New Satisfying Tool for Problem Solving in Group Decision-Support System

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Abstract

A group decision-support system (GDSS) assists groups in performing group decision making by providing tools to facilitate planning, generating, organizing, electronic brainstorming, and evaluating ideas. However, a special tool is required to help the group of decision makers in GDSS to find optimal solution for problems that have multiple and possibly conflicting proposed solution alternatives. That is, selecting an optimal solution that best satisfies the GDSS participants is a challenging process because satisfying one participant may not satisfy the others.

Accordingly, we proposed a tool based on linear Goal Programming (GP) to assist GDSS participants in performing group decision making for problems that have multiple and conflict solution alternatives in a way that attains higher satisfaction for them. The proposed tool looks for solution that best fits or most closely satisfies multiple and conflicting proposed solutions. The advantages of the proposed tool are investigated in an experimental example. The evaluation results demonstrate that the GP tool outperforms other related approaches in terms of improving the participant satisfaction by reducing the deviation by 29%. One concludes that the proposed tool can find the optimal solution that will help improve the satisfaction of the GDSS participants.

Keywords: GDSS, GDSS tools, GP, participant satisfaction
1. Introduction

Decision making in real-world problems often progresses in a multi-person environment, and group decision making tools may be helpful. The complicated characters of group decision makers suggest that a computerized support, in the form of a Group Decision Support System (GDSS) [8]. And, in fact, GDSSs are widely developed and employed [5][6][10][11].

A GDSS is an interactive computer-based system used to facilitate the solution of unstructured problems by a set of decision makers working together as a group [13]. GDSS can assist groups, in analyzing problems and in performing group decision making tasks by providing tools to facilitate planning, generating, organizing, electronic brainstorming, and evaluating ideas. However, a more specialized tool is required in this paper to assist GDSS participants in performing group decision making for specific types of problems such as selecting the most preferred solution among multiple solution alternatives.

Indeed, the focus in this paper is on the problems that have multiple and possibly conflicting solution alternatives proposed by the group of decision makers, and on choosing the most preferred alternative. For example, a group of decision makers need to establish a system performance standard for a marketing campaign to be achieved by each sales representative for a certain type of product each year [20]. In order to make a decision with the help of GDSS, each participant is required to propose a value as a system performance standard. Multiple performance standard values (solution alternatives) may exist and a single solution will need to be selected. The challenge lies in finding an optimal solution value that best fits or most closely satisfies the GDSS participants who proposed solution alternatives. Participant satisfaction is an important issue in GDSS and needs to be considered when performing group decision making for such types of problems.

Finding the optimal solution necessitates a compromise because multiple solution alternatives need to be satisfied, and satisfying one solution may not satisfy the others [16]. Thus, the problem can be encapsulated in the following question:

- How a single solution for the GDSS problems that have multiple and conflict solution alternatives can be selected in a way that attains the highest satisfaction for the GDSS participants?

Hence, the author proposes a tool based on Goal Programming (GP) model to help select the optimal solution that best satisfies the GDSS participants in order to solve
such type of problems. The aim of this tool is to assist the GDSS participants in performing group decision making for problems that have multiple and conflict solution alternatives in a way that attains higher satisfaction for them.

An experimental example with all the necessary information is presented for testing and comparison purposes. Several related approaches have been investigated and compared to the proposed tool. The remainder of this paper is organized as follows: The related works are reviewed in Section 2. Section 3 presents the requirements and detailed design of the proposed tool. Performance evaluation and results are introduced in Section 4. Finally, some conclusions are given in Section 5.

2. Related Works

Participant satisfaction is an important objective to be achieved through the GDSS. Some researches such as [2][15][22][9] state the GDSS lowered group satisfaction and we aim to attain higher satisfaction for the participants. Higher satisfaction can be achieved in this paper through the proposed GP tool when it selects the solution value that best fits or the closest value to all candidate proposed values.

Many available GDSS software packages provides common tools for electronic questionnaires, electronic brainstorming, idea organizers, tools for voting or setting priorities, stakeholder identification and analysis tools, policy formation tools and group dictionaries[7][13]. However, more specific tool or function is required in this research to support decision making for problems that require a selection of an optimal solution from among a set of proposed solution alternatives, for example, setting a standard for evaluation criteria [12][21][17]. As far as we know, there is no tool or function that supports GDSS participants and solves this type of problem in a way that attains higher satisfaction for the GDSS participants.

