JID – JUPITER IMPACT DETECTION

PROGRAM FOR THE DETECTION OF IMPACTS IN JUPITER
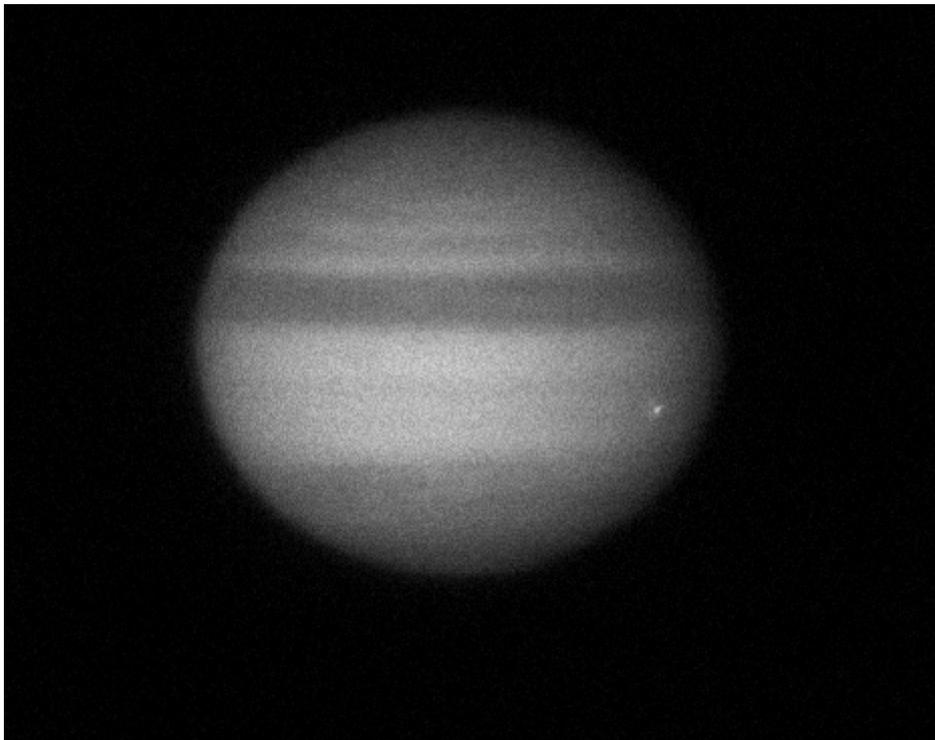
Documentation of the version 2.0

Juan Carlos Moreno

November 2012

Contenido

INTRODUCTION

The purpose of the program JID (Jupiter Impact Detection), is the automatic analysis of sequences of video for the detection of impacts in Jupiter.

The program has been developed in collaboration with the Group of Planetary Sciences of the University of País Vasco.

In the last years have detected by part of amateurs, several impacts in Jupiter, that collected in video records, mainly allocated to the treatment of images by means of the stack of images to obtain an image of the planet. This fact has moved to the Group of Planetary Sciences to the development of a program that can analyze automatically the videos and detect the presence of impacts.

Initially was developed the program DTC, by of Luis Calderón. The program DTC implements an algorithm of detection of impacts that has served of base for the development of the present program.

The initial aim of the program JID is put to disposal of the community of observers of Jupiter a tool that allow the detection of possible impacts without the need to visualize the videos.

The functionality of the program as well as of the algorithm of detection is explained in this manual, with examples of real videos of impacts that kindly have facilitated the observers of the same, through the Group of Planetary Sciences.

All the images showed in this documentation have been generated by means of the program JID, through the options of LOG and by means of captures of screen.

Formats of video used

The program allows the process of files of video, in the formats more commonly used in astronomy. At present the program allows to treat the formats:

FORMAT	UTILISATION
AVI	Format used by the majority of webcam.
MPEG	Format used in the publication of videos.
WMV	Proprietary format of Microsoft
BE	Format used by the cameras Basler

Note on the format WMV

Because of the characteristics of the format WMV, can success that in different executions of a same file WMV, get different results. This is due to the fact that WMV generates the frames to split a frame basic and later adds the changes or differences between frames. After a determinate number of frames generated by means of the changes, goes back to read a frame basic and continuous adding the changes between frames to generate the new. The decoder generates the frames with more or less precision depending on the power of the computer.

In the tests with files WMV realized to date, I has detected same frames generated by the decoder, have varied in some occasion, producing false positives or false negatives. By that, recommend NOT USING this format.

The tests with files AVI, always have generated the frames properly and never has detected a difference between the frames generated in different executions.

To be able to evaluate of easy form if there is a variation in the frames generated between distinct executions of the program, the information of the frames (DataFrames), includes a value CRC of the frame generated.

General operation of the program

The program JID from the version 2.0, it allows two modes of operation

Mode – Processed of videos

This is the basic mode of the program, in which it selects a video file (of the formats allowed) and executes the process of detection of impacts, showing at the end the result of the possible impacts detected.

All the operations realized as well as the result of the process show in the window of messages and console of the program.

In case to detect some impact, when finalizing, the process shows a window with the result of the process and the images of the possible impacts.

The way of processed of videos also has of the modules:

Module of playing video

Is a simple control of playing a video that allows to forward and backward the play, playing the video to the maximum speed allowed, independently of the capturing rate.

Module of simulation of impacts

It has included in the program a simulator of impacts that allows verifying the operation of the distinct parameters of the program. This module has designed during the phase of development of the program for the realization of tests, and has left in the final version of the program, like tool of test of the options.

Mode – Processed by batch

This way of work has entered in the version 2.0, and allows selecting a group of files (of any one of the formats allowed) and adding it to the list of execution.

Once selected the files, verifies that the files are valid, verifying that they correspond to files of video, and can be processed.

After verifying the files, can proceed to the execution of the process.

The module of process by batch, executes the files one after the other, and stores all the information of the process, together with the images and screens of result, in files that later can visualize.

In the execution by batch mode, the user can select the option to work in silent mode.

Phases of the process

The process of the videos alone or in batch mode, is realized in 4 phases:

Phase 1 – Determination of ROI (Region Of Interest). In this phase the program reads a determinate number of frames and determines the size of the planet. From the size of the planet, is determined the region of the frame that will analyze (ROI).

Phase 2 – Determination of the average image. This image generates from a determinate number of frames and is used like reference to apply in the algorithm of detection of impacts.

Phase 3 – Detection of impacts. In this phase process all the frames to determine the most brilliant points and finally executes the algorithm of detection of impacts. During the capture of the frames is visualized in the screen the point more brilliant detected by the algorithm, whenever the value surpass a value set in the parameters.

Phase 4 – Preparation of results. If the algorithm of detection of impacts (phase-3), has detected some candidate to impact, the files is read again and load in memory the images of the possible impacts. Also it calculates a photometry of the region where has detected the impact, since this allows to determine easily if it treats of an impact or a false positive.

Module - Visualization of video

In this modality, activates a video player, and by means of the action of a control of trip, can visualize the frames to forward as to backwards.

To access to the way of video playing has to not being selected the option of general parameters 'Process automatically at open file', as it shows to continuation.
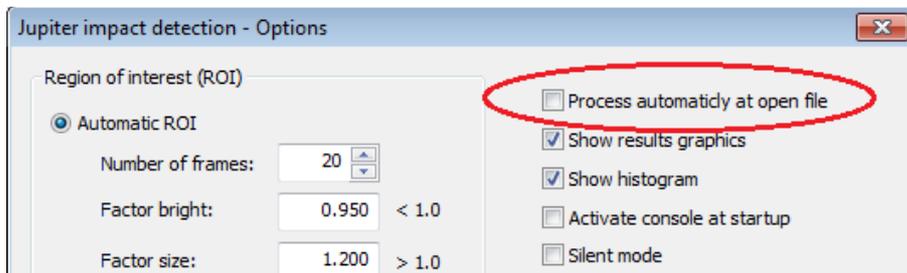
When opening a file, will appear the dialog with information of the video file, and can select 'Play Video'.
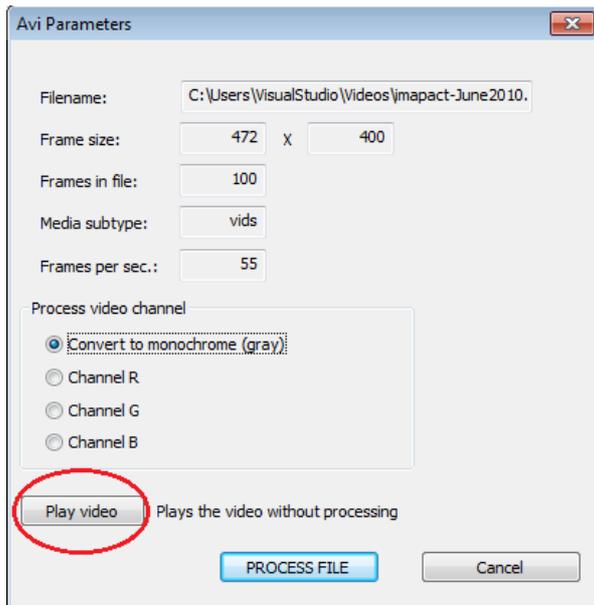
In this moment will visualize the control of playing videos:

In which it can play the video, with the options:

Play – Visualizes the video.

Pause – Stops the play of the video. This button will change to 'Resume'.

Resume – Continues with the playing of the video.

Stop – Stops the playing of the video and goes back to the first frame.

In mode 'Pause', can scroll the bar of position to access to distinct parts of the video n forward as to backward.

