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Editorial: Advanced methods in signal processing, image processing and pattern recognition in geosciences

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Editorial on the Research Topic
Advanced methods in signal processing, image processing and pattern recognition in geosciences

Lately, applications of signal processing, image processing, and pattern recognition have been widely introduced in geosciences, such as in the context of natural resources exploration, either petroleum or mineral, and engineering geology (Gaci and Hachay, 2014; Gaci and Hachay, 2017; Gaci et al., 2021). New methods and algorithms have been implemented to discover additional features in different research areas.

In petroleum exploration, time-frequency decomposition techniques have been widely applied. The variational mode decomposition was used to detect gas affected by a coal layer in a tight sandstone reservoir located in the Ordos Basin, China. In addition, the multivariate variational mode decomposition was used to accurately estimate the absorption gradient coefficient from data acquired in the Puguang gas field, China.

In mineral investigation, airborne hyperspectral remote sensing combined with a random forest algorithm was conducted in Kalatag, Northwest China, for identifying and mapping alteration minerals.

As regards seismology, a new model based on a light earthquake deep neural network was introduced for earthquake detection and phase picking using on the Stanford Earthquake Dataset.

Finally, the last study was devoted to mining engineering. It addressed the investigation of *in situ* stress ratio and its evolution simulation using large datasets from China, to judge the stability of crustal rock mass and to predict the occurrence of earthquakes.

In seismic exploration, the coal seams are associated with strong low-frequency reflections that are identical to the seismic response of gas layers. This similarity hides the reflection anomalies exhibited by the neighboring gas reservoir and makes it extremely difficult to obtain an accurate prediction of the gas reservoir.

To eliminate problems related to gas detection in weak seismic responses of the target reflection affected or hidden by the coal seams, Wang and Xue suggested an adaptive decomposition processing approach based on the variational mode decomposition (VMD). Applications of the VMD technique on real data from the gas field located in the Ordos Basin, China, successfully detected the weak response of the gas reservoirs hidden by the adjacent strong reflection of coal seams for tight sandstone reservoirs and allowed for a superior hydrocarbon-related interpretation.

Energy attenuation properties are broadly used as a meaningful attribute for detecting the presence of fluids in a petroleum reservoir. They are estimated using the absorption gradient or absorption coefficient by studying the high-frequency energy absorption. To accurately evaluate these properties for a better fluid indication, Liu et al. initiated an approach based on a multivariable or multichannel signal processing tool, namely the multivariate variational mode decomposition (MVMD). It allowed for the extraction of *a priori* multivariable modulation oscillations from the seismic data, which can infer some seismic attenuation features in certain frequency bands with lateral continuity. Applications on real field datasets from the Puguang gas field, China, demonstrated that the suggested method accurately quantified the absorption gradient and lead to more reliable hydrocarbon-prone interpretations.

Hyperspectral imaging is of high interest in the remote sensing field. It provides valuable features related to high spectral resolution, clear wavelength continuity, and huge quantities of spectral information, which are broadly used in geological investigations.

Airborne hyperspectral remote sensing has gained more attention in mineral mapping and lithological discrimination owing to its advantages: rapidness, non-destructivity, and high-quality reflectance spectra. In their work, Wang et al. conducted a study using sophisticated (NEO HySpex) cameras to acquire high spectral and spatial resolutions airborne hyperspectral images of Yudai porphyry mineralization in the Kalatag District, Northwest China. After processing data, the distribution of alteration minerals was carried out using the random forest (RF) algorithm. The results highlighted that airborne hyperspectral data can be successfully exploited for the needs of basic geology investigation and mineral exploration, owing to its capacity for obtaining high spatial resolution images of large areas and inaccessible terrains.

Introducing an efficient seismic signal detection and phase picking is of high interest for an on-site early earthquake warning system. For this purpose, deep learning approaches have been proposed to improve the accuracy of this process. However, these models suffer from some disadvantages: high-throughput computing resources are requested, and the deep learning architecture should be adjusted for installing the model in small devices with low-cost sensors for earthquake detection. With this in mind, Lim et al. proposed a lightweight seismic signal detection model called LEQNet that works in even ultra-small devices, where the size of the deep learning model is reduced using different lightweight deep learning techniques, such as the deeper bottleneck, recursive structure, and depth wise separable convolution. The potential of the suggested lightweight deep learning system was carried out using the Stanford Earthquake Dataset and compared with the EQTransformer. When compared to the EQTransformer, the results showed that the LEQNet considerably reduced the number of parameters, with no significant performance deterioration.

In mining engineering, the Mohr–Coulomb criterion is efficiently used to assess the risks and damage to rock mass. It stipulates that the state of rock mass changes from elastic to plastic when the ratio of principal stress, which refers to the ratio of maximum principal stress to minimum principal stress, of crustal rock mass goes beyond the critical value. In this regard, Chen et al. analyzed 574 groups of measured data. The results illustrated that the area with a high ratio of principal stress generally indicates a recent seismic activity; therefore the *in situ* stress ratio can be used as a meaningful index for assessing the stability of crustal rock mass, discriminating shallow and deep parts, and forecasting the occurrence of earthquakes.

Indeed, when the value of this index was close to 1, it corresponded to relative stability of the area stratum, whereas a value near the ratio limit indicated an unstable critical state of crustal rock mass in this area.

Author contributions

SG wrote the first draft. All authors revised the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Gaci, S., and Hachay, O. (2014). *Advances in data, methods, models and their applications in oil/gas exploration"*. USA: science publishing group.

Gaci, S., Hachay, O., and Nicolis, O. (2021). *Methods and applications in petroleum and mineral exploration and engineering geology"*. USA: Elsevier Science.

Gaci, S., and Hachay, O. (2017). *Oil and gas exploration: Methods and application*. USA: John Wiley & Sons.