale_square_f57fc4857a76fe66cb8eb0bbc9e88d9e70f
9de2135d4802c7c18f89bd92060a9.png
[32]   ./grayscale/BruteRatel/grayscale_square_31ACF37D180AB9AFBCF6A4EC5D29C3E1
9C947641A2D9CE3CE56D71C1F576C069.png
[33]   ./grayscale/BruteRatel/grayscale_square_3AD53495851BAFC48CAF6D2227A434CA
2E0BEF9AB3BD40ABFE4EA8F318D37BBE.png
[34]   ./grayscale/BruteRatel/grayscale_square_3ED21A4BFCF9838E06AD3058D13D5C28
026C17DC996953A22A00F0609B0DF3B9.png
[35]   ./grayscale/BruteRatel/grayscale_square_973F573CAB683636D9A70B8891263F59
E2F02201FFB4DD2E9D7ECBB1521DA03E.png
[36]   ./grayscale/BruteRatel/grayscale_square_DD8652E2DCFE3F1A72631B3A9585736F
BE77FFABEE4098F6B3C48E1469BF27AA.png
[37]   ./grayscale/CobaltStrike/grayscale_square_132bdcb986e3e3b9599b5b293b3318
e7c630495e87a9d1fa02287ae80f9e652f.png
[38]   ./grayscale/CobaltStrike/grayscale_square_2160af903da06c25c2f6426931d20e
b7e7a8ea6f9951e144188027252ff64281.png
[39]   ./grayscale/CobaltStrike/grayscale_square_7c2ea97f8fff301a03f36fb6b87d08
dc81e948440c87c2805b9e4622eb4e1991.png
[40]   ./grayscale/CobaltStrike/grayscale_square_83f06213409abbf39756e856aea050
e2b7b40b0c488ac6b966b15cbb2ec1e5fc.png
[41]   ./grayscale/CobaltStrike/grayscale_square_e59cc3a94f6a5119f36c4e0b3fbe6f
04cc474d0b0b9d101163dac75722c809da.png
[42]   ./grayscale/Conti/grayscale_square_2452cf5c6fccf361fa27131d9b261a60253ee
f8b96e6e2f524c85beea6488bd0.png
[43]   ./grayscale/Conti/grayscale_square_5c278c04bb19196dc8559d45b9728b3ba0c1b
c5cdd20a766f56248e561c6f5a6.png
[44]   ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede0
5a15ab75870c0fdb43d421bb42d.png
[45]   ./grayscale/Conti/grayscale_square_a5751a46768149c5ddf318fd75afc66b3db28
a5b76254ee0d6ae27b21712e266.png
[46]   ./grayscale/Conti/grayscale_square_c67ba4c6e872dbcd2b1281c33fb033f886d84
72ea021cf3974a445c4b804fec2.png
[47]   ./grayscale/Conti/grayscale_square_d1e0164c68c9ee348c437127c3a037d08767e
9be5aded7a304bb1300a4a1aa35.png

[48]   ./grayscale/Conti/grayscale_square_d6fb956ada8728768d0bfeb98402cbb4db035
8fa2c0a28966669e770d72b75a5.png
[49]   ./grayscale/Conti/grayscale_square_f7b83f07f6fec1df0fa73c935c96dc2ec8fbe
0de3b17bb56f9963c92c22715c3.png
[50]
./grayscale/CryptBot/grayscale_square_2fa9185ceeb1d25e8bde77a4cf3f70d4.png
[51]
./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png
[52]
./grayscale/CryptBot/grayscale_square_dce4b1e6a5f9b6d836913013606371ce.png
[53]
./grayscale/CryptBot/grayscale_square_deb1c7b83dfe3a38de11c81c355b862c.png
[54]   ./grayscale/Darkside/grayscale_square_06cfe7f5d88e82f7adda6d8333ca8b302d
ebb22904c68a942188be5730e9b3c8.png
[55]   ./grayscale/Darkside/grayscale_square_1b9d3728a2c489d4166e8752525c88cf53
2db6409cf1147d6955ab4302c89b48.png
[56]   ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0f
ce29768f345c88ee10699e22b0ae60.png
[57]   ./grayscale/Darkside/grayscale_square_508dd6f7ed6c143cf5e1ed6a4051dd8ee7
b5bf4b7f55e0704d21ba785f2d5add.png
[58]   ./grayscale/Darkside/grayscale_square_6057380a9a613b3c2b8a2f68b3bd8096e0
5adfc2523f5117c4112b19d4848c6d.png
[59]   ./grayscale/Darkside/grayscale_square_ac092962654b46a670b030026d07f5b816
1cecd2abd6eece52b7892965aa521b.png
[60]   ./grayscale/Darkside/grayscale_square_cc54647e8c3fe7b701d78a6fa072c52641
ac11d395a6d2ffaf05f38f53112556.png
[61]   ./grayscale/Darkside/grayscale_square_da3bb9669fb983ad8d2ffc01aab9d56198
bd9cedf2cc4387f19f4604a070a9b5.png
[62]   ./grayscale/Emotet/grayscale_square_0d20b337979060e2b6a97b9a5fc12dde9ef8
da4f892eaf84773cef7443cfd3ca.png
[63]   ./grayscale/Emotet/grayscale_square_3938e93ce1915e623b3cd470515bc8f0cbd0
373d85ddd8992b567804059f804b.png
[64]   ./grayscale/Emotet/grayscale_square_4f1ad98961cb624301026626251e2a1eaaf8
6a0f51fe22f2ccc1d399f29e7186.png
[65]   ./grayscale/Emotet/grayscale_square_70018479833728926d0e38386f5de35c19b4
dffb47d77befb99a4012dad7c4c4.png
[66]   ./grayscale/Emotet/grayscale_square_7a26906506d063eb7492775688deeb52b76c
ffef75cb5879acf3b3c9565e5c47.png
[67]   ./grayscale/Emotet/grayscale_square_8137acbd9d993e6a15e579381176995c.png
[68]   ./grayscale/Emotet/grayscale_square_8bccd411ebd57796b3b592f7db3037eaea7b
f8f335cb37925404b2ef3305e288.png
[69]   ./grayscale/Emotet/grayscale_square_CB5D0451582313831775C542C874C2FAE664
CF090646987895E5645E33F1B317.png
[70]   ./grayscale/Enemybot/grayscale_square_0801d8f5c028457b5bad66917d39d17471
659eb522c5813f893c76bf4bc3148e.png
[71]   ./grayscale/Enemybot/grayscale_square_31a9c513a5292912720a4bcc6bd4918fc7
afcd4a0b60ef9822f5c7bd861c19b8.png
[72]   ./grayscale/Enemybot/grayscale_square_336008e2b7f2bf194a44984b36d0594d03

103e3636540273eed82c01af407001.png

[73]   ./grayscale/Enemybot/grayscale_square_6a7242683122a3d4507bb0f0b6e7abf8ac
ef4b5ab8ecf11c4b0ebdbded83e7aa.png

[74]   ./grayscale/Enemybot/grayscale_square_7a2a5da50e87bb413375ecf12b0be71aea
4e21120c0c2447d678ef73c88b3ba0.png

[75]   ./grayscale/Enemybot/grayscale_square_8e711f38a80a396bd4dacef1dc9ff6c8e3
2b9b6d37075cea2bbef6973deb9e68.png

[76]   ./grayscale/Enemybot/grayscale_square_97684ae157687ede7bf91bebe6d495da66
e8496c0c273255a8e6134697994966.png

[77]   ./grayscale/Enemybot/grayscale_square_f36ade94ba4261fdff37d53c7d7c493537
4d9263ec4fe92d2bb6c1def5f0783f.png

[78]
./grayscale/FakeDivX/grayscale_square_0E27DF7A010338D554DBA932B94CB11E.png

[79]
./grayscale/FakeDivX/grayscale_square_4E0BFF23A95E8D02800FECBAC184CD5F.png

[80]
./grayscale/FakeDivX/grayscale_square_540F19FF5350E08EFF2C5C4BADA1F01F.png

[81]
./grayscale/FakeDivX/grayscale_square_9577C1B005673E1406DA41FB07E914BB.png

[82]
./grayscale/FakeDivX/grayscale_square_AB0D8F81B65E5288DD6004F2F20280FD.png

[83]
./grayscale/FakeDivX/grayscale_square_B2A381FBC544FE69250AD287B55F435B.png

[84]
./grayscale/FakeDivX/grayscale_square_BE8C528A6BFF6668093E9AABE0634197.png

[85]
./grayscale/FakeDivX/grayscale_square_E1BDA5B01D1AD8C0F48177CD6398B15F.png

[86]   ./grayscale/gameover/grayscale_square_13c5b33339522f8f96d091708e7a8a64b0
939daa6225732352fbe44cb2950e67.png

[87]   ./grayscale/gameover/grayscale_square_532efdeecae3b32d83f032a1a69c28b5f4
d2f2d8ebaeeaf54eda57a67fc0fd2c.png

[88]   ./grayscale/gameover/grayscale_square_6af396928548eca6d87552918a94ed47e6
00dd11a7693bbb18e0949096ac2dee.png

[89]   ./grayscale/gameover/grayscale_square_76ea56f0200d7138016794926eebb2a477
cf2b1bd01eafbf4c2404eb7c876de2.png

[90]   ./grayscale/gameover/grayscale_square_86bcfce2dd342e9a1c04cfc65731d40ed1
c397a4ec47bd9f5b41771297d81100.png

[91]   ./grayscale/gameover/grayscale_square_da286c05353e0dc14d8a18043f9ccb4df6
de18f52f9942f355382ec0ef3212a9.png

[92]   ./grayscale/gameover/grayscale_square_dbcdef61ed483295ae58d02bc83d11d258
5443f2014d329fa8b0318891009d65.png

[93]   ./grayscale/gameover/grayscale_square_efe94c134ed00c0459ff93c291faddabcd
f5cf1f7db0594dda95df6c43a98808.png

[94]   ./grayscale/GrandCrab/grayscale_square_0aeed4dce2f18f8712d965779dad1f521
e4f18bf0a503a65d46dd5d8f5aabcf4.png

[95]   ./grayscale/GrandCrab/grayscale_square_1e57e9a0abcecb7605830f6b1303f2270
1f61defdd72a4e315ca9c9e6062e538.png