The program indicates the number of frame that is visualizing in each moment.

Because of the own characteristics of the format WMV, and taking into account that the generation of the frames realizes by the changes accumulated from a frame of reference, the visualization can result something slower than in other formats.

Module of simulation

Is included a module of simulation of impacts that allows to generate of virtual impacts on any part of the planet. This module is of particular interest to test the program and for adjusting the parameters.

Initially it was developed like a tool of help in the development and the realization of tests with the program, although given his utility, finally it has included in the final version of the program.

Module of generation of traces (LOG)

This module has been of particular use during the development, since it allows generating information of the process in diverse levels of detail, as well as producing images of the frames generated internally by the program during his execution.

The utilization of this module is advisable during adjusting the parameters of the program or to analyze the process of detection of the impacts, since it can generate a big volume of information in the LOG file and a lot of images of the frames processed, what can affect to the performance of the program.

Optimization of the program

To get a fast execution of the algorithm of detection of impacts, have incorporated diverse options that allow activating or deactivating the visualization of the different components during the execution, what allows optimizing the performance of the process when we can control the visualization of the images.

A basic optimization of the process consists in:

- Work in silent mode, so that they do not visualize the frames in screen.
- Not display the histogram.
- Keep the console of messages closed.
- Deactivate the register of the LOG and the generation of intermediate images of the frames.
- Not using the module of simulation, since it slows the execution, and generate a non-existent impact.

Main window of the program

The program has available all the options from the main window in the toolbar, that is the used to interact with the user. The general appearance of the window is:
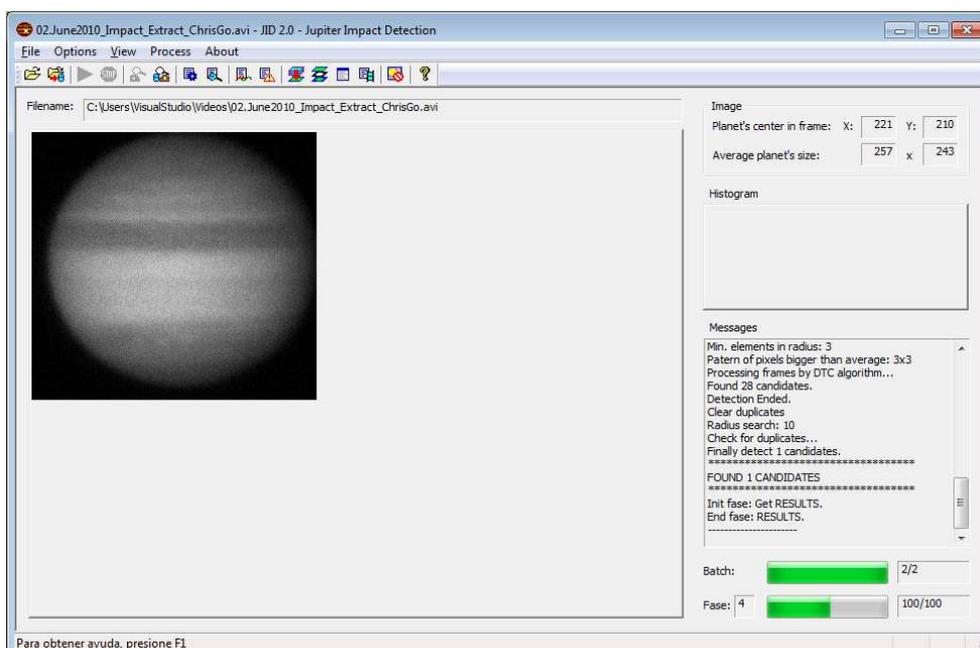
All the options of the menu are accessible through the toolbar, with the exception of the list with the last files processed, as it shows to continuation:
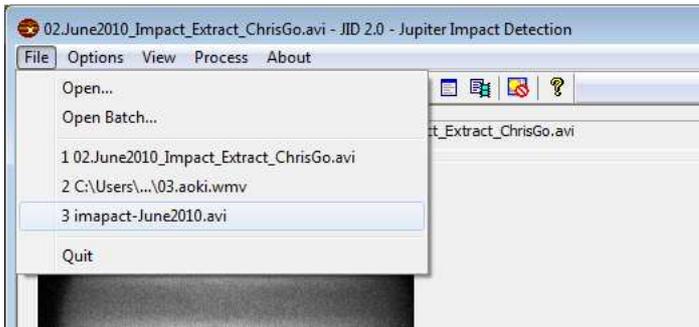
To access to the last files processed, select the option of menu 'File', and will appear the list with the 4 lasts files processed. This option only is applicable for the process of loose files, no for the batch mode.

Toolbar

Appearance of the toolbar and options associated to each button:

The options of the toolbar, as well as in the menu activate or deactivate according to the state of process of the file.

Open file

This option allows selecting the video to process. For the selection opens the dialog to open file (standard of Windows), that allows selecting the format type of the file:
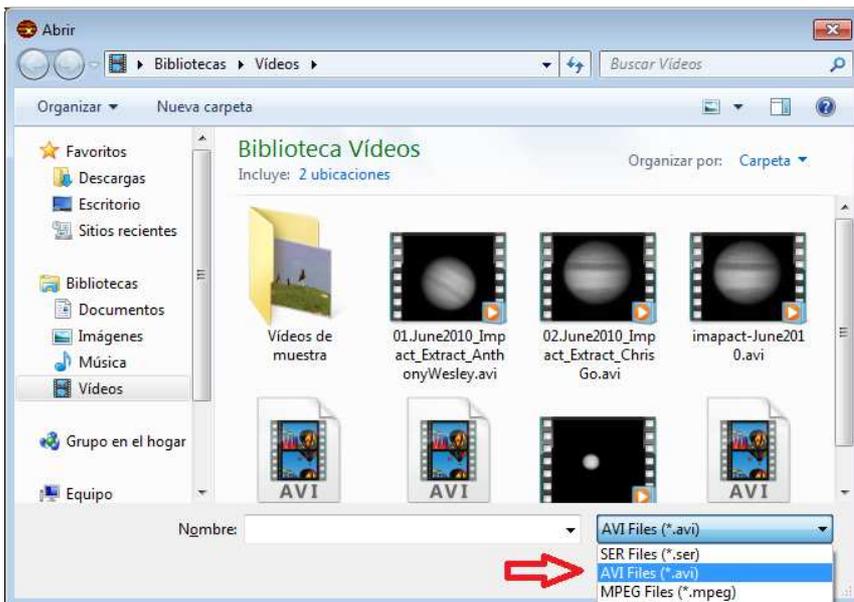
Once selected the file to process, can produce 2 situations depending if in the options of configuration has selected or not, the option of 'Process automatically at open file'.
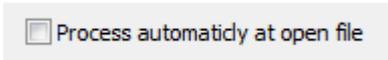
If it has not selected, it visualizes the window with information on the file, and allows selecting if it wishes visualize the file or processing it. Also it can select the color channel on which processes the file.

If it has selected the option, executes automatically the process of detection of impacts.

Window of information of the file

This window visualizes before the execution of the file if it is not selected the option 'Process automatically at open file'.

In this window show the parameters of the file. The content of the varied fields in function of the type of archive selected (*AVI or SER).
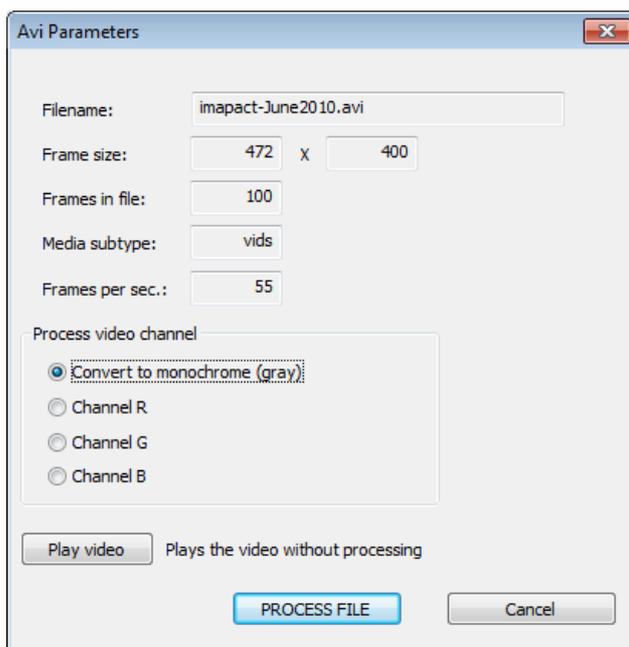
With the options:

It plays the video file, by means of a simple video player.
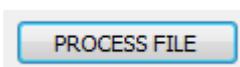
It executes the process of detection of impacts.

🔀 *Select files for batch process*

By means of this option visualizes the window of selection of files to batch process.

