

Soft Computing Agents for Remote Learning

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Abstract - The paper describes a soft computing agent approach to remote learning, which is applied to disabled people suffering from dyslexia. Dyslexia is defined as learning disability by four psychologically obtained factors that present grade of learning deficiency. They are preliminary provided for better understanding and formalization of remote learning process applied to disabled people. The paper discusses selection of appropriate groups for definition of individual remote learning purposes. Soft computing agents are used to perform two tasks: optimal partitioning of distributed data bases in accordance with a grade of disability, and coordination in distributed environment for remote group definition. The first task is realized via two-level hierarchical fuzzy system for optimization of dyslectic parameters. The second is achieved by means of mobile intelligent agents for transmission, coordination, activation, and receiving decisions from/to remote learning nodes. As a final decision the node soliciting optimal group choice obtains information for the group distribution over the whole system.

Key-Words: Learning disability, partitioning in groups, remote learning, soft computing agent

1 Introduction

Recently developed paradigm of remote learning offers increasing possibilities for improving of learning processes in education. This paradigm exploits a promising combination of nowadays opening of social links and a new emerging Internet technology [1]. As a consequence of education globalization, international standardization, and rising requirements of teaching qualification a powerful social impact of remote learning is observed. Technologically, Internet abilities open broad horizons of distributed systems, remote connection, and on-line interactions despite of geographical limitations. A remote distribution of resources changes structure, strategy, and performance of the learning process. Its performance is in a great importance especially to the treatment of the people suffering from learning disability [6], [7]. Firstly, they are highly dispersed among international and even national population, so it is rather difficult they to be gathered in different small groups together on regional principle. Secondly, group formation and learning approach require special attention and individual choice of teaching programs. Some advantages of remote learning can be summarized as follows:

i. Flexible choice of disciplines, programs, and

- ii.* courses that are offered in learning cyberspace,
- ii.* Possibilities to use the most advanced achievements in every particular field of consideration,
- iii.* Convenience in respect to scheduling of learning preferences, personal user choice, individual mental abilities, and time of studying,
- iv.* Smooth advance, which is carefully traced by appropriate tests for every individual user,
- v.* Continuous control on learning level using the best virtual Internet controllable mentors.

All these advantages require new facilities, methods, and tools to be applied. One of them appears to be intelligent agent paradigm. In the great variety of intelligent agents a soft computing agent is chosen to perform double purpose task: optimization of remote task, and coordination in distributed environment. In the paper a soft computing agent to remote learning of disabled people is presented. It considers the first step of learning group formation, namely creation of preference groups in accordance with some preliminary defined criteria. In the second section the necessary conditions for optimal selection of compatible participants are described. Next third section presents three-level hierarchical structure to perform optimal group choice. This structure is postulated as four to one fuzzy system consisting of three two input one output subsystems. It forms intelligent part of Soft Computing Agent (SCA) that is realized as allocation of fuzzy system for optimal

tuning. Fourth section considers mobile part of SCA that is performed on Toshiba Bee-gent platform. Paper ends with some concluding remarks and vision for future development.

2 Assessment of Learning Disability

In accordance with [6] learning disability can be defined as ‘severe difficulty with phonological processing, which includes knowing the relationship between letters and sounds; while problems in the areas of memory, language and spelling are also evident in most cases’. At very beginning we suppose that all dyslectic people subject to remote learning are dispersed in the whole net space. They have been localized in a number of remote databases defined by geographical principle. We suppose that:

- i. There are no admissible means and tools in every distant place, or it is economically inefficient to organize and perform a local learning process in each site due to local and geographical limitations,
- ii. It is possible to initiate organization of virtual remote learning and training groups within Internet environment if some appropriate conditions for this have been arising,
- iii. After some advance in learning process the staff and group position can be changed using flexible Internet group re-allocation. For this reason a similar procedure to initiate partitioning of databases can be realized,
- iv. Group formation finishes after defining of database partitioning. Then every node sends the whole information to node leading the learning process. By this way a number of virtual groups have been formed by the end of database partitioning,
- v. The task of educational organization of courses for every virtual group is a matter of other investigation, and is not considered here.

For example, in Fig.1, four nodes comprising three databases and a node soliciting services are shown. The database can be regarded as distributed data base in which an optimal partitioning has to be sought.

