GIS information layer selection directed by remote sensing for ecological unit delineation

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Abstract

Nowaday, the localisation of vegetation using satellite images is a classical application of remote sensing. More precisely, using very high spatial resolution images (such as IKONOS, Quickbird or Spot Vegetation) allow to accuratly localise forest border. This allow for example to follow the evolution of forest surface in order to prevent deforestation. But to correctly survey biodiversity we have to split forest into more precise area regrouping same kind of vegetation and environment (height, humidity, ground, ...). This is all the more so important if the resources are dispersed and fragile. Most Caribean Island are in this case and biodiversity has to be carrefully supervised.

In this paper we propose a way to iteratively refine the localisation of the different kinds of forest by using a fusion between satellite images information and geographical information.

1 Introduction

Remote sensing researches and applications, developped in the previous decades, allow to extract vegetation from satellite image scenes with a fair accuracy [1, 2, 3, 4]. This allows to study the increase or decrease of forest surface. In fact, with classical remote sensing analysis (segmentation and classification based on multispectral analysis) it is possible to dectect land cover changes by comparing multi-date classifications. But this approach doesn't allow a thin follow-up of the different ecosystems inside the global forest. Moreover, some ecosystems could desappear while the forest has globally increase.

To realize such a task we have to define and caracterize each ecosystem and then to localize and follow them.

The most reliable approach is based on ground truth and allows to precisely define and localize each ecosystem, but it is time expensive. It has been made for the studied forest with a coarsed sampling using small squares manually investigates.

In this study we propose an iterative process to obtain theoretical ecosystems by integrating vectorial information and raster images analysis.

Section 2 defines the ecosystems and the main algorithm. Section 3 presents the main results and section 4 the conclusion and perspectives.

2 Definition and algorithm

Biologist have coarse definition of the existing ecosystems. Indead the main information used to discriminate ecosystems is the kind of vegetation which cover each area. This leads to many hundred kilometer square per area. The survey of the whole forest is made by analysing some representative samples within each ecosystems.

