Book review:

NEURAL NETWORKS AND SEA TIME SERIES. RECONSTRUCTION AND EXTREME-EVENT ANALYSIS

by

B. Tirozzi, S. Puca, S. Pittalis, A. Bruschi, S. Morucci, E. Ferraro and S. Corsini

Nowadays, neural networks (NN) are widely applied to several classification, prediction and approximation tasks. The book under consideration touches one of the less popular application areas, which is analysis, reconstruction and prediction of various marine time series.

The book is composed of eleven chapters, which can functionally be divided into four parts. The first two chapters provide an introduction to the subject. Chapters 3-6 cover mathematical foundations of marine time series description and discuss theoretically the use of NN and statistical methods in approximation and prediction of such series. The next part, composed of the four following chapters, describes several experiments carried out using NN and statistical models. The last chapter provides conclusions and a brief description of open problems encountered by the authors while working on the subject.

The book starts with an introduction to the nature of waves and tides, providing their physical characteristics followed by formal, mathematical description of the notion of significant wave height (SWH) – the phenomenon being one of the main goals for NN-based prediction methods discussed in the book. The other underlying prediction problem, associated with tides, is the reconstruction of sea level (SL) data. The waves occurring along the coast of Italy are monitored by the dedicated network (the National Sea Wave Measurement Network) consisting of 14 huge buoys berthed at the depth of about 100 meters, whereas tides are tracked by the system of 26 stations uniformly distributed along the Italian coast, located mainly in sea ports.

On the theoretical side the book provides a comprehensive introduction to the phenomenology of the marine data and physical models (e.g. wave amplitude model) used for marine events forecasting (Chapter 3), followed by the theoretical discussion on neural networks' applicability to prediction problems (Chapter 4). Both chapters are well written, although the latter one presents quite a narrow point of view, focusing mainly on the architectures and algorithms used in the experiments. Besides the description of a widely known

perceptron model and formulation of theoretical, existential results concerning its application as a general approximation system (Vapnik-Chervonenkis theorem), this part also includes a short, two-page discussion on the less known topic, namely the problem of determining the embedded dimension of a time series, which I have found particularly interesting. Included in this chapter there is also a brief presentation of a simulated annealing optimization method, which I expect to be of interest to the readers, though again its description does not extend beyond standard specification. The next chapter discusses the applicability of NN, regarded as a complete set of functions, to the problem of approximation of an n-dimensional continuous real-valued function by the linear combination of sigmoid functions basing on Stone-Weierstrass and Kolmogorov's theorems. Such an approximation can be straightforwardly implemented by a feed-forward neural network. In Chapter 6 the extreme-value theory is considered as a powerful statistical approach to evaluation of the probability distribution of extreme events, which are usually relatively rare. In particular the case of independent identically distributed (i.i.d.) time series is thoroughly theoretically examined.

The following four chapters are dedicated to description of various computer simulation–based experiments with prediction of marine data. In Chapter 7 mathematical properties of the SWH and SL time series are presented, followed by application of NN to reconstruction of the missing data in these two series. The results are encouraging, especially concerning the experimentally proven long-term efficacy of the proposed methods, which allows data reconstruction in a few months and a few years horizons, respectively for SL and SWH data. Statistical models being an alternative to NN in solving prediction/reconstruction problems are discussed in Chapter 8. Two widely known approaches, namely approximation operators and ARIMA (autoregressive integrated moving average) model are applied to reconstruction of SWH and SL missing data. In the next chapter the problem of extreme events reconstruction and prediction is further considered. In particular, the efficacy of an NN-based system composed of two seasonal subsystems, each of which consisting of two individual NN dedicated to high and low values in the SWH data, respectively is discussed. The ranges of low/high data are defined depending on past distributions of SWH at a particular measuring station under consideration. The system attains promising results, although due to the lack of comparison with alternative methods it is difficult to objectively judge its quality. In Chapter 10 the methods proposed in the book are further validated by their successful application to marine data reconstruction along the Californian coast. Moreover, applications of NN to precipitation forecasting in Northern Italy using appropriately preprocessed historical data and to correction of temperature forecasts generated by wave amplitude model (described in Chapter 3) are discussed in this chapter. Conclusions and possible directions for future research are briefly presented in Chapter 11.

In summary, the book provides a successful blend of theoretical and practical points of view presented by the authors - theoreticians (scientists) from the Department of Physics of Rome University "La Sapienza" and practitioners (en-

gineers) engaged for years in the research concerning marine events prediction
and analysis from the National Department of Technical Services of Italy. It is
generally well written, even though a reader cannot avoid a feeling that it is a
truly multi-author publication, since particular chapters are written in different
styles, specific for their authors. Consequently, the level of detail in description
and deepness of conclusions clearly vary between chapters. The book should
be recommended mainly to professionals (researchers and engineers) interested
in application of NN to a relatively narrow, though highly non-trivial domain,
which is marine data analysis and reconstruction. To the best of my knowledge
this volume is a unique book publication devoted to this subject.

Jacek Mańdziuk