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Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"
Piazzale Tecchio, 80
80125 Naples
web: www.tema.unina.it
e-mail: redazione.tema@unina.it

The cover image shows redeveloped building in the Garibaldi neighbourhood in the city of Milano (Picture by Fastweb, retrieved from: https://www.facebook.com/Fastweb/photos/10158794132149472).

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Investigation of extreme reflections of metal features and salty soils using object oriented Sentinel-2 L1C satellite image processing and SVM classification method

Bahram Imani[a]*, Jafar Jafarzadeh[b]

[a] Geography and Rural Planning, Faculty of Social Sciences, University of Mohaghegh Ardabili, Ardebil, Iran
e-mail: bahram_imani60@yahoo.com
ORCID: http://orcid.org/0000-0002-6158-5925
* Corresponding author

[b] Remote Sensing and Geographic Information Systems, Faculty of Social Sciences, University of Mohaghegh Ardabili, Ardebil, Iran.
e-mail: jjafar1364@gmail.com
ORCID: https://orcid.org/0000-0002-9131-3605

Abstract

The Sentinel-2 provides available multispectral bands at relatively high spatial resolution. In this study, using Sentinel-2 images, the reflectance of metal roofs has been investigated and the differences between these reflections with other high reflections such as saline and dry soils have been evaluated. Bands 2(Blue), 3(Green), 4(Red) and band 8(VNIR), which have a resolution of ten meters, are the most used in extracting different types of reflection. The result of the research shows that using the reflection of materials, it is easy to identify and harvest samples for the purpose of classifying the controlled sample by object-oriented processing. The results show that there is a significant difference between the reflection of the salty soil and the metal roof in the near infrared range, although in the image with the natural color combination, both types of material show same reflection. This paper presents a new approach for extracting training samples from metal roofs compared to saline soils. The classification of SVM (Support Vector Machine) as the best method of classification with an accuracy of 96.9% and Kappa coefficient of 0.9 for categorization in this study was selected among other classification methods. This study compared two types of reflections from metal and saline soils.

Keywords

Sentinel-2 Images; Object oriented processing; Segmentation; Reflection; SVM classifier.

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1. Introduction

Nowadays, remote sensing users could be able to derive different land use/cover maps from satellite images by using specific interpretation techniques. In recent years, a land use map has been created using conventional satellite images such as Landsat and Hyperon. Satellite imagery that has been used in most of the past research, such as Landsat, has a long return period and low spatial accuracy. The satellite images used must have high resolution, spatial and temporal resolution so that the most frequent short-term effects can be detected. Satellite Sentinel 2 is considered as such. This satellite is the newest multi-lens imaging satellite. Sentinel 2 is in four bands, including the visible spectrum, 11 meters in pixels and in six bands of 21 meters in pixels, which is less than the size of the 31-meter pixel landscape. In addition, the return period for Sentinel 2A and Sentinel 2B is in total 5 days, less than the 11-day Landsat period. In total, the images of this satellite have spatial, spatial, temporal, and radiometric resolution higher than those of other similar satellites. Sentinel (RUS) provides a set of pre-installed open source tools on virtual instruments for accessing and processing data from the Copernicus Sentinel satellite orbit (ESA Sentinel-2 Team 2007). Most satellites used for Earth observation, such as Landsat, Spot, IKONOS, Quickbird, Formosat, GeoEye and Orbview, use panchromatic bands to achieve higher spatial resolution than multi-spectral mode (Gašparović & Jogun, 2018). The mission is aimed at meeting the various needs of the user and improving the practical applications of the Copernicus mission (ESA Sentinel-2 Team 2016), which include: Land use observation applications include: LULC status and land use change; environmental and physical parameters assessment; forest change review; urban surveying; spatial planning; environmental and human monitoring; natural resource monitoring; carbon stocks / Estimation of soil carbon content; Global monitoring of agricultural products; Monitoring of coastal areas. Natural disaster management includes: flash floods and forest fires, landslides, eruptions of volcano, droughts. Food security, warning systems; Water resource management; soil protection; Ground Mapping for Humanitarian Assistance and Advancement. Despite the relatively short period of satellite monitoring of Sentinel-2 land-based land surveys, many researchers have already experienced high levels of Sentinel-2 data for classifying vegetation and types of trees (Immitzer et al. 2016), The monitoring of natural and human vegetation (Bontemps et al., 2015; Greco et al., 2018; Song et al., 2017(; map of glaciers (Paul et al., 2016) and waterbodies (Du et al., 2016; Toming et al., 2016; Yesou et al., 2016; assessment and monitoring of water resources (Dörnhöfer et al., 2016); classification of fires (Fernández-Manso et al., 2016; Huang et al., 2016)); Residential maps (Lefebvre et al., 2016; Pesaresi et al., 2016). In general, these data have been proven in various geological studies (van der Werff and van der Meer, 2016). The basic pixel processing of images, single pixel data, and benchmarks are based on. This processing method is the basis of processing in object-oriented processing using similar pixel values and information, to which that object or phenomenon is said to be (Eisank & Drăguţ, 2016). The Sentinel-2A satellite was launched from the launch station on June 23, 2015, and the Sentinel-2B satellite was launched on March 07, 2017 (Arianespace 2017; Copernicus 2015). The Sentinel-2 satellite has a multi-spectral optical instrument sampling in 13 spectral ranges. The bands of this satellite capture the spatial resolution of 10, and 20 meters. Images with a spatial resolution of ten meters in four bands, a resolution of 20 meters in six bands, and a resolution of 60 meters in three bands (Richter et al. 2011). High spatial resolution satellite imagery is widely available for free (agriculture, urban and rural planning, natural resource management, etc.) on a local and national scale (Korhonen et al, 2017). Object-oriented processing of satellite images is one way to study the extent of change on earth (Bahram et al; 2020) This is a prerequisite for creating environmental and weather data archives to obtain continuous products and coordinated series (Berger et al., 2012; Simoniello et al., 2015; Rosa et al. 2018). During the two-year effort, much work has been done by the ESA team and the Sentinel-2 mission groups to enhance the performance of Sentinel-2 data and products. Many refinements have been made to obtain high signal-to-noise ratios in L1C bands. In particular, in the case of SWIR B10, the scattered pixels were modified as "no data" due to the

