INSTALLATION INSTRUCTIONS for the Independent JPEG Group's JPEG software

This file explains how to configure and install the IJG software. We have tried to make this software extremely portable and flexible, so that it can be adapted to almost any environment. The downside of this decision is that the installation process is complicated. We have provided shortcuts to simplify the task on common systems. But in any case, you will need at least a little familiarity with C programming and program build procedures for your system.

If you are only using this software as part of a larger program, the larger program's installation procedure may take care of configuring the IJG code. For example, Ghostscript's installation script will configure the IJG code. You don't need to read this file if you just want to compile Ghostscript.

If you are on a Unix machine, you may not need to read this file at all. Try doing

```
./configure
make
make test
```

If that doesn't complain, do

```
make install
```

(better do "make -n install" first to see if the makefile will put the files where you want them). Read further if you run into snags or want to customize the code for your system.

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BEFORE YOU START

Before installing the software you must unpack the distributed source code. Since you are reading this file, you have probably already succeeded in this task. However, there is a potential for error if you needed to convert the

files to the local standard text file format (for example, if you are on
MS-DOS you may have converted LF end-of-line to CR/LF). You must apply
such conversion to all the files EXCEPT those whose names begin with "test".
The test files contain binary data; if you change them in any way then the
self-test will give bad results.

Please check the last section of this file to see if there are hints for the
specific machine or compiler you are using.

CONFIGURING THE SOFTWARE

To configure the IJG code for your system, you need to create two files:
  * jconfig.h: contains values for system-dependent #define symbols.
  * Makefile: controls the compilation process.
(On a non-Unix machine, you may create "project files" or some other
substitute for a Makefile. jconfig.h is needed in any environment.)

We provide three different ways to generate these files:
  * On a Unix system, you can just run the "configure" script.
  * We provide sample jconfig files and makefiles for popular machines;
    if your machine matches one of the samples, just copy the right sample
    files to jconfig.h and Makefile.
  * If all else fails, read the instructions below and make your own files.

Configuring the software using the automatic "configure" script

If you are on a Unix machine, you can just type
        ./configure
and let the configure script construct appropriate configuration files.
If you're using "csh" on an old version of System V, you might need to type
        sh configure
instead to prevent csh from trying to execute configure itself.
Expect configure to run for a few minutes, particularly on slower machines;
it works by compiling a series of test programs.

Configure was created with GNU Autoconf and it follows the usual conventions
for GNU configure scripts. It makes a few assumptions that you may want to
override. You can do this by providing optional switches to configure:

* If you want to build libjpeg as a shared library, say
        ./configure --enable-shared
To get both shared and static libraries, say
        ./configure --enable-shared --enable-static
Note that these switches invoke GNU libtool to take care of system-dependent
shared library building methods. If things don't work this way, please try
running configure without either switch; that should build a static library
without using libtool. If that works, your problem is probably with libtool
not with the IJG code. libtool is fairly new and doesn't support all flavors
of Unix yet. (You might be able to find a newer version of libtool than the

one included with libjpeg; see ftp.gnu.org. Report libtool problems to
bug-libtool@gnu.org.)

* Configure will use gcc (GNU C compiler) if it's available, otherwise cc.
To force a particular compiler to be selected, use the CC option, for example
        ./configure CC='cc'
The same method can be used to include any unusual compiler switches.
For example, on HP-UX you probably want to say
        ./configure CC='cc -Aa'
to get HP's compiler to run in ANSI mode.

* The default CFLAGS setting is "-O" for non-gcc compilers, "-O2" for gcc.
You can override this by saying, for example,
        ./configure CFLAGS='-g'
if you want to compile with debugging support.

* Configure will set up the makefile so that "make install" will install files
into /usr/local/bin, /usr/local/man, etc. You can specify an installation
prefix other than "/usr/local" by giving configure the option "--prefix=PATH".

* If you don't have a lot of swap space, you may need to enable the IJG
software's internal virtual memory mechanism. To do this, give the option
"--enable-maxmem=N" where N is the default maxmemory limit in megabytes.
This is discussed in more detail under "Selecting a memory manager", below.
You probably don't need to worry about this on reasonably-sized Unix machines,
unless you plan to process very large images.

Configure has some other features that are useful if you are cross-compiling
or working in a network of multiple machine types; but if you need those
features, you probably already know how to use them.

Configuring the software using one of the supplied jconfig and makefile files

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If you have one of these systems, you can just use the provided configuration
files:

Makefile	jconfig file	System and/or compiler
makefile.manx	jconfig.manx	Amiga, Manx Aztec C
makefile.sas	jconfig.sas	Amiga, SAS C
makeproj.mac	jconfig.mac	Apple Macintosh, Metrowerks CodeWarrior
mak*jpeg.st	jconfig.st	Atari ST/STE/TT, Pure C or Turbo C
makefile.bcc	jconfig.bcc	MS-DOS or OS/2, Borland C
makefile.dj	jconfig.dj	MS-DOS, DJGPP (Delorie's port of GNU C)
makefile.mc6	jconfig.mc6	MS-DOS, Microsoft C (16-bit only)
makefile.wat	jconfig.wat	MS-DOS, OS/2, or Windows NT, Watcom C
makefile.vc	jconfig.vc	Windows NT/95, MS Visual C++
make*.ds	jconfig.vc	Windows NT/95, MS Developer Studio
makefile.mms	jconfig.vms	Digital VMS, with MMS software
makefile.vms	jconfig.vms	Digital VMS, without MMS software

Copy the proper jconfig file to jconfig.h and the makefile to Makefile (or whatever your system uses as the standard makefile name). For more info see the appropriate system-specific hints section near the end of this file.

