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Methodology and applications of decision support systems

Proceedings of the 3-rd
Polish-Finnish Symposium
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NADIR ORDINAL RANKING APPROACH (NORA)

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Abstract: One model for aiding the individuals involved in a nogotiation is described in this paper. The model is designed to be used interactively by both parties in a two party negotiation. The Nadir Ordinal Ranking Approach (NORA) to negotiations is a scheme that allows users to identify potential joint gains. A joint gain occurs when trade-offs among the multiple issues increase the utility for both decision makers.The method starts off by having each party rank order the most important jumps from their nadir point for the discretized issues. These ranks are obtained from each participant by asking a series of questions that ask for the most important hop from the bottom of each issue.

1. Introduction and Literature Review

This study focuses on the area of decision making dealing with the two-person group or dyad. Specifically, the paper deals with the area of two-person group decision making when conflict exists such as in negotiations. Single-person models that are meant to deal with the one-person single-objective and multiple-objective problems, have seen extensive development in the last thirty years. Work on the two-person group level and n-person group level problems have intensified in just the last fifteen years, especially in the area of group utility functions or the development of social welfare functions. Work on negotiation support systems and group decision support systems (GDSS) has only begun in the last six years.

1.1 A review of the Literature

Desanctus and Gallupe (1987) describe the foundations ofthe

area of Group Decision Support Systems (GDSS). They layout a format for research in this area of study, and suggest some possible routes.

In a paper by Korhonen et al (1986) "An Interactive Approach to Multiple Criteria Optimization with Multiple Decision-Makers" an algorithm is described which first uses the Zionts-Wallenius discrete alternative approach for a single decision maker who finds his most preferred solution, then the proxy utility functions (PUFs) of all decision makers are used as objective functions in the group problem. The group is asked to respond to pairwise comparison questions to seek the group's preferred solution. Two experiments indicated that the approach is potentially useful as a decision aid for group decision-making problems.

Kersten (1985) designed a system called NEGO which is based on Multiple Objective Linear Programming for multiple decision makers. He has experimented with the system and had positive results. His current work is based more on artificial intelligence techniques which are designed to aid one party in a multi-party negotiation setting.

Jarke et. al. (1987) designed a system called MEDIATOR that uses multiple attribute utility theory to suggest possible settlements in a negotiation setting. Individuals develop their additive value functions, then the system seeks concessions in order to merge the marginal value functions together in order to reach a compromise. The system appears to work better when there is only a slight amount of conflict within each issue, and seems not to work at all when the individuals conflict directly on an issue. Therefore this system would work best on a negotiation between individuals who share similar goals that do not conflict completely, such as a husband-wife purchase decision. A labor management negotiation may have too much conflict for this system.

Hwang and Lin in the book "Group Decision Making under Multiple Criteria" give an extensive review of methods published in the field. They also include a very large list of references.

Raiffa in his book "The Art and Science of Negotiation" (1982) on pages 160-165 describes the theory behind the pareto optimal frontier for a two party, two issue negotiation, and then extends that to more than two issues. He assigns marginal value functions for each party on each issue, then assigns a weight for each party on each issue. He then takes joint evaluations of possible contracts and optimizes the sum of the two value functions for various weights placed on one of the party's evaluation. For example, one party's weight may be half as much as the other party's, or twice as much or 100 times as much. The result is the efficient frontier from which joint gains are no longer possible. The negotiated agreement should be on this frontier. The problem is to first find the frontier, then once it is found, to agree on an alternative on the frontier.

2 Nadir Ordinal Ranking Approach (NORA)

2.1 Starting Out.

The Nadir Ordinal Ranking Approach (NORA) to negotiations is a scheme that allows users to identify potential joint gains. A joint gain occurs when trade-offs among the multiple issues increase the utility for both decision makers.

The method starts off by having each party rank order the most important jumps from their nadir point for the discretized issues. These ranks are obtained from each participant by asking a series of questions that ask for the most important hop from the bottom of each issue. The individuals compare hops from each issue, so that if there are 4 issues, they must consider 4 hops at a time. Even though this approach is meant for multiple criteria with

continuous issues, the issues are initially discretized. As an example, suppose the negotiators agree that the possible range for wage is between 4 and 12 dollars per hour. This issue could be discretized by initially considering only 4,6,8,10, or $12. All of the other issues would be discretized in a similar manner. The users then start at their worst position on each issue and specify the most important hops.

