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Optimizing roommate matching: A multi-factor satisfactory roommates problem using modified SMAR algorithm

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Abstract

To find the best possible match, this method uses an Operations Research model called the Assignment model. The N factor, weighted N-factor satisfying housemates issue is the result of adding several factors and assigning them weights to the original problem.

Keywords: Multi-factor, model, N factor, satisfying, issue

Introduction

Irving provided an efficient solution to solve the Stable Roommates issue, which has been covered in the literature review, while Gale and Shapley created and solved the issue. The operating circumstance makes Irving's steady matching highly baffling to comprehend. Some matched members benefit from the found solutions. Attempting to find a match that is stable and optimal according to some metric is the next logical step.

Some pairs get a good solution with the current approaches, while other pairs get a bad one. As a result, the satisfaction of members in the roommates' issue has not been measured in any research. The next step is to find the best solution that satisfies everyone in the group as much as possible by quantifying their preferences. Thus, the Satisfactory Roommates Problem and its variants are defined and addressed in this chapter. The solution is found by using the recently discovered Satisfactory Matching Algorithm for Roommates (SMAR), which effectively achieves satisfactory matching.

The new SMAR is described using the Assignment model, a well-known optimization model in the field of operations research. In order to fully understand the SMAR algorithm, it is necessary to go over the tools that are used in it. The tools are detailed in the section that follows.

Current approaches solve the 1-factor Roommates Problem, which is a subset of the Stable Roommates Problem. In actual situations, however, group members tend to favour one another over another for a variety of reasons. Consider how a student's proximity, cultural interests, reading habits, etc., might influence their preference for another student. The best way to characterize a multifactor issue is to identify all of its factors. The N-Factor Satisfactory Roommates Problem is an extension of this problem that we conceived of because of this argument.

The N-factor Satisfactory Roommates issue is defined in this chapter as a matching issue when the preference list contains N-Factors. To solve the N-factor Satisfactory Roommates Problem with weights, modified SMAR is also employed, as mentioned. Depending on the preference list member, the weightage of the component could be constant or variable. Appropriate examples are used to illustrate the method in this worry.

Literature Review

N. Logapriya (2024) [1, 2] Finding a pair of roommates who are a good fit is the goal of the Satisfactory Roommates Problem (SFRP). In the SFRP, each element of the set with an even cardinality of 2n ranks the other elements with an odd cardinality of $2n - 1$ according to their choice. Using each person's satisfied level as a metric, the set is divided into 2n/2 roommate pairs. This process is called satisfactory matching. When preference lists include ties, incomplete lists, or both, the satisfying housemates' problem (SFRP) takes on a new dimension. Each of the three people involved in the Three-Person Satisfactory Roommates Problem (TPSRP) has a wish list for the two people they live with. Some individuals prefer bonds with less than 3n − 1. The TPSR method, which takes preference values into account, is used to find good matches in the flat mate issue with ties (TPSRT), ties and incomplete lists (TPSRTI), and other similar situations. This research introduces a novel, sophisticated method for locating rooms with perfect triples.

Logapriya, N. (2024) [1, 2]. When looking for a flatmate match, the Satisfactory Roommates Problem (SFRP) is a good place to start. Everyone in the set with an even cardinality of 2n ranks the other 2n-1 members in preference according to the SFRP. Based on each person's degree of satisfaction, the set is divided into 2n/2 pairs of roommates using the satisfactory matching method. There are three people in this Three-individual Satisfaction-Roommate Problem (TPSRP), and each individual will be given a list of two potential roommates. Each member of the set might have their choice ranked with the other (3n-1) members. A collection of triples is called a matching. In order to locate rooms with perfect triples, this article presents a newly developed approach.

Tiwari (2022) [3] Your college flat mate is more than just a person you live with; they have the potential to greatly impact your mental health, academic performance, and overall outlook on life. It's no secret that college students' daily social lives revolve on their roommates rather than their buddies. Our team built an app that uses a machine learning module to connect users with compatible roommates according to their interests, hobbies, and personality types. Users' responses to the personality assessment helped us refine the product idea by clustering them into more manageable groups for the purpose of matching them with potential housemates using the K-Means Algorithm. Users will be able to peruse the profiles of possible roommates and even like some of them right from the app.

