TX-CNN: Detecting Tuberculosis(TB) in Chest X-ray Images Using Convolutional Neural Network

Chang Liu[1], Yu Cao[1], Marlon Alcantara[1], Benyuan Liu[1], Maria Brunette[2], Jesus Peinado[3], Walter Curioso[4]
{cliu, ycao, bliu}@cs.uml.edu, maria_brunette@uml.edu, jpeinado_ses@pih.org, {marlonmfa, waltercurioso}@gmail.com

Problems and Solutions

Challenges:
- Persistent social inequalities in health,
- Limited number of local healthcare professionals,
- Weak healthcare infrastructure found in resource-poor settings.

Solutions:
- Convolutional Neural Network(**CNN**) based method,
- Transfer learning and fine-tuning strategy,
- An unbalanced, less-category, and large scale TB dataset,
- Achieved 85.68% accuracy for classifying TB manifestation,
- Deployed system in Low and Middle-Income Countries(LMICs) healthcare facilities to speed up TB diagnosis, especially in Perú

Approach

Convolutional Neural Network(CNN)
- Adopt AlexNet and GoogLeNet,
- Use softmax classifier to output probability,
- ReLU and dropout are applied in the models.

Transfer Learning(Fine-tuning)
- Use image preprocessing to crop and rescale training images,
- Pre-trained from ImageNet dataset,
- AlexNet: ℓ = 0.01, η = 0.9, w = 0.0005
- GoogLeNet: ℓ = 0.001, η = 0.9, w = 0.0002
- Cross validation and model average are used to increase accuracy.

Shuffle Sampling
- Remove scarce categories(MI, GH)
- Data augmentation for ***unbalanced*** data.

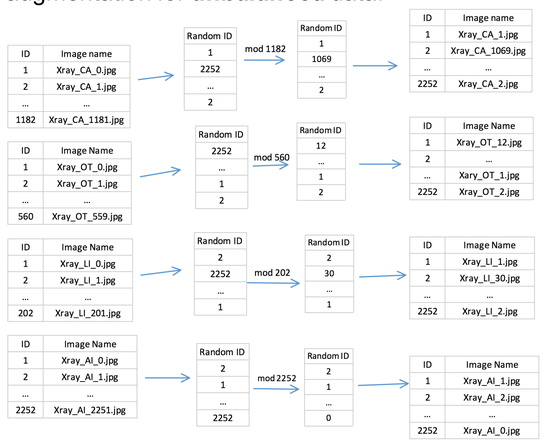


Fig. 2. Illustration of shuffle sampling and data augmentation

Data Augmentation

Category(Name of TB Manifestation)	Total Image
Miliary Disease(MI)	25
Cavitation(CA)	1182
Lympahadenopathy(LI)	202
Ghon Focus(GH)	27
Alveolar Infiltrates(AI)	2252
Other(OT)	560

Tab. 1. Data distribution in TB dataset

Algorithms:
- Choose maximum number as flag to match
- Randomly generate integers to index each training image
- Recalculate the mod value as final indexing value

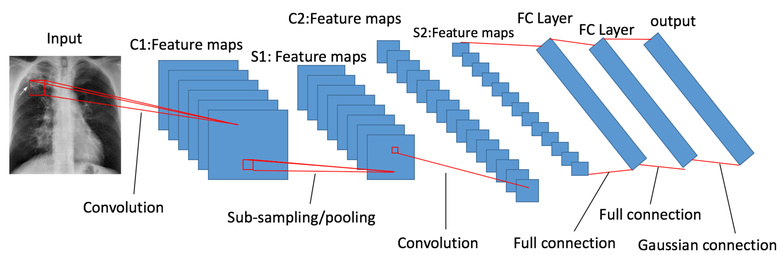


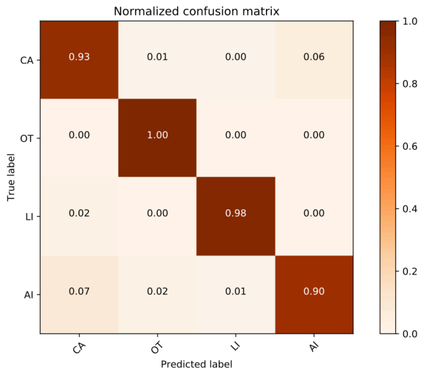
Fig. 1. Illustration of CNN models for TB manifestation classification

