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Coding of Still Pictures

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Joint Bi-level Image Experts Group	Joint Photographic Experts Group

TITLE: **JasPer Software Reference Manual (Version 1.900.0) (Last Revised: 2006-12-07)**

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JasPer Software Reference Manual (Version 1.900.0)

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Contents

List of Figures

Chapter 1

Introduction

1.1 Motivation Behind JasPer

Digital imagery is used in many of today's computer software applications. Consequently, software modules that facilitate the handling of such data are often needed. Almost any application program that deals with images must address the problem of image interchange and import/export. That is, a means must exist for moving image data between an application and its external environment. Moreover, applications must often be capable of rendering an image for display on a particular output device (such as a monitor or printer) with reasonably accurate color/tone reproduction.

Although image import/export and rendering are very basic functionalities, they are often not easily implemented. Usually, an image is represented in a coded format (such as JPEG-2000 JP2 [8] or JPEG [2]). Since coding formats are frequently quite complex, the import/export of image data can be a daunting task. Rendering an image in such a way as to accurately reproduce color/tone requires a color management scheme of some sort. Unfortunately, developing an effective color management engine can require considerable effort.

A search for a solution to the above problems led to the development of the JasPer software. The remainder of this document provides a detailed description of the this software.

1.2 What is JasPer?

In simple terms, JasPer is a software tool kit for the handling of image data. The software provides a means for representing images, and facilitates the manipulation of image data, as well as the import/export of such data in numerous formats (e.g., JPEG-2000 JP2 [8], JPEG [2], PNM [4], BMP [12], Sun Rasterfile [13], and PGX [9]). The import functionality supports the auto-detection (i.e., automatic determination) of the image format, eliminating the need to explicitly identify the format of coded input data. A simple color management engine is also provided in order to allow the accurate representation of color. Partial support is included for the ICC color profile file format [7], an industry standard for specifying color.

The JasPer software consists of a library and several application programs. The code is written in the C programming language [3, 11]. This language was chosen primarily due to the availability of C development environments for most of today's computing platforms. At present, JasPer consists of approximately 40K lines of code. Although written in C, the JasPer library can be easily integrated into applications written in the C++ programming language as well.

1.3 Software License

JasPer software development is based on an open-source model. A copy of the software license can be found in Appendix A.

1.4 Other Sources of Information on JasPer

For more information about the JasPer software, please visit the following web pages:

- JasPer Project Home Page (i.e., `http://www.ece.uvic.ca/˜mdadams/jasper`)
- JasPer Software Announcements Group (i.e., `http://groups.yahoo.com/group/jasper-announce`)

  By joining this group, one can easily obtain up-to-date information about the JasPer Project in a timely fashion. The associated mailing list is used to announce new releases of the software and disseminate other important information about JasPer.
- JasPer Software Discussion Group (i.e., `http://groups.yahoo.com/group/jasper-discussion`).

For more information about the JasPer software and JPEG-2000 standard, the reader is referred to [6, 5].

1.5 Origin of the Name

The JasPer software is named, in part, after Jasper National Park, the largest national park in the Canadian Rockies with 10,878 square kilometres of mountain wilderness. As it happens, jasper is also the name of an opaque cryptocrystalline variety of quartz used for ornamentation or as a gemstone—hence, the implication that the software is precious (i.e., like a gemstone). Lastly, the name “jasper” was also chosen because it contains a letter “J” followed subsequently by a letter “P”, not unlike the abbreviation “JP” that is associated with the JPEG-2000 standard.

Chapter 2

JasPer Software

2.1 Version Identification

As the JasPer software continues to evolve over time, it is important to be able to identify particular releases of the software. Every release of the JasPer software is named by a version identifier. A version identifier is comprised of three integers separated by dots. In order, the three integers correspond to the major, minor, and micro version numbers for the software. For example, the version identifier “1.500.0” corresponds to a major version of 1, a minor version of 500, and a micro version of 0. In instances where the micro version is zero, the version identifier may be truncated after the minor version number. For example, the version identifier “1.500” is completely valid and simply an abbreviation for “1.500.0”.

Given two different releases of the JasPer software, one can easily determine which one is more recent by comparing the version identifiers, as follows: 1) if the major version numbers differ, the release with the higher major version number is newer; 2) if the major version numbers are equal and the minor version numbers differ, the release with the higher minor version number is newer; or 3) if the major version numbers are equal and the minor version numbers are equal, the release with the higher micro version is newer.

2.2 Obtaining the Software

The latest version of the JasPer software can be downloaded from the following locations:

- JasPer Project Home Page (i.e., `http://www.ece.uvic.ca/~mdadams/jasper`)
- JPEG Web Site Software Page (i.e., `http://www.jpeg.org/software`)

2.3 Extracting the Software

The JasPer software is distributed in the form of a Zip file. Therefore, in order to extract the contents of this file, a program capable of handling Zip archives is required. Such software is readily available for many different computing platforms, and can be obtained from:

- Info-Zip Web Site (i.e., `http://www.info-zip.org`). Unzip software for many different computing platforms (e.g., UNIX, DOS, MacOS, etc.).
- WinZip Web Site (i.e., `http://www.winzip.com`). Zip/Unzip software for Microsoft Windows.

