

CHANGE DETECTION IN URBAN AREAS WITH QUICKBIRD IMAGERY AND NEURAL NETWORKS ALGORITHMS

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ABSTRACT:

In this paper we report on some results obtained by applying the high resolution imagery of QuickBird for the analysis of the selected urban test area: the Tor Vergata University campus, located in Italy, South-East of Rome, whose extension is of about 600 ha. Initially, a pixel-based classification algorithm based on neural networks has been implemented to automatically discriminate between some identified type of surfaces, in particular bare soils, vegetated areas, buildings and asphalted surfaces. Change detection maps have been successively produced by applying the classification procedure to two different images taken at different dates.

1. INTRODUCTION

QuickBird satellite provides the highest-resolution multi-spectral and panchromatic commercial imagery. If suitable data processing is applied, very useful information can be derived for urban area monitoring such as the detection of new buildings or the discovery of modifications in the existing ones. However, several issues have to be taken into account to produce accurate change detection maps. One main problem is the classification of each pixel on a single image, that is, to decide if it corresponds to a certain type of surface rather than to another one (for example vegetation or asphalt). Other issues regard the processing of the multi-temporal data. Among them, the coregistration of two or more scenes or the effects on the measurements (such as shadows) due to the different incident angles and/or atmospheric conditions.

In this work we considered a test area, the Tor Vergata University campus in Rome and its surroundings, and tried to set up a methodology able to face with all the aforementioned problems and to provide satisfactory results. The area has an extension of more than 600 ha and, besides the buildings belonging to the campus, it also contains private houses and small parts of suburbs of the city. Two Quickbird multi-spectral images taken on 29 May 2002 and 9 March 2003 have been acquired and analysed. For the classification problem, we considered neural networks algorithms. In fact, artificial neural networks have been shown an efficient alternative to conventional statistical approaches for automating image classification. A pixel-based classification algorithm based on a Multi-Layer Perceptrons (MLP) architecture has been implemented to automatically discriminate among 4 main classes: buildings, roads, vegetated areas, bare soils. The procedure has been applied to both coregistered images to identify the pixels whose classification response in the second date was changed with respect to the first one, and hence to derive change detection maps.

2. THE NEURAL NETWORK ALGORITHM

An artificial neural network (NN) can be viewed as a mathematical model composed of many nonlinear computational elements, named neurons, operating in parallel and massively connected by links characterized by different weights. A single neuron computes the sum of its inputs, adds a bias term, and drives the result through a generally non-linear activation function to produce a single output. In this work we have considered multi-layer perceptron (MLP) architectures. Before a neural network can be used for the inversion, it is necessary a training phase, during which the net learns to approximate the input-output relation. This training phase consists in finding the weights and biases minimizing the cost function that characterize the learning process; to pursue this minimization an algorithm of scaled conjugate gradient (SCG) has been used. With respect to classical methods, neural networks represent a fundamentally different approach to problems like pattern recognition. They do not rely on probabilistic assumptions and do not need particular requirements about normality in data sets. Moreover, they show a considerable ease in using multi-domain data sources.

In this study the aim of the classification was to distinguish among the four categories mentioned before: buildings, roads, parks and bare soil. A training-set with a statistically significant number of pixels for each of the four categories has been generated. The learning of the neural network has then been carried out by feeding it with pairs of vectors: the input vector contained the four channels measurements provided by QuickBird, the output vector contained the corresponding known class of surface. All values of the input vector have been scaled so that the values fed to the network varied in the range between -1 and 1. The iterating procedure which forms the learning process was stopped when the variations in the overall error were below a chosen threshold. As far as the numbers of hidden layers and of their units are concerned, the topology providing the optimal performance both in terms of classification accuracy and of training time has been determined by an extensive search. In this sense the best results were obtained with a 4-15-15-4 topology. The

basic software needed for the neural simulation consisted of the SNNS (Stuttgart Neural Network Simulator) package.

3. CHANGE DETECTION

The neural classification previously described has been applied to both the Quickbird multi-spectral images taken on 29 May 2002 and 9 March 2003 over the test area. The two images have been co-registered using a set of about 30 GCP (*Ground Control Points*) and using the older image as a master. From Fig. 1 to Fig. 3 we show some results obtained with the so far described methodology. In Fig. 1 and 2 the classification maps resulting from the application of the neural network algorithm to a same subarea of the two images are shown. In general the change detection results stem straightforward from the previous maps. The change detection is evaluated in terms of the pixels that have migrated from one class to another throughout the consider time window. From an operational point of view some transitions stand out for their importance. In particular we focused our attention on the constructions of new buildings so the pixels that turned from red into the white color are presented in Fig. 3. The ground-truth confirmed that the building corresponding to the main detected structure was constructed in the considered time interval.

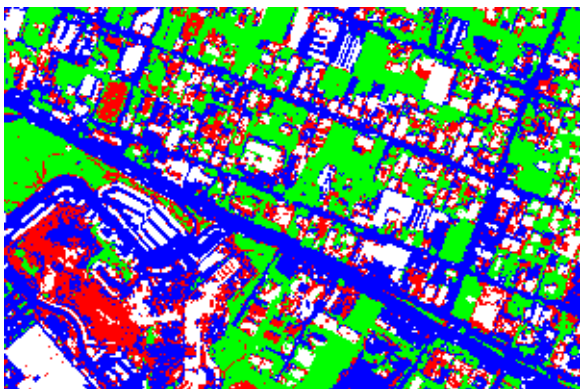


Fig. 1: Neural classification of the Quickbird image taken on 29 May 2002. Green: vegetated areas, white: buildings, blue: asphalted areas, red: bare soil

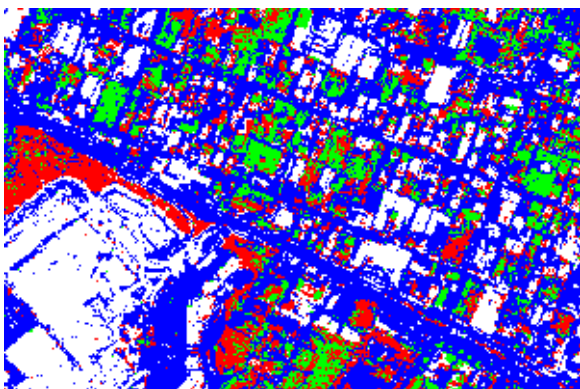


Fig. 2: Neural classification of the Quickbird image taken on 9 March 2003. Colours have the same meaning of Fig. 1

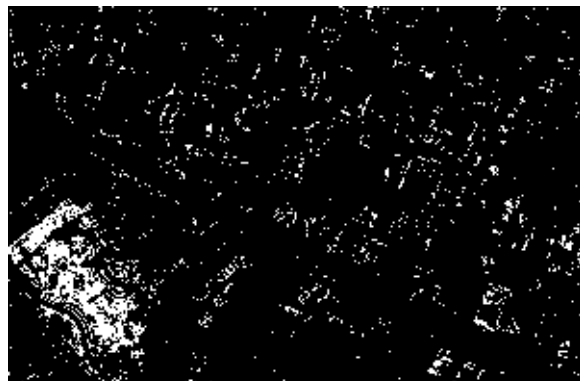


Fig. 3: Structures (white pixels) detected by means of the change detection procedure

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