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Application of Emerging Technologies in Remote Sensing to Process Stored Data and Reduce Environmental Risks

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Abstract: Remote sensing provides relevant data to monitor and manage information from the environment. Obtaining and processing a wide source of images and signals emitted by various satellites will enable a better understanding of natural systems and those in which humanity inevitably intervenes. However, one impediment to the use and monitoring of the environment has been the need for resource managers to understand the new capabilities offered by a constantly growing variety of image sources and analysis techniques. This work proposes guidelines that will allow resource managers to collaborate more effectively to develop and apply technology integration with applications in environmental management. It is therefore proposed to explore, describe and eventually explain specific cases in which it would be possible to reduce environmental risks and generate new knowledge by applying existing and emerging technologies, such as the case of variations in glaciers. The proposal includes specific case studies and applications.

Key words: environmental risks, monitoring, image classification, glaciers, remote sensing

1. Introduction

The unprecedentedly large volumes of information currently provided by satellite sensors pose a new problem: the data exceeds the processing and knowledge generation capacity. Consequently, it is necessary to include machine learning techniques that could improve the analysis of this type of data; however, the latest traditional machine learning algorithms cannot process large volumes of data. Recent progress has led to the possibility of overcoming computational limitations related to Big Data analysis in remote sensing with the implementation of new algorithms, distributed clustering solutions and cloud computing infrastructure to process very large data sets using data mining packages (such as InterCloud). These technologies, which could be used to monitor fluctuations in glacier fronts or even in urban air quality indices, to name a few examples of environmental components critical to life, have not yet been deployed for environmental monitoring in several countries or regions.

The project seeks to explore, gain awareness and take advantage of the use of emerging and existing technologies to obtain, process and apply remote sensors for environmental management. New sources of information and data processing, such as cloud storage (Cloud Storage Connection files), image processing (Image Management), map generation, Deep Learning and Image Classification, and visualization and interpretation tools (Visualization Motion Imagery — Full Motion Video) will allow a better management of ecosystems and urban areas. It is therefore proposed to explore, describe and eventually explain specific cases in which it would be possible to reduce environmental risks and generate new

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knowledge by applying existing and emerging technologies to monitor variations in the fronts of Patagonian glaciers.

2. Material and Methods

2.1 Description of the Problem

Data generation using remote sensors exceeds the processing and knowledge generation capacity related to the environment, which could serve to monitor glaciers and air quality. To reduce this gap between raw data and knowledge extraction, it is necessary to create new forums for scientific cooperation to allow the application of new technologies such as automation and data processing more quickly and efficiently under certain standards.

Floods from glacial ruptures on lakes or bodies of water represent a significant threat to downstream communities and existing infrastructure, primarily due to their potential to rapidly release stored water. In previous field studies in Patagonia, cases of ruptures with local effects were documented in glaciers in the Lago Argentino basin and in Chile [1-3]. The most common triggers for these ruptures are the massive movements of ice entering a lake, the detachment of the glacial front, or the destruction of the terminal moraine due to hydrostatic pressures or a change in glacial dynamics.

Changes in glaciers also indicate changes in regional and global climate. This gives relevance to the detection and evaluation of risks, and the monitoring of glaciers. These changes can pose risks to the communities living in the vicinity. Floods, landslides, debris flows, and rock slides can destroy infrastructure and cause deaths in a sudden avalanche of water, ice, sediment, rocks, and dirt. Ice avalanches can unleash far-reaching hazards such as huge snow avalanches, affecting lakes and mudflows. It is not yet clear if some of these hazards are a normal part of glacial behavior, or if they indicate new dramatic threats from a changing cryosphere. Consequently, the monitoring of glaciers facilitates a better understanding of our climate system, the formation of ice ages, and the effects of these changes.

2.2 Methodology

The main objective of this work is the production of a reference framework and a set of knowledge that will allow the processing of more data from satellites, particularly in relation to the monitoring of glaciers and sources of air pollution.

