Managing Images

The **Save Data** and **Load Data** commands on the Files menu let you save and retrieve images and sequences in Photometrics block file and other popular formats. By exporting and importing, you can exchange images with third-party programs for image processing.

Filenames

The filenames used with the **Save Data** and **Load Data** commands must follow a few rules.

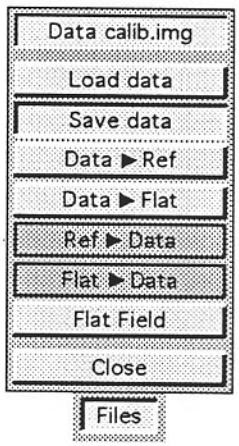
The extension you enter determines the file format; the Save Data and Load Data entry boxes contains a brief guide. If you enter a filename with a `.FIT` or `.FTS` extension, Image200 will use FITS format. If you enter a filename with a `.TIF` extension, Image200 will use TIFF format. All other filenames use Image200's native format, the Photometrics block file.

In addition, the following filenames are reserved for Image200's use:

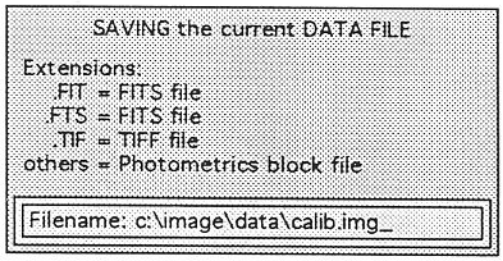
- Names that start with `IMAG`
- Names that end with `.TDF`
- The names `PM_REF` and `PM_FLAT`, with any extension

Saving Data

After you acquire an image or a sequence, it is stored only in Image200's current image buffer. To save the current image permanently, click the **Save Data** button on the Files menu.



An entry box appears



On the entry line, type the DOS pathname and filename you wish to use, up to 30 characters. To abandon the save, press ESC.

When you press ENTER, the current image is copied to this file and the pathname and filename are shown in the display box at the top of the Files menu.

Saving large images or sequences can take a long time. Times depend on the image size, hard disk speed, and CPU speed, but thirty seconds is not unusual.

If you don't save the current image, it will be lost when you acquire a new image, load an image from disk, or quit Image200.

Exporting to FITS

When you save an image in FITS format, only the current region is saved; multiple regions require multiple files. (The current region is the one outlined in red on the Main screen.) For a sequence, the entire sequence of that region is saved.

Image200 uses the minimum specification for a FITS image file. A single Primary HDU is written with the minimum fields to describe the data. The FITS header is defined as follows.

```
SIMPLE  =                    T /VANILLA FORMAT
BITPIX  =                   16 /
NAXIS   =                    3 /
NAXIS1  =                   48 /NUMBER OF COLUMNS
NAXIS2  =                   72 /NUMBER OF ROWS
NAXIS3  =                    1 /NUMBER OF IMAGES
DATE    = '28/10/91          ' /FITS FILE CREATION DATE
INSTRUME= 'TH 7863           ' /SENSOR USED TO CAPTURE IMAGE
DATE-OBS= '24/09/91          ' /IMAGE CREATION DATE
TIME-OBS=              29036.0 /IMAGE CREATION TIME
EXPOSURE=                0.001 /DURATION OF THE EXPOSURE IN SECONDS
MPP     =                    F /MPP MODE WAS USED IN THE EXPOSURE
GAIN    =                    1 /READOUT GAIN OF THE EXPOSURE
END
```

These values will vary depending on the image being saved. For example:

- `BITPLN` is 32 for a 32-bit image
- `NAXIS1` and `NAXIS2` are the size of the region
- `NAXIS3` is the number of exposures in the sequence

The file conforms to the *FITS Draft Standard* NOST 100-0.2f published on May 14, 1991. For information on the latest FITS specification contact:

NASA/OSSA Office of Standards and Technology
Code 933
NASA Goddard Space Flight Center
Greenbelt MD 20771

Exporting to TIFF

Standard TIFF formats support only 8 bits of grayscale data per pixel. Image200 exports the most significant bits of the image data.