[96]   ./grayscale/GrandCrab/grayscale_square_272717dbd9b744fb8bb47cc23860d9acf

0206f5e391516af874a4bcf1c388ab1.png

[97]　　./grayscale/GrandCrab/grayscale_square_559a4aec9408e3394f5fa230bb98f769e
956d12ccd4c5eedd60b84fa2e6bc840.png

[98]　　./grayscale/GrandCrab/grayscale_square_892134ff6db36931061b8fde26f295404
f2db266a6ae54849ce64b378684eaf9.png

[99]　　./grayscale/GrandCrab/grayscale_square_98aecdf0cf3fe7ba1eba8d8a450d2f361
86f062718b10fbcf920bcd711b67561.png

[100]　　./grayscale/GrandCrab/grayscale_square_9c26bf75f4c9a260b325ef09bd3f67e21
65f543e26c3ddf9af38cc822f7ca4e3.png

[101]　　./grayscale/GrandCrab/grayscale_square_e844831cad1b1b0151d4bb349a2197270
a0fe4302589afb7f03a33a5a3f22a68.png

[102]　　./grayscale/HiveRansomware/grayscale_square_065208b037a2691eb75a14f97bdb
d9914122655d42f6249d2cca419a1e4ba6f1.png

[103]　　./grayscale/HiveRansomware/grayscale_square_15a290552f9cdc38b18e6c0babe7
fdd52ff8abfa73ff823220fa994e7f023dc0.png

[104]　　./grayscale/HiveRansomware/grayscale_square_1841ca56006417e6220a857f66c8
e6539502d5e9f539cf337b83a25c15d17a50.png

[105]　　./grayscale/HiveRansomware/grayscale_square_26cb76e67add724d7771d12ffc70
1a4806c71dc436ff7d6ed0288e899dfd0d9b.png

[106]　　./grayscale/HiveRansomware/grayscale_square_567cb1d95c5b0701bc9a5b06842f
9a675a592749cebcace5e7d62e626b2354d1.png

[107]　　./grayscale/HiveRansomware/grayscale_square_6a4ebf513f996bd7198c711bef93
6a989fea148c235817ea56c1e2afafa927f5.png

[108]　　./grayscale/HiveRansomware/grayscale_square_9b68f6082702082205344baf6812
469cf2ef20345acb6b6a94022feebb087c43.png

[109]　　./grayscale/HiveRansomware/grayscale_square_c7c04bcd56f282bc27f160cc80cc
ab73485dd3123f2efb35b9726a8528b7950f.png

[110]　　./grayscale/KrakenGoBotnet/grayscale_square_0f0cabb24d8cc93e5aed340cfc49
2c4008509f1e84311d61721a4375260a0911.png

[111]　　./grayscale/KrakenGoBotnet/grayscale_square_1d772f707ce74473996c377477ad
718bba495fe7cd022d5b802aaf32c853f115.png

[112]　　./grayscale/KrakenGoBotnet/grayscale_square_43f46a66c821e143d77f9311b243
14b5c5eeccfedbb3fbf1cd484c9e4f537a5d.png

[113]　　./grayscale/KrakenGoBotnet/grayscale_square_48c2f53f1eeb669fadb3eec46f7f
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[114]　　./grayscale/KrakenGoBotnet/grayscale_square_7c76ca5eb757df4362fabb8cff1d
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[115]　　./grayscale/KrakenGoBotnet/grayscale_square_d742a33692a77f5caef5ea175957
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[116]　　./grayscale/KrakenGoBotnet/grayscale_square_ddf039c3d6395139fd7f31b0a796
a444f385c582ca978779aae7314b19940812.png

[117]　　./grayscale/LokiLockerRansomware/grayscale_square_15d7342be36d20ce615647
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[118]　　./grayscale/LokiLockerRansomware/grayscale_square_42088f0e3e9c70b7d1d238
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[119]　　./grayscale/LokiLockerRansomware/grayscale_square_5ccee068daf8a672d0e63e
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[124]   ./grayscale/LokiLockerRansomware/grayscale_square_fe40e5c6244c7e0a256689b6ea0881998fef897cece79a2add3ba8f7a23f4f2b.png
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[129]   ./grayscale/Mirai/grayscale_square_a6a7e46bd0e9ec67a1adec64af8fddee18ce019f731ee9cbf8341b35b2519dd9.png
[130]   ./grayscale/Mirai/grayscale_square_cebe20a3e4eb38e9e37b995cf0d8f749.png
[131]   ./grayscale/Mirai/grayscale_square_df7ccd512ed6a321205a5465fabf734d.png
[132]   ./grayscale/Mirai/grayscale_square_f805f22f668bd0414497ddc061e021c5b80b80c9702053d72fc809f19307073b.png
[133]   ./grayscale/Virlock/grayscale_square_0FC1F0925FACCDDBD8521E4962E9A80B87A8876782A961D4B0C6B7CA12AD7AD1.png
[134]   ./grayscale/Virlock/grayscale_square_4E75C9818D97298C542E05B4EB870C78658DC21D816CA6370DA45C0FD66AEFA2.png
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[137]   ./grayscale/Virlock/grayscale_square_92A7631FBEB2E8E28914C7BF8D0498571323009720643CDD63803BCAF1D9479B.png
[138]   ./grayscale/Virlock/grayscale_square_A860C914817665798A022CCE3C0725BE0428E7433414A1CF207A608F78F8955F.png
[139]   ./grayscale/Virlock/grayscale_square_CBFB54371620E4BD2BAB45B5C7AD91D3D896BC6324F621B1FB7457F43E3AEB82.png
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[146]   ./grayscale/Zeus/grayscale_square_3715907255600507abee3e855c0c47269a9fb0eca9cfc9505cc3ff51dc310e32.png
[147]   ./grayscale/Zeus/grayscale_square_385319c04e4ae7036da4adfc8e518280940861

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[153]   ./grayscale/Zeus/grayscale_square_f804e6d969529af3f52ed4b563164fc5701360
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12   View Images labeled to each class

```
[13]: print('malware paths per family:␣
      ↪\n==============================================')
      pprint(dict_unique_families)
```

```
malware paths per family:
==============================================
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                     './grayscale/KrakenGoBotnet/grayscale_square_d742a33692a77f5
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                           './grayscale/LokiLockerRansomware/grayscale_square_b01
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                           './grayscale/LokiLockerRansomware/grayscale_square_fe4
0e5c6244c7e0a256689b6ea0881998fef897cece79a2add3ba8f7a23f4f2b.png'],
 'Mirai':
```

```
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 './grayscale/Mirai/grayscale_square_78e563f06b1fcf509a3da092645b5f59.png',
 './grayscale/Mirai/grayscale_square_7D2C1F3D81A2DF7BEEA99552D0704C2D.png',
          './grayscale/Mirai/grayscale_square_a6a7e46bd0e9ec67a1adec64af8fddee1
8ce019f731ee9cbf8341b35b2519dd9.png',
 './grayscale/Mirai/grayscale_square_cebe20a3e4eb38e9e37b995cf0d8f749.png',
 './grayscale/Mirai/grayscale_square_df7ccd512ed6a321205a5465fabf734d.png',
          './grayscale/Mirai/grayscale_square_f805f22f668bd0414497ddc061e021c5b
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             './grayscale/Virlock/grayscale_square_CBFB54371620E4BD2BAB45B5C7AD9
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             './grayscale/Virlock/grayscale_square_E95D6D0DDB67A70A2C52D9729E2B3
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 'WinMM': ['./grayscale/WinMM/grayscale_square_5880001cbee1a67fd3e898d38dbe14e97
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 'Zeus': ['./grayscale/Zeus/grayscale_square_3715907255600507abee3e855c0c47269a9
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          './grayscale/Zeus/grayscale_square_9d490b59563bddf957ff07fe8c4a0806b6b
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          './grayscale/Zeus/grayscale_square_adddb74a585d301eceb4deeeafdb69ffc32
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          './grayscale/Zeus/grayscale_square_c4ae927e211fe408801c98892315d2f159a
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          './grayscale/Zeus/grayscale_square_ce5d359c2f5cb64f9678527aea6d9830d0a
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```

```
                  './grayscale/Zeus/grayscale_square_f0ea1d50f03d5eb0f86dc8a7ed087e821b5
     4f47f6bc112a6b62442974e336914.png',
                  './grayscale/Zeus/grayscale_square_f804e6d969529af3f52ed4b563164fc5701
     36098fa955cdeb210f8bfa4c868fd.png'],
       'gameover': ['./grayscale/gameover/grayscale_square_13c5b33339522f8f96d091708e7
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     c28b5f4d2f2d8ebaeeaf54eda57a67fc0fd2c.png',
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     4ed47e600dd11a7693bbb18e0949096ac2dee.png',
                  './grayscale/gameover/grayscale_square_76ea56f0200d7138016794926ee
     bb2a477cf2b1bd01eafbf4c2404eb7c876de2.png',
                  './grayscale/gameover/grayscale_square_86bcfce2dd342e9a1c04cfc6573
     1d40ed1c397a4ec47bd9f5b41771297d81100.png',
                  './grayscale/gameover/grayscale_square_da286c05353e0dc14d8a18043f9
     ccb4df6de18f52f9942f355382ec0ef3212a9.png',
                  './grayscale/gameover/grayscale_square_dbcdef61ed483295ae58d02bc83
     d11d2585443f2014d329fa8b0318891009d65.png',
                  './grayscale/gameover/grayscale_square_efe94c134ed00c0459ff93c291f
     addabcdf5cf1f7db0594dda95df6c43a98808.png']}
```

```
[14]: print("Total Image Count:", len(image_list))
      print("Samples:")
      pprint(image_list[:5])
```

```
Total Image Count: 154
Samples:
['./grayscale/7ev3n/grayscale_square_66e1592e69420d6046dfc44ac8d9c45e9f563fb533c
dc13d9565ae6a5438ef51.png',
 './grayscale/7ev3n/grayscale_square_7cea675f189ce2987119cd5963038b24730c8d04dac
36ee14c9b9628bdd93af8.png',
 './grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3
c358bf33f1e64d942e53b.png',
 './grayscale/7ev3n/grayscale_square_bd67c57b7b25c4a288f7253d5d9f4b371c2ec252ac4
95554108fa2609fa0242d.png',
 './grayscale/7ev3n/grayscale_square_ca97d1b9ec53b7d4d860d1440802b4f8d0491f83946
3325e8104993212b25cca.png']
```

13 List possible CNN Image Search Models

