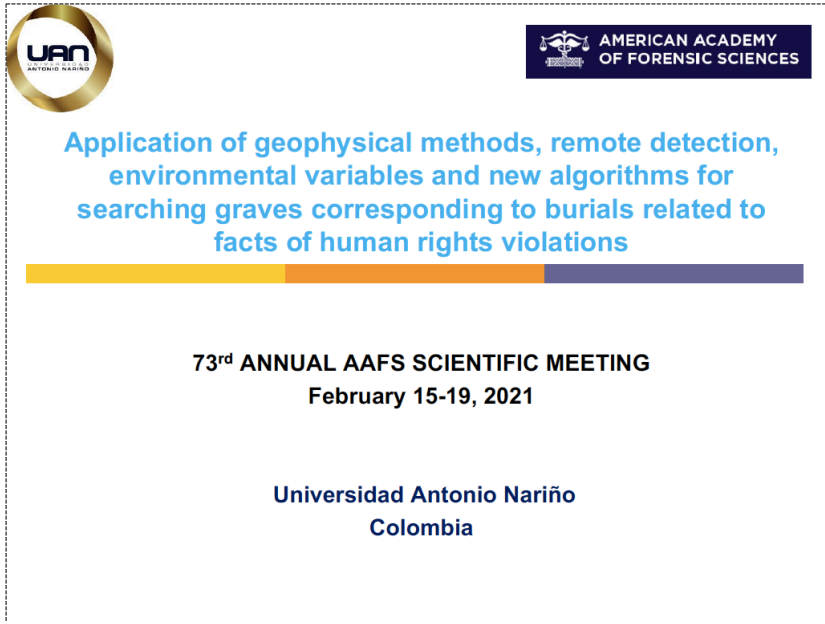
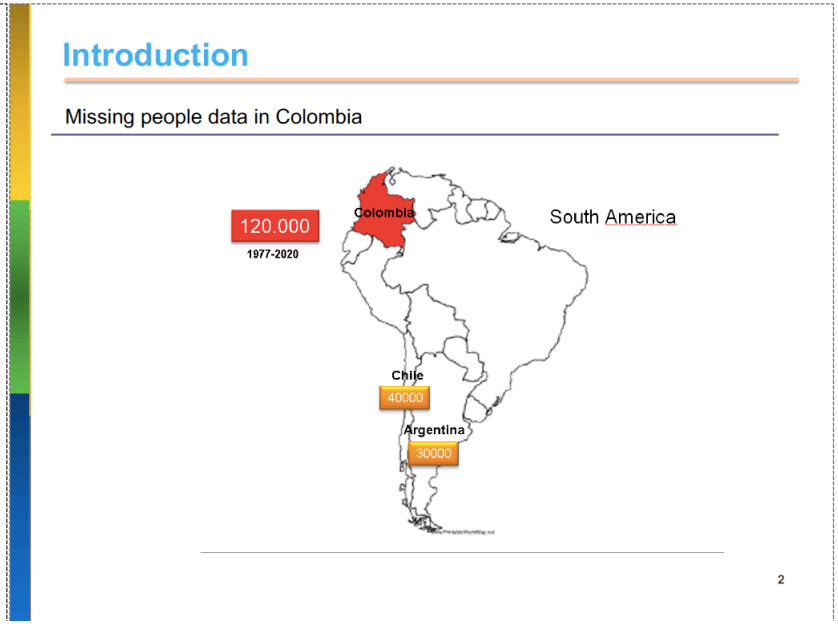