Finding such a value that best fits or most closely satisfies multiple and conflicting values of participants is a key to participant satisfaction. In fact, several existing functions have been proposed to solve similar problems and can be used to select one value from among a set of related proposed values in GDSS. Coulouris recommends using the MAJORITY function for a group of processes in order to select one value [4]. The MAJORITY function returns the value that occurs most often among its arguments or a special value if no majority exists. According to Coulouris, if the values are ordered, then the minimum or maximum functions also can be used. Simple Additive Weighting (SAW) is a simple and most widely used Multiple Attribute Decision Making method [3] that can be applied to our problem. A final selected value using SAW can be determined by multiplying each candidate value by the relative weights as assigned by their sponsors. However, the previous functions
are not looking for the optimal solution that satisfies the set of available solution alternatives or values. Furthermore, they do not take the satisfaction of the GDSS participants in consideration.

Accordingly, a GP model is proposed as a tool that assists GDSS participants in performing group decision making for problems that have multiple and conflict solution alternatives. The proposed GP tool is able to find an optimal solution of such problems in a way that attains higher satisfaction for the GDSS participants. GP can transform a decision model into a satisfying model, in which a single objective is replaced by measurable goals. GP can analyze the decision maker's multiple aspiration levels, relax some of the model constraints, and incorporate the decision maker's preference system for multiple conflicting goals [14].

3. Requirements and Design

As discussed previously, the focus in this paper is on the problems that have a set of solution alternatives proposed by the group of decision makers, and on choosing the most preferred alternative. The most preferred solution is the optimal solution that best fits or most closely satisfies multiple and possibly conflicting solution alternatives. The solution alternatives are the values that proposed by each participant, and the optimal solution is the closest value to all candidate proposed values. Thus, the function of the proposed GP tool is to find the closest value to all candidate values in order to attain higher satisfaction for the GDSS participants. The closer the selected value is to the candidate values, the more satisfied is a GDSS participant.

Let X represent a problem type that has a set of solution alternatives proposed by group of GDSS participant such as [20][21][17]. In order to make a decision for that problem, a group of n GDSS participants $P = \{p_1, p_2, ..., p_n\} (n \geq 2)$ propose a value $s_i$ to be a solution for that problem. From among a set of solution alternatives $S = \{s_1, s_2, ..., s_n\}$, an optimal solution value ($T$) is required for that problem. Accordingly, the GP function needs to be applied to all candidate values to find the closest value ($T$) that best represent the participant objectives (candidate values) to be the optimal solution for that problem. According to [19], GP formulation requires determination of decision variables, goal constraints, and the objective function. The proposed GP function is formulated as shown in Figure 1:
1 Minimize \( Y = \sum_{i=1}^{n} \left( d_i^+ + d_i^- \right) \)
2 Subject to:
3 \( \sum_{i=1}^{n} T - d_i^+ + d_i^- = s_i; \)
4 \( i = 1, \ldots, n; \)
5 \( T, d_i^+, d_i^- \geq 0; \)

Figure 1: The proposed GP function

\( T \) is the decision variable of the problem which is the output of the GP function. The GP function seeks a value that equals each participant objective (proposed value), which serves as the goal constraints and presented line 3. The \( d_i^+ \) and \( d_i^- \) are deviational overachievement and underachievement variables, respectively. The objective function is shown in line 1 which is to minimize the gap or distance between the selected value \( T \) and each candidate value \( s_i \) to achieve higher satisfaction for the participants. The gap is represented by the overachievement \( d_i^+ \) and underachievement \( d_i^- \) of variables.

4. Illustrative Example

To illustrate the functionality of the proposed tool, a GDSS system that consists of 25 participants is assumed. The group of participants need to establish a system performance standard for a marketing campaign to be achieved by each sales representative for a certain type of product each year [20]. Each participant proposes a value to be the system performance standard e.g. \( S = \{4, 97, 75, 29, 23, 1, 70, 13, 60, 29, 99, 21, 100, 30, 24, 92, 25, 20, 22, 99, 16, 32, 10, 99, 15\} \). An optimal solution that best represents these candidate values (solution alternatives) is required. Therefore, the proposed GP tool is applied to these candidate values to find the solution that best represents these values. LINGO solver [18] is a commercial software application that can run linear GP models and is used to run the proposed GP tool in this example. For comparison purposes, the SAW and MAJORITY functions are used and applied to the candidate values to find the value that represent all candidate values. The SAW function calculates the optimal solution value \( T \) by:

\[
T = \sum_{i=1}^{n} w_i v_i
\]

where each participant has equal relative importance i.e. \( w_i = 1/n \) in this example. The selected values by the GP, SAW and MAJORITY are presented in Table 1.
Table 1: selected solution values

