Estimation of the location of bee pastures in Hungary based on SENTINEL satellite images

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Abstract

In my research, I want to estimate the honeybee pastures in Hungary, using satellite earth observation. The data source will be the SENTINEL-2 satellite images of the European Space Agency (ESA) COPERNICUS programme. The processing will be carried out using remote sensing tools and the analysis will be followed by setting up of a geospatial database. The database will be a raster data structure, which will contain the spatial distribution of the isolated plant species and the estimated time of expected flowering, with special emphasis on the periodic isolation of white acacia (Robinia Pseudoacacia) in the south ('lower acacia') and north ('upper acacia'). The resulting database is the bases for an open database in the form of a Web Map Service (WMS).

Keywords:

- ***Bee pastures***
- ***Satellite earth observation***
- ***Geospatial database***

I. Introduction

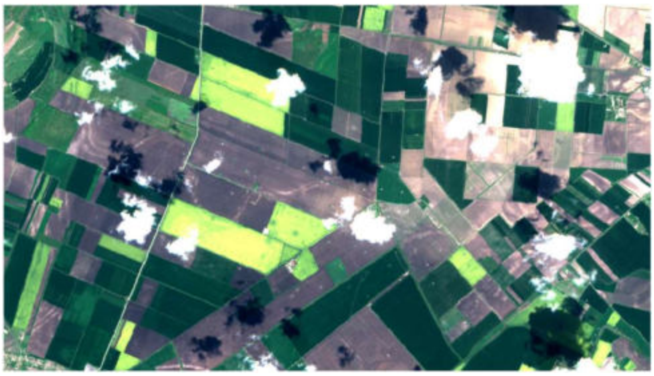
Hungary has one of the most important beekeeping industries in the EU. Currently there are 1.2 million bee colonies in Hungary and 20,000 beekeepers, of which 20% are full-time beekeepers, 70% are part-time beekeepers and 10% are hobby beekeepers. 60 % of beekeepers are migratory beekeepers travelling across the country from flowering to flowering, the remaining 40 % keep a stationary apiary. The number of colonies per square kilometre varies widely across the European Union, with an average of 4.04 colonies per square kilometre, but in Hungary there are up to 13 colonies per square kilometre, currently the highest in the EU [1]. Unfortunately, high bee density not only has a negative impact on overgrazing, but also contributes to spread infections more rapidly.

Major bee pastures in Hungary [2]:

There are three major type of plants, that are important for beekeeping, because of their economic relevance:

1. Rapeseed (*Brassica napus*): herbaceous plant of the Brassica family, one of our most important honey plants. The weather does not particularly affect the quality of the rapeseed flowering, which starts to bloom at about the same time throughout the country, around 15th of April. The flowering period for bee pastures lasts on average two weeks. The bright yellow colour of the flowers makes them easy to identify from satellite imagery [3]. Interestingly, the optimal pH of the honey makes it suitable for people with stomach problems, as it can also be used to relieve acid overload.

1. Figure: rape flowering, beekeeping container on the right



2. Figure Rapeseed fields from satellite imagery. The yellow fields are clearly identifiable during flowering period.

2. White acacia (*Robinia pseudoacacia*), is the most important honey plant in Hungary. The time, quality and length of its flowering is greatly influenced by the weather, which is usually 10 days (± 1-2 days). The flowering propagates from south to north, and in beekeeping terminology it is distinguished from the lower (southern) acacia, and the upper (northern) acacia. When the upper acacia starts flowering, the lower acacia finishes flowering. If the lower acacia is poor quality, the beekeepers will often migrate to the central acacia (central part of the country). Identification of the flowering by satellite imagery is not as straightforward as for rape. For the ease of identification, it is worth identifying the woods themselves first, on a pre-flowering image, and then comparing with the presumed flowering date. It will then be easier to identify the acacia stands to be surveyed.

3. Figure: Acacia forest before flowering in tru color optical satellite image.

4. Figure: The same acacia forest during the flowering. Clearly visible whiteish patches appeared on the forest.

3. Sunflower (Helianthus annuus), a plant with significant industrial and apicultural benefits, the main use for the oil that can be extracted from the seeds. The quality of its flowering is partly influenced by the weather, with the main influence being on the length of flowering, which lasts 2 weeks in average, but in rare cases may last up to one month. Varietal honey is difficult to collect from the flower, as several field plants (such as the stitchwort (*Stachys annua*), which is typically found in pastures and wheat fields) flower at the same time as the sunflower, and is therefore usually sold as mixed flower honey. It is the last of the three major bee pastures in Hungary to flower, so it plays an important role in preparing bees for winter.

