# A Robust Ensemble-Learning Model for Covid-19 Diagnosis on CT Images

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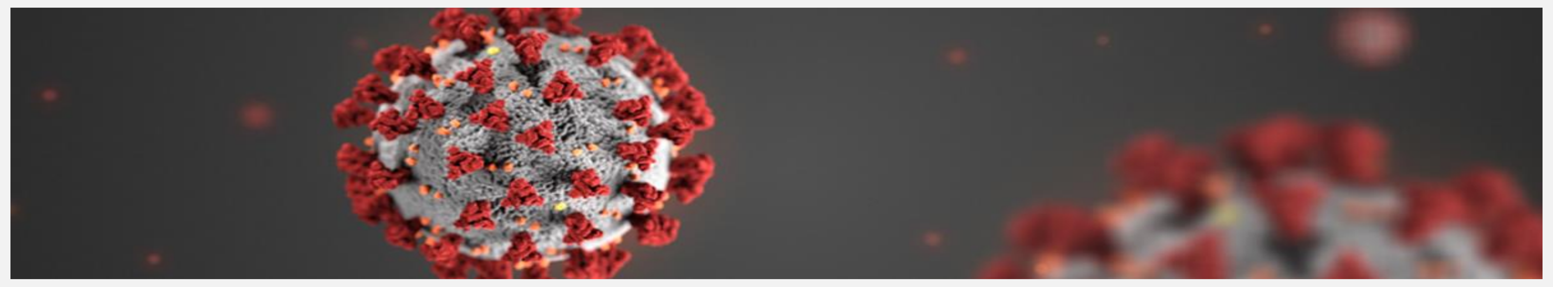
## Research Motivation

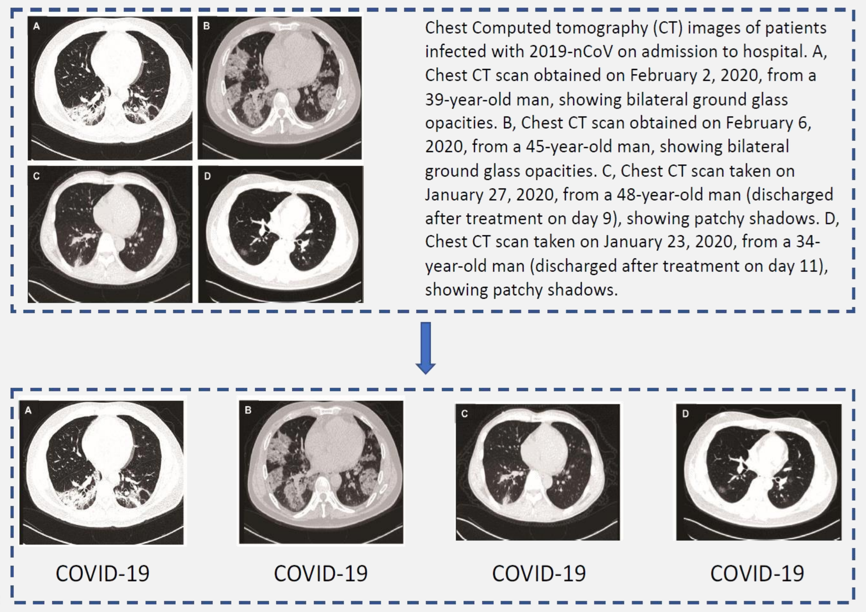
- Coronavirus 2019 (COVID-19) is an infectious disease spreading globally.



- Computed tomography (CT) is preferred COVID-19 diagnosis imaging option.
- Because of the consequent depletion of hospital resources, the use of efficient computer-aided medical diagnosis has become more critical.
- Artificial intelligence (AI) powered COVID-19 detection can facilitate an early diagnosis and further reduce the infectivity and mortality rates.

## Dataset

- Images are extracted from 760 medRxiv and bioRxiv papers.
- Images containing clinical findings of COVD-19 based on their captions are manually selected.
- **Dataset Challenges**
  - Degraded quality
  - Some lesions are market
  - High variability (size, intensity, etc.)