Configuring the software by hand

First, generate a jconfig.h file. If you are moderately familiar with C, the comments in jconfig.doc should be enough information to do this; just copy jconfig.doc to jconfig.h and edit it appropriately. Otherwise, you may prefer to use the ckconfig.c program. You will need to compile and execute ckconfig.c by hand --- we hope you know at least enough to do that. ckconfig.c may not compile the first try (in fact, the whole idea is for it to fail if anything is going to). If you get compile errors, fix them by editing ckconfig.c according to the directions given in ckconfig.c. Once you get it to run, it will write a suitable jconfig.h file, and will also print out some advice about which makefile to use.

You may also want to look at the canned jconfig files, if there is one for a system similar to yours.

Second, select a makefile and copy it to Makefile (or whatever your system uses as the standard makefile name). The most generic makefiles we provide are

    makefile.ansi: if your C compiler supports function prototypes
    makefile.unix: if not.

(You have function prototypes if ckconfig.c put "#define HAVE_PROTOTYPES" in jconfig.h.) You may want to start from one of the other makefiles if there is one for a system similar to yours.

Look over the selected Makefile and adjust options as needed. In particular you may want to change the CC and CFLAGS definitions. For instance, if you are using GCC, set CC=gcc. If you had to use any compiler switches to get ckconfig.c to work, make sure the same switches are in CFLAGS.

If you are on a system that doesn't use makefiles, you'll need to set up project files (or whatever you do use) to compile all the source files and link them into executable files cjpeg, djpeg, jpegtran, rdjpgcom, and wrjpgcom. See the file lists in any of the makefiles to find out which files go into each program. Note that the provided makefiles all make a "library" file libjpeg first, but you don't have to do that if you don't want to; the file lists identify which source files are actually needed for compression, decompression, or both. As a last resort, you can make a batch script that just compiles everything and links it all together; makefile.vms is an example of this (it's for VMS systems that have no make-like utility).

Here are comments about some specific configuration decisions you'll need to make:

Command line style

These programs can use a Unix-like command line style which supports
redirection and piping, like this:

```
cjpeg inputfile >outputfile
cjpeg <inputfile >outputfile
source program | cjpeg >outputfile
```

The simpler "two file" command line style is just

```
cjpeg inputfile outputfile
```

You may prefer the two-file style, particularly if you don't have pipes.

You MUST use two-file style on any system that doesn't cope well with binary data fed through stdin/stdout; this is true for some MS-DOS compilers, for example. If you're not on a Unix system, it's safest to assume you need two-file style. (But if your compiler provides either the Posix-standard fdopen() library routine or a Microsoft-compatible setmode() routine, you can safely use the Unix command line style, by defining USE_FDOPEN or USE_SETMODE respectively.)

To use the two-file style, make jconfig.h say "#define TWO_FILE_COMMANDLINE".

Selecting a memory manager

The IJG code is capable of working on images that are too big to fit in main memory; data is swapped out to temporary files as necessary. However, the code to do this is rather system-dependent. We provide five different memory managers:

* jmemansi.c This version uses the ANSI-standard library routine tmpfile(), which not all non-ANSI systems have. On some systems tmpfile() may put the temporary file in a non-optimal location; if you don't like what it does, use jmemname.c.

* jmemname.c This version creates named temporary files. For anything except a Unix machine, you'll need to configure the select_file_name() routine appropriately; see the comments near the head of jmemname.c. If you use this version, define NEED_SIGNAL_CATCHER in jconfig.h to make sure the temp files are removed if the program is aborted.

* jmemnobs.c (That stands for No Backing Store :-).) This will compile on almost any system, but it assumes you have enough main memory or virtual memory to hold the biggest images you work with.

* jmemdos.c This should be used with most 16-bit MS-DOS compilers. See the system-specific notes about MS-DOS for more info. IMPORTANT: if you use this, define USE_MSDOS_MEMMGR in jconfig.h, and include the assembly file jmemdosa.asm in the programs. The supplied makefiles and jconfig files for 16-bit MS-DOS compilers already do both.

* jmemmac.c Custom version for Apple Macintosh; see the system-specific notes for Macintosh for more info.

To use a particular memory manager, change the SYSDEPMEM variable in your
makefile to equal the corresponding object file name (for example, jmemansi.o
or jmemansi.obj for jmemansi.c).

If you have plenty of (real or virtual) main memory, just use jmemnobs.c.
"Plenty" means about ten bytes for every pixel in the largest images
you plan to process, so a lot of systems don't meet this criterion.
If yours doesn't, try jmemansi.c first. If that doesn't compile, you'll have
to use jmemname.c; be sure to adjust select_file_name() for local conditions.
You may also need to change unlink() to remove() in close_backing_store().

Except with jmemnobs.c or jmemmac.c, you need to adjust the DEFAULT_MAX_MEM
setting to a reasonable value for your system (either by adding a #define for
DEFAULT_MAX_MEM to jconfig.h, or by adding a -D switch to the Makefile).
This value limits the amount of data space the program will attempt to
allocate. Code and static data space isn't counted, so the actual memory
needs for cjpeg or djpeg are typically 100 to 150Kb more than the max-memory
setting. Larger max-memory settings reduce the amount of I/O needed to
process a large image, but too large a value can result in "insufficient
memory" failures. On most Unix machines (and other systems with virtual
memory), just set DEFAULT_MAX_MEM to several million and forget it. At the
other end of the spectrum, for MS-DOS machines you probably can't go much
above 300K to 400K. (On MS-DOS the value refers to conventional memory only.
Extended/expanded memory is handled separately by jmemdos.c.)

BUILDING THE SOFTWARE

Now you should be able to compile the software. Just say "make" (or
whatever's necessary to start the compilation). Have a cup of coffee.

Here are some things that could go wrong:

If your compiler complains about undefined structures, you should be able to
shut it up by putting "#define INCOMPLETE_TYPES_BROKEN" in jconfig.h.

If you have trouble with missing system include files or inclusion of the
wrong ones, read jinclude.h. This shouldn't happen if you used configure
or ckconfig.c to set up jconfig.h.

