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Opinion Makers Section

Neurobiologie de la Décision à la Lumière des Travaux Récents

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1 Introduction

Bien que la décision soit une activité[1] non moins humaine que le langage, sa composante neurobiologique a, contrairement au langage, attendu les dernières années du 20ième siècle pour faire l'objet d'investigations (voir Damasio, 1994 et Damasio et al., 1996).

Très grossièrement résumés, les travaux de ces chercheurs ont conduit à deux résultats importants. Premièrement, on doit à Damasio et quelques autres, la mise en évidence d'un centre intégratif de la décision dans la partie ventro-médiane préfrontale du cerveau (Damasio, 1994; Furster, 1996 ; Berthoz, 2003). La détérioration de cette zone entraîne des conduites "irrationnelles" chez des personnes jusque là sensées (voir le cas exemplaire de Phineas Gage dans Damasio (1994)). Une des incapacités des sujets atteints dans cette partie du cerveau se traduit par une indifférence ou une mauvaise estimation du risque (Damasio, 1994; Adolphs et al., 1996)[2]. Selon une autre interprétation que j'ai avancée (Pomerol, 1997b), on a plutôt le sentiment que les sujets concernés deviennent incapables d'arbitrer entre court terme et le long terme privilégiant les satisfactions plus ou moins immédiates aux gains (ou pertes) futures, d'où l'impression que le risque n'est pas pris en compte[3]. Ce défaut d'anticipation est clairement en cause dans la démence frontotemporale (Berthoz, 2003, p. 99).

Ces travaux ont diffusé dans le public grâce essentiellement aux livres de Damasio (1994, 1999, 2003) et Berthoz (2003). Le débat s'est vite polarisé au tour du rôle des émotions dans la décision. En général, ces discussions ne se réfèrent pas aux modèles que nous, spécialistes de la décision connaissons, à l'exception notable d'Alain Berthoz qui en donne une vision simpliste, nous y reviendrons.

2 Reconnaissance et/ou raisonnement

Le premier à ma connaissance, Damasio et les personnes travaillant autour de lui ont mis en évidence le lien entre des lésions du lobe frontal et des anomalies de comportements dans le domaine de la décision. Grossièrement résumé, la décision n'est pas seulement une affaire de raisonnement mais aussi d'émotion et d'expression du corps. Cette expression mobilise différentes parties du cerveau des plus anciennes[4,] en particulier l'amygdale (Schoenbaum *et al*., 1998), aux plus récentes. L'intégration des différentes informations corporelles et émotionnelles avec le raisonnement se fait semble-t-il dans la partie ventriculaire médiane du cortex préfrontal.

Pour simplifier disons que la composante ancienne de la décision fonctionne selon un mode bien connu d'action-réaction qui a commencé à s'établir il y a plus de 400 millions d'années. L'insecte ou le ver qui détecte une vibration "a le choix" entre fuir dans diverses directions ou faire le mort et le lien entre le stimulus et l'action passe déjà par des neurones peu différents des nôtres. Même si l'on sait que l'évolution procède par mutations, il existe un continuum entre les neurones de la blatte qui lui font

[1] "Decision making is, in fact, as defining a human trait as language" (Damasio *et al*., 1996).

[2] "Subjects with VM (ventromedial) frontal lesions, however, do not show this switch in strategy. They invariably lose money on the task as a result of continuously choosing cards from the risky decks, even after they have had substantial experience with the decks, and have lost money on them. Interestingly, the VM frontal patients are quite aware that they are loosing money, and some even figure out the fact that the decks from which they are choosing are likely to be more risky. None of this knowledge, however, appears to influence their abnormal behavior, and they continue to choose from risky decks despite continued losses" (Adolphs *et al*., 1996, p. 162).

[3] "Ces patients n'utilisaient pas l'expérience émotionnelle qu'ils avaient accumulée au cours de leur vie. Les décisions prises dans ces circonstances donnaient des résultats erratiques, voire négatifs en particulier en ce qui concernaient les conséquences futures" (Damasio, 2003, p. 147).

[4] Certains auteurs font référence au "cerveau reptilien"!

"décider" de fuir ou de faire la morte et les neurones humains. Entre un ver de terre "prenant la décision" de fuir une goutte d'acide et un mouton fuyant l'ombre d'un planeur qu'il a pris pour un rapace, la nature nous offre une large gamme de décisions basées sur la reconnaissance de stimuli plus ou moins complexes. L'évolution durant quatre cent millions d’années explique la multiplicité et la complexité des circuits impliqués par la décision dans le cerveau et les différents loci concernés. Dans un premier temps, du ver de terre au mouton, c'est la complexité des patrons reconnus qui s'accroît (Berthoz, 1996, 2003)[5]. Puis vient, une capacité d'apprentissage pavlovien chez les oiseaux et les mammifères, capacités d’apprentissage très liées à l’amygdale (Schoenbaum et al., 1998) . Enfin, n'est ce pas le début du raisonnement qui s'exprime chez le chien qui va chercher sa laisse quand son maître met son manteau ? Capacités qui culminent chez l'homme, à une toute autre échelle, permettant l'apprentissage et le raisonnement. La grande supériorité du cerveau humain c'est qu'il est non seulement capable de commander l'action mais aussi de générer des images mentales du futur et de peser émotionnellement les conséquences des décisions possibles (Schoenbaum et al., 1998).

D'un côté le stimulus qui déclenche de façon quasi-immédiate une réaction comme lorsque vous retirez votre main d'une surface brûlante et de l'autre le raisonnement qui porte essentiellement sur la partie projection de la décision (Pomerol, 1997a). C'est cette partie que nous spécialistes de la décision modélisons et privilégions dans nos travaux. Cette partie projection suppose bien entendu des représentations du futur et comme vous le savez c'est là que les difficultés commencent.

Cette notion de représentation du futur, plus que la notion de décision en elle-même détermine le degré d'humanité. La représentation du futur et le raisonnement sur le futur nécessitent de la mémoire. Comme l'avaient judicieusement observé Newell et Simon dès 1972, les systèmes de traitement de l'information "intelligents" (*information processing systems*) sont tous formés d'un capteur de stimuli/interpréteur, d'une ou plusieurs mémoires et de capacité de raisonnement symbolique. Le cerveau n'échappe pas à la règle. Or donc, mémoire, raisonnement et décision ont crû de concert dans la lignée humaine. Nous pouvons inclure le langage dans la liste précédente car le langage a des traits communs avec la décision. Dans les deux cas, il s'agit d'une capacité d'enchaînement et de mise bout à bout de sons, de mots pour le langage (Calvin, 1991, 1994); d'images, de souvenirs, d'évènements et d'actions dans le cas de décision. Un scénario est en quelques sorte une histoire d'où l'analogie avec le langage. Plus l’histoire est crédible (belle ?) plus la décision a de chance d’être prise (Tversky et Kahneman, 1982b). On a pu écrire que dans une organisation prendre une décision à laquelle les gens adhérent, c’est raconter une histoire qu’ils croient (Weinberger, 2001). Tout cet aspect "histoire que l’on raconte ou que l’on se raconte" nous emmène un peu loin de la rationalité mais nous rapproche du langage avec lequel la décision a beaucoup de traits communs ne serait-ce que du point de vue phylogénique. Et même sans invoquer Vico (1744), on aurait grand tort d’ignorer cet aspect puisque d’une certaine manière, historiquement avant le raisonnement, il y avait la mythologie et la poésie lyrique qui, sous forme d’histoires, sont les premiers modes de structuration du monde et d’accumulation des connaissances.

Ce type de raisonnement par scénarios est indissociable des capacités de représentation, il a crû a cours de l'évolution, confirmant ainsi le rôle de la partie frontale du cerveau, partie la plus récente du cerveau, dans la décision. Ce qu’on peut dire, c’est que la partie à la fois la plus liée au corps et aux émotions, mettant en œuvre des parties anciennes du cerveau, interfère avec la partie "raisonnement" et que l’intégration des différentes informations se fait dans le cortex préfrontal. Nous voici donc avec les deux pôles de la décision : reconnaissance et raisonnement. Reconnaissance de patrons qui provoque l'émotion, parfois la réaction immédiate, ou sinon s'incorpore avec le raisonnement, dans le lobe frontal pour produire la décision[6]. Mais ni Damasio ni Berthoz n'ont de modèle pour expliquer comment se fait le mélange.

3 Dominance

Comme on vient de le voir, la partie "raisonnement" est surtout la capacité à se projeter dans le futur et, par des phénomènes complexes et mal identifiés, à faire qu’une action domine les autres au sens de Pareto, car il s’agit bien de décision multicritère. Si l’on en croit les neurobiologistes (Berthoz, 2003), le cerveau procède plus par inhibition de solutions potentielles que par choix. Autrement dit, suite à un processus physiologique compliqué mettant en jeu de nombreuses parties du cerveau, une solution dominante finit par inhiber toutes les autres solutions possibles (notons au passage que l’on retrouve le phénomène de "*search for dominance*" décrit par Montgomery (1983, 1987) et que chacun peut observer dans son comportement quand on se persuade a posteriori que l’on a acheté la meilleure voiture ou le meilleur lave-vaisselle compte-tenu de ses contraintes). Cet effort de rationalisation existe soit après l'action et il va réduire la tension consécutive au choix (rationalisation a posteriori), soit il s'impose avant l'action. J'ai appelé ce dernier phénomène "*rationale construction for action*"

[5] "But we have also proposed the idea that, …, higher central loops that have increasingly gained complexity during evolution operate on another mode that we have called a projective process. In this mode, signals are processed in internal loops having no direct link with sensors" (Berthoz, 1996, p. 84).