Specific objectives:

- Generate a reference framework that allows the processing of large volumes of information.
- Establish existing and emerging technologies susceptible of being applied.
- Generate a reference framework for institutions and applications of remote sensors in environmental monitoring.
- Develop cooperation with other international institutions and projects (such as the Global Land Ice Measurement from Space — GLIMS).
- Establish guidelines for the processing and monitoring of the environment in a way that enables the generation of new knowledge by using cases where technology is applied to monitor glaciers.

The methodology for the theoretical framework was based on reading sheets, mapping methods, conceptual maps and prior experience. Bibliography management tools were used. A series of guidelines have been proposed to evaluate, collect, analyze and conduct research based on case studies. Bibliographic searches were carried out using academic search engines, such as the platform of the Ministry of Science, Technology and Innovation (Argentina), Google Scholar and ResearchGate. The Electronic Library of Science and Technology provides access to authorized institutions through the Internet to the full text of scientific-technical journals, books, conferences and congresses, as well as reference databases that are of great value to the scientific community. Keywords used included: environmental risks, monitoring, image classification, glaciers, remote sensing.

The scope of the research has been exploratory and descriptive, with the inclusion of case studies and applications. The design has been of an exploratory nature. The methodology for the theoretical framework was based on the design mentioned previously.

A series of guidelines have been proposed to evaluate, collect, analyze and conduct research based on case studies in the bibliography using certain guiding questions, such as:

1) How is information from remote sensors currently processed? What happens to the information? How is knowledge generated?
2) What problems and reference frameworks can be addressed?
3) What technologies are used and what limitations do they pose?
4) What emerging technologies exist that can be applied to remote sensing to reduce the gap between raw data and the generation of knowledge about the environment?
5) Is it possible to incorporate case studies, such as glacier monitoring and, eventually, air quality monitoring to reduce the gap between raw data and knowledge generation?

3. Results and Discussion

3.1 Glacier Monitoring

Climate change is a current problem facing humanity. Air pollution and the alteration of water resources are becoming increasingly frequent. Glaciers form part of the latter resource as one of the most affected ecosystems. Consequently, knowledge of the dynamics of glaciers, given their critical retreat or melting conditions, can be obtained through the analysis of data from remote sensors (remote sensing). However, given the volumes of unprocessed information that accumulate, this aspect has become increasingly problematic, because the amount of data exceeds the processing capabilities. These aspects have been addressed in studies such as those by Ayma et al. [4], where it is stated that machine learning techniques have the potential to improve the analysis of this type of data; however, most current machine learning algorithms cannot adequately process large volumes of data. In an attempt to overcome computational limitations related to the analysis of Big Data in remote sensing, the use of K-Means and Expectation Maximization algorithms has been proposed as distributed clustering solutions, taking advantage of cloud computing infrastructure capabilities to process very large data sets. The solution was developed using the InterCloud data mining package, a set of distributed classification methods previously used in hyperspectral image analysis. To validate this proposal, Ayma et al. analyzed the Ausangate glacier, located in the Andes Mountains of Peru, by mapping the changes in that environment through a multitemporal remote sensing analysis and clustering configuration on a computing infrastructure in the cloud. Other recently applied technologies include 3D surface model analysis and glacier visualization [5].

Rounce et al. [6] used qualitative and quantitative assessments to understand the hazards associated with eight glacial lakes in the Himalayas of Nepal that are considered highly dangerous, using remote sensing with a risk and management approach to use this remote assessment to guide risk mitigation strategies. The remote assessment was found to provide valuable insight into the hazards facing each glacial lake. Given the limitations of in situ studies in steep and often inaccessible terrain, remotely sensed data is a valuable resource to better understand and quantify these processes [7].

