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STOCHASTIC NEURAL NETWORKS AND THEIR SOLUTIONS TO OPTIMISATION PROBLEMS

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Abstract: *Stochastic neural networks which are a type of recurrent neural networks can be basicly and simply expressed as "the neural networks which are built by introducing random variations into the network". This randomness comes from one of these usages : applying stochastic transfer functions to network neurons or determining the network weights stochastically. This randomness property makes this type of neural networks an ideal tool for optimisation problems which especially cannot be solved with classical methods, or needs better solurions. In this paper, the properties of stochastic neural networks are investigated and the examples of using this type of neural networks for optimisation problems are given.*

Keywords: *Recurrent neural networks, stochastic neural networks, optimisation*

1. INTRODUCTION

As it is known properly, neural networks can be classified according to their neuron numbers, transfer function types, their activation function types, their architects, their learning methods, their layer numbers, their usage fields and in many other ways. In this paper stochastic neural networks which are a special type of recurrent neural networks are investigated. As it can be understood from their name, they have randomness property inside of theirselves. This randomness is provided by transfer functions or network weights.

To transform a neural network to a stochastic neural network, transfer functions can be applied or network weights can be determined stochastically. So they have a different architecture and different properties that can be useful for solving some problems. The randomness property of stochastic neural optimisation problems. Because this randomness provide the networks for escaping from local minima values and they can find optimal and better solutions than classical methods owing to their neural networks properties plus stochastic structure. Some of the optimisation problems that can be solved with stochastic neural networks are organizing urban transportation network efficiently, spontaneous bursting in hippocampal slices, gene regulatory networks, general combinatorial optimisation problems, generating multiple spectrum compatible accelerograms, some FPGA-based implementations, speeding Bayesian implementations up, developing vector quantization of images, modelling displacement fields of wood in compression loading, multispectral image classification. In this paper, it will be tried to investigate the applications and studies of stochastic neural networks makes them an ideal tool for some types of problems but especially for idea about new probable stochastic neural network applications in other fields like computer networks routing problems and cryptography optimisation problems.

2. BOLTZMANN MACHINE

The stochastic neural network type which has stochastic transfer functions instead of stochastic weights is usually called Boltzmann machine. Boltzmann machines have a slow simulation capacity so they are not suitable for practical applications, but their training algorithms are very plausable to be applied biologically so their theoric usages found better solutions than classical methods in many fields. The units of a Boltzmann machine can have only two values. 0 and 1. Apart from the classical neural networks, Boltzmann machine units are stochastic and they have a probability value.

A Boltzmann machine, like a Hopfield network, is a network of units with an "energy" defined for the network. It also has binary units, but unlike Hopfield networks, Boltzmann machine units are stochastic. The global energy, E , in a Boltzmann machine is identical in form to that of a Hopfield network [1]:

$$E = -\sum_{i<j} w_{ij} s_i s_j + \sum_i \theta_i s_i$$

Where:

Wij is the connection strength between unit j and unit i.

s_i is the statse, $s_i \in \{0,1\}$ of unit i

A is the threshold of unit i

The connections in a Boltzmann machine have two restrictions :

$W_{ii} = 0 \quad \forall i$ (no unit has a connection with itself)

$w_{ij} = w_{ji} \quad \forall\, i, j$ (all connections are symmetric) [2].

3. USAGE of STOCHASTIC NEURAL NETWORKS in OPTIMISATION PROBLEMS

networks in the literature according to their types, usages, variables etc and obtaining an stochastic neural networks can be used to find a solution in different kinds of optimisation problems. In this section it is tried to summarize some of these optimisation problems that are handled in the literature.

3.1. Modelling Displacement Fields Of Wood In Compression Loading :

To model the displacement fields of wood in compression, there are some studies that use stochastic neural networks [3,4]. In these studies first of all stochastic neural network is simulated with a function like random noised sine function. With this operation it is checked that if this neural network structure models the stochastic process succeefully or not. In the papers, with the obtained results, it is decided that the process sontinues properly and then the neural network structure is applied to the real world application and it is tried to be understood if it works well or not. It is seen that the real world application also provides a suitable environment for desired process.

