Metrological evaluation of lung ultrasound using virtual vector machine for diagnosis of acute respiratory distress syndrome

ME-LUS-VVM-DARDS

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INMETRO

CONFERENCE 2022 Metrology for Digital Transformation SIM-MWG-14

SIM Sistema Interamericano de Metrología

Metrology for Digital Transformation SIM-MWG-14

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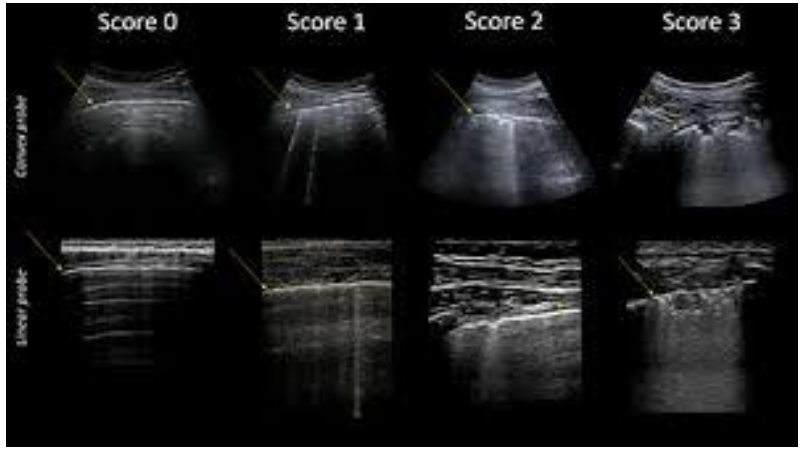
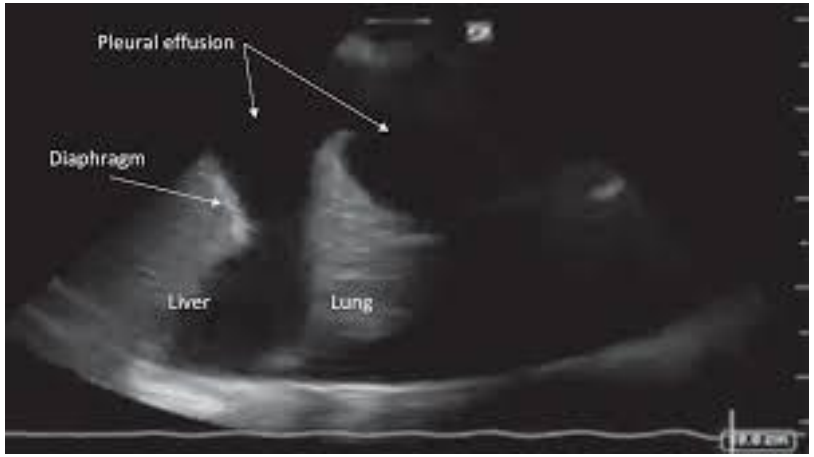
Main concepts

