VOL. 10, NO. 7, APRIL 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

A HYBRID PARADIGM OF ARTIFICIAL IMMUNE SYSTEMS WITH FUZZY COGNITIVE MAPS FOR CLASSIFICATION OF LEARNING DISABLED DATASETS

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ABSTRACT

In recent years, *Soft computing* techniques have been researched and implemented in various domains. These methodologies which include Fuzzy Cognitive Maps (FCMs) are similar to the human reasoning approach and effectively applied in a variety of application domains. These techniques learn from experimental data and deals with the uncertain values and imprecise data. It plays a vital role in image processing, data compression, classification, clustering and decision support systems. Also there is a huge increase in emphasis of interest in studying biologically inspired systems called artificial immune systems (AIS) which are a class of computationally intelligent systems inspired by the principles and processes of the vertebrate immune system. Researchers are particularly interested in the capabilities of this system, whose complexity is comparable to that of the human brain. AIS algorithms are machine-learning algorithms that typically exploit the immune system's characteristics of learning and memory to solve complex problem. It attempts to take advantages and benefits of natural immune systems for use in tackling complex problem domains. It is a class of adaptive or learning computer algorithm inspired by function of the biological immune system, designed for and applied to difficult problems such as intrusion detection, data clustering, and classification and search problems. A new hybrid paradigm of artificial immune recognition system algorithm along with FCM (AIRS_FCM_LD)is proposed for classification of learning disabled datasets and yields a classification accuracy of 94.87%.

Keywords: learning disability, FCM, AIRS, AIS.

1. INTRODUCTION

Learning disability is a neurobiological disorder in which a person's brain works or is structured differently, affecting one or more of the basic processes involved in understanding or using spoken or written language. LD children will have a problem in listening, thinking, speaking ,reading ,writing, spelling or doing mathematical calculations which in turn affects their normal learning process and leads to continual failure even withdrawal from school. Identification of LD children in schools is a big task and also needs an expert like special educators or clinical psychologist to identify [8].

2. FUZZY COGNITIVE MAPS

Fuzzy Cognitive maps (FCM) are fuzzy–graph structures for representing causal reasoning. Their fuzziness allows hazy degrees of causality between hazy causal objects (concepts).Their graph structure allows systematic causal propagation, in particular forward and backward chaining, and it allows knowledge base to be grown by connecting different FCMs. It is used to model and simulate the behavior of any system which consists of concepts that represent variables, states, inputs, outputs and of interconnections among concepts that represent their relationships.

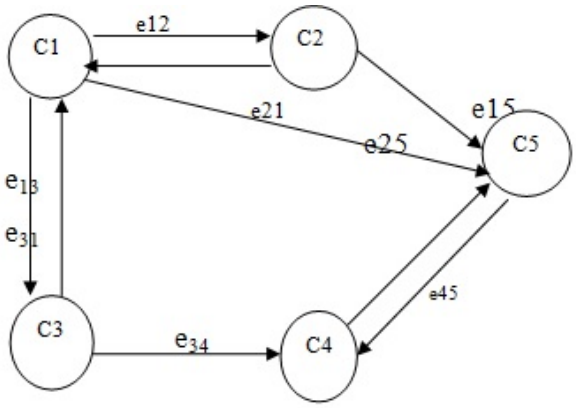

Figure-1. A simple Fuzzy Cognitive map.

Figure-1 illustrates the graphical representation of a simple FCM, where each interconnection e_{ji} between two concepts C_i and C_j has a weight, belonging to the interval [-1, 1].The sign of weight indicates whether the relation between the two concepts is direct or inverse [1,5].

3. ARTIFICIAL IMMUNE SYSTEM (AIS)

The Artificial Immune Recognition System (AIRS) belongs to the field of Artificial Immune Systems, which generally lie in the field of Computational Intelligence. It is a biologically inspired computing paradigm designed specifically and applied to classification problems. The AIRS algorithm exhibits the desirable algorithmic characteristics like self-regulation,

performance, generalization and parameter stability [4]. It maintains a pool of memory cells that are prepared by exposing the system to a single iteration of the training data. Candidate memory cells are prepared when the memory cells are insufficiently stimulated for a given input pattern. A process of cloning and mutation of cells occurs for the most stimulated memory cell. The clones compete with each other for entry into the memory pool based on stimulation and on the amount of resources each cell is using. Here an Artificial Recognition Ball (ARB) represents a set of similar cells and a cell's resources are a function of its stimulation to a given input pattern and the number of clones it may create [2,3,6,7].

