

IRIS

**early Identification of
Respiratory Illness System via
AI and edge computing**

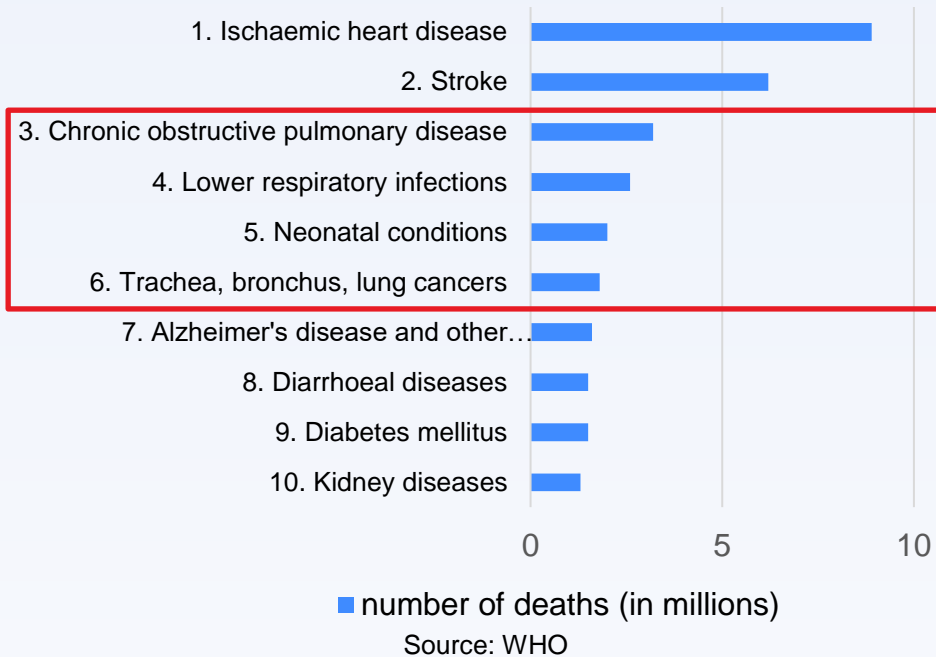
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Research Background & Problem Statement

Disease Burden

2019 world's leading causes of death



- 45.7 million adult asthma patients
- >100 million COPD patients

Challenges

- Missed or delayed diagnosis results in the **delayed** start of effective treatment
- Early detection of respiratory illnesses is vital, but diagnostic tests are **difficult to perform** or difficult to obtain.
- Respiratory disease cannot be managed effectively **without continuous monitoring** data.



Proposed Solution

A system for early identification of respiratory diseases based on edge computing and fast integration of convolutional analysis models

Blood oxygen sensor

Cough sound and blood oxygen data analyzer with algorithmic model for cough sound detection and classification

web-based software to collect baseline data and analysis result on early identification of respiratory disease



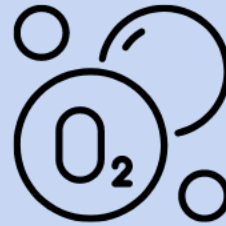
Selected Parameters



COPD-SQ

Mostly used In China for screening. It comprises 7 questions and the highest total score is 38 points.

At risk:
score > 16



blood oxygen

Blood oxygen saturation is the amount of oxygen circulating in the blood. It is a crucial measure of lung function.

At risk:
< 95%



Cough Sound

Cough is a common symptom. 10-38% of respiratory diseases are accompanied by chronic cough.

At risk:
Type of cough sound

Innovation

VS

Multidimensional data to determine risk

Integrative analysis of blood oxygen levels, cough sounds and questionnaire values

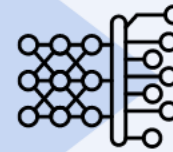


Optimize AUC

Data interpretation

Cough sound model based on MobileNet

Lightweight convolutional network backbone deployed efficiently on a single CPU while obtaining high accuracy



Access and availability

Fast ensemble approach

Improves convolutional network accuracy without adding significant computational complexity