```
[15]: # Get a list of pretrained models
      pretrained_models = timm.list_models(pretrained=True)  # You can set to False
       ↪to initialize training from scratch

      # Print the count of pretrained models
      print(f'Count of pretrained models: {len(pretrained_models)}')
```

```python
# Print models in 3 columns
num_columns = 3

# Calculate the number of rows needed
num_rows = (len(pretrained_models) + num_columns - 1) // num_columns

# Print the models in a grid with indices
print("\nPretrained models:")
for i in range(num_rows):
    row_models = pretrained_models[i * num_columns:(i + 1) * num_columns]

    # Enumerate models and format with index
    formatted_models = [f"[{i * num_columns + j + 1}] {model: <45}" for j,
 ↪model in enumerate(row_models)]

    # Print each row
    print("  ".join(formatted_models))
```

Count of pretrained models: 1457

Pretrained models:
[1] bat_resnext26ts.ch_in1k   [2]
beit_base_patch16_224.in22k_ft_in22k   [3]
beit_base_patch16_224.in22k_ft_in22k_in1k
[4] beit_base_patch16_384.in22k_ft_in22k_in1k   [5]
beit_large_patch16_224.in22k_ft_in22k   [6]
beit_large_patch16_224.in22k_ft_in22k_in1k
[7] beit_large_patch16_384.in22k_ft_in22k_in1k   [8]
beit_large_patch16_512.in22k_ft_in22k_in1k   [9]
beitv2_base_patch16_224.in1k_ft_in1k
[10] beitv2_base_patch16_224.in1k_ft_in22k   [11]
beitv2_base_patch16_224.in1k_ft_in22k_in1k   [12]
beitv2_large_patch16_224.in1k_ft_in1k
[13] beitv2_large_patch16_224.in1k_ft_in22k   [14]
beitv2_large_patch16_224.in1k_ft_in22k_in1k   [15] botnet26t_256.c1_in1k
[16] caformer_b36.sail_in1k   [17]
caformer_b36.sail_in1k_384   [18] caformer_b36.sail_in22k
[19] caformer_b36.sail_in22k_ft_in1k   [20]
caformer_b36.sail_in22k_ft_in1k_384   [21] caformer_m36.sail_in1k
[22] caformer_m36.sail_in1k_384   [23] caformer_m36.sail_in22k
[24] caformer_m36.sail_in22k_ft_in1k
[25] caformer_m36.sail_in22k_ft_in1k_384   [26] caformer_s18.sail_in1k
[27] caformer_s18.sail_in1k_384
[28] caformer_s18.sail_in22k   [29]
caformer_s18.sail_in22k_ft_in1k   [30]
caformer_s18.sail_in22k_ft_in1k_384
[31] caformer_s36.sail_in1k   [32]

```
caformer_s36.sail_in1k_384
[33] caformer_s36.sail_in22k
[34] caformer_s36.sail_in22k_ft_in1k
[35]
caformer_s36.sail_in22k_ft_in1k_384
[36] cait_m36_384.fb_dist_in1k
[37] cait_m48_448.fb_dist_in1k
[38]
cait_s24_224.fb_dist_in1k
[39] cait_s24_384.fb_dist_in1k
[40] cait_s36_384.fb_dist_in1k
[41]
cait_xs24_384.fb_dist_in1k
[42] cait_xxs24_224.fb_dist_in1k
[43] cait_xxs24_384.fb_dist_in1k
[44]
cait_xxs36_224.fb_dist_in1k
[45] cait_xxs36_384.fb_dist_in1k
[46] coat_lite_medium.in1k
[47]
coat_lite_medium_384.in1k
[48] coat_lite_mini.in1k
[49] coat_lite_small.in1k
[50] coat_lite_tiny.in1k
[51] coat_mini.in1k
[52] coat_small.in1k
[53] coat_tiny.in1k
[54] coatnet_0_rw_224.sw_in1k
[55] coatnet_1_rw_224.sw_in1k
[56]
coatnet_2_rw_224.sw_in12k
[57]
coatnet_2_rw_224.sw_in12k_ft_in1k
[58] coatnet_3_rw_224.sw_in12k
[59]
coatnet_bn_0_rw_224.sw_in1k
[60] coatnet_nano_rw_224.sw_in1k
[61] coatnet_rmlp_1_rw2_224.sw_in12k
[62]
coatnet_rmlp_1_rw2_224.sw_in12k_ft_in1k
[63]
coatnet_rmlp_1_rw_224.sw_in1k
[64] coatnet_rmlp_2_rw_224.sw_in1k
[65]
coatnet_rmlp_2_rw_224.sw_in12k
[66]
coatnet_rmlp_2_rw_224.sw_in12k_ft_in1k
[67] coatnet_rmlp_2_rw_384.sw_in12k_ft_in1k
[68]
coatnet_rmlp_nano_rw_224.sw_in1k
[69] coatnext_nano_rw_224.sw_in1k
[70] convformer_b36.sail_in1k
[71]
convformer_b36.sail_in1k_384
[72] convformer_b36.sail_in22k
[73] convformer_b36.sail_in22k_ft_in1k
[74]
convformer_b36.sail_in22k_ft_in1k_384
[75] convformer_m36.sail_in1k
[76] convformer_m36.sail_in1k_384
[77]
convformer_m36.sail_in22k
[78]
convformer_m36.sail_in22k_ft_in1k
[79] convformer_m36.sail_in22k_ft_in1k_384
[80]
convformer_s18.sail_in1k
[81] convformer_s18.sail_in1k_384
[82] convformer_s18.sail_in22k
[83]
convformer_s18.sail_in22k_ft_in1k
[84]
convformer_s18.sail_in22k_ft_in1k_384
[85] convformer_s36.sail_in1k
[86]
convformer_s36.sail_in1k_384
[87] convformer_s36.sail_in22k
[88] convformer_s36.sail_in22k_ft_in1k
[89]
convformer_s36.sail_in22k_ft_in1k_384
[90] convit_base.fb_in1k
[91] convit_small.fb_in1k
[92] convit_tiny.fb_in1k
[93] convmixer_768_32.in1k
[94] convmixer_1024_20_ks9_p14.in1k
[95] convmixer_1536_20.in1k
[96] convnext_atto.d2_in1k
```

[97] convnext_atto_ols.a2_in1k   [98] convnext_base.clip_laion2b   [99] convnext_base.clip_laion2b_augreg
[100] convnext_base.clip_laion2b_augreg_ft_in1k   [101] convnext_base.clip_laion2b_augreg_ft_in12k   [102] convnext_base.clip_laion2b_augreg_ft_in12k_in1k
[103] convnext_base.clip_laion2b_augreg_ft_in12k_in1k_384 [104] convnext_base.clip_laiona   [105] convnext_base.clip_laiona_320
[106] convnext_base.clip_laiona_augreg_320   [107] convnext_base.clip_laiona_augreg_ft_in1k_384   [108] convnext_base.fb_in1k
[109] convnext_base.fb_in22k   [110] convnext_base.fb_in22k_ft_in1k   [111] convnext_base.fb_in22k_ft_in1k_384
[112] convnext_femto.d1_in1k   [113] convnext_femto_ols.d1_in1k   [114] convnext_large.fb_in1k
[115] convnext_large.fb_in22k   [116] convnext_large.fb_in22k_ft_in1k   [117] convnext_large.fb_in22k_ft_in1k_384
[118] convnext_large_mlp.clip_laion2b_augreg   [119] convnext_large_mlp.clip_laion2b_augreg_ft_in1k   [120] convnext_large_mlp.clip_laion2b_augreg_ft_in1k_384
[121] convnext_large_mlp.clip_laion2b_augreg_ft_in12k_384 [122] convnext_large_mlp.clip_laion2b_ft_320   [123] convnext_large_mlp.clip_laion2b_ft_soup_320
[124] convnext_large_mlp.clip_laion2b_soup_ft_in12k_320 [125] convnext_large_mlp.clip_laion2b_soup_ft_in12k_384 [126] convnext_large_mlp.clip_laion2b_soup_ft_in12k_in1k_320
[127] convnext_large_mlp.clip_laion2b_soup_ft_in12k_in1k_384 [128] convnext_nano.d1h_in1k   [129] convnext_nano.in12k
[130] convnext_nano.in12k_ft_in1k   [131] convnext_nano_ols.d1h_in1k   [132] convnext_pico.d1_in1k
[133] convnext_pico_ols.d1_in1k   [134] convnext_small.fb_in1k   [135] convnext_small.fb_in22k
[136] convnext_small.fb_in22k_ft_in1k   [137] convnext_small.fb_in22k_ft_in1k_384   [138] convnext_small.in12k
[139] convnext_small.in12k_ft_in1k   [140] convnext_small.in12k_ft_in1k_384   [141] convnext_tiny.fb_in1k
[142] convnext_tiny.fb_in22k   [143] convnext_tiny.fb_in22k_ft_in1k   [144] convnext_tiny.fb_in22k_ft_in1k_384
[145] convnext_tiny.in12k   [146] convnext_tiny.in12k_ft_in1k   [147] convnext_tiny.in12k_ft_in1k_384
[148] convnext_tiny_hnf.a2h_in1k   [149] convnext_xlarge.fb_in22k   [150] convnext_xlarge.fb_in22k_ft_in1k
[151] convnext_xlarge.fb_in22k_ft_in1k_384   [152]

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deit3_huge_patch14_224.fb_in1k
[217] deit3_huge_patch14_224.fb_in22k_ft_in1k   [218]
deit3_large_patch16_224.fb_in1k   [219]
deit3_large_patch16_224.fb_in22k_ft_in1k
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deit3_large_patch16_384.fb_in22k_ft_in1k   [222]
deit3_medium_patch16_224.fb_in1k
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deit3_small_patch16_224.fb_in22k_ft_in1k
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deit3_small_patch16_384.fb_in22k_ft_in1k   [228]
deit_base_distilled_patch16_224.fb_in1k
[229] deit_base_distilled_patch16_384.fb_in1k   [230]
deit_base_patch16_224.fb_in1k   [231]
deit_base_patch16_384.fb_in1k
[232] deit_small_distilled_patch16_224.fb_in1k   [233]
deit_small_patch16_224.fb_in1k   [234]
deit_tiny_distilled_patch16_224.fb_in1k
[235] deit_tiny_patch16_224.fb_in1k   [236] densenet121.ra_in1k
[237] densenet121.tv_in1k
[238] densenet161.tv_in1k   [239] densenet169.tv_in1k
[240] densenet201.tv_in1k
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[802] repvit_m2_3.dist_450e_in1k              [803] repvit_m3.dist_in1k
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[1441] xcit_small_24_p8_224.fb_in1k   [1442] xcit_small_24_p8_384.fb_dist_in1k   [1443] xcit_small_24_p16_224.fb_dist_in1k

[1444] xcit_small_24_p16_224.fb_in1k   [1445] xcit_small_24_p16_384.fb_dist_in1k   [1446] xcit_tiny_12_p8_224.fb_dist_in1k

[1447] xcit_tiny_12_p8_224.fb_in1k   [1448] xcit_tiny_12_p8_384.fb_dist_in1k   [1449] xcit_tiny_12_p16_224.fb_dist_in1k

[1450] xcit_tiny_12_p16_224.fb_in1k   [1451] xcit_tiny_12_p16_384.fb_dist_in1k   [1452] xcit_tiny_24_p8_224.fb_dist_in1k

[1453] xcit_tiny_24_p8_224.fb_in1k   [1454] xcit_tiny_24_p8_384.fb_dist_in1k   [1455] xcit_tiny_24_p16_224.fb_dist_in1k

[1456] xcit_tiny_24_p16_224.fb_in1k   [1457] xcit_tiny_24_p16_384.fb_dist_in1k

14 Write Names of Pretrained Models to File