There are a fair number of routines that do not use all of their parameters;
some compilers will issue warnings about this, which you can ignore. There
are also a few configuration checks that may give "unreachable code" warnings.
Any other warning deserves investigation.

If you don't have a getenv() library routine, define NO_GETENV.

Also see the system-specific hints, below.

TESTING THE SOFTWARE

As a quick test of functionality we've included a small sample image in
several forms:

testorig.jpg	Starting point for the djpeg tests.
testimg.ppm	The output of djpeg testorig.jpg
testimg.bmp	The output of djpeg -bmp -colors 256 testorig.jpg
testimg.jpg	The output of cjpeg testimg.ppm
testprog.jpg	Progressive-mode equivalent of testorig.jpg.
testimgp.jpg	The output of cjpeg -progressive -optimize testimg.ppm

(The first- and second-generation .jpg files aren't identical since JPEG is
lossy.) If you can generate duplicates of the testimg* files then you
probably have working programs.

With most of the makefiles, "make test" will perform the necessary
comparisons.

If you're using a makefile that doesn't provide the test option, run djpeg
and cjpeg by hand and compare the output files to testimg* with whatever
binary file comparison tool you have. The files should be bit-for-bit
identical.

If the programs complain "MAX_ALLOC_CHUNK is wrong, please fix", then you
need to reduce MAX_ALLOC_CHUNK to a value that fits in type size_t.
Try adding "#define MAX_ALLOC_CHUNK 65520L" to jconfig.h. A less likely
configuration error is "ALIGN_TYPE is wrong, please fix": defining ALIGN_TYPE
as long should take care of that one.

If the cjpeg test run fails with "Missing Huffman code table entry", it's a
good bet that you needed to define RIGHT_SHIFT_IS_UNSIGNED. Go back to the
configuration step and run ckconfig.c. (This is a good plan for any other
test failure, too.)

If you are using Unix (one-file) command line style on a non-Unix system,
it's a good idea to check that binary I/O through stdin/stdout actually
works. You should get the same results from "djpeg <testorig.jpg >out.ppm"
as from "djpeg -outfile out.ppm testorig.jpg". Note that the makefiles all
use the latter style and therefore do not exercise stdin/stdout! If this
check fails, try recompiling with USE_SETMODE or USE_FDOPEN defined.
If it still doesn't work, better use two-file style.

If you chose a memory manager other than jmemnobs.c, you should test that
temporary-file usage works. Try "djpeg -bmp -colors 256 -max 0 testorig.jpg"
and make sure its output matches testimg.bmp. If you have any really large
images handy, try compressing them with -optimize and/or decompressing with
-colors 256 to make sure your DEFAULT_MAX_MEM setting is not too large.

NOTE: this is far from an exhaustive test of the JPEG software; some modules,
such as 1-pass color quantization, are not exercised at all. It's just a
quick test to give you some confidence that you haven't missed something
major.

INSTALLING THE SOFTWARE

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Once you're done with the above steps, you can install the software by
copying the executable files (cjpeg, djpeg, jpegtran, rdjpgcom, and wrjpgcom)
to wherever you normally install programs. On Unix systems, you'll also want
to put the man pages (cjpeg.1, djpeg.1, jpegtran.1, rdjpgcom.1, wrjpgcom.1)
in the man-page directory. The pre-fab makefiles don't support this step
since there's such a wide variety of installation procedures on different
systems.

If you generated a Makefile with the "configure" script, you can just say
	make install
to install the programs and their man pages into the standard places.
(You'll probably need to be root to do this.) We recommend first saying
	make -n install
to see where configure thought the files should go. You may need to edit
the Makefile, particularly if your system's conventions for man page
filenames don't match what configure expects.

If you want to install the IJG library itself, for use in compiling other
programs besides ours, then you need to put the four include files
	jpeglib.h jerror.h jconfig.h jmorecfg.h
into your include-file directory, and put the library file libjpeg.a
(extension may vary depending on system) wherever library files go.
If you generated a Makefile with "configure", it will do what it thinks
is the right thing if you say
	make install-lib

OPTIONAL STUFF
==============

Progress monitor:

If you like, you can #define PROGRESS_REPORT (in jconfig.h) to enable display
of percent-done progress reports. The routine provided in cdjpeg.c merely
prints percentages to stderr, but you can customize it to do something
fancier.

Utah RLE file format support:

We distribute the software with support for RLE image files (Utah Raster
Toolkit format) disabled, because the RLE support won't compile without the
Utah library. If you have URT version 3.1 or later, you can enable RLE
support as follows:

1. #define RLE_SUPPORTED in jconfig.h.
2. Add a -I option to CFLAGS in the Makefile for the directory
   containing the URT .h files (typically the "include"
   subdirectory of the URT distribution).
3. Add -L... -lrle to LDLIBS in the Makefile, where ... specifies
   the directory containing the URT "librle.a" file (typically the
   "lib" subdirectory of the URT distribution).

Support for 12-bit-deep pixel data:

The JPEG standard allows either 8-bit or 12-bit data precision. (For color, this means 8 or 12 bits per channel, of course.) If you need to work with deeper than 8-bit data, you can compile the IJG code for 12-bit operation. To do so:

1. In jmorecfg.h, define BITS_IN_JSAMPLE as 12 rather than 8.
2. In jconfig.h, undefine BMP_SUPPORTED, RLE_SUPPORTED, and TARGA_SUPPORTED, because the code for those formats doesn't handle 12-bit data and won't even compile. (The PPM code does work, as explained below. The GIF code works too; it scales 8-bit GIF data to and from 12-bit depth automatically.)
3. Compile. Don't expect "make test" to pass, since the supplied test files are for 8-bit data.

Currently, 12-bit support does not work on 16-bit-int machines.