User-friendliness and usability

Portable integrated devices allow continuously monitoring physiological data



Questionnaire



blood oxygen



Stethoscope



spirometer

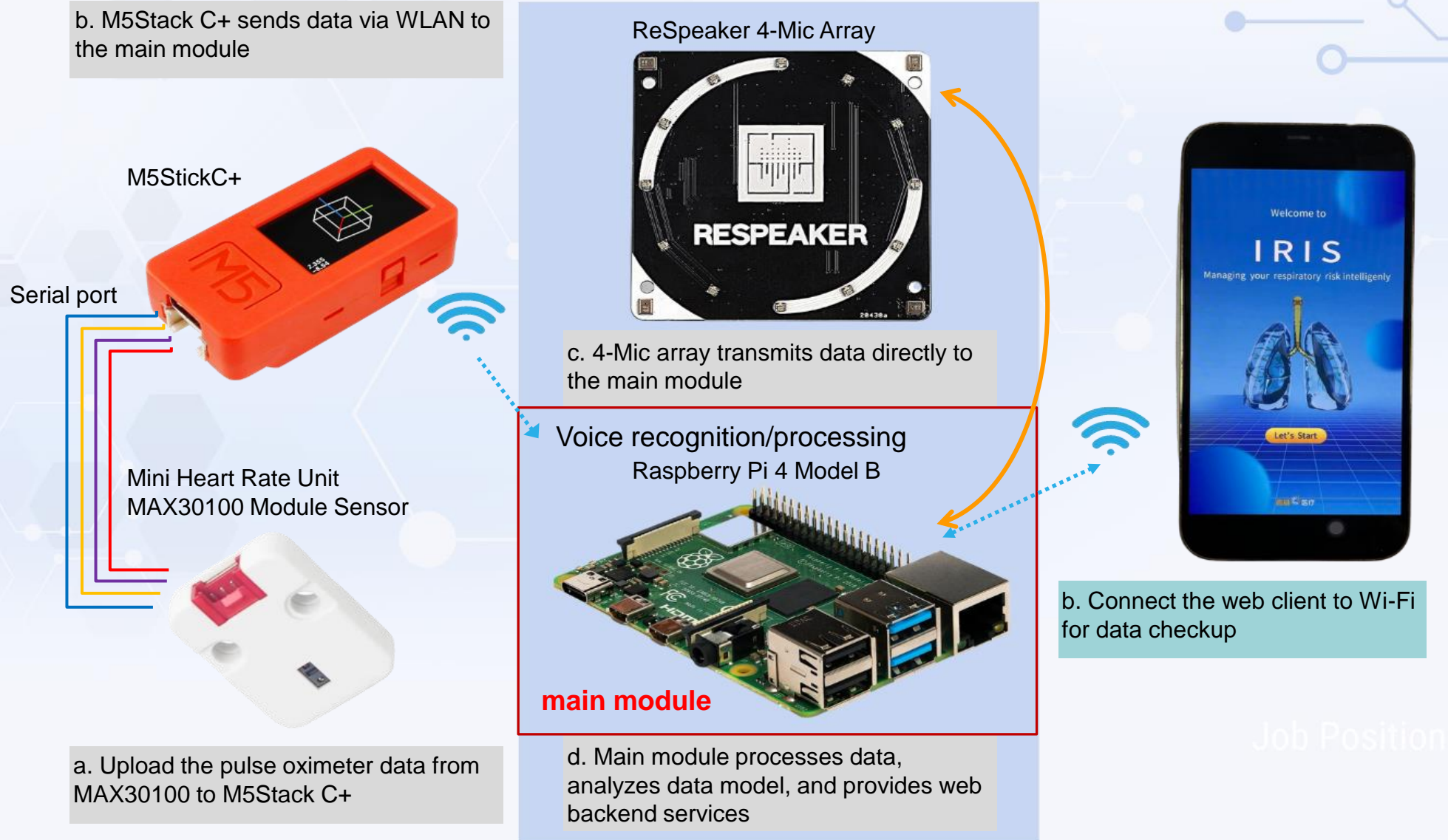


X-Ray Image



CT Scan

Hardware Prototyping

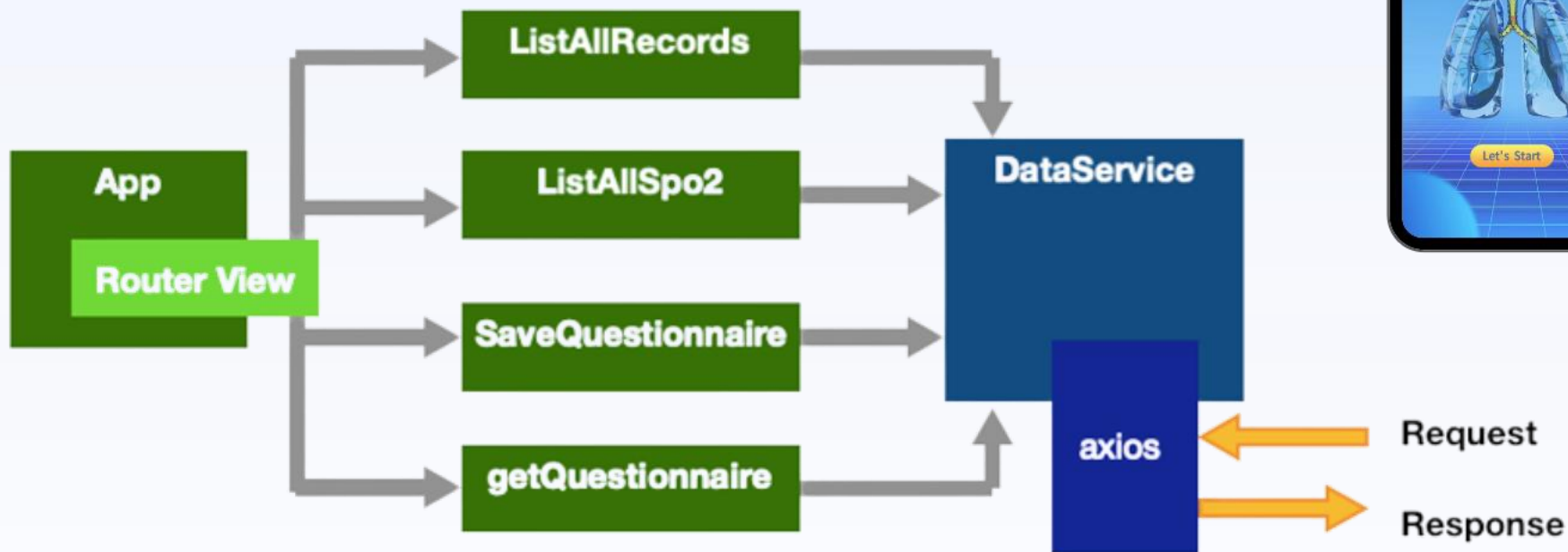


Job Position

Web Application



The django-Vue web application framework



Outlook Design



Idea from the
supermarket basket



- Light & Strong
- Portable
- Effective heat dissipation
- ABS material



Job Function

Open Dataset for Model Training

Cough detection model (A + B dataset)



Lung health diagnosis model



A URBANSOUND8K

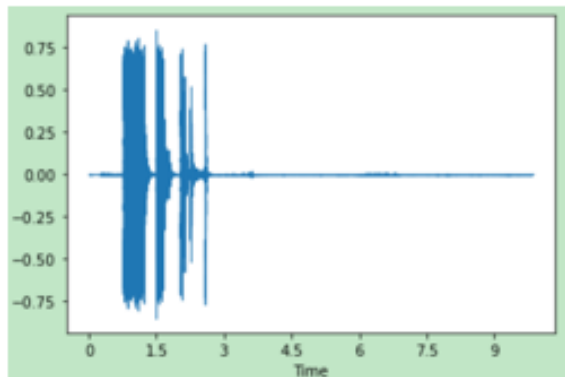
- Sample without cough sounds
- 8,732 annotated audio clips
- Sounds covering air conditioning, car horns, music, construction sounds, and children playing etc.

