Labs and Research

'Kappalab', a GNU R package for capacities and non-additive integral manipulation

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The use of capacities (or fuzzy measures) and non-additive integrals in Multiple Criteria Decision Aiding (MCDA) is not anecdotal anymore. The use of the Choquet integral for instance as an aggregation function is now commonly accepted among many MCDA researchers. It appears therefore more and more necessary to have tools which enable an easy manipulation of capacities and related integrals. The Kappalab package for the GNU R statistical system is an answer to this shortage. It provides a set of high-level routines for the manipulation of capacities and associated non-additive integrals on a finite setting. In particular, it can be useful in MCDA when it comes to the development of new methods or simply to the use of existing capacities identification procedures. The Kappalab package contains several routines for handling various types of set functions such as games or capacities. It can be used to compute non-additive integrals such as the Choquet integral or the Sugeno integral. The analysis of capacities in terms of decision behavior can be performed through the computation of various numerical indices such as the Shapley value, the interaction index, the orness degree, etc. The well-known Möbius transform, as well as other equivalent representations of set functions can also be computed. Furthermore, Kappalab contains seven routines for the identification of capacities from (preferential) data: four least squares based approaches, two maximum entropy-like methods and an unsupervised approach grounded on parametric entropies. The six first methods are of particular interest for MCDA.

What is R? GNU R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. It includes a suite of operators for calculations on matrices, a large, coherent, integrated collection of intermediate tools for data analysis and graphical display, and especially a well-developed, simple and effective high-level programming language. Roughly speaking, one can think of GNU R as a free, Matlab-like software for statistical analysis grounded on an effective high-level language.

Using Kappalab. Kappalab being a package for GNU R, it follows that before being able to use it, a basic knowledge of the R language is necessary. Let us consider a simple example showing how Kappalab can be used for capacity manipulation. Note that we hereafter assume that the reader is familiar with the basic concepts arising from the use of non-additive measures and integrals in the framework of multicriteria decision making and cooperative game theory. One may also download the numerous articles available from the Kappalab web page.
Let us first define a capacity for a fictitious problem with 3 criteria:

```
> mu <- capacity(c(0, 0.07, 0.15, 0.23, 0.28, 0.48, 0.56, 1))
```

This capacity can then be visualized:

```
> mu
{}      0.00    {2}     0.15    {12}    0.28    {23}    0.56
{1}     0.07    {3}     0.23    {13}    0.48    {123}   1.00
```

The Shapley value of the capacity can be computed:

```
> Shapley.value(mu)
0.2333  0.3133  0.4533
```

The Möbius transform of the capacity can be easily obtained:

```
> m <- Mobius(mu)
```

And then visualized:

```
> m
{}      0.00    {2}     0.15    {12}    0.06    {23}    0.18
{1}     0.07    {3}     0.23    {13}    0.18    {123}   0.13
```

Finally, given a vector of partial evaluations, one can compute its Choquet integral with respect to the capacity:

```
> x <- c(0.1, 0.2, 0.8)
> Choquet.integral(mu, x)
0.294
```

Alternatively, the Möbius transform of the capacity can be used:

```
> Choquet.integral(m, x)
0.294
```

There are more than 40 high-level functions in Kappalab. These can be mainly grouped into two categories: functions for capacity manipulation and functions for capacity identification from (preferential) data. For instance, in the framework of MCDA, a natural way of using Kappalab would be first to use a function from the latter group to identify a capacity and then, functions from the former group to analyze the capacity and the related integral in terms of decision behavior. The package can be downloaded from its web page: `http://www.polytech.univ-nantes.fr/kappalab` or from the Comprehensive R Archive Network: `http://cran.r-project.org`.

A small MCDA example. We consider a simple example to illustrate how Kappalab can be used in the framework of Choquet integral based MCDA. Four cooks a, b, c, and d are evaluated according to their ability to prepare three dishes: frogs' legs (FL), steak tartare (ST) and stuffed clams (SC). Their evaluations on a [0,20] scale are given hereafter:

cooks	FL	ST	SC	cooks	FL	ST	SC
a	18	15	19	c	15	18	11
b	15	18	19	d	18	15	11

The decision maker adopts the following reasoning: when a cook is renowned for his stuffed clams, it is preferable that he/she is also better in cooking frogs' legs than steak tartare, which implies that a is preferred to b. However, when a cook badly prepares stuffed clams, it is more important that he/she is better in preparing steak tartare than frogs' legs, which leads to c is preferred to d. Of course, we also immediately have that a is preferred to d and b is preferred to c. Nevertheless these preferences do not contribute to anything since they naturally follow from the monotonicity of the Choquet integral. It can be easily checked that the above preferences do not satisfy mutual preferential independence. Hence, there is no additive model that can represent them. Using Kappalab and the above preferential information, it is for instance possible to obtain the “least specific” capacity such that the Choquet integral with respect to this capacity numerically represents the decision maker's preferences.
Define four vectors representing the profiles of the cooks:

```
> a <- c(18, 15, 19)
> b <- c(15, 18, 19)
> c <- c(15, 18, 11)
> d <- c(18, 15, 11)
```

Indicate that if an alternative is preferred to another, then their difference in terms of global evaluation should be at least equal to one:

```
> delta.C <- 1
```

