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Optimization of modular granular neural networks using hierarchical genetic algorithms for human recognition using the ear biometric measure

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ABSTRACT

A new model of a modular neural network (MNN) using a granular approach and its optimization with hierarchical genetic algorithms is proposed in this paper. This model can be used in different areas of application, such as human recognition and time series prediction. In this paper, the proposed model is tested for human recognition based on the ear biometric measure. A benchmark database of the ear biometric measure is used to illustrate the advantages of the proposed model over existing approaches in the literature. The proposed method consists in the optimization of the design parameters of a modular neural network, such as number of modules, percentage of data for the training phase, goal error, learning algorithm, number of hidden layers and their respective number of neurons. This method also finds out the amount of and the specific data that can be used for the training phase based on the complexity of the problem.

1. Introduction

In this paper, a new model of modular granular neural networks and its optimization using hierarchical genetic algorithms is proposed. The architecture of the modular granular neural network is designed using a hierarchical genetic algorithm. This novel granular approach for neural networks can be used in different areas of application, such as human recognition and times series prediction. In this paper, the proposed approach is tested for the case of human recognition based on the ear biometric measure (Carreira, 1995; Gutierrez et al., 2010a, 2010b; Saleh, 2006).

Human identification as a systematic method and its scientific basis started in the 19th century in Western cultures, but in China, it was used since the 14th century. Alphonse Bertillon (Rhodes Henry, 1956) in 1883 introduced the use of a number of anthropomorphic measurements to identify criminals. This system was short-lived, soon after, approximately in 1900, the human fingerprints were used because of their distinction property. This biometry has been an accepted method in forensic investigations. Over the years, there have been more methods to perform the human recognition with the main idea of providing control of access to data or areas; for this reason, different kinds of biometric measures have been used, such as, iris, ear, voice hand geometry, and face (Daugman, 1993; Jain et al., 2004; Melin et al., 2005, 2010; Mendoza et al., 2009; Salazar-Tejeda et al., 2008; Verma and Blumenstein, 2008). There are various techniques to perform the human recognition including neural networks, which simulate the human brain, and have the ability to derive meaning from complicated relationships, and they can also be used to extract patterns and detect trends that are too complex to be noticed (Khan et al., 2009; Melin et al., 2006; Moreno et al., 1999; Muñoz et al., 2009).

For these reasons, the proposed method uses modular neural networks based on a granular approach and hierarchical genetic algorithms to perform the architecture optimization. These techniques individually have demonstrated to provide good results in different applications (Hidalgo et al., 2008a, 2008b, 2009; Muñoz et al., 2009; Sánchez and Melin, 2010; Vázquez et al., 2010). Granular computing can also provide an advantage when combined with modular neural networks and genetic algorithms, due to the fact that a granule may be interpreted as one of the numerous small particles forming a larger unit. This term was first introduced in 1997 (Lin, 1997; Yao, 2005; Zadeh, 1998) and has become very important in different areas (Bargiela and Pedrycz, 2006; Yao, 2001; Yu and Pedrycz, 2009). In this work, a granulation of the biometric database is performed in order to obtain better results.

A modular neural network can have many parameters. The quality of the obtained results depends on these parameters; therefore, the proposed method performs an optimization of the architecture of the modular neural network, also determining the amount of data (in this case the persons) per module and number of data points (in this case the images) for the testing phase.

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Experimental results with a benchmark database of ear biometrics show that using the proposed approach, results can be significantly improved.

This paper is organized as follows. In Section 2, the description of proposed method is presented. The results obtained using benchmark databases for testing the proposed method are explained in Section 3. Statistical comparisons of the results are presented in Section 4. Finally, conclusions are offered in Section 5.

2. Proposed method

This section describes the general architecture of the proposed method; this method uses modular granular neural networks optimized with a hierarchical genetic algorithm.

2.1. General architecture of the proposed method

The proposed method is based on the modular neural networks with a granular approach and their optimization using a hierarchical genetic algorithm. The main difference between conventional neural networks and modular neural networks is that the modular neural networks are an extension of the principle of divide and conquer. This means that the problem can be divided into smaller sub-problems, and these sub-problems are solved by experts, in this case named modules or sub-granules.

The main idea of this method is to find how many modules are needed depending on the particular application or database. Also, this method can select which data will be used for the training phase based on the percentage of data for training.