2.4 Building the Software

Obviously, before the software can be built, the contents of the archive file containing the JasPer distribution must be extracted.

The JasPer code should compile and run on any platform with a C language implementation conforming to ISO/IEC 9899:1999 [3] (i.e., the ISO C language standard) and supporting a subset of ISO/IEC 9945-1 [1] (i.e., the POSIX C API). Only limited POSIX support is required (i.e., the open, close, read, write, and lseek functions must be supported).

Portability was a major consideration during the design of the JasPer software. For this reason, the software makes minimal assumptions about the runtime environment. The code uses very little floating-point arithmetic, most of which can be attributed to floating-point conversions in printf's. This minimal use of floating-point arithmetic should make the code much easier to port to platforms lacking hardware support for floating-point arithmetic.

The specific procedure required to build the JasPer software depends on the type of system involved. Only two different build methods are supported. The first method is based on the well known make utility and should work on most UNIX (or UNIX-like) systems. The second method is specifically tailored to the needs of Microsoft Visual C under Microsoft Windows. In passing, we note that by using free software such as Cygwin (`http://www.cygwin.com`), one can also create a UNIX-like environment under Microsoft Windows in which to build JasPer using the first method.

If you are unfortunate enough to have a compiler that is not compliant with ISO/IEC 9899:1999, you may need to make some changes to the code. Unfortunately, even some of the most popular C language implementations do not strictly comply with the standard. One such example is Microsoft Visual C 6.0. Due to the popularity of Visual C, however, several workarounds have been added to the JasPer code to ensure that it will compile successfully with Visual C.

The current version of the JasPer software is known to compile in the following environments:

- Red Hat Linux 7.3, GNU C 2.96, GNU Make 3.79.1
- SunOS/SPARC 5.7, GNU C 2.95, SunOS make
- Windows 2000 Professional, Microsoft Visual C 6.0

Of course, the software should compile successfully in many other environments as well. For example, past versions of JasPer have been reported to build successfully in the following environments:

- Apple Macintosh PPC G3, Rhapsody 5.6, GNU C 2.7.2.1
- Power Macintosh, GNU/Linux 2.2.15pre9, GNU C 2.95.2
- Sun SPARC, Solaris 2.7, GNU C 2.95.2
- Compaq/DEC Alpha, OSF/1 4.0F, GNU C 2.95.2
- IBM PowerPC, AIX 4.2, GNU C 2.95.2
- HP 9000/712, HP-UX 10.20, GNU C 2.95.2
- SGI Origin 200, IRIX 6.5, GNU C 2.95.2
- OpenVMS Alpha 7.2-1 with Compaq C compiler V6.2-008 (after creating custom makefiles)

2.4.1 Build Process for UNIX (or UNIX-Like) Systems

The JasPer software is intended to be built using the standard UNIX make utility (in conjunction with a configure script).

If you need a C compiler that is reasonably compliant with the ISO/IEC 9899:1999 standard, you can obtain GNU C from the GNU Project web site (i.e., `http://www.gnu.org`). If you need an implementation of the make utility, you can also obtain GNU Make from the the GNU Project web site. All GNU software is free software.

In what follows, `$TOPDIR` denotes the top level directory of the JasPer software distribution (i.e., the directory containing the file named `configure`). To build the software, the following steps are required (in order):

1. *Set the current working directory to the top level directory of the JasPer software distribution.*

   To set the current working directory as required, type:

   ```
   cd $TOPDIR
   ```

   (where `$TOPDIR` is defined as described earlier in this section).

2. *Perform the initial configuration of the software.*

   This is accomplished by running the configure script. This process allows important information about the system configuration to be determined. The configure script also generates makefiles from makefile templates. In theory, it should not be necessary to manually edit any of the makefile templates (i.e., the Makefile.in files) used by the configure program. To invoke the configure program, type:

   ```
   ./configure
   ```

   The configure script accepts a number of options. These options can be listed by invoking the configure command with the `--help` option. Unless you know what you are doing (or have problems with the default build settings), it is *strongly* recommended that you not override the default settings for configure.

   In some cases, it may be necessary to explicitly disable the use of the IJG JPEG library (i.e., libjpeg). This is accomplished by supplying the `--disable-libjpeg` option to configure. For example, such action may be required if the version of the JPEG library installed on your system is not compatible with the version of JasPer being built. Also, when building under the Cygwin environment, it may be neccessary to explicitly disable the use of the JPEG library.

   In some situations, it may be necessary to explicitly disable the use of the OpenGL libraries. This is accomplished by supplying the `--disable-opengl` option to configure.

3. *Compile and link the software.*

   This is accomplished via the make command. To run the make program, type:

   ```
   make
   ```

4. *Install the software.*

   This step may require special (e.g., superuser/administrator) privileges depending on the target directory for installation. (The default installation directories are normally under `/usr/local`.) To install the executables, libraries, include files, and other auxiliary data, type:

   ```
   make install
   ```

Presuming that the build was successful, the executables for the JasPer application programs can be found in the directory `$TOPDIR/src/appl`.