5. Figure: Sunflower flowering in satellite image. During flowering, a yellowish-green colour appears on the otherwise green-coloured board.

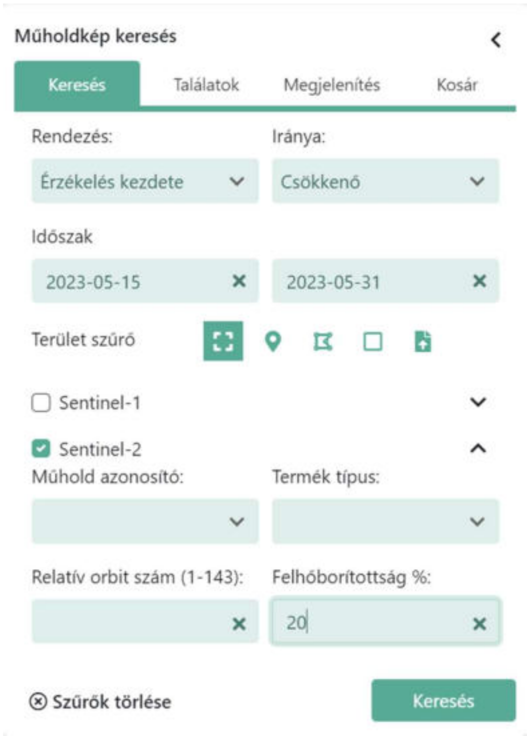
6. Figure: Sunflowers blooming. Because the flowers are not fully upward facing, they do not look as spectacular in satellite images as in rape flowering.

II. DATA

The focus of my research is the mapping of honeybee pastures in Hungary, using the SENTINEL-2 satellites of the SENTINEL satellite family, developed by the European Space Agency's (ESA) Copernicus Programme. SENTINEL-2 is a pair (2A and 2B) of high-resolution earth observation satellites equipped with multispectral sensors, which are phased at 180° to each other and orbit in a sun-synchronous orbit [3]. The satellites have a return period of 10 days, so they take images of the same area in every 10 days, but because they are in pairs, images of the same area are available every 5 days. One of their missions is to monitor the Earth to gather information for agriculture, forestry and to track changes in the Earth's surface cover. By using multispectral sensors, it captures images in 12 bands of visible light, near infrared and mid-infrared part of the spectra, The images are freely availably via Interned [3]. For my project I will mainly use the visible light range (400 nm - 700 nm). The aim of my research is to create a map that will cover the whole of Hungary, provide beekeepers with statistical information and be openly accessible to them.

The source of the data is the Earth Observation Information System ("FIR") [4], from which I downloaded the satellite images. The FIR is operated by Lechner Tudásközpont Nonprofit Ltd (LTK), the Government Agency for Information Technology Development (KIFÜ), the National Infocommunication Service Company (NISZ) and the Digital Government Agency (DKÜ). The website is open to the public and free of charge. The aim of the website is to pre-select the Sentinel images that cover the territory of

Hungary and to make them available in the national projection system of Hungary (EOV). Before downloading, the user have to select the satellite images he/she wants to download (in our case Sentinel 2), select the period and select the interested area. The selection can be made on the current viewpoint, on a specific point, draw a polygon or a simple rectangle, or even upload a shape file of its own that selects the area to be searched. The result can then be filtered. For each type of satellite you can apply different filters. For Sentinel 2, you can filter by satellite ID (Sentinel 2A, or Sentinel 2B), product type, relative orbit number, and maximum tolerance for cloud cover in percent.



7. Figure: Detail of the FIR query graphical user interface

Images can be previewed before downloading, either in real colour or in false color. When downloading, the user also have the option to pre-select which bands he/she want to download.

