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Identification of Lithology Using Sentinel-2A Through an Ensemble of Machine Learning Algorithms

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ABSTRACT

Remotely sensed data has become an effective, operative, and applicable tool that provides critical support for geological surveys and studies by reducing the costs and increasing the precision. Advances in remote-sensing data analysis methods, like machine learning algorithms, allow for easy and impartial geological mapping. This study aims to carry out a rigorous comparison of the performance of three supervised classification methods, random forest, k-nearest neighbor, and maximum likelihood, using remote sensing data and additional information in Souk El Had N'Befourna region. The enhancement of remote sensing geological classification by using geomorphometric features, principal component analysis, gray level co-occurrence matrix (GLCM), and multispectral data of the Sentinel-2A imagery was highlighted. The random forest algorithm showed reliable results and discriminated limestone, dolomite, conglomerate, sandstone and rhyolite, silt and alluvium, ignimbrite, granodiorite, lutite, granite, and quartzite. The best overall accuracy (~91%) was achieved by random forest algorithm.

KEYWORDS

Geomorphometric Features, GLCM, Principal Component Analysis, Remote Sensing, Supervised Classification

INTRODUCTION

Geological maps provide a lot of important information that can be used in various fields such as land use planning, as no construction can be carried out without a prior study of the soil. It also allows the prevention of risks and natural disasters, studies on oil and mineral resources, as well as research and exploitation of water, a vital source for the population, fauna and flora. Geological mapping and mineral exploration focus primarily on field work and more lately on research of remote sensing. The rapid development of remote sensing technologies and new sensor capabilities have provided excellent tools for geologists to undertake geological mapping studies. Remotely sensed images allow geologists to make important distinctions between morphological features and rock

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types, and to aid in prospecting for ores and hydrocarbons Garain et al., (2019). It can provide new geological information that can be used both for producing new geological maps or for updating existing legacy geological maps, in remote areas where collecting field observations is difficult Si Mhamdi et al. (2017). Furthermore, predictive geological map can be generated at a lower cost than traditional field mapping programs in difficult areas within a short time period. Remotely sensed data can yield detailed information on vast areas, particularly in semiarid and arid zones Rezaei et al., (2020). However, in rough terrains lit small solar elevation angles, however, topographic effects hamper the remote sensing classification of lithological units in mountainous regions. Furthermore, dense vegetation coverage like forests complicates lithological classifications that rely on reflectance sensors information Grebby et al., (2010).

The recent growth of Earth Observation technology has resulted to the launch of sophisticated instruments such as that of the Sentinel-2 series from the European Space Agency (ESA). The Sentinel2 Multispectral Imager (MSI) acquires thirteen infrared bands from visible and near infrared (VNIR) to shortwave infrared (SWIR) with a resolution between 10 and 60 meters and a swath of 290 km. The Sentinel-2 mission consists of two satellites: The Sentinel-2A launched on June 23, 2015, and Sentinel-2B launched on March 7, 2017 with every five-day global coverage of the Earth's land surface. The satellite missions focused on environment and security, i.e. monitoring of the marine environment, atmosphere, land and climate change, as well as support for emergency response and security. Furthermore, in recent years, the multispectral Sentinel-2 image was confirmed as having mineral cartographic potential in geological studies, particularly for the absorption of iron, because of the similar or even better spectral framework of the Landsat and SPOT series in the visible and near-infrared regions van der Werff et van der Meer, (2015).

Classification is a well-known image processing procedure for creating thematic maps from remotely sensed data. However, for effective lithological classification, spectral remote sensing data must be supplemented with other information (Qiu & Ming, 2018; Zhou et al., 2019) or other remote sensing data sets that provide geomorphological and subsurface geological information, such as a digital elevation model (Barnett et al., 2004; Ge et al., 2018). This prompted us to investigate the effectiveness of integrating spectral, spatial and textural features using three machine learning algorithms in lithological mapping. In addition to spectral characteristics (reflectance), the texture characteristics of rock types, which may be unique due to differences in erosion and drainage caused by physical weathering, can provide a useful information carrier for distinguishing lithologies. In this study, lithological classification was performed in the Souk El Had N'Befourna region belonging to Ifni inlier (western Anti-Atlas, Morocco). The current research objectives were (1) To compare and assess the efficiency of three machine learning algorithms namely Random Forest, Maximum Likelihood and k-Nearest Neighbor and (2) To evaluated the use of Digital Elevation Model and texture and morphometric features for improved lithological classifications. In this research, we extracted reflectance, Principal Component Analysis, Angular Second Moment, Correlation, Contrast, Entropy, and Mean textures feature were extracted from Sentinel-2A imagery and calculated geomorphometric parameters from Digital Elevation Model (DEM) data of ALOS/PALSAR. The precision of the classified lithological maps was tested through fieldwork and legacy geological map.

GEOGRAPHIC AND GEOLOGICAL SETTINGS OF THE STUDY AREA

Geographical Location

The Ifni Inlier (Figure 1b) is situated approximately 150 km south of the city of Agadir, in the extreme west of the Anti-Atlas, between the parallels 29° 5 'and 29° 45' North and the meridians 9° 50 'and 10° 30' West. It spreads over an area of 1620 square kilometers and borders the Tiznit plain to the North, the Lakhssas plateau to the East, the Bou Izakarn plain to the South, and the Atlantic Ocean to the West. The Souk El Had N'Befourna study area is situated in the northern part of Ifni inlier

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