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# P1.2 - A COMPUTER VISION SYSTEM TO ANALYSE IMAGES OF LIGHTNING FLASHES

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## Motivation and Goals

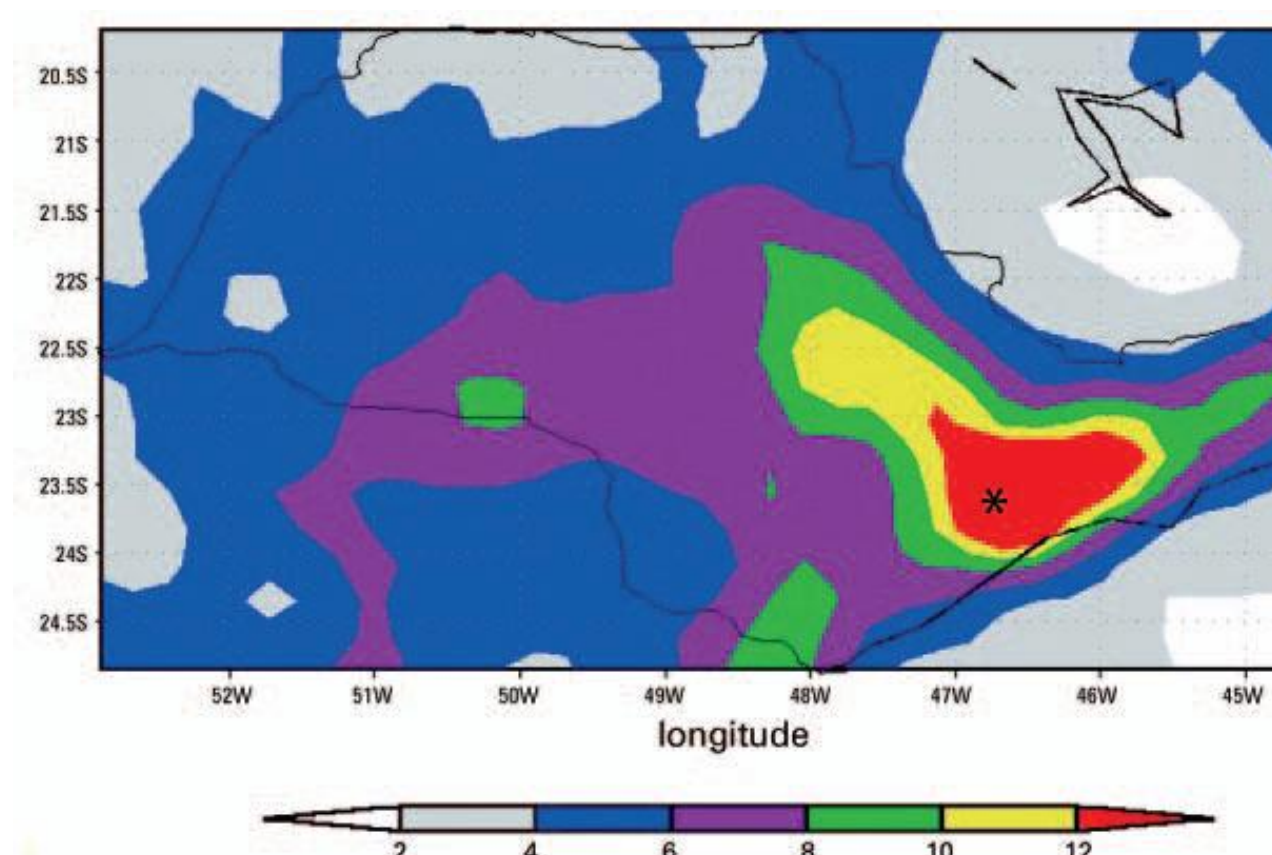


Figure 1: Lightning density of negative discharges in the State of São Paulo, Brazil, 2001. The city of São Paulo, in the vicinity of SBC, is marked with an asterisk.

A recent study showed that, in 2001, more than twenty people were hit, directly or indirectly, by lightning strikes in summer time in the vicinity of São Bernardo do Campo (SBC), Brazil<sup>[1]</sup>. This region presents a high level of lightning activity and density, as showed on figure 1. According to CEMIG – a company that generates and distributes electrical energy in Brazil – about seventy percent of damages on transmission lines and thirty percent on distribution lines are due to electrical discharges<sup>[2]</sup>.

In addition to these high rates of incidents, lightning discharges also reflect the behavior of thunderstorms and can indicate the stage of cloud's electrification as well as the storm's severity<sup>[3]</sup>.

One way to obtain information about the general behavior of thunderstorms is through the monitoring of lightning flashes recorded by video camera. Flash events show the temporal and spatial evolution of convective cells, allowing the visual identification of thunderstorms and its electrical discharges. Figure 2 shows a long continuing luminosity cloud-to-ground flash occurred at SBC, often indicating the presence of heavy precipitation followed by flood events at this region<sup>[4]</sup>.



