Image classification of night time images detected from the International Space Station

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Image classification:

Right now there are around 1.800.000 images at the Johnson Space Center database (The Gateway of the Astronauts) and around of 1.200.000 images came from the ISS (date 20/02/2014). Although, the classified images are a number much smaller and there no archive of georeferenced images. There is a project to classify the day time images (Image detective). But, the techniques that are used in this project are not use full for the classification of night time images. The reason is that the patterns on earth are not the same during the day and night. That's why it's need it other technique to classify night time images.

Moreover, on the research of night time images also are interesting the star fields (Zamorano el al. 2011).

Automatic classification techniques of images:

Classification based on the ISS nadir:

The vertical of the ISS it's a point called Nadir. This position it's possible to be calculated approximately using the time when the image was taken. Also, the JSC give this information some times in their database.

Although, this positions it are only and first approximation and the place that have been captured can be beyond 300 km (187 miles). This effect can produce false positives or negatives depending of tolerance to the moment selected for the instant of the sun set or the sun rise.

This position can be used to classify the images taken from the ISS. Based on the fact: if the sun is over the horizon is not a night time image. Also can be interesting to know if the moon is also over the horizon and the phase. In order to make this calculus, can be useful the python packaged pyephem. We must take account that the time on the EXIF information of the images is on Universal Time (UT).

Classification based on the statistics of the image (histogram):

This technique was explored by J. Gómez Castaño and A. Sánchez de Miguel, cited by M. López Cayuela 2012 Degree Thesis (2012) – in Spanish. This technique it's based on the great number of dark pixels on the night time images. Although, this technique produce a lot of false positives when the astronauts take pictures near the horizon during the day time or pictures

inside the ISS or non-terrestrial images. Also, they can produce false negatives when high resolution images are taken. The high resolution images of big cities don't present places without population, so there are no dark places.

After the automated classification it is need it a manual classification.

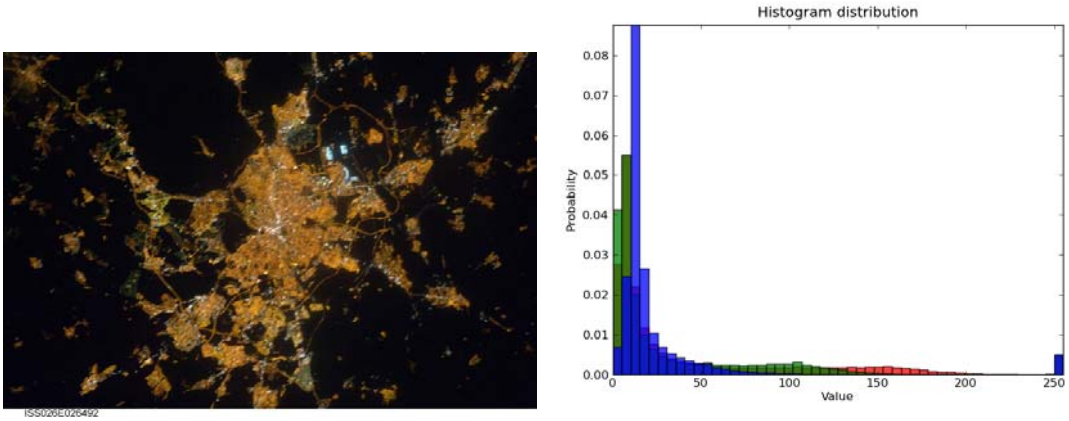

Figure 1 Histogram of a night time image. The mode it's a bit low, a round 11.

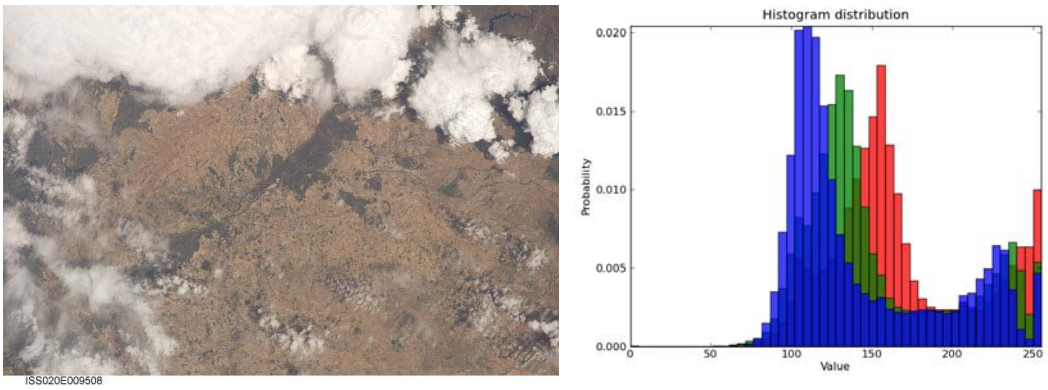

Figure 2 Histogram of a day time image. It's clear that the mode it is clearly higher that on the night image. A round 111 counts.

