Automatic change detection with Pulse Coupled Neural Networks

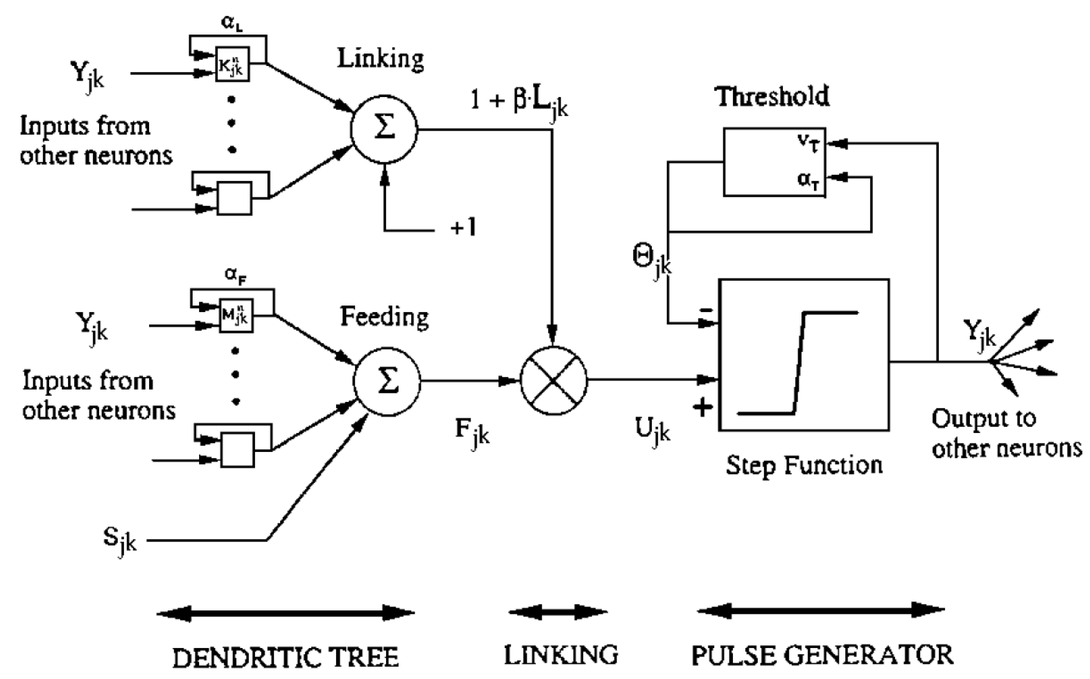
Fabio Del Frate, Fabio Pacifici and Domenico Solimini

Earth Observation Laboratory, Tor Vergata University, Rome, ITALY (f.pacifici@disp.uniroma2.it)

ABSTRACT – Map updating on the status and trends of urban ecosystems is an intensive task requiring timely and accurate information. The recent commercial availability of very high-resolution satellite data has opened a wide range of new opportunities for the use of Earth observing satellite data. Although very high resolution data have great capabilities, several issues have to be considered when changes in the observed surfaces must be detected, by processing multi-temporal data. The crucial ones include the registration of two or more very-high resolution scenes, the effects of changing solar elevation, atmospheric conditions and incidence angles.

PULSE COUPLED NEURAL NETWORK – The pulse-coupled neural network (PCNN) is a relatively new technique based on the implementation of the mechanisms underlying the visual cortex of small mammals. The same mechanisms can be used for several tasks in the field of image processing, such as target recognition or object isolation. PCNN produces a series of binary pulse images when stimulated with a gray scale or color input. It is different from what we generally mean by artificial neural networks in the sense that it does not need to be trained.

