Deep Learning of Lepidolite Images for Real Time Lithium Ore Detection on a Planetary Rover

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Lithium is essential for rechargeable batteries in electric vehicles, energy storage, and electronics, driving the clean energy revolution. With global demand increasing and Earth's reserves limited, exploring outer space sources of lithium is a promising solution. This project focuses on developing an AI-based system for lithium ore detection with lepidolite, a lithium-rich ore, as the primary target. A custom dataset of 3,520 images of lepidolite and non-lepidolite rocks was created. After comparing various neural network algorithms, YOLO (You Only Look Once) was selected for its superior efficiency in real-time object detection. The YOLO model was trained on the custom dataset, and achieved a precision of 99.94% and an mAP@0.5 of 96.62%. The model was deployed onto a predeveloped planetary rover equipped with an onboard camera and processing system. The rover was tested in real-world scenarios under varying conditions of lighting, distance, surface type, and movement speed, achieving an average detection accuracy of 83% based on 160 tests. These results demonstrate the robustness and reliability of the developed system for efficient lithium ore exploration. Future work will focus on enhancing the dataset with more diverse environmental scenarios, expanding capability to other lithium rocks, refining training hyperparameters for faster real-time processing, and integrating advanced sensors, such as multispectral cameras, to improve performance in challenging environments.

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