noise in the data harvesting tool. Sentinel-2 cloud masks are currently adjusted to minimize under detections, which leads, on the other hand, to over detections (Clerc et al., 2018; Rosa et al. 2018).
Blaschke and Strobl (2001) discuss the error in pixels. This debate was nothing new (Cracknell, 1998; see also Blaschke and Strobl (2001), Burnett and Blaschke (2003) and Blaschke et al. (2004) for a more detailed discussion). They saw something like addiction to applications higher than pixels. The common feature of all these applications is that they are made by image segmentation (see also Burnett and Blaschke (2003), Hay et al. (2003), Benz et al. (2004), Liu et al. (2006), Blaschke et al. (2004), Hay et al. (2005), Blaschke and Lang (2006), Lang and Blaschke (2006), Lang (2008), Hay and Castilla (2008) and Blaschke et al. 2008). Image segmentation is nothing new, but it has its roots in industrial image processing that was not used in Geospatial applications in the 1980s and 1990s (Blaschke et al., 2004). OBIA-based image processing techniques focusing on identifying and classifying urban features are numerous, some of which are outlined here. One of the most prominent of these studies is the research of Thomas et al. (2003) for estimating storm-water runoff rates, employing three different methods to obtain land cover / land use information using high spatial resolution images for Scottsdale, Arizona. In this study, they showed that increasing the amount of spatial information in images with a resolution of less than one meter or less increases the image classification resources using supervised and unsupervised spectral classification algorithms. Topaloglu et al (2016) in a study titled Sentinel-2 and Landsat 8 for the accuracy of land cover classification / for map use, covered the accuracy of different classification methods for user land extraction and the results of their work they studied. Their research results show that the Maximum Likelihood Classification method and the SVM classification method perform better than other classification methods. Ting and Young (2015) surveyed urban land use changes and urban development using satellite imagery and GIS. They concluded that the combination of measurement methods and GIS could well reflect changes in urban land use. Figure1, illustrate Sentinel-2 bands accordingly to Richter et al. 2011.

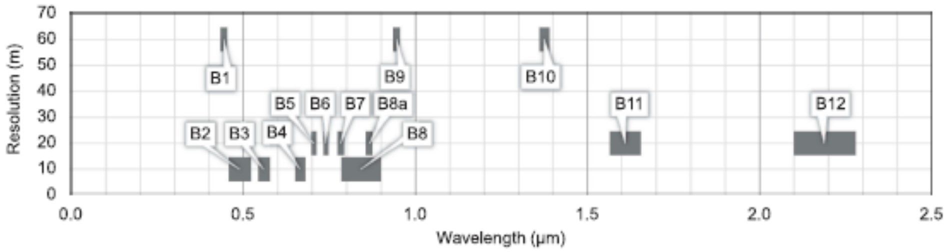

Fig. 1 Sentinel-2 bands accordingly to Richter et al. 2011

In this study, we have tried to investigate the difference between the reflection of metal roofs of buildings and the reflection of saline-containing soils using Sentinel satellite image processing. This research is unique in its kind. It has no similarity and is considered an innovation. In this study, by examining the spectral reflectance of metal roofs and saline soils, we were able to obtain the difference between these two elements. This research can be of great help to researchers in studies related to urban issues as well as issues related to tillage. This method compares different image representations using RGB and HSI display.
One of the questions raised in this research is whether it is possible to investigate the spectral difference of mixed levels by using object-oriented processing of satellite images with high spatial resolution and using intelligent classification methods such as SVM (Support Vector Machine)?
Some characteristics of Satellite images such as: digitally format, production up-to dated data, wide viewing angle (swath width), multispectral as well as multi temporal and revisiting time of data acquisition with high speed on data transformation make those be considered as valuable information on the natural resources management. One of the important applications of remote sensing images is to compare the reflection differences between different uses or to study the differences between the reflections of the electromagnetic spectrum from different levels, which can be used to identify different materials on the ground without direct

physical contact or visiting the desired location. One of the important goals of this research is to use the processing of remote sensing images with high spatial resolution, such as Sentinel 2 images, to find the difference between the spectral reflectance of saline soil surfaces and the surfaces related to metal roofs. Reflection from saline soil surfaces in areas where metal-roofed buildings are constructed is spectrally mixed, making it difficult to separate the two. Therefore, this research tries to identify and eliminate this difference to some extent by processing the images obtained from the Sentinel 2 satellite, which has a high spectral resolution. .

2. Pre-processing of satellite images

Figure 2 shows the process of doing the research as a flowchart. First, the Satellite-2 satellite image was downloaded on 08/29/2018 with Tile T39STC number from the study area with a cloud cover of less than 10 percent and without geometric errors downloaded from the ESA website. Sentinel-2 satellite images are pre-processed using the Level-2A algorithm in the Sen2Cor toolbox (version 2.2.3) with the Sentinel application framework (SNAP, version 6.1). Level 2A image processing has two important tasks: scene classification (SC) pixel classification map (Main-Knorn et al. 2015; Pflug et al. 2016) and atmospheric distortion correction (AC) (Mayer and Kylling 2005). By specifying the user-defined pins on the image, the general categories of plowed soil, vegetation, asphalt roads, salty soil, bare soil, wet soil, metallic roofs in blue, red and gray colors each individually and finally regions water was defined in the region.

To extract useful information from an object-oriented image, the segmentation process separates the primary and main phenomena into an unclassified image. First, we segmented the Sentinel-2 images using the eCognition software. Segmentation method is a multi-resolution segmentation method. Then, different color combinations were created in the two-color systems RGB and HSI. A total of nine color combinations were identified. Finally, we analyzed the results using Snap software.

