DeTeCt3.1:
Jupiter impacts DeTeCtion software

User's guide

(V3.1.0, April 2018)

The latest software release was updated on 13 April 2018

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1. Introduction & installation

This short guide documents the use of the software to examine video observations of Jupiter and Saturn towards finding bright short flashes of light that could represent the impact of a small object with the planet. Known bugs are listed at the end of this file.

Requirements and Installation

The software should run in Windows XP or later. The software does not require any installation. Simply unzip the program in a given folder and click the downloaded executable and the software should start correctly. The software requires the opencv_ffmpeg2413.dll library for correct analysis of some video formats like WMV. Depending on your Windows OS you may need to download the 32 bits version or the 64 bits version.
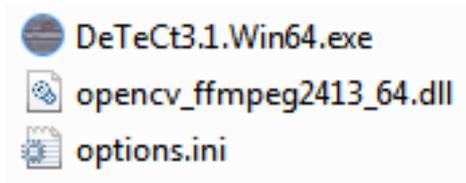
You can place these files under Program Files in a folder called DeTeCt (so it's accessible from the program menu by searching). The three files must be inside the same folder. You may also create a shortcut to the DeTeCt3.1 executable in the Desktop.

Video formats

DeTeCt works well analysing videos with the following formats:

- SER (colour and/or B/W). Bayer mask filtered cameras are automatically detected and colour corrections are applied by reading the file headers.
- AVI (colour and B/W). For B/W videos captured from a Bayer-mask filtered cameras you will need to specify the Bayer pattern in the software (see details on the next section).
- WMV.
- MKV (not fully tested).

2. Graphical User Interface

Click on the DeTeCt3.1.exe file to run the software. This will launch a Graphical User Interface which should appear as it is illustrated below. You can create a software shortcut in the desktop. The Graphics User Interface of DeTeCt 3.1 should appear on the screen.
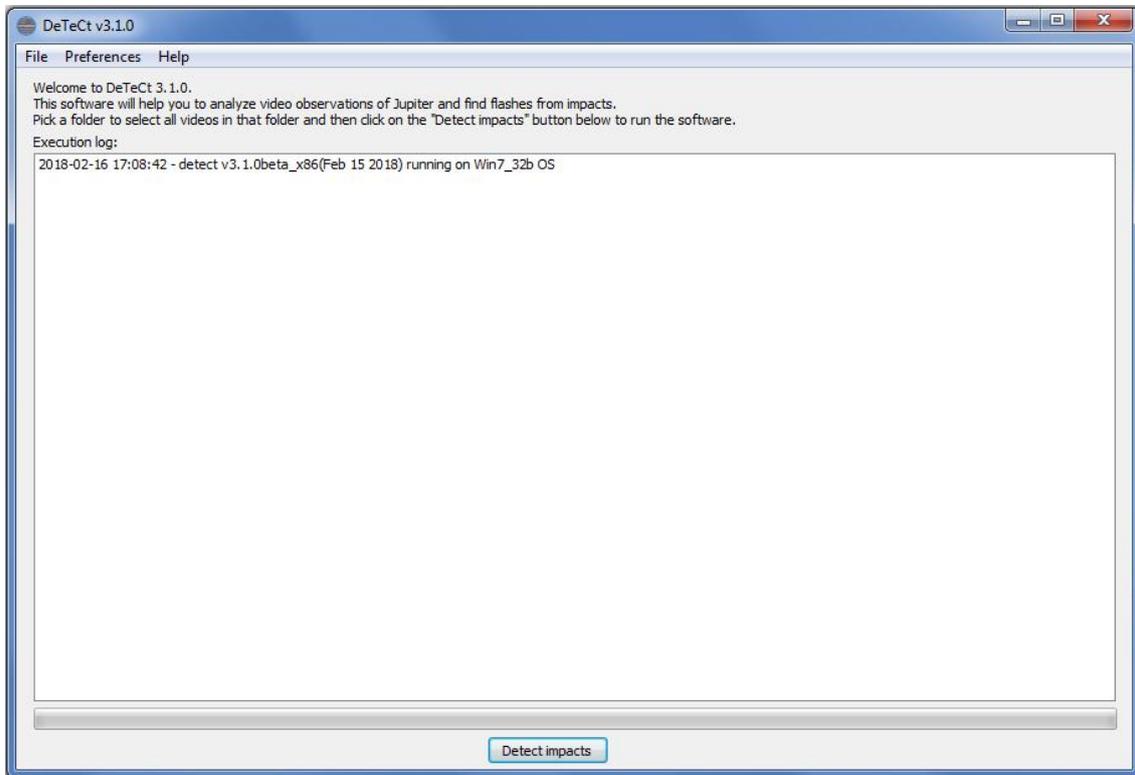
The menu bar contains three buttons: *File | Preferences | Help*

File will open a menu where you can select a single file for analysis or a directory or folder containing several video files including nested directories that will be examined.

Preferences will open a menu which allows control over advanced settings including visualization options.

*Help* displays information about the software version and authors.

The central window (console)

Here text information will appear. The window is scrollable so the user can read the events even when the algorithm is running. All the information appearing in this screen will be saved in a file called `output.log` file which will be located at a folder called `Impact_detection` and will contain all the outputs from the software. The `output.log` file is particularly useful when running an analysis over several files.

Detect impacts button and progress bar
Press the "Detect impacts" button in the lower part to start your analysis. The progress bar will show the progress in the analysis of individual videos. You can run the analysis with standard options but if you want to change these you should use the preferences button before pressing this button.

