# A TOPSIS-based Multi-objective Model for Constrained Crowd Judgment Analysis

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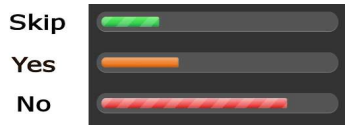
AAAI HCOMP WiP
October 25-29, 2020

# Overview

# Judgment Analysis based on Crowdsourced Opinions

Judgment analysis is in general a way of learning about human decision from multiple opinions.





# Judgment Analysis based on Crowdsourced Opinions

## Response Matrix

| | Question 1 | Question 2 | Question 3 | Question 4 |
|---|---|---|---|---|
| Annotator 1 | *Yes* | — | *Yes* | *Yes* |
| Annotator 2 | *No* | *Yes* | *Yes* | *Yes* |
| Annotator 3 | *Yes* | *Unsure* | — | *No* |
| Annotator 4 | — | — | *Skip* | — |
| Annotator 5 | *I Can't tell* | *Unsure* | *No* | — |

## Judgment Matrix

| | $o_1$ | $o_2$ | $o_3$ | $o_4$ | $o_5$ |
|---|---|---|---|---|---|
| $q_1$ | 1.5 | 1.9 | 0 | 0 | 0.81 |
| $q_2$ | 1.7 | 0 | 0 | 0 | 1.5 |
| $q_3$ | 1.3 | 1 | 0 | 0 | 0.68 |
| $q_4$ | 0 | 0 | 1 | 0.1 | 1.76 |
| $q_5$ | 0 | 0 | 1.66 | 1.8 | 0.51 |

# Motivation

- In some of the real-life applications like smart city planning, facility location problem, etc., it is necessary to realize the exact public demand in different locations of the city.
- There should be an in-depth-knowledge about the demographic information of the city. For example, in different smart city planning applications it is required to allocate resources based on the practical demand in that city. But gathering of proper information within a narrow time with additional constraints is a major challenge.
- So use of human knowledge can be very effective to locate the exact distribution of demands in the city. This can have an immense role to make a robust final decision promptly and it can be used to facilitate various issues relating to smart city planning [Chatterjee, 2020].

# Constrained Judgment

## Response Matrix (Normal Case)

| | Question 1 | Question 2 | Question 3 | Question 4 |
|---|---|---|---|---|
| **Annotator 1** | *Yes* | — | *Yes* | *Yes* |
| **Annotator 2** | *No* | *Yes* | *Yes* | *Yes* |
| **Annotator 3** | *Yes* | *Unsure* | — | *No* |
| **Annotator 4** | — | — | *Skip* | — |
| **Annotator 5** | *I Can't tell* | *Unsure* | *No* | — |

## Response Matrix (Constrained Case)

| | Question 1 | Question 2 |
|---|---|---|
| **Annotator 1** | {(10, 20), (22, 33), (42, 30)} | {(10, 20), (20, 30), (40, 30)} |
| **Annotator 2** | {(10, 21), (20, 30), (44, 35)} | {(40, 30), (20, 30), (10, 20)} |
| **Annotator 3** | {(10, 12), (21, 27), (27, 23)} | {(11, 20), (2, 30), (43, 33)} |
| **Annotator 4** | {(11, 22), (20, 30), (29, 50)} | {(12, 22), (20, 30), (30, 30)} |
| **Annotator 5** | {(11, 23), (20, 30), (50, 30)} | {(10, 10), (20, 30), (40, 30)} |

# Challenges in Constrained Judgment Analysis

- Majority voting and other judgment analysis algorithms are not applicable here.
- As there is a relation between the values therefore majority opinions (component-wise) can not guarantee the appropriate judgment.
- It is not easy to form a judgment matrix for this constrained judgment analysis problem.
- Binning procedure can solve the problem to derive the judment matrix but it can lose the exact information.
- If the number of opinions are very less then deriving perfect judgment becomes very tough.

# Challenges in Constrained Judgment Analysis

- As it is not known to us what are the possible options (only starting and ending point is known) therefore it is hard to find the posterior distributions of all the possible options.
- If the range of opinions are large then it becomes more tough to solve the problem as multiple threshold values are required to perform binning procedure.
- If the opinions are very less therefore to derive a final judgment outside of the input opinions set more number of random solutions should be generated.
- Again, ranking of crowd workers based on their constrained opinions is difficult due to the absense of the exact option set.
- Traditional TOPSIS model can be employed to find the ranking, however, the ideal solution for conflicting situation (benefit and cost criteria) cannot be optimal simultaneously as considered in the traditional case.