We need to distinguish between these categories.

Images of earth with cities.

Figure 3 Example of night time images of cities.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-41063.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-44501.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-10481.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-44520.jpg

Night time images of earth without cities.

Figure 4 Example of night time images without cities.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS034/ISS034-E-45243.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-137690.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-130127.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-158151.jpg

Images of stars:

Figure 5 Example of images with stars.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-149149.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-6460.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-5619.jpg

Images of auroras:

Figure 6 Example of an image of an aurora.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-116196.jpg

Day time images of earth.

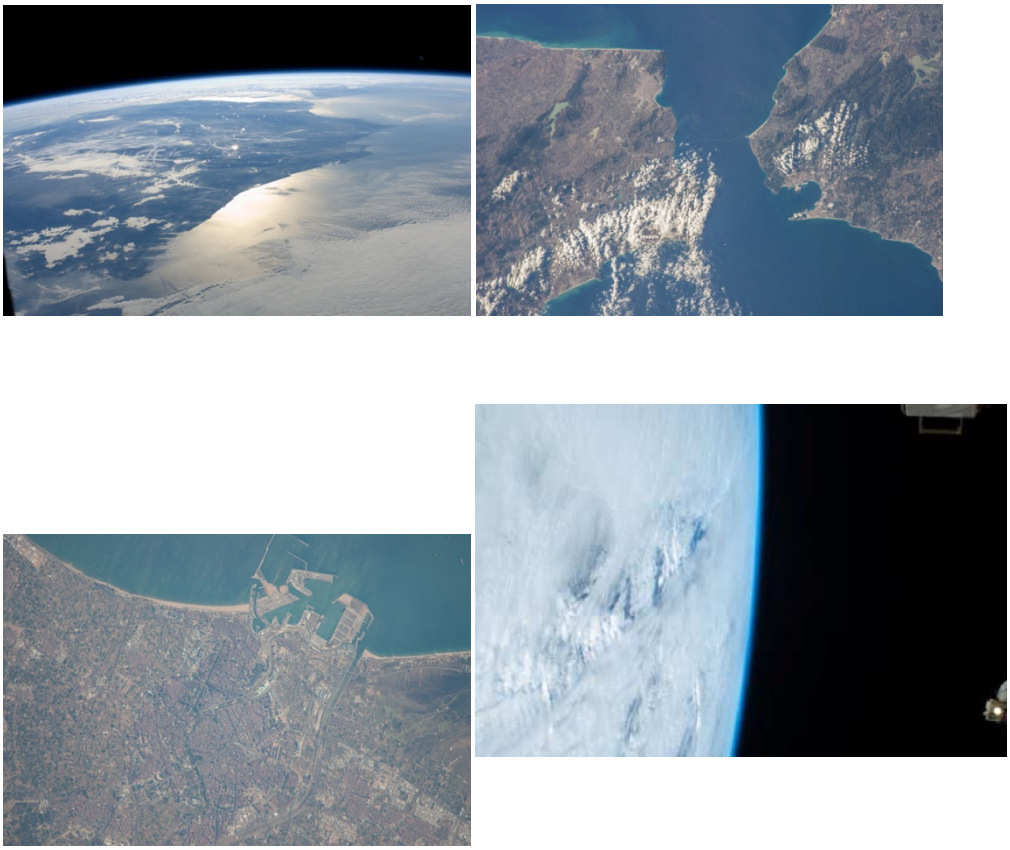

Figure 7 Examples of day time images.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-512.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-20373.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS038/ISS038-E-28104.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-5411.jpg

Infrared images.

