BKMD Capital Partners

Predicting Pneumonia from X-Ray Images

Gates Foundation Presentation

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February 2024

Meet Ruth

2 year old from Malawi Mangochi District

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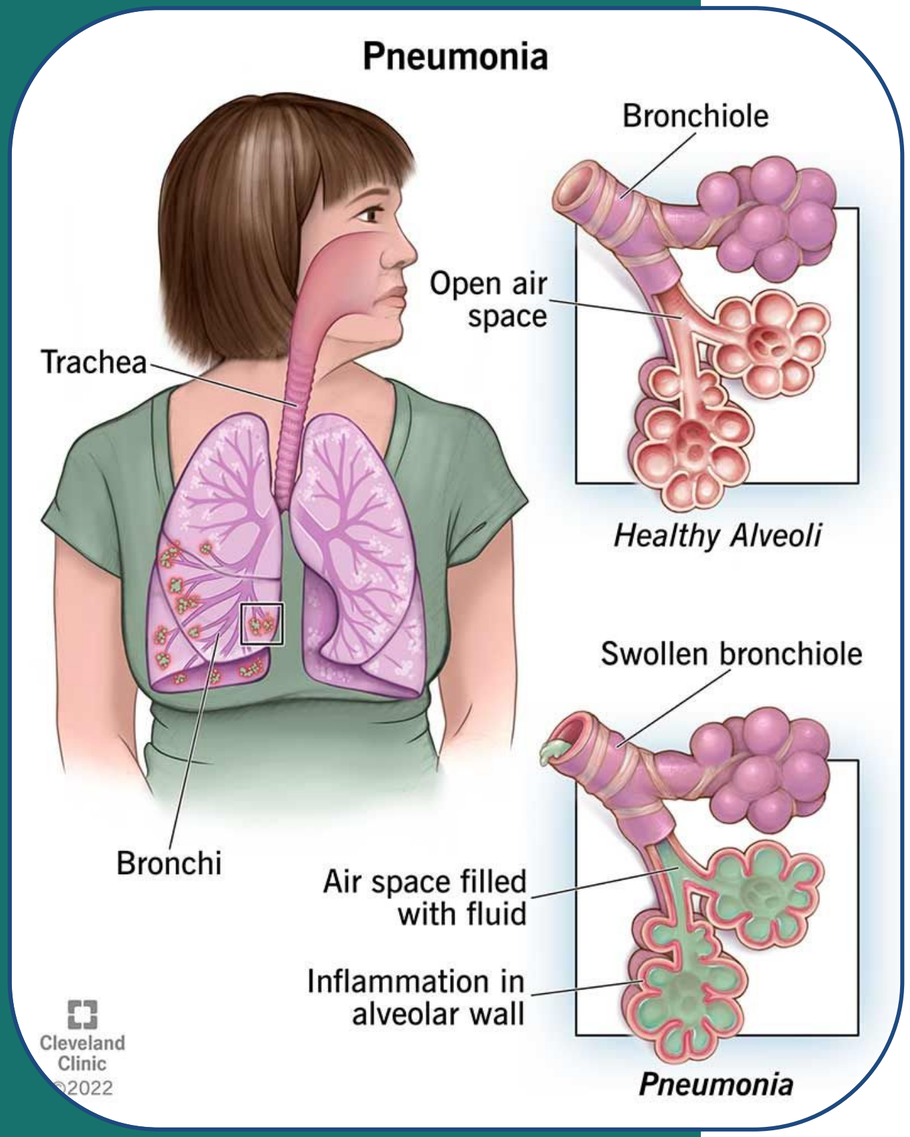


What is Pneumonia?

