



# UAP photo/video Authentication and analysis

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*François Louange, consultant*

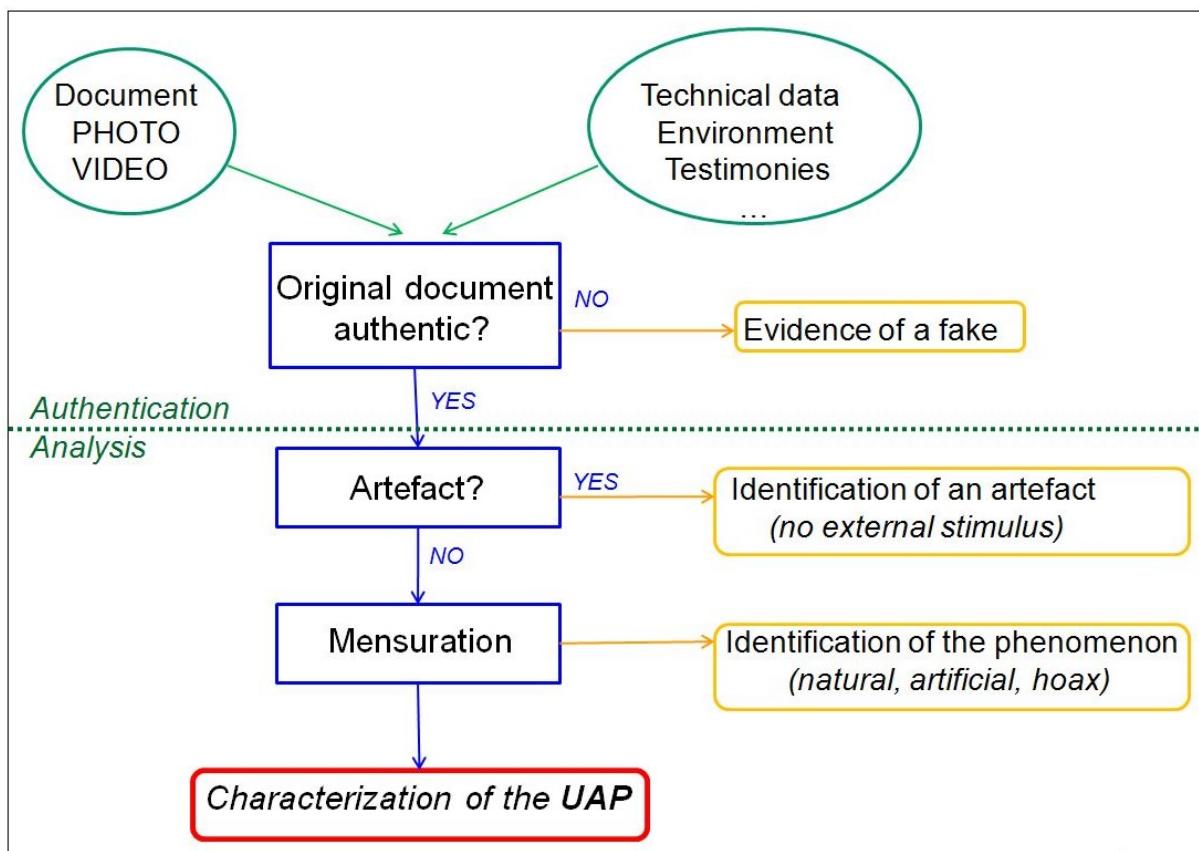
*Antoine Cousyn, analyst*

*Geoff Quick, consultant*

# UAP photo/video

## Authentication and analysis

What can be done with a photo/video?



Step n° 1: Authentication of the document

The first point to be established about a given document is whether it is an "authentic original".

In silver photography, an **original document** is defined as a film (black and white, color negative or slide). In digital photography, a photographic file is deemed **original** if it results from a simple direct copy (under Windows, Linux, Mac OS...) of the file originally created in the camera, and if the picture has been shot without activating any processing or inlaying of an on-line option.

The authentication stage can be divided into two parts:

1. A check of all associated tags and markers (EXIF, IPTC, XPM, JPEG metadata), that can subsequently indicate a possible manipulation of the photo/video document.
2. Comparison with a database that records all the technical data for a given camera.

## Step n° 2: Identification of an artifact

Within an original photo/video document, when an object or a phenomenon is *a priori* non-identified, the next point to be established is whether this apparent object results or not from an **external stimulus** to the imaging device.

It is a matter of record that many apparent anomalous « objects » are, in fact, cases of visual artifacts appearing on photographs, created by a variety of internal effects that may arise within the imaging system:

- in the set of lenses (dust, internal reflections, light leaks)
- on the photosensitive sensor (film in silver photography, photosite i.e. Charged-Couple Device (CCD) array in digital photography)
- in the encoding process (compression) of the image file

On top of that come all cases of fakes and image montages, which modern micro-computing makes easily accessible to everybody. In principle, these cases should have already been eliminated in the frame of Step n° 1.

Demonstrably proving the absence of any external stimulus effectively concludes the analysis of an image.

## Step n° 3: Analysis and mensuration

If it can be established that there did exist an external stimulus to the camera, the next stage is to establish whether it was linked to the physical presence of a **material object** in the scene or, alternatively, to that of an immaterial, purely luminous phenomenon.

In the second case, it could be a natural (atmospheric, meteorological or astronomical) phenomenon or, on the other hand, an artificial one (headlight, laser beam, hologram).

Whether the stimulus is from a material object or not, the analysis of the documentation aims at identifying its exact nature, in a definite and final way if possible, or – if it is not – with an estimated probability.

In case the nature of the phenomenon can definitely not be identified, the goal of the analysis is then to [characterize the unexplained phenomenon](#) as objectively and accurately as possible, through quantitative parameters that can be measured on the image: distance from the camera, size, velocity, acceleration, color, energy... This is the basic approach of all observation sciences.

## Specificities of video

A video sequence may be considered as a series of images (frames). Its analysis requires efficient tools, such as:

- Flexible visualization (slow motion, frame-by-frame)
- Extraction of a frame or a sequence of frames for further image analysis
- Frame de-interlacing in certain cases

In addition, of course, video allows the assessment of trajectories, velocities and accelerations.

## A dedicated software tool: IPACO

François Louange has developed the IPACO software since 2009 in contractual cooperation with CNES/GEIPAN, with the unique goal of providing the UAP photo/video analyst with an easy-to-use dedicated tool which fulfills most of the requirements for in-depth investigations.

This software is based on the existing architecture of an operational intelligence tool, with an appropriate redesign adapted to the specific needs of the UAP problem. It is in a state of permanent evolution.

All types of measurements presented in this paper are made easily possible with IPACO, which manages automatically all metadata associated with the documents under analysis for the sake of computation. Powerful “forensic” authentication tools are also available to establish quickly the authenticity of a picture or a series of pictures from all available metadata, some of which are well documented (EXIF tags), others more difficult to extract and less known by fakers.

IPACO works in English and in French. Future extension to any other language has been foreseen and will be easy to implement on demand, through appropriate co-operations.

This software tool is presented in detail, as well as the associated methodology and galleries of concrete examples, on the specialized website [www.ipaco.fr](http://www.ipaco.fr) (in English and in French).

# Photo/video: Authentication

In today's world, more than ever digitized, the term "*information war*" is extremely relevant, especially when it comes to photographs or videos.

The image holds the real power, as we associate to it the concepts of "*true*" or "*false*" in the media, especially television and even more so the Internet.

Nowadays, however, who can claim with certainty to be sure of the information conveyed by the images that we are perpetually being flooded with?



*Source: Flickr's gallery of user "mchoven" (under Creative Commons license)*

There are many ways to fake a document in order to manipulate the information transmitted. This can be done by cutting, embossing, filtering, metadata handling, etc.

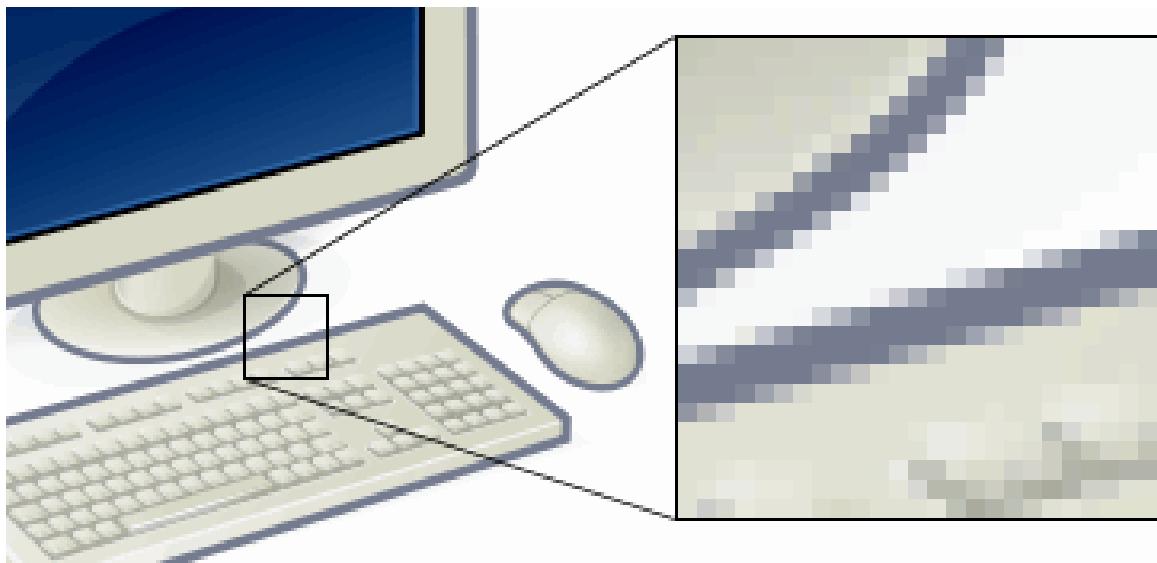
The objective here is to show that solutions exist for the detection of these different faking methods, either by specialized or embedded softwares.

# Definitions

## What is a digital photograph?

It is an electronic file composed of two parts:

1. **The image itself** is built up of pixels (from Picture element, basic units of measurement for a digital image matrix) and is generated by the camera (with its "firmware").



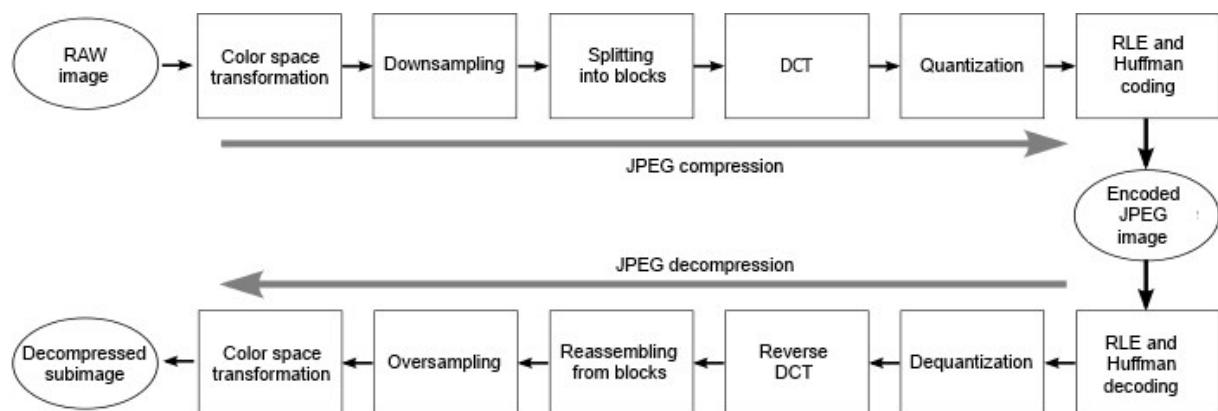
*Digital image with a portion greatly enlarged: the pixels appear here as small squares  
(Image under GNU license)*

The vast majority of images generated by cameras are created with the standard compression called "*jpeg*" (from Joint Photographic Experts Group), which is, in most cases, irreversible and destructive in terms of information, but very practical in terms of space saving.



