Semi-supervised mold differentiation using typical laboratory results as label data

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paper

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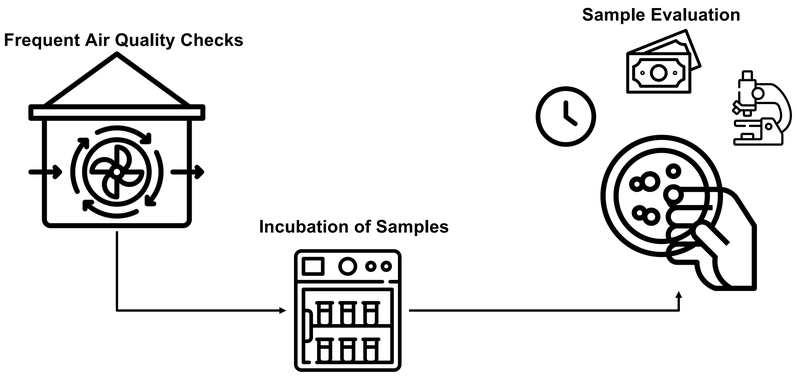
Motivation



Air Quality assessment is critical for the well-being of employees and their operational efficiency. This involves time-intensive, manual mold-differentiation. A Process suited for automation to reduce costs and improve efficiency.

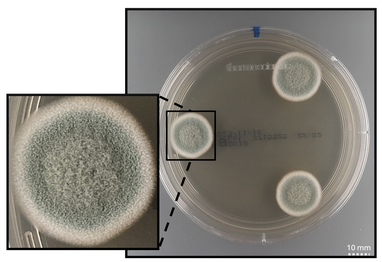
Dataset

Dataset Creation:

A **semi-supervised** approach was used to generate a dataset of **mold colonies** grown on Petri dishes. Mold species were inoculated, incubated and labeled accurately with minimal effort using a pretrained **YoloV7** model. Each dish contained distinct colonies, representing **natural variations** in morphology and size. Images were captured at high resolution, preserving detailed features for training classification models. This **clean culture dataset** provides a consistent, high-quality basis for mold differentiation based on macromorphological features. In addition, an **environmental** dataset of **real-world** mold samples with diverse and complex backgrounds was created to evaluate the effectiveness and generalizability of the method beyond controlled conditions.

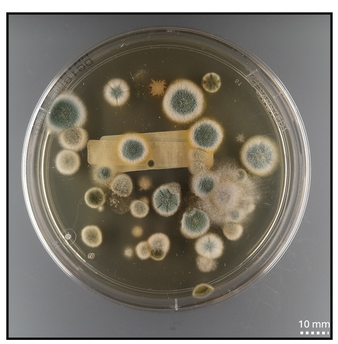
Clean Culture Dataset Properties:

Comprises **589** images of Petri dishes with **2,116** individual mold colonies across **five** primary species and ten additional species marked as "other" to add variation. Colonies vary in size, representing the natural morphology of mold species, being essential for model training.



Environmental Dataset Properties:

Comprises **640** images of Petri dishes with **12,472** individual mold colonies, representing complex environmental conditions. This dataset assesses the models' generalization to real-world scenarios, focusing on adaptability and accuracy.



Training on Clean Culture Dataset

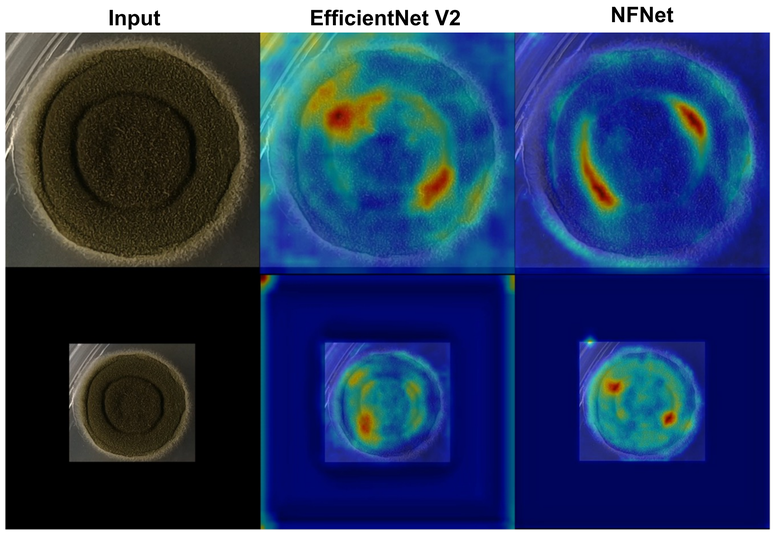
Hardware: NVIDIA GeForce RTX 3090
Models: EfficientNet V2 and Normalization-Free Net pretrained on ImageNet
Training methods: Training using padded colony images with image size 1000x1000 and training using non-padded colony images with a maximum image size of 1000x1000

Training on the clean culture dataset showed **high performance** for **both** models, with NfNet and EfficientNet V2 demonstrating good results.

EfficientNet V2 outperformed NfNet on padded images, achieving **98.6%** accuracy. NfNet shows superiority on non-padded images, with **98.6%** accuracy, vs **74.9%** for EfficientNet V2. NfNet seems to handle natural variations better, while EfficientNet relies on padding consistency. Therefore, NfNet may be more robust in real-world applications.

Feature Inspection using Grad-CAM

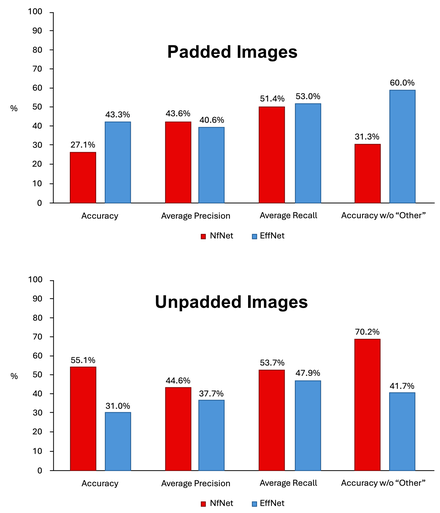
Grad-CAM visualizations show that **NfNet** focuses more **precisely** on key features of the mold colony, while **EfficientNet V2** shows broader, **less focused** attention and also appears to focus on the padding itself. This suggests that **NfNet** may be **better** at identifying specific **morphological details** that are important for accurate classification.



Evaluation on Environmental Dataset

Evaluation on the environmental dataset shows that **NfNet** generally **outperforms** EfficientNet V2, particularly on unpadded images, where it achieves **55.1%** accuracy compared to **31.0%** for EfficientNet V2. While EfficientNet V2 has an edge on padded images with **43.3%** accuracy, NfNet shows a significant advantage in handling natural, unprocessed images, indicating better adaptability to real-world data.

Importantly, when the **"other"** class is **excluded** - reflecting cases where the models are confident in their classification - NfNet maintains a high accuracy of **70.2%** on unpadded images, surpassing EfficientNet V2's **41.7%**. This suggests that NfNet not only generalizes well, but also provides **more reliable predictions**, making it a stronger candidate for use in practical settings.



Take-home Messages

This research supports the use of semi-supervised learning to streamline mold differentiation, enabling automated, cost-effective air quality assessments. NfNet's robust handling of variable colony characteristics demonstrates its potential for accurate classification in uncontrolled environments.

Future research will focus on expanding the model's capabilities to cover a broader range of mold species and real-world environmental scenarios.

Acknowledgements

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