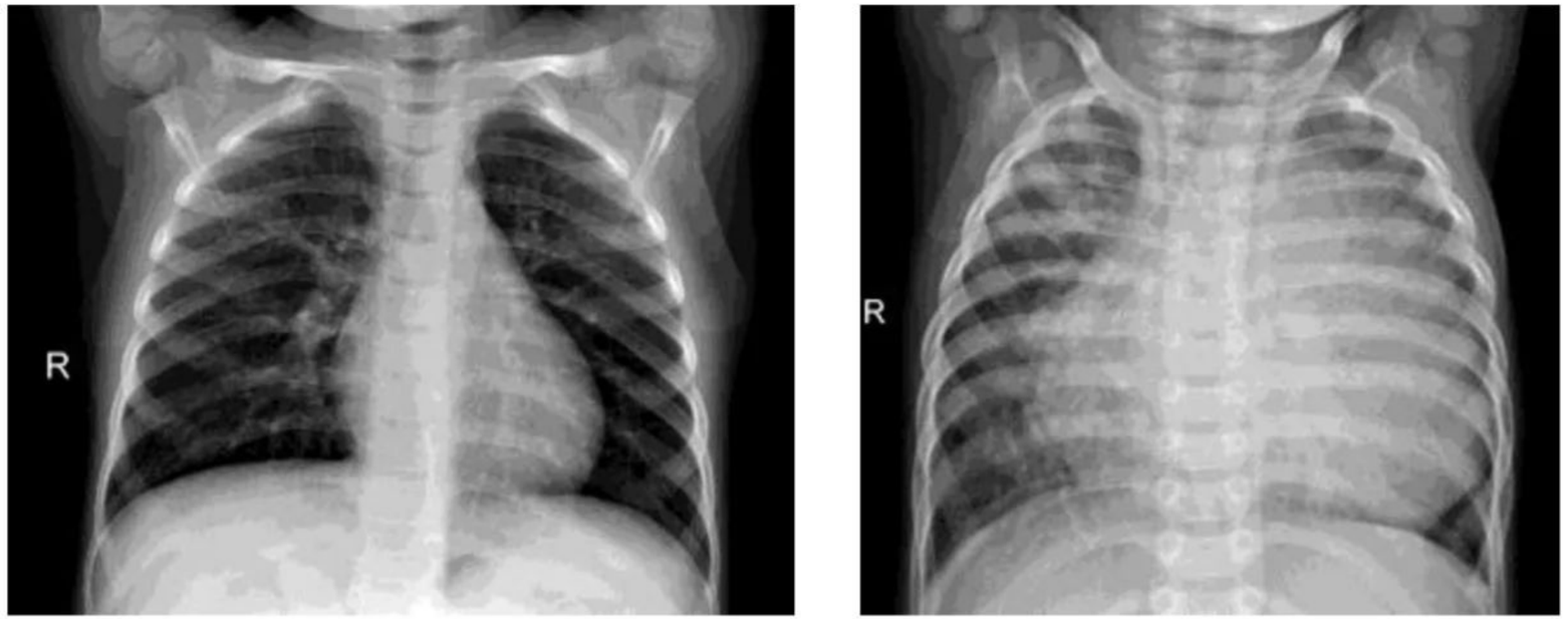
Infection of the lungs

> 1 million hospitalizations

> 50,000 deaths

- Causes inflammation and fluid in air sacs
- Alveoli unable to do gas exchange
- Symptoms: cough, fever, shortness of breath, fatigue, chest pain
- Transmission: Bacterial or viral
- Complications: Respiratory failure, sepsis, death
- Treatment: Antibiotics

Diagnosing Pneumonia



(a) Normal (b) Bacterial Pneumonia

Methods

- Chest X-ray
- Blood tests (CBC)
- Pulse oximetry
- Procalcitonin

→ Interstitial opacity in upper lobe

(Blurred area indicates infection or fluid)

\+ Symptoms

Pediatric Pneumonia in Malawi

226,000 Annual Pediatric Pneumonia Cases

10,000 deaths per year children under 5

HIV/AIDS Highly Prevalent

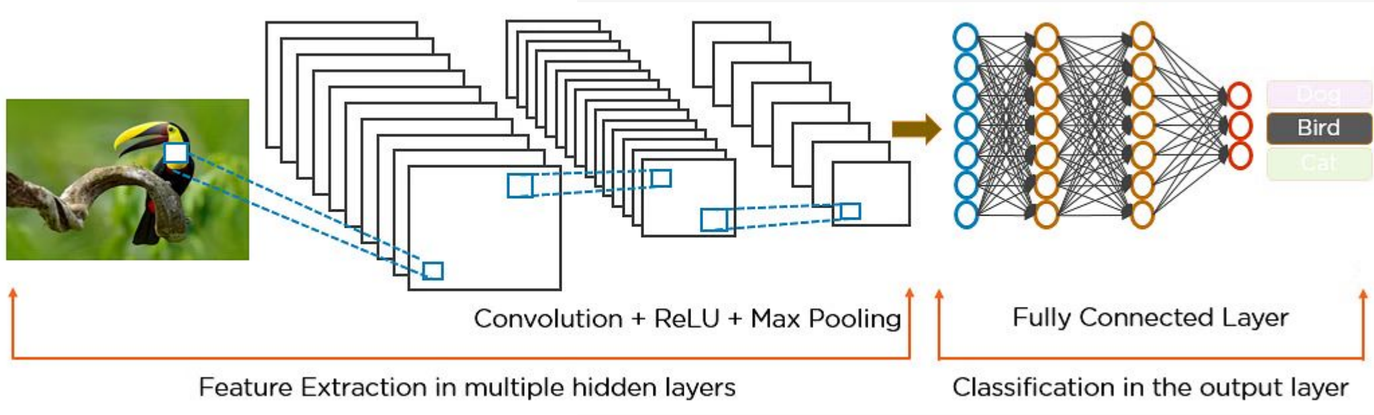
- 1.1 million Malawians have HIV
- HIV attacks CD4 cells
- Weakens immune systems
- Higher susceptibility to Pneumonia

Why Malawi would benefit from our intervention

- Desperate socio-economic scenario
  - Poverty (more than half of population living on <$1.25 per day)
  - Disease
  - Environmental Concerns
  - Lack of infrastructure
- 14% children are orphans with limited healthcare

➔ **Limited resources** (medical equipment and personnel)

Convolutional Neural Network (CNN)