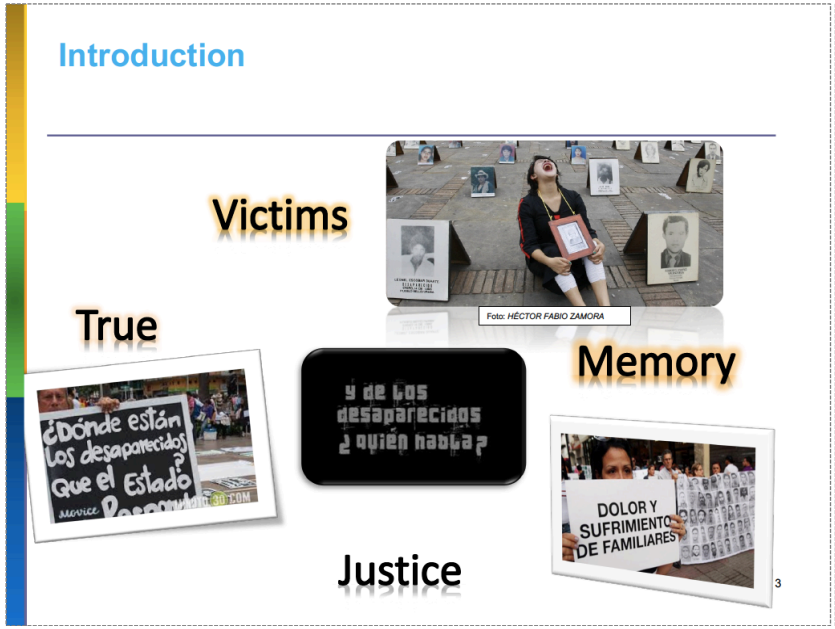
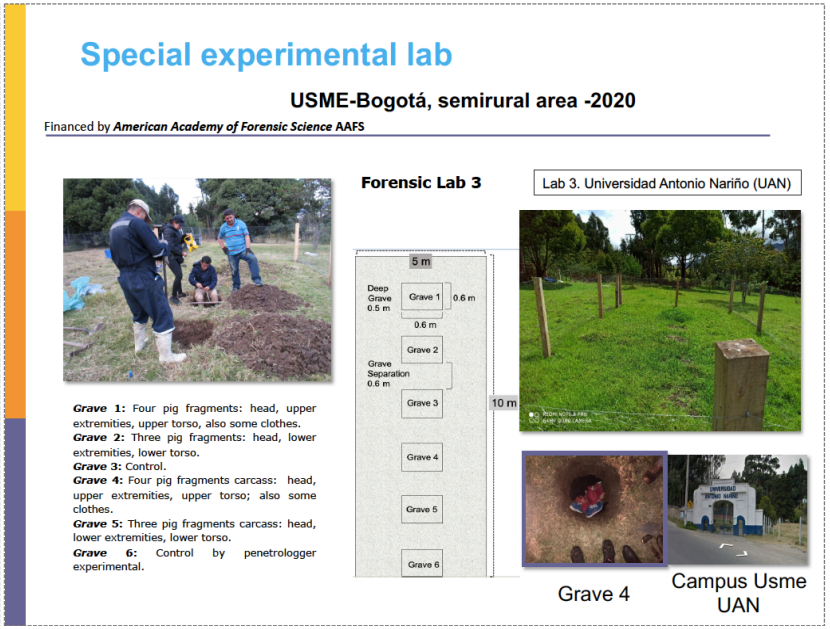