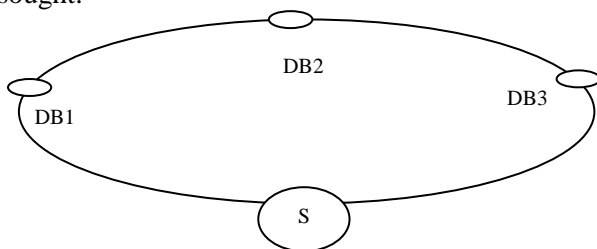


Fig.1

The following equation among databases is satisfied:

$$\sum_{i=1}^{I=5} DB_i = \sum_{j=1}^{J=3} DB_j, \quad (1)$$

where DB_i is a database of virtual groups formed after partitioning (suppose there are five virtual groups), and DB_j is initial database (see Fig.1) Some psychological investigations [7] assess learning disability in respect to deficiency of four factors, namely vocal comprehension (VC), working memory (WM), perception organization (PO), and processing speed (PS). The disabled deficiency for each factor can span from zero to hundred per cent compared with it normal range. All four factors comprise an individual profile of a person into consideration as is shown in Fig. 2.

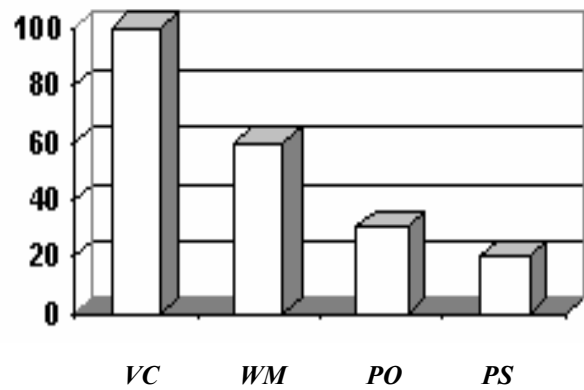


Fig. 2

3 Soft Computing Solutions

Soft Computing Agents are a relatively new class of intelligent agents [2] that combines advantages of soft computing technologies with intelligent agents' abilities. They consist of two independent parts: soft computing and agent. The first explores one or some combination of soft computing methods such as fuzzy logic, neural network, genetic algorithms, probabilistic reasoning etc. This part is responsible to obtain an admissible and well tractable decision in complex, uncertain, and ill-defined environment. The second is described by means of some kind of intelligent agent: mobile, multiple, based on recent developed theory of intelligent swarm, etc. [5]. It takes care for coordination; data transfer; and tools preparation in a really distributed environment of functioning. The task we state is to formulate admissible groups of individual profiles with similar grade of learning disability. There are two conditions for useful SCA application: distributed

environment, and an optimization problem with some extent of uncertainty in its definition. Although factors that define learning disability are crisp by definition, their combination can not be placed in a crisp model frame. The reason is that there exist an infinity of combination among all possible grades of factors. This, in turn, would produce innumerable output classes in learning disability definition, which would lead to unworkable model and solutions. On the other hand a linguistically described combination of the four factors produces good results in definition and human understanding. This is an eloquent example how uncertainty of definition leads to decreasing of complexity and gains for more tractable interpretation and decisions. Instead of crisp values for representative relations of learning disability we propose they to be expressed as fuzzy. This reflects human factor of disability definition. At the same time crisp values of already defined factors can find their proper place in fuzzy relations. So far as the combination of four factors, which define a given profile, may have clear linguistic carrier, it is mostly convenient a fuzzy rule base with similar linguistic qualifiers to be used as a base for their relationships. For example, if we suppose that all the disability dyslectic factors are expressed as linguistic variables with three terms (low, middle, and high assessments of each factor) their representatives are shown in Fig. 3. For this case fuzzy rule base, combining all four factors, obtains the form similar to the next expression:

