

Enhanced Covid-19 (SARS-COV-2) detection An Artificial Intelligence Approach

Dr. Regenold GmbH

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About Us

- Founded in 1994 by Dr. Jürgen Regenold
- Initial focus on clients wishing to access the German market
- Increased international scope of projects
- Extended regulatory advice to drug development projects
- Expanded geographically and established the international network, regulanet® in 2001, which today covers more than 90 countries with over 180 experts
- Started developing our presence in data science and analytics in 2015
- Currently establishing a validated AI platform (according to GAMP), for the development of solutions in the GxP and Medical Device area
- Today the Regenold Group has ~100 employees

Agenda

1. Background
2. What did we do?
3. The Proposed Process
4. Dataset
5. Architecture
6. Approach
 1. Series 1
 2. Series 2
 3. Series 3
7. Comparison
8. Conclusion



Agenda

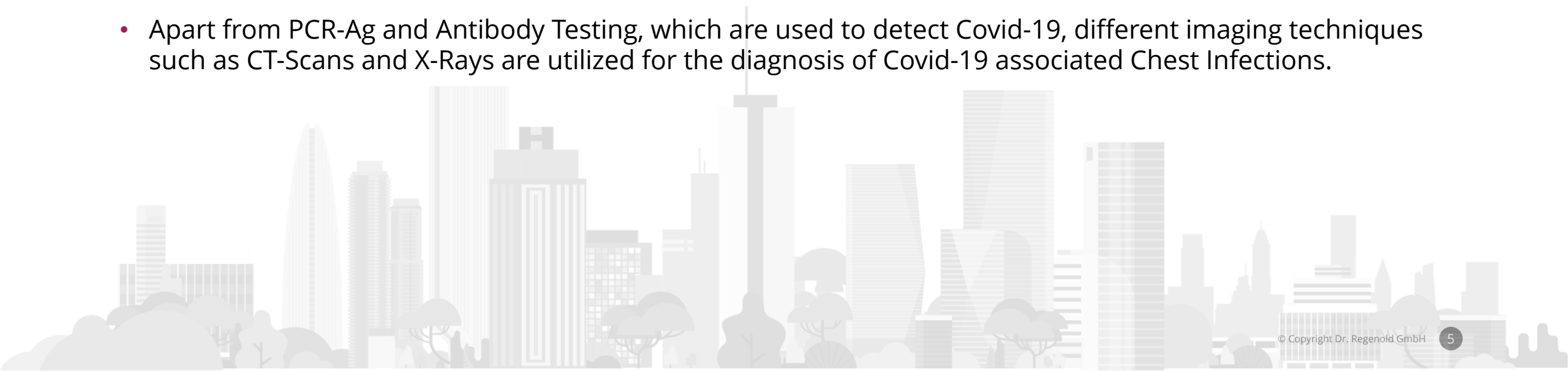
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Background

- Covid-19 (SARS-COV-2) has spread rapidly across the world and is now declared a global pandemic by WHO
- An early and accurate diagnosis of Covid-19 (SARS-COV-2) infection in symptomatic patients is critical from both, a public health and an individual care perspective.
- Apart from PCR-Ag and Antibody Testing, which are used to detect Covid-19, different imaging techniques such as CT-Scans and X-Rays are utilized for the diagnosis of Covid-19 associated Chest Infections.

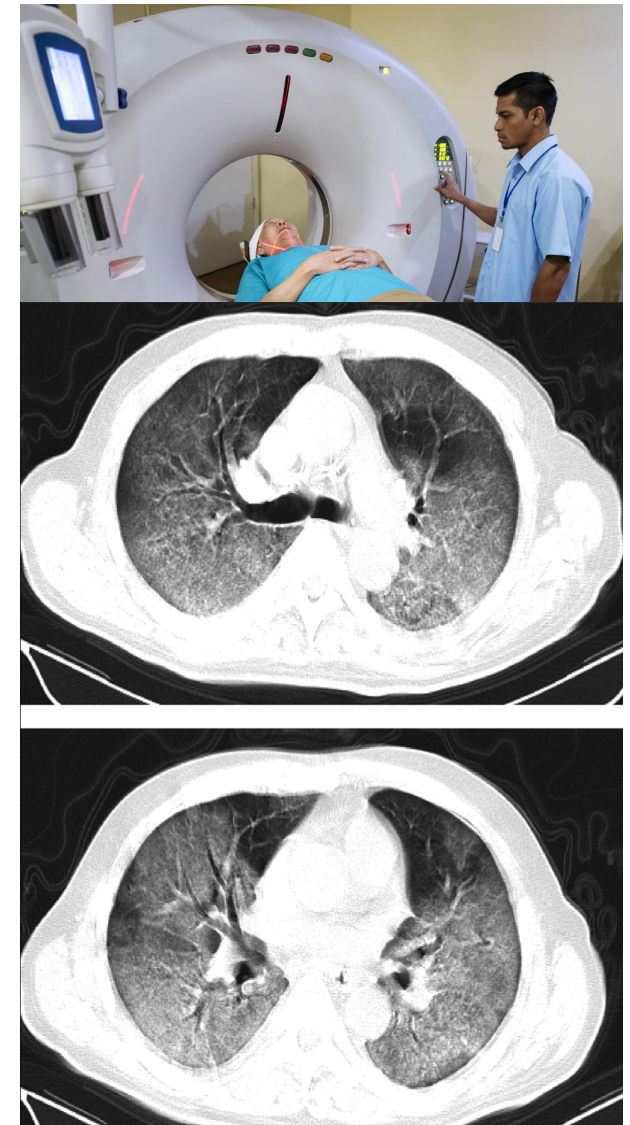


Background

Chest CT images would allow a better differentiation of COVID-19 infection from other causes with an aim to classify potential COVID-19 cases.

