ESPE

UNIVERSIDAD DE LAS FUERZAS ARMADAS

INNOVACIÓN PARA LA EXCELENCIA

USING COMPUTER VISION TECHNIQUES TO GENERATE EMBEDDED SYSTEMS FOR MONITORING VOLCANOES IN ECUADOR WITH TRAJECTORY DETERMINATION

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Using Computer Vision Techniques to Generate Embedded Systems for Monitoring Volcanoes in Ecuador with Trajectory Determination

- Ecuador is a country with a great number of volcanoes.
- The government Ecuadorian estimated necessary the monitoring constant of them volcanoes, however, all the process is manual.
- By this reason is created an algorithm that will allow detect the presence of flows, as well as the trajectory of the themselves

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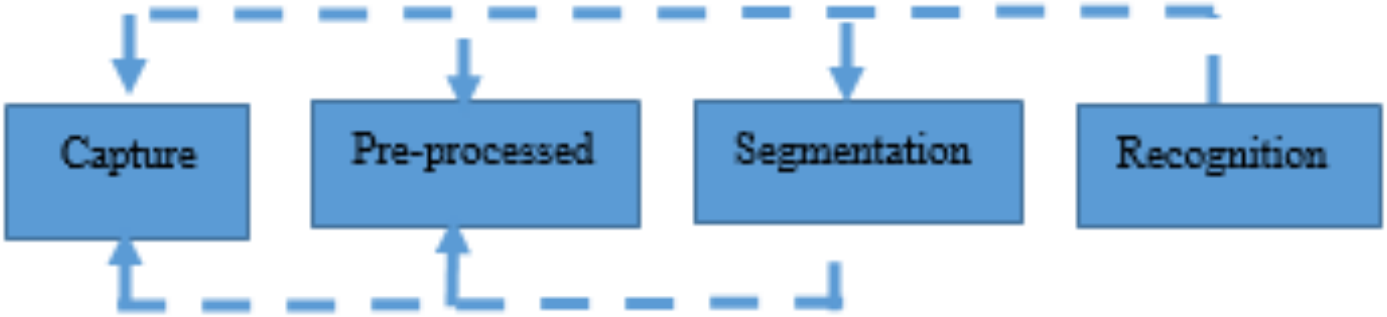

Using Computer Vision Techniques to Generate Embedded Systems for Monitoring Volcanoes in Ecuador with Trajectory Determination

- Create an algorithm robustness:
  - over occlusions
  - Different geometries
  - Different scales.
- Capable to process in real-time large images of eruptions volcanic.
- Use of the Hotelling transform to determine the trajectory of lava flows

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References

- In Mexico it is working on a satellite for the monitoring of the Popocatepetl volcano

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There is not much information related to the monitoring of volcanoes through artificial vision systems, but with this research we hope to make way for more advanced algorithms.

Using Computer Vision Techniques to Generate Embedded Systems for Monitoring Volcanoes in Ecuador with Trajectory Determination - Experimental

- Capture.
- Change Color Space.
- Pre-processed.
- Segmentation.
- Recognition.
- Hotelling transformed.

Capture.

- Acquisition of digital images through some type of sensor, is used a camera with sensor CCD.
- Is important that the sensor present features relevant and necessary as robustness facing the noise produced in environments hostile or by changes of light.