If VC is 0, and WM is 0, and PO is 0, and PS is 0
then PI is 1 or
If VC is 0, and WM is 0, and PO is 0, and PS is 1
then PI is 1 or
.....(2)
If VC is 0, and WM is 0, and PO is 1, and PS is 4
then PI is 1 or
.....
If VC is 1, and WM is 1, and PO is 1, and PS is 1
Then PI is 5,

where: VC , WM , PO , PS are above described factors of inputs, and PI is a performance index as output of the fuzzy system. Equation (2) expresses a fully exhaustive fuzzy rule base. As is well known exhaustive fuzzy rule base with four - three terms inputs and one - five terms output has a number of rules equal to the base three on power four or 81 rules. Its number corresponds to the number of lines in expression (2). Obviously, such a great rule base number is inconvenient in view point of client interpretation and understanding, as well as tuning,

manipulation, remote control, and other purposes. So we state a task to decrease its size and to obtain more tractable solution. Let us suppose for simplicity that we have at first two fuzzy systems each of them consisting of two inputs and one output. The first is (VC, WM) to PI_1 , and the second - (PO, PS) to PI_2 , where: PI_1 and PI_2 are intermediate assessments of performance indexes corresponding separately to both systems. Vocal comprehension and working memory refer to mental ability of person to process information. Hence the first system, respectively PI_1 can be interpreted as performance index pertaining to understanding of disable. On the other hand perception organization and processing speed reflect performance index pertaining to perception of disable, and is denoted as PI_2 . Using this principle we decouple initial system in accordance with human understanding and perception in two separate systems, for which two independent inference rule base can be defined. At the second stage we combine again PI_1 and PI_2 as inputs for the next hierarchical leveled fuzzy system with the same two-to-one structure. Although PI_1 and PI_2 outputs of the first level fuzzy system has five linguistically derived values they are re-estimated again in a new three-term range with the same dimension. By this way we replace the initial four to one system with three identical, hierarchically built up, two-to-one fuzzy subsystems. The initial system with 81 rules and grave interpretation and tuning is replaced by three identical derivative systems with 9 rules and lighter interpretation. All new inputs and outputs have got three and five terms respectively. They take values in accordance with the abbreviations in Table I shown below:

TABLE I

input	0	Low (L)
	1	Middle (M)
	2	High (H)
output	1	Low (L)
	2	Low-Middle (L-M)
	3	Middle (M)
	4	Middle-High (M-H)
	5	High (H)

All three terms of inputs have triangular representative membership functions overlapping at 0,5 membership grade. They form three initial fuzzy classes or groups in accordance with each factor. Intermediate and final performance indexes $PI_{1,2}$, and PI are outputs of the first and second level fuzzy systems. They span in the unite interval $[0, 1]$ as linguistic variable. All five terms have triangular

representative membership functions overlapping at 0,5 membership grade. They form five fuzzy classes or groups that partition initial data base in accordance with fuzzy decision rule base. The outputs of the first level supply inputs to the second, which output is **PI**. The whole structure is shown in Fig. 3., where three fuzzy sub-systems have

identical firing look-up table shown in TABLE II.