As with FITS, only the current region is saved. For a sequence, the entire sequence of that region is saved, but it is saved as a single image containing all the individual exposures joined end to end (in the parallel direction on the CCD).

Image200 uses the minimum specification for a TIFF Version 5.0 Class G grayscale image to write the file. The TIFF header is defined as follows.

```
/* TIFF Header and IFD structure initialization */
static tiff_g_ifd_type tiff_g_ifd = {
    { INTELTIFF, 42, sizeof(TIFFHDR) }, /* TIFF File header */
      13, /* Tags in the IFD (TIFF V5.0 Class G) (0s will be set below) */
    { TGNEWSUBFILETYPE,             TIFFLONG,1,SINGLE_IMAGE },
    { TGIMAGEWIDTH,                 TIFFLONG,1,0 },
    { TGIMAGELENGTH,                TIFFLONG,1,0 },
    { TGBITSPERSAMPLE,             TIFFSHORT,1,8 },  /* 8 bits per pixel  */
    { TGCOMPRESSION,               TIFFSHORT,1,NO_COMPRESSION },
    { TGPHOTOMETRICINTERPRETATION,TIFFSHORT,1,WHITE_HIGH },
    { TGSTRIPOFFSETS,               TIFFLONG,0,0 },
    { TGSAMPLESPERPIXEL,           TIFFSHORT,1,1 },  /* 1 Sample per pix. */
    { TGROWSPERSTRIP,               TIFFLONG,1,1 },  /* 1 Row per Strip   */
    { TGSTRIPBYTECOUNTS,           TIFFSHORT,0,STRIPCNT_START },
    { TGXRESOLUTION,          TIFFRATIONAL,1,XRES_START },
    { TGYRESOLUTION,          TIFFRATIONAL,1,YRES_START },
    { TGRESOLUTIONUNIT,          TIFFSHORT,1,INCH_RESOLUTION },
      0 };
/
```

For maximum compatibility with other software, the pixels are written out in a one-row-per-strip format. This is not very efficient in disk space, and allows strips up to 2K pixels long.

For information on the latest TIFF specification contact:

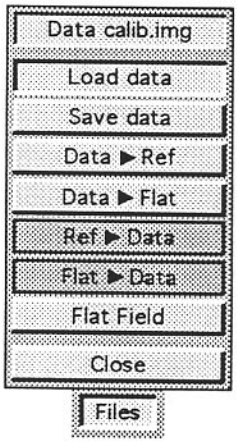
Windows Marketing Group
Microsoft Corporation
16011 NE 36th Way
Box 97017
Redmond, WA 98073–9717
(206) 882–8080

or:

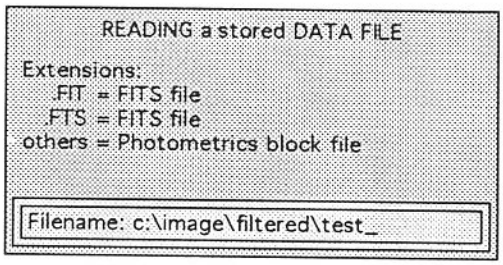
Developers' Desk
Aldus Corporation
411 First Ave. South
Suite 200
Seattle, WA 98104
(206) 622–5500

Loading Data

To load a disk file as the current image, click the **Load Data** button.



An entry box appears



As in the Save Data entry box, type the DOS pathname and filename you wish to use, up to 30 characters. To abandon the load, press ESC.

When you press ENTER, the disk file is copied to the current image buffer and the pathname and filename are shown in the display box at the top of the Files menu.

When you read an image from disk, it replaces the current image.

To display the image, Image200 reads the region definition from the file; but it uses the display orientation set in the Hardware Options dialog box.

Like saving, loading large images or sequences can take a long time.

Loading FITS

Image200 can read 8-bit, 16-bit, and 32- bit FITS files. Files with a `.FIT` or `.FTS` extension are assumed to be FITS image files.

Image200 cannot read TIFF files.