The corresponding data to the processed is stored in the directory selected by the button 'Select file', that allows to select the name of file to store the general data. This file has the extension '*.arc'. The details of each file processed is saved in the same directory, and with the extensions '*.arp'. The name of the files of type *.arp, are created with the same name that the file '*.arc', and with the number of process realized.
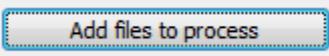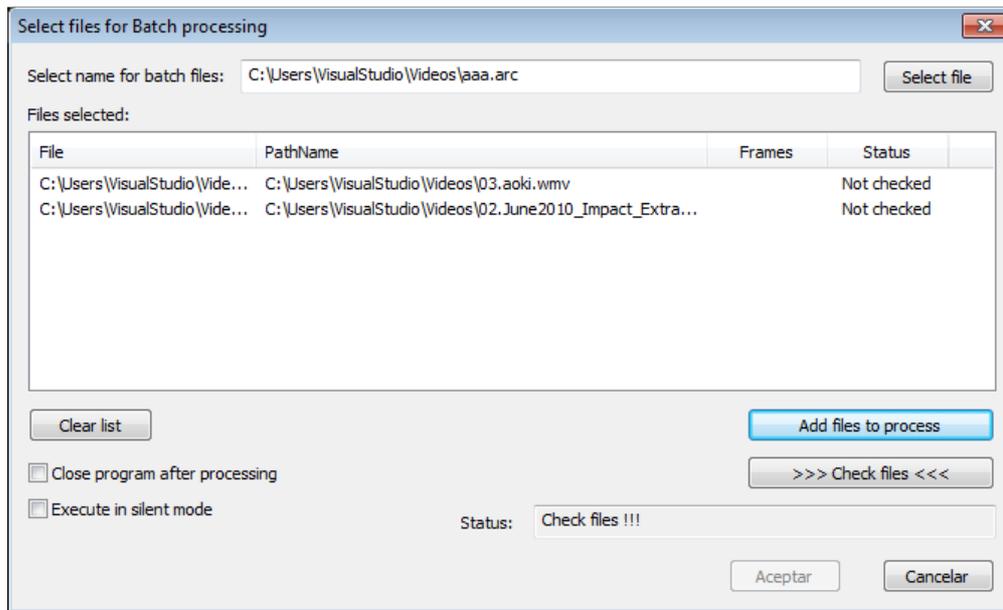
By means of the button [Add files to process], can add files to the list, being able to select files of distinct directories and of distinct formats (AVI, WMV, SER).

Once created the list of files, has to verify that the files can be processed, for this is necessary to select the option [>>> Check files <<<], that verifies that all the files selected can be processed, showing its state in the list, as well as the number of frames of the file:
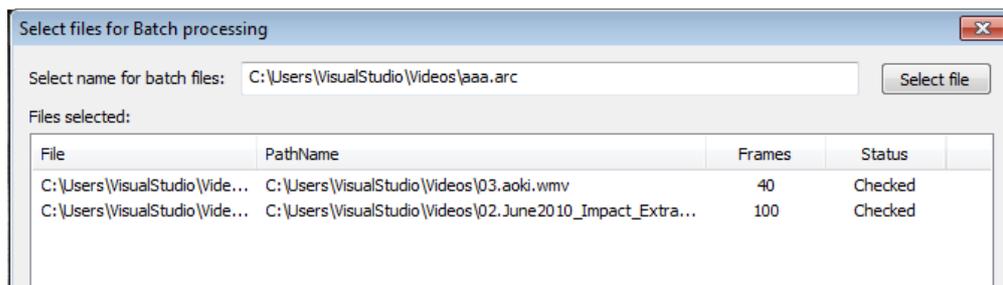
Once validated all the files, the process can be initiated. If there is any file that cannot be processed, this is indicated in the list and will not be processed.

To control the process, can select the options:

☐ Close program after processing
☐ Execute in silent mode
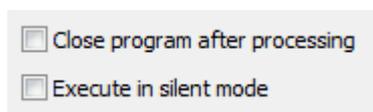
Finally if it accepts the information of the window, initiates the batch process, with the options indicated in the window of general options and the parameters of research of impacts.

The process can last several minutes depending of the number of files to be processed and of the options selected.

The button ![stop], can stop the batch process, remaining the result of the processed files that have been processed until the moment to press the button.

Execute the detection of impacts

This option is activated after each execution in case it wants to go back to execute the process of detection of impacts, after varying the parameters of the algorithm.

This option allows not having to select the file in successive executions.

Stop process

This option is activated during the execution of the process of detection of impacts, and allows stopping the process at anytime.

During the execution of the batch process, this button allows to stop the batch process.

Visualize results

If the process of detection of impacts, detects any candidate to impact, activates this button, that allows to visualize the dialog to analyze the impact and determine if it treats of a real impact or of a false positive.

The dialog of visualization of results can activate automatically when finalizing the process of detection (option in the dialog of general parameters).
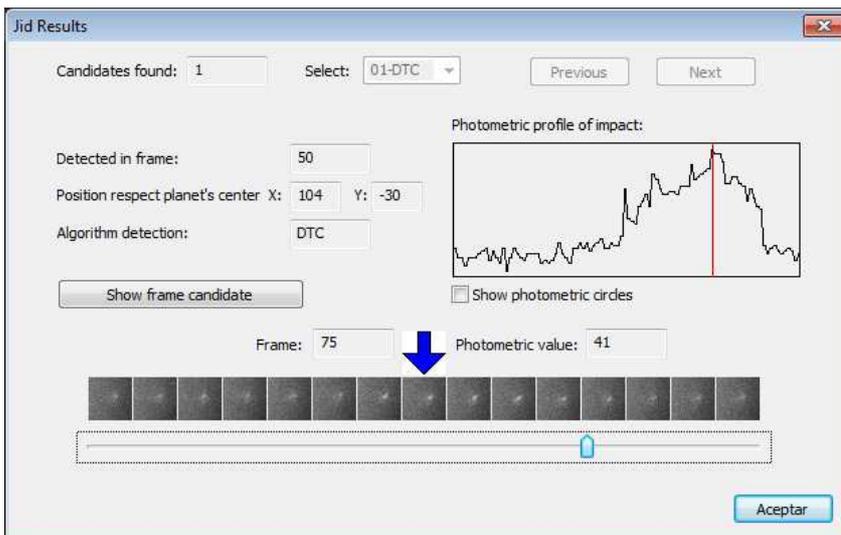
For each candidate to impact detected, shows the region of the image where has been detected the possible impact, that can visualize along all the frames of the video, showing also the photometric profile of the impact.
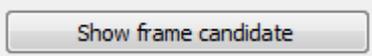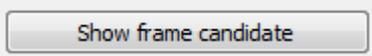
By means of the button [Show frame candidate] , shows the frame complete where the impact has been detected.

Visualize results of batch process

This option allows to access to the window of visualization of results of the batch process. By defect always visualize the corresponding results to the last process realized.
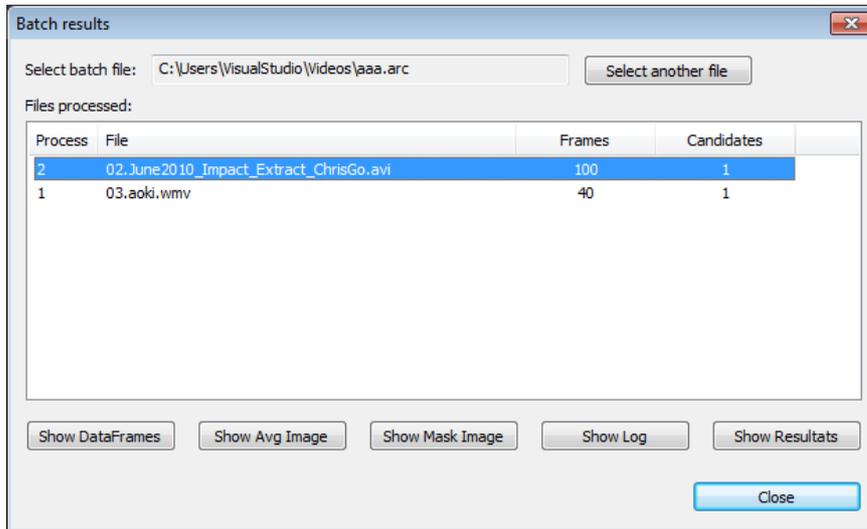
By means of the button 'Select another file', can select the file and directory where store the results of the processes.

Once selected the file '*.arc', shows the list with the files processed, as well as the number of frames processed and the candidates to impact detected.

If double clicking in the corresponding file accesses to the screen of results of the process of the file selected.

Once selected a file, can access to all the results of the process by means of the corresponding buttons, so that they can recover all the data of the process:

Show DataFrames - shows the window with the list of frames processed and the brilliant points detected.

Show Avg Image - shows the image average obtained in the phase 2 of the process.

Show Mask image - shows the mask of the process superimposed to the average image.

Show Log - shows the LOG file generated by the process of the file, with all the parameters used during the process.

Show Results - shows the screen of results, of the same form that double clicking in the file of the list.