- Lung ultrasound (LUS)
  - Ultrasonography of lungs

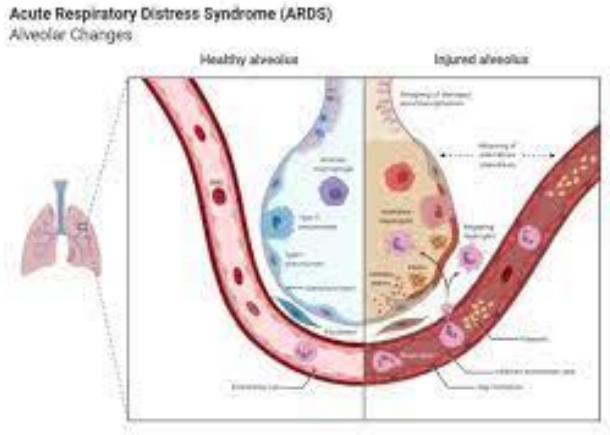


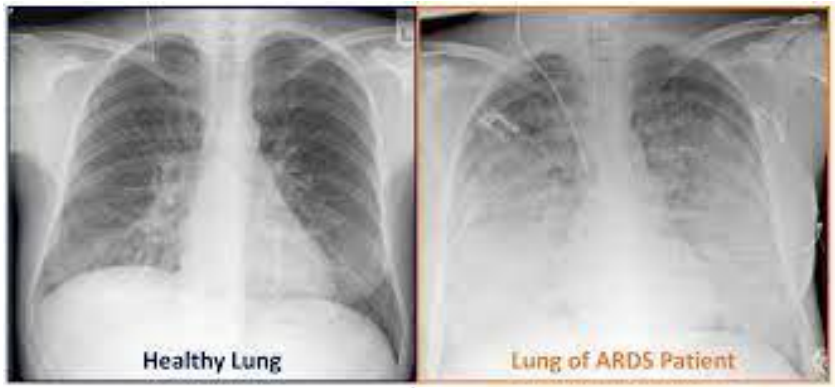
- LUS “scores” (LUSS)
  - Semiquantitative score that measures lung aeration loss caused by different pathological conditions (ARDS, for instance)



Main concepts

- Acute Respiratory Distress Syndrome (ARDS)
  - ARDS happens when the lungs become severely inflamed from an infection or injury
  - The inflammation causes fluid from nearby blood vessels to leak into the tiny air sacs in your lungs, making breathing increasingly difficult
  - COVID-19 may lead to ARDS in some circumstances

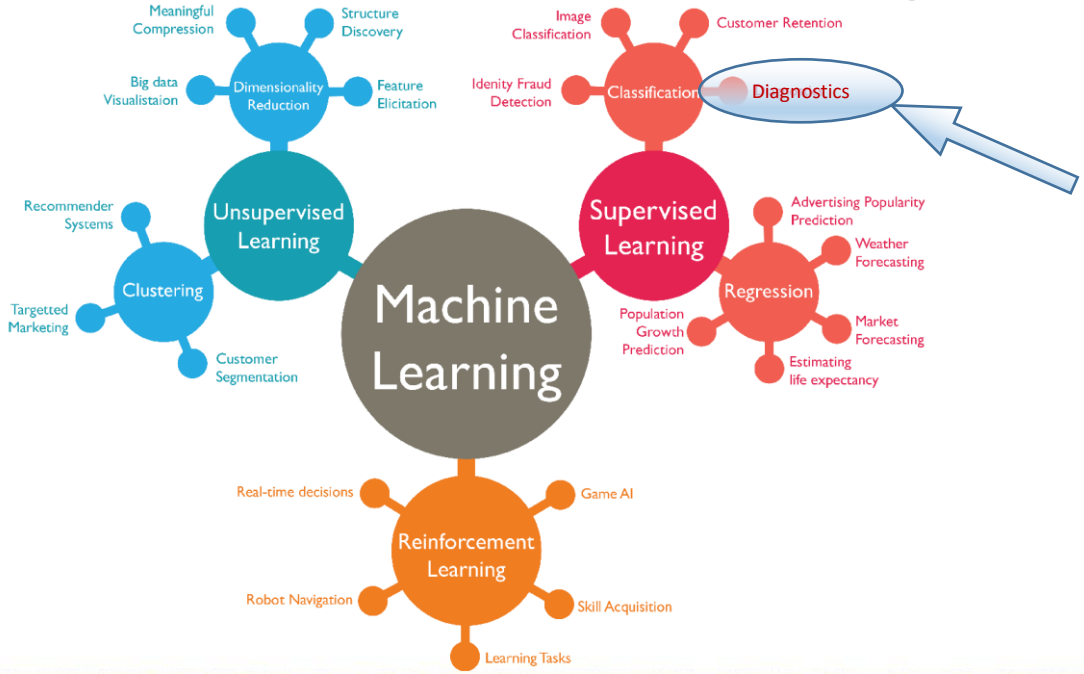




Radiography, not LUS

Main concepts

- Virtual Vector Machine (VVM)
  - Supervised learning models with associated learning algorithms that analyze data for classification and regression analysis
  - VVM ⊂ Machine Learning ⊂ Artificial Intelligence



Motivation

- LUS is widely available
  - Easy to be used
    - Professional certification may be required
  - Relatively low cost
    - Comparing with radiology, for instance
  - Non-ionizing radiation
    - Proper dose measurement for IR is available
  - Accessible as Point of Care Testing (POCT)
    - Easy to be used, low cost, and non-ionizing

- LUS has been successfully used to COVID-19 diagnosis
  - A thousand or more papers had been published recently
    - A systematic review is undergoing
      - Cooperation of Inmetro and the Federal University of Rio de Janeiro (UFRJ)