Image Correction and Math

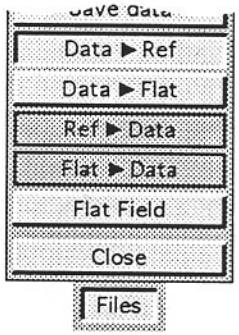
In addition to image acquisition, Image200 provides some simple image processing functions. Two commands on the Acquire menu allow you to set up and perform two specialized image correction operations—reference subtraction and flat field correction—as an integral part of an exposure acquisition. The Math dialog box allows you to perform image and constant arithmetic operations on single images.

Reference Subtraction

Image200 lets you define a reference image to be automatically subtracted from newly acquired exposures. This feature can be used to remove the DC bias and dark current from an exposure, or to compare exposures to a defined standard. For the best assurance of data integrity, however, you may prefer to use flat field correction, discussed on page 64.

Defining a Reference Image

The reference image is stored in an Image200 buffer. To copy the current image to the reference image, click the **Data › Ref** button on the Files menu



The operation overwrites any existing reference image.

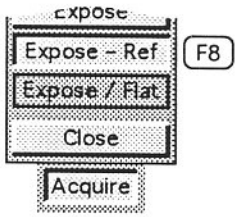
To copy the reference image back into the current image, click **Ref › Data**. This overwrites any existing current image.

When you quit Image200, the reference image is saved in the Image200 directory as a Photometrics block file named `PM_REF.TDF`, allowing the reference image to remain defined the next time you use Image200.

When you restart Image200, the reference image is not read from the disk until it is needed. If you are using memory buffers (as set in the Setup dialog box), calculation times will be faster if you force the reference image to be copied into memory by clicking **Ref › Data** then **Data › Ref**.

Using Expose – Ref

The **Expose – Ref** button on the Acquire menu



allows you to acquire an exposure and automatically subtract the reference image. The button is available only when the reference image is defined and Image200 is configured for a single exposure.

The exposure must have the same region definition as the reference image, or reference subtraction will not work.

When you click **Expose – Ref**:

1. A single exposure is acquired, just as if you had clicked **Expose**
2. The reference image is subtracted from the exposure
3. The result is displayed as the current image

Reference subtraction can require large amounts of memory. If the raw camera data is 16 bits, the subtraction may create 32-bit data.

Flat Field Correction

Each pixel within a CCD array has unique light sensitivity characteristics. A CCD image can be calibrated to remove these characteristics by the process of *flat field correction*, also called shading correction. The process removes the effects of the detector responsivity, variations in the illumination pattern from the light source, spatial attenuation due to dust particles, and apodization due to optics. The effects of flat field correction can be shown as follows:

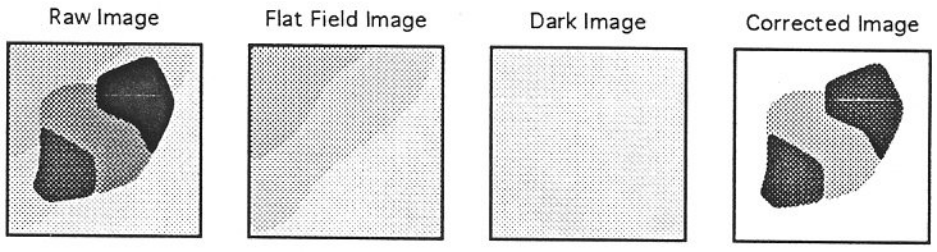


Image200 lets you define a flat field image which, together with the reference image, can be used to automatically perform flat field correction on newly acquired exposures. This section first explains the theory behind flat field correction, then describes how to perform flat field correction with Image200.

Theory

The flat fielding process can be summarized by the equation

$$\text{Corrected Image} = \frac{[\text{New Image} - \text{Reference}] \times \text{Mean Pixel Value}}{[\text{Flat Field} - \text{Reference}]}$$

This equation involves five calculation steps:

1. The flat field image is corrected for DC bias and dark current by subtracting the reference image from it.
2. The mean pixel value of the corrected flat field image is ascertained. The mean pixel value is unique to each combination of reference and flat field images.
3. The new image is corrected for DC bias and dark current by subtracting the reference image from it. (This is not necessarily the same reference image.)
4. The result is multiplied by the mean pixel value of the corrected flat field image.
5. Finally, that image is divided by the corrected flat field image.