01 **Spatial Hierarchies**

Identify high and low level patterns

02 **Translate Invariance**

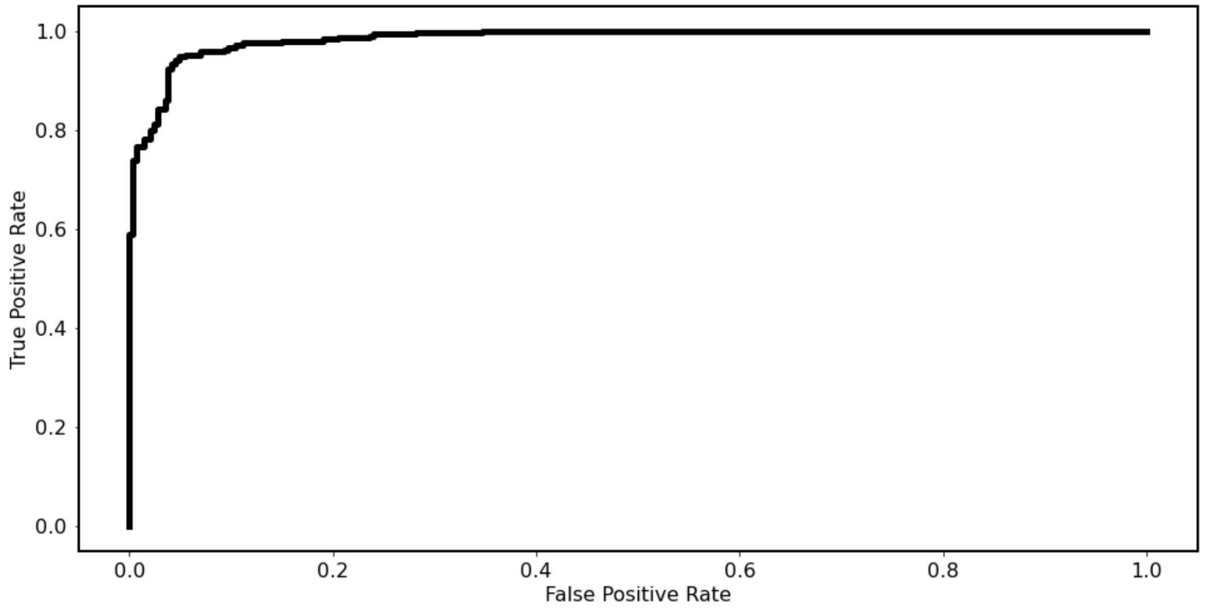
Identify patterns no matter location

03 **Adaptability**

Augmentation allows various size and quality of data

Model Evaluation

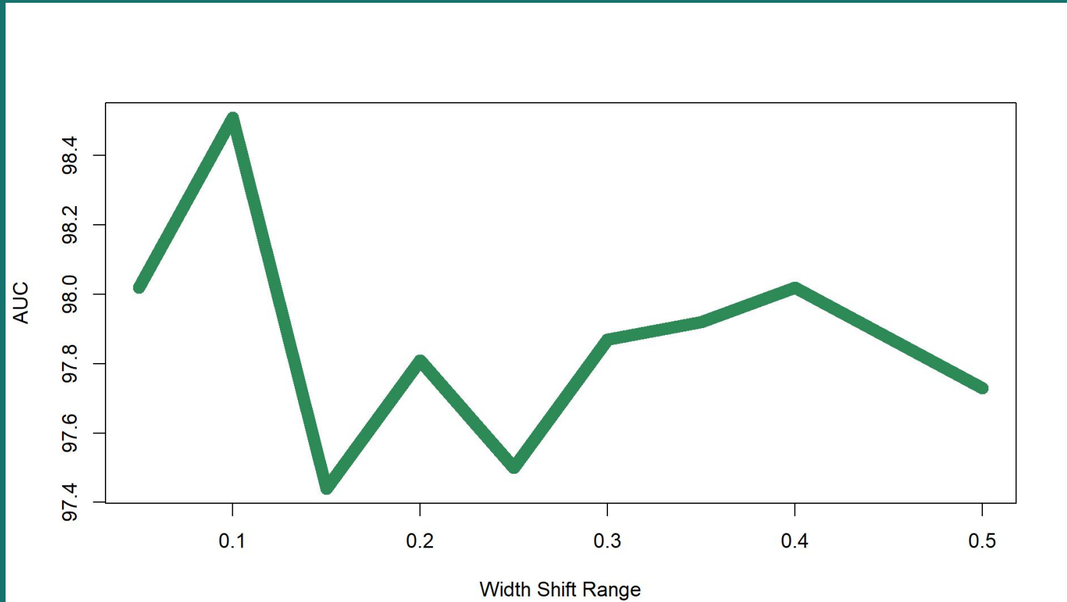
Area Under Curve (AUC)