Change Color Space

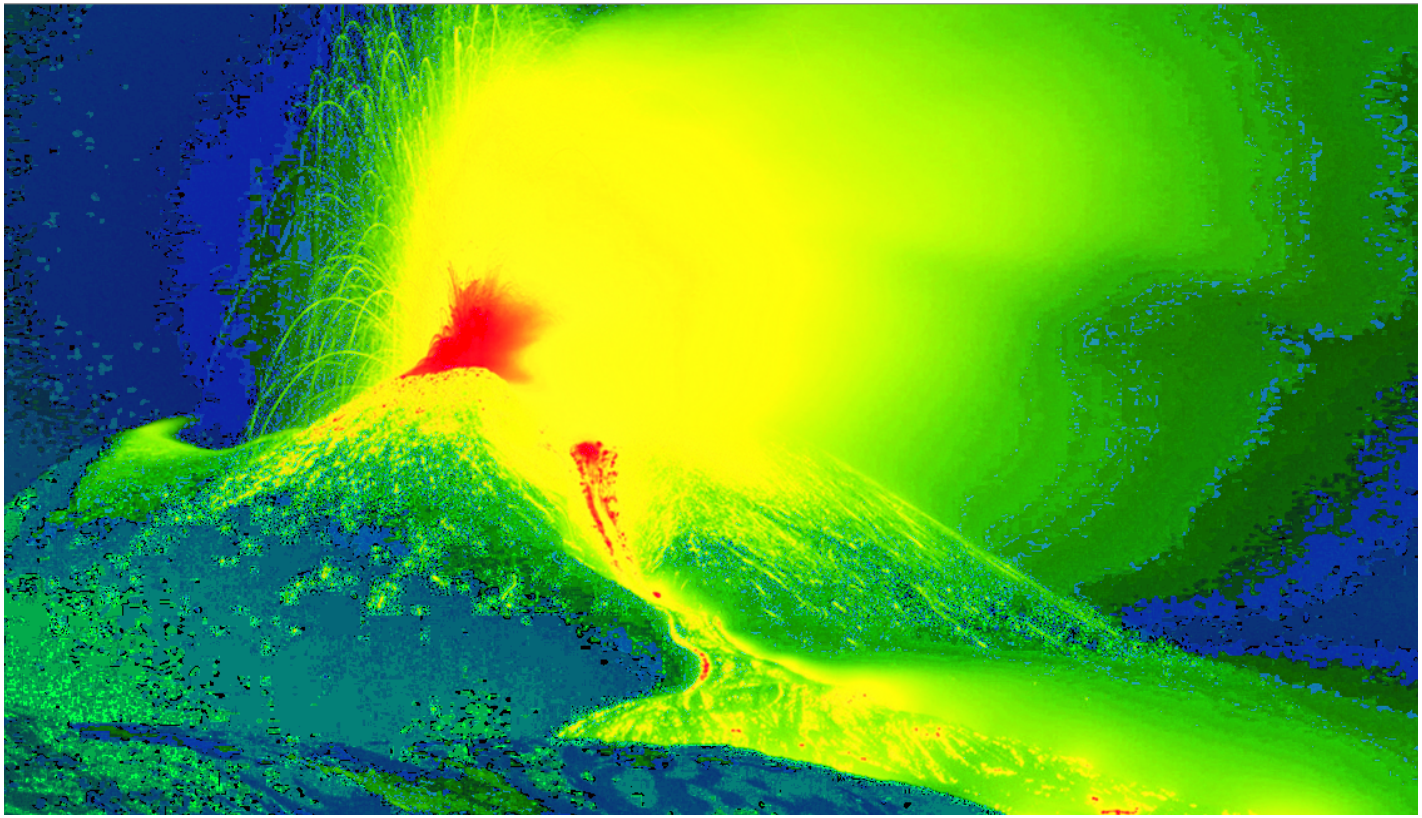
- Usually the images captured by cameras are in Red, Green, Blue (RGB) color space, but is necessary change it to Hue, Saturation, Value (HSV) color space for more robust monitoring,

- The primary advantage is the isolation the brightness into a single channel (Value), leaving only the hue (tint) and the saturation channels for the analysis.

Change Color Space

1) Image in RGB space color.

Change Color Space



2) Change image in HSV space color.

Pre-processed

- Prepare the image by removing the non-useful parts and/or enhancing the parties of interest.
- Uses the thresholding and binarization to separate the background of the image to focus us in the cone of the volcanoes
- For edge analysis it is necessary to use the Canny command, this method analyzed the image to extract the specific characteristics of the region of interest.