<table>
<thead>
<tr>
<th>Selection method</th>
<th>GP function</th>
<th>SAW function</th>
<th>Majority function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected optimal solution</td>
<td>29</td>
<td>44.2</td>
<td>99</td>
</tr>
</tbody>
</table>

5. Performance Evaluation and Results

Selecting a value from among multiple candidate values that achieves higher satisfaction for GDSS participants is the objective of this work. Thus, the ability of the GP function to attain higher satisfaction for the GDSS participants is introduced to measure its performance. The related approaches SAW and MAJORITY are used for comparison purposes.

The function of the proposed GP tool is to select a value that best represents or is closest to the proposed candidate values. The closer is the selected value to the candidate values; the more satisfied are the GDSS participants. Therefore, the distance between the obtained selected value and each candidate value proposed by a participant can represent participant satisfaction. Distance is the gap or deviation degree of the selected value among a set of related candidate values. The less the distance achieved is, the more satisfied the participants are. The selected value and the candidate values are used to calculate the total distance for all GDSS participants through the following equation:

\[ D = \sum_{i=1}^{n} |T - s_i| \]  

(1)

Where \( n \) is number of GDSS participants and \( s_i \) is the candidate value proposed by the \( i \)th participant. We evaluate the performance of the GP function in minimizing the distance and compare the result with the SAW and MAJORITY functions. Thus, if Eq. No.(1) is substituted by the candidate values presented in the previous section and the value that is selected by the GP function (\( T=29 \)), the obtained distance or deviation will be \( D=688 \). Furthermore, if Eq. No.(1) is substituted by the candidate values and the value that selected by the SAW function (\( T=44 \)), then the obtained distance or deviation will be \( D=774 \). Finally, the obtained distance or deviation using the value that selected by the MAJORITY function (\( T=99 \)) will be \( D=1305 \).

The results showed that the GP function outperforms SAW and MAJORITY functions in the degree of participant satisfaction and achieves a lower distance or deviation degree. Since the deviation degree is lower with the GP function, the participant satisfaction would be higher. Using the efficiency standard equation [1],
the efficiency of GP function over SAW function was 11.11% and over MAJORITY function was 47%. The efficiency (E) values are computed by:

\[
E = \frac{\text{Metric value}_{\text{our approach}} - \text{Metric value}_{\text{related approach}}}{\text{Metric value}_{\text{related approach}}} \times 100%
\]

or

\[
E = \frac{\text{Metric value}_{\text{related approach}} - \text{Metric value}_{\text{our approach}}}{\text{Metric value}_{\text{related approach}}} \times 100%
\]

Here, the first equation is for benefit criteria and the second equation is for cost criteria. Benefit criteria are the criteria in which the higher value is better.

5. Conclusion

This study addresses the problem of enabling the GDSS participants to solve problems that have multiple and possibly conflicting solution alternatives in such a way that attains a higher satisfaction for them. In conclusion, higher participant satisfaction was achieved through using the proposed GP tool. Comparatively, in other related studies, there was no specific guidance used to support GDSS participants to solve such problems and participant satisfaction was not considered and attained. Indeed, finding optimal solution for these types of problems using the GP model attains higher satisfaction for the GDSS participants than the approaches based on SAW and MAJORITY functions.

The proposed tool is based on a linear GP model and seeks an optimal solution that best satisfies the GDSS participants which enables our solution to make the participant satisfaction objective more attainable. The GP considers each proposed value and finds the closest value to that value, and so forth for all candidate values. On the other hand, the other related method does not consider the distance or deviation between the candidate values and the solution. Minimizing the distance or deviation between the candidate values and the solution will results in higher satisfaction for the participants. Therefore, GP was the appropriate choice and performed better. In future work, this solution may be extended to cover the none numerical proposed value by participants.

References


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