2.4.2 Build Process for Microsoft Visual C Studio under Microsoft Windows

With Microsoft Visual C, the entire build process is driven from workspace and project files. For the sake of convenience, all of the workspace and project files necessary to build the JasPer software are provided.

In what follows, `$TOPDIR` denotes the top level directory of the JasPer software distribution (i.e., the directory containing the file named `configure`). To build the software, the following steps are required (in order):

1. *If necessary, install the OpenGL and GLUT libraries on your system.*

   These libraries are required in order to build the jiv application program which is included in the JasPer software. The JasPer library itself and the other application programs included with JasPer can be built without the OpenGL and GLUT libraries, however.

2. *Run Microsoft Visual C.*

3. *Open the JasPer workspace file.*

   The JasPer workspace file is called `jasper.dsw` and can be found in the directory `$TOPDIR/src/msvc`. The workspace file can be opened using the “File” menu.

4. *Build the code.*

   From the “Build Menu”, select the “Batch Build” item. Choose the projects/configurations that are to be built, and then, click on the “Build” button. If you do not have the OpenGL and GLUT libraries (and their associated header files) installed on your system, you should not attempt to build the jiv application.

Presuming that the build was successful, the release and debug versions of the executables for the JasPer software can be found in the directories `$TOPDIR/src/msvc/Win32_Release` and `$TOPDIR/src/msvc/Win32_Debug`, respectively.

2.4.3 Dependencies on Other Software

In order to have access to the full functionality of the JasPer sofware, you may need to install some additional software on your system. This software must be installed before you attempt to build JasPer.

In order to compile the JasPer software with JPEG support, you will need to download and install the free IJG JPEG library which is available from the IJG web site (i.e., `http://www.ijg.org`). If you are not using a configure-based build for JasPer, then you will need to manually change the build process to use the code in the files `jpg_enc.c` and `jpg_dec.c` instead of `jpg_dummy.c`. (Note: These three files are contained in the JasPer distribution, not the IJG library.)

In order to build the jiv application, you will need the OpenGL and GLUT libraries installed on your system. It would appear that Windows 2000 and Windows XP ship with the OpenGL library from Microsoft. Most recent versions of UNIX ship with OpenGL support included. The GLUT library is less common and, therefore, may not be installed on your system. To obtain the GLUT library, one can visit: `http://www.opengl.org/developers/documentation/glut`. For more information on the OpenGL library, see: `http://www.opengl.org`.

At the time of this writing, a binary distribution of the GLUT library for Windows is available from the OpenGL web site:

`http://www.opengl.org/developers/documentation/glut/glutdlls37beta.zip`

This archive file contains three files of interest: 1) `glut.h`, 2) `glut32.lib`, and 3) `glut32.dll`. The file `glut.h` file should be installed in a directory in which the C compiler searches for header files (e.g.,

`$TOPDIR/src/include/jasper`). The `glut32.lib` file should be installed in a directory in which the C compiler searches for libraries. The `glut32.dll` file should be installed in a directory in which the system looks for dynamically-linked libraries.

2.5 Reporting Bugs

If you are unfortunate enough to encounter any problems with the JasPer software, please submit a bug report. In order to ensure that your bug report can be properly processed, always be sure to include *all* of the following information:

- The version of JasPer in which the problem was found.
- The details of the run-time system (i.e., operating system, version number).
- The compiler that you are using (i.e., vendor, version number).
- The exact command line options used when the problem was observed.
- Indicate whether or not the problem is reproducible. If the problem is reproducible, indicate the exact steps required to reproduce the problem.
- A detailed description of the problem that you are experiencing.

It is essential that you include all of the above information. Failure to do so may result in the bug report not being processed. Your complete bug report should be sent to `mdadams@ieee.org`.

Chapter 3

JasPer Library

3.1 Introduction

The heart of the JasPer software is the JasPer library. In fact, most of the code in JasPer is associated with this library (as opposed to the JasPer sample application programs). The JasPer library provides classes for representing images, color profiles (i.e., color space definitions), and other related entities. Each of these classes has a well-defined interface through which an application may interact with class objects. The library can be used to manipulate images, import/export image data in a variety of formats, and perform basic color management operations.

Conceptually, the JasPer library is structured as shown in Fig. 3.1. The library consists of two distinct types of code: 1) core code, and 2) codec drivers. The core code provides the basic framework upon which the library is built, while the codec drivers only provide the means for encoding/decoding image data in various formats. All application interfaces are through the core code. The codec drivers are only ever directly called by the core code, never by an application.

The codec support in the JasPer library is both modular and extensible. A well-defined interface exists between the core code and codec drivers. Moreover, support for a new image format can be easily added without having to modify the library in any way. To do so, a codec driver for the new format simply needs to be provided. Furthermore, an application need only include codec drivers for the image formats that it will use. In this way, an application can avoid the cost of increased memory consumption for codec drivers that are never to be employed.

