RSNA 2017 Pediatric Bone Age Challenge

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December 27, 2017
About myself and our ODS team

@alxndrkalinin, Alexandr Kalinin, University of Michigan

- BSc, MSc in Applied Math and Informatics from NSTU, 2004-2010
- Fulbright Scholar in Statistics at University of California, Los Angeles, 2013
- 5th year PhD Candidate in Bioinformatics at University of Michigan

- @ternaus, Vladimir Iglovikov, Lyft Inc.
- @rakhlin, Alexander Rakhlin, National Research University of Electronic Technology
- @shvetsiya, Alexey Shvets, MIT
Goals of the project

**Pediatric bone age assessment** – is a common clinical practice to diagnose endocrine and metabolic disorders in child development.

**Goal:** Develop an algorithm which can most accurately determine skeletal age on a validation set of pediatric hand radiographs.
Challenge organization and logistics

Radiological Society of North America (RSNA) – international society of radiologists, medical physicists and other medical professionals with more than 54,000 members from 136 countries. Custom competition platform.

- Training phase start: Aug. 5, 2017, midnight
- Leaderboard phase start: Sept. 1, 2017, midnight
- Test phase start: Oct. 7, 2017, midnight
- Competition end: Oct. 15, 2018, 3:55 a.m.

The Challenge winners invited to join the Challenge panel at the RSNA Annual Meeting in Chicago, Nov 26. Data made publicly available.
Data description

Data structure:

- X-ray images of a left hand
- patient sex
- [outcome] bone age in month

Number of patients:

- Training: 12.6k
- Validation set: 1425
- Test: 200
EDA: train set patient sex distribution

- Approx 50/50 sex ratio
- Up to 20 years old
- Most ages divisible by 6
EDA: varying quality of radiographs

- annotations
- very light/dark areas
- rotated images
- contrast issues
- etc

average:
Preprocessing: segmentation by @ternaus

U-Net positive mining:

1. manually label 100 masks with Supervisely
2. train U-Net
3. predict the rest of training set
4. in every image leave 1 biggest CC
5. visually inspect all predicted masks to keep those of good quality
6. repeat steps 2-5 x5 more times
7. manually label 100 worst masks
Preprocessing: registration by @rakhlin

Needed to evaluate different areas of the hand (A,B,C)

1. manually label 800 radiographs with keypoints
2. train VGG-like net on downsides images
3. predict coordinates on the rest
4. register with affine transform
Preprocessing: registration by @rakhlin
VGG-like architectures

- ELU
- Adam

Regression:
- MAE loss
- age in $[-1, 1]$

Classification:
- BCE loss
- 240 age bins
Results: different models, bones, and sex

Sex is important

MAE(B) > MAE(C) > MAE(A) > MAE (ensemble)

Classification performs slightly better than regression

Ensembling improves results
Results: skeletal development stages

Unlike previous studies, we found carpal bones not the most important compared to others.

More data per age – higher accuracy.
Results: winning solution

- based on Inception v3
- images resized to 500x500
- no preprocessing
- 5 networks in final ensemble
- TTA-10
Conclusions

- we joined late & didn’t win the competition

BUT

- we learned a lot
- we produced potentially useful solution
- we published a preprint that was downloaded >300 times in 12 days

Pediatric Bone Age Assessment Using Deep Convolutional Neural Networks

Vladimir Iglovikov, Alexander Rakhlin, Alexandr Kalinin, Alexey Shvets
doi: https://doi.org/10.1101/234120

This article is a preprint and has not been peer-reviewed [what does this mean?].

ARTICLE USAGE

Article usage: December 2017 to December 2017

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<th>Show by month</th>
<th>Abstract</th>
<th>Pdf</th>
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<tbody>
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<td>Total</td>
<td>1,173</td>
<td>315</td>
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Framework

- dynamic, imperative, fast
- aims to be a drop-in replacement for NumPy with GPU support and autodiff
- provides convenient DataLoader with out-of-the-box multiprocessing
- provides many DL abstractions
- supports multi-GPU out-of-the-box
- has decent tutorials, forum, and not-too-steep learning curve