In Fig. 1 the granulation process is illustrated. The main granule is the whole database, and this database is divided into different numbers of sub-granules, each sub-granules can have different

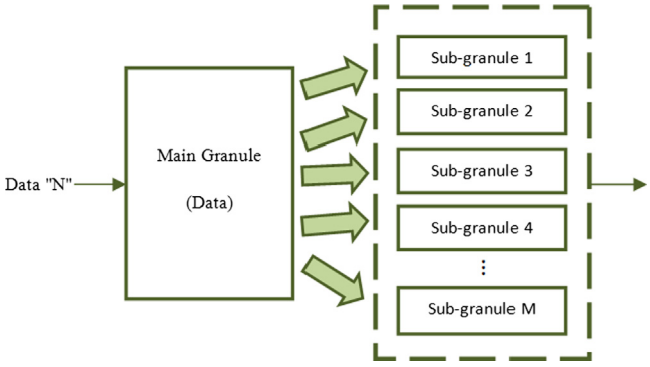

Fig. 1. The general architecture of the proposed method.

Table 1
Table of parameters.

Genetic operator	Value
Population size	10
Maximum number of generations	30
Selection	Roulette wheel
Selection rate	0.85
Crossover	Single point
Crossover rate	0.9
Mutation	bga
Mutation rate	0.01

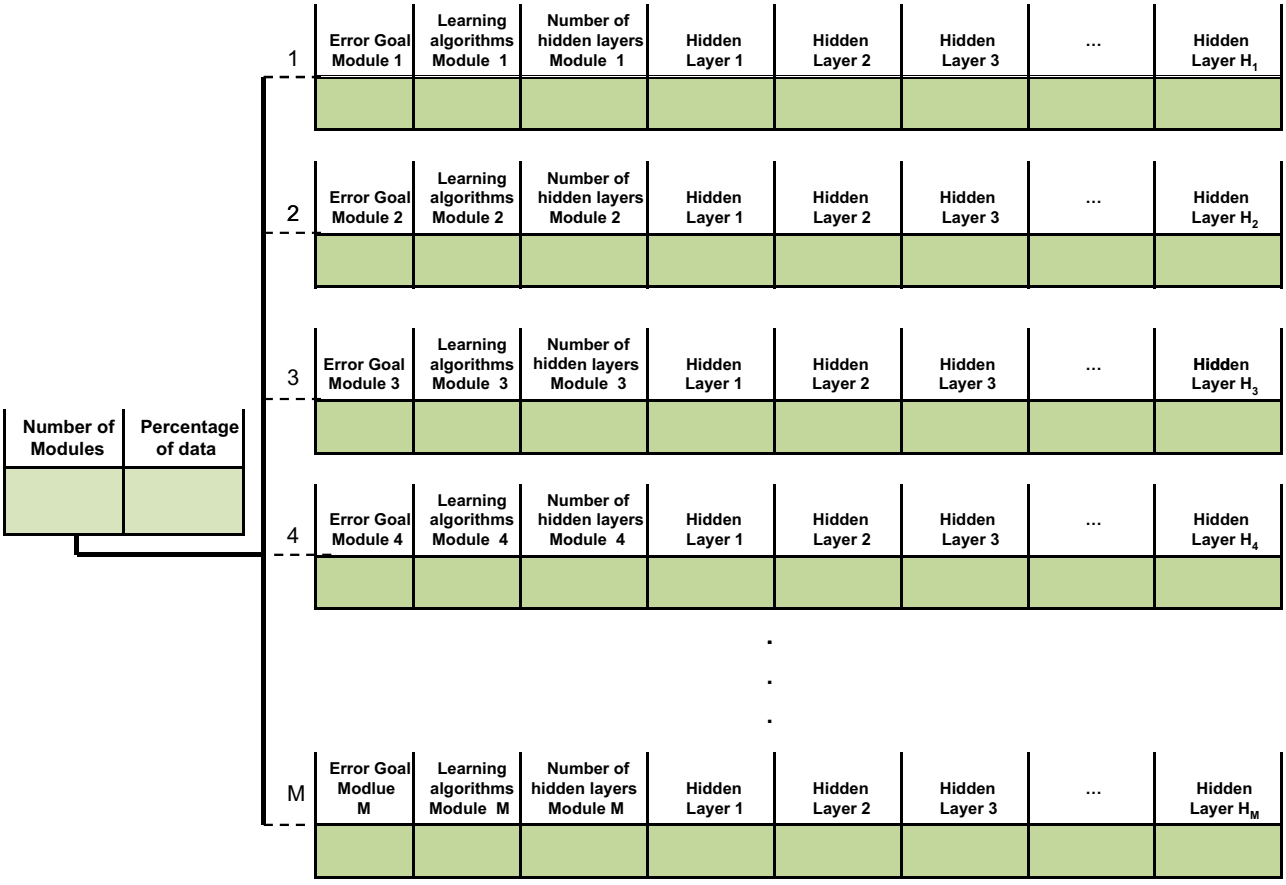

Fig. 2. The chromosome for the MNN.