As an example, say we have a management-labor negotiation with four issues, wage, vacation, security and benefits. The ranges and discretized values for the issues are shown in the table. Starting from the nadir point of labor, they say that the wage jump from 4 to 6 is most important of the four possible hops, the jump from 6 to 8 is next in importance, security next from none to low, vacation next from 0 to 1, and so on until all jumps have a labor rank (LR) associated with them. Management does the same starting at their Nadir point which is the top of every issue. Their most important hop is from 12 to 10 on wage, next-important is 4 to 3 on vacation and so on.

LR	WAGE	MR	LR	VAC	MR	LR	SEC	MR	LR	BEN	MR
12	12	0	16	4	0	14	VHI	0	15	8	0
8	10	1	13	3	2	10	HI	7	11	6	3
2	8	4	7	2	5	6	MED	9	9	4	6
1	6	8	4	1	12	3	LO	11	5	2	10
0	4	13	0	0	16	0	NONE	14	0	0	15

2.2 Finding the starting position

NORA has potential to be used in a couple of different ways. One way is to start at a position that is bad for both parties. This approach is similar to the single negotiating text (SNT)

as described by Raiffa (1982). As an example in figure 1, for made up utility values for the 625 alternatives (5*5*5*5), a good starting position might be the circled alternative. From that point there are many possible alternatives that offer joint gains in utility. Starting there, both parties will voice their complaints to the mediator who will make trades based on the ranks for joint gain. The trades will be made until no other joint gains exist.

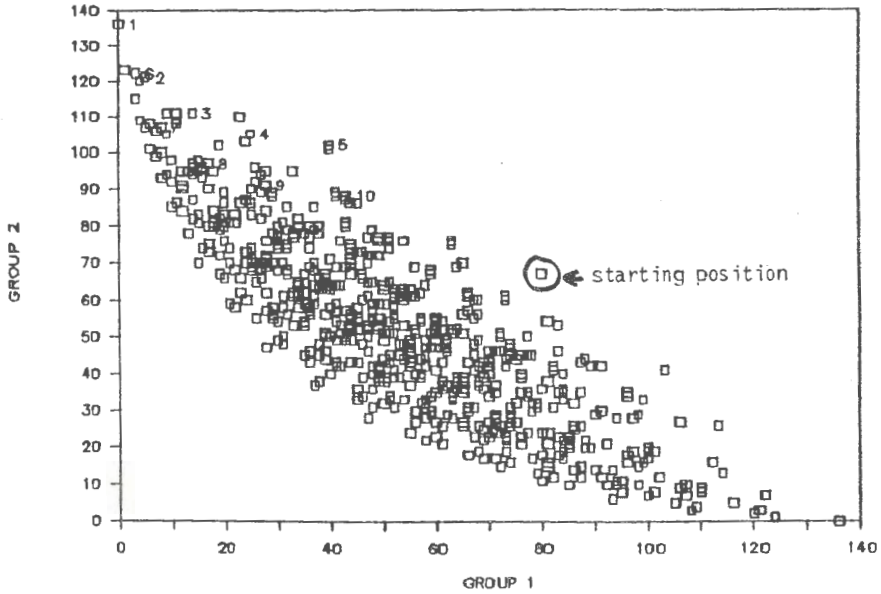

Figure 1. Cumulative summation of ranks

The starting position is very important in this method since this will ultimately determine which end points are possible to achieve. The starting position is selected by using the cumulative summation of ranks, specifically the point that maximizes the minimum summation is selected. The cumulative ranks as used in the example are shown in the table below. As an example as to how the alternative is found, the management ideal point (or bottom of every issue) has a cummulative rank summation score of 0 for labor, and 136 for management. The Nadir

point for management (the top of every issue) has a cummulative rank summation of 136 for labor and 0 for management. The starting position for this example, wage 4, vacation 4, security none, and benefits 8, has a cummulative rank summation score of 80 (0+40+0+40) for labor, and 67 (26+0+41+0) for management.

