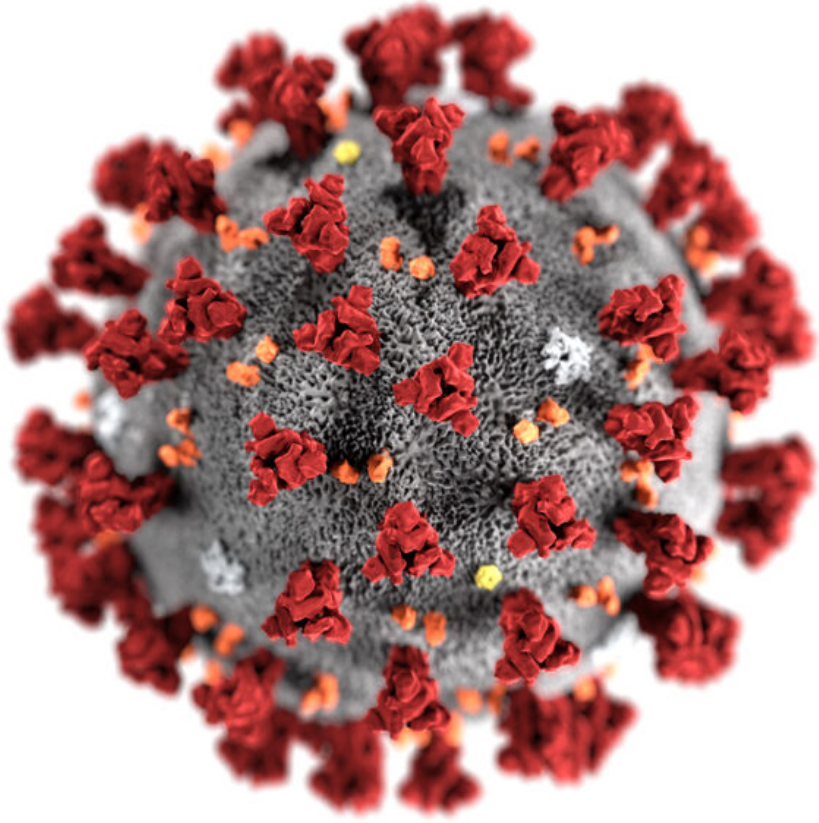

Detection and Localization of COVID-19 using Chest Radiographs (CXR)

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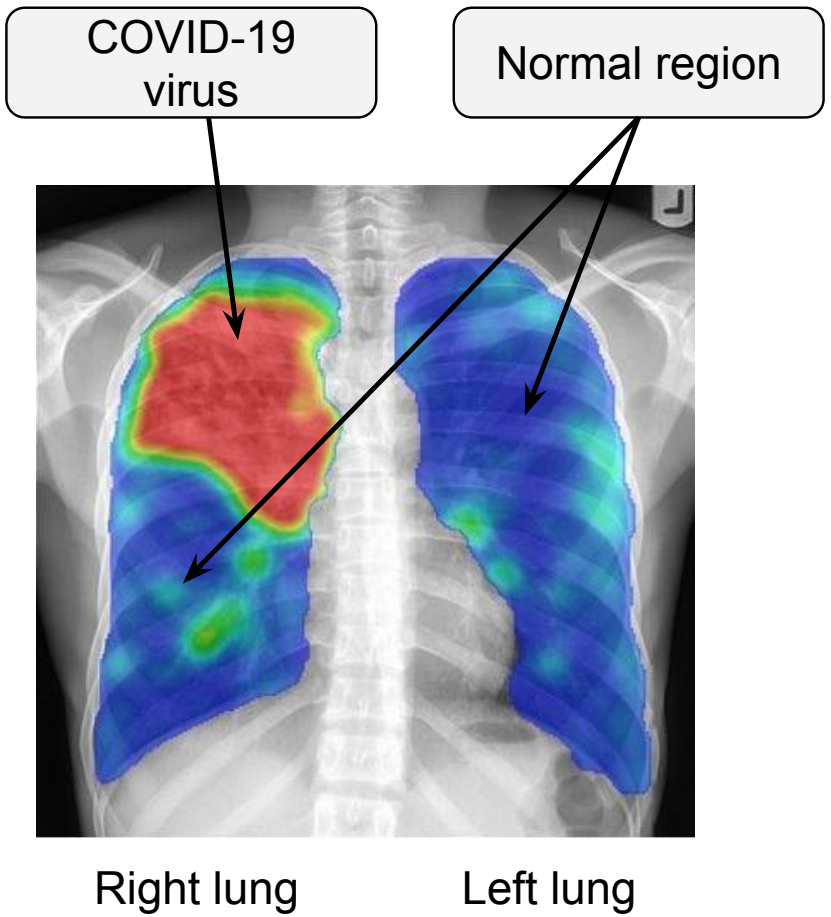
Overview

