ViSION Pro

CCD Cameras Handling Software Vers. 1.37:

HiRes, Hurricane, CHROMA, NCC, SCC

May 1999

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PERSONAL COMPUTER REQUIREMENTS

- CPU Pentium 90 Mhz .
- 16 Mb of RAM.
- Microsoft Windows 95,98.
- Hard Disk with free 40 Mb at least.
- SVGA video card with 16K colors at least.

RECOMMENDED REQUIREMENTS FOR PERSONAL COMPUTER

- CPU Pentium II 350 Mhz or enhanced.
- 128 Mb of RAM.
- Hard disk ENHANCED-IDE (EIDE).
- Color Monitor.

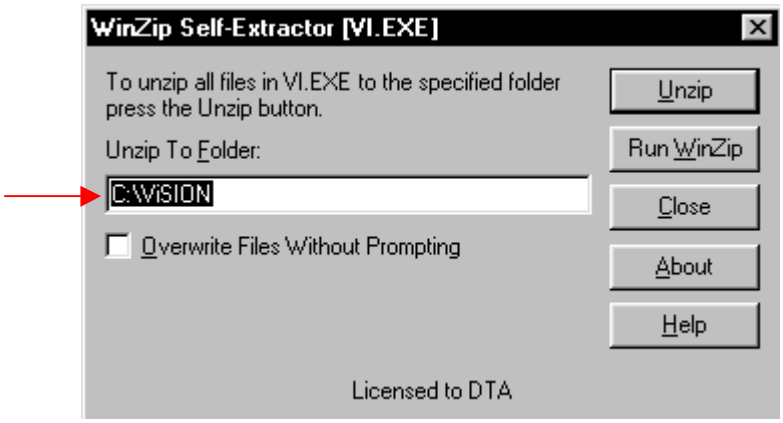
SVGA video card true color (24 bits).

In order to have a rough idea about memory consumption by ViSION, we need to consider the resolution of the CCD being used or the typical resolution of images subject to processing. For instance, if you are using a HR 1600 for the imaging, its sensor provides a resolution of 1526 x 1024 and since the sampling is executed at 16 bits, we will have a memory consumption of 1526 x 1024 x 2 = 3125248 bytes per image. Therefore, with the use of about 3 Mb per image, it will be necessary to have at least 32 Mb of RAM in order to process at least 5-6 images at the same time, without the operative system being forced to execute continuous and very slow swaps on disk. The same consideration applies to the video card that must have sufficient memory in order to contain the entire image.

SOFTWARE
ViSION Pro INSTALLATION

From the installation disk, start the Vi.exe. file. The following window will appear:

By pressing ENTER on the keyboard or by clicking with the mouse on the **OK** button in the figure, the following window will appear:



In the line pointed by the red arrow, insert the directory in which to install the camera handling software (the **C:\ViSION** default directory is already inserted in the line).
Press ENTER or click with the mouse on the **UNZIP** button in the figure to start the installation.
Once the installation has been completed, add the following line to the AUTOEXEC.BAT file:

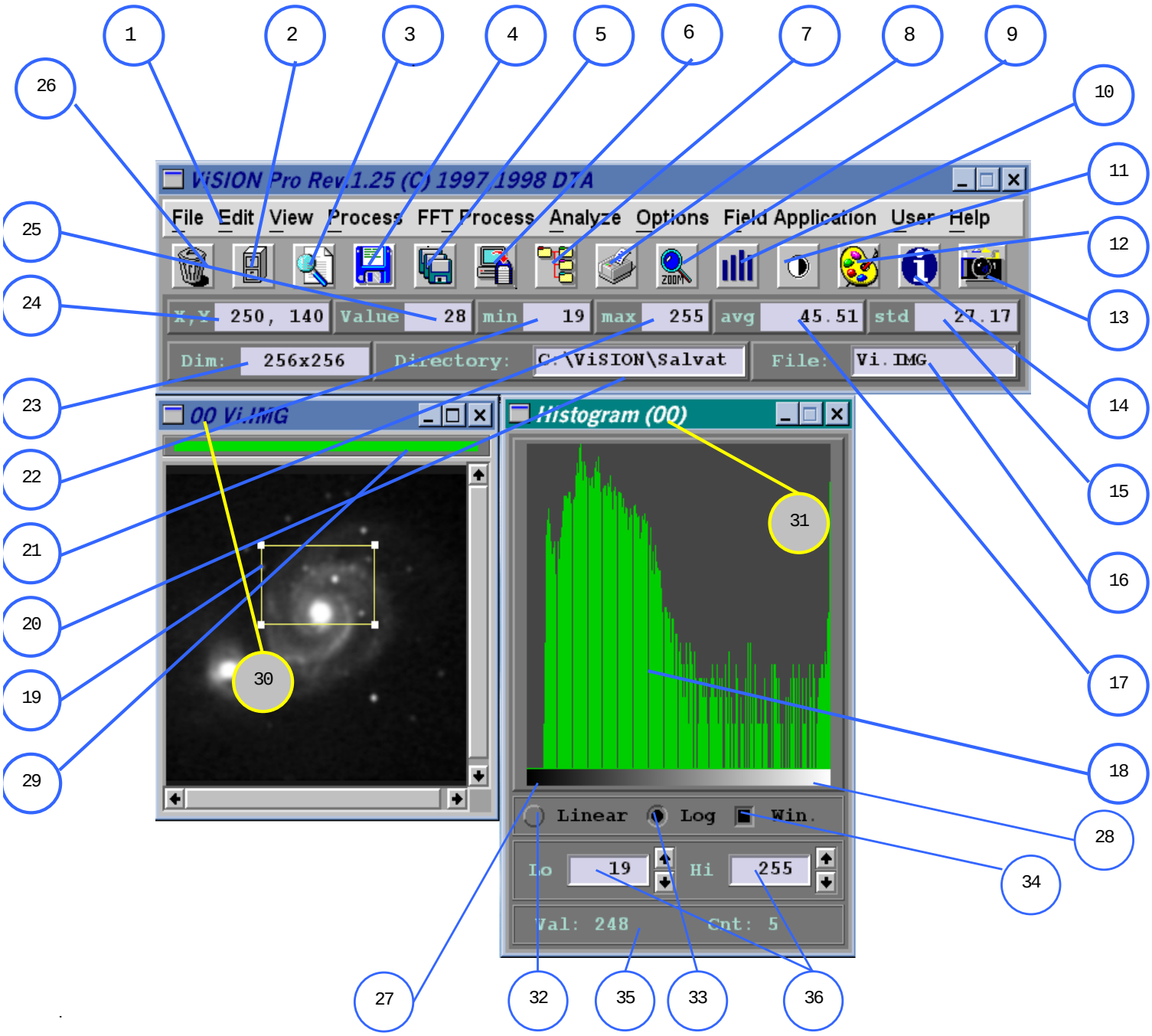
SET MGUIDIR= **path mgui**

whereas **path mgui** is the **SYS** directory path of the ViSION program just installed. For instance, if you choose the default installation directory, you should add the following line:

SET MGUIDIR=**C:\ViSION\SYS**

Restart the system to enable the change.
To start the camera handling software, start the Vision file in the installation directory.

HANDLING PROGRAM VIEW



CONTROL PANEL

On the control panel are several keys that enable different functions of the program, these are available by clicking on the selected key or by pressing on the keyboard the underlined letter of the listed.
Many keys have a double function that can be enabled with the right or left mouse buttons.
Most of the functions that are set by pressing the keys, remain active until the same key is pressed again.

1. MENU BAR: allows the access to the available menus.
2. By pressing this key, you can load a saved image in the proprietary format (.IMG) or in the FIT and FTS formats.
3. QUICK VIEW: allows to display the image files .FTS, .FIT, .IMG . As a matter of fact, it is a shortcut to quickly display the stored files, otherwise you should execute subsequent Load & Close.
4. By pressing this key, you can save the displayed image in the proprietary format (.IMG).
5. By pressing this key, you can quickly save (in the current folder) all the images currently opened.
6. IMAGE MIRROR: by pressing this key, provided that N images are opened, image N files of these images are created on the disk whose identifiers are *xx_name* whereas *xx* indicates a progressive number from 0 to N-1. This step is necessary in order to use some functions of the program (for instance the IMAGE MERGE) that must necessarily be used on files and not on RAM.
7. By pressing this key, you can choose a workfolder, for the LOAD and SAVE functions, from the available ones.
8. By pressing this key, you can access the print menu.
9. This key enables the magnifying lens function (see LENS in the VIEW menu).
10. By pressing this key, you can open a window with the image histogram in the foreground.
11. This key enables the utility for the manual setting of the image contrast and brightness: see TRANSFER FUNCTION item.
12. It opens a palette editor.
13. By pressing this key, you can display the menu for the camera control, as at the CAMERA ON item of the FILE menu.
14. This key displays some information about the selected image.
15. Standard deviation of the image.
16. Indication of the image in the foreground. By inserting directly in this field the name of an image present in the current work folder, it is possible to open a new image.
17. Average value of the image.
18. Image histogram, if available; also, if you click in this area, a menu will allow you to choose different kinds of contrast.
19. In the area of the image, you can select with the MOUSE a section of it where you need to execute some processings. To do this, position the mouse cursor on a vertex of an imaginary rectangle that contains the section on which you want to work, press the left button and at the same time move the mouse until the window is the size you want it to be. It is possible to delete this window by using the CLEAR WINDOW function in the EDIT menu or by pressing the mouse right button. Also, by positioning the mouse cursor on a vertex and by holding the left button down, you can change the size of the window; alternatively, by using the right button on a vertex, you can change its position.
20. Work folder. You can change the work folder by inserting its name and path directly in this field.
21. Maximum value of image intensity.
22. Minimum value of image intensity.
23. Image dimension.
24. Position of mouse pointer.
25. Intensity value of image pixel concerning the current position of the mouse pointer.
26. By pressing the UNDO button, you can recover the previous image before the latest processing.
27. By clicking the left mouse button in this area, you can set, proportionally to the distance from the edge, the minimum value of image display.
28. By clicking the right mouse button in this area, you can set, proportionally to the distance from the edge, the maximum value of image display.
29. GREEN color bar that indicates the selected image.

30. Number that identifies the image, this code is required in several processing controls.
31. Number that identifies the image to which the histogram belongs.
32. By pressing this key, the histogram is displayed by using a linear vertical scale.
33. By pressing this key, the histogram is displayed by using a logarithmical vertical scale.
34. By pressing this key, you can display the histogram of a window drawn on the image.
35. Data concerning the position of the mouse cursor on the histogram.
36. Minimum and maximum editable values of image representation.

FILE MENU

Text Editor
Change DIR
New Directory
New Image
Open Image
Quick View
Delete Image
Import Image
File Name Prefix
Save Image
Save Image As
Export Image
Print Image
Image Info
Run IPBL Program
Camera ON
Camera Select
Camera Setup
Auxilary Device
Show ViSION History
Exit

-TEXT EDITOR:
with this item, you can edit ASCII files; it is a utility that lets you analyze several VISION configuration files, to write IPBL programs or to analyze images with an ASCII format.

-CHANGE DIR:
By enabling this item, you can change the directory where images are saved or loaded.

-NEW DIRECTORY:
item that lets you create a new work folder.

-NEW IMAGE:
lets you create a new image and to set its size according to the x, y axes.

-OPEN IMAGE:
with this item, you can load an image saved in the proprietary format (.IMG) or in the FIT and FTS formats.

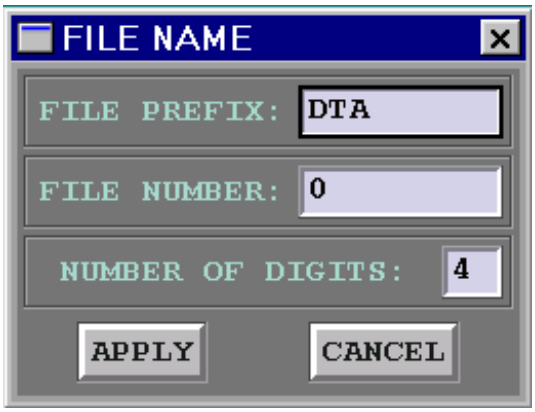
-QUICK VIEW:
lets you display .FTS, .FIT, .IMG image files. It is a shortcut for quickly displaying the files stored in the workfolder, otherwise you should execute subsequent Load & Close.

-DELETE IMAGE:
this utility lets you delete groups of files, it is possible to make multiple selections, only for the display (VIEW key) you must select a single file.

-IMPORT IMAGE:
lets you import image files other than the default ones (IMG, FIT and FTS), the codifications of the accepted files are: RAW, BMP, GIF, JPEG, TIFF*****. For the RAW format, you must specify its codification; all the others are directly loaded into the memory. All the formats are converted into monochromatic (gray scale) and for possible comparisons, you can display an original version of the image on which it is not possible to execute processings. By default, all images are converted into numbers without sign at 16 bits.

*** note.** such formats have an 8 bits image codification, while the **IMG**, **FIT** and **FTS** formats have a 16 bits codification.

-FILE NAME PREFIX:
lets you set the name codification of the image files, for their automatic saving during the acquisition. You should specify an alphanumeric prefix and a number of digits to add to it.
The parameters to be specified are: an alphanumeric prefix (FILE PREFIX) with not more than 8 letters, the value of initial calculation (FILE NUMBER) and the number of the digits being used. For instance, by applying the inputs in the window, you will create the following file names: DTA0000.IMG DTA0001.IMG etc.



-SAVE IMAGE:
with this item, you can save the current image (in the IMG format).

-SAVE IMAGE AS:
with this item, you can save the current image by specifying its name and directory (in the IMG format).

-EXPORT IMAGE:
lets you export the selected image in the following formats: FITS, RAW, ASCII, BMP, GIF, JPEG, TIFF. For the FITS, RAW, ASCII formats, pixel codifications at 16 bits are used, while for the others the codification is at 8 bits and the image is exported as it is seen, with possible contrast, color conditions and so on.

note.
Images are usually saved in a proprietary format since the image includes some typical information about the appliance and the imaging mode, this information is not given by ordinary graphic formats, therefore in order to have all useful information of a photographed image, you must always save in this format. The GIF files format codifies the image at 8 bits (256 levels) instead of the 16, 14 or 12 bits (65536 to 4096 levels) of the internal format or of the FITS. For the export of files with a GIF format, the information is transmitted as a color tonality as represented on the screen.

-PRINT IMAGE:
lets you make a print of the selected image.

-IMAGE INFO:
it displays some information about the selected image; if the image comes from the environment of acquisition, it shows the date and time of imaging, the exposure time, the CCD temperature and so on.

-RUN IPBL PROGRAM:
with this item, you can load and run the programs written in IPBL.

-CAMERA ON:
by clicking on this item, you can display the CCD Control menu about the camera control. See **CCD CONTROL MENU**.

-*CAMERA SELECT:
lets you select the CCD camera that you want to use, this setting must be executed only the first time that you use the program; you must know the platform and sensor being used. This procedure must be executed again every time you install a new version of the software.

-*CAMERA SETUP:
by clicking on this item, you access the following submenu.

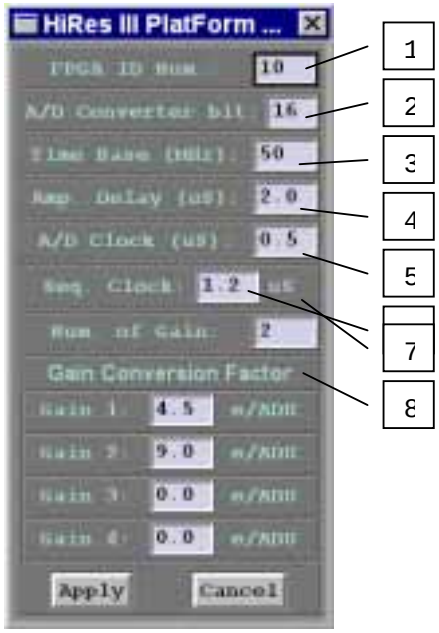
Port Setup
Platform Parameter
CCD Parameter
Intrinsic Camera

*Warning: all the parameters being set can be subsequently overwritten when you load a **new version** of software. Therefore you need to make a copy on paper of all the parameters present on these menus to be used as a reference when you load a new release.*

***PORT SETUP**:
with this control, you can specify the kind of port being used and its address, if necessary (not used for PCI).
This procedure must be executed again everytime you install a new version of software.

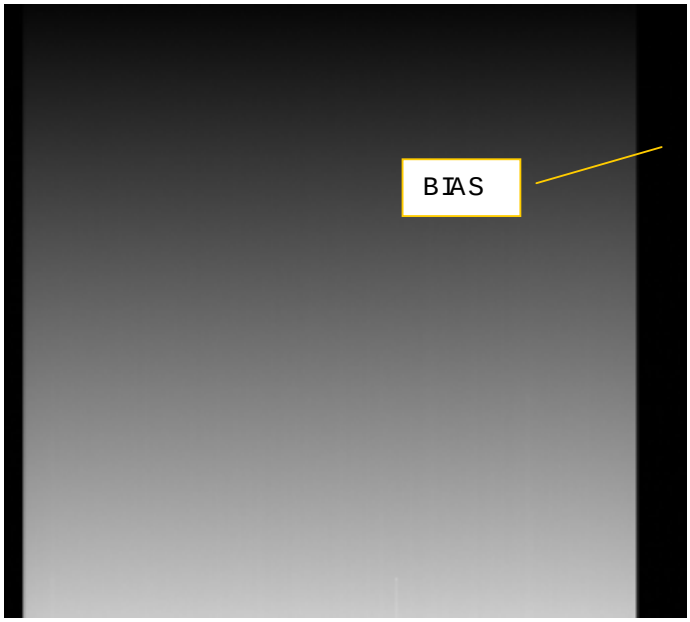
***PLATFORM PARAMETER**:

you access a submenu of the camera technical parameters.
Remember that when you install a new release of software, these parameters must be verified with those attached to the camera in the SETUP DATA sheet.



In the above example, you can see the list of parameters, from 1 to 5 they are values set by DTA and these cannot be changed, otherwise this would affect the good functioning of the camera. The parameter 6 specifies the CCD reading speed, this value can be changed but the one being set is always the optimal one. The parameter 7 is the same for any kind of cameras and cannot be changed, the parameter 8 indicates the CCD gain and this value can be changed or taken from the SETUP DATA supplied with the camera, the purpose of this parameter is for information only.

***CCD PARAMETER**:
submenu of the technical features of the CCD sensor.
These parameters must be checked everytime you install a new version of the software.
The parameters page, concerning the CCD being used, lets you execute useful customizations of the size. In this parameters page, most of these have an information purpose only, but some such as: *Horizzontal Pixel*, *Vertical Pixel*, *Horizzontal Dummy Pixel*, *Num. Of Pixel*, also affect the imaging mode. In particular, items such as *Horizzontal and Vertical Pixel* define the efficient resolution for the sensor imaging, whereas *Horizzontal Dummy Pixel* defines the number of fictitious pixels present in the CCD horizontal register and *Num. Of Pixel* defines the total number of pixels contained in the horizontal register. By changing these parameters, for example, it is possible to execute an overscan of the sensor and so to photograph the BIAS too, not only the image. In the above example, the CCD would have a nominal resolution of 512x512 and of 12 dummy pixels in the horizontal register; if you use the parameters indicated you will have an image of 570 x 512 that, as we said, contains not only the image but the BIAS too; as you can see, there is a black column on the left that is caused by the setting of the 0 value in the *Horizzontal Dummy Pixel* window. By changing these parameters, you can "cut" or "magnify" the image being photographed, provided that you respect the following inequality:



Num. Of Pixel ≥ *Horizzontal Pixel* + *Dummy Pixel*

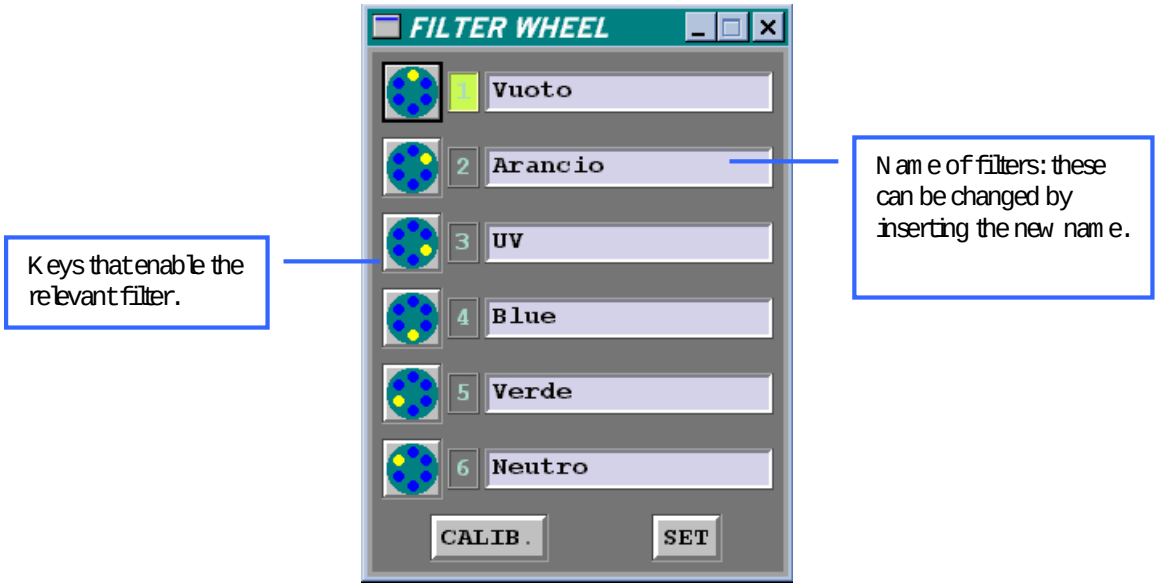
Even if the overscan is not displayed, it must be active.
Another important setting you can execute from this menu is *Enable Pixel Correction*, by activating this key and by defining a file name with the .COR

extension it is possible to define a list of faulty pixels or columns of the CCD that must be corrected during the acquisition. For more details on this possibility, refer to the ***Cosmetic CCD*** control.

INTRINSIC CAMERA:
reserved.

