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Peer-to-Peer Carpooling: Forging a Path to Sustainable Transportation

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Abstract: *Carpooling is an excellent choice for sustainable transportation, with numerous benefits for both individuals and the environment. However, traditional carpooling systems deal with numerous issues like privacy, match-making, and pricing. At different college or organizations, research has been dug deep into the various aspects of carpooling, emphasizing its potential to reduce pollution, reduce traffic congestion, and minimize carbon emissions. The research explored many aspects of carpooling and highlighted how it can lower pollution, reduce traffic congestion, and promote sustainability through our application. In the proposed research, we have implemented a ride-matching algorithm designed to efficiently pair riders with passengers based on nodal points and destinations. This algorithm simplifies the process of finding compatible travel companions, ultimately making carpooling a more accessible and convenient option for our college com- munity. It simplifies the process for riders to find suitable passengers quickly. With so many advantages for people, communities, and the environment, car-pooling offers a feasible solution to the problems associated with transportation. By adopting carpooling as a means of transportation, we move towards a more sustainable future and leave a cleaner, greener environment around the college premises.*

Keywords: *Carpooling, environmental-friendly, traffic- congestion, sustainable-transportation, ride-sharing, Optical Character Recognition, TensorFlow, Tesseract.*

1. INTRODUCTION

Carpooling involves sharing rides among drivers and riders who have similar starting and ending points. Multiple drivers who travel similar routes can share their cars with passengers going the same way. This helps use personal vehicles more efficiently and decreases the number on the road, easing traffic jams in crowded cities. As urban areas face challenges like too many people, traffic, environmental issues, and changing gas prices, carpooling has become a good solution. Numerous research studies in the area of ride-sharing and transportation systems have looked into various aspects of this type of transportation. Yu et al. [1] conducted research on the potential impact of carpooling on traffic congestion, highlighting the importance of environmentally sustainable transportation. However, their research had few drawbacks in terms of its focus and flexibility. Although there are some traditional carpooling applications, they often face several challenges, including pricing, time wastage during matchmaking, and privacy concerns. Current carpooling systems often face challenges in setting up fair payment

systems, which can cause conflicts between drivers and riders. During harsh weather conditions, there may be an unexpected surge in prices for trips. Researchers suggest merging self-driving cars with carpooling to make transportation more eco- friendly [2]. If pricing issues are not handled well, people may not want to take trips. Also, traditional carpooling methods can be inefficient and time-consuming. Finding appropriate drivers and passengers can be challenging, especially when considering different destinations, schedules, and locations. Delays in finding suitable matches can find carpooling less useful, reducing the effectiveness of the system. A study by Julagasigorn et al.

[1] identified the psychological reasons why people choose to carpool, providing valuable findings into the complex human decision-making process when it comes to environmentally friendly transportation. However, there is a limitation in the proposed system where the data used in the study is biased since the research team only considered individuals from a specific location for their study. Also, passengers using these modern carpooling applications might be worried about their privacy and safety. The passengers may think once or twice to ride with strangers due to concerns about their safety and whether they can be trusted or not. It is important to address these privacy concerns to build trust and get more people to use carpooling programs. Hence, in the proposed research, College/organization IDs are used for verification of the students and staff associated with them to enhance safety and security measures. Also, the proposed system not only eases the ride-sharing experience for riders and passengers but also prioritizes security and verification through some technologies like Optical Character Recognition (OCR) using Tesseract and TensorFlow validation. The plat- form uses specific algorithms and user-friendly features to make ride-matching easier, promote community engagement, and create a sustainable transportation system. The individual modules within the ride-sharing platform play a crucial role in enhancing user experience, ensuring security, and optimizing platform efficiency. The authors also explore how ride-sharing services contribute to various aspects of transportation. The research investigates the potential benefits of integrating intelligent matching systems into ride-sharing platforms. These advanced algorithms can optimize ride-matching processes, making ride-sharing services more convenient and efficient. As people and communities look to reduce traffic congestion, and carbon emissions, and ease the bur- den on the transportation system, carpooling has become increasingly popular as a sustainable transportation solution in recent years. This could significantly shape the future of urban transportation in the years ahead.