The project Application of geophysical methods, remote detection, environmental variables, and new algorithms for searching graves corresponding to burials related to human rights violations is developed in Colombia (South America) in the post-conflict context that has been affected the country for many decades.

Official data establish that there are at least 120,000 people in Colombia who disappeared for social, armed conflict, and political reasons, leading in South America that problem that requires finding solutions through various means, one of them the academy.





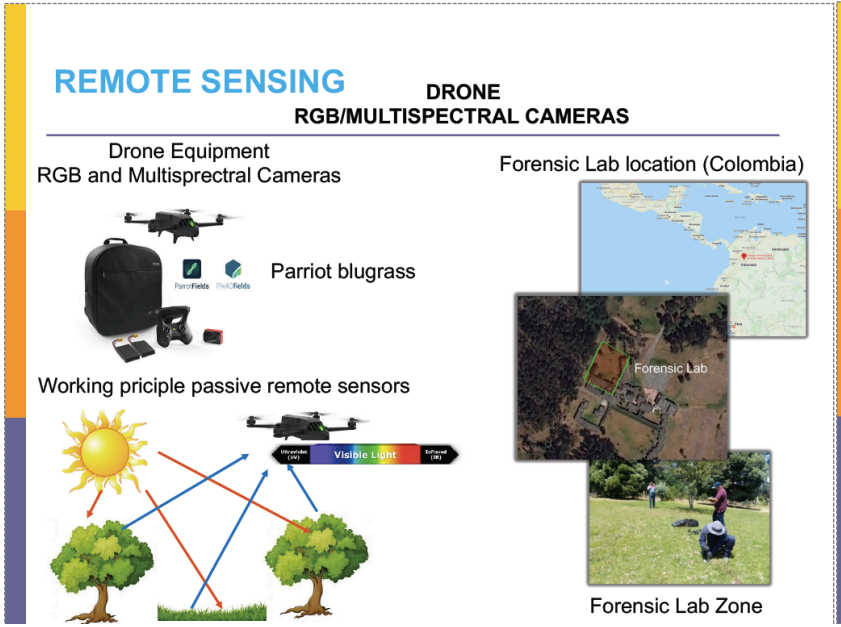
The victims' families demand truth, justice, memory, and reparation through demonstrations and special days, such as August 30, which is the international day of the disappeared. Similarly, several family organizations work with non-governmental organizations and lawyers to pressure them to search for their loved ones.

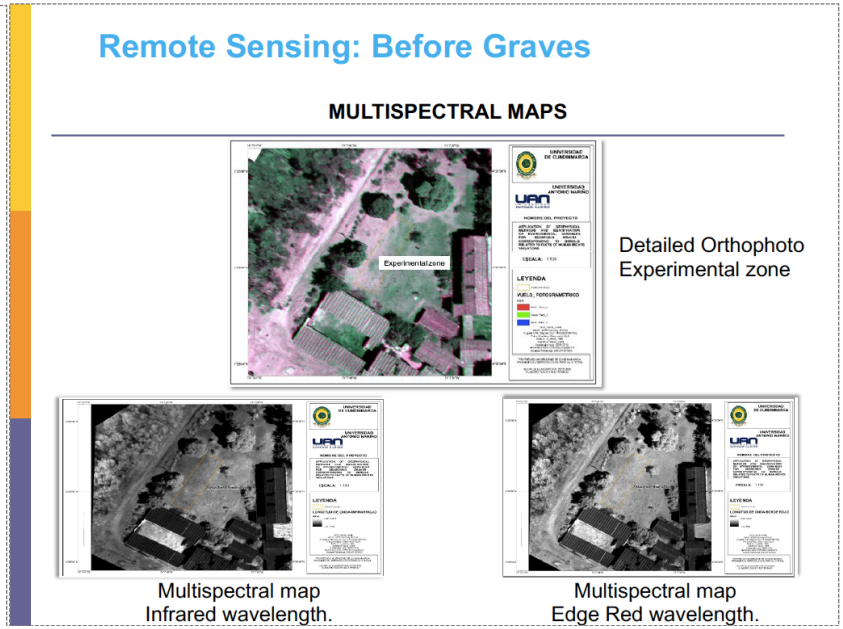
In Colombia, the search for graves was done manually without geophysics, so it was decided to carry out experimental laboratories where the characteristics of size, depth, and human remains were found in graves for the police judicial. We have three experimental labs.

The new research project is located in a semi-rural area of the Antonio Nariño University Camps in Bogotá. The graves have dimensions of 60 cm wide, 60 cm long, and 50 cm deep since they correspond to those made by the paramilitary groups that dismembered thousands of people alive in Colombia, thus also applying the economy of crime, spending less time in bury their victims. To carry out the experimental graves' design, pigs were dismembered and buried, and in some of them, clothes were added.

It was decided to use the two geophysical methods that have given the best results, as well as to use of remote sensors.

