Representation, aggregation and classification models for decision making aiding under imprecise information

TIN2006-06190

Javier Montero *
Faculty of Mathematics
Complutense University of Madrid

Abstract

This project represents an evolution within a consolidated research group, which has been granted from the Spanish Programme for the Promotion of General Knowledge since 1988. The project is based on past results obtained in the framework of previous projects. The main core of this project is to study different components of decision aid tools under different kinds of uncertainty, being these tools mainly understood as representation techniques. In particular, a key paper published by this research team allows measurements of the quality of each classification system, taking into account particular families of operational and consistent aggregation rules, being therefore the basis for subsequent learning and optimization procedures. This approach is specially significative when classes have no clear borders and large transition zones appear, since in this context a pure statistical analysis may be inappropriate. Hence, particular emphasis is devoted to develop algorithm representation techniques with non probabilistic uncertainty. The project pursues the design of classification aid models by putting these pillars together, to be checked in several scientific fields where we have already some experience, in collaboration with other research groups (stars or cells classification, land cover use, systems reliability, preference representation, etc.)

Keywords: Decision making, preference representation, knowledge representation, aggregation information, classification, fuzzy sets, optimization.

1 Objectives

Being this project a project on basic research, it must be made clear that the first objective we pursue is the development of models and tools potentially useful for some specific problems, not the practical resolution of these problems. Nevertheless, the policy of this research team has been always to strength scientific links with partners in direct contact to those problems. Without them we can not produce useful results. We think this procedure is in the best

*Email: monty@mat.ucm.es
scientific tradition and indeed they provide us the inspiration framework for most theoretical objectives. Whenever we get so close to a real implementation, a contract is signed in advance in order to clarify scientific achievements from their industrial implications. In this sense, this team has always stressed the operationality of each approach, avoiding the development of tools that can not be taken by our partners, because its computational or conceptual requirements.

There were five main theoretical objectives being declared in the application of this still ongoing project:

1. The bottom aggregative subproject has deserved a special attention, being a main component of the project. In particular, we have stressed the recursive approach for aggregation operations as a constructive approach that contains a relevant proportion of aggregation rules that can be found in practice. Although we have shown also some limits, perhaps the most relevant consequence of our study is the paper that appeared in Fuzzy Sets and Systems [18] pointing out that structure should be made always explicit in any context (objects, criteria, classes, alternatives, etc.) The general model proposed in this paper will become one of the key foundations for next next project we are actually applying to. As a first consequence, this paper offers an interesting explanation of the great dispute that has been created around Atanassov's "Intuitionistic" fuzzy sets: it is the absence of such a structure the missing argument that makes a difference between two models with different intuitive support. It is a extremely original ongoing research. In parallel, several studies have been developed on interval fuzzy sets, in collaboration to H. Bustince's research group at the Public University of Navarra [33, 35]. In addition, we have obtained a functional characterization of migrativity [34] in collaboration to R. Mesiar from Slovakia.

2. The consistency issue has also devoted an attention that has been always present in past projects. In particular, we have developed several algorithms to approximate inconsistent preferences to the closet consistent preference, according to several transitive-based consistencies [7]. Related to consistency we have also presented original approaches to Arrow's paradox in group decision making [58] together with some positional paper pointing out the role of fuzziness in decision making and Science [19, 60].

3. In order to deal with the computational problems related to dimensional representation, we have developed an alternative representation approach [51]. Although this approach has been shown useful to estimate criteria weights, we are still working on the uniqueness issue (i.e., which one is the good representation among the family of possible representations. It is again an extremely original research that has lead in the past to the first algorithm to evaluate dimension within the crisp context (published in Journal of Algorithms).

4. Great results have been obtained within the segmentation and coloration subproject, developing and applying our algorithms to remotely sensed images, with the collaboration of G. Biging at the University of California, Berkeley (USA). Improved algorithms have been applied to real images [47, 49, 50]. Classical crisp models have been translated to the fuzzy context, allowing a fuzzy clustering that is conceptually simpler than the equivalent crisp clustering, and more informative due to the structure of regions being created. It is again quite original and it is increasingly cited by other researchers.
5. First steps towards a fuzzy verification process have been developed \cite{56, 57}, an issue that we think deserve more effort since quite a number of practical situations do not allow an appropriate statistical analysis to check results \cite{(quite often the consistency of the supporting argument or algorithm is the only support for a decision)}. There is still a lot of work ahead, but we are missing a more sophisticated partner to fix the mathematical foundation for a general model, and we are actually trying to introduce some new elements \cite{26, 27}.