Problems with CT Scans as the diagnostic tool for Covid-19 Infections:

1. CT Scans are very expensive
2. The CT Scan facility is not available in every hospital.



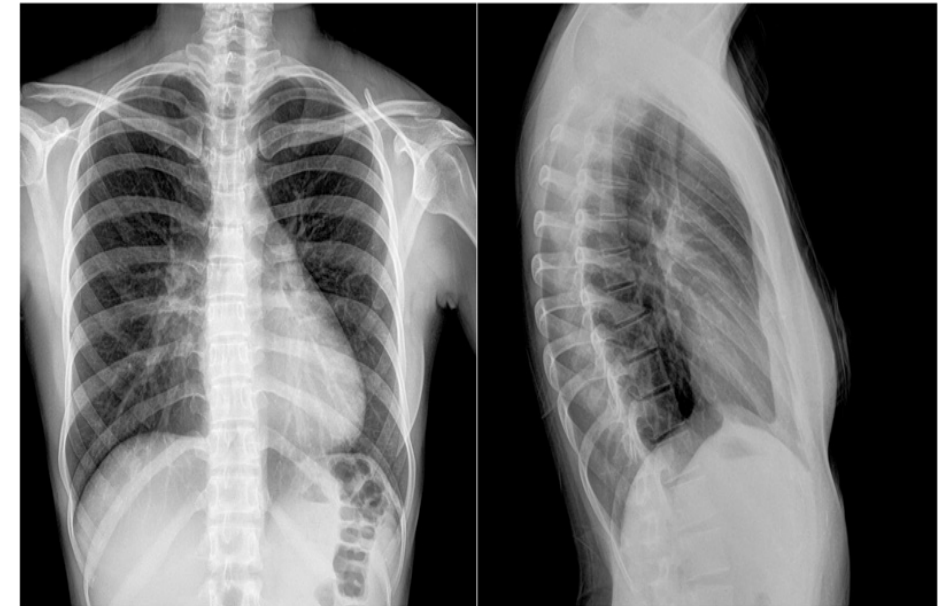
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What did we do?

- Although X-ray imaging technique has its limitations, Chest X-ray summation images ("X-ray") are still the standard for the diagnostic procedure in symptomatic patients at admission and during follow-up.
- At Dr. Regenold GmbH, we developed an AI model that can use chest X-RAY images of the infected patients to differentiate a Covid-19 (SARS-COV-2) infection from other viral and bacterial infections.
- The AI model can improve the quality and speed of the identification of Covid-19 (SARS-COV-2) specific lesions on chest X-ray images of unselected populations (e.g. at triage stations in large hospitals).

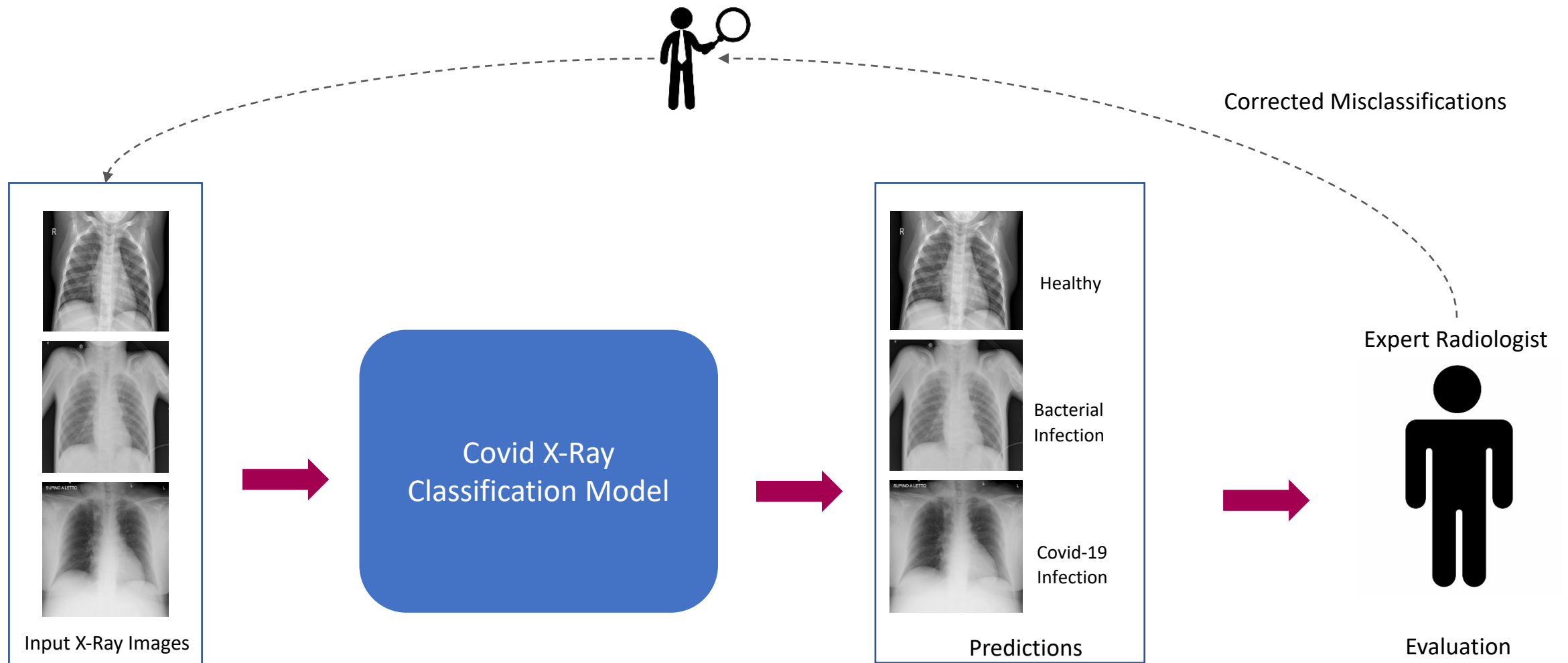


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The Proposed Process



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Dataset

Data source 1 - Overview

Normal Lungs, Bacterial Pneumonia Lungs and Viral Pneumonia Lungs Dataset

Source	https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia
Total Number of X-Ray Images	5863
Healthy Lungs X-Ray Images	1585
Bacterial Pneumonia X-Ray Images	2772
Viral Pneumonia X-Ray Images	1493

Data source 2 - Overview

Covid-19 Infected Lungs X-Ray Image Dataset Overview

Source	https://github.com/ieee8023/covid-chestxray-dataset
Total Number of Patients	135
Mean Age	54 years
Range of Age	12-87 years
Number of Male Patients	41
Number of Female Patients	33
Number of COVID-19 patients	103
Number of COVID-19 X-Ray Images	188
Number of other infections (Chlamyidophila, Pneumocystis, Streptococcus, Legionella, E.Coli, SARS, MERS) X-Ray Images	59