THE NEURON MOEDL –The network consists of multiple nodes coupled together with their neighbors within a definite radius, forming a grid (2Dvector). The PCNN neuron has two input compartments: linking and feeding. The feeding compartment receives both an external and a local stimulus, whereas the linking compartment only receives a local stimulus. The internal activity rises until it becomes larger than an active threshold value. Then the neuron fires and the threshold will decay until once again the internal activity becomes larger. Such a process gives rise to the pulsing nature of the PCNN.



$$F_{ij}[n]=e^{\alpha_F\delta_n}F_{ij}[n-1]+S_{ij}+V_F\sum_{kl}M_{ijkl}Y_{kl}[n-1]$$

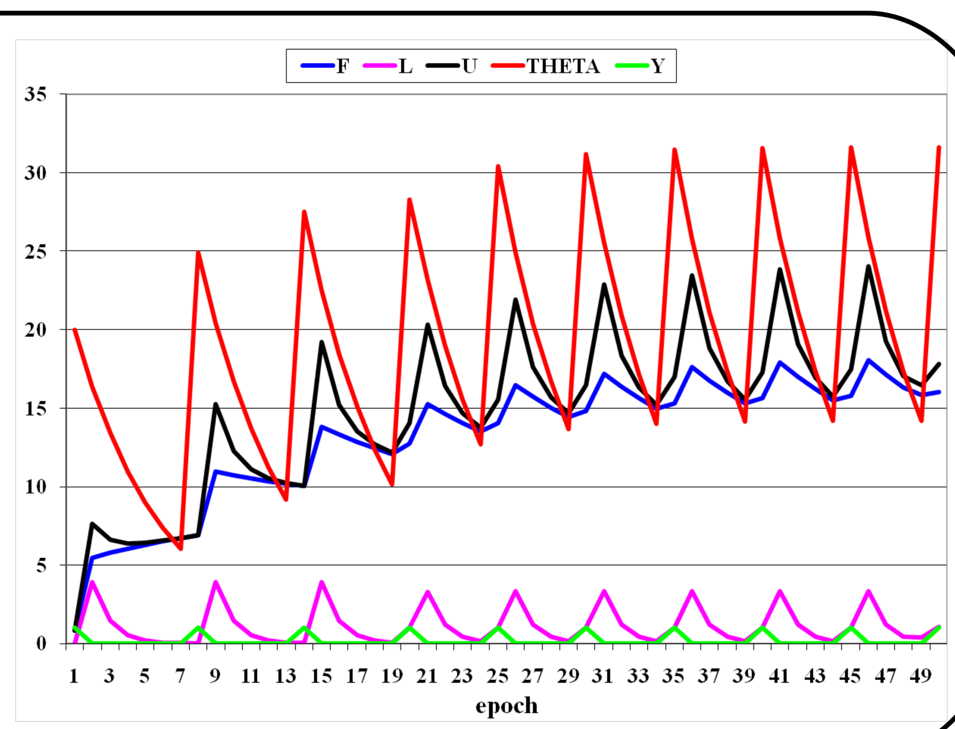
$$L_{ij}[n]=e^{\alpha_L\delta_n}L_{ij}[n-1]+V_L\sum_{kl}W_{ijkl}Y_{kl}[n-1]$$

$$U_{ij}[n]=F_{ij}[n]\{1+\beta L_{ij}[n]\}$$

$$Y_{ij}[n]=\begin{cases}1 & \text{if } U_{ij}[n]>\Theta_{ij}[n-1]\\ 0 & \text{Otherwise}\end{cases}$$