2. RELATED WORK

Various research studies in the areas of carpooling and transportation systems have identified numerous aspects on how and why people tend to choose this type of transportation. Research on the possible effects of carpooling on traffic congestion was done by Yu et al. [1], who identified the importance of promoting sustainability and minimizing environmental impact under certain circumstances. However, their work was limited to a particular scope and lacked flexibility. Ostrovsky et al. [2] propose combining self-driving cars and carpooling to further improve environmental friendliness in transportation. A research study by Julagasigorn et al. [3] examines the psychological factors that affect individual's choices to carpool, offering insights into the complex human behavior in making environment-friendly transportation decisions. Unfortunately, the proposed system contains biased data, as the factors considered by the research team does involve individuals from a specified area for research purposes. Rey- Merch´an et al. [4] focused on providing incentives for teachers to choose carpooling, looking at both the drivers and passengers to promote more environmentally friendly transportation. Moreover, their study was focused only on teachers, where the actual size of students is 10x the strength of teachers. This leaves a great amount of scope to work on those aspects. Furthermore, Lee et al.'s [5] work revealed the growing acceptance of carpooling among specific groups, showing a shift in preferences toward more environmentally friendly types of transportation. However, the issue with their work is that their focus is only on specific demographics. So, their study cannot represent the population as a whole. Hasan et al. [6] have proposed a smart carpooling system that prioritizes sustainability and reducing carbon emissions. Their study effectively connected travelers heading in the same direction, which very much reduces the occupancy of vehicles on the road, leading to a large drop

in traffic congestion. Lugo et al. [7] have developed Ucarpooling, a platform for ride-sharing that promotes sustain- able and environmentally friendly transportation options in their region. Dimitrijevi´c et al [8] present an efficient real-time carpooling system that not only reduces traffic congestion but also contributes to a more sustainable environment. Azzali et al.'s concepts for environmentally friendly transport planning [9] highlight the significance of taking the environment into account while making transportation-related decisions. In evaluating the effects of autonomous cars on the environment, Tom´as et al. [10] put an important focus on how technology may be used to develop more environ- mentally friendly transportation options. Research conducted by Park et al. [11] and Parezanovi´c et al. [12] highlights the importance of sustainability and environmental friendliness in transportation choices. Also, in order to encourage environmentally friendly commuting patterns, Zhou et al. [13] have developed a carpooling platform which focuses on saving costs but has a drawback of not considering the traffic routes optimally. Future study directions for carpooling sustainability are suggested by Aquilera et al. [14], who stress the necessity for ongoing studies in the development of sustainable transportation solutions. Researchers have explored carpooling behavior to promote eco-friendly transportation. Bachmann et al. [15] focused on utilizing psychological principles to encourage people to choose sustainable travel options. This includes providing perks and benefits for travelling in shared vehicles. Agatz et al. [16] aimed to optimize ride - sharing pairings by developing different algorithms and testing them parallelly. Gargiulo et al. [17] developed ride- sharing services that emphasize sustainability and appeal to environmentally conscious individuals. Meanwhile, Najmi et al. [18] created innovative matching algorithms to enhance the efficiency and environmental friendliness of ride-sharing systems as a part of community services in the region of Alabama. Petrovi´c et al. [19] highlight best practices in carpooling across Europe, offering recommendations for implementing sustainable transportation initiatives. Collectively, these studies provide valuable insights into the costs and benefits of carpooling systems, with a strong importance on technological innovation, psychological factors, and sustainable practices. By promoting sustainability and environmental friendliness in carpooling, researchers are looking for a way for a more eco-friendly and efficient transportation. Together, this research advances our knowledge of carpooling as a way to reduce traffic congestion and incorporate environmentally friendly travel habits.

3. METHODOLOGY

The peer-to-peer Carpool platform comprises several interconnected modules designed to provide a seamless user experience. The riders have the ability to select specific points of interest or hotspots such as their starting location, destination, and any desired stops throughout the journey. Simultaneously, passengers are given the flexibility to choose their own starting and ending points, with one of the nodes being the college. When a rider initiates a trip from their location to the college, potential passengers are displayed whose points fall within with the designated nodal points, with the college serving as the final destination. Similarly, if the rider starts their journey from the college back to their location, passengers whose points fit within the specified nodal points are shown, with the college being the starting point. Passengers are then allowed to select their pickup or drop-off points within the rider's nodal points, and the rider has the option to accept or decline them according to preference.