Dataset

Combined Dataset

Images are collected from the two sources and combined such that all the classes have roughly same number of samples to avoid the class imbalance problem

Source	https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia + https://github.com/ieee8023/covid-chestxray-dataset
Total Number of X-Ray Images	827
Healthy Lungs X-Ray Images	125
Bacterial Pneumonia X-Ray Images	155
Viral Pneumonia X-Ray Images	420
COVID-19 X-Ray Images	126

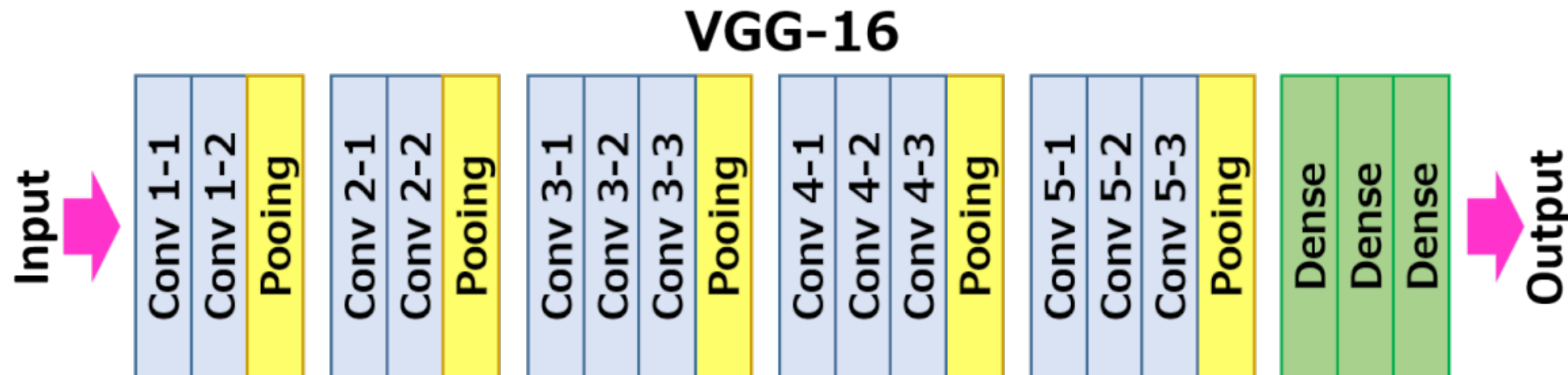
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Architecture

- VGG-16 Architecture is used which consist of 16 Layers (comprised of Convolution and Pooling)
- The network is pre-trained on ImageNet dataset.
- ImageNet dataset consist of images collected from the web and labeled by human labelers.
- The dataset consist of 1000 images in each of 1000 categories resulting in around 1.2 million training images



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Approach

The experiments on the dataset are performed in the following series:

- Series 1 - The analysis on X-ray images included images with three different classes:
 - Bacterial Pneumonia
 - Covid-19 Pneumonia
 - Healthy subjects
- Series 2 – The images from patients with **viral pneumonia** were included in the dataset of Series 1.
- Series 3 – The images from Viral and Bacterial Pneumonia into a single pneumonia class to improve the overall potential misclassifications.



Series 1

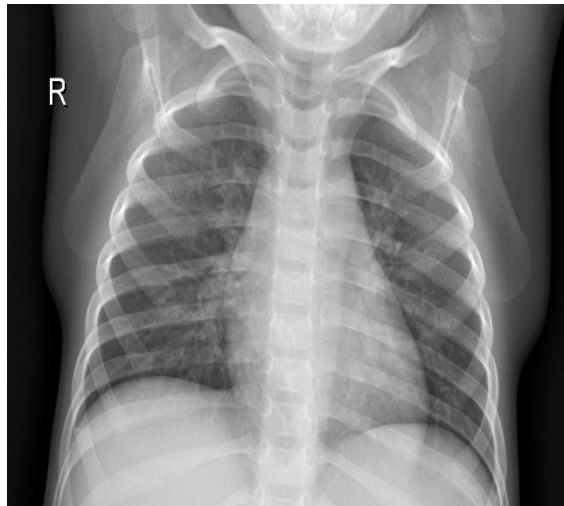


Series 1 - Overview

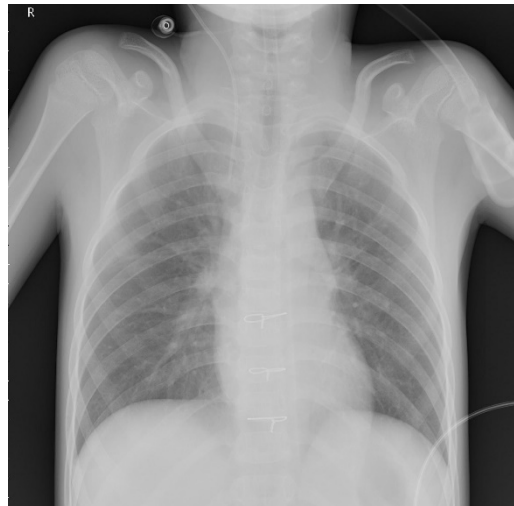
In the first stage, the analysis on X-Ray images is performed keeping in mind three classes to be classified

1. Healthy Lungs
2. Bacterial Pneumonia Lungs
3. Covid-19 Lungs

Viral Pneumonia X-Rays were intentionally excluded because Covid-19 is a virus itself



