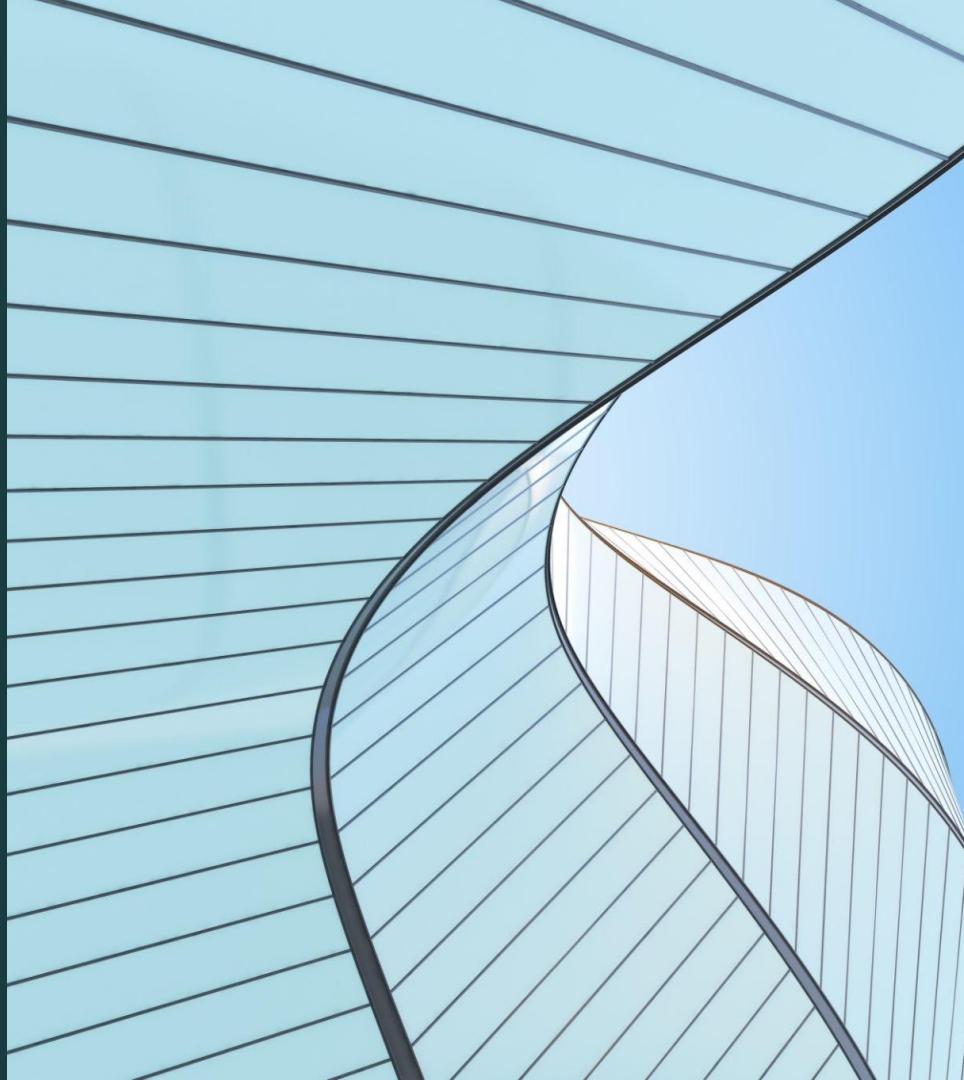


GradCAM Analysis on CNNs for Medical Imaging

Wadie Abboud
Henry Morris
Arjun Rao



Presentation *outline*

1

Motivation

2

GradCAM

3

Lung Disease
Features

4

Model Details

5

ResNet50 Model
Results

6

ResNet50
GradCAM Findings

7

Model Comparison

8

Conclusion

Motivation

Why do we need to analyze ML models?

Motivation

- Diagnosing can be a time consuming, frustrating process for patients and providers
- A machine learning diagnosing tool can reduce the load on radiologists
- Deep learning models can increase diagnosing accuracy while providing a faster turnaround for patient-provider interaction



Motivation

- How can doctors trust the predictions of ML models?
- GradCAM allows insights into what model is actually viewing
- Goal: Increase trust between doctors and model by understanding what features of CXRs the model is focusing on

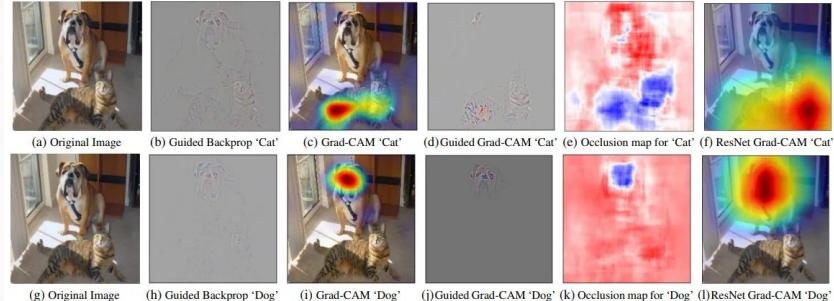


GradCAM

What is GradCAM analysis of a model?

GradCAM

- Stands for Gradient-weighted Class Activation Mapping
- Looks at the gradients flowing into the last convolutional layer of the CNN
- Generates a heatmap of the gradients
- Develops trust between users and model



What do you see?

Your options:

Horse

Person

Both robots predicted: Person

Robot A based its decision on Robot B based its decision on

Which robot is more reasonable?

Robot A seems clearly more reasonable than robot B

Robot A seems slightly more reasonable than robot B

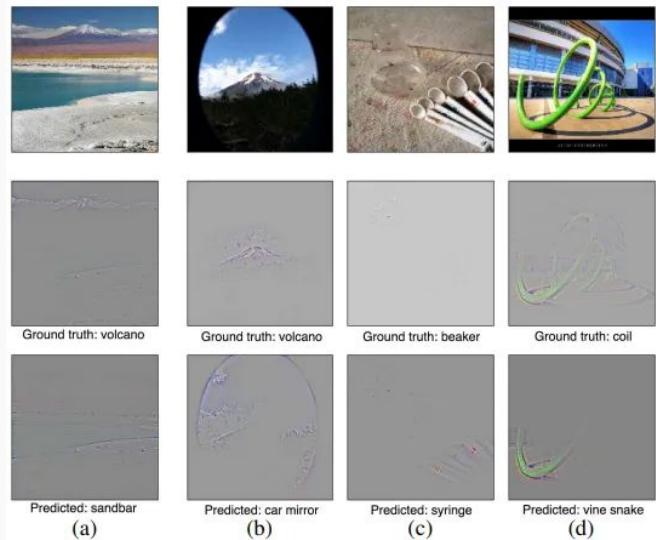
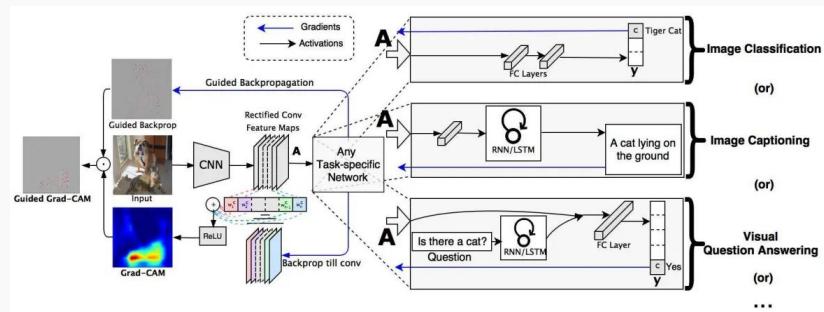
Both robots seem equally reasonable