After accepting a passenger, a one-time password (OTP) is sent to the email of the passenger for verification before the ride commences. Moreover, the system includes advanced features such as OCR using Tesseract, which allows for the extraction of text from images. Also, the system performs validation of license images for specific keywords to ensure authenticity. It also checks for the presence of valid QR codes for added security measures. Also, the system verifies car images using TensorFlow's COCO-SSD function, improving the overall safety and credibility of the ride-sharing process.

International Journal of Environmental Sciences
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Fig. 1 The workflow diagram of the Peer-to-peer carpooling system

3.1. Working of the Algorithm

The ride-matching algorithm is an important component of the Peer-to-peer carpooling platform that efficiently connects riders with passengers based on their routes and destinations. Let,

- R be the set of nodal points selected by the rider.
- P be the set of passengers
- startpass be the starting point of a passenger
- destinationpass be the destination point of a passenger
- pick-uppass be the pickup point of a passenger
- drop-offpass be the dropping point of a passenger

3.1.1. Algorithm

1. Rider selects nodal points R = start, intermediate stops, destination
2. Passenger selects start and destination points, P = startpass, destinationpass
3. If rider starts a ride from their location to college:

- Filter passengers P such that startpass in R and destinationpass = individual or particular college.
- Passengers select their pick-up point pick-uppass
- If pick-uppass in R, show passengers to the rider
- Rider accepts or rejects passengers based on preference

4. If rider starts a ride from individual or particular college to their location:

- Filter passengers P such that startpass = individual or particular college and destinationpass in R.
- Passengers select their drop point drop-offpass.
- If drop-offpass in R, show passengers to the rider.
- Rider accepts or rejects passengers based on preference.

5. Once a rider accepts a passenger:

- Generate OTP and send it to the passenger.
- Passenger shares OTP with rider to start the ride.

The algorithm efficiently manages ride-sharing requests considering both rider's and passenger's preferences while maintaining security through OTP verification.

4. SYSTEM ARCHITECTURE

The system architecture of the individual or particular carpool platform is quite simple and user-friendly.

1. **Homepage:** This is where users land when they visit the platform. It provides an overview of the various services offered by the application.
2. **Sign-up or Sign-in:** New users can sign up for an account by providing the necessary details, which are stored in a MongoDB database for future reference. Returning users can sign in using their credentials.
3. **Give ride or Take ride:** Once signed in, users can choose to either offer a ride or request a ride.

(a) **Give ride:** Riders wishing to offer rides need to register their vehicle and provide details about the trip, such as the start, destination, and time.

(b) **Take ride:** Passengers searching for rides can view available ride details, including start, destination, and other relevant details.

4. **Ride details:** Both riders and passengers can view the ride details on their respective dashboard pages. Matching ride: The riders choose to accept or deny any ride requests from passengers requesting rides based on the costs and locations.
5. **Starting Ride:** Once a ride is matched, riders may need to enter a one-time password (OTP) provided by passengers for security verification before starting the ride.
6. **End Ride:** Once the ride is completed, riders can mark it ended, and any necessary ratings can be provided.

