Developing a Large-Scale Tele-Dermatology Program

Session 268, February 14, 2019
Eduardo Cordioli, Telemedicine Medical Manager, Hospital Israelita Albert Einstein
André Santos, Telemedicine IT Project Coordinator, Hospital Israelita Albert Einstein
Conflict of Interest

Eduardo Cordioli, Telemedicine Medical Manager

André Santos, Telemedicine IT Project Coordinator

Both have no real or apparent conflicts of interest to report.
Agenda

• Brazilian's Physician Demography

• Teledermatology Consultation Flow

• Growth Curves

• Clinical Staff Management Challenges

• Software Platform: Security, Scalability and Availability

• Deep Neural Networks Training Steps
Learning Objectives

• Detail the steps to develop a large-scale social tele-dermatology program with a low-cost operation

• Identify the most common pitfalls in large database optimization for medical image acquisition

• Describe how to develop a network of dermatologists available to screen, diagnose and treat diseases from dermatological images
Physician demographics in Brazil

• Access to health care is historically a chronic problem in Brazil. For example, in the 60's the ratio of doctors and inhabitants had a percentage of only 0.0623%. (SCHEFFER et al, 2018)

• Now in 2018, the percentage is approximately 0.22% However, the growth does not reflect benefits for the population. (SCHEFFER et al, 2018)

• There are 452,801 physicians in Brazil. However, the distribution among regions suffers a great inequality (SCHEFFER et al, 2018).
Distribution inequality among regions

- The percentage of physician distribution by population varies from 0.28% in the Southeast to only 0.12% in the North (SCHEFFER et al, 2018).

- Only the state of São Paulo concentrates 28% of the total number of doctors in the country (SCHEFFER et al, 2018).

- In contrast, in the state of Maranhão and Pará, the distribution of physicians by inhabitants is only 0.09% of the population (SCHEFFER et al, 2018).
Challenges providing specialized care in Brazil

• According to Brazilian Society of Dermatology, from the 5,565 municipalities only 504 (9.1%) of Brazilian cities have dermatologists.

• Dermatology is the second specialty most referred by primary care physicians. With an average waiting time of 108 days. (VIEIRA et al, 2014)

<table>
<thead>
<tr>
<th>Speciality</th>
<th>Waiting days average</th>
<th>Waiting days maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otolaryngology</td>
<td>399</td>
<td>550</td>
</tr>
<tr>
<td>Dermatology</td>
<td>137</td>
<td>108</td>
</tr>
<tr>
<td>Angiology</td>
<td>174</td>
<td>174</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>68</td>
<td>81</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>370</td>
<td>449</td>
</tr>
<tr>
<td>Endocrinology</td>
<td>381</td>
<td>507</td>
</tr>
</tbody>
</table>

(VIEIRA et al, 2014)
Brazil public health system specialist consultation flow

Patient identify the symptoms → schedule an appointment with a general physician → Go to a Basic Health Unit (UBS) → Get a referral

3-5 months queue

Receive a phone call → schedule an appointment with a specialist → Go to a consultation With a specialist → Finally starts treatment
Teledermatology consultation flow

1. Patient identify the symptoms
2. A technician takes lesions images
3. A.I. referrals the patient
   - 27% Consultation with a specialist
   - 70% Diagnosys by Teledermatology
   - 3% Biopsy procedure

- 70% Diagnosys by Teledermatology
- 3% Biopsy procedure
- 2 weeks Starts treatment

- 1 week Consultation with a specialist
- 2 weeks Biopsy procedure
Mobile App
Medical Platform
# Growth Curve

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1°</td>
<td>172</td>
</tr>
<tr>
<td>2°</td>
<td>2282</td>
</tr>
<tr>
<td>3°</td>
<td>3080</td>
</tr>
<tr>
<td>4°</td>
<td>3408</td>
</tr>
<tr>
<td>5°</td>
<td>4534</td>
</tr>
<tr>
<td>6°</td>
<td>6386</td>
</tr>
<tr>
<td>7°</td>
<td>11562</td>
</tr>
<tr>
<td>8°</td>
<td>12503</td>
</tr>
</tbody>
</table>
Operation Key points

• High performance medical staff
• Microservices Oriented Platform
• Information Security
• Knowing what questions to ask for Artificial Intelligence
Dermatology Medical Staff – 1st Reaction
Dermatology Medical Staff – 1st Reactions

• “I do not believe that you could deliver high quality images”

• “We have to see the whole patient”

• “I doubt that general practice doctors or nurses would do the anamnesis correctly”

• “I already saw a similar attempt in the literature and it did not work”

• “Are the info and images of the patient in a safe environment”
Changing Culture

• Give examples of successful cases.

• Show that they could be paid in the same way as working in person, with the advantage of doing homeoffice, consulting dermatology atlas, dictate your own work rhythm.

• Show that the institution's top leadership was committed to the project.

• Sensitize them by the social scope of the project.

• Possibility of various scientific works.
Do the doctor’s trust Teledermatology?

Confidence in teledermatology diagnosys before the project:
- Little confident: 25%
- Confident: 33%
- Very confident: 42%

Confidence in teledermatology diagnosys after the project:
- Confident: 83%
- Very confident: 17%
Ok, but... the doctors enjoy working with Teledermatology?

