

Abstract

Since the early 1950s, Poland has been regularly photographed from the air for both military and civilian purposes, primarily for cartographic use. Until the mid-2000s, all of these images were analog, captured on roll film. These materials are archived in the State Geodetic and Cartographic Resource, which holds approximately two million photographs in total. This is an extensive collection, offering an exceptionally detailed visual record of the Polish landscape over several decades. Their scientific value is considerable—they can help us understand how the environment has changed over time: how land use has evolved, how natural habitats have disappeared, or how urban areas have expanded.

Unlocking this potential, however, presents several challenges. Many of the images are of limited quality compared to modern data acquisition methods, and their utility may have been further diminished by suboptimal storage conditions or late digitization. Nevertheless, aerial photographs possess qualities that make them unique among spatial data sources—especially in terms of temporal availability (the oldest materials date back nearly a century), high spatial resolution (in Poland typically 20–50 cm, compared to the 80 meters of the first Landsat satellite in 1972), and consistent coverage—many areas were photographed every 5 to 10 years, enabling multitemporal analyses.

Despite these advantages, archival aerial photographs remained largely underutilized in scientific research for decades. This was primarily due to technical constraints: lack of metadata for image orientation, missing information on camera specifications, limited availability of ground control points, and difficulties in accurately georeferencing the images. Today, however, this situation is changing rapidly thanks to advances in digital photogrammetry and artificial intelligence. Progress in image processing and interpretation—especially through deep learning—is opening new avenues for analyzing these historical data.

Photogrammetry, derived from the Greek words *photo* (light), *gramma* (to describe), and *metron* (to measure), is a discipline concerned with measuring and describing the environment using light (electromagnetic waves). When combined with advanced machine learning techniques, it enables an entirely new perspective on archival materials. These tools make it possible to automatically extract environmental and landscape information that would have once taken experts years to analyze manually. The aim of the project is to explore methods that significantly automate the processing and analysis of archival aerial photographs taken over Poland since the early 20th century—images that until now have been used primarily by specialists and only in a limited capacity. Today, with the development of artificial intelligence technologies and analytical methods, it is becoming possible to process these data precisely and extract vast amounts of information about how the landscape—nature, built environment, and land cover—has changed over the course of many decades.

The research will employ state-of-the-art image analysis methods, including convolutional neural networks (CNNs) for semantic segmentation and object detection tasks, as well as Generative Adversarial Networks (GANs) for colorizing grayscale images and enhancing spatial resolution. These algorithms will make it possible to generate maps that illustrate how the landscape in a given area has changed over time—for example, where forests have expanded, wetlands have disappeared, or urban development has intensified. To enable such analyses, the archival materials must first undergo a series of preparatory steps, including contrast and color enhancement, followed by their transformation into coherent image mosaics and 3D models, which will serve as the basis for further investigation.

The project will also explore whether additional image processing—such as colorization (converting grayscale imagery to RGB) or resolution enhancement (improving both the spatial and geometric detail of features)—can improve the recognition of specific land cover classes and objects, and ultimately support more accurate detection of changes between image collections from different time periods.

As a result, the planned research aims not only to deliver specific outcomes—such as identifying models that improve automated detection of land cover changes or evaluating the quality of segmentation in archival imagery—but, more importantly, to deepen scientific understanding of the potential, limitations, and value of historical aerial data. The project is exploratory in nature: it seeks to advance knowledge of how, and to what extent, meaningful environmental information from the past can be extracted from archival materials, and what technical and methodological conditions determine the success of such analyses. This insight may, in the future, support broader environmental research, but its core contribution lies in recognizing the scientific utility of long-acquired data and advancing the methods used to analyze them.

The findings will have universal relevance—the methods developed in this project can eventually be applied to archival aerial imagery from other countries, regions, or time periods. As such, the project contributes to a broader, global interest in historical landscape imaging and long-term environmental change. A deeper understanding of the dynamics of natural systems over time—enabled through the analysis of past imagery—has the potential to inform diverse academic fields, from geography and history to nature conservation and climate science.