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Machine Learning approach for multi-perspective volcanic eruption recognition using thermal infrared images

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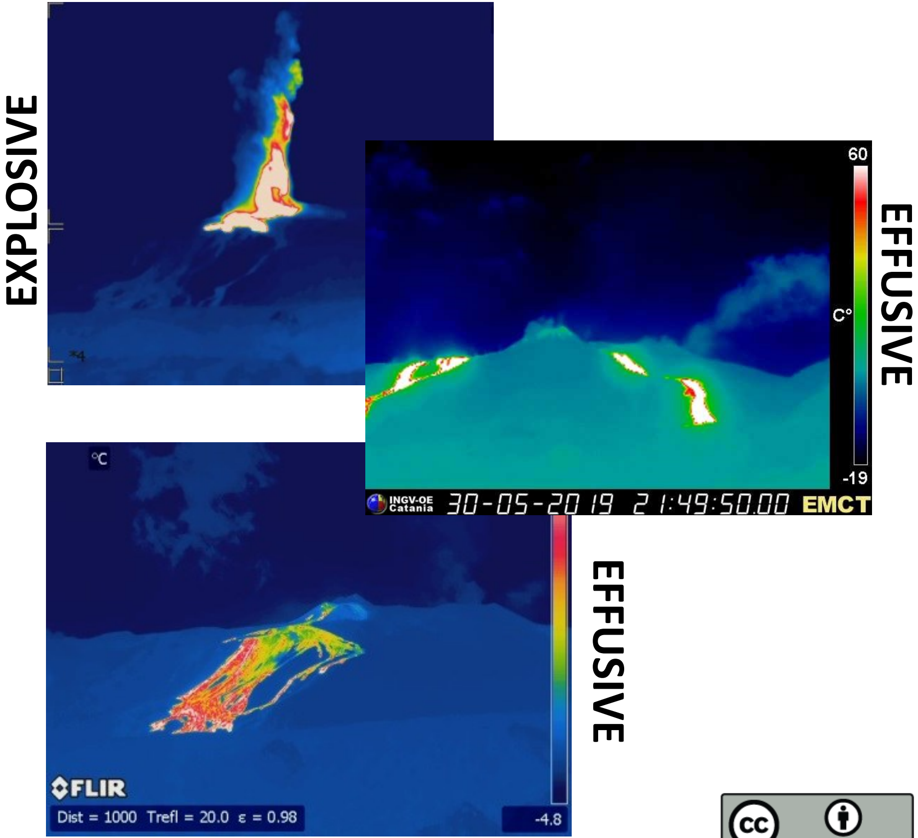
Goal: Detection and automatic classification of the eruptive activity typology using thermal images

- Detecting, locating and characterizing eruptions in real-time is fundamental to monitor volcanic activity.
- Here, we present an automatic system able to discover and identify the main types of eruptive activities by exploiting infrared images acquired by the thermal cameras installed around Mount Etna volcano.
- The proposed system applied to each image of all thermal cameras over Etna in real-time, provides two outputs, namely the visibility level and the recognized activity status.
- By merging the outcomes coming from each thermal camera, the monitored phenomena can be fully described from different perspectives getting deeper information in real-time and in an automatic way.