Introduction

- COVID-19 is a severe acute respiratory disease caused by SARS-CoV-2 virus
- Detection of disease is important to control its spread
- Localization of disease infected area is necessary to monitor the spread of virus and to take precautions accordingly
- Mobile application for lay audience
- Percentage of damage done to the lungs
- Prediction of duration of hospitalization (if needed)
- Field of study: Medical Imaging, Machine Learning



Literature Review I

Method [1]	Results	Limitations
1. First time application [1] of ML algorithms (15 deep CNN visual extractors + 6 ML Classifiers)	1. Accuracy of 99% (MobileNet and InceptionV3)	1. Model is trained on limited dataset (COVID-19 image data collection, Chest X-Ray images - 117 COVID +ve CXR images) and is not tested on independent dataset
2. No extensive data preprocessing or augmentation	2. Precision, recall and f1-score of 98% (DenseNet121)	2. Detection System not validated by medical specialists/radiologists
3. End-to-end web-based detection system		3. Possibility of presense of viral or bacterial pneumomonia not taken into consideration

[1] S. H. Kassania, P. H. Kassanib, M. J. Wesolowskic, K. A. Schneidera,and R. Detersa, "Automatic detection of coronavirus disease (covid-19) in x-ray and ct images: A machine learning based approach," Biocybernetics and Biomedical Engineering, vol. 41, no. 3, pp.867–879, 2021.

Literature Review II

Method [2]	Results	Limitations
1. Used VGG16, ResNet50 and EfficientNetB0[2]	1. Accuracy of 93% with VGG16	1. Model trained on limited dataset (COVID-19 image data collection - 468 COVID +ve CXR images)
2. Trained a Generative Adversarial framework (CycleGAN) to generate synthetic COVID positive images	2. Accuracy over 93% with synthetic images (VGG16)	2. Shape deformations in some synthetic COVID +ve images
	3. Recall score of 90% and 93% precision	3. Model is not tested on independent dataset

[2] T. Zebin and S. Rezvy, "Covid-19 detection and disease progression visualization: Deep learning on chest x-rays for classification and coarse localization," Applied Intelligence, vol. 51, no. 2, pp. 1010–1021, 2021.

Literature Review III

Method [3]	Results	Limitations
1. Used VGG16[3] and ResNet50	1. Accuracy of 89.2%	1. Model trained on limited dataset (COVID-19 image data collection, Radiopedia - 135 COVID +ve and 320 pneumonia CXR images)
2. Performed 10-fold cross validation	2. Specificity of 0.99	2. Lack of information on what stage of disease CXR is from and lack of information on outcomes
3. Augmentation to enhance dataset	3. AUC of 0.95	3. Reduced resolution of images and no pixel intensification or pre-processing done to cope with irregular opacity shapes

[3] L. O. Hall, R. Paul, D. B. Goldgof, and G. M. Goldgof, "Finding covid-19 from chest x-rays using deep learning on a small dataset," arXiv preprint arXiv:2004.02060,2020.

Literature Review IV

Method [4]	Results	Limitations
1. Used DenseNet-based UNet architecture[4]	1. IoU score of 0.9	1. Limited dataset (J. P. Cohen - 701 COVID +ve, 4283 pneumonia images)
2. Used Amazon Sagemaker Ground Truth tool to create mask images	2. Dice coefficient of 0.92	
3. Used Gradient-weighted class activation mapping to visualize activation maps		

[4]. J. Hasan, M. S. Alom, and M. S. Ali, "Deep learning based detection and segmentation of covid-19 pneumonia on chest x-ray image," in 2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD). IEEE, 2021, pp. 210–214.

Literature Review V

Method [5]	Results	Limitations
1. Used transfer learning[5]	1. Accuracy of 96.78%	1. Limited dataset (J. P. Cohen, Radiopedia, RSNA, COVID-19 Xrays - 224 COVID +ve, 700 pneumonia images)
2. Performed 10-fold cross validation	2. Sensitivity of 98.66%	2. Model not tested on independent dataset
3. Used VGG19 and MobileNetVt2	3. Specificity of 96.46%	

[5] I. D. Apostolopoulos and T. A. Mpesiana, "Covid-19: automatic detection from x-ray images utilizing transfer learning with convolutional neural networks,"Physical and Engineering Sciences in Medicine, vol. 43, no. 2, pp.635–640, 2020.

