A Konet-based Tool for Adaptive Learning: an Application for Ethnic Learning of Music

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Abstract. *Brazilian musical scenario presents a structural problem, which is the lack of institutional incentives for formal learning of music through well-established courses in the basic education system. Nowadays, music-related courses are not part of any level of formation, pushing students who have affinity with this kind of art to look for alternative instruction. This paper presents an adaptive learning system applied to meaningful learning of musical concepts, focusing on Brazilian musical rhythms. Kohonen networks (Konets) are used to dynamically recover and arrange pre-built Learning Objects, dynamically creating learning resources according to regional, cultural and ethnic aspects.*

1. Introduction

Music learning in Latin America, specifically in Brazil, suffers a structural problem: people lacks incentive concerning music learning through regular courses in fundamental education, as well as in other levels (Castilho, 2001). Thus, even though students are interested by music, they are not fully supported by formal education system (Beaumont and Fonseca, 2003). Considering that to have access to undergraduate courses on music demands higher levels of apprenticeship on music theory, superior formation on music tends to be excessively elitist, selecting for this area only those who have funds to sponsor such costs. According to Loureiro (2003), Brazil's situation nowadays on musical culture is clearly polarized: in one hand, some few people that have access to specialized music schools; on the other hand, almost all the rest of population who does not have access to musical education while studying basic levels.

In spite of the fact that Brazil has different kinds of popular rhythms, its learning – despite all Brazilian national music tradition –does not take into account cultural or regional characteristics of learners. In order to perform such task, it would be necessary an adaptive device that would work with the cultural context of students.

A possible solution for this problem would be the implementation of some web-based systems that aims to encourage music practice by a social-political contextualization in order to allow formal, or even informal, courses to be carried through. Nonetheless, if such system were to be implemented relying over static, nonadaptive content, it barely would fulfill the requirements previously cited. It is needed a context-aware adaptation mechanism in order to consider the social, geographic and political situation of each student, in order to truly obtain a contextualized, meaningful ethnic learning of music.

The present paper focuses on an adaptive learning object architecture for teaching-learning musical concepts, initially covering Brazilian musical rhythms. Wiley (2000) defines Learning Objects (LOs) an “any digital resource that can be reused to support learning”. Adaptive learning objects, on the other hand, are meant to be dynamically recovered from LORs – Learning Objects Repositories. To provide this, techniques are applied in order to properly select LOs that are adequate to some adaptation factor, which can change according to learning context requirements.

2. Musical Cognition and Adaptive Learning

Considering musical education, one could imagine that it is limited to learning to play some instrument. Nonetheless, truly musical education is not only about technically giving an instrumental formation, but to make people sensible about music. This context involves the development of musical preferences, critical spirit, abilities of reflection, learning styles and some cognitive and affective skills (Swanwick, 1988). To complement this approach, music education also needs to consider ethnical elements related to cultural diversity where students grow up and live.

Some authors like Castells (1996) indicate that the development of communication technology changes the way of living and implements a network-shaped architecture usually called Network Society. The world connectivity had been already anticipated by Marshall McLuhan (1967) when he presented the “Global Village” concept, where distance and space concepts disappear because of the advent of an interconnected “tribe”. However, this proposal does not implies in homogenization, but in one effort to sustain distinct identity of group through cultural behavioral patterns as linguistic terms, fashion clothes and even musical preferences.

To explore this framework, it is relevant to consider the human perception. It could be defined as a sensation-aware conscience of simple experiences. Perception involves analysis, association, and synthesis and was determined by sense organs and central neural system in an individual perspective that permits human being to adapt him to the environment around. The information extraction in this case involves input stimuli (physical information), sensorial transduction (message codification that results in neural impulses), cerebral activity (that is responsible for reception and selection of elements), and output feedback (behavioral response) (Gyton, 1971). In special case of sonorous perception, the physiological approach presents the possibility to differentiate sound height, intensity, timbre, and duration (Hamel, 1976). The physiological vision of perception complements this scope because music sensations are an affective perception and can be researched from both historical and geographical point of view, which involves technologies, generations, and other elements as political-economical systems or cultural diversity.

According to this, it is possible to model a music learning experience through ethnical approach for the development of musicality. Such a system should be designed in a way that adhere to users’ reality, build over a Meaningful Learning basis (Ausubel, 1962). The system must be able to be ethnically and culturally-aware, regarding Brazilian reality, in order that ethnic learning could be the key point to be considered.