[6] "Le signal émotionnel n'est pas un substitut du raisonnement proprement dit. Il joue un rôle auxiliaire et accroît l'efficacité du processus du raisonnement et l'accélère" (Damasio, 2003, p. 150).

(Pomerol, 2003) dans un cadre où des opérateurs interprètent le contexte pour justifier les actions qu'ils entreprennent (Brézillon *et al.*, 2002).
Sur le plan cognitif et mnésique, cela veut dire que certaines situations sont marquées dans la mémoire et vont orienter les choix grâce à l'émotion dès lors qu'elles sont reconnues. A ce niveau nous ne sommes pas loin du "frame effect " (Tversky et Kahneman, 1974, 1982a, 1988). Un sujet qui a eu une expérience désagréable, même à la suite d'une bonne décision hésitera à reprendre la même décision. Dans son livre de 1994, Damasio postule l'existence de marqueurs somatiques qui transmettent les émotions vers le cortex préfrontal où elles sont intégrées aux images du futur et au raisonnement. Que les émotions dominent ou que le raisonnement du froid calculateur l'emporte, sauf en cas d'aboulie, une action finit par émerger. Comme le disait Keen (1977) ce qu'il y a d'étonnant dans la décision, c'est qu'en théorie il n'y a pas de solution mais en pratique on choisit quand même (sauf l'âne de Buridan qui reste un cas d'école !).

4 Critique des modèles classiques

Les critiques de Damasio et Berthoz envers les modèles classiques de la décision doivent être distinguées. Pour Damasio c'est d'abord Descartes qui est la cible avec sa distinction entre le corps et l'âme puisque Damasio prouve le rôle des émotions et du corps dans les décisions (Damasio, 1994). La dualité n'est sûrement pas l'apport le plus important de Descartes et l'on ignore ce que ses considérations sur l'âme doivent à l'opportunité religieuse du moment. Pour ce qui concerne les sciences de la décision, personne n'a jamais nié qu'il put y avoir de la décision immédiate par reconnaissance de cas. Klein (1993) a forgé le terme "*Recognition Primed Decision*".

Simon (1995), a proposé un modèle de l'intuition et de différentes réactions comportementales. D'un autre côté, le raisonnement par cas offre un cadre adapté à la modélisation des réactions par reconnaissance (*e.g.* Gilboa et Schmeidler, 1995, 2000a, 2000b). Or donc, nul ne nie le rôle de l'émotion et de l'humeur corporelle dans la décision humaine sans qu'il soit nécessaire d'invoquer Spinoza (Damasio, 2003)[7]. La question implicite posée par ces travaux est : faut-il en tenir compte si l'on veut être rationnel ? A mon sens non, ou alors il faut l'inclure dans le raisonnement sous la forme de cas et d'anticipations tirés de l'expérience, voir Pomerol (2001).

D'un autre côté, Berthoz (2003, Chapitre 2) s'en prend directement aux modèles de la décision. Il croit ou feint de croire que les modèles de la décision prétendent décrire le fonctionnement du cerveau. Critique non pertinente, car ne serait-ce que les probabilités, l'on sait très bien qu'elle ne se trouvent pas à l'état natif dans le cerveau. Un modèle reste un modèle surtout s'il n'a aucune prétention biologique ! Il faut interpréter les critiques de Berthoz comme une critique de la rationalité[8]. Le malentendu est complet, car il ne s'agit pas seulement de reconnaître le rôle des émotions et du corps dans la décision, mais de critiques des modèles rationnels de décision, non pour leur vrais défauts et présupposés, ce qui a déjà été fait par Simon lors de l'introduction de la rationalité limitée (voir Pomerol, 2002), mais pour leur manque de tendresse et d'altruisme[9]. Critique non relevante puisque la fonction d'utilité peut fort bien et même doit contenir des composantes morales ainsi que le futur des enfants si ces composantes contribuent à la satisfaction de l'individu. Comme le dit Berthoz (2003, p. 22) : "Nous ne prenons pas nos décisions, qu'elles soient motrices ou intellectuelles, au terme d'une analyse rationnelle de la situation", certes mais les modèles de décision n'y sont pour rien, tout au plus peut-on dire, ce qui n'est pas un scoop, que l'utilité est une idéalisation.

Le contre-sens est encore plus flagrant à propos des probabilités. Comme l'indique la citation ci-dessous[10], Berthoz souscrit d'abord à la notion de recherche de dominance de Montgomery, mais le rapport aux probabilités n'est pas évident. Que la dominance ne s'exprime pas sous forme agrégée comme une perte ou un gain, certes, puisque comme nous allons le voir elle est essentiellement multicritère, mais cela n'a rien à voir avec les probabilités qui sont une représentation du futur ! Tout au plus concéderais-je que la manipulation des probabilités est un moyen de recherche de la dominance

[7] Sacha Guitry disait en se moquant de la sagesse populaire : "méfiez-vous de votre première impression c'est toujours la bonne".

[8] "Nous ne prenons pas nos décision, qu'elles soient motrices ou intellectuelles, au terme d'une analyse complètement rationnelle de la situation" (Berthoz, 2003, p. 22).

[9] "Pourtant, la relation entre émotion et décision, par exemple est évidente. Les décisions sont souvent prises autrement qu'en fonction de l'intérêt personnel. D'autres valeurs humaines importantes interviennent comme les idées religieuses ou politiques, le sacrifice pour ses enfants, la loyauté, la droiture, la justice, la compassion, la réciprocité, la confiance.

Toutes ces approches n'ont pas vraiment tenu compte, jusqu'à présent, du fait que les décisions sont prises par un cerveau vivant" (Berthoz, 2003, p. 41).

[10] "La compétition entre les solutions différentes qui s'offrent à nous lorsque nous prenons une décision dépend donc autant de notre capacité à faire dominer une solution qu'à en éliminer d'autres. C'est ce que les théories probabilistes de la décision ne peuvent pas vraiment prendre en compte. Le problème n'est pas d'évaluer un coût et un gain, et de choisir en fonction d'une certaine probabilité de gagner plus qu'on ne perd. L'opposition gain, perte n'est pas de la même nature que l'opposition excitation/inhibition, que la compétition entre des comportements. Il y a dans cette compétition une richesse que nous sommes loin de comprendre, mais qui dépasse de beaucoup la froide estimation des calculs de probabilités…" (Berthoz, 2003, p.306).

en terme d'espérance d'utilité. C'est un phénomène connu, voir ***e.g.*** Kahneman et Lovallo (1993).

5 Décision multicritère

Ce que nous enseigne la neurobiologie, c'est que le multicritère est, soit inclus dans la partie émotionnelle de la décision, soit fait l'objet d'un raisonnement projectif dans la partie frontale du cerveau. Cette projection est, par nature, multicritère par au moins deux dimensions, le court terme (ou la satisfaction immédiate des besoins de la vie (on revient au *conatus* de Spinoza)) versus le moyen - long terme. Ce qui est intriguant c'est que l'anticipation de gains à long terme arrive à contrer l'attrait de la satisfaction immédiate chez beaucoup d'individus. Via les émotions, l'éducation et les inhibitions[11] ? Chaque composante temporelle se décline en de multiples critères. Cette tension entre les critères se résout visiblement dans le lobe frontal[12]. Mais on ne sait pas bien comment mais la recherche de dominance et la rationalisation pour l'action (qui est une sorte de recherche de dominance préalable à l'action, Pomerol, 2003) interviennent pour finir par inhiber toutes les actions possibles sauf une. Vraisemblablement il y a des effets de seuil dans la décharge des neurones qui font que le gagnant emporte le tout ("***winner takes all*** "). On peut bien sûr modéliser ce type de phénomène en décision multicritère mais, à un moment ou un autre, on attribue des poids ou une importance relative aux critères, phénomène que l'on n'identifie pas dans le cerveau et qui reste caché dans les neurones.