Key questions / hypothesis

- Is LUS safe for ARDS diagnosis?
  - That is partially responded by the project motivation
- Is LUS a proper metrological tool for ARDS diagnosis?
  - To be confirmed by the project outcomes
- Can VVM improve the rapidness for ARDS diagnosis?
  - Diagnostics accuracy is a premise
    - A comparison between a human and a VVM analysis is part of the methodology

Challenges

- Metrology
  - LUS images accuracy to be checked
  - VVM accuracy to be checked

- Technology
  - LUS as ARDS reliable diagnostics tool to be checked

- Methodology
  - Available LUS images databases completeness to be checked

Objectives

- Main objective
  - Find out the applicability of VVM to help on the Diagnostics of ARDS (DARDS) based on LUS images

- Complementary objectives
  - To find and check out LUS databases for ARDS
  - To retrieve a large amount of data regarding LUS and ARDS
  - To develop a VVM to categorize different LUSS based on LUS images
  - To propose a tool to Diagnose Acute Respiratory Syndrome (DARDS) based on VVM

That is the utmost objective: DARDS

Material and Methods

- Search for databases
  - LUS applicable to ARDS diagnosis
- Evaluate the integrity and reliability of the databases
  - Equipment used to extract the images
  - Post-extraction treatment
- Develop a VVM to categorize LUS images with respect to DARDS
  - Supervised tests
  - Accuracy check

Main outcomes

- An automated tool to diagnose ARDS based on different LUS scores
  - Technologically validated
  - Metrologically validated
  - Free to use worldwide
    - Industrial and Intellectual properties to be well-adjusted throughout the project

- Spread out knowledge of LUS, ARDS, VVM among SIM's NMI
  - Technical exchange
  - Internships
  - Culturalization on M4DT regarding ultrasound usefulness

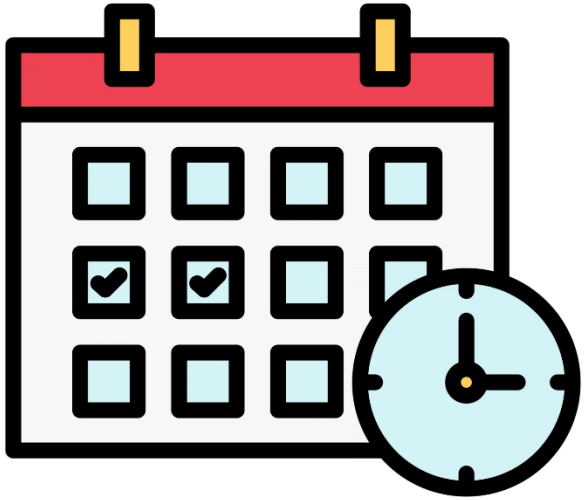
MUCH MORE TO BE EXPLOITED

Expected impacts

- Better, faster and more accurate diagnostics for ARDS
  - Based on a technical development project
- Easiness to apply the tool
  - M4DT as a dip-needle to forthcoming entrepreneurship on metrology agreed value investments
- POCT viability with an additional value on metrology
  - Metrology showing up as useful for a broader audience
- Health care and health tech investments
  - Circular and globally economy improvement
- Better communication with the citizens regarding the metrology

Time schedule

- Warming up the engines
  - 14OCT2021
    - Kick-off meeting
  - 27OCT2021
    - Interaction and first planning
- Forthcoming activities
  - 5 internships
    - To be arranged
    - Expected to be held from OCT2022 to MAY2023
  - Final meeting
    - Expected to be held on JUN-AUG2023
- Projected time span
  - OCT2021 to SEP2023 (24 months)



