Semi-automatic Design of near-optimal Torrent Control Policies by using Cellular Automata and Intelligent Random Search Techniques

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Torrent control measures (TCM) in catchments aim at mitigating risk. Limited financial resources force decision-makers to design cost-effective TCM bundles, a classical case of an optimization problem. This requires knowledge about processes to influence and the impact of TCMs depending on their spatial distribution. Until now, such problems were solved by expert knowledge and rules of thumb. Increasing availability of computational resources and digital geoinformation favour computer-aided approaches for improving the cost-effectiveness of TCMs by selecting optimal spatial pattern under economic and environmental constraints.

The mass-fluxes of water runoff and sediment delivery in a torrent catchment will be affected by TCMs in the slope and the channel. For modeling purposes, the catchment is divided in a regular grid of cells whose state and inter-cell mass fluxes are represented using cellular automata (CA). In a first step, the solution-space for the optimization problem is constrained by identifying feasibility areas for the different TCMs. The second step includes design of the CA. Fluxes of water F_w and solids F_s through cells are represented by functions for the outflux $F_w = f($influx water, influx solids, slope, precipitation, infiltration rate, saturation$)$, $F_s = f($influx water, influx solids, erodibility, soil, saturation$)$ and influence state variables for soil and infiltration rate. The state of the cell depends on fluxes, state variables and neighborhood conditions. It is determined by combination of location (channel, slope), cover and type of TCM. The external input is precipitation with known recurrence period. The third step uses the effect of TCMs on fluxes to determine risk-mitigation, and searches for the maximum value of effectiveness by using a heuristic search method. It is expected that

such an approach improves both the understanding of the mass flux / TCM interaction and the efficiency and effectiveness of TCM concepts, thus providing decision support to decision-makers.

An upcoming PhD-project will give opportunity to further develop this method as a continuation of a previous thesis that showed that the combination of CA and heuristic search methods provides a powerful tool for solving problems as shown above.