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SPIRA: System for Early Detection of Respiratory Insufficiency viaAudio Analysis

Why detect respiratory insufficiency?

Initial response of the Artificial Intelligence (AI) area to the COVID-19 pandemic

- Silent hypoxia, serious COVID-19 symptom
- But also: Influenza (H1N1), heart disease, lung problems, sleep disorders, anxiety attacks, etc.

Idea

- Ester C. Sabino, FM-USP
- Anna Sara Levin Shaferman, FM-USP
- Marcelo Finger, IME-USP

Project Start

- Approval from Ethics Committee (CEP-HC-FMUSP)
- Financing: Fapesp Project 2020 / 06443-5
- Organization of a multidisciplinary team
- Currently: Phase 2 data collection

Project Organization: Phase 1

Database construction: speech as a biomarker, "wild" data

Pre-processing of audio samples

Three investigative fronts:

1. Prediction: **Big Data** Approach (Black Box)
2. Detecting Respiratory insufficiency with **Machine Learning**
3. Data description: **Small data** approach (White box)
4. Statistical description of respiratory failure in audio samples
5. Software development for data collection/prediction

Initial Dataset Construction

Covid19 Voices

Approx 600 samples HC+HU+BP

Healthy Voices (Control)

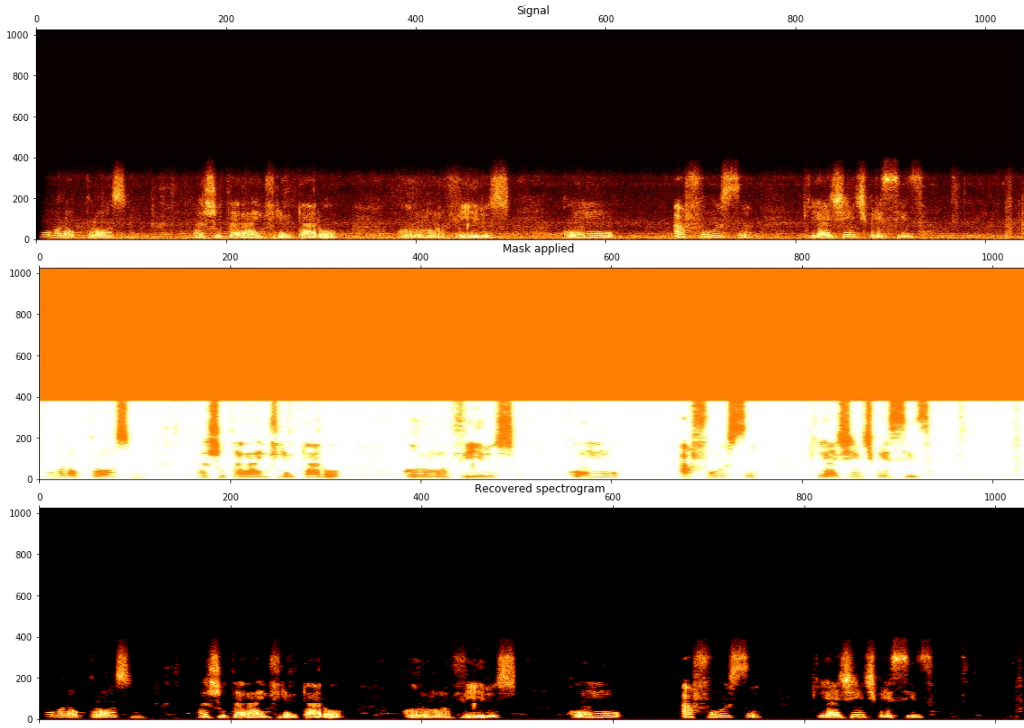
Over 6000 voice donations

Collecting ward backgrund noise

Data Collection: Phase 1

- Nurses and doctors unavailable (pandemic overload)
- Collection made by medical students or foreign medical visitors, coordinated by Dr Anna Sara Levin
- Cell phone use in COVID wards (no special equipment)
- Program via whatsapp (opus format)
- COVID wings:
  - Public university hospitals: Hospital das Clínicas, University Hospital
  - Private hospital: Beneficência Portuguesa
  - First wave of the pandemic (06-07/2020)

Pre-processing



Background bias

- Very noisy COVID wards
- Donations in “different” environments

Would we lose information in sound filtering?