```python
[16]:  # you can research these models to learn more about specific ones
       file_path = "./output/deep_image_search_pretrained_models.txt"


       pretrained_models = timm.list_models(pretrained=True)
       with open(file_path, "w") as file:
           # Write each model name to the file
           for model_name in pretrained_models:
               file.write(model_name + "\n")


       print(f"Pretrained models list written to {file_path}")
```

```
Pretrained models list written to
./output/deep_image_search_pretrained_models.txt
```

15 Helper function

```python
[17]:  ##############################################################
       #########################
       #################
       def print_exception(error, mtd_name, print_stack_trace):
           print("\n*\n\n* * * Exception Caught in mtd \"" + mtd_name + "\" Type [",
        ↪type(error).__name__, "] at line number [",error.__traceback__.tb_lineno, "]
        ↪error message \"[", error, "]\n*\n*\n*\n")


           if print_stack_trace:
               traceback.print_exc()
```

16 Specify models

```python
[18]:  # you can use the full name e.g. 'resnet50.a1_in1k' to specify the CNN you'd
        ↪like to use
       lst_models = ['resnet50',
                     'efficientnet_b4.ra2_in1k',
                     'darknet53',
                     'resnext101_64x4d',
                     'vgg19',
                     'inception_v4',
                     'densenet201.tv_in1k',
                     'xception71',
                     'tresnet_xl',
```

```
              'rexnetr_300.sw_in12k_ft_in1k',
]
```

17 Create Dataframe for Evaluation Score Values

```python
[19]: # define cols
cols = ['model_name',
        'precision',
        'recall',
        'f1_score',
        'accuracy',
        'execution_time_mins'
]

# create df
df_evaluation_score = pd.DataFrame(columns=cols)
```

18 Create for training and test hold-out

```python
[20]: # set test size
tst_size = 0.20

dict_training = dict()
dict_test = dict()

# overall list of paths
lst_training = list()
lst_test = list()

# set the seed for reproducibility
random.seed(42)

# dict_path_to_image_index is populated previously

# iterate through the image list for each family label
for family_name in dict_unique_families.keys():
    # get the list of entries
    lst_paths = dict_unique_families[family_name]

    # get count of entries
    entry_count = len(lst_paths)

    # determine test hold-out count
    count_test_hold_out = int(np.ceil(float(entry_count) * tst_size))
```

```
    # shuffle the list
    shuffled_list = list(lst_paths)
    random.shuffle(shuffled_list)

    # finally, assign the first (SHUFFLED) entries to test, and the rest to
 ↪training
    dict_test[family_name] = list(lst_paths[:count_test_hold_out])
    dict_training[family_name] = list(lst_paths[count_test_hold_out:])

    # append overall lists
    lst_test = lst_test + lst_paths[:count_test_hold_out]
    lst_training = lst_training + lst_paths[count_test_hold_out:]


print(f'size of test set: {len(lst_test)}')
print(f'size of training set: {len(lst_training)}')
print(f'total size of training + test dataset: {len(lst_test) +
 ↪len(lst_training)}')
```

```
size of test set: 39
size of training set: 115
total size of training + test dataset: 154
```

19   Train & Evaluate the Models!

[21]:
```
%%time

REMOVE_PREV_TRAINED_MODEL = True

dict_trained_models = dict()

# key == model name, value for each model will be another tree counting the
 ↪number of labels for each class
dict_confusion_matrix = dict()

# specifically holds count of TP successfully identified by the model (not just
 ↪the count from confusion matrix)
dict_TP_matrix = dict()

# iterate through each model
for mdl_name in lst_models:


    ␣
 ↪###########################################################################################
    # Train
```

```
    ␣
→##############################################################################################

    # Start time
    start_time = time.time()

    dict_confusion_matrix[mdl_name] = dict()
    dict_TP_matrix[mdl_name] = dict()

    # notify
    notify = False

    # remove prev trained directory
    if REMOVE_PREV_TRAINED_MODEL:
        try:
            # skip if directory does not exist
            if os.path.isdir('./metadata-files/' + str(mdl_name)):
                # remove directory
                shutil.rmtree('./metadata-files/' + str(mdl_name))
        except Exception as error:
            #print_exception(error, inspect.currentframe().f_code.co_name + "␣
→on model --> " + str(mdl_name), False)
            #print("\n\n* * * NOTE: I could not remove prev metadata directory␣
→* * *\n\n")
            pass



    # training model
    print('\n')
    print('#'*100)
    print(f"# commencing training on model --> {mdl_name}")
    print('#'*100)

    # instantiate model
    st = Search_Setup(image_list=lst_training, model_name=mdl_name,␣
→pretrained=False, image_count=None)

    # Index the images - Train the model
    st.run_index()

    # Get metadata
    metadata = st.get_image_metadata_file()
    if notify:
        print('\n␣
→features\n=================================================================================
        print(metadata)
```

```python
    # link the trained model
    dict_trained_models[mdl_name] = st


  ␣
↪####################################################################################
    # save trained model
  ␣
↪####################################################################################

    # create output top folder
    #saved_trained_models_path_to_top_folder = 'trained_models'
    #os.makedirs(saved_trained_models_path_to_top_folder, exist_ok=True)
    os.makedirs(path_to_pretrained_models, exist_ok=True)

    # save trained model
    model_path = os.path.join(path_to_pretrained_models, str(mdl_name) + '.pkl')
    with open(model_path, 'wb') as fos_trained_model:
        pickle.dump(st, fos_trained_model)

    # notify
    print(f'{mdl_name} training complete. Trained model saved to -->␣
↪{model_path}\n')




  ␣
↪####################################################################################
    # Evaluate
  ␣
↪####################################################################################
    TP = 0
    FP = 0
    FN = 0
    TN = 0
    PRECISION = 0

    for i in range(len(lst_test)):
        test_image_path = lst_test[i]
        try:
            # here, we can specify how many images we wish to be returned that␣
↪match greatest similarity to the test image specified
            # the most similar image is the first image returned. Extract this␣
↪image as the model's classification prediction
            dict_similar = st.
↪get_similar_images(image_path=str(lst_test[i]),number_of_images=1)
```

```python
        path_to_predicted_label = str(list(dict_similar.values())[0])
        print('found: ', path_to_predicted_label)

        # take the first value from the dictionary returned, then query
→main family path if we predict the same label
        predicted_label = dict_family_from_path[path_to_predicted_label]

         # tabulate values for confusion matrix
        if predicted_label not in dict_confusion_matrix[mdl_name]:
            # add new entry
            dict_confusion_matrix[mdl_name][predicted_label] = 1
        else:
            #dict_my_confusion_matrix = dict_confusion_matrix[mdl_name]
            #dict_my_confusion_matrix[predicted_label] =
→dict_my_confusion_matrix[predicted_label] + 1
            dict_confusion_matrix[mdl_name][predicted_label] =
→dict_confusion_matrix[mdl_name][predicted_label] + 1


        # tabulate correctness
        if predicted_label == dict_family_from_path[test_image_path]:
            TP += 1

            # store the TP count for this class to this specific malware
→classificaiton label
            if not predicted_label in dict_TP_matrix[mdl_name]:
                # add new entry
                dict_TP_matrix[mdl_name][predicted_label] = 1
            else:
                dict_TP_matrix[mdl_name][predicted_label] =
→dict_TP_matrix[mdl_name][predicted_label] + 1

        else:
            FP += 1

            #                        PREDICTED CLASS
            #                        ---------------
            #                      POSITIVE   |   NEGATIVE
            # ACTUAL    POSITIVE      TP       |      FN
            # CLASS     NEGATIVE      FP       |      TN


            #                              PREDICTED CLASS
            #                              ---------------
            #                         FACE DETECTED   |   FACE NOT DETECTED
            # ACTUAL    FACE EXISTS        TP         |       FN
```

```python
                    # CLASS      NOT EXISTS             FP     |     TN
    except:
        FP += 1



  # FN == what we failed to detect an image from the class. i.e., an image of
→the class exists, yet we did not identify it from our TP count
  FN = len(lst_test) - TP

  # TN states how many instances that we did not identify as belonging to
→this class that truly are not part of this class
  TN = len(lst_test) - TP - FP

