Recent Advances of Neural Networks Models and Applications: An Introduction

Anna Esposito[1], Simone Bassis[2], and Francesco Carlo Morabito[3]

[1] Second University of Napoli, Department of Psychology and IIASS, Italy
[2] University of Milano, Department of Computer Science, Italy
[3] University "Mediterranea" of Reggio Calabria,
Department of Civil Engineering, Energy, Environment and Materials (DICEAM), Italy
iiass.annaesp@tin.it, bassis@di.unimi.it, morabito@unirc.it

Abstract. Recently, increasing attention has been paid to the development of approximate algorithms for equipping machines with an automaton level of intelligence. The aim is to permit the implementation of intelligent behaving systems able to perform tasks which are just a human prerogative. In this context, neural network models have been privileged, thanks to the claim that their intrinsic paradigm can imitate the functioning of the human brain. Nevertheless, there are three important issues that must be accounted for the implementation of a neural network based autonomous system performing an automaton human intelligent behavior. The first one is related to the collection of an appropriate database for training and evaluating the system performance. The second issue is the adoption of an appropriate machine representation of the data which implies the selection of suitable data features for the problem at hand. Finally, the choice of the classification scheme can impact on the achieved results. This introductive chapter summarizes the efforts that have been made in the field of neural network models along the abovementioned research directions through the contents of the chapters included in this book.

Keywords: Neural network models, behaving systems, feature selection, big data collection.

1 Introduction

Human-machine based applications turn out to be increasingly involved in our personal, professional and social life. In this context, human expectations and requirements become more and more highly structured, up to the desire to exploit them in most environments, in order to decrease human workloads and errors, as well as to be able to interact with them in a natural way. Along these directions, neural network models have been privileged because of their computational paradigm based on brain functioning and learning. However, it has soon become evident that, in order for machines to show autonomous behaviors, it would not suffice to exploit human learning and functioning paradigms. There are issues related to database collection, feature selection and classification schema that must be accounted for in order to

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obtain computational effectiveness and optimal performance. These issues are briefly discussed in Sections 2 to 4. Section 5 summarizes the contents of this book by grouping the received contributions into 5 different sections devoted to the use of neural networks for applications, new or improved models, pattern recognition, signal processing and special topics such as emotional expressions and daily cognitive functions, as well as bio-inspired networks memristor-based.

2 The Data Issue

In training and assessing neural networks as a paradigm for complex systems to show autonomous behaviors, the first issue that arises is the appropriateness of the data exploited for it. It has become evident that system performances strongly depend on the database used and the related complexity of the task. If the database is poor in reproducing the features of the task at hand, inaccurate inferences can be drawn, and the trained neural system cannot perform accurately on other similar data. Therefore, it is necessary to assess the database in order to ascertain if it reproduces a genuine setting of the real world environment it aims to describe. The questions that must then be raised in order to define the suitability of the data are:

a) Have data been collected in a natural or artificial context? As an example, this can be necessary if the system must discriminate among genuine emotional speech or real world seismic signals, as opposed to acted emotional speech or synthetic signals [3,4,6];
b) Are data equally balanced among the categories the system must discriminate? In this case, consider as an instance a speech recognition task. If gender is not an issue, then the data must be equally balanced between male and female subjects;
c) Are data representative of the final application they are devoted to? This last question calls for the importance, in designing the database, of the actual task the system is designed for.

3 Feature Selection

This issue relates to the way the data are processed in order to extract from them suitable features efficiently describing the different categories among those the system must discriminate for the task at hand. The selection of features can be very hard and difficult depending on the task. An interesting example to describe this problem is to consider a speech emotional recognition task. In this case, the features selection task can be simple (as for a speaker dependent approach [17]) or very complex (if the task is speaker independent [3,4]) and even more in a noisy environment (as in the case of speech collected through phone calls [1,7]). The features selection procedure is strongly dependent on the data and the task, and its effectiveness relies on the knowledge the experimenter applies to understand data and identify features for them, as illustrated by Likforman-Sulem et al. in this volume and deeply explained in [14]. In addition, features from different sources can be combined

and fused, as it is tradition in the field of speech, where linguistic (such as language and word models [12]) and/or prosodic information (such as F0 contour [19]) and visual features (such as action units [13] are fused with acoustic features [8,20]. Automatic approach to feature selection can produce a huge amount of features [2] making hard the neural network training process. Of course, the relevance of this step is not limited to speech signal processing (see, for example, [21]).

4 Classification Schema

There are several classification schema proposed in literature for detection and classification tasks. The most exploited are Artificial Neural Networks (ANN) Gaussian Mixture Models (GMM), Hidden Markov Models (HMM), and Support Vector Machine (SVM) [9,10,18,22]. Advantage and drawbacks in their use have been reviewed recently in [11]. It is not the aim of this short chapter to go deep inside the problematics of the different classification schema. However, it is important to point out that they can be fused together in more complex models as reported in [15] or be complicated by sophisticated learning algorithms as those related to deep learning architectures, illustrated by Schuller in this volume and deeply explained in [5].

5 Contents of This Book

For over twenty years, Neural Networks and Machine Learning (NN/ML) have been an area of continued growth. The need for a Computational (bioinspired) Intelligence has increased dramatically for various reasons in a number of research areas and application fields, spanning from Economic and Finance, to Health and Bioengineering, up to the industrial and entrepreneurial world. Besides the practical interest in these approaches, the progress in NN/ML derives from its interdisciplinary nature.