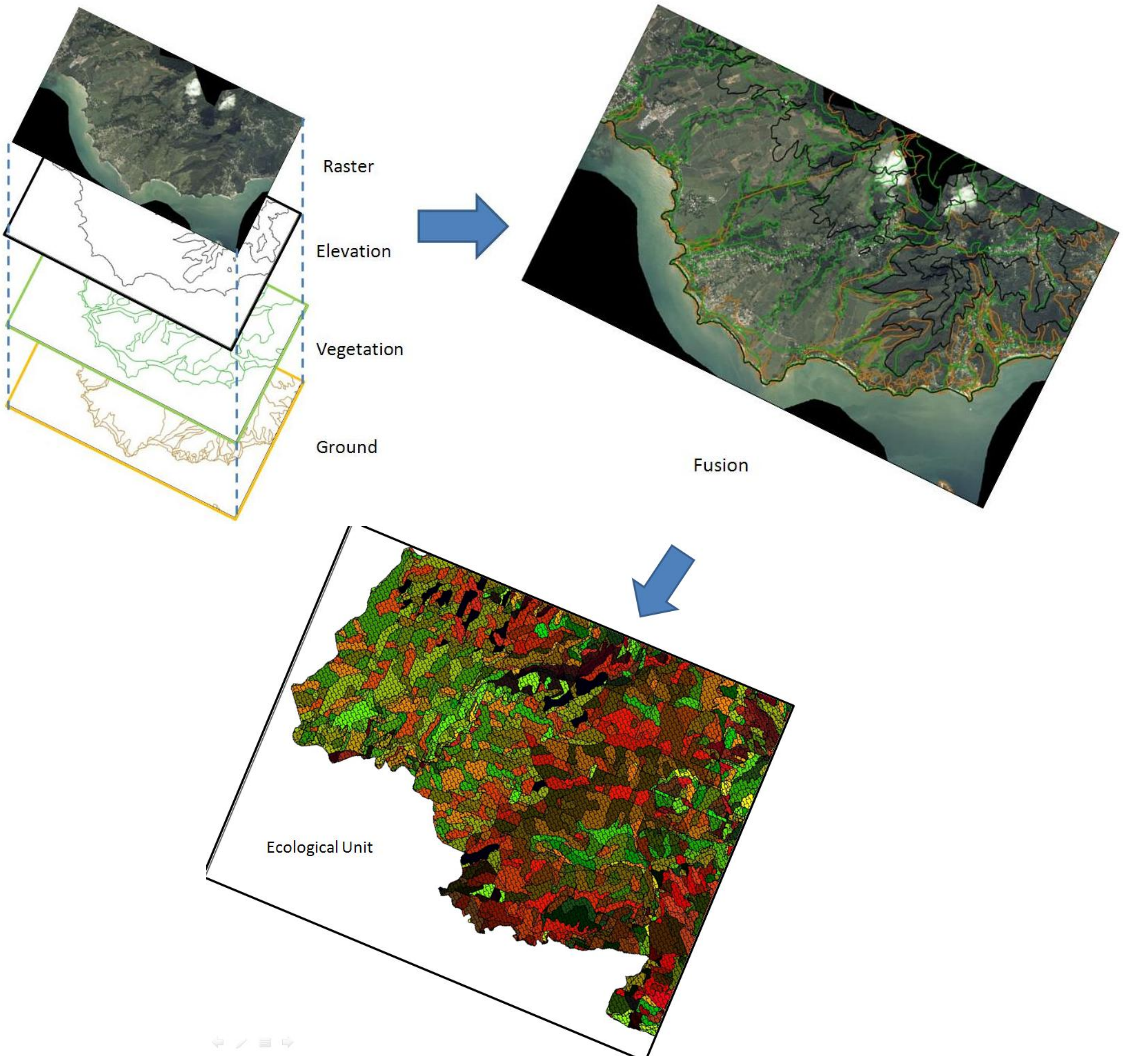

Figure 1: Ecological unit

The main problem is to localize such samples. Biologists know there is a correlation between ecosystems and environment including elevation, rain, temperature, ground, exposition, vegetation. Each of this information are stored in Geographical Information System (GIS) layers (more than 20 layers used).

We define an ecological unit as beeing a land surface having common values for some selected layers. An ecological unit could be composed of several samples having disjointed areas. Figure 1summarize this definition.

So there is a correlation between ecosystems and ecological units. We suppose that there is a subset of layers that leads to the exact ecosystems delineation.

At this step, we have to advisedly choose the layers to obtain ecological units close to the underlying ecosystems : some of the required layers have been identified by the experts but they lead to very large ecological units composed of several ecosystems; Using all layers leads to a lot of very small units, some representing the same ecosystem artificially split.

So we have to make a trade-off in order to :(i)select representative survey samples, (ii)reduce the number of samples. In this way we introduce a criterion based on remote sensing analysis. The approach is based on the hypothesis, approved by the experts and by some experiments, that all samples of the same ecosystem are visually close (same texture). For this study, we use very high resolution satellite images from IKONOS and QuickBird satellites and orthophoto in order to have as much details as possible.

So we compute features from the images on all ecological unit samples : (i)color features : we use diffrent moments such as mean or standard deviation [8], (ii)texture features : we use geometrical, statistical, frequential and fractal approaches with co-occurrence matrix [5], Gabor filters[6], Laws filters [7], Hue moments [8] and fractal dimension [9].

We use these features in order to evaluate ecological unit homogeneity and then if the selected layers lead

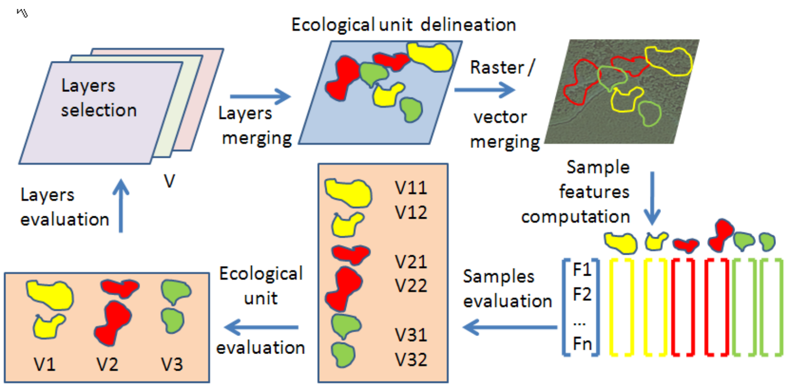

Figure 2: Main steps

to representative ecological units. In this way each unit is evaluated with an intraclass variance (in the features space) but without integrating the most distant samples. This allow to reject unit samples affected by human activities (agriculture) or natural disaster (ground slippage) which have a completely different visual aspect.