D'un autre côté, l'homme n'aime pas la tension créée par le choix multicritère (Kottemann et Davis, 1991 ; Berthoz, 2003, p. 286), il faut toujours faire un effort pour penser que l'on ne peut pas avoir le beurre et l'argent du beurre. Bien souvent il va chercher à rationaliser son choix, soit par la recherche de dominance (Montgomery, 1983, 1987), ce choix de la dominance est d'ailleurs confirmé par les neurobiologistes (Berthoz, 2003, p. 306), soit en utilisant le raisonnement par analogie, soit en "écoutant" son corps via les émotions et presque jamais en ayant recours à l'agrégation qui apparaît comme un effort de rationalisation des scientifiques. Souvent le décideur préfèrera, suivant les voies de la recherche heuristique et de la rationalité limitée, procéder par essai-erreur via des méthodes interactives (voir Pomerol et Barba-Romero, 1993) et des adaptations locales en fonction des niveaux d'aspiration (Lévine et Pomerol, 1986 ; Selten, 2002). Ni Berthoz, ni Damasio n'abordent la question des critères comme je le fais, même en ce qui concerne l'opposition court terme, long terme. Damasio (1994, p. 199) cependant se pose la question de l'agrégation en des termes que nous pourrions approuver : "…., *Criteria are provided by somatic markers, which express, at any given time, the cumulative preferences we have both received and acquired. But how do somatic markers function as criteria* ?" La question évidemment reste entièrement ouverte, d'autant plus que les marqueurs somatiques n'ont plus cours dans le dernier livre de Damasio. Comme on le voit l'agrégation conserve son mystère…

6 Conclusion

L'apport fondamental des travaux sur la neurobiologie de la décision concerne le rôle des émotions et du corps dans la décision. Bien sûr l'on connaissait depuis toujours ce rôle, mais on commence à entrevoir ses modes d'intervention. Il n'y a pas de doute : reconnaissance et raisonnement sont les deux pôles de la décision via la complexification des boucles de contrôle, leur déconnection de la perception et leur branchement sur les images mentales du futur (voir note 5), l'intégration de l'ensemble des informations se faisant dans le cortex préfrontal médian.

La deuxième confirmation est celle de l'utilisation essentielle de multiples critères, des critères différents mobilisant vraisemblablement des circuits neuronaux distincts jusqu'à ce qu'une action domine les autres suivant des phénomènes inconnus, d'équilibrage et d'inhibition de réseaux de neurones. Il n'y a pas de fonction d'utilité, agrégée, on s'en doutait déjà, il n'y a que de l'ajustement progressif et fragile. C'est cette fragilité et imprévisibilité qui font tout le charme de la décision et la force de la liberté[13].

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[11] "Parmi les émotions/sentiments, j'accorde une importante particulière à celles qui sont associées aux résultats futurs de nos actions…" (Damasio, 2003, p. 149).

[12] "La myopie en ce qui concerne l'avenir causée par une lésion préfrontale à un équivalent chez ceux qui modifient leurs sentiments normaux en prenant des narcotiques ou de grandes quantité d'alcool" (Damasio, 2003, p. 154).

[13] Une version étendue de ce travail avec une large bibliographie paraîtra en 2004 dans le traité des sciences de l'ingénieur : Concepts et méthodes pour l'aide à la décision, D. Bouyssou, D. Dubois, M. Pirlot, H. Prade (Eds), Hermès, Paris.

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Forum

Robustness Analysis: A Bayesian point of view

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Introduction

The latest issues of the EWG-MCDA Newsletter have presented several views on what is robustness analysis. In this note, I would like to complement them describing what is understood by such term, within the Bayesian arena. Further details may be seen in Ruggeri et al (2004). The Bayesian approach to inference and decision analysis, see French and Rios Insua (2000), essentially suggests:

- Modelling beliefs about a parameter of interest through a prior which, in presence of further information, is updated to the posterior.
- Modelling preferences and risk attitudes about (multicriteria) consequences, with a multiattribute utility function.
- Associate with each alternative its (multiattribute) posterior expected utility.
- Propose the alternative which maximises the posterior expected utility.

As in any quantitative approach, there are many reasons to check the sensitivity of the output (the optimal alternative) with respect to the inputs (model, beliefs and preferences). In addition, since, in this framework, inputs to the analysis encode the DM's judgements, she should wish to explore their implications and possible inconsistencies. The need for sensitivity analysis is further emphasised by the fact that the assessment of beliefs and preferences is a difficult task. This is an especially important point, as her judgements will evolve through the analysis until they are *requisite*. Robust Bayesian analysis guides this process.

The usual practical motivation underlying robust Bayesian analysis is the difficulty in assessing the prior distribution. Consider the simplest case in which it is desired to elicit a prior over a finite set of states Θi, $i=1,..,I$. A common technique to assess a precise $\Pi(\Theta i)= pi$, with the aid of a reference experiment, proceeds as follows: one progressively bounds $\Pi(\Theta i)$ above and below until no further discrimination is possible and then takes the midpoint of the resulting interval as the value of pi. Instead, however, one could directly operate with the obtained constraints $\alpha i <= \Pi(\Theta i) <= \beta i$, acknowledging the cognitive limitations.

The same situation holds when modelling preferences. One might assess the utility of some consequences through, say, the certainty equivalent method, and then fit a utility function. However, in reality, we only end up with upper and lower constraints on such utilities, possibly with qualitative features such as monotonicity and concavity, if preferences are increasing and risk averse. These constraints can often be approximated by an upper and a lower utility function, leading to the consideration of all utility functions that lie between these bounds. If a parametrised utility function is assessed, the constraints are typically placed on the parameters of the utility, say the risk aversion coefficient. Of course, in developing the model for the data itself there is typically great imprecision, and a need for careful study of model robustness.

A final comment concerning the limits of elicitation concerns the situation in which there are several decision makers and/or experts involved in the elicitation. Then it is not even necessarily possible theoretically to obtain a single model, prior, or utility; one might be left with only classes of each, corresponding to differing expert opinions.

Basic concepts

Robust Bayesian analysis provides tools to check the impact of the utility function, the prior and the model on the optimal alternative, and its posterior expected utility. We distinguish three main approaches to Bayesian robustness. We illustrate it considering robustness with respect to changes in the prior, but similar issues are raised when considering likelihoods and utilities. A "guided tour" through these three approaches is presented in Berger et al. (2000) and the references therein.

Informal approach

The first approach is the *informal* one, which considers several priors and compares the quantity of interest (e.g., the posterior mean) under them. The approach is very popular because of its simplicity. Its rationale is that since we shall be dealing with messy computational problems,

why not analyse sensitivity by trying only some alternative pairs of utilities and priors? While this is a healthy practice and a good way to start a sensitivity analysis, in general this will not be enough and we should undertake more formal analyses: the limited number of priors chosen might not include some which are compatible with the prior knowledge and could lead to very different values of the quantity.

It is worth mentioning that the consideration of a finite number of utilities links clearly with multi-objective decision making problems.

Global robustness

The most popular approach in Bayesian robustness is called *global sensitivity*. All probability measures compatible with the prior knowledge available are considered and robustness measures are computed as the prior varies in a class. Computations are not always easy since they require the evaluation of suprema and infima of quantities of interest.

The robustness measures provide, in general, a number that, in principle, should be interpreted in the following way:

1. if the measure is "small", then robustness is achieved and any prior in the class (possibly one computationally simple) can be chosen without relevant effects on the quantity of interest;

2. if the measure is ``large", then new data should be acquired and/or further elicitation narrows the class, recomputing the robustness measure and stopping as in the previous item; o.w. ….

3. …. if the measure is "large" and the class cannot be modified, then a prior can be chosen in the class but we should be wary of the relevant influence of our choice on the quantity of interest. Alternatively, we may use an ad hoc method such as the *G-minimax*, to select an alternative.

Given a class G of prior measures, global sensitivity analysis will usually pay attention to the range of variation of a posterior (or predictive) functional of interest as the prior ranges over the class.

Local robustness

The last approach looks for *local sensitivity* and studies the rate of change in inferences and decisions, using functional analysis differential techniques, such as Frechet derivatives of posterior expected utilities and their norms, total derivatives or Gateaux differentials.

Decision and utility robustness

An important and occasionally controversial issue is the distinction between decision robustness and expected utility robustness. A variety of situations may hold. For instance, when performing sensitivity analysis, it may happen that expected utility changes considerably with virtually no change in the optimal Bayes action, even if the utility is fixed.

Foundations

A number of results show that we may model imprecision in beliefs and preferences through a class of probability distributions and a class of utility functions. These results have two basic implications. First, they provide a qualitative framework for sensitivity analysis, describing under what conditions we may undertake the standard and natural sensitivity analysis approach of perturbing the initial probability-utility assessments, within some reasonable constraints. Second, they point to the basic solution concept of robust approaches, thus indicating the basic computational objective in sensitivity analysis, as long as we are interested in decision analytic problems: that of *non-dominated alternatives*. This corresponds to a Pareto ordering of decision rules, see White (1982), based on inequalities on the posterior expected utility.

As a consequence of this model, the solution concept is the set of non-dominated alternatives. In some cases, non-dominance is a very powerful concept leading to a unique non-dominated alternative. However, in most cases the non-dominated set will be too large to imply a final decision. It may happen that there are several non-dominated alternatives and differences in expected utilities are non-negligible. If such is the case, we should look for additional information that would help us to reduce the classes, and, perhaps, reduce the non-dominated set. Some tools based on functional derivatives to elicit additional information may be seen in Martín and Ríos Insua (1997). Tools based on distance analysis may be seen in Ríos Insua (1990).

Stability Theory

Stability theory provides another unifying, general sensitivity framework, formalising the idea that imprecisions in elicitation of beliefs and preferences should not affect the optimal decision greatly. When *strong stability* holds, careful enough elicitation leads to decisions with expected utility close to the smallest achievable; when *weak stability* holds, at least one stabilised decision will have such property. However, when neither concept of stability applies, even small elicitation errors may lead to disastrous results in terms of large losses in expected utility.