Note that a 12-bit version will not read 8-bit JPEG files, nor vice versa; so you'll want to keep around a regular 8-bit compilation as well. (Run-time selection of data depth, to allow a single copy that does both, is possible but would probably slow things down considerably; it's very low on our to-do list.)

The PPM reader (rdppm.c) can read 12-bit data from either text-format or binary-format PPM and PGM files. Binary-format PPM/PGM files which have a maxval greater than 255 are assumed to use 2 bytes per sample, LSB first (little-endian order). As of early 1995, 2-byte binary format is not officially supported by the PBMPLUS library, but it is expected that a future release of PBMPLUS will support it. Note that the PPM reader will read files of any maxval regardless of the BITS_IN_JSAMPLE setting; incoming data is automatically rescaled to either maxval=255 or maxval=4095 as appropriate for the cjpeg bit depth.

The PPM writer (wrppm.c) will normally write 2-byte binary PPM or PGM format, maxval 4095, when compiled with BITS_IN_JSAMPLE=12. Since this format is not yet widely supported, you can disable it by compiling wrppm.c with PPM_NORAWWORD defined; then the data is scaled down to 8 bits to make a standard 1-byte/sample PPM or PGM file. (Yes, this means still another copy of djpeg to keep around. But hopefully you won't need it for very long. Poskanzer's supposed to get that new PBMPLUS release out Real Soon Now.)

Of course, if you are working with 12-bit data, you probably have it stored in some other, nonstandard format. In that case you'll probably want to write your own I/O modules to read and write your format.

Note that a 12-bit version of cjpeg always runs in "-optimize" mode, in order to generate valid Huffman tables. This is necessary because our default Huffman tables only cover 8-bit data.

Removing code:

If you need to make a smaller version of the JPEG software, some optional functions can be removed at compile time. See the xxx_SUPPORTED #defines in

jconfig.h and jmorecfg.h. If at all possible, we recommend that you leave in decoder support for all valid JPEG files, to ensure that you can read anyone's output. Taking out support for image file formats that you don't use is the most painless way to make the programs smaller. Another possibility is to remove some of the DCT methods: in particular, the "IFAST" method may not be enough faster than the others to be worth keeping on your machine. (If you do remove ISLOW or IFAST, be sure to redefine JDCT_DEFAULT or JDCT_FASTEST to a supported method, by adding a #define in jconfig.h.)

OPTIMIZATION

Unless you own a Cray, you'll probably be interested in making the JPEG software go as fast as possible. This section covers some machine-dependent optimizations you may want to try. We suggest that before trying any of this, you first get the basic installation to pass the self-test step. Repeat the self-test after any optimization to make sure that you haven't broken anything.

The integer DCT routines perform a lot of multiplications. These multiplications must yield 32-bit results, but none of their input values are more than 16 bits wide. On many machines, notably the 680x0 and 80x86 CPUs, a 16x16=>32 bit multiply instruction is faster than a full 32x32=>32 bit multiply. Unfortunately there is no portable way to specify such a multiplication in C, but some compilers can generate one when you use the right combination of casts. See the MULTIPLYxxx macro definitions in jdct.h. If your compiler makes "int" be 32 bits and "short" be 16 bits, defining SHORTxSHORT_32 is fairly likely to work. When experimenting with alternate definitions, be sure to test not only whether the code still works (use the self-test), but also whether it is actually faster --- on some compilers, alternate definitions may compute the right answer, yet be slower than the default. Timing cjpeg on a large PGM (grayscale) input file is the best way to check this, as the DCT will be the largest fraction of the runtime in that mode. (Note: some of the distributed compiler-specific jconfig files already contain #define switches to select appropriate MULTIPLYxxx definitions.)

If your machine has sufficiently fast floating point hardware, you may find that the float DCT method is faster than the integer DCT methods, even after tweaking the integer multiply macros. In that case you may want to make the float DCT be the default method. (The only objection to this is that float DCT results may vary slightly across machines.) To do that, add "#define JDCT_DEFAULT JDCT_FLOAT" to jconfig.h. Even if you don't change the default, you should redefine JDCT_FASTEST, which is the method selected by djpeg's -fast switch. Don't forget to update the documentation files (usage.doc and/or cjpeg.1, djpeg.1) to agree with what you've done.

If access to "short" arrays is slow on your machine, it may be a win to define type JCOEF as int rather than short. This will cost a good deal of memory though, particularly in some multi-pass modes, so don't do it unless you have memory to burn and short is REALLY slow.

If your compiler can compile function calls in-line, make sure the INLINE
macro in jmorecfg.h is defined as the keyword that marks a function
inline-able. Some compilers have a switch that tells the compiler to inline
any function it thinks is profitable (e.g., -finline-functions for gcc).
Enabling such a switch is likely to make the compiled code bigger but faster.

In general, it's worth trying the maximum optimization level of your compiler,
and experimenting with any optional optimizations such as loop unrolling.
(Unfortunately, far too many compilers have optimizer bugs ... be prepared to
back off if the code fails self-test.) If you do any experimentation along
these lines, please report the optimal settings to jpeg-info@uunet.uu.net so
we can mention them in future releases. Be sure to specify your machine and
compiler version.

HINTS FOR SPECIFIC SYSTEMS

We welcome reports on changes needed for systems not mentioned here. Submit
'em to jpeg-info@uunet.uu.net. Also, if configure or ckconfig.c is wrong
about how to configure the JPEG software for your system, please let us know.

Acorn RISC OS:

(Thanks to Simon Middleton for these hints on compiling with Desktop C.)
After renaming the files according to Acorn conventions, take a copy of
makefile.ansi, change all occurrences of 'libjpeg.a' to 'libjpeg.o' and
change these definitions as indicated:

```
CFLAGS= -throwback -IC: -Wn
LDLIBS=C:o.Stubs
SYSDEPMEM=jmemansi.o
LN=Link
AR=LibFile -c -o
```

Also add a new line '.c.o:; $(cc) $< $(cflags) -c -o $@'. Remove the
lines '$(RM) libjpeg.o' and '$(AR2) libjpeg.o' and the 'jconfig.h'
dependency section.

