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

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Refinement of Feature Vector

Lack of information or misinformation often cause confusion for DNNs. Hence, DNNs often make prediction on samples based on sub-optimal features extracted from noisy samples. To some extent, DNN classifiers (e.g. softmax or sigmoid) are robust to these feature noise due to the supervised feedback process. However, DbFF (Sarker et al. 2020) method heavily rely on the features learned by the pretrained DNN, while unlike other complex methods, it does not require retraining from scratch. Moreover, precise calculation of centroids is prerequisite to the success of the framework, as these centroids are utilized to determine the confusing samples. Hence, we explore ways to minimize the variance of the DNNs by filtering out the noisy features. To address this, we propose to utilize statistical analysis of the features to filter out noisy or constant features rather than using all of them. Specifically, we utilize chi-square test to obtain a scores on each features and based on an empirical threshold we filter-out the features with low statistical scores. χ^2 is defined as,

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where, O is the observed value and E is the expected value of the distribution. Here, if two features are independent, the observed count would be close to the expected count, which provides evidence of dependency of these two features.

Effects of Feature Selection on Uncertainty Estimation

We experimented with the proposed feature selection method on the COVIDx dataset. The results are presented on Table 1. In this experiment we empirically set 1024 features as optimum number of features and a threshold was set accordingly. As we can see, the chi-square test based selection method achieves better performance over vanilla DbFF framework. The effectiveness of the feature selection method can be observed with the t-SNE visualization in Figs. 1(a-b). We can observe that the distributions are much more well defined for the later figure (Fig. 1(b)). We argue that static or noisy features often create issues with the centroid calculation utilized in DbFF method. After filtering these unwanted features, class constrained centroids become more robust to noise, hence improving performance.

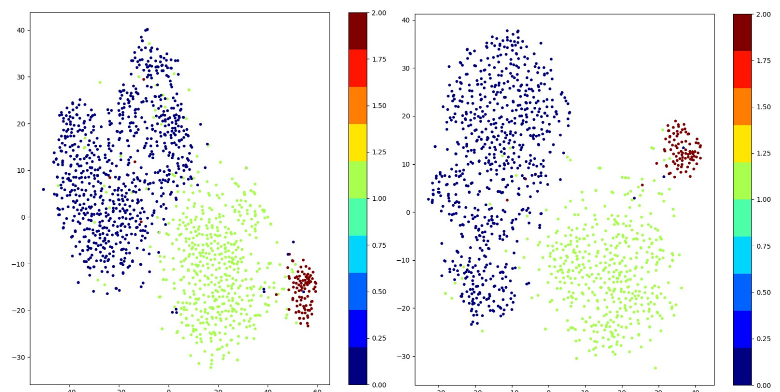
References

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 .

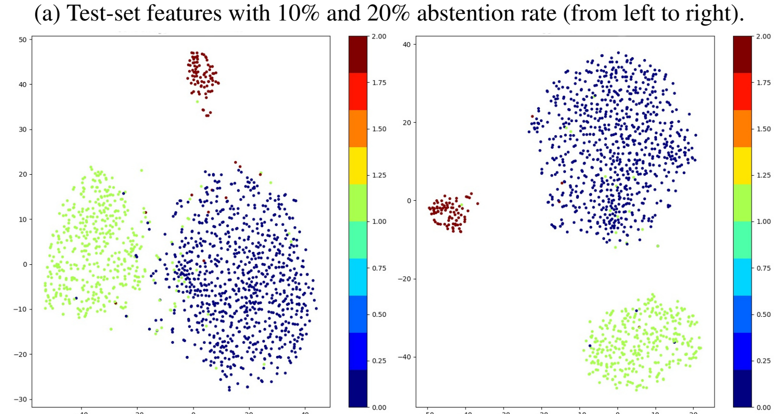
Wang, L.; and Wong, A. 2020. COVID-Net: A Tailored Deep Convolutional Neural Network Design for Detection of COVID-19 Cases from Chest X-Ray Images. *arXiv preprint arXiv:2003.09871* .

Abstention Rate	Positive Predictive Value W/O Feature Selection			Positive Predictive Value W Feature Selection		
	Normal	Pneumonia	COVID	Normal	Pneumonia	COVID
10%	97.30%	97.10%	95.70%	**97.40%**	**97.50%**	**96.20%**
20%	**98.60%**	**99.60%**	96.60%	**98.60%**	99.50%	**98.80%**

Table 1: Experiment demonstrating the effects of feature selection with DbFF (Sarker et al. 2020) method integrated with COVID-Net (Wang and Wong 2020) on COVIDx dataset.



(a) Test-set features with 10% and 20% abstention rate (from left to right).



(b) Test-set features with 10% and 20% abstention rate after feature selection (from left to right).

Figure 1: t-SNE visualization of COVIDx test-set in the feature space.