EXPANDED RESEARCH ON
ATTENTION-GUIDED DISCRIMINATIVE REGION LOCALIZATION
AND LABEL DISTRIBUTION LEARNING FOR

Bone Age Assessment

C&S Bio 185

By Trevor Brokowski, Marlene Lin, Nikhil Patel, Anish Patel, Shiqin Tan

Background

Bone age assessment

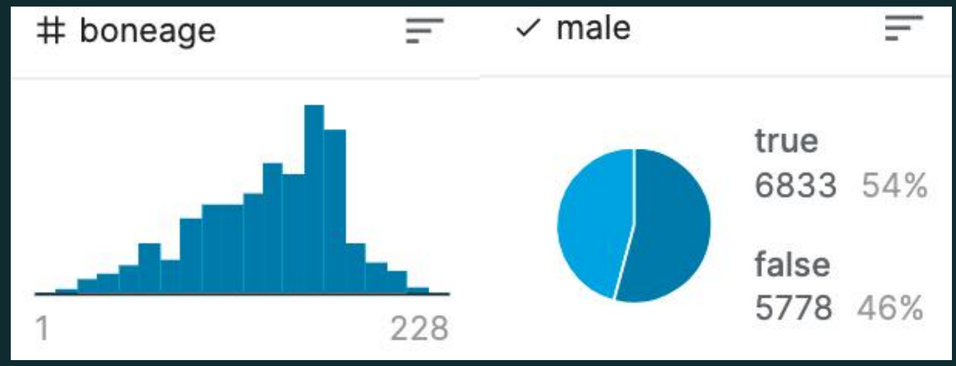
Attention-Guided Discriminative Region Localization and Label Distribution Learning for Bone Age Assessment

Chao Chen, Zhihong Chen, Xinyu Jin, Lanjuan Li, William Speier, Corey W. Arnold

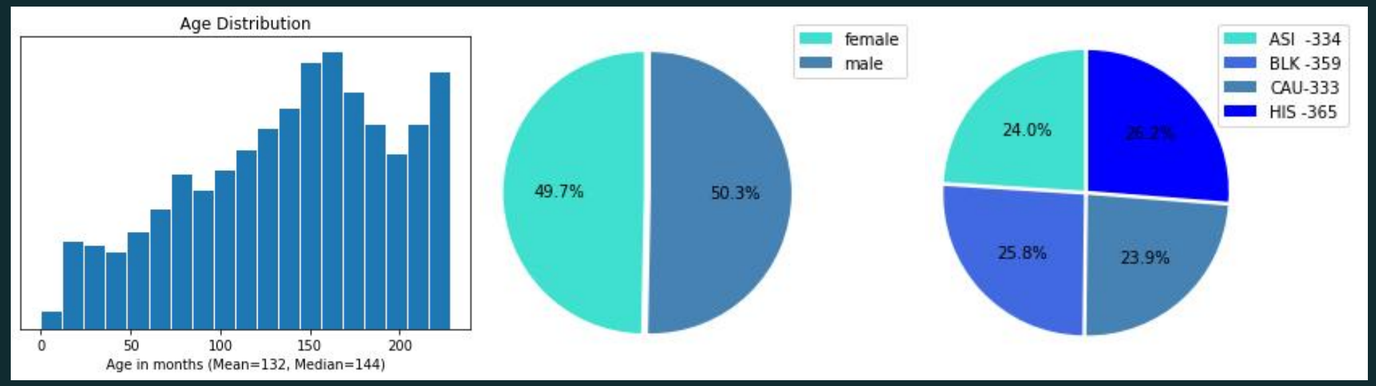
Expanding Research

Transferability to Digital Hand Atlas of USC

RSNA metrics



USC metrics



Our goal

Understand

- ability to transfer to more datasets
- concatenate ethnicity to see if overfit

Selected Paper

- Model: **Xception**
- Accuracy. **More efficient with comparable precision to published BAA methods**