Copy jconfig.doc to jconfig.h. Edit jconfig.h to define TWO_FILE_COMMANDLINE
and CHAR_IS_UNSIGNED.

Run the makefile using !AMU not !Make. If you want to use the 'clean' and
'test' makefile entries then you will have to fiddle with the syntax a bit
and rename the test files.

Amiga:

SAS C 6.50 reportedly is too buggy to compile the IJG code properly.
A patch to update to 6.51 is available from SAS or AmiNet FTP sites.

The supplied config files are set up to use jmemname.c as the memory manager, with temporary files being created on the device named by "JPEGTMP:".

Atari ST/STE/TT:

Copy the project files makcjpeg.st, makdjpeg.st, maktjpeg.st, and makljpeg.st to cjpeg.prj, djpeg.prj, jpegtran.prj, and libjpeg.prj respectively. The project files should work as-is with Pure C. For Turbo C, change library filenames "pc..." to "tc..." in each project file. Note that libjpeg.prj selects jmemansi.c as the recommended memory manager. You'll probably want to adjust the DEFAULT_MAX_MEM setting --- you want it to be a couple hundred K less than your normal free memory. Put "#define DEFAULT_MAX_MEM nnnn" into jconfig.h to do this.

To use the 68881/68882 coprocessor for the floating point DCT, add the compiler option "-8" to the project files and replace pcfltlib.lib with pc881lib.lib in cjpeg.prj and djpeg.prj. Or if you don't have a coprocessor, you may prefer to remove the float DCT code by undefining DCT_FLOAT_SUPPORTED in jmorecfg.h (since without a coprocessor, the float code will be too slow to be useful). In that case, you can delete pcfltlib.lib from the project files.

Note that you must make libjpeg.lib before making cjpeg.ttp, djpeg.ttp, or jpegtran.ttp. You'll have to perform the self-test by hand.

We haven't bothered to include project files for rdjpgcom and wrjpgcom. Those source files should just be compiled by themselves; they don't depend on the JPEG library.

There is a bug in some older versions of the Turbo C library which causes the space used by temporary files created with "tmpfile()" not to be freed after an abnormal program exit. If you check your disk afterwards, you will find cluster chains that are allocated but not used by a file. This should not happen in cjpeg/djpeg/jpegtran, since we enable a signal catcher to explicitly close temp files before exiting. But if you use the JPEG library with your own code, be sure to supply a signal catcher, or else use a different system-dependent memory manager.

Cray:

Should you be so fortunate as to be running JPEG on a Cray YMP, there is a compiler bug in old versions of Cray's Standard C (prior to 3.1). If you still have an old compiler, you'll need to insert a line reading "#pragma novector" just before the loop

```
    for (i = 1; i <= (int) htbl->bits[l]; i++)
      huffsize[p++] = (char) l;
```

in fix_huff_tbl (in V5beta1, line 204 of jchuff.c and line 176 of jdhuff.c). [This bug may or may not still occur with the current IJG code, but it's probably a dead issue anyway...]

HP-UX:

If you have HP-UX 7.05 or later with the "software development" C compiler,
you should run the compiler in ANSI mode. If using the configure script,
say
    ./configure CC='cc -Aa'
(or -Ae if you prefer). If configuring by hand, use makefile.ansi and add
"-Aa" to the CFLAGS line in the makefile.

If you have a pre-7.05 system, or if you are using the non-ANSI C compiler
delivered with a minimum HP-UX system, then you must use makefile.unix
(and do NOT add -Aa); or just run configure without the CC option.

On HP 9000 series 800 machines, the HP C compiler is buggy in revisions prior
to A.08.07. If you get complaints about "not a typedef name", you'll have to
use makefile.unix, or run configure without the CC option.

Macintosh, generic comments:

The supplied user-interface files (cjpeg.c, djpeg.c, etc) are set up to
provide a Unix-style command line interface. You can use this interface on
the Mac by means of the ccommand() library routine provided by Metrowerks
CodeWarrior or Think C. This is only appropriate for testing the library,
however; to make a user-friendly equivalent of cjpeg/djpeg you'd really want
to develop a Mac-style user interface. There isn't a complete example
available at the moment, but there are some helpful starting points:
1. Sam Bushell's free "To JPEG" applet provides drag-and-drop conversion to
JPEG under System 7 and later. This only illustrates how to use the
compression half of the library, but it does a very nice job of that part.
The CodeWarrior source code is available from http://www.pobox.com/~jsam.
2. Jim Brunner prepared a Mac-style user interface for both compression and
decompression. Unfortunately, it hasn't been updated since IJG v4, and
the library's API has changed considerably since then. Still it may be of
some help, particularly as a guide to compiling the IJG code under Think C.
Jim's code is available from the Info-Mac archives, at sumex-aim.stanford.edu
or mirrors thereof; see file /info-mac/dev/src/jpeg-convert-c.hqx.

jmemmac.c is the recommended memory manager back end for Macintosh. It uses
NewPtr/DisposePtr instead of malloc/free, and has a Mac-specific
implementation of jpeg_mem_available(). It also creates temporary files that
follow Mac conventions. (That part of the code relies on System-7-or-later OS
functions. See the comments in jmemmac.c if you need to run it on System 6.)
NOTE that USE_MAC_MEMMGR must be defined in jconfig.h to use jmemmac.c.

You can also use jmemnobs.c, if you don't care about handling images larger
than available memory. If you use any memory manager back end other than
jmemmac.c, we recommend replacing "malloc" and "free" by "NewPtr" and
"DisposePtr", because Mac C libraries often have peculiar implementations of
malloc/free. (For instance, free() may not return the freed space to the
Mac Memory Manager. This is undesirable for the IJG code because jmemmgr.c
already clumps space requests.)

