Enrique Herrera-Viedma, José Luis García-Lapresta, Janusz Kacprzyk,
Mario Fedrizzi, Hannu Nurmi, and Sławomir Zadrożny (Eds.)

Consensual Processes

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Editor-in-Chief

Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

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Editors

Prof. Enrique Herrera-Viedma
Universidad Granada
Depto. Ciencias de la
Computación e
Inteligencia Artificial
C/ Periodista Daniel Saucedo
Aranda s/n
18071 Granada, Spain
E-mail: viedma@decsai.ugr.es

José Luis García-Lapresta
Universidad de Valladolid
Departamento de Economía
Aplicada
Avenida Valle Esgueva 6
47011 Valladolid, Spain
E-mail: lapresta@eco.uva.es

Janusz Kacprzyk
Polish Academy of Sciences
Systems Research Institute
ul. Newelska 6
01–447 Warsaw, Poland
E-mail: kacprzyk@ibspan.waw.pl

Prof. Dr. Mario Fedrizzi
Università di Trento
Fac. Economia
Dipto. Informatica e Studi
Aziendali
Via Inama 5 38100 Trento Trento, Italy
E-mail: fedrizzi@cs.unitn.it

Hannu Nurmi
University of Turku
Department of Political Science
and
Contemporary History
Turku, Finland
E-mail: hnurmi@utu.fi

Sławomir Zadrożny
Polish Academy of Sciences
Systems Research Institute
ul. Newelska 6
01-447 Warsaw, Poland
E-mail: zadrozny@ibspan.waw.pl

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Preface

Consensus has been a much talked about word for centuries, maybe millennia since people have always been aware of its importance for arriving at proper decisions which have had a long lasting impact on life of groups of people, countries or even civilizations. Needless to say that the growing complexity of the present world has made the word to be used so frequently nowadays.

The first question is, as always, the one that relates to the very meaning of the word. In general, one can say that by consensus is meant, on the one hand, a general agreement within the group of people, or agents, both human and software, in a more general setting. Clearly, in the strict meaning the general agreement has been viewed in a "yes-no" way, that is, in the sense of full and unanimous agreement. Since this may be an unreachable ideal, people has been for a long time trying to make this definition more realistic and have replaced this ideal concept by a more realistic one that encompasses all forms of partial, graded, etc. agreements within a group.

The second sense of this word is related to a process of reaching consensus which aims at reaching an agreement, possibly a high one, of all, or most, agents. It can involve the resolution and/or mitigation of some minor objections concerning options or aspects in question or individual agents involved.

It is easy to see that the second sense of consensus does involve the first sense because the process of reaching an agreement must be related to some assessment of what, and to which extent the current agreement within the group exists.

This volume is concerned with consensus reaching processes which may occur both within human groups and groups of intelligent agents. We adopt, first of all, a modern and realistic definition of consensus that considers consensus not necessarily as full and unanimous agreement but as agreement to some extent. This calls for some soft computational tools and techniques and we mainly use fuzzy and possibilistic ones to be able to account for imprecision in the very meaning of many concepts, issues and properties that play a role in both that more realistic definition of consensus and the very process of consensus reaching.

The volume is intended to provide a comprehensive coverage of various issues related to consensus and consensual processes.

Part I focuses on consensus from dynamical points of view. The chapters are concerned with fundamental issues of consensus dynamics:, notably aggregation, ranking, opinion changing propensity, preference modeling, etc.

D. Eckert and Ch. Klamler ("Distance-Based Aggregation Theory") consider the problem of aggregating several objects into an object that best represents them which is a central problem in diverse fields exemplified by economics, sociology, political science, statistics, biology, etc. This problem[s] has also been extensively dealt with in the theory of social choice which analyses the aggregation of individual preferences into a collective preference. In this context, the idea of a consensus is normatively particularly appealing. A natural way to operationalize the consensus among a group of individuals is by means of a distance function that measures the disagreement between them, and this approach is followed in the paper. Thus, in particular, the construction of aggregation rules based on the minimization of distance functions inherits the normative appeal of consensus. Clearly, the distance-based approaches to aggregation theory are not limited to the construction of aggregation rules, but can fruitfully be applied to the comparison of aggregation procedures as well as to the geometric representation and to generalizations of the aggregation problems as discussed in the paper. A discussion of related problems such as the complexity of distance-based aggregation rules is also included.

