Detection of Urban Buildings by Using Multispectral Gokturk-2 and Sentinel 1A Synthetic Aperture Radar Images †

Mustafa Kaynarca 1 and Nusret Demir 2,*

1 Department of Remote Sensing and GIS, Institute of Science and Technology, Akdeniz University, Antalya 07058, Turkey; mustafakaynarca@gmail.com
2 Department of Space Science and Technologies, Faculty of Science, Akdeniz University, Antalya 07058, Turkey
* Correspondence: nusretdemir@akdeniz.edu.tr; Tel.: +90-242-310-2235

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Abstract: Urban areas are important for city planning, security, traffic purposes, decision makers etc. Remotely sensed data are useful to detect urban areas either with active or passive systems. Each system has advantages and disadvantages. Passive images are mainly multispectral images and have rich information with their rich spectral resolution. In addition, they are affected by the atmospheric conditions, so there should not be clouds over the sensed region during data acquisition. On the other hand, SAR (Synthetic Aperture Radar) systems are not affected by the atmospheric conditions, but their spectral resolution is low, with mainly one-channel SAR systems. Also, the structure of passive images is completely different from that of multispectral images. Moreover, the geometrical and electrical properties of objects play an important role in the pixel values. In this study, a multispectral GOKTURK-2 MS (Multispectral) image and a SENTINEL 1A SAR image were used to detect urban buildings, using the advantages of both datasets. Firstly, the SVM (Support Vector Machines) method was applied to detect the buildings in the GOKTURK image. Then, the buildings were detected from the SAR image with the fuzzy logic approach. Finally, the buildings were detected by intersecting the results from both methods. The results from the SAR image could eliminate the false negative results from the GOKTURK-2 image. The study area was selected in Antalya province, Kepez district. The detected urban area was 288.353 m² in the selected study area.

Keywords: building detection; multispectral image; Gokturk; Sentinel; SAR; fuzzy; SVM

1. Introduction

The buildings are important objects for many purposes, such as city planning, flood simulation, real estate, municipality progress, etc. Satellite data are efficient sources for detecting and updating buildings. There are two types of remote sensing methodology, namely, passive and active remote sensing, which have both advantages and disadvantages when compared to each other. Optical satellite image data were used for building detection purposes in the past [1–5]. SAR (Synthetic Aperture Radar) satellites can operate in all weather conditions, 24 h per day, since they use their own energy to detect the radiation reflected from the Earth surface. This makes SAR remote sensing time- and weather-independent. The detection of urban features was also the focus of many previous research works [6–10].
In this work, the buildings were detected from multispectral Gokturk images and Sentinel 1A SAR images. The support vector machine (SVM) classification method was applied on multispectral images, and fuzzy clustering was used for detecting the buildings from the SAR data. In the last step, the intersection of the results from the two datasets gave the most accurate detection results.

2. Experiments

2.1. Test Site

The study area was selected from one of the developing neighborhoods in Antalya province, Kepez district, where buildings are dense. The test area is approximately 771.861 m². Figure 1 shows the test site.

![Figure 1. Test site (Left): Antalya (up); Kepez (below); (middle) (test site on Google Earth); (right) Zoomed view.](image)

2.2. Used Data

In this study, Gokturk MS and Sentinel 1A SAR images were used. The used images are shown in Figure 2. GÖKTÜRK-2, is the first high-resolution ground observation originally developed in Turkey, designed by Turkish engineers, and placed in the mission orbit by a launching operation in 2012. Gokturk-2 image contains four visible bands, i.e., blue, green, red, and near infrared, with resolution of 2.5 m and a panchromatic band with a 5 m resolution.

![Figure 2. Göktürk 2 Multispectral Image (left) and Sentinel 1A SAR image (right).](image)

The used SAR image was acquired in Interferometric Wide Swath Mode (IW) with GRD (Ground Range Detected) file type selected. The properties of the used SAR image are given in Table 1.
Table 1. Features of the S1A level-1 product GRD (Ground Range Detected).

<table>
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<th>04.08.2016</th>
</tr>
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<td>Instrument:</td>
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<td>Operational mode:</td>
<td>IW swath mode</td>
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<tr>
<td>Polarization:</td>
<td>VH, VV</td>
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<td>Range and Azimuth Spacing:</td>
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<td>Azimuth and Range Looks:</td>
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2.3. Method

The method consisted of three parts. Firstly, the building areas were detected from the Gokturk image, using the SVM method. Then, a fuzzy clustering was applied on the SAR image to detect the buildings. Then, the intersection of the results was performed to identify the buildings.

2.3.1. Building Detection from the Gokturk Image

The workflow of the methodology is shown in Figure 3.

![Figure 3. Workflow of the building detection method from the Gokturk image.](image)

Six training classes were defined, which were road, vegetation, bare ground, shadow, orange colored roofs, concrete roofs.

The support vector machines classification was applied by collecting 150–200 pixels for each class. The following radial basis function was used:

\[ K(x_i, x_j) = \exp(-g \|x_i - x_j\|^2), \ g > 0 \]

where \( g \): gamma function

The separability values were analyzed. According to the analysis, concrete roofs and roads were not well separated. Therefore, OSM (OpenStreetMap) data were used to determine the road classes. The accuracy of the classification was calculated as 82%. The classes of vegetation, bare ground, and shadows were excluded. The concrete and orange roofs were merged. Then, a morphological erosion operator (3 × 3) was applied to eliminate the errors. The final roofs class was converted to the vector format, as the building detection result.

2.3.2. Building Detection from Sentinel Image

The workflow of the methodology for building detection from the SAR image is shown in Figure 4.

After acquisition, the Sentinel 1A SAR image was preprocessed for speckle reduction and topographic correction. Then, an MSLarge (Mean Standard Deviation Large) fuzzy membership function was used to calculate the building membership values. Defuzzification was applied, with
thresholding on the membership values. The pixels with a larger membership value than 0.5, were considered as buildings. The following equation was used to calculate the membership:

\[
\text{If } x > a \times m: u(x) = 1 - \frac{b \times s}{x - (a \times m) + (b \times s)}
\]

where \( m \) is the mean value of all the pixels, \( s \) is the standard deviation, \( a \) and \( b \) are the multiplier parameters.

3. Results and Discussion

The building detection results from the Göktürk and Sentinel 1A images were intersected, and the final detection result was produced.

As shown in Figure 5, the open market roof was eliminated with the intersection (red circle), because this roof did not reflect the signals of the C band with its thin structure, which was smaller than the used RADAR wavelength. The roof of the open market is shown in Figure 6.
4. Conclusions

The Göktürk image could be used to detect the buildings but it included structures which were not buildings, like open markets, because of the similar reflectance of the roofs compared to the other buildings in multispectral channels. However, the use of the SAR image could eliminate this problem, since this type of structures did not reflect the signals of the C band RADAR. So, urban buildings could be detected much accurately. Total urban building area was calculated as 288.353 m² by this study. As a future work, the integration of 3D data might improve the detection results.

Author Contributions: Both authors developed the idea; Mustafa Kaynarca implemented the methodology; both authors wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

References