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JasPer: A Portable Flexible Software Toolkit for Image Coding/Processing

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Summary

The use of digital imagery by computer software is pervasive. Therefore, many application programs and libraries have a need to represent images as well as encode and decode image data in a variety of formats. Consequently, a very strong need exists for software packages that can provide such functionality. In what follows, we present one such software package, known as JasPer.

JasPer (*JasPer Project Web Site*, 2024) is a portable flexible open-source software toolkit for handling image data. It consists of a library and several application programs that use this library. The code is written in the C programming language (*ISO/IEC 9899*, 2011). The JasPer library provides a means to represent and manipulate images, as well as encode and decode image data in a variety of formats. Native support is provided for several commonly-used image formats, including:

- JPEG-2000 file (JP2) and codestream (JPC) (*ISO/IEC 15444-1*, 2000)
- Portable Graymap/Pixmap (PNM) (Netpbm contributors, 2013)
- Microsoft Bitmap (BMP) (Wikipedia contributors, 2024a)
- Sun Rasterfile (RAS) (Wikipedia contributors, 2024b)
- JPEG-2000 Verification Model (PGX) (*ISO/IEC 15444-4*, 2002)

In addition, a few other image formats are supported non-natively (i.e., with some assistance from external libraries), including JPEG (*ISO/IEC 10918-1*, 1994) and HEIC (*ISO/IEC 23008-12*, 2022). The JasPer library supports multithreaded applications. It is also highly configurable, allowing a number of key parameters and callbacks to be specified by the library user (e.g., for custom memory allocation and logging). The library is also extensible, providing an application programming interface (API) whereby additional user-defined codecs can be employed with the library. The JasPer software provides several application programs, including:

- jasper, an image transcoder program for converting between image formats;
- imginfo, a program for querying the properties of an image, such as: width, height, number of components, and the number of bits per sample;
- imgcmp, a program for comparing two images using various distance metrics, such as peak absolute error (PAE), mean absolute error (MAE), and peak signal to noise ratio (PSNR); and
- jiv, an image viewer.

The JasPer software has detailed documentation in the form of a (Doxygen-generated) manual, which includes specifications of all of the key APIs provided by the library as well as descriptions of the command-line interfaces used by the application programs. The online manual for the most recent release of JasPer (as well as numerous past releases) can be found at (*JasPer Reference Manual*, 2024).

Portability has been a primary consideration in the development of JasPer. This software was designed to make minimal assumptions about the compile- and run-time environments, and should compile and run on any platform with a C language implementation that is reasonably compliant with the C11 standard (*ISO/IEC 9899*, 2011) and has some limited support for the POSIX C API (*ISO/IEC 9945*, 2009). The JasPer software is known to work on many platforms, including Unix/Linux, Windows, macOS, and WebAssembly (WA) runtimes with WA System-Interface (WASI) support (*WebAssembly Core Specification*, 2019) (*WASI*, 2024).

The JasPer software is available under an open-source license that is based on the well-known BSD license. The license used by JasPer is listed as an officially approved open-source license by the Fedora Project (Fedora Project, 2024) and OpenSuse (openSUSE, 2024). Moreover, JasPer is used in many open-source projects, and has been packaged for many Linux distributions (e.g., Fedora, openSUSE, Gentoo, Arch, Red Hat Enterprise Linux, SUSE Linux Enterprise Server, and Amazon Linux), numerous BSD variants (e.g., FreeBSD, NetBSD, and OpenBSD), NixOS, Homebrew (Homebrew Project, 2024) (for macOS), and Conan (Conan Project, 2024).

A Brief Historical Perspective

The JasPer software has long history, spanning over two decades. The author of this paper is also the primary author of JasPer and has been responsible for all major feature development for this software over the years. The JasPer software was initially developed in order to provide an open-source implementation of the JPEG-2000 Part-1 codec as well as a portable and extensible software framework for image representation, encoding, and decoding. Work on the software began in September 1999, and in December 2000, the software was first released in source code form to the general public. In approximately 2002, the JasPer software was published in the JPEG-2000 Part-5 standard (*ISO/IEC 15444-5*, 2002) as an official reference implementation of the JPEG-2000 Part-1 codec (*ISO/IEC 15444-1*, 2000). The very early versions of JasPer were briefly discussed in the two conference papers (Adams & Kossentini, 2000) and (Adams & Ward, 2004), which were co-authored by the author of this paper. Since that time, the JasPer software has continued to evolve with many major improvements being made over the years, such as adding support for multithreading, memory-usage limiting, and greater configurability. In September 2016, JasPer development transitioned from using a private local repository to a public Git repository hosted by GitHub (*JasPer GitHub Page*, 2024). Since its initial creation, this public Git repository has accumulated over 1500 commits. In recent years, the JasPer project has placed a much greater emphasis on security, with many code changes having been made to improve the resilience of the software to attacks by bad actors and a high priority being placed on timely bug fixes for reported security vulnerabilities.

Statement of Need

Digital imagery is used in a great many research areas, including image processing, computer vision, digital forensics, AI image synthesis, geographic information systems, remote sensing, biology, and medicine, to name but a few. For this reason, the functionality provided by JasPer is of potential interest to a great many researchers.

To date, JasPer has been used in many research projects and has been cited in many papers in the research literature. The two conferences papers (Adams & Kossentini, 2000) and (Adams & Ward, 2004) (mentioned earlier) that briefly discuss the very early versions of JasPer (circa 2000–2004) are quite well cited. For example, as of the time of this writing (February 2024), Google Scholar indicates that (Adams & Kossentini, 2000) and (Adams & Ward, 2004) have 306 and 66 citations, respectively. Since digital imagery is used in many research disciplines, the uses of JasPer for research purposes is quite varied. For example, JasPer has been used for research in areas related to JPEG 2000 (Menichelli et al., 2011; Yeung & Au, 2005), image coding (Rubino et al., 2019; Verhack et al., 2015), watermarking (Nasir et al., 2008),

steganography (Sae-Tang et al., 2014), image processing (Park et al., 2011), wavelet/subband transforms (Chung et al., 2022; Wong et al., 2007), biometrics (Wu et al., 2015), microscopy (Corredor et al., 2015; Gómez et al., 2007), medical imaging (Falcón-Ruiz et al., 2010), and deep space communications (Bisio et al., 2010). JasPer is also used by other software packages that are often used for research purposes, such as the Open Computer Vision Library (OpenCV) (*OpenCV Web Site*, 2024). All of the above demonstrates that JasPer has been clearly beneficial to the research community.

Since native JPEG-2000 support is often one of the features of JasPer that motivates its use, we would like to note, in passing, that another open-source implementation of the JPEG-2000 codec can be found in the OpenJPEG software (*OpenJPEG GitHub Page*, 2024). At present, however, the OpenJPEG software is not as well maintained as JasPer, with OpenJPEG having a very large number of unresolved bugs, some of which are associated with security vulnerabilities that are quite old. Moreover, at the time of this writing, the last official release of OpenJPEG (namely, 2.5.0) on GitHub is dated May 13, 2022, which is almost two years ago.

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