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Other documentation files in the distribution are:

User documentation:

install.doc How to configure and install the IJG software. Usage instructions for cjpeg, djpeg, jpegtran, rdjpgcom, and wrjpgcom. usage.doc *.1 Unix-style man pages for programs (same info as usage.doc). Advanced usage instructions for JPEG wizards only. wizard.doc change.log Version-to-version change highlights. Programmer and internal documentation: libjpeg.doc How to use the JPEG library in your own programs. Sample code for calling the JPEG library. example.c structure.doc Overview of the JPEG library's internal structure. filelist.doc Road map of IJG files. coderules.doc Coding style rules --- please read if you contribute code.

Please read at least the files install.doc and usage.doc. Useful information can also be found in the JPEG FAQ (Frequently Asked Questions) article. See ARCHIVE LOCATIONS below to find out where to obtain the FAQ article.

If you want to understand how the JPEG code works, we suggest reading one or more of the REFERENCES, then looking at the documentation files (in roughly the order listed) before diving into the code.

OVERVIEW _____

This package contains C software to implement JPEG image compression and decompression. JPEG (pronounced "jay-peg") is a standardized compression method for full-color and gray-scale images. JPEG is intended for compressing "real-world" scenes; line drawings, cartoons and other non-realistic images are not its strong suit. JPEG is lossy, meaning that the output image is not exactly identical to the input image. Hence you must not use JPEG if you have to have identical output bits. However, on typical photographic images, very good compression levels can be obtained with no visible change, and remarkably high compression levels are possible if you can tolerate a low-quality image. For more details, see the references, or just experiment with various compression settings.

This software implements JPEG baseline, extended-sequential, and progressive compression processes. Provision is made for supporting all variants of these processes, although some uncommon parameter settings aren't implemented yet. For legal reasons, we are not distributing code for the arithmetic-coding variants of JPEG; see LEGAL ISSUES. We have made no provision for supporting the hierarchical or lossless processes defined in the standard.

We provide a set of library routines for reading and writing JPEG image files, plus two sample applications "cjpeg" and "djpeg", which use the library to perform conversion between JPEG and some other popular image file formats. The library is intended to be reused in other applications.



Issued: October 04, 2017

In order to support file conversion and viewing software, we have included considerable functionality beyond the bare JPEG coding/decoding capability; for example, the color quantization modules are not strictly part of JPEG decoding, but they are essential for output to colormapped file formats or colormapped displays. These extra functions can be compiled out of the library if not required for a particular application. We have also included "jpegtran", a utility for lossless transcoding between different JPEG processes, and "rdjpgcom" and "wrjpgcom", two simple applications for inserting and extracting textual comments in JFIF files.

The emphasis in designing this software has been on achieving portability and flexibility, while also making it fast enough to be useful. In particular, the software is not intended to be read as a tutorial on JPEG. (See the REFERENCES section for introductory material.) Rather, it is intended to be reliable, portable, industrial-strength code. We do not claim to have achieved that goal in every aspect of the software, but we strive for it.

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The Unix configuration script "configure" was produced with GNU Autoconf. It is copyright by the Free Software Foundation but is freely distributable. The same holds for its supporting scripts (config.guess, config.sub, ltconfig, ltmain.sh). Another support script, install-sh, is copyright by M.I.T. but is also freely distributable.

It appears that the arithmetic coding option of the JPEG spec is covered by patents owned by IBM, AT&T, and Mitsubishi. Hence arithmetic coding cannot legally be used without obtaining one or more licenses. For this reason, support for arithmetic coding has been removed from the free JPEG software. (Since arithmetic coding provides only a marginal gain over the unpatented Huffman mode, it is unlikely that very many implementations will support it.) So far as we are aware, there are no patent restrictions on the remaining code.

The IJG distribution formerly included code to read and write GIF files. To avoid entanglement with the Unisys LZW patent, GIF reading support has been removed altogether, and the GIF writer has been simplified to produce "uncompressed GIFs". This technique does not use the LZW algorithm; the resulting GIF files are larger than usual, but are readable by all standard GIF decoders.

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REFERENCES



Issued: October 04, 2017

We highly recommend reading one or more of these references before trying to understand the innards of the JPEG software.