Mertens, Stephan. (2014) [4]. There is a time and space complexity of $O(n^2)$ for the generic stable roommates issue with n agents. However, random examples may be solved more quickly and using less memory. On average, the time and space complexity of our approach is $O(n^\frac{3}{2})$ under randomized circumstances. With this approach, we may model the stable roommate's issue on a large scale and find the probability p_n that a random n-size case allows a stable matching. Our findings lend credence to the hypothesis that $p_n = \Theta(n^{-1/4})$.

Goodarzian (2023) [5] Pandemic modelling has become a top priority for public policymakers throughout the globe because to the COVID-19. However, there is still a big obstacle when it comes to COVID-19 medical waste detoxification center forecasting and modelling. In order to foretell the COVID-19 medical waste, this study introduces a Fuzzy Inference System. Next, individuals are categorized into five groups based on the severity of their symptoms: healthy, suspicious, mild, and extreme COVID-19. To that end, we have created the first ever COVID-19 medical waste supply chain network fuzzy sustainable model, which takes waste management into account when making choices about where to put things and how to distribute them. The primary goals of this document during the COVID-19 pandemic are to reduce expenses in the supply chain, lessen the negative effects of medical waste on the environment, set up detoxification centres, and manage the social responsibility centres. Important parameters undergo sensitivity analysis to demonstrate the performance of the proposed model. To back up the model, we recommend looking at a real-life situation in Iran or Tehran. This study contributes in many ways. It classifies individuals into distinct categories, examines novel AI approaches based on TS and GOA algorithms, and considers sustainability in the COVID-19 medical waste supply chain network. The findings indicate that in order to decrease the occurrence of this pandemic, decision-makers should hire a COVID-19 medical waste purification center and utilised a FIS for COVID-19 waste forecasting.

Satisfactory roommates' problem with ties and incomplete lists

The extension of the Roommates issue is the Satisfactory Roommates problem with Ties and incomplete lists. Members are free to submit partial lists that include ties in this configuration. One way to show disinterest in a possible spouse is to allow ties in the preference list, which eliminates the need to specify a clear order of preference. An iteration of the Satisfactory Roommates Problem known as SFRPTI combines both expansions specified above.

Modifying step 2 of the SMAR makes it easy to apply it to the SFRPTI instance; for example, instead of assigning a value to members of ties, it would provide no value to those who are undesirable on the preference list. This case's satisfactory matching is described with an appropriate example.

Example: 1 Take the 4-item issue instance and their preferred order into account to find Satisfactory Matching using SMAR.

1:	2	(4	3)
2:	3	1	
3:	1	(2	4)
4:	1	3	

Solution

When looking for Satisfactory matching in the context of SFRPTI, the SMAR is used. An average value is given to members in ties, and no value is given to members who are undesirable based on their position in the preference list. After that, a Preference Value Matrix is created to tabulate the preference values.

The Matrix of Preferences

$$PVM = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{3}{3} & \frac{1}{2} & \frac{1}{2} \\ \frac{2}{3} & - & \frac{3}{3} & - \\ \frac{3}{3} & \frac{1}{2} & - & \frac{1}{2} \\ \frac{3}{3} & - & \frac{2}{3} & - \end{pmatrix} \end{array}$$

The Satisfactory Value Matrix

$$SVM = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{5}{3} & \frac{9}{6} & \frac{9}{6} \\ \frac{5}{3} & - & \frac{9}{6} & - \\ \frac{9}{6} & \frac{9}{6} & - & \frac{7}{6} \\ \frac{9}{6} & - & \frac{7}{6} & - \end{pmatrix} \end{array}$$

When you input your roommate preferences using the SVM and the Hungarian method, you'll get a perfect match every time. And for the two matchings, the satisfying value is 9/6 for the matching pair.