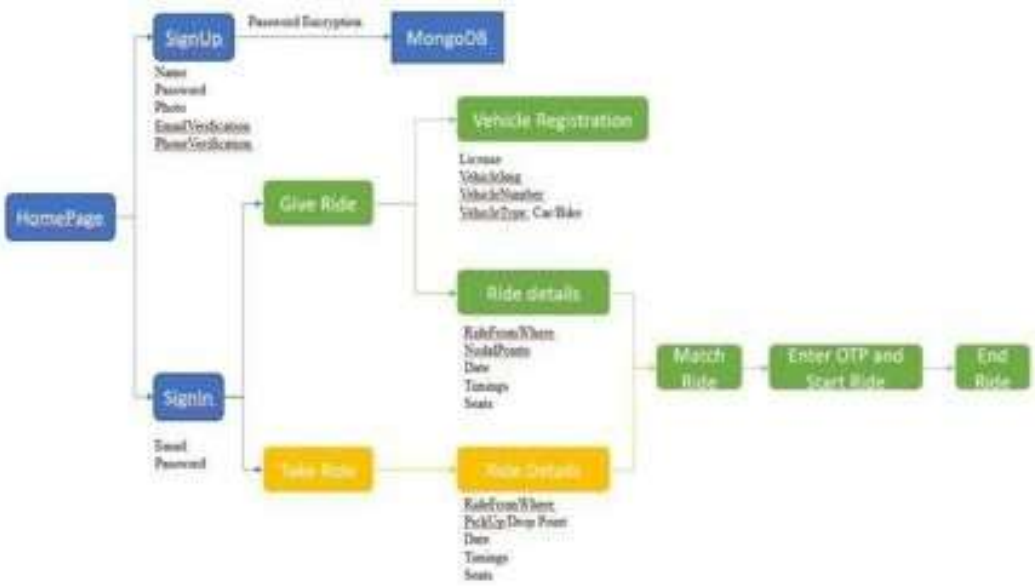

Fig. 2 System architecture of the Peer-to-peer carpooling platform

5. RESULTS

The application prototype has been developed and deployed successfully. The following figures show the main interfaces a user encounters while interacting with the application. Figure 3 given below

International Journal of Environmental Sciences
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represents the homepage of the platform. Figure 4 and Figure 5 shows the signup page and login page respectively.

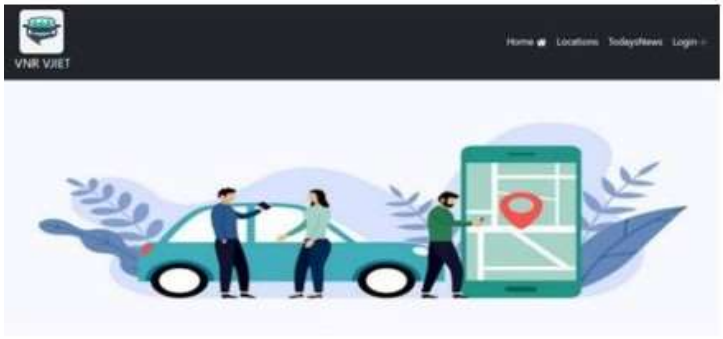

Fig. 3 Homepage

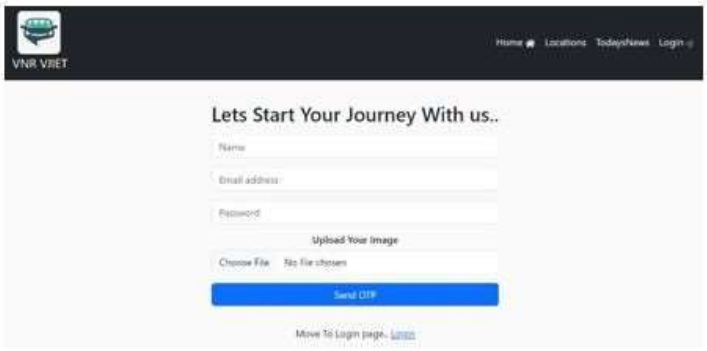

Fig. 4 Signup page

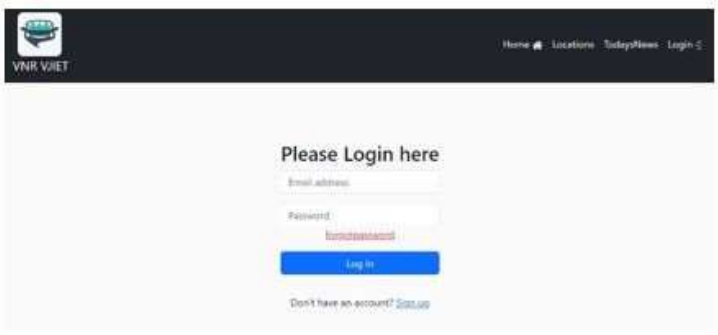

Fig. 5 Login page

The user after registering may choose to give a ride or take a ride. Figure 6 showcase a scenario of a rider registering his vehicle by providing relevant details and images after signing up as a user. Upon choosing to be a rider, they must provide their license and vehicle details for registering their vehicle in the database.