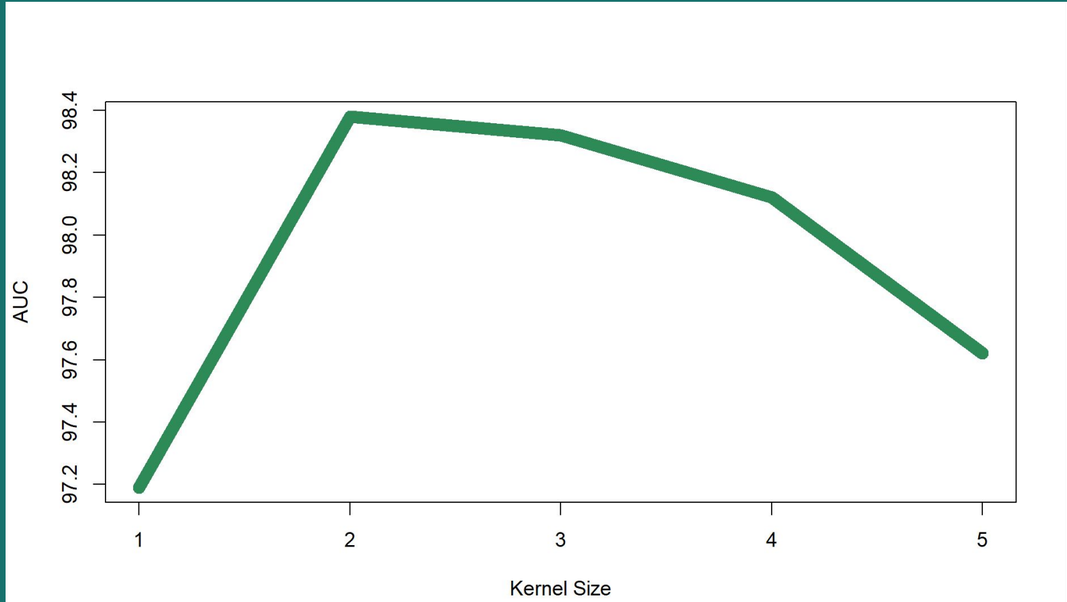


$$\text{Accuracy} = \frac{\text{Correct Predictions}}{\text{Total Predictions}}$$