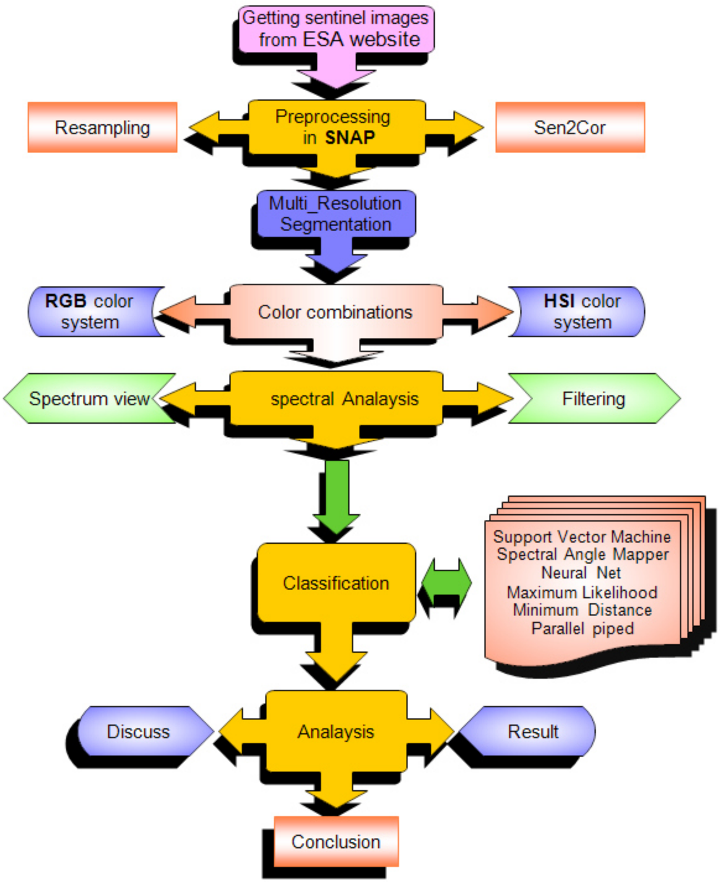

Fig.2 Research process

2.2 Support-Vector Machine classifier

In machine learning algorithms, support vector machines (SVMs, support vector networks) (Theodoridis & Cotterbass, 2009) are related learning models whose task is to analyze the data used for classification and regression analysis. SVMs can perform nonlinear classification in addition to linear classification using the kernel method (Campbell & Ying, 2011). The SVM algorithm is categorized as a pattern recognition algorithm. SVM algorithm can be used wherever it is required to recognize a pattern or categorize objects in particular classes. SVM theory is mainly derived from the problem of binary classification. Its main idea can be concluded as the following two points: First, it constructs a nonlinear kernel function to present an inner product of feature space, which corresponds to mapping the data from the input space into a possibly high-dimensional feature space by a nonlinear algorithm. Thus, it is possible to analyze the nonlinear properties of samples in the feature space with linear algorithm. Secondly, it implements the structural risk minimization principle in statistical learning theory by generalizing optimal hyper-plane with maximum margin between the two classes. While this method is visually simple, the idea actually plays the role of capacity control and makes the machine not only learn a few experimental aberrations but also has good generalization performance. The SVM classification method has many advantages both fundamentally and practically (Xiao et al., 2000).

3. Results and discussion

3.1 Results

Remote sensing images obtained at different times can be used to detect the type of changes as well as the spatial distribution created in the landscape (Friedl et al., 2002; Zhan et al., 2002). Pixel processing is based on images, single-pixel, benchmark and base information. This is where in object-oriented processing, the values and information of a similar pixel set, called the object or phenomenon, are the basis of the processing (Nazmfar & Jafarzadeh, 2018). As such, the algorithms use both spectral and spatial information simultaneously (Herold et al., 2003; Hodgson et al., 2003a; Tullis and Jensen, 2003). The first threshold is in the spectral range of B2 blue band (band 2, 0.490μm), which is related to dense vegetation with little reflection. To avoid confusion between salty soil and metal roofs, SWIR channels B11 (band 11, 1.610μm) and B12 (band 12, 2.190μm) are also used because wet soil has a high reflectance at these wavelengths. Salty soil and metal roofs have both a high reflectance in the bands B11 and B12, an additional threshold on B10 (1.375μm). In Tab.1, bundle combinations, as well as the factors of shape, compactness, and scale in segmentation of the image are shown. Also, the number of segmented pixels is also given.

			B1	B2	B3	B4	Shape	Comp	Scale	N of Obj
Combining bands	A	R		*	*	*	0.9	0.1	35	1501
		G			*					
		B				*				
	B	R	*				0.6	0.04	20	1480
		G		*						
		B			*					

Description: B1= band2 sentinel; B2= band3; B3= band4; B4= NIR band; Comp= Compactness; N of Obj= Number of Objects

Tab.1 Band constituents and shape and compactness values and number of pixels

In Figure 3, segmented images using eCognition software are shown. Figure 3(A), image with RGB color system. Figure 3(A') shows the segmentation image. Figure 3(A'') shows the illustrated segmentation image. Also, in Figure 3(B), the image shows an HSI-colored system. Figure 3(B') shows the segmentation image. Figure 3(B'') shows the illustrated segmentation segment. Segmental image is used to extract precision components for object-oriented processing as well as detecting pieces with different reflections. The difference between Figure 3(A′) and 3(A″) is that Figure 3(A″) has been selected to remove additional segments. This is also true for Figure 3(B′) and 3(B″).

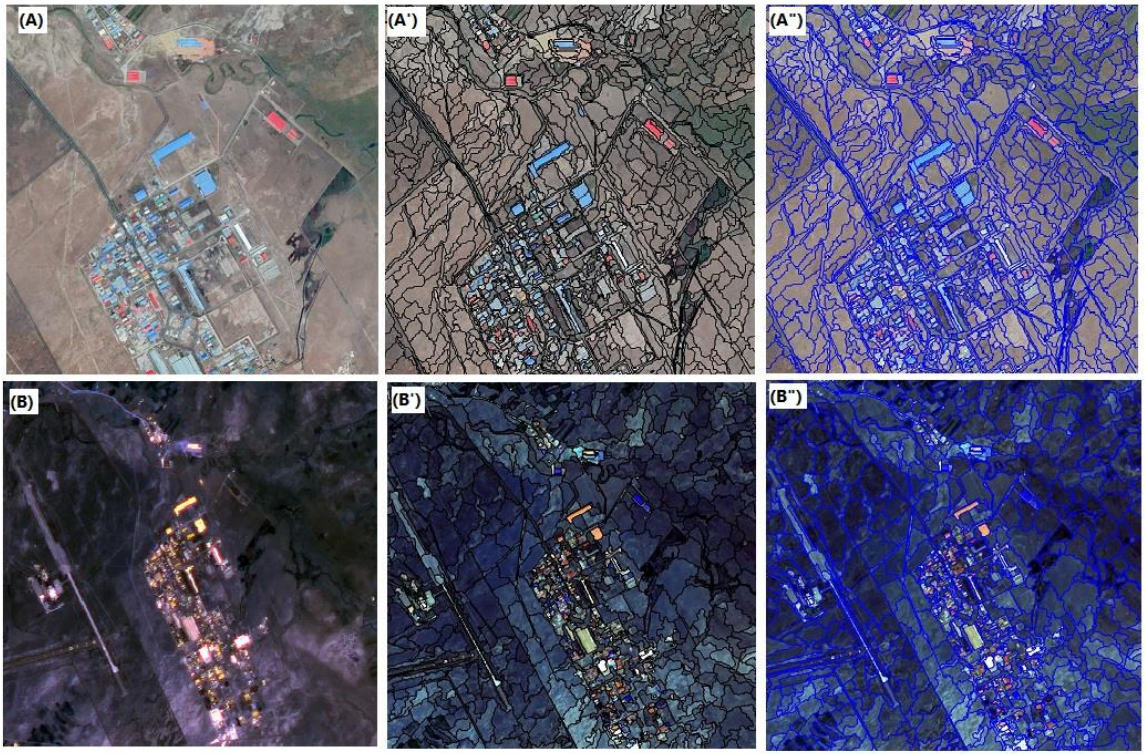

Fig.3 Segmented images using the eCognition software

Figure 4 shows the magnified segmented image. In this image, the red boxes represent a sample of segmentation pieces that display the precision.

Fig.4 Segmented image zoomed

Then, in the SNAP software, nine different colour combinations were created in both the colour scheme of the RGB and HSI. Figures 5 and 6 shows the colour combinations, as well as Tab.2, the type of compounds and the combined bands.