*Example of quality degradation of an image resultant from the compression ratio decreasingly applied to the raw image (left to right).  
(Image under free license)*

The creation of a compressed image file with this standard is done by a process that comprises six well-defined steps: color space transformation, downsampling, block splitting, discrete cosine transform (DCT), quantization and entropy coding, RLE and Huffman compression.



*Baseline sequential JPEG encoding and decoding processes*

These compression functions are sometimes performed in a very different way, depending on the algorithms used by the manufacturers of digital cameras and editing software, who print then with what we might call a “*signature compression*” of their own.

Consequently, any subsequent use of editing software on the original jpeg file is highly likely to change one or more of these six steps irreversibly, replacing the native data compression by those of the particular software.

**2.** The **metadata**, created by this same camera, which specify in particular the conditions of shooting, and that may possibly be modified and supplemented by various softwares used with the picture, whether for copying, for storage or for modification purposes.

This generic term, widely used in the field of photography and video, covers a variety of data sets associated with a given file, defining and describing this file in a more or less accurate way.

In digital photography, the **Exif metadata** describe:

- *the parameters for the device*: the brand and model,
- *the settings* used during the shooting: focal length, aperture, flash use ...

And, optionally:

- *geolocation data ("GPS")*.
- *copyright data*.

There are also the colorimetric parameters (**ICC metadata**) and data used by photographers, press agencies and newspapers (**IPTC metadata**).

These data have been widely expanded since 2001 by the **XMP metadata**, extensible to other formats (photo and video), useable in Unicode and particularly used by the editing softwares.

Comment EXIF data IPTC data Custom view

**Camera**

Make	Canon
Model	Canon PowerShot A720 IS
Date modified	2012:07:07 21:09:36
Orientation	1
X-Resolution	180/1
Y-Resolution	180/1
Resolution unit	2
YCbCr-Positioning	1

**Image**

Date taken	2012:07:07 21:09:36
Date digitized	2012:07:07 21:09:36
Exposure time [s]	1/320
Exposure mode	0
Exposure bias [EV]	0/3
F-Number	45/10
Focal length [mm]	26749/1000
ISO value	80
Shutter speed [s]	266/32
Aperture	139/32
Max. aperture	139/32
Digital zoom	3264/3264
Flash	24
Metering mode	5
White balance	0
Colour space	1
Sensing method	2
File source	L
Custom rendered	0
Subject program	0
Image width	3264
Image height	2448
Components configuration	01 02 03 00
Average compression ratio	5/1
Focal plane X resolution	3264000/225
Focal plane Y resolution	2448000/169
Focal plane res. unit	2
EXIF version	0220
FlashPix version	0100
Makernote	1C 00 01 00 03 00 30 00 00 00 00 08 04 00 00 02 00

**Thumbnail**

Compression	6
X-Resolution	180/1
Y-Resolution	180/1

EXIF thumbnail

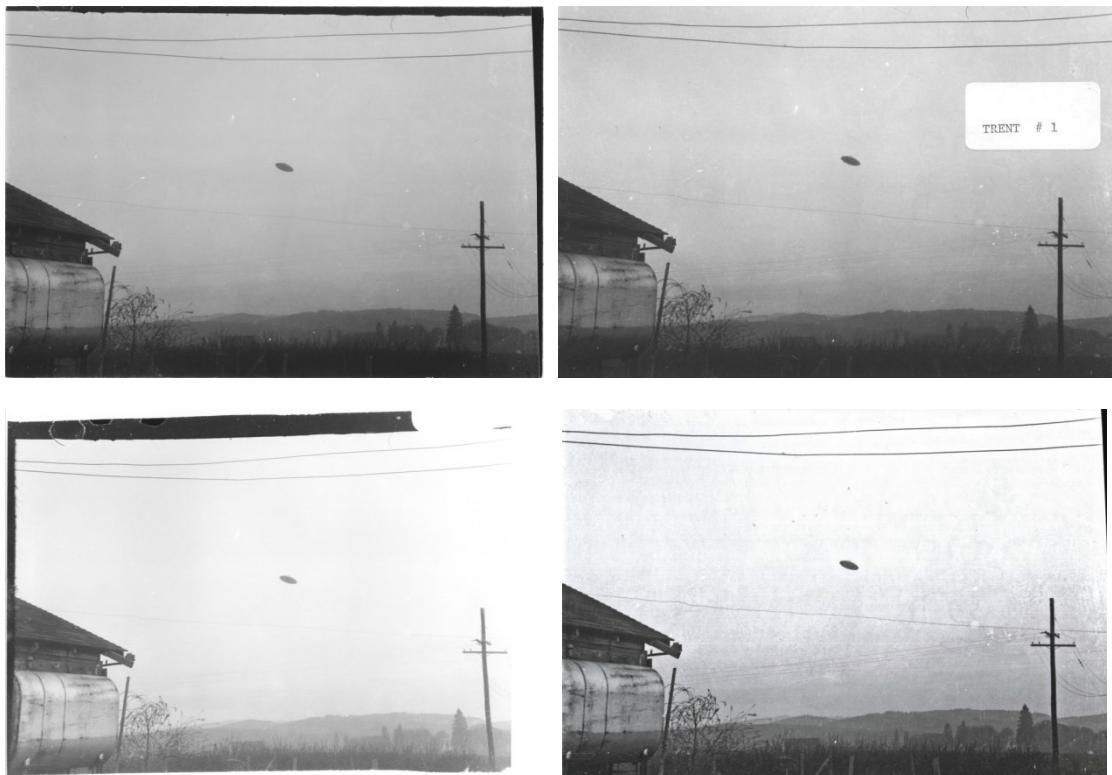
Example of metadata associated with a .jpeg file, read with "EXIFer"

## What is an authentic original photograph?

- In *silver photography*, an *original document* can only be a film (black and white, color negative or slide).

This definition excludes all other “second hand” documents, such as prints, scanned prints, etc. Indeed, the process used to create these “intermediate” documents may distort some useful data (RGB values, luminance, width/length ratio, cropped parts ...).

For example, the McMinnville photos exist in several printed/scanned specimens that were created from the original film with various scan and print settings:



In this case, the analyst will have to choose, in the lack of an original film, the best (the largest or biggest file, for example) “second hand” document, from the most reliable source.

- In *digital photography*, a photographic file is deemed *original* if it results from a simple direct copy (under Windows, Linux, Mac OS...) of the file originally created in the camera, and if the picture has been shot without activating any processing or inlaying of an on-line option.

The following examples show what it is possible to do with a custom process activated during the shoot with some cameras. The last picture is the original and the only authentic one that can be used by the analyst.



# Expertise strategy for authentication

## Existing tools

Up to now, the analyst had to deal with various softwares that have helped, in certain conditions, to properly analyze the UAP photo/video document.

It was a laborious work requiring juggling with many tools that were absolutely not intended for UAP document analysis.

### ➤ Reading and interpretation of the metadata

There are many more or less complete tools that handle different types of metadata: *ExifTool*, *EXIFTool*, *XnView*, etc.

The most comprehensive is certainly *EXIFTool*, which allows the complete management (add, delete and modify) of all metadata of many file types, including of course the jpeg format, in command line.

```
C:\Users\maison\Desktop\exiftool(-k).exe
ExifTool Version Number      : 8.51
File Name                   : BW32ft.JPG
Directory                  : C:/Users/maison/Desktop
File Size                   : 6.4 MB
File Modification Date/Time : 2013:08:20 23:31:40+02:00
File Permissions            : rw-rw-rw-
File Type                   : JPEG
MIME Type                   : image/jpeg
Exif Byte Order             : Big-endian (Motorola, MM)
Make                        : NIKON CORPORATION
Camera Model Name          : NIKON D5000
Orientation                 : Horizontal (normal)
X Resolution                : 300
Y Resolution                : 300
Resolution Unit             : inches
Software                    : Ver.1.00
Modify Date                 : 2013:07:27 13:05:31
YCbCr Positioning          : Co-sited
Exposure Time               : 1/400
F Number                     : 10.0
Exposure Program            : Not Defined
ISO                         : 200
Exif Version                : 0221
Date/Time Original          : 2013:07:27 13:05:31
Create Date                  : 2013:07:27 13:05:31
Components Configuration    : Y, Cr, - 
Compressed Bits Per Pixel   : 4
Exposure Compensation        : 0
Max Aperture Value          : 3.5
Metering Mode                : Multi-segment
Light Source                 : Unknown
Flash                        : Auto, Did not fire
Focal Length                 : 18.0 mm
Maker Note Version           : 2.10
Quality                       : Fine
White Balance                 : Auto
Focus Mode                   : AF-A
Flash Setting                 : Normal
Flash Type                   : 
White Balance Fine Tune     : 0 0
WB RB Levels                 : 1.99609375 1.16796875 1 1
Program Shift                 : 0
Exposure Difference           : 0
Compression                  : JPEG (old-style)
Preview Image Start           : 10392
Preview Image Length          : 23281
Flash Exposure Compensation   : 0
ISO Setting                   : 200
```

Example of metadata read using EXIFTool

Unfortunately, EXIFTool does not allow an automated way to distinguish the different types of metadata. Indeed, the determination of a possible modification of the file is not in its concept, let alone analyzing alleged UAP photos.

- Determination of a modification of the jpeg compression signature

Very few systems are capable of detecting such complex changes.

We retain the excellent *JPEGsnoop*, which is able to integrally read the jpeg compression process and compare it to an existing database.

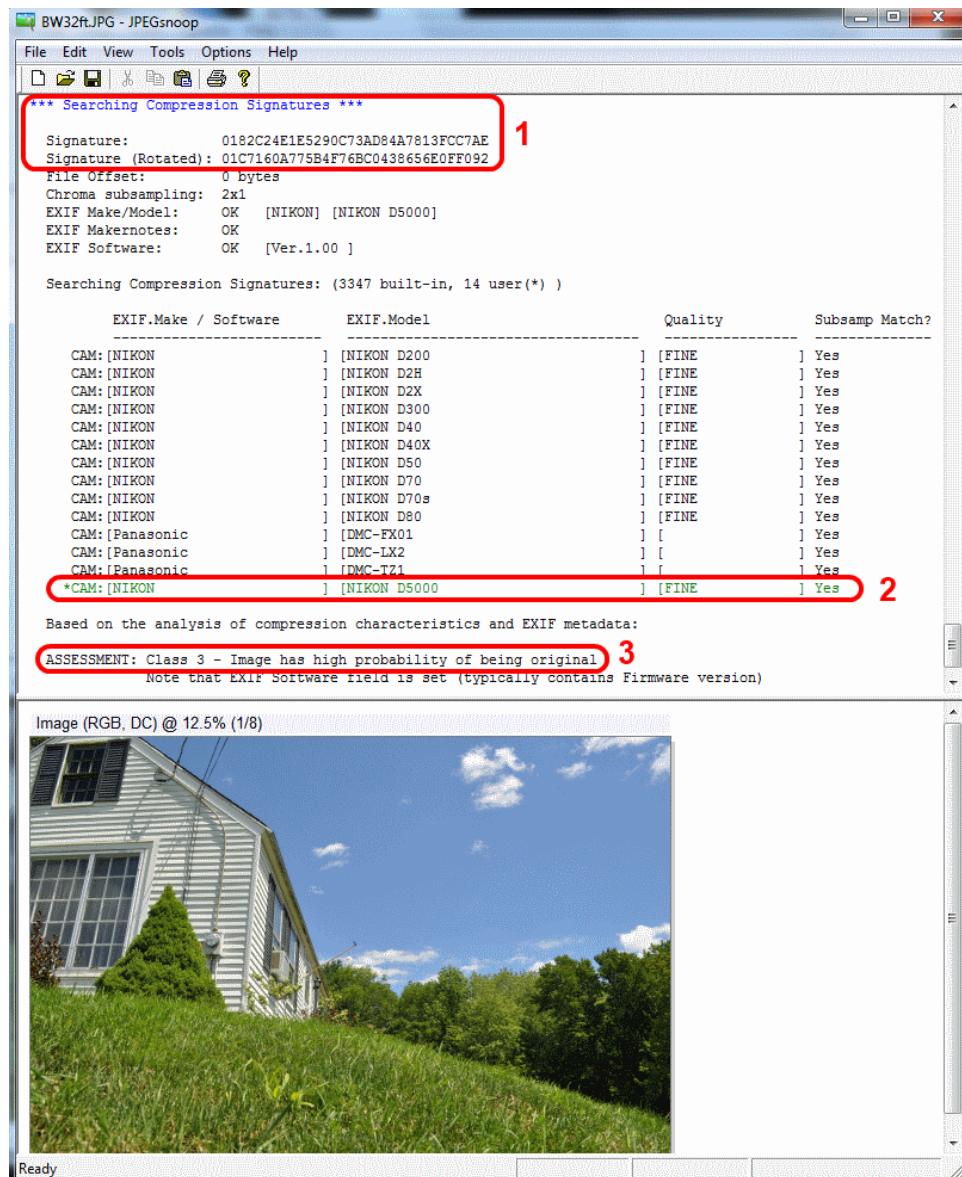
The results are shown in the form of a short summary, as follows:

- Signature compression.
- Camera used (if detected).
- Editing software used (if detected).
- Estimation of the probability that the image has been retouched.

### **A concrete example:**



The reading of the above file with *JPEGSnoop* gives the following results:

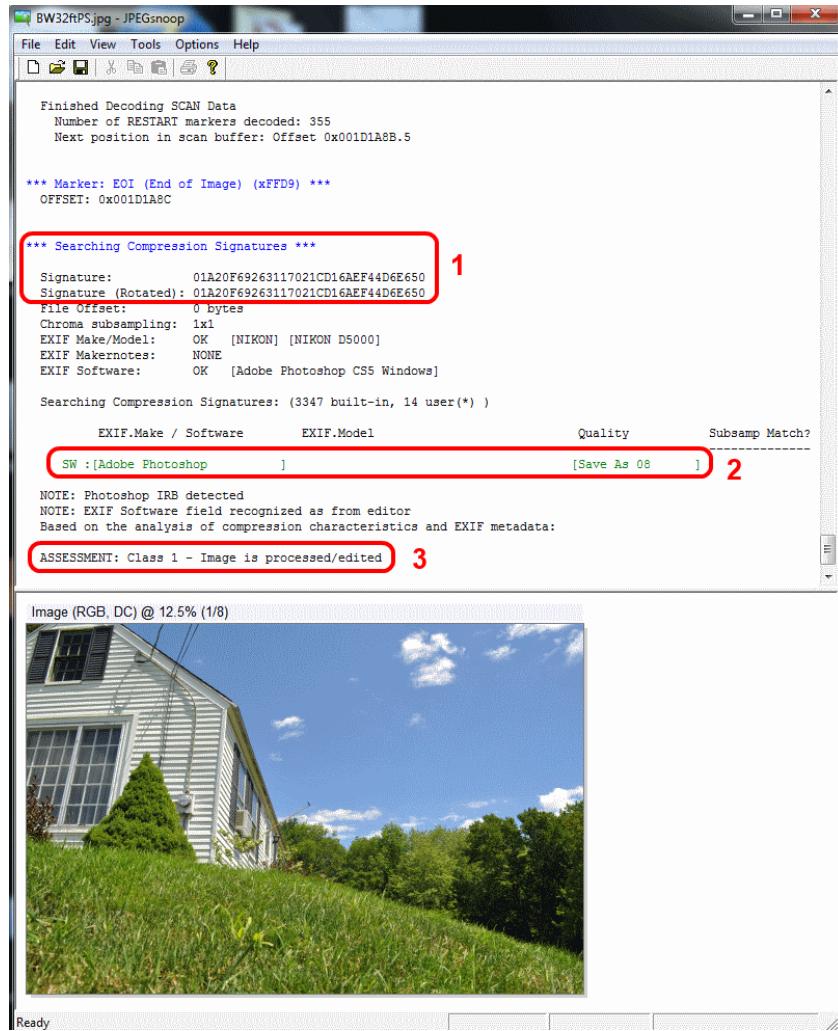


In '1' is located the signature compression of the jpeg file.

In '2' is located the name and model of the camera the signature compression of which, found in the database, matches the one determined in '1'.

In '3' is the final conclusion: "***Image has a high probability of being original.***"

A modification of the image, even small, with a well-known editing software radically transforms the results:



In it is still located the signature compression of the jpeg file, but this one is completely different from that of the original file. This highlights the fact that software was used.

In '**2**' is located the name of the software the signature compression of which, found in the database, matches the one determined in '**1**'.

In '**3**' is the final conclusion: "***Image is processed/edited.***"

It is important to note that, for most image processing softwares, to simply open the original image and then save it without doing any change is enough to modify its jpeg compression signature.

Finally note that *JPEGsnoop* also advantageously includes a comparative study of metadata, with some limitations, mainly due to the integration and update of its database.

## A new dedicated tool: IPACO

IPACO provides a set of specific authentication functionalities, which are divided into two parts:

- 1. A check of all associated tags and markers** (EXIF, IPTC, XPM, JPEG metadata), that can subsequently indicate a possible manipulation of the photo/video document.

The main causes of suspicion are the following:

- Use of an image processing software.
- Use, on the camera, of a « custom process » option.
- Last modification date different from shooting date or from digitizing date.
- Absence of a thumbnail (possibly suppressed in order to hide a touching up).
- Presence of IPTC tags (never created at shooting time).
- Presence of XMP tags (ditto), except for specific tags automatically generated by certain cameras.

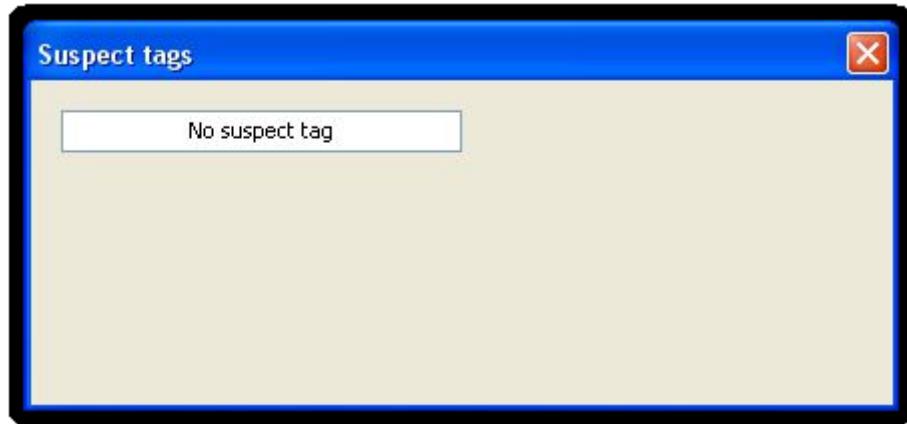
A few other markers, less known and more difficult to extract, enable IPACO to establish that an image has gone through an image processing software, even if all usual tags have been faked. For obvious reasons, no more details will be given here.

The check can be done either in one file previously imported into IPACO with the **“Suspect tags”** function or in one or several files not imported into IPACO with the **“Remote check”** function.

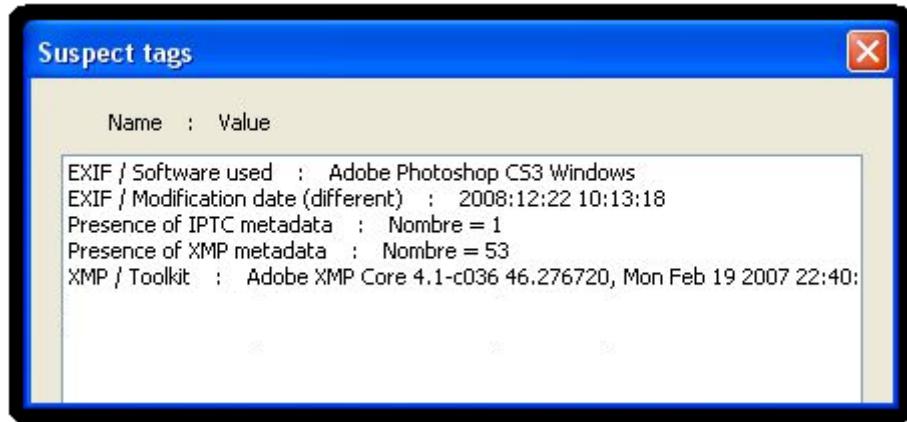
(In the current version of IPACO, this function is only operational with files in **JPEG** format)

- “Suspect tags” function

Once the file is imported into IPACO, if no suspect tag is detected in the displayed Image’s metadata, the following message appears:



If, on the contrary, suspect tags are detected, they are listed for the analyst’s attention:



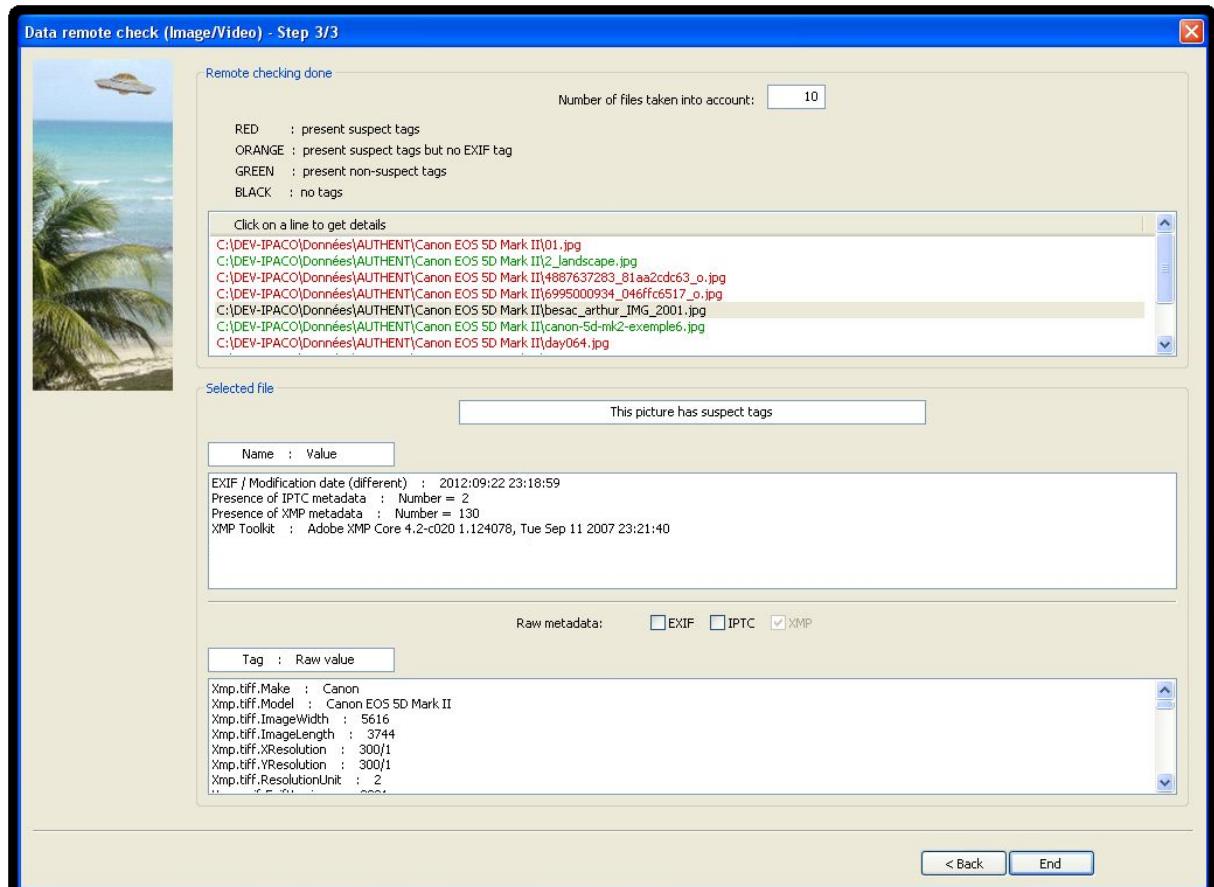
- “**Remote check**” function

This function is used to quickly establish the authenticity of one or several photos, present in a given folder readable by IPACO, without having to import these photos into IPACO. The principles are identical to those of the **Suspect tags** function.