Methods	Image Size	Extra Labels	Data Augment	Model Ensembling	MAE
[6]	750 × 750	mask & keypoint	Yes	18 model results	6.4
[3]	224×224	No	Yes	No	9.5
[16]	512 × 512	No	Yes	No	5.99
	512 × 512	No	Yes	50 model results	4.26
[5]	500×500	Bbox & keypoint	Yes	No	4.14

Ours	O	H	R1	R2	H+R1	R1+R2	O+H+R1	H+R1+E	H+R1+R2
ℓ_1	7.3	6.4	6.1	7.0	5.4	5.6	5.4	4.7	4.8
$\ell_{MAE} + \ell_{reg}$	6.2	5.6	5.3	6.2	4.8	5.1	4.7	4.3	4.3

	Vgg19	InceptionV3	ResNet50	Xception	Xception (with ethnicity)
Test Results (MAE)	9.3	9.2	9.3	8.8	9.4

Our Result

- Model: **Xception**
- Accuracy: **Comparable to conventional BAA methods**
- Training time: **6+ hours**

So…How do we get these results?

>>> Ideal Pipeline of Our Implementation

Our Methods

Train, Test, Concatenate

Train	Read	Test	Concatenate	Evaluate
RSNA-BAA.ipynb Original dataset & original model	Updated Code.ipynb Preprocess & Encoding USC images	X Test USC images on original model	Updated code.ipynb Train & Test USC images on concatenated ethnicity model	Final Report.docx Compare loss & Mean Absolute Error

Our Methods

Train, Test, Concatenate

Train

RSNA-BAA.ipynb

Original dataset & original model

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Updated Code.ipynb

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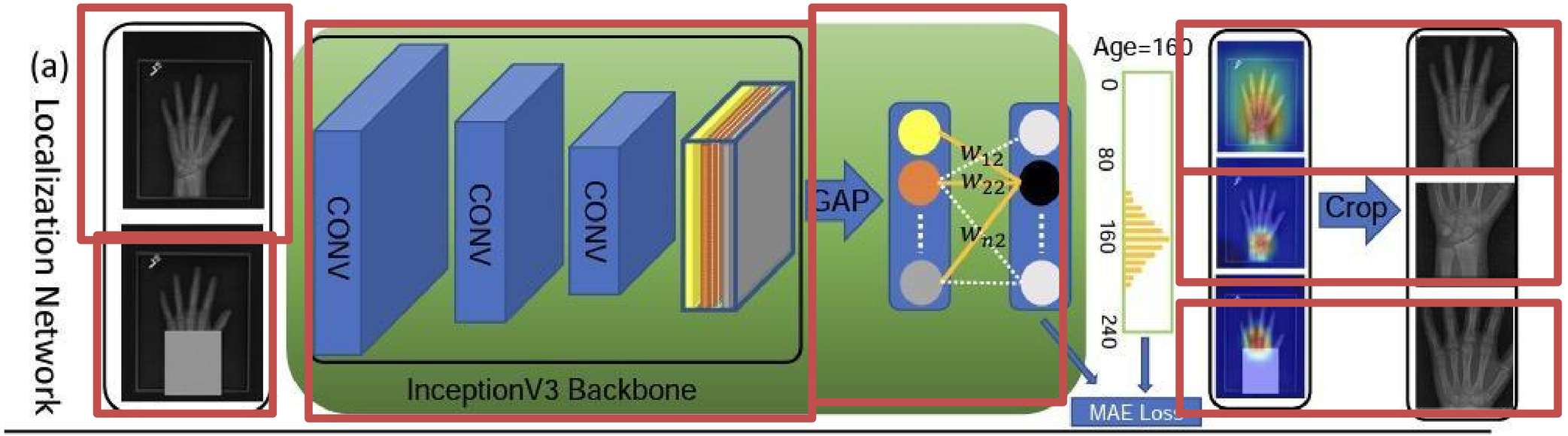
Our Methods

