

RASTER IMAGE FILE FORMATS FEATURES AND PERFORMANCE ANALYSIS SOFTWARE

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In the digital era, raster images are essential for communication and art, spanning web, social media, photography, medical imaging and more. A wide array of formats exists (e.g., JPEG, PNG, GIF, TIFF, WebP), developed with different goals and employing distinct compression techniques. These differences cause significant variations in file size, visual quality, supported features, and computational requirements. However, end-users and creators often lack clear information to select the format most appropriate for their needs. The continued use of older formats like JPEG and PNG, despite the efficiency advantages of newer codecs like AVIF and JpegXL, indicates a lack of practical understanding and accessible tools, hindering their adoption. Suboptimal format choices can lead to unnecessarily large files, slower loading times, wasted storage, or compromised visual fidelity. Therefore, a systematic analysis of modern formats and the development of tools for informed decision-making are highly relevant.

The goal of the research is to conduct a comprehensive comparative analysis of the features, underlying compression technologies, and performance characteristics (compression efficiency, visual quality, encoding/decoding speed) of prominent raster image file formats, and to conceptualize a software tool that enables users to perform practical comparisons and select optimal formats based on defined criteria.

The object of research are the properties, capabilities, and performance trade-offs inherent in various raster image file formats, including both traditional (JPEG, PNG, GIF) and modern (WebP, AVIF, JpegXL) standards.

The subject of research are methods and metrics for evaluating image file formats, encompassing analysis of compression algorithms, comparison of feature support, and assessment of performance based on file size, objective quality metrics (e.g., SSIM, PSNR), and computational cost. The conceptual framework for a software application designed to automate and visualize these comparisons.

Background and Overview. Raster image formats have evolved significantly, from early formats like BMP that stored uncompressed pixel data, to compressed ones like GIF that utilized lossless compression (LZW), JPEG, which revolutionized photographic image storage by using lossy Discrete Cosine Transform (DCT) based compression, and PNG, which emerged as a lossless alternative, particularly strong for graphics with transparency, using DEFLATE compression (LZ77 + Huffman coding).

Modern formats like WebP, AVIF, and JpegXL build on this, offering improved compression and features using advanced techniques. AVIF, based on AV1, excels at lower bitrates and supports HDR, while JpegXL is a versatile format aiming to supersede older ones with excellent compression and features like progressive decoding.

Despite the technical advantages adoption of formats like AVIF and JpegXL is slow due to familiarity, browser/software support, and inertia favoring the well-established JPEG and PNG formats. Furthermore, objective comparison is challenging as "quality" settings differ across formats. Effective comparison requires targeting either a specific perceptual quality level (e.g., SSIM) or a specific file size budget, and then evaluating the resulting size or quality, respectively.

Currently, there is a lack of accessible, user-friendly tools that perform such nuanced, multi-format comparisons directly. Users often rely on incomplete or misleading advice, outdated guidelines, or simple trial-and-error, which may not yield optimal results. This research aims to address this gap by first performing a structured theoretical and empirical analysis of the formats and then conceptualizing a software tool based on these findings.

Proposed Software Concept. To bridge the gap between theoretical format knowledge and practical application, this project includes the conceptualization of a desktop software application. The primary purpose of this tool is to serve as an analytical instrument, allowing users to make data-driven decisions about image format selection. The core workflow involves the user loading a source image, selecting a set of target formats for comparison (e.g., JPEG, PNG, WebP, AVIF, JpegXL), and choosing a comparison mode. Potential modes include:

- **Target Visual Quality:** The user specifies a desired quality level, and the tool finds the smallest file size for each format achieving that quality.
- **Target File Size:** The user specifies a maximum file size, and the tool finds the best achievable quality for each format within that constraint.
- **Fixed Encoder Settings:** The user provides specific settings (such as quality, effort), allowing direct comparison of format behavior under fixed parameters.
- **Lossless Comparison:** Based on resulting file sizes, compares formats capable of lossless compression when complete preservation of source data is crucial.

The software would perform the necessary encoding operations using underlying codec libraries, measure key metrics (file size, calculated SSIM/PSNR, encoding time), and present the results in a clear, comparative table alongside visual previews (original vs. encoded, side-by-side comparisons). This allows users to objectively assess the trade-offs and select the format that best balances quality, file size, and features for their specific image and use case, ultimately aiding in optimizing storage, reducing bandwidth usage, and improving user experience.

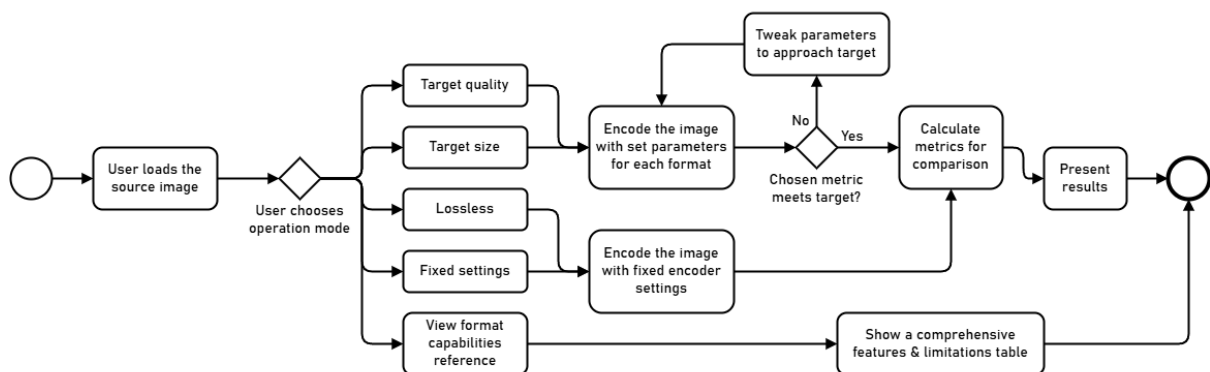


Fig. 1. Conceptual workflow of the proposed image format analysis software

Conclusion. Understanding the nuances of raster image file formats is crucial for efficient digital media handling. This research provides a necessary comparative analysis of modern formats, evaluating their technological underpinnings and performance characteristics. The conceptualized software tool offers a practical application of this research, empowering users with the ability to make informed, optimized choices regarding image format selection, contributing to better resource management and enhanced digital experiences.

LIST OF SOURCES

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**НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ БІОРЕСУРСІВ І
ПРИРОДОКОРИСТУВАННЯ УКРАЇНИ
ФАКУЛЬТЕТ ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ**



ТЕОРЕТИЧНІ ТА ПРИКЛАДНІ АСПЕКТИ РОЗРОБКИ КОМП'ЮТЕРНИХ СИСТЕМ

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