General options

The general options of execution of the program are accessed by means of this button that visualizes the following dialog:
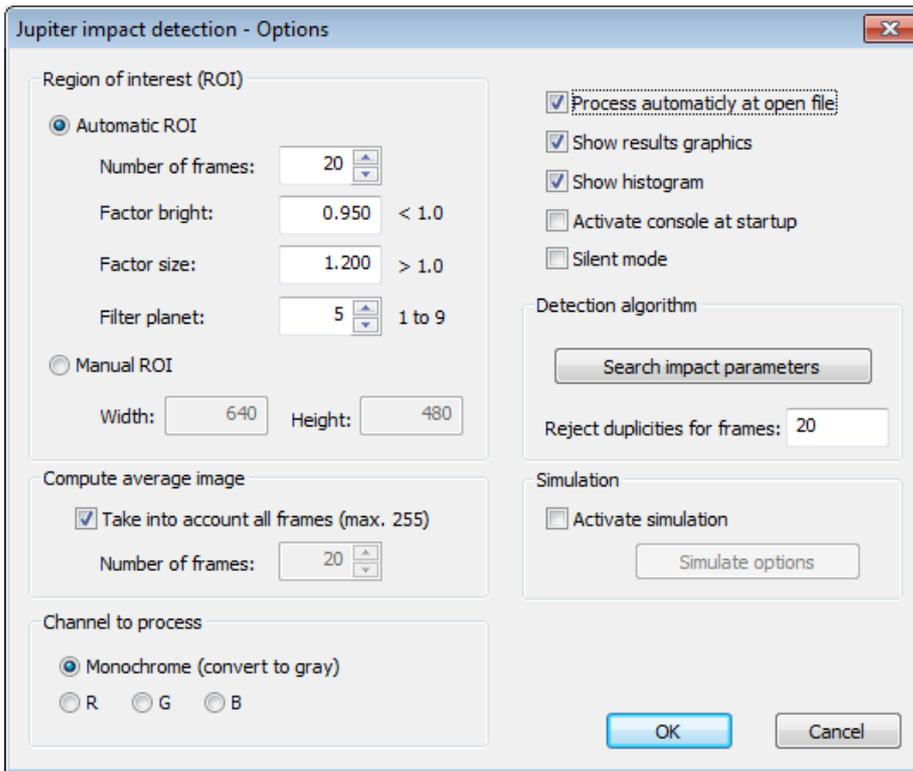
In this dialog the options have grouped in blocks of information:

Region of Interest (ROI)

 This group allows to control the form in that it is selected the size of the image to process. The parameters are the following:

Number of frames – frames to process to determine ROI.

Factor bright – allows selecting the factor between the shine of the centre of the image and the background sky to determine the limb of the planet. The suitable values oscillate between 0,9 and 0,95.

Factor size – is a factor that applies to the dimensions of the planet to determine the size of ROI. The very near values to 1.0 can cut the limb of the planet, by that a value of 1.2 is sufficient for clip the image.

Filter planet – Is a filter of low pass that applies to determine the position of the limb. A value 1 does not apply filter, and a value 9 softens in excess. This filter does not affect to the image of the planet, since only it is used to determine ROI.

Manual ROI – allows fixing a size in manual way.

Compute average image

This block allows controlling the frames that processed during the phase 2 of the process, in the generation of the image sum of the frames selected.

The maximum number of frames that can process in the current version of the program is 255.

Channel to process

This block allows selecting that channel of video that will be processed. If is selected 'Monochrome', it will execute a conversion of color to monochrome.

Due to characteristics of the video formats, some files of video although they have generated with monochrome cameras, the file of video contains the image in color (grey color).

Detection algorithm

It allows to access directly from the general options to the options of the algorithm of detection of impacts.

The field 'Reject duplicities for frames', it allows to select the number of frames that will be checked after each frame with a candidate to impact, and deleted the possible duplicities. To determine if it is a duplicate impact, this has to be inside the clear-cut radius in the algorithm of detection of impacts.

Simulation

It allows activating the module of simulation of impacts. When selecting this option, is activated the button that allows to access directly to the dialogue of the simulator of impacts.

Options of control of the program

Process automatically at open file – Will execute the process of detection of impacts immediately after selecting a file.

Show results graphic – Shows the window of results automatically after finalizing the process of detection of impacts, whenever it have detected a possible candidate to impact

Show histogram – Allows visualizing the histogram of the image during the process.

Activate console at startup – Opens the window of the console to the start of the execution of the program. It has effect in the next execution of the program.

Silent mode – Executes the process of detection of impacts without visualizing the frames. Only it shows the information of the frame in process.

Options of the algorithm of detection

This button opens the dialogue with the parameters of the algorithm of detection of impacts.
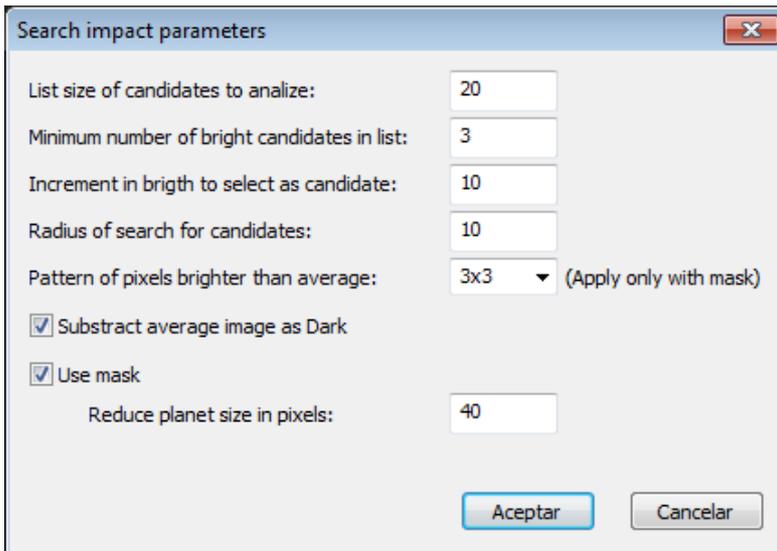
List size of candidates to analyze – Fixed the size of the list of frames that is processed to determine the number of possible impacts that detect . The maximum value allowed is 100.

Minimum number of bright candidates in list – Is the minimum number of candidates that detect in the list inside the clear-cut radius and with an increase of upper shine to the fixed.

Increase in bright to select as candidates – Is the minimum increase in shine that has to have a point on the average of the planet to define it like candidate to impact.

Radius of search for candidates – Is the radius in which they have to join a minimum number of candidates to mark the frame like candidate to impact.

Pattern of pixels brighter than average – Indicates the area size in which the pixels have to surpass the limit (Increase in bright to select as candidates), to be selected as a brilliant point of the image. It can select between 1 pixel and an area 4x4. Only it applies if it has selected the process by masks.

Subtract average image as Dark – Subtracts the average image determined in the phase 2 of the execution so that the algorithm of detection of impacts applies on the image difference between the frame in process and the average image.

Use mask – Allows selecting a mask of the planet to minimize the effects produced in the limb of the planet.

It reduces planet size in pixels – Is the number of pixels that will be reduced the size of the mask so that it delete more or less the limb of the planet.

📊 *Options of simulation*

This button accesses to the options of the module of simulation of impacts.

This dialog allows establishing the parameters that will use to generate virtual 'impacts' on the image of the planet.

It can define the following parameters:

- Relative position to the centre of the planet
- Size of the impact in pixels
- Variation of the position of the impact in each frame (random variation).
- Increase in total shine of the impact on the image of the planet.
- Increase that will produce in each frame until reaching the maximum. Also it applies to the decrease of the shine when finalizing the impact.
- Variation in intensity in each frame (random variation).
- Initial frame with the image of the impact.
- Length of the impact in frames.

*Options of proof and *log*

This option opens the dialogue with the parameters of proof and *log of the process.

IMPORTANT: The activation of some of these options can produce that the program execute very slowly, because of the big quantity of information that generates.
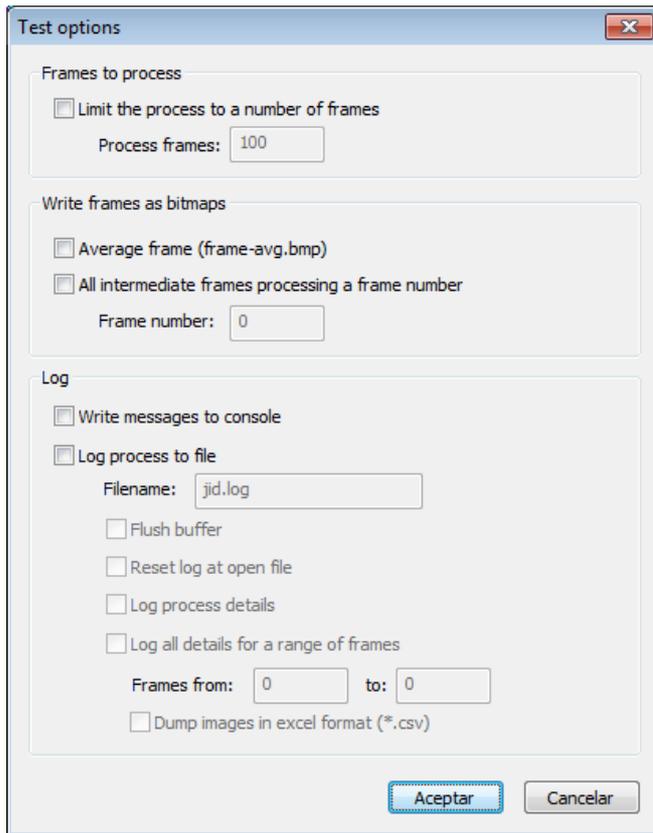
The options of this dialogue activate or deactivate according to the selection realized.

The parameters are grouped in 3 blocks:

Frames to process

Define the number of frames to process. This allows to process a small number of frames, although the video contain a lot of frames.

Write frames as bitmaps

It allows generate files in format *.BMP of:

- Image average of the frames selected in the phase 2.
- All the images generated internally by the program for a determined frame. The images generated, are:
  o The frame read of the file of video.
  o The frame converted to monochrome.
  o The frame differentiates between the image average and the frame (adjusted to ROI).
  o The mask used in the process.

Group LOG

Select the options to generate a LOG file of the process, with the options:

Generate LOG and define the name of the file LOG.

Flush buffer – Closes the file after writing, this option is useful to determine problems that can cause an unexpected closing of the program.

Reset log at open file – Initializes the content of the file LOG every time that it initiates the process of a file.

Log process details – Registers details of the process and of the phases of execution.