Model: Attention-guided localization

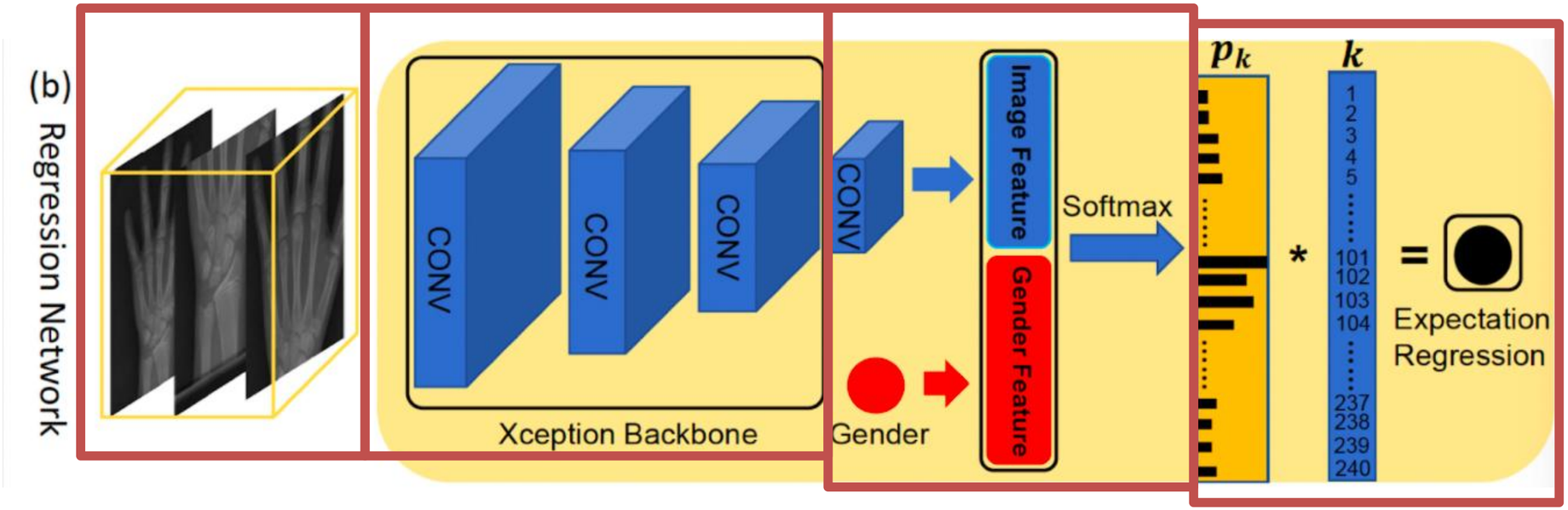


Original x-ray images resized -> localized hand region/localized Region of Interests 1 (carp bones)

Original image with R1 erased -> localized Region of Interests 2

Our Methods

Model: Age regression



Our Methods

Reimplementation (RSNA dataset)

1. Data loading:

   RSNA: 12, 611 labeled img -> out of ram -> progressive loading -> out of time -> rand. 1390

2. Localized hand & Regions of Interests 1 & Masked out R1:

learning rate = 0.0003 for the first 60 epochs, learning rate = 0.0001 for the next 30 epochs with a batch size of 32

3. Test results (MAE/Month):

   `val_MAE = 8.2505`

learning rate = 0.0003 for the first 40 epochs, learning rate = 0.0001 for the next 20 epochs with a batch size of 16