Literature Review VI

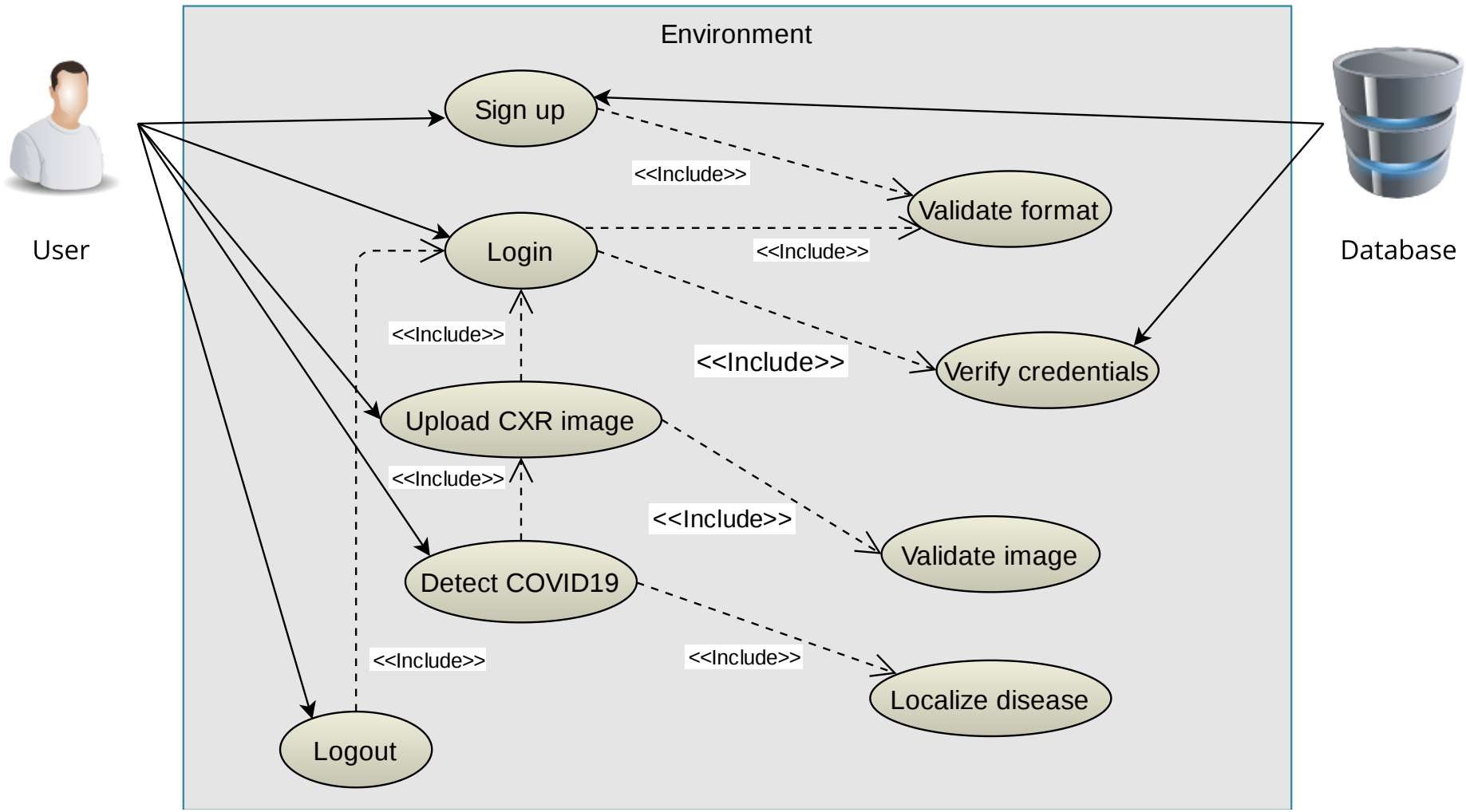
Method [6]	Results	Limitations
1. Supervised Machine Learning[6]	1. Precision of 96.8%	1. Images of normal lungs not considered for comparison with COVID +ve images
2. Used Color Layout Descriptor to obtain numerical values from images	2. Recall of 98.4%	2. Limited dataset (COVID-19 image data collection - 63 COVID +ve images)
3. Used MPEG-7 visual descriptor	3. F-measure of 97.6%	

[6] L. Brunese, F. Martinelli, F. Mercaldo, and A. Santone, "Machine learning for coronavirus covid-19 detection from chest x-rays,"Procedia Computer Science, vol. 176, pp. 2212–2221, 2020.

Problem Statement

The existing methods operate on limited datasets, while for larger datasets, the presence of multiple disease signatures in lungs, hazy lung opacities, irregular opacity shapes make the COVID-19 detection and localization a daunting task. This project will address the above problems by designing and implementing a robust solution utilizing the chest radiographs.