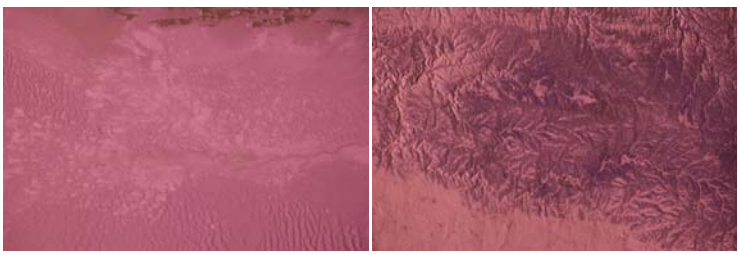

Figure 8 Example of infrared images. They are clearly more red than normal images.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-41672.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-41549.jpg

Moon and other celestial bodies.

Figure 9 Example of images of the moon from the ISS.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-170022.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-275771.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-147343.jpg

Sunsets and sunrises:

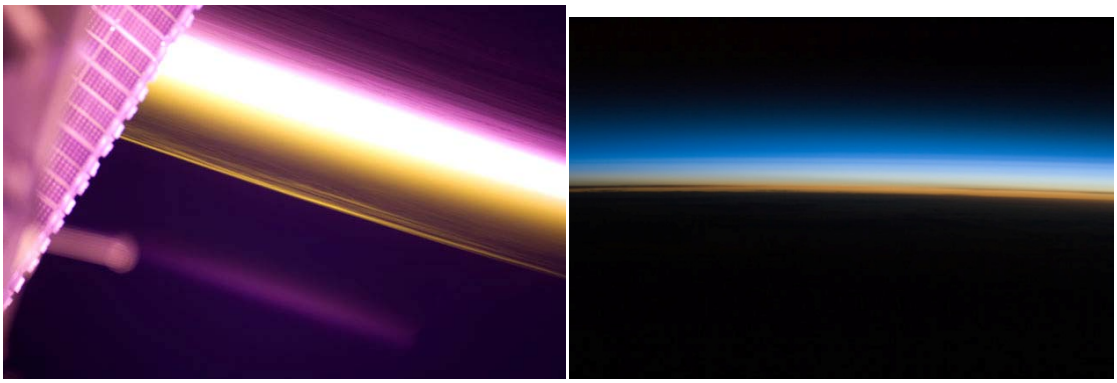

Figure 10 Images of the sunset or sun rise from the ISS.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-31485.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-37642.jpg

Inside the ISS:

Figure 11 Examples of images taken inside the ISS.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-7551.jpg

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-32252.jpg

Other (combination previous categories).

Figure 12 Example of one image with stars, infrared and storms.

http://earth.jsc.nasa.gov/sseop/images/ESC/small/ISS030/ISS030-E-21177.jpg

Stars, infrared, cities, and storms.

Georeferenciation:

First step.

As we have explain on the introduction, based on the time that the picture was taken and the coordinates given from the JSC we can know approximately where was taken the images. Although, the astronauts don't shoot only to their nadir. So, sometimes the center of the images can be more than 300 km (186 miles) from their nadir. That's why we have to inspect around to find the center of the image. Because the maps and the day time images are very different of to the night time, we will use the images of the satellite SUOMI-NPP and its instrument VIIRS/DNB.

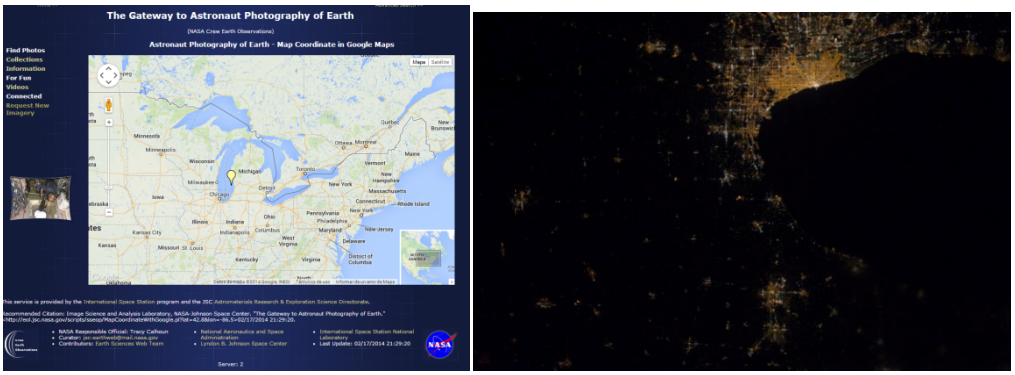

Figure 13 Example of the precatalog coordinates from the JSC.