Possibly the most well-accepted educational theory about music considers students as inheriting not only values, but also cultural practices, so that learning process must stimulate students to participate in quotidian musical activities, making school a locus for discovery and recognizing of musical traditions. According to such idea, this paper proposes a system that provides to students a proper, context-aware sequencing of learning objects related to music.

Generally, to build systems that take into account users' characteristics as determining factors for interactivity, it is supposed that a user profile will be formed in order to plenty satisfy user' expectances about the system. For this, there are various computational techniques that could be used to obtain such adaptive results (Russel and Norvig, 1995). For instance, Bayesian Networks, Expert Systems, Fuzzy Logic based systems, Evolutive Computing and Neural Networks. In the context of this work, Kohonen Networks –or Konets– (Kohonen, 2001) will be used to reach such adaptation.

Konets are a specialization of Neural Networks (Fausett, 1994). In a general way, a Neural Network is a computer-based element whose foundations rely on an approximated model of how human brain process information: a Neural Networks is thus composed of a set of nodes interlaced in a network; each one of these nodes are simple processors, possibly having a small amount of local memory, which a limited quantity of communication channels, the connections.

Each node's state can be described by activating values, which are the basis of the output generated by a node after an input. Node connections are weighted edges; the output value of a node is transmitted to every connected node. By this mechanism, one node's output can influence the activation of other nodes. One node's activation value is calculated by a weighted sum of its inputs, thus determining the output through a function. It is said that networks learn by changing its connections' weights.

As every Neural Network, Konets are composed by a set of simple elements, the neurons, organized in a more complex set, the network itself. Whish makes Konets distinguished from simple Neural Networks is its two-tiered structure: one for the input and another one for processing, where the "map" is effectively formed. This processing tier is a grid of neurons equally spaced, connected only to their immediate neighbors. The elements that are to be classified by such network in clusters are presented, one by one, to the input neurons. The stimuli generated by this element are captured by neurons on input layer and equally transmitted to the neurons of processing layer (the map). In the map, the neuron that reacts more strongly to one element's stimuli "wins" such element. Besides, it reinforces its connections with it neighborhood, making their neighbors more "sensible" to the characteristics of the captured element. The next time a similar element is presented to the Konet, the whole "sensible" region will react more strongly to its stimuli. However, since neurons can have different configurations, even at the same region, each winner's neighbor can react more or less to an element.

Konets training process is performed by changing neurons' sensibility profile at each time new elements are introduced to the map. Such changes diminish progressively, making map's configuration converge to some stable disposition. In this point, it is said that Konet is trained for a certain set of elements, since it learned how to classify them in clusters according to some similarity criteria.

Figure 1 shows an example of a Konet.

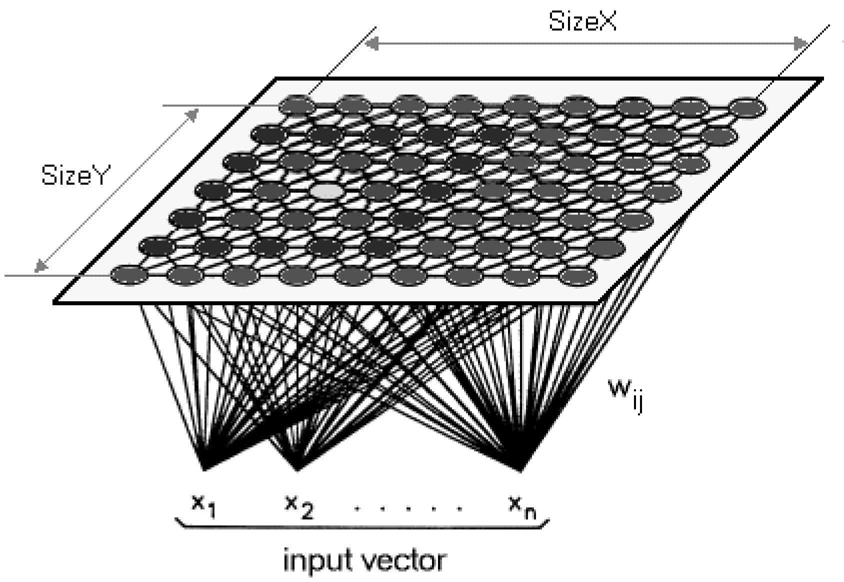

Figure 1: A Konet

Each Konet neuron stores an array of weight, each one of them corresponding to one input from an array of inputs. When a new input occurs, each map's neuron calculates its activation level through the following definition:

$$\sqrt{\sum_{i=0}^{n}(w_i - input_i)^2} \qquad (1)$$

In (1), wi is the ith element of the weight array and inputi is the ith input. The neuron with lowest activation level (that nearest to input vector, regarding Euclidian space) can adjust their weights in order to approximate it from the input array, in the same manner that their neighbors.