From this point, there should exist many possible joint trades. In addition, the position appears equitable to both sides. The graph that displays the cummulative rank scores for the 625 possible starting points are shown in figure 1. The starting position found is circled. Notice that in the case of cummulative ranks, joint gain is found by going in a southwesterly direction instead of a northeasterly direction as in the made up utility graph.

LR	WAGE	MR	LR	VAC	MR	LR	SEC	MR	LR	BEN	MR
23	12	0	40	4	0	33	VHI	0	40	8	0
11	10	1	24	3	2	19	HI	7	25	6	3
3	8	5	11	2	7	9	MED	16	14	4	9
1	6	13	4	1	19	3	LO	27	5	2	19
0	4	26	0	0	35	0	NONE	41	0	0	34

2.3 Presentation of Joint Trades

Assuming that marginal value functions are concave (or linear) and that the issues are preferentially independent, joint gains can be found from any point by using the rule that if a rank that a person gains in a trade is less than the rank that a person gives up in the trade, and that is true for both parties, there exists a joint gain. Say for example that we start at wage 6, vacation 3, job security medium, and benefits 4. The

parties would like to trade a higher wage for a lower vacation since the rank that labor gains is 2 for wage, but gives up a rank of 13 for vacation. Management in the same trade gains a rank of 5 for vacation, but gives up a rank of 8 for wage. Since the rank they are gaining is less than the rank they are giving up, they will both gain utility.

From any position, there may exist more than one possible trade that is jointly beneficial. If that is the case, all possible trades are presented to the negotiators, who then have to decide together which joint trade they will pick. As an example, from the previous starting position with a wage of 6, vacation 3, security at medium, and benefits at 4, all possible joint trades from that point are listed below.

	NORA ranks from parties (not displayed as output)			
trade	management gain	management loss	labor gain	labor loss
1.				
wage from 6 to 8		8	2	
vac from 3 to 2	5			13
2.				
sec from m to hi		9	10	
vac from 3 to 2	5			13
3.				
ben from 4 to 6		6	11	
vac from 3 to 2	5			
13				

When the dyad chooses which trade to make, the more powerful

party is allowed to gain more utility over the weaker party in the trades. In the above example, management would prefer trade two, and labor would prefer trade one since they give up the least to gain the most utility.

2.4 Fine Tuning

Once all of the joint trades have been made, and no single level joint gains are available, there may exist other trades that can be made, but over a smaller interval, in order to achieve joint gain. These fractional trades are dealt with by a "fine tuning" process.

This process would begin by taking the final solution from the previous step. This should be a relatively acceptable rank non-dominated point. (rank non- dominated means that there are no single level joint trades available from that point) This point would then become the middle of new ranges for the issues with the endpoints being one level above and one level below that point. The issues would be discretized as before, and the individuals would then again rank the hops from the nadir point, that is the NORA procedure would be repeated except with new, more narrow ranges on the issues.

The starting point is found again by using the new cummulative ranks. From this point joint gains can be found by using the same trade rule as discussed earlier. This iterative process could repeat until no more joint trades are possible from which joint gain occurs. If this final point then is acceptable by both parties, the solution is found, and the procedure ends.

2.5 NORA Shaving

Another way that the ranks could be utilized by the parties is

to start at different points and find concessions that mean much to one party, but mean little to the other party.(shaving can be used for example in combination with the VIG procedure to reduce the efficient frontier) The affect of this is to attempt to follow the Pareto Optimal frontier from opposite extremes toward one another. The starting positions are the ideal points as indicated on the graph in figure 1.

Notice that this procedure is different from the single negotiating text method in the sense that there are two starting positions instead of one. As an example, suppose that both labor and management begin at their own ideal points. Management should concede 4 to 6 on wage since this jump is so important to labor (ranked 1 by labor), but not that important to management (ranked 12). They next should concede vacation level 0 to 1 for the same reason. Labor on the other hand should concede wage from 12 to 10 since they do not care that much about 12(ranked 12), but management does (ranked 1). Next they should concede benefits from 8 to 6 for the same reason. Eventually if labor and management make these types of concessions, they should eventually meet.