Usecase Diagram



Usecase Scenario - Login

Description	**Details**
Goal	Successful login
Preconditions	User must enter username and password
Successful End	User logs in
Failed End	User is unable to login
Primary Actors	User
Secondary Actors	Database
Trigger	User clicks login button
Main Flow	User enters credentials - Database validate credentials - User successfully logs in
Alternate Flow	User enters credentials - Database validate credentials - Credentials not found - User doesn't log in

Usecase Scenario - Validate Login

Description	Details
Goal	Correct login validation
Preconditions	User enters credentials to login
Successful End	Correct validation of credentials
Failed End	Incorrect validation of credentials
Primary Actors	None
Secondary Actors	Database
Trigger	User attempt to login
Main Flow	User enters credentials - Database validates credentials - Successful login if correct credentials
Alternate Flow	User enters credentials - Database server crashes - Credentials not validated

Usecase Scenario - Validate Image

Description	Details
Goal	Validate image
Preconditions	User is logged in
Successful End	Image is validated correctly
Failed End	Image is validated incorrectly
Primary Actors	None
Secondary Actors	External System
Trigger	User uploads image
Main Flow	User uploads an image - System checks image - Image validated correctly
Alternate Flow	User uploads an image - Server crashes - Image validation not done

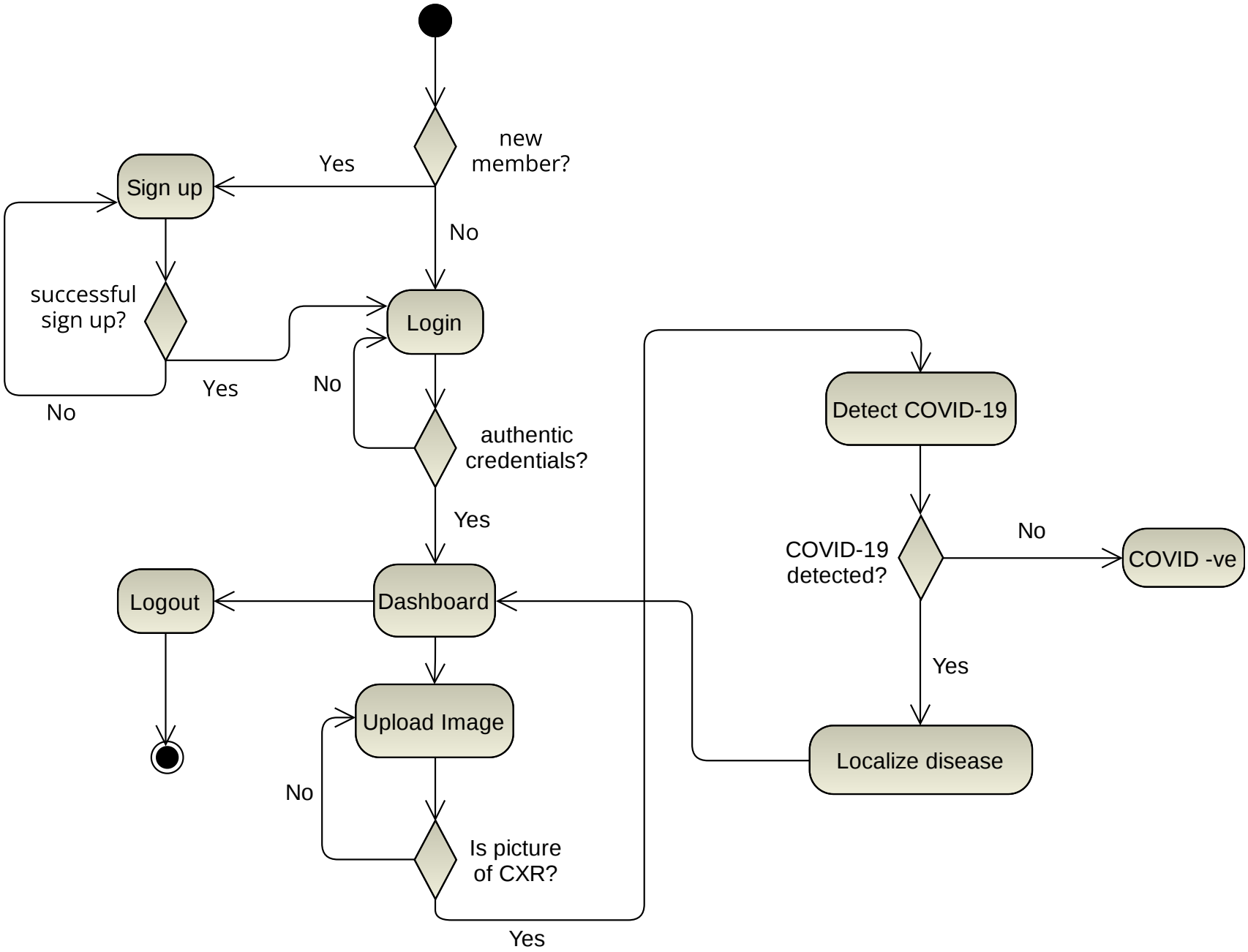
Usecase Scenario - Detect COVID-19

Description	**Details**
Goal	Detection of COVID-19
Preconditions	User successfully logged in, valid image uploaded
Successful End	Accurate detection of disease
Failed End	Normal lungs marked as infected by virus
Primary Actors	User
Secondary Actors	External System
Trigger	User clicks on 'Detect' after uploading CXR image
Main Flow	User uploads image of CXR - System detects COVID-19 - Healthy lungs are marked as normal
Alternate Flow	User uploads image of CXR - System detects COVID-19 - COVID-19 is detected in CXR of healthy lungs