Once the files are selected, those that are compliant with their standard format are immediately listed (non-compliant files produce an error message and are ignored), in 4 different colors:

- **Green**: no suspect tag is detected (original picture)
- **Red**: suspect tags are detected
- **Orange**: suspect tags are detected, but no EXIF tag is present
- **Black**: no tags are present

The number of effectively checked files is displayed. Details about a given suspect file can be obtained by clicking on its name, as well as raw contents of EXIF, IPTC or XMP tags, if present:



**2. Comparison with a technical database** that records all the technical data for a given camera.

The use of a technical camera database that contains all the useful data for each camera model (Image sizes, shutter speed, burst rate, JPEG compression signature, etc.) allows the analyst to determine, among many other things, whether the image size of the photograph conforms to all the possible image sizes for the given camera, then indicates if the picture is cropped.

Such a specific "CamCAT" database, interfaced with IPACO, is currently under implementation.

**A concrete example:**



The above photograph was taken with a Canon EOS Rebel T1i and has a size of 2435 x 3168 pixels.

A quick interactive check with IPACO and the interfaced database clearly shows that this size is not an original size for this camera; instead it could be for example 4752 x 3168 pixels, meaning that the original photograph was deliberately cropped in order to hide the light source (the sun here) that produce the reflection in the camera's lenses.

ID	Make	Type	Camera Model Name	Image Size	Sens	Se	Imz	Image	Imq	Image	Flasf	Flash	Burs	Exr	Exposure	F Numl	F Nui	F
1	Canon	Camera	Canon EOS 5D Mark II	2784x1856; 3861x2574; 4080x2720	24	36	2784	5616	1856	3744			3,9	30,00	0,00012500	1,0	91,0	
2	Canon	Camera	Canon EOS 7D	2592x1728; 3456x2304; 3888x2592	14,9	22,3	2592	5184	1728	3456			8	30,00	0,00012500			
3	Canon	Camera	Canon EOS REBEL T2i; Canc 2592x1728; 3456x2304; 5184x3456	14,9	22,3	2592	5184	1728	3456				3,7	30,00	0,00025000	1,0	91,0	
4	Canon	Camera	Canon EOS REBEL T3i; Canc 2592x1728; 3456x2304; 5184x3456	14,9	22,3	480	5184	480	3456				3,7	30,00	0,00025000	1,0	91,0	
5	Canon	Camera	Canon EOS 60D	2592x1728; 3456x2304; 3888x2592	14,9	22,3	480	5184	400	3456			5,3	30,00	0,00012500			
6	Canon	Camera	Canon EOS 5D Mark III	1920x1280; 720x480; 5760x3840; 3	24	36	720	5760	480	3840			6,0	30,00	0,00012500			
7	Canon	Camera	Canon EOS REBEL T3; Canc 1920x1280; 720x480; 4272x2848; 3	14,7	22,2	720	4272	480	2848				3	30,00	0,00025000			
8	Canon	Camera	Canon EOS REBEL T1i; Canc 3456x2304; 4752x3168; 2353x1568	14,9	22,3	2353	4752	1568	3168				3,4	30,00	0,00025000	1,0	91,0	
9	Canon	Camera	Canon EOS DIGITAL REBEL ; 4272x2848; 3088x2048; 2256x1504	14,8	22,2	2256	4272	1504	2848				3,5	30,00	0,00025000	1,0	91,0	
10	Canon	Camera	Canon EOS DIGITAL REBEL ; 3888x2592; 2816x1880; 1936x1208	14,8	22,2	1936	3888	1288	2592				3	30,00	0,00025000	1,0	91,0	
11	Canon	Camera	Canon EOS DIGITAL REBEL ; 3888x2592; 2816x1880; 1936x1208	14,8	22,2	1936	3888	1288	2592				3	30,00	0,00025000	1,0	91,0	
12	Canon	Camera	Canon EOS 50D	3456x2304; 4752x3168; 2353x1568	14,9	22,3	2353	4752	1568	3168			6,3	30,00	0,00012500	1,0	91,0	
13	Canon	Camera	Canon EOS 40D	3888x2592; 2816x1880; 1936x1208	14,8			3888	1288	2592			6,5	30,00	0,00012500	1,0	91,0	
14	Canon	Camera	Canon EOS REBEL T4i; Canc 2592x1728; 3456x2304; 5184x3456	14,9			5184	480	3456				5	30,00	0,00025000			
15	Canon	Camera	Canon EOS DIGITAL REBEL ; 3456x2304; 2496x1664; 1728x1152	14,8	22,2	1728	3456	1152	2304				3	30,00	0,00025000	1,0	91,0	
16	Canon	Camera	Canon EOS 5D	3456x2304; 4752x3168; 2353x1568	23,9	35,8	2496	4368	1664	2912			3	30,00	0,00012500	1,0	91,0	
17	Canon	Camera	Canon EOS 6D	1920x1280; 720x480; 5472x3648; 3	24	36	720	5472	480	3648			4,5	30,00	0,00025000			
18	Canon	Camera	Canon PowerShot G12	640x480; 1920x1080; 480x480; 281	5,58	7,44	480	3648	384	2736	7,00	4,00	2	15,00	0,00025000	2,8	4,5	
19	Canon	Camera	Canon EOS 200D	3504x2336; 2544x1696; 1728x1152	15	22,5	1728						5	30,00	0,00012500	1,0	91,0	
20	Canon	Camera	Canon PowerShot X40 HS	640x480; 1920x1080; 480x480; 281	4,55	6,17							,3	15,00	0,00031250	2,7	5,8	
21	Canon	Camera	Canon EOS-1D Mark IV	4896x3264; 4320x2880; 3552x2368	18,6	27,9	24						10	30,00	0,00012500			
22	Canon	Camera	Canon EOS 30D	3504x2336; 2544x1696; 1728x1152	15	22,5	1728						5	30,00	0,00012500	1,0	91,0	
23	Canon	Camera	Canon PowerShot S95	640x480; 1920x1080; 480x480; 281	5,58	7,44							,9	15,00	0,00062500	2,0	4,9	
24	Canon	Camera	Canon PowerShot S100; C	640x480; 1920x1080; 480x480; 281	5,58	7,44							,6	15,00	0,00050000	2,0	5,9	
25	Canon	Camera	Canon EOS-1D X	2592x1728; 3456x2304; 5184x3456	24	36	2592						14	30,00	0,00012500			
26	Canon	Camera	Canon EOS-1D Mark III	3456x2304; 3888x2592; 2816x1880	18,7	28,1	19						10	30,00	0,00012500			
27	Canon	Camera	Canon PowerShot SX50 HS	640x480; 1920x1080; 480x480; 281	4,55	6,17							,2	15,00	0,00050000	3,4	6,5	
28	Canon	Camera	Canon PowerShot SX30 IS	3072x2304; 640x480; 320x240; 160	4,55	6,17							,6	15,00	0,00031250	2,7	5,8	
				640x480; 3648x2736; 3648x2048; 2	5,58	7,44							,1	15,00	0,00025000	2,8	4,5	
				3072x2048; 2048x1360; 1536x1024									,5	30,00	0,00025000	1,0	91,0	
				640x480; 1920x1080; 480x480; 281	4,55	6,17							,4	15,00	0,00050000	2,8	5,9	
				3072x2304; 640x480; 3648x2736; 1	5,58	7,44							,7	15,00	0,00025000	2,8	4,5	
				640x480; 1920x1080; 480x480; 281	4,55	6,17							,4	15,00	0,00031250	3,5	6,8	
				2592x1728; 3456x2304; 5184x3456	24	36	2592						14	30,00	0,00012500	0,0	0,0	
				2592x1728; 3456x2304; 5184x3456	14,9	22,3							5	30,00	0,00025000	0,0	0,0	
				640x480; 2816x2112; 320x240; 400	4,55	6,17							4	30,00	0,00025000	0,0	0,0	
				640x480; 320x240; 1600x1200; 204	4,308	5,744							1	15,00	0,00040000	3,4	5,6	
				640x480; 1600x1200; 2592x1944; 4	4,55	6,17							,3	15,00	0,00066666	2,8	4,9	
				640x480; 4000x3000; 4000x2248; 1	5,58	7,44							,7	15,00	0,00031250	3,1	5,9	
													2	15,00	0,00050000	2,8	4,8	



# UAP photo/video: Analysis

## The intrinsic limits of photo analysis

Photo = projection + integration (4D → 2D)

Considering a scene observed through the objective of a camera, a photograph is the representation of the **reality in 4 dimensions** (N.B. depth and time) through conic projection and time integration onto a medium **in 2 dimensions** (i.e. height and width). Projection is a simple geometric concept, whilst time integration is performed during the period of exposure.

Therefore it is clear that one photo of a scene will not be able to provide all the information contained in the original scene. In-depth investigations will require additional information, which has to be extracted from various other sources.

Video = series of photos (time sampled)

The rendering of movements provided by a video is limited by the sampling process, which takes pictures so many times per second. Some of the spurious effects of this process are well-known, such as the wheel of a chariot, which seems to turn backwards (stroboscopic effect).

Here again, very quick movements may not be detected on a video, because of the limitations in temporal resolution.

Fake = unlimited possibilities

It has always been possible to build a fake photo that may resist analysis, but this used to be a tricky job with silver photography. Nowadays it is easy for even a lay person to play with each single byte of a digital document.

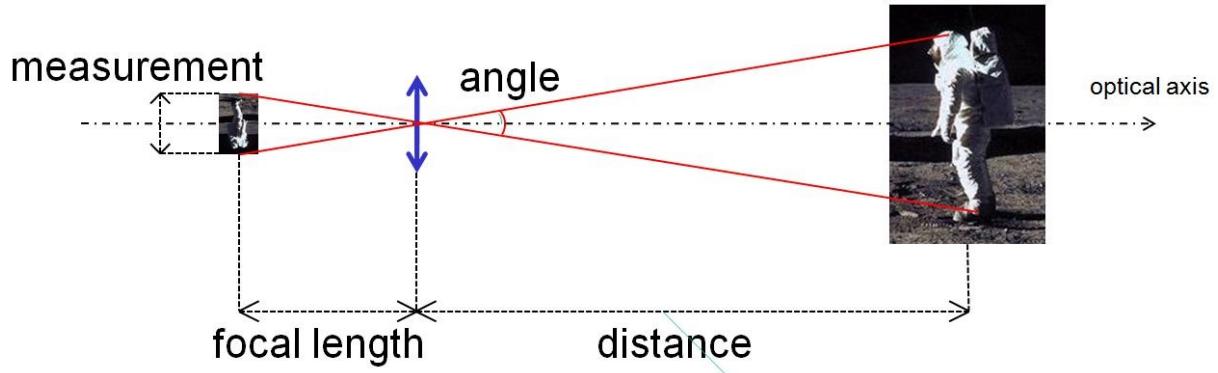
Conclusion

One photo/video will never be proof

... **but** it may still prove very useful!