***Unexperienced users are advised NOT to make changes on these items.**

-AUXILIARY DEVICE:
menu for the use of auxiliary devices, one of these is the RPF6 Filter Wheel. This device lets you use six 31.75 mm filters; if you want to enable it, select the FILTER WHEEL item, the following panel will appear:

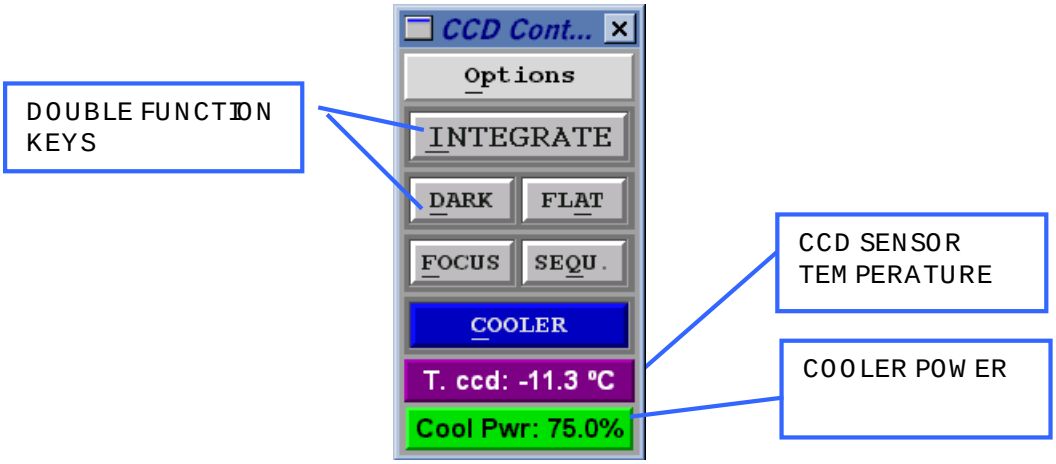


You can control the RPF6 Filter Wheel through the AUX port. Everytime this control is enabled, the RPF6 is initialized (position filter 1), therefore you must always keep this panel active when this device is used and use the “reduce to icon” key if you need more visibility on the screen.

-SHOW ViSION HISTORY:
displays all the activities executed in the current session. At every work session of ViSION, the HISTORY.TXT file is created, here all the controls being enabled are recorded, this can be useful if you want to locate possible defects of the program or to see again the controls being executed.

-EXIT:
by selecting this item, you exit the program.

CCD CONTROL MENU



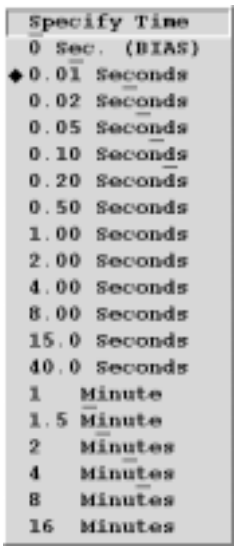
This menu appears when you enable the CCD camera control; a basic image will be created to contain the image being photographed. The size of the image derives directly from the size of the CCD in binning 1. This image, when the *CCD Control* is active, cannot be closed. The possible previous settings of the COOLER are enabled as the last time the camera was used.

-OPTIONS:
by clicking this key, you enable a menu for further settings of the device. See **MENU CCD OPTIONS**.

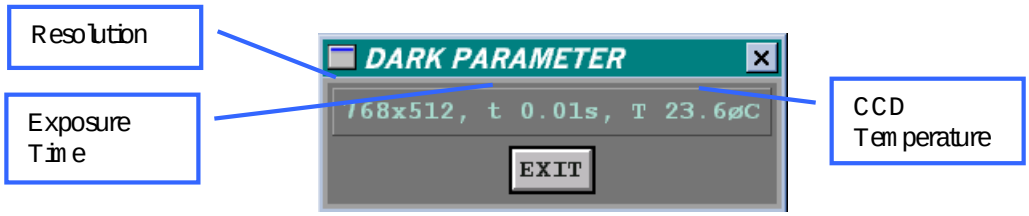
-INTEGRATE:
this key has a double function. By clicking the left mouse button, you can start the acquisition of an image, while with the right mouse button you can set the exposure time, according to the list on the right. The *specify time* item lets you set the exact time you wish. Remember that these exposure times may have limits for some shutters being used. In particular, the minimum exposure time changes according to the size of the shutter, as you can see in the following table:

25 mm	35 mm	45 mm
> 0.008s	> 0.023s	> 0.031s

If you are using an FLC shutter or a CCD *frame transfer*, these limits are extended a few microseconds more.



-DARK:
executes and stores a CCD image to use as DARK; once you select this option, the DARK is taken out from each acquired image (operation indicated by the consequent change of color of the key). It is necessary to execute again the DARK in the following cases: change of CCD temperature, change of type of binning, change of exposure time or of gain. To cancel this operation, click again on the key; to know the significant parameters of the stored dark, click the right mouse button on the key which will be displayed:

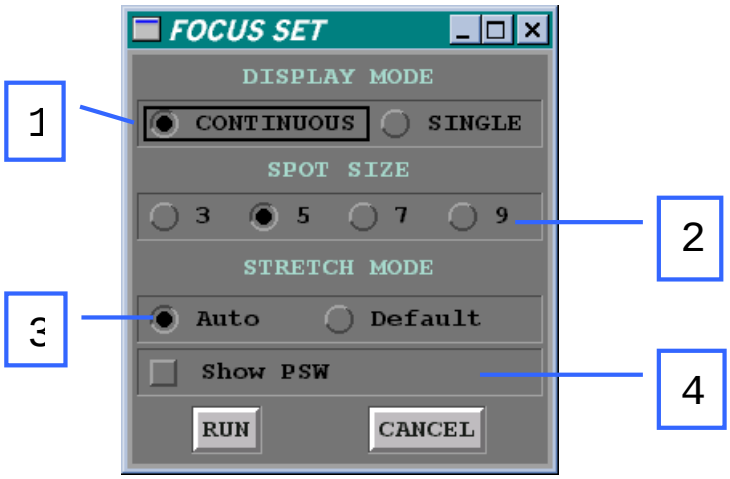


-FLAT:
executes and stores a CCD image to use as FLAT FIELD; once you select this option, each acquired image is corrected by FLAT FIELD (operation indicated by the consequent change of color of the key), it is necessary to execute again this operation every time the mechanical and optical conditions change. In order to make this correction, the following equation is applied:

$$e(x,y) = k * i(x,y) / f(x,y)$$

whereas “e” is the corrected image, “i” is the raw image,“f” is the flat field and “k” is the medium value of the flat field.

-FOCUS:
With this key you can execute some focusing procedures; the simplest one, FULL FRAME, proposes in a continuous sequence full resolution images, with binning and exposure time already set. A more efficient procedure is to frame with the mouse a small section of the image, which is more useful for the focusing, and to choose WINDOW FRAME; the following panel will appear:



The possible options have the following functions:

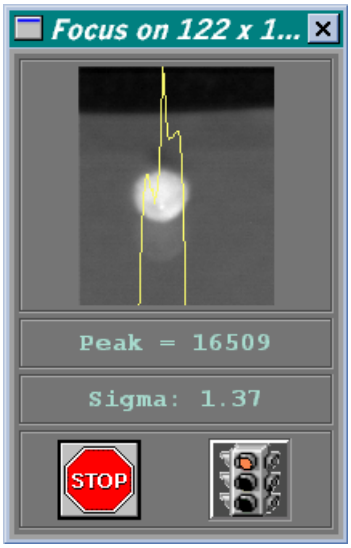
1. By selecting CONTINUOUS, the image is proposed at the maximum speed and each new image is indicated by an acoustic message. By selecting the SINGLE mode, the process is interrupted at each photographed image and it is necessary  to press the key to resume the acquisition.

2. The SPOT SIZE option sets the size in pixels of a punctiform object present in the image, such as a star or an artificial source (pin hole). This function is used to make intensity or shape measures around the maximum peak detected.

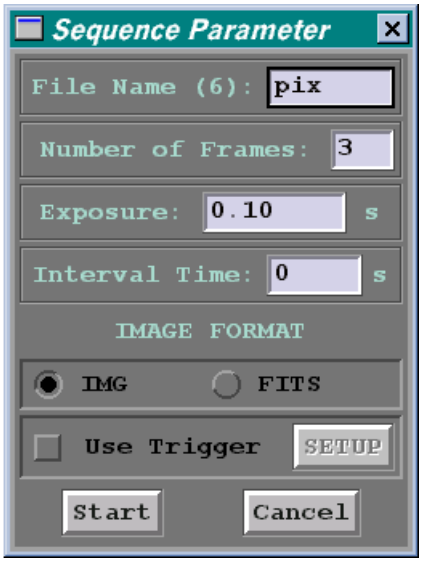
3. STRETCH MODE decides when to use for the image contrast the current values, the DEFAULT ones, or to calculate each time these values in AUTO.

4. If there is a punctiform source in the image, the SHOW PSF control can be very useful; not only this displays the horizontal profile of the image in the maximum peak detected but also shows the sigma value of the PSF.

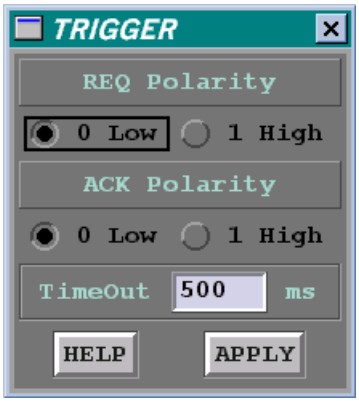
Example of focusing with SHOW PSW



-SEQU:
The opportunity to photograph and save sequences of images is a very useful function of this control. The following panel will appear:



It is necessary to specify the common root of the file name, up to a maximum of six characters, the number of frames to take (1-99), the exposure time to use, the waiting interval time between a frame and the following one and the saving format of the files. The USE TRIGGER control is very useful if you want to synchronize the acquisition with an external event. For this mode, you must use the AUX port of HiRes to receive a trigger signal and to respond to this with a consent signal (ACK) when the image is acquired. The SETUP key enabled by this function brings up a panel where you must specify the signals' polarity and timing.



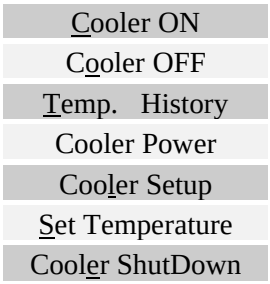
The HELP key displays the following text:

```
This option lets you synchronize a sequence with an external trigger.
The necessary signals are available on the AUX port, and the pins
concerned are:

            Pin 3, ACK  (out)
            Pin 7, REQ  (in)
            Pin 8, GND

Note that this opportunity is not available if on this port there is the
Filter Wheel in case a HiRes II is used.
When you enable a sequence and the trigger is enabled, before imaging the
camera awaits this signal to be active according to a level specified in
the setup.
Once the REQ is enabled, the camera stores the image, and only at the
end, it generates an ACK signal, according to a polarity set in the
setup.
The length of the ACK signal is programmable in a range from 1 to 9999
ms, otherwise by setting 0 it is kept active until the nex REQ.
All the signals being used are standard TTL 0-5 Volts.
Different values might cause the malfunction or a damage of the camera.
```

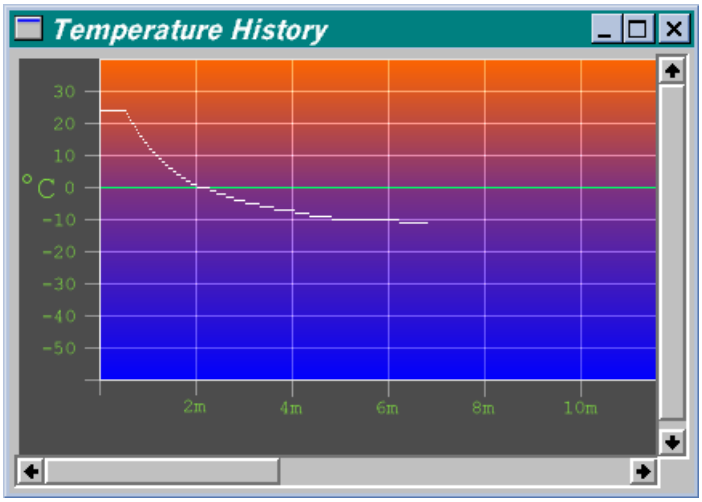
-COOLER:
By pressing this key, you access the following submenu for the cooling system. See **CAMERA COOLING.**



Cooler ON
Control that switches the cooling system on, without having to check the temperature and with the power being set in Cooler Power.

Cooler OFF
Control that switches the cooling system off, if this is ON.

Temp History
The history of the CCD sensor temperature is displayed in a diagram where the time scale is represented on the x's axis and the temperature on the y's axis.



*** Cooler Setup**
It displays the COOLER CONTROL window (see **COOLER CONTROL** MENU).

*** Set Temperature**
With this option, you can set the CCD temperature (provided that the power lets you reach this value).

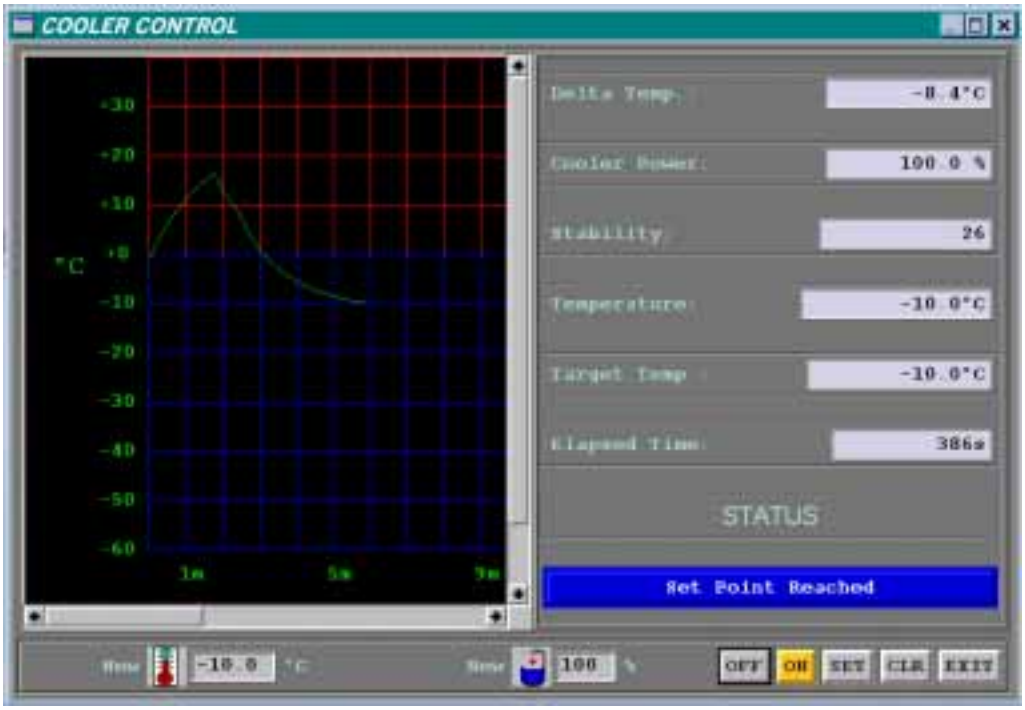
***Cooler ShutDown**
Option that gradually switches the cooling system off in order to avoid thermal shocks.

***Cooler Power**
Option that lets you choose the value on which to set the cooler power.

Functions marked with ***** are not available on NCC cameras, besides, the power used by the cooler for these cameras is always at the 100%.

COOLER CONTROL MENU

The following diagram represents the temperature history.



-DELTA TEMP. :
it provides the temperature range.

-COOLER POWER:
cooling power being used.

-STABILITY:
degree of stability.

-TEMPERATURE:
CCD current temperature.

-TARGET TEMP. :
temperature that you want to reach.

-NEW °C:
window to reset the target temperature.

-NEW %:
window to reset the power being used.

-OFF:
key that switches the cooling system off.

-ON:
key that switches the cooling system on.

-SET:
by pressing this key, you can set the current temperature as the target temperature.

-CLR:
key that sets the **delta temperature** at zero. This is useful if you want to check the stability level of the system (once it has reached the target temperature).

When the target temperature is reached (provided that the system is able to do this), the cooling system stabilizes on it and in the STATUS field the following message appears: **Set Point Reached**.

CCD OPTIONS MENU

New Buffer
Binning 1x1
Binning 2x2
Binning 3x3
Binning 4x4
CCD User Size
Vertical Binning
Set CCD Gain
Use Image as DARK
Fast(Slow) 8(16) bit Acq.
Camera Diagnose
Operation Mode
Windows Location

-NEW BUFFER:
it opens a new work image.

-Binning 1x1
Binning 2x2
Binning 3x3
Binning 4x4
With these controls you can set the binning of the pixels inside the CCD, this procedure lets you modify the sensor resolution and the size of the equivalent pixel. In particular, the size of the pixel also determines the camera sensibility which of course improves according to the pixel's size. You must remember that there is a material limit in the use of the binning, since the horizontal register that contains the vertical binning and the output knot, that contains the horizontal binning, have a capacity limit of the electrons, therefore there might be a blooming inside one of the two registers.
For instance, a CCD KAF400 by Kodak has a Full Well of 85000 electrons for the pixels, of 170000 electrons for the horizontal register and of 340000 electrons for the output knot, so if the pixels are full, it is not possible to make a binning higher than 2x2 without one of the output registers having to overflow.
Another natural consequence of the binning is the unloading time of an image and the space occupied by this on the disk, both are reduced if the binning is higher.

-CCD USER SIZE:
this control lets you define the area of the sensor that you want to use in the image acquisition.
The opportunity to size to your liking the image size is useful when you need to have a high resolution but the object to photograph is small, this way you can reduce the unloading time of the image and the space occupied on the disk. To define the area, you can use the mouse in the usual way to frame a section or you can define it numerically from the keyboard, keeping in mind that the origin of the axes X=0, Y=0, is on the top part on the left. To go back to the normal size, select any binning.

-VERTICAL BINNING:
option that lets you force the vertical binning to a value other than the horizontal one (useful in spectroscopy).

-SET CCD GAIN:
with this control you can set the amplification of the CCD signal. Usually, on CCD cameras the amplification is calculated in a fixed way in order to optimize the **F**ull **W**ell **C**apacity with the range of the A/D converter. Otherwise, it is possible to have two gains at your disposal, one standard that is FW = Max A/D Range and the other one that varies according to the kind of sensor being used. For instance, for KODAK sensors, the **gain 2** is an optimization of RANGE for the **binning 2**.

KAF 400
Binning 1 1.3e- ADU
Binning 2 2.6e- ADU

Differently, for the SITE sensor we have:

Binning 1 4.5e^- x ADU
Binning 2 9.0e^- x ADU

Warning: the above gain values are only an example, the actual values are different for each camera.

-USE IMAGE AS DARK :
option that lets you use the current image as DARK. With this control you can use previously saved DARKs.

-FAST 8 BIT ACQ.:
option for the acquisition of an image at 8 bits (fast). Function available with HiRes Gen. II only.

-SLOW 16 BIT ACQ.:
option for the acquisition of an image at 16 bits (slow). Function available with HiRes Gen. II only.

-CAMERA DIAGNOSE:
you access a menu that lets you make a test on the hardware and to set calibrations of the instrument (see CAMERA DIAGNOSE menu).

-OPERATION MODE:
With this series of settings you can set some operative modes of the CCD camera and/or set automatisms for the acquisition of images.

Silent Mode
By selecting this item during the acquisition, no message or indication will be provided on the screen in order to reduce the noise. The completion of the acquisition will be indicated by a beep.

Disable Fan
Option that disables the cooling fan in order to reduce the noise during acquisition (vibrations are reduced).

AutoSave
The photographed image is automatically saved by using the parameters of the FILE NAME PREFIX control.

FITS Format
Option related to AutoSave that decides that the saved file format is a FITS, by default it is IMG.

Auto Ctrst
Option that sets the automatic contrast for each photographed image. Function available with HiRes III only.

-WINDOWS LOCATION:
with this function you can choose the default position for the **EXPOSURE** and **MESSAGE** windows (windows that appear during the acquisition).

CAMERA DIAGNOSE MENU

Relay 1
Relay 2
Relay 3
Relay 4
These keys switch the auxiliary relays on/off.

-SHUTTER:
by clicking on this key, you open/close the camera shutter in order to verify its functioning or to clean the optical window.
Caution: to avoid any damage, do not absolutely touch the shutter blades.

-COOLER:
key that switches the cooling system on/off by bringing it onto the power set in the COOLER POWER item.

-FAN:
key that switches the cooling fan on/off.

-A/D CALIBRATION:
key that executes the calibration of the A/D converter since this is able to calibrate itself. This operation is always executed at every switching on.

-COOLER POWER:
from this window you can manually select the power (in percentage) of the cooling system. The accepted values range is between 0 and 100, you can also specify a decimal.

-**DIGITAL OUTPUT:**
from this window, you can manually set a digital value on the AUX port.

-RAM TEST:
by clicking on this key, you can test the ram inside the camera (pattern generator).

-BIT NOISE:
reserved for technical assistance by the manufacturer.

EDIT MENU

Undo
Duplicate
Shift
Rotate
Resize
Rescale
Flip Horizontal
Flip Vertical
Image Square
Pixel Square
Clear Window
Set Window
Fill Window
Image Edit
User Options
Saved Parameter
Create Polygon
Erase Poligon

-UNDO:
this item does not execute any processing but lets you restore the previous image; if an operation does not have the wanted effect, you can click on this item to restore the previous version.

-DUPLICATE:
lets you create a duplicate of the image in the foreground. This function is useful if you want to make processings on the image leaving the original intact.

-SHIFT:
lets you shift the image on the two axes by an arbitrary value. This function is useful if you want to centre a group of images. Also, in the **FILL VALUE** field, you can insert a fill value for the areas of the image left uncovered.

-ROTATE:
lets you rotate the image. You can choose a clockwise or anticlockwise 90° rotation angle or, through the **ARBITRARY ANGLE** function, you can set one of your own. In the latter case, you will be requested from a specific window to specify the rotation angle, the x, y coordinates of the rotation centre and a possible fill value for the uncovered areas of the image.

-RESIZE:
with this option you can resize the image. By clicking this item, you access the following submenu:

Window Resize
Parameters Resize
Dilate/Contract

Window Resize
It reduces the image on which a window has been previously selected with the mouse.
Parameters Resize
Unlike the previous option, the window whose image you want to reduce must be specified by inserting the relevant coordinates.
Dilate/Contract
In this case, the image is dilated or contracted along the x and y axes by directly inserting the number N of pixels that must be added (N>0) or subtracted (N<0) along the axes. If the image is dilated, you must also insert the fill value that must be assigned to the new portion of image.

-RESCALE:
With this control you can multiply, separately for the two axes, by a scale factor. If the coefficient being used is higher than 1, the image is enlarged proportionally, otherwise it is made smaller. In both cases, a method of linear interpolation is used in order to avoid the degeneration of the final image aspect. This control can be useful if you want to square the images photographed with a rectangular pixel CCD.

-FLIP HORIZONTAL:
this function converts the image contents into Y.

-FLIP VERTICAL:
this function converts the image contents into X.

-IMAGE SQUARE:
by clicking on this item, you access the following submenu:

Upper Full Image
Lower Full Image
Upper Window
Lower Window

Upper Full IMage
This option brings the image format to the highest possible power of 2.
Lower Full Image
This option brings the image format to the lowest possible power of 2.
Upper Window,Lower Window
Functions similar to the previous ones that work on the portion of image enclosed in a window .