The long-term monitoring of the world's glaciers enables the development of a historical database and early detection of climate changes to predict and prevent dangers for the human communities exposed to them. Glaciers are monitored in various ways, such as in situ mass balance measurements and aerial and space imaging systems (remote sensing), as is the case with the primary data source used by GLIMS. The GLIMS project is an initiative designed to monitor the world's glaciers using primarily data from remote sensing instruments. It is a shared project designed by various institutions including NASA (National Aeronautics and Space Administration), NSIDC (National Snow and Ice Data Center) and professionals from various international universities and institutes. GLIMS is the most complete and ambitious project worldwide. From an estimated total of 200,000 existing glaciers on Earth, with an approximate area of 750,000 km^2 (not including the Greenland and Antarctic ice sheets), 129,387 glaciers have been monitored until 2016 or 2018, depending on the area. This implies that 65% of the planet's glaciers (excluding the Greenland and Antarctic ice sheets) have been monitored, and there is a temporary delay in the processing and generation of knowledge. The GLIMS project has begun a process of updating and establishing relationships with new institutions and professionals since, as expressed in its online publication:

"The result is that the number of glaciers and the area covered by ice is too large for the current state of the monitored glaciers."

This international project is currently seeking cooperation to solve the issues related to the monitoring of glaciers and data processing. GLIMS project organizers Regine Hock (University of Innsbruck) and Fabien Maussion (University of Alaska) have been contacted to establish a possible future cooperation.

3.2 Air Quality Monitoring

The problem described in relation to the monitoring of glaciers also affects air monitoring. Air pollution is another frequent problem, where the volume of information provided by satellite sensors exceeds the processing capacity and knowledge generation. It is also possible to incorporate new data processing technologies related to air quality or pollution control. To this end, reliable contamination indices have begun to be developed to address the issue of identifying an individual or sectorized source of contamination, based on data from remote sensors, thus generating a useful tool for air quality management [8]. Other works [9] have proposed the development of an artificial intelligence-based quantitative monitoring algorithm to assess air pollution using remote sensing. Quantitative monitoring by remote sensing of air pollution would be possible according to the turbidity of aerosols. Experimental results have shown that the proposed algorithm is highly efficient for monitoring purposes, allowing a wide monitoring range and high precision.

3.3 Proposal for an Interconnected and Automated Environmental Alert Monitoring System

The complexity of the environmental variables could be addressed by implementing a management model integrated into a satellite image processing system that envisages the immediate and continuous provision of images by the various providers and space agencies. This would ensure automated data processing without delays, with a view to generating early alerts to inform agencies, technical managers and rescue forces. Below is a proposal that integrates some of the technologies proposed (see also Fig. 1 and Fig. 2):

- Institutional agreements for the provision of satellite images.
- Development and validation of various application programming interfaces (API).
- Determination of areas to be mapped and monitored.
- Configuration of the cloud-based data provision, georeferencing and storage.
- Mosaic image generation from preconfigured territories (e.g.: Patagonian ice is located between latitudes 46º30'S and 51º30'S on longitude 73º30'W).
- Algorithms implementation for multispatial and multispectral comparisons of pre-stored and pre-dated georeferenced satellite image mosaics.

- Mapping generation by comparative differences between mosaics.
- Issue of alerts and reports.