Image200 can perform these calculations with minimal user input.

Acquiring Calibration Images

Flat field correction requires two calibration images: a reference image and a flat field image. Because these images are used to provide quantitative calibration of pixel signals, both images must be obtained close to the time of the exposures to be calibrated. If you are going to compare corrected images, all must be corrected using the same calibration images.

The reference image is usually a dark image, but a bias image may be used for correcting short exposures.

The flat field image measures the response of each pixel in the CCD array to illumination. The optical system most likely introduces some variation in response. Because the flat fielding process corrects for uneven illumination only if that illumination is a stable characteristic of each exposure to be corrected, the flat field image should be as representative of the background illumination as possible. The illumination should be bright enough, or the exposure long enough, that the CCD pixel signals are *at least* 25 percent of full scale. At the same time, it is important to avoid saturation. Improperly applied, flat fielding can seriously degrade the "corrected" image.

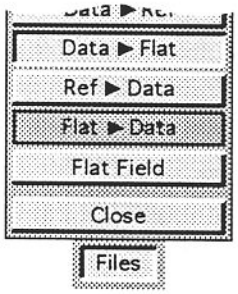
Defining a Flat Field Image

To perform flat field correction, Image200 requires both a reference image and a flat field image. The reference image is defined as described in the section *Reference Subtraction* on page 63. The flat field image is stored in an Image200 buffer.

The image stored in the flat field buffer must be *already corrected* for DC bias and dark current, using the **Expose – Ref** command or the Math dialog box.

Although Image200 will let you use an uncorrected image, the results of the flat field correction will be invalid.

To copy the current image to the flat field image, click the **Data › Flat** button on the Files menu.



The operation overwrites any existing flat field image.

To copy the flat field image back into the current image, click **Flat › Data**. This overwrites the existing current image.

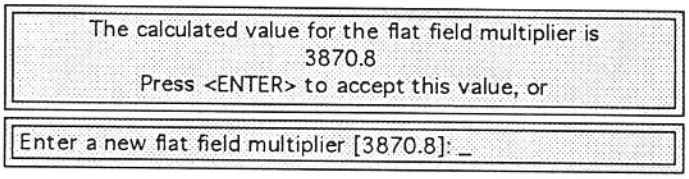
When you quit Image200, the flat field image is saved in the Image200 directory as a Photometrics block file named `PM_FLAT.TDF`, allowing the flat field image to remain defined the next time you use Image200.

When you restart Image200, the flat field image (like the reference image) is not read from the disk until it is needed. With buffers in memory, you can force the flat field image to be copied into memory by clicking **Flat › Data** then **Data › Flat**.

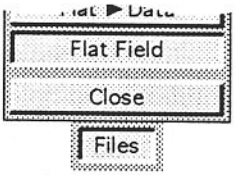
Defining a Flat Field Multiplier

Using the mean pixel value of the corrected flat field image as the flat field multiplier ensures that the pixel values of the corrected image are roughly comparable to those in the raw image.

When you click **Data › Flat**, Image200 calculates the mean pixel value of the flat field image and suggests this value as the flat field multiplier.



Once the flat field image is defined, you can change the multiplier by clicking the **Flat Field** button on the Files menu.

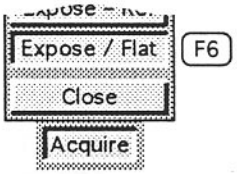


A different entry box appears.

As usual, press ENTER to accept the entry or press ESC to cancel and leave the current value unchanged.

Using Expose / Flat

The **Expose / Flat** button on the Acquire menu



allows you to acquire an exposure and automatically perform flat field correction. The button is available only when both reference and flat field images are defined and Image200 is configured for a single exposure.