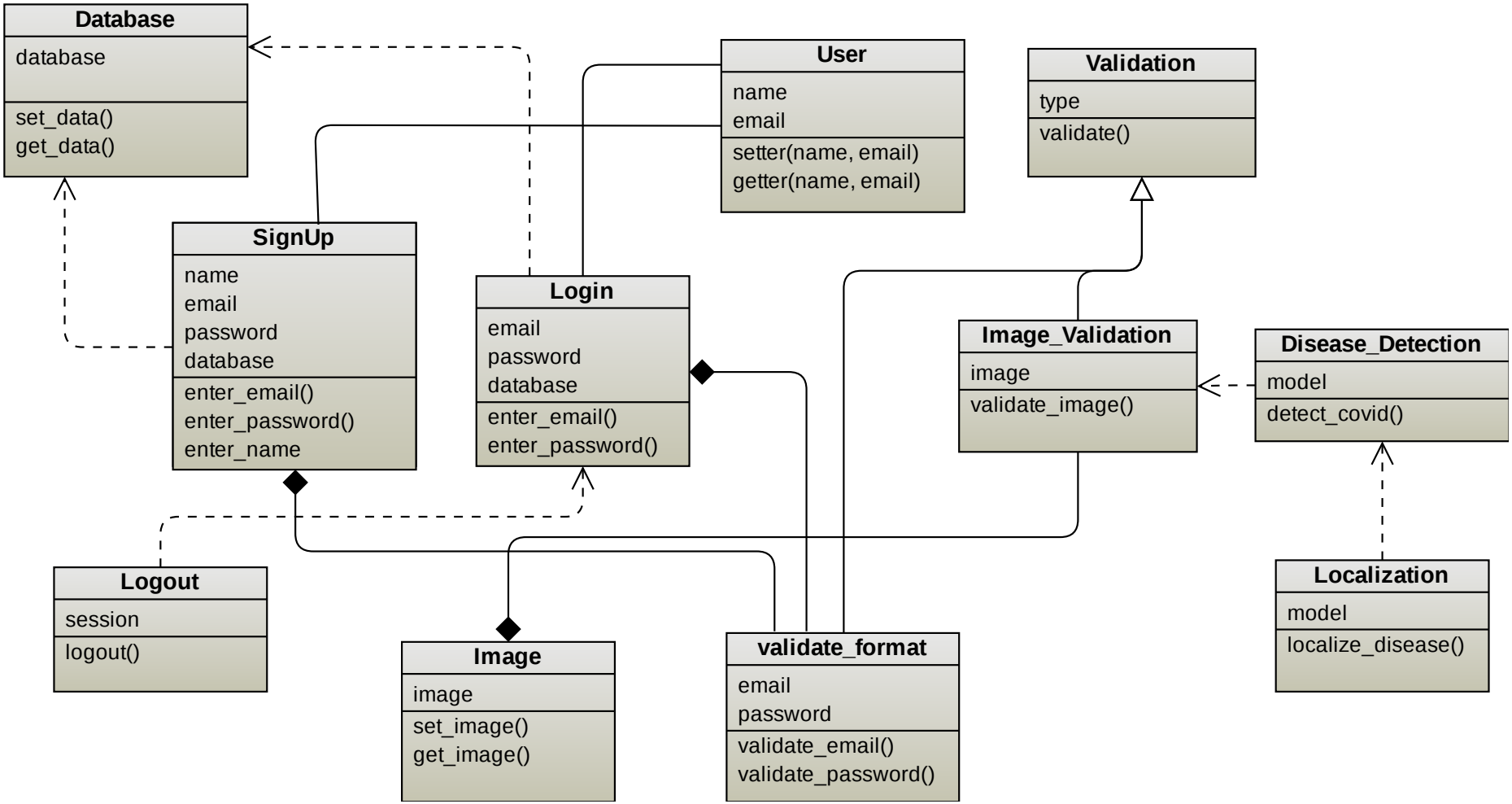
Usecase Scenario - Logout

Description	Details
Goal	Successful logout
Preconditions	User is logged in
Successful End	User logs out successfully
Failed End	User doesn't logout
Primary Actors	User
Secondary Actors	External System
Trigger	User clicks logout button
Main Flow	User clicks on 'Logout' - User logs out successfully
Alternate Flow	User clicks on 'Logout' - Server goes down - User is unable to logout