Log all details for a range of frames – Defines a rank of frames for which will register the maximum of information on the same.

Dump images in excel format (*.csv) – Allows to generate compatible files with Excel, where represents the value of each pixel in each cell of the leaf of calculation. This option allows studying the frames with the numerical values of each pixel.

Visualise image average

Sample in a window the image resultant average of the phase 2 of the process.

Visualise mask of process

Sample in a window the mask that uses in the algorithm of detection of impacts. The mask (in color red) visualizes on the image average.

Console of the program

Sample or unseen the console of the program, where detail the phases of the process and the frames processed.

The console is only of visualization of messages, does not allow the writing and all the messages visualized, are directed to the file of log in case to have activated the option of *log in file.

Data of the frames

This button opens the window where show the data of the frames processed.

```
Data frames                                                                    ☒

Frame  58 planet size: 263:255 CM: 221:212 Candidate pixel: 264:118 (166) CRC: 17799000         ▲
Frame  59 planet size: 259:253 CM: 221:211 Candidate pixel: 260:118 (163) CRC: 17762463
Frame  60 planet size: 265:255 CM: 221:212 Candidate pixel: 121:100 (161) CRC: 17758803
Frame  61 planet size: 263:251 CM: 221:212 Candidate pixel: 261:119 (174) CRC: 17761437
Frame  62 planet size: 263:251 CM: 221:211 Candidate pixel: 157:165 (162) CRC: 17759691
Frame  63 planet size: 263:253 CM: 221:211 Candidate pixel: 258:117 (170) CRC: 17760822
Frame  64 planet size: 263:253 CM: 220:211 Candidate pixel:  95:136 (164) CRC: 17840787
Frame  65 planet size: 261:251 CM: 220:210 Candidate pixel: 263:120 (169) CRC: 17916507
Frame  66 planet size: 261:253 CM: 219:210 Candidate pixel: 121:134 (165) CRC: 17897415
Frame  67 planet size: 261:253 CM: 220:210 Candidate pixel: 259:119 (165) CRC: 17886255
Frame  68 planet size: 261:255 CM: 220:211 Candidate pixel: 262:119 (178) CRC: 17829192
Frame  69 planet size: 265:255 CM: 219:211 Candidate pixel: 263:119 (170) CRC: 17881428
Frame  70 planet size: 263:251 CM: 220:210 Candidate pixel: 261:121 (194) CRC: 17912091
Frame  71 planet size: 261:255 CM: 219:210 Candidate pixel: 262:119 (178) CRC: 17847057
Frame  72 planet size: 259:251 CM: 219:210 Candidate pixel: 262:121 (182) CRC: 17851383
Frame  73 planet size: 261:249 CM: 219:210 Candidate pixel: 264:122 (187) CRC: 17828271
Frame  74 planet size: 263:255 CM: 220:210 Candidate pixel: 263:120 (211) CRC: 17840085 Candidate: Detected
Frame  75 planet size: 259:247 CM: 219:210 Candidate pixel: 265:120 (221) CRC: 17846319 Candidate: Cleared
Frame  76 planet size: 263:249 CM: 220:210 Candidate pixel: 263:119 (219) CRC: 17791551 Candidate: Cleared
Frame  77 planet size: 261:255 CM: 220:210 Candidate pixel: 262:119 (213) CRC: 17814537 Candidate: Cleared
Frame  78 planet size: 263:251 CM: 220:210 Candidate pixel: 263:118 (198) CRC: 17817423
Frame  79 planet size: 261:253 CM: 220:210 Candidate pixel: 263:118 (199) CRC: 17814042
Frame  80 planet size: 263:249 CM: 219:210 Candidate pixel: 264:118 (182) CRC: 17800218
Frame  81 planet size: 259:247 CM: 219:210 Candidate pixel: 263:118 (177) CRC: 17779626
Frame  82 planet size: 263:249 CM: 220:210 Candidate pixel: 263:118 (172) CRC: 17752872
Frame  83 planet size: 261:249 CM: 219:210 Candidate pixel: 260:116 (172) CRC: 17728293
Frame  84 planet size: 263:249 CM: 219:210 Candidate pixel: 263:119 (173) CRC: 17734119
Frame  85 planet size: 267:251 CM: 220:210 Candidate pixel: 262:118 (172) CRC: 17762583
Frame  86 planet size: 261:247 CM: 220:210 Candidate pixel: 263:119 (170) CRC: 17750646
Frame  87 planet size: 267:247 CM: 220:210 Candidate pixel: 264:120 (168) CRC: 17803536
Frame  88 planet size: 265:251 CM: 220:210 Candidate pixel: 264:120 (167) CRC: 17784372
Frame  89 planet size: 263:249 CM: 219:210 Candidate pixel: 264:123 (165) CRC: 17826420         ▼

 [ Generate CSV file ]   (Excel compatible)

                                                                          [ Close ]
```

The information showed in screen is:

- Number of frame
- Size of the planet
- Position of the centre of the planet inside the frame
- Pixel candidate, with the position inside ROI and value of the pixel.
- CRC Of the frame.
- Indicator if the frame is marked like candidate to impact or if it has been deleted this state by vicinity to another frame marked as candidate.

The data of the frames can download in a file *.csv, Excel compatible, for his analysis by means of a spreadsheet.

🔲🔲 *Silent mode*

This button allows establishing the program in silent mode, so that it does not visualize any image.

The varied icon according to the silent way was or no activated.

❓ *Information on the program*

It shows information on the program and version of the same.

Area of visualization

In this area show the images of the frames, once applied ROI, and superimposes a green circle centered in the most brilliant point that has been detected, and that it is the point that stores for his analysis by the algorithm of detection of impacts.

This area only shows if the silent mode is not activated.

Only show images during the process of the phase 3. For the rest of the phases this area remains empty.

Area of information of the planet in the frame

In this area show the values calculated for the centre of the planet in the frame original, and the value calculated of the size of the planet.

Histogram

Optionally it can show the histogram of the image, whenever it was not activated the silent mode.

Console of messages

They show the results of each one of the phases. The information showed indicate if they have detected candidates to impact at the end of process.

To obtain a greater detail of the processes is precise to open the window of console of messages.

Example of messages after finding a candidate to impact:
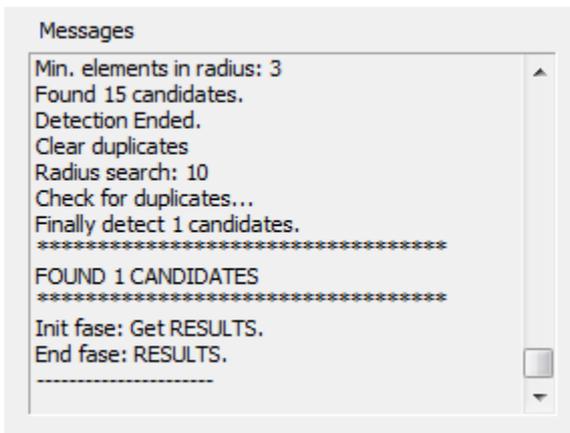
Frame In process

It indicates at all times the number of the frame in process, and the total of frames of the video. In this form can determine the degree of advance of the process.

If It Is executing a batch process, shows the number of file that is processing .
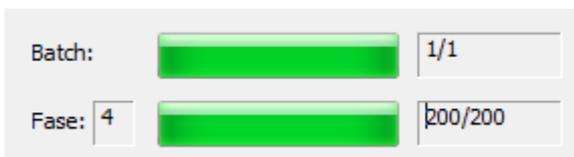
Algorithm of detection of impacts

The operation of this algorithm is based in the presented by Luis Calderón in his project 'Analysis and detection of impacts in video of Jupiter'.

The algorithm implemented in the current version of the program, is a variation on the algorithm detailed by Luis Calderón in his work. It has included the use of masks to delete the effects produced in the limb of the planet. The improvement of results with the utilization of masks is remarkable, mainly in the videos of low quality.

The option to use mask during the detection of impacts, is optional, but given the results obtained recommends his utilization.

Mask of process

The incorporation of masks in the algorithm DTC has showed a success when reducing the effects that produce in the limb of the planet.

These effects are generated by small deformations in the image of the planet because of the atmospheric turbulence, and that to the subtract the frame of reference, remain some parts of the limb of the planet out of the image of reference, with what generate false positive in the limb. These false positive in a lot of occasions mask the true impacts, mainly in low quality videos and with a lot of turbulence.

The generation of the mask realizes from the frame of reference (average frame) generated in the phase 2 of the process. This frame can be generated with 255 frames in the current version of the program.

To determine the limb in the frame of reference, the program uses the same algorithm of detection of the size of the planet (in the phase 1 of determination of ROI).

Once determined the size of the planet, generates the mask, with a planet totally white on a black background.