The exposure, the reference image, and the flat field image must all have the same region definition, or flat field correction will not work.

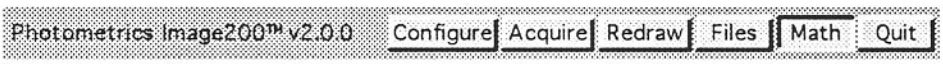
When you click **Expose / Flat**:

1. A single exposure is acquired, just as if you had clicked **Expose**
2. The reference image is subtracted from the exposure
3. The result of step 2 is multiplied by the flat field multiplier
4. The result of step 3 is divided by the flat field image
5. The final result is displayed as the current image

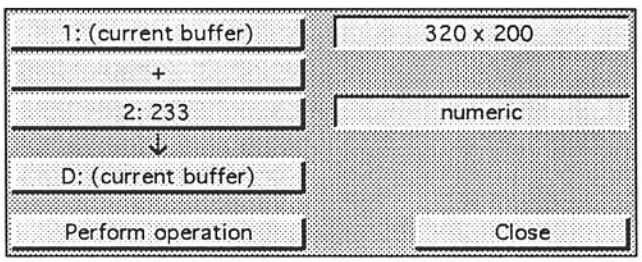
Flat field correction can require large amounts of memory. The arithmetic operations are likely to create 32-bit data, regardless of the data resolution of your camera hardware. To perform flat field correction on a full image, you must have the recommend amound of memory listed in the chapter *Installing Image200*.

Math

When you click the **Math** button on the Main screen,



the Math dialog box appears.



The Math dialog box lets you perform basic arithmetic operations involving two single images, or one image and a floating-point constant.

The buttons on the left side of the dialog box let you choose the operands, the operation, and the destination file. Two display fields on the right show in-

formation about the chosen operands. The **Perform operation** button removes the dialog box and performs the operation, and the **Close** button removes the dialog box with no effect.

Filenames

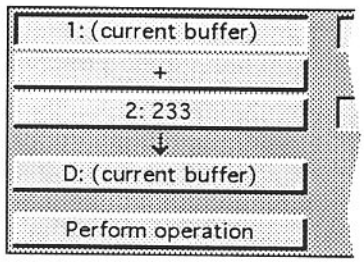
The filenames used in the Math dialog box must follow a few rules. The following names are reserved for Image200's use:

- Names that start with `IMAG`
- Names that end with `.TDF`, `.FIT`, `.FTS`, or `.TIF`
- The names `PM_REF` and `PM_FLAT`, with any extension

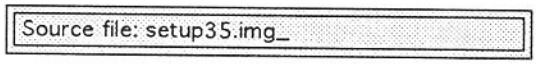
The Math dialog box can operate only on Photometrics block files.

Choosing the Operands

The first operand must be a single image stored in a Photometrics block file. When you click the **1:** button,

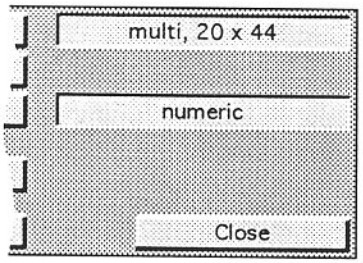


an entry box appears



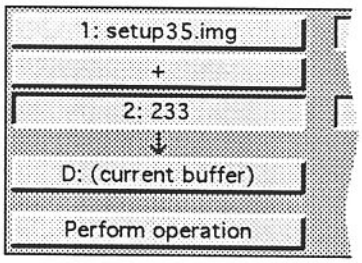
where you can enter a pathname and filename for the source file. You can access the current image directly by leaving the entry box blank. As usual, press `ENTER` to accept the entry or press `ESC` to cancel and leave the current entry unchanged.

