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A Cellular Automata based model for Simulating Forest Fire Dynamics

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In the latest years, the full recognition of the environmental, economical and social impact of forest fires, as well as the progresses made in the field of modelling and simulation, have leaded land managers to be increasingly interested in software tools for improving the techniques of fire fighting and preventions, and for the productions of risk scenarios. Some models (Green, 1983; Gonçalves and Diogo, 1994; Karafyllidis and Thanailakis, 1997; Malamud and Turcotte, 2000) were developed in terms of the Cellular Automata (CA) paradigm, which is widely used for modelling and simulating complex dynamical systems whose evolution depends exclusively on the local interactions of their constituent parts. A CA involves a regular division of the space in cells, each one characterised by a state that represents its actual condition. The state changes according to a transition function, which depends on the states of neighbouring cells and of the cell itself. At the starting time, cells are in states describing initial conditions, and subsequently the CA evolves changing the state of all the cells simultaneously at discrete steps, according to the transition function. We present an improved CA-based tool for the simulation of forest fire spreads, in which the main dynamic mechanisms of the phenomenon are modelled by local rules derived from experimental studies carried out in the past by various researchers (e.g. Rothermel, 1972, 1983; Albini, 1976; Anderson, 1982, 1983). Differently from the above cited CA fire models, the proposed tool make uses of a hexagonal lattice, where the neighbourhood pattern includes the double order of hexagons around the cell. This proves capable of avoiding the spurious symmetries that often arises when spreading phenomena are simulated by CA using square cells. Besides, the developed fire model comprises the

three dynamic mechanisms of the forest fire propagation in presence of heterogeneous fuels and complex orography, that is, the surface fire, which burns the fuels in contact with the ground surface, the crown fire, which may affects the tree crowns under particular conditions, and the spotting phenomenona, which may happen when trees become as torches and some embers are projected forward by the wind. The validation of fire spread models is difficult because usually standard fire records don't account for all the data necessary to the simulation, and indeed few works describe validations based on real fires. Nevertheless, we report some preliminary results of a comparison between the outcomes of the proposed CA model and some real forest fire spreadings. The reported results show a significant fitting, both in qualitative (e.g., the shape of the final spread) and in quantitative terms (e.g. the burnt area and the average fire velocity).