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Avalanche Danger Forecasting with Machine Learning Methods

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Whilst developments in computational modeling of snowpack development and avalanche dynamics have been rapid in recent years, the direct application of such models in operational avalanche forecasting is still relatively limited. A key reason for this limited application lies in the complex relationship between weather, snowpack and stability and the methodologies applied by those involved in the production of avalanche forecasts. In contrast to more physical models, some form of Nearest Neighbours (NN) approach has been widely applied in operational avalanche forecasting, whereby a range of weather and snowpack variables are used to classify similar conditions and events in the past. Such approaches can be considered to provide useful information to the forecaster in the form of an *aide-memoire*.

However, within the Machine Learning domain NN approaches are considered to be a baseline technique for data-driven modeling. The advanced Machine Learning techniques include Support Vector Machines. They are independent of the dimensionality of the input feature space and allow development of robust non-linear models with good generalization abilities. These methods were recently introduced in the scope of Statistical Learning Theory. According to the inductive learning principles of the Statistical Learning Theory, the optimal predictive model for a given data modeling task has to be built by finding the trade-off between the model complexity and its fit to training data. It gives rise to excellent generalization abilities of the Support Vector Machines. An important feature of this method is that the predictive classification is based on the Support Vectors – the most important and discriminative samples in the dataset, which are extracted by the algorithm. Thus, the model output is interpretable, an important prerequisite for real-life decision-support. This is not the case for the

"black box" neural network models.

The contribution of this paper is the development of the approach of applying a Support Vector Machine classifier for local avalanche prediction based on weather observations. A case study based on weather and snowpack data together with avalanche observations for the Lochaber region in Scotland is presented. The developed method is compared with the baseline NN approach, and the probabilistic neural network. The results of Support Vector Machines decisions are among the best and seem very promising. The practical issues of including the SVM into the real-life prediction process and the perspectives of further developments using the available prior information are discussed.