Preferences window
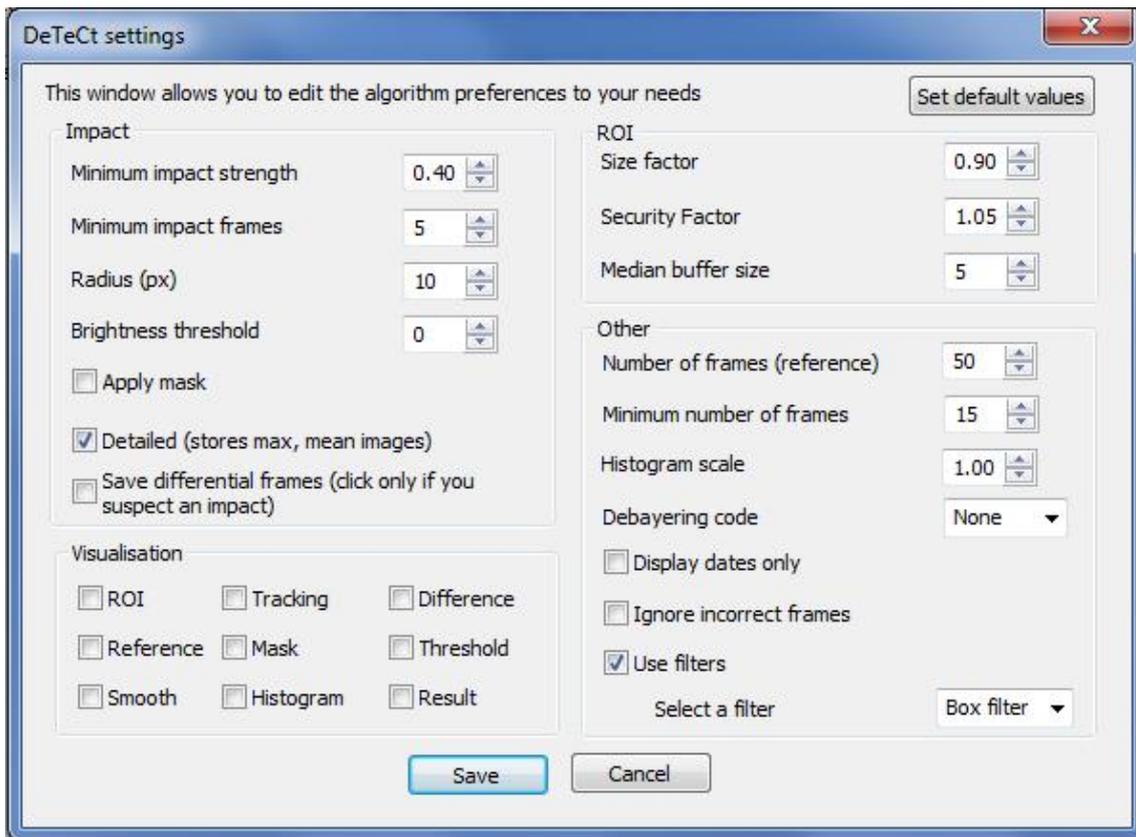
This window shows the settings the detection algorithm uses. Default values appear above. Modifications of these options will be stored in the `options.ini` file and will be saved for later uses. The options above contain different categories:

1. Impact parameters

Parameters regarding the detection of impacts. The detection algorithm runs differential photometry over co-registered images in the video. There are three parameters that increase the strength of the signal, the continuity of the impact over a given number of frames and the location of the impact which should be very close for a true impact.

- **Minimum Impact Strength:** This option controls the "visibility" of impacts. Lower this number to search for weaker impacts. Lowering this number will increase the rate of false positives. 0.30 - 0.40 are good choices for this number that make the software to succeed in 70% of all video observations of true impacts. Increase this number if your video observations produce too many false positives.

- **Minimum impact frames:** Only impacts that remain visible within a small distance for a given number of frames will be detected. Default value is 5. Note that in general the impacts are located at the peak of the brightness and that later analysis of the video can show the impact to last for several tens of frames.

- **Radius(px):** This is the regions where brightness continuity will be looked for. Default value is 10 pixels.

- **Brightness threshold:** A minimum threshold for the differential photometry. Set this value to higher values if you think you get too many false positives. Default value is 0 to have a normalized scale of detection confidence levels.

- **Detailed:** Additional information will be stored in a `Details` folder inside the `Impact_detection` folder.

- **Save differential frames:** **Do not click this option unless you suspect a true impact!** This option will produce differential photometry images of a whole video or sequence of videos generating image files for each frame containing differential images.

2. Region of Interest (ROI) and video co-registration parameters

These parameters control how the co-registration of images is done. This is in fact done before performing differential photometry. **In general these parameters should not be modified.** The planet is located with a "**center of brightness**" algorithm and its size determined with photometric cuts in the vertical and horizontal directions.

- **Size factor:** This option controls the size of the ROI around the planet. Use lower values to select smaller ROIs and higher values to select higher ROIs. 0.90 is a good measure.

- **Security factor:** Once the planet size is identified we apply an increase of size of the ROI to be sure to contain the full planet. This is a multiplicative factor. 1.05 is a good measure for high and low quality videos. Modifying this parameter has very similar effects to the previous one.

- **Median buffer size:** This is a technical parameter in the code. In general you don't need to modify this number.

3. Other options

Miscellanea options.

- **Number frames (reference):** This option includes the size of the reference image that will be used to compute differential photometry images. The video is read sequentially computing a suitable reference image. Before the number of frames here specified is reached, the reference is made as an average of the previous frames. The reference image becomes a moving reference afterwards, computed with the previous N frames. All frames in the reference image are coregistered.
- **Minimum number of frames:** This is the minimum number of frames a video has to have to be analyzed by the software. You can modify this number and use it to ignore short dark/flat videos.
- **Histogram scale:** This option only affects the visualization of images histograms.
- **Debayering code:** Cameras using Bayer masks can produce video files in SER or AVI formats. SER files include headers that provide the information of the Bayer mask and are analyzed without problems by the software. However, if your camera uses a Bayer-mask filtered detector and you have AVI files you need to indicate here the type of Bayer-mask filter used. You can leave this empty if you don't know.

- The possible values are `RGGB, GRGB, BGGR, GBRG` which will affect the correct execution of the algorithm. Bear in mind that this `option is ignored for SER videos`.
- **`Display dates only:`** This optio**n** **is included for debug purposes only.** Clicking this option will only create the DeTeCt.log file and **will not run the detection algorithm**. The software will only check the **datation of the video**.
- **`Use filters:`** This controls if the differential photometry images are processed with any type of smoothing filter before trying to find the brightest pixel where an impact may be located. Weak impacts or videos **with low quality can be sensitive** to these parameters. An optimal solution is not clear in the software tests run so far and we recommend not touching this option which is mainly included for algorithm testing.