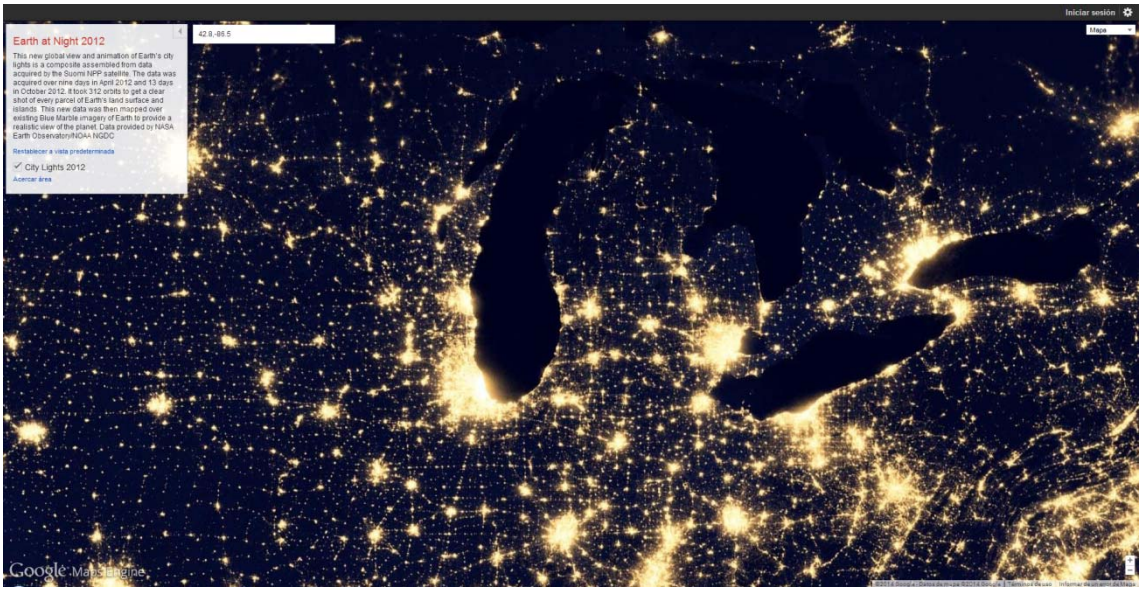

Figure 14 Example of the image of the SUOMI-NPP VIIRS/DNB on the Google Earth Galery. Center on the saame coordinates of the figure 13.

http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS030&roll=E&frame=51845

https://mapsengine.google.com/10446176163891957399-13737975182519107424-4/mapview/?version=2&hl=es

Full georeferenciation.

We need to make a high quality georeferenciation, so we need no change the shape of the image. So we will capture the geographic coordinates that correspond to some coordinates X and Y of the image. On the zoom out or low resolution images we will use the night layer, but on the high resolution ones we will use the day time images or the street maps.