Table 1: Satisfactory matching

Satisfactory Matching	Satisfactory Values of members	Satisfactory Level of members	Satisfactory Value of pair	Satisfactory Level of pair
(1,4)	$1 \to 4 = \frac{1}{2}$	50%	$(1,4) = \frac{9}{6}$	75%
	$4 \to 1 = \frac{3}{3}$	100%		
(2,3)	$2 \to 3 = \frac{3}{3}$	100%	$(2,3) = \frac{9}{6}$	75%
	$3 \to 2 = \frac{1}{2}$	50%		

With SMAR, we can ensure that all of the pairings in the previous example are satisfied to the greatest extent feasible.

N-factor satisfactory roommates problem

According to the members' wishes, the N-Factor Satisfactory Roommates Problem (N-Factor SFRP) has N preference lists. The introduction of the N-Factor in the SFRP is a result of the members' individual preference lists as factors.

The N-Factor Roommates issue is solved by using SMAR with the adjustment made in step 4. Each factor's weight determines the relative importance of the resulting satisfying value matrices. The resulting matrix is then processed using the Hungarian method, which produces the most optimal and satisfying member matching. We describe N-Factor SFRP with equal weight and provide appropriate examples to help you grasp it better.

Example: 1 Consider the 4-item instance based on the following factors: intelligence, sports interest, music interest, spiritual interest, and cultural interest, in the following order of preference, to discover N-Factor Satisfactory Matching using modified SMAR. In this case, we give equal weight to five elements.

The Preference list based on the Intelligence factor (F_1)

1: 2 3 4

2: 1 3 4

3: 1 2 4

4: 1 2 3

The preference list based on the sports interest factor (F_2)

1: 3 2 4

2: 4 1 3

3: 2 4 1

4: 3 1 2

The Preference list based on the Music interest factor (F_3)

1: 2 3 4

2: 1 3 4

3: 1 2 4

4: 1 2 3

The Preference list based on the Spiritual interest factor (F_4)

1: 4 2 3

2: 3 4 1

3: 1 4 2

4: 1 2 3

The Preference list based on the Cultural interest factor (F_5)

1: 3 4 2

2: 4 1 3

3: 2 1 4

4: 1 3 2

Solution

To identify Satisfactory matching in the case of SFRP, the SMAR is employed. According to their position in the preference list, each member's preference value is allocated. The next step is to create a table with the preference values; this will provide a Satisfactory Value Matrix for each of the variables that follow.

The Intelligence Factor's Satisfactory Value Matrix

$$SVM_{(F_1)} = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & - & \frac{6}{3} & \frac{5}{3} & \frac{4}{3} \\ 2 & \frac{6}{3} & - & \frac{4}{3} & \frac{3}{3} \\ 3 & \frac{5}{3} & \frac{4}{3} & - & \frac{2}{3} \\ 4 & \frac{4}{3} & \frac{3}{3} & \frac{2}{3} & - \end{array}$$

Sports Enthusiasts' Satisfying Value Matrix

$$SVM_{(F_2)} = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & - & \frac{4}{3} & \frac{4}{3} & \frac{3}{3} \\ 2 & \frac{4}{3} & - & \frac{4}{3} & \frac{4}{3} \\ 3 & \frac{4}{3} & \frac{4}{3} & - & \frac{5}{3} \\ 4 & \frac{3}{3} & \frac{4}{3} & \frac{5}{3} & - \end{array}$$

The Music Interest Factor's Satisfactory Value Matrix

$$SVM_{(F_3)} = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & - & \frac{6}{3} & \frac{5}{3} & \frac{4}{3} \\ 2 & \frac{6}{3} & - & \frac{4}{3} & \frac{3}{3} \\ 3 & \frac{5}{3} & \frac{4}{3} & - & \frac{2}{3} \\ 4 & \frac{4}{3} & \frac{3}{3} & \frac{2}{3} & - \end{array}$$