	Colour System	Fig name	a	b	c	d	e	f	g	h	i
Composite Colour	RGB		4-3-2	8-4-3	8-11-2	8-11-4	11-8a-2	11-8-4	12-8-3	12-11-3	12-11-4
	HSV		4-3-2	8a-4-3	8-11-2	8-11-4	11-8-2	11-8-4	12-8a-3	12-11-3	12-11-4

Tab.2 The type of compounds and the combined bands

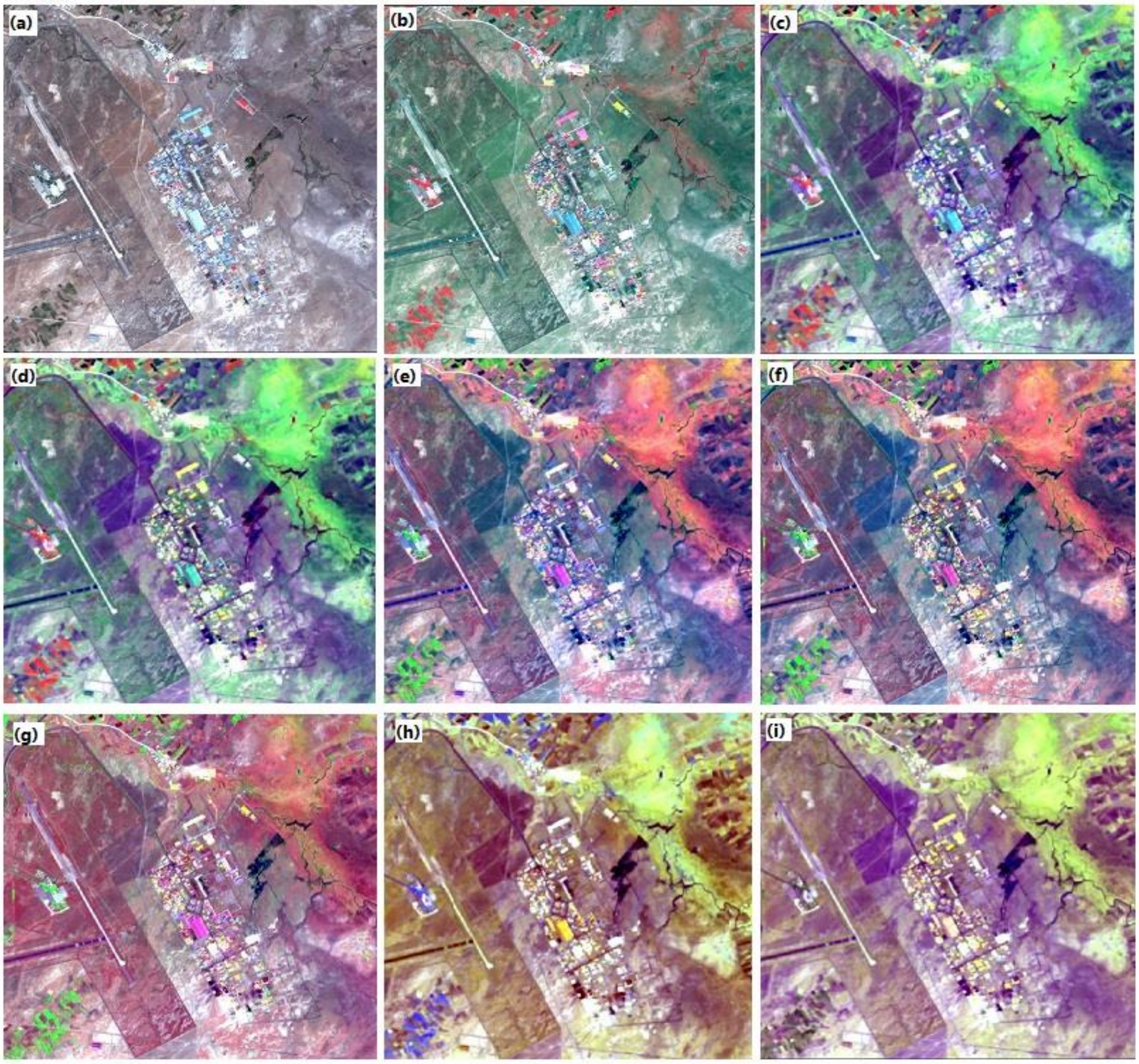

Fig.5 Nine different colour combinations in both colour systems of RGB

In Figure7, the spectral reflection spectrum of different materials is shown. Figure 7(X) represents the total reflection curve in the full range. Figure 7(Y) shows the reflection of materials in the 430-nanometer range and Figure 7(Z) shows the reflection in the range of 1375 nm.