Macintosh, Metrowerks CodeWarrior:

The Unix-command-line-style interface can be used by defining USE_CCOMMAND.
You'll also need to define TWO_FILE_COMMANDLINE to avoid stdin/stdout.
This means that when using the cjpeg/djpeg programs, you'll have to type the
input and output file names in the "Arguments" text-edit box, rather than
using the file radio buttons. (Perhaps USE_FDOPEN or USE_SETMODE would
eliminate the problem, but I haven't heard from anyone who's tried it.)

On 680x0 Macs, Metrowerks defines type "double" as a 10-byte IEEE extended
float. jmemmgr.c won't like this: it wants sizeof(ALIGN_TYPE) to be a power
of 2. Add "#define ALIGN_TYPE long" to jconfig.h to eliminate the complaint.

The supplied configuration file jconfig.mac can be used for your jconfig.h;
it includes all the recommended symbol definitions. If you have AppleScript
installed, you can run the supplied script makeproj.mac to create CodeWarrior
project files for the library and the testbed applications, then build the
library and applications. (Thanks to Dan Sears and Don Agro for this nifty
hack, which saves us from trying to maintain CodeWarrior project files as part
of the IJG distribution...)

Macintosh, Think C:

The documentation in Jim Brunner's "JPEG Convert" source code (see above)
includes detailed build instructions for Think C; it's probably somewhat
out of date for the current release, but may be helpful.

If you want to build the minimal command line version, proceed as follows.
You'll have to prepare project files for the programs; we don't include any
in the distribution since they are not text files. Use the file lists in
any of the supplied makefiles as a guide. Also add the ANSI and Unix C
libraries in a separate segment. You may need to divide the JPEG files into
more than one segment; we recommend dividing compression and decompression
modules. Define USE_CCOMMAND in jconfig.h so that the ccommand() routine is
called. You must also define TWO_FILE_COMMANDLINE because stdin/stdout
don't handle binary data correctly.

On 680x0 Macs, Think C defines type "double" as a 12-byte IEEE extended float.
jmemmgr.c won't like this: it wants sizeof(ALIGN_TYPE) to be a power of 2.
Add "#define ALIGN_TYPE long" to jconfig.h to eliminate the complaint.

jconfig.mac should work as a jconfig.h configuration file for Think C,
but the makeproj.mac AppleScript script is specific to CodeWarrior. Sorry.

MIPS R3000:

MIPS's cc version 1.31 has a rather nasty optimization bug. Don't use -O
if you have that compiler version. (Use "cc -V" to check the version.)
Note that the R3000 chip is found in workstations from DEC and others.

MS-DOS, generic comments for 16-bit compilers:

The IJG code is designed to work well in 80x86 "small" or "medium" memory
models (i.e., data pointers are 16 bits unless explicitly declared "far";
code pointers can be either size). You may be able to use small model to
compile cjpeg or djpeg by itself, but you will probably have to use medium
model for any larger application. This won't make much difference in
performance. You *will* take a noticeable performance hit if you use a
large-data memory model, and you should avoid "huge" model if at all
possible. Be sure that NEED_FAR_POINTERS is defined in jconfig.h if you use
a small-data memory model; be sure it is NOT defined if you use a large-data
model. (The supplied makefiles and jconfig files for Borland and Microsoft C
compile in medium model and define NEED_FAR_POINTERS.)

The DOS-specific memory manager, jmemdos.c, should be used if possible.
It needs some assembly-code routines which are in jmemdosa.asm; make sure
your makefile assembles that file and includes it in the library. If you
don't have a suitable assembler, you can get pre-assembled object files for
jmemdosa by FTP from ftp.uu.net:/graphics/jpeg/jdosaobj.zip. (DOS-oriented
distributions of the IJG source code often include these object files.)

When using jmemdos.c, jconfig.h must define USE_MSDOS_MEMMGR and must set
MAX_ALLOC_CHUNK to less than 64K (65520L is a typical value). If your
C library's far-heap malloc() can't allocate blocks that large, reduce
MAX_ALLOC_CHUNK to whatever it can handle.

If you can't use jmemdos.c for some reason --- for example, because you
don't have an assembler to assemble jmemdosa.asm --- you'll have to fall
back to jmemansi.c or jmemname.c. You'll probably still need to set
MAX_ALLOC_CHUNK in jconfig.h, because most DOS C libraries won't malloc()
more than 64K at a time. IMPORTANT: if you use jmemansi.c or jmemname.c,
you will have to compile in a large-data memory model in order to get the
right stdio library. Too bad.

wrjpgcom needs to be compiled in large model, because it malloc()s a 64KB
work area to hold the comment text. If your C library's malloc can't
handle that, reduce MAX_COM_LENGTH as necessary in wrjpgcom.c.

Most MS-DOS compilers treat stdin/stdout as text files, so you must use
two-file command line style. But if your compiler has either fdopen() or
setmode(), you can use one-file style if you like. To do this, define
USE_SETMODE or USE_FDOPEN so that stdin/stdout will be set to binary mode.
(USE_SETMODE seems to work with more DOS compilers than USE_FDOPEN.) You
should test that I/O through stdin/stdout produces the same results as I/O
to explicitly named files... the "make test" procedures in the supplied
makefiles do NOT use stdin/stdout.

MS-DOS, generic comments for 32-bit compilers:

None of the above comments about memory models apply if you are using a

32-bit flat-memory-space environment, such as DJGPP or Watcom C. (And you should use one if you have it, as performance will be much better than 8086-compatible code!) For flat-memory-space compilers, do NOT define NEED_FAR_POINTERS, and do NOT use jmemdos.c. Use jmemnobs.c if the environment supplies adequate virtual memory, otherwise use jmemansi.c or jmemname.c.