From this moment can reduce the size of the mask, to isolate more effectively the effects in the limb. In the dialog of the algorithm of detection, can indicate the number of pixels to reduce the diameter of the planet:
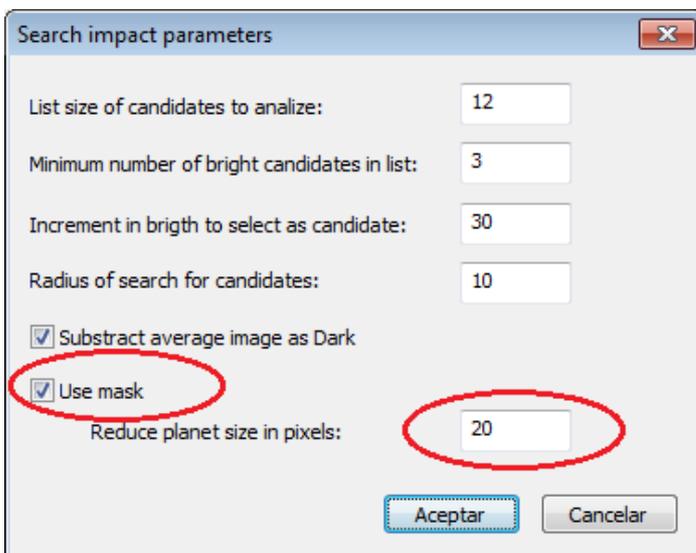
Example of a mask generated with the same size of the planet:
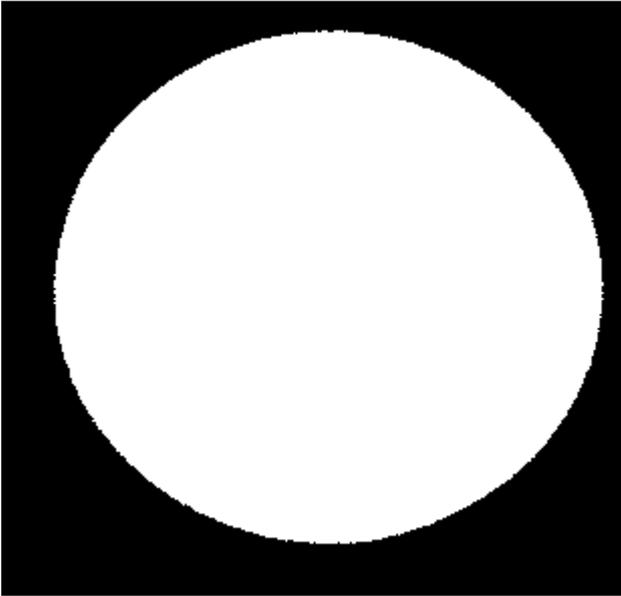
The same mask after reducing it 20 pixels:
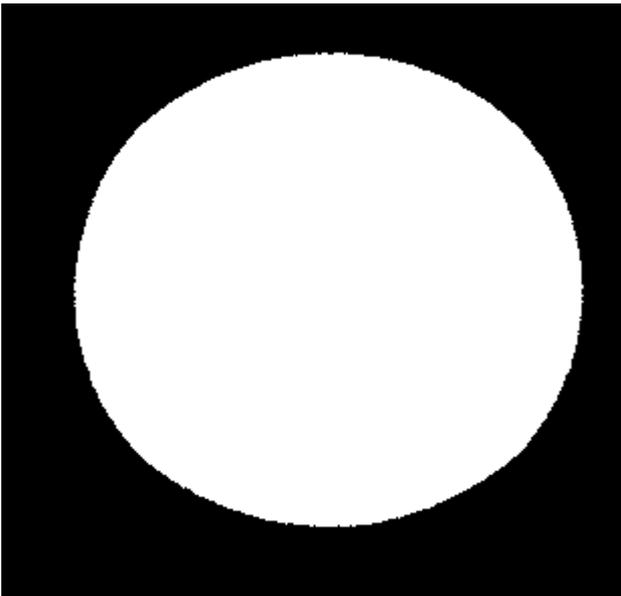
Visualization of the mask on the image of the planet, as it can obtain with the button of the toolbar.

Of this form can appreciate the reduction of the mask compared with the image of reference of the planet.

Detection of candidates in the frames

During the phase 3 of the process, with the reference frame and the mask frame, the program adjusts the frames to ROI. Then the program proceeds to the detection of the pixels candidates to be an impact in each frame.

The process initiates by the extraction of a frame and adjust to ROI:
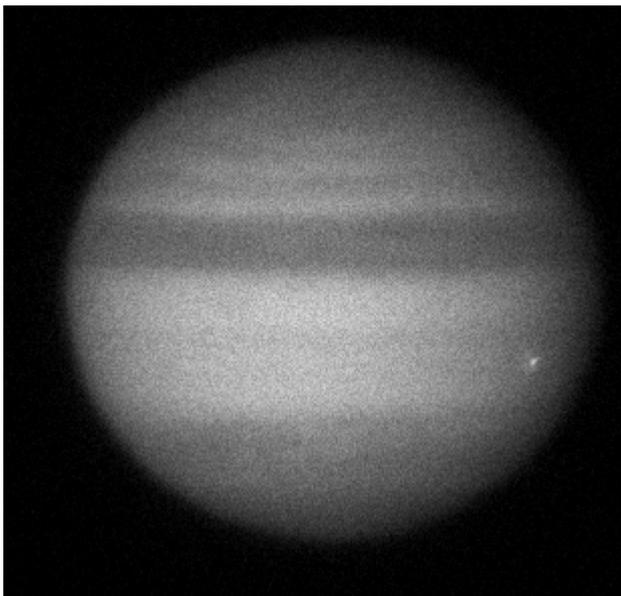
To this frame subtract the frame of reference:
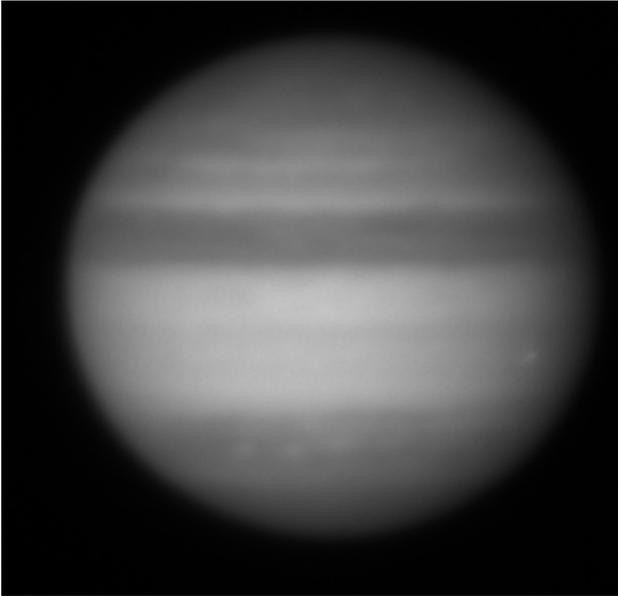
In this example and due to the fact that the video contains very few frames, and between them the ones of the impact, the own impact appears in the reference frame. This situation does not produce in videos with a greater number of frames.

Once calculated the difference between the frames in process, with the frame of reference and applying the mask, the result is:
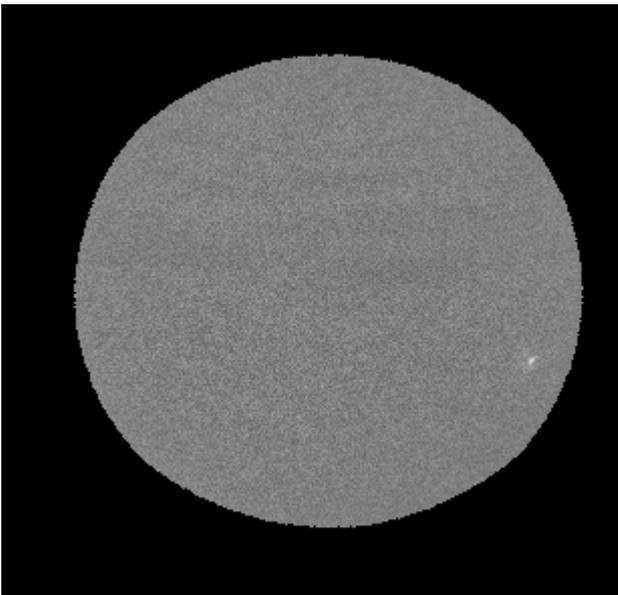
In this image of the process, can be appreciated the impact. Also they can see very slightly the effects of some bands of the planet, since a unique frame does not have the same gray level that the reference frame that has been generated by the sum of a lot of frames.

With the image generated, the program search for the most brilliant pixel in the frame. In this image can appreciate the effect to work with mask, since the limb of the planet is totally clipped away.

As an example, shows the same process (with the same parameters) except that it does not use a mask to delete the effects of the limb, with what appreciates a brilliant limb that in the case of feeble impacts can mask the impact.
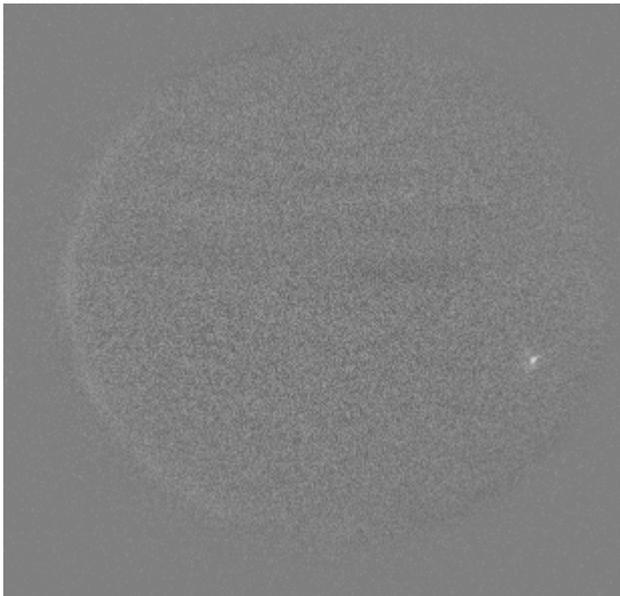
Generation of the list DataFrames

This list acts like a register of data of the processed frames, and during the phase 3 of the process, annotate the coordinates (referred to ROI) and the value of the most brilliant pixel of the frame.