Conclusion

The approach we propose may be summarised as follows: at a given stage of analysis, we elicit information on the DM's beliefs and preferences, and consider the class of all priors and utilities compatible with such information. We approximate the set of non-dominated solutions; if these alternatives do not differ too much in expected utility, we may stop the analysis; otherwise, we need to gather additional information, possibly with the tools outlined above. This would further constrain the class: in this case the set of non-dominated alternatives will be smaller and

we could hope that this iterative process would converge until the non-dominated set is small enough to reach a final decision. It is conceivable in this context that at some stage we might not be able to gather additional information yet there remain several non-dominated alternatives with very different expected utilities. In these situations, *L × G-maximin solutions* may be useful as a way of selecting a single robust solution. We associate with each alternative its worst expected utility; we then suggest the alternative with maximum worst expected utility.

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MCDA Research Groups

Laboratory of Industrial and Energy Economics

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The Laboratory of Industrial and Energy Economics (LIEE) is an educational and research unit at the National Technical University of Athens (NTUA), one of the oldest and most prestigious academic institutions of Greece. The unit is part of the Chemical Engineering Department, having strong links with other departments of NTUA in both teaching and research activities. LIEE currently employees 6 faculty members and a total of 18 researchers and PhD candidates and is directed by Prof. L. Papagiannakis.

The activities of LIEE are developed in two parallel but interrelated streams:

- **Industrial Economics and Policy,** with emphasis on corporate strategies and the impact of technological change on industrial dynamics, headed by Assistant Prof. Y. Caloghirou.
- **Energy/Environmental Economics and Policy,** with emphasis on energy system planning under environmental and economic limitations, headed by Associated Prof. D. Diakoulaki.

The research subjects addressed in both streams entail the analysis of complicated, ill-defined and highly uncertain systems with implications on the whole economy and society. Thus, MCDA methods take up a dominant place in the methodological arsenal used to deeply investigate relevant issues and assist in the policy making procedure, with emphasis on the following research areas:

- **Energy system analysis and planning.** The research conducted in LIEE focuses on the problems related with the penetration of new energy sources and technologies with emphasis on renewable energies. MOLP and MIMOLP models are developed for identifying efficient investment combinations, which are further analyzed to find out the most preferred operational plans, at the national and regional level, as well as on a single unit level such as hotel units and hospitals. On the other side, MCDA methods are used for the comparative evaluation of discrete energy plans and policies with the active involvement of relevant stakeholders.
- **Analysis and design of environmental policies.** The emphasis here is on the optimal implementation of economic policy instruments, such as energy taxation and emissions trading. The main objective is to investigate the impact of such policies on the competitiveness of different economic entities –sectors or firms- by means of MCDA classification methods. Another research topic is the use of MOLP models in the optimal allocation of allowances in an emissions trading system.
- **Financial analysis and firm or project selection.** Besides the ranking/classification of firms on the basis of the multiple aspects of their financial performance – mainly related with courses' exercises- research is principally oriented in multicriteria combinatorial

problems handled with the use of MCDA methods jointly with integer programming models.

Although relevant research activities are primarily concerned with MCDA applications, methodological advances are also achieved. The CRITIC method was developed for assisting the weights elicitation procedure by quantifying in the form of 'objective' weights the intrinsic information carried by the decision criteria. The MultiCriteria Branch and Bound (MCBB) method developed in the PhD thesis of G.Mavrotas (actually lecturer in LIEE) generates all the efficient solutions of a Mixed Integer MOLP problem by first identifying all efficient combinations, thus providing a particularly useful information to the DM. Moreover, the exploitation of fuzzy set theory in MIMOLP formulations has also been advanced. Finally, a recent research task is to investigate the association between CBA and MCDA in order to exploit their mutual strengths.

At the educational level, the aim is to equip future engineers with knowledge on MCDA theory and applications. Besides seminars in the course 'System Analysis and Decision Making', 3-6 diploma theses are elaborated in LIEE each year, while 4 PhD students have successfully completed their thesis in this field (E. Georgopoulou-1998, G. Mavrotas-2000, Y. Sarafidis-2003 and V. Hontou-2004).

As an epilogue, we would like to mention that our participation in the EWG on MCDA was very helpful for us to get in touch with the progress and debates of the European MCDA community on crucial issues of theory and practice. It was a pleasure and honor for LIEE to organize in co-operation with HELORS the 53rd Meeting of the Group in Athens and we look forward to host our friends in a future Meeting.

MCDA-relevant publications of the last 10 years

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Software

Multiple Criteria Sorting: TOMASO A Solution in the Presence of Interacting Points of View

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Abstract

This short article briefly presents the main features of the multiple criteria sorting tool TOMASO (**T**echnique for **O**rdinal **M**ulti-**A**ttribute **S**orting and **O**rdering) and its implementation. Its main particularities are the possibility to consider interacting points of view and the use of the Choquet integral as a discriminant function. The capacities are learnt through the use of protoypes, which are well known alternatives for the Decision Maker.

1. Introduction

Let A be a set of a potential alternatives and $F=\{g_1,\mathbf{K},g_n\}$ be a set of ordinal points of view. Each alternative is evaluated on each of the points of view. For each index of point of view $j\in J=\{1,\mathbf{K},n\}$, this evaluation is done according to a s_j-point ordinal performance scale represented by a totally ordered set $X_j \coloneqq \{g_1^j \ \mathbf{p}\ \mathbf{K}\ \mathbf{p}\ g_{s_j}^j\}$. Therefore, an alternative $x\in A$ can be identified with its corresponding profile $(x_1,\mathbf{K},x_n)\in\prod_{j=1}^{n}X_j =: X$, where for any $j\in J$, x_j is the partial evaluation of *x* on point of view *j*. Let us now suppose that the Decision Maker (DM) would like to assign the alternatives of *A* to *m* increasingly ordered classes $\{Cl_t\}_{t=1}^{m}$ (which means that for any $r>s\in\{1,\mathbf{K},m\}$ the elements of Cl_r are considered as better than the elements of Cl_S). The objective is therefore to partition *A* into the classes $\{Cl_t\}_{t=1}^{m}$.

Most of the classical Multiple Criteria Decision Aiding methods use the classical weighted sum as an aggregator. In order to allow interaction among the points of view, we use the Choquet integral [Cho] as a discriminant function. For an alternative *a* and its corresponding profile $(x_1,\mathbf{K},x_n)$ it is defined by $C_v(x)\coloneqq\sum_{i=1}^{n}x_{(i)}\left[v(A_{(i)})-v(A_{(i+1)})\right]$, where v is a fuzzy measure on *J*, the parentheses used for indices represent a permutation on *J* such that $x_{(1)}\le\mathbf{K}\le x_{(n)}$ and $A_{(i)}$ stands for the subset $\{(i),\mathbf{K},(n)\}$.

The use of the Choquet integral as an aggregator allows to calculate numerical upper and lower boundaries of the classes. Nevertheless, the DM is not asked to provide any technical information on weights (capacities of the Choquet integral) or thresholds. He should only provide a set of prototypes $P\subseteq A$. A prototype is a well-known alternative for the DM. He must be aware of the global quality of each prototype in order to assign each of them to one and only one of the predefined classes. The prototypes can be fictitious elements which are not necessarily among the analysed alternatives. Nevertheless, they should be potentially existing alternatives because information will be extracted from their assignments to the classes.

In the following section we briefly present each of the steps of the TOMASO procedure. The interested reader should refer to [Mar] or [Mey] for details.

2. General ideas on the method

The different stages of the TOMASO technique are listed hereafter :

1. Modification of the original ordinal evaluations into normalised scores ;
2. Definition of the set of prototypes, and assignment of the prototypes to the predefined classes ;
3. Assessment of the capacities of the Choquet integral by solving a linear or a quadratic program ;
4. Calculation of the numerical boundaries of the classes ;
5. Assignment of the prototypes and the remaining alternatives of *A* to the classes ;
6. Analysis of the results.

In the first step, a scoring approach is used to allow us to work on the same scale for each point of view. Such scores, whose definition might vary from an application to another, should have a precise meaning for the decision maker.

Two natural approaches can be considered: either the score of each alternative is built on the basis of all the alternatives in A or this score is constructed in a context-free manner, that is, independently of the other alternatives. The decision maker must be aware that the final results may significantly differ according to the considered approach. Therefore, a prior analysis of the problem is recommended to choose the scores appropriately.

In the first approach, one possible way to build the scores is to consider comparisons of the alternatives on each of the points of view. We define the j th partial net score of alternative x in A along point of view j, as the number of times that x is preferred to any other alternative of A minus the number of times that any other alternative of A is preferred to x for point of view j. We furthermore normalize these scores so that they range in the unit interval. Clearly, this normalized score is not a utility, and should not be considered as such. Indeed, observing an extreme value (close to 0 or 1) means that x is rather *atypical* compared to the other alternatives along point of view j. Thus, the resulting evaluations strongly depend on the alternatives which have been chosen to build A.

Consider now the second approach, that is, where the score of each alternative does not depend on the other alternatives in A. In this case, we suggest the decision maker provides the score functions as utility functions. Alternatively, we can approximate these utility functions by linear ones. These functions do not necessarily represent a real utility and probably do not correspond to the utility the decision maker has in mind. We therefore continue to call it a score. Notice that the case study we present in the next section is treated by means of the scores of the first type, i.e., based on the comparison of alternatives.