You'll still need to be careful about binary I/O through stdin/stdout.
See the last paragraph of the previous section.

MS-DOS, Borland C:

Be sure to convert all the source files to DOS text format (CR/LF newlines).
Although Borland C will often work OK with unmodified Unix (LF newlines) source files, sometimes it will give bogus compile errors.
"Illegal character '#'" is the most common such error. (This is true with Borland C 3.1, but perhaps is fixed in newer releases.)

If you want one-file command line style, just undefine TWO_FILE_COMMANDLINE.
jconfig.bcc already includes #define USE_SETMODE to make this work.
(fdopen does not work correctly.)

MS-DOS, Microsoft C:

makefile.mc6 works with Microsoft C, DOS Visual C++, etc. It should only be used if you want to build a 16-bit (small or medium memory model) program.

If you want one-file command line style, just undefine TWO_FILE_COMMANDLINE.
jconfig.mc6 already includes #define USE_SETMODE to make this work.
(fdopen does not work correctly.)

Note that this makefile assumes that the working copy of itself is called "makefile". If you want to call it something else, say "makefile.mak", be sure to adjust the dependency line that reads "$(RFILE) : makefile". Otherwise the make will fail because it doesn't know how to create "makefile". Worse, some releases of Microsoft's make utilities give an incorrect error message in this situation.

Old versions of MS C fail with an "out of macro expansion space" error because they can't cope with the macro TRACEMS8 (defined in jerror.h). If this happens to you, the easiest solution is to change TRACEMS8 to expand to nothing. You'll lose the ability to dump out JPEG coefficient tables with djpeg -debug -debug, but at least you can compile.

Original MS C 6.0 is very buggy; it compiles incorrect code unless you turn off optimization entirely (remove -O from CFLAGS). 6.00A is better, but it still generates bad code if you enable loop optimizations (-Ol or -Ox).

MS C 8.0 crashes when compiling jquant1.c with optimization switch /Oo ... which is on by default. To work around this bug, compile that one file with /Oo-.

Microsoft Windows (all versions), generic comments:

Some Windows system include files define typedef boolean as "unsigned char".
The IJG code also defines typedef boolean, but we make it "int" by default.
This doesn't affect the IJG programs because we don't import those Windows
include files. But if you use the JPEG library in your own program, and some
of your program's files import one definition of boolean while some import the
other, you can get all sorts of mysterious problems. A good preventive step
is to make the IJG library use "unsigned char" for boolean. To do that,
add something like this to your jconfig.h file:

```
/* Define "boolean" as unsigned char, not int, per Windows custom */
#ifndef __RPCNDR_H__          /* don't conflict if rpcndr.h already read */
typedef unsigned char boolean;
#endif
#define HAVE_BOOLEAN       /* prevent jmorecfg.h from redefining it */
```

(This is already in jconfig.vc, by the way.)

windef.h contains the declarations

```
#define far
#define FAR far
```

Since jmorecfg.h tries to define FAR as empty, you may get a compiler
warning if you include both jpeglib.h and windef.h (which windows.h
includes). To suppress the warning, you can put "#ifndef FAR"/"#endif"
around the line "#define FAR" in jmorecfg.h.

When using the library in a Windows application, you will almost certainly
want to modify or replace the error handler module jerror.c, since our
default error handler does a couple of inappropriate things:

1. it tries to write error and warning messages on stderr;
2. in event of a fatal error, it exits by calling exit().

A simple stopgap solution for problem 1 is to replace the line

```
fprintf(stderr, "%s\n", buffer);
```

(in output_message in jerror.c) with

```
MessageBox(GetActiveWindow(),buffer,"JPEG Error",MB_OK|MB_ICONERROR);
```

It's highly recommended that you at least do that much, since otherwise
error messages will disappear into nowhere. (Beginning with IJG v6b, this
code is already present in jerror.c; just define USE_WINDOWS_MESSAGEBOX in
jconfig.h to enable it.)

The proper solution for problem 2 is to return control to your calling
application after a library error. This can be done with the setjmp/longjmp
technique discussed in libjpeg.doc and illustrated in example.c. (NOTE:
some older Windows C compilers provide versions of setjmp/longjmp that
don't actually work under Windows. You may need to use the Windows system
functions Catch and Throw instead.)

The recommended memory manager under Windows is jmemnobs.c; in other words,
let Windows do any virtual memory management needed. You should NOT use
jmemdos.c nor jmemdosa.asm under Windows.

For Windows 3.1, we recommend compiling in medium or large memory model;
for newer Windows versions, use a 32-bit flat memory model. (See the MS-DOS
sections above for more info about memory models.) In the 16-bit memory
models only, you'll need to put

```
#define MAX_ALLOC_CHUNK 65520L          /* Maximum request to malloc() */
```

into jconfig.h to limit allocation chunks to 64Kb. (Without that, you'd
have to use huge memory model, which slows things down unnecessarily.)
jmemnobs.c works without modification in large or flat memory models, but to
use medium model, you need to modify its jpeg_get_large and jpeg_free_large
routines to allocate far memory. In any case, you might like to replace
its calls to malloc and free with direct calls on Windows memory allocation
functions.

You may also want to modify jdatasrc.c and jdatadst.c to use Windows file
operations rather than fread/fwrite. This is only necessary if your C
compiler doesn't provide a competent implementation of C stdio functions.

You might want to tweak the RGB_xxx macros in jmorecfg.h so that the library
will accept or deliver color pixels in BGR sample order, not RGB; BGR order
is usually more convenient under Windows. Note that this change will break
the sample applications cjpeg/djpeg, but the library itself works fine.

Many people want to convert the IJG library into a DLL. This is reasonably
straightforward, but watch out for the following:

1. Don't try to compile as a DLL in small or medium memory model; use
large model, or even better, 32-bit flat model. Many places in the IJG code
assume the address of a local variable is an ordinary (not FAR) pointer;
that isn't true in a medium-model DLL.