From a practical point of view, consequences of theoretical results in the subsequent modeling have been tested in different practical frameworks, together with a number of decision making fields that allow a more complete view of the general project that guides this particular three-years research. Additional and relevant results have been obtained in related fields, that not being included in the list of main objectives, will perform the next three-years research (there is for example an underlying absolutely needed research related to graphs and networks as key structures to be taken into account in the next future). The long-term objective of the research group, perhaps never formally stated in a three-years project, is to create a interdisciplinary group with theoretical, technological and human capacity to address every stage of a decision making process, from experimentation, data analysis and representation tools, decision analysis (amalgamating and decomposition), choice and final verification of the process itself and its results. At this point, important results relative to decision making modeling have been obtained in scheduling and social networks. These collaborations have been developed with the Department of Natural Resources at UC Berkeley, the US technological company Smiths Aerospace (Grand Rapids, Michigan), the Department of Astronomy at Complutense University of Madrid, some Non-Governmental Organizations (like Red Cross and Médicos sin Fronteras) and some national energy and transport companies, among others, taking advantage of the interdisciplinary composition of our research group and in some particular cases bringing some complementary economic (and human) support from other institutions.

2 Status of the project

Below we include a quite complete list of articles produced during the first two years of the project. It is important to realize that the project has almost 1/3 of its time ahead, so we expect to complete results during 2009 \cite{(we plan to ask on time for an extension of the project till December 31 because of the initial delay in the real access to funding)}. Nevertheless, we think results already obtained are extremely good not only because of the number and quality of publications produced, but because of the maturity reached by the research group, which has extended contacts with other research groups in Madrid, Spain and the whole world. The research group has been able to get involved into this project to new young and senior researchers (some of them barely needed in order to cover the whole decision making process), and has attained major impact in the scientific community. The organization of the 8th international FLINS conference \cite{(200 participants, see http://www.mat.ucm.es/congresos/flins2008) including the active participation of leading researchers in the field like L.A. Zadeh, P. Bonissone, W. Pedrycz, J. Kacprzyk, E. Trillas and F. Herrera, among others, and the organization of the 1st FuzzyMAD meeting for the whole fuzzy community in Madrid (40 attendants)}, had helped the group to get ready to more important scientific objectives.
In the present research team we are 12 researchers: V. Cutello, L. Garmendia, D. Gómez, E. Kerre, V. López, J. Montero (I.P.), S. Muñoz, T. Ortuño, J.T. Rodríguez (Ph.D. student), B. Vitoriano, J. Yáñez plus E. Roano, recently incorporated. It is indeed relevant the number of collaborations (in terms of joint published papers) with other research groups that the new team (that will hopefully include profs. T. Calvo, L. de Ledesma and A. Pradera plus 2 Ph.D. students) will present as a guarantee for the next three-years project application within the national research framework:

- At Complutense University, the research groups of A.I. Gómez de Castro (Dept. of Astronomy), M. Santos (Faculty of Informatics) and J. Tejada (Statistics and Operational Research).

- In Spain, the groups of H. Bustince (Public University of Navarra) and L. Escudero (Rey Juan Carlos University) among the rest, but also the groups of E. Carreño (National Geographical Institute), E. Castiñeira and S. Cubillo (Technical University of Madrid), F. Herrera (Granada University), J.L. García Lapresta (Valladolid University), L. Martínez (University of Jaén), G. Mayor (University of the Balearic Islands), P. Sobrevilla and E. Montseny (Technical University of Catalunya) and E. Trillas (European Centre for Soft Computing, Mieres).

- And around the world, A. Amo (GE Aviation Systems, Grand Rapids, Michigan, USA), G. Beliakov (Australia), G. Biging (University of California at Berkeley, USA), K. Cios (moving from the University of Ohio, Toledo, USA), V. Cutello (University of Catania, Italy), B. De Baets (University of Gent, Belgium), J. Fodor (Hungary), E.E. Kerre (University of Gent, Belgium), J. Lu (Australia), A.D. Pearman (University of Leeds, UK) and R.R. Yager (University of New York, USA)

A weakness of the present team is the low number of Ph.D. students, but the fact is that during the last years quite a number of students asked us to join our research group, but finally we had to redirect them to join other research teams with Ph.D. grants. Getting Ph.D. grants associated to the new research project we are actually applying to is a major priority.

References


TIN2006-06190

[34] H. Bustince, J. Montero and R. Mesiar: Migrativity of aggregation operators. FUZZY SETS AND SYSTEMS (in press)


[41] L.F. Escudero and S. Muñoz: Improvements on the extended rapid transit network design problem modelling. Technical Reports on Statistics and Decision Sciences, TR08/01, Universidad Rey Juan Carlos, Spain