The best short technical introduction to the JPEG compression algorithm is

Wallace, Gregory K. "The JPEG Still Picture Compression Standard", Communications of the ACM, April 1991 (vol. 34 no. 4), pp. 30-44. (Adjacent articles in that issue discuss MPEG motion picture compression, applications of JPEG, and related topics.) If you don't have the CACM issue handy, a PostScript file containing a revised version of Wallace's article is available at ftp://ftp.uu.net/graphics/jpeg/wallace.ps.gz. The file (actually a preprint for an article that appeared in IEEE Trans. Consumer Electronics) omits the sample images that appeared in CACM, but it includes corrections and some added material. Note: the Wallace article is copyright ACM and IEEE, and it may not be used for commercial purposes.

A somewhat less technical, more leisurely introduction to JPEG can be found in "The Data Compression Book" by Mark Nelson and Jean-loup Gailly, published by M&T Books (New York), 2nd ed. 1996, ISBN 1-55851-434-1. This book provides good explanations and example C code for a multitude of compression methods including JPEG. It is an excellent source if you are comfortable reading C code but don't know much about data compression in general. The book's JPEG sample code is far from industrial-strength, but when you are ready to look at a full implementation, you've got one here...

The best full description of JPEG is the textbook "JPEG Still Image Data Compression Standard" by William B. Pennebaker and Joan L. Mitchell, published by Van Nostrand Reinhold, 1993, ISBN 0-442-01272-1. Price US\$59.95, 638 pp. The book includes the complete text of the ISO JPEG standards (DIS 10918-1 and draft DIS 10918-2). This is by far the most complete exposition of JPEG in existence, and we highly recommend it.

The JPEG standard itself is not available electronically; you must order a paper copy through ISO or ITU. (Unless you feel a need to own a certified official copy, we recommend buying the Pennebaker and Mitchell book instead; it's much cheaper and includes a great deal of useful explanatory material.) In the USA, copies of the standard may be ordered from ANSI Sales at (212) 642-4900, or from Global Engineering Documents at (800) 854-7179. (ANSI doesn't take credit card orders, but Global does.) It's not cheap: as of 1992, ANSI was charging \$95 for Part 1 and \$47 for Part 2, plus 7% shipping/handling. The standard is divided into two parts, Part 1 being the actual specification, while Part 2 covers compliance testing methods. Part 1 is titled "Digital Compression and Coding of Continuous-tone Still Images, Part 1: Requirements and guidelines" and has document numbers ISO/IEC IS 10918-1, ITU-T T.81. Part 2 is titled "Digital Compression and Coding of Continuous-tone Still Images, Part 2: Compliance testing" and has document numbers ISO/IEC IS 10918-2, ITU-T T.83.

Some extensions to the original JPEG standard are defined in JPEG Part 3, a newer ISO standard numbered ISO/IEC IS 10918-3 and ITU-T T.84. IJG currently does not support any Part 3 extensions.

The JPEG standard does not specify all details of an interchangeable file format. For the omitted details we follow the "JFIF" conventions, revision 1.02. A copy of the JFIF spec is available from:

Literature Department C-Cube Microsystems, Inc. 1778 McCarthy Blvd. Milpitas, CA 95035 phone (408) 944-6300, fax (408) 944-6314 tScript version of this document is

A PostScript version of this document is available by FTP at ftp://ftp.uu.net/graphics/jpeg/jfif.ps.gz. There is also a plain text version at ftp://ftp.uu.net/graphics/jpeg/jfif.txt.gz, but it is missing the figures.

The TIFF 6.0 file format specification can be obtained by FTP from ftp://ftp.sgi.com/graphics/tiff/TIFF6.ps.gz. The JPEG incorporation scheme found in the TIFF 6.0 spec of 3-June-92 has a number of serious problems. IJG does not recommend use of the TIFF 6.0 design (TIFF Compression tag 6). Instead, we recommend the JPEG design proposed by TIFF Technical Note #2 (Compression tag 7). Copies of this Note can be obtained from ftp.sgi.com or from ftp://ftp.uu.net/graphics/jpeg/. It is expected that the next revision of the TIFF spec will replace the 6.0 JPEG design with the Note's design. Although IJG's own code does not support TIFF/JPEG, the free libtiff library uses our library to implement TIFF/JPEG per the Note. libtiff is available from ftp://ftp.sgi.com/graphics/tiff/.

