Semi-Automated 2D Material Flakes Detection

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INTRODUCTION

Motivation: Manual screening of exfoliated 2D materials is a critical bottleneck in materials science, figure 1. The process is slow and laborintensive, and it suffers from low reproducibility due to the subjective interpretation of subtle optical contrast [1].

We present a user in AI framework. First, the system captures expert knowledge via an interactive interface to create a robust optical model. Then, it uses unsupervised machine learning to perform segmentation on new samples, applying the expert's model to accurately identify monolayer candidates. This semi-automated approach provides a practical tool for current laboratory work and paves the way for fully autonomous systems in the future.[2]

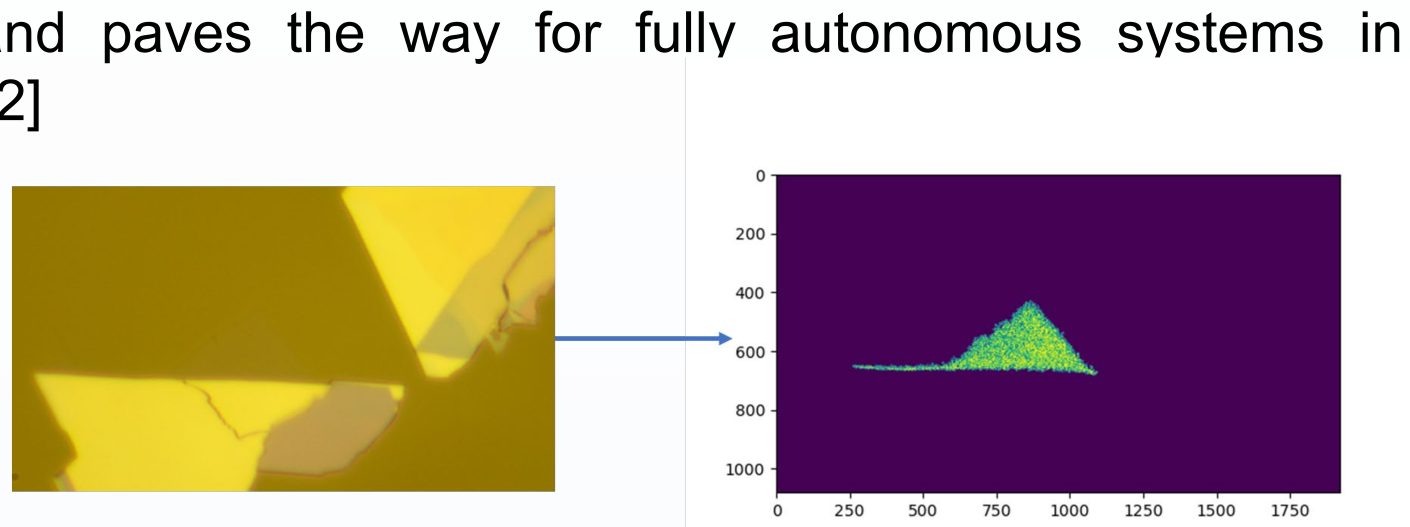

Fig 1. Goal image

APPORCHES

Our methodology evolved through a two-stage development process. First, we created a Semi-Automated 2D Material Flakes Detection based on direct user input, figure 2. After identifying the system's limitations, we advanced to a hybrid AI framework that integrates unsupervised machine learning for more robust and intelligent segmentation.