Bringing the image format back to a power of 2 (128,256,512,etc.) is useful for its processing in **FFT**.

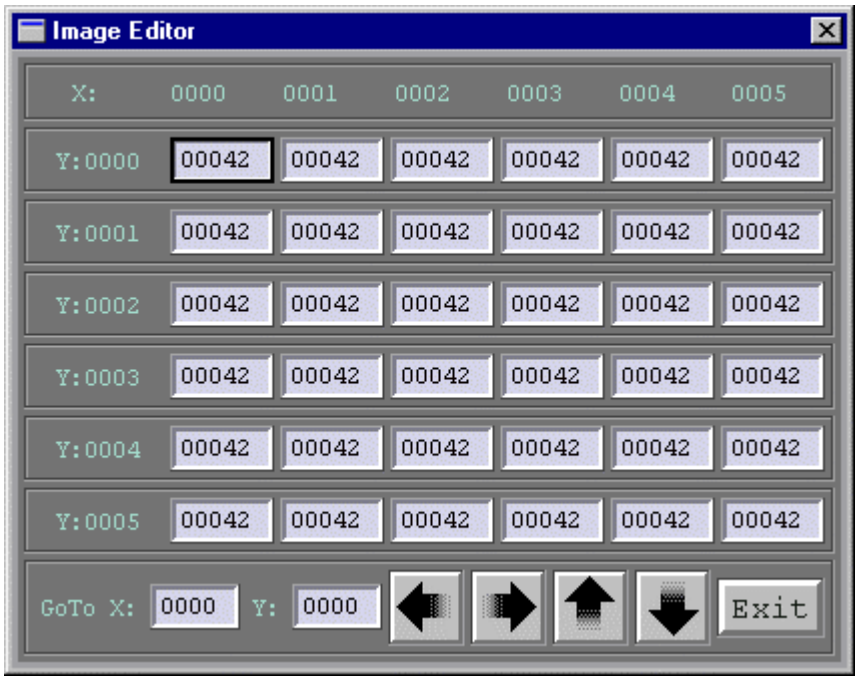
-PIXEL SQUARE:
It lets you correct the aspect of an image photographed with a rectangular pixels CCD camera (NCC), as long as you know the size in microns of the camera pixel for the x and y axes and you will have a corrected image by using the linear interpolation. Remember, for the calculation of the pixel size, whether the binning was used or not in order to find the equivalent size of it. If the CCD CONTROL is active, that is we are photographing some images, the pixels' dimensional values will be automatically set, so you will have only to select APPLY to have an adjustment of the image.

-CLEAR WINDOW:
it clears the window with the yellow outline (see point 22 of the image on page 10) present on the image.

-SET WINDOW:
it lets you open a window on the current image by specifying its xy coordinates of the origin and the size.

-FILL WINDOW:
with this function you can fill with a specific value a window selected on the current image. This can mainly be used in an image spectrum (FFT) in order to delete one of its components.

-IMAGE EDIT:
with this function you can access the following Image Editor.



The Editor displays a matrix with the values of the pixels of the image. Such values are editable by using the keyboard. You can scroll the pixels with the arrow keys of the Editor or, more quickly, by using the x,y coordinates of the GoTo field.

-USER OPTION:
it lets you edit the user's instrumental information and notes attached to the image**.** The proposed mask changes according to the item chosen in the *Science Field*, in the example on the right we have represented the one for astronomy. The *Filter* field is managed automatically in case of the RPF6 Filter Wheel or a LCD-RGB. The information here given are always attached to .IMG files and optionally to FITS files, all the other formats do not contemplate the storage of this kind of information. Note that these info are attached to the image only when this is acquired.

-SAVED PARAMETER:
it lets you edit the user's and instrumental information saved with the image. As we have seen for the previous control, to each saved image a series of information is attached; some of these can be set by the user, others are automatically set, such as the date, the time, the exposure time and so on. With this control you can edit these parameters too.

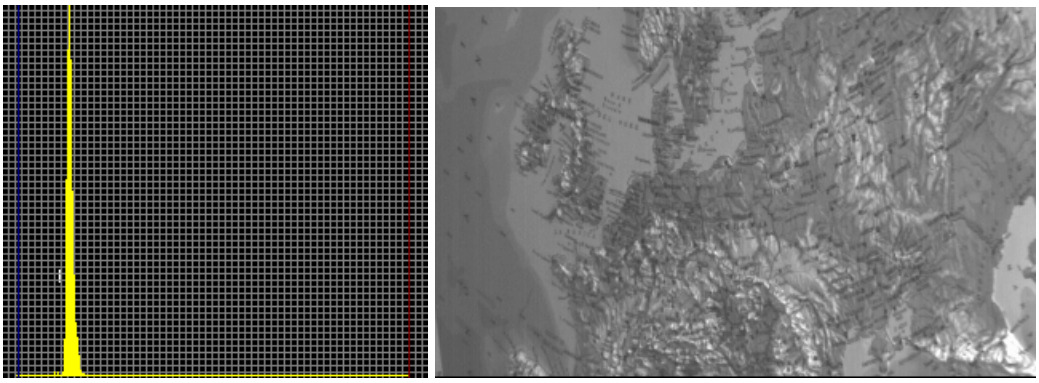
-CREATE POLYGON:
it lets you create an editable polygon in order to define irregular areas of the image too. Once specified the number of vertices, it is possible to move the created figure by positioning the mouse cursor on a vertex, and by holding down the left button, you can move it where you want. By repeating this operation with the other vertices, you can delimit an area with the wanted shape. The analysis function connected with this control is *Polygon Analysis.*

-ERASE POLYGON:
it erases a polygon, if present.

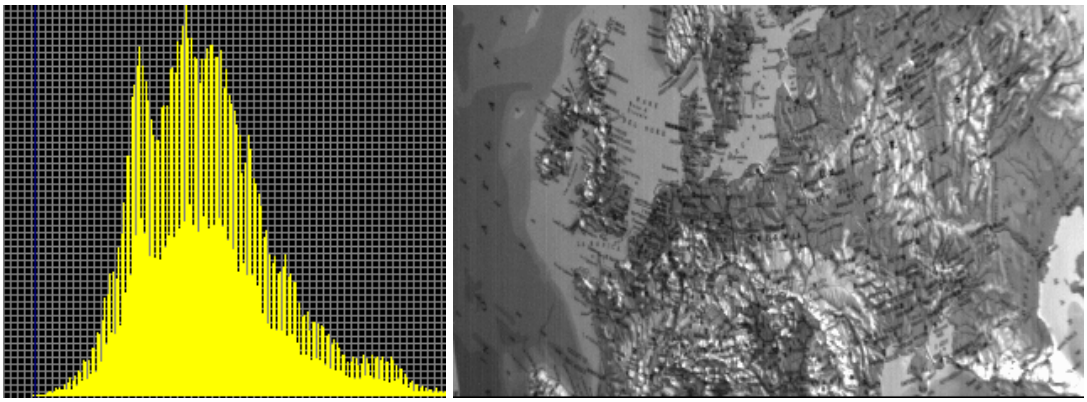
IMAGE PROCESSING

ViSION produces many functions for image processing, the purpose is to parallelly create during the acquisition some processings without having to exit the program in order to use a specific software.
Some processings are useful on the field to verify the quality of the work carried out, it is understood that specific programs are more powerful and versatile and we leave to these the final processing of our imagings.
The controls for the image processing are reachable through some items in the VIEW, PROCESS, FFT and ANALYZE menus of the control panel.
Before explaining these controls, it is a good idea to introduce a fundamental instrument for the analysis of an image: the histogram.
By selecting the **Histogram** item from the ANALYZE menu or from the  icon, we will have a statistical representation of the current image.
The colors used are reported on the abscissas, while the number of pixels belonging to a color are represented on the ordinates.
In a few words, we will see on how many colors the image is dispersed. The contrast mode by default is the Min/Max, in practice this works as follows: the black is associated with the minimum value of the image, the white is associated with the maximum value.
We have now introduced the first typical topic: the contrast; in fact if, for instance, our image is dispersed on 56 **continuous** color tones, our eye will perceive a much less “defined” image than the one obtained by using the usual well spaced 56 color tones.

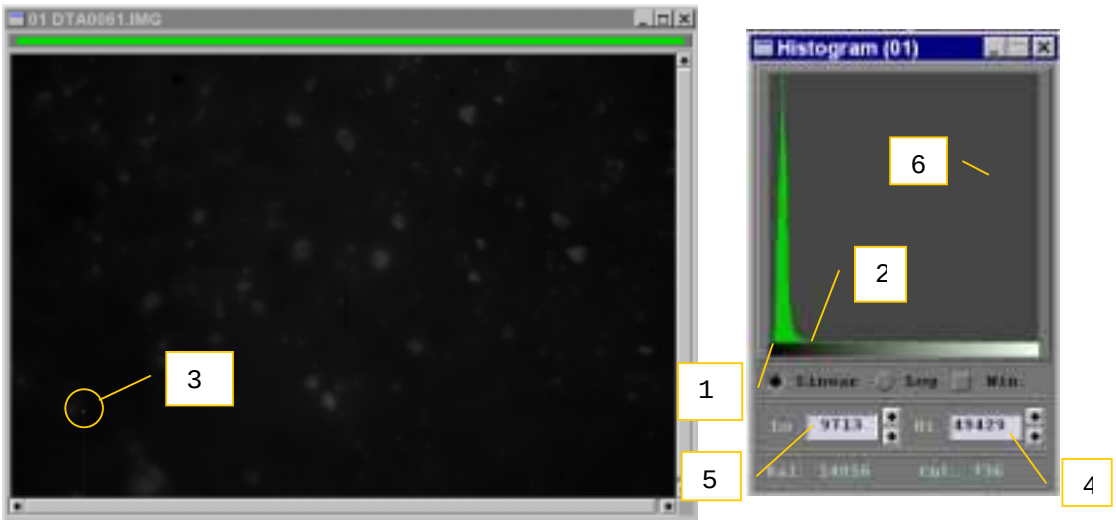
IMAGE AND RELEVANT HISTOGRAM WITH LITTLE CONTRAST



SAME IMAGE CONTRASTED



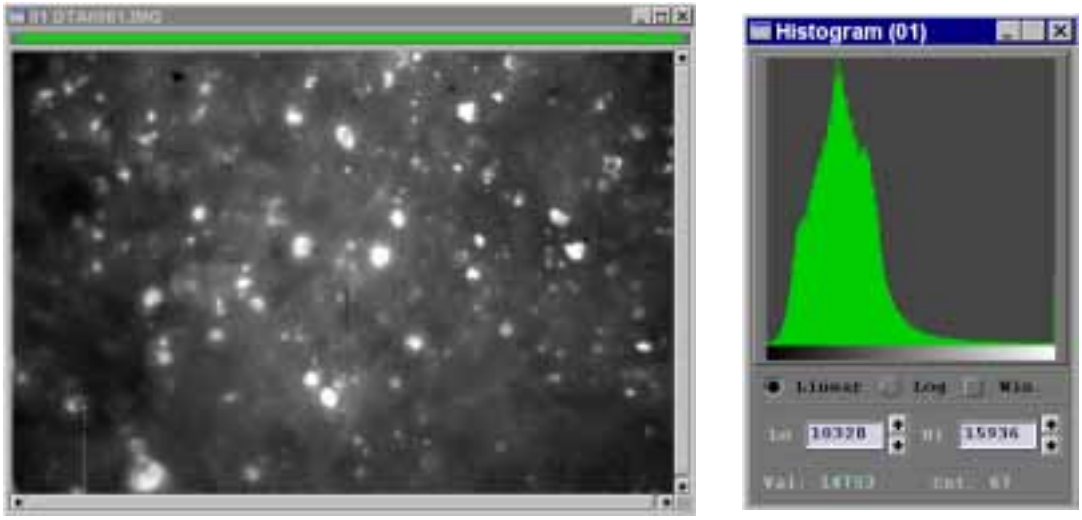
The program lets you vary the contrast through the *Image Stretch* submenu of the**VIEW** menu from the histogram itself**.** Note that the contrast does not change in any way the numeric contents of the image but represents the image in a different way only. When you photograph or process an image, it is advisable to use the Histogram function in order to vary the contrast, by using the mouse on the diagram showed by the image.



In the above example, an image is presented in fluorescence (special paper) photographed at the microscope; as you can see from the relevant histogram, most of the pixels are dispersed between points 1 and 2, this happens for having chosen the Min/Max mode that in this case is “disturbed” by a single point of the image (Hot pixel) which diverts much from the normal numeric distribution. In order to better display our image, we need to intervene manually. For instance, you can insert new min/max values by typing some numbers in the input fields 4 and 5 or you can click with the mouse on the cursors of these windows. Otherwise, you can work directly on the histogram itself in the following way:

1. Position the mouse cursor on point 1 making sure that the cursor is inside the colored band, then click the mouse left button. We have now set the minimum value.
2. Follow the same above procedure but position the cursor on point 2 and click the mouse right button. We have now set the maximum value.

The result is as follows:



If something is not correct, you can restore the display by placing the mouse inside the area 6 and holding the left button down choose an item from the menu that appears.

Min/Max
Sigma
Window

Min/Max:
it executes the autocontrast by using the minimum and maximum values of the pixels contained in the image.

Sigma:
it executes the autocontrast by using the variance value.

Window:
this control sets the maximum contrast of the image by using the minimum and maximum values contained inside an area defined with the mouse.

Full Range:
the image is represented by using 0 as a minimum value and, as a maximum value, the full scale value of the A/D converter which can be 65535, 16383 or 4095 for 16, 14 and 12 bits converters.

VIEW MENU

FullFit
Zoom In
Zoom Out
Zoom Window
Lens
ImageStretch
Load Palette
Default Palette
Palette Editor
Mark Gray Level
Negate
Show Sight
View as Spectral
Sequence as Movie

ZOOM FUNCTIONS (FullFit, Zoom In, Zoom Out, Zoom Window, Lens).
With these functions you can choose enlargements and different ways of displaying. In the following zoom functions, the image contents is not changed at all, but you only work on its display; if you want to permanently change the size of the image, use the RESCALE control.

-FULL FIT:
this option fits the image with the maximum size of display allowed by the screen.

-ZOOM IN
-ZOOM OUT:
these functions enlarge the image by a 2X or 0.5X factor without changing the origin.

-ZOOM WINDOW:
with this control you can frame a portion of image in order to enlarge it on full screen.

-LENS:
magnifying lens function. A new window appears showing the area, where the mouse pointer is positioned, enlarged.
By using the + - keys, you can vary the enlargement factor (2 ~ 20), while by changing with the mouse the size of the window, you can vary the surface of the lens itself.

-IMAGE STRETCH:
you access a menu where you can change the contrast of the image. This is done without altering its contents but only working on the colors that represent it. The choice of the right contrast is a major problem in case of a very small intrascenic range of the image. In the relevant submenu, you can choose among several automatic or manual modes; for the most complicated cases, we advise you to use the HISTOGRAM function from the ANALYZE menu and to operate on this for the optimization of the contrast.
The VGA graphic cards can only represent, in black and white, 64 levels of gray since they have DACs at 6 or 8 bits.

By Slides
Min/Max
Sigma
Window
Type Value
Full Range
Transfer Function

By Slides:
option for the manual setting of contrast and brightness.

Min/Max:
it executes the autocontrast by using the minimum and maximum values of the pixels contained in the image.

Sigma:
it executes the autocontrast by using the variance value.

Window:
this control sets the maximum contrast of the image by using the minimum and maximum values contained inside an area defined with the mouse.

Type Value:
lets you set the contrast by manually typing the minimum and maximum values.

Full Range:
the image is represented by using 0 as a minimum value and the bottom scale value of the A/D converter as a maximum value, the latter can be 65535, 16383 or 4095 for converters with 16, 14 and 12 bits.

Transfer Function:

With this mode you can make complex contrast modes. The image is contrasted by a transfer function that acts on the palette and whose course can be defined through the available functions:

LIN linear course, a straight line is set at 45 degrees.

LOG-, LOG+ It sets a logarithmical course, the curve undergoes a curving according to this function, this can be changed by using the +/- keys more than once.

DIV The selected function is divided into different parts according to a settable parameter. At each point of the piecewise-linear there is a small square that you can lock with the mouse by clicking inside of it and by holding the left mouse button down during the repositioning.

POS It executes a posterization on settable n levels.

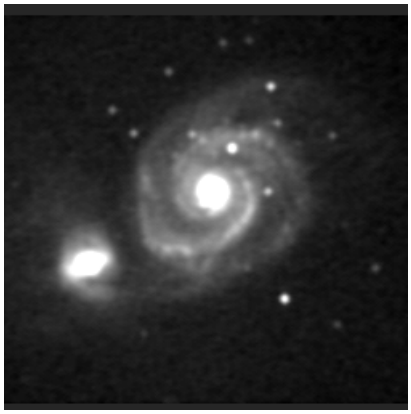
With the **LOW** and **HIGH** cursors, you can vary the lower and upper limit of the band in which to apply the selected function.

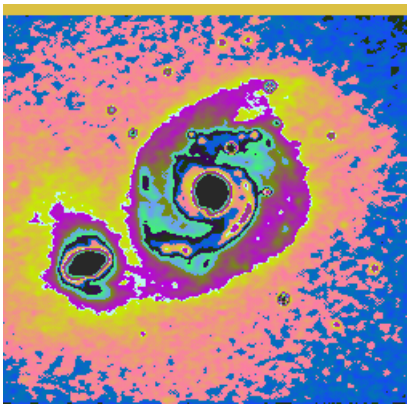
With the **CTRST** and **BRGHT** cursors, you can vary the contrast and brightness manually. By acting on them, you always set the linear mode.

By setting the **Cont. Preview** button, you can display in real-time the changes that will be applied to the transfer function.

We remind you that the best way to use the cursors is to position the mouse pointer inside of them and by holding the right button down you can move it quickly.

-LOAD PALETTE:
With this control you access a menu where you can choose the colors palette to use. This function is useful since it highlights several light intensities without changing the image contents. The following example of the M51 galaxy highlights its different variations of brightness that are not distinguishable in the black and white image.



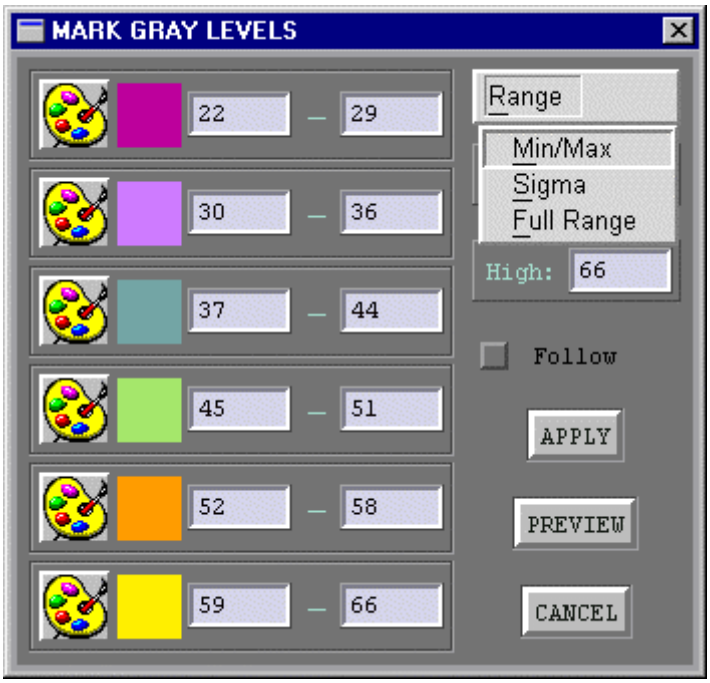


The files that contain the palette have the .MAP extension and are ASCII files that contain 256 lines composed of three numbers (0..255) which identify the RGB values.

-DEFAULT PALETTE:
lets you apply to the image the default palette which is represented by a 256 grays scale.

-PALETTE EDITOR:
enables a palette editor with which you can create your own colors palette. The LINEAR, SIN, LOG functions are enabled only with the gray scales.

-MARK GRAY LEVEL:
you access the following window.



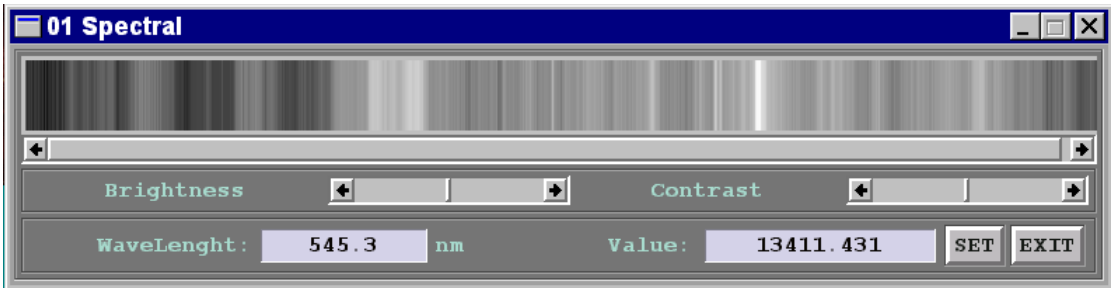
You can assign arbitrary colors (the choice of the color is made by clicking with the mouse on the relevant palette) to 6 different intervals of gray tones. The intervals can be changed manually by using the specific input windows. You can also choose among three different default settings that you access by clicking on the RANGE key.

-NEGATE:
it makes the negative of the image.

-SHOW SIGHT:
a red viewfinder appearing on the main image indicates the center of the image. You can delete the viewfinder by clicking again on the same key.

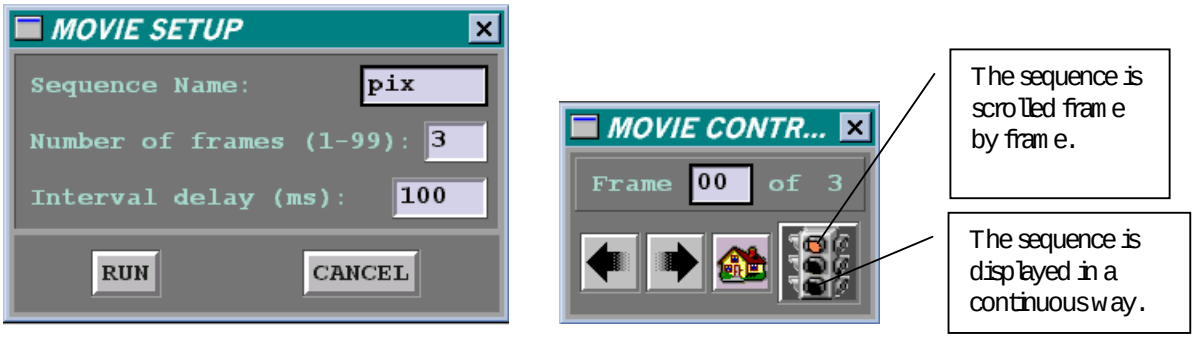
-VIEW AS SPECTRAL:

function for the spectral analysis of the image. The following window will appear.
The image is displayed by making a vertical binning of all the lines, this mode lets you better display the spectroscopy imagings. By positioning the mouse pointer on a point of the spectrum, the relevant wavelength and the corrisponding value are given. By clicking on the SET key, you can specify the spectral band by inserting the initial and



final values (this operation is necessary since the band depends on the instrument used) . You can also specify a possible multiplicative constant in order to bring the values back to a particular unit of measure. The *Brightness* and *Contrast* cursors modify the display of the spectrum. This function can always be left active when you acquire spectrums; particularly when very strong vertical binnings are used, the image window does not clearly show its contents since it is limited to few vertical lines, but this way you can better display what you are imaging. The window is refreshed at every new acquisition.
NOTE: to use this function during the acquisition, select the image connected to the CCD Control and then enable this function.