ARCHIVE LOCATIONS

The "official" archive site for this software is ftp.uu.net (Internet address 192.48.96.9). The most recent released version can always be found there in directory graphics/jpeg. This particular version will be archived as ftp://ftp.uu.net/graphics/jpeg/jpegsrc.v6b.tar.gz. If you don't have direct Internet access, UUNET's archives are also available via UUCP; contact help@uunet.uu.net for information on retrieving files that way.

Numerous Internet sites maintain copies of the UUNET files. However, only ftp.uu.net is guaranteed to have the latest official version.

You can also obtain this software in DOS-compatible "zip" archive format from the SimTel archives (ftp://ftp.simtel.net/pub/simtelnet/msdos/graphics/), or on CompuServe in the Graphics Support forum (GO CIS:GRAPHSUP), library 12 "JPEG Tools". Again, these versions may sometimes lag behind the ftp.uu.net release.

The JPEG FAQ (Frequently Asked Questions) article is a useful source of general information about JPEG. It is updated constantly and therefore is not included in this distribution. The FAQ is posted every two weeks to Usenet newsgroups comp.graphics.misc, news.answers, and other groups. It is available on the World Wide Web at http://www.faqs.org/faqs/jpeg-faq/ and other news.answers archive sites, including the official news.answers archive at rtfm.mit.edu: ftp://rtfm.mit.edu/pub/usenet/news.answers/jpeg-faq/. If you don't have Web or FTP access, send e-mail to mail-server@rtfm.mit.edu with body

send usenet/news.answers/jpeg-faq/part1

send usenet/news.answers/jpeg-faq/part2

RELATED SOFTWARE

Numerous viewing and image manipulation programs now support JPEG. (Quite a few of them use this library to do so.) The JPEG FAQ described above lists some of the more popular free and shareware viewers, and tells where to obtain them on Internet.

If you are on a Unix machine, we highly recommend Jef Poskanzer's free PBMPLUS software, which provides many useful operations on PPM-format image files. In particular, it can convert PPM images to and from a wide range of other formats, thus making cjpeg/djpeg considerably more useful. The latest version is distributed by the NetPBM group, and is available from numerous sites, notably ftp://wuarchive.wustl.edu/graphics/graphics/packages/NetPBM/. Unfortunately PBMPLUS/NETPBM is not nearly as portable as the IJG software is; you are likely to have difficulty making it work on any non-Unix machine.

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A different free JPEG implementation, written by the PVRG group at Stanford, is available from ftp://havefun.stanford.edu/pub/jpeg/. This program is designed for research and experimentation rather than production use; it is slower, harder to use, and less portable than the IJG code, but it is easier to read and modify. Also, the PVRG code supports lossless JPEG, which we do not. (On the other hand, it doesn't do progressive JPEG.)

FILE FORMAT WARS

Some JPEG programs produce files that are not compatible with our library. The root of the problem is that the ISO JPEG committee failed to specify a concrete file format. Some vendors "filled in the blanks" on their own, creating proprietary formats that no one else could read. (For example, none of the early commercial JPEG implementations for the Macintosh were able to exchange compressed files.)

The file format we have adopted is called JFIF (see REFERENCES). This format has been agreed to by a number of major commercial JPEG vendors, and it has become the de facto standard. JFIF is a minimal or "low end" representation. We recommend the use of TIFF/JPEG (TIFF revision 6.0 as modified by TIFF Technical Note #2) for "high end" applications that need to record a lot of additional data about an image. TIFF/JPEG is fairly new and not yet widely supported, unfortunately.

The upcoming JPEG Part 3 standard defines a file format called SPIFF. SPIFF is interoperable with JFIF, in the sense that most JFIF decoders should be able to read the most common variant of SPIFF. SPIFF has some technical advantages over JFIF, but its major claim to fame is simply that it is an official standard rather than an informal one. At this point it is unclear whether SPIFF will supersede JFIF or whether JFIF will remain the de-facto standard. IJG intends to support SPIFF once the standard is frozen, but we have not decided whether it should become our default output format or not. (In any case, our decoder will remain capable of reading JFIF indefinitely.)