AUC > Accuracy

Process





Experimentation

Structured Approach

Isolate each parameter: find optimal

Kernel Size

Balance small and large patterns

Epochs

Give model enough time to learn

Augmentation

Allow model to be adaptable

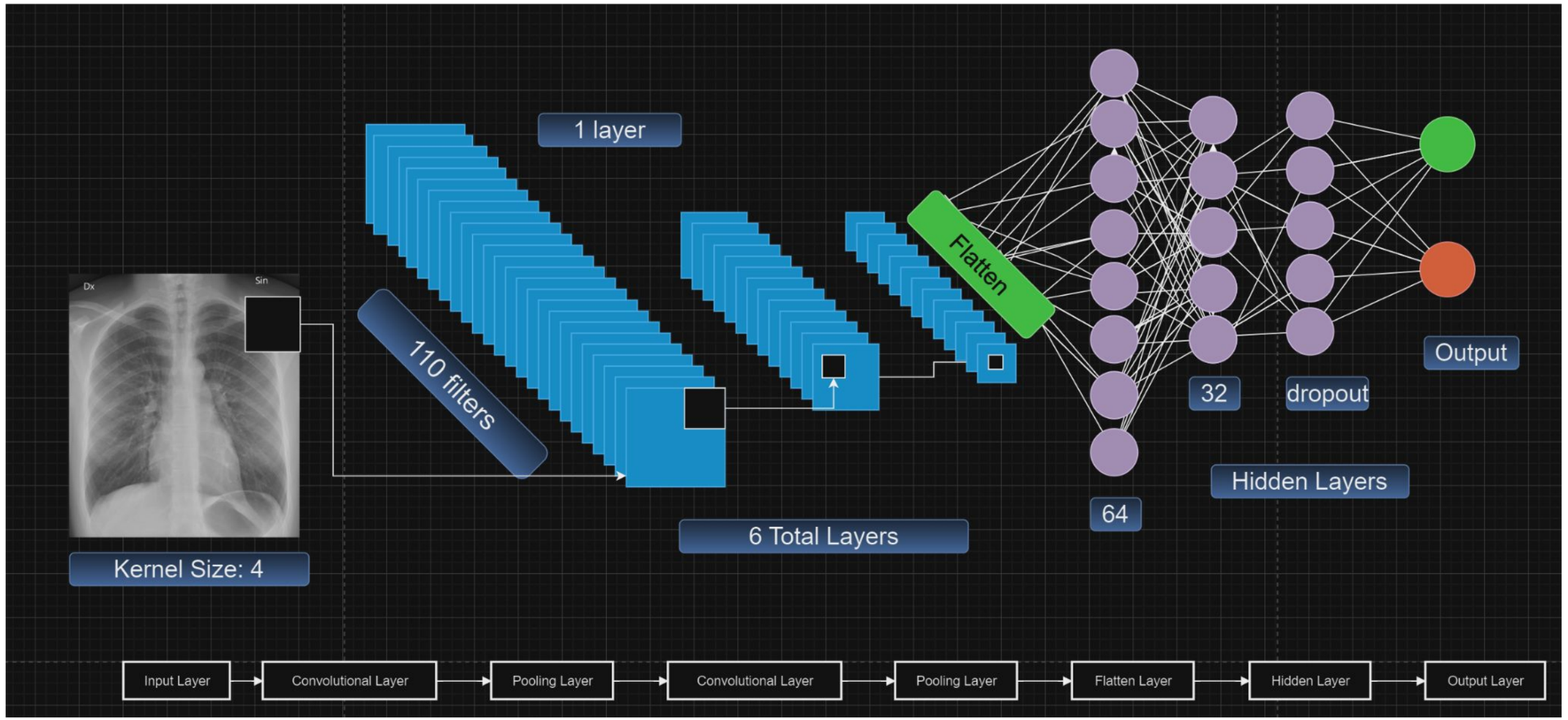
Art and Science

Considered relationships of each parameter

Layers | Epochs

Kernel Size | Max Pooling

Model Architecture

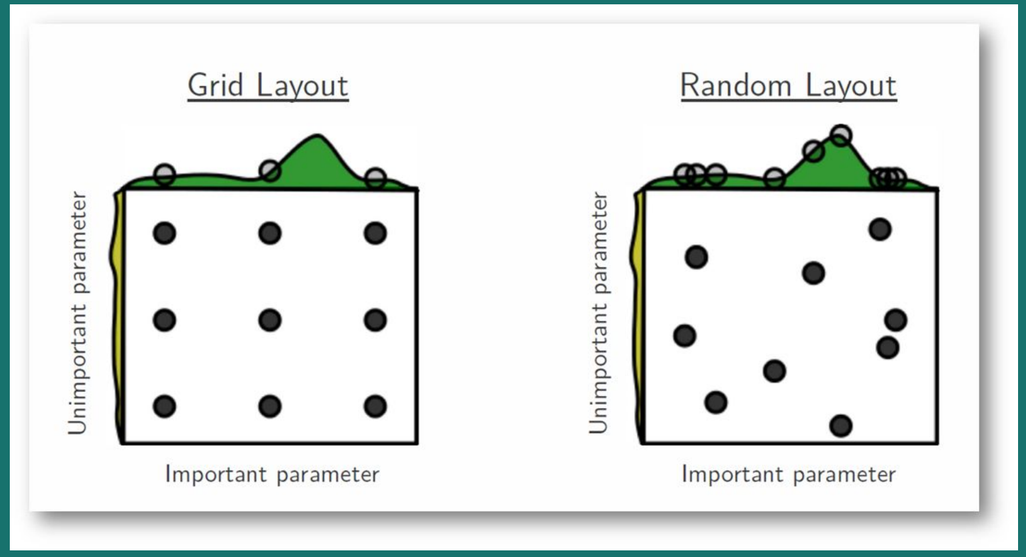


Rotation Range	15
Width Shift Range	0.1
Height Shift Range	0.2
Horizontal Flip	True
Vertical Flip	True
Shear Range	0.2
Zoom Range	0.2
Number of Layers	6
Number of Filters	110
Kernel Size	4
Dropout Value	0.25
Max Pooling	2
Number of Classes	2
Batch Size	40
Learning Rate	0.0001
Epochs	30