-SEQUENCE AS MOVIE:
with this control you can create an animation by using sequences of images previously photographed. Files must have a root of the common name, up to six characters, followed by a progressive numbering from the 00 value to n. After the prefix there must be always two figures as well as the progression.



PROCESS MENU

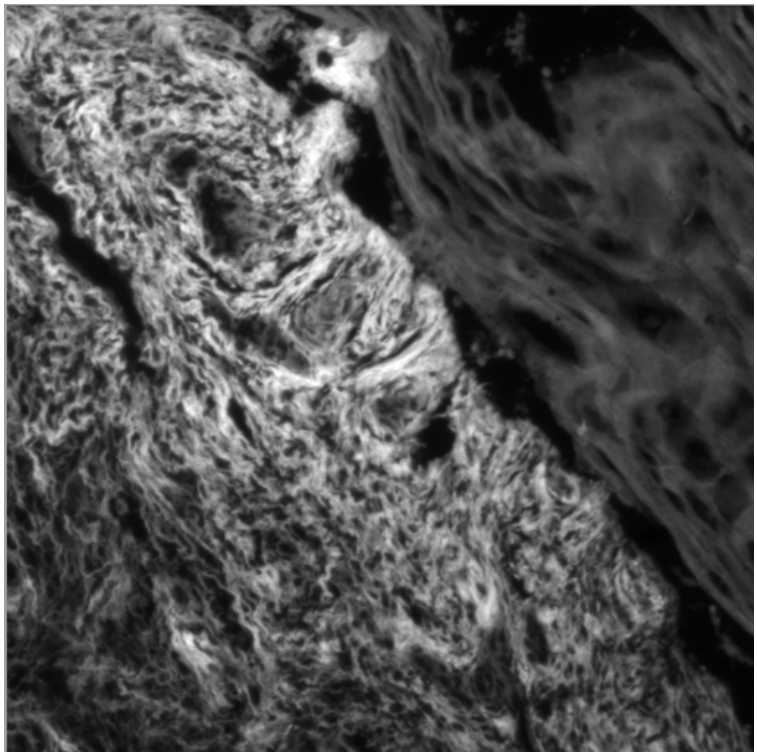
High Pass Filter
Low Pass Filter
Edge Filter
Morphological Filter
User Filter
Noise Maker
Equalize
LOG Stretch
Add Multiply
Images Merge
Sequence Merge
Sequence Align
Calibrate
Cosmetic CCD

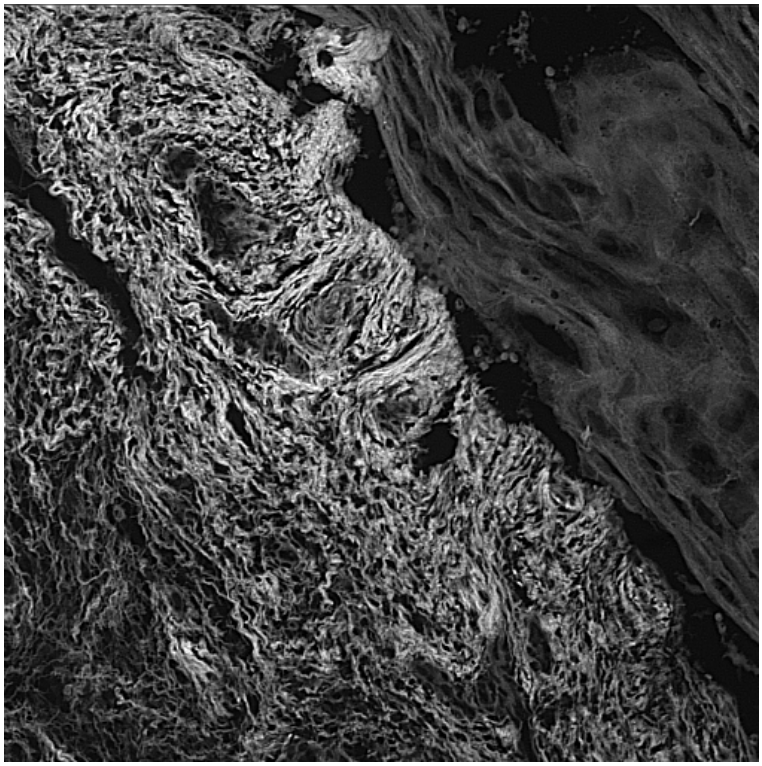
The Process menu executes on the image a series of operations performed in the spatial-domain. Here you can find different kinds of convolutive filters: HIGH & LOW PASS, EDGE, MORPHOLOGICAL and so on, but also some controls for the alignment of the images or for their merge. Most of these controls alter the numerical contents of the image, so to return to the previous one you must use the UNDO function.

-HIGH PASS FILTER

From this item you access a menu with several kinds of convolutive filters, such as the HIGH-PASS. Its use makes the image clearer, it can be used in all those images that require a better definition.

PHOTOGRAPH OF A HUMAN TISSUE BEFORE AND AFTER THE HIGH-PASS SHARPEN FILTER

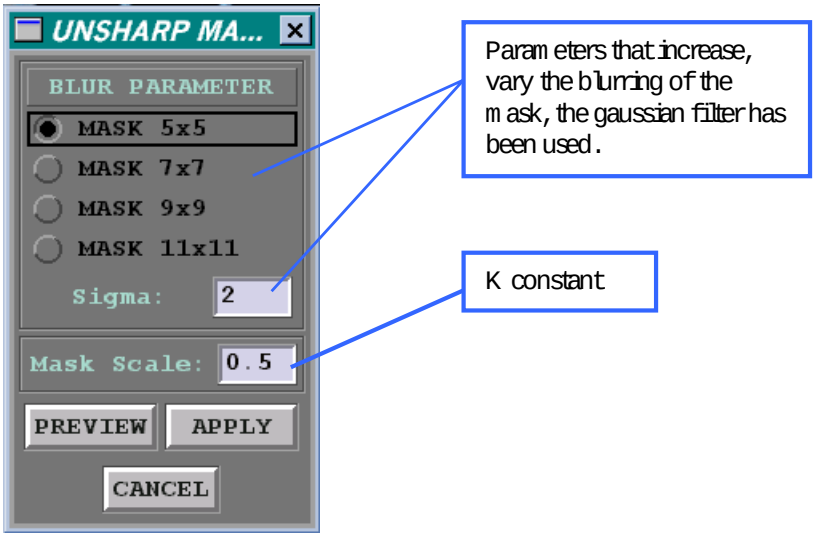




All the filters in this menu use convolution matrices of 3X3 except UNSHARP MASKING that adopts a traditional procedure which creates an image as a result of the difference between the original image and the one blurred according to:

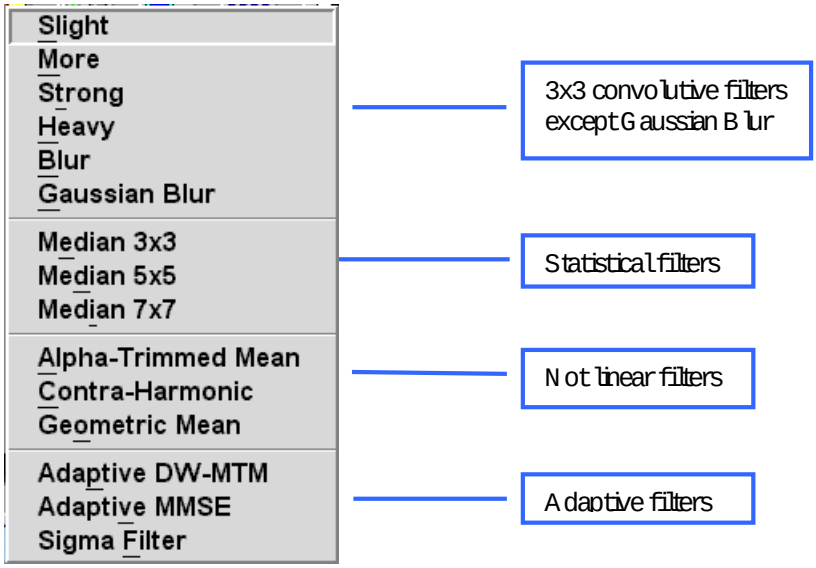
$$f_{sharp}(x,y) = f(x,y) - k * g(x,y)$$

whereas g is the blurred image and k is a constant that varies 0.2 to 0.8 with an enlargement of the detail according to the rise of this value.



-LOW PASS FILTER:

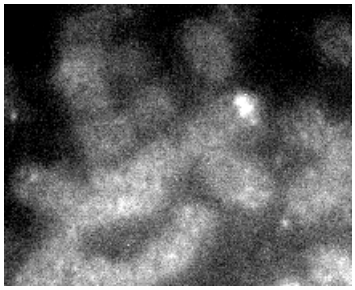
From this item you access a menu of several kinds of convolutive filters, such as the LOW-PASS. Its use makes the image less clear, it is useful if you want to remove external disturbances (cosmic rays) or to make an image less defined.
The following menu will appear:

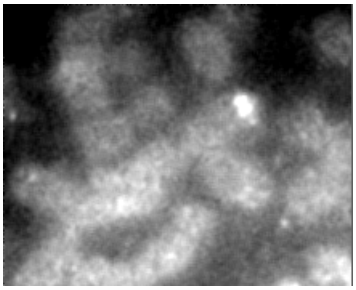


Slight
More
Strong
Heavy
Blur

These four Low-Pass filters blur the image with a different intensity, realized with a convolutive 3X3 matrix.

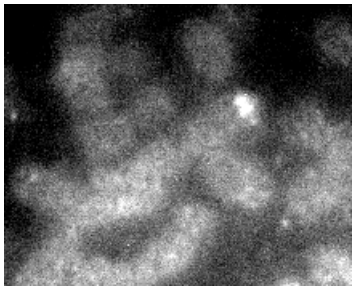
In the following images you can see the effect of the HEAVY filter on an image of chromosomes photographed in fluorescence.

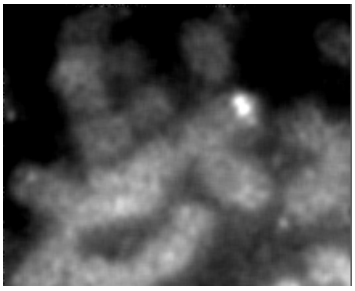




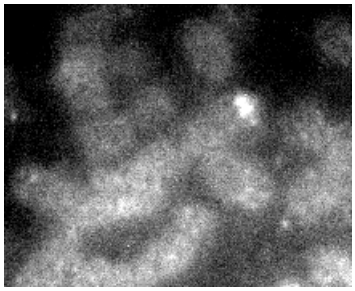
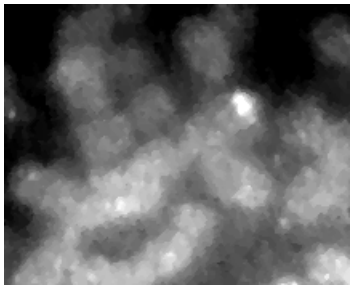
Gaussian Blur

This control creates a gaussian convolutive matrix, of the wanted size, with settable sigma values. In the following example, you can see the effect of this filter on an image of chromosomes photographed in fluorescence, using a sigma of 4 and a 5x5 matrix.

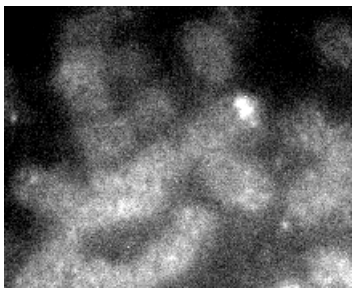
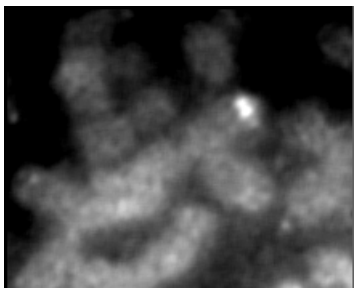




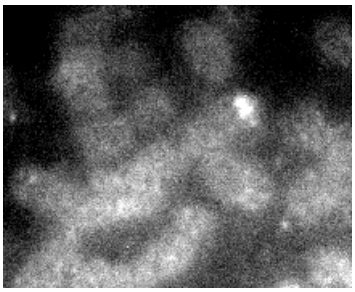
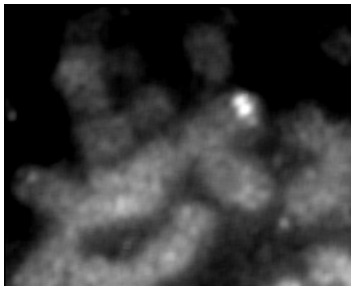
Median 3x3
Median 5x5
Median 7x7
Series of statistical filters with variable size; the bigger the size of the matrix you have used, the higher the Low-Pass effect of the filter. In the following example, you can see the effect of this filter on an image of chromosomes photographed in fluorescence using a 3x3 Median.

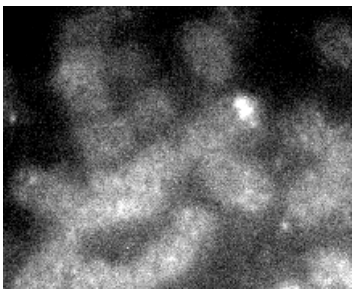
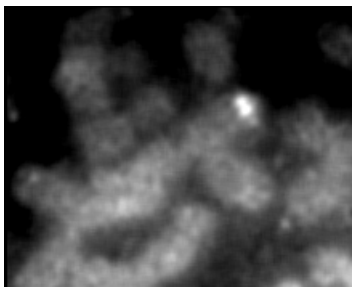
-Alpha Trimmed Mean Filter
Filter based on a statistical order that varies between the Median and the mean. It is used when an image contains different kinds of noise, for instance of the gaussian type, plus a “Salt&Pepper”. You need to specify the size of the mask (always odd) and the Endpoint parameter that indicates how many pixels are deleted by the array of ordered numbers, for instance if you indicate 1, you will delete from the calculation of the mean the minimum and maximum values of the mask that has been read. In the following example, you can see the effect of this filter on an image of chromosomes photographed in fluorescence using an Endpoint of 3 and a 5x5 mask.

Contra-Harmonic
This filter is useful to remove a gaussian noise, preserving, compared to a mean, the details. It requires the filter order and the mask size as its parameters. In the following example, you can see the effect of this filter on an image of chromosomes photographed in fluorescence, using an Order of 4 and a 5x5 mask.

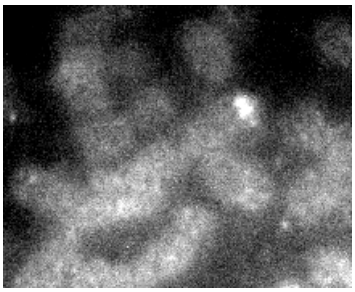



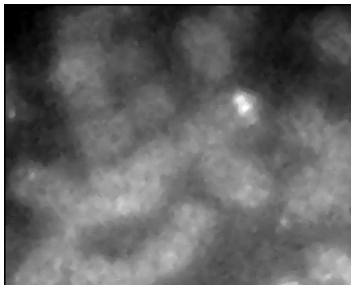
Geometric Mean
This filter is defined as the product of all the mask pixels raised to the 1/n whereas n is the size of the mask. The required parameter is the size of the mask to use. In the following example, a 5x5 mask was used.

Adaptive DW-MTM

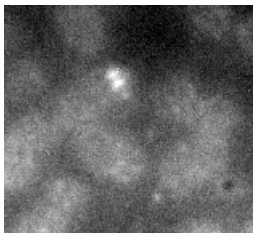
Adaptive filter that reduces the noise of an image without removing any detail. For its functioning, it needs a standard deviation value (STD) and a threshold. The optimal values of the threshold are between 1.5 and 2.5; with values of the threshold equal to zero, the filter behaves as a median filter while with high values it is as if we used a mean of the mask. In the following example, an STD of 10 and a Threshold of 1.5 have been used.

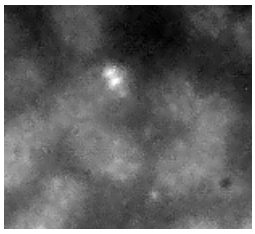




Adaptive MMSE

Adaptive filter defined as Minimum Mean Square Error. It uses the set variance value to determine whether the mean filter must be applied to a region (mask) of the image. In the following example, this filter has been applied using a variance of 800 and a mask of 5.

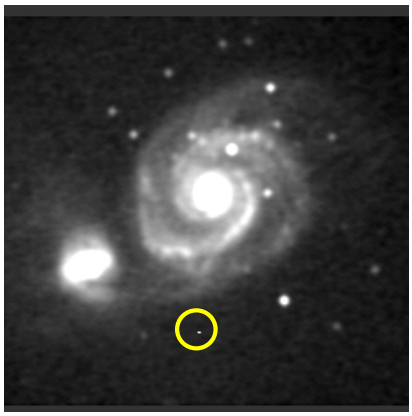


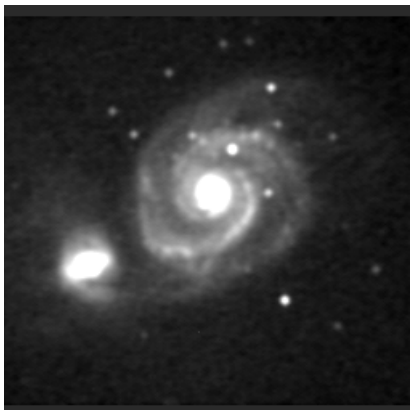


Sigma Filter

Adaptive filter that uses the standard deviation information to know whether the value of the tested pixel of a given area overflows or not, by specified n times, from the value of this. All the points found outside this threshold are replaced with the mean value of the mask. This filter is especially used to remove the effect of cosmic rays on the image.

In the following example, the photograph of M51 highlights in the lower part a typical spot due to a cosmic ray (inside the yellow circle); in the image on the right, the picture has been cleaned after using a filter with a mask of 7 and a deviation of 3.





-EDGE FILTER:
With this item you can access a menu of filters: gradient and contour types.

TEST OF THESE FILTERS ON THE AUTHOR'S IMAGE

Original image

N-E Gradient

S-W Gradient

Contour Mask 2

Canny Edge Detector

Shen-Castan

-**MORPHOLOGICAL FILTER**:

This kind of filters treat the images as if they were composed of a set of elements (pixels) that form up groups having a bidimensional structure. Some mathematical manipulations on these sets of pixels can highlight specific aspects of their structures, in order to recognize them. The basic operations are the following:

- **Dilation -** a small area concerning a pixel is appropriately structured.
- **Erosion –** the pixels composing a specific structure are deleted.
- **Opening –** sequential application of the **erotion** and **dilation** operations executed by using the same structural element (see below). This application is very useful, for instance, if you want to delete black noise pixels.
- **Closing –** operation similar to the previous one where the **dilation** comes before the **erotion.** This application is very useful if you want to delete white noise pixels.
- **Top-Hat –** executes a difference between the original image and an image in gray tones (**mask**). This filter is useful to highlight details with little contrast.

To apply these filters, it is necessary to have a **mask** that is the reference **structure** with which to execute the image processing. This mask (**structure**) can be created, loaded or edited by using the specific items in the submenu related to the Morphological Filter item.

EXAMPLES ON THE USE OF THESE FILTERS

Original Image

Dilation

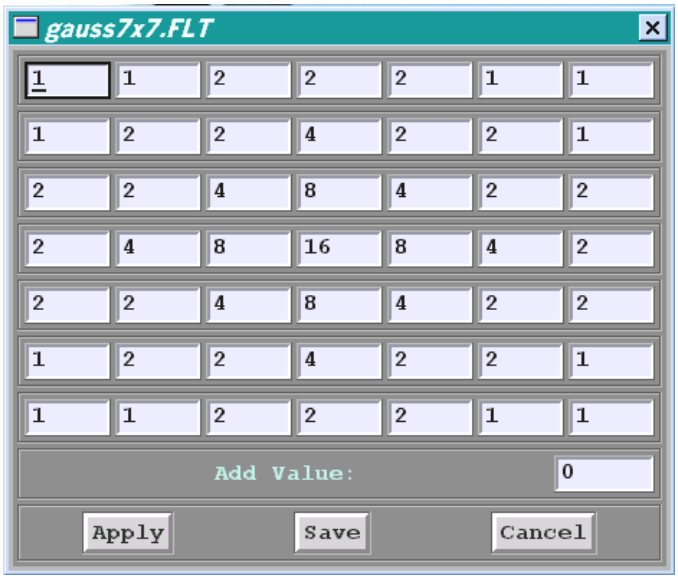
Erosion

Opening

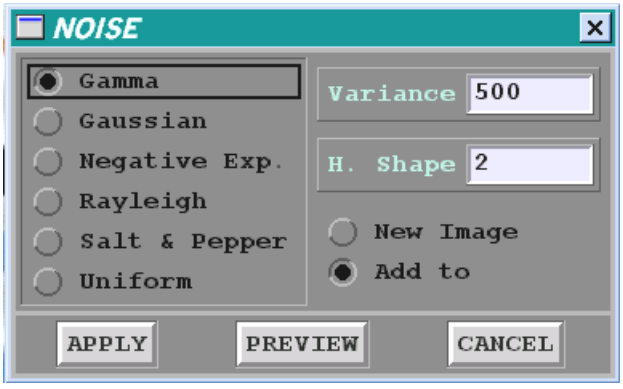
Closing

-USER FILTER:
with this item you access a submenu with which you can create, edit, load and apply a user filter. You can create filters with convolutive matrix from a minimum of 3X3 up to a maximum of 15x15 using a whole format or a floating point. For each created filter, you can also add a constant value to the image, this is done when one or more elements of the filter are negative, since the images handled by ViSION only contemplate the use of numbers at 16 bits with no sign.