Various proprietary file formats incorporating JPEG compression also exist. We have little or no sympathy for the existence of these formats. Indeed, one of the original reasons for developing this free software was to help force convergence on common, open format standards for JPEG files. Don't use a proprietary file format!

to do

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The major thrust for v7 will probably be improvement of visual quality. The current method for scaling the quantization tables is known not to be very good at low Q values. We also intend to investigate block boundary smoothing, "poor man's variable quantization", and other means of improving quality-vs-file-size performance without sacrificing compatibility.

In future versions, we are considering supporting some of the upcoming JPEG Part 3 extensions --- principally, variable quantization and the SPIFF file format.

As always, speeding things up is of great interest.

Please send bug reports, offers of help, etc. to jpeg-info@uunet.uu.net.

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one (1) copy of LabVIEW and the applicable software toolkits;

one (1) copy of LabWindows/CVI and the applicable software toolkit;

one (1) copy of Measurement Studio and the applicable software toolkits

Debug License; NI TestStand Semiconductor Module

Software Components Required:

NI TestStand Semiconductor Module;

NI TestStand runtime execution engine for executing your sequences and the complete NI TestStand sequence editor development environment;

one (1) copy of LabVIEW and the applicable software toolkits;

one (1) copy of LabWindows/CVI and the applicable software toolkit;

one (1) copy of Measurement Studio and the applicable software toolkits

Debug License: LabVIEW

Software Components Required: one (1) copy of LabVIEW and the applicable software toolkits

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Software Components Required: one (1) copy of LabWindows/CVI and applicable software toolkits

Debug License: Measurement Studio

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There is no home usage exception for debug licenses.

With the exception of concurrent debug licenses, you may transfer the debug license to a third party in the same country in which you purchased the license or within the European Union if you purchased the license in the European Union, provided that you notify NI in writing of such transfer, including the name and location of such third party; such third party accepts the terms and conditions of this Agreement; and after such transfer you do not retain any copies of the Software, including any upgrades and updates that you may have received, nor retain any of the written materials accompanying the Software. NI may, in its discretion, charge you a fee for the transfer of the license.

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2. Term. The VLP will be effective the date that NI sends the VLP Startup Kit to you ("VLP Effective Date"). The initial term of the VLP will start on the VLP Effective Date and continue for a period of one (1) year (the "Initial VLP Term"). You may renew the VLP for additional one (1) year periods (the Initial VLP Term and each such renewal term each referred to herein as a "VLP Term").

3. Software under the VLP may be used by your employees only on those computers located at the physical location to which NI delivers the Software unless otherwise specified in the VLP Documentation (the "Site"). Your use of the Software under the VLP will, at all times during the VLP Term and thereafter, be subject to all terms and conditions set forth in the Agreement regarding the specific type of license you have acquired under the VLP (i.e. named user, computer-based, or concurrent).

4. You must acquire and maintain during the VLP Term the Software Services for each individual Software license identified in the VLP Documentation and for which NI makes such Software Services available. Software Services will be described in VLP Documentation. NI reserves the right to restrict Software Service to the then most current version of the Software that is commercially available. You understand that NI may not make available Software Service for all Software available under the VLP. You must maintain during the VLP Term a minimum of five (5) licenses to a version of a single NI software product that is considered by NI to be a development version.

5. You must designate an individual in your organization who is responsible for distributing and overseeing the installation and use of the Software, including use of any master installation media and any approved volume license manager, ("Software Administrator") for each Site. You must promptly notify NI in writing of any changes to a Software Administrator.

6. NI will deliver the master installation media for the Software and, if provided for in the applicable written quotation from NI or its authorized affiliate, make available NI's volume license manager to the Software Administrator(s) for internal installation and use by your employees. Software documentation is provided in electronic form only and comes with the master installation media for the Software.

