gradcam

April 24, 2025

[1]:
```
import os
import random
import numpy as np
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
from gradcam import make_gradcam_heatmap, display_heatmap, load_images
```

[2]:
```
MODEL_PATH = "../models/baseline_model.keras"
COVID_DIR = "../data/processed/test/COVID/"
NORMAL_DIR = "../data/processed/test/NORMAL/"
IMG_SIZE = (224, 224)
LAST_CONV_LAYER_NAME = "conv2d_20"
PREDICTION_THRESHOLD = 0.5
```

[3]:
```
def get_image_paths(data_dir):
    """
    get image paths for a given data directory

    params
    ------
    data_dir: str
        path to the data directory

    returns
    -------
    list
        list of full image paths
    """
    paths = []
    if not os.path.isdir(data_dir):
        print(f"warning: directory not found {data_dir}")
        return paths
    for fname in os.listdir(data_dir):
        if fname.lower().endswith((".png", ".jpg", ".jpeg")):
            paths.append(os.path.join(data_dir, fname))
    return paths
```

[4]:
```
def predict_and_classify(model, image_paths, actual_label):
    """
    make predictions for images and classify results

    params
    ------
    model: tf.keras.Model
        trained keras model
    image_paths: list
        list of image paths
    actual_label: int
        the true label for this set of images (0 for covid, 1 for normal -␣
 ↪based on alphabetical order)

    returns
    -------
    dict
        dictionary containing lists of paths for tp, fp, tn, fn
    """
    results = {"tp": [], "fp": [], "tn": [], "fn": []}
    print(
        f"predicting {len(image_paths)} images with actual label {'COVID' if␣
 ↪actual_label == 1 else 'NORMAL'}"
    )

    # process images one by one for simplicity, batching could optimize
    for img_path in image_paths:
        img_batch, _ = load_images([img_path], IMG_SIZE)
        prediction = model.predict(img_batch, verbose=0)[0][0]
        predicted_label = 1 if prediction >= PREDICTION_THRESHOLD else 0

        if actual_label == 1:  # actual is covid
            if predicted_label == 1:  # predicted covid
                results["tp"].append(img_path)
            else:  # predicted normal
                results["fn"].append(img_path)
        else:  # actual is normal (actual_label == 0)
            if predicted_label == 0:  # predicted normal
                results["tn"].append(img_path)
            else:  # predicted covid
                results["fp"].append(img_path)

    print(
        f"  results: tp={len(results['tp'])}, fn={len(results['fn'])},␣
 ↪tn={len(results['tn'])}, fp={len(results['fp'])}"
    )
    return results
```

[5]:
```
def generate_heatmap_for_image(model, img_path):
    """
    generate and display grad-cam heatmap for a single image

    params
    ------
    model: tf.keras.Model
        loaded keras model
    img_path: str
        path to the image file
    """
    print(f"generating heatmap for: {os.path.basename(img_path)}")

    image_batch, display_batch = load_images([img_path], IMG_SIZE)
    heatmap = make_gradcam_heatmap(image_batch.numpy(), model,␣
↪LAST_CONV_LAYER_NAME)

    # display heatmap (display_heatmap handles figure creation and showing)
    display_heatmap(display_batch.numpy()[0], heatmap, alpha=0.4)
```

[6]:
```
model = keras.models.load_model(MODEL_PATH)
covid_paths = get_image_paths(COVID_DIR)
normal_paths = get_image_paths(NORMAL_DIR)
all_results = {"tp": [], "fp": [], "tn": [], "fn": []}
```

[7]:
```
covid_results = predict_and_classify(model, covid_paths, actual_label=1)
all_results["tp"].extend(covid_results["tp"])
all_results["fn"].extend(covid_results["fn"])
```

```
predicting 100 images with actual label COVID
  results: tp=91, fn=9, tn=0, fp=0
```

[8]:
```
normal_results = predict_and_classify(model, normal_paths, actual_label=0)
all_results["tn"].extend(normal_results["tn"])
all_results["fp"].extend(normal_results["fp"])
```