The list can be consulted by means of the toolbar (![icon]). To continuation shows a part of the list that contains the impact of the previous images (frame 76).


```
Data frames                                                                        ☒

Frame  52 planet size: 263:249  CM: 221:211  Candidate pixel: 157:137 (164) CRC: 17716950
Frame  53 planet size: 265:249  CM: 221:211  Candidate pixel: 105:158 (168) CRC: 17727939
Frame  54 planet size: 259:253  CM: 221:211  Candidate pixel: 264:121 (175) CRC: 17802795  Candidate: Detected
Frame  55 planet size: 265:255  CM: 221:212  Candidate pixel:  89:110 (163) CRC: 17816991
Frame  56 planet size: 261:251  CM: 221:212  Candidate pixel: 128:152 (164) CRC: 17830119
Frame  57 planet size: 259:249  CM: 221:212  Candidate pixel: 183:145 (169) CRC: 17787531
Frame  58 planet size: 263:255  CM: 221:212  Candidate pixel: 264:118 (166) CRC: 17799000
Frame  59 planet size: 259:253  CM: 221:211  Candidate pixel: 260:118 (163) CRC: 17762463
Frame  60 planet size: 265:255  CM: 221:212  Candidate pixel: 121:100 (161) CRC: 17758803
Frame  61 planet size: 263:251  CM: 221:212  Candidate pixel: 261:119 (174) CRC: 17761437  Candidate: Cleared
Frame  62 planet size: 263:251  CM: 221:211  Candidate pixel: 157:165 (162) CRC: 17759691
Frame  63 planet size: 263:253  CM: 221:211  Candidate pixel: 258:117 (170) CRC: 17760822
Frame  64 planet size: 263:253  CM: 220:211  Candidate pixel:  95:136 (164) CRC: 17840787
Frame  65 planet size: 261:251  CM: 220:210  Candidate pixel: 263:120 (169) CRC: 17916507
Frame  66 planet size: 261:253  CM: 219:210  Candidate pixel: 121:134 (165) CRC: 17897415
Frame  67 planet size: 261:253  CM: 220:210  Candidate pixel: 259:119 (165) CRC: 17886255
Frame  68 planet size: 261:255  CM: 220:211  Candidate pixel: 262:119 (178) CRC: 17829192  Candidate: Cleared
Frame  69 planet size: 265:255  CM: 219:211  Candidate pixel: 263:119 (170) CRC: 17881428
Frame  70 planet size: 263:251  CM: 220:210  Candidate pixel: 261:121 (194) CRC: 17912091  Candidate: Cleared
Frame  71 planet size: 261:255  CM: 219:210  Candidate pixel: 262:121 (178) CRC: 17847057
Frame  72 planet size: 259:251  CM: 219:210  Candidate pixel: 262:121 (182) CRC: 17851383
Frame  73 planet size: 261:249  CM: 219:210  Candidate pixel: 264:122 (187) CRC: 17828271
Frame  74 planet size: 263:255  CM: 220:210  Candidate pixel: 263:120 (211) CRC: 17840085  Candidate: Cleared
Frame  75 planet size: 259:247  CM: 219:210  Candidate pixel: 265:120 (221) CRC: 17846319  Candidate: Cleared
Frame  76 planet size: 263:249  CM: 220:210  Candidate pixel: 263:119 (219) CRC: 17791551  Candidate: Cleared
Frame  77 planet size: 261:255  CM: 220:210  Candidate pixel: 262:119 (213) CRC: 17814537  Candidate: Cleared
Frame  78 planet size: 263:251  CM: 220:210  Candidate pixel: 263:118 (198) CRC: 17817423
Frame  79 planet size: 261:253  CM: 220:210  Candidate pixel: 263:118 (199) CRC: 17814042  Candidate: Cleared
Frame  80 planet size: 263:249  CM: 219:210  Candidate pixel: 264:118 (182) CRC: 17800218  Candidate: Cleared
Frame  81 planet size: 259:247  CM: 219:210  Candidate pixel: 263:118 (177) CRC: 17779626  Candidate: Cleared
Frame  82 planet size: 263:249  CM: 220:210  Candidate pixel: 263:118 (172) CRC: 17752872
Frame  83 planet size: 261:249  CM: 219:210  Candidate pixel: 260:116 (172) CRC: 17728293

  [ Generate CSV file ]   (Excel compatible)

                                                                      [ Close ]
```

Once generated the list with all the frames of the video, processes with the algorithm DTC, and with the parameters:

- Size of the list.
- Minimum number of candidates in the list.
- Area inside a radius in which they find the candidates.
- Minimum value of increase of bright to consider a candidate.

Algorithm of detection of impacts DTC

We can analyze the operation of the algorithm of detection of impacts from the file LOG generated during the process.

This is a fragment of the file LOG corresponding to the frame 22 of a low quality video, by what the parameters in this case are the following:

As it can be seen it has adjusted the minimum increase in bright to be able to detect the impact.

The frame where has been detected the impact:
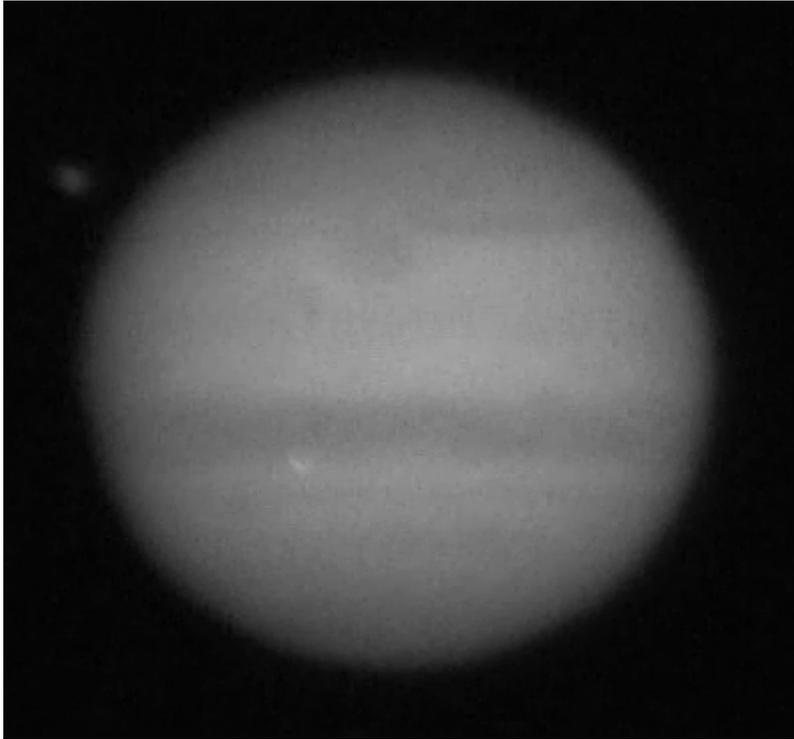
And the same frame once subtracted the frame of reference and applied the mask:
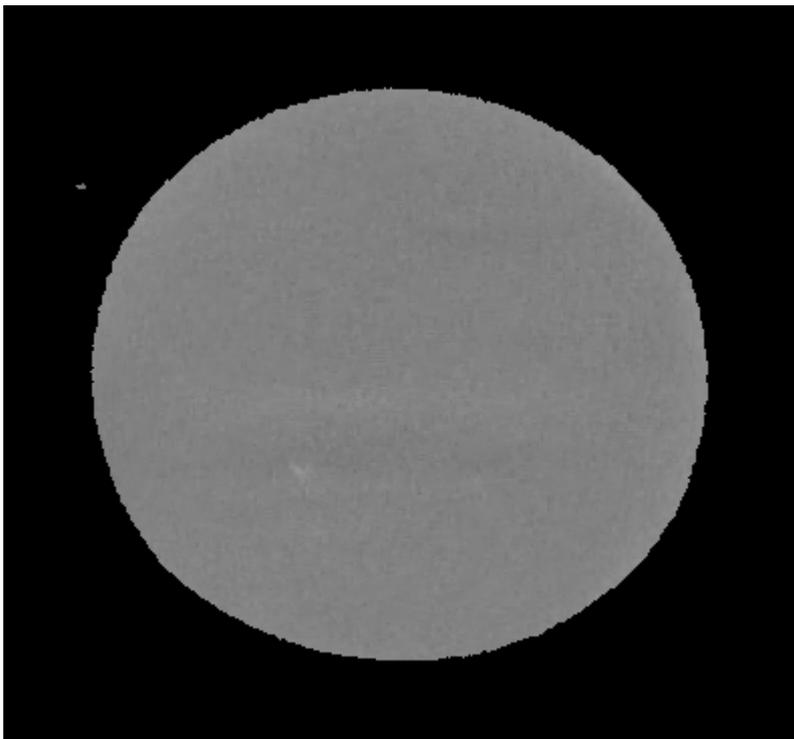
As it can be observed, the impact is less visible, and the effects of the limb of the planet still are appreciable, in spite of the utilization of the mask.

For this impact, the algorithm of detection of impacts has generated the following LOG, in the frame 19, where has detected a brilliant pixel and has identified the frame 22, as the one who contains the maximum bright.