After having found the best layer set, according to the homogeneity criterion, we solve local heterogeneous problems by selecting among remaining layers ones allowing to split concerning units into more homogeneous ones.

Figure 2 summarize the different steps.

As a remark, we underline that we couldn't adopt a direct analysis to solve this problem (i.e. starting from satellite images with traditional image computing methods) because (*i*) transition between ecosystems are not clearly distinct, (*ii*) two different ecosystems could have the same visual aspect.

3 Results

Concerning the results, we have experiment the process with synthesis data : (*i*) a virtual set of ecosystems, (*ii*) a virtual set of information layers leading, with a satisfactory subset, to ecological units close to the ecosystems, (*iii*) a virtual image built with textures with the following constraints : an ecosystem is represented with a unique texture but different ecosystems could have the same texture. After about 20 simulations, about 96% of the ecological units were correctly identified. Most of the mistakes come from the texture resemblance between to different units.

Concerning real case experimentaiton, the algorithm has been used over the Guadeloupean national parc in the Caribbean. The raster image is an extract of an IKONOS scene (4 spectral bands) and an orthophoto (3 spectral bands). Some ecological units have been investigate by the experts in order to validate the approach. Results are convincing but more investigation are necessary to statistically validate the model. Meanwhile, a visual interpretation of the results shows that most of the ecological units are quite homogeneous. Moreover, some areas visually close have been split into different units using the GIS layers.

Figure 3illustrate the results with two cases. In the first line the two textures were extracted from the same vegetation unit (obtained using vegetation layer) but this unit cover different kind of vegetation (forest and low vegetation) because of ground and elevation differences. Using other layers (ground and elevation) and an texture homogenous criterion leads to split this unit into more precise ones (line 2, blue unit).

4 Conclusion

On conclusion, the GIS framework offers to remote sensing technologies a way to reach more applications and users. There is more and more datas which are collected by different ways and different institutions and accessible in a GIS environment. Remote sensing images are often used as background images to bring out some information layers but rarely used as a real information layer. By computing local features (color or texture features in the scope of this study) we also produce a new vectorial information layer.

In this study we present the interest of using images to handle problematics not reachable with vectorial datas. As an illustration we use both vectorial and raster information to define and localize ecosystems.

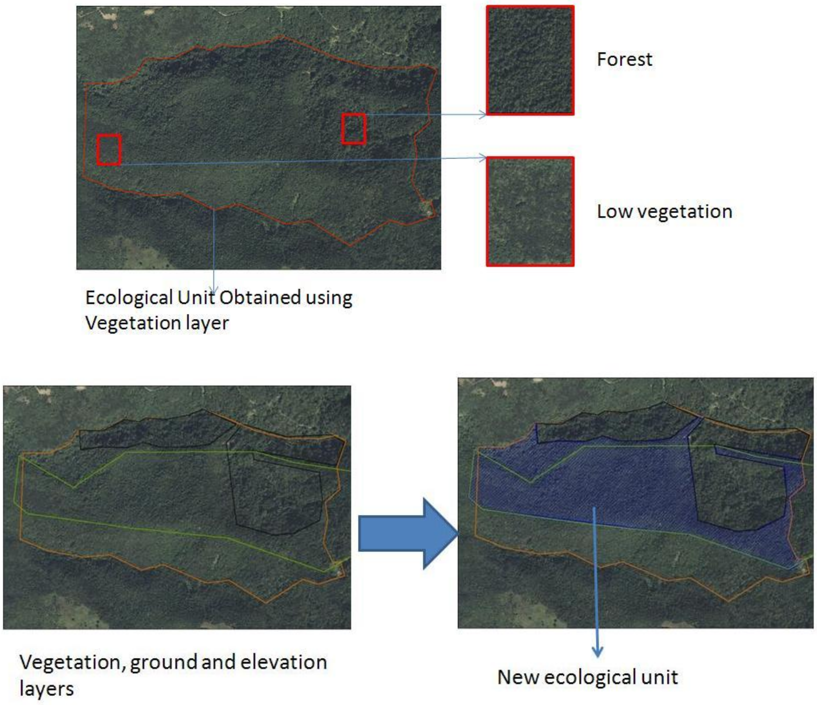

Figure 3: Results

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