Next Steps for Model

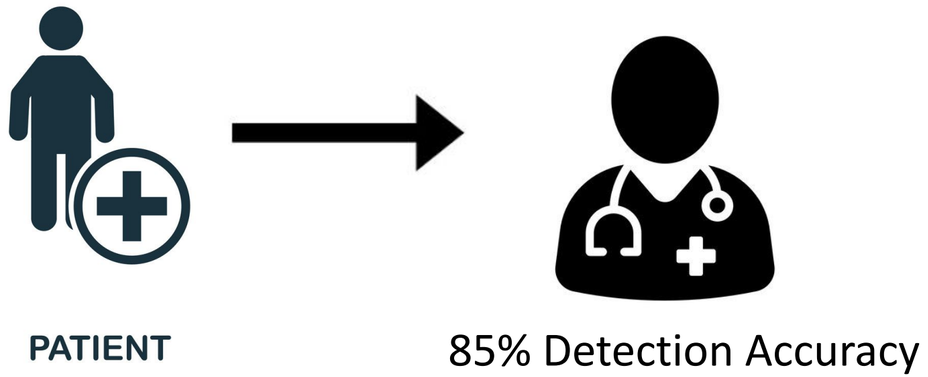
More Experimentation with Relationships

Grid Search Approach

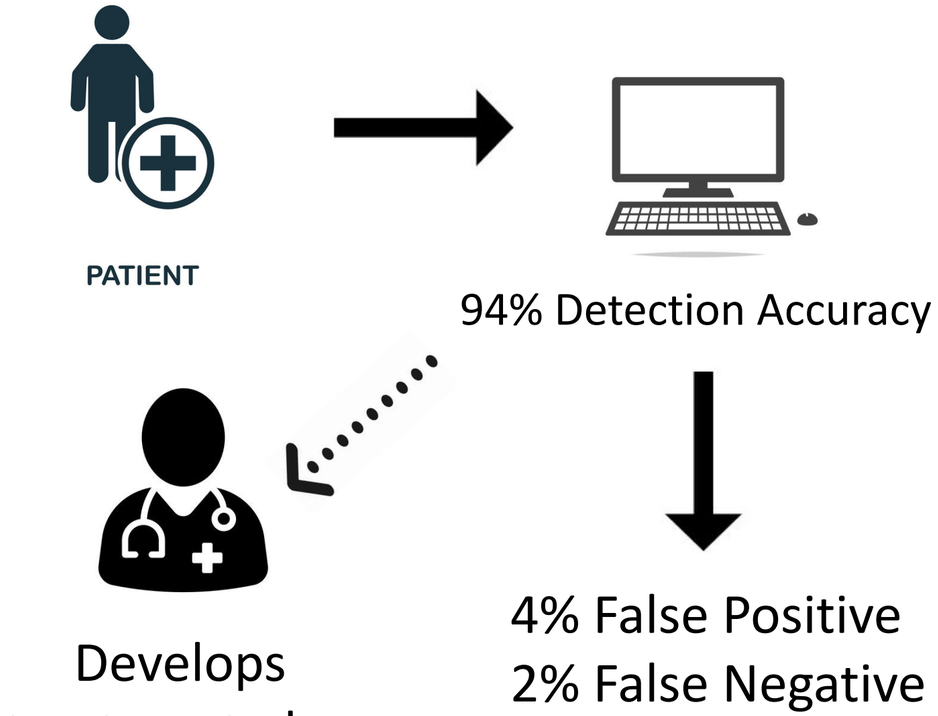


Intervention

Current State



Using our Model to Automate Process



Cost Benefit Analysis

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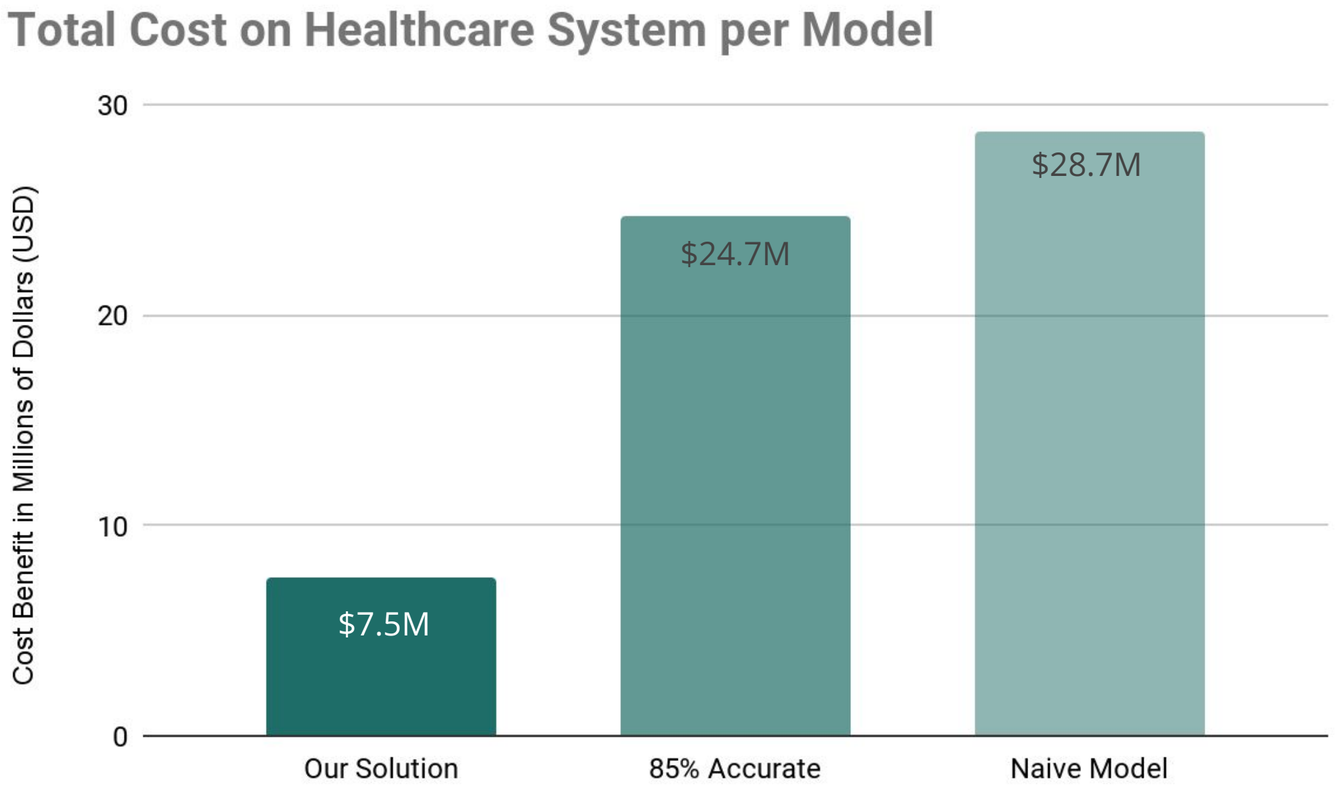

Annual Pediatric Pneumonia

Malawi Population 19.890M

Children Under 5 in Africa 207.449M

African Population 1.216B

% of Children Under 5 ..... 17%

Children Under 5 in Malawi 3.393M

Pneumonia Rate..... 6.65%

225,650 Sick Children

$24.7M – $7.5M = $17.2M in Cost Savings with our Model Solution

Cost Benefit Analysis

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False Negative Costs

Oxygen Therapy $29.28

Vasopressors $18

% of Patients in ICU 30%

ICU Stay $3,632.67

Traumatologist Salary $13.12

$1,108.04

False Positive Costs

Wasted Medication $0.46

Healthcare Professional $2.25

Non-ICU Hospital $119

Respiratory Therapy $4

Return to Hospital $119

$244.71

Current 85% Accurate Model

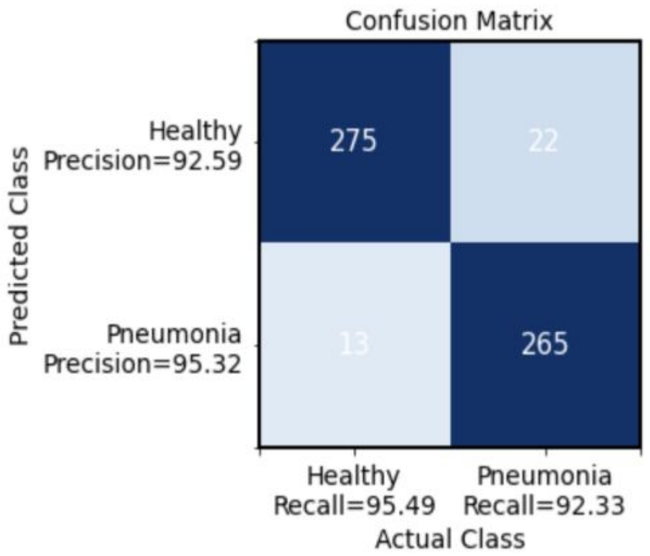
False Positives: 43 (7.5%)

False Negatives: 43 (7.5%)

True Positives: 244

True Negatives: 245

$24.7M



Naive Model

False Positives: 288 (50.1%)

False Negatives: 0 (0%)

True Positives: 287

True Negatives: 0

$28.7M

Our Solution

False Positives: 13 (2.26%)

False Negatives: 22 (3.83%)

True Positives: 265

True Negatives: 275

$7.5M

Cost Breakdown

How far will this $2M go?