## Research Gap

- Deep learning has enabled breakthrough in a variety of computer vision tasks.
- Exhibit comparable performance with radiologist (Maghdid et al. 2020)
- Limitations of deep learning are the reliability concerns about the generalizability to all cases and the blackbox nature, hindering interpretability.

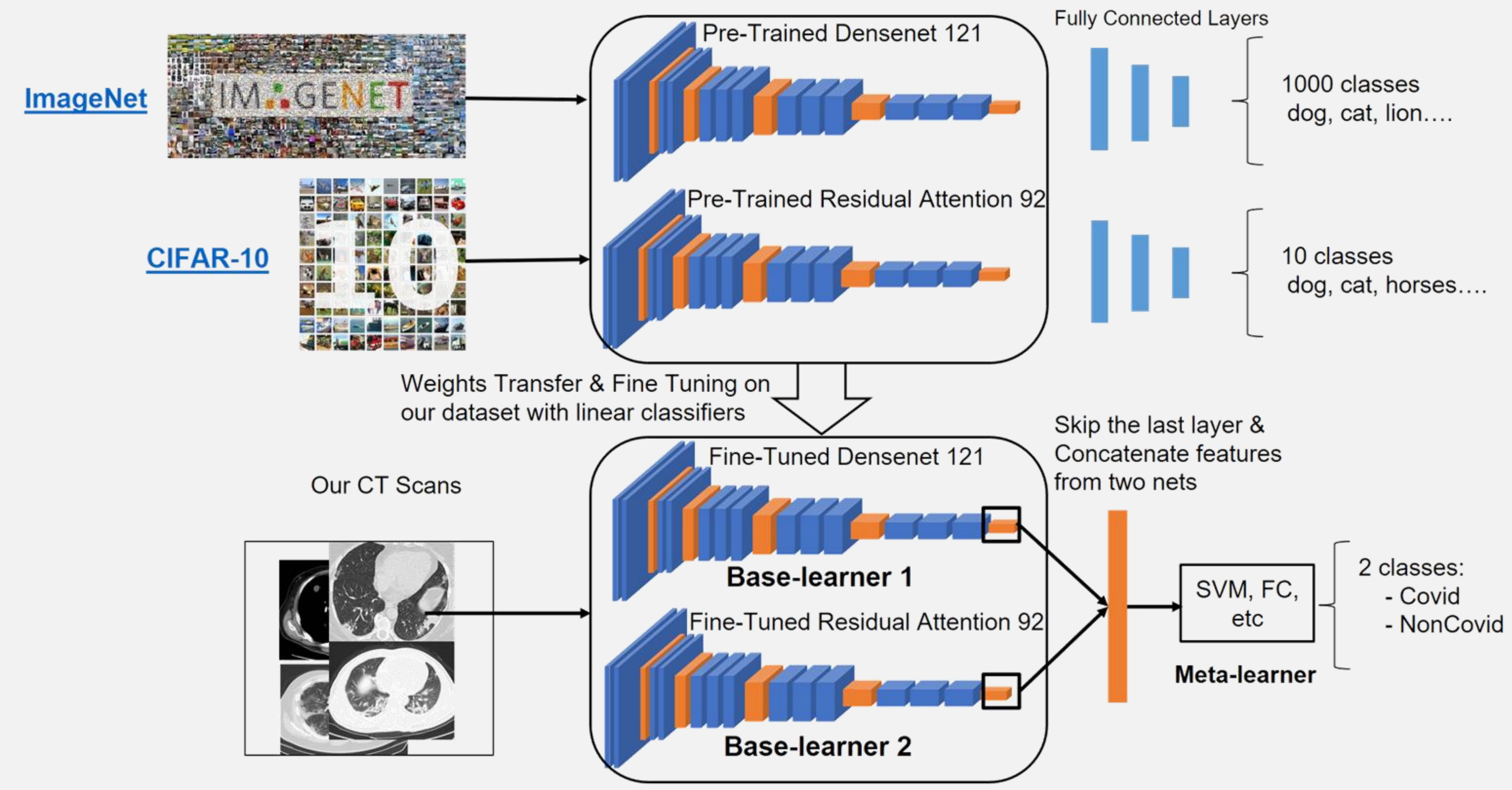
**Research gap is to improve generalizability and interpretability of deep learning.**