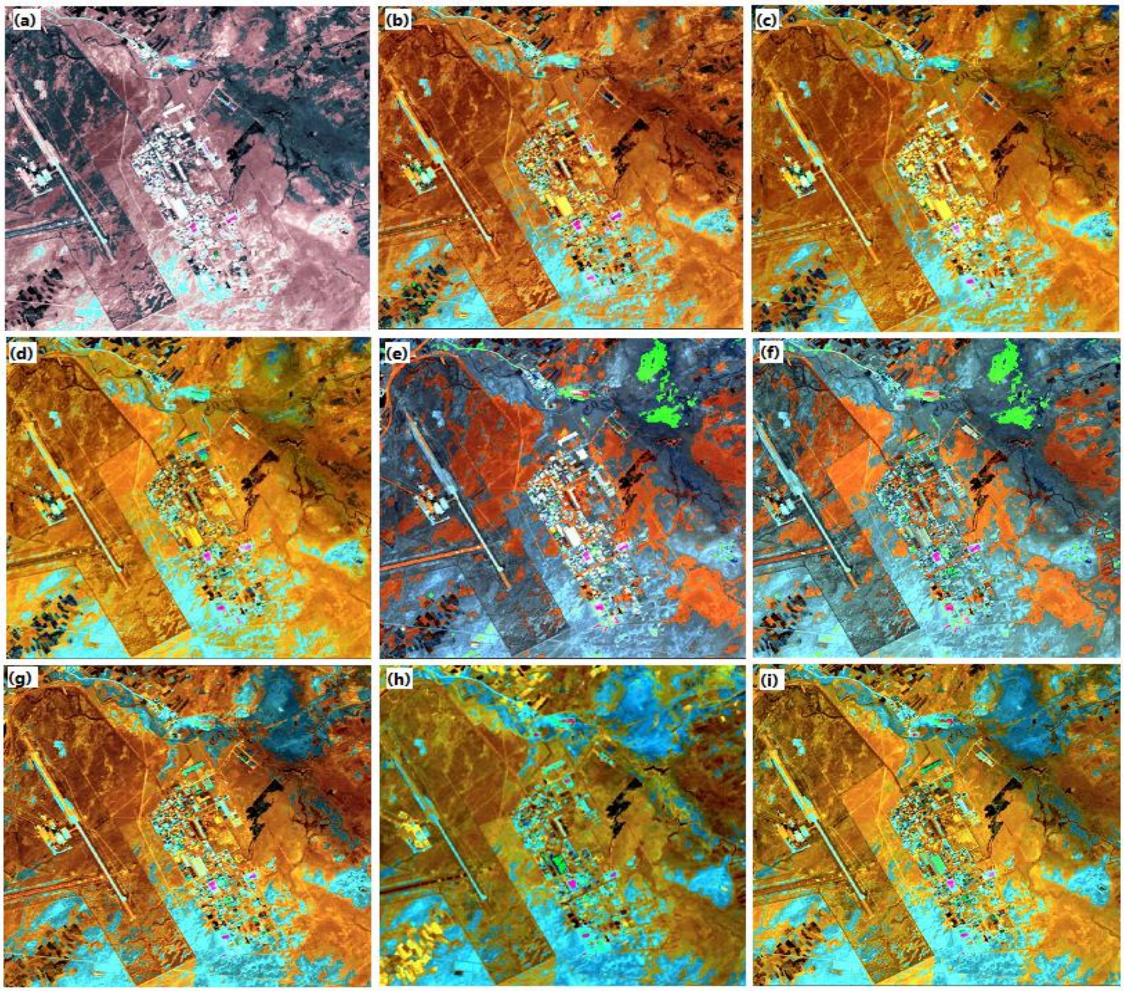

Fig. 6 Nine different colour combinations in both colour systems of HIS

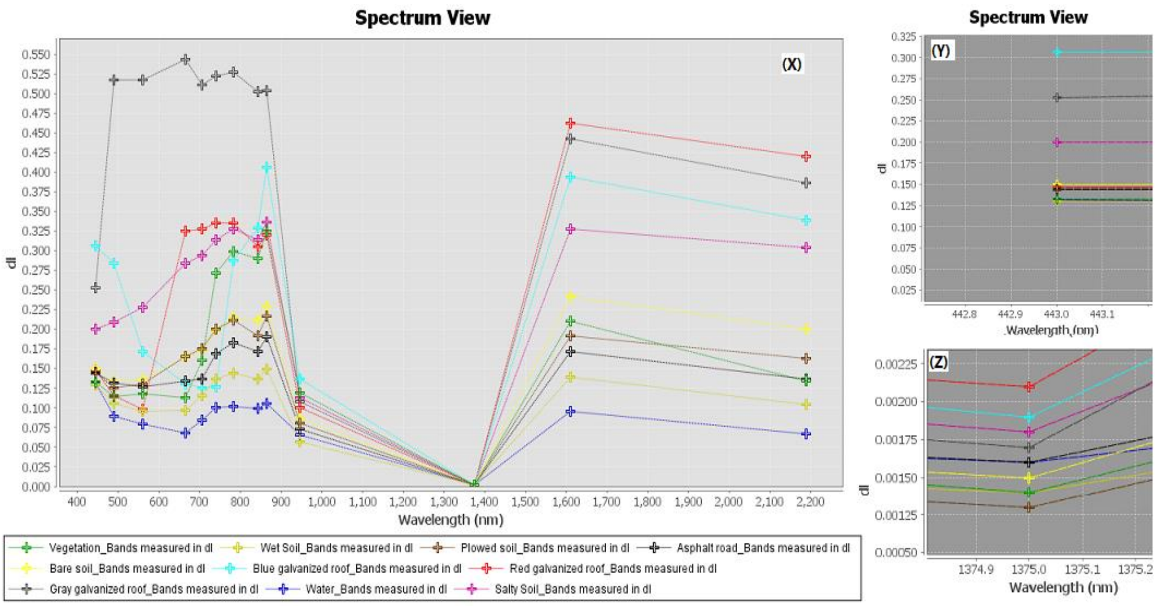

Fig.7 The spectral reflection spectrum of different materials (Wavelength versus DN number)

Figure 8 shows the spectral reflection curve of Fig. 7 in the form of a zoomed-in visible light (range from 400 to 700 nm).

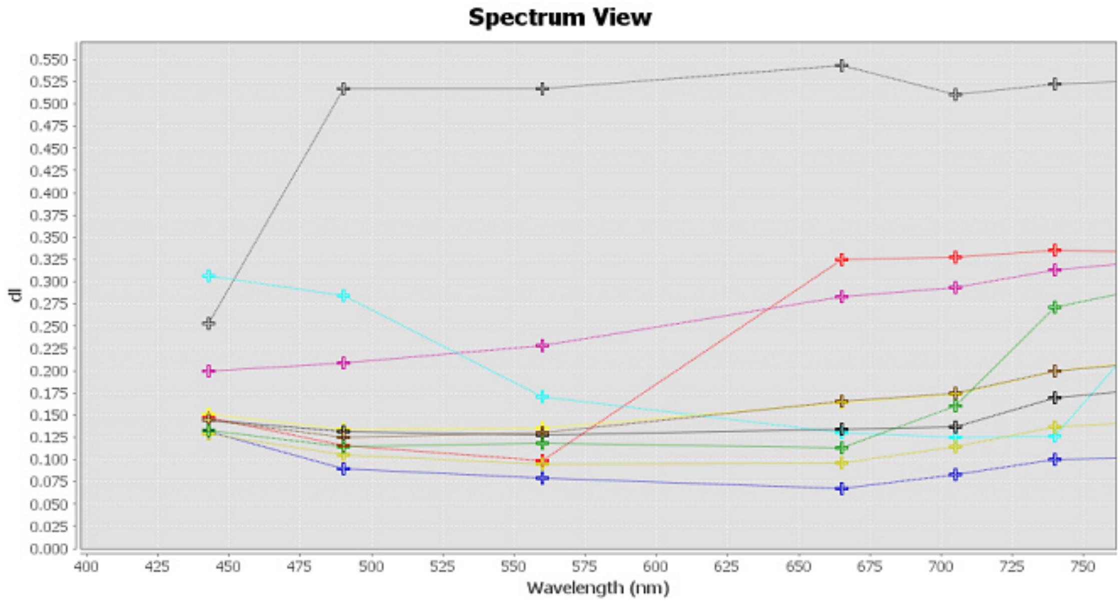

Fig. 8 The spectral reflection spectrum of different materials in visible light

Then, by applying a high-Pass filtering, we highlighted the areas of metal ceilings. The convolution filter of type 5 in 5 kernel size as high-pass filtered and used with ENVI software. Figure 9(1 and 2) shows the filtered image.