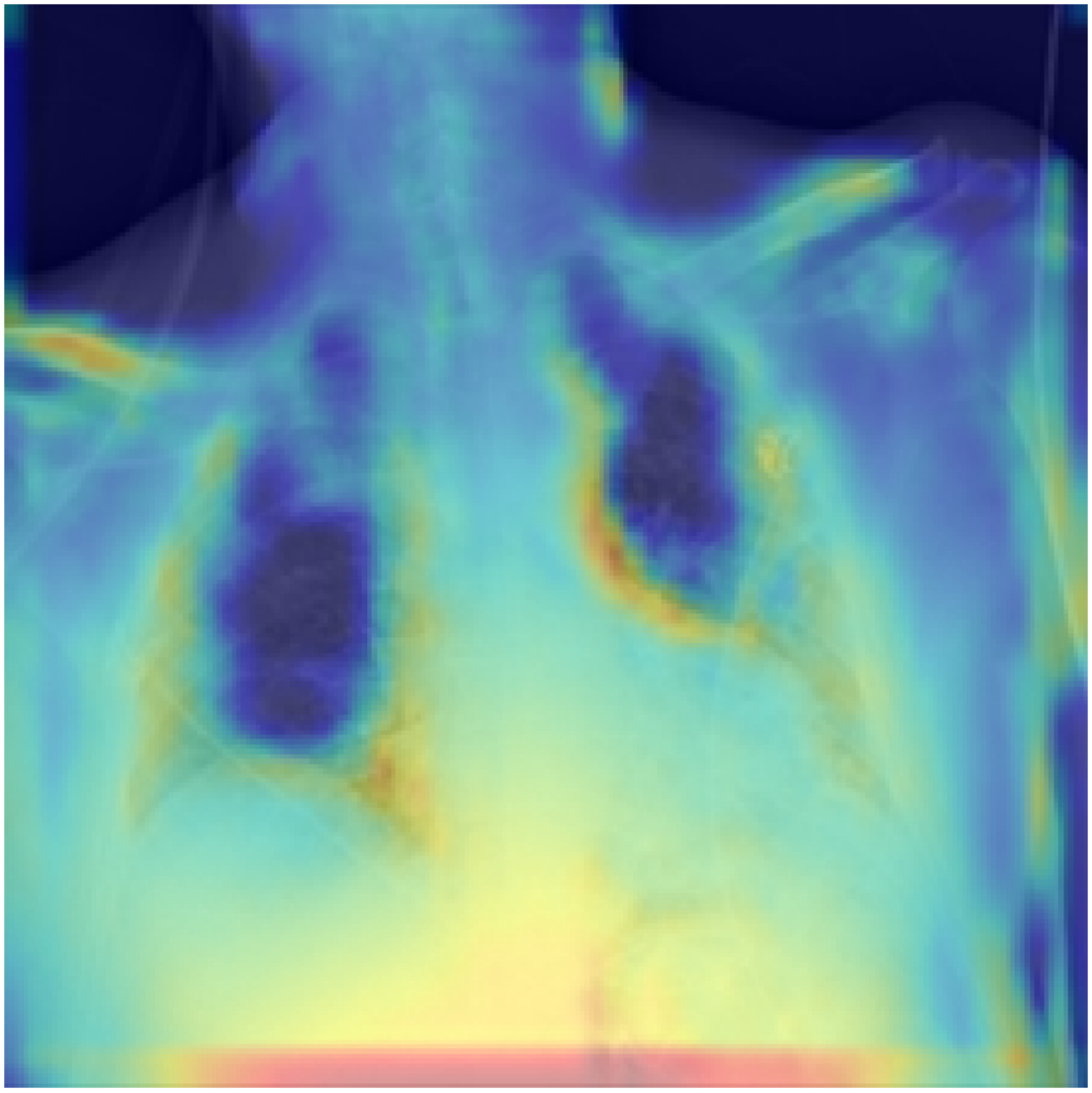
```
predicting 100 images with actual label NORMAL
  results: tp=0, fn=0, tn=70, fp=30
```

[9]:
```
# select a random image for each category
sampled_paths = {}
for category, paths in all_results.items():
    sampled_paths[category] = random.choice(paths)
```