B Covid19-Cough

- Anonymized
- 1,324 subjects
- Label: COVID19-positive/respiratory symptoms
- 682 positive(382 PCR results, 295 symptomatic)
- Recordings: total 58 minutes of cough sound, average 2.6s each
- Symptomatic samples as positive and other samples as negative

Model Framework - 1

Traditional approach: machine learning models based on audio feature extraction

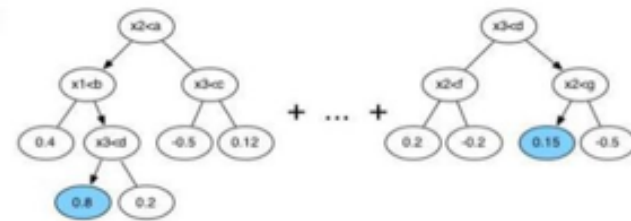


Waveform



- MFCC coefficients
- Spectral Centroid
- Zero Crossing Rate
- Chroma Frequencies
- Spectral Roll-off

特征提取

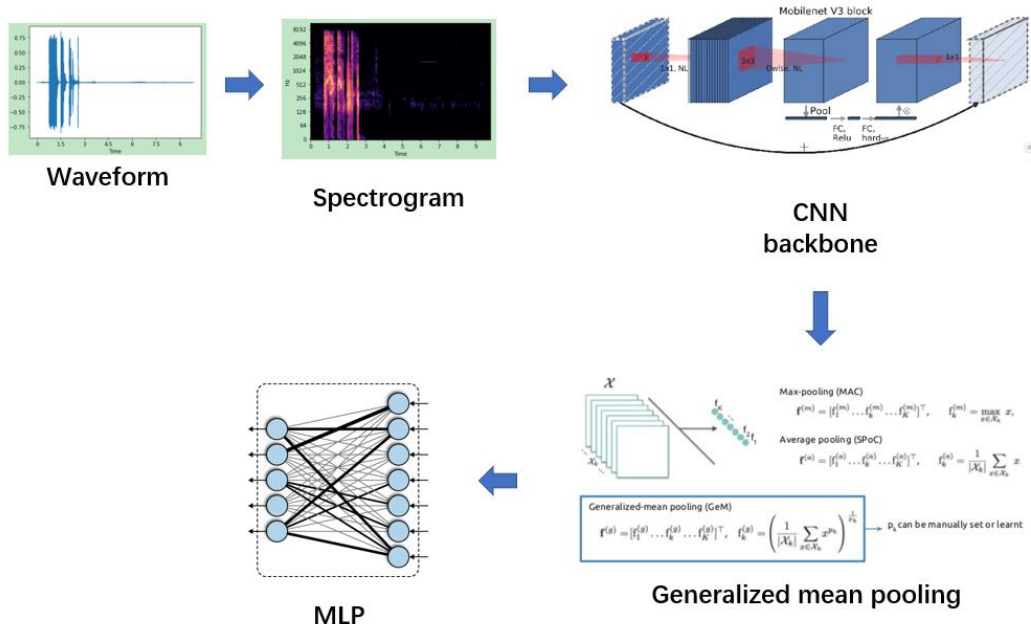


ML classifier

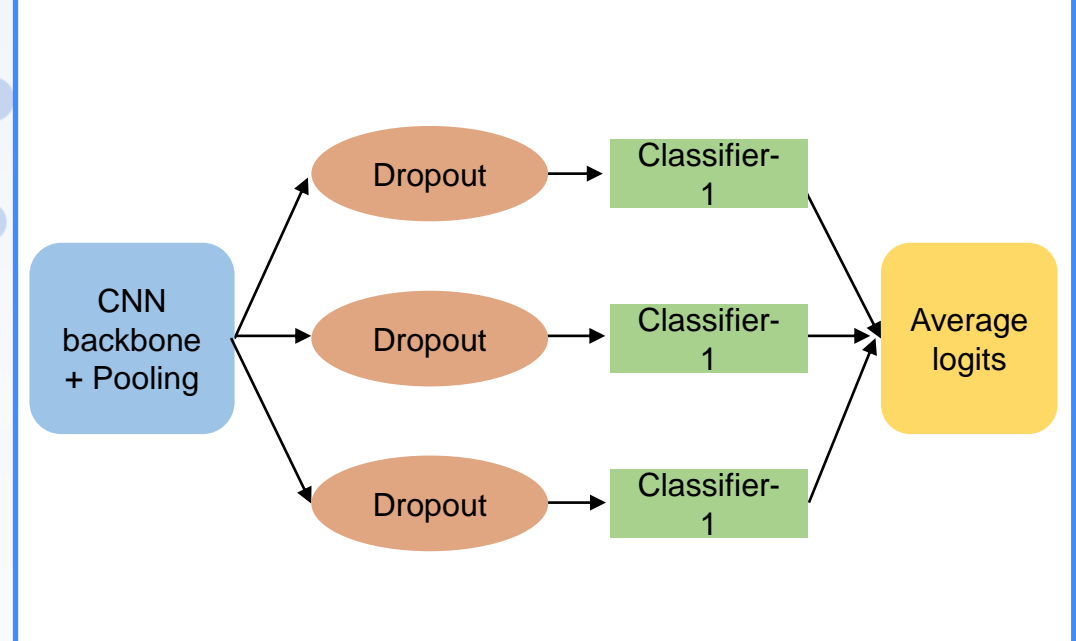
Model Framework - 2

- Deep convolutional networks offer better performance on a variety of audio tasks due to:
 - Powerful automatic feature extraction capability;
 - Pre-training on ImageNet: better parameter initialization;
- Fast Ensemble method: provide model ensemble during inference without much loss of efficiency

Cough sound classification based on spectrogram and convolutional neural network



Fast-ensemble Method



Model Performances

Cough detection model				
	Model	AUC(%)	TPR(%)	TNR(%)
Machine learning	LightGBM	78.5	73.2	80.1
Deep learning	MobileNet-v3 (not pretrained)	86.8	80.6	85.7
	MobileNet-v3	97.1	91.5	94.2
	MobileNet-v3 + Fast Ensemble	97.9	92.7	94.5

Lung health diagnosis model				
	Model	AUC(%)	TPR(%)	TNR(%)
Machine learning	LightGBM	65.3	56.7	61.1
Deep learning	MobileNet-v3 (not pretrained)	73.1	58.7	72.7