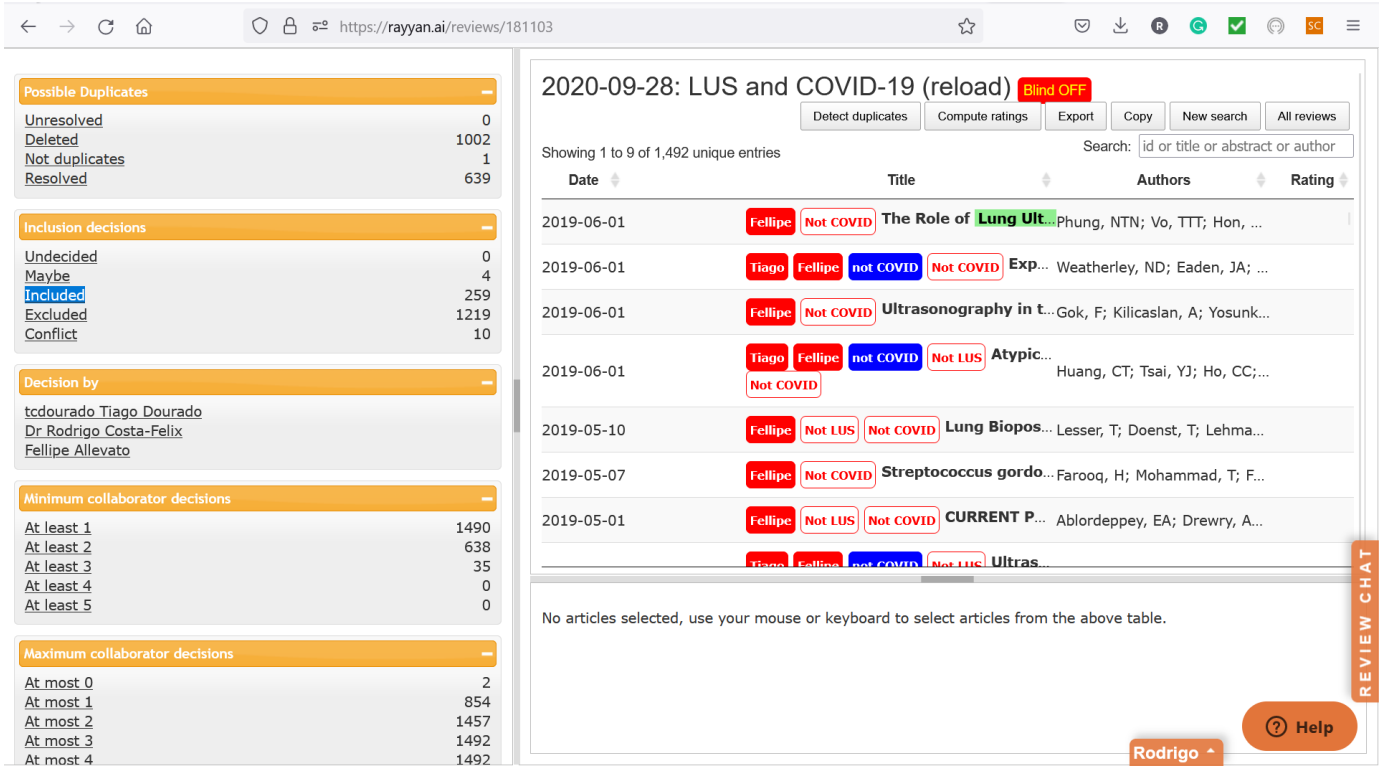
Budget

- Digital data storage in the clouds for 18 months
  - USD 2k
- Scientist's exchange
  - USD 20k
    - Travelling support for 5 researchers
    - Air ticket and day allowance
    - Up to 4 weeks each
- Final meeting
  - USD 12k
    - Travelling support for 6 researchers
    - Air ticket and day allowance
    - Up to 4 days each

Total: USD 34 k

What has been done?

- Systematic literature review
  - 958 papers selected from the literature (first trial)
    - 1492 in a second trial
    - Third trial do be done
    - About 259 papers included (in revision)
- Ryann app



What has been done?

- Search for databases
  - Main databases identified as potential sources of images
    - https://www.nature.com/articles/s41551-020-00633-5
    - https://github.com/jannisborn/covid19_ultrasound
    - https://arxiv.org/abs/2004.12084
    - https://github.com/nrc-cnrc/COVID-US
  - Real images from an existing repository such as POCUS
    - https://github.com/jannisborn/covid19_ultrasound
    - https://github.com/jannisborn/covid19_ultrasound/tree/master/data

What has been done?

- Other approaches to be done
  - Create a repository of correlated images with tomography from patients in local hospitals (validated images)
  - Generate images from validated lung phantoms
  - Generate the images synthetically, from real images, using a generative adversarial network model
  - Generate the images by numerical simulation (with FIELD II or k-Wave, for instance), from tomographic and scattering data

- Interchanges planning
  - To be enrolled from JUN2022 to SEP2022

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Gracias
Merci
Obrigado
Thank you

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