Need to compensate for bias due to background noise

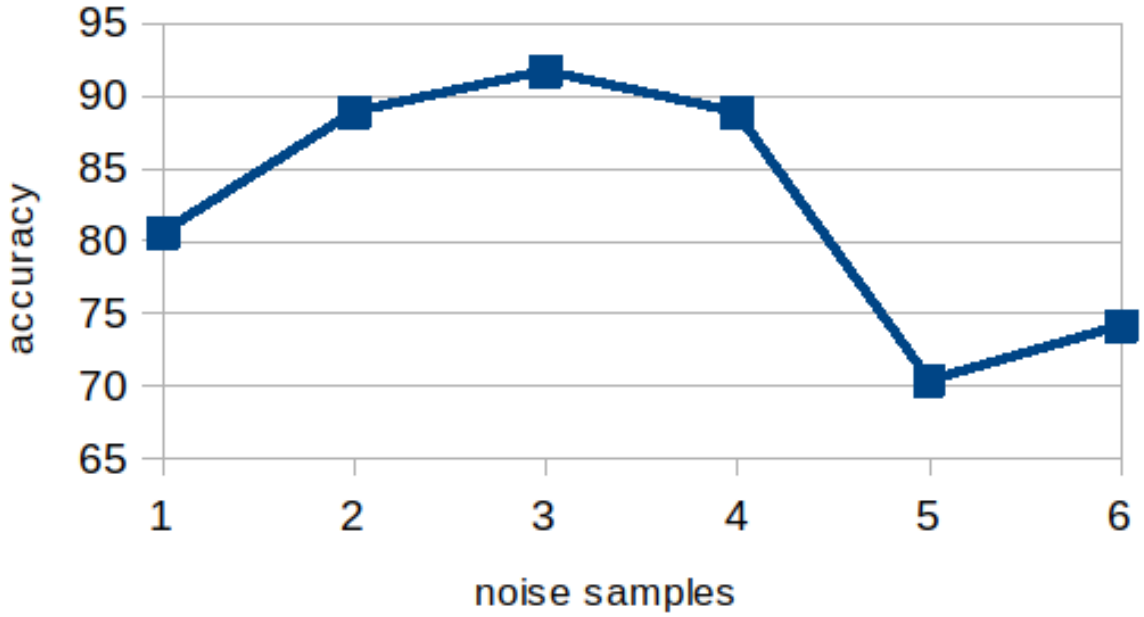
Dilemma: noise reduction *vs* noise insertion

Big Data: Results

Balanced data: patient/control, gender, age

Technique for dealing with audio bias in "real" situations

- Neural networks over MFCC-grams
- Insertion of noise in patient and control data
- CNN Technique: Accuracy 91%



Respiratory insufficidency can be detected in speech with 96.5% accuracy, using Transformers neural nets

Small Data: Signal Description

Two general hypotheses

- Pauses are longer in patients
- Most frequent vocal deviation in patients

Results: Pause as a Biomarker for COVID-19: First prize at the Brazilian Speech Therapy Symposium

To do: Identification of differences between patient/control groups:

- temporal measures
- prosodic measures
- spectral measurements

Other Results

- INTERSPEECH Stefan Steidl Computational Paralinguistics Award, COVID-19 Cough Sub-Challenge Prize 2021.
- First Place: Speech Emotion Recognition in Portuguese, SE&R2022

Second Phase

Second phase data collection (BP, UNIMAR, Sta Casa Marília):