Robot B seems slightly more reasonable than robot A

Robot B seems clearly more reasonable than robot A

GradCAM

- Does not reduce performance of model
- Critical in high-risk fields such as medicine
- Despite providing insights, not an exact comprehensive explanation of the model
 - Further analysis should be done to garner more trust in the model and its predictions

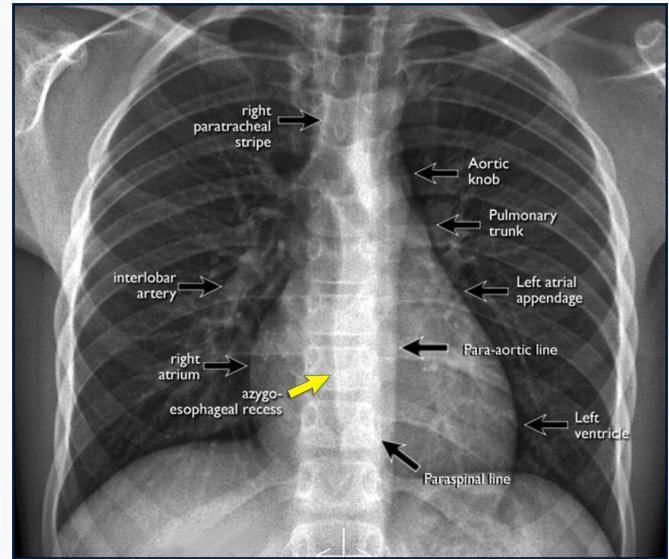


Lung Disease Features

What parts of the lung *should* the model focus on?

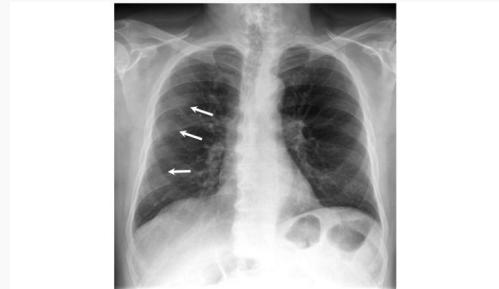
Normal Features

- CXR shows a lung with mostly black indicating mostly air
- Veins and blood vessels are visible through thin branches
- There should be no haziness or patches of white
- Thus, model should not focus on whiteness and instead focus on empty lung and prominent veins



COVID-19 Features

- **GGO:** hazy regions in the lung that do not completely obscure underlying structures
- Opacities should be around edges of lungs
- More focus towards the lower part of both lungs
- Thus, model should focus on lower parts and edges of the lungs



(a) Patchy GGOs with peripheral distribution in the right lung [28]



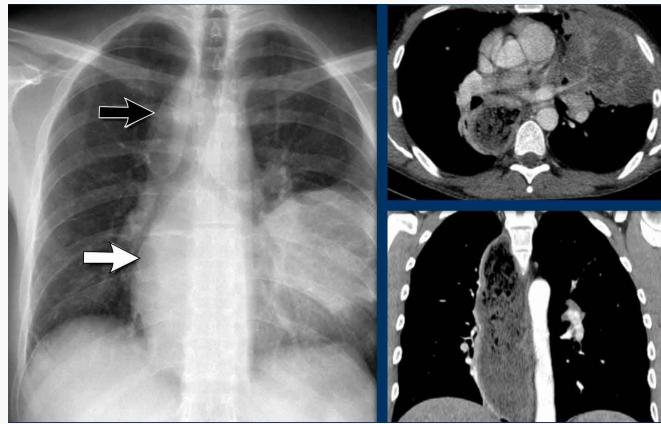
(b) Peripheral GGOs in mid- and lower-third of thorax [29]



(c) Bilateral GGOs more prominent in the right upper lobe and right paramediastinal region [30]

Viral Pneumonia Features

- More spread out areas of whiteness
- Hazy margins and net-like patterns within the lungs
- Less focus on the lower parts of the lung and more focused on the entire lung
- Thus, model should focus on net-like patterns and focus should be on higher parts of both lungs



Other Lung Disease Features

- Patterns and abnormalities could be shown in a single lung instead of both
- Extreme whiteness with a hard cutoff could indicate blockages caused by cancer
- Thus, model should highlight these abnormalities and see that they do not follow a consistent pattern with other diseases

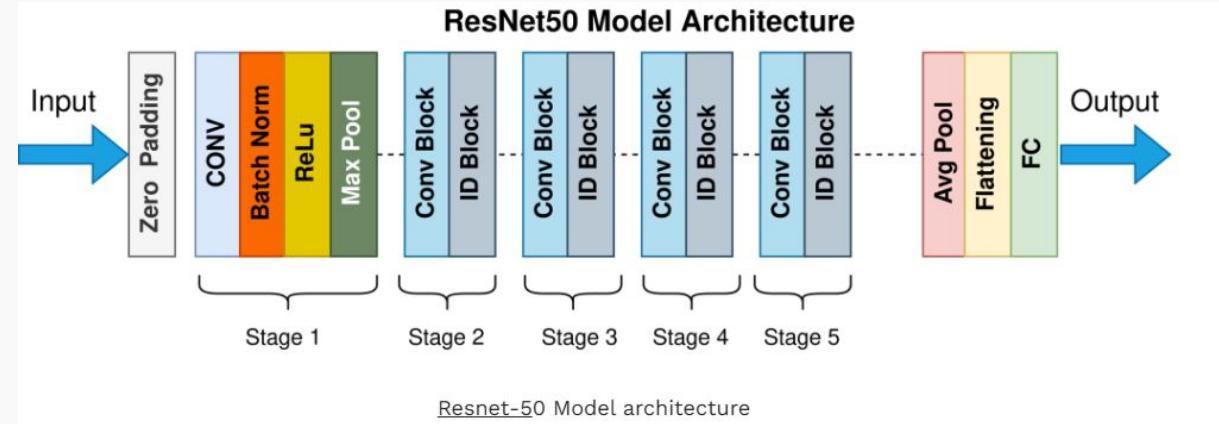


Model Details

What is the structure of our model?