# Possible measurements

## Angular measurements



### Required data:

- Camera's technical data and settings
- OR
- Original EXIF metadata (included in any digital photo)

### Direct measurements:

- Transverse angular dimension (angle, solid angle)
- Transverse angular velocity (long exposure or video)
- Transverse angular acceleration (video)

### Useful derived results:

- **Transverse dimension/Distance ratio**
- **Transverse velocity/Distance ratio**
- **Transverse acceleration/Distance ratio**

## Distance assessment

Considering an unidentified object visible on a picture, for which it is possible to compute the dimension/distance ratio, the main question is to determine whether it was big and far, or small and near.

There is no way to derive directly from a picture the distance of such an object from the camera, but limits may be established in several ways:

- Estimate from other identified and localized objects which may be obviously nearer or farther than the object (building, cloud...).
- Exploitation of cast shadow.
- Analysis of the depth of field: this technical parameter, which may often be derived from metadata, defines a range of distance between the lens and an object, inside which a photo is sharp (outside movement blur). Therefore it indicates, if the object under analysis does appear sharp or blurred, possible distance ranges between that object and the lens.
- Atmospheric propagation effects on apparent luminance: in a day picture, particularly one with diffuse lighting (dull sky), the laws of atmospheric propagation of light (diffusion and absorption - see all relevant equations on *ipaco.fr*) may be used to establish whether an unknown object was nearer or farther from the camera than another known object. This is particularly apparent if those objects have dark parts that, by absorbing nearly all incident visible light, may be approximately considered as analogous to "black bodies".
- Atmospheric diffusion effects on sharpness: depending on weather conditions, atmospheric diffusion effects on apparent sharpness of contours may be brought out and compared between various reference objects and the analyzed object, which leads to the derivation of a range of possible distances between that object and the camera.
- Flash range: on a picture taken by night, if an object appears lit by the flash, its distance from the camera cannot be further than the flash range.

From the assessment of a possible range of distance from the camera, it is therefore possible to derive ranges of:

- Transverse dimensions (photo, video)
- Transverse velocity (long exposure photo, video)
- Transverse acceleration (video)

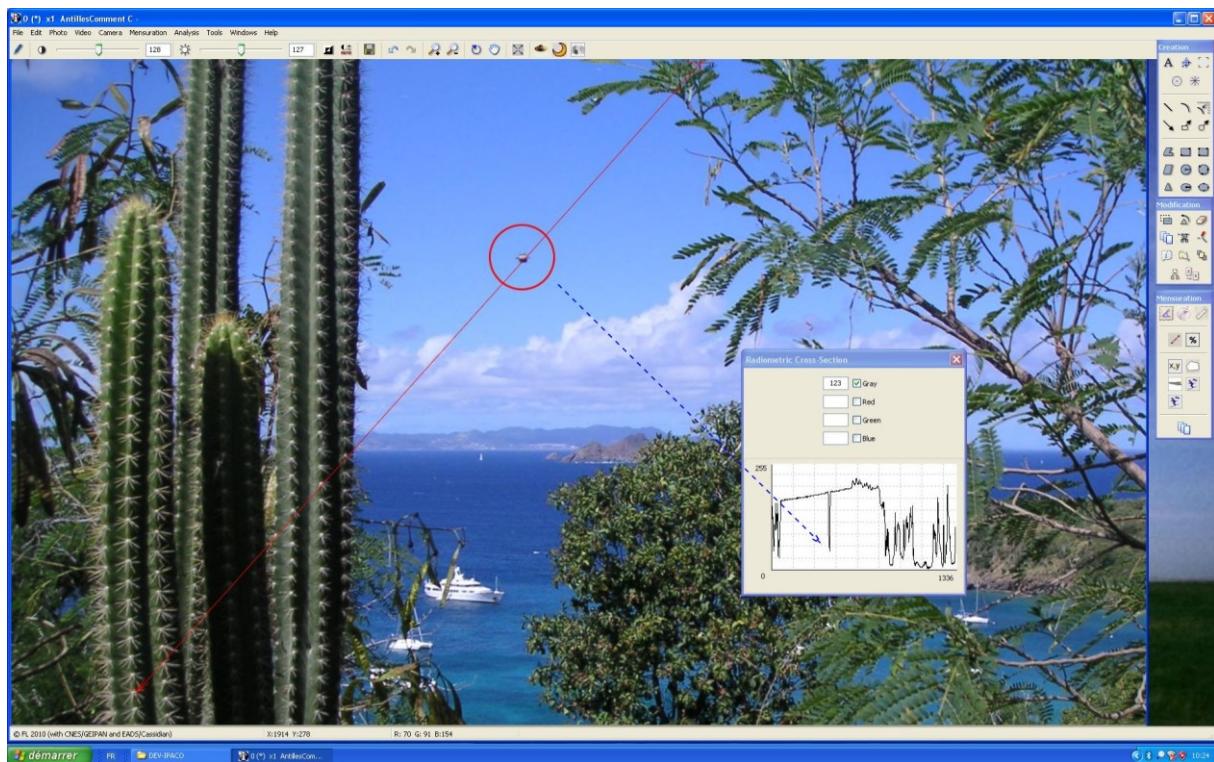
# Distance assessment from estimates of luminance

Measurement of levels (red, green, blue, gray):

- On one pixel
- In a given area (statistics)
- Along a segment (*radiometric cross section*)

## Useful derived results:

- Comparison and ordering of respective distances of different objects from the camera
- Range of possible transverse dimensions (and sometimes velocity, acceleration) for the object under analysis



*Radiometric cross section (IPACO)  
The dark object in the sky, very close to the camera, is an insect*

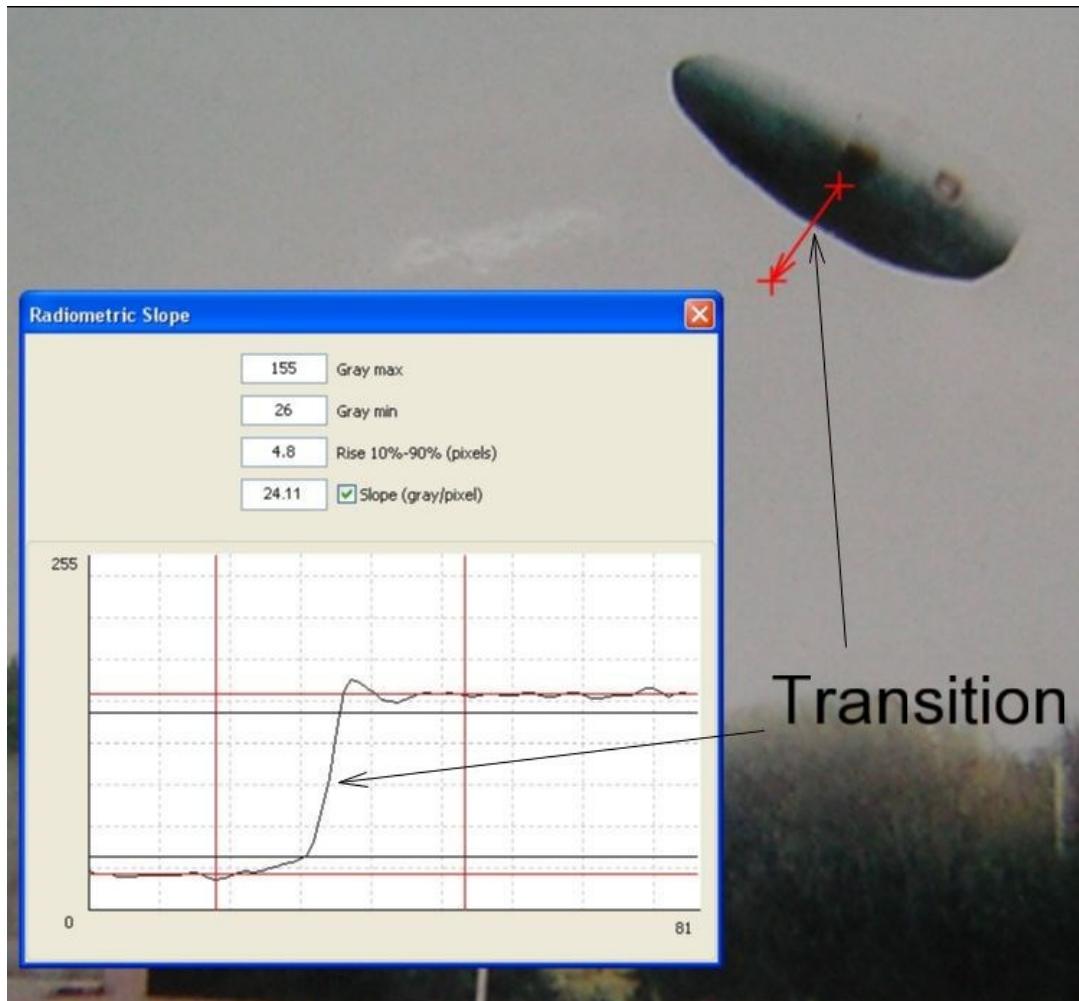
## Distance assessment from sharpness assessment

Estimate of the sharpness or blurredness through the analysis of contours:

- Transition along a segment perpendicular to a contour (*slope measurement*)

### Useful derived results:

- Comparison and ordering of respective distances of different objects from the camera
- Range of possible transverse dimensions (and sometimes velocity, acceleration) for the object under analysis

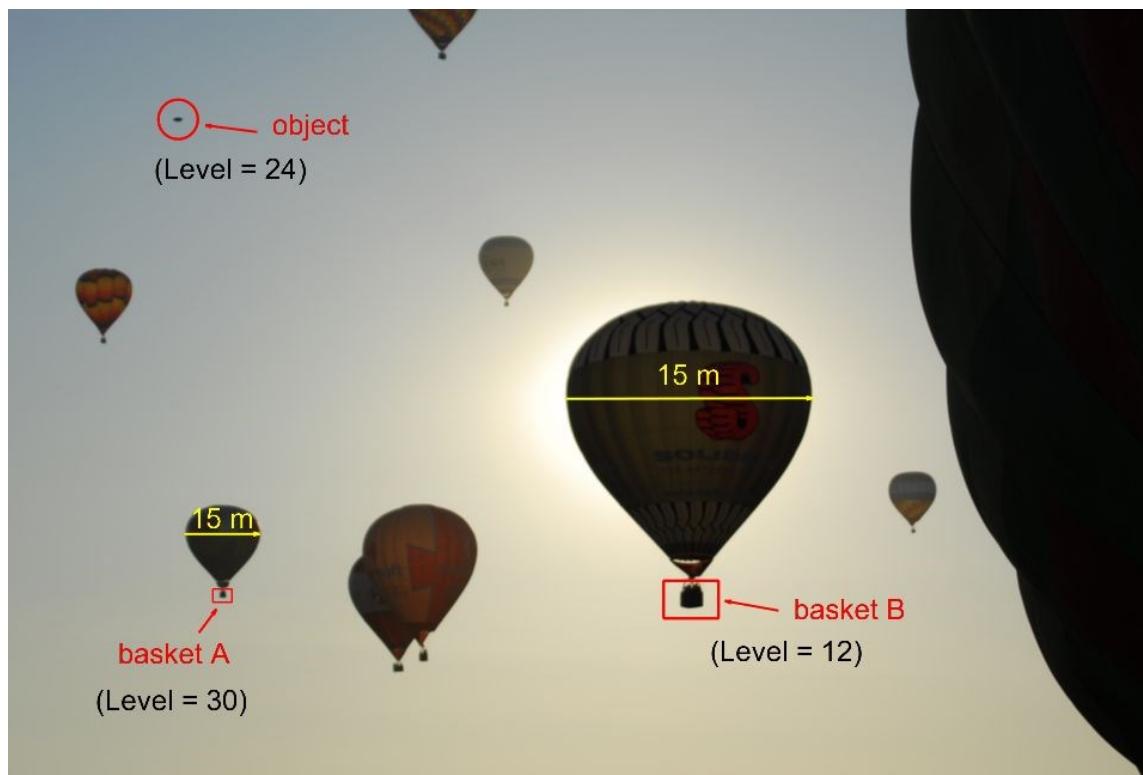
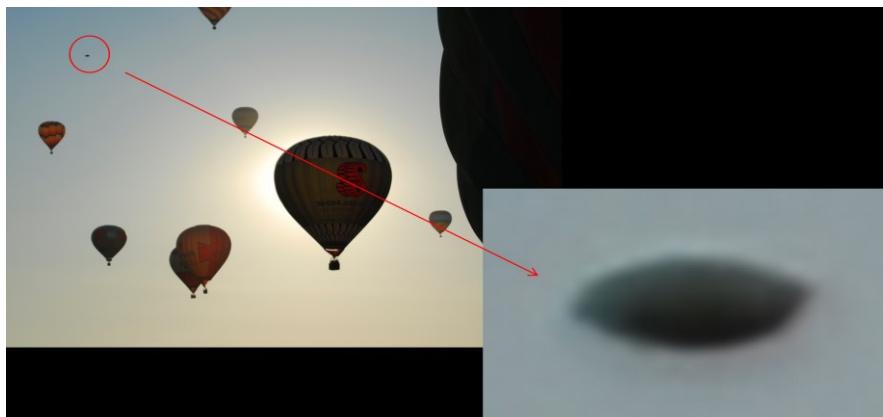


