Interpretation of Remote Sensing Imagery

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Abstract. The process of interpretation and analysis of remote sensing data is based on extracting meaningful information from satellite imagery. The quality of visual interpretation depends on the resolvability and recognisability of the main visual characteristics of each photo or images. The current process of image analysis is based on digital processing limited by used satellite or airborne sensors.

1. Introduction

Interpretation of remote sensing imagery follows the image processing phase and represents the process of reading and analysing the satellite image. The methods of interpreting an image depend on the type of recorded file, resolution, and quality of the displayed data. In the past, the identification and analysis of objects were performed directly on the photographic image. Currently, image data interpretation is realized by many software applications, which are controlled by visual techniques depending on the type of record (digital or analogue). Software applications allow to evaluate the digital recording or digitize the older analogue one. Interpretation is a reconstruction of a record, which is performed by a band-interleaving system, where the record is stored line by line and pixel by pixel or sequentially in individual bands, where the record is stored by a band, first-line then the next and then another band or the record is stored sequentially in all bands, the first pixel then the second, the third, and so on. Although digital interpretation is faster, more accurate and more convenient, it does not fully replace visual and manual interpretation. Manual interpretation usually follows the digital analysis of the record and consists of corrections to the digital file.

2. Visual image interpretation

Visual interpretation of satellite imagery is based on the recognition of imagery objects. Visual identification of objects in vertical air photos normally requires a ground sample distance 3-5 times smaller than the object itself. For example, to positively identify a house with dimensions of 10 m x 10 m, the camera system needs a ground sample distance of 2-3 m. Generally, these are the main characteristics, which are assumed to be interpreted and analysed in air photos [1, 2]:
• **Tone or colour.** Grey tone and colour are how we recognize and distinguish objects. The tone or colour of an object helps to separate it from other features in the scene, especially from features with high contrast. Colour may be an important item to the object’s identity of water, soil, vegetation, rocks, etc.

• **Shape.** Natural shapes tend to follow the lay of the land. Human shapes, on the other hand, are often geometric with straight lines, sharp angles, and regular forms. In one single image, only 2D shapes can be appreciated fully. In stereo images, the full three dimensions become apparent.

• **Size and height.** Absolute size and height are important items that depend on the scale of the image. Some object sizes result from common experience, for example, a car, tree, and house. But many objects seen on images are not so obvious, and height may be difficult to judge in vertical images. Always check the image scale for a guide to object size.

• **Shadow.** Shadows can be useful for identifying objects, as seen from above. Trees, buildings, animals, bridges, and towers are examples of features that cast distinctive shadows. Shadows on the landscape also help with depth perception. Images without shadows often seem “blank” and difficult to interpret.

• **Pattern.** The spatial arrangement of discrete objects may create a distinctive pattern. This is most apparent for cultural features, for example, city street grids, airport runways, and agricultural fields. Patterns in the natural environment also may be noticeable in some cases, for example, bedrock fractures, drainage networks, and dunes.

• **Texture.** This refers to group objects that are too small or too close together to create distinctive patterns. Examples include tree crowns in a forest canopy, individual plants in an agricultural field, ripples on a water surface, grave sheets of different grain size in a river bed, etc. The difference between texture and pattern is largely determined by image scale.

• **Context.** The association and site location of objects are often important for aiding interpretation. Note land cover and land use as items to help identify related features in the scene, and refer to existing maps or census data for ancillary information. This is often a matter of common sense and experience for image interpretation.

3. **Digital processing of image data**

Radiation reflected from the earth's surface passes through the optics and is then divided into individual parts of the electromagnetic spectrum using a beam splitter. The radiation (intensity) is converted into an electrical signal and the measured value of the electrical signal is changed by convector (assignment of a numerical value) to a digital image value corresponding to one pixel. These values are recorded in a suitable format in binary code. The raw data from the satellites have any distortions that have to be compensated before the analysis and interpretation. The process of raw data compensation is based on two types of appropriate corrections: radiometric and geometric.

The radiometric corrections mainly aim at minimizing errors related to the sensor, calibration of the sensor, the state of the atmosphere, changes related to the season, etc. The main radiometric corrections are as follows:

• reconstruction of periodic row outages (banding),
• removal of noise and atmospheric influences,
• sun height and distance correction,
• conversion of digital expression of brightness to absolute radiation values,

Radiometric correction is performed to calibrate pixel values and to correct their errors. This process improves the interpretability and quality of remote sensing data. Radiometric calibration and corrections are especially important when comparing multiple data sets over some time. The energy recorded by sensors in aircraft or satellite may differ from the actual energy emitted or reflected from the surface on the ground. It is caused by the azimuth of the sun, altitude and atmospheric conditions that may affect it.
energy observed by the sensor. Therefore, to obtain actual values of ground radiation or reflection, radiometric errors must be taken into an account.

For example, LANDSAT MSS records 6 lines of the image using 6 sensors at the same time. If any sensor does not work, every 6th line has zero values (periodic line failures). LANDSAT (TM) records 16 lines. MSS 6, all calibrated for sensitivity. Sensitivity impairment causes periodic banding [3,4].

