

Board 47: A Mentor-Mentee Matching Algorithm to Automate Process of Finding an Ideal Mentor for Students

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Work In Progress: MentorMate: A Platform to Empower Students' Path to Success Through Tailored Mentor-Mentee Pairings

Abstract

Limited access to resources for students' technical and personal development poses challenges. Existing universities' mentorship resources do not fulfill students' goals and interests. MentorMate proposes a matching algorithm that allows students to automatically match with mentors who have similar backgrounds and interests. The matching algorithm is a MERN web application that serves as an interface to register users as mentor or mentee. The backend, utilizing K-means clustering, facilitates and automates an effective grouping. After rigorous testing, matching execution response time is 4.08 seconds for a database of 1500 users. Performance analysis revealed 99.7% of matches as valid, indicating mentors and mentees shared two or more similarities.

Introduction

Successful mentorship in engineering education by *Akerele, Vermeulen, and Marnewick* [1], demonstrates the pivotal role of mentorship in transforming theoretical knowledge into practical skills. A study published in the *International Journal for Academic Development* indicates that students with mentors exhibit a higher likelihood of successfully completing their engineering degrees and actively pursuing careers in the field [2]. In response to the limitations of existing resources, MentorMate introduces an automated solution with a matching algorithm aimed at simplifying and expediting the mentorship process. Our objective is to devise an algorithm and construct a website with a precise, quantifiable aim: facilitating the matching of at least 80% of students with mentors who not only share a minimum of two common interest areas but also possess a comparable level of experience.

Existing Frameworks

Table 1 shows an existing mentorship resource used by our university. In contrast to these systems where students need to manually search for mentors, MentorMate utilizes an algorithm that automates the mentor-student matching process. This way, matching the right mentor becomes more efficient and tailored, eliminating any manual effort.

Table 1: Existing resource and its disadvantages

Existing Technology	Disadvantages
Universities Mentorship Database [3]	<ul style="list-style-type: none"> - Need to scroll through programs to find suitable one - Matching is not performed based on student interest - Many broken links

Architecture

MentorMate comprises of two parts: a dynamic and responsive frontend that communicates with servers, and a backend that houses servers which handle the matching process. Figure 1 illustrates a system diagram for the MentorMate. Microservices in our backend include user management, authentication, questionnaire/data storage, and the algorithm used to identify pairings. The website can only be accessed by registered users; hence, information is securely stored in MongoDB Cloud. Frontend components including the login system, matching webpages, and profile information are developed using React. This technical framework aims for a secure, scalable, and user-friendly mentorship platform.

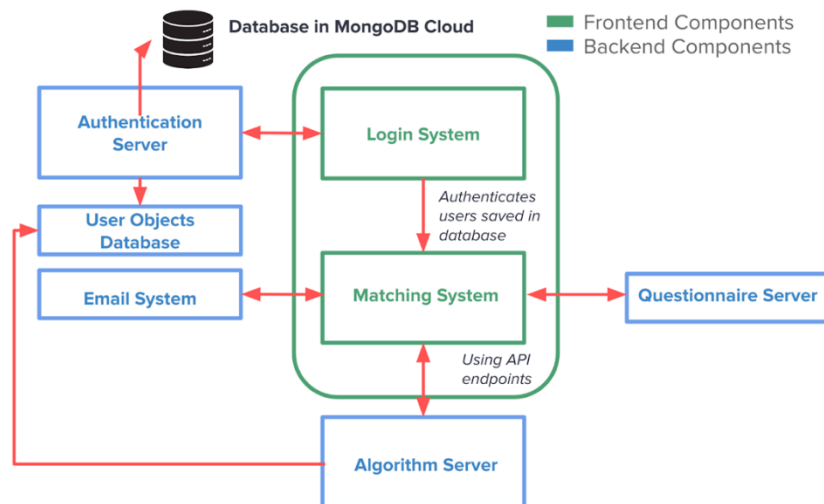


Figure 1: Shows the high-level system diagram of MentorMate

The 'Algorithm Server' implements the K-means algorithm responsible for facilitating matching between Users. Users are obtained from the 'User Objects Database' which is created when a user registers on the website. Their questionnaire answers are obtained from the 'Matching System', and the algorithm is then run on unassigned users with their answers to facilitate matches. If matched, the users are sent an email with details on their mentor/mentee, and the

match information is sent back to the 'Matching System' to display on the frontend.