ResNet50 Architecture

- CNN with 50 layers
- Optimizer: Adam (learning rate: 0.0001)
- Loss function: Cross-entropy
- Batch size: 32
- Regularization: Dropout

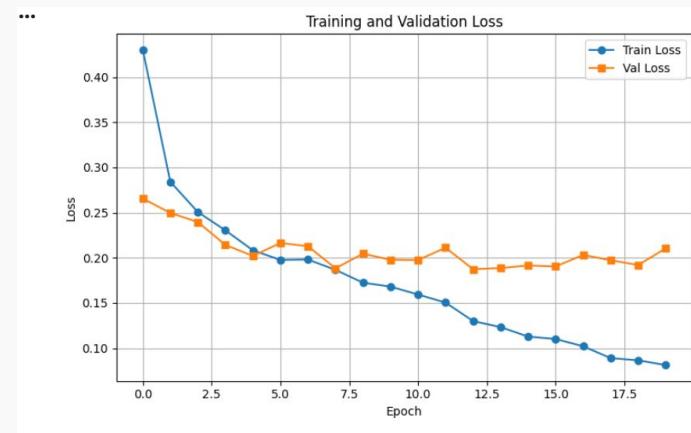
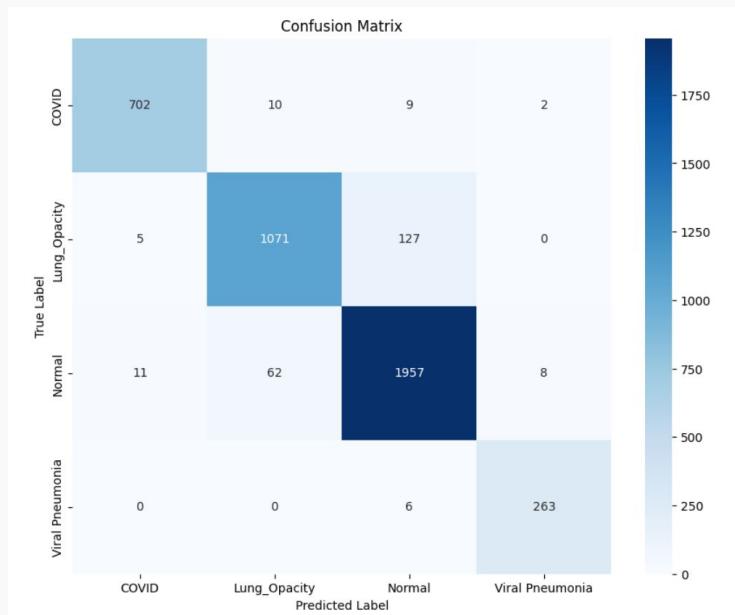


ResNet50 Model Results

How did these models perform?

Model Results

93.62% validation accuracy

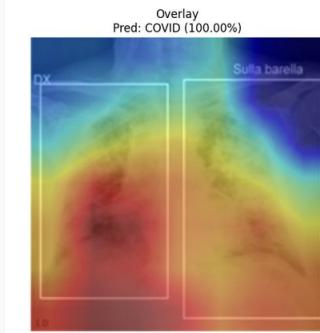
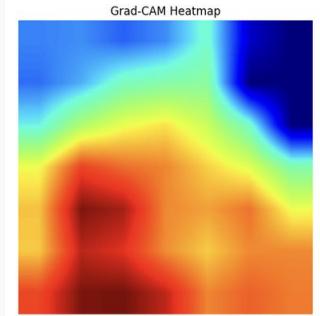


ResNet50 GradCAM Analysis Findings

What parts of the CXRs did the model actually focus on?

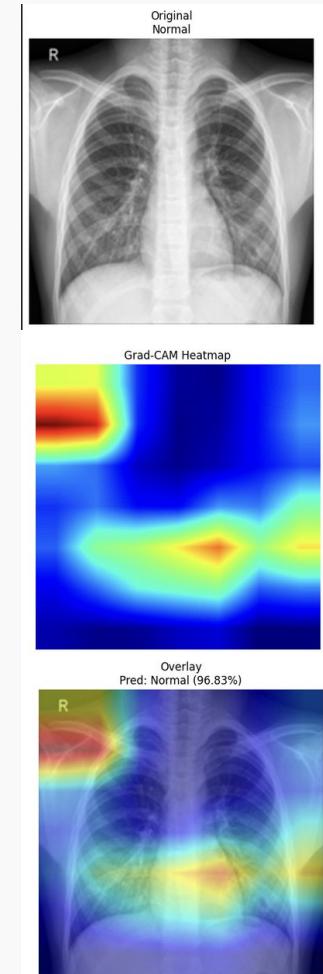
COVID-19 Sample

- Model focuses on lower regions of both lungs
- Model focuses on areas of darkness between white patches
 - Could be the model analyzing the structure of the GGOs
 - Structure of GGOs could indicate whether sample is a COVID sample or not



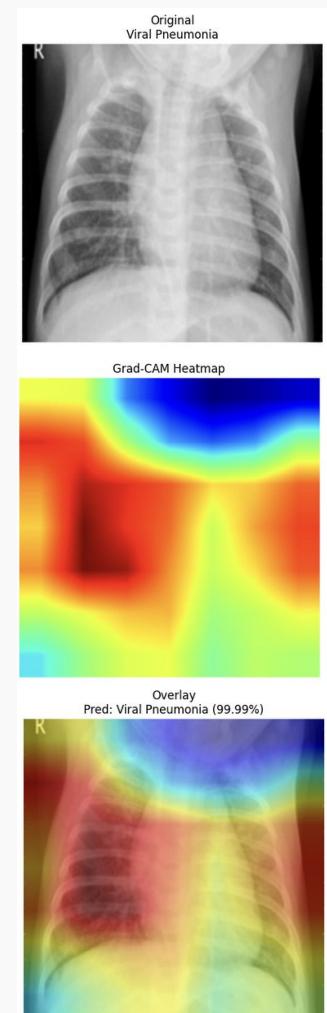
Normal Sample

- Model ignores the areas of darkness indicating no abnormalities
- Instead focuses on areas of whiteness
- In this case, areas of whiteness are the heart and external features
 - This could indicate that no abnormalities were detected by the model