The second stage of TOMASO consists in defining the prototypes by assigning elements of A to the classes. Each class should be « described » by at least one element. The assessment of the fuzzy measure of the Choquet integral is then done by « learning » from the information provided by the prototypes.

In case the prototypes don't violate the axioms for the existence of a Choquet integral as a discriminant function [Wak], a linear constraint satisfaction problem is solved (TOMASO 1). The unknowns are the coefficients of the fuzzy measure. The resulting capacities are then used to define the numerical limits of each of the clearly separated classes (maximum and minimum).

In case the prototypes violate for example the triple cancellation axiom [Wak], the Choquet integral cannot be used as a discriminant function. In that case, we solve a quadratic problem where the unknowns are the capacities of the Choquet integral and a global evaluation (score) for each alternative which respects the sorting imposed by the DM on the prototypes (TOMASO 2). The goal is to minimise the distance between the values of the Choquet integral and the global evaluations. The resulting capacities are then used to define the numerical boundaries of the classes, which are not necessarily well separated.

In the first ideal scenario, each prototype is correctly assigned to the classes, with respect to the DM's classification. The Choquet integral of the remaining alternatives is then calculated, and each of them is assigned to a single class or the union of two classes.

In the second case, the prototypes are not necessarily correctly assigned to a single class. It may happen that the classes overlap or that the prototypes are not classified according to the DM's classification. Similarly to the ideal scenario, the Choquet integral of the remaining alternatives is then calculated. Ambiguous assignments to more than one class can occur. It is possible to force each of the alternatives of A to belong to a single class after the assignment. This is done by a k-nearest neighbour approach for the classification.

After the assignments of the prototypes and the remaining alternatives, it can be interesting to analyse the behaviour of the fuzzy measure. This is done through two indexes, namely the Shapley index for the importance of each point of view, and the interaction index. But at this point, the user must be aware of an important fact : any information which is extracted from the assignment of the prototypes depends on the definition of the set A of potential alternatives and the subset P. The importance and interaction indexes are therefore only valid for the given problem, and should not be taken out of their context.

Let us finally show the use of the method on a classification problem in the next section.

3. Application

The TOMASO method is implemented in a freeware which can be obtained from the authors. A tutorial regarding the method can also be found there. As the research on this multiple criteria sorting procedure is still in progress, the software is regularly updated and improved. Nevertheless we show how the method behaves on a small example which is presented in further details in [Mar].

Consider the classical example of 27 different students evaluated on 3 courses (Mathematics, Physics and Literature) on a qualitative ordinal scale with 3 levels : bad (B) < medium (M) < good (G). Each student has to be assigned to one of the following 3 classes : bad < medium < good. A teacher has chosen to assign the follwing students as prototypes to the 3 classes:

Good	G,GM	G,G,M	G,M,G	G,G,G				
Med.	G,M,B	G,G,B						
Bad	G,B,B	B,M,B	B,G,B	G,B,M	B,G,M	G,B,G	B,M,G	B,G,G

Table 1 : The prototypes

The objective is to assign the remaining 13 students to the classes, according to the preferences of the DM, expressed by the prototypes. A solution exists for a 2-additive [Mey] fuzzy measure. The importance and interaction indexes are given in the following table:

Importance indexes			**Interaction Indexes**		
Mat	**Phy**	**Lit**	**Mat/Phy**	**Mat/Lit**	**Phy/Lit**
0.5	0.3	0.2	0.2	0	0.4

Table 2 : Importance and Interaction indexes

The remaining students are assigned to the classes as given in the following table :

od	M,G,G								
d.	M,M,G	M,G,M	M,M,M						
d	B,B,B	M,B,B	M,M,B	M,G,B	B,B,M	M,B,M	B,M,M	M,B,G	B,B,G

Table 3 : Assignments of the remaining students

As we have already mentionned earlier, the importance and interaction indexes only apply to this particular example. If the teacher decides to change his prototypes or the set *A* of the 27 students (by reducing it for example), the model should be recalculated.

4. Conclusions

This article has presented a few ideas on the TOMASO method, and its application to a small example. Its main advantage is its ability to cope with interacting points of view. Furthermore, the DM does not have to provide difficult technical information for the calculation of the model. Some work is currently done on the building of models in case some information is known on the interaction and / or importance indexes (ranking, approximative value,…). Besides, the software is constantly improved, and new graphical tools are being developped to provide easier and more readable information for the DM.

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Generic Multi-Attribute Analysis System

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The **G**eneric **M**ulti-**A**ttribute **A**nalysis (GMAA) System is a *Decision Support System* (DSS) based on an additive multi-attribute utility model that accounts for incomplete information concerning the inputs and is intended to allay many of the operational difficulties involved in the *Decision Analysis* cycle.

The user can interactively create or delete nodes and branches to build or modify an objectives hierarchy. Alternatives and their consequences, in terms of the attributes associated with the lowest-level objectives, can be easily entered by hand or loaded from file. The system admits uncertainty about consequences.

The system also admits incomplete information about the DM's preferences through value intervals as responses to the probability questions the DM is asked, which leads to classes of utility functions and weight intervals. This is less demanding for a single DM and also makes the system suitable for group decision support.

The different alternatives under consideration can be evaluated by means of an additive multiattribute utility function. The additive model is used to assess, on the one hand, average overall utilities, on which the ranking of alternatives is based and, on the other, minimum and maximum overall utilities, which give further insight into

the robustness of this ranking. It is also possible to select another objective to rank by. The system provides different displays of ranking results: *Stacked Bar Ranking, Measure Utilities for Alternatives, Compare Alternatives Graph* and *Paired Attributes Correlation.*

Finally, the system provides several types of Sensitivity Analysis (SA), like classical SA, which involves changing the parameters and observing their impact on the ranking of alternatives, or the assessment of *weight stability intervals*. The assessment of *non-dominated* and *potentially optimal* alternatives and the application of *Monte Carlo* simulation techniques take advantage of the useful imprecise information collected during the assignment of the component utilities and weights and the uncertain alternative consequences entered.

In some cases, the information obtained from the alternatives evaluation is not meaningful enough so as to definitively recommend an alternative. In these cases, the above techniques play a very important role. They may provide more meaningful information, and an iteration process can be carried out by tightening the respective imprecise alternative consequences, component utilities and weights and reassessing the non-dominated and potentially optimal alternatives or performing the Monte Carlo simulation techniques again, until a dominant strategy is found.

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New Software: Product Description

By Multistat

Key part of Multistat Optimizer is Method of Visualization for Multidimensional Models by Projections (VMFP), (www.multistat.com) which has been patented in 2002 (U.S. patent # 6,417,852.) VMFP also can be considered as a method of multi-objective optimization and graphical analysis for high-dimensional functions.

There is a fundamental difference between VMFP and conventional methods of Multidisciplinary and Structural Optimization: VMFP method substitutes model by a multidimensional dataset, and then works just with the dataset.

On the first step model values are calculated on the points of a Uniformly Distributed Sequence (UDS) that have special properties (see details on www.multistat.com.) Generated multidimensional dataset is an approximation of the model with predetermined accuracy.

On the second step the dataset is visualized in the interactive mode by using widely known visualization techniques for multidimensional datasets. UDS uniformly covers the entire domain. So, if the dataset is split into differently colored subsets by a split-criterion then hidden things become visible: Pareto-set, set of feasible solutions, contour diagrams, etc.

See a paper dedicated to solving Structural Optimization task by VMFP method, and published on the Second MIT Conference on Computational Fluid and Solid Mechanics:
http://www.multistat.com//download//MITConf2003Paper.pdf

In addition to interactive visualization tools, Multistat Optimizer provides the following features:

- Two methods of multi-objective optimization
- Built-in experimental design tool
- Effective global approximation methods those allow for substituting time-consuming finite elements models by corresponding Neural Networks or polynomial models
- Integration with any models developed in MATLAB
- Easy integration with NASTRAN, ADAMS and other scientific software packages
- Integrated development environment

Multistat Optimizer is the only truly multi-objective commercial product on the market that does not use the weighted sum of a set of objectives. It optimizes many objectives simultaneously, and allows user to pick the best design later on from a set of optimal designs for various trade-offs.

VMFP and similar UDS based methods were successfully used by different companies for solving optimization problems in aerospace, defense, automotive industries, financial services, structural optimization, materials science. Click here to see list of references and successful applications:
http://www.multistat.com//download//VMFP&PSI_Methods.pdf

Multistat Optimizer is not only a powerful instrument for scientists and engineers but also an excellent tool for classroom use.

Persons and Facts

On 29 August 2003 the Senate of Hercen State Pedagogical University of Russia, St. Petersburg awarded the degree of Doctor Honoris Causa to Prof. Dr Sc. Edmundas Kazimieras Zavadskas, the Principal Vice-rector at Vilnius Gediminas Technical University (Lithuania), the Director at Institute of Internet and Intellectual Technologies.

Our collegue Valerie Belton is the current president of the Operational Research Society of U.K.