Two data acquisitions have been carried out with the Electric Resistivity Tomography ERT, which marks a good result before making the graves and after constructing them and placing the objects, as observed for the month of February, however, due to the current public health situation around the world, it was only possible to take the new data collection in October, which continues to show anomalies on the graves 2, 4 and 5, where there are fragments of pigs. It is expected to contextualize these data with GPR, which was only possible to do in February and whose results were not good, probably because the soil is clayey and wet, which prevents the electromagnetic signal from penetrating adequately.

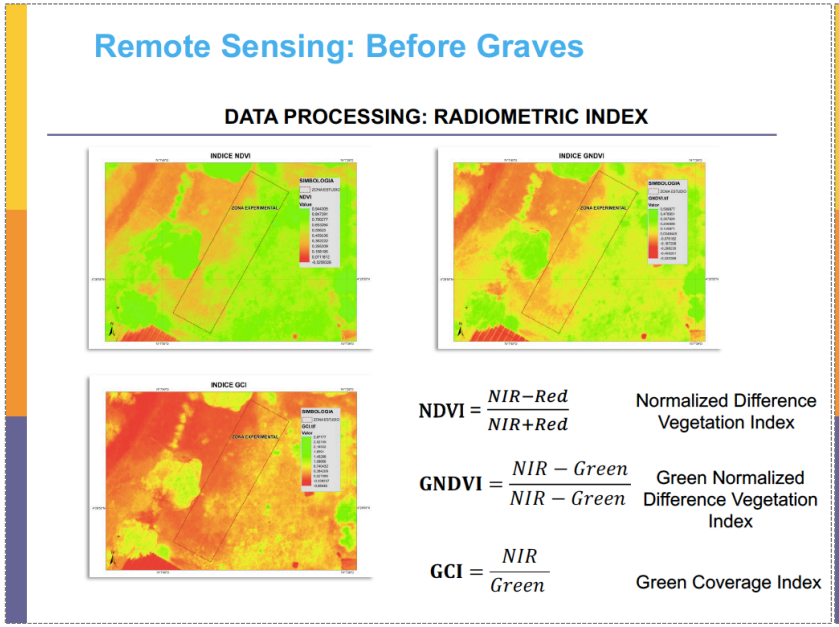


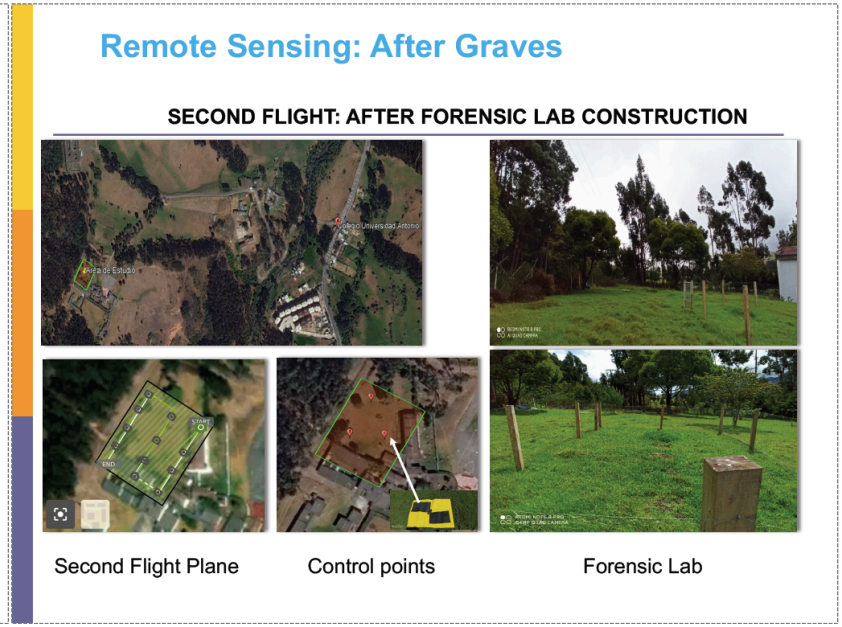


The Remote sensing technique consists of collecting information about an object or phenomenon without making physical contact with the object. This is used in many fields such as geography, military, earth science, among others. The sensors work collecting the radiation reflected by the objects or surrounding areas.