$$\Theta_{ij}[n]=e^{\alpha_\Theta\delta_n}\Theta_{ij}[n-1]+V_\Theta Y_{ij}[n]$$

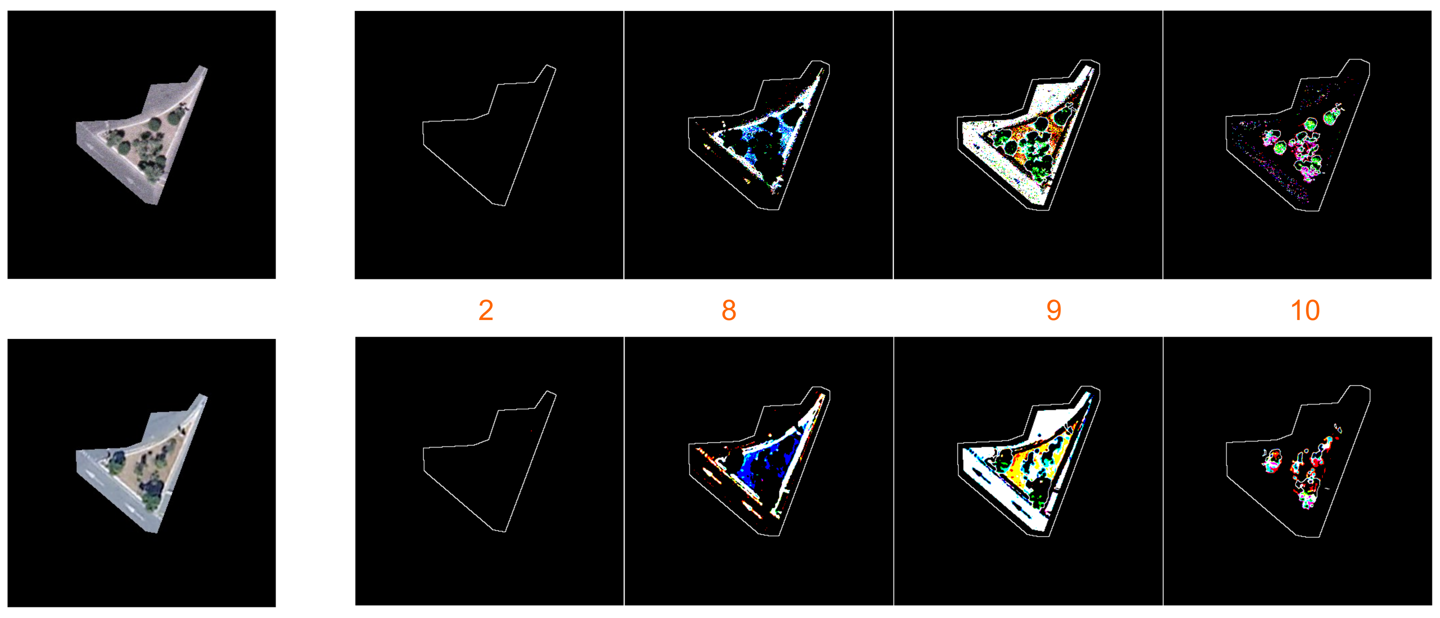
$$G[n]=\sum_{i,j}Y_{ij}[n]$$

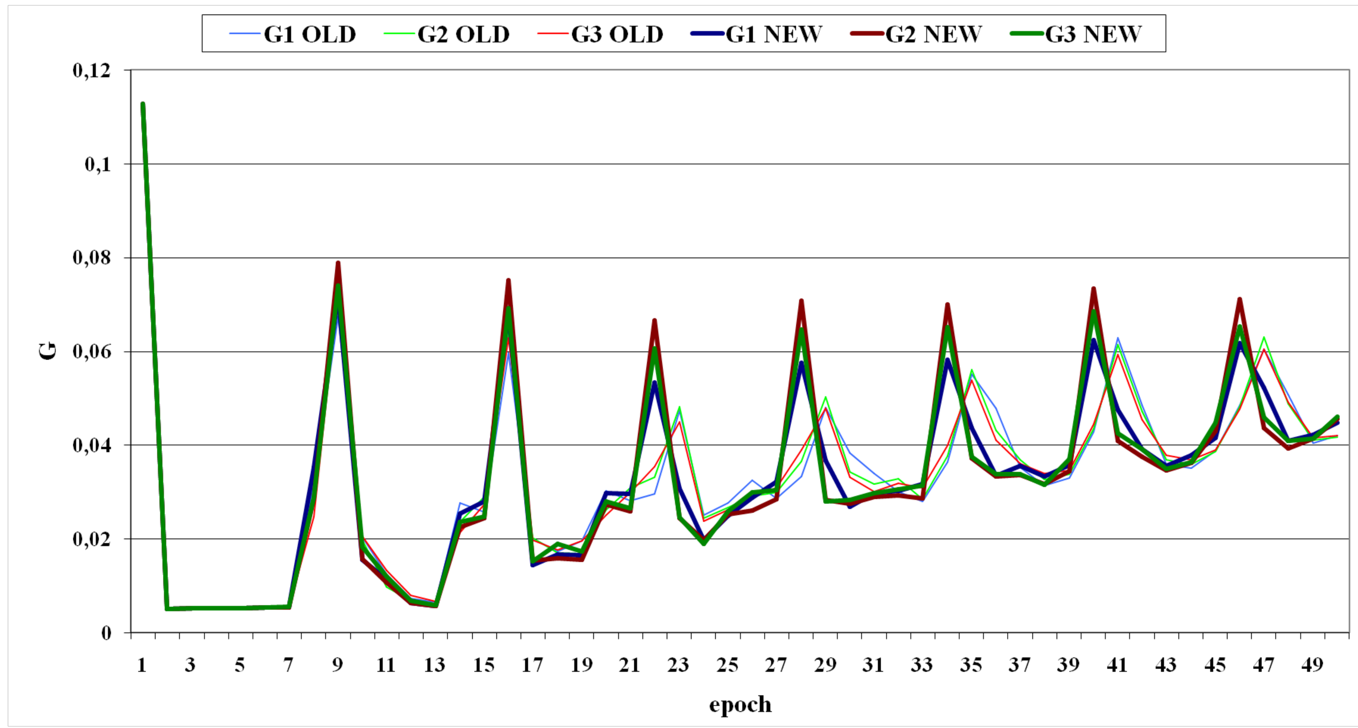


CHANGE DETECTION –The waves generated in a moving window by each iteration of the algorithm create specific signatures of the scene which are successively compared for the change detection. We considered very-high resolution aerial imagery (20 cm). False alarms due to different