2.5 NORA Checking

Nora can be used to make sure that a solution is at least rank non-dominated, that is no joint gains are obvious from that point. Once a position of the issues is tentatively agreed upon, NORA can be used to check the position, and also to suggest possible joint trades from that point. If the parties do not wish to make the trades, they can stop at their agreed upon point, otherwise the NORA procedure can continue.

3. Conclusions

Nora procedure has been tested together with VIG (Visual interavtive goal programing method) and unaided method at the State University of New York at Buffalo. The experiments are based on controlled laboratory studies where the negotiation is based on a series of negotiation games or situations. In the tests we found that Nora method worked well and was of substantial help for decision makers. (see APPENDIX)

However much more work needs to be undertaken in this area of negotiation support systems before useful methods can be expected to be implemented by the public at large. They do hold much potential for users to help get as much as possible for both sides.

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Post Test Subject Questionnaire

1. Rank the overall quality of the three approaches. (1st, 2nd, 3rd)

_____ Unaided method
_____ VIG method
_____ NORA

2. Rank the methods according to confidence in the final solution.

_____ Unaided method
_____ VIG method
_____ NORA

3. Rank the methods according to ease of use of the method.

_____ Unaided method
_____ VIG method
_____ NORA

4. Rank the methods according to amount of information provided by the method.

_____ Unaided method
_____ VIG method
_____ NORA

5. Which statement applies best to each of the three methods?

a. The "best" compromise solution was obtained by the method.
b. A "Reasonably good" solution was obtained by the method.
c. A satisfactory solution was obtained by the method.
d. Fairly certain that an unsatisfactory solution was obtained.
e. Certain that an unsatisfactory solution was obtained.

_____ Unaided method
_____ VIG method
_____ NORA

6. Which statement applies best to each of the three methods?

a. The method was very easy to use.
b. The method was moderately easy to use.
c. The method was moderately difficult to use.
d. The method was very difficult to use.

_____ Unaided method
_____ VIG method
_____ NORA

7. Which statement applies best to each of the three methods?

a. The method was very easy to understand.
b. The method was moderately easy to understand.
c. The method was moderately difficult to understand.
d. The method was very difficult to understand.

_____ Unaided method
_____ VIG method
_____ NORA

8. Which statement applies best to each of the three methods?
   a. The method provided useful information that helped make quick decisions.
   b. The method provided basic information that helped derive the necessary information.
   c. The necessary information was never presented by the method.

_____ Unaided method
_____ VIG method
_____ NORA

9. Which statement applies best to each of the three methods?
   a. The method worked very well and was of substantial help.
   b. The method worked well.
   c. The method did not work very well.
   d. The method was practically useless.

_____ Unaided method
_____ VIG method
_____ NORA

Office use only.

UN	Case 1	1st	Labor	Management
VIG	Case 2	2nd	Labor	Management
NORA	Case 3	3rd	Labor	Management

number_____

e

#1 NUMBER OF TIMES RANKED:

quality	1st	2nd	3rd
unaided	5	10	5
vig	2	5	13
nora	13	5	2

Borda ranking nora (25), un(40), vig(51) refer to gdm hwang book for borda score calculations. no statistical tests yet (kendel' rank test)

#2 confidence

	1st	2nd	3rd
un	8	5	7
vig	0	8	12
nora	12	7	1

Borda ranking: nora (29), vig (52), un (64)

#3 ease of use:

	1st	2nd	3rd
un	12	3	6
vig	2	8	9
nora	6	9	5

Borda rannking: un(36), nora (39), vig (45)

#4 amt of information:

	1st	2nd	3rd
un	4	7	9
vig	2	10	8
nora	14	3	3

Borda ranking: nora (29), Un (45), vig (46)

#5. solution:

	a	b	c	d	e
un	3	11	4	2	0
vig	0	10	7	2	1
nora	7	8	4	0	1

#6. ease:

	a	b	c	d
un	11	6	3	0
vig	5	8	6	1
nora	11	6	3	0

#7 understanding:

	a	b	c	d
un	16	3	1	0
vig	7	10	3	0
nora	15	3	2	0

#8 amt info

	a	b	c
un	2	14	4
vig	3	15	2
nora	10	10	0

#9 performance:

	a	b	c	d
un	1	17	1	1
vig	2	10	7.	1
nora	9	11	0	0