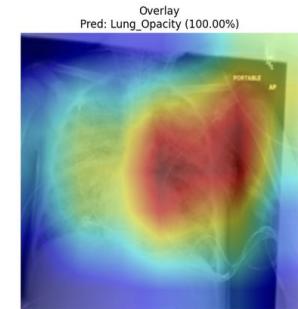
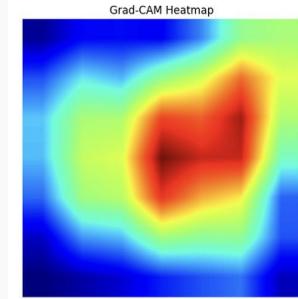
Viral Pneumonia Sample

- Model highlighted hazy net-like webbing in the left lung
- Also highlighted upper parts of both lungs in contrast with COVID-19 sample
- Net-like webbing plus cloudiness in both lungs indicates presence of viral pneumonia



Other Lung Disease Sample

- Model highlighted only one lung instead of both lungs
- More focused on upper part of the right lung
- Stark whiteness in upper right part of lungs is different compared to hazy opacities of COVID or net-like patterns of viral pneumonia

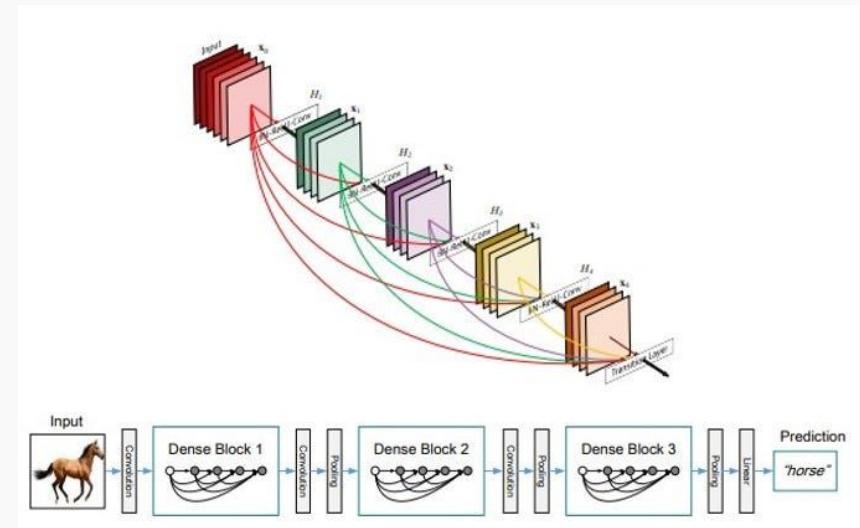


Model Comparison

How did the three models compare?

DenseNet121 Architecture

- CNN with 121 layers, intended for medical imaging application
- Starts with convolution and pooling layers
- Followed by 4 dense blocks, containing 6, 12, 24, and 16 layers respectively
- Optimizer: Adam (learning rate: 0.0001)
- Loss function: Cross-entropy
- Batch size: 32
- Regularization: Dropout



Simple CNN Architecture

- Similar to how the CNN was constructed in Homework 3
- Four convolution layers followed by a flatten and two linear layers.
- Loss function: Cross-entropy
- Batch size: 32
- Regularization: Dropout

```
class SimpleCNN(nn.Module):  
    def __init__(self, num_classes):  
        super(SimpleCNN, self).__init__()  
        self.features = nn.Sequential(  
            nn.Conv2d(3, 32, kernel_size=3, padding=1),  
            nn.ReLU(),  
            nn.MaxPool2d(2),  
            nn.Conv2d(32, 64, kernel_size=3, padding=1),  
            nn.ReLU(),  
            nn.MaxPool2d(2),  
            nn.Conv2d(64, 128, kernel_size=3, padding=1),  
            nn.ReLU(),  
            nn.MaxPool2d(2),  
            nn.Conv2d(128, 256, kernel_size=3, padding=1),  
            nn.ReLU(),  
            nn.MaxPool2d(2)  
        )  
        self.classifier = nn.Sequential(  
            nn.Flatten(),  
            nn.Linear(256 * 14 * 14, 512),  
            nn.ReLU(),  
            nn.Dropout(0.5),  
            nn.Linear(512, num_classes)  
        )  
  
    def forward(self, x):  
        x = self.features(x)  
        x = self.classifier(x)  
        return x
```

Model Results

ResNet50:

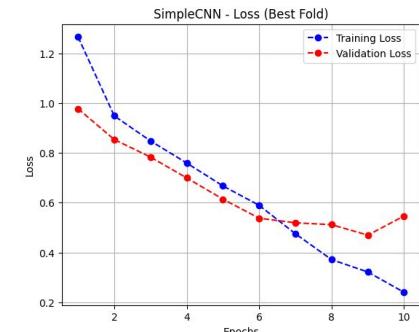
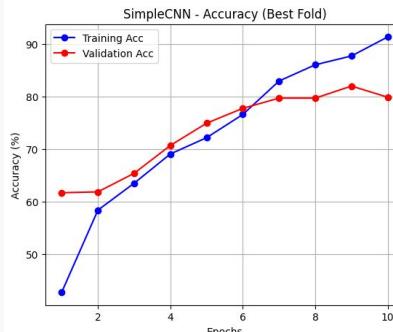
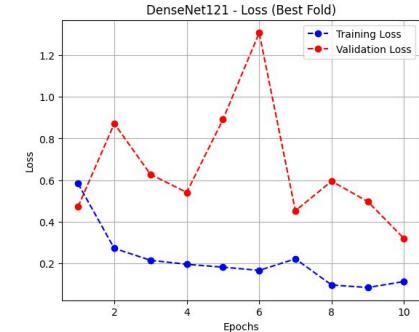
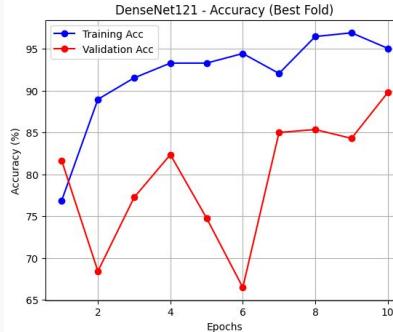
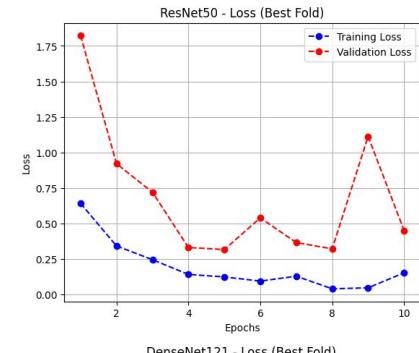
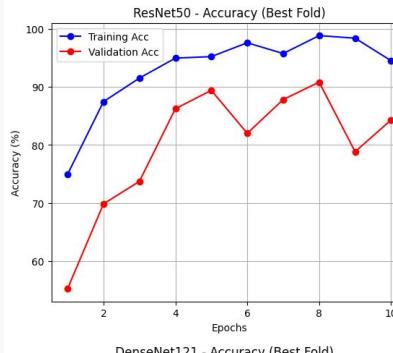
- 88.33% test accuracy