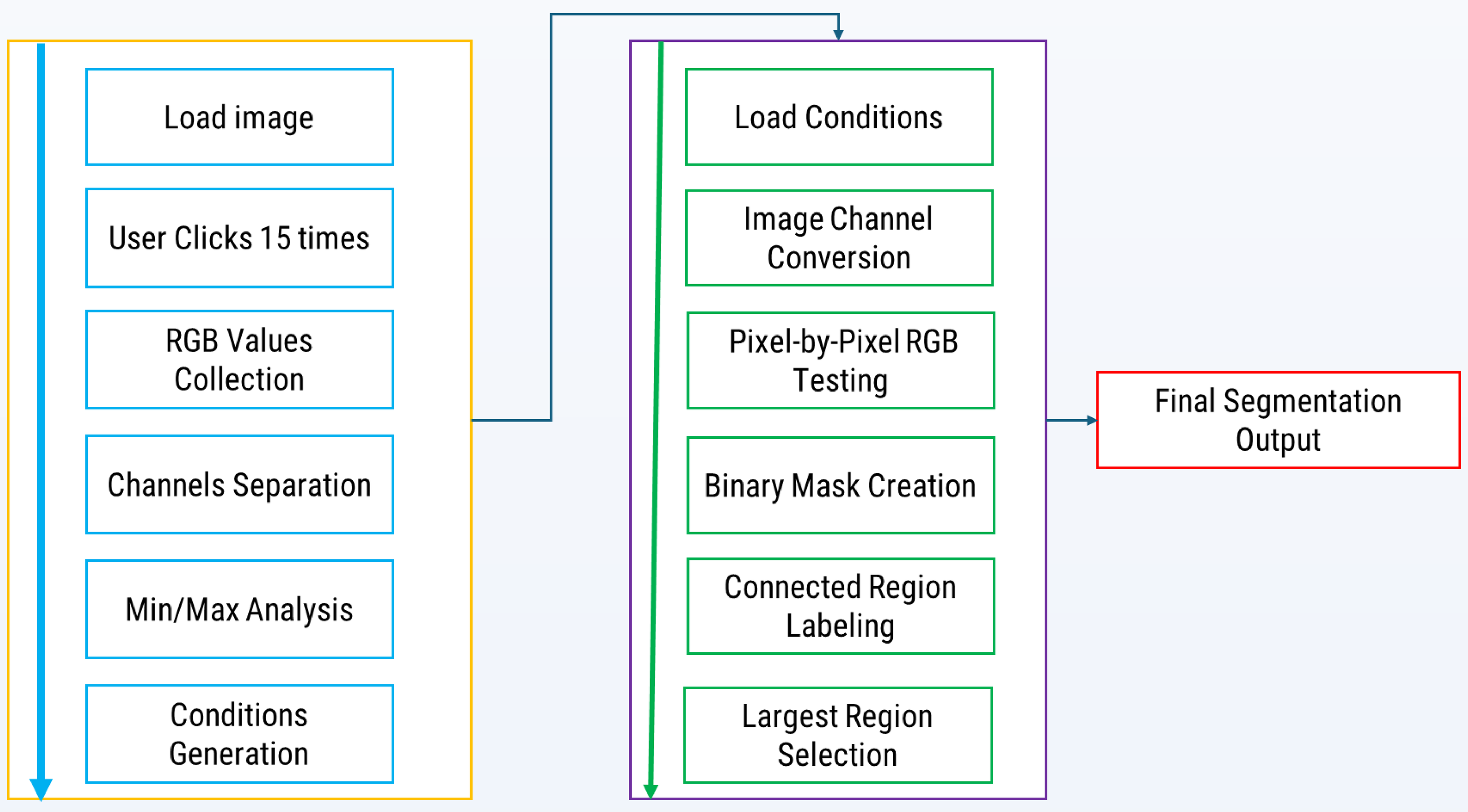

Fig 2. Image Process Workflow

A digital color image is composed of three primary color channels: Red, Green, and Blue (RGB). The first step is to decompose the image into these channels to analyze the intensity value of each pixel, figure 3.