4. Visualization options

Before clicking these options please note that the software is intended to run fully autonomous without requiring you to supervise the differential photometry. However you can check the software performance by using these options. We use this visualization tools to optimise the default values of the software parameters.

- **`ROI:`** shows a cropped image of the frame limited by the ROI coordinates.
- **`Tracking:`** the shows the original frame with the ROI and Centre of Brightness.
- **`Difference:` This shows the differential photometry of individual frames**. Tick this option and you will see the analysis of the video as it proceeds. It the most useful visualization tool of the program.
- **`Reference:`** shows the reference frame. The reference frame is an average of the last N frames where N can be defined as explained previously.
- **`Mask:`** The mask is a binary mask that is used to compute the reference frame. Intended only for debug.
- **`Threshold:`** Intended only for debug.
- **`Smooth:`** shows the smoothed difference frame.
- **`Histogram:`** shows the histogram of the image.
- **`Result:` shows the result of the algorithm.** This can be very similar to the difference image but it can be different if you apply a smoothing algorithm of the differential photometry image. Since the algorithm looks for the location of the brightest pixel in this image the smoothing step provides some better stability to the detection strategy and lower number of false positives.

Help button in the menu bar

This button shows the following message
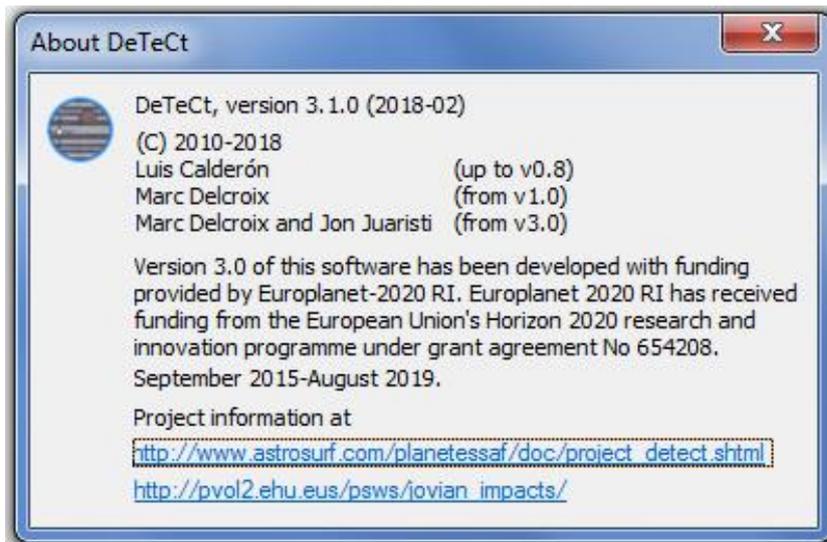
3. Results of the DeTeCt analysis

Once the software finishes evaluating the selected video files a notification window will appear. The following example is for the analysis of the video observation of the September 2012 impact recorded by George Hall.

The report shows the potential impacts found (if any) and the frames where the impact is detected. The "Confidence" number is a measure of the strength of the impact and the quality of the detection. In this case the confidence is very high. In case of errors a message stating the problem encountered while running the algorithm would be displayed here. Errors related with running the algorithm are generally related to extremely dark frames and sometime format errors. **In case of a suspected impact you should always look at the detection image in the impact Detection folder.**

Important outputs are produced in a folder created by the software and called `Impact_detection_run`. The folder is located in parallel to the video file being analyzed or the folder being analyzed. The folder is also tagged with the date the analysis was done. This allows to make different analyses with different software settings or versions. The folder contains the following files:

Text files

DeTeCt.log

This file contains the log results of the analysis. Even if you don't find impacts in your analysis these files are very important to us because they can be analysed statistically to know the rate of impacts in the planet. **Please send these DeTeCt.log files to delcroix.marc@free.fr**

The DeTeCt.log contains some important numeric factors like the **Certainty (t**he higher the number the highest the intensity of a possible detected impact) and the **Rate** (the number of possible impacts in the image). The rest of the data, such as the start time and end time of the video provide information essential to interpret how often and when we observe Jupiter from Earth from the ensemble of amateur observations.

You can check the statistics of the analysis of these DeTeCt.log files in the website run by **Marc Delcroix** over at:

http://www.astrosurf.com/planetessaf/doc/project_detect.shtml

Output.log

This file contains a copy of the text in the software console, excluding some lines that direct the user to this file. Useful for execution of multiple files and/or when something fails. In the case of an impact this file also includes the possible frames where impacts have been found.

Important note on DeTecTion images:

Sometimes the algorithm does not find impacts but you may find the signature of the impact visually in the detection image. Also sometimes the algorithm finds false positives that you can disregard looking at this detection image.

Video_file_dtc_max-mean1.jpg

where `Video_file` will be the name of your video and `_dtc_max-mean1.jpg` is added afterwards. This is a detection image with the position of the possible impact found by the algorithm highlighted with a red cross and an automatic analysis of the detection image with the brightest pixel highlighted with a green cross. When the two crosses are very close you can expect a higher probability of having found a true impact. Examples of detection images are provided at the end of this document. The example at right is a very clear detection.
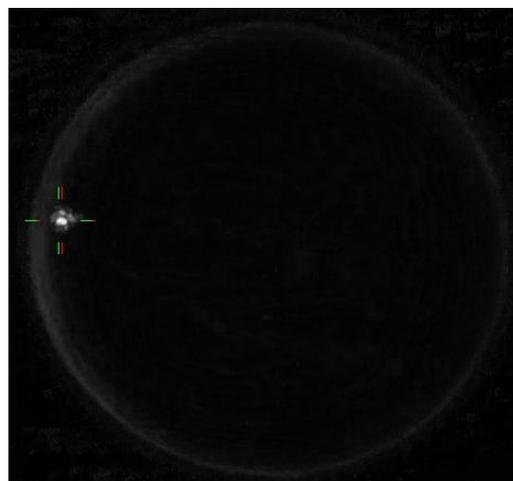
Video_file_dtc_mean.jpg