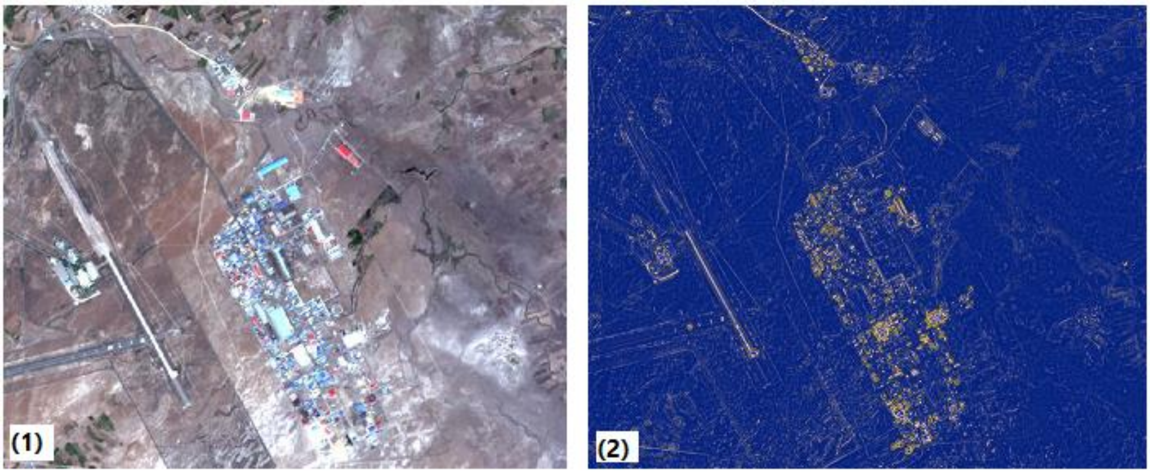

Fig. 9 The spectral reflection spectrum of different materials in visible light

Finally, we chose the SVM method for classification by testing different classification methods and choosing the best classification method based on Overall Accuracy and Kappa coefficient. In Fig. 10, the classified image is displayed in an SVM method. Table 3 also shows the Overall Accuracy and Kappa coefficients for the six types of supervised classification. It is noteworthy that the SVM method with a total accuracy of 96.9% and a Kappa coefficient of 0.9 has the highest accuracy among other methods. So, to continue working, we use the supervised classification method with the SVM method.

Accuracy Type	Parallel piped	Minimum Distance	Maximum Likelihood	Neural Net	Spectral Angle Mapper	Support Vector Machine
Overall Accuracy (%)	71.25	77.27	90.51	92.09	63.26	96.91
Kappa Coefficient	0.58	0.69	0.86	0.88	0.53	0.90

Tab. 3 Overall Accuracy and Kappa Capacity for Different Supervised Classification Procedures

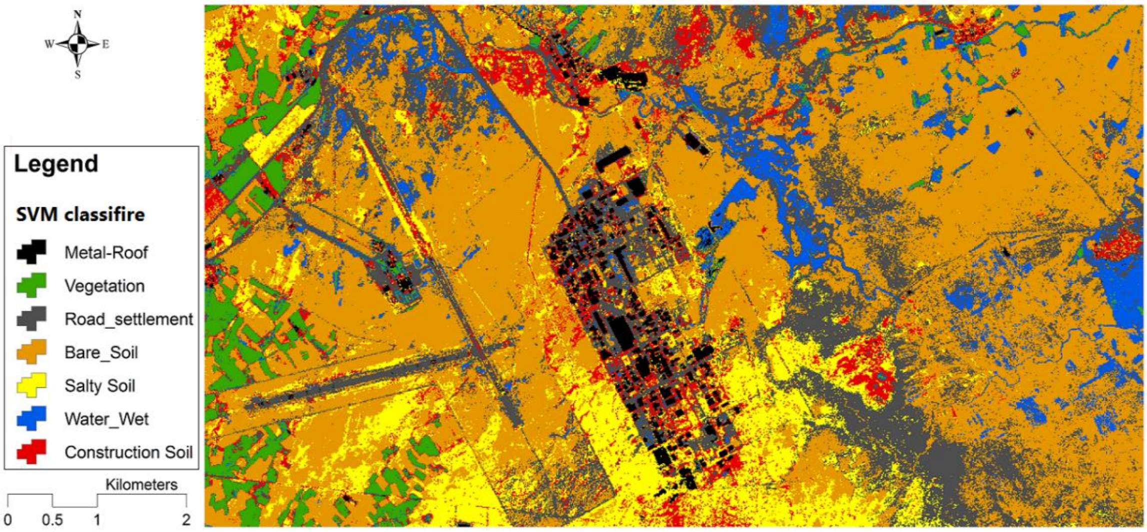

Fig. 10 Image classified by using SVM

3.2 Discussion

This research has been conducted to extract educational samples for supervised classification. Considering the results obtained in the previous section, we will analyze and discus the findings. First, by observing Figures. 3(A) and (B), we can say that reflection varies in different materials, and this reflection difference causes different parts in the segmentation process. Although, apparently, the reflection difference cannot be clearly seen. Although the reflection of a metallic ceiling with a reflection of salty soil, both appear to be the same in the natural color image composite (4.3.2), but in the process of segmentation by multi-resolution, the components are well-recognized.

Also, in the segmented image shown in Figure 3(B), which has been color-coded in 4.3.2 in the HSI color system, metal ceilings (roofs) have become very bright. Second, according to Figure 5, it can be seen that by applying different color combinations of the Sentinel-2, the extraction of complications is well-established. This difference in the representation in Figure 5, (f), (h), and (g) is well known and it can be seen that the reflection of the metal ceiling is completely separated from the spectral reflection of the surrounding saline soil. Also, in Figure 6, the (d), (e) and (i), have shown a good difference in the spectral reflection of metal ceilings and saline soil.

Third, Figure 7 shows the spectral reflection curve of different materials. Additional markup colors are described below. Figure 7(X), is shown in Figure 8 as a zoom. With regard to Figure 8, which shows the visible range, it can be seen that the spectral reflection of the metallic ceilings in blue and red, and the reflection of salty soil is high and almost interrelated. But these reflections vary in the infrared range. In the infrared range (Figure 7(Z)), the red and blue metallic roofs are above the reflection of salty soils, but reflection of the salty soil, in contrast to the visible light range in which the metal ceiling was higher, is higher than the gray ceiling Color is placed.

Figure 9 shows the filtered image by the high pass filter method. In this form, metal ceilings are well separated from other features in the image. Reflection of metal ceilings from salty soils and other reflections of natural features around metal ceilings have also been isolated. Due to the fact that high pass filters highlight the details of the effects in the image, the study also uses a convolution-high pass filter with a 5-in-5 kernel. Finally, in Figure 10, the sketch image is shown in the SVM method.

In this picture, according to the map guide, the black spots represent metal-colored roofs (red or blue or gray) and are well-spaced from high reflection salts (yellow in the map) around these areas. In this study, interesting results were obtained by studying the spectral reflectance of metal roofs and saline soils using object-oriented processing. First, the best samples for use in classification were extracted using the multi-segmentation method by eCognition software.

Then, by examining important and different methods of classification of satellite images, the best classification method was obtained using kappa and overall accuracy coefficients. Finally, using the Support Vector Machine classification method, a classification was performed on the image and different uses were extracted. In the last step, i.e. classification, the use of metal roof and saline soil was clearly obtained and is shown in Figure 10.

In this research, the method of visual interpretation of satellite images has also been used. This method compares different image representations using RGB and HSI display methods.

4. Conclusion

Sentinel-2 is a high-resolution imaging satellite designed to support data continuity as well as enhance Landsat data and other missions ESA's recent launch of the Sentinel-2 sensor will increase the availability of medium to high resolution free images for use in a variety of applications. Compared to the spatial, spectral, and temporal resolution of satellites in the Sentinel -2 sensor presents new and interesting properties.

The results of this research demonstrate the added value of the Sentinel -2 red and NIR bands to improving segment mapping and encourage multi-sensor for next researches.