Our drone equipment has integrated an RGB camera and a multispectral one. With RGB, we can acquire three visible spectral bands red, blue, and green. On the other hand, we can collect information from the not visible light spectrum with the multispectral camera, such as edge infrared, near-infrared.
On the left slide, you can see the zone of the study described before and its location on a google map on the right pictures. On the left images, you see our drone and the working principle of cameras.

On the right slide is shown the first flight before the construction of the graves, which was called Diagnostic Photogrammetric Flight. It permitted us to obtain a detailed orthophoto of the experimental zone, which is a photo presentation that integrated the detailed features of aerial photos and geometric properties of a plane, as you can see in the image above. The multispectral information allows maps of soil cover, photosynthetic, and phenological state of plants. It is more visible with the near-infrared and edge red wavelengths, as shown in the images below.

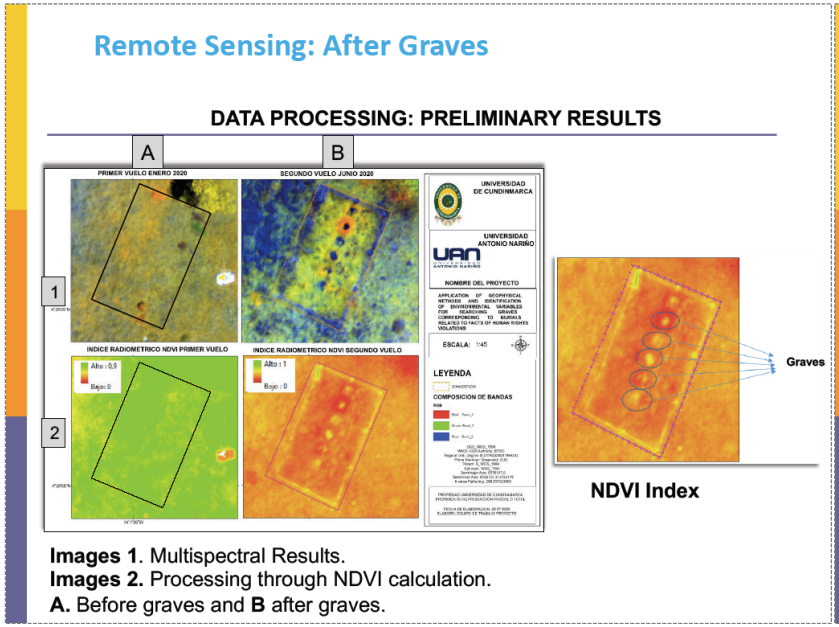




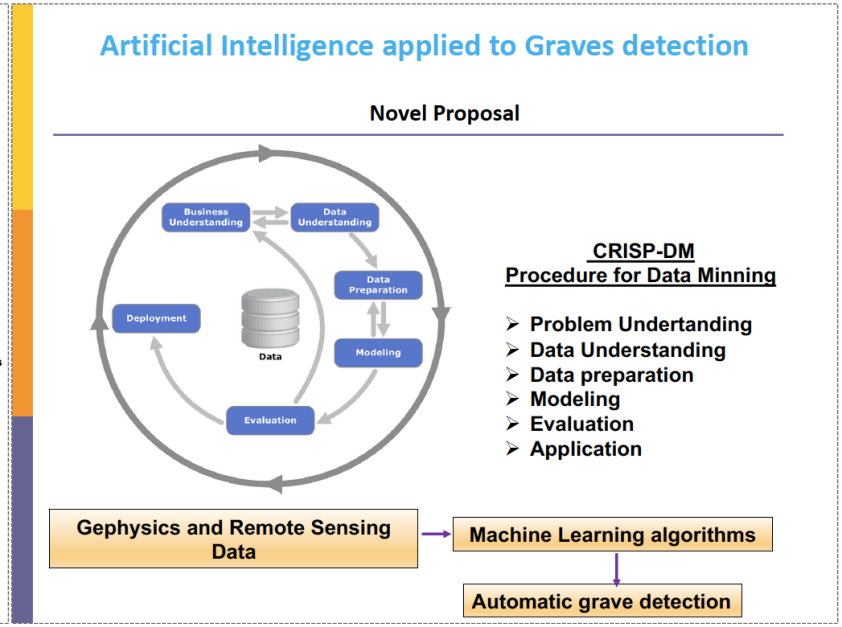
Left slide shows the coverage before the construction of graves, which was characterized using the radiometric variables from data processing.