  # calculate evaluation score
  PRECISION = TP / (TP + FP)
  RECALL = TP / (TP + FN)
  ACCURACY = (TP + TN) / (TP + TN + FP + FN)
  NPR = TN  / (TN + FN)
  F1_SCORE = 2 * PRECISION * RECALL / (PRECISION + RECALL)

  # End time
  end_time = time.time()

  # Calculate execution time
  EXECUTION_TIME = "{:.2f}".format((end_time - start_time) / 60)

  print(f'\nEvaluation for model
→{mdl_name}\n==========================================================================
  print(f'TP == {TP}')
  print(f'FP == {FP}')
  print(f'FN == {FN}')
  print(f'PRECISION == {PRECISION}')
  print(f'RECALL == {RECALL}')
  print(f'F1_SCORE == {F1_SCORE}')
  print(f'ACCURACY == {ACCURACY}')
  print(f'EXECUTION_TIME == {EXECUTION_TIME} mins')

  # populate dataframe
  instance = {    'model_name': mdl_name,
                  'precision': PRECISION,
                  'recall': RECALL,
                  'f1_score': F1_SCORE,
                  'accuracy': ACCURACY,
                  'execution_time_mins': EXECUTION_TIME
  }
```

```python
        # append
        df_evaluation_score.loc[len(df_evaluation_score)] = instance




# notify
print('\n\nTRAINING & EVALUATION COMPLETE!')

# End time
end_time = time.time()

# Calculate execution time
#EXECUTION_TIME = "{:.2f}".format((end_time - start_time) / 60)
print(f'EXECUTION TIME: {EXECUTION_TIME} in mins\n')
```

```
################################################################################
####################
# commencing training on model --> resnet50
################################################################################
####################
 Please Wait Model Is Loading or Downloading From Server!

 Model Loaded Successfully: resnet50

100%|        | 115/115 [00:14<00:00,  8.03it/s]
```

Image Meta Information Saved: [metadata-files/resnet50/image_data_features.pkl]

Saved The Indexed File:[metadata-files/resnet50/image_features_vectors.idx]

resnet50 training complete. Trained model saved to -->
./trained_models/resnet50.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/GrandCrab/grayscale_square_559a4aec9408e3394f5fa230bb98f769e956d12ccd4c5eedd60b84fa2e6bc840.png

found: ./grayscale/GrandCrab/grayscale_square_e844831cad1b1b0151d4bb349a2197270a0fe4302589afb7f03a33a5a3f22a68.png

found: ./grayscale/LokiLockerRansomware/grayscale_square_84d9ef8cb92d57b178cce655f3f7808c6f5cf42f15c468f741b253f37ffc39fc.png

found:
./grayscale/AgentTesla/grayscale_square_5b14a7366cf5dbea3386c6afbd25f012.png

found: ./grayscale/Bankshot/grayscale_square_9e74ffcd50b75d36850637e0c1bca2d9761e9c1ada63712e862db346bca68b35.png

found: ./grayscale/Bizarro/grayscale_square_8c30d08ef7a407fc32e721dd8d8f49260faf0451b41d7be5d61dd89361fb5d03.png

found: ./grayscale/Bizarro/grayscale_square_f57fc4857a76fe66cb8eb0bbc9e88d9e70f9de2135d4802c7c18f89bd92060a9.png

found: ./grayscale/BruteRatel/grayscale_square_973F573CAB683636D9A70B8891263F59E2F02201FFB4DD2E9D7ECBB1521DA03E.png

found: ./grayscale/WinMM/grayscale_square_af3fbe4df7f2bd0240c5fda23b7f64ec57557e1da53d21a579a9faff6023e89d.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/Zeus/grayscale_square_9d490b59563bddf957ff07fe8c4a0806b6b67691e2ffc9ca4a828f6dd67bc23b.png

found:
./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0fce29768f345c88ee10699e22b0ae60.png

```
100%|        | 115/115 [00:10<00:00, 10.82it/s]
```

Image Meta Information Saved: [metadata-files/efficientnet_b4.ra2_in1k/image_data_features.pkl]

Saved The Indexed File:[metadata-files/efficientnet_b4.ra2_in1k/image_features_vectors.idx]

efficientnet_b4.ra2_in1k training complete. Trained model saved to -->

./trained_models/efficientnet_b4.ra2_in1k.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found:
./grayscale/FakeDivX/grayscale_square_9577C1B005673E1406DA41FB07E914BB.png

found:
./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png

found: ./grayscale/Virlock/grayscale_square_CBFB54371620E4BD2BAB45B5C7AD91D3D896BC6324F621B1FB7457F43E3AEB82.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/HiveRansomware/grayscale_square_c7c04bcd56f282bc27f160cc80ccab73485dd3123f2efb35b9726a8528b7950f.png

found: ./grayscale/Bizarro/grayscale_square_261b9e4b576b1d2a1c4ce44a4b48cd776981e392615c8ee5556c066b82aeca21.png

found: ./grayscale/BruteRatel/grayscale_square_3ED21A4BFCF9838E06AD3058D13D5C28026C17DC996953A22A00F0609B0DF3B9.png

found: ./grayscale/Mirai/grayscale_square_cebe20a3e4eb38e9e37b995cf0d8f749.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/HiveRansomware/grayscale_square_26cb76e67add724d7771d12ffc701a4806c71dc436ff7d6ed0288e899dfd0d9b.png

found:
./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0fce29768f345c88ee10699e22b0ae60.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede0

```
100%|        | 115/115 [00:22<00:00,  5.20it/s]
```

Image Meta Information Saved: [metadata-files/darknet53/image_data_features.pkl]

Saved The Indexed File:[metadata-files/darknet53/image_features_vectors.idx]

darknet53 training complete. Trained model saved to -->

./trained_models/darknet53.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/WinMM/grayscale_square_af3fbe4df7f2bd0240c5fda23b7f64ec57557e1da53d21a579a9faff6023e89d.png

found: ./grayscale/Enemybot/grayscale_square_7a2a5da50e87bb413375ecf12b0be71aea4e21120c0c2447d678ef73c88b3ba0.png

found: ./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png

found: ./grayscale/gameover/grayscale_square_efe94c134ed00c0459ff93c291faddabcdf5cf1f7db0594dda95df6c43a98808.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/Enemybot/grayscale_square_7a2a5da50e87bb413375ecf12b0be71aea4e21120c0c2447d678ef73c88b3ba0.png

found: ./grayscale/Bizarro/grayscale_square_f57fc4857a76fe66cb8eb0bbc9e88d9e70f9de2135d4802c7c18f89bd92060a9.png

found: ./grayscale/BruteRatel/grayscale_square_3ED21A4BFCF9838E06AD3058D13D5C28026C17DC996953A22A00F0609B0DF3B9.png

found: ./grayscale/Mirai/grayscale_square_f805f22f668bd0414497ddc061e021c5b80b80c9702053d72fc809f19307073b.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/Darkside/grayscale_square_da3bb9669fb983ad8d2ffc01aab9d56198bd9cedf2cc4387f19f4604a070a9b5.png

found: ./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0fce29768f345c88ee10699e22b0ae60.png

```
100%|       | 115/115 [00:50<00:00,  2.27it/s]
```

```
 Image Meta Information Saved: [metadata-
files/resnext101_64x4d/image_data_features.pkl]
 Saved The Indexed File:[metadata-
files/resnext101_64x4d/image_features_vectors.idx]
resnext101_64x4d training complete. Trained model saved to -->
./trained_models/resnext101_64x4d.pkl
found:  ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9
b1d6c3c358bf33f1e64d942e53b.png
found:  ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9
b1d6c3c358bf33f1e64d942e53b.png
found:  ./grayscale/GrandCrab/grayscale_square_892134ff6db36931061b8fde26f295404
f2db266a6ae54849ce64b378684eaf9.png
found:  ./grayscale/GrandCrab/grayscale_square_98aecdf0cf3fe7ba1eba8d8a450d2f361
86f062718b10fbcf920bcd711b67561.png
found:
./grayscale/AgentTesla/grayscale_square_5b14a7366cf5dbea3386c6afbd25f012.png
found:  ./grayscale/CobaltStrike/grayscale_square_e59cc3a94f6a5119f36c4e0b3fbe6f
04cc474d0b0b9d101163dac75722c809da.png
found:  ./grayscale/Bankshot/grayscale_square_9e74ffcd50b75d36850637e0c1bca2d976
1e9c1ada63712e862db346bca68b35.png
found:  ./grayscale/HiveRansomware/grayscale_square_6a4ebf513f996bd7198c711bef93
6a989fea148c235817ea56c1e2afafa927f5.png
found:  ./grayscale/Bizarro/grayscale_square_f57fc4857a76fe66cb8eb0bbc9e88d9e70f
9de2135d4802c7c18f89bd92060a9.png
found:  ./grayscale/HiveRansomware/grayscale_square_6a4ebf513f996bd7198c711bef93
6a989fea148c235817ea56c1e2afafa927f5.png
found:  ./grayscale/Mirai/grayscale_square_f805f22f668bd0414497ddc061e021c5b80b8
0c9702053d72fc809f19307073b.png
found:  ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede0
5a15ab75870c0fdb43d421bb42d.png
found:  ./grayscale/GrandCrab/grayscale_square_559a4aec9408e3394f5fa230bb98f769e
956d12ccd4c5eedd60b84fa2e6bc840.png
found:
./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png
found:  ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0f
ce29768f345c88ee10699e22b0ae60.png
```