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Workflow

DATA

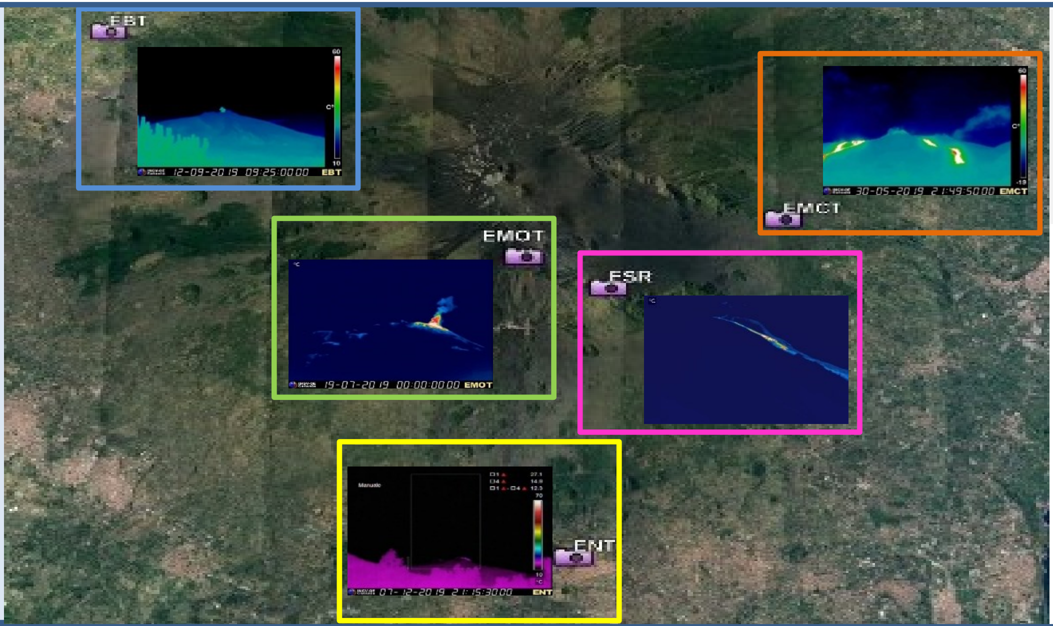


Fig. 1: Location of thermal cameras on Etna. Google Earth view of summit area showing each thermal camera position and the corresponding sample image, namely ENT (yellow box), EMOT (green box), EBT(blue box), ESR (pink box) and EMCT (orange box).

Table 1: Thermal cameras main features.

Thermal camera	Location	Distance from summit	Elevation s.l.m.	Field of VIew
EMOT	La Montagnola	3 km S	2600 m	18.8° x 25°
ESR	Schiena dell'Asino	~5 km SSE	1985 m	18.8° x 25°
EMCT	Monte Cagliato	8.5 km ESE	1160 m	18.8° x 25°
EBT	Bronte	~12 km WNW	971 m	18° x 24°
ENT	Nicolosi	15 km S	730 m	18° x 24°

METHOD

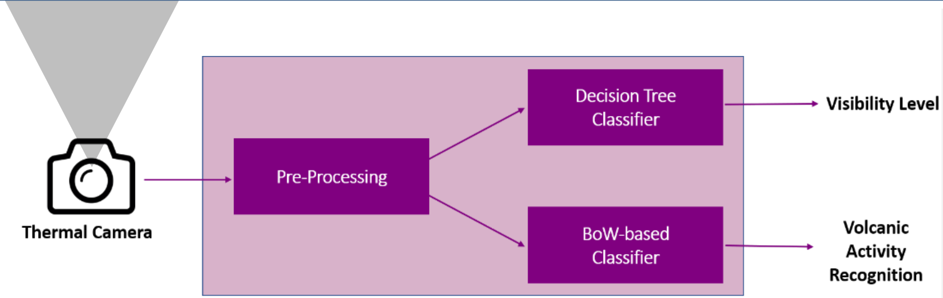


Fig.2: Scheme of the machine learning approach to classify volcanic eruptions using thermal images. The images acquired from each thermal camera located on Etna (Fig.1) are used as input of the proposed ML approach. After a pre-processing step consisting in manipulating the raw false-color images, a *Decision Tree (DT)* classifier is adopted to recognize the visibility conditions of the monitored scene and a *Bag of Words (BoW)-based classifier* is used to detect the onset of the eruptive activity and recognize the eruption type among explosive, effusive, explosive and effusive and degassing classes.

