Forecasting visibility with Artificial Neural Networks

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Forecasting visibility is of considerable importance to several weather-dependent human activities and operations, on most of which it even has a direct life and property safety impact(e.g. aviation). The generally non-linear character of the atmospheric processes underlying the formation of poor visibility conditions renders Artificial Neural Networks (ANN) a suitable tool for forecasting such events. The highly complex nature underlying such processes goes beyond human comprehension and in this respect, ANN appear to be appropriate in an attempt to by-pass a total understanding of the physical processes involved. In this respect, ANN have been employed in an attempt to investigate their suitability in low visibility forecasting.

The ANN approach has been used for two locations, one at Larnaka Airport in Cyprus and the other at Gardenmoen Airport in Norway. Data from Automatic Weather Observing Systems at these two sites have been used to train and test the ANN created. The aim is the development of a practical too in operational for forecasting low visibilities. In this approach, the focus is on forecasting probabilities for a set of five visibility ranges. In order to provide the best possible guidance for meteorologists and other decision makers, forecasts should be formulated in probabilistic terms. The probabilistic approach was chosen as it is more informative to the deterministic approach.

The selection of predictors is the first step in this endeavor; this is based on a greedy forward search algorithm. At the first step, neural nets with one predictor variable are trained, as described above, for all possible predictor candidates. The predictor contributing to the best prediction with respect to either RPS or RMSE is chosen. At the second step, neural nets with two predictor variables, where the first of these are the one chosen at the previous step, are considered. The best combination is then chosen. The process is repeated until addition of new predictor variables no longer improves the validation score.

Various ANN modeling approaches are investigated:

(a) Standard probabilistic neural net

A forward search for the best predictor set is carried out on the training set; a new probabilistic neural net is then trained using all the training data.

(b) Multi-model averaging

Instead of using only the best set of predictors, several neural nets can be trained one for each predictor combination. Predictions for each model are then made for the test data and the average applied. A weighted average can also have be applied.

(c) Two-stage neural net modeling

The basic idea in the two-stage modeling process is to use deterministic neural nets to make input variables for the probabilistic neural nets. It is most natural to start with making a deterministic neural net whose output are predicted visibility in meters. A forward search for predictors is then carried out, followed by training and predictions for the test data. For the training data the cross-validated predictions are applied as the new input variables. A probabilistic neural net is then fitted using the predicted visibility as the input variable.

In addition to having deterministic predictions of visibility as an input variable, it may also be useful to have predictions of its error as a quantitative measure of uncertainty. A forward search for predictors is carried out, then retraining the best model and finally making predictions of absolute errors on the test data. A probabilistic neural net is then fitted using the predicted visibility and the predicted absolute error as input variables and predictions made for the test data.

For most purposes reduced visibility events are more important than good ones, and it may be of interest to put more weights on these cases. In probabilistic forecasting this is difficult to achieve without making biased probabilities. The two stage approach, however, provides an option; in the deterministic neural nets used to create predictors, weights can be included to the loss function. This will result in biased predictions. The weight for a given case is in the examples denoted as one minus its empirical class probability.