```
100%|        | 115/115 [01:03<00:00,  1.82it/s]
```

Image Meta Information Saved: [metadata-files/vgg19/image_data_features.pkl]

Saved The Indexed File:[metadata-files/vgg19/image_features_vectors.idx]

vgg19 training complete. Trained model saved to --> ./trained_models/vgg19.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/9002Rat/grayscale_square_c95d38d92f81e8d0fe6a664f6aa0cb1001916715e51b25efd85f192afbc87b2e.png

found: ./grayscale/9002Rat/grayscale_square_b5817f0a289c55f52647a2b6925578370d4bb91dbc89056673dc07197c7e4621.png

found: ./grayscale/gameover/grayscale_square_da286c05353e0dc14d8a18043f9ccb4df6de18f52f9942f355382ec0ef3212a9.png

found: ./grayscale/gameover/grayscale_square_efe94c134ed00c0459ff93c291faddabcdf5cf1f7db0594dda95df6c43a98808.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/WinMM/grayscale_square_7e3489d42f56d6ef975ed7d6cd7b926737e7fcb71b0f0ca8ded8678e7c85c0db.png

found: ./grayscale/Bizarro/grayscale_square_261b9e4b576b1d2a1c4ce44a4b48cd776981e392615c8ee5556c066b82aeca21.png

found: ./grayscale/BruteRatel/grayscale_square_973F573CAB683636D9A70B8891263F59E2F02201FFB4DD2E9D7ECBB1521DA03E.png

found: ./grayscale/WinMM/grayscale_square_af3fbe4df7f2bd0240c5fda23b7f64ec57557e1da53d21a579a9faff6023e89d.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/Conti/grayscale_square_d6fb956ada8728768d0bfeb98402cbb4db0358fa2c0a28966669e770d72b75a5.png

found: ./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_ac092962654b46a670b030026d07f5b8161cecd2abd6eece52b7892965aa521b.png

found: ./grayscale/Darkside/grayscale_square_6057380a9a613b3c2b8a2f68b3bd8096e05adfc2523f5117c4112b19d4848c6d.png

```
100%|        | 115/115 [00:25<00:00,  4.50it/s]
```

Image Meta Information Saved: [metadata-files/inception_v4/image_data_features.pkl]

Saved The Indexed File:[metadata-files/inception_v4/image_features_vectors.idx]

inception_v4 training complete. Trained model saved to --> ./trained_models/inception_v4.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/9002Rat/grayscale_square_c95d38d92f81e8d0fe6a664f6aa0cb1001916715e51b25efd85f192afbc87b2e.png

found: ./grayscale/9002Rat/grayscale_square_b5817f0a289c55f52647a2b6925578370d4bb91dbc89056673dc07197c7e4621.png

found: ./grayscale/FakeDivX/grayscale_square_E1BDA5B01D1AD8C0F48177CD6398B15F.png

found: ./grayscale/gameover/grayscale_square_86bcfce2dd342e9a1c04cfc65731d40ed1c397a4ec47bd9f5b41771297d81100.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/Bizarro/grayscale_square_684e6bdced0521344b38a3dbd0ee159a0691ca47a766a3f0ea8ca5578ed0816d.png

found: ./grayscale/Bizarro/grayscale_square_9e533c9f14375ca958fadc504b80dd89569a33b70275362bb1b6b6f9f27d03b8.png

found: ./grayscale/BruteRatel/grayscale_square_973F573CAB683636D9A70B8891263F59E2F02201FFB4DD2E9D7ECBB1521DA03E.png

found: ./grayscale/Darkside/grayscale_square_da3bb9669fb983ad8d2ffc01aab9d56198bd9cedf2cc4387f19f4604a070a9b5.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/GrandCrab/grayscale_square_9c26bf75f4c9a260b325ef09bd3f67e2165f543e26c3ddf9af38cc822f7ca4e3.png

found: ./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_ac092962654b46a670b030026d07f5b8161cecd2abd6eece52b7892965aa521b.png

```
100%|        | 115/115 [00:18<00:00,  6.33it/s]
```

```
 Image Meta Information Saved: [metadata-
files/densenet201.tv_in1k/image_data_features.pkl]
 Saved The Indexed File:[metadata-
files/densenet201.tv_in1k/image_features_vectors.idx]
densenet201.tv_in1k training complete. Trained model saved to -->
./trained_models/densenet201.tv_in1k.pkl
found:  ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9
b1d6c3c358bf33f1e64d942e53b.png
found:  ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9
b1d6c3c358bf33f1e64d942e53b.png
found:  ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e89
74770258c440d398dcafe3d4ddd8a5.png
found:  ./grayscale/9002Rat/grayscale_square_b5817f0a289c55f52647a2b6925578370d4
bb91dbc89056673dc07197c7e4621.png
found:
./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png
found:
./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png
found:  ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e89
74770258c440d398dcafe3d4ddd8a5.png
found:  ./grayscale/Bizarro/grayscale_square_684e6bdced0521344b38a3dbd0ee159a069
1ca47a766a3f0ea8ca5578ed0816d.png
found:  ./grayscale/Bizarro/grayscale_square_9e533c9f14375ca958fadc504b80dd89569
a33b70275362bb1b6b6f9f27d03b8.png
found:  ./grayscale/BruteRatel/grayscale_square_973F573CAB683636D9A70B8891263F59
E2F02201FFB4DD2E9D7ECBB1521DA03E.png
found:  ./grayscale/Mirai/grayscale_square_f805f22f668bd0414497ddc061e021c5b80b8
0c9702053d72fc809f19307073b.png
found:  ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede0
5a15ab75870c0fdb43d421bb42d.png
found:  ./grayscale/WinMM/grayscale_square_af3fbe4df7f2bd0240c5fda23b7f64ec57557
e1da53d21a579a9faff6023e89d.png
found:
./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png
found:  ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0f
ce29768f345c88ee10699e22b0ae60.png
```

```
100%|        | 115/115 [00:33<00:00,  3.48it/s]
```

Image Meta Information Saved: [metadata-files/xception71/image_data_features.pkl]

Saved The Indexed File:[metadata-files/xception71/image_features_vectors.idx]

xception71 training complete. Trained model saved to --> ./trained_models/xception71.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/WinMM/grayscale_square_7e3489d42f56d6ef975ed7d6cd7b926737e7fcb71b0f0ca8ded8678e7c85c0db.png

found: ./grayscale/FakeDivX/grayscale_square_BE8C528A6BFF6668093E9AABE0634197.png

found: ./grayscale/BruteRatel/grayscale_square_3AD53495851BAFC48CAF6D2227A434CA2E0BEF9AB3BD40ABFE4EA8F318D37BBE.png

found: ./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/CobaltStrike/grayscale_square_7c2ea97f8fff301a03f36fb6b87d08dc81e948440c87c2805b9e4622eb4e1991.png

found: ./grayscale/Bizarro/grayscale_square_e13fe434eb19987ee1239caae2eca96df2cd2d78dec0f8d414e04b856bcf2b2e.png

found: ./grayscale/BruteRatel/grayscale_square_3ED21A4BFCF9838E06AD3058D13D5C28026C17DC996953A22A00F0609B0DF3B9.png

found: ./grayscale/Darkside/grayscale_square_da3bb9669fb983ad8d2ffc01aab9d56198bd9cedf2cc4387f19f4604a070a9b5.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/Enemybot/grayscale_square_6a7242683122a3d4507bb0f0b6e7abf8acef4b5ab8ecf11c4b0ebdbded83e7aa.png

found: ./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0fce29768f345c88ee10699e22b0ae60.png

```
100%|          | 115/115 [00:50<00:00,  2.29it/s]
```

Image Meta Information Saved: [metadata-files/tresnet_xl/image_data_features.pkl]

Saved The Indexed File:[metadata-files/tresnet_xl/image_features_vectors.idx]

tresnet_xl training complete. Trained model saved to -->
./trained_models/tresnet_xl.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/9002Rat/grayscale_square_c95d38d92f81e8d0fe6a664f6aa0cb1001916715e51b25efd85f192afbc87b2e.png

found: ./grayscale/Enemybot/grayscale_square_6a7242683122a3d4507bb0f0b6e7abf8acef4b5ab8ecf11c4b0ebdbded83e7aa.png

found: ./grayscale/AgentTesla/grayscale_square_413ca1f198008a2980f7891c059bc188.png

found: ./grayscale/CobaltStrike/grayscale_square_2160af903da06c25c2f6426931d20eb7e7a8ea6f9951e144188027252ff64281.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/Bizarro/grayscale_square_684e6bdced0521344b38a3dbd0ee159a0691ca47a766a3f0ea8ca5578ed0816d.png

found: ./grayscale/Bizarro/grayscale_square_f57fc4857a76fe66cb8eb0bbc9e88d9e70f9de2135d4802c7c18f89bd92060a9.png

found: ./grayscale/BruteRatel/grayscale_square_973F573CAB683636D9A70B8891263F59E2F02201FFB4DD2E9D7ECBB1521DA03E.png

found: ./grayscale/Mirai/grayscale_square_f805f22f668bd0414497ddc061e021c5b80b80c9702053d72fc809f19307073b.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/gameover/grayscale_square_efe94c134ed00c0459ff93c291faddabcdf5cf1f7db0594dda95df6c43a98808.png

found: ./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0fce29768f345c88ee10699e22b0ae60.png