Once you have chosen a source file, the button shows the file name and the display field to the right of the button shows information about the file:



- An error message, if the file does not exist, is not a Photometrics block file, or is an image sequence
- The dimensions of the image for a single-region image
- The dimensions of the first region for a multiple-region image

The second operand may be a single image stored in a Photometrics block file or a floating-point number. When you click the **2:** button,

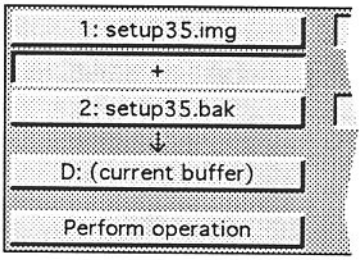


an entry box appears for the second operand. The display field to the right of the button shows "numeric" if the entry is a number.

Only the second operand may be numeric.

Choosing the Operation

The operation button

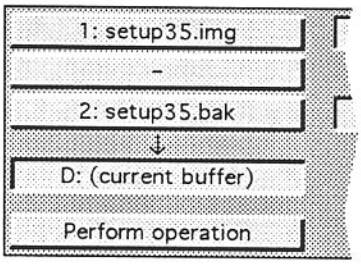


cycles through the four basic arithmetic operations. Click the button, or press "O" (for operation), to change the selected operation.

All results are saved as integer values, so division can cause some loss of resolution.

Choosing the Destination

The single image resulting from the operation is stored in a Photometrics block file. When you click the **D:** button,



an entry box appears. The destination file can be the same as either source file. To store the result in the current image buffer, leave the entry blank.

The destination file overwrites any existing file with the same name.

Performing the Operation

When you click **Perform operation**

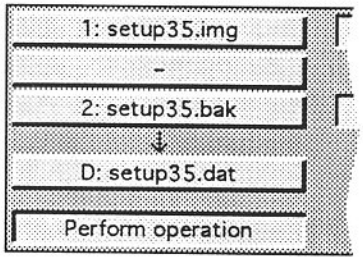


Image200 loads the source image(s) for the operands into memory, performs the operation, and saves the result in the destination file.

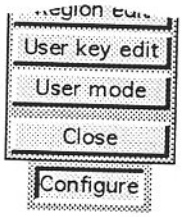
Depending on the operands and the operation selected, the operation may create 32-bit data. If there is not enough memory to perform the operation, or not enough disk space to save the result, an error message appears.

The User Key

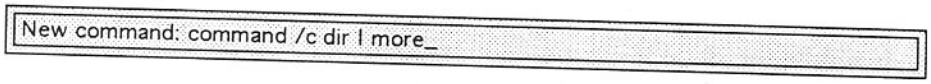
The User key allows you to integrate functions not provided by Image200 into your imaging environment. Through this simple interface, you can bring up directory listings, run external equipment control programs, switch to an image processing program, and perform other functions.

Defining the User Command

The User command is defined by the **User key edit** and **User mode** commands on the Configure menu.



When you click **User key edit**, an entry box appears



where you can enter text which will be passed to DOS as an executable command line when you press the User key. As usual, press ENTER to accept the entry or press ESC to cancel and leave the current entry unchanged. The User command is limited to 65 characters.

The **User mode** command button sets the display mode associated with the User command. The button toggles between two settings: Text and Graphic. When the button is set to Graphic, the current graphics mode will be used for command execution. When the button is set to Text, text mode will be used.

Executing the User Command

The User key is function key F9. To execute the User command, press function key F9 from the Main screen. The User command is passed to DOS as an executable command.

Pressing the F9 key is not the same as clicking the **User key edit** button.

The exact sequence of events is:

- Image200 execution is suspended
- The display mode is set to text, if **User mode** is Text
- DOS executes the User command
- The display mode is set to graphics
- Image200 is re-entered

All data and display settings are restored when you re-enter Image200.

Using DOS Commands

The User command can call any executable file. Executable files include directory utilities, batch files, and many others. Most standard DOS commands, however, do not qualify as executable files.

To use commands such as `dir`, `copy`, and `rename` (called internal commands), the User command must first execute the file `command.com`, then pass the operation in as an argument. For example, to view a directory and pipe it through the `more` filter, enter the User command

```
command /c dir | more
```

For more information, see your DOS manual.

The User command is limited to 65 characters. If you need more room, you can create a batch file and enter the name of the batch file in the User command.