This image shows the mean brightness of the pixels of the planet computed from co-registered images. In general you should not expect to find an impact in this image but the image can be used to check the quality of the stacking and co-registration.
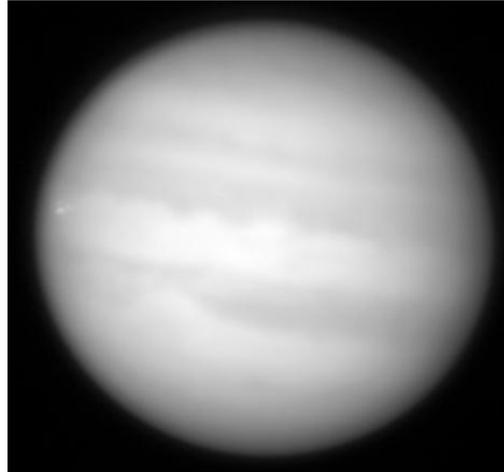
Calculation of the Detection Confidence / certainty:

Impact detection confidence (or certainty in the log files) is computed from DeTeCt with a simple formula that takes into account how many frames show the impact (N_{real}) compared with the minimum number of frames required to find an impact ($N_{minimum}$) and the strength of the impact. The strength of a detected impact (the brightness factor or *BF*) is computed from the maximum of the differential photometry images (max (B)) compared with the typical maximum brightness difference ($\overline{B}$).

$$BF = \frac{\max(B)}{\overline{B}} - 1$$

The detection certainty is computed as:

$$Certainty = \frac{BF}{MIS} \cdot \log_{10}\left(\frac{N_{real}}{N_{minimum}} \cdot 10\right),$$

where MIS is the minimum impact strength required (0.40 typically; see page 4) . The longer an impact is above the minimum impact strength, or the higher the maximum brightness of the impact compared with the minimum required, the larger the computed certainty.

In those cases where the algorithm finds an impact but the detection image shows possible impacts in other locations the Certainty is arbitrarily divided by a factor of 4. This provides low values of confidence or certainties in the impacts detected by the algorithm that can be checked by the user in the detection image. See detection images example on Section 5 for more information on this. **Confidence levels below 1.5 are most probably false positives. In case of a suspected impact you should always look at the detection image.**

4. Known bugs

1. FPS are not always well interpreted. Some SER files have incongruences between the actual frames per second of the video and the values returned by the software as a result of changes in file specifications. Some videos incorrectly as well return 0 as the frames per second
2. Some WMV files return erroneous number of frames and fps. The algorithm executes correctly; but it affects visual components.

This list might be extended soon as feedback from the users is gathered. Please write an email to jon.juaristic@ehu.eus to communicate bugs and other feedback in the software.

5. DeTeCtion images examples explained

This section is provided to constitute a quick reference of what you should expect when running the software in the case of a true detection of an impact and in false positives.

Detection images of different video files are shown here on the left compared with the mean images. The first set of images is obtained from analysis of all previous flashing impacts in the planet. The second set shows typical false positives where the software identifies a possible impact which is not real. Confidence levels higher than 3 are in general robust detections. **Confidence levels below 1.5 are most probably false positives. In case of a suspected impact you should always look at the detection image.**

5.1. Analysis of true impacts

Anthony Wesley's video observation – impact on July 2010.
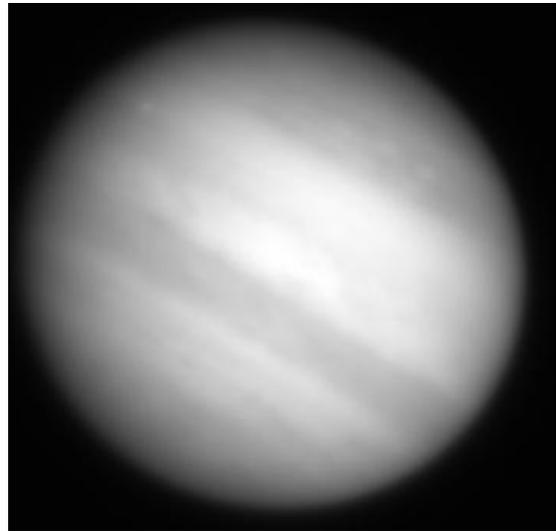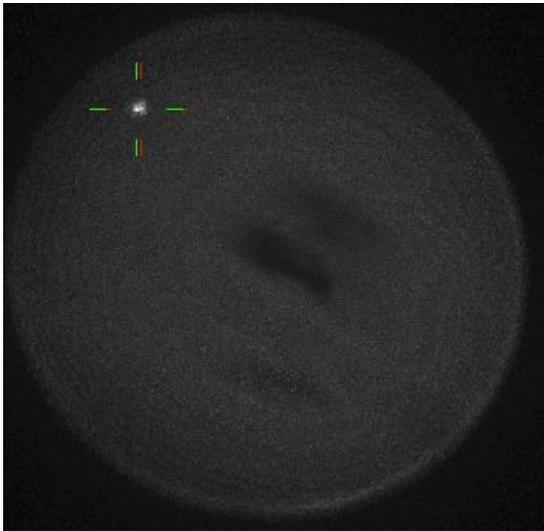
Detection confidence: 7.37 with minimum Brightness 0.30
Detection confidence: 5.53 with minimum Brightness 0.40

Christopher Go's video observation – impact on July 2010.
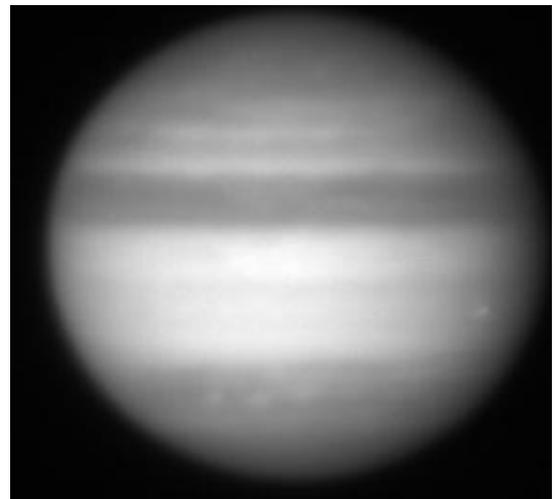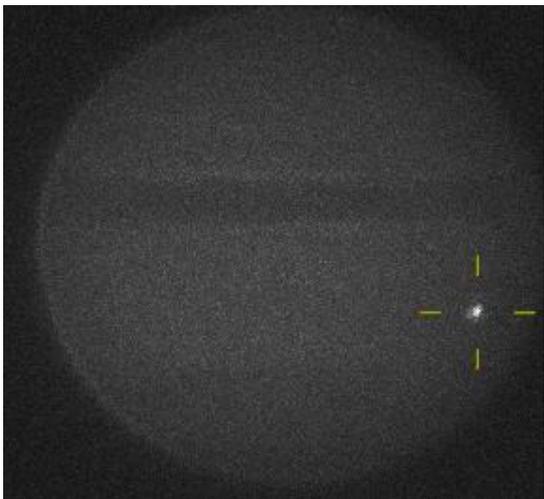
Detection confidence: 5.16 with minimum Brightness 0.30
Detection confidence: 3.87 with minimum Brightness 0.40