The purpose of geometric corrections is to minimize or eliminate the facts affecting the geometry of the image record. The geometric corrections involve compensation of remote sensing data from the following parameters:

- Earth’s motion. Due to the rotation of the Earth, the assumed rectangular shape of the captured scene is therefore skewed.
- Satellite deck movement. Undesirable changes in the orientation of the satellite deck (carrier) in the direction of the three axes (tilt in the direction of flight, perpendicular to the direction of flight and rotation). These vibrations cause problems in scoring the viewing angle of individual sensors.
- Sensor movement. Ideally, the movement of the scanning mirror in the west-east and back directions should be constant, but this cannot be physically ensured. As a result of this uneven movement, discontinuities occur in the rows of the raw scene. Adjacent image elements (pixels) are not spaced at constant intervals (30 m) from each other.
- Location of the detector in different focal planes. The positions of individual detectors for spectral bands are in the primary so-called cold focal plane differently, and therefore there is a shift between the individual raw image channels. When creating syntheses, such input data would be unusable because the bands could not be loaded on top of each other. The correction of this distortion is in principle simple, because the geometry of the focal planes is known, and thus this distortion can be compensated in the pre-processing stage.
- The curvature of the Earth. The sensor records the image of the Earth as a 2-dimensional, but it is a 3-dimensional surface, so the image recording does not geometrically correspond to reality. The consequence of the curvature of the Earth can be removed by redrawing into the selected cartographic projection (e.g. UTM, Gauss Krueger, Křovák, etc.). When redrawing itself, the nearest neighbour method or cubic convolution is used for the algorithm for calculating the new pixel value. Redrawing is a critical stage that will significantly affect the quality of the image. It also meets the two natures of the correction, and therefore the requirements for the final products need to be considered in advance.

4. Interpretations of Specific Remote Sensing Imagery
When interpreting satellite images, image resolution plays an important role. According to particular applications, the resolution of remote sensing images can be divided into three types: spectral resolution, spatial resolution, and time resolution.

The detail of the identification depends on the spectral resolution. When evaluating images of a forest stand, where it is assessed e.g. infestation of the forest by pests, broadband images will not be entirely appropriate, as they may not capture the colour change of the damaged stand as narrow spectral images or single-band images. Spatial resolution is important in detailed mapping, where the populated areas shown in the images do not require as high detail as agricultural areas with a recognizable culture or in assessing irrigation needs. Time resolution is not so important e.g. when interpreting geological structures, on the contrary, when assessing hazard or water regime, the time resolution is of the utmost importance [5, 6].
4.1. Interpretation of Vegetation
Fauna belongs to a very important area, which needs remote sensing data interpretation and analysis. The condition of vegetation, pest infestation, the need for irrigation or a change in growth is just some of the phenomena that we can capture by classifying and interpreting the radar images. The radiation can capture the water content of vegetation and discolouration caused by non-standard influences. When finding the so-called vegetation stress or damage uses infrared wavelengths that capture the change in crop structure or colour caused by a decrease in chlorophyll.

4.2. Interpretation of Forestry
Forest companies use hyperspectral imagery for mapping of land cover in the forest region of interest. The example of the interpretation of forest remote sensing imagery is shown in Figure 1, which represents the land cover map contains the following classes that differ in colour or shade:

- dark green represents coniferous stands,
- green means lower branches,
- light purple represents gravel,
- yellow represents deciduous,
- orange means dry ground cover,
- red means wet ground cover,
- light blue means water,
- dark blue means deep or clear water.

![Figure 1. Land cover map obtained by the compact airborne imaging spectrometer [7]](image)

4.3. Interpretation of Geology
Radar images of remote sensing are a suitable means of obtaining information about the geological structure of the earth, which will give a picture of surface and subsurface sources of minerals, rocks, sediments, etc. An important piece of information obtained from radar images is a change in the magnetic field, which also accompanies a change in the structure of the earth's subsurface layers [8].

4.4. Interpretation of Hydrology
Images from remote sensing of the earth are a suitable source of information on the hydrological conditions of the landscape, the level of groundwater, the degree of humidity of the ground cover, flood monitoring. The most widely used and suitable satellite system used to interpret hydrological conditions is RADARSAT, which provides images with high sensitivity to water even in the dark or in high clouds [9].
5. Conclusions
In common, the quality of remote sensing data interpretation and analysis depends on positional and thematic accuracy. The positional accuracy determines how close is the position of discrete objects shown on an image in comparison with true position. The thematic accuracy depends on the attributes derived from radiometric information. The most used method to define positional accuracy in any geodetic output is a comparison of identical points with a known position [10]. In case the number of control points is not sufficient or their spatial distribution is suboptimal, the use of generic features such as roads, edges, polygons, etc. is very suitable. Assessment of the thematic accuracy of remote sensing imagery is based on creating an error matrix based on statistics, which compare the output of a classifier and known test data. These statistics include overall accuracy, individual class accuracy, user's and producer's accuracy, and several other statistics.

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