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Unsupervised Classification for Illegal Building Monitoring

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Abstract

In 2013 the Ministry of Construction and Physical Planning has brought an act by which all illegally built objects must be legalized. To this date almost 75% legalization request has been solved. It is expected that by the end of 2019 all of the illegally built objects will be legalized. In order to prevent further construction of illegal objects the Ministry of Construction and Physical Planning is seeking a way to easily detect start of illegal construction. Since the Copernicus satellite images are available free of charge and with resolution of 10m it should be possible to detect mentioned objects. This paper will provide analysis of Copernicus Sentinel 2A imagery for such use based on unsupervised classification using machine learning. If such procedure results in satisfying accuracy it will be proposed model for automation of the process for monitoring the illegal building construction based on Sentinel 2A imagery.

Keywords: Illegal Building; Copernicus; Machine Learning; Unsupervised Classification; Accuracy Assessment

Introduction

Construction is building process and with a ground-connected assembly constructed of purposefully connected construction products with or without installation, a built-in assembly unit or an independent ground-based or assembled building [1]. According to Republic of Croatia [1] every building built without construction permit is built illegally. In the construction sector illegal buildings should be understood as the violation of standards-assisted by administrative and penal sanctions [2]. In Croatia there is online service available where citizens can apply for construction permit and where government sees all of issued construction permits. Although small in size in Croatia there is a huge amount of illegally built buildings. To legalize illegal buildings Ministry of Construction and Physical Planning has conducted legalization act and to this day almost 75% of legalization request has been solved [3]. In order to prevent further illegal construction key is to develop efficient way to monitor construction in space. Fastest way to do it would be performing supervised classification on high resolution imagery such as WorldView-2, IKONOS or QuickBird. Although this images have highest resolution they are often expensive and not freely available [4]. Since 2015 and development of Sentinel 2A in Copernicus satellite missions frame it became mostly considered satellite mission in land observation. Immitzer, Vuolo and Atzberger [5] have used the Random Forest classifier in order to assess the potentials of Sentinel-2 data for crop type and tree species mapping. They have confirmed expected capabilities that the Sentinel-2 data can produce reliable land cover maps. Radoux, et al. [6] tested Sentinel-2's potential for sub-pixel landscape feature detection where they have determined the minimum object size for an accurate detection. However Radoux, et al. [6] considered only linear objects and minimum width of roads to correctly extract should be 2 meters. Kranjčić, Župan and Rezo [7] used Sentinel-2 data in order to calculate forest area infected with bark beetles based on different spectral resolution of infested forest. Wessel, Brandmeier and Tiede [4] used principles of machine learning and pointed out that Sentinel-2 results are only slightly worse than commercial high-resolution satellite sensors for forest analysis on a tree-stand level.

Some authors analyze Sentinel 2A imagery in order to perform classification and vegetation extraction [4-7] where others use it to test different machine learning algorithms [8]. Accordingly a lot of papers are published regarding automatic object extraction from aerial imagery [9-14]. However some of the papers focused on high resolution imagery or combination of high resolution and low resolution imagery [15,17] provided assessment of the added-value of Sentinel-2 for detecting built-up areas. Pesaresi, et al. [17] stated out that because of high resolution images and frequent revisiting time the use of Sentinel-2 data is highly suitable for mapping and monitoring human settlements at a global level. Main advantage of Sentinel-2 data with high resolution lies in free of charge use, which is important for local government.

Materials and Methods

Study area is located in Varaždin, Croatia. For analyze three location in Varaždin are chosen. Location one is family house building, located in urban part of the city and second and third location are industrial building placed outside urban area. It is expected that during the analysis problems could occur regarding family house because it is located among other family houses, and it covers area around 80m^2 where size of the pixel is 100 m^2. Location two and location three are industrial buildings located outside the urban area, larger than 100 m^2 and it should be easily detectable on satellite images. To confirm that selected locations are suitable for this research from Google Earth have been downloaded images before and after construction. Figure 1 shows location one before and after construction. Figure 2 shows location two before and after construction, and Figure 3 shows location three before and after construction. Images before construction were recorded throughout the period of 2013. Images after construction were recorded throughout the period of 2018.

Figure 1: Study area 1.

Figure 2: Study area 2.

Figure 3: Study area 3.

For the classification process two sets of Sentinel 2 MSI images were downloaded, first set for date 11/07/2015 and second set for date 20/10/2018. To perform unsupervised classification in order to evaluate the quality of Sentinel 2 imagery for monitoring of the illegal building construction. Idea is to develop processing model which could automatically detect change in landscape and highlight such areas. Study area for year 2015 and for year 2018 presented on Sentinel images is shown on Figure 4.