G. Beliakov, T. Calvo and S. James ("On Penalty-Based Aggregation Functions and Consensus") consider the problem of aggregating individual preferences in order to arrive at a group consensus in contexts like elections where a candidate must be chosen that best represents the individuals' differing opinions, sport competitions and the fusion of sensor readings. In these applications the aggregated result should be as close as possible to the individual inputs giving rise to the need of methods that minimize this difference and this is what penalty-based aggregation functions are about drawing upon various notions of a "difference". One of more difficult issues when aggregating preferences is how to best assign numerical scores if only ordinal or pairwise preferences are given. In terms of penalty-based aggregation, the problem is further complicated by determining how the penalties should be calculated. The rationale behind using certain functions and certain measures of distance or penalty is context dependent. To use arithmetic means in group decision making, for example, implies a faith in the individuals to make accurate and sincere judgments that will not skew the results. Medians are not as susceptible in this way. When using aggregation methods, how consensus is interpreted will affect how it is achieved. A measure of distance or deviation from this value, or the imposition of a penalty for not having consensus has been studied in various forms, The authors draw upon the results on the penalty-based aggregation functions and penalty functions in general. They present some well used definitions of penalty and show how some aggregation functions correspond to minimizing the overall penalty associated with a given input vector. They consider some alternative frameworks of penalty and also introduce the idea of aggregating penalties using the OWA operator. It is shown that the penalty-based aggregation functions provide a natural framework for mathematical interpretations of consensus.

I. Contreras, M.A. Hinojosa and A.M. Mármol ("Ranking Alternatives in Group Decision-Making with Partial Information. A Stable Approach") propose in their paper some procedures for constructing global rankings of alternatives in situations in which each member of a group is able to provide imprecise or partial

information on his/her preferences about the relative importance of criteria that have to be taken into account. The authors first propose an approach based on the assumption that the final evaluation depends on the complete group since no possibility exists that the group might split into coalitions that look for more favorable solutions for the [the] coalition members. To this end, the partial information on criteria weights provided by each individual is transformed into ordinal information on the alternatives, and then the aggregation of individual preferences is addressed within a distance-based framework. In a second approach, the possibility of coalition formation is considered, and the goal is to obtain rankings in which disagreements of all the coalitions are taken into account. These rankings will exhibit an additional property of collective stability in the sense that no coalition will have an incentive to abandon the group. This last approach may be of interest in political decisions where different sectors have to be incorporated into a joint evaluation process aiming at a consensus across all possible subgroups.

M. Brunelli, R. Fullér and J. Mezei ("Opinion Changing Aversion Functions for Group Settlement Modeling") consider opinion changing aversion (OCA) functions which are used to quantify the decision makers' resistance to opinion changing. The authors obtain a collective representation of preferences by solving a non-linear optimization problem to minimize the total level of disagreement and seeking an optimal, consensual, solution, the least disagreed one. Whenever such a consensual solution has to be found, a single valued, nonnegative cost function, an opinion changing aversion (OCA) function, is assigned to each decision maker and then the overall cost is minimized. The authors focus on the quadratic OCA functions and show that the group decision (or settlement) boils down to the center of gravity of the opinions of the decision makers. It is shown that if each expert has a quadratic opinion changing aversion function, then the minimum-cost solution is the weighted average of the individual optimal solutions where the weights are the relative importances of the decision makers. The authors consider the minimum-cost solutions for group settlements under crisp and fuzzy budget constraints.

S. Montes, D. Martinetti, S. Díaz and S. Montes ("Statistical Preference as a Tool in Consensus Processes") deal with a so called statistical preference, a modern method of comparing probability distributions in the setting of consensus processes in which the intensities of preference can be expressed by means of probability distributions instead of single values. Since classical methods do not provide the possibility of comparing any pair of probability distributions, statistical preference is considered in the paper. One of its most remarkable advantages is that it allows to compare any pair of probability distributions. The authors study in depth some properties of this method and the relationship between the most commonly employed stochastic dominance and statistical preference. They also consider some of the most important families of distributions and analyze statistical preference among probability distributions in the same families.

Part II is concerned with issues underlying the meaning, composition and outcomes of individual and group decision making as well as social choice that are of relevance for consensus and consensual processes. It includes concepts and models dealing with social choice, group characterization and identification, veto power distribution, etc.

M. Regenwetter and A. Popova (“Consensus with Oneself: Within-person Choice Aggregation in the Laboratory”) follow their former efforts to [to] cross-fertilize individual and social choice research[,] and apply behavioral social choice concepts to individual decision making. Though repeated individual choice among identical pairs of choice alternatives often fluctuates dramatically over even very short time periods, social choice theory usually ignores this because it identifies each individual with a single fixed weak order. Behavioral individual decision research may expose itself to Condorcet paradoxes because it often interprets a decision maker’s modal choice (i.e., majority choice) over repeated trials as revealing their “true” preference. The authors investigate the variability in choice behavior within each individual in the research lab. Within that paradigm, they look for evidence of Condorcet cycles, as well as for the famed disagreement between the Condorcet and Borda aggregation methods. They also illustrate some methodological complexities involved with likelihood ratio tests for Condorcet cycles in paired comparison data.