EXAMPLE OF GAUSSIAN FILTER

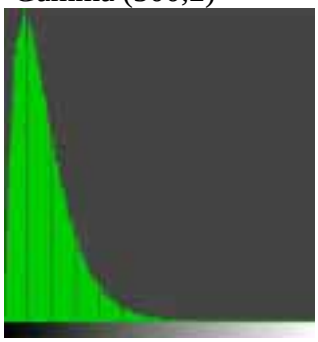


-NOISE MAKER:
with this function you can apply a noise to the current image or to a copy of it, you can also specify the main features of such noise. These noise makers are of course useful for educational purposes and for the adjustment of filters.

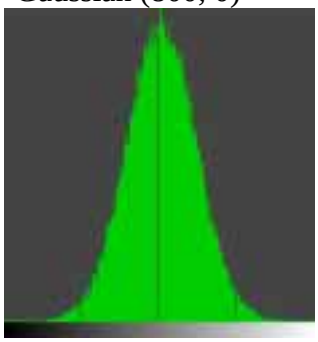


The algorithms that we use generate different statistical distributions of the noise, for this reason we will use the histogram to represent their action.

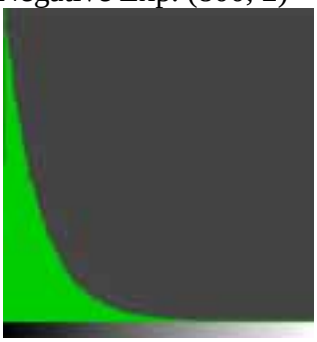
Gamma (500,2)



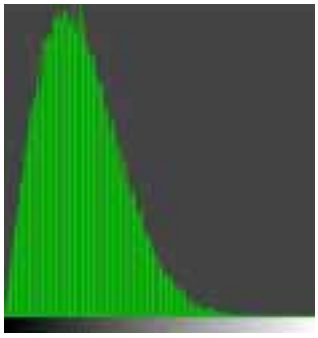
Gaussian (800, 0)



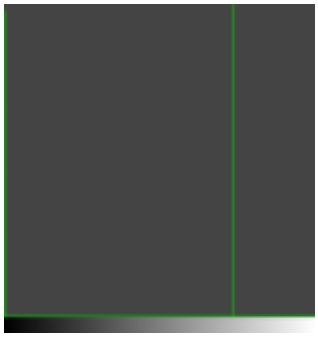
Negative Exp. (800, 2)



Rayleigh (600,2)



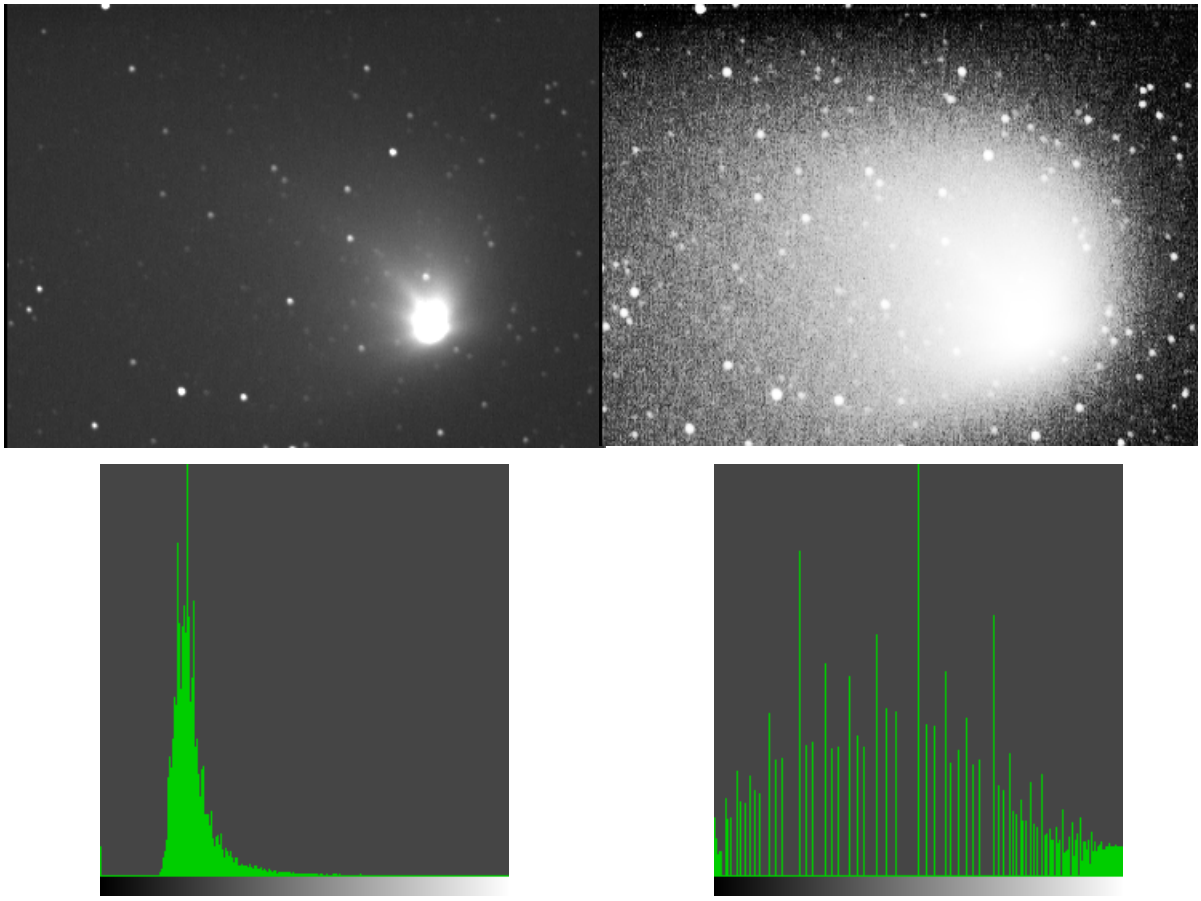
Salt & Pepper (20)



Uniform (800,0)

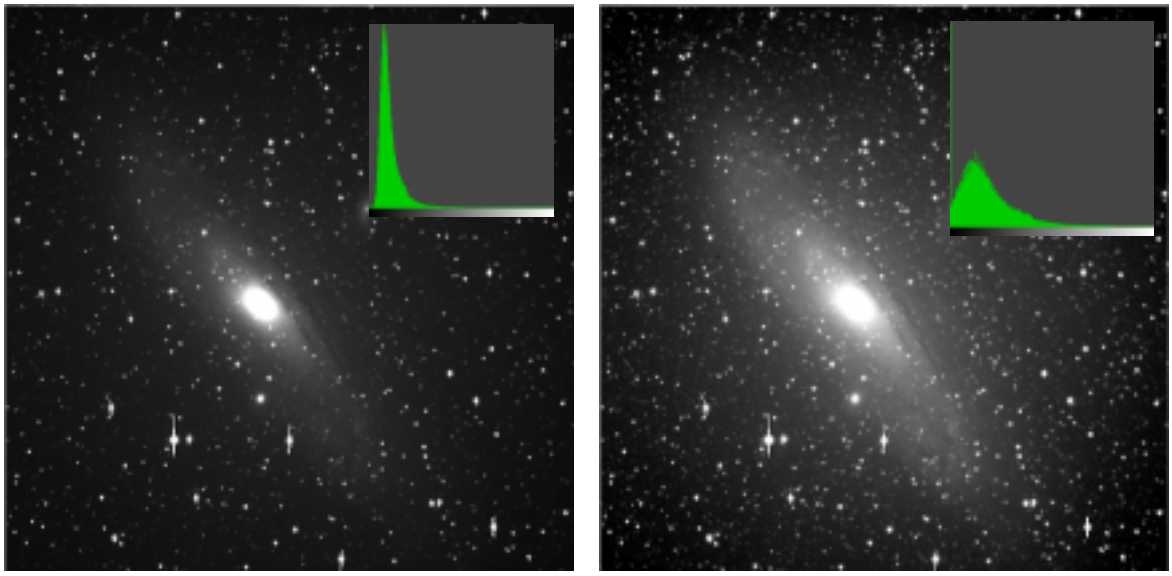
-EQUALIZE:
executes an equalization of the contrast (histogram leveling), the purpose of this method is to find a transformation function so that the distribution on the histogram is uniform. In other words, after this processing, different levels of gray will have the same probability. This procedure can be adopted for images where very bright sources coexist with very weak objects and you want to highlight the latter ones.

IMAGE OF THE HALEBOOP COMET BEFORE AND AFTER THE EQUALIZATION AND RELEVANT HISTOGRAMS

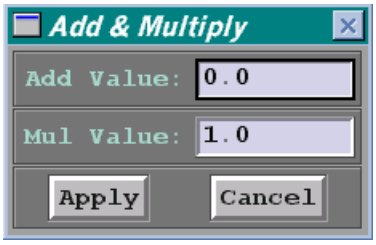


-LOG STRETCH:
This processing gives results similar to the equalization but with a less intense effect. In practice, the normalized logarithm of the image is made in order to have a levelling of the image for each application. It is only necessary to subtract the resulting offset level. To do so, you must examine the histogram, with the mouse cursor, to find the value to use in the ADD MULTIPLY as a subtraction value.

IMAGE OF M31 BEFORE AND AFTER THE APPLICATION OF THE LOG STRETCH FUNCTION (3 TIMES).

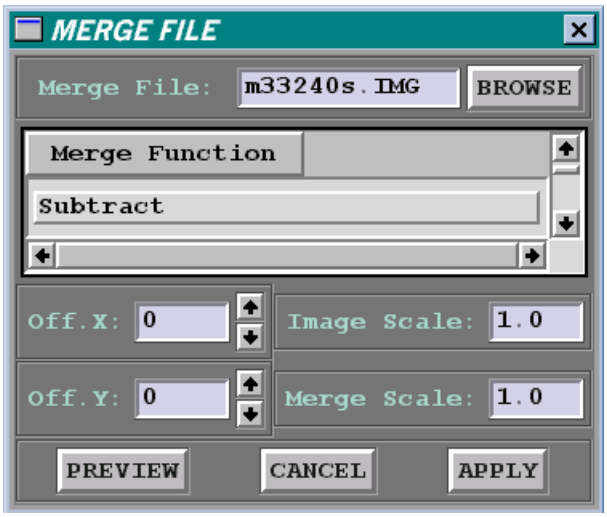


-ADD MULTIPLY:
It is often necessary to add or subtract a value from the image or to multiply or divide by a certain value. This control executes the four arithmetical operations of a constant on the image.



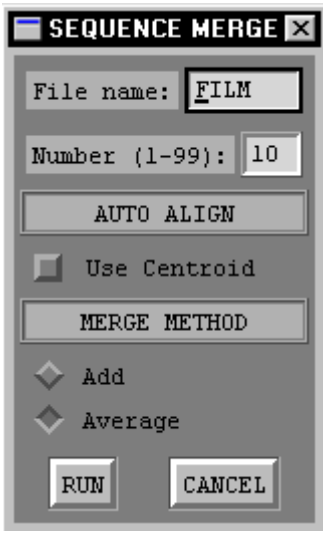
In the relevant two fields, you can use numbers with floating point; if you want to make subtractions, set negative values in the ADD VALUE field, if you want to make divisions, use the inverse of the desired number.

-IMAGES MERGE:



with this option you can make different kinds of logical or mathematical operations between images. You can work with the main image plus a second one (merge image) indicated in the **Merge File** field. You can choose the operation to make in the **Merge Function** field. The two **Offset** fields are useful for a possible alignment between images. The **Image Scale** field is for scaling the image values (not the size but the brightness values of the image dots), the **Merge Scale** field makes the same operation on the merge image.

-SEQUENCE MERGE:



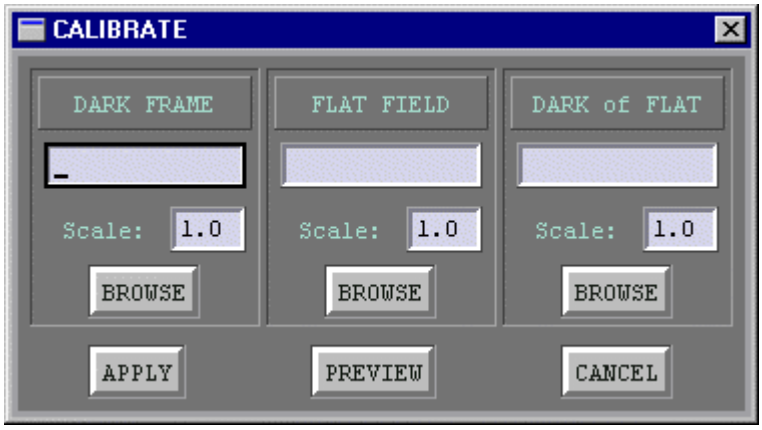
with the **Sequence Merge** option, you can work on a sequence of images by using the ADD and AVERAGE operations. In the **File Name** field, type in the sequence name. In the **Number** field, type in the number of sequence frames. By selecting the **Use Centroid** button, the images will be automatically aligned according to the following procedure:
in the first image of the sequence, you must select an object by using a window;
the centroid of this object will be found;

in the following images of the sequence, the centroid of the same object will be automatically recalculated;
all the sequence will be aligned for the chosen operation by using these centroids as a reference.
To start the sequence, click on the **RUN** key.

-SEQUENCE ALIGN:

with this function you can align a sequence of images (whose identifier must be typed in the **Source Name** field) by using as a reference an object present in them. In the **Dest. File Name** field, type in the destination file name. **Num. of files** contains the number of frames to align. **Fill Value** is for filling the areas that might be left uncovered. It is necessary to frame the object to use as a reference with a window at least as large as the oscillation of the object inside the frames to align.

-CALIBRATE:



subsequent calibration of a raw image. In the **DARK FRAME** field, you must specify the image of dark; in the **FLAT FIELD,** type in the image of flat; in **DARK of FLAT,** type in the dark of the flat. In the **Scale** fields, possible weighs can be typed in.

The calibration is executed according to the following formula:

$$K \frac{R(x,y,t)-N(x,y,t)\alpha}{\beta F(x,y,t')-N'(x,y,t')\gamma}$$

- R = raw image;
- t = raw image exposure time;
- t' = exposure time of the flat;
- N = image of dark;
- N' = image of dark of the flat:
- F = image of flat;
- α,β,γ = weighs relevant to dark, flat and dark of the flat;
- K = average value of the flat intensity.

-COSMETIC CCD:

with this function, you can correct faulty columns and/or pixels of the CCD sensor. The correction is executed by linear interpolation by using the values present in the pixels next to the faulty areas.

The parameters necessary for the correction must be specified in a text file with COR. extension. The following is an example of a file in which the syntax has been specified too (REM lines).

```
REM List of faulty pixels and columns
REM Possible instructions
REM ITM indicates the number of item to correct
REM PIX faulty pixel coordinates (x,y)
REM COL faulty column coordinates (x, y, start y, end y)
REM END       end list
REM Coordinates are specified as x,y and start from 0

ITM    2
COL    1233,0,1233,1023
PIX     555,600
END
```

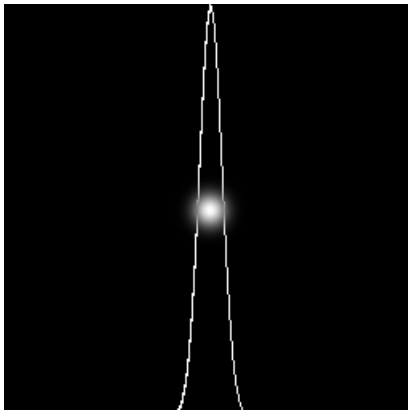
FFT PROCESS MENU

Create PSF
FFT Apply
FFT Inverse
High Pass
Low Pass
High Hemphasis
Homomorphic Filter
Inverse
Wiener
Richardson-Lucy
Maximum Entropy
Maximum Power Entropy
Add Structured Noise

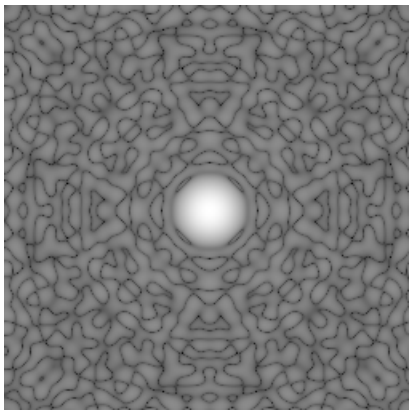
note. To apply the functions relevant to the FFT, the image being used must be square and have a numerical dimension equal to a power of 2, for example: 64,128,256,512 and so on, otherwise you will need to modify it by using the IMAGE SQUARE function of the EDIT menu .

-CREATE PSF:
it creates a PSF (Point Spread Function) which is necessary for the deconvolution operations. In the relevant window, you must specify the size of the PSF, the value of the standard deviation and the range. You can choose between two kinds of PSF: gaussian or cylindrical. There is also an input in the panel where you can specify the maximum level of the PSF; actually, you do not need to change this default value since these images are usually normalized.

PSF (Sigma 10) with profile



Same PSF after FFT

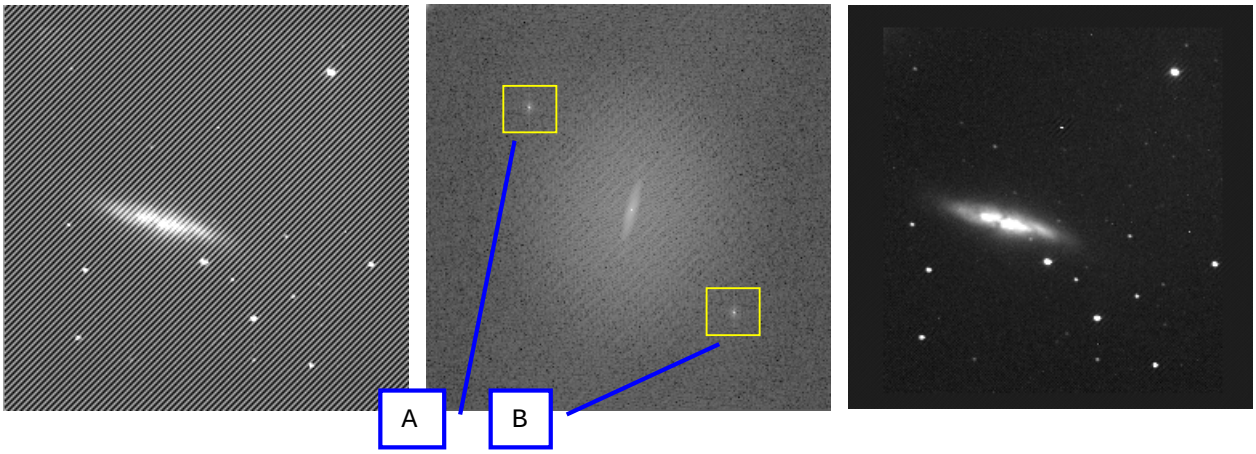


-FFT APPLY:
the image FFT is obtained: you switch from the spatial-domain to the frequency-domain.

-FFT INVERSE:
inverse function of the previous one: you switch from the frequency-domain to the spatial-domain.

In the following example, for educational purpose only, we show some possibilities given by the Fourier transforms. In the below sequence of images, from left to right, the first image of M82 contains a structured noise that damages its contents, in the second image the FFT has been applied so it is possible to locate the components of the frequency that disturbs our image (A and B). With the mouse, you can draw a window around point A and by using the FILL WINDOW control, you can fill its area with the 0 value; repeat the same operation for point B, then apply FFT INVERSE to obtain the third image cleared of the noise.

Image with noise Fourier Transform Final image

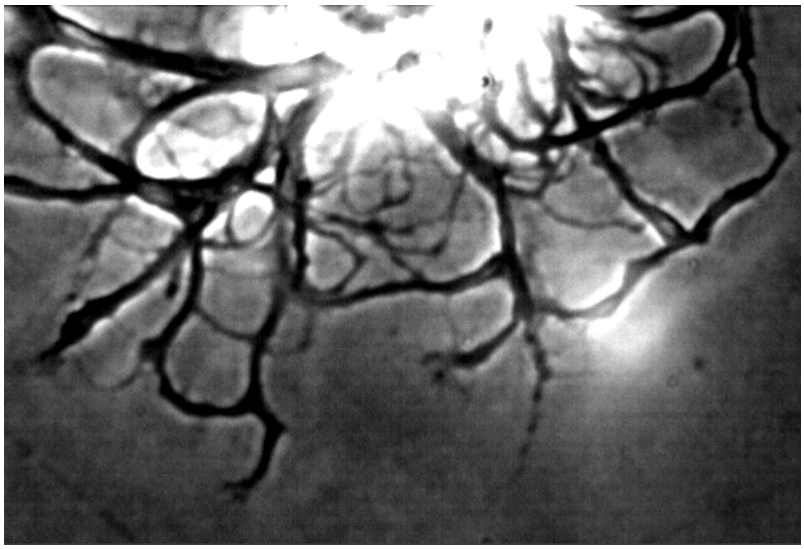


-HIGH PASS, LOW PASS
when an image is transformed in the frequencies domain, you can easily implement High Pass and Low Pass filters by simply setting a given area at zero. In fact, the parameter required by these two controls is the radius of the circle that will be "drawn" in the FFT image where it will be set at zero in the inside for the High Pass filter and in the outside for the Low Pass.

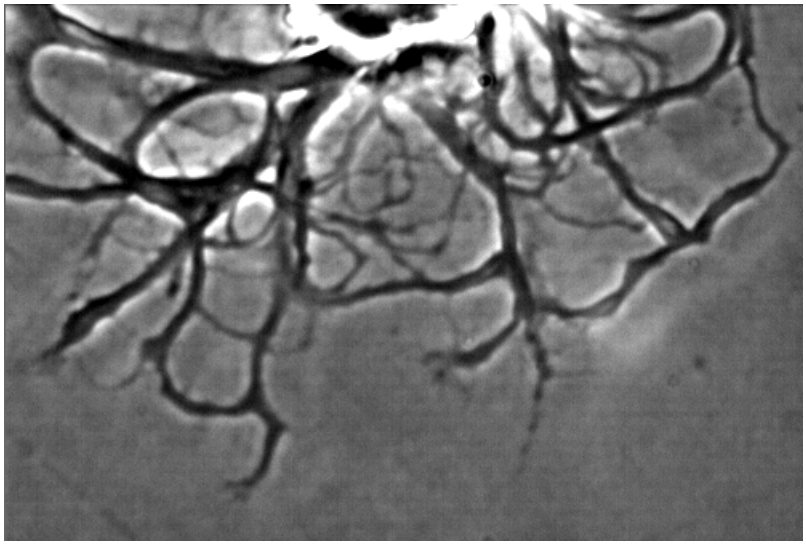
-HIGH EMPHASIS

In the following two images, you can see how this filter works: the image being photographed, a neuron, has a large dynamic range (about 20000) but wanting to better display the weaker parts with the contrast will “saturate” the more intense ones, so it will not be possible to have an overview. On the contrary, by applying this filter, image B, you can easily notice the higher number of details.