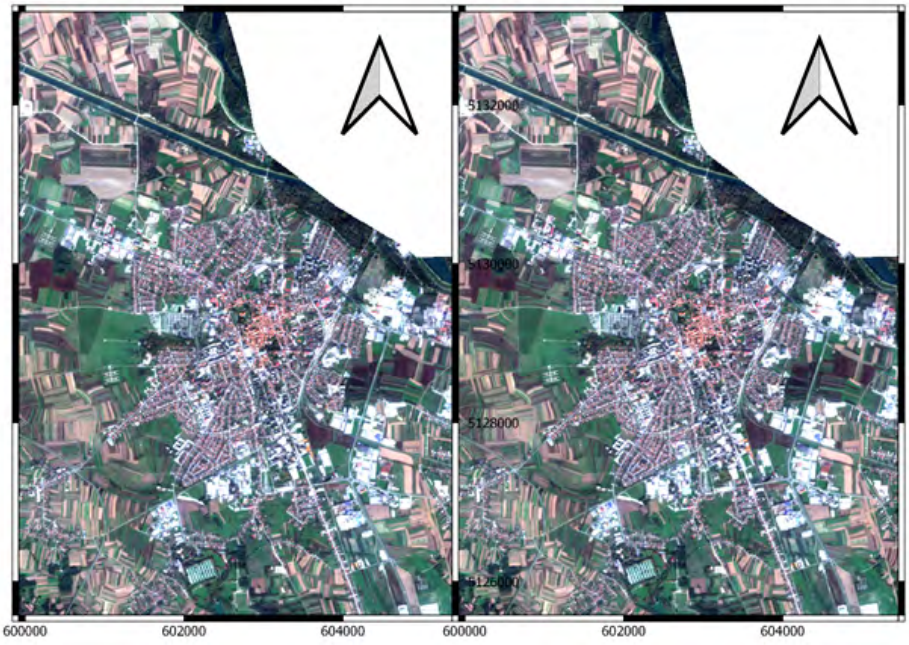

Figure 4: Sentinel 2 imagery of study area, (year 2015 left) (year 2018 right).

Results

Unsupervised classification K-means clustering for grids with Hill-Climbing method has been applied to both images. Number of clusters was 5 and maximum number of iterations was 100. Figure 5 presents results of study area.

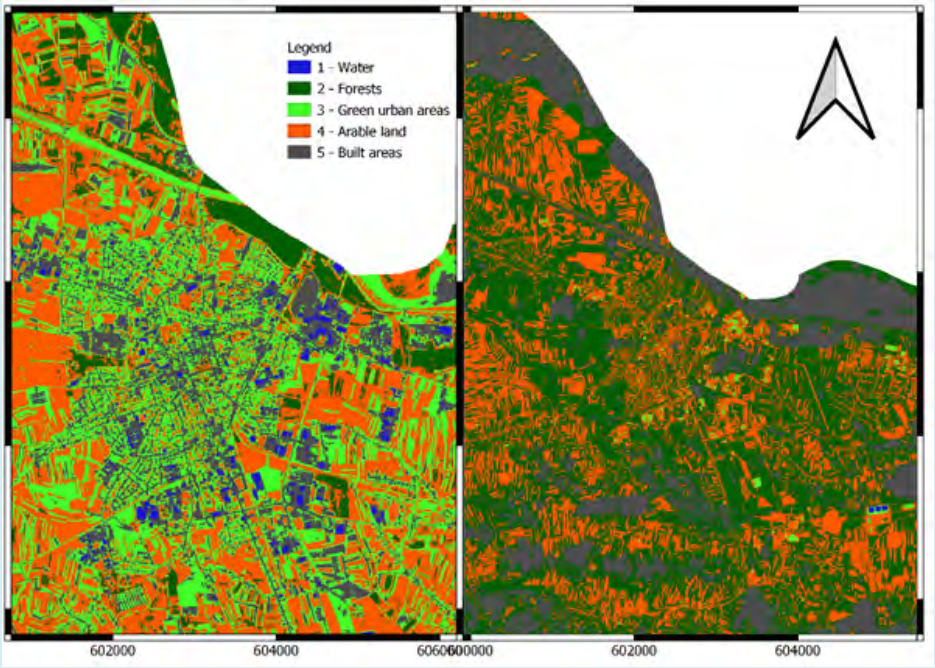

Figure 5: Unsupervised classification, (year 2015 left) (year 2018 right).

	2015		2018	
Class ID	**Number of elements**	**Standard deviation**	**Number of elements**	**Standard deviation**
1	18139	0.177	6089	4431.739
2	4346679	0.007	3383249	183.014
3	1418464	0.017	43705	1213.344
4	3287536	0.012	1634864	299.291
5	430161	0.035	4433262	163.364

Table 1: Classification statistics.

As seen from Figure 5 and Table 1 results of unsupervised classification is not satisfactory. For year 2015 it could be stated that there is low standard deviation and classification is correct. However, there is more overlapping in classes and this should be avoided in further analysis. For year 2018 there is absolute problem with unsupervised classification as classes overlap and standard deviation indicates that classification is poor.

Conclusion

Illegal construction of building is growing problem in the world. Satellite missions can achieve high resolution imagery of earth surfaces. There are many possibilities how to interpret this imagery. Most common ones are supervised and unsupervised classification processes. There is need to evaluate these methods in order to provide more precise information. In this paper, use of unsupervised classification K-Means methods has been shown. Method is simple to use, however results indicate that it should be careful while working with this method. In order to improve these unsupervised processes, other available methods should be examined and evaluated.

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