geometrical views (misregistration or different acquisition angle) are typical for this kind of data.

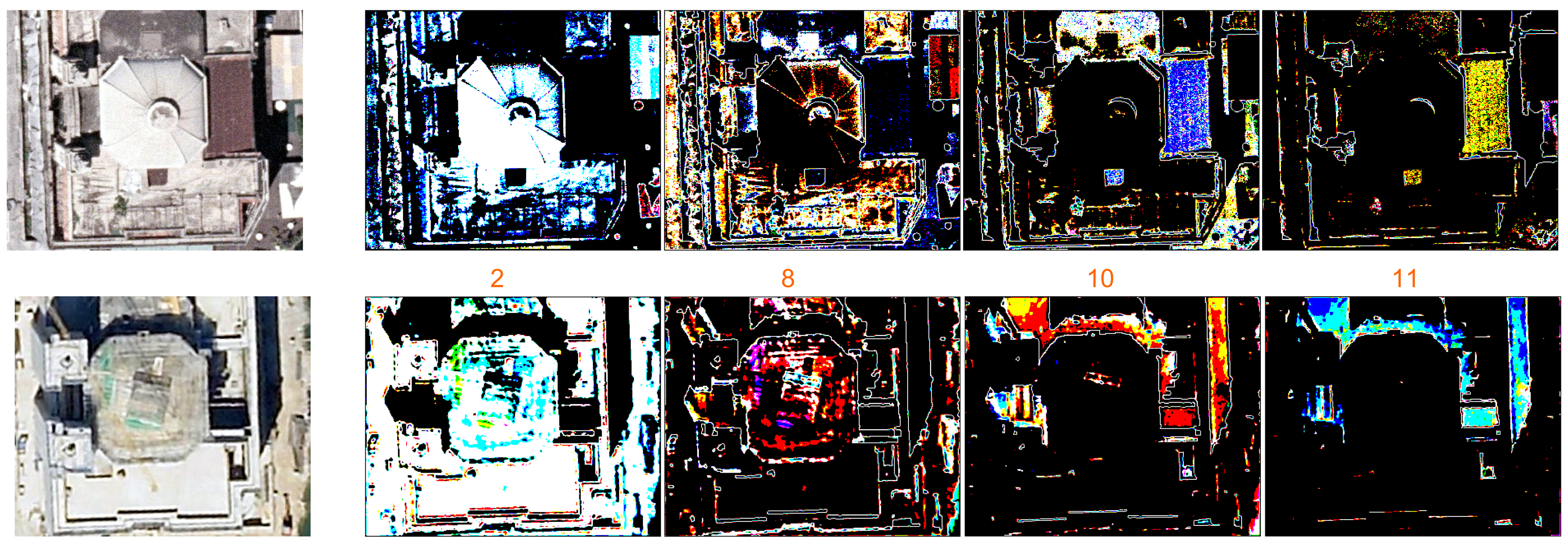
SIGNATURE ANALYSIS– The signal associated to the PCNN is invariant to changes in rotation, scale, shift, or skew of an object within the scene. These features make PCNN a promising tool for sub-metric change detection applications. Three different test cases are investigated: *No/Light changes*, *Changes* and *Huge Changes.*

