CoughWatch: Real-world Cough Detection Using Smartwatches

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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
<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Non-silent</th>
<th>Coarse Grain Annotated</th>
<th>Fine Grain Annotated</th>
<th>Coughs Discovered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4225</td>
<td>1726</td>
<td>97.4 hours (65,974 segments)</td>
<td>3.1 hours (approx. 2100 segments)</td>
<td>1279</td>
</tr>
</tbody>
</table>

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

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