## Contributions

- We propose a **robust ensemble deep learning model** for Covid-19 Diagnosis on Lung CT Scan Images.
- The two **base-learners**, **Residual Attention92** and **Densenet121** networks, are chosen as they consolidate each other by focusing on complementary features.
- We compared different **meta-learner**s and found **SVM with radial basis function kernel** to give the best performance.
- Our experimental results demonstrate our proposed method's robustness with **an average 4% accuracy improvement** over each individual base-learner.
- Our code and results are available open source on Github: https://github.com/maftouni/Corona_CT_Classification.git

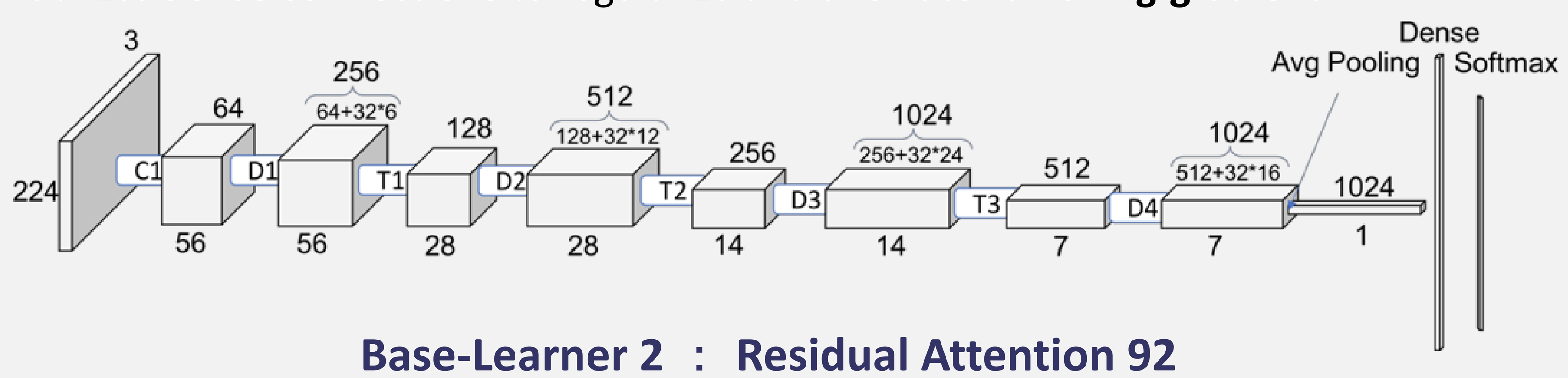
## Proposed Methodology

- The two **base-learners** are fine-tuned on CT images. The features extracted from base-learners are stacked together and processed by a **meta learner** for the final prediction.