DenseNet121:

- 88.33% test accuracy

SimpleCNN:

- 77.00% test accuracy



Covid Sample

ResNet50:

- Model focuses on lower regions of both lungs

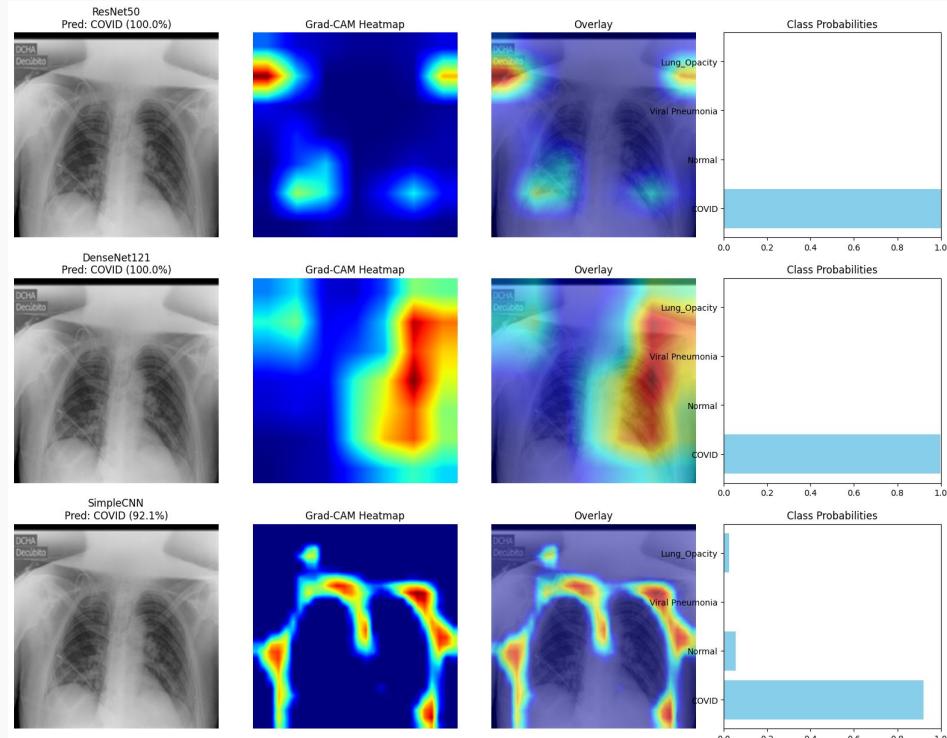
DenseNet121:

- Focuses solely on right lung edge to make prediction

SimpleCNN:

- Seems to focus on the outer lining of the lung

All models focus on the lower part or edges of lungs



Pneumonia Sample

ResNet50:

- Focus on Left edge of Left Lung

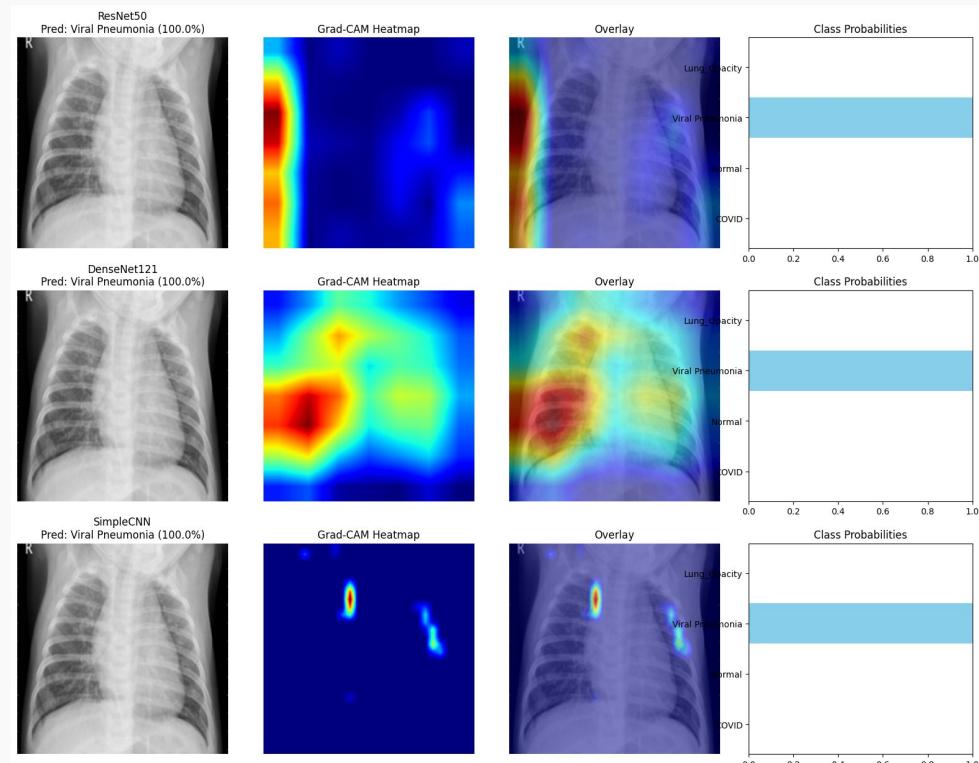
DenseNet121

- Focuses more on entire Lung

SimpleCNN:

- Seems to focus on an arbitrary Point in the upper left lung

DenseNet121 seems to have done a better analysis as it focuses on the entire lung noticing cloudiness



Normal

ResNet50:

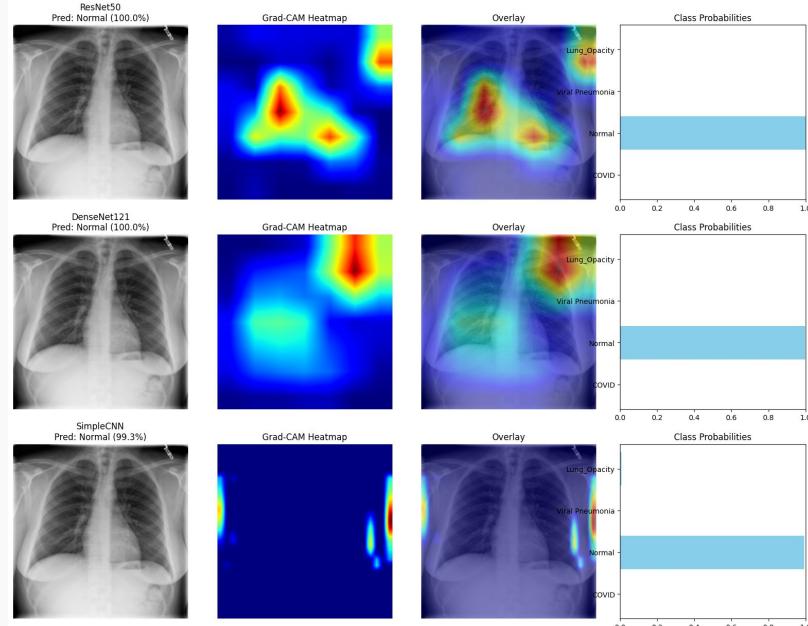
- Focuses on the middle area in Each lung

DenseNet121:

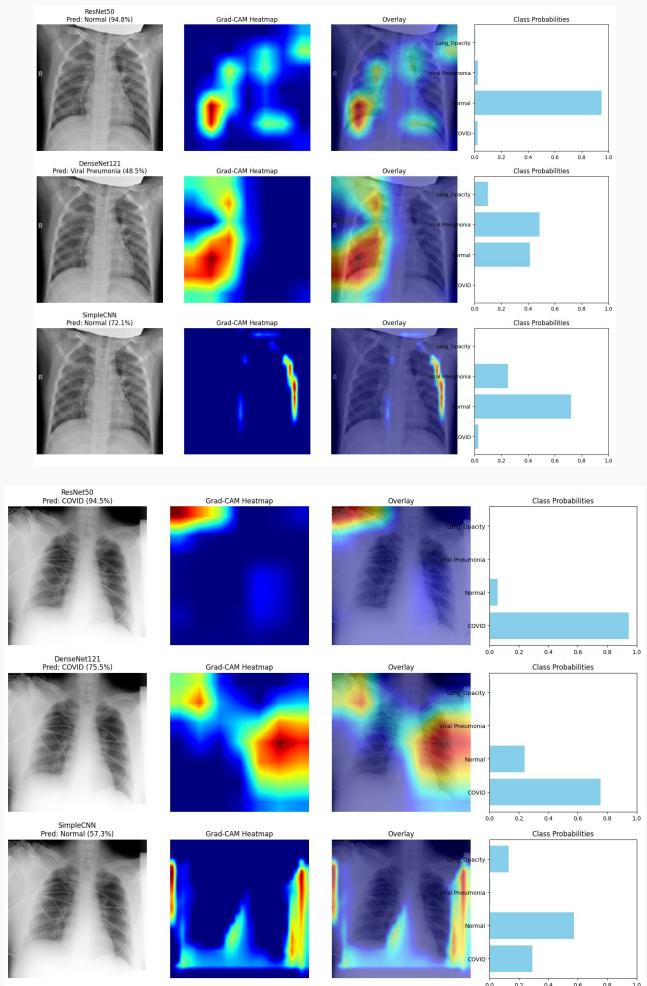
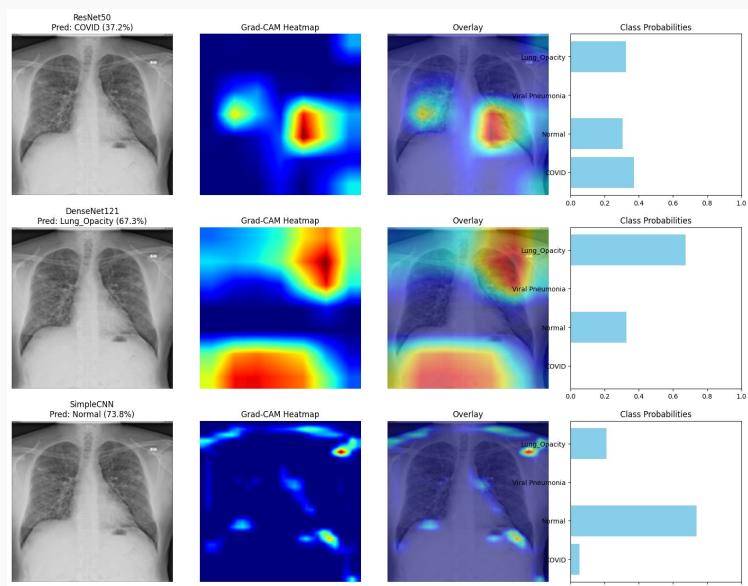
- Focuses in the middle and the top right of the lung

SimpleCNN:

- Focuses on the edges of the image



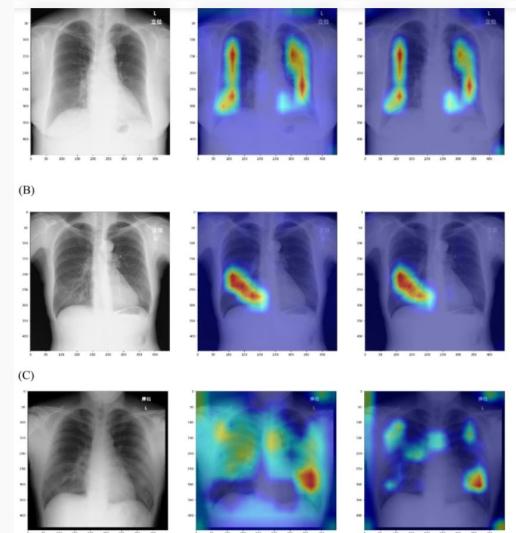
Some Odd Samples



Conclusion

Conclusion

- Models are able to pick up general areas of interest but not specific patterns
- Doctors cannot fully trust the model yet and must verify manually
- However, model could guide doctors towards a diagnosis which still saves time compared to iterating through all possible lung diseases
- Model analysis can be improved through other methods and more training data



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<https://doi.org/10.1183/20734735.0186-2023>

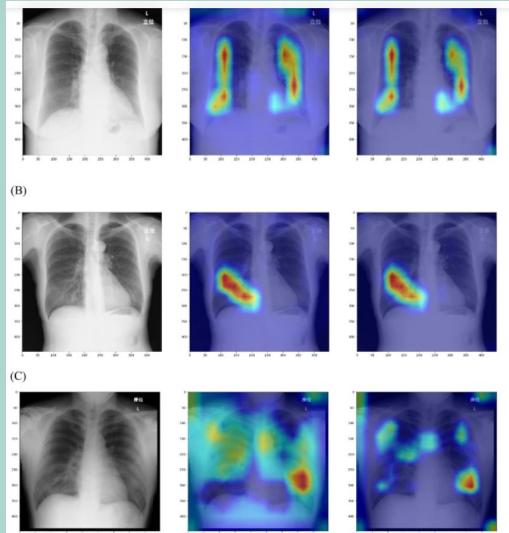
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- *The Radiology Assistant: Chest X-Ray—Basic Interpretation*. (n.d.). Retrieved December 14, 2025, from <https://radiologyassistant.nl/chest/chest-x-ray/basic-interpretation>

Thank you

We hope you learned something
about ML models in medicine
analyzed using GradCAM methods!