Masayuki Tachikawa's video observation – impact on September 2010.
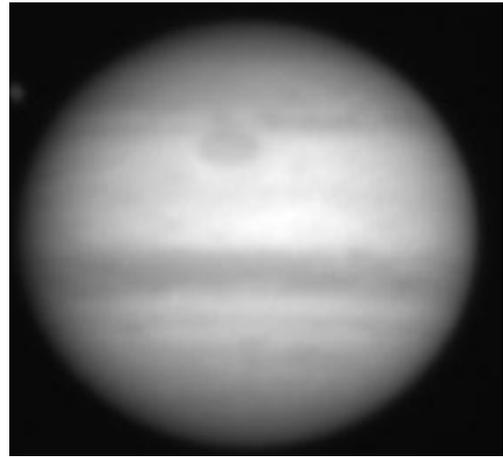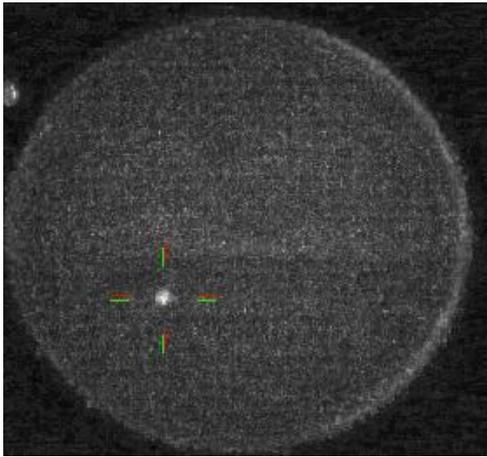
Confidence: 3.65 with minimum brightness 0.30
Confidence: 2.72 with minimum brightness 0.40

**Masayuki Ichimaru's video observation – impact on September 2010.**
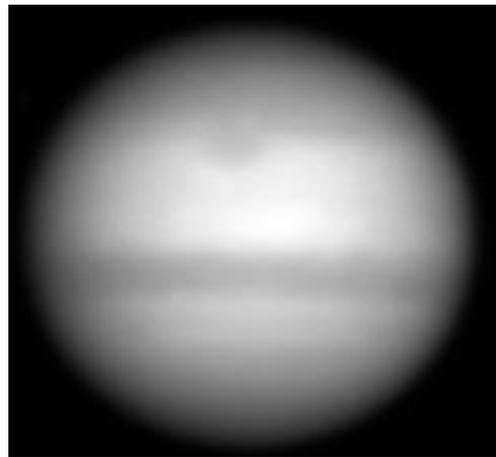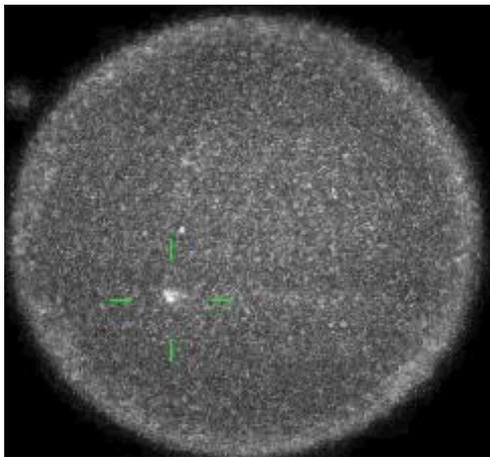
No impact detection by the DeTeCt algorithm but impact is clearly seen in the detection image and identified by the automatic analysis of this image highlighted with a green cross.

**Kazuo Aoki'video observation – impact on September 2010.**
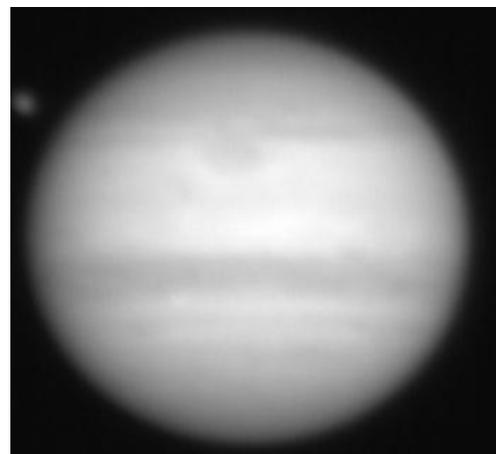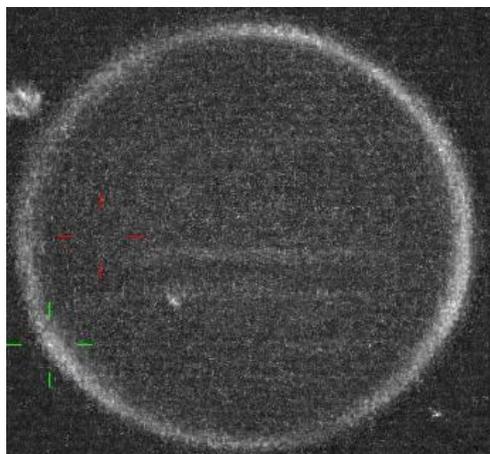
No impact detection by the algorithm or the automatic analysis of the detection image. Note however that the impact is visible in the detection image and highlighted with a green cross.