7. You are responsible for ensuring that an Approved Volume License Manager, together with the most current license file provided by NI that controls end-user access to the Software (to the extent NI has made the Software compatible with an Approved Volume License Manager) is in use at all times, during the term of the VLP and



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8. If you have existing computer-based or named user licenses for the Software that are to be covered by the VLP, you must notify NI in writing of the product, platform, and serial number information for each such license. Each such license and the individual serial number for each license will, as of the VLP Effective Date, no longer be in effect and will be superseded by the licenses within the VLP, which will have a single, common serial number.

9. Concurrent Use License. If you have obtained a concurrent use license under the VLP, you will be bound by the terms for concurrent use licenses. However, the definition of "Site" will also include all of your physical locations located within the same country as the Site. In addition, (i) if your Site is located

in a member of the North American Free Trade Agreement, then all of your physical locations within a member of the North American Free Trade Agreement will be considered in the same country; (ii) if your Site is located in South America, then all of your physical locations within South America will be considered in the same country; (iii) if your Site is located in Iceland, Norway, Switzerland, Africa or any member country of the European Union, then any of your physical locations within the foregoing countries will be considered in the same country; and (iv) if your Site is located in Asia, then all of your physical locations in Asia will be considered located in the same country. If you have purchased a global concurrent license, then all of your locations worldwide will be considered in the same country as the Site.

10. You acknowledge and agree that in no event may your use of the Software under the VLP exceed the maximum total number of licenses set forth in the VLP Documentation in addition to any licenses that may be added to the VLP after the Effective Date and any licenses available through the "Overdraft" feature. You agree to pay for licenses accessed through the Overdraft feature.

11. Activity Compliance Logs. You are required to provide an activity compliance log ("Activity Compliance Log") for each Site to NI promptly, but in no event no later than fifteen (15) days following the annual anniversary of the VLP Effective Date and following the VLP termination date. The Activity Compliance Log must be in a format acceptable to NI.

12. **Renewals.** If you desire to renew the VLP, you must provide a current Activity Compliance Log to NI at least sixty (60) days before the end of the then current VLP Term. NI or its authorized affiliate will then provide you with a quote for Software Services, any fees for additional VLP licenses added during the VLP Term, including through the "Overdraft" feature, that are applicable ("Additional VLP Fees"), and any new VLP licenses that you request for the renewal VLP Term (the "VLP Renewal Fee"). You must promptly notify NI if the information in the Activity Compliance Log regarding the number of VLP licenses in use changes following your submission, and NI reserves the right to revise the VLP Renewal Fee to reflect any additional VLP licenses used and not reflected in the applicable Activity Compliance Log that you provided to NI at the time you renewed. **IF, PRIOR TO THE END OF THE THEN CURRENT VLP TERM, YOU DO NOT ISSUE A PURCHASE ORDER FOR THE SOFTWARE SERVICES AND ANY ADDITIONAL VLP FEES THAT ARE DUE, (I) THE VLP WILL AUTOMATICALLY TERMINATE AT THE END OF THE CURRENT VLP TERM AND (II) ALL SOFTWARE SERVICES FOR THE VLP WILL AUTOMATICALLY TERMINATE AT THE END OF THE THEN CURRENT VLP TERM.**

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ii. for each renewal term: in the amount of VLP Renewal Fees and any Additional VLP Fees prior to the end of the then current VLP Term

14. Software Services are charged on an annual basis. Additional VLP Fees will be pro-rated on a quarterly basis, based on the quarter of the VLP Term in which the Software under such VLP license was first used or such shorter basis as NI may designate.

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Issued: October 04, 2017

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A. Upon such periodic basis as set forth in the EP Documentation (but at least annually), your representatives must meet with NI's representatives to discuss the EP and your use of the EP, including evaluating usage of the NI Software and any training credits under the EP and determining the adequacy of licensing levels and number of EP Locations under the EP.

B. Thirty (30) days prior to the meeting referenced in sub-section A above or upon such other reasonable basis as NI may request, you must provide NI with (i) an activity compliance log identifying requests for permission to use the Software in a format acceptable to NI ("Activity Compliance Logs") for each of the EP Locations and (ii) a usage log showing check-outs and check-ins of the Software ("Usage Log") as generated by the Approved Volume License Manager for the Software at the EP Locations.

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