Slope measurement across a contour (IPACO)

## Example of analysis: the Chambley case

In August 2007, as every year, the French town of Chambley hosted an international hot-air balloon competition. One particular picture displayed a flying object having obviously nothing to do with a hot-air balloon.

The analysis of gray levels of darks areas and the knowledge of the standard size of a hot-air balloon's diameter (15 m) led to the conclusion that this object was around 300 m away from the camera, with a size of the order of 80 cm, thus being probably a child's balloon.



Later on, a proper on-site investigation was able to identify the child's balloon's owner, and to confirm these conclusions and figures.

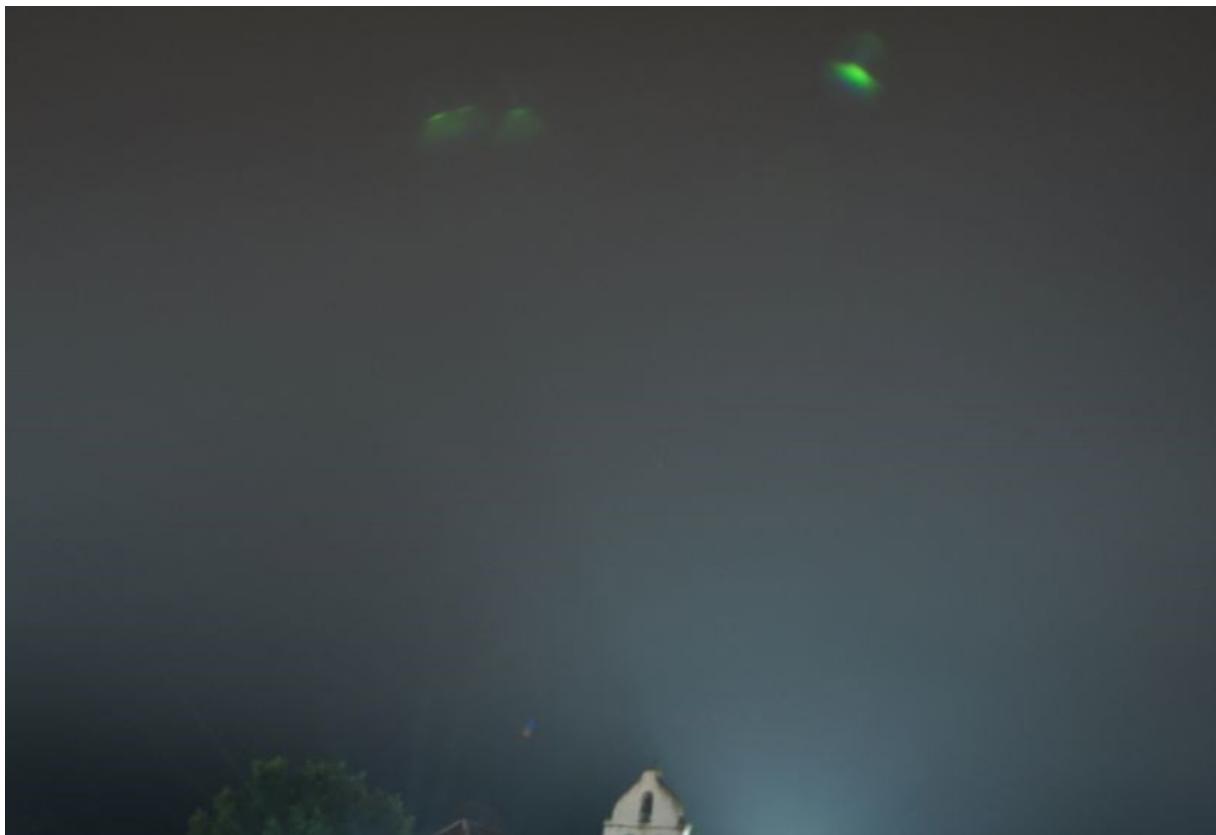
## IPACO's dedicated analysis tools

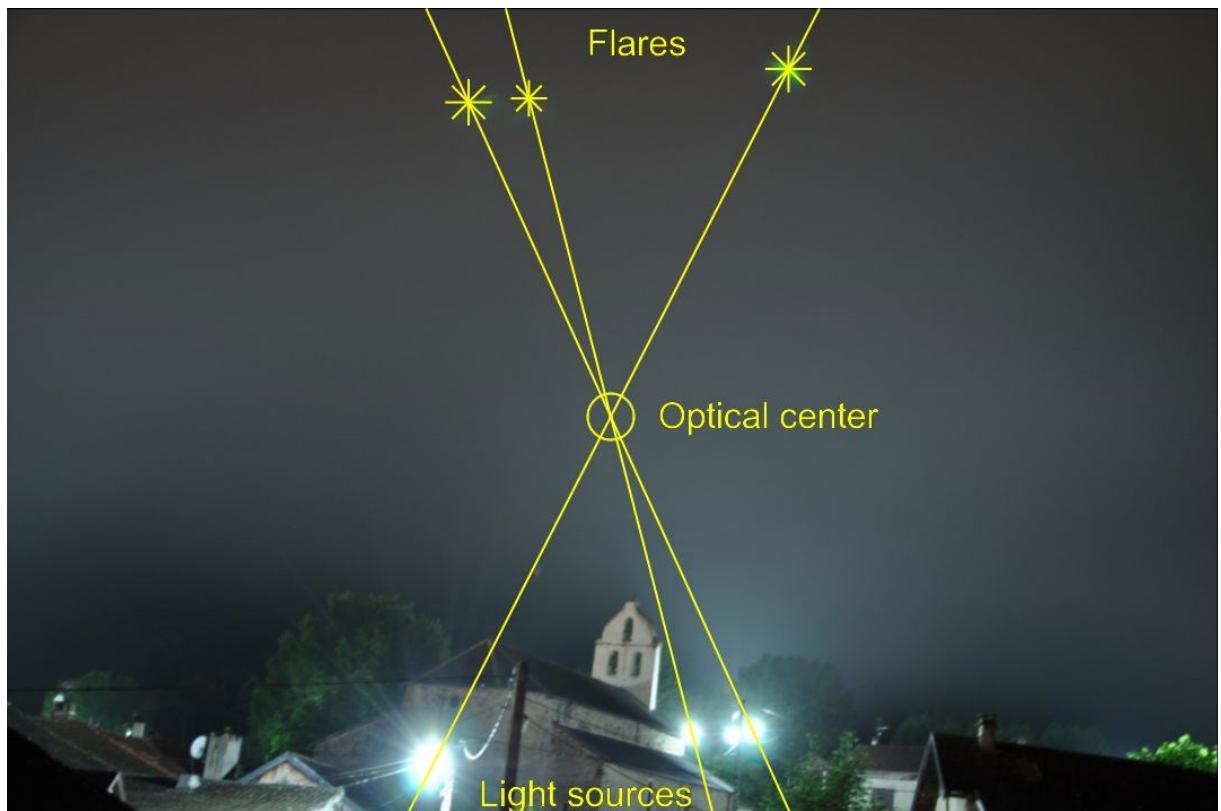
### Quick detection of lens flares

Sometimes strange luminous shapes appear on pictures shot at night, although nothing particular has been observed. The origin can be the reflection of light in the camera's lenses (lens flares).

Such flares can be recognized as follows: the straight line which connects each flare with the corresponding light source always passes through the optical center of the image (which in turn is most of the time very close to the geometric center of the image). A flexible dedicated tool enables IPACO's users to bring out this characteristic graphically.

The following picture was shot in Ariège (French department).





*Evidence of lens flares*

## Detection of a suspending thread

Uncovering a classic type of hoax, produced by shooting a model hanging by a thread, is sometimes tricky or even impossible, depending on the thinness of the thread as well as on its distance from the camera. In certain cases, classic image processing tools (contrast enhancement, high-pass filtering) do enable visualization of the thread, but this approach often proves to be insufficient.

An original and more powerful method may be used, in particular if, in the area where the thread could be present, the sky's background is relatively uniform and may be compared to "noise" (i. e. noise from atmospheric diffusion and/or digitization noise). This method consists of increasing the signal-to-noise ratio by summing columns of pixels parallel to the thread, in a chosen area above the alleged UAP.

The "Vertical thread" tool implemented in IPACO was applied to the two well-known photographs from McMinnville (Oregon, May 1950), which had been analyzed by many specialists worldwide, including, lately, by the "IPACO team" (full report on the website). The upshot was a strong suspicion that a small object was hanging from a power cable, but the presence of a suspending thread had never been formally revealed thus far.

The result obtained from IPACO was the evidence, with a very high probability, for a thread to be present in both McMinnville pictures, with an angle of ca.  $-11^\circ$  from the vertical.

The following snapshots illustrate the method in 5 steps.



