Emergent Case-Based Reasoning Applications

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There are new Case-Based Reasoning applications that are starting to emerge and that deserve attention. Some representative ones are included in this section. A very representative emerging field is music. The first work that applied CBR to music is that of Arcos, Lopez de mantaras, and Serra, [1998] that won the Best Paper Award at the 1997 International Computer Music Conference. In this work, the authors describe a system, called SaxEx, capable of synthesizing high quality expressive tenor sax solo performances of jazz ballads based on cases representing human solo performances. Previous rule-based approaches to that problem could not deal with more than two expressive parameters (such as dynamics and rubato) because it is too difficult to find rules general enough to capture the variety present in expressive performances. Besides, the different expressive parameters interact with each other making it even more difficult to find appropriate rules taking into account these interactions. With CBR, the authors have shown that it is possible to deal with the five most important expressive parameters: dynamics, rubato, vibrato, articulation, and attack of the notes. To do so, SaxEx uses a case memory containing examples of human performances, analyzed by means of spectral modelling techniques and background musical knowledge. The score of the piece to be performed is also provided to the system. The heart of the method is to analyze each input note determining its role in the musical phrase it belongs to, identify and retrieve (from the case-base of human performances) notes with similar roles, and finally, transform the input node so that its expressive properties (dynamics, rubato, vibrato, articulation, and attack) match those of the most similar retrieved note. Each note in the case base is annotated with its role in the musical phrase it belong to as well as with its expressive values. Furthermore, cases do not contain just information on each single note but they include contextual knowledge at the phrase level. Therefore, cases in this system have a complex object-centered representation. Although limited to monophonic performances, the results are very convincing and demonstrate that CBR is a very powerful methodology to directly use the knowledge of a human performer that is implicit in her playing examples rather than trying to make this knowledge explicit by means of rules. Some audio results can be listen at www.iiia.csic.es/arcos/noos/Demos/Aff-Example.html. More recent papers by Arcos and Lopez de Mantaras [2001] and by Lopez de Mantaras and Arcos [2002], describe this system in great detail. Other applications of CBR to expressive music are those of Suzuki, Tokunaga, and Tanaka, and those of Tobudic and Widmer. Suzuki et al. [1999], also use examples cases of expressive performances to generate multiple performances of a given piece with varying musical expression, however they deal only with two expressive parameters. Tobudic and Widmer [2003] apply instance-based learning (IBL) also to the problem of generating expressive performances. The IBL approach is used to complement a note-level rule-based model with some

predictive capability at the higher level of musical phrasing. More concretely, the IBL component recognizes performance patterns, of a concert pianist, at the phrase level and learns how to apply them to new pieces by analogy. The approach produced some interesting results but, as the authors recognize, was not very convincing due to the limitation of using an attribute-value representation for the phrases. Such simple representation does not allow to take into account relevant structural information of the piece, both at the sub-phrase level and at the interphrasal level. In a subsequent paper, Tobudic and widmer [2004], succeeded in partly overcoming this limitations by using a relational phrase representation. Another arts-related application is a system for poetry generation developped by Díaz-Aguado, Gervás, and González-Calero, [2002]. The system works by entering a query consisting of a sequence of words. This query determines the indices to retrieve an existing poem in the case base and the adaptation step will substitute words of the retrieved poem by appropriate words from the query. Another emergent field of application is molecular biology. Indeed, as it is pointed out in the paper by Jurisica et al. [2001], genomics projects are likely to produce every year hundreds of proteins for structural analysis. In order to use crystal X-ray diffraction to determine the protein structure, a process of crystal growth for proteins has to be done. The main goal of the research work of Jurisica et al. is to speed up the crystal growth process. An intelligent decision support system is being developped with this aim, that contains a case-based reasoning component that provides support for the design of crystal growth experiments by retrieving previous similar cases and adapting them to solve the problem at hand. More concretely, the so-called precipitation index of a new protein is compared to the precipitation indexes of all the proteins in the case base using a k-NN approach. The crystallization plans of proteins with the most similar precipitation indexes are retrieved and reused forplanning the crystallization experiment of the new protein. Successful crystallizations are added to the case base for future use. Failed crystallizations are also kept since failures are useful to avoid repeating negative results. Other CBR systems have been developed to address other problems in molecular biology such as the problem of analyzing genomic sequences and determining the structure of proteins. See [I. Jurisica, and J. Glasgow, 2004] for further information.

A final worth to mention emergent field of application of CBR is in geographical information systems (GIS). The approach consists of combining CBR and GIS to solve spatial reasoning probelms. The pioneering work in that field is by Holt and Benwell [1999]. In that paper they apply CBR and GIS to the problem of soil classification which is solved by searching the case base for spatial cases similar to the problem at hand. The authors conclude that the CBR approach has many advantages compared to previous methods used for soil classification.

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