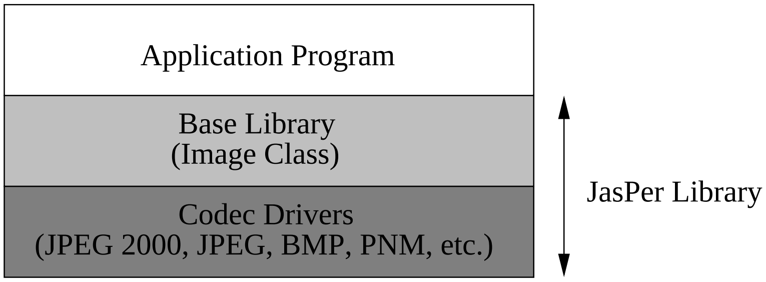


Figure 3.1: Software structure.

3.2 Core Code

The core code provides a number of key classes as described below. (To avoid name space collisions, all of the identifiers used by the core code are prefixed with either `jas_` or `JAS_`.)

1. Image class (i.e., `jas_image_t`). This class is used to represent an image. Methods are provided for such things as: image creation/destruction, querying general image properties (e.g., reference grid width and height, color profile), querying component properties (e.g., width, height, grid offset, grid spacing, component type, sample precision/signedness), setting various image properties, loading and saving an image (i.e., encoding/decoding), copying an image, adding and deleting components, and reading and writing component data.

2. Color profile class (i.e., `jas_cmprof_t`). This class is used to define a color space. Such a definition is made relative to a reference color space such as CIE XYZ or CIE Lab [7].

3. Color transform class (i.e., `jas_cmxform_t`). This class is used to apply a color space conversion to image data. A color space transform is created from two or more color profiles.

4. Stream class (i.e., `jas_stream_t`). This class provides I/O streams similar to that of standard C library [3], but with additional functionality required by other code in the JasPer library. This extra functionality includes: 1) the ability to associate an object other than a file descriptor with a stream (such as a memory buffer), and 2) multi-character unget.

5. Fixed-point number class. This templated class (i.e., a set of macros) provides a fixed-point number class. Support is provided for basic arithmetic operations, type conversion, and rounding.

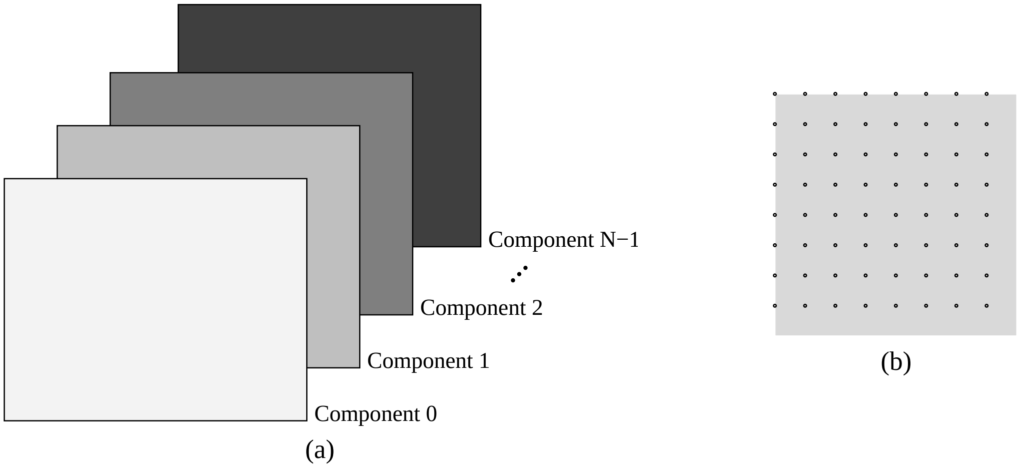
6. Tag-value parser class (i.e., `jas_tvp_t`). This class is used to parse strings containing one or more tag-value pairs. A tag-value pair is a string of the form “tag=value”. Tag-value pairs are used by some interfaces within JasPer in order to pass parameters. For example, such pairs are used to pass options to codec drivers for encoding/decoding operations. Methods are provides for such things as: creation/destruction, finding the next tag-value pair in a string, and querying the current tag and value.

In addition to the above classes, some other functionality is provided, including command line parsing routines (similar in spirit to UNIX `getopt`).

3.3 Codec Drivers

The core code provides a framework for housing codec drivers. A codec driver provides the means for encoding/decoding of image data in a particular format. Each driver provides three methods: 1) an encoding, 2) decoding, and 3) validation method. The encoding method emits the coded version of an image (i.e., a `jas_image_t` object) to a stream (i.e., a `jas_stream_t` object). The decoding method creates an image (i.e., a `jas_image_t` object) from the coded data in a stream. The validation method is used to quickly test if the data in a stream is formatted correctly for the image format in question. This particular method is used for the autodetection of image formats.

The codec drivers provided with the JasPer distribution are written in order to accommodate streamed data. In other words, image data streams are always processed in a single pass. This design philosophy eliminates the need for a stream object to be seekable. As a result, it is possible to write application programs that receive data from, or send data to, pipelines or other entities that do not support random access to data.



(a)

(b)

Figure 3.2: Image model. (a) An image with N components. (b) Individual component.