'DtcData' Is the number of frame, and 'val', is the value of the pixel with the coordinates.

```
Process frame: 19

CJidDtc::CreateList - DUMP List DtcData

DtcData:   19 *val:   19 (144,138)

DtcData:   20 *val:   19 (348,188)

DtcData:   21 *val:   19 (346,161)

DtcData:   22 *val:   21 (146,136)

DtcData:   23 *val:   13 (143,138)

DtcData:   24 *val:   13 (200,176)

DtcData:   25 *val:   15 (180,131)

DtcData:   26 *val:   14 (222,174)

DtcData:   27 *val:   16 ( 98,285)

DtcData:   28 *val:   15 ( 40,279)

DtcData:   29 *val:   16 (156,169)

DtcData:   30 *val:   14 (328,118)

CJidDtc::SortList - DUMP ORDERED List DtcData
```

DtcData: 22 *val: 21 (146,136)

```
DtcData:   21 *val:   19 (346,161)

DtcData:   20 *val:   19 (348,188)
```

DtcData: 19 *val: 19 (144,138)

```
DtcData:   27 *val:   16 ( 98,285)

DtcData:   29 *val:   16 (156,169)

DtcData:   25 *val:   15 (180,131)

DtcData:   28 *val:   15 ( 40,279)

DtcData:   30 *val:   14 (328,118)

DtcData:   26 *val:   14 (222,174)
```

DtcData: 23 *val: 13 (143,138)

```
DtcData:   24 *val:   13 (200,176)

CJidDtc::SearchImpact

ptrData->m_iPixMax: 21 IncBright: 20

Compare with frame: 22

CJidDtc::SearchImpact – IncBright > limit

IsNearPoint with frame: 19

IsNearPoint with frame: 23

Found 3 elements near

Found CANDIDATE in frame: 22
```

First it shows the list created from the list DataFrame (generated in the phase 3), and that contains the data of 12 frames from the 19, without ordering.

To continuation orders the list by the value of the pixel, and compares the corresponding position to the frame that has the most brilliant pixel (frame 22) with the position of the rest of frames, according to the radius prefixed in the parameters.

Since there is 2 frames additional (marked in red) with candidates, that frame is marked as candidate. In total there are 3 frames with pixels brilliant inside the radius indicated.

Once we have all the frames where have detected candidates, the program proceeds to delete impacts, for what reads the list 'DataFrames' in reverse order, and if they detect candidates inside the radius indicated for the research, the program deletes it. Only remains frames marked as candidates for the first frame in a sequence.

If 2 frames are marked as candidate, at a distance inferior than the specified in the parameters, the flag to candidate is cleared.
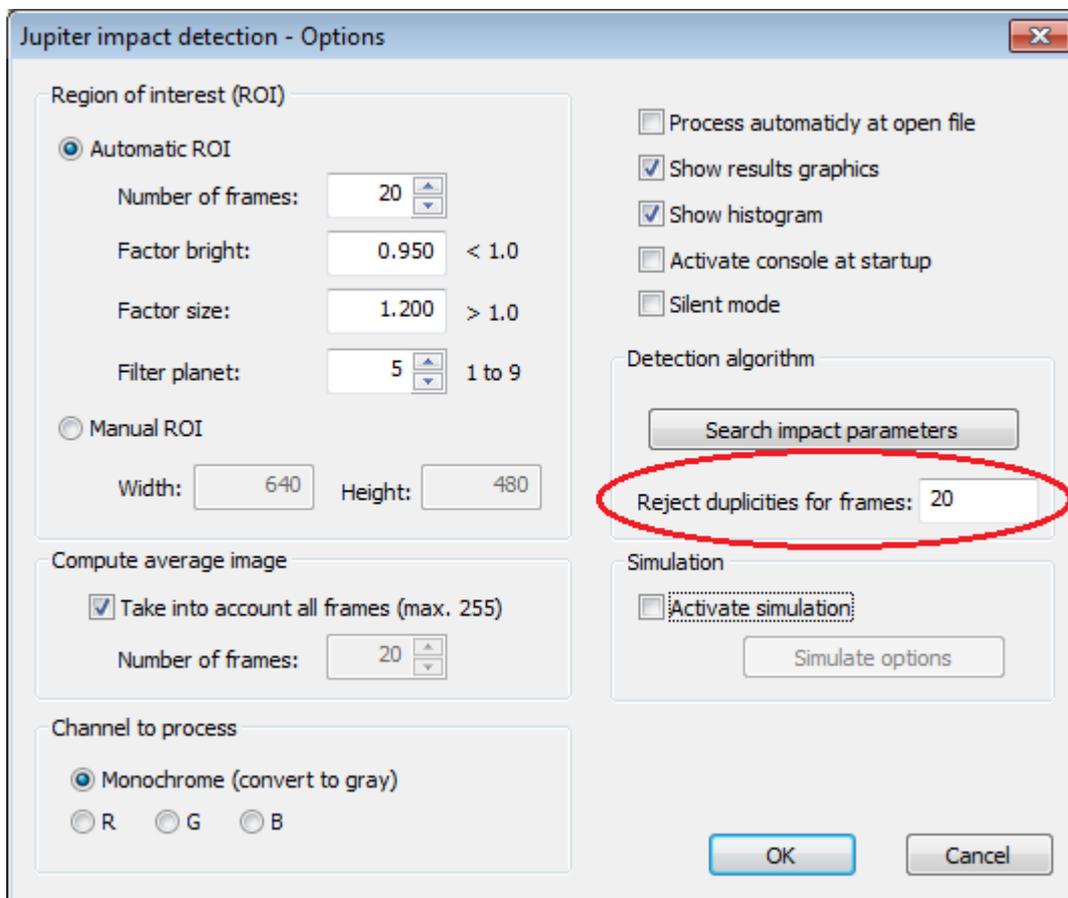
Generation of the list of results

From the frames marked in the list 'DataFrames' as candidates to impact, generates internally in the program a new list to show the results.

This list initiates with the candidates detected, with his Cartesian coordinates (referred to the centre of the planet).

In this version of the program, the list of candidates to impact in the results list is limited to 15.

From this list, the program executes the phase 4 of the process, in which, read the frames and save in memory the corresponding images to the areas of the impacts. These images are stored in memory, since in the window of presentation of results can show the complete sequence of the area of the impact along all the video.

Also it shows the photometric profile of the area of the impact, this photometry calculates, by the difference in the average value of the pixels of the area visualized. They compare the average value of the pixels inside the small circle (diameter of 16 pixels) with the average value of the pixels inside the bigger circle (diameter of 32 pixels). These circles can be visualized in the images.
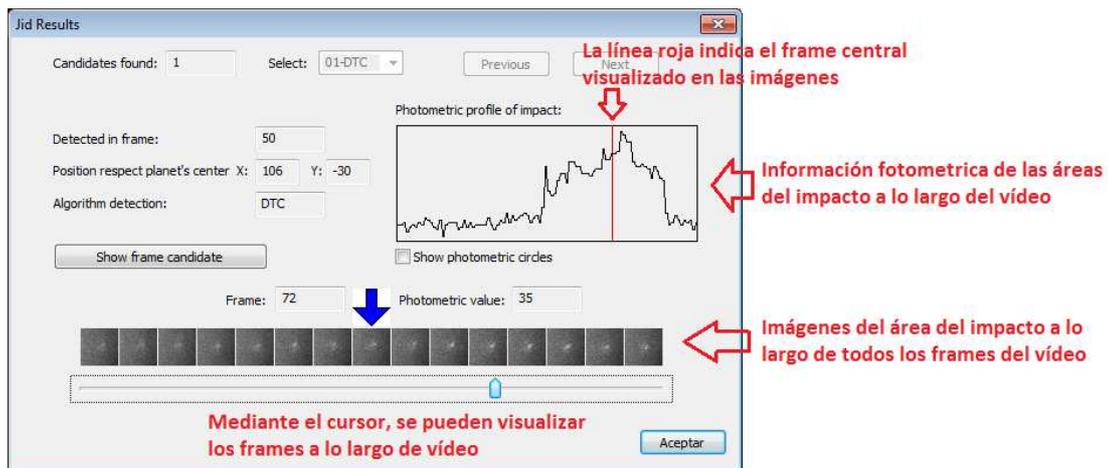
Limitations of the program the version 2.0

This version of the program, with code of version 2.0, contains the following limitations:

- For files of type SER, with more than 8 bits by pixel, the frames are reduced to 8 bits by pixel.

- The maximum number of frames that process in the phase 1 of the program (determination of ROI) is 255.

- The maximum number of frames that process in the phase 2 of the program (determination of the average image) is 255.

- In the window of process, the maximum size of the images visualized is of 640x480, although internally the program realizes the calculations with the real size of the image.

- The maximum number of candidates that can visualize in the window of results is 15, visualizing the first 15 that have calculated and discard the rest. This situation warns in the console of messages.

- The list of frames to process by the algorithm of detection of impacts is 100 frames. Usually it is sufficient to use a list of 12 to 20 frames.

- The maximum number of files to process in the batch mode, is 100.

Problems known

Since it treats of an initial version of the program, there are some appearances that are slopes of improvement, to continuation detail together with the actions to solve them.

- The utilization of the list of the last files processed (from the menu File), cannot initiating automatically the process. For a greater guarantee to execute automatically the process, use the option 'open file' of the toolbar.

- The sequences of video in format WMV, can generate frames slightly different in executions with the same parameters of processed, being able to obtain different results (false positive or false negative). This is a problem of the format WMV and of the codec used in Windows that they can vary the generation of a frame determinate in function of the power of calculation of the processor.

Links of interest

http://www.astrosurf.com/jcmoreno - Information and download of the program.

http://www.pvol.ehu.es/software - Web of the Group of Planetary Sciences of the University of the País Vasco, with information of the programs of detection of impacts.