Figure 15 Example of control points using the SUOMI Image

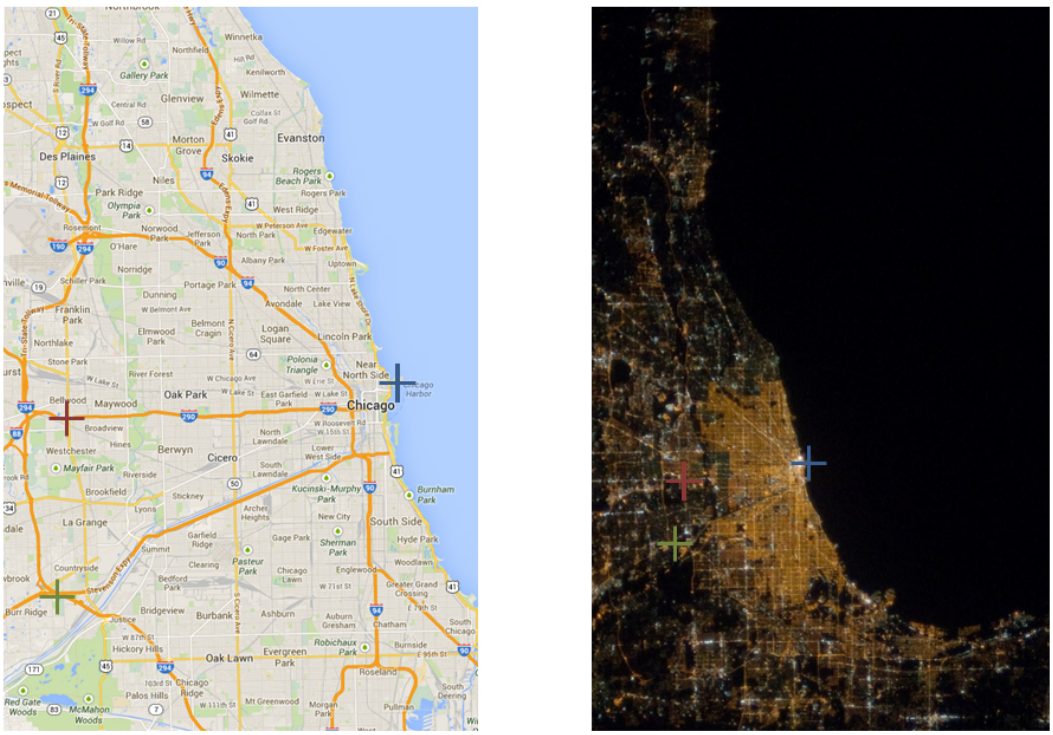

Figure 16 Example of control points using the google maps street map.

Other interesting aspects of the classification.

Also there are some other aspects that can be interesting to take account. As can be the presence of clouds or the sharpness of the images.

Figure 17 Blurred image of Madrid but clear.

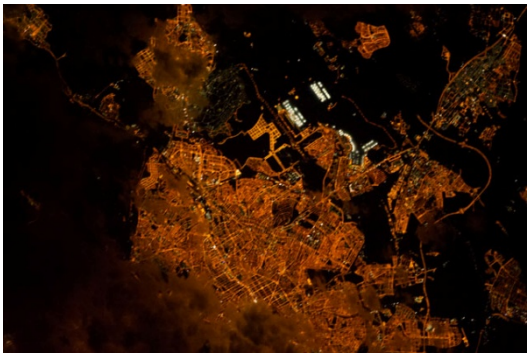

Figure 18 Clouds on the 30% of the image buts it is a very sharp image.

Fields that should be on the database:

ID of the classification: Number of classification. Example: 10000.

ID of the image on the ISSNight database. Example: ISS030-E-51845

ID of the IMAGE: ID of the image on the JSC database. Example: ISS030-E-51845

Nadir JSC: The **nadir** is the direction pointing directly *below* a particular location. Based on the JSC information. Example: Nadir Latitude: **42.8** Nadir Longitude: **-86.5**

Nadir TIME: The **nadir** is the direction pointing directly *below* a particular location. Based on the time of the camera and the orbit of the ISS.

Country: Country we is the centre of the center of the image.

Place: The name of the nearest recognizable place on the image.

Orientation: Where is the north on the image.

Comments: Particular things characteristics of the image. Presence of reflections or other things.

Link to the image: Link to de original JPG on the JSC web.

Author of the classification: User ID.

Quality: sharpness of the image.

Lens: AF Nikkor 50mm f/1.4D

Focal length: 50.0 mm

Camera model. NIKON D3S S/N: 2008336

Shutter.Example:1/40

Aperture. Example:1.4

ISO. Example:10000

Already classified by JSC: Boolean.

Other references: Twitter, new or papers. Example:

https://twitter.com/PC0101/status/435784019024703488/photo/1

Tilt: Example: 50º

Tags: Tags corresponding to the normalized classification. Example: Cities at Night.

Control points Image (pixels): Coordinates on X and Y. Example: 200.39, 300.89

Control points on earth (decimal degrees): Geographical coordinates of the image Control points. Example: 40.365, -3.765

Sun Elevation Angle: **-60** *(Angle in degrees between the horizon and the sun, measured at the nadir point)*

GMT Date: **20120129** *(YYYYMMDD)* GMT Time: **071621** *(HHMMSS)*

Resources:

Website of JSC:

http://eol.jsc.nasa.gov/

URL large images: http://eol.jsc.nasa.gov/sseop/images/ESC/large/ISS026/ISS026-E-35953.JPG

URL small images: http://eol.jsc.nasa.gov/sseop/images/ESC/small/ISS023/ISS023-E-29061.JPG

URL of the thumbs: http://eol.jsc.nasa.gov/sseop/images/thumb/ISS030/ISS030-E-9660.jpg

URL of the record card of the image:

http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS030&roll=E&frame=51845

URL exif data: http://eol.jsc.nasa.gov/sseop/camera/ISS030/ISS030-E-51845.txt

Usefull libraries:

Pyephem: http://rhodesmill.org/pyephem/

References:

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