3.4 Image Model

The set of applications for which JasPer may be a useful tool is dictated, in part, by the image model that JasPer employs. Therefore, it is prudent to introduce this model here. The image model employed by JasPer is quite general and partially inspired by the one used in the JPEG-2000 standard.

An image is comprised of one or more components. In turn, each component consists of rectangular array of samples. This structure is depicted in Fig. 3.2. The sample values for each component are integer valued, and can be signed or unsigned with precision from 1 to (nominally) 16 bits/sample[1]. The signedness and precision of the sample data are specified on per-component basis. All of the components are associated with same spatial extent in an image, but represent different types of information.

There is considerable flexibility in the interpretation of components. A component may represent spectral information (e.g., a color plane) or auxiliary information (e.g., an opacity plane). For example, a RGB image would have three components, where one component is associated with each of the red, green, and blue color planes. A RGBA (i.e., RGB with transparency) image would have four components, one associated with each of the red, green, blue, and alpha planes. The various components need not be sampled at the same resolution. In other words, different components may have different sampling periods. For example, when color images are represented in a luminance-chrominance color space, it is not uncommon for the luminance information to be more finely sampled than the chrominance information.

Since an image can have a number of components, a means must exist for specifying how these components are combined together in order to form a composite image. For this purpose, we employ an integer lattice known as the reference grid. The reference grid provides an anchor point for the various components of an image, and establishes their alignment relative to one another.

Each component is associated with a rectangular sampling grid. Such a grid is uniquely specified by four parameters: the horizontal offset (HO), vertical offset (VO), horizontal spacing (HS), and vertical spacing (VS). The samples of a component are then mapped onto the points where the sampling grid intersects the reference grid. In this way, sample (i, j) of a component is mapped to the position $(\mathrm{HO} + i\mathrm{HS}, \mathrm{VO} + j\mathrm{VS})$ on the reference grid.

To clarify the above text, we now present an illustrative example. Consider an image with three components. For the kth component, let us denote the horizontal grid offset, vertical grid offset, horizontal grid

---

[1] The maximum allowable precision is platform dependent. Most common platforms, however, should be able to accommodate at least 16 bits/sample.

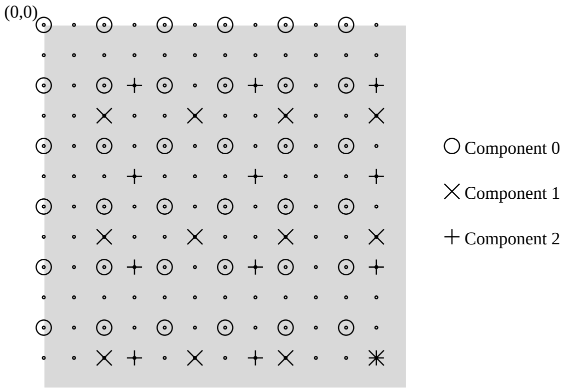


Figure 3.3: Alignment of components on the reference grid.

spacing, and vertical grid spacing, as HO_k, VO_k, HS_k, and VS_k, respectively. Suppose, for example, that these parameters have the following values:

k	$(\mathrm{HO}_k, \mathrm{VO}_k)$	$(\mathrm{HS}_k, \mathrm{VS}_k)$
0	(0, 0)	(2, 2)
1	(2, 3)	(3, 4)
2	(3, 2)	(4, 3)

In this scenario, the component samples would be aligned on the reference grid as illustrated in Fig. 3.3. Perhaps, it is worth nothing that the above set of parameter values was chosen in order to provide an enlightening example, and is not meant to represent a set of values that is likely to be used with great frequency by applications.

From above, we can see that the image model used by JasPer is quite general. The main constraint imposed by this model is that rectangular sampling must be employed. The vast majority of applications, however, use such sampling. Also, with JasPer, one can easily accommodate grayscale, color, and other multi-band data (with or without opacity information).

3.5 JasPer Header Files

In order to use the JasPer library, a C source file normally must include the main JasPer library header file `jasper/jasper.h`. This can be accomplished with the following preprocessor directive:

```
#include <jasper/jasper.h>
```

The main header file includes all of the other library header files. Therefore, in order to insulate application code from possible changes to the names of the other library header files, one should only ever include the main library header directly.

3.6 Initializing the Library

The first usage of the library must always be to initialize it. This is accomplished by calling `jas_init`. If any other functionality of the library is used before this initialization is performed, the resulting behavior is undefined.

3.7 Memory Allocation

All memory allocation in the libjasper library is performed via the functions `jas_malloc`, `jas_realloc`, `jas_calloc`, and `jas_free`. If one is trying to port the JasPer code to an embedded platform, it might be necessary to change these functions to use a platform-specific memory allocator, rather than `malloc` and friends.

3.8 Adding Support for a New Image Format

Support for new image formats can be easily added to JasPer. In order to add support for a new image format, one must provide three functions:

1. an encoding function,
2. a decoding function, and
3. a validation function.