DT and BoW- based Classifier

Decision Tree Classifier

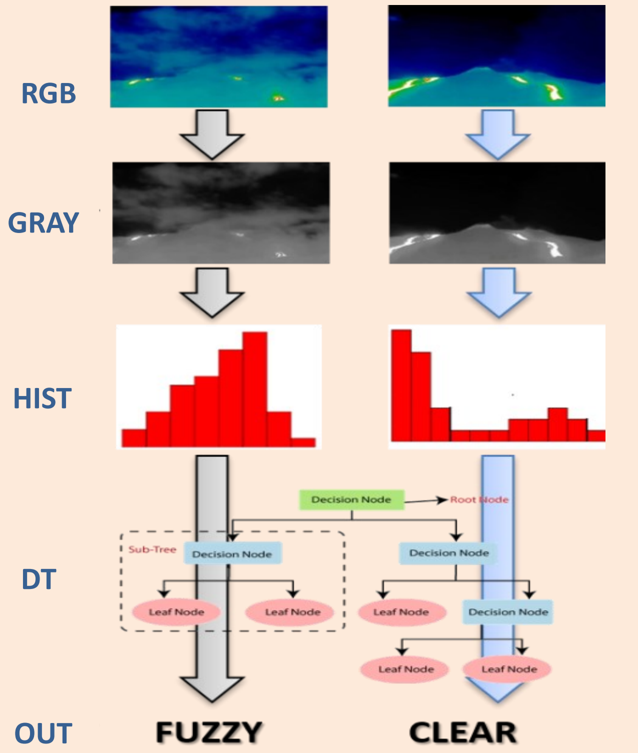


Fig.3: Decision Tree classifier. The RGB images are converted in GRAY images and their intensity histograms are set as attributes of the DT. By opportunely setting thresholds intensity levels (i.e. DT nodes' criteria) during the training phase, DT is able to distinguish between "clear" and "fuzzy" classes