Activity Diagram

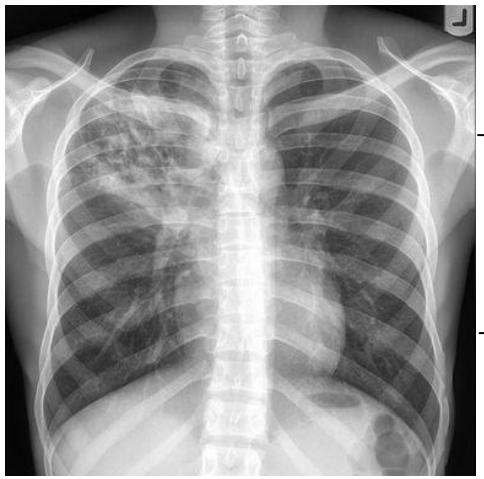


Class Diagram

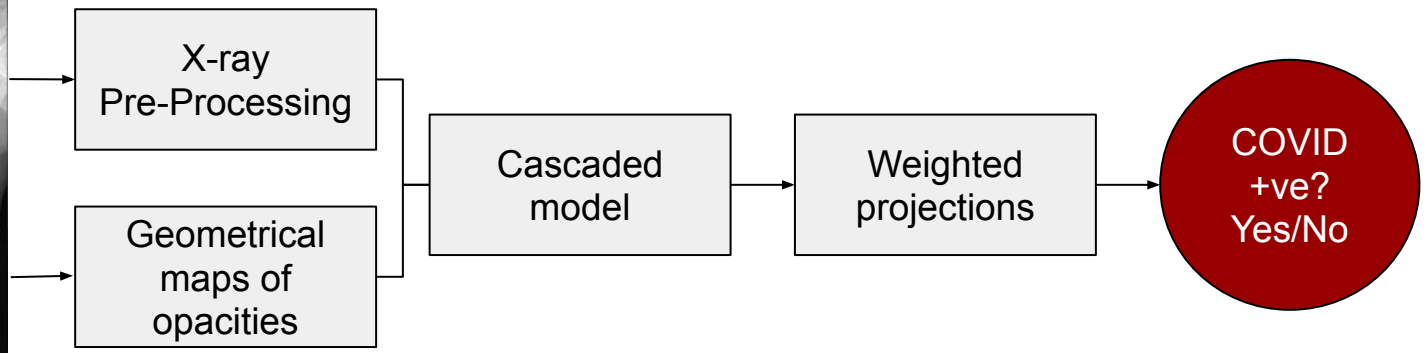


Proposed Methodology

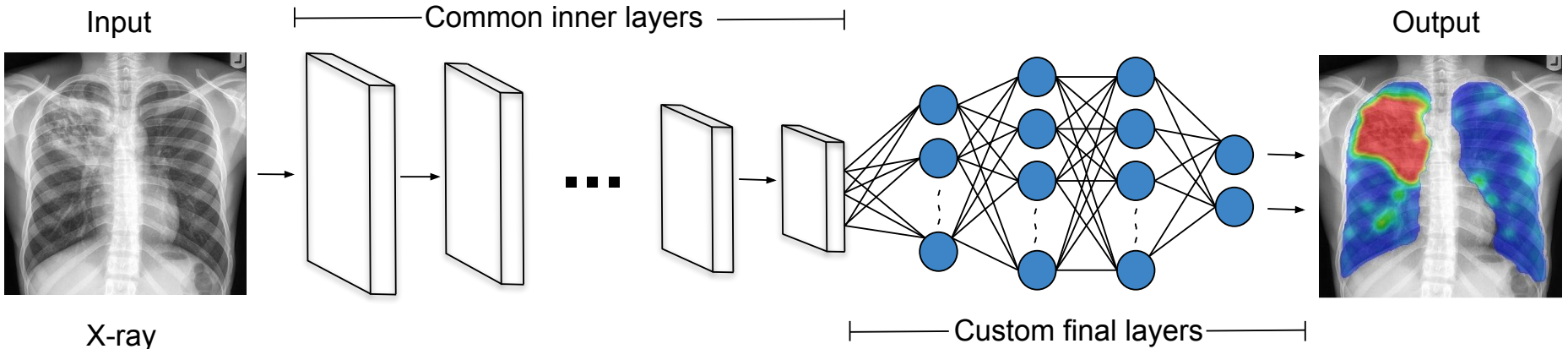
Model for Detection



X-Ray

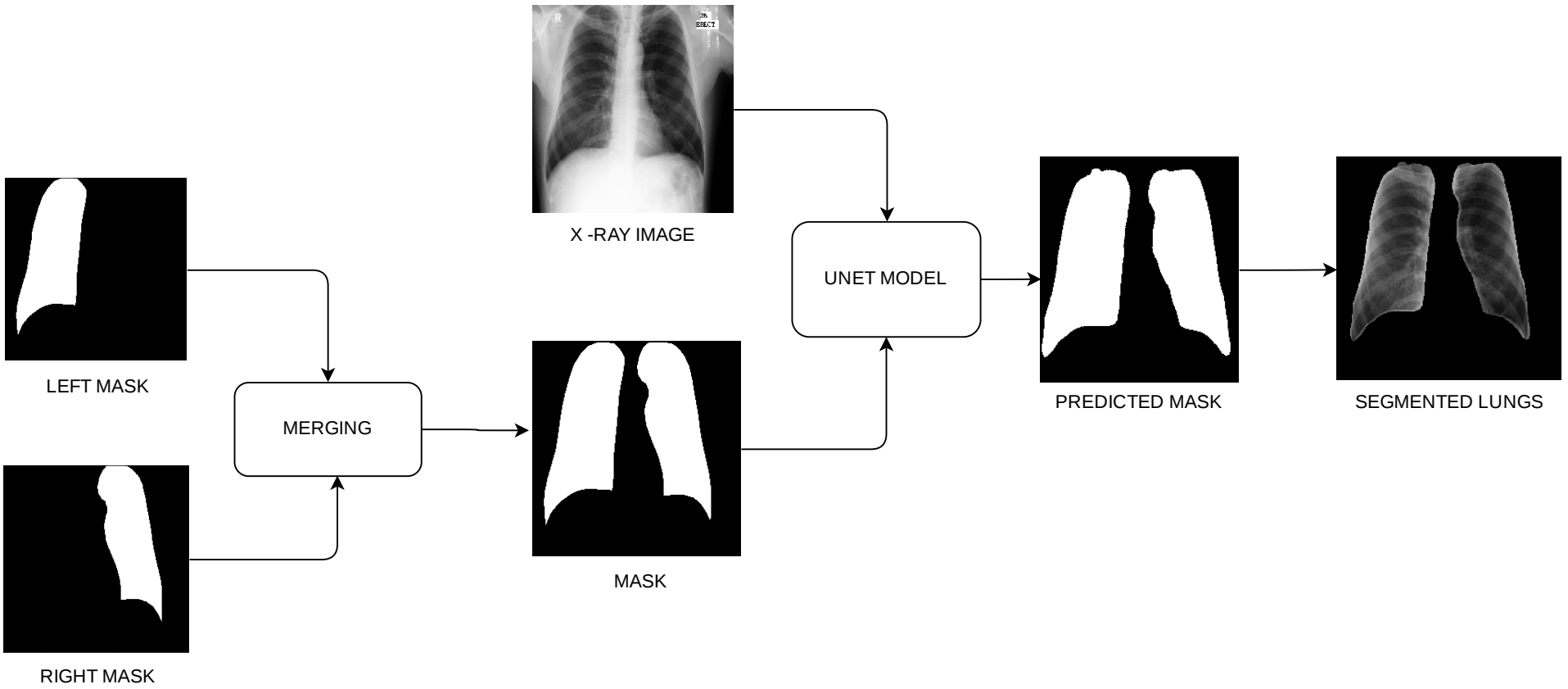


Transfer Learning model for Localization

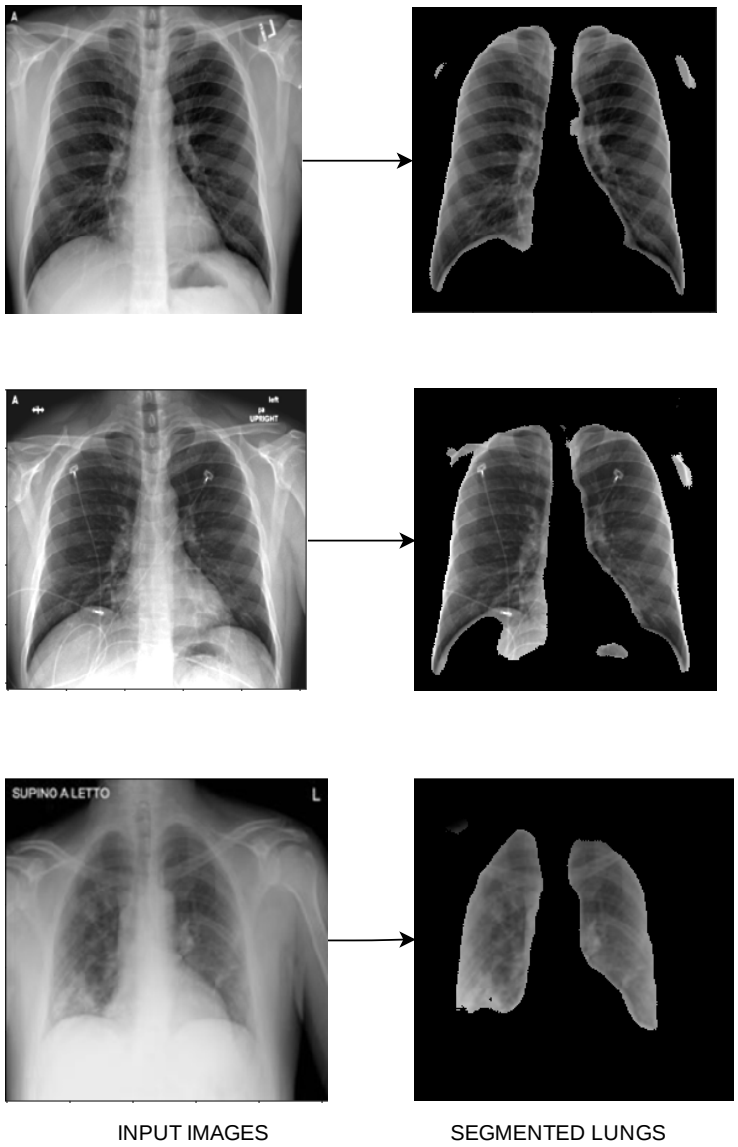


Progress

Lungs' segmentation using UNet Architecture



Results



INPUT IMAGES SEGMENTED LUNGS

- Image shows initial segmentation results
- Dice coefficient: 0.906548023
- IoU: 0.830218256
- Precision: 0.971458793
- Recall: 0.982139111

References

[1] S. H. Kassania, P. H. Kassanib, M. J. Wesolowskic, K. A. Schneidera, and R. Detersa, "Automatic detection of coronavirus disease (covid-19) in x-ray and ct images: A machine learning based approach," *Biocybernetics and Biomedical Engineering*, vol. 41, no. 3, pp. 867–879, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S020852162100067X