The encoding function emits the coded version of an image (i.e., an `jas_image_t` object) to a stream (i.e., a `jas_stream_t` object). The decoding function creates an image (i.e., an `jas_image_t` object) from the coded data in a stream (i.e., a `jas_stream_t` object). The validation function is used to quickly test if a data stream is formatted correctly for the image format in question. (This functionality is necessary for the autodetection of image formats.)

The exact types and arguments taken by the encoding, decoding, and validation functions can be found by examining the code for the image formats already supported by JasPer (e.g., PNM, BMP, JPEG). Once the above functions have been written, the JasPer library can be made aware of the new image format through a call to `jas_image_addfmt`. This call, of course, must be made after the JasPer library has been initialized. The code for the `jas_init` function gives several examples of how the `jas_image_addfmt` function might be invoked.

Chapter 4

Application Programs

4.1 Introduction

In order to demonstrate how the JasPer library can be used, several sample application programs are provided in the JasPer software distribution. These programs include: `jasper`, `jiv`, `imgcmp`, and `imginfo`. The `jasper` program is an image transcoder (i.e., it converts image data from one format to another). The `jiv` program is a simple image viewer (based on OpenGL). The `imgcmp` program is an image comparison utility. It measures the difference between two images using one of numerous distortion metrics (such as peak signal-to-noise ratio, mean squared error, root mean squared error, peak absolute error, and mean absolute error). The `imginfo` program provides basic information about an image, such as its geometry (i.e., number of components, width and height of components, and so on). Although the above-mentioned programs are intended mainly for demonstration purposes, they have also proven quite useful in their own right, especially the `jasper` and `jiv` programs. In the sections that follow, each of the above-mentioned programs is described in more detail.

4.2 The jasper Command

Synopsis

`jasper` [options]

Description

The jasper command converts image data from one format to another. In other words, this command functions as a general-purpose transcoder. Since the JPEG-2000 format is supported by this software, it can be used as a JPEG-2000 encoder and/or decoder.

Options

The jasper program accepts the following options:

`--help`
Print usage information and exit.

`--version`
Print the version and exit.

`--input` *file*
`-f` *file*
Read the input image from the file named *file*. By default, the input image is read from standard input.

`--input-format` *format*
`-t` *format*
Specify the format of the input image as *format*. In most circumstances, this option should not be needed, as the format is normally autodetected by examining the image data directly or deduced from the input file name extension if an input file is specified (via the `--input` option).

`--input-option` *option*
`-o` *option*
Provide the option *option* to the decoder. The valid values for the argument *option* are determined by the input image format. See below for more details.

`--output` *file*
`-F` *file*
Write the encoded image to the file named *file*. By default, the encoded image is written to standard output.

`--output-format` *format*
`-T` *format*
Produce the output image in the format indicated by *format*. The output format must be specified if an output file is not given (via the ”–output” option). If an output file is given and no output format is specified, an attempt will be made to deduce the correct format from the output file name extension.

`--output-option` *option*
`-O` *option*
Provide the option *option* to the encoder. The valid values for the argument *option* are determined by the output format. See below for more details.

`--verbose`
Enable verbose mode.

`--force-srgb`
Force the image to be converted to the sRGB color space before encoding. As a side effect, the image will also be homogenously sampled (i.e., all components are sampled at the same points on the reference grid).

The argument *format* must have one of the following values:

Value	Description
bmp	Windows BMP
jp2	JPEG-2000 JP2
jpc	JPEG-2000 Code Stream
jpg	JPEG
pgx	PGX
pnm	PNM/PGM/PPM
mif	My Image Format
ras	Sun Rasterfile

Examples

1. Suppose that we have an image stored in the PNM/PPM format in a file called `lena.ppm`. To encode this image (losslessly) in the JPEG-2000 JP2 format, and store the result in a file called `lena.jp2`, type:

   ```
   jasper --input lena.ppm --output lena.jp2 --output-format jp2
   ```

   Or, alternately (using short option names), type:

   ```
   jasper -f lena.ppm -F lena.jp2 -T jp2
   ```

2. Suppose that we have a RGB color image stored in the JPEG-2000 JP2 format in a file called `lena.jp2`. To encode this image in the PNM/PPM format, and store the result in a file called `lena.ppm`, type:

   ```
   jasper --input lena.jp2 --output lena.ppm --output-format pnm
   ```

   Or, alternately (using short option names), type:

   ```
   jasper -f lena.jp2 -F lena.ppm -T pnm
   ```

3. Suppose that we have an image stored in the BMP format in a file called `lena.bmp`. To encode this image in a lossy manner at 100:1 compression in the JPEG-2000 (code stream) format, and store the result in a file called `lena_lossy.jpc`, type:

   ```
   jasper -f lena.bmp -F lena_lossy.jpc -T jpc -O rate=0.01
   ```

4. Suppose that we have an image stored in a file called `sachie.pnm` in the PNM/PPM format, and we want to encode the image in the JPEG-2000 (code stream) format and store the result in a file named `sachie_new.jpc`. Further, suppose that we want the JPEG-2000 format to employ the following parameters:

   - code blocks are 64 samples in width and 32 samples in height
   - no multicomponent transform is to be employed
   - 4 resolution levels should be employed for each component
   - the compression is lossy at 64:1

   In order to accomplish the above, type:

   ```
   jasper -f sachie.pnm -F sachie_new.jpc -T jpc -O cblkwidth=64 -O cblkheight=32
   -O nomct -O numrlvls=4 -O rate=0.015625
   ```

4.3 The imgcmp Command

Synopsis

`imgcmp` [options]

Description

The imgcmp command compares two images. The two images being compared must have the same geometry (i.e., the same width, height, number of components, component subsampling factors, etc.).