Bow-based Classifier

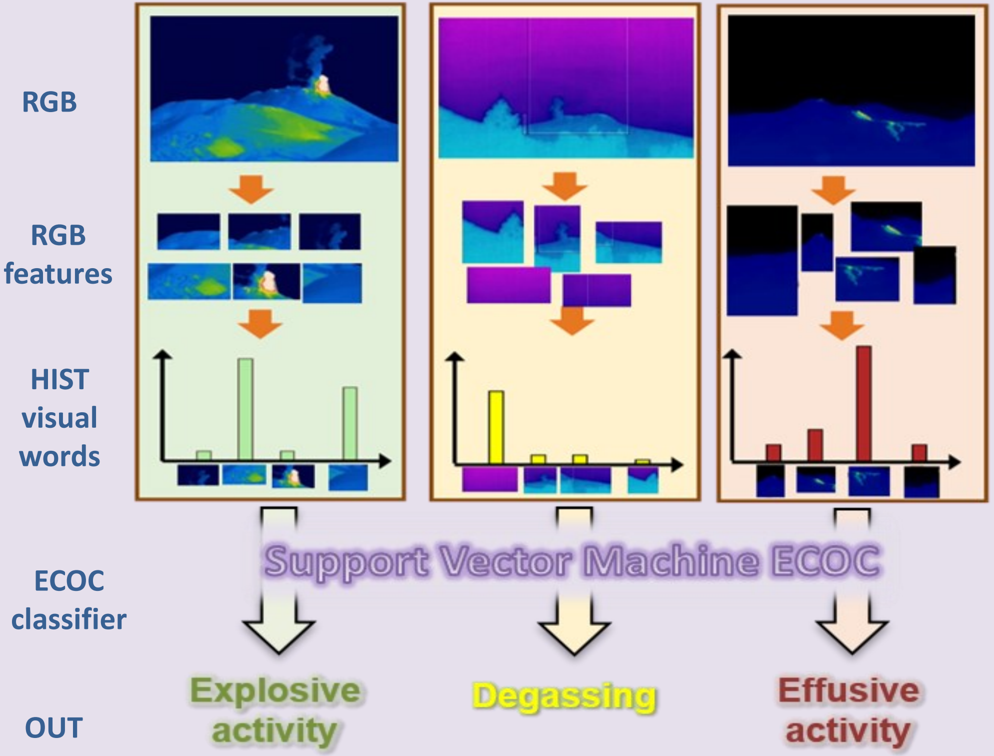
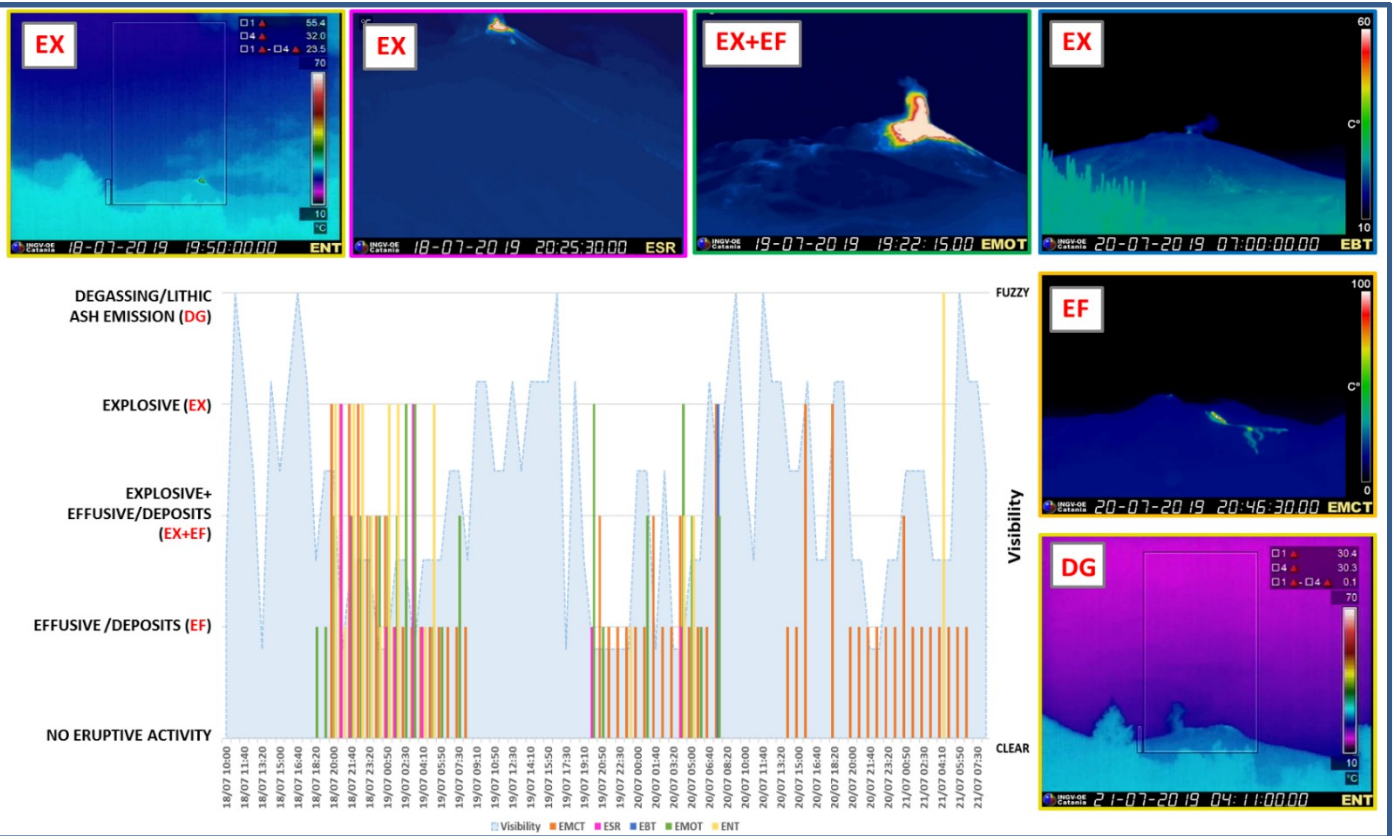


Fig. 4: BoW-based Classifier. Image features are extracted from each RGB image by using the Speeded Up Robust Features (SURF) method and then grouped with the k-means algorithm. Considering each centroid corresponding to a feature, i.e. visual word (VW), each image is represented as an occurrence histogram of VWs. Finally, an error-correcting output codes (ECOC) framework classifies the BoW histograms by combining the output of several binary Support Vector machine (SVM) classifiers.

Results

Fig.5: Output of the ML approach for the July 2019 volcanic eruption.
Volcanic activity evolution detected by the ML algorithm from the 18th to the 21st of July, 2019. "EX","EX+EF", "EF" and "NA" stand for explosive, explosive and effusive, effusive and no activity respectively.
For each day, the retrieved activity for each thermal camera is shown as a colored bar, namely yellow (ENT), green (EMOT), blue (EBT), pink (ESR) and orange (EMCT).
The visibility index is given by the average of the visibility indexes for all the cameras.



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