Segmentation

- Isolate elements of interest for its subsequent interpretation, through operations morphological for obtain relevant specific characteristics

Recognition

- Distinguish the different objects segmented according to their characteristics, framing areas that are of interest to analyze them using the Hotelling transform to describe their paths in the case of pyroclastic flows.

Hotelling transformed

- Is a transformation that allows reduce the information redundant in the images through the use of algorithms statistical-mathematical
- The objective of this technical is reduce all the information unnecessary contained in a original set of N bands to a smaller set of new bands or components
- The objective general of the PCA is reduce a group of variables and transform it in a joint smaller without losing a part significant of the information original

Hotelling transformed

- Calculation of principal components [Eq.1 Eq.2], factor extraction [Eq.3] and percentage of variability [Eq.4]

Each y_j $(where\ j = 1, \ldots, p)$ is a linear combination of the $x_1, x_2, \ldots, x_p$ original, that is to say:

$$y_j = a_{j1}x_1 + a_{j2}x_2 + \cdots + a_{jp}x_p = a'_j x \qquad (1)$$

$$a'_j a_j = \sum_{k=1}^{p} a^2{}_{kj} = 1 \qquad (2)$$

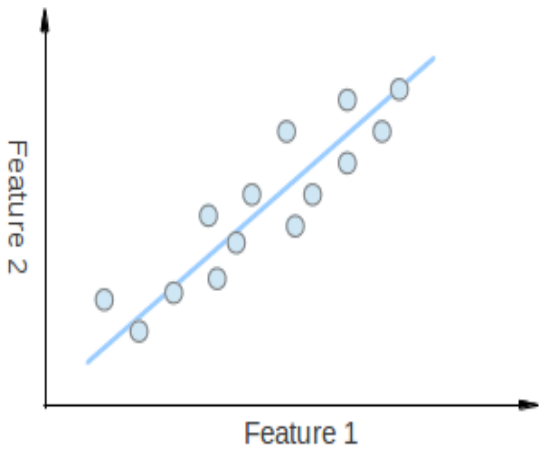
EXTRACTION OF FACTORS. We try to choose a_1 of such way that will maximize the variance of y_1 with the restriction of that $a'_1 a_1 = 1$

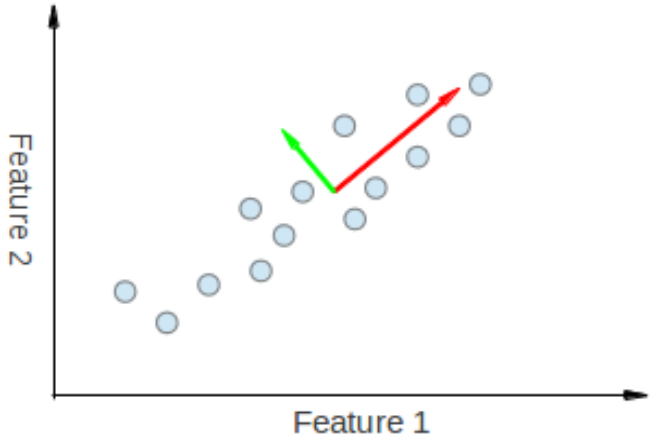
$$Var(y_1) = Var(a'_1 x) = a'_1 \sum a_1 \qquad (3)$$

$$\sum_{i=1}^{p} Var(y_i) = \sum_{i=1}^{p} \lambda_i = traza(\Lambda) \qquad (4)$$