This paper presents a new approach for extracting training samples from metal roofs compared to saline soils. In this paper, the spectral behavior of different materials, in particular metal ceilings and saline soil, and the comparison of different color combinations from the images in the two-color systems of the RGB and HSI, the spectral reflection of the materials extracted and used for research work it is possible to use a supervised classification map.

Finally, the classification method of SVM as the best method of classification with a general accuracy of 96.9 and a Kappa coefficient of 0.9 for categorization in this study was selected among other classification methods. The results obtained from Figure 8 and Figure 10 show that the spectral reflectance of saline soil with a very high metal roof has been resolved using the Support Vector Machine classification method and this difference is well separated by this classification method.

The results of this study could pave the way for further studies in the field of using intelligent classification methods such as Support Vector Machine as well as the use of satellite images with high spatial resolution such as Sentinel_2. In future studies, it is also possible to study the methods of intelligent integration of satellite and radar images in the separation of spectral unmixing of different levels by referring to this research.

References

Arianespace (2017). *VV09 Sentinel-2B*. Retrieved from: http://www.ariane/space.com/wp-content/uploads/2017/02/VV09-launchkit-EN.pdf.Last accessed: April 2021.

Bahram, I., Farshid, S., Jafar, J. (2020). Evaluating metropolises grow and their impact on the around villages using Object-Oriented Images. *Tema. Journal of Land Use, Mobility and Environment, 13* (1), 41-53. http://dx.doi.org/10.6092/1970-9870/6525

Benz, U.C., Hofmann, P., Willhauck, G., Lingenfelder, I., Heynen, M. (2004). Multiresolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. *ISPRS Journal of Photogrammetry and Remote Sensing 58* (3_4), 239_258. https://doi.org/10.1016/j.isprsjprs.2003.10.002

Berger, M., Moreno, J., Johannessen, J.A., Levelt, P.F., Hanssen, R.F. (2012). ESA's sentinel missions in support of Earth system science. *Remote Sens. Environ. 120*, 84–90. https://doi.org/10.1016/j.rse.2011.07.023

Blaschke, T., Burnett, C., Pekkarinen, A. (2004). New contextual approaches using image segmentation for object-based classification. In: De Meer, F., de Jong, S. (Eds.), *Remote Sensing Image Analysis: Including the Spatial Domain* (pp. 211-236). Kluver Academic Publishers, Dordrecht.

Blaschke, T., Lang, S. (2006). Object based image analysis for automated information extraction - A synthesis. In: Measuring the Earth II ASPRS Fall Conference 6-10 November 2006, San Antonio, Texas, on CD-ROM.

Blaschke, T., Lang, S., Hay, G.J. (Eds.). (2008). *Object Based Image Analysis*. Springer, Heidelberg, Berlin, New York.

Blaschke, T., Strobl, J. (2001). What's wrong with pixels? Some recent developments interfacing remote sensing and GIS. *GIS _ Zeitschrift für Geoinformationssysteme 14* (6), 12_17.

Bontemps, S., Arias, M., Cara, C., Dedieu, G., Guzzonato, E., Hagolle, O., Inglada, J., Morin, D., Rabaute, T., Savinaud, M., Sepulcre, G., Valero, S., Defourny, P., Koetz, B. (2015). Sentinel-2 for agriculture: supporting global agriculture monitoring. *IEEE 4185–4188*. https://doi.org/10.1109/IGARSS.2015.7326748.

Burnett, C., Blaschke, T. (2003). A multi-scale segmentation/object relationship modelling methodology for landscape analysis. *Ecological Modelling 168* (3), 233_249. https://doi.org/10.1016/S0304-3800(03)00139-X

Campbell, Colin; and Ying, Yiming. (2011). *Learning with Support Vector Machines*. Morgan and Claypool. ISBN 978-1-60845-616-1.

Clerc, S., Devignot, O., Pessiot, L. (2018). S2 MPC-Data Quality Report. ESA (No. 23). reference S2-PDGS-MPC-DQR.

Copernicus (2015). Sentinel-2A Launch. (2017). Available at: https://www.copernicus.eu/en/library/library. Last accessed: April 2021.

Cracknell, A.P. (1998). Synergy in remote sensing. What's in a pixel? *International Journal of Remote Sensing 19* (11), 2025-2047. https://doi.org/10.1080/014311698214848

Dörnhöfer, K., Göritz, A., Gege, P., Pflug, B., Oppelt, N. (2016). Water constituents and water depth retrieval from sentinel-2A—a first evaluation in an oligotrophic lake. *Remote Sens. 8*, 941. https://doi.org/10.3390/rs8110941.

Du, Y., Zhang, Y., Ling, F., Wang, Q., Li, W., Li, X. (2016). Water bodies' mapping from sentinel-2 imagery with modified normalized difference water index at 10-m spatial resolution produced by sharpening the SWIR band. *Remote Sens. 8*, 354. https://doi. org/10.3390/rs8040354

Eisank, C., Drăguţ, L. (2016). Automated classification of topography from SRTM data using object-based image analysis, Geomorphology 141-142:21-33.

ESA CCI LC project. (2016). *Land Cover CCI, Product User Guide - Version 2.5*. Retrieved from: http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-PUG-v2.5.pdf. Last accessed: April 2021.

ESA Sentinel-2 Team (2007). GMES Sentinel-2 Mission Requirements. Retrieved from: https://esamultimedia.esa.int/docs/GMES/Sentinel-2_MRD.pdf. Last accessed: April 2021.

Fernández-Manso, A., Fernández-Manso, O., Quintano, C. (2016). SENTINEL-2A red-edge spectral indices suitability for discriminating burn severity. Int. J. *Appl. Earth Obs. Geoinf. 50*, 170–175. https://doi.org/10.1016/j.jag.2016.03.005.

Gašparović, M. & T., Jogun. (2018) The effect of fusing Sentinel-2 bands on land-cover classification, International Journal of Remote Sensing, 39:3, 822-841. https://doi.org/10.1080/01431161.2017.1392640

Greco, S., Infusino, M., De Donato, C., Coluzzi, R., Imbrenda, V., Lanfredi, M., Simoniello, T., Scalercio, S. (2018). Late spring frost in Mediterranean beech forests: extended crown dieback and short-term effects on moth communities. *Forests 2018*, 9(7), 388. https://doi.org/10.3390/f9070388.

Hay, G.J., Blaschke, T., Marceau, D.J., Bouchard, A. (2003). A comparison of three image-object methods for the multiscale analysis of landscape structure. *ISPRS Journal of Photogrammetry & Remote Sensing 57*(2003), 327–345.

Hay, G.J., Castilla, G. (2008). Geographic Object-Based Image Analysis (GEOBIA): A new name for a new discipline. In: Blaschke, T., Lang, S., Hay, G. (Eds.), *Object Based Image Analysis* (pp. 93-112). Springer, Heidelberg, Berlin, New York, pp.