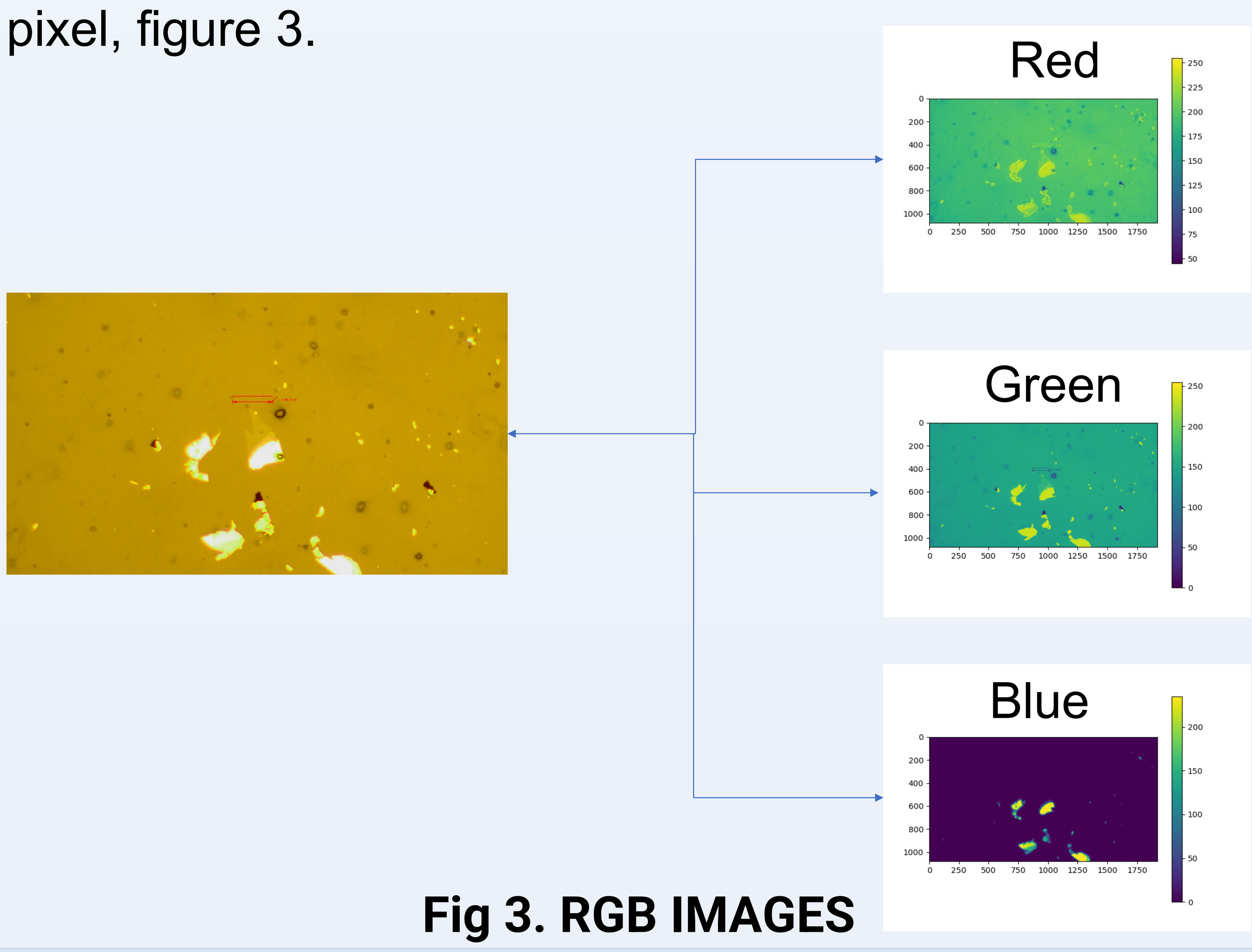

Fig 3. RGB IMAGES

RESULTS

Applying user-defined RGB thresholds creates an initial binary mask. However, this mask is often noisy because color alone is not a unique identifier, figure 4.

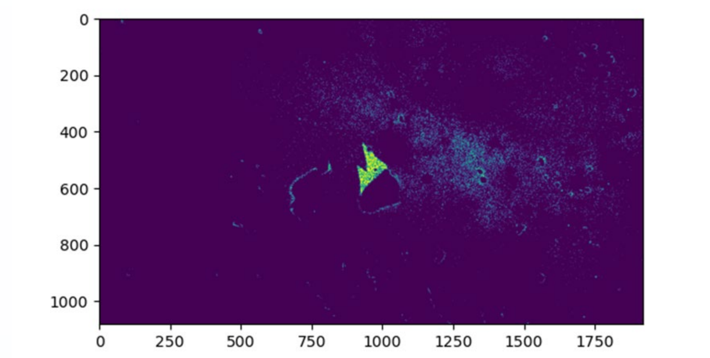

Fig 4. Initial image, binary mask with noise

We use connected component analysis to isolate our target from the noise. This algorithm scans the binary mask and groups all adjacent "on" pixels into distinct, continuous regions, applying a unique label to each region. Assuming that the desired monolayer is the largest flake, we analyze these labeled regions and select the region with the most pixels as our final result, figure 5.