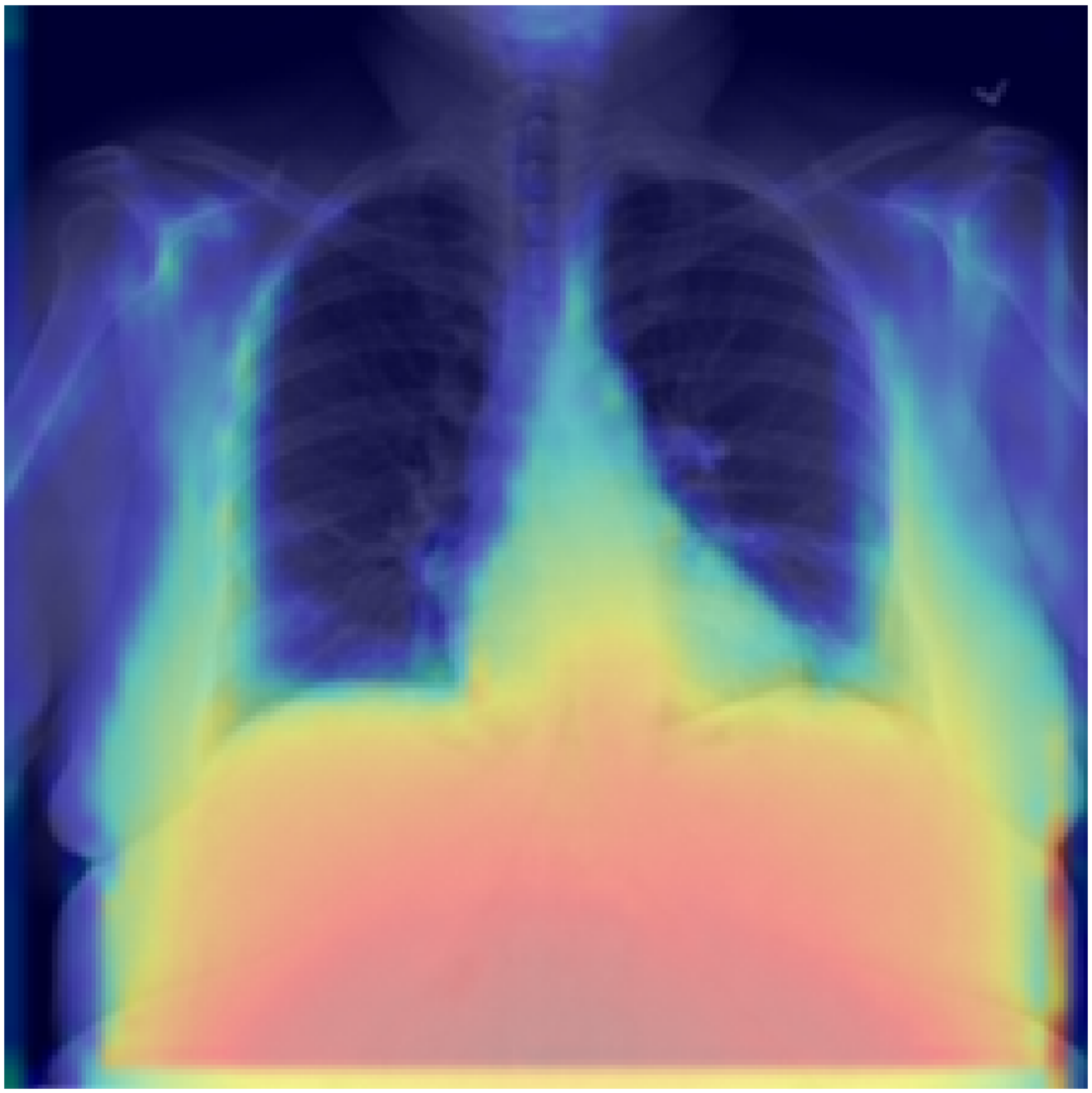
[10]:
```
print("\ngenerating heatmaps for randomly selected samples")
category_map = {
    "tp": "True Positive (COVID)",
    "fn": "False Negative (COVID as NORMAL)",
```

```
    "tn": "True Negative (NORMAL)",
    "fp": "False Positive (NORMAL as COVID)",
}

for category, img_path in sampled_paths.items():
    print(f"\nDisplaying: {category_map.get(category, category.upper())}")
    generate_heatmap_for_image(model, img_path)
```