Hotelling transform

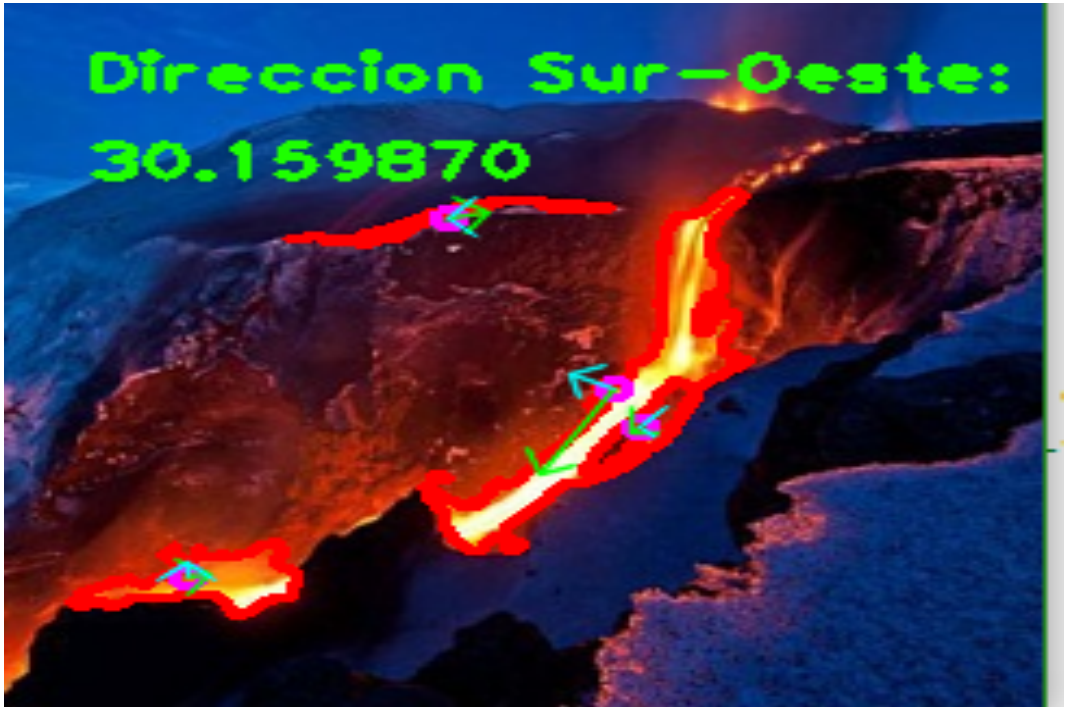
- The points of dispersion have a typically elongated shape, showing some correlation or dependency between both bands.
- Therefore, the PCA shows us the address at which the data show more variance





Hotelling transformed

- With the information obtained through the Hotelling transform, we can calculate the trajectories according to the variance of the components main obtained



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Testing of the algorithm	Detection of flows and address (%)	Type of cone volcanic and eruption
	Flow 57% Address 78%	Boiler Eruption Strombolian
	Flow 66% Address 85%	Stratovolcano Eruption Hawaiian
	Flow 89% Address 95%	Cone of ash Eruption Vulcanian
	Flow 96% Address 90%	Stratovolcano Eruption Vulcanian
	Flow 95% Address 98%	Dome of lava Eruption Peleana

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- The algorithm implemented have:
  - A reliability of a 80% when evaluated with images of erupting volcanoes.
  - A reliability of a 90% when evaluated with videos of erupting volcanoes
  - The actual algorithm is capable to analyze images in real time.

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- To evaluate the algorithm, we used photographs and videos of real volcanic eruptions obtained from existing digital databases

- The databases were used to evaluate the algorithm with different types of volcanoes and different types of rashes, obtaining a robust system.

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- Exist a lot of possible application for algorithm, for example, determine the trajectory of a person u others objects in movement depending on the region of interest that is select.

- Develop an algorithm that combines robustness but without creating an excessive burden of processing the computer is the challenge for have a monitoring in real time.

Using Computer Vision Techniques to Generate Embedded Systems for Monitoring Volcanoes in Ecuador with Trajectory Determination

- The algorithm is very effective for to identify the lava flows and the direction of the same
- The algorithm combines robustness but without creating an excessive burden of processing the computer.

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- We recommended the implementation of other algorithms to focus better on the areas of interest or with the use of a thermal imaging camera that would eliminate the low visibility generated by volcanic ash.

THANK YOU FOR YOUR ATTENTION

Any questions or suggestions : fxviteri1@espe.edu.ec