A



B



-HOMOMORPHIC FILTER:

By using the Homomorphic filter, the image is transformed in a new space where it is easy to implement operations for the correction of the background dishomogeneity. In the following example, an image of M33 has the vignetting defect, it is evident that the optimal for the correction of this image would have been the application of the FLAT FIELD imaging, but since this has not been done, we must use this filter.

Image of M33 with an apparent vignetting

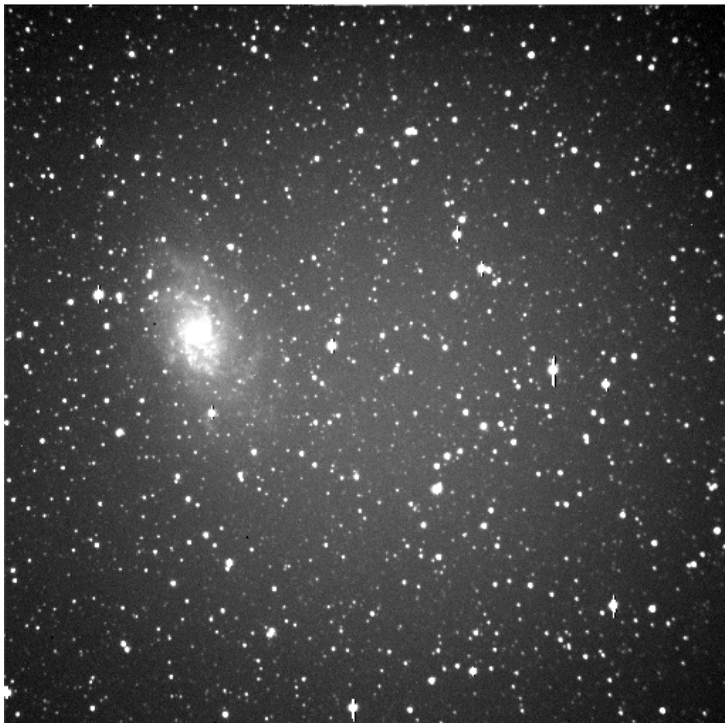
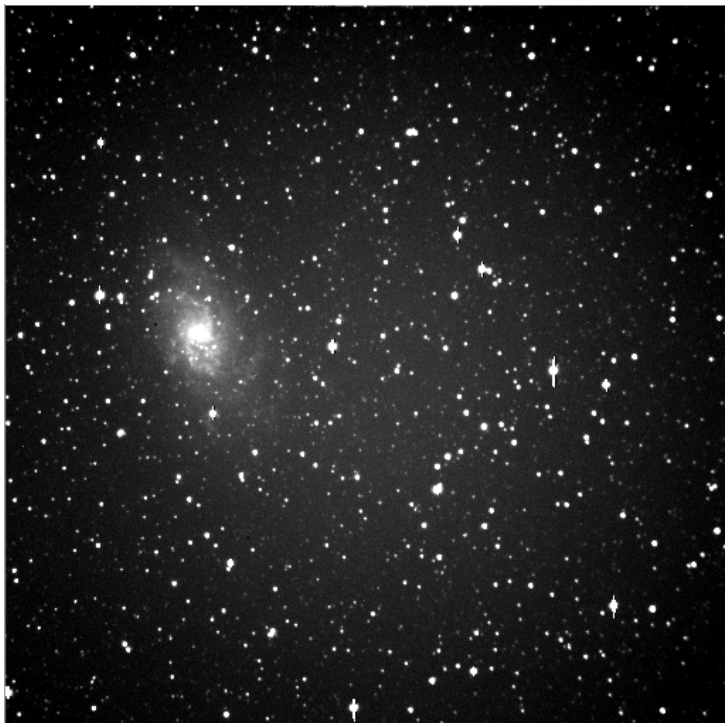


Image of M33 after applying Homomorphic



DECONVOLUTIVE FUNCTIONS

In the images photographed through the earth atmosphere, such as astronomic imagings, optical aberrations or defects of focusing damage the quality of the image. The following restoration procedures let you repair these aberrations.
Mathematically, it can be expressed as:

$$g = f \otimes h + n$$

Whereas:
g = is the image.
h = is the PSF
n = is the noise
⊗ is the convolution symbol

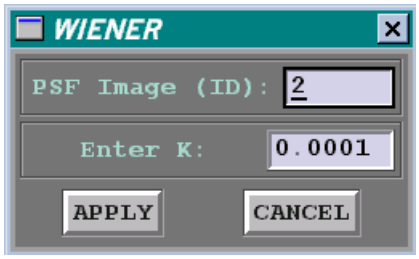
It is obvious that knowing h you can execute the inverse function.

-INVERSE:
inversion of the above function (allows to obtain f). Actually, the simple inversion amplifies the noise term, therefore this operation has an educational purpose only. In the following example, a synthetic noiseless image was used to show how this principle works.

Original image | Blurred image (Blur 2,9) | Inverse Filter

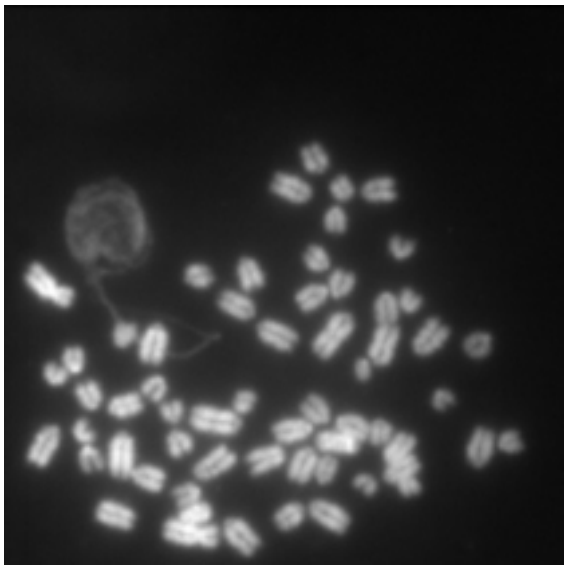
(PSF 3)

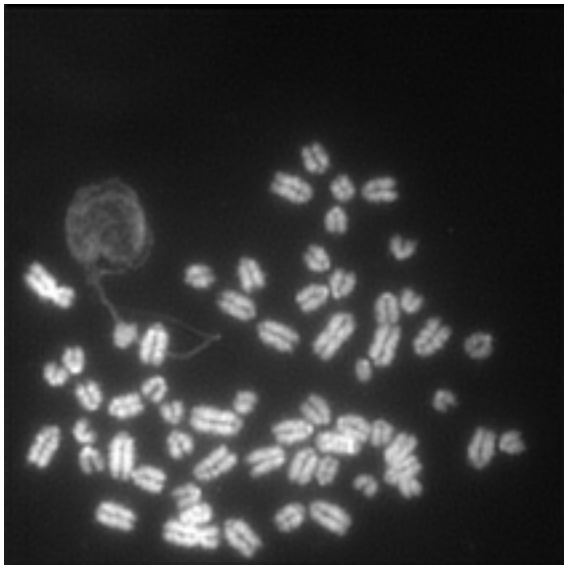
-WIENER:
The Wiener filter (Helstrom 1967) is a deconvolutive filter that lets you rebuild the image even in case of a significant presence of the noise. This filter requires good information on the image signal and on the properties of the disturbing noise. To use this filter, specify the identifier of the PSF image and a K parameter. In practice, to deconvolute an image, you must first build an image having the same size as the one you want to process with the CREATE PSF control, specifying the SIGMA value that the PSF must have, then select the image to process (by clicking on it with the mouse) and launch the instruction. The following window will appear:



Where you must specify the identification number of the image containing the PSF and the K value. For the choice of K, you can use the variance value of the noise (Gonzalez 1992).

Example of an image of chromosomes photographed in fluorescence where refocusing is necessary, in this case a PSF with a sigma of 3 and a K of 0.00005 was



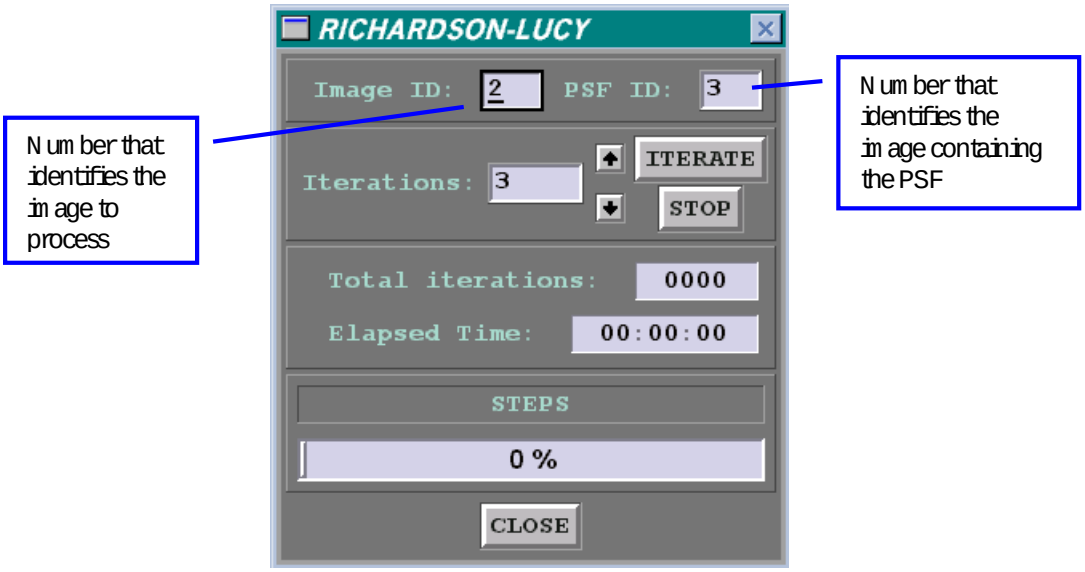


used.

-RICHARDSON-LUCY:

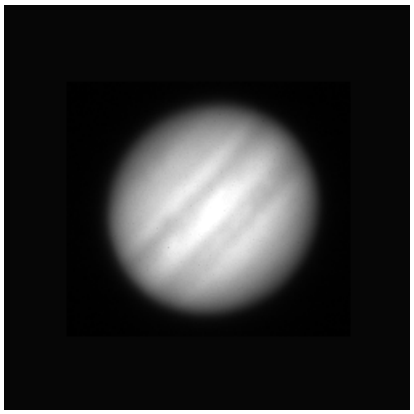
Iterative deconvolutive filter, widely used (most of the images photographed with the Hubble Space Telescope have been rebuilt with this method). It is derived from the typical equation of the image and the Poisson statistic. The ID of the image containing the PSF and the number of iterations must be specified. The final image is named with ESTIMATE. Like the previous deconvolution methods, you must first create a PSF image (CREATE PSF) with the same size of the raw image, then you must select the raw image and launch the instruction. The following panel will appear:

The major problems in image deconvolution are represented by the choice of the right

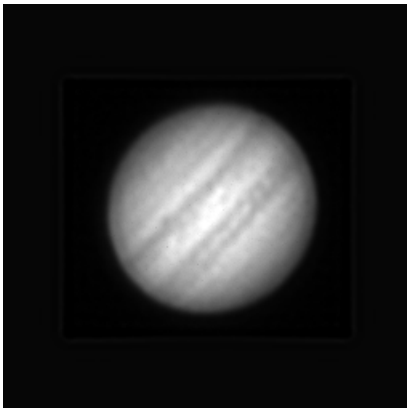


PSF and when to stop iterating. In both cases, choosing the wrong PSF or executing too many iterations create some artifacts. Therefore, you need a certain experience with these procedures if you want to find the right values. In the following example, you can see an image of Jupiter deconvoluted with this method.

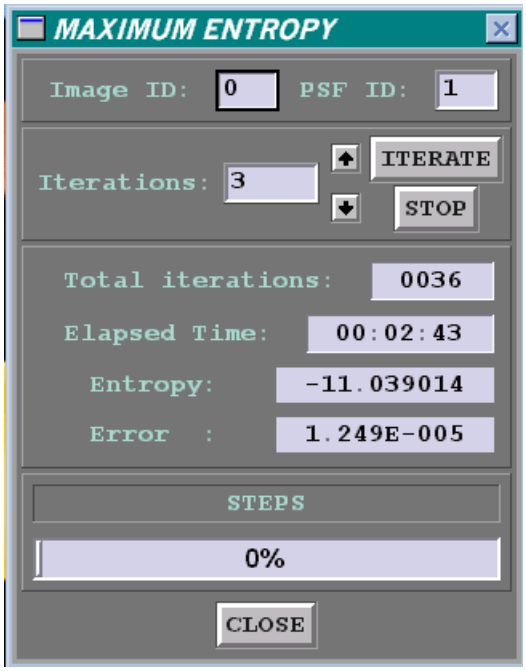
Raw image



After 40 iter. RL with PSF of 3.7

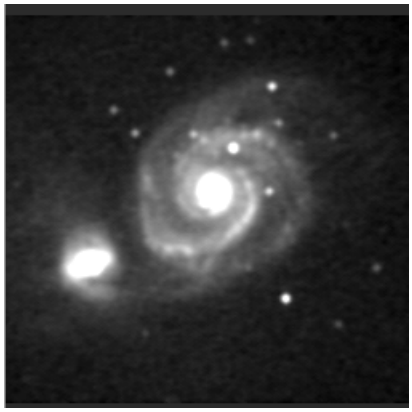


-MAXIMUM ENTROPY:
Very complex deconvolutive filter, whose efficiency lies in not "involving" the noise component in the deconvolution. Like the previous filters, it requires a PSF to be built. At the start up, it creates images for its own use that are automatically closed with the appearance of the control panel but that must not be closed during its functioning. The following panel appears:

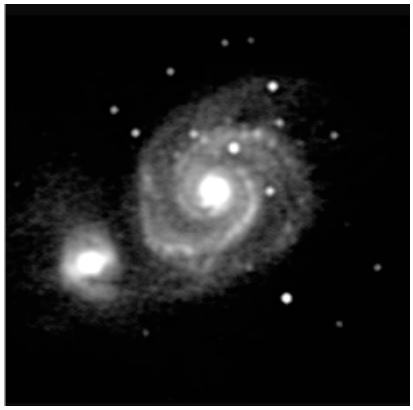


During the iterations, you must always check the ENTROPY and ERROR values, these must decrease at each iteration in order to have convergence. In the following example, the M51 galaxy has been processed with this filter, the result has been obtained by using a PSF of 2 and after 36 iterations.

Raw image



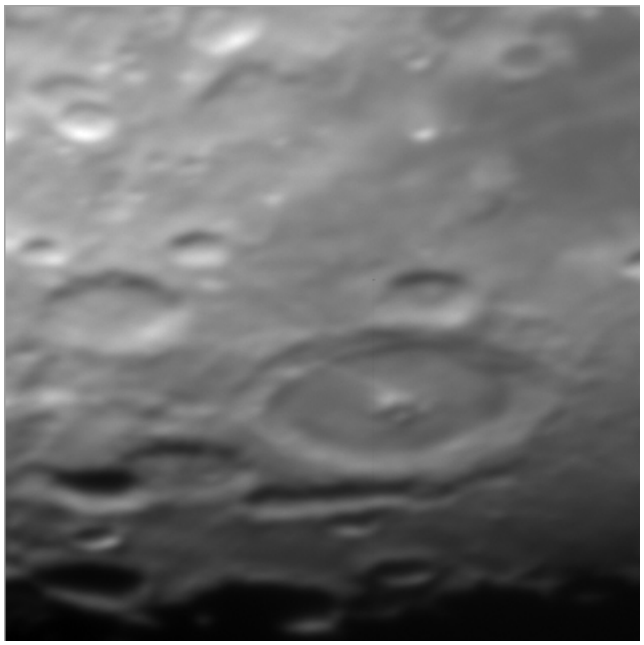
Processed with MEM



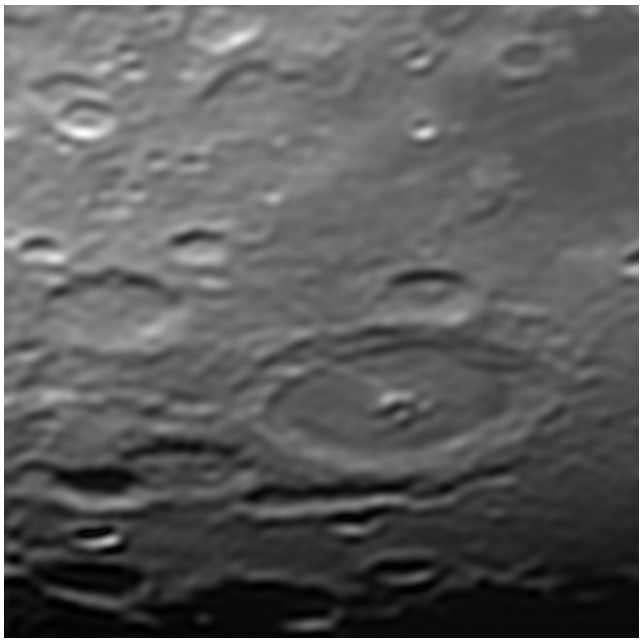
Warning: this algorithm does not allow in the image values of pixels equal to zero! If necessary, use the *Add Multiply* control to remove possible zero values.

-MAXIMUM POWER ENTROPY:
filter similar to the previous one, mainly suitable for very extensive objects. A lack of convergence may occur during processing. If so, you must change the values of the **K Pix** and **Alfa** parameters that you can access with the **PARAM** key.
In the following example, a photograph of the Moon degenerated by the atmospheric turbulence has been rebuilt by using a PSF of 5.2 and after 12 iterations.

Raw image



Rebuilt image



-ADD STRUCTURED NOISE:
with this option, you can add a noise component to your image. For educational use only.

ANALYZE MENU

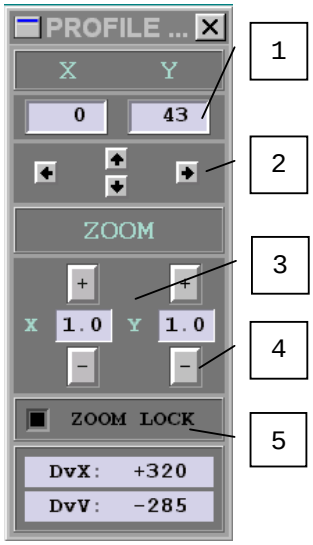
Histogram
3D View
X Profile
Y Profile
Advanced Profile
Find Centroid
Window
Polygon
Shape

-HISTOGRAM:
you enable the histogram display, a graphic representation of the statistic of the pixels colors.

-X PROFILE:
you enable a graphic representation of the statistic of the pixels values present along the line parallel to the x axis on which the mouse pointer is positioned. To disable this representation, select this item again.

-Y PROFILE:
you enable a graphic representation of the statistic of the pixels values present along the line parallel to the y axis on which the mouse pointer is positioned. To disable this representation, select this item again.

-ADVANCED PROFILE:



you enable a window that executes the profile on the horizontal axis of a line. When the control is enabled by default, the central line is selected; otherwise, you can select a different line by using the control panel. This control is realized for a spectroscopic use and, if enabled on the image, is refreshed every time that new data are present.
This control, when enabled, creates a graphic window with the graphic profile of the selected line, and a control panel where you can vary the display and the contents of the graphic window.
Description of control panel:

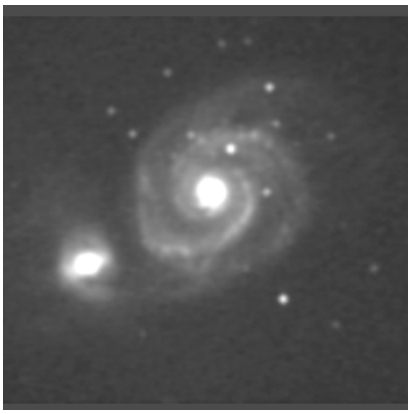
1. Apart from displaying the coordinate of where the profile is executed, it is also an input cell where you can digit new values.
2. Cursor keys to move the profile location.
3. Zoom control keys.
4. Button that enables the syncronic zooms control.
5. Values measured between the *marker* and the mouse cursor.

The graphic window lets you execute linear measures of level (DvV) and of wavelength (DvX). When you move the mouse cursor inside the graph, you can read the horizontal position (X) and the value of the associated point (Value:). If you want to place a marker line, you need to press the left mouse button. The marker will be canceled every time the graph is drawn again.

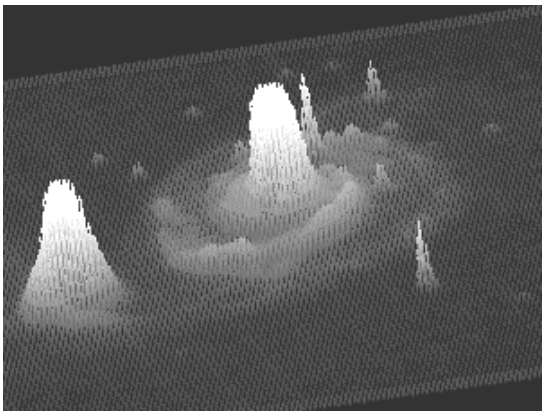
-3D VIEW:
displays the image in three dimensions where the Z axis is represented by the light intensity.
This kind of representation can be useful to examine according to different points of view, so to highlight structures that are not identificable at first sight (see example in the figure). When you access this function, a window is enabled where you must initialize the parameters necessary for the extrapulation of the 3D image. Such parameters are:

- Phi, Theta: rotation angles;
- Gain: Z axis magnification;
- Zoom: magnification factor x,y and z.

Image of M51



Plot in 3D of M51

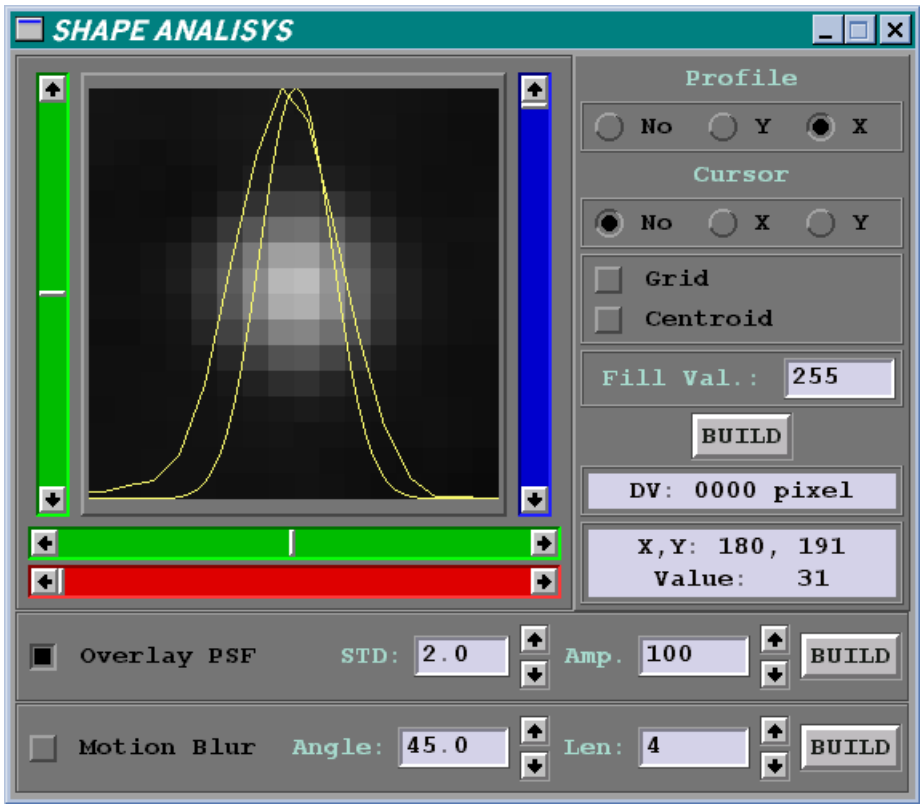


-FIND CENTROID:
by delimiting with the mouse the desired area, it finds the centroid of the present object.