# Proposed Approach

- We provide a multi-objective opinion aggregation model for a recently proposed crowd opinion based judgment analysis model termed as 'constrained judgment analysis'. Here accuracy in terms of coverage of area and deviation of a solution from mean are simultaneously optimized to find out a set of non-dominated solutions.
- We show that defining the option set is not necessary to reach the near optimal set of solutions and it is very much helpful when there is a very limited number of opinions.
- The efficiency of the proposed method is shown by applying it on a synthetic crowd opinion dataset. It demonstrates that aggregation of opinions by this model can generate much better solutions from any of the original crowd solutions.
- Next to rank the crowd, the optimized solution obtained from the multi-objective approach is employed as the ideal solution of the traditional TOPSIS model.

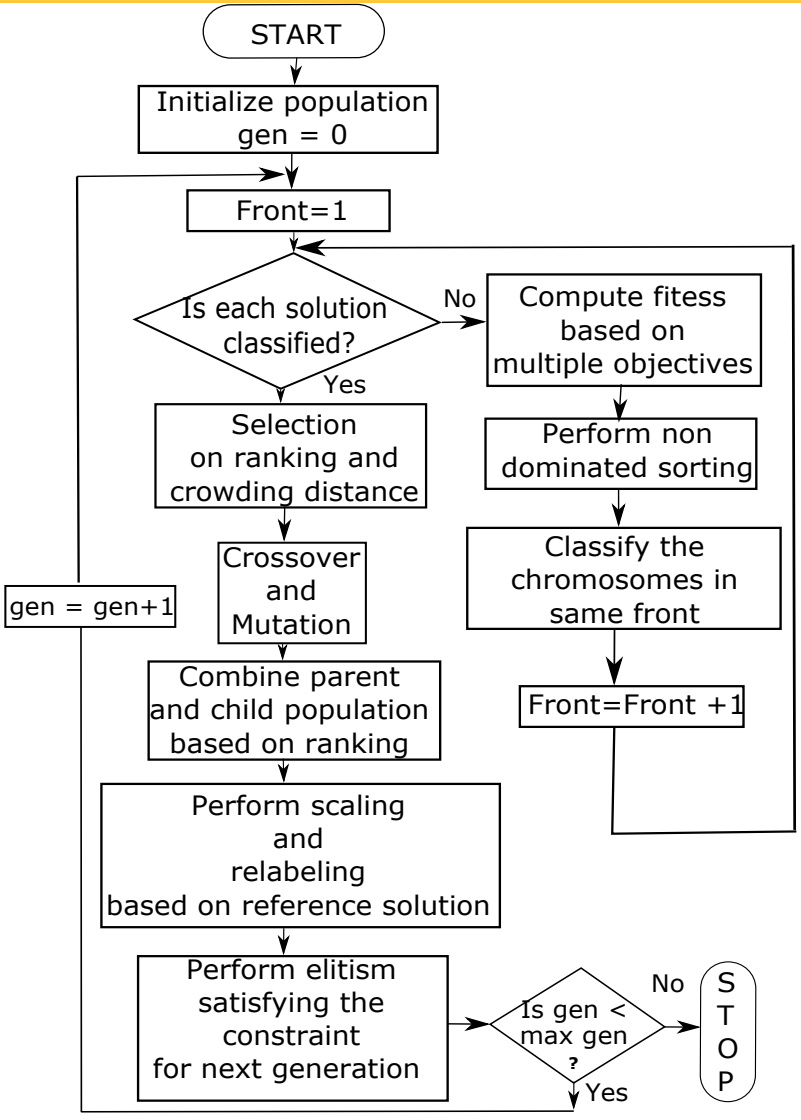



Figure: Flowchart demonstrating the different phases of the overall process.

# Dataset Preparation


Figure: Snapsot of a sample UNIST grid map to collect the opinions from crowd for smart-city planning.

Table: Performance analysis of top-4 constraint satisfying solutions for the first dataset. The top solutions are considered based on Objective 1.

| | Objective 1 | Objective 2 |
|---|---|---|
| Solution 1 | 1.9502 | 0.0569 |
| Solution 2 | 1.8234 | 0.0546 |
| Solution 3 | 1.7754 | 0.0537 |
| Solution 4 | 1.6846 | 0.0519 |

Experimental analysis demonstrates that the best solution of original crowd has the objective 1 value as 1.2 and objective 2 has value 0.0499. Similarly, the second best solution has objective 1 value as 1.13 and objective 2 value has 0.0551.

# Conclusion

- There are so many real-life applications where we need to gather the public opinions according to their real-demand.
- To investigate this we have treated the constrained crowd judgment analysis model in multiobjective framework to simultaneously optimize two objective functions.
- Coverage of area and deviation from mean are considered as the prime objectives in this planning model. We have shown that the solutions obtained by the proposed algorithm produce better agreement than any of the original crowd solutions.
- In future, the other specific charateristics of the crowd workers except these two can be considered in order to produce better solutions.
- The experimental analysis for ranking of crowd in other crowdsourced dataset containing constrained opinions are needed to be considered.

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