Options

The following options are supported:

`-f` *file*
Read the primary (i.e., reference) image (for comparison purposes) from the file named *file*.

`-F` *file*
Read the secondary image (for comparison purposes) from the file named *file*.

`-m` *metric*
Use the difference metric specified by *metric*. The *metric* argument may assume one of the following values:

Value	Description
psnr	peak signal to noise ratio (PSNR)
mse	mean squared error (MSE)
rmse	root mean squared error (RMSE)
pae	peak absolute error (PAE)
mae	mean absolute error (MAE)
equal	equality

The `-f` and `-F` options must always be specified. There is currently no way to explicitly specify the format of the images. If the format of either image cannot be autodetected, the command will exit with an error.

Examples

1. Suppose that we have two slightly different versions of an image stored in files `original.pgm` and `reconstructed.pgm`. In order to calculate the difference between these images using the PSNR metric, type:

```
imgcmp -f original.pgm -F reconstructed.pgm -m psnr
```

4.4 The imginfo Command

Synopsis

`imginfo` [options]

Description

The imginfo command displays information about an image. This command is really only intended to be used from shell scripts for testing purposes.

4.5 The jiv Command

Synopsis

`jiv` [options] [file1 file2 . . .]

Description

The jiv command displays an image. Basic pan and zoom functionality is provided. Components of an image may be viewed individually. Color components may also be viewed together as a composite image. At present, the jiv image viewer has only trivial support for color. It recognizes RGB and YCbCr color spaces, but does not use tone reproduction curves and the like in order to accurately reproduce color. For basic testing purposes, however, the color reproduction should suffice.

Options

The following options are supported:

`--help`
: Print help information and exit.

`--wait` *n*
: Automatically step from one image to the next, pausing for *n* seconds in between.

Chapter 5

Codecs

The JasPer software provides implementations of several popular codecs. Likely, the ones of most interest are those associated with the JPEG-2000 standard. The sections that follow describe the various codecs in more detail.

5.0.1 BMP Codec

One of the most popular image formats on the Microsoft Windows platform is Microsoft's BMP format. The BMP codec in JasPer was written without the benefit of the BMP format specification from Microsoft. This means that the BMP support will inevitably not work correctly for all valid BMP files.

Encoder Options

The encoder does not support any special options.

Decoder Options

The decoder does not support any special options.

5.0.2 JP2 Codec

One of the two image formats specified in the JPEG-2000 Part-1 standard (i.e., ISO/IEC 15444-1 [8]) is the so called "JP2" format.

Encoder Options

The encoder supports all of the same options as the JPC encoder.

Decoder Options

The decoder supports all of the same options as the JPC decoder.

5.0.3 JPC Codec

One of the two image formats specified in the JPEG-2000 Part-1 standard (i.e., ISO/IEC 15444-1 [8]) is the so called JPEG-2000 code stream format. The JPC codec in JasPer implements this format.

The design of the JPEG-2000 codec implementation was driven by several key concerns: execution speed, memory usage, robustness, portability, modularity, maintainability, and extensibility. In some cases, however, during the design process, modularity, portability, and understandability of the code were weighed more heavily than execution speed and memory usage. Code understandability and portability were critical considerations since this software was intended to be used as a reference implementation of the JPEG-2000 Part-1 codec in the JPEG-2000 Part-5 standard [10].

Since the JPEG-2000 standard does not specify any means for encoding color space information in a JPEG-2000 code stream, the decoder must make certain assupmtions about the color space of an image. If accurate color representation is important, the JPEG-2000 code stream format should not be employed. The JPEG-2000 JP2 format should be used instead.

Encoder Options

The following options are supported by the encoder:

`imgareatlx=`*x*
: Set the x-coordinate of the top-left corner of the image area to *x*.

`imgareatly=`*y*
: Set the y-coordinate of the top-left corner of the image area to *y*.

`tilegrdtlx=`*x*
: Set the x-coordinate of the top-left corner of the tiling grid to *x*.

`tilegrdtly=`*y*
: Set the y-coordinate of the top-left corner of the tiling grid to *y*.

`tilewidth=`*w*
: Set the nominal tile width to *w*.

`tileheight=`*h*
: Set the nominal tile height to *h*.

`prcwidth=`*w*
: Set the precinct width to *w*. The argument *w* must be an integer power of two. The default value is 32768.

`prcheight=`*h*
: Set the precinct height to *h*. The argument *h* must be an integer power of two. The default value is 32768.

`cblkwidth=`*w*
: Set the nominal code block width to *w*. The argument *w* must be an integer power of two. The default value is 64.

