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Landslide Susceptibility Mapping Using Adaptive Support Vector Machines and Feature Selection

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Landslide susceptibility maps are very useful tools for natural hazards assessment and for territorial planning. A lot of research is carried out in the field by focusing on the understanding of the connection between the conditioning factors (mainly topographic, hydrological and geological features) and the occurrence of landslides.
The lack of knowledge due to the complex, non-linear and even unknown relations between the triggering factors and the presence of landslides motivates the use of statistical classification models against physical approaches. Given a dataset with known landslide areas (positive class) and known safe places (negative class), logistic regressions, artificial neural networks (ANN) and recently support vector machines (SVM) can be trained to discriminate the two classes in the high-dimensional space of explanatory features. Main research efforts consider the definition of optimal sampling strategies to select places which are relevant for the triggering of landslides and the comparison of different classification models according to the performance achieved. However, less attention is paid to the understanding and interpretation of the classification models. Machine learning algorithms are often used for landslides classification because of their ability in dealing with high-dimensional spaces effectively leading to high classification performances. At the same time they do not give a direct way of analysing the relevance of contributing features, e.g. they do not provide interpretable models of the reality. Feature selection methods can be used in combination with machine learning methods to select the relevant variables for the task.
The goal of this study is to apply SVMs for mapping of landslide susceptibility in canton Vaud (Switzerland) by applying efficient methods of feature selection which eventually enhance models' interpretability.
The three main geological regions of Vaud (Prealpes, Plateau and Jura) were chosen as separate study zones. Morphological features describing the terrain shape and hydrological context were extracted from the digital elevation model with 25x25 square meters of spatial resolution. Categorical features relating to the geologic types were also included in the models to account for the differential properties of the mother rock and of the material in place. Classic data splitting techniques were used for model selection and assessment purposes with particular care in selecting spatially independent landslides for the different sets. SVMs are then applied independently to the three study zones by analysing the impact of varying dataset sizes and to set a baseline classification performance. Then, a recent SVM-based feature selection method, the adaptive scaling SVM, is used to assess the relevance of input features and to give interpretability to the models. It allows finding optimal scaling parameters for input features by finding an adapted metric. The minimization of the SVM error function by gradient descent is performed to achieve this goal. The final distribution of scaling factors provides hints about the contribution of features. High scaling factors are given to important features and low ones, or even null ones by enforcing solution sparseness, to irrelevant features. The recursive feature elimination, a state-of-the-art algorithm exploiting the properties of SVM, is also used for comparison. It consists in a sequential elimination of variables starting from the least important to the most important according to the relative change of the SVM margin.
Results show that the contributing features depend on the study region unveiling the different triggering mechanisms. Models computed with the reduced set of features demonstrate similar accuracies encouraging the elimination of irrelevant information. The resulting model is consequently simplified and more interpretable for a further analysis regarding the triggering factors.