The Objective



- Use CNN to classify CXR lung images into the following class: Normal, Covid-19, Lung Opacity, and Viral Pneumonia
- Analyze various different models and their efficacy
- Ensure our project is classified as XAI - Explainable AI
- Perform Grad-CAM analysis to build trust, identify potential bias, and add transparency to our diagnosis method

OUR MISSION

This is your mission statement, your chance to *articulate your vision*. In a few words, identify what you do, why you do it, and who you do it for. *Be concise. Be confident.*



Add a few words expanding on the above. You can explain why this mission is important to you and your company and how you'll achieve it.

“Add a quote that captures your *mission statement*. Announce the impact you want to achieve and who you aim to help. Show where your *company is heading*, the ultimate goal.”



Full Name
Title

“Add a quote that captures your *mission statement*. Announce the impact you want to achieve and who you aim to help. Show *where your company is heading*, the ultimate goal.”



Full Name
Title



THE PROBLEM

What pain point are you tackling?
What gap are you going to fill?

Briefly describe the impact of the problem and why people should *care*.

THE SOLUTION

Explain what your company or product does, and why it's critical in the current market.

01

VALUE PROPOSITION

Describe a key benefit that your company, product, or service offers to customers.

02

VALUE PROPOSITION

Define what distinguishes your company, product, or service from what's available.

03

VALUE PROPOSITION

Identify your customers and how you'll connect to their behaviors and needs.

04

VALUE PROPOSITION

Copy this slide and add as many items as necessary to fully outline your company's value.

VALUE PROPOSITION

Identify your company's primary benefit to customers and what makes your business or product distinctive.

OBJECTIVES

Write a *confident statement* defining what success looks like to your company.

Introduce a specific business objective

To establish how you'll measure success, identify your key performance indicators (KPIs) and list them like this:

- KPI 1

- KPI 2

- KPI 3

- KPI 4

Introduce a specific business objective

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- KPI 1

- KPI 2

- KPI 3

- KPI 4

AUDIENCE

Write a keen insight about your persona or target audience.

◆ **Needs and motivations**

What does your persona want to achieve? What are their goals?

◆ **Pain points**

Identify an obstacle your persona struggles with. What interferes with their needs and motivations?

◆ **How we can help**

Explain where your product or service fits.



Full Name

Introduce your audience persona. Highlight some key traits and mention their age, profession, and location.



Full Name

Age	00
Occupation	Job title
Status	Marital status
Education	Highest degree
Location	Place name
Archetype	Book club

“Quote the persona on their needs and wants. This can be a fictional line or an excerpt from a real user interview.”

Bio

Introduce your persona, including who they are and where they come from. Think about a hypothetical user or customer who represents an audience segment.

Personality



Current emotions



Goals

- What do they want to achieve and why?
- What do they want to achieve and why?
- What do they want to achieve and why?

Frustrations

- What is keeping them from their goals?
- What is keeping them from their goals?
- What is keeping them from their goals?

Favorite brands



COMPETITIVE LANDSCAPE

Write a *high-level insight* about the competitive ecosystem

	COMPETITOR 1	COMPETITOR 2	COMPETITOR 3	COMPETITOR 4
FEATURES	<ul style="list-style-type: none">• List the features of this product or service• 2 or more	<ul style="list-style-type: none">• List the features of this product or service• 2 or more	<ul style="list-style-type: none">• List the features of this product or service• 2 or more	<ul style="list-style-type: none">• List the features of this product or service• 2 or more
STRENGTHS	<ul style="list-style-type: none">• Point out the strengths of this product or service• 2 or more	<ul style="list-style-type: none">• Point out the strengths of this product or service• 2 or more	<ul style="list-style-type: none">• Point out the strengths of this product or service• 2 or more	<ul style="list-style-type: none">• Point out the strengths of this product or service• 2 or more
WEAKNESSES	<ul style="list-style-type: none">• Call out the weaknesses of this product or service• 2 or more	<ul style="list-style-type: none">• Call out the weaknesses of this product or service• 2 or more	<ul style="list-style-type: none">• Call out the weaknesses of this product or service• 2 or more	<ul style="list-style-type: none">• Call out the weaknesses of this product or service• 2 or more

THE OPPORTUNITY

Based on your *competitive analysis* in previous slides, describe the *growth opportunities for your business*. Write a comprehensive claim here, then break it down into individual learnings.

Key learning 1

Go deeper into a specific insight from the competitive analysis and what it means for your business.

Key learning 2

Point to the gap your product will fill and explain how your business can claim that space.

Key learning 3

Consider your brand and customer segments. Explain why you're ideally positioned to reach them.

THE OPPORTUNITY

Based on your *competitive analysis* in previous slides, describe the *growth opportunities for your business*. Write a comprehensive claim here, then break it down into individual learnings.

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Key learning 2

Point to the gap your product will fill and explain how your business can claim that space.

Key learning 3

Consider your brand and customer segments. Explain why you're ideally positioned to reach them.

MARKET ANALYSIS

Provide *key insights* into the state of the market. Share your company's perspective on where the market has been and where it's headed.

Add any additional context about forces or factors influencing the market and how your business is meeting the moment.

00%

Add a few words to explain this metric.

00+

Add a few words to explain this metric.

00M

Add a few words to explain this metric.

00M

Add a few words to explain this metric.

Market analysis

Key players



Market value	00
Historic growth rate	00
Projected growth rate	00
Cost of entry	00

Context

Provide some insight on the state of the market today. Describe any challenges, forces, or factors influencing the market. Share your company's perspective on where the market has been and where it's headed.

Customer segments

Segment 1	Segment 2
Segment 3	Segment 4

Pricing strategy

MARKET	PRICE POINT		
	High	Medium	Low
Premium			
Mid-level			
Economy			

Market analysis

Context

Provide some insight into the state of the market today. Describe any challenges, forces, or factors influencing the market. Share your company's perspective on where the market has been and where it's headed.