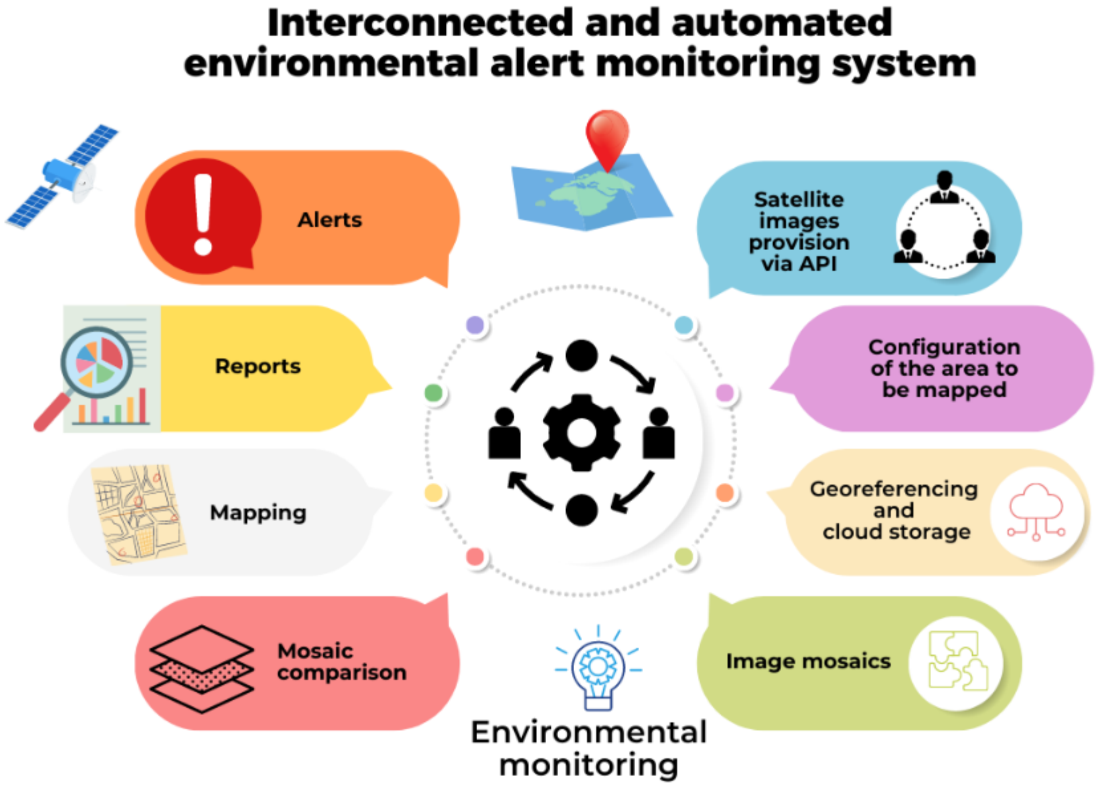

Fig. 1 Real-time environmental monitoring system using satellite images provided by different agencies or institutions.