[2] T. Zebin and S. Rezvy, "Covid-19 detection and disease progression visualization: Deep learning on chest x-rays for classification and coarse localization," *Applied Intelligence*, vol. 51, no. 2, pp. 1010–1021, 2021. [Online]. Available: https://link.springer.com/article/10.1007/s10489-020-01867-1

[3] L. O. Hall, R. Paul, D. B. Goldgof, and G. M. Goldgof, "Finding covid-19 from chest x-rays using deep learning on a small dataset," *arXiv preprint arXiv:2004.02060*, 2020. [Online]. Available: https://arxiv.org/abs/2004.02060

[4] M. J. Hasan, M. S. Alom, and M. S. Ali, "Deep learning based detection and segmentation of covid-19 & pneumonia on chest x-ray image," in *2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD)*. IEEE, 2021, pp. 210–214. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9396878?casa_token=SlFazgNZ_V8AAAAA:JkJE4Ss7j0CP5V8MI8_lKgHyKTjWb6yds5UnNL71W3ENq9T79LuvtN-fXZ3wu4LscSJ8Xn4HNaaF3Q

[5] I. D. Apostolopoulos and T. A. Mpesiana, "Covid-19: automatic detection from x-ray images utilizing transfer learning with convolutional neural networks," *Physical and Engineering Sciences in Medicine*, vol. 43, no. 2, pp. 635–640, 2020. [Online]. Available: https://link.springer.com/article/10.1007/s13246-020-00865-4

[6] L. Brunese, F. Martinelli, F. Mercaldo, and A. Santone, "Machine learning for coronavirus covid-19 detection from chest x-rays," *Procedia Computer Science*, vol. 176, pp. 2212–2221, 2020. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1877050920321621