-WINDOW:
with this option you can create a window containing the average value of the values of the image pixels present in a window defined by the user. Also, the total sum of the values of the image pixels is indicated.

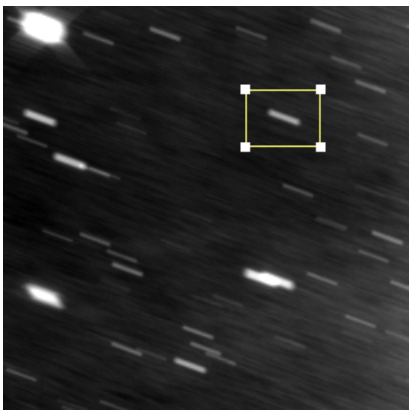
-POLYGON:
function similar to the previous one, where a polygon area defined by the user with the Create Polygon item of the EDIT menu is taken as an analysis area.

-SHAPE:
procedure that allows the profiles analysis of objects belonging to the image. Among the various functions, you can execute the measure of the objects in x and y, find by superimposition the PSF and create it, create particular images for the deconvolution.

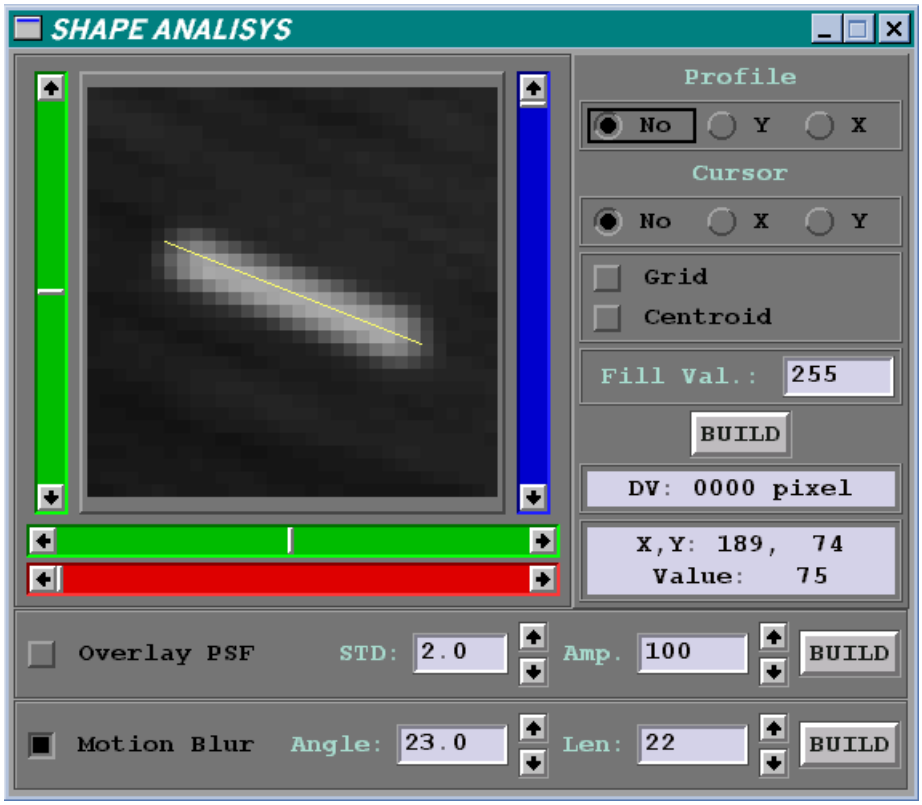


To enable this window, you must first frame an object. The two functions contemplated by the shape analysis are the creation of the PSF and the MOTION BLUR.
The PSF can be created so to be very similar to the image profile along the x or y axis (such profiles are showed by selecting the x or y item under the Profile label present in the window). To create the PSF, you must select the **PSF Overlay** item that displays a gaussian whose modelling can be executed by using the two **STD** and **Amp**. Controls; finally, you can proceed with the PSF creation by pressing the relevant **BUILD** key. Another way to obtain a PSF is to rebuild pixel by pixel the object to study by clicking with the mouse pointer on its image (some pixels will appear whose value can be assigned with the **Fill Val.** item), the PSF will be built by pressing the relevant **BUILD** key.
Usually, a motion blur is used to make blurred images sharper.
To create a MOTION BLUR, you should select the relevant item in the window. A segment will appear on the image (motion blur) of which you can establish the length and the orientation by using the **Lens** and **Angle** controls This segment must be as similar as possible to the object taken as a reference in the image. The creation of the motion blur is done by pressing the relevant **BUILD** key. Another way to draw any figure is to use directly the mouse on the image square, in fact by positioning the cursor on a pixel and by pressing the left mouse button, it will be enabled; by pressing the right button, it will be disabled.
The PSF and the MOTION BLUR are applied to the convolutive functions of the FFT PROCESS menu. In the following example, the deconvolution of a blurred image is executed by building a MB image.

First, you must frame a star to use as a reference.

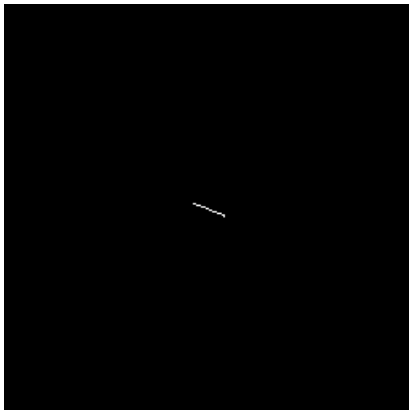


Then, select the Shape control and center the image by using the Centroid key or the cursors; select the Motion Blur key and by varying the Lens and Angle values, build by superimposition a vector that traces the blurred star, finally enable the relevant BUILD.

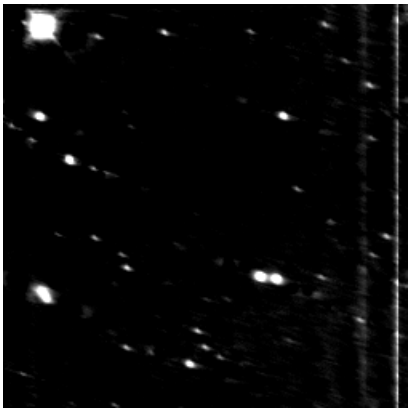


By using the image of MB being built and by iterating it with the raw image by using the RL, you will obtain the following final image.

Image of MB



Final image



-Sigma FWHM:
with this control, you can calculate the standard deviation and the Full Width Half Maximum of a punctiform source present in the image.

OPTIONS MENU

Color Attributes
Science Field
Hide Tool Bar
Load Desktop Color
Save Desktop Color
Help Language
FITS Keyword

-COLOR ATTRIBUTES:
with this item, you access a submenu for the setting of the graphic interface colors.

-SCIENCE FIELD:
The CCD cameras are used in different science fields, each of which requires specific measurement and calibration functions.
From this menu, you can choose between two main fields:

Astronomy
Biology

Once the science field has been chosen, you can select the relevant control from the **Field Application** menu. Further details are available in the manual attached to every specific application.

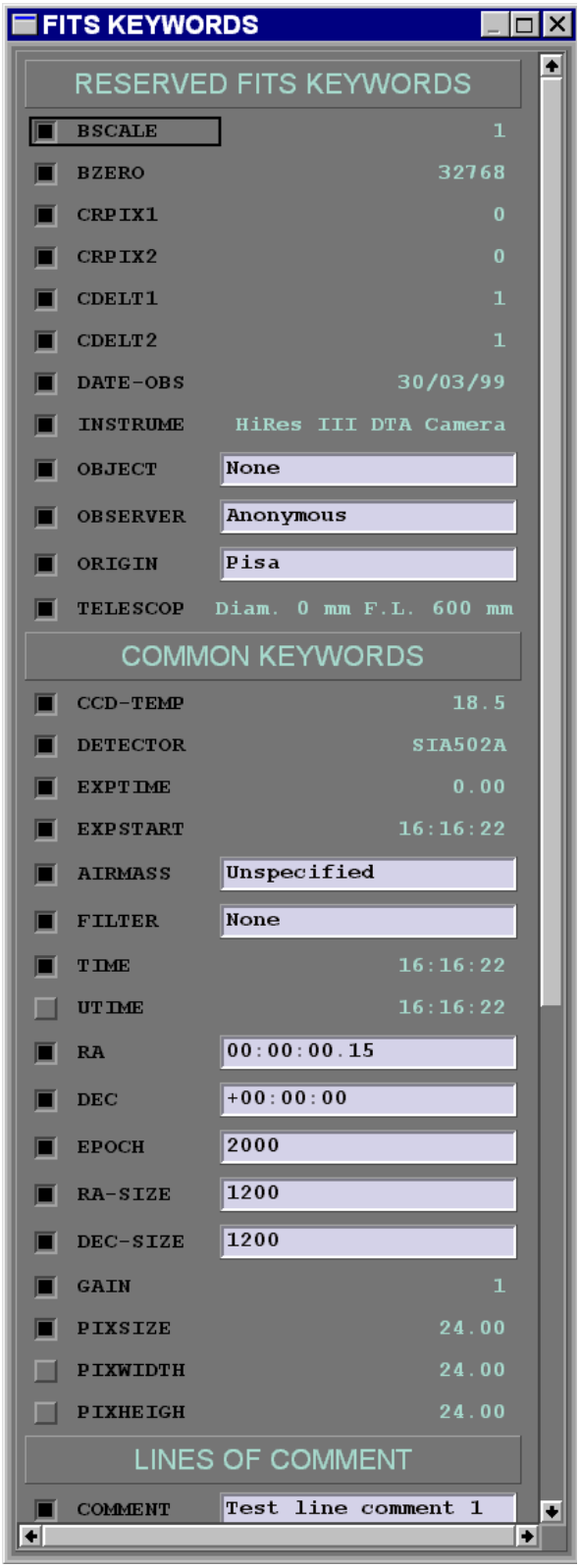
-HIDE TOOLBAR:
option which lets you hide the toolbar.

-LOAD DESKTOP COLOR:
option which lets you load a set of colors previously saved.

-SAVE DESKTOP COLOR:
option which lets you save a set of colors chosen with the COLOR ATTRIBUTES item.

-HELP LANGUAGE:
with this option, you can choose the on-line help language.

-FITS KEYWORD:
with this option, you can choose the keywords which will be used in the creation of the FITS files.



FIELD APPLICATION MENU

Evaluate Magnitude

-EVALUATE MAGNITUDE:
note. Control present only if in the **Science Field** field the Astronomy item is selected.

Magnitude evaluation of a star. The procedure necessary for this operation is as follows.

1. Define the size of the star to examine by selecting the matrix on SPOT SIZE.

2. Frame with the mouse an area of sky and click the DARK REGION button.

3. Frame with the mouse the star of which you know the magnitude, insert its value in the edit field relevant to MAGNITUDE REF., then press the relevant button.

4. Frame with the mouse the star of which you want to evaluate the magnitude and press the relevant button, the value displayed in the MAGNITUDE field is the one of the selected star.

Repeat step 4 for all the stars you want to evaluate.

Warning: the size of the chosen spot affects the magnitude evaluation; also, to reduce the error, always use a frame of the same size.

USER MENU

You can also define a customized menu where you can run programs written in IPBL. During the initialization of ViSION, a file named “USERCOM.LST” is searched for, if it is found, the listed controls are interpreted. This kind of file is written in ASCII and any editor is suitable for writing. Inside of it, a list of keywords followed by a parameter must be written; the available statements are:

REM specifies a comment line
TIT “Name you want to assign to the menu”
PRG “Name of control” “Name of IPBL file that executes it”
END end of list

Example:

```
REM Customized menu writing test
TIT “My Filter”
PRG “Unsharp Masking” “UNSHARP.IPB”
PRG “Blur” “BLUR.IPB”
PRG “Solarize” “SOLAR.IPB”
END
```

HELP MENU

-HELP BROWSER:
lets you select a HTML browsing program in order to view the help file.

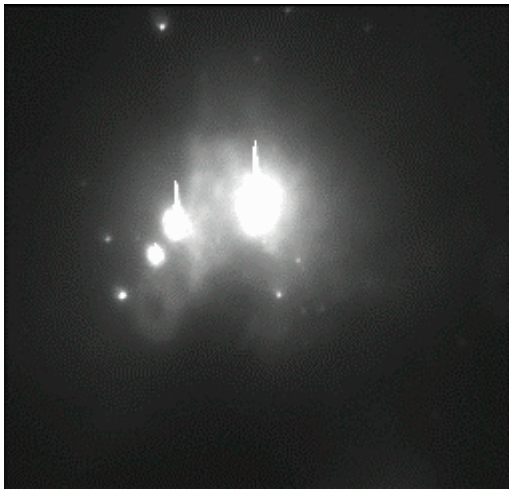
-MAIN HELP:
help file opening through the above specified browser.

CAMERA COOLING

The camera cooling inevitably develops with the increase of exposure times; it is optional for planetary imaging, but it becomes fundamental for the imaging of weak objects.
The problem is connected with an intrinsic behaviour of the CCD: the selfsaturation after some time, even in the absence of light. This behaviour is commonly called “dark current”, the only way to reduce this effect is to cool the CCD; the lower the temperature, the longer the exposure that you will be allowed. The DARK CURRENT is also affected by the CCD operative modes, for instance by the BINNING that increases it quadraticly with number of united pixels. In order not to subject your instrument to thermal shocks, we advise you to gradually execute the temperature decrease by using the **Set Temperature** control that progresses in a slow way and also by always using the **Cooler ShutDown** control to switch the cooler off.

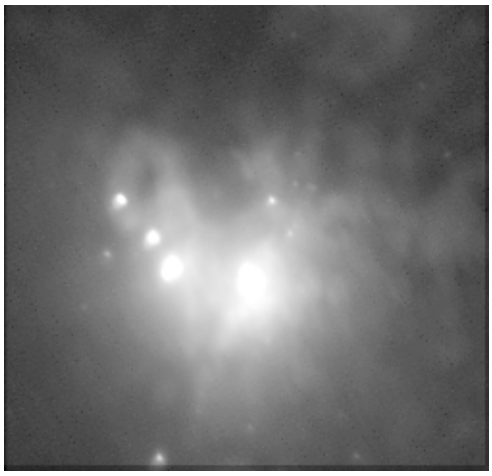
CCD BLOOMING AND SEQUENCES OF IMAGES

A physical feature of the CCD is the number of electrons that every pixel can contain. This value varies according to the size of the pixel and the manufacturing technology being used, usually from 70.000 to 500.000 electrons (of photoelectric origin) per pixel.
If the light source is too intense, a phenomenom called BLOOMING occurs, that is the charges exit the potential well and overflow into the neighboring pixels by causing the typical tail shape in the stars.



M42 with a 60 seconds' exposure.

The above figure shows this phenomenom. In order to well image the nebulosity of M42, a long exposure time would be required but the intense brightness of the central stars generates a BLOOMING in the device that ruins the image. To avoid this phenomenom, you can use an imaging procedure of more images with a shorter exposure and then add digitally the images being obtained.



M42 photographed with 5 images of 20 seconds' exposure.

CAMERA MAINTENANCE AND CLEANING

The good functioning of the camera is directly proportional to its use and maintenance.
Extra care must be taken for the storage of the camera that must be kept in a closed bag or container with dehumidification salts.
For its cleaning, use a soft cloth slightly soaked in a solvent, such as alcohol or similar, that does not leave any greasy residues. It may be necessary to clean the optical window, for this delicate operation use a typical photograph brush; then, rub the surface with an antistatic cloth for glasses after misting it with your breath; **do not use any cleaning liquids.**
The connecting cables must not be subject to very sharp bendings or excessive stretchings.

APPENDICES

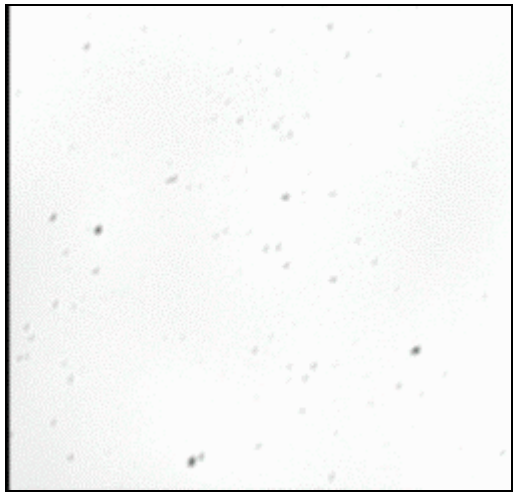
A

TUTORIAL FOR USE IN ASTRONOMIC FIELD

ORGANIZATION OF AN ELECTRONIC IMAGING NIGHT

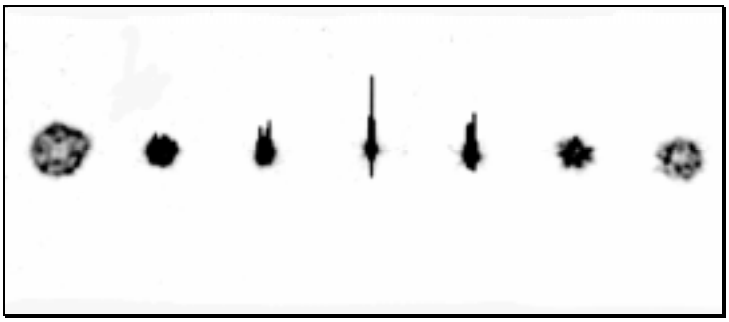
If this is your first experience with a CCD camera, it is a must to become more confident about the instrument during the **day,** by using faraway objects to point with the telescope.
The main difficulties that you may encounter in using the CCD imaging technology are the focusing of the object and the pointing.
This is the reason why we suggest a first daytime approach, taking notes about the positions of focusing and pointing.

1. Connect the HEAD to the BASE and the latter to the PC.
2. Switch the PC on and then the camera.
3. Launch the handling program (VI).
4. Create a new work directory.
5. Enable the camera cooling by pressing the COOLER key from the CCD Control menu (if you want to image weak objects).
6. Once the temperature reaches the minimum value, wait for a heat stabilization of the HEAD for at least 20 minutes.
7. Execute the FLAT FIELD by placing on the lens of the instrument an opal glass and by setting an exposure time that does not saturate the A/D converter (A/D range < 100%).



Typical FLAT FIELD image, the gray dots are small dust particles present on the CCD optical window.

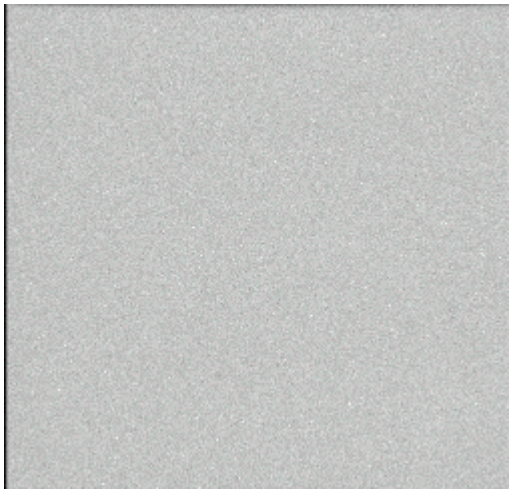
8. Execute the camera focusing by setting a binning of 3x3 or 4x4, an exposure time from 1 to 5 seconds and by pressing the FOCUS key. The program will continuously display images spaced out by a BEEP of ready image, then work on the telescope focuser with a very slow movement spaced out with the acquisition of the image. As an object, we suggest you to use a star having a 4, 5 magnitude.



As an indication for the correct focusing, you can evaluate the blooming length caused by the star: the higher this length is, the better the focusing is. The previous image is displayed in negative only for problems concerning the printing.

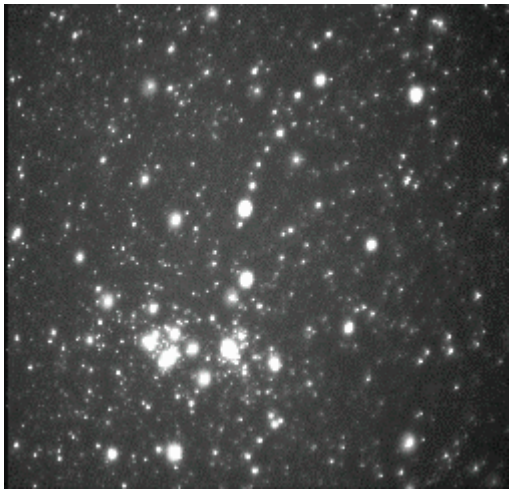
9. Once the focus has been adjusted, you can point the desired object by always using the FOCUS mode to find some reference objects.

10. Once you are sure that the object will be present in the CCD field, you must set the exposure time and execute the DARK, making sure to cover the instrument lens with a black cap in case of NCC cameras.



Typical image of a DARK exposure, the variations among pixels are caused by a non uniformity of response among the different photosensitive elements of the CCD.

11. By removing the cap being used for the DARK, you can execute the actual exposure with the INTEGRATE key.



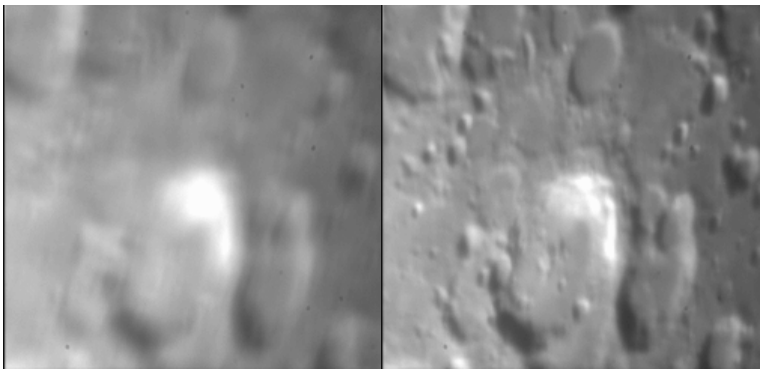
Final image after the DARK has been removed and divided by the FLAT.