```
100%|        | 115/115 [00:16<00:00,  7.04it/s]
```

Image Meta Information Saved: [metadata-files/rexnetr_300.sw_in12k_ft_in1k/image_data_features.pkl]

Saved The Indexed File:[metadata-files/rexnetr_300.sw_in12k_ft_in1k/image_features_vectors.idx]

rexnetr_300.sw_in12k_ft_in1k training complete. Trained model saved to -->

./trained_models/rexnetr_300.sw_in12k_ft_in1k.pkl

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/7ev3n/grayscale_square_bbfda711882063cc7b41b55dbdabf3a92a4e9b1d6c3c358bf33f1e64d942e53b.png

found: ./grayscale/GrandCrab/grayscale_square_892134ff6db36931061b8fde26f295404f2db266a6ae54849ce64b378684eaf9.png

found: ./grayscale/Mirai/grayscale_square_7D2C1F3D81A2DF7BEEA99552D0704C2D.png

found: ./grayscale/gameover/grayscale_square_da286c05353e0dc14d8a18043f9ccb4df6de18f52f9942f355382ec0ef3212a9.png

found: ./grayscale/gameover/grayscale_square_efe94c134ed00c0459ff93c291faddabcdf5cf1f7db0594dda95df6c43a98808.png

found: ./grayscale/Bankshot/grayscale_square_582789fabf681d2a1148373aaecf9c2e8974770258c440d398dcafe3d4ddd8a5.png

found: ./grayscale/HiveRansomware/grayscale_square_6a4ebf513f996bd7198c711bef936a989fea148c235817ea56c1e2afafa927f5.png

found: ./grayscale/Bizarro/grayscale_square_e13fe434eb19987ee1239caae2eca96df2cd2d78dec0f8d414e04b856bcf2b2e.png

found: ./grayscale/BruteRatel/grayscale_square_3ED21A4BFCF9838E06AD3058D13D5C28026C17DC996953A22A00F0609B0DF3B9.png

found: ./grayscale/WinMM/grayscale_square_8713bafa5457ef9b89bd52330b8e0be2f0903ede1e55ef457494b7fe82c9b182.png

found: ./grayscale/Conti/grayscale_square_6f0c6f447a18ad9fd81382b062d16d07eede05a15ab75870c0fdb43d421bb42d.png

found: ./grayscale/Conti/grayscale_square_d6fb956ada8728768d0bfeb98402cbb4db0358fa2c0a28966669e770d72b75a5.png

found: ./grayscale/CryptBot/grayscale_square_979d1d97ef97c7ae5737a88e87757ec4.png

found: ./grayscale/Darkside/grayscale_square_243dff06fc80a049f4fb37292f8b8def0fce29768f345c88ee10699e22b0ae60.png

found: ./grayscale/Mirai/grayscale_square_a6a7e46bd0e9ec67a1adec64af8fddee18ce0

20 View Performance of each Model

[22]: `df_evaluation_score`

[22]:

	model_name	precision	recall	f1_score	accuracy	\
0	resnet50	0.769231	0.769231	0.769231	0.625000	
1	efficientnet_b4.ra2_in1k	0.589744	0.589744	0.589744	0.418182	
2	darknet53	0.564103	0.564103	0.564103	0.392857	
3	resnext101_64x4d	0.666667	0.666667	0.666667	0.500000	
4	vgg19	0.692308	0.692308	0.692308	0.529412	
5	inception_v4	0.717949	0.717949	0.717949	0.560000	
6	densenet201.tv_in1k	0.794872	0.794872	0.794872	0.659574	
7	xception71	0.589744	0.589744	0.589744	0.418182	
8	tresnet_xl	0.743590	0.743590	0.743590	0.591837	
9	rexnetr_300.sw_in12k_ft_in1k	0.666667	0.666667	0.666667	0.500000	

	execution_time_mins
0	0.33
1	0.25
2	0.52
3	1.16
4	1.46
5	0.59
6	0.42
7	0.77
8	1.17
9	0.41

21 Sort Model Performance

[23]:
```
df_evaluation_score_sorted = df_evaluation_score.sort_values(by='f1_score',
 ↪ascending=False)
df_evaluation_score_sorted
```

[23]:

	model_name	precision	recall	f1_score	accuracy	\
6	densenet201.tv_in1k	0.794872	0.794872	0.794872	0.659574	
0	resnet50	0.769231	0.769231	0.769231	0.625000	
8	tresnet_xl	0.743590	0.743590	0.743590	0.591837	
5	inception_v4	0.717949	0.717949	0.717949	0.560000	
4	vgg19	0.692308	0.692308	0.692308	0.529412	
3	resnext101_64x4d	0.666667	0.666667	0.666667	0.500000	
9	rexnetr_300.sw_in12k_ft_in1k	0.666667	0.666667	0.666667	0.500000	
1	efficientnet_b4.ra2_in1k	0.589744	0.589744	0.589744	0.418182	
7	xception71	0.589744	0.589744	0.589744	0.418182	
2	darknet53	0.564103	0.564103	0.564103	0.392857	

```
      execution_time_mins
6                     0.42
0                     0.33
8                     1.17
5                     0.59
4                     1.46
3                     1.16
9                     0.41
1                     0.25
7                     0.77
2                     0.52
```

22 Need Confusion matrix to view how well each model predicting each class

```python
[24]: # define cols
      cols  = list(dict_unique_families.keys())

      # create df count of TP
      df_confusion_matrix = pd.DataFrame(columns=cols)

      for model_name in dict_confusion_matrix.keys():
          #df_confusion_matrix.loc[len(df_confusion_matrix)] =␣
       ↪dict_confusion_matrix[model_name]

          # TP report for confusion matrix
          df_confusion_matrix.loc[model_name] = dict_confusion_matrix[model_name]   #␣
       ↪add with index name


      # finally, fill in NaN with 0's
      df_confusion_matrix = df_confusion_matrix.fillna(0)
      df_confusion_matrix
```

```
[24]:                            7ev3n  9002Rat  AgentTesla  Bankshot  Bizarro  \
      resnet50                       2      0.0         1.0         1        2
      efficientnet_b4.ra2_in1k       3      0.0         1.0         2        1
      darknet53                      2      0.0         1.0         1        5
      resnext101_64x4d               2      0.0         1.0         1        1
      vgg19                          3      3.0         0.0         1        1
      inception_v4                   2      3.0         0.0         1        2
      densenet201.tv_in1k            2      1.0         2.0         2        3
      xception71                     2      0.0         2.0         2        2
      tresnet_xl                     2      1.0         1.0         1        3
      rexnetr_300.sw_in12k_ft_in1k   2      0.0         2.0         1        1
```

	BruteRatel	CobaltStrike	Conti	CryptBot
resnet50	1	0.0	1	1
efficientnet_b4.ra2_in1k	1	0.0	3	1
darknet53	1	2.0	1	1
resnext101_64x4d	1	1.0	1	1
vgg19	1	0.0	2	1
inception_v4	1	0.0	1	1
densenet201.tv_in1k	1	0.0	1	1
xception71	2	1.0	1	1
tresnet_xl	1	1.0	1	1
rexnetr_300.sw_in12k_ft_in1k	1	1.0	2	1

	Darkside	Emotet	Enemybot	FakeDivX	gameover
resnet50	2	1	4	1	0.0
efficientnet_b4.ra2_in1k	1	1	4	3	0.0
darknet53	3	1	6	1	1.0
resnext101_64x4d	3	2	3	1	0.0
vgg19	3	1	3	1	2.0
inception_v4	4	1	2	2	1.0
densenet201.tv_in1k	2	1	3	1	0.0
xception71	4	2	3	2	1.0
tresnet_xl	5	1	4	1	1.0
rexnetr_300.sw_in12k_ft_in1k	2	1	3	1	2.0

	GrandCrab	HiveRansomware	KrakenGoBotnet
resnet50	5	2	2
efficientnet_b4.ra2_in1k	3	4	2
darknet53	3	3	1
resnext101_64x4d	5	4	1
vgg19	2	4	1
inception_v4	4	2	2
densenet201.tv_in1k	3	2	1
xception71	2	2	2
tresnet_xl	2	2	1
rexnetr_300.sw_in12k_ft_in1k	3	3	2

	LokiLockerRansomware	Mirai	Virlock	WinMM
resnet50	4	2	2	2.0
efficientnet_b4.ra2_in1k	2	4	3	0.0
darknet53	1	1	2	2.0
resnext101_64x4d	2	3	2	2.0
vgg19	1	4	2	3.0
inception_v4	3	3	1	2.0
densenet201.tv_in1k	2	3	2	3.0
xception71	1	2	1	3.0
tresnet_xl	2	4	2	1.0
rexnetr_300.sw_in12k_ft_in1k	1	5	2	2.0

```
                              Zeus
resnet50                       3.0
efficientnet_b4.ra2_in1k       0.0
darknet53                      0.0
resnext101_64x4d               2.0
vgg19                          0.0
inception_v4                   1.0
densenet201.tv_in1k            3.0
xception71                     1.0
tresnet_xl                     1.0
rexnetr_300.sw_in12k_ft_in1k   1.0
```

23 Create Classification Report

```python
[25]: # dict_confusion_matrix is a dictionary that contains a dictionary of each model
      # e.g., dict_confusion_matrix['vgg19'] retrieves the dictionary of 'vgg19' TP␣
       ↪for each class it successfully classified
      # dict_unique_families holds each unique family name and the path to each image␣
       ↪per class in our dataset
      dict_classification_accuracy = dict()
      for model in dict_TP_matrix.keys():
          # create entry for this model that stores accuracy percentages
          dict_classification_accuracy[model] = dict()

          # get TP dictionary for each model
          dict_TP = dict_TP_matrix[model]
          #print(f'\n{model} {dict_TP}')
          # iterate through each class
          for malware_label in dict_test.keys():
              # retrieve count in test set
              count_class_instances_in_test_set = len(dict_test[malware_label])

              # retrieve TP count from this model for this family
              tp_malware_label = 0
              if malware_label in dict_TP:
                  tp_malware_label = dict_TP[malware_label]

              # store the accuracy for this specific class into dictionary for this␣
       ↪specific model
              dict_classification_accuracy[model][malware_label] =␣
       ↪float(tp_malware_label) / float(count_class_instances_in_test_set)
```

```python
[26]: # create df count of TP
      df_classification_report = pd.DataFrame(columns=cols)
```

```python
for model_name in dict_classification_accuracy.keys():
    # TP report for confusion matrix
    df_classification_report.loc[model_name] =
 ↪dict_classification_accuracy[model_name]    # add with index name


# finally, fill in NaN with 0's
df_classification_report = df_classification_report.fillna(0)
df_classification_report
```

[26]:

	7ev3n	9002Rat	AgentTesla	Bankshot	Bizarro \
resnet50	1.0	0.0	0.5	1.0	1.0
efficientnet_b4.ra2_in1k	1.0	0.0	0.5	1.0	0.5
darknet53	1.0	0.0	0.5	1.0	0.5
resnext101_64x4d	1.0	0.0	0.5	1.0	0.5
vgg19	1.0	1.0	0.0	1.0	0.5
inception_v4	1.0	1.0	0.0	1.0	1.0
densenet201.tv_in1k	1.0	0.5	1.0	1.0	1.0
xception71	1.0	0.0	0.5	1.0	0.5
tresnet_xl	1.0	0.5	0.5	1.0	1.0
rexnetr_300.sw_in12k_ft_in1k	1.0	0.0	0.0	1.0	0.5

	BruteRatel	CobaltStrike	Conti	CryptBot \
resnet50	1.0	0.0	0.5	1.0
efficientnet_b4.ra2_in1k	1.0	0.0	0.5	1.0
darknet53	1.0	0.0	0.5	1.0
resnext101_64x4d	0.0	0.0	0.5	1.0
vgg19	1.0	0.0	1.0	1.0
inception_v4	1.0	0.0	0.5	1.0
densenet201.tv_in1k	1.0	0.0	0.5	1.0
xception71	1.0	0.0	0.5	1.0
tresnet_xl	1.0	0.0	0.5	1.0
rexnetr_300.sw_in12k_ft_in1k	1.0	0.0	1.0	1.0

	Darkside	Emotet	Enemybot	FakeDivX	gameover \
resnet50	1.0	0.5	1.0	0.5	0.0
efficientnet_b4.ra2_in1k	0.5	0.5	1.0	1.0	0.0
darknet53	0.5	0.5	1.0	0.5	0.0
resnext101_64x4d	1.0	0.5	1.0	0.5	0.0
vgg19	1.0	0.5	1.0	0.5	0.0
inception_v4	1.0	0.5	1.0	0.5	0.0
densenet201.tv_in1k	1.0	0.5	1.0	0.5	0.0
xception71	0.5	0.5	0.5	0.5	0.0
tresnet_xl	1.0	0.5	1.0	0.5	0.0
rexnetr_300.sw_in12k_ft_in1k	0.5	0.5	1.0	0.5	0.0

	GrandCrab	HiveRansomware	KrakenGoBotnet \