Our Methods

Reading USC images &

Concatenate ethnicity info

Step 1: Process and extract information from DICOM (.dcm) files

- Extract the patient id, gender, ethnicity, age, and, initially, the image*, from the dicom file and the path name using python string manipulation and the os library.
- Example Path: “/Digital Hand Atlas/DICOM/ASIF/ASIF01/5024.dcm”
- * Due to dimensionality and color channel issues with the Xception base model, the image had to be loaded in using opencv instead of pydicom. (3 color channels vs 1)

```
Dataset.file_meta -------------------------------
(0002, 0000) File Meta Information Group Length  UL: 206
(0002, 0001) File Meta Information Version       OB: b'\x00\x01'
(0002, 0002) Media Storage SOP Class UID         UI: Secondary Ca
pture Image Storage
(0002, 0003) Media Storage SOP Instance UID      UI: 1.3.6.1.4.1.
9590.100.1.1.503277170116541836331307893800484035 76
(0002, 0010) Transfer Syntax UID                 UI: Implicit VR
Little Endian
(0002, 0012) Implementation Class UID            UI: 1.3.6.1.4.1.
9590.100.1.0.100.4.0
(0002, 0013) Implementation Version Name         SH: 'IPI LAB 4.0
'
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(0008, 0005) Specific Character Set              CS: ['', 'ISO 20
22 IR 87', 'ISO 2022 IR 13']
(0008, 0016) SOP Class UID                       UI: Secondary Ca
pture Image Storage
(0008, 0018) SOP Instance UID                    UI: 1.3.6.1.4.1.
9590.100.1.1.503277170116541836331307893800484035 76
(0008, 0020) Study Date                          DA: '20000308'
(0008, 0023) Content Date                        DA: ''
(0008, 0030) Study Time                          TM: ''
(0008, 0033) Content Time                        TM: ''
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(0008, 0064) Conversion Type                     CS: 'DF'
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(0008, 1030) Study Description                   LO: '1.83,1.0,78
.80,10.40,46.99,2.25,2.00'
(0008, 1060) Name of Physician(s) Reading Study  PN: ''
(0008, 1080) Admitting Diagnoses Description     LO: ''
(0010, 0010) Patient's Name                      PN: '5024 ASIF01
'
(0010, 0020) Patient ID                          LO: '84115024'
(0010, 0030) Patient's Birth Date                DA: '19980504'
(0010, 0040) Patient's Sex                       CS: 'F'
(0010, 1010) Patient's Age                       AS: ''
(0010, 1020) Patient's Size                      DS: None
(0010, 1030) Patient's Weight                    DS: None
(0018, 0015) Body Part Examined                  CS: 'HAND'
(0018, 1012) Date of Secondary Capture           DA: '20050725'
(0018, 1014) Time of Secondary Capture           TM: '151029'
(0018, 1016) Secondary Capture Device Manufactur LO: 'Array Corpo
ration'
(0018, 1018) Secondary Capture Device Manufactur LO: 'IPI LAB'
(0020, 000d) Study Instance UID                  UI: 1.2.392.2005
```
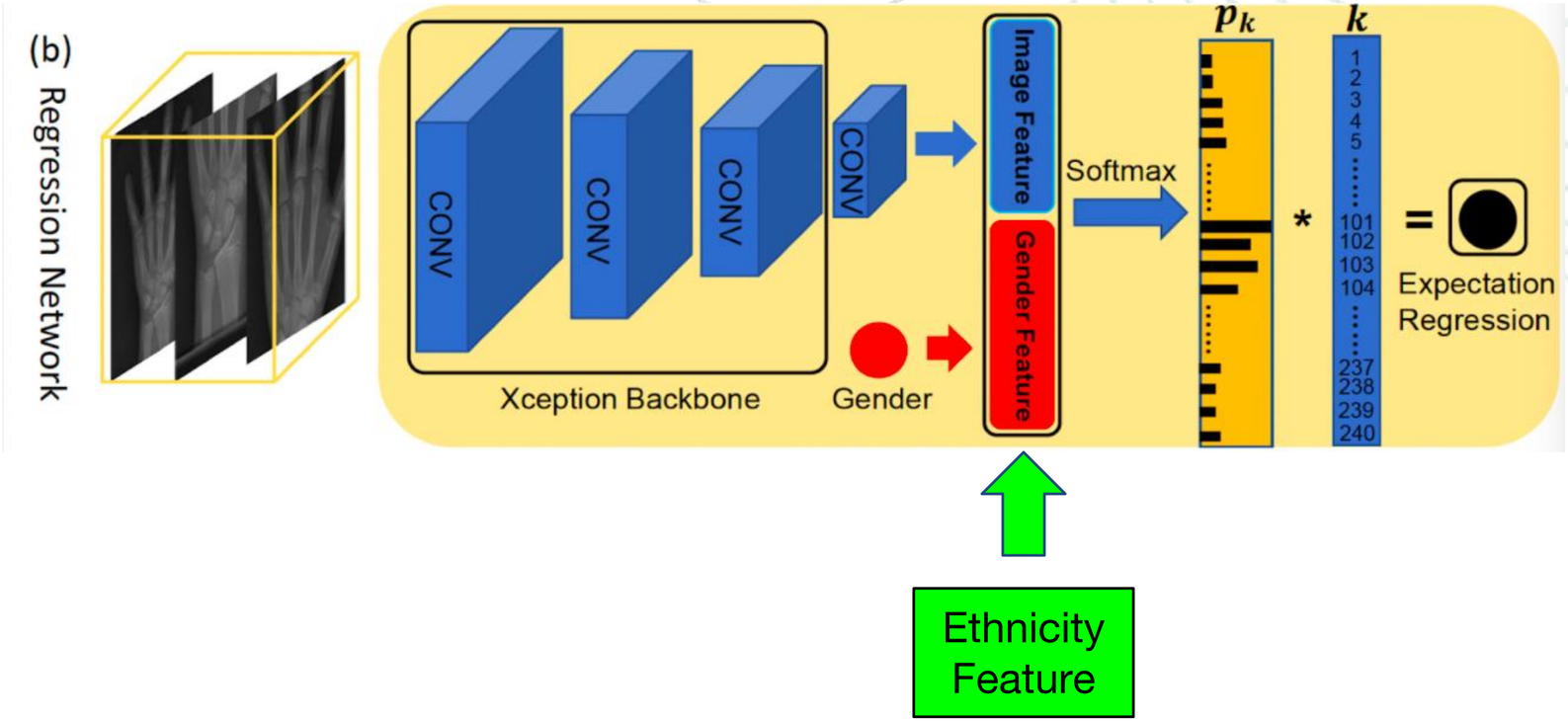

