REMOTE SENSING TECHNOLOGY THROUGH THE PRISM OF YEARS

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SAR is an active radar system that emits and receives its own signals, allowing it to obtain images of the Earth's surface in any weather conditions. This technology became an innovation only half a century ago. It opened up new opportunities for accurate research of land relief in hard-to-reach places, analysis of vegetation cover, and much more. Currently, SAR is a common method of remote sensing. And the comprehensive implementation of artificial intelligence opens up great prospects again. Interestingly, it all started with the introduction of microwave sensing into radar systems and satellites (Hajnsek, 2021).

In the 1950s, SLAR (side-looking airborne radar) was invented—an early radar system, i.e., an antenna mounted on the fuselage of an aircraft. The technology involved the use of a cathode ray tube with phosphorus. The system operated at different frequencies but had severe limitations in terms of antenna length. To obtain clear images, an antenna hundreds of meters long would be required. Despite its low resolution, SLAR technology was still in demand, especially in the military sphere. In particular, the use of microwave radiation made it possible for the first time to penetrate clouds almost unhindered (Ulaby, 1986, p. 7).

It is clear that a completely different approach is needed to improve the images. This raises the question of integrating microwave scanning, applying the principles of coherent interference, and, most importantly, processing the recorded reflected signals. The combination of these methods would make it possible to distinguish between different types of land cover: fields, forests, snow cover, ice, etc. However, analyzing the information obtained after the waves are reflected from the surface requires complex mathematical logic and computer calculations. But, ultimately, over the next 30 years, this becomes possible. As the satellite or aircraft moves, a short physical antenna sends pulses from different points along the trajectory. Then, thanks to the preservation of phase information, computer processing “synthesizes” all the signals received as if they were recorded by one huge virtual antenna. This is how, in the 1980s, a new satellite with a SAR (Synthetic Aperture Radar) was launched. It marked the beginning of a new era of remote sensing based on active instruments (Ulaby, 1986, p. 9).

Today, SAR is a powerful tool for comprehensive assessment of land cover, vegetation detection, soil analysis, relief, etc. All this has become possible thanks to polarimetry and interferometry technologies. The signal that the SAR device sends to Earth is scattered differently depending on the type of surface. This type of data can be used, for example, to assess the impact of military actions on the environment or infrastructure.

It has been found that metal structures respond better to SAR signals, so debris of this material will appear more clearly in images. This can be illustrated by the example of SAR data before and after the bombing of the Azovstal plant (Copernicus Open Access Hub, 2022):

Fig. 1

The use of different polarization channels, such as VV, VH, etc., allows for the analysis of territories depending on their type (NASA Earth Science Data Systems, 2021).

The future of SAR technology looks promising. Currently, machine learning is being implemented for the analysis and processing of radar system image data. This will allow even the smallest objects to be distinguished, even at low resolution. Synthetic aperture antennas have complex geometric configurations, and image data processing still requires resource-intensive calculations. This creates a basis for further improvement of SAR technology. Multi-channel operation (polarimetry, multi-frequency), enhanced range and azimuth resolution, time series (repeated revisits of the same area), and observation angle diversity (interferometry and tomography) can all help achieve the higher information content in SAR images that is required by the trend for future systems (Hajnsek, 2021).

References:

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