Notre collègue Philippe Vincke est le vice président IFORS et le doyen de la faculté des sciences de l'ULB.

About the 59th Meeting

Jean-Pierre Barthélemy and Philippe Lenca

The 59th Multi Criteria Decision Aid EWG Meeting hold in Brest (France) on April, 29th and 30th, 2004. This meeting was particularly (but not exclusively) devoted to applications in banking and finance. It was preceded by a meeting of the ROADEF Working group PM2O (Programmation Mathématique Multi Objectifs). At a whole 60 participants attended the meetings. Moreover about 60 students involved in actuarial and financial studies have also participate to this event.

An over characteristic of the meeting was two tutorials on decision making in financial business. First, J. Janssen (CESIAF, Charleroi, Belgium) spoke about quantitative management of risks for banks and insurances firms. Then J. Moussavou (Brest Business School) spoke about decision processes for investments assignment and performance of portfolio managers.

The complete program of the meeting will be given below.

Within the 60 participants about the half came from France, the over half came from Europe (as a continent) or (for 6 of them) from non European countries.

Social events included:

1. A reception at the Town Hall
2. A conference dinner with a participation of Claude Leroux (la Chanteuse de Recouvrance)
3. A visit of Océanoplis (sea museum and aquariums)
4. A cruise with lunch in the Brest Harbour

The meeting was conjointly organised by Ecole Nationale Supérieure des Télécommunications de Bretagne (Bretagne Institute of Telecommunications), Ecole Supérieure de Commerce de Bretagne-Brest (Bretagne Business School at Brest) and EURO Institut d'Actuariat de Brest (European Institute of Actuarials Studies of Brest). It took place at the Ecole Supérieure de Commerce de Bretagne-Brest and had been sponsored by the several local institutions.

Finally, the organisators plan to publish refereed Proceedings within November 2004 for papers delivered at the meeting.

Les 59e journées du groupe de travail européen «Aide multicritère à la décision» se sont tenues à Brest (France) du 29 au 30 avril 2004. Ces journées étaient particulièrement (mais pas exclusivement) dédiées aux applications à la banque et à la finance. Elles étaient précédées de la réunion du groupe de la ROADEF PM2O (Programmation mathématique Multi Objectifs). En tout, ces journées ont réuni 60 participants. De plus environ 60 étudiants en actuariat et en finance ont participés à cet événement.

Les journées ont débuté avec deux tutoriaux sur la prise de décision en finance. Dans un premier temps, J. Janssen (CESIAF, Charleroi, Belgique) présenta les approches utilisées en gestion quantitative des risques pour les banques et les assurances. Puis, J. Moussavou, (Ecole Supérieure de Bretagne-Brest) donna une conférence sur les processus de décision en allocation d'actifs et performances des gérants de portefeuilles professionnels.

Le programme complet des journées est joint ci-dessous.

Parmi les 60 participants, environ la moitié venait de France, la seconde venait de membres de l'Europe (en tant que continent) ou (pour 6 d'entre-eux) de pays non européens.

Divers évènements ont marqué ces journées :

- Une réception à la mairie de Brest
- Un dîner avec la chanteuse de Recouvrance Claude Leroux
- Une visite d'Océanopolis
- Une promenade sur la Rade de Brest avec déjeuner

Ces journées ont été organisées conjointement par l'Ecole Nationale Supérieure de Bretagne, l'Ecole Supérieure de Commerce de Bretagne-Brest et l'EURO Institut d'Actuariat de l'Université Occidentale de Bretagne. Elles se tenaient à l'Ecole Supérieure de Commerce de Bretagne-Brest et ont reçu le soutien financier de plusieurs institutions locales.

Finalement, les organisateurs prévoient de publier des actes, après sélection, courant novembre 2004.

Final Program / Programme Définitif

Mercredi 28 avril / Wednesday, April 28, Réunion du groupe PM2O / PM2O meeting
(http://www.lifl.fr/PM2O/).

Jeudi 29 avril / Thursday, April 29
10.00-12.00 / Session d'ouverture/ Opening session

J. Janssen, R. Manca, Gestion quantitative des risques pour les banques et les assurances

J. Moussavou, Processus de décision d'allocation d'actifs et performances des gérants de portefeuilles professionnels

13.30-14.30 / Session 1 /Analyse multicritère – Application à la chimie / Multicriteria Analysis – Chemical application

S. Hoppe, C. Fonteix, F. Pla, K. Zaras, Optimisation multicritère et aide à la décision par Rough Sets appliquées à l'extrusion de polyuréthannes à usage médical

J. Renaud, C. Fonteix, Proposition de deux approches d'analyse multicritères : bilan de flux et méthode des Rough Sets. Présentation de 3 cas industriels chimique et agroalimentaires

14.30-15.50 / Session 2 / Axiomatisation / Axiomatisation

D. Bouyssou, M. Pirlot, An axiomatic approach to concordance relations

A. Rolland, P. Perny, Une approche axiomatique de l'agrégation de préférences avec points de référence

16.20-16.50 / Vie du groupe et prochaines réunions/Working group matters and next meetings

16.50-18.20 / Session 3 / Applications en finance / Financial applications

P. Meyer, Use of an ordinal sorting technique (TOMASO) in stock selection

M. Daubie, N. Meskens, M. Doumpos, C. Zopounidis, Using non financial variables for business failure prediction : a multicriteria approach for the belgian case

L. Sakalauskas, A. Scarelli, Stochastic modeling of preferences in finance

Vendredi 30 avril / Friday, April 30

09.00-09.50 / Session 4 / Décision Multi-objectifs / Multiple Objective Decision Making W. Brauers, Multiple Objectives and sustainable development

10.15-12.00 / Session 5 / Agrégation multicritère / Multicriteria aggregation

M. Basle, Le classement de la gouvernance nationale ou régionale : agrégation d'indicateurs ou évaluation multicritères

A. Scarelli, The assignment of the weights between Simos procedure and the steady-state vector

Y. Siskos, A. Bouranta, N. Tsotsolas, Measuring Service quality for students in higher education the case of a business university

13.30-15.20 / Session 6 / Aspects théoriques / Theoretical aspects

A. Kazakci, Structuration de problème, construction des alternatives et leurs évaluations : enseignements des théories de conception

D. Bouyssou, T. Marchant, Axiomatic characterization of some classification models

J.-L. Marichal, k - intolerant capacities and Choquet integrals

15.50-17.20 / Session 7 / Applications bancaires et financières / Banking and financial applications

V. Kalika, Applying a new MCDA approach to multi-criteria analysis of stock buying on stock market

J. Rauch, L. Austova, M. Aust, J. Halova, Determination of relevant criteria for multicriteria evaluation in the bank and finance fields

N. Halouani, H. Chabchoub, J. M. Martel, Une méthodologie multicritère pour l'évaluation de la performance des agences d'une banque tunisienne

Papiers soumis à discussion (ordre alphabétique) /Papers submitted for discussion (alphabetical order)

N., Belacel, Optimisation algorithms for multicriteria classification problems

G. Condurache, R. M. Ciobanu, Connections between value analysis and engineering and multicriteria decision aiding

A. Zinflou, C. Gagné, M. Gravel, W. Price, Algorithmes génétiques et système interactif pour la prise de décision en ordonnancement

M. L. Galves, Enhancing the role of structuring decision situations

J.R. Kala Kamdjoug, Une méthodologie multicritère d'évaluation de l'impact des projets de développement dans une circonscription territoriale délimitée

I. Kaldo, O. Vaarmann, On approximate Gauss-Newton methods for nonlinear teast squares problems

N. Matsatsinis, P. Delias, A multicriteria negotiation protocol implemented in a multi-agent environment

A. Tikniouine, Contribution de l'analyse multicritère aux systèmes d'information décisionnels

B. Vaillant, P. Meyer, S. Lallich, P. Lenca, Useful characterization and multicriteria decision aid: A two step approach to interestingness measure selection

http://mcda59.enst-bretagne.fr/

mcda59@enst-bretagne.fr

Forthcoming Meetings

(This section is prepared by Luís Dias and Carlos Henggeler Antunes)

Forthcoming EWG Meettings/Prochaines réunions du Groupe

Note:

- It should be remarked again that this is a bilingual group; all the papers should be presented in both official languages of the group (i.e. French with English slides, and *vice-versa*).
- Ceci en un groupe bilingue ; tous les papiers doivent être présentés dans les deux langues officielles du groupe (i.e. en français avec les transparents en anglais et *vice-versa*).

October 14-15, 2004. 60th Meeting of the European Working Group on MCDA, Tilburg University, Netherlands. Topic: MCDA in electronic markets, auctions and negotiations. Organiser: Bartel Van De Walle. www.tilburguniversity.nl/faculties/few/mcda60.

March 10-11 or March 17-18, 2005. 61st Meeting of the European Working Group on MCDA, Luxembourg, Grand Duchy of Luxembourg. Topic: Preference Modelling. Organisers: Jean-Luc Marichal (jean-luc.marichal@univ.lu) and Raymond Bisdorff (raymond.bisdorff@pt.lu).

