Interpretability of Automatic Infectious Disease Classification Analysis with Concept Discovery

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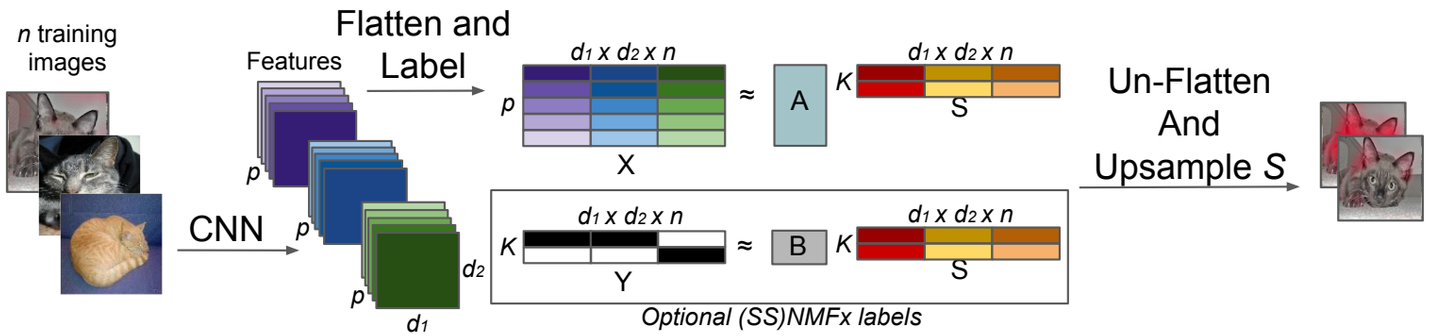
GOAL

Understand concepts learnt by a neural network classifying infectious disease (Tuberculosis (TB) and Monkeypox) image behavior

OVERVIEW

- We seek to explain behavior by using a post-hoc concept extraction (CE) technique
- the presented method (NMFX) is based on nonnegative matrix decomposition (NMF) from Collins [1] and is flexible to work in unsupervised, semi-supervised or weakly supervised fashion, and provided labels do not need to correspond to the labels that the underlying network was trained for



OPTIMIZATION DETAILS

Let $X \in \mathbb{R}^{n_1 \times n_2}$ denote the nonnegative data matrix of n_2 data points in $\mathbb{R}^{n_1}$. Lee and Seung [2] propose to decompose X into a topic matrix A and a weight matrix S using the following, Frobenius-norm optimization objective:

$$\min_{A,S} \|X - AS\|_F^2$$

Here, $A \in \mathbb{R}_{\geq 0}^{n_1 \times k}$ denotes the topic matrix with k topics and $S \in \mathbb{R}_{\geq 0}^{k \times n_2}$ denotes the representative weight matrix.

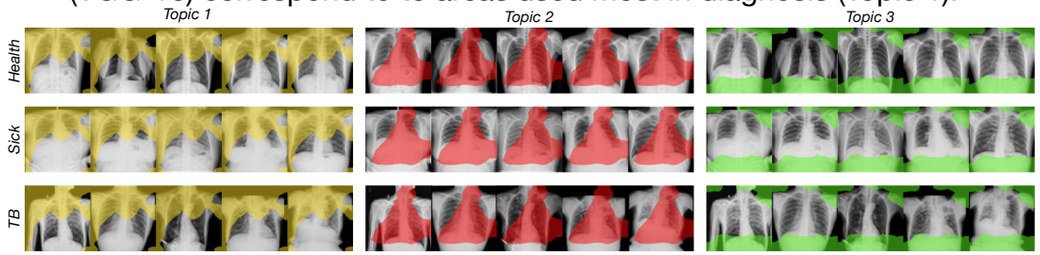
NMF with Image Label Supervision

When information about the data points' labels is available, we can encode it into $Y \in \mathbb{R}^{l \times n_2}$, a binary label matrix where columns correspond to data points in X and rows represent their class membership. The resulting objective becomes:

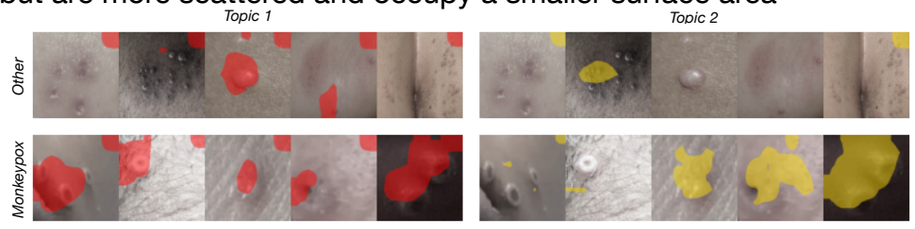
$$\min_{A,B,S} \|X - AS\|_F^2 + \lambda \|Y - BS\|_F^2$$

RESULTS

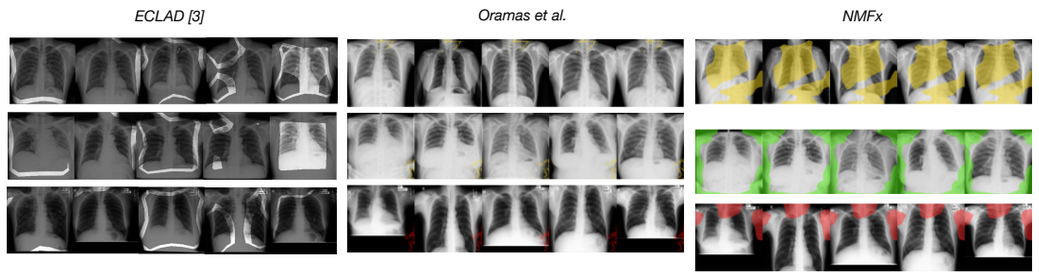
Visual explanations extracted using NMFx in TB classification (VGG-16) correspond to to areas used most in diagnosis (Topic 1).



Visual explanations extracted using NMFx in Monkeypox classification (EfficientNet-B3) are centered on the lesions and regions corresponding to monkeypox lesions, while in non-monkeypox examples, topics identify some visually similar lesions but are more scattered and occupy a smaller surface area



In contrast to baselines (ECLAD[3] and the method of Oramas[4]), the NMFx method identifies larger and more consistently positioned regions in the input X-ray images.



CONCLUSION

- CE techniques are a promising visual explanation technique for understanding infectious disease classification using neural networks
- CE using NMFx is a lightweight and versatile method for analyzing NN decisions

BIBLIOGRAPHY

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[4] Jose Antonio Oramas Mogrovejo, Kaili Wang, Tinne Tuytelaars.Visual explanation by interpretation: Improving visual feedback capabilities of deep neural networks. In ICLR, 2019