Healthy Lungs



Bacterial Pneumonia Lungs



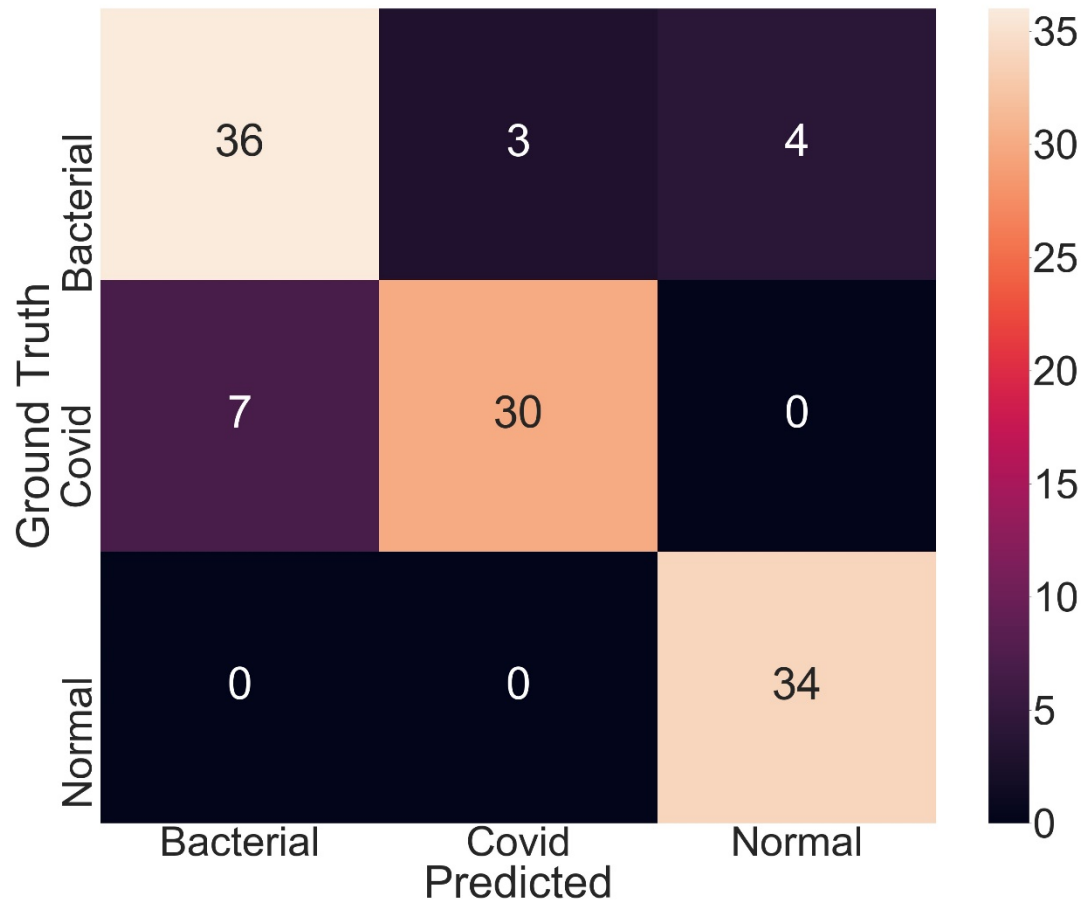
Covid-19 Infected Lungs

Series 1 – Data Distribution

Sample Distribution based on 80-20 split.

Training X-Ray Images	Proportion Training (Bacterial, Covid-19, Healthy)	Testing X-Ray Images	Proportion Testing (Bacterial, Covid-19, Healthy)
292	(112, 89, 91)	114	(43, 37, 34)

Series 1 - Results



Classes	Precision	Recall	F1-Score	Support
Bacterial Pneumonia Lungs	0.84	0.84	0.84	43
Covid-19 Infected Lungs	0.91	0.81	0.86	37
Normal Lungs	0.89	1.00	0.94	34

Overall Test Accuracy: 88%



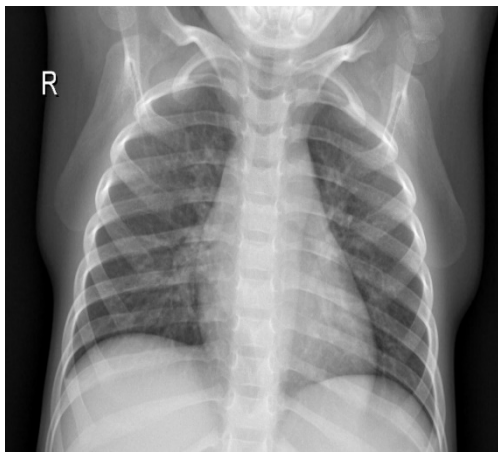
Series 2



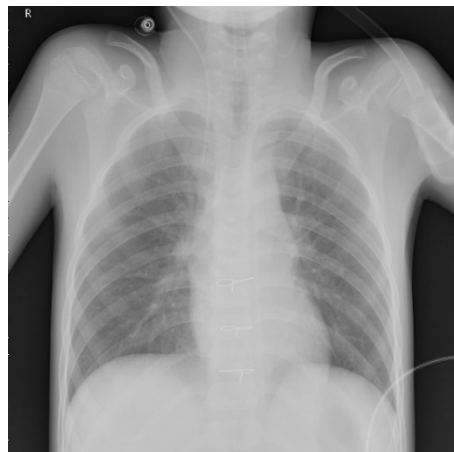
Series 2 - Overview

In the second stage of experiments, Viral Pneumonia X-Ray Images are added to the existing set of classes