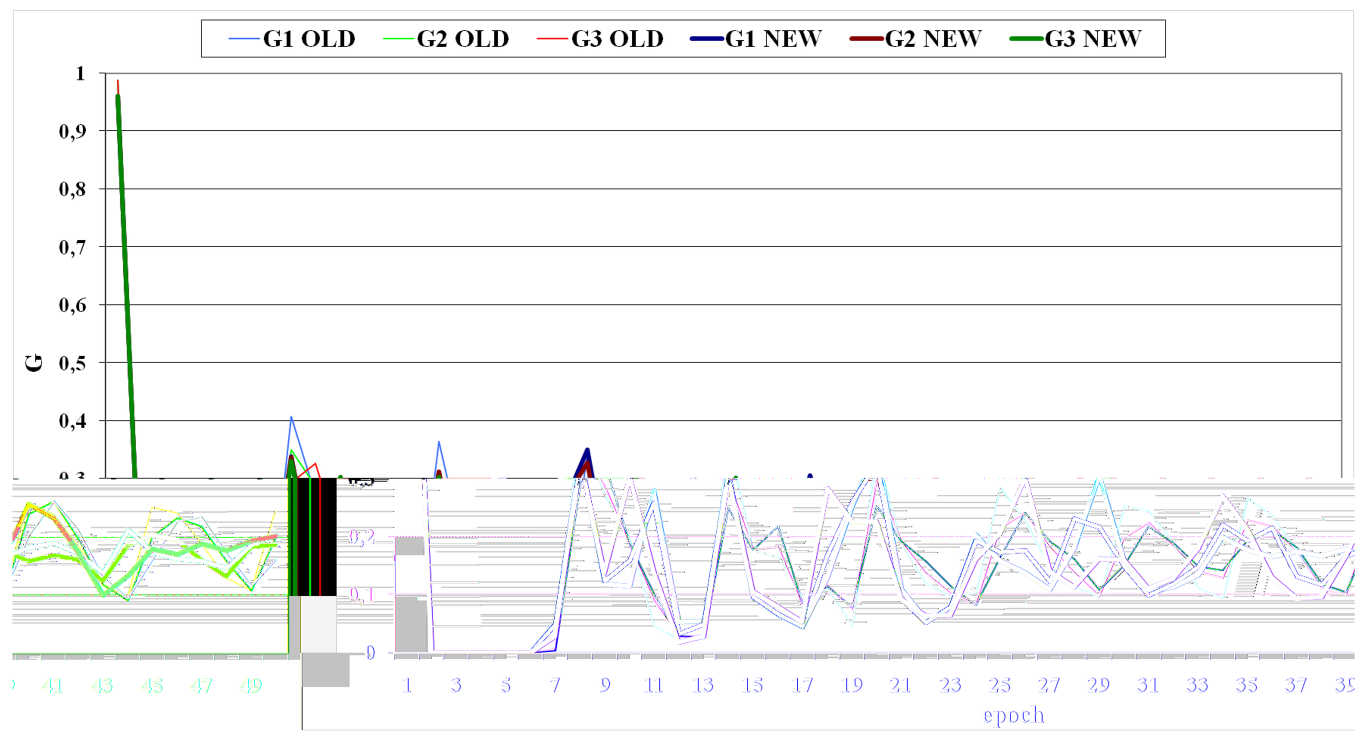
No/Light Changes



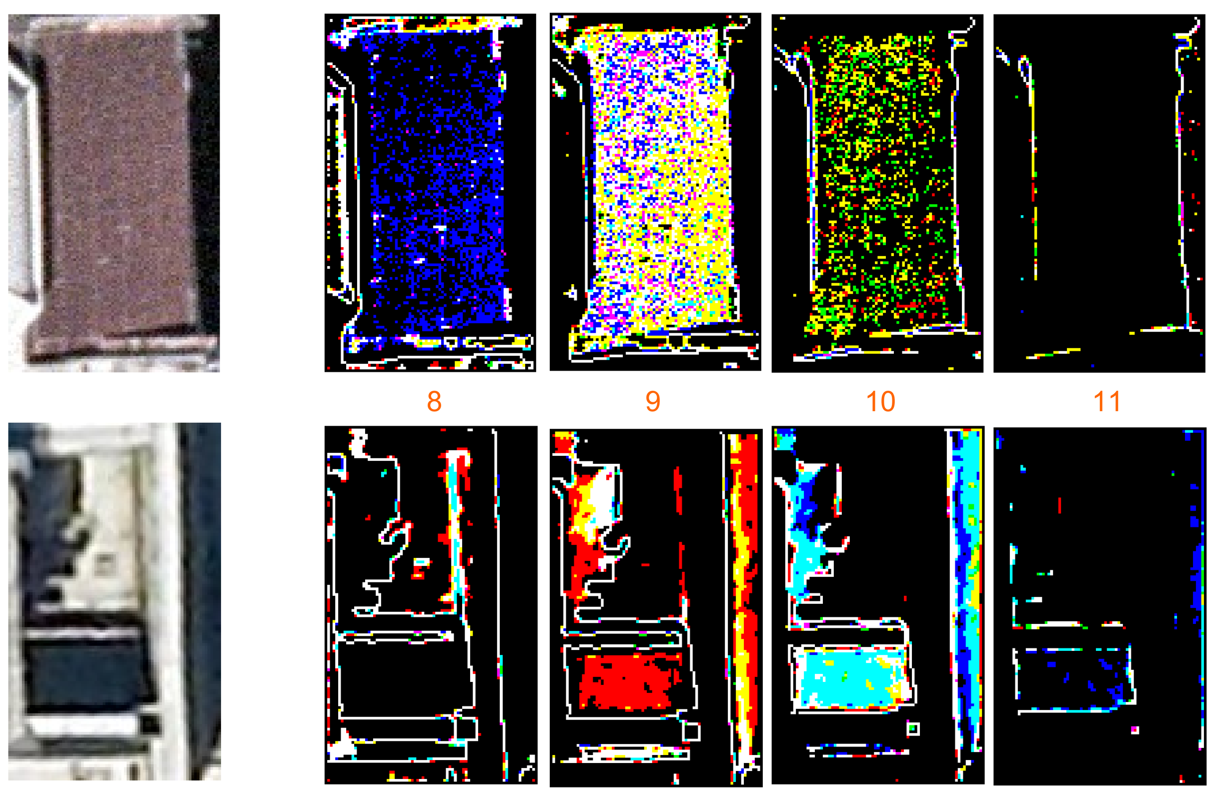


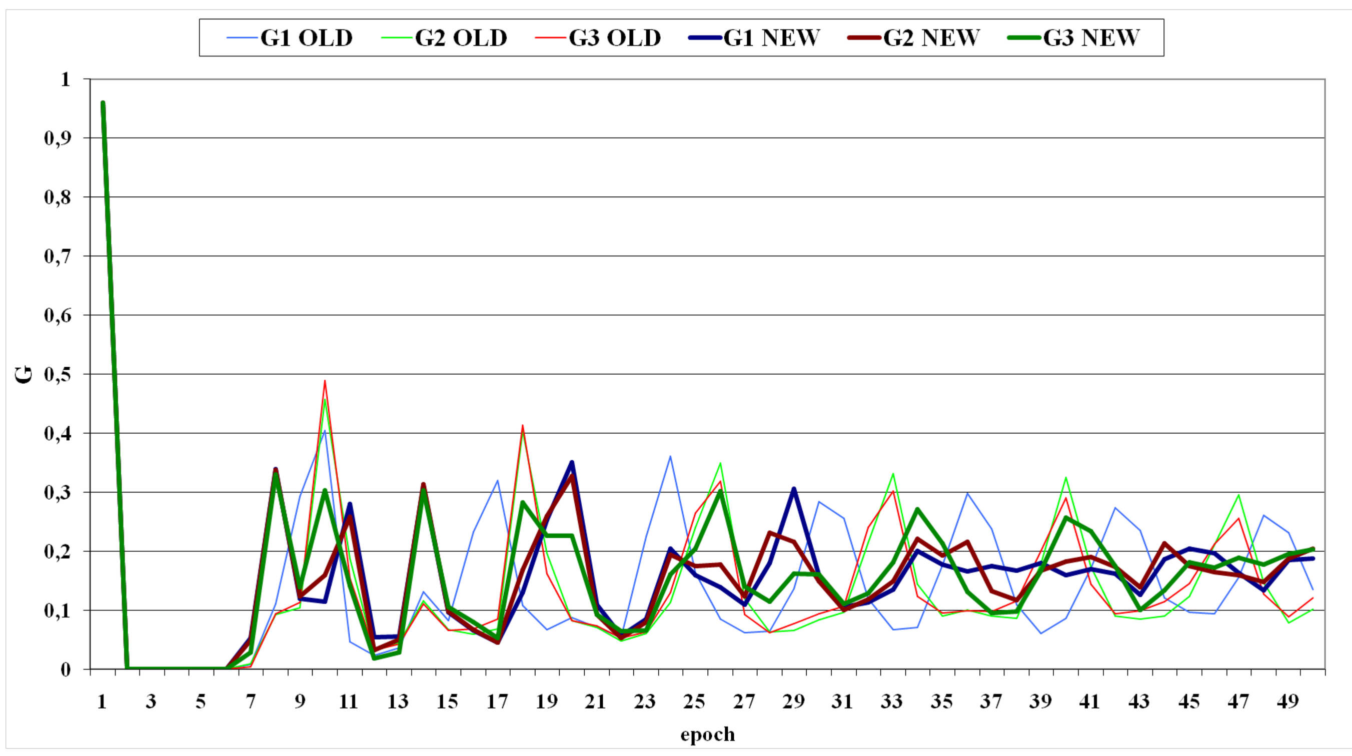
Changes





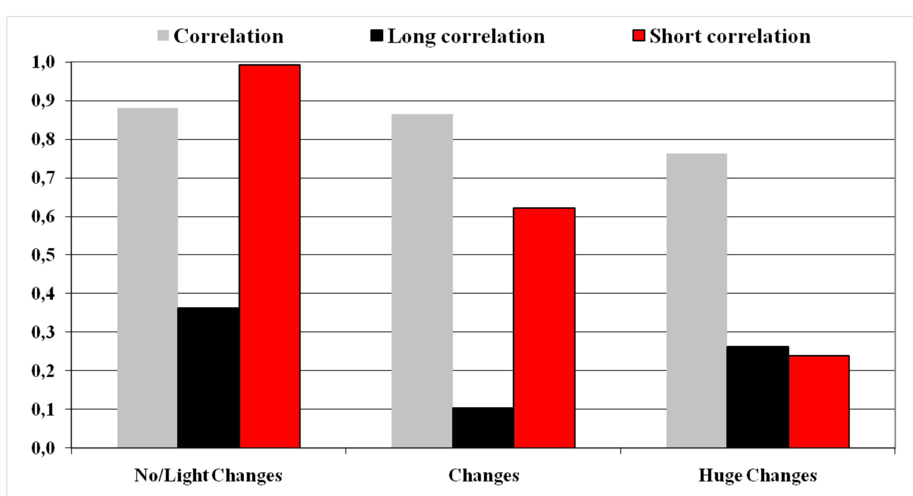
Huge Changes





CORRELATION ANALYSIS – It takes several iterations before the threshold values decay enough to allow the neuron to fire. Experimental results for the considered cases showed that neurons fired after 7 iterations (i.e., similar signatures in the interval 1-6). Therefore, the correlation between the different signatures can be further investigated considering all iterations or part of them. In particular, we considered three intervals: 1-50 for *Correlation*, 21-50 for *Long Correlation* and 7-20 for *Short Correlation.*

Among these features, *Short Correlation* only reflects the levels of change, ranging from 0.992 to 0.238.



CONCLUSION – The potential of an automatic change detection technique based on PCNN was investigated. The waves generated by PCNN in a moving window in each iteration of the algorithm create specific signatures of the scene which can be successively compared for the generation of change maps. The results shows that it is possible to distinguish between three different levels of change using the *Short Correlation* feature.