Market value 00

Historic growth rate 00

Projected growth rate 00

Cost of entry 00

Key players



Customer segments



Pricing strategy

MARKET	PRICE POINT		
	High	Medium	Low
Premium			
Mid-level			
Economy			

BUSINESS MODEL

Clearly outline your business model. This is how you'll create, deliver, and capture value.

Key activities

What are the core activities your company undertakes to deliver its value proposition? Think about production, research, or fabrication.

Key partnership

Who are your key partners or suppliers? What resources do they provide? And how do they contribute to your business model?

Cost structure

What are the major costs of your proposal? Think about salaries, rent, or marketing.

- Expense 1

- Expense 2

- Expense 3

Revenue streams

Outline how you plan to generate revenue through sales, subscriptions, or other methods.

- Revenue 1

- Revenue 2

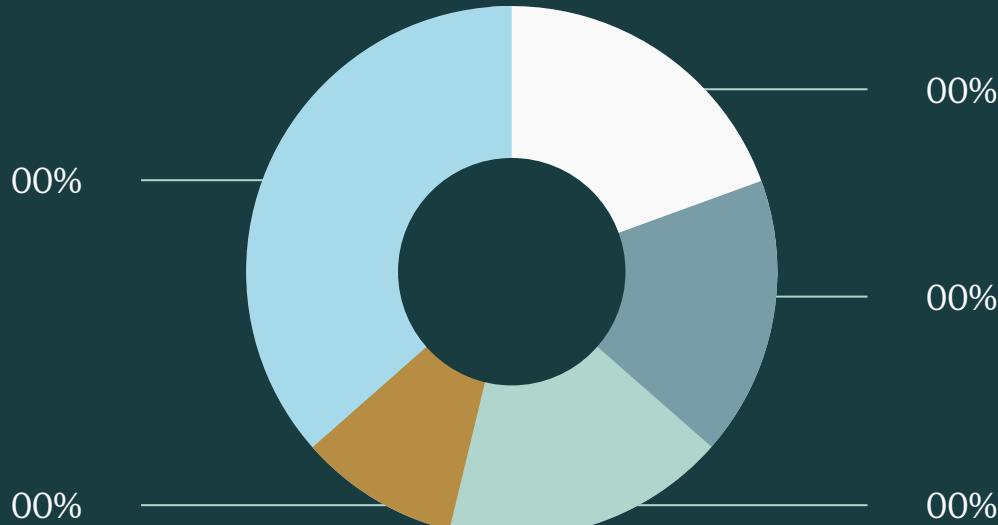
- Revenue 3

Customer segments

Use this space to restate or prioritize specific customer segments based on your business model.

- Customer segment
- Customer segment
- Customer segment

COST STRUCTURE



◆ Staffing

◆ Taxes

◆ Marketing

◆ Logistics

◆ Technology

-00%

Estimate potential cost savings in an area or department.

-00%

Add any other potential cost savings in an area or department

If you anticipate changes to your expenses, mention the impact to your cost structure here.

REVENUE MODEL

00%

00%

00%

00%

Revenue stream 1

Define how you'll generate income from this source. Identify relevant pricing or channels.

Revenue stream 2

Define how you'll generate income from this source. Identify relevant pricing or channels.

Revenue stream 3

Define how you'll generate income from this source. Identify relevant pricing or channels.

Revenue stream 4

Define how you'll generate income from this source. Identify relevant pricing or channels.

Revenue stream 5

Define how you'll generate income from this source. Identify relevant pricing or channels.

KEY ACTIVITIES

Primary activity *name*

Describe the core activity of your business, how you create and deliver your products or services. This might be manufacturing, product design, software engineering, customer service, marketing, or project management.

Support activity name

Break down your primary activity into the additional activities required to successfully deliver your value proposition. These should contribute to your core business function.

Support activity name

Think about your everyday operations. For example, if your primary activity is software engineering, your support activities may be customer support, software integration, or maintenance.

Support activity name

Show your audience what a day in the life of your organization looks like. Help them understand what's required to do what you do.

CUSTOMER SEGMENTS

Define your target audiences and how you'll speak to them

Target audience 1

Describe a target audience or customer group you want to reach. Identify their traits, values, behaviors, or preferences.

Target audience 2

While your user personas represent ideal individual customers, segments represent a wider range of people who share certain characteristics.

Target audience 3

Think about how each target audience or segment relates to your product or service, why they need it, and how they'll use it.

Target audience 4

Refer back to your user personas and point out which segments they belong to. This will help your presentation feel more interconnected.

Target audience 5

For example, a tech-savvy user persona might fall into a broader Tech Enthusiast or Industry Professional audience segment.

OPERATIONAL PLAN

Announce your vision for scaling operations

STEP TITLE

Define your first goal toward making your business more productive and efficient.

01

STEP TITLE

Identify what you'll focus on next to help your team work together and grow your operations.

02

STEP TITLE

Describe the outcome you want to achieve next. Provide any relevant details about how you'll get there.

03

STEP TITLE

Bring it all together. Share how you'll evaluate, maintain, and advance your operations for long-term sustainability.

04

FINANCIAL DATA

Evaluate your revenue trajectory relative
to your goals

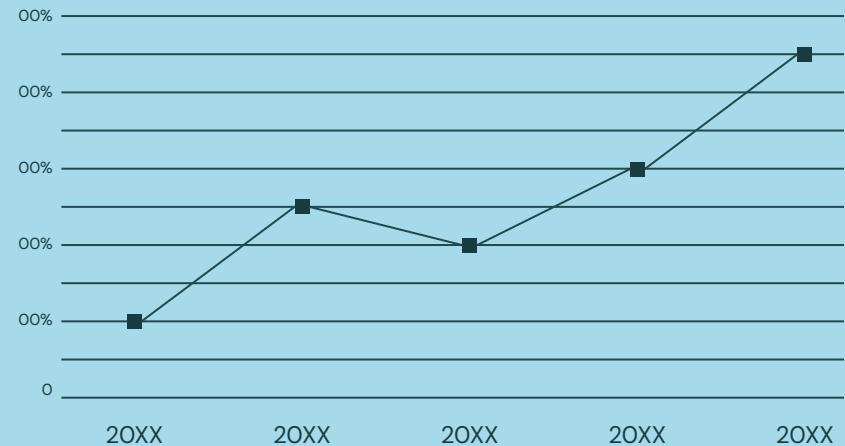
Yearly revenue

\$00

Net revenue

Gross revenue

Revenue growth





NEXT STEPS

Invite your audience to *learn more* about your organization and to *keep in touch*.

Contact

Full Name

Title

name@example.com

example.com

NEXT STEPS

Invite your audience to *learn more* about your organization and to *keep in touch*.



Contact

Full Name

Title

name@example.com

example.com

Thank you

Conclude the presentation by
thanking your audience for listening
and participating.