12. Save the image by pressing the SAVE key.

The list of steps being described is only approximate since some of them are optional, such as the FLAT-FIELD that can be executed afterwards; also the sequence and the operative modes can be changed.
For instance, nothing prevents you from executing the focusing before the camera cooling etc.

MULTIPLE IMAGING AND QUICK EXPOSURE TIMES TO BLOCK THE SEEING IN PLANETARY OBSERVATION

The procedure using sequences of multiple images with quick exposure times is useful in planetary imaging.
Even by using a very quick exposure time, often you cannot avoid the unpleasant effects of a very bad seeing, since this causes an out of focus effect; therefore a very quick exposure time is useless.
On the contrary, by using a sequence of images, it is statistically possible to capture a good image out of a certain group being acquired.



Images of the Moon extracted from a sequence with exposure times of 130 mS.

In NCC cameras, you can enable the antiblooming mode from the main menu, you can do this by selecting the **CCD Specific Function** item that lets you choose the efficiency of this device by setting a numeric value from 0 to 255 (255 max antiblooming).
We must say that the antiblooming reduces the camera sensibility according to the value being set.

B

FILENAMES EXTENSIONS USED BY ViSION

.FLT File of a convolutive matrix.
.ASC Image file in ASCII format.
.BMP Windows bit map image file used for ViSION icons.
.CFG ViSION configuration file.
.COL Description file for desktop colors.
.DRK DARK file for automatic subtraction.
.DRV Specification file of CCD sensor.
.FIT Image file in FITS format.
.FTS Image file in FITS format.
.IMG Image file in DTA proprietary format.
.IPB Ascii file containing IPBL language source.
.LOG LOG file of ViSION. LOGOUT.LOG file containing work directory.
.LST USERCOM.LST file where customized Menus are described.
.MAP File containing a colors palette.
.PAR Intrinsic constants of CCD camera .
.PTF Configuration file relevant to the platform being used.
.RAW Image file in raw binary format.
.SEN FLAT field file for automatic correction.
.TXT Text file.

C

IPBL SYNTAX AND CONTROLS

IPBL is a BASIC type language that lets you handle in a complete way the CCD camera being used, to handle photographed or saved images, not only to execute the ordinary statements of the BASIC.
IPBL normally resides in ASCII files editable with a normal text EDITOR, there are no limits on the dimension of this file, provided that there is sufficient memory. Note that all the statements, labels etc. can contain lower or upper case characters indifferently. IPBL handles two kinds of variables: the doubles in the range from 1.7E–308 to 1.7E+308 and the strings up to 256 characters.
The numeric variables (max 26) are identified by the letters from A to Z, in a similar way the string variables are identified from A$ to Z$.
Inside the string variables some check codes can be inserted, always preceded by the \ character followed by the special character. Check characters that you can insert are: \n Line feed, \t Tab, \7 Bell, \r Return. The specified characters strings must always be enclosed between two double primes.

Example: by following this instruction:

```
WPRINT 1, "HELLO WORLD\nCIAO MONDO"
```

We will obtain:

Some limits of the interpreter are:

Max. number of handled labels:	1000
Max. size of the label:	16 characters
Max. size of string variables:	256 characters
Max. number of hidden FOR NEXT’s:	32
Max. number of hidden GOSUB’s:	32
Max. number of open files:	32

The basic statements being handled are:

for <espressione> to <espressione> [step] <espressione>
.
next
if <espressione> >, >=, <, <=, =, <espressione> then <statement>
gosub <label>
return
goto <label>
ongoto <espressione>,<label>,<label>.....

stop
end
\\ Comment
Rem Comment.

You can define some labels, these must be at the beginning of the line and end with a colon.
Example of valid labels:

Start:
end:
pio:

FUNCTIONS CLASSES

- IMAGE TREATMENT AND PROCESSING

ADDMUL	Add & Multiply.
BLUE	Reads the n value of the blue.
CLOSEIMG	Closes an image server
CONVOL	Convolutive filter.
CREATEIMG	Creates an image server.
DIMX	Dimension of x axis image.
DIMY	Dimension of y axis image.
DISPLAY	Displays the image.
GETPAL	Reads the image palette.
GREEN	Reads the n value of the green.
IMAX	Max value in the image.
IMGDIR	Sets the work directory.
IMIN	Min value in the image.
LFITS	Loads a FITS file.
LDPAL	Loads a palette.
LOAD	Loads an IMG file.
LOADPAL	Loads a palette file.
MATHIMG	Mathematical operations among images.
MEDIA	Image medium value.
NOTIMG	Denies image.
PAL	Allows to edit a palette element.
RDMAT	Reads an image pixel.
RED	Reads the n value of the red.
ROTIMG	Rotates the image.
SAVE	Saves the image in IMG format.
SAVEPAL	Saves a palette file.
SCANIMG	Calculates some characteristic values of the image.
SERVER	Selected image.

SFITS	Saves the image in FITS format.
SHIFT	Image Shift.
SIGMA	Standard deviation.
STRETCH	Image contrast adjustment.
USRFILT	Executes a spatial filter defined by the user.
WRMAT	Writes an image pixel.

- FILE

CHDIR	Changes the work directory
CLOSE	Closes a file
FINPUT	Reads from a file
FPRINT	Writes in a file
OPEN	Opens a file
PRINTFILE	Prints an ascii file
REMOVE	Removes a file
SHOWFILE	Displays a textfile

- CCD CAMERA CONTROL

BINNING	Sets the camera binning
CAMERA	Returns the status of the CCD camera
CAMERAOFF	Closes the tasks of the CCD camera
CAMERAON	Initializes the CCD camera
CLRCCD	CCD cleaning
COOLER	Ables or disables the cooler
COOLPWR	Sets cooler power
EXPO	Sets exposure time
FWHEEL	Selects a filter of the wheel
GETCCD	Displays and unloads a CCD image
OPENFW	Initializes the FilterWheel
RELE	CCD camera relay control
SETTEMP	Sets CCD temperature
TCCD	Returns the CCD temperature
TRIGGER	Returns the status of the trigger line

- GENERAL AND IPBL LIBRARY INSTRUCTIONS

CLOSEOBJ	Closes a video object
DELAY	Executes a delay
END	Ends the IPBL execution
FIX	Sets decimal number
FORMAT	PRINTs print format
GMAX	Max x axis graph. coord.
GMAY	Max y axis graph. coord.
LCASE	Converts a string into lower case

MODE	Sets operative modes
ONGOTO	Conditioned skip
OPENOBJ	Opens a video object
OPRINT	Prints on a video object
REM	Comment line
SOUND	Executes a sound
SPRINT	Prints in a string
STOP	Stops the IPBL execution
STRLEN	Returns the string length
TIMER	Returns the timer (ms) from a system
UCASE	Converts a string into upper case
WINPUT	Executes an INPUT from the console
WPRINT	Prints on the console
WLPRINT	Prints on the console at certain coordinates

- MATHEMATICAL FUNCTIONS

ABS	Returns absolute value
ACOS	Arc cosine
ASIN	Arc sine
ATAN	Arc tangent
ATAN2	Arc tangent (a/b)
CEIL	Rounding up >
COS	Cosine
COSH	Hyperbolic cosine
EXP	Calculates exponential
FLOOR	Rounding up <
LOG	Natural logarithm
MOD	Module
PI	Pi value
POW	Power raising
SIN	Sine
SINH	Hyperbolic sine
SQRT	Square root
TAN	Tangent
TANH	Hyperbolic tangent

IPBL FUNCTIONS IN ALPHABETICAL ORDER

ADDMUL <add>, <mul>

Adds to the selected image the value given by the add expression and multiplies it by the value given by the mul expression.

BLUE <num>

Returns the value of the palette blue component of the selected image.

BINNING <hbin>, <vbin>

Sets the CCD camera binning with two different parameters for the horizontal (hbin) and for the vertical (vbin).

CAMERA

Function that informs you on the CCD camera operative status, returns 1 if this is operative and 0 if not.

CAMERAOFF Closes the CCD camera tasks.

CAMERAON Initializes the CCD camera.

CHDIR <path>

Lets you change work directory.

CLOSE <espressione>

Function that lets you close the file identified by the expression specified in the field from 0 to 31.

CLOSEIMG <server>

Closes an image server, the server valid values are from 0 to 15.

CLOSEOBJ <numobj>

Closes the video object specified in the numobj expression.

CLRCCD Fictitious reading of the CCD for its cleaning.

COOLER <sts>

Ables (sts = 1) or disables (sts = 0) the CCD camera cooler.

COOLPWR <power>

Sets the cooler power to use, the power parameter value is from 0 to 100 and the first decimal is significant.

CONVOL <p1>, <p2>, <p3>, <p4>, <p5>, <p6>, <p7>, <p8>, <p9>, <add>

This control processes the active image with a convolutive matrix of 3x3 determined by the first nine expressions, while the last parameter expression represents the value to add algebrically after processing the single pixel.

CREATEIMG <dimx>, <dimy>, <name>

Creates an image server with dimx horizontal dimension, with dimy vertical dimension and titled “name”. After the creation, this is the enabled server.

DELAY <espressione>

Executes a milliseconds delay specified by the expression.

DIMX, DIMY

Return the dimension on the x axis or on the y axis of the selected image.

DISPLAY <espressione>, <mode>

Displays the nth image determined by the expression specified as first parameter, the second expression, that must be specified, determines with a result other than 0 that the image will be on foreground, otherwise its level of display will not be changed.
With this control, the image you display is SELECTED.

END Ends the program execution.

EXPO <espressione>

Sets the CCD camera exposure time.

FINPUT <identificatore file>, <variabile>

With this function, you can read from file a numeric or string variable, the first parameter (file identifier) is an expression that indicates which of the possibly opened files must be written, its values field is from 0 to 31.

FIX <espressione>

This control specifies the number of decimal numbers that are displayed by the family of PRINT functions. Valid values are from 0 to 20.

FORMAT <stringa>

Specifies the format of the numeric output given by the family of PRINT functions. The syntax of this string is standard ANSI C.
Example: FORMAT "%10.3lf" specifies that for the output, a cypher dimension of 10 total characters will be reserved, where three cyphers will be decimal.

FPRINT <identificatore file>, <espressione>,....

This basic function lets you print on video file the result of all the specified expressions or strings, the file identifier parameter is an expression that indicates which of the possibly opened files must be written, its values field is from 0 to 31.

FWHEEL <filter>

Selects a filter of the wheel, valid filter values are from 1 to 6.

GETCCD <mod>

Photographs and unloads an image of the CCD camera, the image contents is unloaded in the CCDSERVER. The mod parameter establishes whether the image is a dark (mod = 0) or it is exposed (mod = 1). The exposure time is determined by the EXPO control.

GETPAL

The current values of the selected image palette are loaded in the palette buffer of the IPBL.

GMAX Returns the max value of the X coordinate of the set graphics.

GMAY Returns the max value of the Y coordinate of the set graphics.

GREEN <num>

Returns the value of the green component of the palette of the selected image.

IMAX Returns the max value present in the selected image.

IMGDIR <path>

Sets the path name of the images directory. The SAVE, LOAD, LFITS, SFITS functions will refer to this directory.

IMIN Returns the min value present in the selected image.

LCASE <stringa>

Converts a string into lower case.

LDPAL Loads into the selected image a palette created with the PAL control.

LDPATT <fname>

Loads the filename into the pattern generator.

LFITS <fname>

Loads into memory and displays an image previously saved with the name given by 'fname' in the FITS format. The specified parameter contains only the filename complete with extension (.FTS), the directory is the one currently selected.

LOAD <fname>

Loads into memory and displays an image previously saved with the name given by 'fname' in the IMG format. The specified parameter contains only the filename complete with extension (.IMG), the directory is the one currently selected.

LOADPAL <fname>

Loads a colors palette in the selected image, fname indicates the name of the file that contains the palette, this must respect the relevant specification of ViSION and must have the .MAP. extension. This control, like the SAVEPAL, assumes that the file is in the SYS directory.

MATHIMG <dst>, <src>, <op>, <xof>, <yof>, <dscal>, <sscal>

This control lets you execute mathematical operations between two <dst> and <src> images with the result placed in <dst>, the meaning of the parameters is the following:

<dst> image where the result of the chosen mathematical operation is placed.
<src> operator image identifier.
<op> code that indicates the kind of mathematical or logical operation to execute, available codes:

0 - Addition
1 - Subtraction
2 - Subtraction 1: dst = dst + 100 - src
3 - Average
4 - Multiplication

5 - Division
6 - And
7 - Or
8 - Xor
9 - Module

<xof> Algebric X shift value for source image
<yof> Algebric Y shift value for source image
<dscal> Scale factor of first image.
<sscal> Scale factor of second image

Operations procedures:
Shift of src according to xof and yof,
dst = (dst * dscal) OPERATOR (src * sscal)

MEDIA Returns the medium value of the selected image.

MODE <operator>

This control lets you specify the numeric display mode of the PRINTs family and to specify whether the numbers passing to transcendental functions are in degrees or radiants.
Possible operators:

DEG After this control, angles are considered in degrees.
RAD After this control, angles are considered in radiants.
ENG After this control, numbers are printed in an engineeristic way.
FLT After this control, numbers are printed in floating point.

NOTIMG Denies the contents of the selected image.

ONGOTO <espressione>, <label1>, <label2>, ..., <labeln>

This function, according to the result of the expression being specified, allows the program to skip to the specified label, the expression result must be between 1 and n.

OPEN <espressione>, <fname> , <fmode>

Function that opens a file, the first parameter is an expression that specifies the logical number of the file you want to open in the field from 0 to 31, the fname string field decides the name of the file you are opening, while the fmode string field decides the opening mode of the file. The opening mode follows the ANSI C standard and contemplates the following possibilities:

"r" Opens the file under reading. If the file cannot be found, an error will be given.

"w" Creates a new file; in case of an existing file with the same name, this will be overwritten.

"a" Places data at the end of the file, if existing, otherwise it creates it.

"r+" Opens a file under reading/writing. (The file must be existing).

"w+" Opens a file under reading/writing.

"a+" Opens a file under reading/writing; when data are written, these are placed at the end.

In addition to the previous ones, you can add the following characters to specify a possible data translation.

t Opens the file in text mode. In doing this, CTRL+Z is interpreted as character of end-of-file.

b Opens the file in binary mode, no translation of characters is executed.

OPENFW Initializes the FilterWheel.

OPENOBJ Procedure that opens a video object, returns its identifier number.

PI Procedure that returns the pi value.

OPRINT <numobj>, <espressione>,....

Control of output print on a video object identified by the numobj expression, for the rest it implements the same modes of the PRINTs family.

PAL <num>, <red>, <green>, <blue>

Lets you edit an element of the palette specified by the n parameter (0-255) by using the values specified in red, green, blue in the 0-255 range. To apply the changes, execute the LDPAL control after editing the values.

PRINTFILE <filename>

Prints an ascii file.

RDMAT <xpos>, <ypos>

Reads the value of the pixel at the coordinates given by the 'xpos' and 'ypos' expressions. This procedure returns a value between 0 and 65535 and the coordinates must be within the limits imposed by the image size.

RED <num>

Returns the value of the red component of the selected image palette.

RELE <rele>, <sts>

Executes the check on the camera relays, the relay parameter is a number from 0 to 3 while sts establishes whether it is switched on (1) or off (0).

REMOVE <fname>

Removes the fname specified file.

REV Returns the review of the IPBL interpreter program.

REM Opens a comment line.

ROTIMG <xcentre>, <ycentre>, <angle>, <fill>

Executes an image rotation of the angle value with xcentre and ycentre rotation center, the 'uncovered' parts of the image being created are filled with the fill value. The angle parameter is expressed in degrees.

SAVE <fname>

Saves on file the image currently selected in the .IMG proprietary format. The specified parameter contains only the filename complete with (.IMG) extension, the directory is the one currently selected.

SAVEPAL <fname>

This control lets you save the current colors of the image in a palette file; fname must have the .MAP extension so that the file can be subsequently used by ViSION too. The file is saved in the SYS directory of ViSION.

SCANIMG Executes the scanning of the selected image by calculating minimum (IMIN), maximum (IMAX), medium (MEDIA) value and the standard deviation (SIGMA). This procedure must be executed every time you change the image contents.

SERVER

Returns the number of the graphic server being currently used. Every image present on the desktop bears an identification number from 0 to 15.

SETTEMP <temp>

Sets the CCD operating temperature.

SFITS <fname>

Lets you save on file the currently selected image in the FITS format. The specified parameter contains only the filename complete with extension (.IMG), the directory is the one currently selected.

SHIFT <img>, <xof>, <yof>, <fill>

Executes a shift of the image selected by the img expression, with value in x and y given by the xof and yof expressions, while the fill parameter is used to fill the 'uncovered' parts of the resulting image.

SHOWFILE <fname>

Lets you display a text file.

SIGMA Returns the value of standard deviation of the selected image.

SOUND <par1>, <par2>

Executes a sound signal with the frequency specified by the par1 expression for a lasting period in milliseconds specified by the par2 expression.

SPRINT <variabile stringa>, <espressione>,....

This control works like all the PRINTs, the only difference is that the output is produced in the specified string variable.

STOP Stops the program execution.

STRETCH <low>, <high>

Changes the contrast of the selected image, by using the 'low' & 'high' expressions to determine the color. If the pixel value is <= than low, the color is black, if it is >= than high, the color is white, while the values between low and high are proportionally faded.

STRLEN <stringa>

Returns the string length indicated as variable or constant.

TCCD Returns the CCD temperature.

TIMER Procedure that returns the number of milliseconds gone by since the start of the system.

TRIGGER Returns the value of the trigger line (0 or 1).

UCASE <stringa>

Converts a string into upper case.

USRFILT <stringa>

Control that allows to execute a spatial filter defined by the user, the string parameter specifies the name of the file associated to our filter. To define these filters, you must use the relevant control present in ViSION USER FILTER. Also, the default directory where the filter file is searched for is the SYS.

WINPUT <title>, <label>, <variabile>

This function executes a numeric or string input from the console. Title is a string or a string variable that specifies the title of the resulting input window, Label is the label that is placed before the input field, Variable is the field where you need to specify a string or numeric variable. If you do not want to specify the title or label field, it is sufficient to insert the sequence of characters "".

WPRINT <mode>, <espressione>, <espressione> .....

This basic function lets you print on screen the result of all the specified expressions or strings, the mode parameter determines the action on the wprint program; if it is specified at 0, the program generates the output and then continues, otherwise if other than 0 the program stops on this statement and does not continue until the CONTINUE key appearing on the output window is selected.

WLPRINT <mode>, <xpos>, <ypos>, <espressione> .....

This function is similar to the WPRINT, except for the fact that you must pass two further xpos, ypos parameters to specify the screen coordinates where the print window will appear.

WRMAT <xpos>, <ypos>, <value>

Lets you write a pixel of the image placed at the coordinates given by the 'xpos', 'ypos' expressions with value given by the ‘value’ expression. This function writes in the memory of the selected server, the ‘value’ value can be from 0 to 65535 and the coordinates must be within the limits imposed by the image size.

D

IMG FORMAT FILES

By default, ViSION uses IMG format files, this a DTA proprietary format. In IMG files are contained, not only the image but also many information about the CCD camera, the CCD being used, the imaging and display procedure. Those who want to read these files with a program of their own, can refer to the following list in C language.

```
int _load_img(char *f)
{
        Int     fd, c, s, er, l, lccd = -1, lptf;
        Int     ilow, ihig, ctrs, ver;
        char    ffile[80];

        fd = open(f, O_RDONLY | O_BINARY);
        if(fd < 0)  return(2);

        // Set dir var for old compability
        Mat[s].ptf = Mat[s].ccd = -1;

        // Version of program written in the file
        read(fd, &ver, 2);
        if(ver > 10)
        {
                read(fd, &ctrs, 2);             // Values of
                read(fd, &ihig, 2);             //   manual
                read(fd, &ilow, 2);             //         contrast
        }
        read(fd, &Mat[s].SExp, sizeof(double));     // Exposure time in seconds
        read(fd, &Idx[s], 2);                   // X dimension of image
        read(fd, &Idy[s], 2);                   // Y dimension of image
        read(fd, &Mat[s].Low, 2);               // Image data minimum value
        read(fd, &Mat[s].High, 2);              // Image data maximum value
        read(fd, &Mat[s].Media, 4);             // Sum of all values (float)
        read(fd, &Mat[s].TAMB, 2);              // Room temperature
        read(fd, &Mat[s].TCCD, 2);              // CCD temperature
        read(fd, &Inf[s].FLen, 2);              // Telescopy focal length
        read(fd, &c, 2);                        // Switch!
        read(fd, Inf[s].AirMass, 20);           // Ascii string
        read(fd, Inf[s].Observer, 20);          // Ascii  string
        read(fd, Inf[s].Filter, 20);            // Ascii string
        read(fd, &Inf[s].Diameter, 2);          // Telescopy diameter (mm)
        switch(c)
        {
        case 1:
                        break;
        case 2:
                        read(fd, &lccd, 2);     // Type of CCD
```

```
                read(fd, &lptf, 2);       // Hardware platform
                break;
        }
        User[s] = Bin[s] = 0;
        read(fd, &User[s], 1);          // Window area?
        read(fd, &Bin[s], 1);           // Binning value
        if(User[s])
        {
                read(fd, &ccdXoff[s], 2);      // Location
                read(fd, &ccdYoff[s], 2);      //  and
                read(fd, &ccdWx[s], 2);        //    dimension
                read(fd, &ccdWy[s], 2);        //      of window area
        }
        if(Bin[s] == 0) Bin[s] = 1;
        read(fd, &Mat[s].DATE, sizeof(Mat[s].DATE));    // Date (8 bytes)
        read(fd, &Mat[s].TIME, sizeof(Mat[s].TIME));    // Time  (8 bytes)
        read(fd, Inf[s].Notes, 20);             // Ascii string

        Mat[s].Ctrst = ctrs;
        Mat[s].IHigh = ihig;
        Mat[s].ILow = ilow;
        if(lccd >= 0)
        {
                Mat[s].ccd = lccd;
                Mat[s].ptf = lptf;
        }
        // Reads image data
        for(c = 0; c < Idy[s]; c++)
                read(fd, &Mat[s].Imat[c * Idx[s]], Idx[s] * 2);

        // New parameter in 1.3 version, palette!
        if(ver > 12)
        {
                read(fd, &PAL[s].r[0], sizeof(pal));
                for(c = 0; c < 256; c++)
                {
                        MFreeColor(iPAL[s][c]);
                        iPAL[s][c]=MAllocColor(PAL[s].r[c],PAL[s].g[c],
PAL[s].b[c]);
                }
        }
        else
                StdPAL();       // Default palette

        close(fd);
        return 0;
}
```

E

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