George Hall video observation – impact on September 2012.
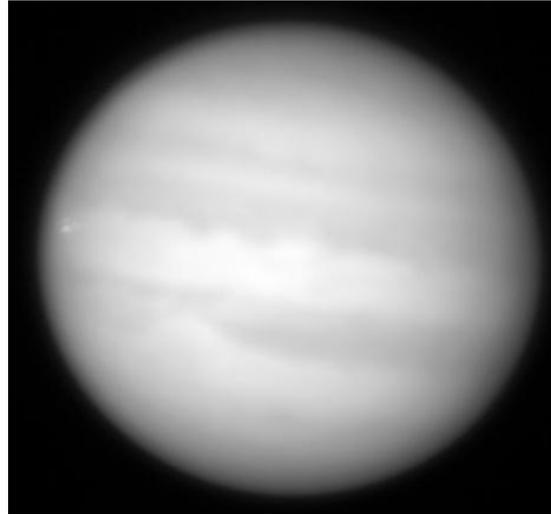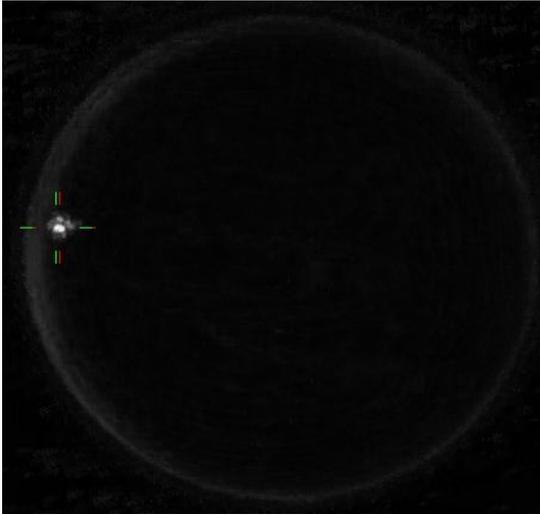
Detection confidence: 16.45 with minimum brightness 0.30
Detection confidence: 12.33 with minimum brightness 0.40

John McKeon's video observation – impact on March 2016.
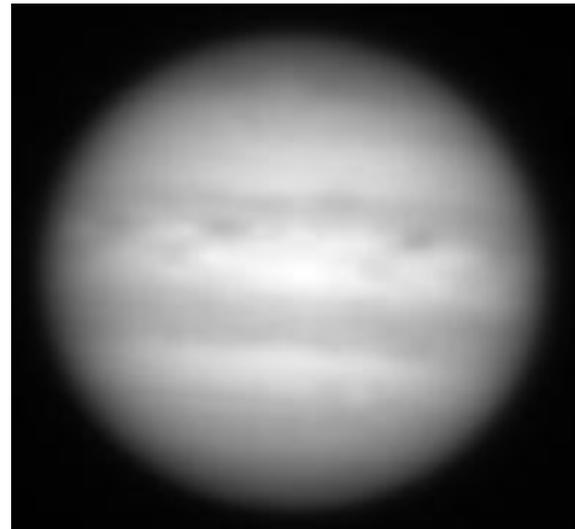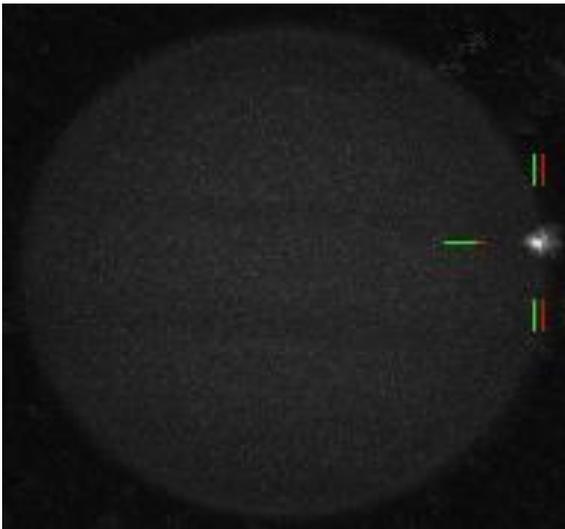
Confidence: 17.35 with minimum brightness 0.30
Confidence: 13.01 with minimum brightness 0.40
The location on the planet's limb contributes to provide better visibility of the impact raising the detection confidence.

Gerrit Kernbauer's video observation – impact on March 2016.
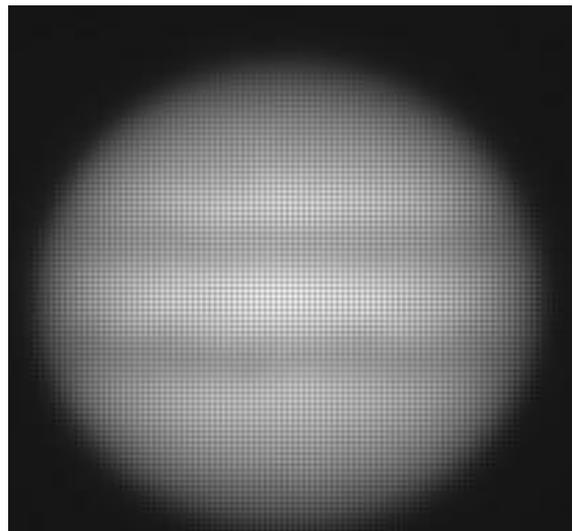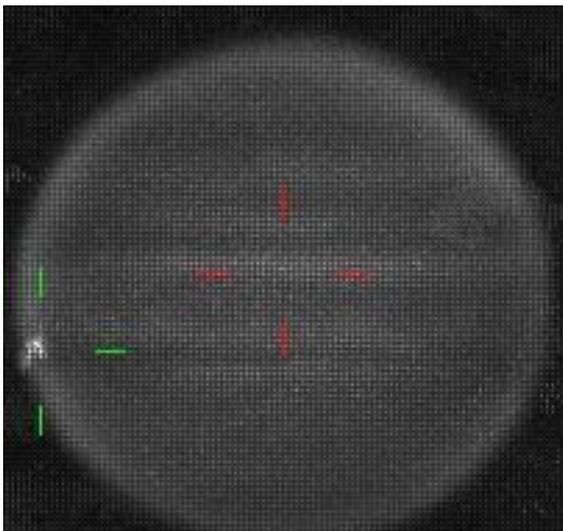
Confidence: 1.36 with minimum brightness 0.30
Confidence: 1.02 with minimum brightness 0.40
The detection algorithm finds the brightest pixel on the planet's upper right limb. This is a negative detection by the algorithm. The detection image correctly finds the impact and its location on the bottom left limb. Video processed on an AVI file without knowledge of the Bayer-Mask used in the detector. The algorithm finds the impact but the automatic analysis of the detection image shows a discrepancy related to the Bayer-Mask errors.