D. Dimitrov (“The Social Choice Approach to Group Identification”) gives an overview of selected topics from the theory of group identification intended to answer the question: given a group of individuals, how to define a subgroup in it?. The problem of group identification is then viewed as a process of group formation. As a starting point the author uses different axiomatic characterizations of the ``libera" rule for group identification whereby the group consist of those and only those individuals who view themselves as members of the group. The focus of the paper is then on consent rules and recursive procedures for collective determination in which the opinions of other individuals in the society also count. Finally, the author addresses recent developments in the literature with respect to gradual opinions and group identity functions.

A. Laruelle and F. Valenciano (“Consensus versus Dichotomous Voting”) consider consensus [meant] as a general, maybe unanimous, agreement among possibly different views. Reaching a consensus is often a complex and difficult process involving adjustments, concessions, threats and bluffing, with no general rules, and dependent on the particular context. In which social rules, customs, past experience and communication constraints play a role. By contrast, dichotomous voting rules are in principle simple mechanisms for making decisions by using a vote to settle differences of view: the winning side enforces the decision to accept or reject the proposal on the table. Thus, these rules may be viewed in their spirit completely opposed to the idea of consensus. Nevertheless, it is often the case that a committee whose only formal mechanism to make decisions is a specified dichotomous voting rule reaches a consensus about an issue. Moreover, in many such cases the final vote is a purely formal act ratifying the agreement resulting from a consensual process and dichotomous voting rules which are a means of making decisions by using votes to settle differences of view. A natural question is therefore: How then can it often be the case that a committee whose only formal mechanism for decision-making is a dichotomous voting rule reaches a consensus? In this paper, based on a game-theoretic model developed in the authors’ previous papers, an answer to this question is provided.

J. Mercik ("On a priori Evaluation of Power of Veto") considers primarily the evaluation of power when some players have the right to veto, i.e. to stop the action of others permanently or temporarily. In certain cases, it is possible to calculate a value of power of veto attributed to the decision maker and to give the exact value of the power index as well. In other cases, it is only possible to compare the situation with and without veto attribute. In this paper the author analyzes the power of a player with a right to veto, expecting that the difference between the power of the player with veto and his or her power without veto makes it possible to evaluate directly or indirectly the power of veto itself.

Part III focuses on the environment and substantive content of consensus in various fields as well as provides an overview of approaches to measuring the degree of consensus, and some related topics.

H. Nurmi ("Settings of Consensual Processes: Candidates, Verdicts, Policies") considers the setting of social choice theory which basically deals with mutual compatibilities of various choice criteria or desiderata, and thus provides a natural angle to look at methods for finding consensus. The author distinguishes between three types of settings of consensus-reaching. Firstly, one may be looking for the correct decision. This is typically the setting where the participants have different degrees of expertise on an issue to be decided. Also jury decision making falls into this category. Secondly, the setting may involve the selection of one out of a set of candidates, for instance for a public office. Thirdly, one may be looking for a policy consensus. This setting is otherwise similar to the candidate choice setting, but usually involves more freedom in constructing new alternatives. The author first provides a review of these settings and relevant results in each one of them, and then discusses the implications of some choice paradoxes to consensus-reaching methods.

M. Martínez-Panero ("Consensus Perspectives: Glimpses into Theoretical Advances and Applications") gives a survey of polysemic meanings of consensus from several points of view, ranging from philosophical aspects and characterizations of several quantification measures within the social choice framework, paying also attention to aspects of judgment aggregation as well as fuzzy or linguistic approaches, to practical applications in decision making and biomathematics, to name a few. More specifically, the author first presents some philosophical aspects of consensus essentially focused on the doctrine that men are joined together within a society by a contract with explicit or hidden agreements, as Rousseau believed. Then, he outlines some further developments and connections, such as the link between Rousseau and Condorcet. The author also distinguishes between the concept of consent and the more technical and recent idea of consensus as appearing in modern political science and sociology. Next, he deals with several formal approaches to consensus mainly from the social choice framework, and some distance based, fuzzy or linguistic points of view. Moreover, he points out some aspects of an emergent research field focused on judgment aggregation, and concludes with a presentation of some applications as signs of the power of consensus-based methods in practice, a reference to the way of aggregating different estimates of each candidate through a median-based voting system.