Hay, G.J., Castilla, G., Wulder, M.A., Ruiz, J.R. (2005). An automated object-based approach for the multiscale image segmentation of forest scenes. *International Journal of Applied Earth Observation and Geoinformation 7* (4), 339-359. https://doi.org/10.1016/j.jag.2005.06.005

Immitzer, M., Vuolo, F., Atzberger, C. (2016). First experience with Sentinel-2 data for crop and tree species classifications in Central Europe. *Remote Sens.2016 8*, 166. https://doi.org/10.3390/rs8030166

Ingegnoli, V. (2003). *Landscape Ecology: A Widening Foundation*. Springer Verlag, New York, Berlin, Heidelberg.

Korhonen, L., P. Packalen, and M. Rautiainen. (2017). Comparison of Sentinel-2 and Landsat 8 in the Estimation of Boreal Forest Canopy Cover and Leaf Area Index. *Remote Sensing of Environment 195*, 259–274. https://doi.org/10.1016/j.rse.2017.03.021

Kovalskyy, V., Roy, D. (2015). A one-year Landsat 8 conterminous United States study of cirrus and non-cirrus clouds. *Remote Sens. 7*, 564–578. https://doi.org/10.3390/ rs70100564

Lang, S., Blaschke, T. (2006). Bridging remote sensing and GIS - what are the main supporting pillars?. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXVI-4/C42.

Lang, S., Schöpfer, E., Langanke, T. (2008). Combined object-based classification and manual interpretation _ Synergies for a quantitative assessment of parcels and biotopes. *Geocarto International 23* (4), 1-16. https://doi.org/10.1080/10106040802121093

Liu, Y., Li, M., Mao, L., Xu, F. (2006). Review of remotely sensed imagery classification patterns based on object-oriented image analysis. *Chinese Geographical Science 16* (3), 282-288.

Main-Knorn, M., B. Pflug, V. Debaecker, and Louis J. (2015). Calibration and Validation Plan for the L2A Processor and Products of the Sentinel-2 Mission. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* 40(7):1249–1255. 36th International Symposium on Remote Sensing of Environment. Berlin, May 11–15. 10.5194/isprsarchives-XL-7-W3-1249-2015

Mayer, B., and A. Kylling. (2005). "Technical Note: The libRadtran Software Package for Radiative Transfer Calculations-Description and Examples of Use. *Atmospheric Chemistry and Physics 5* (7), 1855–1877. https://doi.org/10.5194/acp-5-1855-2005

Nazmfar, H., Jafarzadeh, J. (2018). Classification of Satellite Images in Assessing Urban Land Use Change Using Scale Optimization in Object-Oriented Processes (A Case Study: Ardabil City, Iran). *Journal of the Indian Society of Remote Sensing 46*, 1983–1990 (2018). https://doi.org/10.1007/s12524-018-0850-7.

Pflug, B., M. Main-Knorn, J. Bieniarz, V. Debaecker, and J. Louis. (2016). *Early Validation of Sentinel-2 L2A Processor and Products*. Proceedings of Living Planet Symposium 2016. Prague, May 9–13. https://doi.org/10.5194/isprsarchives-XL-7-W3-1249-2015

Richter, R., X. Wang, M. Bachmann, and D. Schläpfer. (2011). Correction of Cirrus Effects in Sentinel- 2 Type of Imagery. *International Journal of Remote Sensing 32* (10): 2931-2941. https://doi.org/10.1080/01431161.2010.520346

Rosa C., Vito I., Maria L., Tiziana S. (2018). A first assessment of the Sentinel-2 Level 1-C cloud mask product to support informed surface analyses. *Remote Sensing of Environment 217* (2018), 426–443. https://doi.org/10.1016/j.rse.2018.08.009

Simoniello, T., Coluzzi, R., Imbrenda, V., Lanfredi, M. (2015). Land cover changes and forest landscape evolution (1985–2009) in a typical Mediterranean agroforestry system (High Agri Valley). *Nat. Haz. Earth Syst. Sci. 15* (6), 1201–1214. https://doi.org/10.5194/nhess-15-1201-2015

Song, X., Yang, C., Wu, M., Zhao, C., Yang, G., Hoffmann, W., Huang, W. (2017). Evaluation of sentinel-2A satellite imagery for mapping cotton root rot*. Remote Sens. 2017, 9*(9), 906. https://doi.org/10.3390/rs9090906

Theodoridis, Sergios; and Koutroumbas, Konstantinos. (2009). *Pattern Recognition*, *4th Edition*. Academic Press. ISBN 978-1-59749-272-0.

Thomas, N., Hendrix, C., Congalton, R.G. (2003). A comparison of urban mapping methods using high resolution digital imagery. *Photogrammetric Engineering & Remote Sensing 69* (9), 963/972. https://doi.org/10.14358/PERS.69.9.963

Ting Liu, Xiaojun Yang. (2015). Monitoring land changes in an urban area using satellite imagery, GIS and landscape metrics. *Applied Geography 56*, 42-54. https://doi.org/10.1016/j.apgeog.2014.10.002

Topaloğlu, Raziye Hale, Elif SERTEL, Nebiye MUSAOĞLU. ASSESSMENT OF CLASSIFICATION ACCURACIES OF SENTINEL-2 AND LANDSAT-8 DATA FOR LAND COVER / USE MAPPING. (2016). The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLI-B8, 2016 XXIII ISPRS Congress, 12–19 July 2016, Prague, Czech Republic.

Xu, Meng, Jia, Xiuping, Pickering, M. (2014). Automatic cloud removal for Landsat 8 OLI images using cirrus band. *IEEE 2511–2514*. https://doi.org/10.1109/IGARSS.2014. 6946983

Yesou, H., Pottier, E., Mercier, G., Grizonnet, M., Haouet, S., Giros, A., Faivre, R., Huber, C., Michel, J. (2016). Synergy of Sentinel-1 and Sentinel-2 imagery for wetland monitoring information extraction from continuous flow of sentinel images applied to water bodies and vegetation mapping and monitoring. *2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 2016, pp. 162-165.* https://doi.org/10.1109/IGARSS.2016.7729033

Zhu, Z., Wang, S., Woodcock, C.E. (2015). Improvement and expansion of the Fmask algorithm: cloud, cloud shadow, and snow detection for Landsats 4–7, 8, and Sentinel 2 images. *Remote Sens. Environ. 159*, 269–277. https://doi.org/10.1016/j.rse.2014. 12.014.

Author's profile

Bahram Imani

Bahram Imani is an associate Professor in Geography and Rural Planning at the department of Urban and Rural Planning, Faculty of Social Sciences - University of Mohaghegh Ardabili (UMA), Ardebil, Iran. He is rural planner for many companies. He has conducted projects and teaching activities (Geography and rural planning) at University courses for undergraduate and master students, University of Mohaghegh Ardabili. He has many published papers in his field of study.

Jafar Jafarzadeh

Jafar Jafarzadeh is an invited lecturer in the department of Natural Geography at the Faculty of Social Sciences, University of Mohaghegh Ardabili, Ardebil, Iran. He is a PhD student in Remote Sensing and Geographic Information Systems, University of Tehran. He has many published papers and books on different areas of study.