Other Meetings

3-7 June 2004. International Conference on Automated Planning and Scheduling 2004 (ICAPS 2004), Whistler, BC, Canada. http://icaps04.icaps-conference.org

9-11 June 2004. IPCO X, New York City, USA. www.corc.ieor.columbia.edu/ meetings/ipcox/ipcox.html

June 20-23, 2004. Evolutionary Multiobjective Optimization Session at the 2004 Congress on Evolutionary Computation (CEC'2004). Organizer: Dr. Carlos A. Coello Coello. email: ccoello@cs.cinvestav.mx. URL : http://delta.cs.cinvestav.mx/~ccoello/

MCO 2004 (Modelling, Computation and Optimization in Information Systems and Management Sciences), July 1-3, 2004, Metz, France. Homepage: http://lita.sciences.univ-metz.fr/~mco04/.

4-7 July 2004. EURO XX. Rhodes. Greece. OR and the Management of Electronic Services. http://www.euro-rhodes2004.org/

25-28 July 2004. Optimization 2004. The fifth international conference on optimization. Faculty of Sciences. University of Lisbon. Portugal. www.opti2004.fc.ul.pt

6-11 August 2004. The 17h International Conference on Multiple Criteria Decision Analysis, Whistler, British Columbia, Canada. www.bus.sfu.ca/events/mcdm

18-21 August 2004. FRANCORO IV, Switzerland, Fribourg. Organizer: Marino Widmer: marino.widmer@unifr.ch.

1-3 September 2004. OR2004 - SYMPOSIUM ON OPERATIONS RESEARCH, Tilburg University. www.uvt.nl/OR2004.

2-4 September 2004. The IV International Conference on Decision Support for Telecommunication and Information Society will be held in Warsaw, Poland.

22-24 September 2004. 15th Mini-EURO Conference: "Managing Uncertainty in Decision Support Models", Coimbra, Portugal. http://www.inescc.pt/mudsm2004

20-22 October 2004. International Symposium TICE 2004 – UTC, France. Anne.claire-prevost@utc.fr, karine.sliwak@utc.fr

20-22 October 2004. IV-International Conference of Entreprise Science. Faculty of Entreprises Sciences, Central University Marta Abreu of Las Villas, Santa Clara, Cuba. www.universitur.uclv.edu.cu

24-27 October 2004. INFORMS Annual Meeting Denver 2004. Denver, Colorado, USA.

November 2004. FIFTH ALIO/EURO WORKSHOP ON APPLIED COMBINATORIAL OPTIMIZATION Paris, FRANCE. Organisers: Olivier Hudry and Irene Charon. E-mail: hudry@infres.enst.fr.

19-21 December 2004. 2nd International Industrial Engineering Conference. Riyadh, Saudi Arabia. http://www.iiec2004.ksu.edu.sa/

11-15 July 2005. 17th Triennial Conference of the International Federation of Operational Research Societies 2005. Honolulu, Hawaii, USA. http://www.informs.org/Conf/IFORS2005/

13-16 November 2005. INFORMS Annual Meeting, New Orleans 2005, New Orleans, Louisiana, USA.

Call for Paper

Web site for Call for Papers:
www.inescc.fe.uc.pt/~ewgmcda/CallforPapers.html

Books

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Aide Multicritére à la Décision / Multicriteria Decision Aiding
(56e Journées du Groupe de Travail Européen AIDE MULTICRITÈRE À LA DÉCISION
56th Meeting of the European Working Group MULTIPLE CRITERIA DECISION AIDING
Coimbra, Portugal, 3-5 / 10 / 2002)

Carlos Henggeler Antunes
José Figueira
João Clímaco
(Editors)

Contents: C. Henggeler Antunes, J. Figueira, J. Clímaco – "Preface" . Acknowledgment to the reviewers. **I Conceptual Issues**: J.-P. Brans - "La gestion du futur: le respect, le multicritère, le bonheur"; L. Dias, A. Tsoukiàs – "On the constructive and other approaches in decision aiding"; B. Roy - "Robustesse de quoi et vis-à.-vis de quoi mais aussi robustesse pourquoi en aide à la décision?". **II – Theory and Methodology** : R. Bisdorff, M. Roubens - "On clear choices with ordinal valued binary relations"; M. Doumpos, C. Zopounidis - "An outranking relation approach for classification problems based on pairwise comparisons" ; P. Kunsch, A. Chevalier - "The representation of dynamic trajectories with the Kolm's triangle for multiple-factor decision problems"; R. Lourenço, J. P. Costa - "The LinearTri software: sorting solutions in multiple objective mixed integer linear programming problems"; C. Mousset - "Répresentation numériques de familles de relations non complètes" ; G. Munda - "Social multi-criteria evaluation" ; A. Scarelli - "Electre III model and stochastic dominances" . **III – Modelling Uncertainty**: C. Bana e Costa, J. C. Lourenço, J. O. Soares - "An interval weighting assignment model applied to credit risk assessment"; R. Hites - "The aggregation of preferences method for solving the robust p-elements problem"; R. Lahdelma, S. Makkonen, P. Salminen - "Modelling dependent uncertainties in Stochastic Multicriteria Acceptability Analysis" ; M. Matos - "Eliciting and aggregating preferences with fuzzy inference systems". **IV – Applications:** D. Diakoulaki, V. Hontou, G. Mavrotas - "A multicriteria descriptive approach for classifying countries with respect to environmental indicators"; F. Freire, J. Malça, S. Rozakis - "Integrated economic and environmental life cycle optimization: an application to biofuel production in France"; E. Grigoroudis, Y.Politis, O. Spyridaki, Y. Siskos - "Modelling importance preferences in customer satisfaction surveys"; O. Larichev, D. Kochin, L. Ustinovicius - "A multicriteria method for choosing the best object for investments".

Coimbra, 2004. Forthcoming.

Ce livre sera envoyé à tous les membres du groupe qui ont participé aux Journée de Coimbra en Octobre 2002. Pour tous ceux qui souhaiteraient un exemplaire supplémentaire ou voudraient le faire commander, il vous sera envoyé moyennant des frais à fixer. Contact: Madame Sónia Nabais, INESC-Coimbra, Rua Antero de Quental 199, 3000-033 Coimbra, Portugal. E-mail: secretaria@inescc.pt

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Multiobjective Linear Programming: From the classic linear programming model to the explicit consideration of several objective functions
(in Portuguese)

João Namorado Clímaco
Carlos Henggeler Antunes
Maria João Gomes Alves

The study of models that consider multiple and conflicting evaluation criteria is a significant and momentous research area since the reality is intrinsically multidimensional, and mono-criterion approaches are simplistic in many such situations. This book makes a bridge between the classic linear programming model with only one objective function (in which the computation of the optimal solution is intrinsically a technical issue) and models that consider explicitly more that one objective function, thus calling into question the optimality paradigm. The multiobjective linear programming model is presented as a natural extension of the mono-criterion case, which enables the comparison of the normative character of the latter with the symbiosis of the qualitative and subjective aspects inherent to the former. These characteristics have a particularly relevant role in interactive methods devoted to problems that explicitly consider multiple, incommensurable and conflicting axes of evaluation. The second part of the book presents methodological developments, and also software and applications in the areas of energy planning and telecommunications network

planning, ensuing research work carried out by the authors.

This book is essentially meant for didactic purposes, and many illustrative problems are presented and solved. This book results from the authors' conviction of the increasing importance of this topic in the teaching of operational research, as a scientific basis to support the process of making better decisions.

Contents: General information. I Linear Programming. II Multicriteria Linear Programming. III Interactive methods in Multicriteria Linear Programming. IV TOMMIX: A base for Interactive Multiobjective Linear Programming Methods. V. SOMMIX: A base of procedures based on a Control Panel. VI. Applications. PART A. Multicriteria Decision Aid in an Energy Planning Problem. PART B. Multicriteria Decision Aid in Strategic Planning of the Modernization of Telecommunication Networks. References.

Editor: Coimbra • Imprensa da Universidade de Coimbra, 2003.

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Metaheuristics for Multiobjective Optimisation

X. Gandibleux, M. Sevaux, K. Sorensen, V. T'Kindt (editors)

About the book: The success of metaheuristics on hard single-objective optimization problems is well recognized today. However, many real-life problems require taking into account several conflicting points of view corresponding to multiple objectives. The use of metaheuristic optimization techniques for multi-objective problems is the subject of this volume. The book includes selected surveys, tutorials and state-of-the-art research papers in this field, which were first presented at a free workshop jointly organized by the French working group on Multi-objective Mathematical Programming (PM2O) and the EURO working group on Metaheuristics in December 2002. It is the first book which considers both various metaheuristics and various kind of problems (e.g. combinatorial problems, real situations, non-linear problems) applied to multiple objective optimization. Metaheuristics used include: genetic algorithms, ant colony optimization, simulated annealing, scatter search, etc. Problems concern timetabling, vehicle routing, and more. Methodological aspects, such as quality evaluation, are also covered.

Contents:

1. Methodology: A Tutorial on Evolutionary Multiobjective Optimization. Bounded Pareto Archiving: Theory and Practice. Evaluation of Multiple Objective Metaheuristics. An Introduction to Multiobjective Metaheuristics for Scheduling and Timetabling
2. Problem-oriented Contributions: A Particular Multi-Objective Vehicle Routing Problem Solved by Simulated Annealing. A Dynasearch Neighborhood for the Bicriteria Travelling Salesman Problem. Pareto Local Optimum Sets in the Biobjective Travelling Salesman Problem: An Experimental Study. A Genetic Algorithm for Tackling Multi-Objective Job-Shop Scheduling Problems. RPSGAe - Reduced Pareto Set Genetic Algorithm: Application to Polymer Extrusion.