Other unsupervised clustering algorithms such as mean shift clustering, and hierarchical clustering were considered. MentorMate uses a modified version of the K-means algorithm where it iteratively groups data samples (mentees) into K clusters (mentors), where each sample (mentee) belongs to the cluster (mentor) with which it has the nearest Euclidean distance [4]. For this problem, the mentors will be fixed as cluster centroids, and one or more mentees will be assigned to each mentor cluster (depending on the calculated similarity score), differing from the updating centroids in a classic K-means problem. The mean shift algorithm is a non-parametric algorithm that clusters data iteratively by finding the densest regions (clusters) in a feature space [4]. However, since we have fixed cluster centroids (mentors) and know how many maximum data points (mentees) we can assign to a mentor, K-means is better suited. Hierarchical clustering begins with each data point (mentee) as a separate cluster and then combines the nearest clusters until there is only one cluster left [5][6]. The key distinction between hierarchical clustering and K-means is that in K-means, we can set the number of clusters and use fixed centroids for distance comparison. This is in contrast hierarchical clustering, which calculates distances between individual data points (mentees) [5][6]. Additionally, K-means is known for being faster and more efficient, especially for larger datasets [5][6]. This is important as we calculate the similarity between each mentee and each mentor in our dataset before assignments instead of going with a density grouping approach such as mean shift.

Questionnaire

The questionnaire encompasses several categories for both mentors and mentees. Mentor-related categories include background and experience, mentoring style, availability and goals. Mentee-related categories comprise of goals, preferred mentor characteristics, availability, and areas of focus. Each category for mentors aligns with a related category for mentees, facilitating a comparison of similarities. Appendix A, displays a selection of questions from the questionnaire, organized to highlight which questions will be compared to ascertain similarity scores and screenshots of the webpages from the website. A representative of the questionnaire follows.

- What are your primary goals for seeking a mentorship? [Mentee]
- Are there any specific courses or subjects you're particularly passionate about? Are you specializing in any areas? [Mentor]

Testing and Results

Algorithm

To assess the performance of our algorithm, a series of tests were conducted using a standardized method for creating dummy mentor and mentee users. These were initialized with randomly generated questionnaire answer arrays. In the first test (Figure 2), we simulated a one-to-one matching scenario with the same number of mentors and mentees. Our matching algorithm prioritizes the creation of pairs that yield the highest compatibility scores. In Figure 2, for instance, Mentee 4 is matched with Mentor 0, showcasing the algorithm's inclination towards optimizing for the best possible match based on overall compatibility.