Figure 2: A lightning flash captured by the local monitoring system, occurred at SBC in 2006-11-25. The time interval between frames is 33,3ms.

This project proposes the development of an automated system to analyze, using computer vision techniques, the lightning flashes images occurring in the vicinity of SBC. Lightning events are identified and classified by the system, providing information about the thunderstorm that qualifies and validates the data of electromagnetic field sensors also in operation at the University of FEI.

## Acknowledgements

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## Software Development: Methodology

Built in C++ language, the software identifies the lightning flashes and classifies each lightning stroke into two categories: vertical flash (VF) and horizontal flash (HF). These main categories will be used to identify cloud-to-ground flashes, intracloud flashes and air discharges in future studies.

The first part of the pre-processing stage aims to define fixed obstacles in the video image. The obstacles are manually selected by the user, and this process is done only once for each camera since all the video monitors have fixed positions and orientations.



Figure 3: Image of a video camera. The red rectangles define obstacles and the white line defines the horizon line.

In addition to the obstacles, the horizon line is also defined at this point through an analogous process. Figure 3 shows these definitions applied to one camera.

The edge detection block closes the pre-processing stage with the objective of making the contour of the lightning flashes more salient. Its methodology is based on Sobel's morphological operator<sup>[5]</sup>, and returns the intensity of image's gradient as well as its direction.

This characteristic is the foundation of two parallel processes that feeds the segmentation stage.

The first process uses the resulting vector of Sobel's operator to calculate which points of the image are discontinuous simultaneously on the horizontal and vertical directions. This process returns high values of intensity for a given point when that point presents high levels of discontinuity in both directions.

The second process calculates which points of the image are discontinuous in the horizontal or in the vertical direction. This process returns high values of intensity for a given point when that point presents a high level of discontinuity in any direction. Figure 4 presents the

result of this process applied to a lightning image.

The first part of the segmentation stage is a continuity analysis, which helps to connect continuous areas and lines that could have been disconnected at the edge detection stage or at the thresholding stage.

The reinforced binary images are subjected to a contour detection process. At this point, regions of interest (ROI's) are defined as the smallest rectangle containing all points of a given contour. Next, an algorithm mixes superposed ROI's that eventually remained disconnected, and also discards ROI's that are too small to be a lightning stroke.

Finally, the classification stage uses the horizon line information to make a comparison among the lightning contours. In case one or more points of the lightning contour intersects the horizon line, the lightning is classified as a VF flash. In any other case, the lightning is classified as an HF flash.

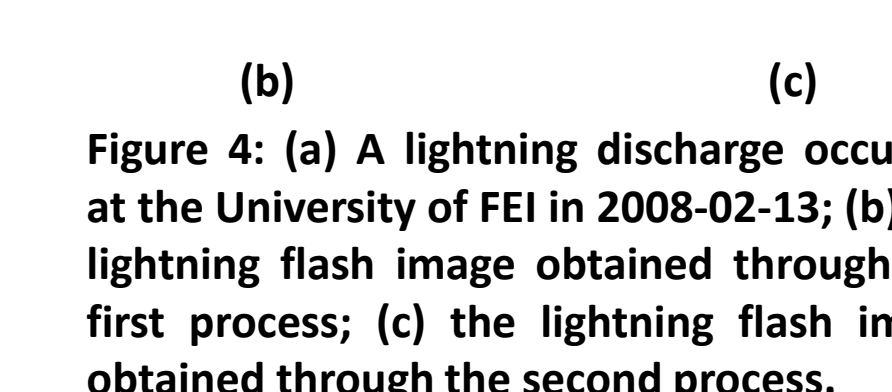
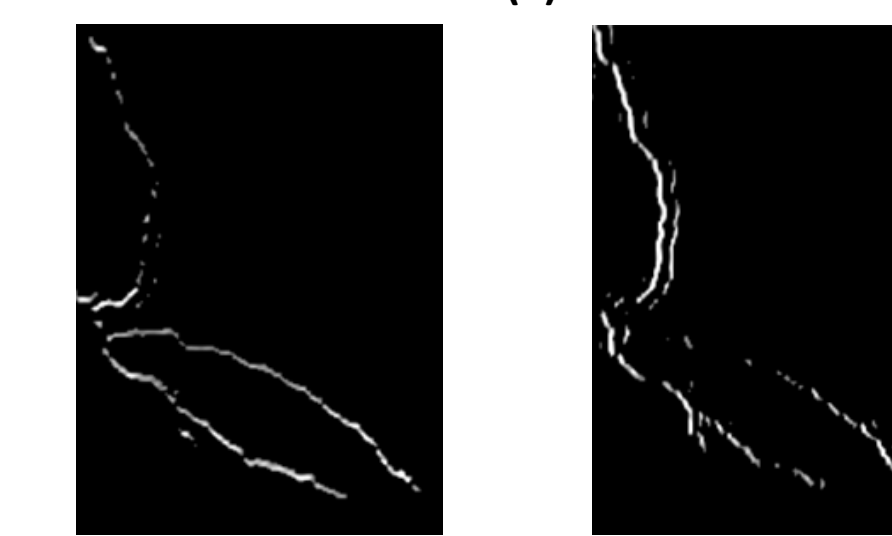


