REAL TIME DETECTION OF FOREST FIRES AND VOLCANIC ERUPTIONS FROM METEOSAT SECONDE GENERATION IMAGES USING A NEURAL NETWORK

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1. INTRODUCTION

One of the most important parameters in the estimation of the evolution of global warming is the gas composition of the atmosphere and its temporal variation. Amongst the various and complex processes that absorb or produce gases, the biomass burning has very important short and long term effects [1]. Remote sensing plays a key role in monitoring these effects [2], but you have to make a compromise in temporal, spectral and spatial resolution [3, 4]. As burning savannas represents the main contribution to global biomass burning, monitoring Africa becomes a priority. Because of its near real time imaging capacities and its position over the African Continent, Meteosat Seconde Generation appears to be a very promising satellite to efficiently do this task.

In this article, co-written with undergraduate students, we start by describing the data used and the way to obtain them. Then we describe two different algorithms to perform the detection of near real time forest fires and volcanic eruptions detection on Meteosat Seconde Generation images.

2. THE METEOSAT SECONDE GENERATION DATABASE

The image database used has been obtained by a home-made receiving, processing and archiving stations developed in collaboration with our undergraduate students.

Our first attempts to receive images directly from satellites occurred in 2002 [5]. These stations were analogical stations and in 2004 we developed digital receiving stations [6] to be able to receive the latest generation of meteorological satellites (Meteosat Second Generation). In recent years, we have extended the reception to other satellites like the polar ones. In this section, we present our latest recommandations in developping and managing this kind of receiving, processing and archiving stations.

2.1. The hardware part of the network

To avoid the whole chain stopping when a problem occurs, it is very important to dedicate one computer to each critical task like receiving, processing and archiving. Even if this leads to a more complex network, it is a very efficient way to isolate problems

Thanks to EUMETSAT agency for the autorization of receiving satellite images.

spectral channel (μm)	0.6, 0.8, 1.6, 3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12.0, 13.4
sampling distance (km)	1×1 (HRV channel) 3×3 otherwhise
radiometry depth	10 bits per pixel
image size	11136×5568 (HRV channel), 3712×3712 otherwise
time sampling	15 minutes

Table 1. Main characteristics of the MSG data (HRV channel for High Resolution Visible channel)

and to permit the rest of the chain to continue to work. Stations running on Linux Operating Systems seems to be more stable than Windows Operating Systems. The monitoring task of the whole chain can also be more easily done using Simple Network Management Protocol (SNMP).

2.2. New software solutions as a key of an efficient operational management

After testing different software architectures, the best results obtained are based on Ruby On Rails framework(RoR), which is an object oriented script language with Object Relational Mapping Methods. This architecture based on RoR is fully compatible with the SNMP monitoring and postgreSQL with PostGIS server, permits a very efficient access to huge databases (3 Tera-Octet/year only for MSG) and simplifies a lot the development of image processing algorithms.

2.3. The Meteosat Seconde Generation Images

The data used in this work are Meteosat Second Generation images. In table 1, you will find the main characteristics of the data [7]. Obviously, as Meteosat Second Generation (MSG) is a geostationary satellite, it is particularly well adapted for near real time applications.

3. FOREST FIRES AND VOLCANIC ERUPTION DETECTION

3.1. The physical phenomenon

First of all, in order to define these eruption detection algorithms, we start by describing the context and the physical properties that lead us to identify the most efficient spectral bands for hot spots detection. We pay attention particularly to important aspects that we have to take into account, like the solar influence for example.

3.2. An hybrid morphological and multispectral algorithm

The algorithm starts by filtering images with a tophat morphological filter. By doing this, i.e. making the difference between the original image with the opening mathematical morphological operator, we focus attention on patterns smaller than the morphological element used (a square for us). In this way, we obtain the potential fire areas. On these areas, we then use the multispectral difference between the 3.9 μm and the 10.8 μm channels. This difference is a good estimator because it grows up of fire [8] but false alarms remain.

3.3. An Artificial Neural Network to improve performances

Given the results we have obtained with this algorithm, we wanted to know if an artificial neural network (ANN) could improve the accuracy of the detection considering the time and its exactness (is it a real eruption or not?). In particular, we focus on the interest of a weighted sum of other channels than only the 3.9 and 10.8 ones. So we chose to use an ANN with supervised learning. Indeed, we have at our disposal a lot of data thanks to our images storage on our own ground station (gathered over many years) and to the ground data coming from the different volcano survey programs.

3.4. Results and validation

We complete this article with a comparison between the results we obtained with both algorithms, the hybrid one and the hybrid with neural network one and we highlight the strong and weak points of those two methods.

4. CONCLUSION

In this article, we have presented our solutions in receiving, processing and archiving images directly from satellites, dealing with the hardware and software aspects. We then have used the data acquired to work on real time detection of forest fires and volcanic eruptions. We have presented two algorithms, one based on a hybrid multi-spectral and morphological approach and the other one based on an adapted neural network approach and tested the performance of each algorithm.

In the undergraduate teaching world (university or engineering school), it is our responsability to find answers to fundamental questions like : how can we optimize the training of our students to be operational in the research or industrial worlds or how to create vocations for scientific careers. At our scale, we, a French Engineering School called ESIEA, have decided to emphasize very soon in the teaching the relationships between our undergraduate students and our research laboratories. In this article, we have presented a concrete example of research activities co-developed with undergraduate students and the scientifical level of competences reached during this kind of cross-collaboration.

5. REFERENCES

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