Spiritual interest factor's Satisfactory Value Matrix

$$SVM_{(F_4)} = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & - & \frac{3}{3} & \frac{4}{3} & \frac{6}{3} \\ 2 & \frac{3}{3} & - & \frac{4}{3} & \frac{4}{3} \\ 3 & \frac{4}{3} & \frac{4}{3} & - & \frac{3}{3} \\ 4 & \frac{6}{3} & \frac{4}{3} & \frac{3}{3} & - \end{array}$$

A Cultural Interest Factor Satisfaction Matrix

$$SVM_{(F_5)} = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & - & \frac{3}{3} & \frac{5}{3} & \frac{5}{3} \\ 2 & \frac{3}{3} & - & \frac{4}{3} & \frac{4}{3} \\ 3 & \frac{5}{3} & \frac{4}{3} & - & \frac{3}{3} \\ 4 & \frac{5}{3} & \frac{4}{3} & \frac{3}{3} & - \end{array}$$

Adding the SVM of five components yields the Satisfactory Value Matrix, which is shown below.

Everything in the Satisfactory Value Matrix

$$SVM = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & - & \frac{22}{3} & \frac{23}{3} & \frac{22}{3} \\ 2 & \frac{22}{3} & - & \frac{20}{3} & \frac{18}{3} \\ 3 & \frac{23}{3} & \frac{20}{3} & - & \frac{15}{3} \\ 4 & \frac{22}{3} & \frac{18}{3} & \frac{15}{3} & - \end{array}$$

By applying the Hungarian algorithm to the previously given Satisfactory Value Matrix, we are able to get the results of the Satisfactory matching (1,4) and (2,3) along with their respective Satisfactory Values and Satisfactory levels.

Table 2: Satisfactory matching

Satisfactory Matching	Satisfactory Values of members	Average Satisfactory Level of members	Satisfactory value of the pair	Average Satisfactory Level of pair
(1,4)	$1 \to 4 = \frac{8}{3}$	53.3%	$\frac{22}{3}$	73.3%
	$4 \to 1 = \frac{14}{3}$	93.3%		
(2,3)	$2 \to 3 = \frac{9}{3}$	60%	$\frac{20}{3}$	66.7%
	$3 \to 2 = \frac{11}{3}$	73.3%		

All it takes to get this matching are the five criteria listed above. According to the data shown above, 33.3 percent of the time is spent at a suitable level of matching with (1,4) and 66.7 percent with (2,3).

Example 2: Think about the 4-factor case based on modified SMAR to find N-Factor Satisfactory Matching. F_1, F_2, F_3, F_4 and F_5 in the following indicated order of choice. All five considerations are given equal weight in this case.

A list of preferences derived from factors (F_1)

$$\begin{array}{llll} 1: & 3 & 2 & 4 \\ 2: & (4 & 3) & 1 \\ 3: & 2 & 4 & 1 \\ 4: & 1 & (2 & 3) \end{array}$$

Preference list based on Factor

$$\begin{array}{llll} 1: & 2 & 4 & 3 \\ 2: & 4 & (3 & 1) \\ 3: & (1 & 2) & 4 \\ 4: & 3 & 1 & 2 \end{array}$$

Preference list based on Factor

$$\begin{array}{llll} 1: & (4 & 2) & 3 \\ 2: & 1 & 3 & 4 \\ 3: & 2 & 1 & 4 \\ 4: & (3 & 2) & 1 \end{array}$$

Preference list based on Factor

$$\begin{array}{llll} 1: & 3 & (2 & 4) \\ 2: & 4 & 1 & 3 \\ 3: & 1 & 4 & 2 \\ 4: & 1 & (3 & 2) \end{array}$$

Preference list based on Factor

$$\begin{array}{llll} 1: & 2 & (4 & 3) \\ 2: & 3 & 4 & 1 \\ 3: & 1 & 2 & 4 \\ 4: & (1 & 3) & 2 \end{array}$$

Solution

In SFRPT cases, the modified SMAR is used to find satisfying matching. When members' positions on the preference list are tied, the average value is used to determine their choice. The next step is to create a Satisfactory Value Matrix for each of the following criteria by tabulating the preference values in a Preference Value Matrix.