TABLE II

input 1	0 0	0 1	1	1 2	2 2
input 2	0 1	2 0	1	2 0	1 2
output	1 1	2 2	3	4 4	5 5

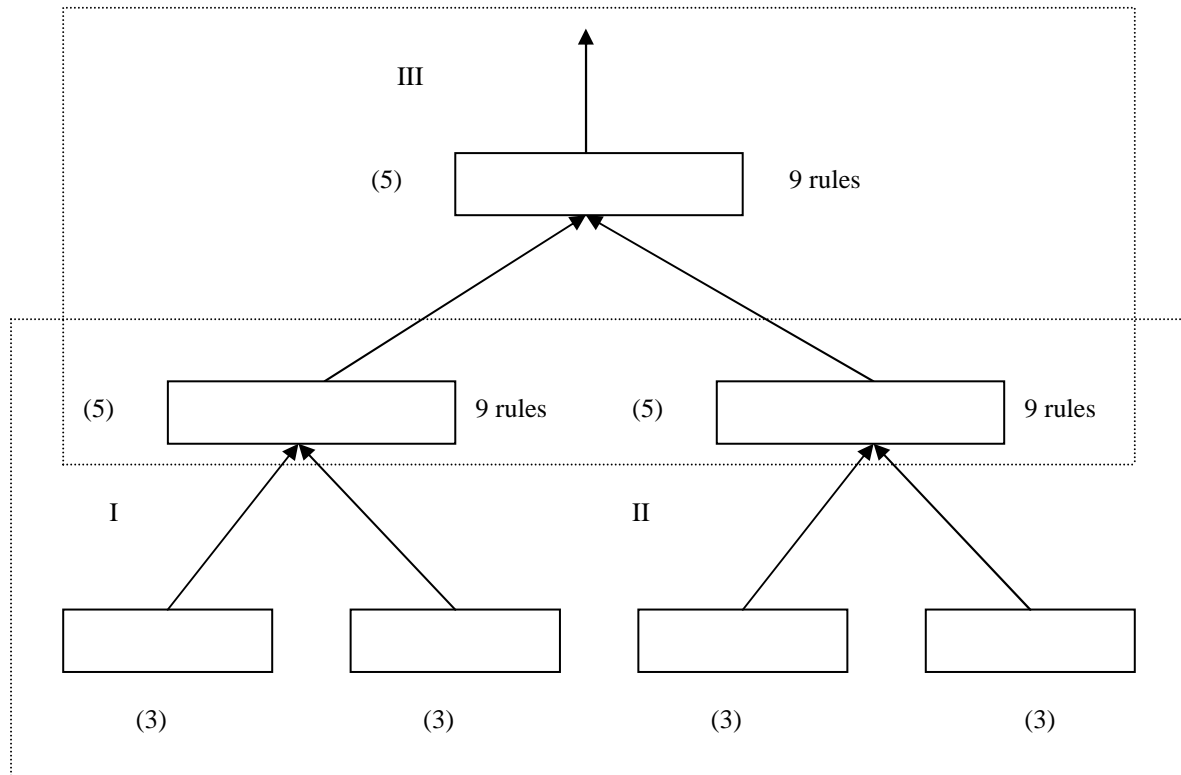


Fig. 3

Let us now suppose that there are such hierarchical fuzzy systems in every remote node. When we supply input to this systems with individual profiles of every remote data base we obtain as outputs different grades of **PI**, which can be comprised in similar groups depending on **PI** values. All profiles with similar **PI** grades will correspond to a definite group. Five fuzzy groups with triangular norms, preliminary defined, present final partitioning of distributed data bases. Every selected profile is assigned to at least one group using a principle of closest **PI** to the corresponding membership grade of a group. Now we are ready to involve this specific optimization technique into mobile agent paradigm in order to produce mobile SCA.

4 Mobile SCA

An agent can be described as a software component that performs a specific task autonomously on behalf of a person or an organization. It contains some level of intelligence, ranging from predefined

rules to self-learning Artificial Intelligence mechanisms. Thus agents may operate rather asynchronously to the user and may communicate with the user, system resources and other agents as required to perform their tasks. They are often event or time triggered.

A mobile agent (MA) is one of the seven agent types identified in [8]. An agent is an object with its private thread of execution, also known as “active object”. An MA is the kind of agent that is not bound to the host where it begins execution. It has a unique ability to transport itself from one host in a network to another. As it travels, it performs work on behalf of a network user. Agent mobility is probably the most challenging agent property, in that it provides an intelligent agent with the potential to influence the traditional way of communications and service realization. Customizability is the result of the diffusion of network services and applications. It allows users to tailor services according to their specific needs and preferences. Flexibility and extensibility are due to

the dynamic nature of the underlying network infrastructure and service demand. Other arguments for mobile agents have also been forthcoming.

In the past, the main motivations for the application of mobile agents were the lack of capacity to execute programs locally, and the desire to share resources and improve load balancing in a distributed system. In contrast to these concepts designed for rather specific or closed environments, new agent concepts aim for open environments (e.g. the Internet). Today, flexibility is a key design issue for emerging network service architecture in order to adapt quickly to the changing customer service demands. The following are some of reasons for using MA technologies:

- i.* An MA-based approach may reduce the network load when compared to Remote Procedure Call (RPC)-based approach,
- ii.* Asynchronous and autonomous execution provide the possibility for realization of advanced services by means of using mobile agents,
- iii.* Being independent of the underlying network infrastructure makes the service architecture extendable,
- iv.* MAs allows new services to be provided dynamically either by customization or (re)configuration of existing services,
- v.* MAs provide an effective way for deployment and utilization of advanced services within a distributed environment.