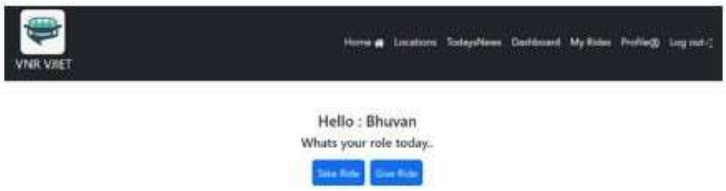

Fig. 6 Dashboard of the user displaying the options to choose whether to take a ride or give a ride

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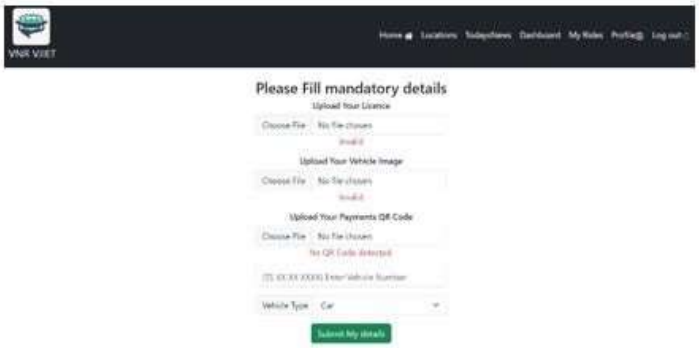

Fig. 7 After choosing to be a rider, the above page will be shown

After registration, the rider must submit details regarding his upcoming ride such as date, time, number of seats, locations (nodes), etc, as shown in figure 8. The rider also has the option to view his vehicle details and may choose to edit his vehicle details as well in the dashboard module.

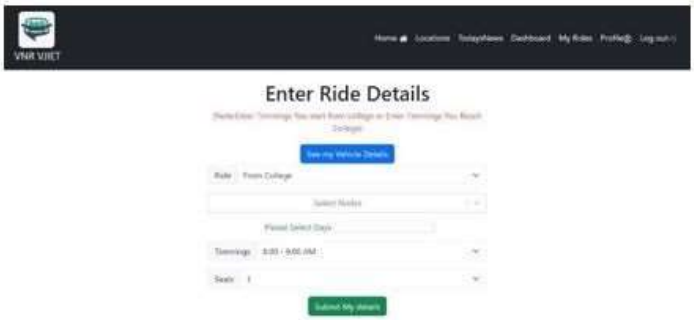

Fig. 8 The driver starts a ride selecting his location and timings

After the successful submission of ride details, the rider can access their current ride information in the My Rides module. (Refer figure 9)

Fig. 9 The driver starts a ride selecting his location and timings

In the same way, a passenger will fill in the ride details on their dashboard page. Then, the passenger will be able to access the rides that are currently active and he/she will choose a ride that is relevant to their location and timings. Once the passenger selects a ride, then they can access the ride details on their dashboard page.

6. CONCLUSION AND FUTURE SCOPE

Carpooling presents a sustainable solution to the challenges of traffic congestion within college premises. By facilitating shared rides among students and faculty with similar routes, carpooling optimizes the utilization of personal vehicles, reducing the over- all number of vehicles within the college premises. However, traditional carpooling methods often encounter hurdles such as pricing conflicts, efficient matchmaking, and privacy concerns. To address these issues and enhance safety and security, our platform utilizes college IDs for verification, ensuring a trustworthy environment for students and staff. As college increasingly prioritizes the reduction of traffic congestion and carbon emissions, carpooling emerges as a key environmentally friendly solution. The commuting initiative has a bright future ahead of it, full of room for development and creativity. Although there is some

engagement among students and faculty, we would like to create a sense of community by enabling students and staff to create ride-sharing groups based on shared interests, academic programs, or extracurricular activities. This feature encourages social interaction and networking among college members. In the first place, the authors tried integrating blockchain technology into their work, however, blockchain technology presented challenges due to its high computational costs. To overcome these challenges, the authors chose to focus on web development instead of integrating blockchain into their research study. This decision considered factors like limited resources, the complexity of implementing blockchain, and the specific needs of the study. While blockchain offers benefits like enhanced security and transparency, its high computational demands can outmatch these benefits, especially when resources are limited or simpler solutions are suitable. In the future, integrating neuroscience into the ride-sharing platform could revolutionize the way they monitor the health and well-being of both passengers and drivers. By leveraging advancements in neuroscience technology, such as brain-computer interfaces (BCIs) and neuro-sensing devices, the platform could offer real-time insights into the mental and physical states of individuals during their journeys. Collaborating with campus services such as student affairs, transportation departments, and campus security to integrate the carpool application with existing campus resources and initiatives would be a definitive approach to move forward in the future.

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