This book is a follow-up of the scientific workshop on Neural Network held in Vietri sul Mare, Italy in May 15-16th 2014, as a continued tradition since its founder, Professor Eduardo Caianiello, thought to it as a way of exchanging information on worldwide activities on the field. The volume brings together the peer-reviewed contributions of the attendees: each paper is an extended version of the original submission (not elsewhere published) and the whole set of contributions has been collected as chapters of this book. It is worth emphasizing that the book provides a balance between the basics, evolution, and NN/ML applications.

To this end, the content of the book is organized in six parts: four general sections are devoted to Neural Network Models, Signal Processing, Pattern Recognition, and Neural Network Applications; two sections focused on more specialized topics, namely, “Emotional Expression and Daily Cognitive Functions” and “Memristors and Complex Dynamics in Bio-inspired Networks”.

This organization aims indeed at reflecting the wide interdisciplinarity of the field, which on the one hand is capable of motivating novel paradigms and relevant improvement on known paradigms, while, on the other hand, is largely accepted in

many applicative fields as an efficient and effective way to solve classification, detection, identification and related tasks.

In Chapter 2 either novel ways to apply old learning paradigms or recent updates to new ones are proposed. To this aim the chapter includes six contributions respectively on Belief propagation in Normal Factor Graphs (proposed by Buonanno et al.), Genetic Embedding and NN regression (proposed by Panella et al.), Echo-State Networks and Pruning for Reservoir's Neurons (proposed by Scardapane et al.), Functional Link (proposed by Comminiello et al.), Continuous-Time Spiking Neural Networks (proposed by Cristini et al.) and Online Spectral Clustering (proposed by Rovetta & Masulli).

Chapter 3 presents interesting signal processing procedures and results obtained using either Neural Networks or Machine Learning techniques. In this context, section 1 (proposed by Labate et al.) describes an Empirical Mode Decomposition (EMD) to diagnose brain diseases. The following section reports on the effects of artifact rejection and the complexity of EEG (Labate et al., 2015b). Section 3 (proposed by D'Auria et al.) describes the ability of Self-Organizing Maps to de-noise real world as well as synthetic seismic signals, explaining how a self-learning algorithm would be preferable in this context. The following two sections in this chapter focus respectively on the integration of audio and video clues for source localization (by Parisi et al.) and an integrated system based on Spiking Neural Networks known as NeuCube (by Capecci et al.) to model EEGs in Alzheimer Disease data.

Chapter 3 main objective is to illustrate pattern recognition procedures defined through neural networks and machine learning algorithms. To this aim, Camastra et al. propose semantic graphs for document characterization, while Graph Neural Networks are used for web spam detection by Belahcen et al. Some complex network concepts, like hubs and communities, are proposed (by Mahmoud et al.) in financial applications. The last section of this chapter (proposed by Di Nardo et al.) presents a video-based access control by automatic license plate recognition.

Chapter 4 is devoted to various applications of ML/NN. They span different research fields such as behavioral analysis in maritime environment (by Castaldo et al.), forecasting of domestic water and natural gas demand (by Fagiani et al.), referenceless thermometry (by Agnello et al.), risk assessment (by Cardin and Giove), fingerprint classification (by Vitello et al.), FEEM sustainable composite indicator (by Farnia and Giove); autonomous physical rehabilitation at home (by Borghese et al.) and building automation systems (by De March et al.).

Chapter 5 is devoted to illustrate the contributions that were submitted to the workshop special session on emotional expressions and daily cognitive functions organized by Anna Esposito, Vincenzo Capuano and Gennaro Cordasco form the International Institute for Advanced Scientific Studies (IIASS) and the Second University of Napoli (Department of Psychology). The session intended to collect contributes on the current efforts of research for developing automatic systems capable to detect and support users' psychological wellbeing. To this aim the proposed contributions were on behavioral emotional analysis and perceptual experiments aimed to the identification of cues for detecting healthy and/or non-healthy psychological/physical states such as stress, anxiety, and emotional disturbances, as well as cognitive declines from a social and

psychological perspective. These aspects are covered by the contributions proposed by Esposito et al., as well as, Maldonato and Dell'Orco, Matarazzo and Baldassarre, Baldassarre et al., Hristova and Grinberg, Senese et al, Gnisci et al., included in this volume. In addition, the special session was also devoted to show possible applications and algorithms, biometric and ICT technologies to design innovative and adaptive systems able to detect such behavioral cues as a multiple, theoretical, and technological investment. These aspects are covered by the sections proposed by Schuller, as well as, Likforman et al., and Faundez-Zanuy et al.

Chapter 6 includes five papers on Memristive NN, a fast developing field for NN neurons and synapses implementation based on the original concept invented by Leon Chua, in 1971 [16]. They have been presented within the related session, organized by Fernando Corinto and Eros Pasero from the Polytechnic of Milano, Italy. Memristive systems are used for the synchronization of two Rossler oscillators (in Frasca et al.); for realizing an electrostatic loudspeaker (by Troiano et al.); for an analogic implementation of nonlinear networks in complex dynamic analysis (by Petrarca et al.); for high efficient learning with binary synapses circuitry (by Secco et al.); for quantum-inspired optimization techniques (by Fiaschè).

The nature of an edited volume like this, containing a collection of contributions from experts that have been first presented and discussed at the WIRN 2014 Workshop, and then developed in a full paper is quite different from a journal or a conference publication. Each work has been left the needed space to present the details of the proposed topic. The chapters of the volume have been organized in such a manner that the readers can easily seek for additional information from a vast number of cited references. It is our hope the book can contribute to the progress of NN/ML related methods and to their spread to many different fields, as it was in the original spirit of the SIREN (Italian Society of Neural Networks − Società Italiana REti Neuroniche) Society.

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