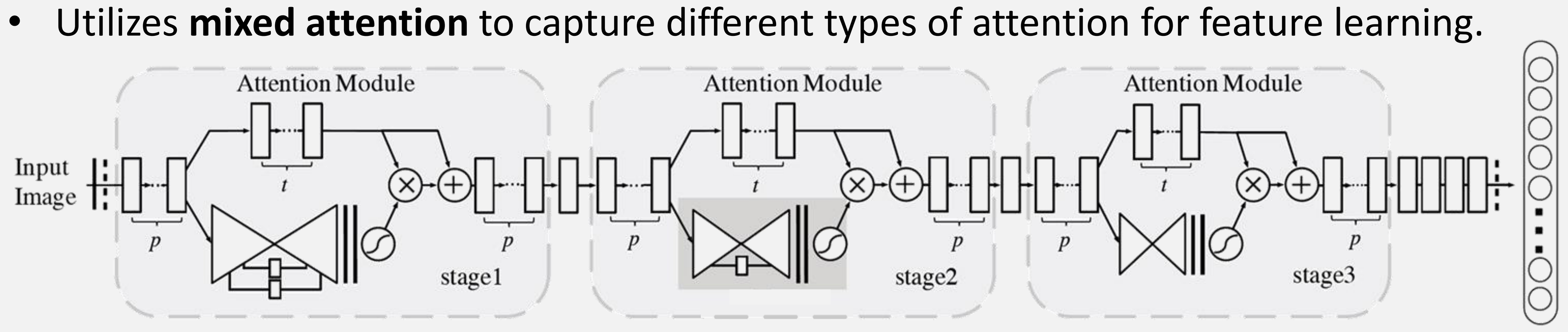

### Base-Learner 1 : DenseNet121

- Utilizes **dense connections** to regularize and **alleviate vanishing-gradient**.



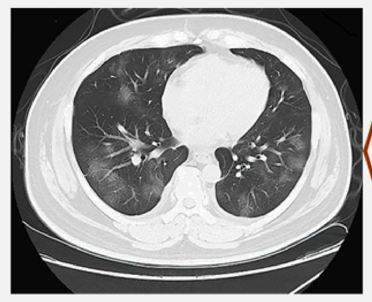

### Base-Learner 2 : Residual Attention 92

- Utilizes **mixed attention** to capture different types of attention for feature learning.

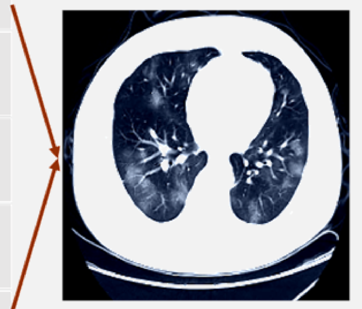



## Data Preprocessing & Model Training

- Used **6-fold cross-validation**, giving 452 training and 91 validation images.
- Used **Bayesian Optimization** to tune the hyperparameter of the model.
- Applied the following **transformations** and **augmentations** on training and only transformations on validation set:

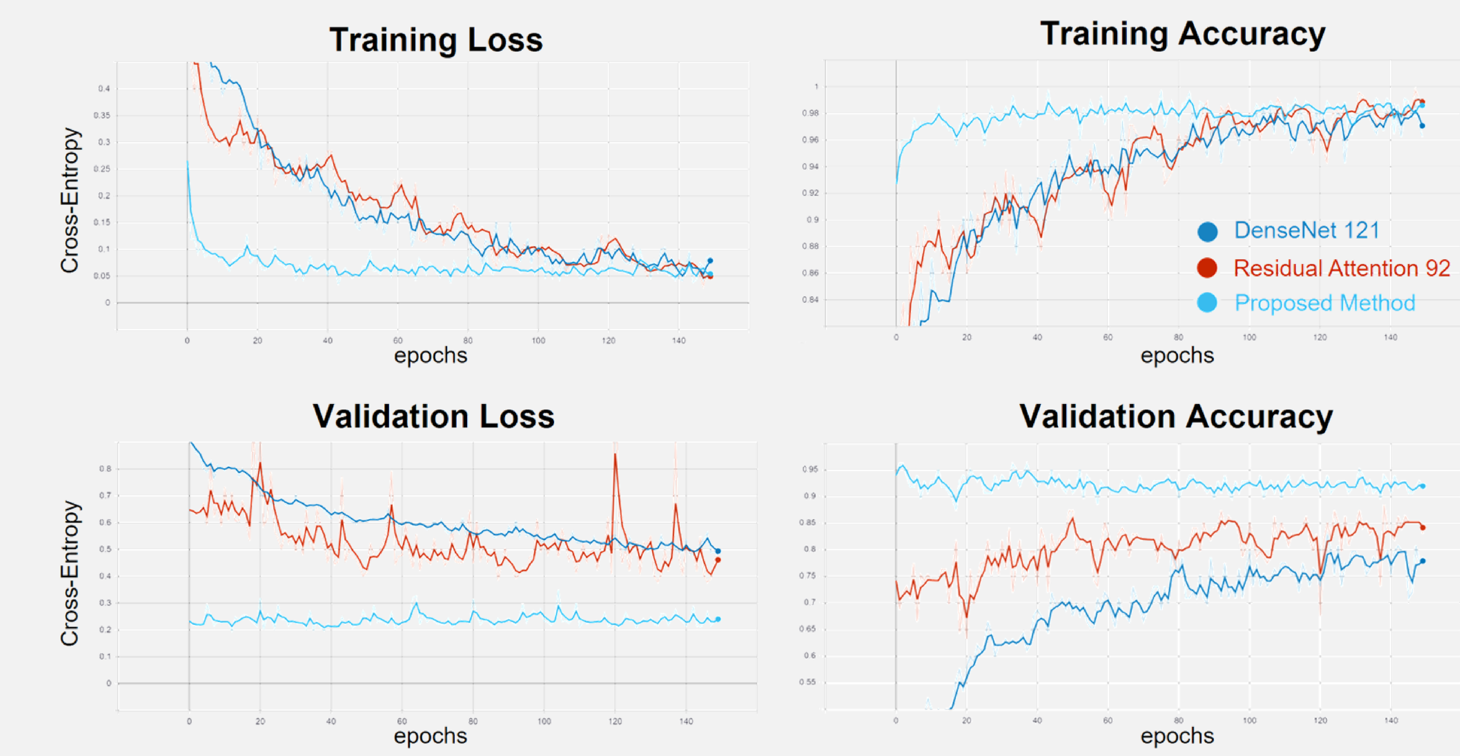


| Types | Parameters |
|---|---|
| Resize | Training: [ 256 , 256 ]<br>Validation: [ 224 , 224 ] |
| Random Resized Crop * | Scale = (0.5, 1)<br>Size = 224 |
| Random Horizontal Flip * | Probability = 0.5 |
| Random Rotation * | max left rotation=10<br>max right rotation=10 |
| Normalize Each Channel | Mean = [0.485, 0.456, 0.406],<br>Standard Deviation = [0.229, 0.224, 0.225] |