J. Alcalde-Unzu and M. Vorsatz ("Measuring Consensus: Concepts, Comparisons, and Properties") study approaches of how to measure the similarity of preferences in a group of individuals which is what they mean by consensus. First, the consensus for two individuals is determined and then the average over all possible pairs of individuals in the society is calculated. In the dual approach, first, the consensus between two alternatives is determined and then the average over all possible pairs of alternatives is calculated. The authors show that the choice between the two measures used in the above processes reduces to the choice between different monotonicity and independence conditions. Finally, some recent approaches are surveyed that take into account the fact that alternatives which are on the average ranked higher by the members of the society are more important for the social choice and should therefore be assigned a higher weight while calculating the consensus.

J.L. García-Lapresta and D. Pérez-Román ("Measuring Consensus in Weak Orders") consider the problem of how to measure consensus in groups of agents when they show their preferences over a fixed set of alternatives or candidates by means of weak orders (complete preorders). Consensus is here related to the degree of agreement in a committee, and agents do not need to change their preferences. The authors introduce a new class of consensus measures on weak orders based on distances, and analyze some of their properties paying special attention to seven well-known distances. They extend Bosch's consensus measure to the context of weak orders when indifference among different alternatives is allowed, and consider some additional properties like a maximum dissension (in each subset of two agents, the minimum consensus is only reached whenever preferences of agents are linear orders and each one is the inverse of the other), reciprocity (if all individual weak orders are reversed, then the consensus does not change) and homogeneity (if we replicate a subset of agents, then the consensus in that group does not change). Then, the authors introduce a class of consensus measures based on the distances among individual weak orders paying special attention to seven specific metrics: discrete, Manhattan, Euclidean, Chebyshev, cosine, Hellinger, and Kemeny.

L. Roselló, F. Prats, N. Agell and M. Sánchez ("A Qualitative Reasoning Approach to Measure Consensus") introduce a mathematical framework, based on the absolute order-of-magnitude qualitative model, which makes it possible to develop a methodology to assess consensus among different evaluators who use ordinal scales in group decision-making and evaluation processes. The concept of entropy is introduced in this context and the algebraic structure induced in the set of qualitative descriptions given by evaluators is studied. The authors prove that it is a weak partial semilattice structure which under some conditions takes the form of a distributive lattice. The definition of the entropy of a qualitatively-described system enables us, on the one hand, to measure the amount of information provided by each evaluator and, on the other hand, to consider a degree of consensus among the evaluation committee. The methodology presented makes it possible to manage situations when the assessment given by experts involves different levels of precision. In addition, when there is no consensus within the group decision, an automatic process measures the effort needed to reach consensus.

M. Xia and Z. Xu ("On Consensus in Group Decision Making Based on Fuzzy Preference Relations") propose a method to derive the multiplicative consistent fuzzy preference relation from an inconsistent fuzzy preference relation. The fundamental characteristic of the method proposed is that it can get a consistent fuzzy preference relation taking into account all the original preference values without translation. Then, the authors develop an algorithm to transform a fuzzy preference relation into the one with the weak transitivity by using the original fuzzy preference relation and the constructed consistent one. After that, the authors propose an algorithm to help the decision makers reach an acceptable consensus in group decision making. It is worth pointing out that the group fuzzy preference relation derived by using the method proposed is also multiplicative consistent if all individual fuzzy preference relations are multiplicative consistent. The results obtained are illustrated by some examples.

S. Zadrożny, J. Kacprzyk and Z.W. Raś ("Supporting Consensus Reaching Processes under Fuzzy Preferences and a Fuzzy Majority via Linguistic Summaries and Action Rules") deal with the classic approach to the evaluation of the degree of consensus due to Kacprzyk and Fedrizzi (1986, 1988, 1989) in which a soft degree of consensus has been introduced as a degree to which, for instance, ``most of the important individuals agree as to almost all of the relevant options". The fuzzy majority is equated with a fuzzy linguistic quantifiers (most, almost all, …) and handled via Zadeh's classic calculus of linguistically quantified propositions and Yager's OWA (ordered weighted average) operators. The consensus reaching process is run by a moderator who may need a support which is provided by a novel combination of: first, the use of the a soft degree of consensus due, and then the linguistic data summaries, in particular in its protoform based version proposed by Kacprzyk and Zadrożny to indicate in a natural language some interesting relations between individuals and options to help the moderator to identify crucial (pairs of) individuals and/options which pose some threats to the reaching of consensus. Third, using results obtained in the authors' recent paper, additionally a novel data mining tool, a so-called action rule proposed by Raś and Wieczorkowska is employed. The action rules are used in the context considered to find the best concessions to be offered to the individuals for changing their preferences to increase the degree of consensus.