Would you recommend to a colleague trying work with Teledermatology?
Answer: Yes 100%

Do you want to keep working with Teledermatology?
Answer: Yes 100%

Do you believe that Teledermatology is the future?
Answer: Yes 100%
Artificial intelligence in the clinical operations. Are we there?
Microservices architecture

Auto Scaling

- Authentication service
- A.I. service
- Queue service
- Application service
- Report service
- Images Handler Service

Load Balancer
Information Security

End-To-End Encryption

- VPN
- Concentrator

VPN

HTTPS

Load Balancer

MD5 Encryption

IP Whitelist

Authentication service

Local Network

+ WAF
+ DDOS
+ Firewall
+ Etc
Working With Artificial Intelligence

The first step is to set your goals.

Define what you want to do with your A.I. Algorithm!

1° Give the appropriate referral to the patient

2° Set the priority of care

3° Provide support diagnosys to the clinical staff
Clusters optimization

210 Possible diagnostics grouped in 17 cluster

- Inflammation of unknown cause
- Surface Infection
- Eczema
- Traumatic cause
- Benign tumor
- Genetic cause
- Pigmentation disturbance
- Adverse Drug Reaction
- Metabolic cause
- Malignant tumor
- Benign cyst
- Collagenose
- Deep infection
- Pre-malignant
- Psychiatric Disorder

Encaminhamento

- Biopsia
- Dermatologia
- Teledermatologia
Clusters lesions distribution

[Bar chart showing the distribution of clusters by lesions type and group, with specific numbers for each category.]
Environment & tools

OpenCV

Keras

Python

TensorFlow
First A.I. Attempt: Original Images
Neural Networks Architectures

- LeNet
- AlexNet
- VGG
- Google Inception
- ResNet
First A.I. Attempt: Original Images
Second A.I. Attempt: Object recognition

mask_scale: Using default '1.000000'
Loading weights from yolo.weights...Done!
data/dog.jpg: Predicted in 13.944889 seconds,
dog: 82%
cor: 22%
truck: 64%
bicycle: 85%
(tensorFlow) MacInBoxes-MBP:darknet macinbox$
Third attempt: To develop a system able to identify the region of interest and crop it
## Tested Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Model Description</th>
<th>Train Accuracy</th>
<th>Validation Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1 - ConvNet as fixed feature extractor</strong></td>
<td>Inception V3 Feature Extraction</td>
<td>0.8000</td>
<td>0.6600</td>
</tr>
<tr>
<td></td>
<td>VGG19 Feature Extraction</td>
<td>0.4576</td>
<td>0.5000</td>
</tr>
<tr>
<td></td>
<td>Resnet50 Feature Extraction</td>
<td>0.2150</td>
<td>0.2000</td>
</tr>
<tr>
<td><strong>Scenario 2 - Extending model &amp; re-initialization strategy</strong></td>
<td>Inception V3 Extending Model</td>
<td>0.8893</td>
<td>0.5417</td>
</tr>
<tr>
<td></td>
<td>VGG19 Extending Model</td>
<td>0.7124</td>
<td>0.6667</td>
</tr>
<tr>
<td></td>
<td>Resnet50 Extending Model</td>
<td>0.9886</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Scenario 3 – Scratch</strong></td>
<td>Inception V3 Scratch</td>
<td>0.9506</td>
<td>0.6562</td>
</tr>
<tr>
<td></td>
<td>VGG19 Scratch</td>
<td>0.8417</td>
<td>0.8333</td>
</tr>
<tr>
<td></td>
<td>Resnet50 Scratch</td>
<td>0.1946</td>
<td>0.2000</td>
</tr>
</tbody>
</table>
# Specificity and Sensitivity

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Model</th>
<th>Specificity</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inception V3</td>
<td>0.90</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Feature Extraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>VGG19</td>
<td>0.88</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Feature Extraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Resnet50</td>
<td>0.80</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Feature Extraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Inception V3</td>
<td>0.88</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Extending Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>VGG19</td>
<td>0.91</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Extending Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Resnet50</td>
<td>0.80</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Extending Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Inception V3</td>
<td>0.91</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Scraph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>VGG19</td>
<td>0.95</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Scrach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Resnet50</td>
<td>0.80</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Scrach</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Classification Results

Scenario 1: train accuracy

Scenario 2: train accuracy

Scenario 3: train accuracy

Scenario 1: validation accuracy

Scenario 2: validation accuracy

Scenario 3: validation accuracy
Lessons learned from CNN training

• Before training your network, first analyze properly your database and define your targets with wisdom.

• Do not trust that the network will discover the region of interest by itself.

• Do not be afraid of run a high number of epochs.

• Always test different algorithms and different learning paradigms, it will help you to understand your dataset better.
Conclusions

• Brazil has an extremely promising environment for implementation and growth of distance health care programs due to its size and the concentration of health professionals in the major economic centers

• The doctors may be resistant at first, but as they start using technology on their daily routines they start to enjoy it and get more confident every day. This data can be measured by the growth of doctors answering that they are very confident about performing virtual diagnosis from 25% to 83%

• Convolutional Neural Networks are perfectly capable of performing tasks such as screening and diagnostic suggestions when properly designed. The referrals already reached 83% of accuracy and they have potential to improve even more

• Microservices based architectures and cloud platforms are essential in order to provide the consistence and availability that a high scaled health operation requires
Questions

Eduardo Cordioli
eduardo.cordioli@einstein.br
https://www.linkedin.com/in/eduardo-cordioli-94896119/

André Pires dos Santos
andre.dsantos@einstein.br
https://www.linkedin.com/in/asantos4/

Please remember to complete the online session evaluation!

Thank you!