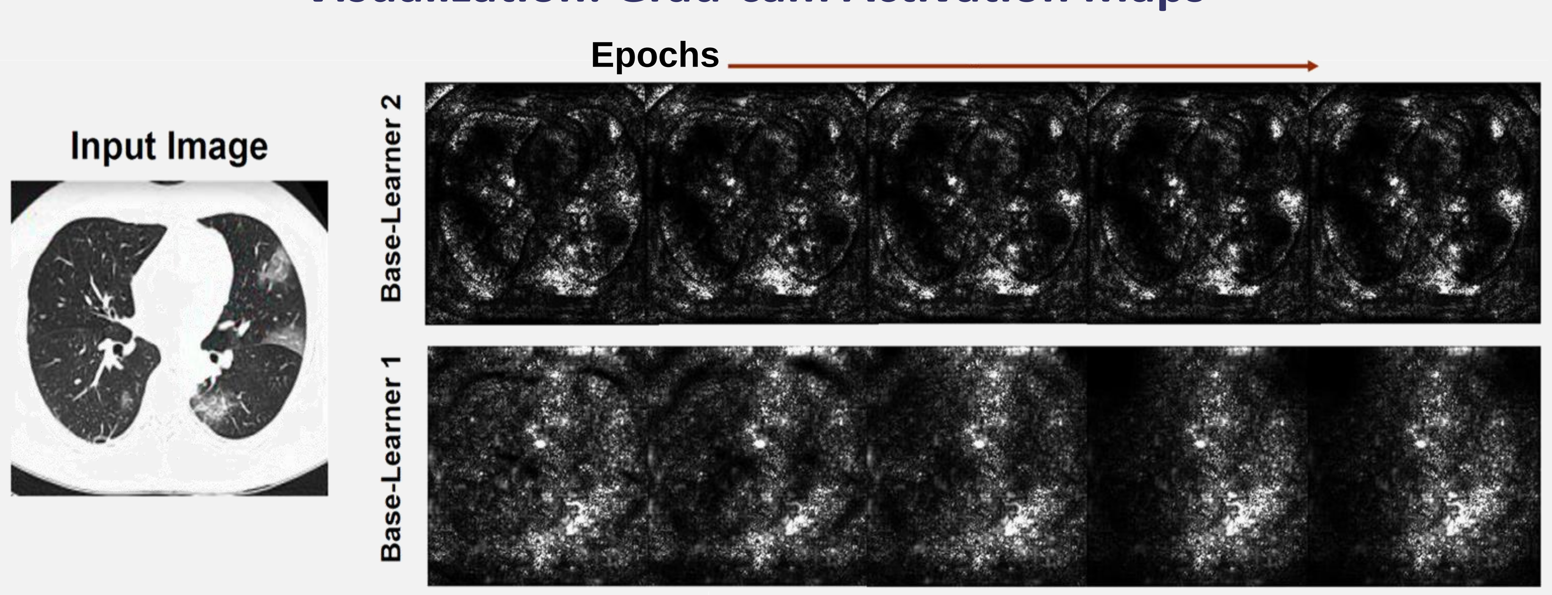


## Experimental Results

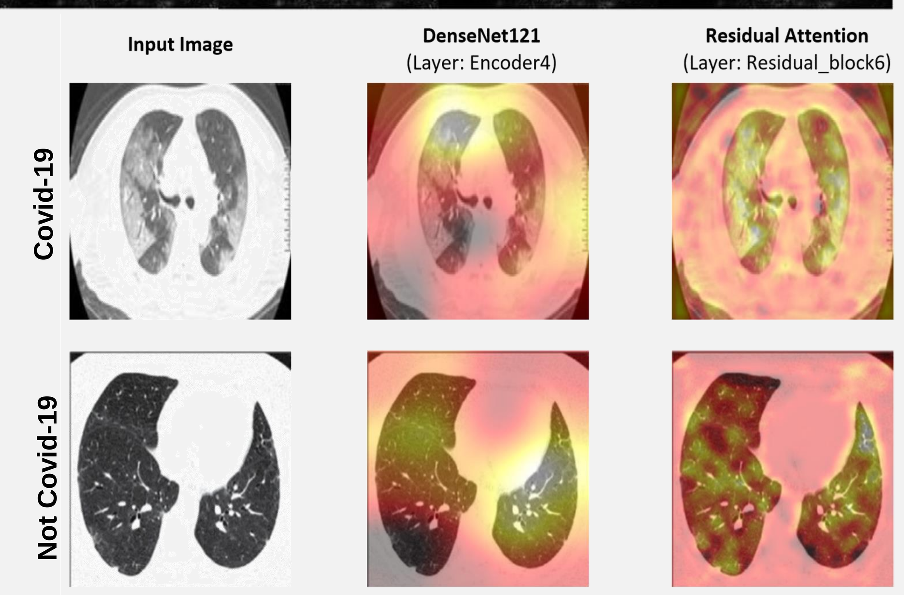
| Structure | Training Accuracy | Training F1 score | Cross-Validation Accuracy |
|---|---|---|---|
| DenseNet121 | 94.12% | 93.49% | 90.81% |
| Residual Attention | 94.50% | 94.99% | 91.34% |
| Proposed Method | 98.89% | 98.79% | 95.68% |




### Visualization: Grad-cam Activation Maps




- The more epochs we run, the **more focus** is given to **covid-19 manifestations**.
- This focus is more evident in the **second base-learner** as it uses **attention modules**.
- Base-learners focus on **complementary, attention-aware,** and **global features.**




## References

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