1. Healthy Lungs
2. Bacterial Pneumonia Lungs
3. Covid-19 Lungs
4. **Viral Pneumonia Lungs**



Healthy Lungs



Bacterial Pneumonia Lungs



Covid-19 Infected Lungs



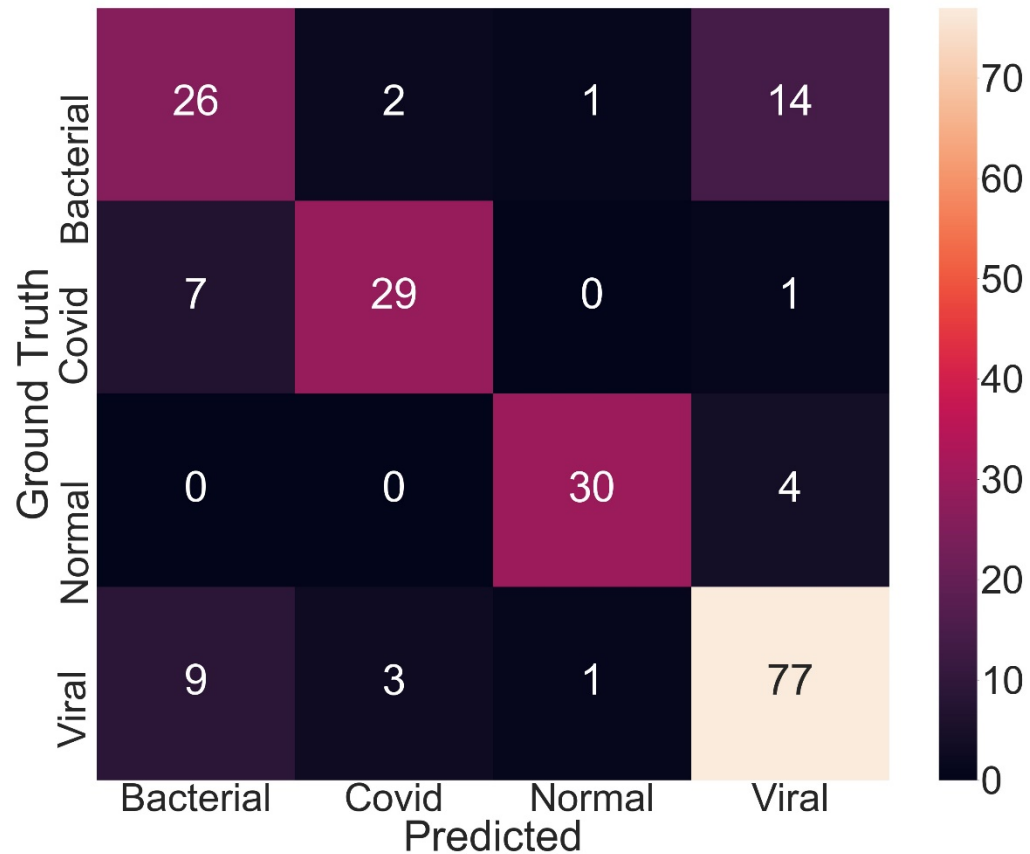
Viral Pneumonia Infected Lungs

Series 2 – Data Distribution

Sample Distribution based on 80-20 split.

Training X-Ray Images	Proportion Training (Bacterial, Covid-19, Normal, Viral)	Testing X-Ray Images	Proportion Testing (Bacterial, Covid-19, Normal, Viral)
622	(112, 89, 91, 330)	204	(43, 37, 34, 90)

Series 2 - Results



Classes	Precision	Recall	F1-Score	Support
Bacterial Pneumonia Lungs	0.62	0.60	0.61	43
Covid-19 Infected Lungs	0.85	0.78	0.82	37
Normal Lungs	0.94	0.88	0.91	34
Viral Pneumonia Lungs	0.80	0.86	0.83	90

Overall Test Accuracy: 79%



Series 3



Series 3 - Overview

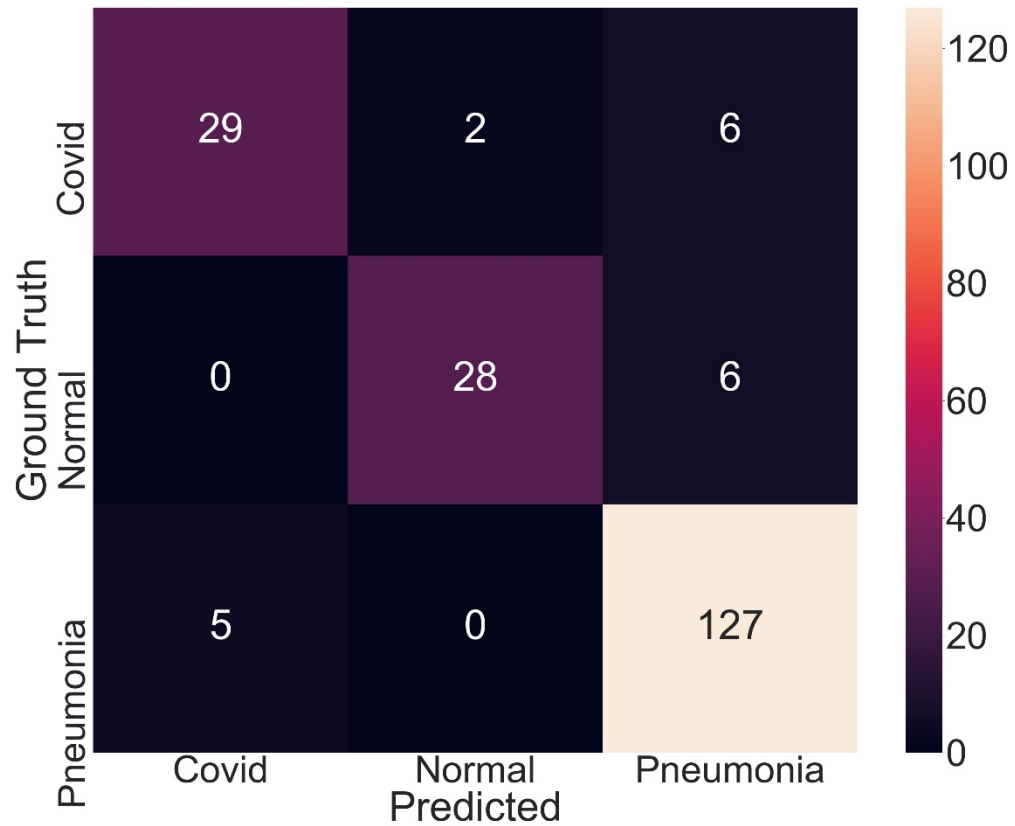
- Results in the previous experiment specify that the classifier often gets confused between Viral and bacterial pneumonia
- However, the classifier classifies Covid-19 infections with other infections correctly most of the time.
- In order to overcome this issue, we combined Bacterial Pneumonia and Viral Pneumonia X-Ray images in a single class and named it Pneumonia. The classes now become as follows:
 - Pneumonia Lungs (Bacterial + Viral Pneumonia X-Ray Images)
 - Covid-19 Lungs
 - Healthy Lungs

Series 3 – Data Distribution

Sample Distribution based on 80-20 split.