Gerrit Kernbauer's video observation – impact on March 2016.
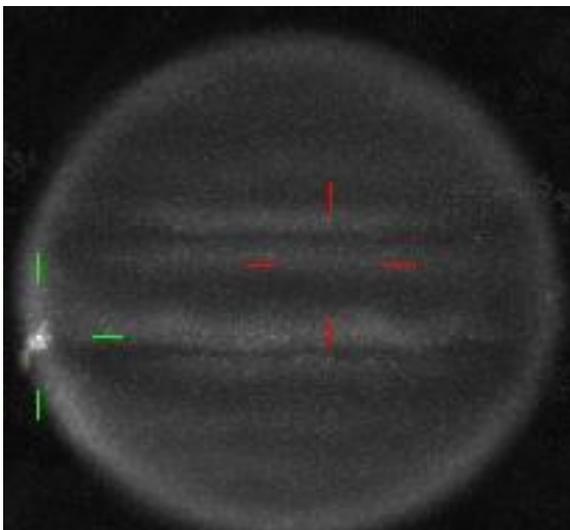
Confidence: 1.47 with minimum brightness 0.30
Confidence: 1.11 with minimum brightness 0.40
Video processed on an AVI file with knowledge of the Bayer-Mask used in the detector (GRBG). The detection algorithm finds a false impact in the planet's center and the detection image finds correctly the impact.

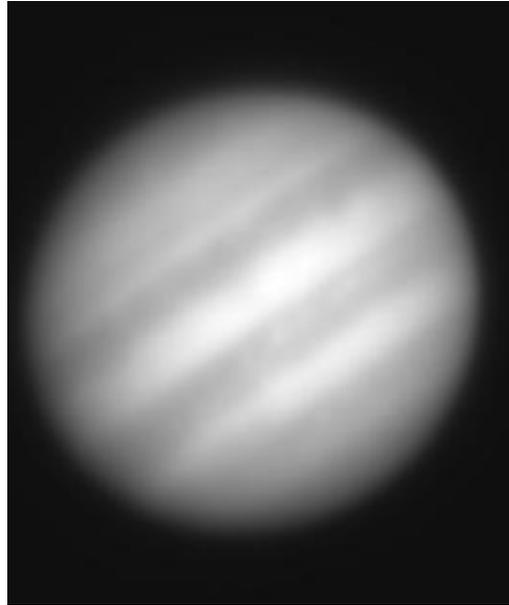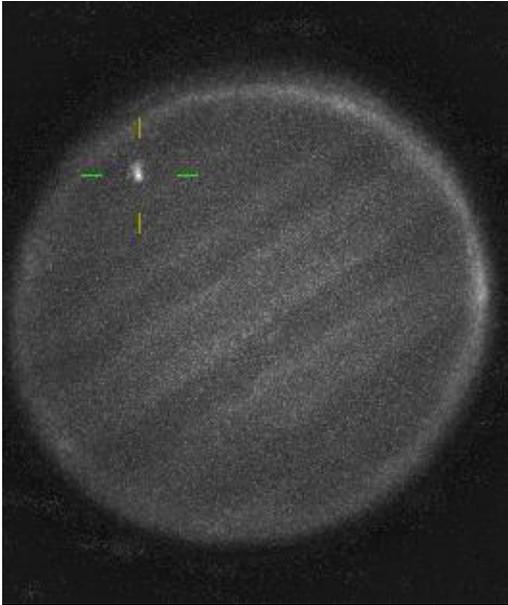**Sauveur's Pedranghelu video observation – impact on May 2017.**
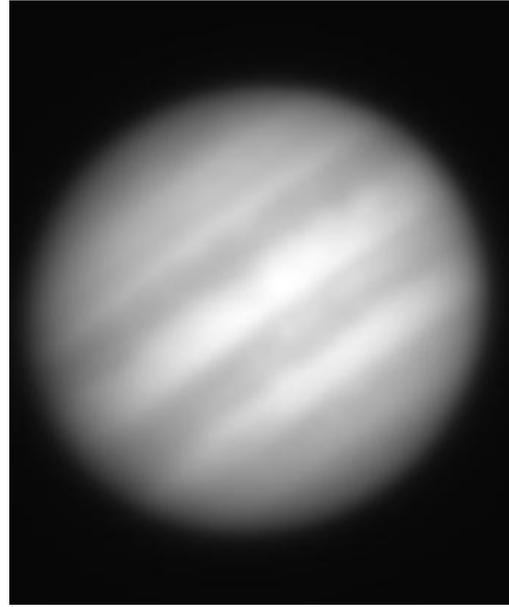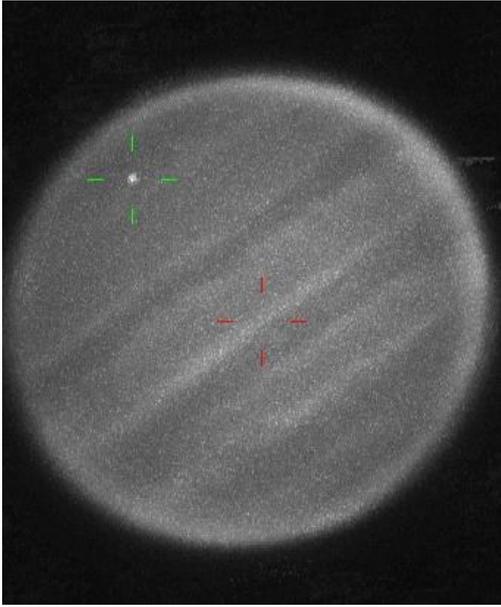
Confidence: 0.63 with minimum brightness 0.30.
Impact not found by the algorithm with minimum brightness 0.40.
This low number comes from the discrepancy between the Detection algorithm and the automatic analysis of the detection image. The impact is clearly observable in the detection image.
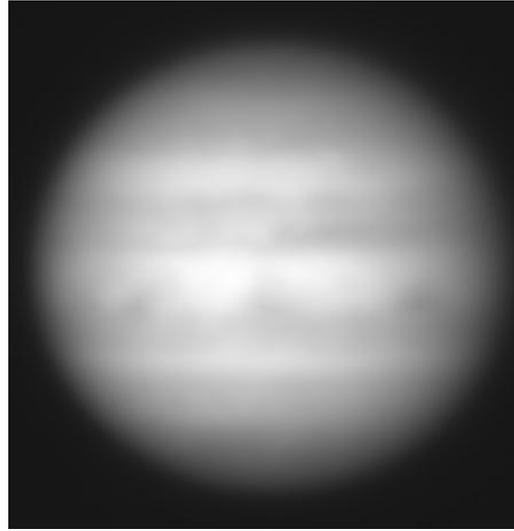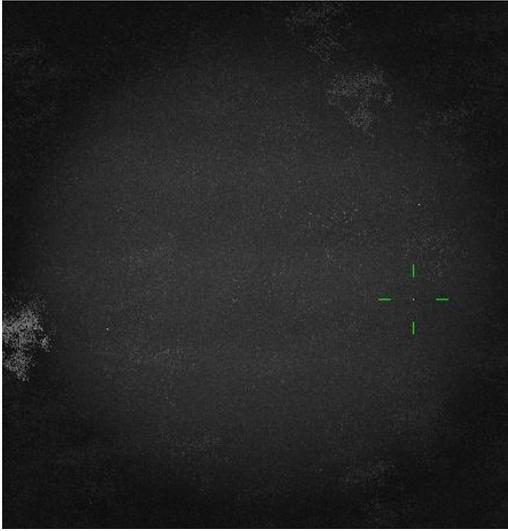
Thomas Riessler's video observation – impact on May 2017.