3.2. Transportation Systems Modelling :

A transportation network can be a good example of the real time applications that have stochastic properties because of the random choices of the drivers and the stochastic parameters like road capacities and traffic light durations. So while modelling a transportation system a stochastic model must be used. When stochastic neural networks are used in order to solve this problem generally the network is designed as nodes correspond to roads and edges correspond to running lines. The approaches are shown by a supervised learning algorithm of Hopfield rule [5,6].

3.3. Spontaneous Bursting In Hippocamcal Slices

This is another problem study thatstochastic neural networks are used. The results of the study suggest that spontaneous population bursting in hippocampcal slices may be a manifestation of stochastic bistable dynamics rather than of deterministic chaos. The results also investigate the reliability of some of the recently proposed, UPO-based statistical methods for detecting determinism and chaos in experimental time-series data [7].

3.4. Image Classification :

In the previous sections, it is said that

on several times. In one of the studies that is considered as an example in this paper, multispectral image classifcation is made with gabor filters and stochastic relaxation neural networks [8], in another study to classify hyperspectral images efficiently semi-supervised neural network is used [9] and in the third study, artificial neural networks and other methods are compared [10].

3.5. Multiple Spectrum Compatible Accelerograms

In 1997, a new method for generating artificial earthquake spectrum capatible accelerograms from response spectra was presented. This method is based on Neural Network methodology and the learning capabilities of neural network were used to develop the knowledge of inverse mapping [11].
Because this process have some stochastic properties besides the deterministic ones, if the neural network which is used for this purpose has stochastic properties it will be a more suitable situation.
With this type of network, in compressing the eqrthquake accelerograms and extracting their characteristics efficiency is increased [12,13].

3.6. Approximating Random Processes

In random processes, artificial neural networks can be thought as an important model for simulating biological systems and human brain behaviours [14].
When random processes attend to the operations, stochastic neural networks become a more suitable choice. Developing a suitable mathematical model for stochastic neural networks is based on canonical representation of stochastic processes or systems by means of Karhunen-Loeve Theorem and it gives an increment in understanding of the simulation [15,16,17].

3.7. Vector Quantization of Images

Vector quantization is a technique that can be used in discrete data sources in digital data sequences for storage and transmission map analogue waveforms.
To speed up the coding process which is a basic process in vector quantization different methods like artificial neural networks are used in many studies. Because some parameters are stochastic in this technique stochastic Image classification is a popular problem that is investigated with stochastic neural networks
In the studies about vector quantization in the literature neural network are used with or without stochastic properties [18,19].
In one study with, stochastic neural network a method named a Local Stochastic Competition (LSC) is presented. LSC approach is related to Radial Basis Function (RBF) Neural Network architecture [20].

3.8. Gene Regulatory Networks

In gene regulatory processes, to constitute a mathematical model, large amount of data is necessary. Because gene expression involves some noise, stochastic models are more suitable to define gene regulatory.
The study about this subject [21], presented a stochastic model by combining stochastic processes with neural networks for large scale gene networks and showed that it is an effective way to represent this problem with this type of neural networks.

3.9. FPGA-Based Implementation

Stochastic neural networks are not only implemented mathematically or soft, but also with hardware reconfigurable field-programmable gate arrays (FPGAs) provide an effective programmable resource for implementing hardware-based artificial neural networks and they do not implement only Hopfield neural networks but also stochastic type neural networks [22].

3.10. Economic and Financial Applications

On the contrary to general opinion, neural networks are not only used in physical sciences problems but they can be also a solution for social sciences like economics and finance.
There are some example papers in the literature that handles economics and financial problems. One of the examples of this type of applications is prediction of fall or rise of TOPIX (Tokyo Stock Price Index). But it is understood that the stochastic neural network is not so advantageous over other networks or models for prediction of the TOPIX used for training [23]. In forecasting financial chaotic time series, stochastic neural networks are also an alternative solution method and examined in [24].

3.11. Reinforcement :

models provide better descriptions for this method usually.
networks is first studied in 1992 in [25] and after that in 2006 in [26] a more general formulation is found.

4. CONCLUSIONS

In this paper, it is summarized the studies in the literature which use stochastc neural networks for solving optimisation problems.
Artificial neural networks are already alternative heuristic methods for optimisation problems apart from the classical methods. When the situation that is investigated with neural networks have some random and stochastic properties, this type of properties must also be added to the neural network structure used. This type of neural network is called stochastic neural network and provides usually better solutions to optimisation problems than classical Hopfield neural networks.

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