The MA paradigm and emerging agent technologies are considered key for implementing open, flexible and scalable services. There are many commercial and nearly commercial agent platforms such as Grasshopper (IKV++), Agents Workshop (IBM), Voyager (Object Space), Concordia (Mitsubishi), etc. In our investigations we chose Bee-gent of Toshiba [9]. The reason is that:

- i.* Bee-gent paradigm has clear definition of two type mobile agents: wrapping and mediation. The first can capsule the necessary information into portable format, while the second realizes transmission of these packages,
- ii.* Frequency of communication is reduced compared to a purely message-based system and network loads are decreased largely because communication links can be disconnected after launch of the mediation agent. It is very convenient when searching techniques take place

- iii.* Processing efficiency is improved because the mediation agent communicates with the applications locally,
- iv.* Fuzzy decision technique can be easily involved drastically decreases 'idle' variants, size of transferred files based on performance indexes,
- v.* Application interoperability increases and therefore it is easier to build open systems,
- vi.* Large-scale system development becomes easier because procedures for handling application coordination do not have to be known explicitly,
- vii.* It is possible to protect information in a superior manner and to control process priorities by autonomously dealing with requests from the mediation agents.

An implementation of mobile SCA based on Bee-gent platform is presented in the following algorithm:

- i.* Activation of user dialogue in the node soliciting services. The dialogue produces information about customer personal preferences for: number of hierarchical systems and system type; number of in/outs, definition of representative membership functions; inference table for each fuzzy system; type of inference engine and defusification principle; number and definition of final partitioning groups as fuzzy classes.
- ii.* Capsulation of hierarchical fuzzy systems using agent wrapping resources. It is performed using several fields: identification code (usually IP address of the node, the unique variable values that define difference of wrapping agents), several strings presenting definitions described in previous point.
- iii.* Cloning of initial wrapping agent. The number of clones is equal to the number of nodes of distributed data base, for which optimization has to be implemented.
- iv.* Generation of mediation agents, one for every clone, that transmit wrapping agents to every node in accordance with particular IP address of wrapping agents.
- v.* Creation of a new wrapping agent based on meditation agent on site (one for each node) for defining of fuzzy decision inference engine.
- vi.* Rebuilt fuzzy inference engine using unique information for every node described in p. *i.*
- vii.* Activation of fuzzy inference engine to scan profiles in distributed data base. Every decision is assigned to one of primary defined partitioning

groups. Inference engine performs exhaustive scanning of local data base in cycle.

- viii. Capsulation of all decisions, which is followed by back transmission to the soliciting node. The procedure uses resources of wrapping and mediation agents.
- ix. Soliciting node unpacks information and forms remote learning groups based of the whole information of nodes participating in distributed data base.

By the end of the tasks Bee-gent forms a number of virtual learning groups consisting of participants from all the nodes in the net. They have similar performance index within such defined fuzzy groups, a pledge for successful approach in educational process of disables.

4 Conclousns

The soft computing mobile agent based service architecture solution is proposed in this paper. It is dedicated to solution of remote learning problems for people suffering from learning disability called for short dyslexia. It provides the following features and benefits. The architecture can:

- i. Resolve the problems of remote learning where participants possess different ability to accept, estimate, and process information. In this situation a crucial point for stable functioning is group formation consisting of compatible participants with similar abilities, which is derived using SCA.
- ii. Enable the provision of flexible software solutions, where supplementary services software is partitioned into mobile service agent realizing dedicated functionalities (e.g. wrapping, cloning, transportation, distribution, optimal decision, etc.).
- iii. Rebuilt flexibly group partitioning in changing initial requirements, advance in learning process that demand for new distribution or activation of other node soliciting the same service.
- iv. Enable on demand provision of customized supplementary services by dynamic construction of a user service agent that uses downloaded service code from a node soliciting action to all receiving nodes.
- v. Allow for decentralized realization of supplementary services by means of bringing the user services agents directly onto the user terminals.

We have demonstrated that soft computing decisions may be successfully integrated with existing mobile agents and protocols for provision of advanced services. This combination realizes mobile SCA. The architecture that this paper proposes seeks to address the entire service lifecycle, an important consideration on opening the IP marketplace to non-traditional service providers. Our future work consists of IP services not currently defined by existing specifications in order further to validate the architecture. Finally, a performance evaluation of the existing architecture using typical hardware and software platforms need to be performed.

Result of these activities will be communicated in future publications.

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