Confidence: 2.05 with minimum brightness 0.30
Impact not found by the algorithm with minimum brightness 0.40.

**Andre Fleckstein's video observation – impact on May 2017.**

The impact is not found, nor in the detection image, neither by the algorithm. Note that the impact is barely observable even when knowledge of its position is provided. The video has a relatively low quality due to bad seeing. This can be judged from the statcke "mean" image on the right.

5.2. Analysis of false positives

*Images courtesy of Jose Félix Rojas using a Meade 14'' telescope*

False positive detection #1
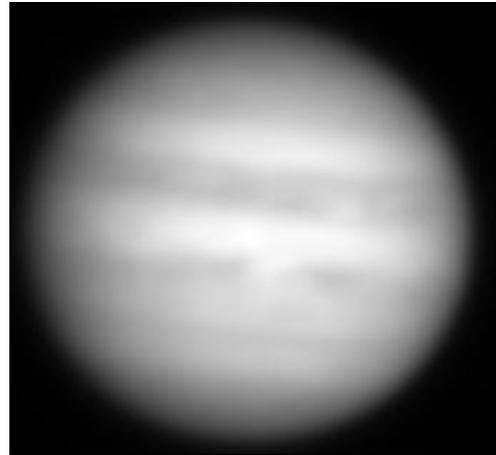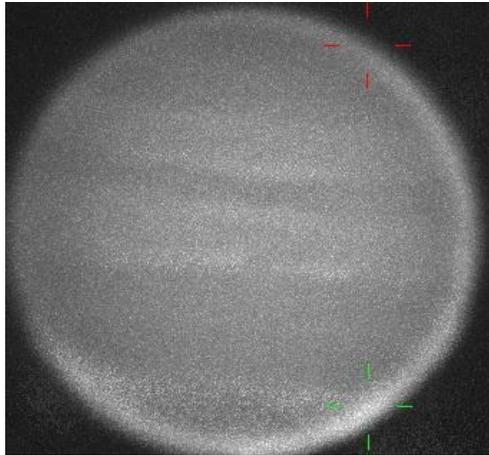
Confidence: 4.26166

False impact produced by registration problems under bad seeing in the limb of the planet.
Note the different position of both crosses and the limb position to discard a real detection. The red cross does not show over a particularly bright location of the video.

False positive detection #2
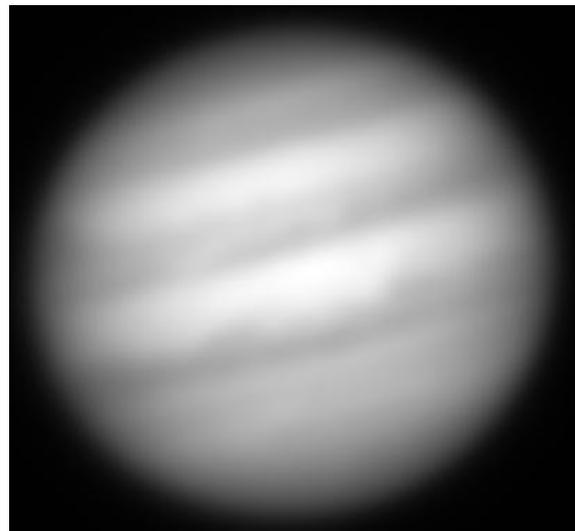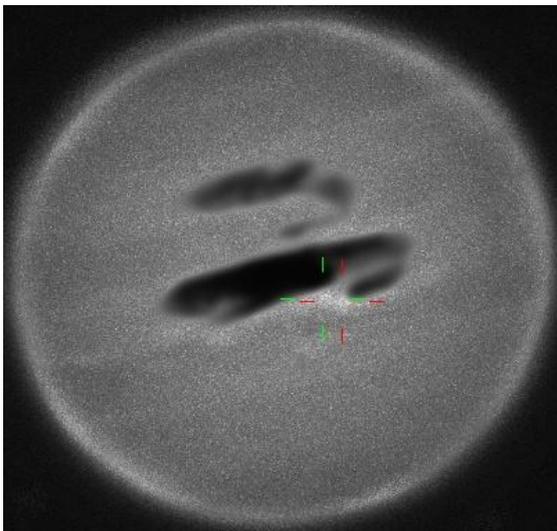
Confidence: 3.59543

False impact produced by registration problems under bad seeing. In this case the false detection occurs near a bright equatorial cloud close to a dark equatorial feature.