Encode the preferential information “a is preferred to b” and “c is preferred to d” in an R matrix:

```
> Acp <- rbind(c(a,b,delta.C),c(c,d,delta.C))
```
Use a maximum entropy like method to determine the “least specific” capacity compatible with the provided preferential information:
```
> s <- mini.var.capa.ident(3,3,A.Choquet.preorder = Acp)
```
Display the solution:
```
> mu <- zeta(s$solution)
{}      0.00    {2}     0.50    {12}    0.67    {23}    0.50
{1}     0.17    {3}     0.34    {13}    0.84    {123}   1.00
```
And compute the global evaluations of the cooks:
```
> Choquet.integral(mu,a)   > Choquet.integral(mu,b)   > Choquet.integral(mu,c)   > Choquet.integral(mu,d)
17.83334                   16.83334                   15.16666                   14.16666
```
They are in accordance with the decision maker's preferences.
This short example illustrates how Kappalab can be used in the framework of Choquet integral based MCDA.

Book Announcements

J. Lu, D. Ruan, G. Zhang,
E-Service Intelligence -- Methodologies, Technologies and Applications, Springer, 2007. 711 pages, ISBN-10: 3-540-37015-3; ISBN-13: 978-3-540-37015-4.
Link: http://www.springer.com/east/home/engineering?SGWID=5-175-69-173623546-0

Description: E-Service Intelligence integrates intelligent techniques into e-service systems for realizing intelligent Internet information searching, presentation, provision, recommendation, online system design, implementation, and assessment to internet users.

This book offers a thorough introduction and systematic overview of the new field and covers the state-of-the-art of the research and development in E-Service Intelligence ranging from e-services and/or intelligent techniques to web information presentation, search, and mining, to personalization, privacy, and trust in e-services, to e-service evaluation, optimization and knowledge discovery, and to intelligent e-service system developments. This book is written for researchers, engineers, computer scientists, and graduate students in Computational Intelligence.

Brief announcements

- C. Alsina, M. J. Frank, B. Schweizer, B., *Associative functions: triangular norms and copulas*, WorldScientific, 2006. 252 pages. ISBN 981-256-671-6.
  http://www.worldscibooks.com/mathematics/6036.html
- E. Sanchez, (Ed.), *Fuzzy Logic and the Semantic Web*, Elsevier, 2006. 496 pages. ISBN: 0-444-51948-3.
  http://www.elsevier.com/wps/product/cws_home/706920
- E. Herrera-Viedma, G. Pasi, F. Crestani, (Eds.), *Soft Computing in Web Information Retrieval - Models and Applications*, Series: Studies in Fuzziness and Soft Computing 197, Springer. ISBN 3-540-31588-8.
  http://www.springer.com/west/home/engineering?SGWID=4-175-22-120133316-0
- M. Sato-Ilic, L. C. Jain, *Innovations in Fuzzy Clustering*, Series: Studies in Fuzziness and Soft Computing 205, Springer, 2006. 152 pages, ISBN 3-540-34356-3
  http://www.springer.com/west/home/engineering?SGWID=4-175-22-170209126-0
- S. Kendal, M. Creen, *An Introduction to Knowledge Engineering*, 2006. 290 pages. ISBN 1-84628-475-9.
  http://www.springer.com/west/home/computer/artificial?SGWID=4-147-22-165247224-0
- A. Gegov, *Complexity Management in Fuzzy Systems*, Series: Studies in Fuzziness and Soft Computing, Springer 211, 2007. 351 pages, ISBN 3-540-38883-4.
  http://www.springer.com/west/home/default?SGWID=4-40356-22-173676527-0
- V. Torra, Y. Narukawa, *Modeling Decisions: Information Fusion and Aggregation Operators*, Springer, 2007. 240 pages, ISBN 3-540-68789-0.
  http://www.springer.com/3-540-68789-0

Conferences and Calls for Papers

Conference reports

Linz Seminar on Fuzzy Set Theory (http://www.flll.uni-linz.ac.at/research/linz2007)

The 28th Linz Seminar on Fuzzy Set Theory „Fuzzy Sets, Probability, and Statistics – Gaps and Bridges“ was held in Linz February 6–10, 2007. It was co-chaired by D. Dubois, IRIT Toulouse, and R. Mesiar, STU Bratislava, and organized by E. P. Klement, JKU Linz.

This year the seminar was devoted to various aspects of probability and fuzzines. Six invited speakers (A. Colubi, University of Oviedo, G. De Cooman, Ghent University, P. Hájek, CS CAS Prague, J. Lawry, University of Bristol, C. Sempi, Università del Salento, Lecce, and L. Utkin, State Forest Technical Academy St. Petersburg) presented state-of-the-art overviews in fuzzy random variables, possibility theory, fuzzy logics of „probably“, label semantics, copulas and imprecise inference models.

In 29 contributed talks, the speakers have presented several fresh ideas and recent results. The official program was accompanied by numerous fruitful discussions among the 46 participants – these discussions are a trademark of the inspirative atmosphere of the Linz Seminars.

The 29th Linz Seminar, focusing on foundations of lattice-valued mathematics and its applications to algebra and topology, will be co-chaired by S. E. Rodabaugh (Youngstown State University, OH) and L. N. Stout (Illinois Wesleyan University, Bloomington, IL), and it is scheduled to take place February 12–16, 2008.

D. Dubois and R. Mesiar, co-chairmen of 28th Linz Seminar.