Optimal Factor Satisfaction Matrix

$$SVM_{(F_1)} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{3}{3} & \frac{4}{3} & \frac{4}{3} \\ \frac{3}{3} & - & \frac{11}{6} & \frac{4}{3} \\ \frac{4}{3} & \frac{11}{6} & - & \frac{7}{6} \\ \frac{4}{3} & \frac{4}{3} & \frac{7}{6} & - \end{pmatrix} \end{array}$$

Optimal Factor Satisfaction Matrix

$$SVM_{(F_2)} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{3}{2} & \frac{7}{6} & \frac{4}{3} \\ \frac{3}{2} & - & \frac{4}{3} & \frac{4}{3} \\ \frac{7}{6} & \frac{4}{3} & - & \frac{4}{3} \\ \frac{4}{3} & \frac{4}{3} & \frac{4}{3} & - \end{pmatrix} \end{array}$$

Optimal Factor Satisfaction Matrix

$$SVM_{(F_3)} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{11}{6} & \frac{3}{3} & \frac{7}{6} \\ \frac{11}{6} & - & \frac{5}{3} & \frac{7}{6} \\ \frac{3}{3} & \frac{5}{3} & - & \frac{7}{6} \\ \frac{7}{6} & \frac{7}{6} & \frac{7}{6} & - \end{pmatrix} \end{array}$$

The Satisfactory Value Matrix of Factor

$$SVM_{(F_4)} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{7}{6} & \frac{6}{3} & \frac{3}{2} \\ \frac{7}{6} & - & \frac{2}{3} & \frac{3}{2} \\ \frac{6}{3} & \frac{2}{3} & - & \frac{7}{6} \\ \frac{3}{2} & \frac{3}{2} & \frac{7}{6} & - \end{pmatrix} \end{array}$$

The Satisfactory Value Matrix of Factor F_5

$$SVM_{(F_5)} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{4}{3} & \frac{3}{2} & \frac{4}{3} \\ \frac{4}{3} & - & \frac{5}{3} & \frac{3}{3} \\ \frac{3}{2} & \frac{5}{3} & - & \frac{7}{6} \\ \frac{4}{3} & \frac{3}{3} & \frac{7}{6} & - \end{pmatrix} \end{array}$$

The sum of all Satisfactory Value Matrix

$$SVM = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} - & \frac{41}{6} & \frac{42}{6} & \frac{40}{6} \\ \frac{41}{6} & - & \frac{43}{6} & \frac{38}{6} \\ \frac{42}{6} & \frac{43}{6} & - & \frac{36}{6} \\ \frac{40}{6} & \frac{38}{6} & \frac{36}{6} & - \end{pmatrix} \end{array}$$

We acquire the outcomes of the Satisfactory matching (1,4) and (2,3) with their corresponding Satisfactory Values and Satisfactory levels by using the Hungarian algorithm to the aforementioned Satisfactory Value Matrix.

Table 3: Satisfactory matching

Satisfactory Matching	Satisfactory Values of members	Average Satisfactory Level of members	Satisfactory value of the pair	Satisfactory Level of pair
(1,4)	$1 \to 4 = \frac{17}{6}$	56.6%	$\frac{40}{6}$	66.6%
	$4 \to 1 = \frac{23}{6}$	76.6%		
(2,3)	$2 \to 3 = \frac{20}{6}$	66.6%	$\frac{43}{6}$	71.6%
	$3 \to 2 = \frac{23}{6}$	76.6%		

According to the data shown above, (2,3) has an average acceptable level of matching of 71.6% and (1,4) has an average of 66.6%. The two matchings here are more closely spaced.

Conclusion

So far, several scholars have defined the Roommates Problem and found solutions by focusing on a single aspect. By solving the N-Factor Satisfactory Roommates Problem with all additional extended situations, we study the optimal matching. Furthermore, Weighted N-Factor Satisfactory Roommates Problem handles several elements with varying weightages.

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