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Fusion of VNIR-SWIR and LWIR for Mineral Mapping in a Machine Learning Framework

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Mineral mapping is an important task in exploration campaigns where it is required to obtain a preliminary idea about the composition of ore deposits. Hyperspectral imaging is becoming a trending technology within the mining community to map minerals during exploration campaigns. This is because minerals have unique spectral responses in specific parts of the electromagnetic spectrum. These responses depend on the bonds between the atoms and electron orbitals of the minerals. In other words, based on the molecular vibrations and composition of the minerals the light reflects differently from the minerals and therefore, the spectral responses vary. In general, alteration minerals (e.g., phyllosilicates) can be mapped using the visible to near-infrared (VNIR) and short-wave infrared (SWIR) parts of the electromagnetic spectrum, whereas rock-forming minerals, (e.g., feldspars and quartz) are better distinguishable using the long-wave infrared (LWIR). Therefore, fusing the VNIR-SWIR and LWIR parts of the electromagnetic spectrum provides a complete range of data for the mineral mapping task. The benefit of using hyperspectral data from both regions of the electromagnetic spectrum to map minerals is clear and it has been previously implemented in an independent manner. However, in this work, we focus on different machine learning strategies to fuse VNIR-SWIR and LWIR hyperspectral data for an accurate mineral mapping. We test two fusion scenarios: feature-level fusion and decision-level fusion. For the feature-level fusion, we adopt a state-of-the-art multiple feature learning technique to adequately exploit the information containing in both data types. Hence, we take advantage of the complementary information using only one classifier. For the decision-level fusion, we integrate the independent classification results obtained using the VNIR-SWIR and LWIR data. In this way, higher robustness is expected from the combination of the classification results. The experiments are carried out on real hyperspectral datasets of drill core samples. With this contribution, we introduce a novel approach for the mining community to map minerals using a full range of hyperspectral data where not only alteration minerals but rock-forming minerals can be jointly mapped. Moreover, our proposed approach can accurately map minerals with weak spectral responses in both wavelength ranges. Based on preliminary attempts, the fusion of the VNIR-SWIR and LWIR at both decision and feature levels performed better than considering both datasets independently.