The algorithm behind training process consists in the following steps (Kohonen, 2001; Roussinov and Chen, 2001):

- Initialize input, output nodes and weights: a bi-dimensional nxm grid is created, with n input and m output nodes. Such grid is organized as a bipartite graph, initializing the weights w_{ij} of the connections between each one of the i^{th} input nodes and j^{th} grid nodes with random values. Each one of the j^{th} output nodes is thus associated to an array of weights w_{ij}.
- Provide input nodes: as the user interacts with the system, information about its preferences and social, geographical and cultural aspects are being presented to the Konet. Each i^{th} user input in a certain time t is represented by an array *vi(t)*.

- Calculate Euclidian distance: compute Euclidian distance d_j between each one of input arrays *vi(t)*and weight array w_{ij}:

$$d_j = \sum_{i=0}^{n-1} (v_i(t) - w_{ij}(t))^2 \qquad (2)$$

- Select winner node *j** and actualize the weights of *j** and its neighbors: the winner node *j** is the one that produces the lowest d_j. Weight actualization must diminish the distance of *j** and its neighbors to *vi(t)*:

$$weight_{ij}(t+1) = weight_{ij}(t) + \eta(t)v_i(t) - weight_{ij}(t) \quad , 0 \leq \eta \leq 1 \qquad (3)$$

  In (3), η is an error-adjusting coefficient that diminishes along the time. After such actualizations, the neighbor nodes of *j** are more similar to input vector *vi(t)*.
- Label map regions: After training, to each output is assigned the highest weight as a valuating term, named "winning term". Every node in the neighborhood with the same term is grouped in clusters, thus representing conceptually near regions.

3. System Architectural Proposal

Figure 2 below shows an overview, through an UML Activity Diagram, of the proposed system.

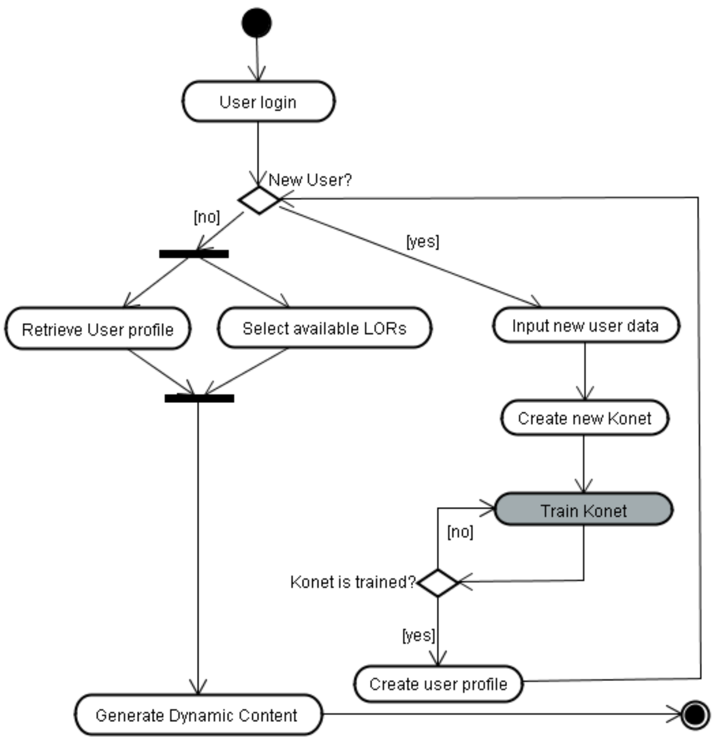

Figure 2: UML Activity Diagram

Figure 2 describes a general schema about the activities of the system: users access it through a proper interface; if it is a new user, the system tries to capture the first user information, used to generate its first profile through an adequate training process of a Konet. According to the associations done by the Konet, a customized, ad hoc set of learning objects is retrieved from a pool of LORs and arranged in order to constitute a dynamic learning resource adapted to student context, inferred by the Konet.