Figure 4: (a) A lightning discharge occurred at the University of FEI in 2008-02-13; (b) the lightning flash image obtained through the first process; (c) the lightning flash image obtained through the second process.

## Results and Discussions

- The intensity of light and the contrast characteristics of electrical discharges associated with the background image are the fundamentals on which this system's development is based. In fact, lightning discharges possesses random forms, imposing great limitations on its comparison to or approximation by other known forms and shapes.

- The edge detection process is the heart of ROI's definition. Therefore, we chose to separate it into two parallel processes to improve its robustness. The first process showed a good immunity to noise, but also proved to be inefficient in the detection of distant and ramified lightning flashes. In contrast, the second process showed greater precision in the detection of distant and ramified lightning flashes, but was also a little more sensitive to noise.

- At the segmentation stage, ROI's are defined based on the contour line of the lightning flash. With the objective of connecting contour points of the lightning that eventually remained disconnected until this point, the following algorithm mixes the superposed ROI's, granting a good connection level of all the lightning areas, as shown in figure 5.

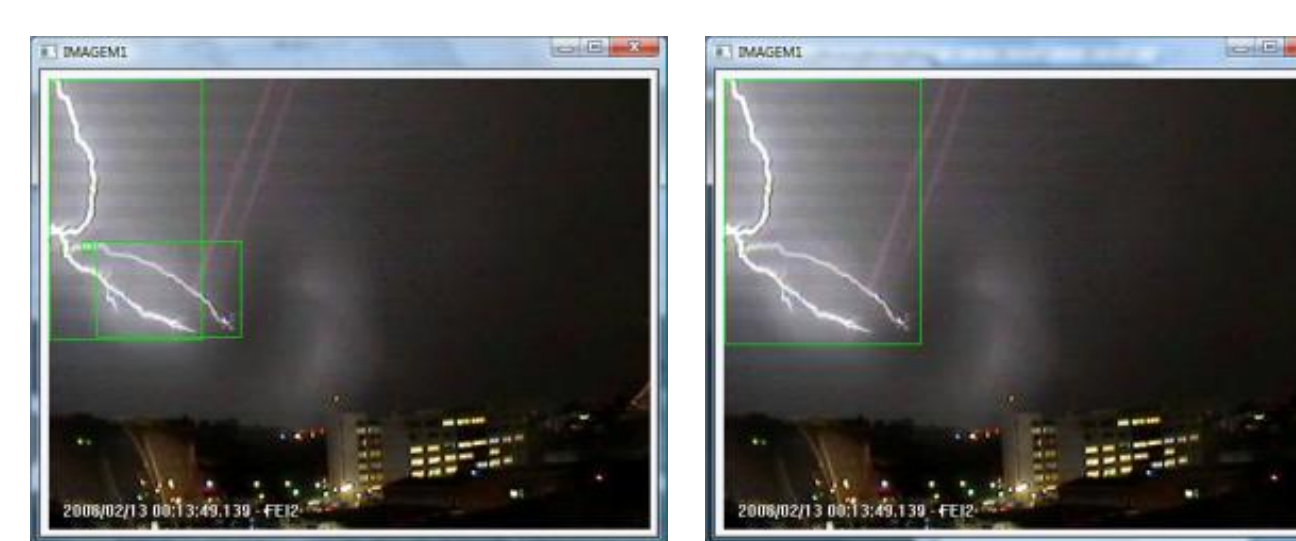


Figure 5: Image of a lightning flash occurred in 2008-02-13, with the green rectangles representing (a) the independent ROI's; (b) the mixed ROI's

## Conclusions

At the current state of development, the system obtained reliable results on the segmentation of the lightning channel from the background image and on the classification of the segmented images into two primary categories. A more precise classification process is being developed. At the pre-processing stage, although the obstacles and the horizon line definitions are being made in a supervised way, with the interaction of a user, the automation of this process would not result in a practical gain when considering the fixed position and the small number of monitoring cameras at the University of FEI. As a future proposal, a machine learning approach could help to differentiate the fixed background from the interesting image data. The conclusion of this project will allow the expansion of the current covering area of the local monitoring, still limited by the high volume of video information to be manually analyzed.

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