Markovian forecast of extreme events by methods of symbolic dynamics

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The records in time series which are upper than the some level or threshold are called extreme events. Usually threshold is chosen in such a way that these extreme values belongs to tail of the distribution function. The task of extreme events predictions appears in different fields, for example in geophysics. There were two approaches considered.

First of them is based on selection of a certain threshold value, which is considered as extreme event. We applied symbolic dynamics techniques to obtain an empirical measure. The extreme events we coded as ones, other records is zero. As a result we received a consecution of symbols. From this symbolic representation of the time series we construct the words or patterns of symbols with fixed length. The frequency distribution of such words could be seen as empirical estimation of measure. In the most interesting cases multifractal analysis showed that the measure has multifractal properties. So it could be modeled with a Recurrent Iterated Function System with probabilities. Such system represents random dynamical system. Its trajectories lie on the attractor which has a unique ergodic measure. So, the coefficients and the probabilities could be found by solving the inverse problem in fractal theory. We used "collage-distance" as an objective function of the problem. In such a way we generated theoretical measure and used it for the prediction. The predictor was implemented in a form of Markovian chain.

The second approach is based on patterns of order. This approach could be applied in the cases when we could not define a fixed threshold for time series. We divided whole time series into the short samples with a fixed length. The sequence of counts in each word was encoded in accordance to the relation of strict order. The prediction was based on using matrix of transitional probabilities between different words. Numerical results of real data prediction were received for both methods and they showed that such approaches are very perspective.