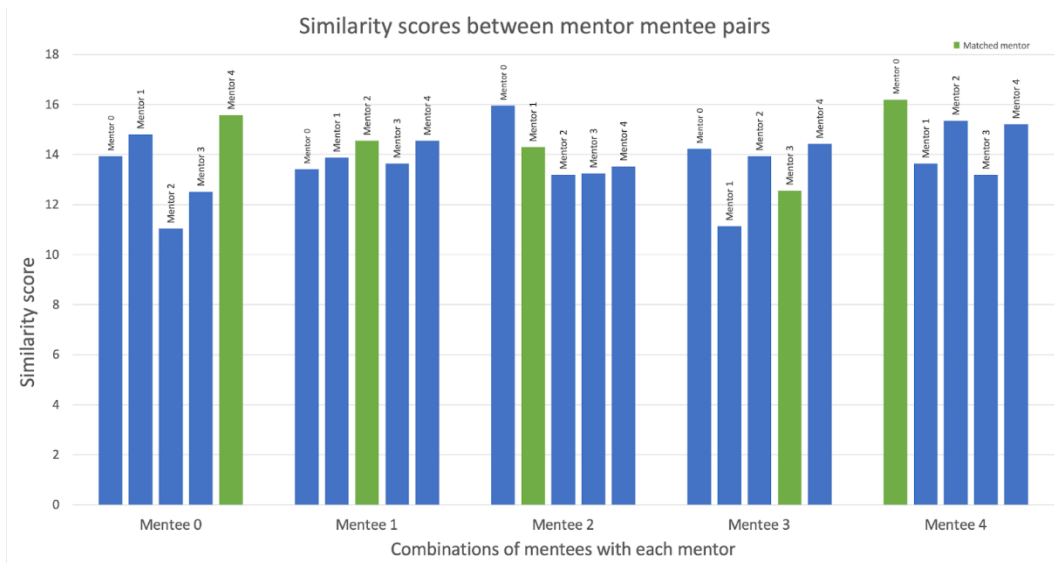


Figure 2: Test results for one-to-one test scenario. Check Appendix B for algorithm output

To thoroughly assess the algorithm's performance in terms of speed and accuracy, a substantial dataset comprising 1000 mentees and 500 mentors was introduced. Each mentor's capacity was capped at 2. The matching execution time, as outlined in Table 2, demonstrated efficiency at 4.08 seconds which is lower than the anticipated value for the runtime. Given that many matching algorithms often exhibit a complexity of $O(n^2)$, where n is the number of users in the database, the algorithm's runtime of 4.08 seconds is indicative of its rapid processing capabilities [7]. Figure 3 illustrates the algorithm's performance, with 99.7% of matches deemed valid—meaning mentors and mentees shared two or more similarities based on questionnaire answers. This achievement surpasses our initial objective of achieving 80% valid matches, underscoring the algorithm's robustness and effectiveness in generating highly compatible mentor-mentee pairs.

Table 2: Algorithm results on 1000 mentee database

Metric	Value
Time	4.08 seconds
Matches with at least 2 similarities	997
Matches with less than 2 similarities	3

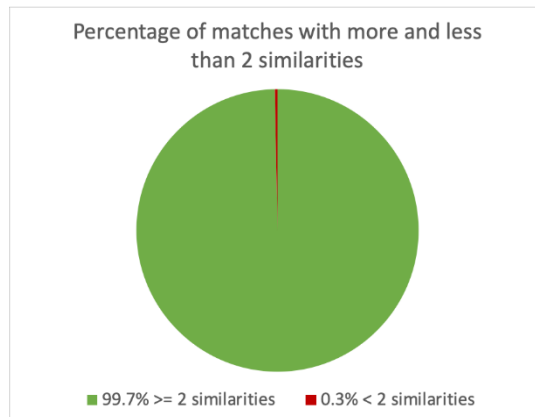


Figure 3: Percentage of matches with \geq 2 similarities and $<$ 2 similarities

User Testing

A crucial step in assessing the effectiveness of MentorMate involves using evaluation data through user surveys. This process gathers qualitative and quantitative data to identify the level of user satisfaction. As a result, users were presented with a feedback survey within the email response. This survey focused on the user’s satisfaction with the matching process. Additionally, our aim is that users should be able to locate buttons, features and complete the questionnaire to receive match results without confusion. This is evident from students’ feedback as follows.

“MentorMate is a game-changer for students! The website’s user-friendly design made it very easy to navigate. The questions were intuitive, delving deep into my academic and personal interests.”, *“MentorMate is awesome! The UI is aesthetically pleasing and intuitive. The platform’s is responsiveness on both desktop and mobile. Highly user-friendly and impactful!”*

Remarks

MentorMate tackles the challenge of providing students with accessible resources for personal and technical development through a speedy algorithm that achieves more than 80% accuracy on a 1500 user database. By accomplishing this objective, we simplify the process of finding the right mentor or mentee, ultimately empowering students to enhance their skills and personal growth while fostering a supportive educational environment.

