Reducing Risk and Uncertainty of Deep Neural Networks on Diagnosing COVID-19 Infection

Krishanu Sarker, Sharbani Pandit, Anupam Sarker, Saeid Belkasim, Shihao Ji

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1. MOTIVATION

- CAD can play a crucial part in the battle against COVID-19.
- DNN based CAD systems are widely studied.
- Yet CAD systems are still unreliable.
- CAD systems are not being widely deployed in clinical practice.
- The predictive Uncertainty of DNNs received a lot of attention.
- Most of these works experimented on Benchmark Datasets.

More **rigorous and comprehensive** comparative study is required on uncertainty estimation of CAD systems in COVID-19 detection.

2. Goal of the Research

- **Comprehensively study the uncertainty of CAD systems on COVID diagnosis.**
- **Identify the best performing uncertainty estimation framework on COVID diagnosis.**
- **Validate the results from the best performing framework by Medical Professionals.**

3. Compared methods

- *Test Time Augmentation (TTAUG)*[1]
- *SelectiveNet*[2]
- *Density based Filtering Framework (DbFF)*[3]

4. Unique Properties of DbFF

- **Simple and Intuitive**: Distant samples in feature-space are different from each other.
- **Plug-and-Play**: Easy to incorporate with off-the-shelf DNN, requires no modification.
- Performs Comparatively with State-of-the-art Uncertainty Estimation methods.

5. Workflow of DbFF

Identify Core Data Distributions

↓

Calculate Centroid of all Distributions

↓

Calculate Distance between a sample, s and centroids (d^a_s, d^b_s)

↓

Abstain if, $|d^a_s - d^b_s| < \eta$

6. Experimental Results

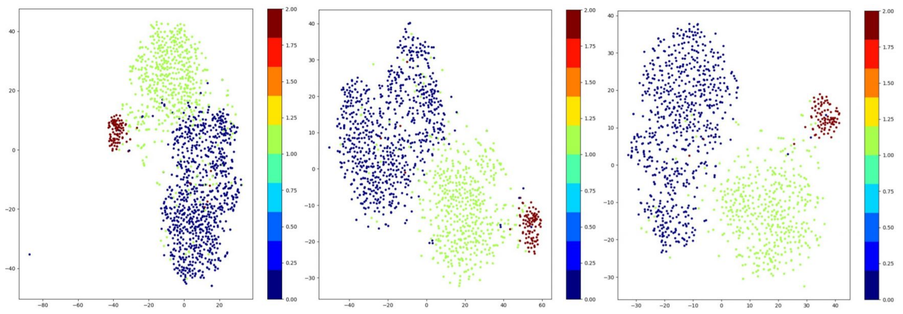
Comparative Accuracy results on COVIDx Dataset

Abstention Rate	Model		
	TTAUG	SelectiveNet	DbFF
5%	93.07%	93.58%	**94.13%**
10%	94.51%	94.55%	**95.29%**
15%	95.75%	95.18%	**96.13%**
20%	**96.75%**	96.04%	96.70%
25%	97.21%	96.75%	**97.38%**
30%	97.73%	97.14%	**98.10%**

Effects of DbFF framework on COVIDNet

Abstention Rate	Accuracy	Sensitivity			Positive Predictive Value		
		Normal	Pneumonia	COVID	Normal	Pneumonia	COVID
0%	94.82%	94.80%	94.90%	94.00%	96.30%	92.80%	94.00%
10%	97.16%	97.80%	96.60%	94.80%	97.30%	97.10%	95.70%
20%	98.81%	99.60%	98.30%	95.60%	98.60%	99.60%	96.60%
30%	99.18%	99.70%	99.00%	96.60%	99.00%	99.70%	97.70%

Visualization of Feature space distribution with varying abstention rate



How Good is DbFF?

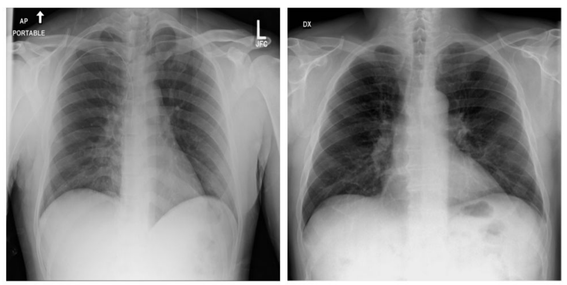
Samples Correctly identified and not abstained

(a) COVID(COVID) (b) Normal(Normal) (c) Pneumonia(Pneumonia)

Samples Wrongly identified but abstained

(d) Normal(Pneumonia) (e) Normal(Pneumonia) (f) Pneumonia(COVID)

Samples Wrongly identified yet not abstained



(g) Pneumonia(Normal) (h) COVID(Normal)

7. REFERENCES

1. Ayhan, M. S.; Kuehlewein, L.; Aliyeva, G.; Inhoffen, W.; Ziemssen, F.; and Berens, P. 2020. *Expert-validated estimation of diagnostic uncertainty for deep neural networks in diabetic retinopathy detection.* Medical Image Analysis 101724.
2. Geifman, Y.; and El-Yaniv, R. 2019. *Selectivenet: A deep neural network with an integrated reject option.* arXiv preprint arXiv:1901.09192.
3. Sarker, K.; Yang, X.; Li, Y.; Belkasim, S.; and Ji, S. 2020. A Unified Plug-and-Play Framework for Effective Data Denoising and Robust Abstention. arXiv preprint arXiv:2009.12027 .