4. PROPOSED APPROACH(AIRS_FCM_LD)

The proposed approach uses 4 phases. First phase is the construction of fuzzy cognitive maps wherein input and weights between the concepts are initialized. Training of datasets using AIRS algorithm with given parameters will occur and then ends with the classification of learning disabled datasets as high learning disability(HLD),Low learning disability(LLD) and no learning disability(NLD).

Given parameters

Mutation Rate(MR),Affinity threshold (AT), Stimulation Threshold(ST), Clonal Rates (CR), Hyper mutation rate (HMR), Knn, Number of resources (RES), total number of Instances (tot), memory cell (MC).

Phase 1: Preprocessing step

Step-1. for constructing FCM , normalize the input values in the range 0 to 1 using interval valued fuzzy matrices initialize weights between the concepts. Each interconnection between the concepts are evaluated by the experts and an aggregated value is assigned.

Step-2. Calculate the input for AIRS algorithm:

Input attributes =

$$\omega_{f * d(x,y)} \quad (3)$$

where d(x,y) = data instances x and y.

Phase 2: Seeding phase

Randomly chosen data vectors are used to form an initial population of memory cells which belongs to different class. Memory Pool (MP) for each class is defined:

MP(i)=randomly selected vector(training data) (4)

where i= 1 to n, where n is the number of classes

Phase 3: Training phase

Step-1: Calculation of affinity and stimulation:
Affinity= Euclidean distance / max possible distance (5)

Stimulation = 1 - Affinity (6)

Step-2: Process of cloning and mutation takes place on stimulation value.

Step-3: Memory cell identification and ARB generation process:

Clone and mutate the highest affinity memory cell and add them to the set of ARBs (P).

No of mutated Clones = stimulation X CRX HMR (7)
ARBs (P) = ARBs (P) + Number of mutated Clones (8)

Step-4: Competition for resources and development of a candidate memory cell:

For each ARBs (p), calculate

resources = stimulation * CR (9)
total (resources) = sum(resources) (10)

IF total (resources) > RES
sort ARBs(p) by allocated resources descending, delete resources of ARBs(p) starting from end of the list and delete ARB with zero resources until (calculated no of resources = RES) and (average stimulation of each ARBs(p)) > ST

Step-5: Memory Cell (MC) introduction:

MC = maximum stimulation value
from ARB (11)

IF stimulation (ARBs(P) > stimulation(memory pool data) THEN memory cell pool = ARBs(P)

Phase 4: Classification stage

Now memory pool cells become core for AIRS classifier. The classification is performed with the *k* best matches to data instances located and the class is determined by using a majority vote.

5. RESULTS AND DISCUSSIONS

A questionnaire is prepared as in Appendix A which is based on manual of DSM [8]. Datasets are collected from nearby schools and further it is classified for LD using the hybrid approach of FCM and AIRS algorithm. Simulation results are obtained from the proposed classification algorithm of FCM as in Table-1. Table-2 gives the detailed accuracy by class like HLD,LLD and NLD. Table-3 gives the classification confusion matrix of the datasets.

Table-1. Classification of Learning Disability using FCM- AIRS Algorithm

Kappa statistic	0.712
Mean absolute error	0.0833
Root mean squared error	0.2887
Relative absolute error	32.4%
Root relative squared error	83.966%
Total number of instances	137
Classification accuracy	94.7%

Table-2. Detailed accuracy by class.

	TP Rate	FP Rate	Precision	F-Measures	Recall	ROC Area	Class
	0.842	0	1	0.842	0.914	0.921	HLD
	1	0	1	1	1	1	LLD
	1	0.143	0.5	1	0.667	0.929	NLD
Weighted Avg	0.875	0.018	0.938	0.875	0.89	0.929	

Table-3. Confusion matrix.

	HLD	LLD	NLD
HLD	55	0	10
LLD	0	43	0
NLD	0	0	29

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APPENDIX A (Questionnaire)

Motor Skills
Does the child have problems with small or large motor co-ordination?
Cognitive Skills
Does the child explore the environment? If so, how?
How does the child problem-solve?
How does the child transition from one activity to another?
What activities hold the child's attention?
How long is the child's attention span?
Language Skills
Can the child follow directions?
Does the child communicate with words?
Social Skills
Does the child make eye contact?
Will the child play with other children or does he/she prefer to play alone?
Psychological Development
What is the child's reaction to physical contact?
Whether the child aggressive? (hit, kick, bite, .
.spit, throw objects or verbally lash out at others)
How does the child express emotions such as fear, anger, frustration and sadness?
What is the child's frustration level? What does he/she do when frustrated?