NDVI is an index that related the spectral behavior between the near-infrared and the red band. It showed the photosynthetic activity in the zone. The green zone shows high photosynthetic activity.
On the other hand, the GNDVI= relates the spectral behavior between the green and near-infrared bands. This is very useful when the pasture and weeds coverture impacts strongly to the NDVI index, which could lead to the index saturation and, as a consequence, does not reveal evident photosynthesis differences of the biomass.
Finally, the GCI: shows the variations in chlorophyll content in vegetation. It permits to evaluate of the phenological state of vegetation. This is weak when there is low pasture.

The right slide shows the flight plan was made established three control points inside the rectangular polygon that describe the study zone. Once the marking process was done, the flight of the drone started. The patch for the study was about 2,137 m2. The total route took 2 minutes, at the height of fifty meters (50 m).



Images 1. Multispectral Results.
Images 2. Processing through NDVI calculation.
A. Before graves and **B** after graves.

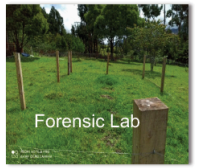


It is important to remark that our purpose is graves detection. Therefore, the preliminary results were satisfactory. On the left slide, the Images called A correspond to multispectral results before the grave's construction, and the images B were taken after this.
The first row is the multispectral results, and the second row is the images obtained from the NDVI index calculation.
The NDVI reveals the photosynthetic activity with the difference between the red and near-infrared bands. It generated a very good contrast that permits the detection of the anthropic intervention or the graves' presence for this case.

Finally, we would like to show on the right slide the general aspects of a novel proposal related to the application of artificial intelligence. We want to check machine learning algorithms' feasibility to detect graves using geophysics and remote sensing data. In other words, we want to study the possibility of building a virtual machine capable of detecting graves automatically.
To work on this proposal, we are using a well-known procedure for data mining called CRISP-DM, where the data needs to be understanding, prepare for be model, evaluated, and applied. We hope to show you results on the next opportunity.

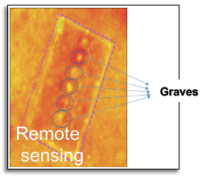
Conclusions

- The forensic Lab has small graves 60cmx60cmx 50cm. This kind of graves is linked to paramilitary groups.
- The selected suburban zone (Bogotá-Colombia) was strongly impacted by the conflict armed. It is an excellent place to develop this research.
- Preliminary results show that the ERT technique seems appropriate to detect recent graves in clayed soil as this study zone.



Conclusions

- Preliminary results of GPR show to the detection of recent graves. It could be due to the clayed and compact soil of the terrain.
- Preliminary multispectral results with the remote sensors (drone) presented satisfactory results for recent graves.
- Artificial intelligence is a novel proposal for the automatic detection of graves, but needs a significant amount data. It could be a robust tool to support investigators during its fieldwork.



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Special thanks!

American Academy of Forensic Science
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Participating Research Groups

- **GRESIA, GIFAM, GEPRO, GEOFÍSICA-** Universidad Antonio Nariño Colombia
- **CARTOGRAFÍA** - Universidad de Cundinamarca Colombia
- **GEOSENSE SAS** Colombia

Thank you very much
for your attention
The best for you and your families!

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