CoughWatch: Real-world Cough Detection Using Smartwatches

2745

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Motivation

- Coughing is very common symptom
- Relevant to many illnesses
  - Chronic Obstructive Pulmonary Disease (COPD)
  - COVID-19
- European Respiratory Society stated urgent need for continuous cough detection [1]

Objective

- Use sensor data collected from a smartwatch to detect coughs

Methods and Materials

- Collect data from 16 participants who had moderate to severe COPD
- Each wore watch in-the-wild for approx. 3 months
- 4225 hours of audio collected

Challenges → Solutions

- Data is noisy → Combine data from multiple sensors
- Events of interest are rare → Use data augmentation
- Hard to get labels → Improve annotation process

Improved Annotation Process

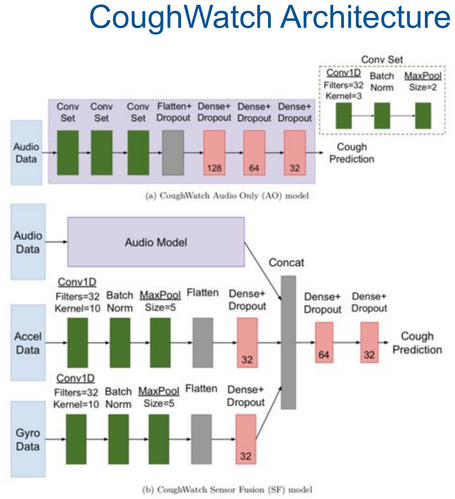
- Step 1: Automatically remove Silence (1726 hours of audio remain)
- Step 2: Split audio into short (up to 10 sec) segments
- Step 3: “Coarse grain” annotate segments – Binary yes or no
- Step 4: “Fine grain” annotate positive segments

	Data
Total	4225 hours
Non-silent	1726 hours
Coarse Grain Annotated	97.4 hours (65,974 segments)
Fine Grain Annotated	3.1 hours (aprox. 2100 segments)
Coughs Discovered	1279

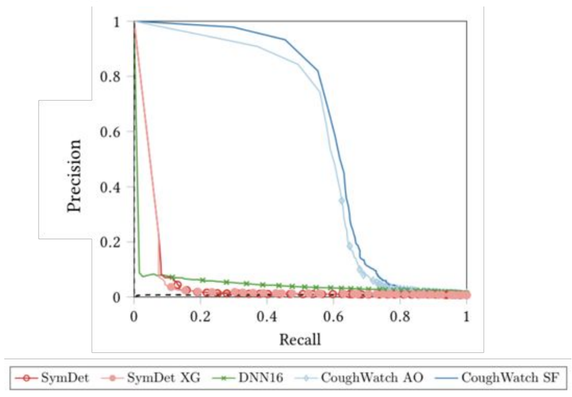
Training

- Classification task: Given up to 10 seconds of sensor data, does it contain a cough (binary classification)
- Use Monte Carlo cross validation

CoughWatch Architecture

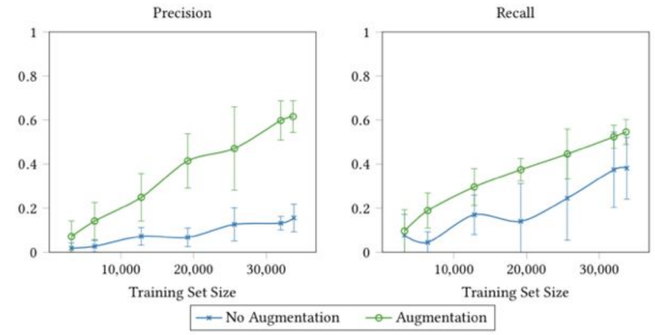


Cough Detection Precision-Recall Curve



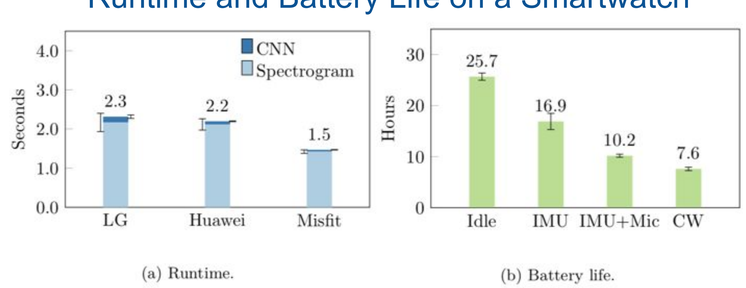
CoughWatch achieves significantly better precision and recall than existing models