Step 2: Concatenate Ethnicity Information.

- Created a dictionary that performed one-hot-encoding on the variables.
  - ASI → [1,0,0,0]
  - CAU → [0,1,0,0]
  - HIS → [0,0,1,0]
  - BLK → [0,0,0,1]



- Concatenate the list of encoded ethnicities after the convolutions as new input layer for the activation function and the prediction output.

Discussion

Broader Implications

- Concerns: Algorithmic Bias Amplification

- AI Models have proven to:
  - Amplify Healthcare Disparities
  - Exhibit worse results for minority populations
  - Replicate biases in training data

Discussion

Known Biological Differences: Ethnicity

Recent Studies have show that:

1. Significant Differences in Bone Density between ethnicities

1. Rate of bone maturation differs across ethnic lines

Discussion

Inclusion of Ethnicity Data in Models

How to combat algorithmic bias?

No consensus: Proposed including ethnicity data by:

- Entirely separate models
- Including as model input
- Including as model output
- Adjusting input data for know biological differences across ethnic lines

Discussion: Preliminary Results

No significant improvement with Ethnicity.

Important Considerations

- Limited Computing Power
  - Made batching and data set size adjustments to improve training time
  - No time to tune hyperparameters
- Tuning hyperparameters and using larger datasets may improve accuracy beyond baseline
- More research is needed to assess this method of ethnicity inclusion
- Could be a beneficial method to improve algorithmic bias in radiological applications

Thank you for Listening!

Code Availabities

- The source code of selected paper is available at their Github page: https://github.com/chenchao666/Bone-Age-Assessment

- Our commented code is available at our Google Drive page: https://drive.google.com/drive/folders/1QGTlIN27TLcWAEKVbjfI8-M8-E6HzAO8?usp=sharing

- The RSNA dataset is available at Kaggle: https://www.kaggle.com/kmader/rsna-bone-age

- The Digital Hand Atlas of University of Southern California is available at their lab page: ipilab.usc.edu/research/baaweb/