Results

Set	Class name	Precision	Recall	F1-score	Miss rate
Train	CA	0.90	0.94	0.92	0.06
	OT	0.87	0.99	0.93	0.01
	LI	0.91	1.00	0.95	0
	AI	0.98	0.91	0.94	0.09
Test	CA	0.87	0.93	0.90	0.07
	OT	0.90	1.00	0.95	0
	LI	0.91	0.98	0.94	0.02
	AI	0.97	0.90	0.93	0.10

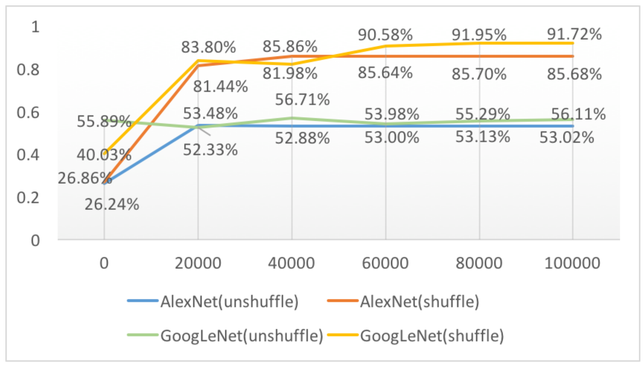
Discussion

- Evaluation on test set stays consistent with training set
- Each class achieves high accuracy using our training protocols(FT, SS)
- The accuracy for categories with more training images is easier to be sacrificed and adjusted for multi-class training.

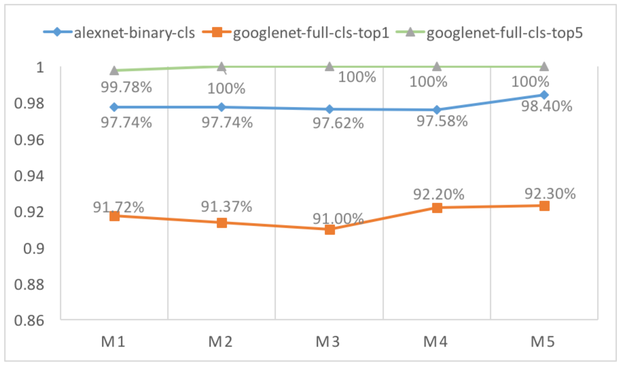


Evaluation

- Improvement of shuffle sampling is stable and significant in various models.
- Average accuracy plateaus as iteration goes, but fluctuates in early stages when fine-tuning with small epochs and training images.



- Every model is stable when chosen right hyper parameters.
- GoogLeNet is working best for classifying all TB manifestations.
- AlexNet is finely tailored for detecting abnormal TB images.



Contact

Chang Liu[1], Yu Cao[1], Marlon Alcantara[1], Benyuan Liu[1], Maria Brunette[2], Jesus Peinado[3], Walter Curioso[4]

[1] Department of Computer Science, University of Massachusetts Lowell, USA
[2] Department of Work Environment, University of Massachusetts Lowell, USA
[3] Partners in Health Perú
[4] Department of Biomedical and Health Informatics, University of Washington, Seattle, USA
{cliu, ycao, bliu}@cs.uml.edu, maria_brunette@uml.edu, jpeinado_ses@pih.org, {marlonmfa, waltercurioso}@gmail.com

References

[1] Cao, Yu, et al. "Improving tuberculosis diagnostics using deep learning and mobile health technologies among resource-poor and marginalized communities." *IEEE First International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE)*, 2016.
[2] Shin, Hoo-Chang, et al. "Deep convolutional neural networks for computer-aided detection: CNN architectures, dataset characteristics and transfer learning." *IEEE transactions on medical imaging* 35.5 (2016): 1285-1298.
[3] Zhou, S. Kevin, Hayit Greenspan, and Dinggang Shen, eds. "Deep Learning for Medical Image Analysis." Academic Press, 2017.
[4] Szegedy, Christian, et al. "Going deeper with convolutions." Proceedings of the IEEE conference on computer vision and pattern recognition. 2015.
[5] Xu, Tao, et al. "Novel coarse-to-fine dual scale technique for tuberculosis cavity detection in chest radiographs." EURASIP Journal on Image and Video Processing 2013.1 (2013): 3.