References

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- [7] K. N. Jarapala, “Understanding gale-shapley (stable matching) algorithm and its time complexity,” Medium, [https://medium.com/aiskunks/understanding-gale-shapley-stable matching-algorithm-and-its-time-complexity-4b814ee2642](https://medium.com/aiskunks/understanding-gale-shapley-stable-matching-algorithm-and-its-time-complexity-4b814ee2642) (accessed Jan. 25, 2024).

Appendix A: List of questions

These questions will be asked to the mentee and mentor to facilitate the matching process and understand their interests. Table 1 outlines the questions and Figure 1 and Figure 2 show a screenshot of the webpages.

Table 1: Tentative list of questions

Mentee	Mentor
<p>What is your major or field of study? What is your year of study? Are you involved in any clubs, organizations, or student groups on campus?</p>	<p>Are you currently in school? 1. What is your major or field of study? 2. What level of education are you currently pursuing (i.e., Undergraduate, Master, Ph.D.) 3. What is your year of study? 4. Are you involved in any clubs, organizations, or student groups on campus?</p>
<p>What are your primary goals for seeking a mentorship?</p>	<p>What do you hope to achieve through mentoring?</p>
<p>Are there any specific courses or subjects you're particularly passionate about?</p>	<p>Are there any specific courses or subjects you're particularly passionate about? Are you specializing in any areas?</p>
<p>Are there any areas of research that you are interested in?</p>	<p>Have you been involved in any research projects or academic initiatives? If so, what fields?</p>
<p>If you're seeking a mentor for career related mentorship, what career paths are you most interested in?</p>	<p>Have you completed any internships or gained relevant work experience in your field of interest?</p>
<p>Are there specific qualities or traits you value in a mentor?</p>	<p>What specific skills or expertise do you feel are your greatest strengths?</p>

Are there specific challenges or areas where you feel you need the most guidance?	Are there particular courses or career stages or other challenges where you feel you can provide the most assistance?
How frequently would you like to connect with your mentor?	How much time per month are you willing to commit to mentoring?

Are you open to virtual or in-person mentoring sessions?	Are you open to virtual or in-person mentoring sessions?
What is your preferred mode of communication for mentoring interactions?	What is your preferred mode of communication for mentoring interactions?

Figure 1: Mentor Questionnaire Screenshot

The screenshot shows the MentorMate website interface. At the top, there is a green navigation bar with the text '<> MentorMate'. Below this, the main heading is 'Mentor Questionnaire'. Underneath the heading, there is a text input field labeled 'Enter your name:'. Following this, there are four dropdown menu questions: 'How many mentees would you like to mentor?', 'What is your major or field of study or industry?', 'What is your year of study?', and 'Are you involved in any clubs, organizations, or student groups on campus?'. Each dropdown menu has a small downward-pointing arrow on its right side.