Part IV includes contributions which deal with the implementation of theoretical models within decision support systems for running consensus reaching sessions, notably in the Web environment, and some more important application areas, including broadly perceived multicriteria decision making.

I.J. Pérez, F.J. Cabrerizo, M.J. Cobo, S. Alonso and E. Herrera-Viedma ("Consensual Processes Based on Mobile Technologies and Dynamic Information") present a prototype of a group decision support system based on mobile technologies and dynamic information. It is assumed that the users can run the system on their own mobile devices in order to provide their preferences anytime and anywhere. The system provides consensual and selection support to deal with dynamic decision making situations. Furthermore, the system incorporates a mechanism that makes it possible to manage dynamic decision situations in which some information about the problem is not constant throughout the time. It provides a more realistic decision

making setting through high dimensional or dynamic set of alternatives, focussing the discussion on a subset of them that changes in each stage of the process. The experts' preferences are represented by using a linguistic approach. Therefore, the authors provide a new linguistic framework that is mobile and dynamic, to deal with group decision making problems.

L. Iandoli ("Building Consensus in On-line Distributed Decision Making: Interaction, Aggregation and Construction of Shared Knowledge") discusses the possibility of exploiting large-scale knowledge sharing and mass interaction taking place on the Internet to build decision support systems based on distributed collective intelligence. Pros and cons of currently available collaborative technologies are reviewed with respect to their ability to favor knowledge accumulation, filtering, aggregation and consensus formation. In particular, the author focuses on a special kind of collaborative technologies, a so called online collaborative mapping, whose characteristics can overcome some limitations of more popular collaborative tools, in particular thanks to their capacity to support collective sense-making and the construction of shared knowledge objects. The author discusses some contributions in the field and argues that the combination of online mapping and computational techniques for belief aggregation can provide an interesting basis to support the construction of systems for distributed decision-making.

F. Mata, J,.C. Martínez and R. Rodríguez ("A Web-based Consensus Support System Dealing with Heterogeneous Information") show a novel Web application of a consensus support system to carry out consensus reaching processes with heterogeneous information, i.e. the decision makers may use different information domains (in particular: numeric, interval-valued and linguistic assessments) to express their opinions. The software application developed has the following main characteristic features: it automates virtual consensus reaching processes in which experts may be put in different places, experts may use information domains near their work areas to provide their preferences and it is possible to run the system on any computer and operating system. This application may be seen as a practical development of a theoretical research on consensus modeling. It could be used by any organization to carry out virtual consensus reaching processes.

J. Ma, G.-G. Zhang and J. Lu ("A Fuzzy Hierarchical Multiple Criteria Group Decision Support System – Decider – and its Application") discuss Decider, a Fuzzy Hierarchical Multiple Criteria Group Decision Support System (FHMC-GDSS) designed for dealing with subjective, in particular linguistic, information and objective information simultaneously to support group decision making particularly focused on evaluation. The authors introduce first the fuzzy aggregation decision model, functions and structure of the Decider. The ideas of how to resolve decision making and evaluation problems encountered in the development and implementation of Decider are presented, and two real applications of the Decider system are briefly illustrated. Finally, some further future research in the area are briefly outlined.

D. Ben-Arieh and T. Easton ("Product Design Compromise Using Consensus Models") discuss the costs associated with decision making using group consensus, and then describe three methods of reaching a minimum cost consensus assuming quadratic costs for a single criterion decision problem. The first method finds the group opinion (consensus) that yields the minimum cost of reaching

throughout the group. The second method finds the opinion with the minimum cost of the consensus providing that all experts must be within a given threshold of the group opinion. The last method finds the maximum number of experts that can fit within the consensus, given a specified budget constraint. In all of them the consensus process is defined as a dynamic and interactive group decision process, which is coordinated by a moderator, who helps the experts to gradually move their opinions until a consensus is reached. The work focuses on product design compromise and discusses how group consensus can be used in this process, and demonstrates the importance of the consensus process to the product design compromise process, and presents there models as mentioned above that can be used to obtain such a compromise.

We wish to thank all the contributors for their excellent work. All the contributions were anonymously peer reviewed by at least two reviewers, and we also wish to express our thanks to them. We hope that the volume will be interesting and useful to the entire research community working in diverse fields related to group decision making, social choice, consensual processes, multiagent systems, etc. as well as other communities in which people may find the presented tools and techniques useful to formulate and solve their specific problems.

We also wish to thank Dr. Tom Ditzinger and Mr. Holger Schaepe from Springer for their multifaceted support and encouragement.

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E. Herrera-Viedma
J.L. García-Lapresta
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H. Nurmi
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