Learning Curve with Augmentation



Introducing data augmentation improves both precision and recall

Runtime and Battery Life on a Smartwatch



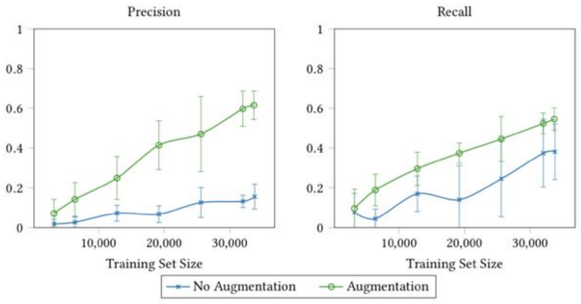
Our model is able to run in realtime and last 7.6 hours on a smartwatch

Results

- CoughWatch achieves better precision and recall than existing state-of-the-art models
- Data augmentation improves precision and recall
- CoughWatch runs in real-time on a smartwatch
- Battery impact can be avoided using duty cycling

Conclusion

- We built a cough detector using smartwatch data
- Proposed an improved annotation process
- Used data augmentation to improve precision and recall
- Used additional sensors to reduce false positive rate
- Showed that our cough detector works better than existing ones on in-wild data



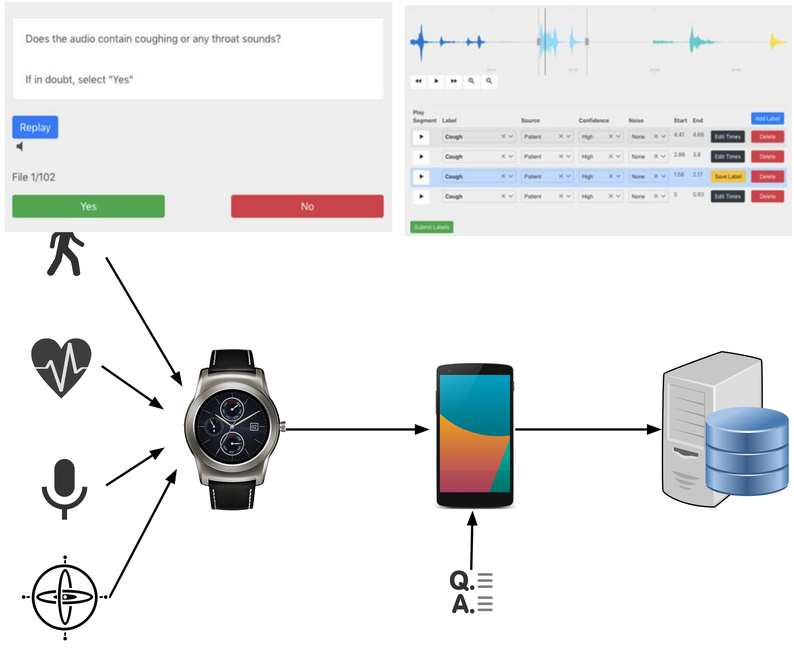
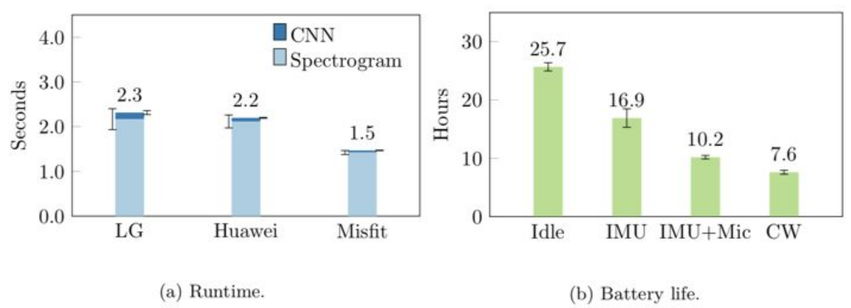


Fig 1: Dataflow of the WearCOPD system



(a) Runtime.

(b) Battery life.