Figure 2: Site Homepage

Find Your Perfect Mentor

Unlock your greatest potential with the guidance of like-minded mentors

REGISTER

LOG IN

Appendix B- Terminal Testing for algorithm

This appendix shows the Terminal output screenshot for one-to-one test.

```
Distance calculated mentor0 -> mentee0 : 13.934530001821539
Distance calculated mentor1 -> mentee0 : 14.810845339727148
Distance calculated mentor2 -> mentee0 : 11.046971276013137
Distance calculated mentor3 -> mentee0 : 12.511821973201794
Distance calculated mentor4 -> mentee0 : 15.578349791872629
Distance calculated mentor0 -> mentee1 : 13.416407864998739
Distance calculated mentor1 -> mentee1 : 13.875398400759329
Distance calculated mentor2 -> mentee1 : 14.550430099091244
Distance calculated mentor3 -> mentee1 : 13.64288188791655
Distance calculated mentor4 -> mentee1 : 14.550430099091244
Distance calculated mentor0 -> mentee2 : 15.95755553756505
Distance calculated mentor1 -> mentee2 : 14.298422026699349
Distance calculated mentor2 -> mentee2 : 13.195528385006218
Distance calculated mentor3 -> mentee2 : 13.250246195853599
Distance calculated mentor4 -> mentee2 : 13.52891890067005
Distance calculated mentor0 -> mentee3 : 14.236641370361937
Distance calculated mentor1 -> mentee3 : 11.135707614676074
Distance calculated mentor2 -> mentee3 : 13.934530001821539
Distance calculated mentor3 -> mentee3 : 12.562720003865187
Distance calculated mentor4 -> mentee3 : 14.423425841804125
Distance calculated mentor0 -> mentee4 : 16.196265772028923
Distance calculated mentor1 -> mentee4 : 13.64288188791655
Distance calculated mentor2 -> mentee4 : 15.360679774997898
Distance calculated mentor3 -> mentee4 : 13.195528385006218
Distance calculated mentor4 -> mentee4 : 15.219251346455048
Match created:
Mentor: mentor0 Mentee: mentee4
Num similarities: 10

Match created:
Mentor: mentor4 Mentee: mentee0
Num similarities: 6

Match created:
Mentor: mentor2 Mentee: mentee1
Num similarities: 4

Match created:
Mentor: mentor1 Mentee: mentee2
Num similarities: 6

Match created:
Mentor: mentor3 Mentee: mentee3
Num similarities: 3
```

Appendix C- Terminal testing for algorithm

This appendix provides the Terminal Output for many-to-one test.

Distance calculated mentor0 -> mentee0 : 13.033300721909082
Distance calculated mentor1 -> mentee0 : 14.236641370361937
Distance calculated mentor2 -> mentee0 : 11.82502602214516
Distance calculated mentor0 -> mentee1 : 13.195528385086218
Distance calculated mentor1 -> mentee1 : 14.298422026699349
Distance calculated mentor2 -> mentee1 : 13.64288188791655
Distance calculated mentor0 -> mentee2 : 13.52891890867005
Distance calculated mentor1 -> mentee2 : 14.175327003125448
Distance calculated mentor2 -> mentee2 : 12.562720803865187
Distance calculated mentor0 -> mentee3 : 15.149577224069919
Distance calculated mentor1 -> mentee3 : 14.298422026699349
Distance calculated mentor2 -> mentee3 : 13.087061279502194
Distance calculated mentor0 -> mentee4 : 13.47248535768231
Distance calculated mentor1 -> mentee4 : 13.52891890867005
Distance calculated mentor2 -> mentee4 : 13.934530001821539
Distance calculated mentor0 -> mentee5 : 13.70042573715351
Distance calculated mentor1 -> mentee5 : 12.360679774997898
Distance calculated mentor2 -> mentee5 : 16.27791724469968
Distance calculated mentor0 -> mentee6 : 15.879939076590038
Distance calculated mentor1 -> mentee6 : 12.821287760828442
Distance calculated mentor2 -> mentee6 : 13.875398400759329
Distance calculated mentor0 -> mentee7 : 13.64288188791655
Distance calculated mentor1 -> mentee7 : 14.810845339727148
Distance calculated mentor2 -> mentee7 : 13.875398400759329
Distance calculated mentor0 -> mentee8 : 12.76901672837246
Distance calculated mentor1 -> mentee8 : 14.67953402712929
Distance calculated mentor2 -> mentee8 : 11.497899283797683

Match created:
Mentor: mentor2 Mentee: mentee5
Num similarities: 5

Match created:
Mentor: mentor0 Mentee: mentee6
Num similarities: 9

Match created:
Mentor: mentor0 Mentee: mentee3
Num similarities: 8

Match created:
Mentor: mentor1 Mentee: mentee7
Num similarities: 4
Match created:

Mentor: mentor1 Mentee: mentee8
Num similarities: 3

Match created:
Mentor: mentor1 Mentee: mentee1
Num similarities: 9

Match created:
Mentor: mentor1 Mentee: mentee0
Num similarities: 5

Match created:
Mentor: mentor1 Mentee: mentee2
Num similarities: 5

Match created:
Mentor: mentor2 Mentee: mentee4
Num similarities: 3