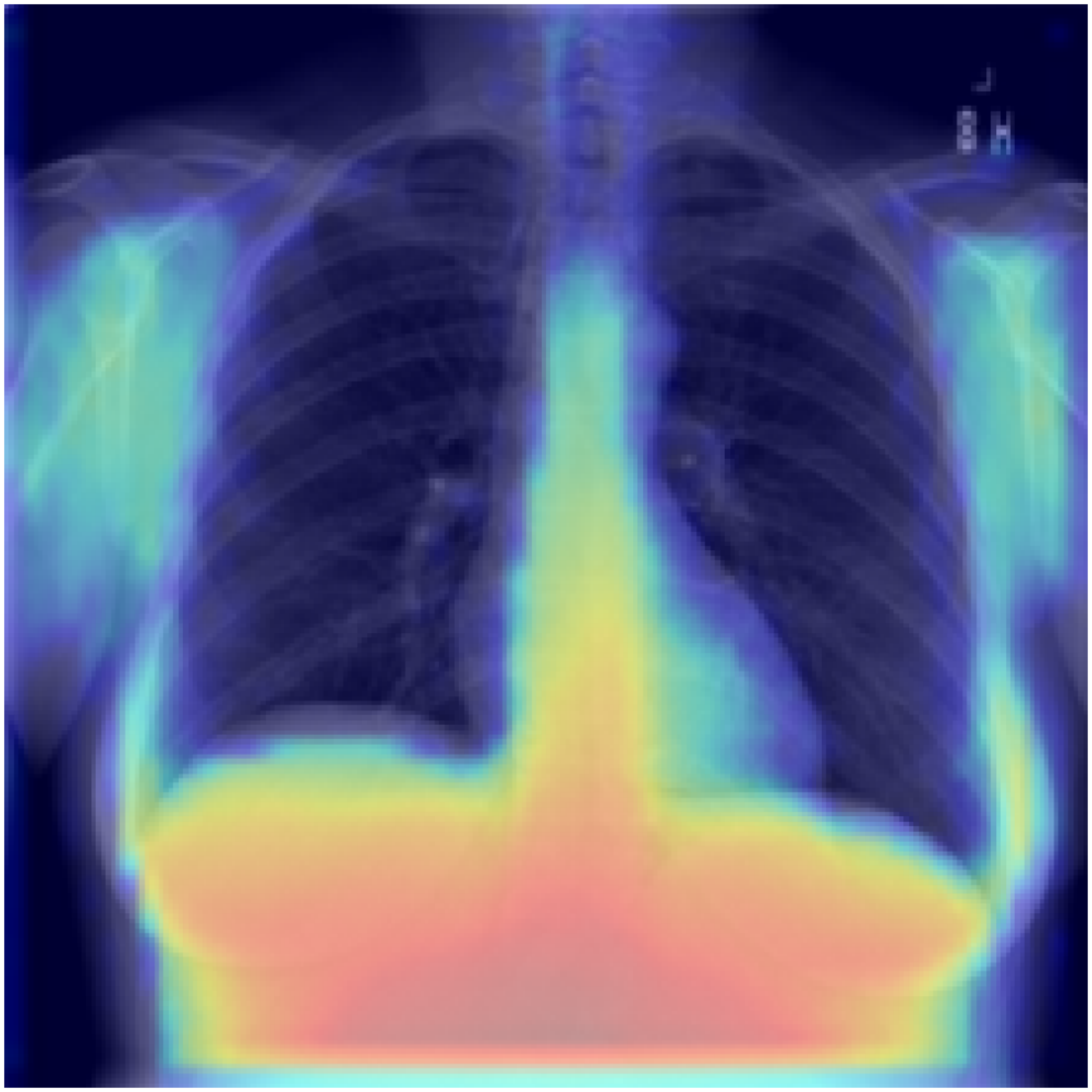
```
generating heatmaps for randomly selected samples

Displaying: True Positive (COVID)
generating heatmap for: COVID-2034.png
input array shape: (1, 224, 224, 3)
```