2. Microsoft C cannot pass file pointers between applications and DLLs.
(See Microsoft Knowledge Base, PSS ID Number Q50336.) So jdatasrc.c and
jdatadst.c don't work if you open a file in your application and then pass
the pointer to the DLL. One workaround is to make jdatasrc.c/jdatadst.c
part of your main application rather than part of the DLL.

3. You'll probably need to modify the macros GLOBAL() and EXTERN() to
attach suitable linkage keywords to the exported routine names. Similarly,
you'll want to modify METHODDEF() and JMETHOD() to ensure function pointers
are declared in a way that lets application routines be called back through
the function pointers. These macros are in jmorecfg.h. Typical definitions
for a 16-bit DLL are:

```
#define GLOBAL(type)            type _far _pascal _loadds _export
#define EXTERN(type)            extern type _far _pascal _loadds
#define METHODDEF(type)             static type _far _pascal
#define JMETHOD(type,methodname,arglist)  \
        type (_far _pascal *methodname) arglist
```

For a 32-bit DLL you may want something like

```
#define GLOBAL(type)            __declspec(dllexport) type
#define EXTERN(type)            extern __declspec(dllexport) type
```

Although not all the GLOBAL routines are actually intended to be called by
the application, the performance cost of making them all DLL entry points is

negligible.

The unmodified IJG library presents a very C-specific application interface, so the resulting DLL is only usable from C or C++ applications. There has been some talk of writing wrapper code that would present a simpler interface usable from other languages, such as Visual Basic. This is on our to-do list but hasn't been very high priority --- any volunteers out there?

Microsoft Windows, Borland C:

The provided jconfig.bcc should work OK in a 32-bit Windows environment, but you'll need to tweak it in a 16-bit environment (you'd need to define NEED_FAR_POINTERS and MAX_ALLOC_CHUNK). Beware that makefile.bcc will need alteration if you want to use it for Windows --- in particular, you should use jmemnobs.c not jmemdos.c under Windows.

Borland C++ 4.5 fails with an internal compiler error when trying to compile jdmerge.c in 32-bit mode. If enough people complain, perhaps Borland will fix it. In the meantime, the simplest known workaround is to add a redundant definition of the variable range_limit in h2v1_merged_upsample(), at the head of the block that handles odd image width (about line 268 in v6 jdmerge.c):

```
  /* If image width is odd, do the last output column separately */
  if (cinfo->output_width & 1) {
    register JSAMPLE * range_limit = cinfo->sample_range_limit; /* ADD THIS */
    cb = GETJSAMPLE(*inptr1);
```

Pretty bizarre, especially since the very similar routine h2v2_merged_upsample doesn't trigger the bug.
Recent reports suggest that this bug does not occur with "bcc32a" (the Pentium-optimized version of the compiler).

Another report from a user of Borland C 4.5 was that incorrect code (leading to a color shift in processed images) was produced if any of the following optimization switch combinations were used:

```
        -Ot -Og
        -Ot -Op
        -Ot -Om
```

So try backing off on optimization if you see such a problem. (Are there several different releases all numbered "4.5"??)

Microsoft Windows, Microsoft Visual C++:

jconfig.vc should work OK with any Microsoft compiler for a 32-bit memory model. makefile.vc is intended for command-line use. (If you are using the Developer Studio environment, you may prefer the DevStudio project files; see below.)

Some users feel that it's easier to call the library from C++ code if you force VC++ to treat the library as C++ code, which you can do by renaming all the *.c files to *.cpp (and adjusting the makefile to match). This avoids the need to put extern "C" { ... } around #include "jpeglib.h" in your C++ application.

Microsoft Windows, Microsoft Developer Studio:

We include makefiles that should work as project files in DevStudio 4.2 or later. There is a library makefile that builds the IJG library as a static Win32 library, and an application makefile that builds the sample applications as Win32 console applications. (Even if you only want the library, we recommend building the applications so that you can run the self-test.)

To use:
1. Copy jconfig.vc to jconfig.h, makelib.ds to jpeg.mak, and
   makeapps.ds to apps.mak. (Note that the renaming is critical!)
2. Click on the .mak files to construct project workspaces.
   (If you are using DevStudio more recent than 4.2, you'll probably
   get a message saying that the makefiles are being updated.)
3. Build the library project, then the applications project.
4. Move the application .exe files from `app`\Release to an
   appropriate location on your path.
5. To perform the self-test, execute the command line
        NMAKE /f makefile.vc test

OS/2, Borland C++:

Watch out for optimization bugs in older Borland compilers; you may need to back off the optimization switch settings. See the comments in makefile.bcc.

SGI:

On some SGI systems, you may need to set "AR2= ar -ts" in the Makefile. If you are using configure, you can do this by saying
        ./configure RANLIB='ar -ts'
This change is not needed on all SGIs. Use it only if the make fails at the stage of linking the completed programs.

On the MIPS R4000 architecture (Indy, etc.), the compiler option "-mips2" reportedly speeds up the float DCT method substantially, enough to make it faster than the default int method (but still slower than the fast int method). If you use -mips2, you may want to alter the default DCT method to be float. To do this, put "#define JDCT_DEFAULT JDCT_FLOAT" in jconfig.h.

VMS:

On an Alpha/VMS system with MMS, be sure to use the "/Marco=Alpha=1" qualifier with MMS when building the JPEG package.

VAX/VMS v5.5-1 may have problems with the test step of the build procedure reporting differences when it compares the original and test images. If the error points to the last block of the files, it is most likely bogus and may

be safely ignored. It seems to be because the files are Stream_LF and Backup/Compare has difficulty with the (presumably) null padded files. This problem was not observed on VAX/VMS v6.1 or AXP/VMS v6.1.