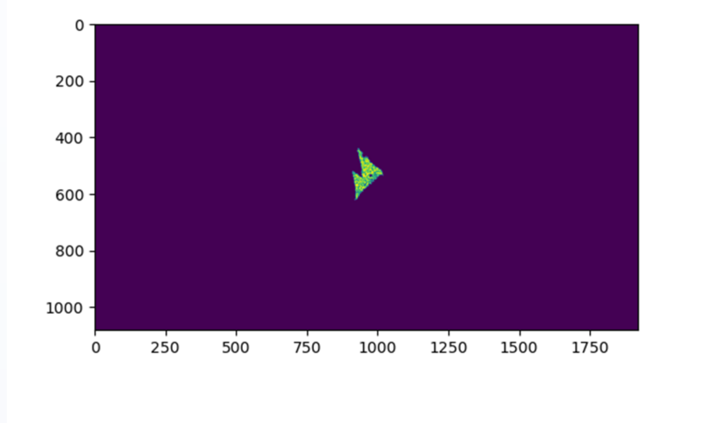

Fig 5. Final selected area, also monolayer result

CONCLUSIONS

Successfully Demonstrated:

- Working prototype
- Reproducible results
- Speed
- Noise filtering

Current Stage Limitation:

- Human input still required

Future working :

- High-contrast samples
- Consistent imaging setup
- Training applications
- Documentation
- Machine Learning(K means), figure 6

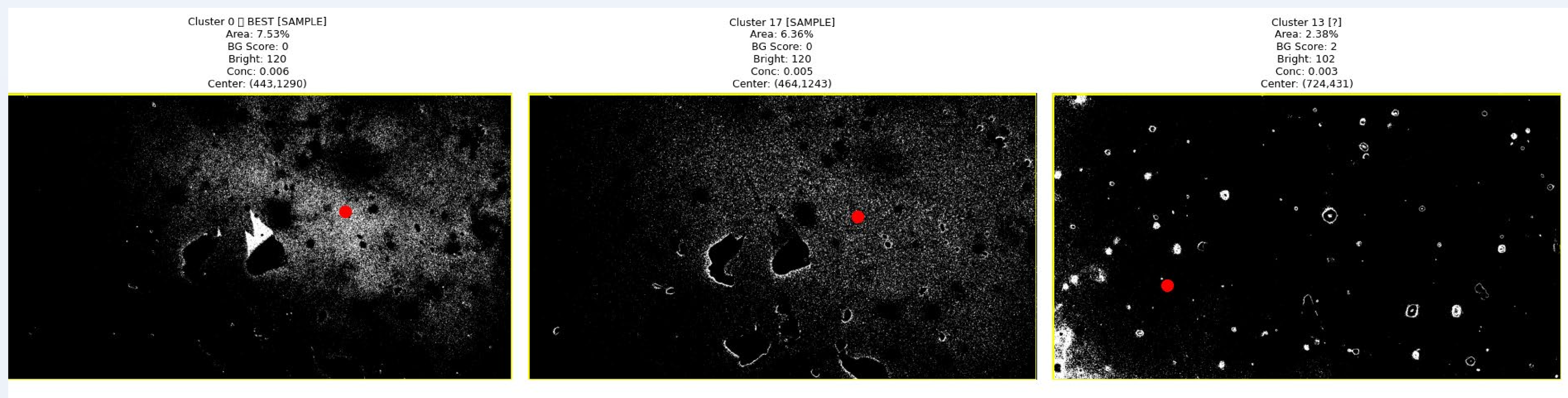

Fig.6 Using K means to find monolayer

REFERENCES

[1] Anzai, Y., et al. (2019). Appl. Phys. Express, 12(4), 045505.

[2] Uslu, J-L., et al. (2024). MaskTerial: A Foundation Model for Automated 2D Material Flake Detection. arXiv:2412.09333.