`cblkheight=`*h*
: Set the nominal code block height to *h*. The argument *h* must be an integer power of two. The default value is 64.

`mode=`*m*
: Set the coding mode to *m*. The argument *m* must have one of the following values:

Value	Description
int	integer mode
real	real mode

If lossless coding is desired, the integer mode must be used. By default, the integer mode is employed. The choice of mode also determines which multicomponent and wavelet transforms (if any) are employed.

`rate=`*r*

Specify the target rate. The argument *r* is a positive real number. Since a rate of one corresponds to no compression, one should never need to explicitly specify a rate greater than one. By default, the target rate is considered to be infinite.

`ilyrrates=`$r_0[,r_1,\ldots,r_{N-1}]$

Specify the rates for any intermediate layers. The argument to this option is a comma separated list of *N* rates. Each rate is a positive real number. The rates must increase monotonically. The last rate in the list should be less than or equal to the overall rate (as specified with the `rate` option).

`prg=`*p*

Set the progression order to *p*. The argument *p* must have one of the following values:

Value	Description
lrcp	layer-resolution-component-position (LRCP) progressive (i.e., rate scalable)
rlcp	resolution-layer-component-position (RLCP) progressive (i.e., resolution scalable)
rpcl	resolution-position-component-layer (RPCL) progressive
pcrl	position-component-resolution-layer (PCRL) progressive
cprl	component-position-resolution-layer (CPRL) progressive

By default, LRCP progressive ordering is employed. Note that the RPCL and PCRL progressions are not valid for all possible image geometries. (See [8] for more details.)

`nomct`

Disallow the use of any multicomponent transform.

`numrlvls=`*n*

Set the number of resolution levels to *n*. The argument *n* must be an integer that is greater than or equal to one. The default value is 6.

`sop`

Generate SOP marker segments.

`eph`

Generate EPH marker segments.

`lazy`

Enable lazy coding mode (a.k.a. arithmetic coding bypass).

`termall`

Terminate all coding passes.

`segsym`

Use segmentation symbols.

`vcausal`
Use vertically stripe causal contexts.

`pterm`
Use predictable termination.

`resetprob`
Reset the probability models after each coding pass.

`numgbits=`*n*
Set the number of guard bits to *n*.

Decoder Options

The decoder does not support any special options.

Rate Specification

All rates are specified in terms of compression factors (i.e., as reciprocals of compression ratio) and not as actual bit rates! Although image coding folks frequently use the number of bits per pixel to specify rate, this quantity is often inconvenient to use when dealing with images that have differing sample precisions. Furthermore, the number of bits per pixel is not well defined for multicomponent images with distinct subsampling factors. The compression factor, however, is independent of sample precision and well defined for all types of images. For these reasons, JasPer uses the compression factor and not the number of bits per pixel to specify rates.

5.0.4 JPG Codec

For lossy coding, one of the most popular image formats is specified in the JPEG standard (i.e., ISO/IEC 10918-1 [2]). In JasPer, the JPG codec implements this format.

The JPEG support in JasPer requires the JPEG library from the Independent JPEG Group (IJG). For legal reasons, the IJG JPEG library source code is not included with JasPer. The source code for this library can be downloaded from the IJG web site (i.e., `http://www.ijg.org`).

Encoder Options

The following options are supported by the encoder:

`quality=`*q*
Set the quality factor to *q*. This is used in order to indirectly control the bit rate for lossy coding.

Decoder Options

The decoder does not support any special options.

5.0.5 PGX Codec

The JPEG-2000 Verification Model software employs a non-standard format called PGX. In JasPer, this format is handled by the PGX codec. The PGX format can only handle single components images, and consequently, is of limited use.

Encoder Options

The encoder does not support any special options.

Decoder Options

The decoder does not support any special options.

5.0.6 MIF Codec

The MIF format is not a standard format. This format was invented solely for the purpose of testing the JasPer software. The support for the MIF format is experimental. It is intended to be used for advanced testing of the JasPer JPEG-2000 codec implementation.

Encoder Options

The encoder does not support any special options.

Decoder Options

The decoder does not support any special options.

5.0.7 PNM Codec

On UNIX platforms, the Portable Pixmap/Graymap/Bitmap (PNM) format is quite popular for coding image data. The PNM codec in JasPer supports this format. In JasPer, the support for the PNM/PGM/PPM format is complete. Therefore, the use of this format is favored over the BMP format. A (nonstandard) extension has also been added to the support for the PNM format so that it can handle images with signed sample values.

Encoder Options

The following options are provided by the PNM encoder:

`text`
: Use a non-raw (i.e., non-binary) flavor of PNM format.

Decoder Options

The decoder does not support any special options.

5.0.8 RAS Codec

One popular image format on Sun workstations is the Sun Rasterfile format. The RAS codec in JasPer implements this format.

Encoder Options

The encoder does not support any special options.

Decoder Options

The decoder does not support any special options.

Appendix A

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The JasPer software may only be used under the terms of the license below.

```
__START_OF_JASPER_LICENSE__

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```

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