*McMinnville pictures*

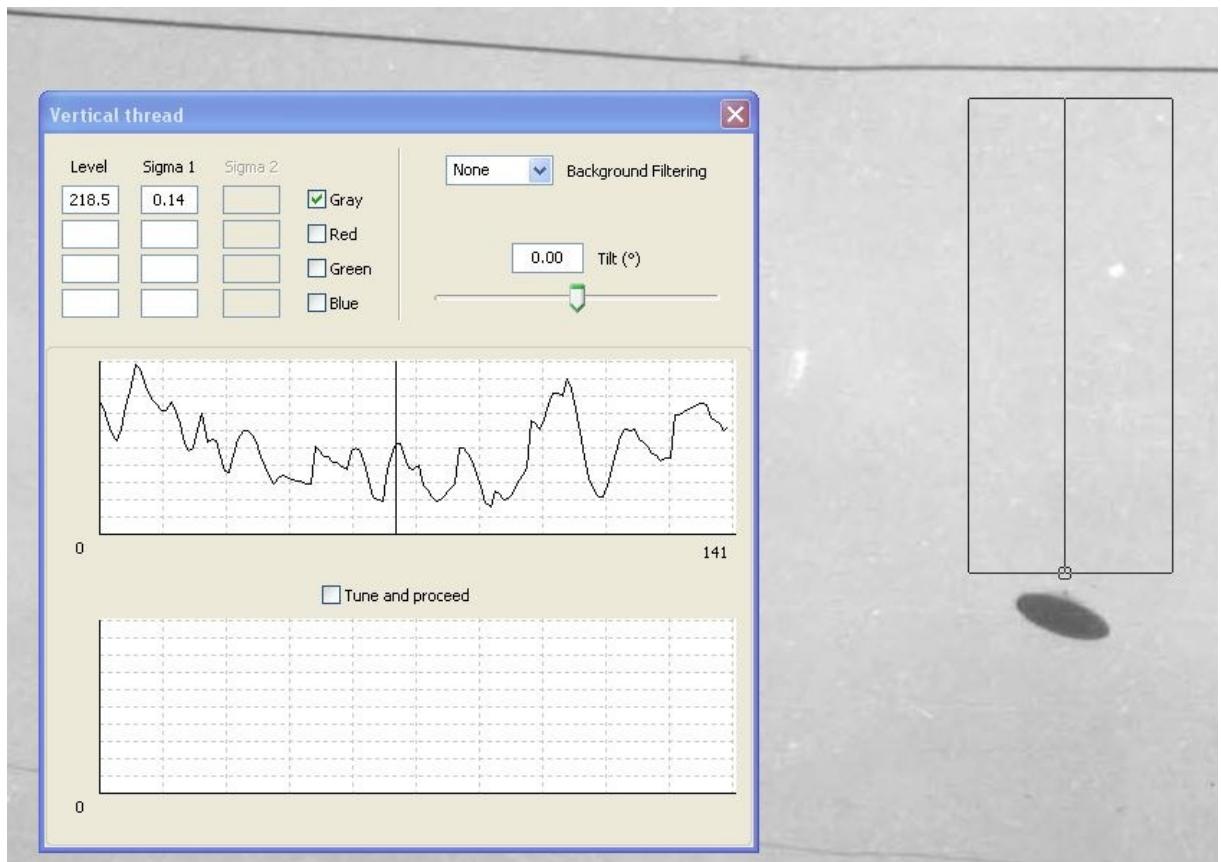
## **Step 1**

Designate a vertical rectangle above the alleged UAP, covering the area where a thread is likely to be present. A curve is displayed in a window, showing the mean value of pixels in each column of the rectangle.



## **Step 2**

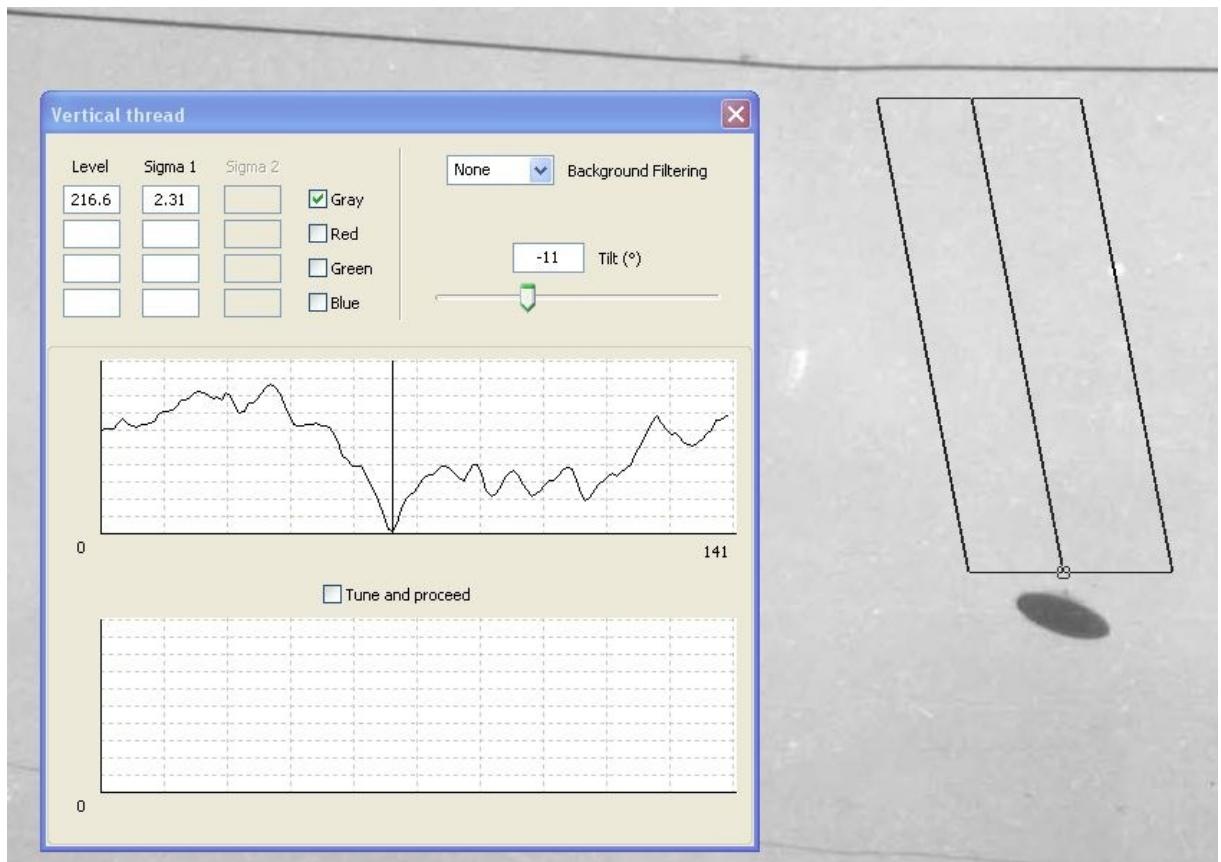
Slide the cursor along the rectangle's lower side in the image and monitor the vertical bar at the corresponding position of the curve. Position the cursor at the location of the supposed attachment point of the thread. If there is a thread perfectly vertical with reference to the picture, and if the obtained increase of the signal-to-noise ratio is sufficient, the curve displays a peak in front of the bar, which is positive or negative depending on compared gray (or color) levels of the thread and the sky's background. The mean value of the pixels of the column corresponding to the bar's position is permanently displayed, as well as the gap between this value and the curve's mean, normalized by the standard deviation (number of sigma).



### **Step 3**

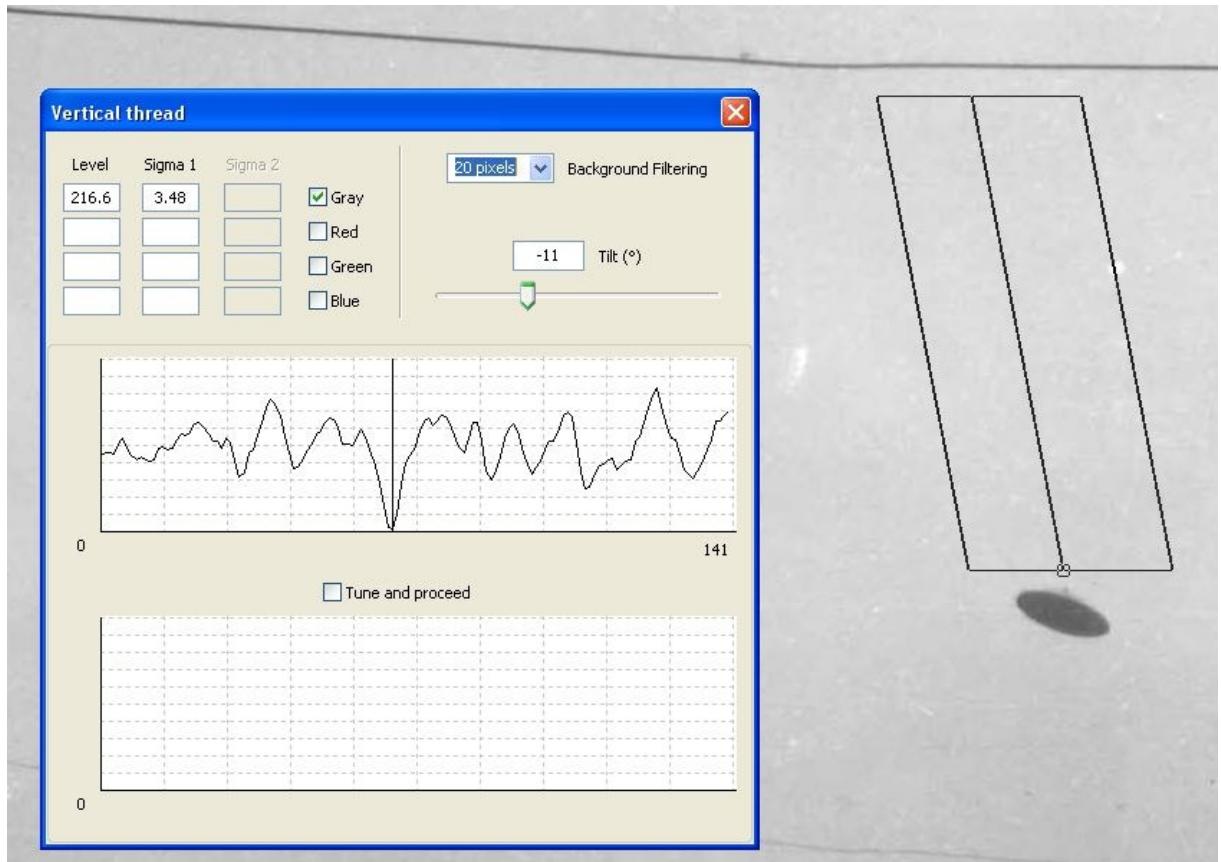
In general, a suspension thread is typically not strictly parallel to the picture's vertical axis, thus nothing significant appears at this stage. The tool, however, enables the reference rectangle to be tilted by an angle between  $-30^\circ$  and  $+30^\circ$  from the vertical. More precisely, the rectangle is changed into a parallelogram, the lower side of which remains fixed and the height constant. The pixel summing columns are also tilted by the same angle, with the curve changing as the angle is modified.

It is then possible to check whether an angle exists for which a significant peak appears in front of the supposed location of the attachment point. Such a peak indicates the probable existence of a thread, especially if the gap between this peak and the mean value is noticeably significant.