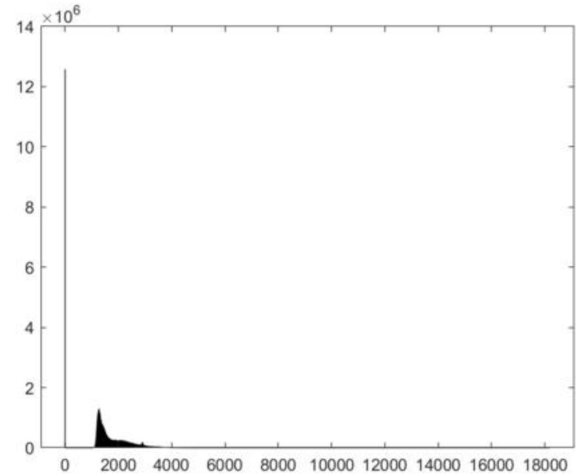
III. METHODOLOGY

I started processing the data in Matlab, with using the "Mapping Toolbox" add-on. With the Mapping Toolbox, I was able to call up GeoTIFF files previously downloaded from FIR's system and retrieve descriptive data from them. The scanned GeoTIFF files were stored in Matlab in 3-dimensional matrixes. I first selected the bands that were of interest to me and then viewed the histograms of those bands. Based on the histograms I plotted, I decided which range of values for the bands was the most relevant, and I rescaled the distribution of values between the minimum and maximum values of the range using the "rescale" command [6]. The rescaling was necessary to make the images interpretable, without the process, the images are very dark and practically uninterpretable (this process is called histogram equalization).

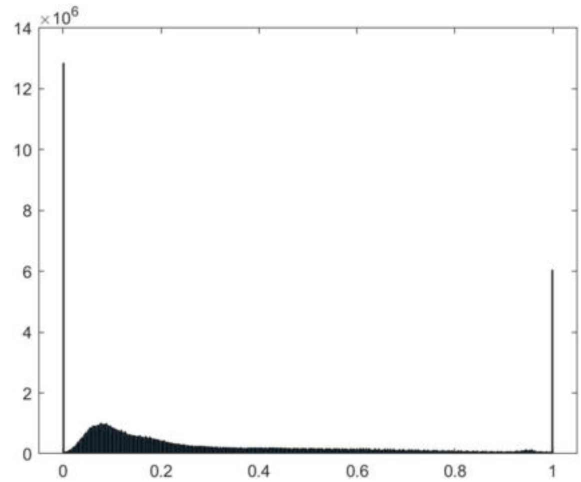
After the rescaling was done, I can start analysing the images. I started by detecting the bee pastures.

For this I had the help of several beekeepers, (including István Böröcz, personal communication), who provided me with coordinates of the bee pastures they grazed during the beekeeping season. I analyzed each flowering periodically, at times before, during, and after bloom.

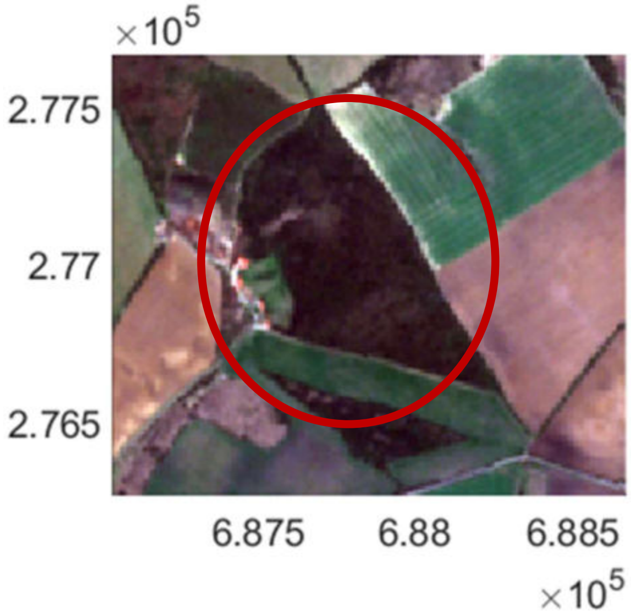
Using the Mapping Toolbox I was able to display the scanned images in EOV coordinate system. First I located the area in the image where the bloom was visible. Then, using the "ginput" command, I subtracted two EOV Y and X coordinates, which formed two opposite corners of a square. I then used the "mapcrop" command to crop the square, and then used the same EOV coordinates to crop the same area from the other satellite images.