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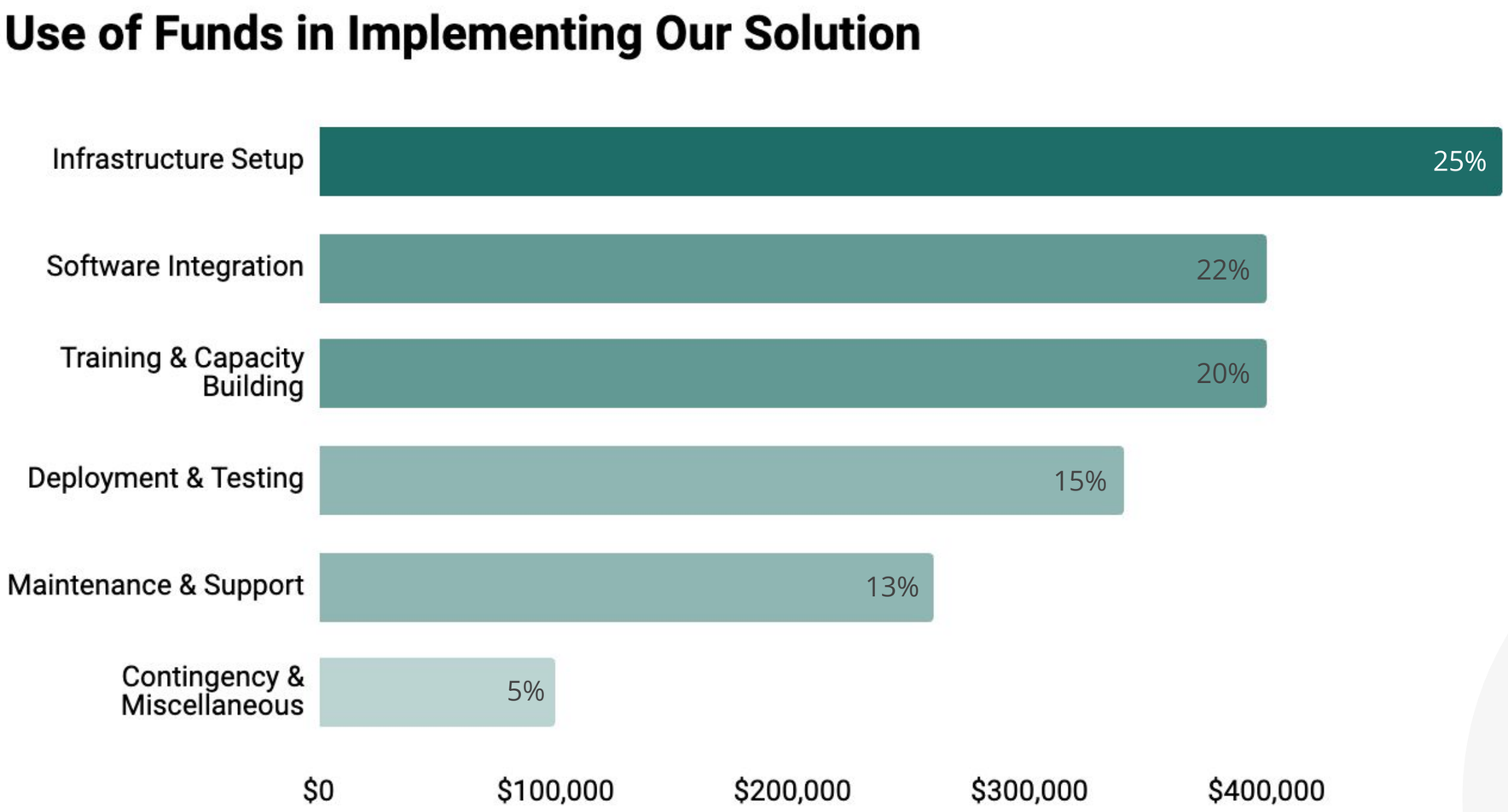

Cost Breakdown

How far will this $2M go?

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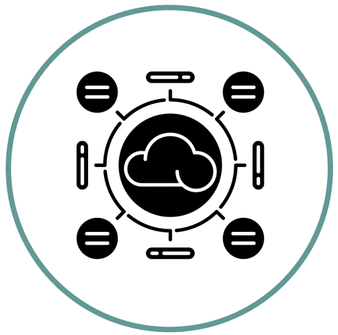


Infrastructure Setup

$500K

25%

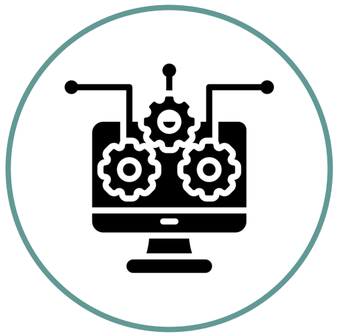
- Servers, GPUs, & Storage Systems
- Reliable Internet Connectivity & Backup Power
- Cloud solution integration
- Ethical considerations for Data Security