Training X-Ray Images	Proportion Training (Pneumonia, Covid-19, Normal)	Testing X-Ray Images	Proportion Testing (Pneumonia, Covid-19, Normal)
622	(442, 89, 91)	204	(133, 37, 34)

Series 3 - Results



Classes	Precision	Recall	F1-Score	Support
Covid-19 Infected Lungs	0.85	0.78	0.82	37
Normal Lungs	0.93	0.82	0.87	34
Pneumonia Lungs	0.91	0.96	0.94	133

Overall Test Accuracy: 91%

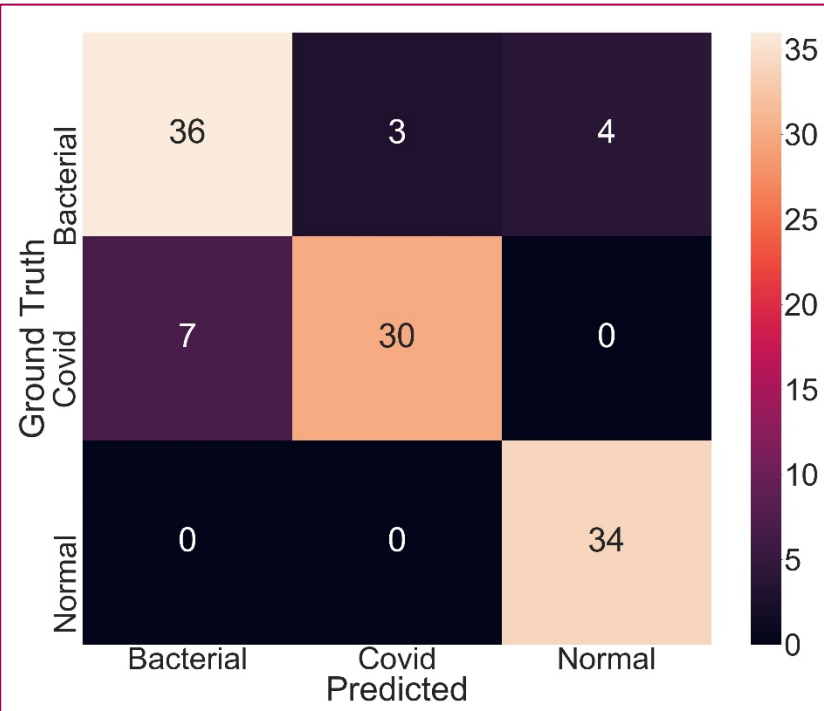
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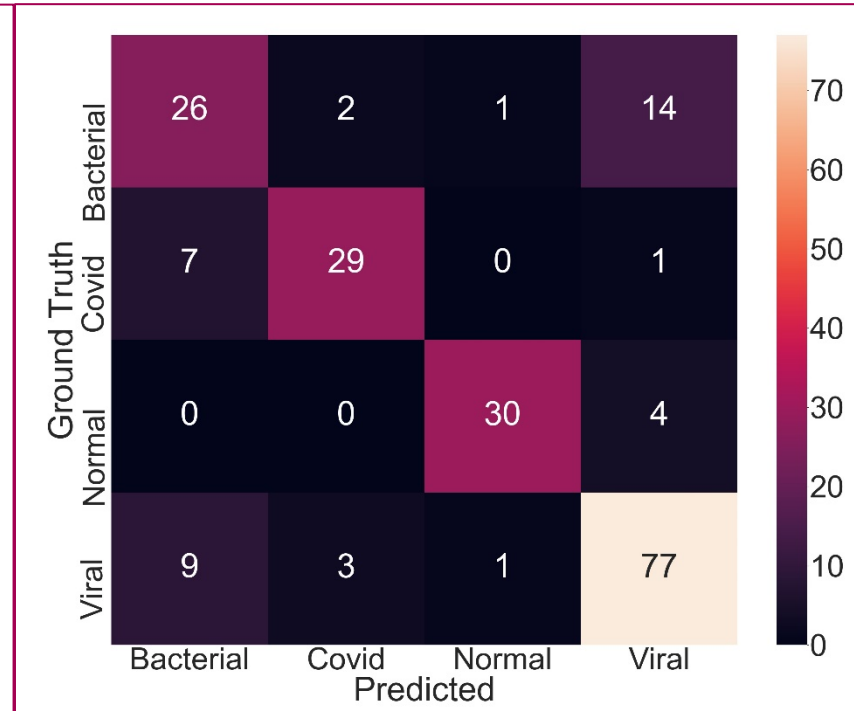