	MobileNet-v3	81.1	70.6	80.3
	MobileNet-v3 + Fast Ensemble	82.5	71.3	81.6

Adopted the pre-trained lightweight network *MobileNet-v3* provided by the Pytorch-Image-Models framework as our convolution backbone.

Performances:

- The AUC of the cough detection model reached **97.9%**, and the AUC of the lung health diagnosis model reached **82.5%**
- Fine-tuning pre-trained backbone models significantly improves the results;
- The fast ensemble method further improves fine-tuned models effectively

Product Scenario

- Personalized continuous respiratory health monitoring and decision making.
- Use algorithmic models to detect health risks and ensure early intervention
- Ease the burden on healthcare systems and ensure that medical resources are allocated efficiently, especially during epidemics.



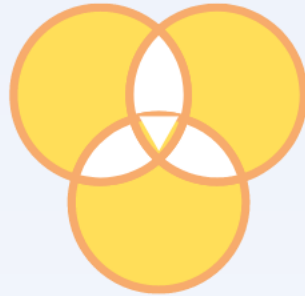
Future Works

Now

Future

Calculate separately

Analyze the risk of COPD-SQ, blood oxygen saturation, and cough sounds separately



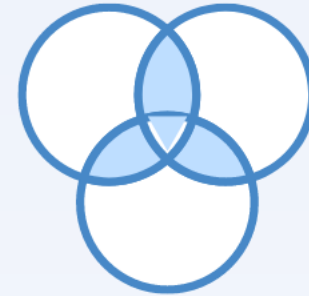
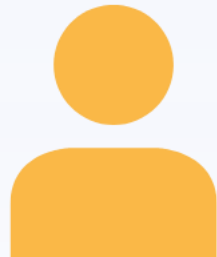
Binary

Results are classified as healthy and under risk



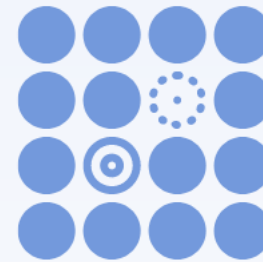
Individual

User's own personal data



Cross-calculate

Combining multiple indicators to determine respiratory disease risk



CDSS

Support the diagnosis of different respiratory diseases



China Dataset

An open database for cough sounds and physiological indicators

THANK YOU

