Point of Care Image Analysis for COVID-19

Team

● Team Coordinators:
  • Dr. Yishai Elyada, Mobileye – X-ray
  • Dr. Nogah Shabshin, Haemek Medical Center – Medical
  • **Dr. Shai Bagon**, Weizmann AI Center (WAIC) - Ultrasound
  • Prof. Libertario Demi, University of Trento - Ultrasound

● Participants:
  • Clinical forum at Weizmann + Drs. Ahuva Grubstein (Beilinson), Naama Bogot (SZMC), Amiel Dror (Nehariyah Medical)
  • Volunteers from various companies and hospitals throughout Israel including Daniel Yaron, Daphna Keidar, Elisha Goldstein, Yair Shachar, Nadav Nehmadi, Meirav Galun, Oz Frank, Nir Schipper
  • Collaborators in Italy: Frederico Mento, Gino Soldati, Andrea Smargiassi, Riccardo Inchingolo, Elena Torri
  • Computing services from WEXAC
The Challenge

- To provide rapid diagnosis and monitoring for COVID-19 patients from different hospitals
- To create a method that is faster and more sensitive than RT-PCR
- To use Lung Ultrasound (LUS) for COVID-19 monitoring and stratification
Our Solution

- Identifying COVID-19 in X-ray & Ultrasound scans using Deep Learning
- Using X-ray data from four different hospitals in Israel
- Using LUS data from five different hospitals in Italy
Chest X-Ray

- Chest X-ray: COVID-19 is a respiratory disease – presentation in the lungs
- High access to X-ray machines, field deployment
- Portable X-rays are easy to transport & sanitize
Chest X-Ray

- Challenges:
  - Hard to distinguish COVID-19 from other respiratory diseases
  - Publicly available datasets have strong limitations
Pipeline

Use X-Ray images dataset
Collecting as much different images from many hospitals

Comparing our results
Compare different networks performance to find the best one

Building datasets
Training various NN
Analyzing results

Train our NN
Testing the different networks on our dataset
Dataset Collection

- Shaare Zedek Medical Center ~1000 Images
- Rabin Medical Center Beilinson ~800 Images
- Emek Medical Center ~300 Images
- Galilee Medical Center ~100 Images

\[ \begin{align*}
\text{~1100 Covid-19 images} \\
\text{~1100 Non-Covid-19 images}
\end{align*} \]

Controls: patients with a variety of respiratory diseases
Image Pre-processing

1. **Normalization**: size, brightness, etc.
Image Pre-processing

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2. **Augmentation**: rotate, sharpen, contrast, shear, blur, scale, flip
   - Discussed with Radiologists to verify the parameters
   - Augmentations don’t change the image label
Image Pre-processing

1. **Normalization**: size, brightness, etc.
2. **Augmentation**: rotate, sharpen, contrast, shear, blur, scale, flip
   - Discussed with Radiologists to verify the parameters
   - Augmentations don’t change the image label
3. **Segmentation**: segment the lungs using a U-net
Use X-Ray images dataset
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Neural Network Ensemble

- Based on transfer learning
- **Networks used:** ResNet18, ResNet50, ResNet101, VGG16, Chexpert
- Output prediction - average score of 4 best networks
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Results

- Over 90% detection accuracy on diverse data of admitted patients
- Immediate on-site results
Confidence in labels

![Histogram of confidence for labeled data](image)

- **GT: positive for Covid-19**
- **GT: negative for Covid-19**

**Axes:**
- **X-axis:** Confidence
- **Y-axis:** Frequency
Confidence increases with time from onset

Time from onset in which the scan was taken

Classification score

GT: Covid-19 positive
GT: Covid-19 Negative
COVID-19 vs non-COVID-19 features
Lung Ultrasound

(LUS)
Lung US - Collaboration

- Collaboration with a group of Italian clinicians and researchers
- **Libertario Demi, Frederico Mento**
  Department of Information Engineering and Computer Science, University of Trento
- **Gino Soldati**
  Diagnostic and Interventional Ultrasound Unit, Valle del Serchio General Hospital, Lucca
- **Andrea Smargiassi, Riccardo Inchingolo**
  Dept. of Cardiovascular and Thoracic Sciences-Fondazione Policlinico Universitario A. Gemelli IRCCS
- **Elena Torri**
  Bresciamed
The Challenge of LUS
The Challenge of LUS

LUS frames taken from ICLUS dataset, Ultrasound Laboratory Trento (ULTRa)
Grading COVID-19 Using LUS

Grading COVID-19 Using LUS

Grading COVID-19 Using LUS

Vertical Artefacts

Convex

Linear
Vertical Artefacts
Vertical Artefacts
Vertical Artefacts
Grading COVID-19 Using LUS: Deep Model

ResNet-18

ResNet-18

LUS prediction
Grading COVID-19 Using LUS

- ICLUS Dataset
  - 35 Patients from 5 hospitals
  - 277 LUS videos corresponding to 58,924 frames
- Annotations - “COVID-19 severity” score \{0, ..., 3\}

# Grading COVID-19 Using LUS: Classification

<table>
<thead>
<tr>
<th>Model</th>
<th>Settings 1</th>
<th>Settings 2 Drop Transition Frames (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Frames</td>
<td>K=1</td>
</tr>
<tr>
<td>ResNet-18 (Roy et al)</td>
<td>62.2</td>
<td>63.9</td>
</tr>
<tr>
<td>CNN-Reg-STN (Roy et al)</td>
<td>65.1</td>
<td>66.7</td>
</tr>
<tr>
<td><strong>ResNet-18 (ours)</strong></td>
<td><strong>68.7</strong></td>
<td><strong>70.0</strong></td>
</tr>
</tbody>
</table>
Summary: Bridging the Expert Gap

- Many opportunities for advanced AI methods in detection and monitoring of COVID-19 via imaging
- Very good results with relatively simple networks
- Data sets are a crucial part of the success
- Working on hospital deployment and will be made public to benefit the community

AI for COVID19 can pave the way to more pervasive use of ultrasound and Xray monitoring for lung patients more generally
Thank You!

If you found this interesting …
Looking for further clinical collaborators
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