X-ray and AI in triaging for TB and COVID-19

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www.delft.care
Today

• Introduction Delft Imaging

• History and implementation of CAD4TB (AI)

• The role of X-ray in COVID-19

• Validation & implementation of CAD4COVID (AI)

• Conclusion
40 countries
150+ projects
250+ installations
6 million+ TB screenings
How it all started: AI for TB (CAD4TB)

1996 Delft launches first digital X-ray for TB screening; Dutch grant to develop software to analyze radiographs

2001 First publications on automated detection of TB from chest radiographs

2007 CAD4TB project by Delft and Radboud University starts in cooperation with Lung Institute in Cape Town

2011 First prototype tested in South Africa and Zambia

2015 CAD4TB CE certified and used in SA prisons

2016 Launch of CAD4TBbox for full offline use

2020 CAD4TB is being used to screen over 7,000+ people every day, with more than 1.5 million people screened in 2019 alone. CAD4TB is active in 40 countries.
Our solutions for TB

**Delft Light**
Portfolio of portable X-ray

**EasyDR**
Stationary X-ray systems

**Mobile clinics**
TB, Laboratories (UN supplier)

**Artificial intelligence**
CAD4TB, CAD4COVID

Fits within a backpack

250+ installations

100+ mobile TB clinics globally

Over 6M+ people screened
Combining CAD4TB and GeneXpert
Saving both time and costs in screening programs
Publications and studies (40+)

- Useful where trained human readers are scarce, [Muyoyeta et al., PLOS One, 2014]

- In Tanzania, **CAD4TB performance was significantly better than a clinical officer** [Breuninger et al., PLOS One, 2014]

- Reduces cost per identified TB case and the cost per screened subject by almost half, [Philipsen et al., Nature Scientific Reports, 2015]

- **CAD4TB on par with human expert readers**, [South Africa; Hogeweg et al., IEEE Trans Med Imaging, 2015], [Tanzania; Steiner et al., Public Health Action, 2015], [Zambia; Melendez et al., IJTL, 2017], [London; Melendez et al., IJTL, 2018]

- In Pakistan, cost per screened subject using CAD4TB is almost half in comparison to screening without, while **doubling daily throughput** [Murphy et al., Nature Scientific Reports, 2020]

- Offers good **diagnostic accuracy** as triage for TB screening among **diabetes patients** [Habib et al., Nature Scientific, 2020]
AI for COVID-19/TB screening; how does it work?
The Coding of Roentgen Images for Computer Analysis as Applied to Lung Cancer

GWILYM S. LODWICK, M.D., THEODORE E. KEATS, M.D., and JOHN P. DORST, M.D.

This paper will describe a concept of converting the visual images on roentgenograms into numerical sequences that can be manipulated and evaluated by the digital computer and will report the results of employing this system to the diagnosis of lung cancer. It is possible to carry out a non-destructive study of a mass of any size, cause, against a background of air density, the intimate details of the relationship between tumor and host may be faithfully reproduced roentgenographically. Parenthetically, it may be stated that similar density ranges exist in the relationships between bone and soft tissue and that such a coding system would be of value in this area.
Deep learning
Tuberculosis: yes
Continuously being improved

Radiological reference

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Bacteriological reference

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The role of X-ray in COVID-19

• RT-PCR is the gold standard to confirm COVID-19, so where does radiology come in?

• Early stages can be undetected by the lab test; CT imaging has found to be a highly sensitive method to detect COVID-19¹

• X-ray is not as sensitive as CT, but uses less radiation, is often cheaper, easier to use and generally more available in TB-burdened countries

• A positive diagnosis from radiology (CT) is definitive, even when a lab test is negative²

• Moreover, radiology allows for tracking disease progression & recovery

• But, X-ray is not a diagnostic tool for COVID-19; it is a triage tool


² CT Imaging and Differential Diagnosis of COVID-19, Canadian Association of Radiologists Journal, March 4 2020; https://doi.org/10.1177/0846537120913033
COVID Score: 65
Affected Lung Area: 35%
COVID Score: 2
Affected Lung Area: 0%
ROC curve: explained
Scientific validation CAD4COVID

- Single center study
- 454 COVID suspects
  - 223 PCR positive
  - 231 PCR negative
- 6 radiologists from hospitals in the Netherlands

- Performance among radiologists differ
- CAD4COVID has similar performance to radiologists
- For COVID-19, limit to what can be seen on CXR (also for radiologists). Different for TB.
- Sensitivity and specificity depend on threshold and dataset
- Paper submitted to *Radiology* journal
Case study – Bernhoven (Netherlands)

- One of the highest-burdened hospitals in the Netherlands.

- Triage tent upon entering hospital. Selection for radiology based on symptoms (e.g. fever, cough). First-line triage with digital X-ray;
  - If CXR is abnormal -> RT-PCR
  - If CXR is normal -> CT (before RT-PCR)

- Highly prevalent setting: 90% of patients with symptoms had COVID-19

- In 60-70% of cases, COVID-19 abnormalities were visible on the CXR

- A number had COVID-19 (abnormalities), but negative 1st/ 2nd RT-PCR

- Currently, exploring different use cases for TB-burdened countries (e.g. Peru/SA/Nigeria)
CAD4COVID: accessible already to healthcare facilities in twelve countries (Left: Hungary, Right: Peru)
CAD4COVID-CT

- CAD4COVID-CT is now also available, live April 20th
- Also free-of-charge during the crisis
- Output:
  - Severity score
  - Heatmap
  - % of lung tissue affected
  - Cloud-based, and available to 10,000+ radiologists globally through partnership with German company Smart Reporting
- For access, go to www.thirona.eu/cad4covid
Considerations on implementing AI for TB/COVID-19

• The algorithm is only part of the solution; also consider factors like
  • Extent of scientific validation
  • Ease-of-use
  • Offline availability
  • Service & support

• Take privacy and data security in consideration
Key takeaways

• Overall, AI tools are not diagnostic tools, but intended as a triage tool

• **X-ray for TB**: highly sensitive, and reasonably specific

• **AI for TB** (with CAD4TB): extensively validated: 6M+ screenings, 40+ publications, CE certified

• **X-ray for COVID-19**: limited sensitivity; needs to be in combination with symptoms / rapid POC tests


• For access to CAD4COVID (free-of-charge during crisis), go to www.delft.care/cad4covid
Thank you for your attention

For more information, visit www.delft.care