Springer-Verlag, LNEMS 535, 2003

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Vector Optimization: Theory, Applications, and Extensions

Jahn, Johannes

About this book: This book presents fundamentals and important results of vector optimization in a general setting. The theory developed includes scalarization, existence theorems, a generalized Lagrange multiplier rule and duality results. Applications to vector approximation, cooperative game theory and multiobjective optimization are described. The theory is extended to set optimization with particular emphasis on contingent epiderivatives, subgradients and optimality conditions. Background material of convex analysis being necessary is concisely summarized at the beginning.

Written for: Researchers, graduate students

Keywords: Convex analysis, multiobjective optimisation, set optimisation, vector optimisation.

Contents: Preface v. I Convex Analysis: 1. Linear Spaces, 2. Maps on Linear Spaces, 3. Some Fundamental Theorems. II Theory of Vector Optimization: 4 Optimality Notions, 5 Scalarization, 6 Existence Theorems, 7 Generalized Lagrange Multiplier Rule, 8 Duality. III Mathematical Applications: 9 Vector Approximation, 10 Cooperative n Player Differential Games. IV Engineering Applications, 11 Theoretical Basics of Multiobjective Optimization, 12 Numerical Methods, 13 Multiobjective Design Problems. V Extensions to Set Optimization: 14 Basic Concepts and Results of Set Optimization, 15 Contingent Epiderivatives, 16 Subdifferential, 17 Optimality Conditions. Bibliography. List of Symbols. Index

2004, XIII, 465 p. 62 illus., 14 tabs., Hardcover. ISBN: 3-540-20615-9. Springer Verlag

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Interactive Decision Maps: Approximation and Visualization of Pareto Frontier

Alexander V. Lotov, Vladimir A. Bushenkov, Georgy K. Kamenev

For details (including free software and Web resources) see http://www.ccas.ru/mmes/mmeda/book6.htm. The book is devoted to application of computer visualization in the framework of multi-criteria optimization. To be precise, methods are described that apply Pareto frontier visualization in the case of three, four, five and more criteria. Both linear and non-linear models are studied.

To visualize the Pareto frontier a special technique was developed, called the Interactive Decision Maps (IDM) technique. The main feature of the technique consists in approximation of the variety of feasible criterion vectors (Feasible Criterion Set, FCS) and further interactive visualization of its Pareto frontier. The Pareto frontier is provided in the IDM technique in the form of decision maps, that is, collections of frontiers of differently colored bi-criterion slices of the FCS (or broader sets that have the same Pareto frontier). Decision maps are displayed in the interactive mode (on-line). As a part of the interactive display of decision maps, animation of them is used.

Since the volume may be of interest to a broad variety of people, it is arranged in parts that require different levels of mathematical background.

Part I, which is devoted to applications, is written in a simple form and can be assessed by any computer-literate person interested in the application of visualization methods in decision making. This part will be of interest to specialists and students in various fields related to decision making including environmental studies, management, business, engineering, etc.

In Part II computational methods are introduced in a relatively simple form. This part will be of interest to specialists and students in the field of applied optimization, operations research and computer science.

Part III is written for specialists and students in applied mathematics interested in the theoretical basis of modern optimization.

Due to this structure, the parts can be read independently. For example, students interested in environmental applications could restrict themselves to Part I and the Epilogue. In contrast, those who are interested in computational methods can skip Part I and read Part II only. Finally, specialists, who are interested in the theory of approximation of multi-dimensional convex sets or in estimation of disturbances of polyhedral sets, can read the corresponding chapters of Part III.

Kluwer Academic Publishers, Boston
Hardbound, ISBN 1-4020-7631-2
February 2004, 336 pp.
Book Series: APPLIED OPTIMIZATION : Volume 89
http://www.wkap.nl/prod/s/APOP

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Multicriteria Scheduling: Theory, Models and Algorithms

T'kindt, Vincent, Billaut, Jean-Charles

About this book: Scheduling and multicriteria optimisation theory have been subject, separately, to numerous studies. Since the last fifteen years, multicriteria scheduling problems have been subject to a growing interest. However, a gap between multicriteria scheduling approaches and multicriteria optimisation field exists. This book is a first attempt to collect the elementary of multicriteria optimisation theory and the basic models and algorithms of multicriteria scheduling. It is composed of numerous illustrations, algorithms and examples which may help the reader in understanding the presented concepts.

Written for: Researchers, graduate students

Keywords: Multicriteria optimization, multicriteria scheduling, scheduling.

Contents: 1. Introduction to scheduling. 2. Complexity of problems and algorithms. 3. Multicriteria Optimisation Theory. 4. An approach to multicriteria scheduling problems. 5. Single machine Just-in-Time scheduling problems. 6. Single machine problems. 7. Shop problems. 8. Parallel machines problems. 9. Shop problems with assignment. A. Notations. B. Synthesis on multicriteria scheduling problems. References. Index.

2002, XVI, 303 p. 148 illus., Hardcover. ISBN: 3-540-43617-0. Springer.

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Articles Harvest

(This section is prepared by Maria João Alves and Carlos Henggeler Antunes)

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Daniel VANDERPOOTEN
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Dissertations

GANDIBLEUX, Xavier: Optimisation multiobjectif : problèmes combinatoires, résolutions exactes et approchées, applications (Habillitation à Diriger des Recherches, Université de Valenciennes, Décembre, 2003). Jury : Arnaud Fréville (Univ. Valenciennes), Patrick Millot (Univ. Valenciennes), Christian Proust (Univ. de Tours), Celso Ribeiro (Univ. Católica do Rio de Janeiro), Ralph Steuer (Georgia Univ.), Philippe Vincke (ULB), Bernard Roy (Univ. Paris-Dauphine), Roman Slowinski (Poznan Univ.).

RESUME :
Située au point de convergence entre l'optimisation combinatoire et l'aide multicritère à la décision, l'optimisation combinatoire multiobjectif est un domaine qui a été longtemps peu étudié. Ce constat est d'autant plus étonnant sachant qu'un problème d'optimisation combinatoire réel véhicule souvent plusieurs objectifs généralement conflictuels. Une modélisation réaliste de ces problèmes, ainsi que l'élaboration de recommandations d'actions à leur apporter, peuvent dificilement se faire en se référant à un cadre fondé sur un critère unique de synthèse. Les spécificités du domaine nécessitent donc l'élaboration de connaissances, méthodes, techniques et procédures opérationnelles propres à l'optimisation combinatoire multiobjectif. Nos travaux de recherche s'inscrivent précisément dans ce domaine. Ils relèvent plus largement de la problématique de l'aide à la décision avec un positionnement sur les thématiques suivantes : l'optimisation discrète, les métaheuristiques, la modélisation et la résolution de problèmes réels, et l'optimisation multiobjectif. Ils sont menés depuis 1990 au Laboratoire d'Automatique, de Mécanique et d'Informatique industrielles et Humaines, unité mixte de recherche 8530 du CNRS de l'Université de Valenciennes et du Hainaut-Cambrésis. Deux facettes complémentaires structurent nos travaux. D'une part, la résolution exacte et approchée de problèmes d'optimisation combinatoire multiobjectif et d'autre part, l'expérimentation et l'insertion de processus décisionnels in situ. Le mémoire présentant ces travaux de recherches est organisé en trois parties : un parcours scientifique dans lequel sont positionnés nos contributions à la problématique de l'aide à la décision, une synthèse du domaine de optimisation combinatoire multiobjectif, et une présentation des perspectives envisagées.

SPANJAARD, Olivier. Exploitation de préférences non-classiques dans les problµemes combinatoires: modèles et algorithmes pour les graphes (Thèse de Doctorat, Université Paris-Dauphine, Décembre 2003). Jury: Patrice Perny, Didier Dubois, Jacques Teghem, Michel Minou, Roman Slowinski, Philippe Vincke.

RESUME:
Cette thèse porte sur la recherche de solutions préférées dans les problèmes décisionnels admettant un ensemble combinatoire de solutions. Dans les approches classiques, les préférences sont représentées par une fonction scalaire additive. Cependant, dans de nombreux problèmes pratiques, les préférences ne sont pas réductibles à une telle fonction. La théorie de la décision fournit des modèles de préférences plus sophistiqués. Ils sont toutefois plus di_ciles à exploiter algorithmiquement. Cette thèse cherche à concilier les préoccupations de modélisation des préférences et d'algorithmique dans une optique d'aide à la décision. On s'intéresse à des problèmes de graphes (arbres, chemins) où les préférences sont représentées par des structures mathématiques diverses (relations binaires, dioïdes). Nous proposons des algorithmes de résolution et examinons les conditions garantissant leur admissibilité. Enfin, nous spécifions ces algorithmes pour des contextes décisionnels particuliers.
Mots-clés : Aide à la décision, modélisation des préférences, optimisation combinatoire, graphes, recherche heuristique.

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