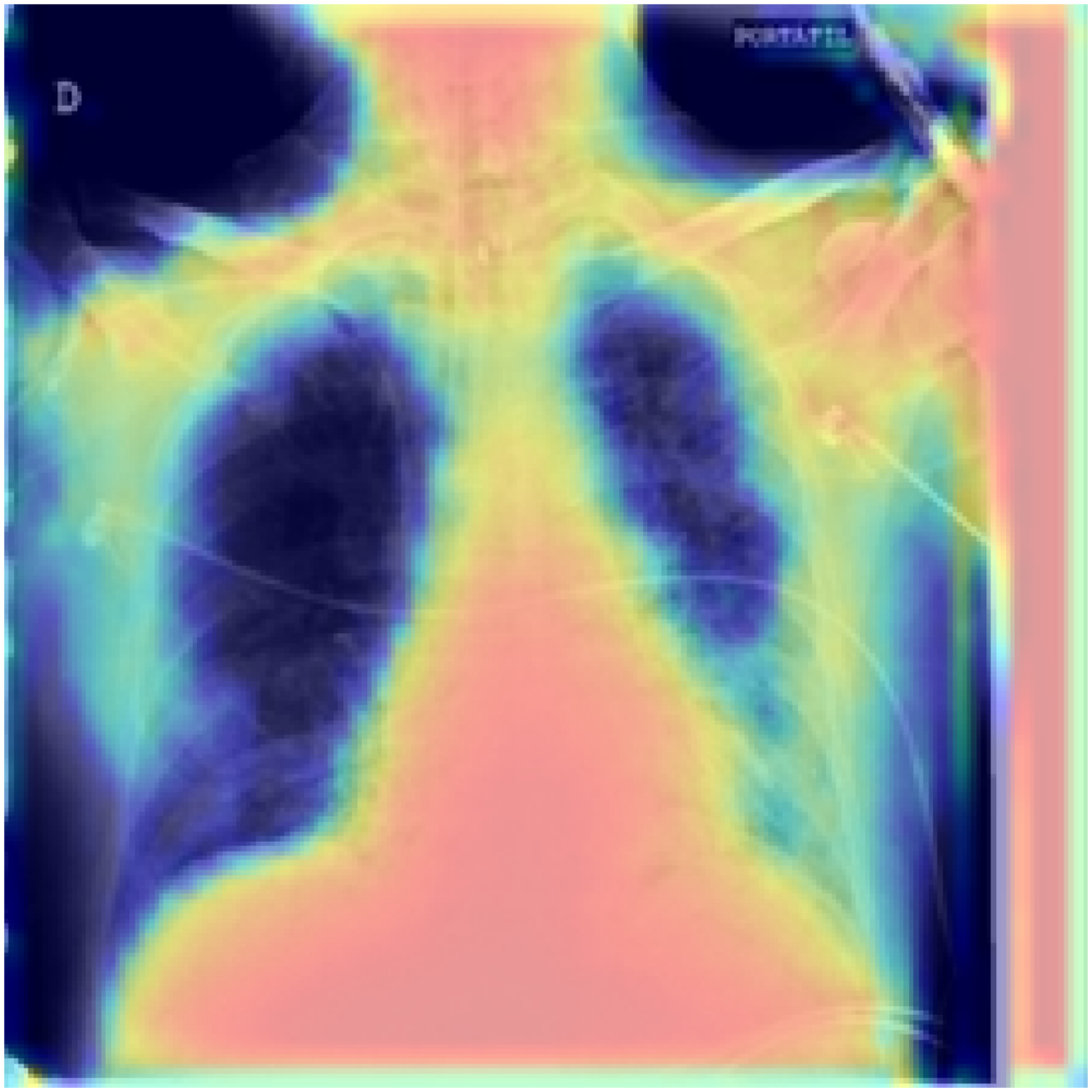
```
Displaying: False Positive (NORMAL as COVID)
generating heatmap for: Normal-2094.png
input array shape: (1, 224, 224, 3)
```



```
Displaying: True Negative (NORMAL)
generating heatmap for: Normal-2048.png
input array shape: (1, 224, 224, 3)
```



```
Displaying: False Negative (COVID as NORMAL)
generating heatmap for: COVID-2013.png
input array shape: (1, 224, 224, 3)
```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