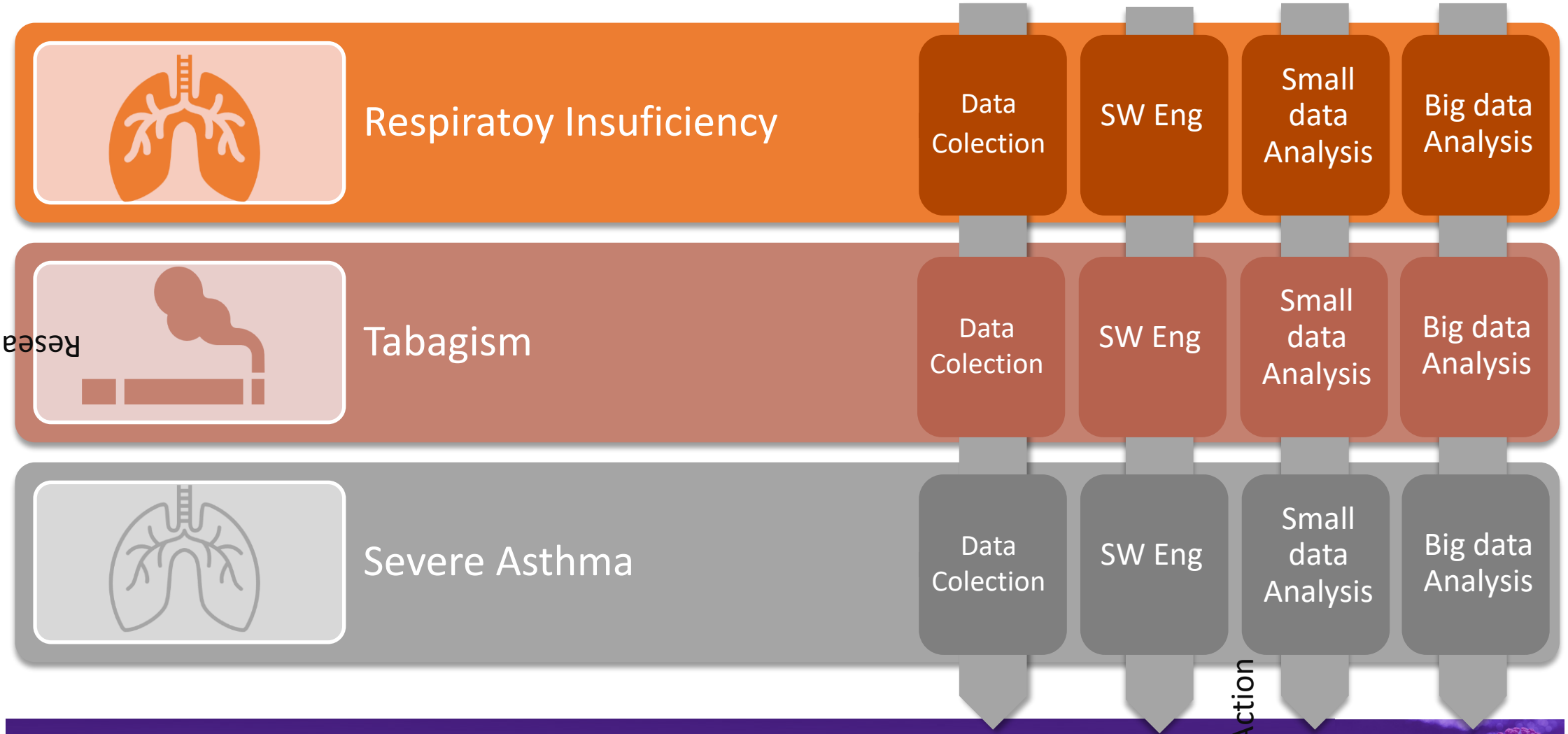
1. General respiratory insufficiency

2. Influenza (H1N1), heart disease, lung problems, severe asthma, sleep disorders, psychiatric disorders, post-covid, etc.

3. IR source classification by machine learning

4. SpO2 prediction by voiceSegunda fase de coleta de dados (BP, UNIMAR, Sta Casa Marília)

Project Sequel: SPIRA Biomarkers



SPIRA-BM: Respiratory Insufficiency via audio analysis

- Detection of RI from several etiologies (causes):
  - Heart condition, COPD, Influenza, Asthma etc, besides COVID
- Predicting the most probable etiology for RI
- Oxygen Saturation regression (SpO2)
  - Early results show this is harder than RI detection
- Clinical tests for AI tool

SPIRA-BM: Tabagism

- Estimation of COex
  - Can exhaled CO be detected by audio analysis?
  - Gamification of Smoking Cessation
- Estimation of “Tabagistic Load”
  - Can we detect the number of years of smoking activity by audio analysis?
- Respiratory insufficiency due to smoking

SPIRA-BM: Severe Asthma

- Prediction of asthma exacerbation (attack) by audio analysis
  - Improve patient quality of life
  - Decrease costs due to hospitalization
- Can we predict an attack 48h before it occurs
  - Development of new therapies (respiratory physical therapies)
- Respiratory insufficiency due severe asthma

OBRIGADO!

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