Comparison

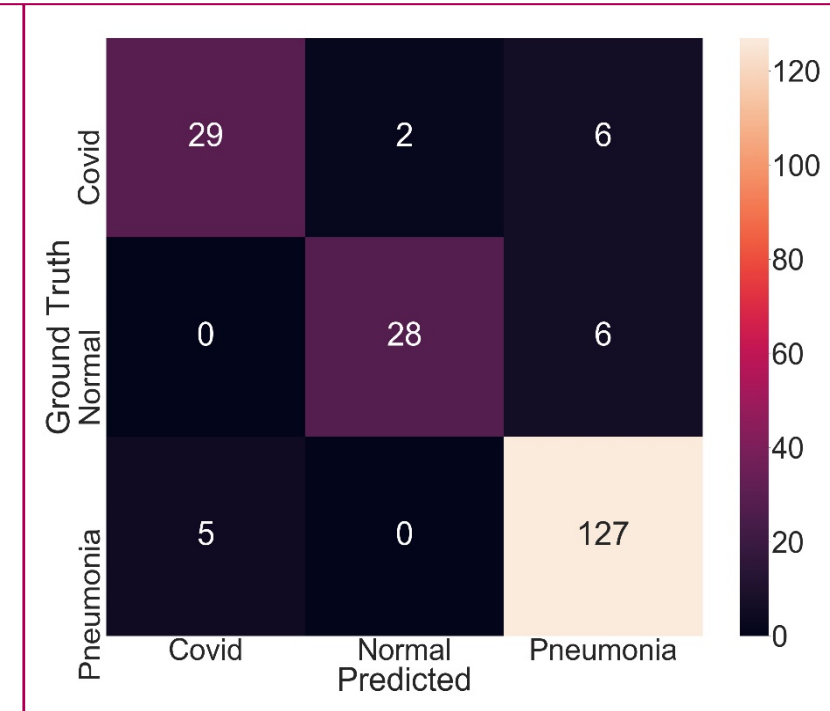
Series 1 vs Series 2 vs Series 3



Series 1
F1- Score of Covid: 0.86



Series 2
F1-Score of Covid: 0.82



Series 3
F1-Score of Covid: 0.82

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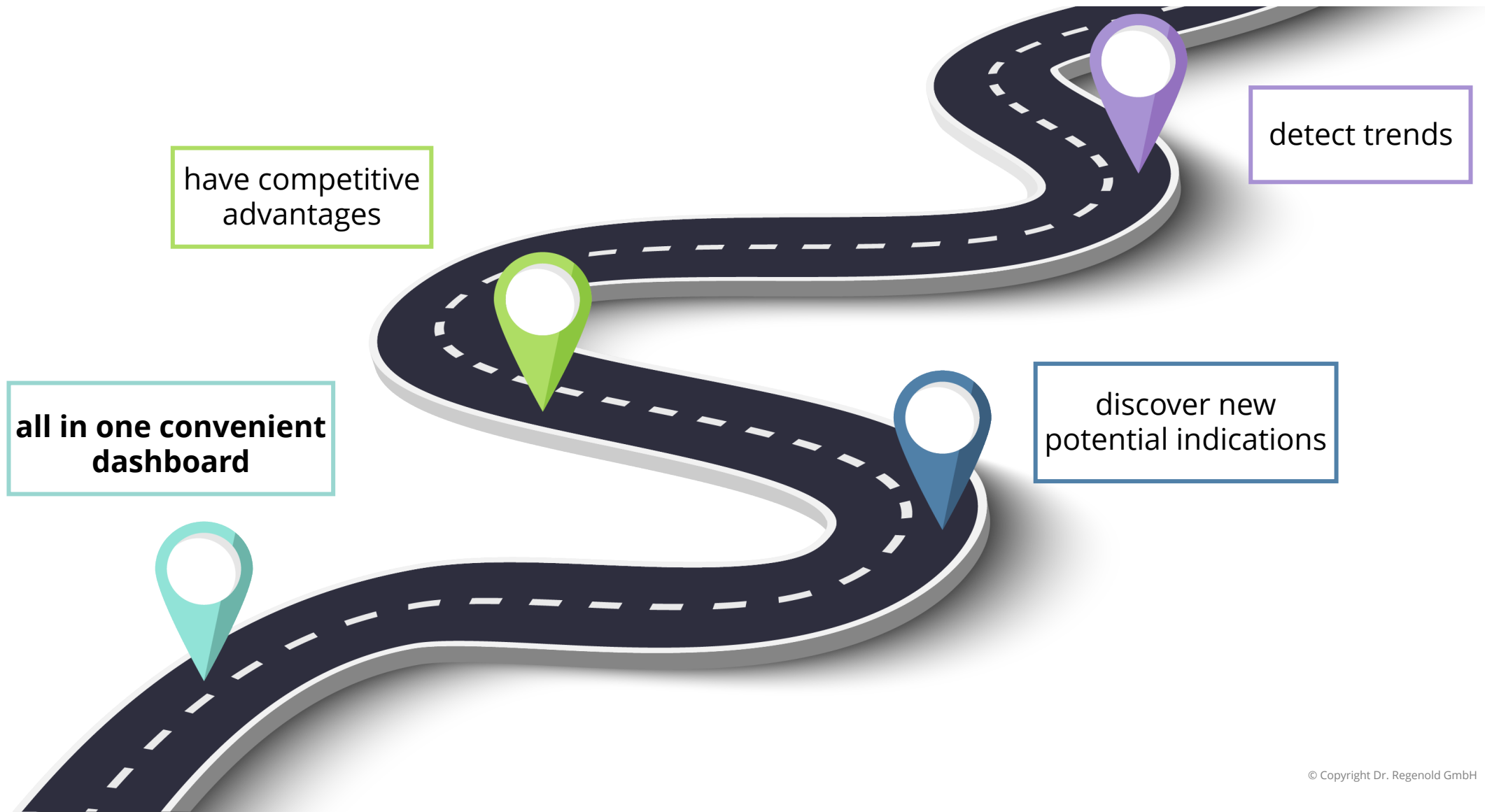
Conclusion

- A pattern of improved discrimination between Covid-19 from Healthy lung was observed in all series.
- Although a reasonable discriminative pattern of Covid-19 from Viral Pneumonia lungs was observed, the Machine Learning Classifier found some overlapping patterns between Covid-19 and Bacterial Pneumonia and hence wrongly predicted some Covid-19 infections as Bacterial.
- In order to prove the above mentioned findings, the ML Model needs to be trained with large numbers of pictures from many different categories of Chest X-Rays.
- Apart from it, clinical studies also need to be performed to verify if there are overlapping patterns between all these types of infections and whether any distinguishing pattern can be observed.