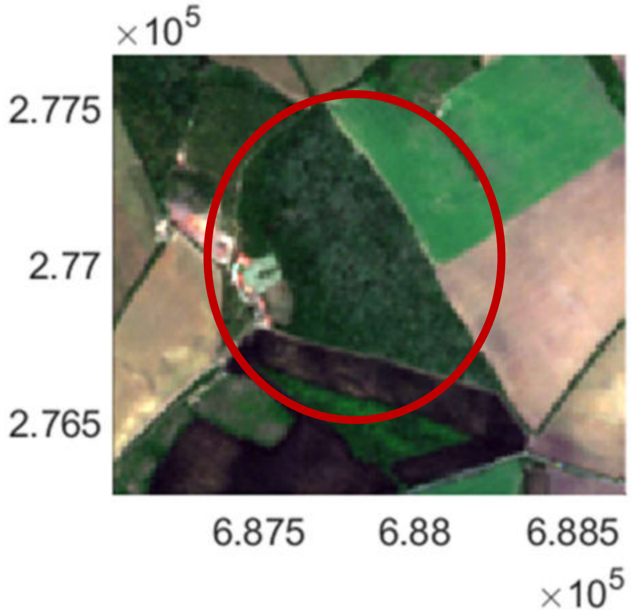
8. Figure: Histogram of the red band (B4)of one of the satellite images in Matlab, before the rescaling. It can be clearly seen that there is a huge value area within the band, but the significant values are between 1100 and 3000. In Sentinel-2 images, the grayscale values are stored in 12 bits, so their values range from 0 to 4095. However, as observed in the diagram, the images downloaded from the FIR system can exhibit grayscale values over a much larger range. Nevertheless, I have not found an explanation for this wider range within the FIR system.



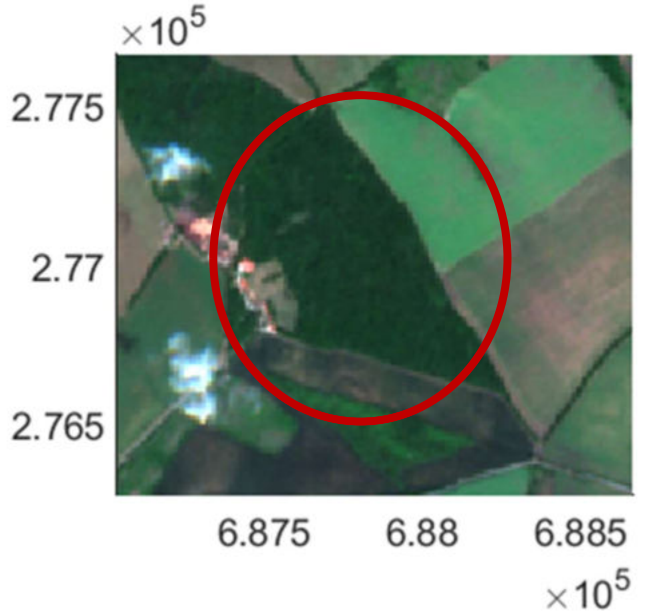
9. Figure: The same satellite image histogram, after the rescaling. The values are clearly distributed between 0 and 1.



10. Figure: Acacia forest surveyed as seen on SENTINEL-2 true color satellite image, in spring (04.02.2020) before flowering, near Szirák (north Hungary). Map coordinates are in EOV coordinate system



11. Figure: The same acacia forest as on Fig. 11. during the flowering period of the examined acacia forest (05.22.2020). The whitish spots are the trees, while darker spots represent tree shadows.



12. Figure: The same acacia forest as on Fig. 11 and 12. after flowering (06.06.2020.). In the forest, observable white patches have disappeared.

IV. Discussions

In Hungary the primary bee pastures are rape, white acacia and sunflower. They can be identified from satellite imagery, but, with the exception of rape, this task requires the analysis of several images. Because satellite images are not always taken of the same area, it is not possible to select the areas to be analysed using image coordinates, and it is necessary to use Georeferenced images. Matlab makes it easier to process satellite imagery, but because of its many functions, it is essential to use the Mapping Toolbox, which allows Matlab to handle projection systems and perform various mapping operations, such as map cropping. Thanks to the Matlab Mapping Toolbox, I could display the original image in a projection system and then to select the boundaries of the area to be cropped on the map, which can be used to perform the cropping on other images without the need to locate the area again. I have saved the resulting crops in GeoTIFF format so that I do not have to create new crops for later parts of the work.

In the future, I intend to use the clippings for a machine learning system to automate the extraction of the searched areas, and to link the resulting data to the Hungarian Beekeeping Geospatial Support System [7]I developed earlier in the form of a WMS service.

V. References

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