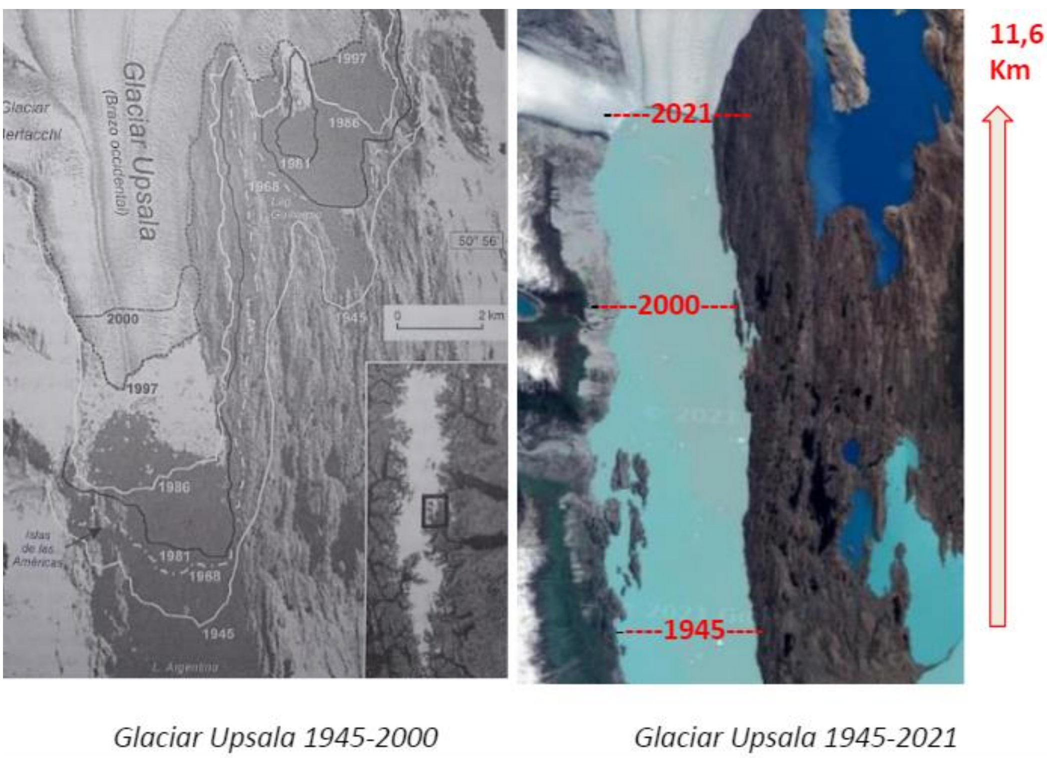

Fig. 2 Simulation of preliminary monitoring of Upsala glacier (Patagonian Icefield). Own production based on previous publications (Chinni, G.A.) and new satellite images (Google Earth).

4. Conclusion

Until recently, the processing of information from remote sensors was carried out ex post (i.e., not in real time). In other words, once the images are obtained, the volume of data is stored until required. Technological progress and the launch of new satellites means that raw data is generated constantly awaiting to be transformed into knowledge. Automated environmental monitoring could be a solution to generate alerts and real-time reports. It is also necessary to establish proposals for scientific cooperation in order to apply these new technologies efficiently with the aim of generating knowledge susceptible of being applied and reducing environmental risks; such could be the case of glacier monitoring or tracking sources of air pollution.

New experiences could accelerate the application of the proposed model, an aspect that is expected to be developed in greater depth in future investigations.

References

[1] Guillermo A. Chinni, *Glaciares del Lago Argentino & El Chalten*. Ciudad de Buenos Aires: Zagier & Urruty Pubns, 2004a, p. 160.

[2] Guillermo Chinni and Charles Warren, The 2004 outburst flood at Glaciar Perito Moreno, Argentina, *Journal of Glaciology* (2004b) (50) 615-616, doi: 10.3189/172756504781829792.

[3] Guillermo A. Chinni, *Glaciares de la Patagonia*, Buenos Aires: Zagier & Urruty Pubns, 2007a, p. 224.

[4] Victor Ayma, Cesar Beltrán Castañón, Patrick Nigri Happ, Gilson Costa and Raul Feitosa (2019). Mapping glacier changes using clustering techniques on cloud computing infrastructure, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* (XLII-2/W16) 29-34, doi: 10.5194/isprs-archives-XLII-2-W16-29-2019.

[5] Wang Xianwei and Xie Hongjie, A review on applications of remote sensing and geographic information systems (GIS) in water resources and flood risk management, *Water* 10 (2018) 608, doi: 10.3390/w10050608.

[6] Rounce David, Mckinney Daene, Lala Jonathan, Byers Alton and Watson C. Scott, A new remote hazard and risk assessment framework for glacial lakes in the Nepal Himalaya, *Hydrology and Earth System Sciences* 20 (2016) 3455-3475, doi: 10.5194/hess-20-3455-2016.

[7] Kirschbaum Dalia, Watson C. Scott, Rounce David, Shugar Dan, Kargel Jeffrey, Haritashya Umesh, Amatya, Pukar Man, Shean David, Anderson Eric and Jo, Minjeong, The state of remote sensing capabilities of cascading hazards over High Mountain Asia, *Frontiers in Earth Science* 7 (2019), doi: 10.3389/feart.2019.00197.

[8] Chen Yunping, Wang Shudong, Han Weihong, Xiong Yajv, Wang Wenhuan and Tong Ling, A new air pollution source identification method based on remotely sensed aerosol and improved glowworm swarm optimization, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (2017) 1-11, doi: 10.1109/JSTARS.2017.2690943.

[9] Liu Yun, Jing Yuqin and Lu Yinan, Research on quantitative remote sensing monitoring algorithm of air pollution based on artificial intelligence, *Journal of Chemistry* (2020) 1-7, doi: 10.1155/2020/7390545.