Training & Capacity Building

$440K

22%

- Workshops, seminars, & training sessions
- Integrate with U.S. radiologists
- Educational Materials and guides
- Travel allocation to conduct training & oversight



Software Integration

$400K

20%

- Integrate CNN model into existing healthcare network
- Customized network if necessary
- Customize user interfaces & dashboards
- Thorough testing
- Further development costs

Deployment & Testing

$300K

15%

- Deployment of trained individuals & necessary software
- Establish workflows & protocols for data collection, annotation & feedback
- Train local technicians

Maintenance & Support

$260K

13%

- Dedicated Malawi based support team
- Partner with U.S. based team for oversight
- Implement monitoring & alert systems
- constant updates & enhancements

Miscellaneous

$100K

5%

- Unforeseen expenses & emergencies
- Free Cash to integrate this system into other disease lines or hospital needs

Projected Timeline

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Years 1-4

1. Implement technology in Malawi

2. Expand across villages

4. Expand to other countries in Sub-Saharan Africa

Years 5-10

5. Expand the model across other diseases (heart disease)

10. Open first fully automated radiologist office, determine if it is possible for an automated clinic

Years 10+

15. Open the first fully automated doctors office in the world
    - Malawi is the perfect test population

20. Expand to other countries

Automated Clinic

WHAT WE COULD DO...

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Patient Arrival at Kiosk

The patient will arrive at the kiosk and be able to express how they are feeling and and what they have been experiencing

Test Selection Automation

Our model will then provide specific diagnostic tests to be administered to the individual at the clinic

Nurse Intervention

Nurses will be instrumental in assisting this process and properly administering tests (drawing blood, taking blood pressure, etc.),

SOLUTIONS

Malawi Children's Village Partnership

01 What is Malawi Children's Village?

"Our mission is to enhance the lives of orphans by providing health, social and educational resources in 39 villages along the southwest shore of Lake Malawi"

- Village-based care for vulnerable children

02 Expanding our technology

We plan to bring the BKMD technology into places where it can have the most valuable impact on society– hence there is no better place than the Malawi Children's Village to save lives

03 Changing lives

By leveraging our advanced technology we hope to transcend the lives of Sub-Saharan children. We will closely monitor the results of our work and best implement strategies for improvement

Conclusion

Automating Pneumonia Diagnosis

Save Lives

Improve accuracy from 85% to 94%

Increase healthcare accessibility

Help children like Ruth reach their fifth birthday plus many more

Other Benefits

Cost Savings= $17.2 million cost savings in Malawi alone

Innovation = Opens the door to expand our model to other diseases and countries around the world

BKMD Capital

THANK YOU

We Appreciate Your Consideration

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February 2024

Appendix

Calculations

01

Annual Pediatric Pneumonia Calculation		
Population of Malawi		19,890,000.00
Number of kids under 5 in Africa		207,449,000.00
Africa population		1216000000.00
% of kids under 5		0.17
Number of kids under 5 in malawi		3,393,224.19
66.5/ 1000 kids get pneumor		225,649.41

https://jscholarship.library.jhu.edu/items/69fee8d2-15bb-4e33-8aee-ec1eb8f24f36
https://www.statista.com/statistics/1226211/population-of-africa-by-age-group/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3345619/#:~:text=French%20has%20estimated%20that%20the,70%25%20will%20be%20HIV%20associated

Appendix

02

Cost of FP	$	244.71
Wasted Medication	$	0.46
Healthcare professional		$2.25
Short-term non-ICU hospital		$119
Repiratory therapy		$4
Return to hospital to resolve actual problem		$119

At least 40 kg: 500 mg orally every 8 hours or 875 mg every 12 hours, 15 capsules
https://www.health.gov.za/wp-content/uploads/2021/03/HP02-2019AI-Add-2-15-CPA-Effective-1-April-2020.pdf

$0.375 per hour x 6 hours = $2.25
https://bdeex.com/malawi/?type=medicine#google_vignette

Mean cost per bed/day
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8782501/

https://www.erieri.com/salary/job/respiratory-therapy-technician/south-africa

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8782501/

Appendix

03

Cost of FN	$1,108.04
Oxygen therapy	$29.28
Vasopressors	$18
ICU stay	$3,632.67
Traumatologist Salary	$13.12
Percent of Pneumonia going to cirtical ICU (multiply this by sum of above costs)	30%

Oxygen therapy to treat respiratory failure = $7.32 per hour, 4 hours, $29.28,
https://elifeonline.net/cost-of-oxygen/

Treat patients in septic shock (norepinephrine and vasopressin), cost $40, 46% untreated pneumonia chance of going into sepsis = $18.40
https://bdeex.com/malawi/?type=medicine#google_vignette

ZAR22 870= $1210.89
3 days of ICU $3632.67
https://pubmed.ncbi.nlm.nih.gov/30606302/

4 day cost, 8 hours a day = $13.12
https://bdeex.com/malawi/?type=medicine#google_vignette

https://erj.ersjournals.com/content/18/1/151

Appendix

Model Tuning Process Tracking Sheet

https://docs.google.com/spreadsheets/d/1ktDvrfFREljriblMR7JcYPz3REncYQ32oAgET9th0Mo/edit#gid=0