Possible applications

- Triage screening in emergency medical settings

A roadmap to the authentic voice of the patient





Covid-19 Diagnostic Tools

Analysis on Social Media Data

Wednesday, 25 March 2020 23:59:57 to Tuesday, 21 April 2020 23:59:59

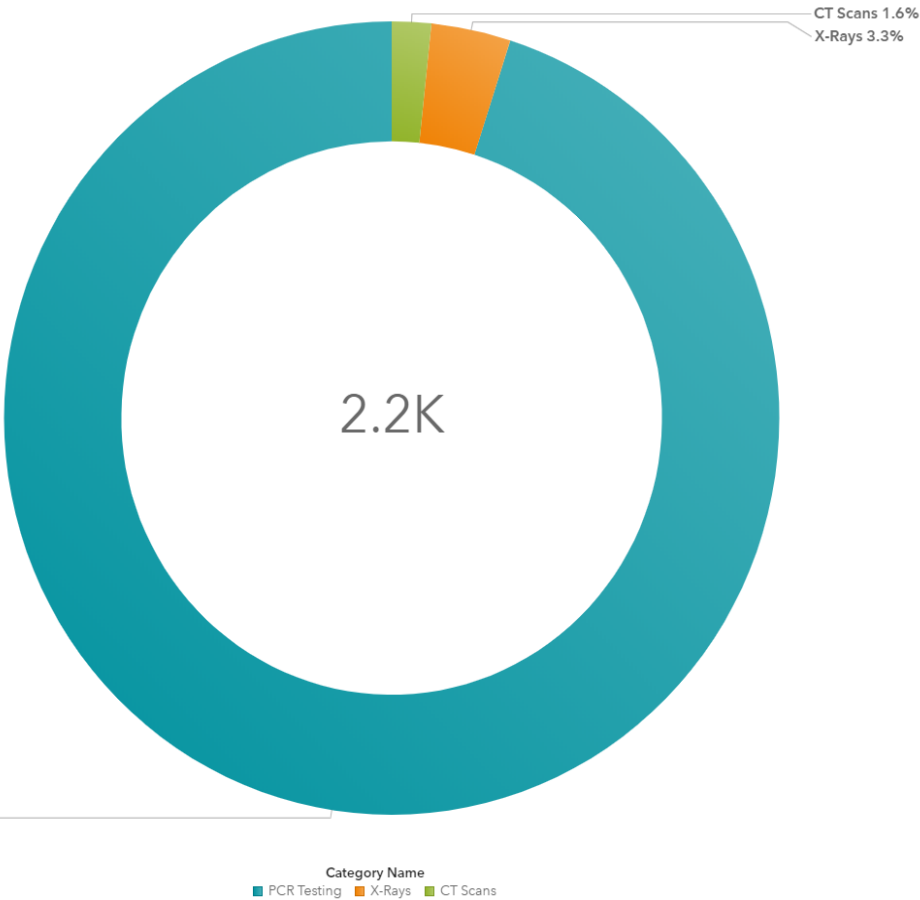
Wednesday, 25 March 2020 23:59:57

Tuesday, 21 April 2020 23:59:59

Filters: No selections

Frequency of Category Name

Frequency



Complete_Text

Zweli Mkhize pays respect to Professor Gita Ramjee who was Chief Scientific Officer at the Aurum Institute and former chief specialist scienti...

Zum Thema Corona Tracking App. <https://t.co/wcEu1iZXgf> #lanz #linuzifer

Zulum denies self easter holiday, takes cash, food to 11,000 in Magumeri ... Advocates on Covid-19 ... Visits Soldiers ... Orders rebuilding o...

Zulfi Bukhari criticises opposition for doing politics over corona crisis #APPNews @sayedzbukhari #CoronaVirus #CoronaVirusUpdates #CO...

Zuia SARs-Cov-2 Put on Protective Mask #KomeshaCorona #BeSafeOutThere SARs-Cov-2 is real Comply with @MOH_Kenya directives http...

Zubiri: I got the body pains on March 11. I must have gotten #COVID19 from visitors in the senate; one was probably asymptomatic. I took p...

Zpack is bc u will end up with 2ndary BACTERIAL infection- in lungs, + this will beat that. If u dont treat WITH Zpack- STOOPIID!! Anndd HYD...

Zoonotic Corona: Tiger tests positive for coronavirus, three lions show symptoms in US <https://t.co/4DsEyyIPk>

Zoonosis, meet the doctor whos just called out your human enablers for the mess theyâ€™ve made. #SARS_COV_2 <https://t.co/zo8b9jU4S>

Zoonosis is animal to human Reverse zoonosis is human to animal We donâ€™t yet know how common this is, but you may want to avoid an...

Zoomlion Ghana Limited (ZGL), a subsidiary of the Jospong Group of Companies (JGC), has donated GHC 120,000.00 to the Institute to su...

zoomed with my dr to follow up on the inhaler she gave me and she was like anyway iâ€™m almost positive u had corona in january so write...

Zoomed today with a friend who was in ICU with Corona Virus this time last week after almost a week on a ventilator. Now out and recovering...

Zoomâ€™s security and privacy problems are snowballing <https://t.co/FTCTKLJyVE>

Zoom video Conf app is safe enough to be used by UK Cabinet but Indiaâ€™s Home Ministry has declared a company listed on NASDAQ a...

Zoom Video Communications saw a boom in its user base, ever since lockdowns across the world due to the COVID-19 pandemic forced pe...

Zoom trying to find where all their users went once the corona vaccine is released <https://t.co/ud4kAew4bD>

Zoom Press Conference and 1st COVID-19 Death in Barbados (April 5, 2020) <https://t.co/YBnKJ2TyNH> <https://t.co/hysmhE4d13>

Zoom is video chat. @MicrosoftTeams is video chat, a full technology ecosystem, no security issues. No, @MicrosoftAU doesn't pay me, I'm ju...

Zoom is not perfect (as nothing is). As attorney/ADR practitioner using Zoom, you should be aware of its flaws & changes coming to its...

Zoom is facing questions about how private or secure it really is <https://t.co/RVaQ78nSRV> #CoronaVirus #CoronaVirusOutbreak #COVID201...

Zoom has issues, Pinterest founderâ€™s new COVID-19 research app, record Q1 spending â€™ TechCrunch <https://t.co/dyGjGWtsMD> <https://t.co/nNYN...>

Zoom Fatigue Syndrome. If you haven't caught #COVID19, you may have this! #lawyers #academics <https://t.co/ARYg0aghIF> via @mdionnet...

Zoom chief Eric Yuan said the company is cooperating with authorities as it has fielded questions from 27 U.S. attorney generalâ€™s offices...

Zoom call: â€™ heard you cough you have COVID-19?â€™ <https://t.co/TXQQ8Ed33D>

Zoom App Steps Up in the Time of Corona Virus <https://t.co/9Okc0swGLf> <https://t.co/0u5R2GQ0Wn>

Zoom app created coronavirus

Zoom \$ZM settled +5.1% to \$128.20, on the Corona 'work from home' issue. There are inherent problems in terms of privacy/security, but fe...

Zoelady terrorizing all my cousins with this corona virus prevention smoothie ðŸ™

Zoe is improving slowly. Sheâ€™s on half the original sedation. She has opened her eyes and taken some breaths but is still on the ventilato...

Zoa Morani on her battle with coronavirus: My first symptom was a fever, followed by cough, weakness and breathlessness <https://t.co/nNYN...>

Zoa Morani on her battle with coronavirus: My first symptom was a fever, followed by cough, weakness and breathlessness <https://t.co/C412...>

Zoa Morani on her battle with coronavirus: My first symptom was a fever, followed by cough, weakness and breathlessness <https://t.co/aiFKt...>

Zoa Morani on her battle with coronavirus: My first symptom was a fever, followed by cough, weakness and breathlessness <https://t.co/0j3z0...>

Zlatan has to be the biggest cheat chaser on this app, always hopping on trends, did someone with cheaters dropped a song called corona...

Questions & Answers





Thank you.

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Founder of