```
resnet50                              1.0         1.0         1.0
efficientnet_b4.ra2_in1k              1.0         1.0         0.5
darknet53                             1.0         1.0         0.5
resnext101_64x4d                      1.0         1.0         0.5
vgg19                                 1.0         1.0         0.5
inception_v4                          1.0         1.0         1.0
densenet201.tv_in1k                   1.0         1.0         0.5
xception71                            1.0         1.0         0.5
tresnet_xl                            1.0         1.0         0.5
rexnetr_300.sw_in12k_ft_in1k          1.0         1.0         1.0

                              LokiLockerRansomware  Mirai  Virlock  WinMM  \
resnet50                                       1.0    1.0      1.0    1.0
efficientnet_b4.ra2_in1k                       0.5    0.5      1.0    0.0
darknet53                                      0.5    0.0      1.0    1.0
resnext101_64x4d                               0.5    1.0      1.0    1.0
vgg19                                          0.5    1.0      1.0    1.0
inception_v4                                   1.0    1.0      0.5    1.0
densenet201.tv_in1k                            1.0    1.0      1.0    1.0
xception71                                     0.5    1.0      0.5    1.0
tresnet_xl                                     1.0    1.0      1.0    1.0
rexnetr_300.sw_in12k_ft_in1k                   0.5    1.0      1.0    1.0

                              Zeus
resnet50                       1.0
efficientnet_b4.ra2_in1k       0.0
darknet53                      0.0
resnext101_64x4d               1.0
vgg19                          0.0
inception_v4                   0.0
densenet201.tv_in1k            1.0
xception71                     0.5
tresnet_xl                     0.5
rexnetr_300.sw_in12k_ft_in1k   0.5
```

24 Save Results

```python
[27]: df_evaluation_score.to_csv('./output/analysis_summary.csv' , index=False)
      df_confusion_matrix.to_csv('./output/confusion_matrix.csv' , index=False)
      df_classification_report.to_csv('./output/classification_report.csv' ,
       →index=False)
```

25 ==

26 Load pretrained Models

```
[28]: if LOAD_PRETRAINED_MODELS:
          # accumulate *.pkl files if present
          lst_pre_trained_models = list()

          for root, dirs, files in os.walk(path_to_pretrained_models):
              for file in files:
                  if file.endswith('.pkl'):
                      path_pkl_model = os.path.join(root, file)
                      lst_pre_trained_models.append(path_pkl_model)

          # ensure at least 1 file is populated
          if len(lst_pre_trained_models) < 1:
              print(f'PUNT!! I did not locate at least 1 pre trained model at path␣
      ↪{path_to_pretrained_models}')
              print('I will disable loading pretrained models and retrain models␣
      ↪below.')
              LOAD_PRETRAINED_MODELS = False

          else: # populate each model
              for model_path_pkl in lst_pre_trained_models:

                  # get model name
                  fle_name= os.path.basename(model_path_pkl).strip()
                  # remove extension
                  mdl_name = fle_name[:fle_name.rindex('.')].strip()

                  # load the model
                  with open(model_path_pkl, 'rb') as fos_model:
                      dict_trained_models[mdl_name] = pickle.load(fos_model)
                      print(f'{mdl_name} successfully loaded')
              print(f'\nComplete. {len(dict_trained_models)} model(s) successfully␣
      ↪loaded.')
```

27 Get similar images specifying image path

```
[33]: if LOAD_PRETRAINED_MODELS:
          # get similar image using direct path
          dict_similar_images = dict_trained_models['vgg19'].
      ↪get_similar_images(image_path='./grayscale/HiveRansomware/
      ↪grayscale_square_c7c04bcd56f282bc27f160cc80ccab73485dd3123f2efb35b9726a8528b7950f.
      ↪png', number_of_images=4)
          pprint(dict_similar_images)
```

```
{78: './grayscale/HiveRansomware/grayscale_square_567cb1d95c5b0701bc9a5b06842f9a
675a592749cebcace5e7d62e626b2354d1.png',
 79: './grayscale/HiveRansomware/grayscale_square_6a4ebf513f996bd7198c711bef936a
989fea148c235817ea56c1e2afafa927f5.png',
 80: './grayscale/HiveRansomware/grayscale_square_9b68f6082702082205344baf681246
9cf2ef20345acb6b6a94022feebb087c43.png',
 81: './grayscale/HiveRansomware/grayscale_square_c7c04bcd56f282bc27f160cc80ccab
73485dd3123f2efb35b9726a8528b7950f.png'}
```
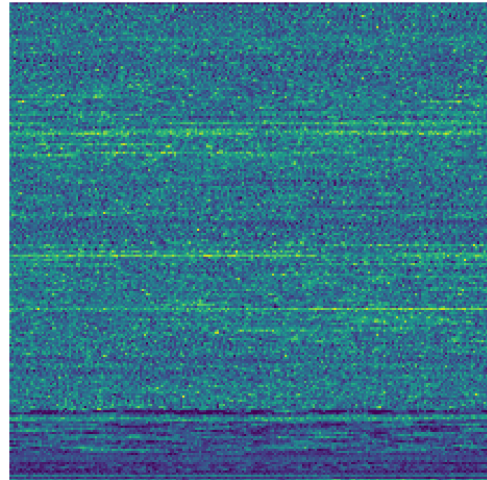
28 Get similar images specifying image index

```python
[34]: if LOAD_PRETRAINED_MODELS:
          # get similar image using direct path
          idx = dict_path_to_image_index['./grayscale/HiveRansomware/
      grayscale_square_c7c04bcd56f282bc27f160cc80ccab73485dd3123f2efb35b9726a8528b7950f.
      png']
          dict_similar_images = dict_trained_models['vgg19'].
      get_similar_images(image_path=image_list[idx], number_of_images=4)
          pprint(dict_similar_images)
```

```
{78: './grayscale/HiveRansomware/grayscale_square_567cb1d95c5b0701bc9a5b06842f9a
675a592749cebcace5e7d62e626b2354d1.png',
 79: './grayscale/HiveRansomware/grayscale_square_6a4ebf513f996bd7198c711bef936a
989fea148c235817ea56c1e2afafa927f5.png',
 80: './grayscale/HiveRansomware/grayscale_square_9b68f6082702082205344baf681246
9cf2ef20345acb6b6a94022feebb087c43.png',
 81: './grayscale/HiveRansomware/grayscale_square_c7c04bcd56f282bc27f160cc80ccab
73485dd3123f2efb35b9726a8528b7950f.png'}
```
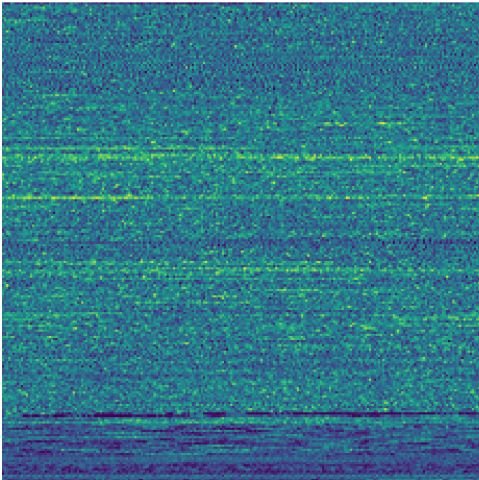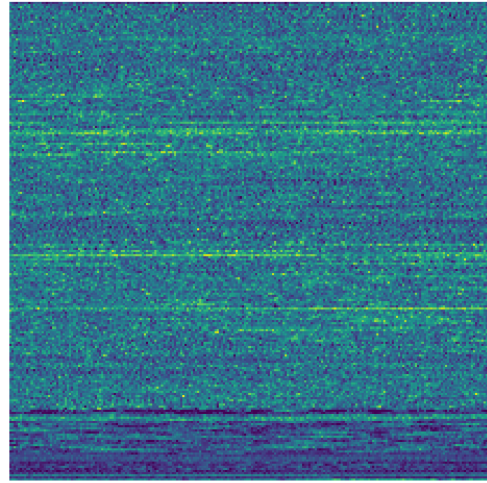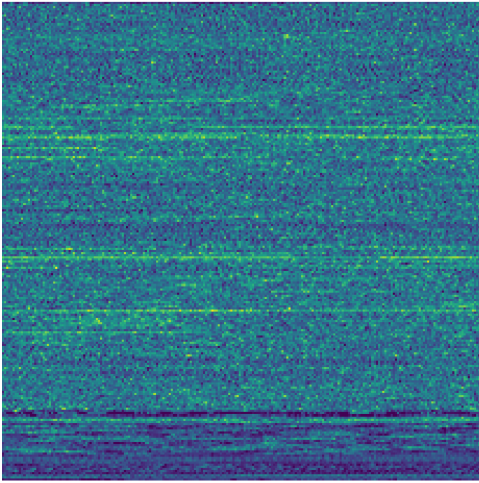
29 Visualize Image Similarity

```python
[35]: if LOAD_PRETRAINED_MODELS:
          similar_images = dict_trained_models['vgg19'].
      plot_similar_images(image_path = image_list[109],number_of_images=4)
```

Input Image

Similar Result Found