The "Train Konet" activity, as performed in this system, can be expanded by another UML Activity Diagram, as can be seen in Figure 3, adapted from Heaton (2005).

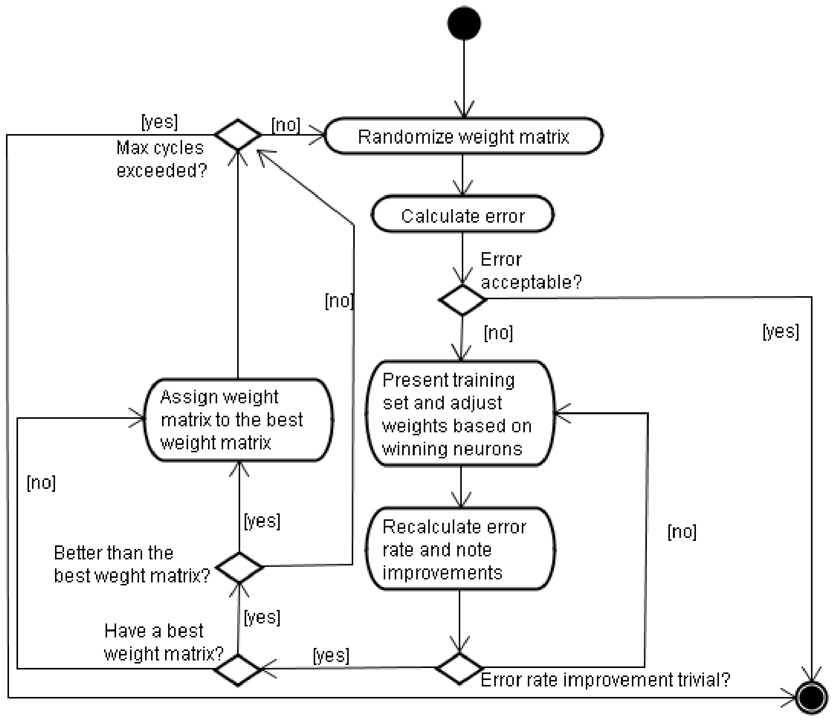

Figure 3: UML Activity Diagram for the "Training Konet" Activity

As said before, the whole architecture of the system is web-based. Through user's interaction, the Konet obtains the necessary pieces of information for its training, which allow the classification of users in an appropriate cluster. The more users are added to the system, the more clusters will be created, thus providing a finer classification.

Figure 4 shows a UML Component diagram of the system.

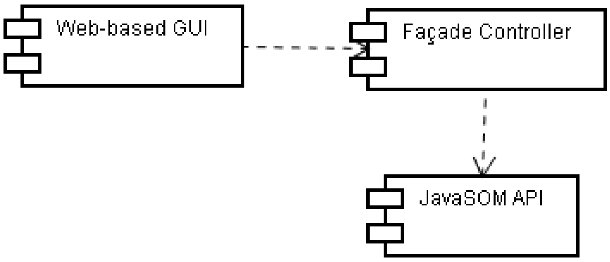

Figure 4: UML Component Diagram

It can be observed in Figure 5 that the web-based GUI component is coupled to the general façade controller. This component uses the Konets provided by JavaSOM API (Suuronen, 2006) in order to make a proper selection of LOs in pools of LORs. Using such API allows application portability, as well as the Konet modeling process through the generated XML file.

At the end of Konet's training phases, JavaSOM API returns the map with elements organized by Euclidean spatial coordinates. Such results can be easily viewed through a PDF or XML file, being able to serve as entries to the Façade Controller, responsible to gather the adequate LOs and to dynamically build a customized learning resource for the student.

4. Conclusions and further work

Neural Networks, as Konets, are being used in this work applied to teaching-lçearning process in order to provide computational mechanics to automatize the process of selecting Learning Objects from repositories in an adaptive way, in order that the set of retrieved LOs is adequate to some student's needs.

The learning of musical concepts could considerably have a gain with such a tool, since it provides a mechanism to retrieve meaningful, context-aware content to students that suffer from a vary of difficulties to learn music, specially large countries like Brazil, with lots of diverse cultural flavors spread over its territory.

Further works include to finish the system implementation and to make a deep analysis about the results obtained by it and by other SOM-based systems. The application of such a tool in a group of students is also being planned, in order to verify its impact in the musical learning process.

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