#### **Step 4**

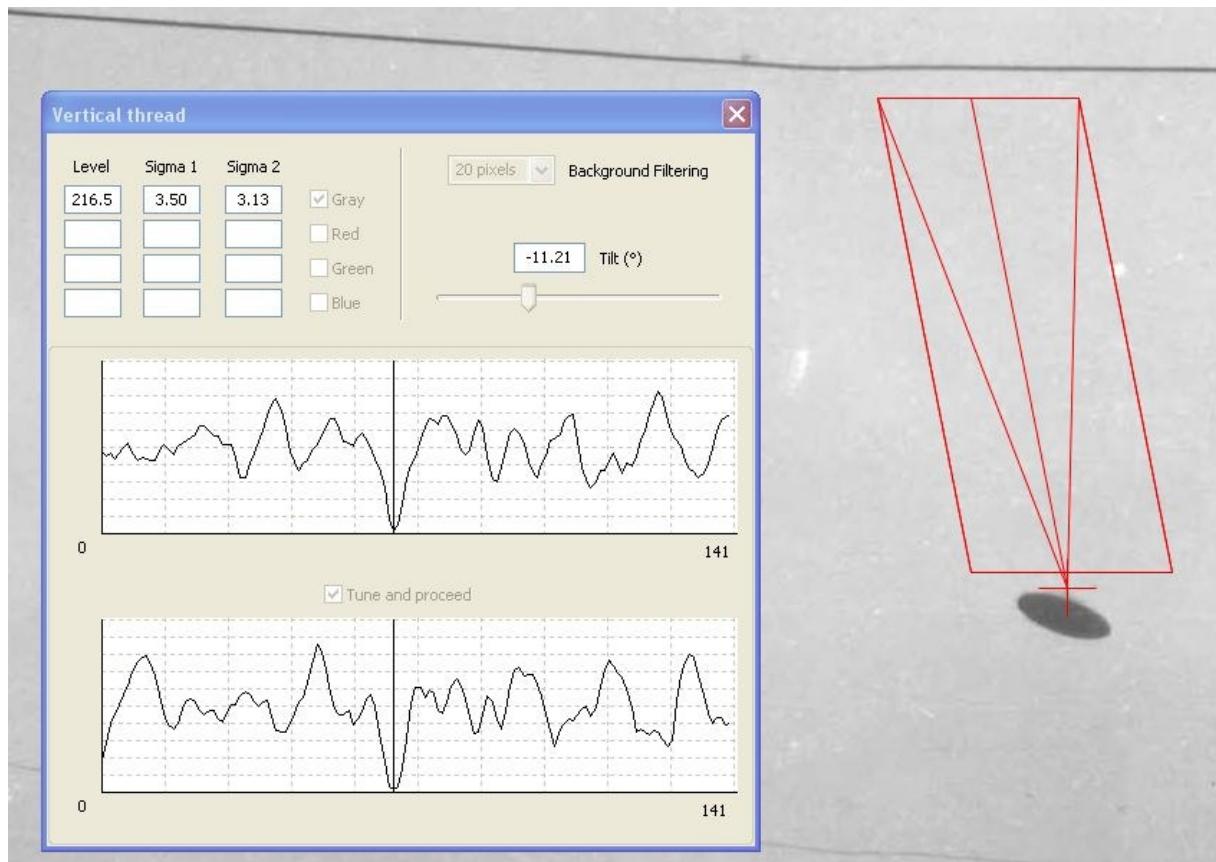
If the curve shows slow variations, for instance due to vignetting, it is possible to get rid of them through spatial high-pass filtering, obtained by subtracting from it a copy of the same curve previously smoothed by a low-pass spatial frequency filter (convolution by a rectangular window). This provides a more significant standard deviation value.



## Step 5

If a peak is indeed present, the tool can then launch an automatic optimization which will accurately tune the tilt angle and the bar's position, so as to obtain a maximum value for the difference between the peak and the curve's mean value.

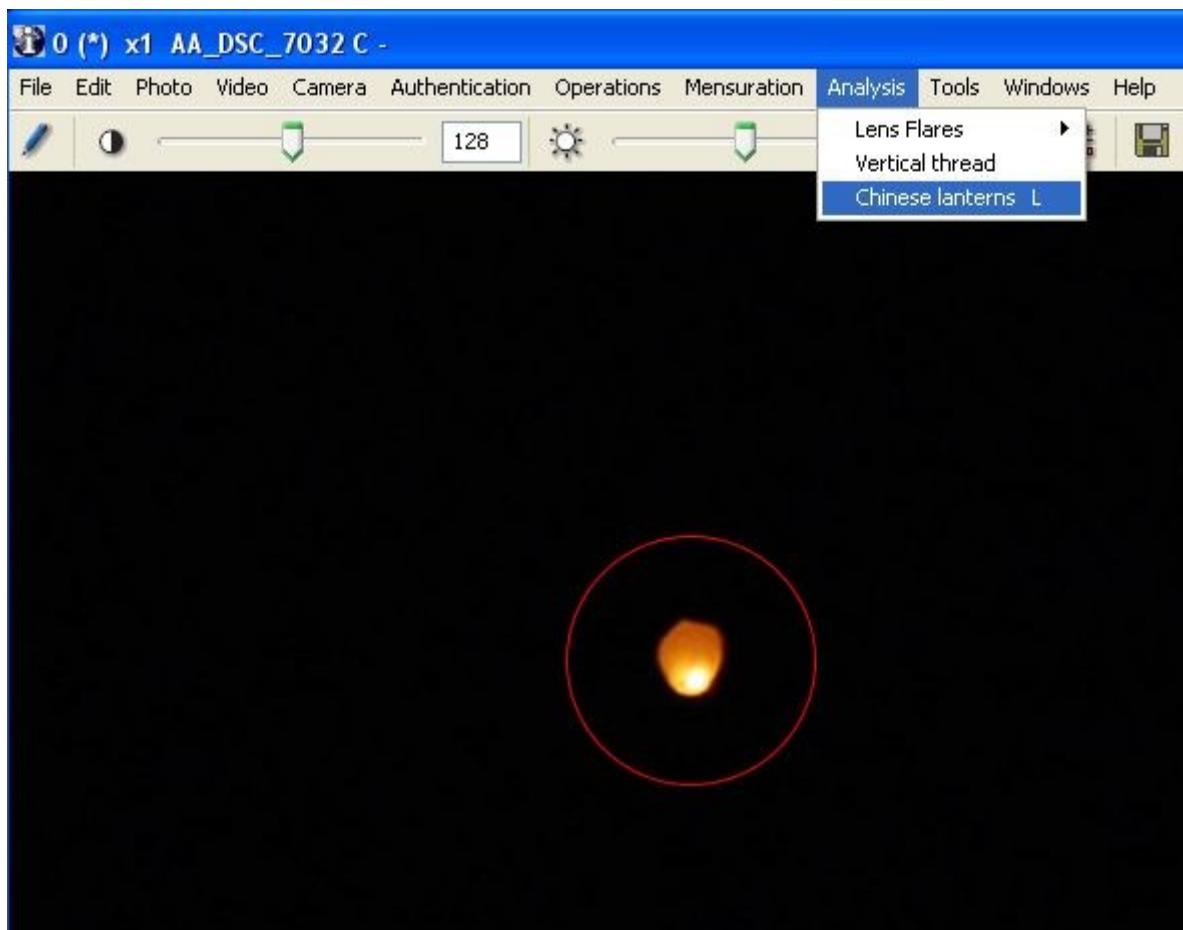
If the results tend to confirm the existence of a thread, the tool also enables an extra verification to be performed. Based on the most probable straight line for the thread's location and also on the supposed position of the attachment point on this line, a circular scanning is performed around this point: pixels of the columns taken into account for the summation are those contained in the parallelogram. A second curve is then displayed in the window, showing the mean value of each column's pixels during the circular scanning. If another peak appears, corresponding to the previously found angle, the probability of existence of a thread is doubly established, especially if the difference between the new peak and the second curve's mean value is significant.



A very similar result is obtained for the second McMinnville picture, which confirms the demonstration.

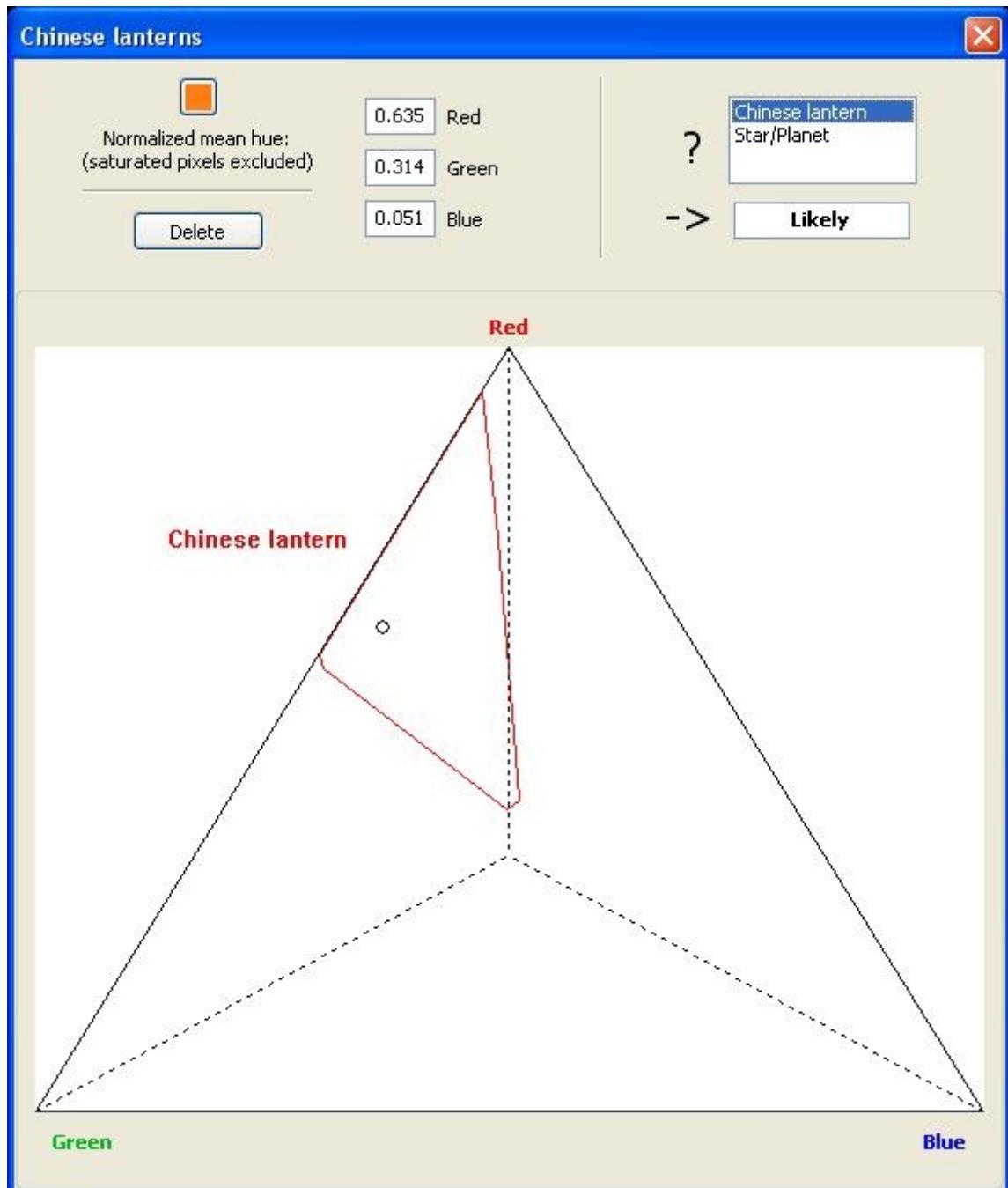
## Detection of a Chinese lantern

Nowadays, countless sincere reports stem from the nocturnal observation of Chinese lanterns in flight. In order to ease the frequent processing of such trivial cases, a specific tool has been implemented in IPACO. This tool does not produce a formal proof, but it gives an invaluable indication of the probability of an explanation being provided by the presence of a Chinese lantern in the sky.



The principle consists of designating the light source, computing the mean RGB levels of those pixels of the source that are not saturated, correcting them from the sky background values around and deriving the mean chromaticity of these pixels. This mean value of the chromaticity is then displayed in the « Maxwell triangle » and compared to characteristic zones of certain types of light sources (lanterns, stars/planets, aircraft...). These zones have been built up from a large number of night pictures of the sky showing light sources the nature of which is known, using a large variety of cameras or smartphones with different settings. It will be possible to refine these with growing exploitation of this technique.

If the mean chromaticity of the light source under study only falls within the « Lantern zone », the **likely** explanation is provided by it being due to a lantern. If it falls within the « Lantern zone » and also within one of the other zones, the explanation is deemed **possible**. Finally if it falls totally outside of the « Lantern zone », the explanation is presented as of it being **unlikely**.



### Chinese lantern



Normalized mean hue:  
(saturated pixels excluded)

0.399 Red

0.302 Green

0.298 Blue

Delete

?

->

Possible

Chinese lantern  
Star/Planet

