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Vehicle Fixing Recommender System Using User-Based Collaborative Filtering Algorithm

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ABSTRACT

The study refers to vehicle fixing support, an Online Application System for vehicle owners with vehicular problems guided by features on recommending service providers according to their geographical location and performance rating of service providers using the Collaborative Filtering Algorithm. As the number of vehicle owners increases, the tendency for services related to vehicle fixing and maintenance could also increase, providing the chance for vehicle service providers to be in the limelight in the digital world. The system stakeholders include the vehicle owners, vehicle service providers, and the technical support team that administers the registration and approval process among vehicle owners and service providers. Data management with transactions established are properly kept to track and trace services availed by vehicle owners served as the basis for collaborative filtering. The Front-end and back-end of the system are structured using HTML5, Bootstrap 4, CodeIgniter4, JavaScript, and MySQL for its database. The system was found to have advertised the service providers' skills and services to the customers as vehicle owners who search for and therefore book an appointment with the available service providers online. The desired results were met when the transaction is done from booking appointments through the system to successful services offered on-site. The search results had shown the recommended service providers that precisely fit the vehicle owner's or driver's search parameters criteria. The system's availability has been concluded which obtained a rating of 5 with the quality description of excellent functionality by the end-user reviews by the software requirements specifications.

Key words: collaborative filtering algorithm, online application system, recommender system, vehicle fixing.

1. INTRODUCTION

Vehicle fixing is the act of performing a repair to a vehicle while on travel or before and after the travel. While on travel, unavoidable scenarios can occur such as battery problems, ignition coils, fuel system issues, motor oil, tire troubles, exhaust system problems, etc. to name only a few which are common and most frequent vehicle problems. For example, traveling to the destination where the vehicle's tires get punctured or are badly deflated, running out of fuel and forgetting to bring a fuel backup, or the vehicle's engine gets stalled while being somewhere in the city or rural areas or stranded in the middle of the road. A few fixing options include (1) contact to someone who is a mechanic or an expert in that field through the available contact phone number, (2) asking someone who can fix the vehicle problem while stranded in the location, or (3) manual towing of vehicle to the nearest shop's location. The last option is the most taxing, especially since particular uncertainties to the availability of vehicle repair shops could not be defined, and pulling vehicles on raw strength can be very exhausting. The first and second options can be great only if there is somebody readily available at any particular time and space. Someone that can be recommended to rescue or to help fix the vehicle problem and who can be trusted and equipped with enough skills and facilities. Additionally, in the highly skilled and competitive service providers' scenarios, many would advertise their shop locally on the radio and sometimes on television. However, it won't certainly attract customers that much, and what can be more depressing is it costs a hefty amount of money to small or average-scale motor shops or mechanicians. Not even developing their website could cut the cost or an advertisement online could certainly capture customers if not recommended by an experienced and satisfied customer. This is where the Online Recommender System for Vehicle Fixing comes in for this study.

The main goal of Online Recommender systems is to provide users with recommendations about vehicle fixing with the available vehicle repair shops, mechanics, or any vehicle service providers. In the context of E-commerce, a recommender system is a tool that enables users to explore a collection of information that is relevant to their interests and preferences [1]. It also helps users make decisions by leveraging recommendations from others when they lack personal knowledge or experience about the available alternatives [2]. The user's preferences, choices, and history of fixing their corresponding vehicle are collected and used as input to recommend the most satisfying services to others.

A recommender system, as its name suggests, actively suggests relevant items to users without requiring them to search for or be aware of these items. The term 'relevant' implies that users typically interact with these suggestions, although the specific meaning of 'engage with them' may vary depending on the situation [3]. The presence of a recommender system offers advantages and value by boosting sales for businesses, promoting customer satisfaction through relevant recommendations, streamlining the search process for the right item, and enhancing businesses' understanding of their customer's preferences [4]. Recommender systems are incorporating diverse recommendation algorithms such as Collaborative Filtering Algorithm which has two approaches: User-based and Item-based Collaborative Filtering. In the User-based approach, the recommendation is based on users of the same neighborhood with whom he or she shares common preferences [5] while in the Item-based approach, similar items build neighborhoods on the behavior of users [6]. These two approaches are defined to be effective in providing recommendations although using the User-based approach is taken from the process of completing the transaction of vehicle fixing which ends with the users' rating to the service providers.

The roots of recommender systems can be traced back to research in cognition science and information retrieval. Their initial implementation can be seen in the Usenet communication system, developed by Duke University during the latter half of the 1970s. [7]. Numerous surveys and books have been dedicated to exploring recommendation models. The majority of early recommendation models are classified under collaborative filtering technologies. Before 2005, collaborative filtering technologies held a dominant position in recommender system applications and research, as seen from the perspective of recommendation models [8]. A standard collaborative filtering recommender system framework comprises three main stages: 1) Data Collection, 2) Pre-processing, and 3) Collaborative Filtering. To begin with, user data is gathered via wireless networks and subsequently stored in the cloud database. By employing Collaborative Filtering algorithms, user interests are predicted and relevant items are recommended, leading to time and effort savings [9]. Recommender systems find extensive application across diverse industries, serving companies and businesses alike. Remarkably, within the media industry, [10] prominent platforms like Netflix, YouTube, and Spotify extensively leverage recommender systems. Additionally, Amazon, being one of the largest companies, employs collaborative filtering to match products with customers based on their previous purchases [11]. After conducting statistical analysis on successful collaborative filtering implementations, notable improvements were observed: Amazon experienced a sales increase of 29%, Netflix saw a 60% rise in movie rentals, and Google News' click-through rates surged by 30.9% [12]. Simply put, a collaborative filtering-based recommender system is a software or systematic approach that leverages users' collected and processed preferences or data to predict their preferences, or those of other users, for specific products or services, thereby enhancing the economic status of the business or company.

Within the context, Maximilian Beckers [13] provided a compilation of the present-day algorithms applied in recommendation systems, encompassing content-based filtering for entertainment sources like movies [14], collaborative filtering for health-related data [15], and hybrid recommendation models [16]. Some recommender systems involved Self-Organizing Maps (SOM) [17] or Singular Value Decomposition (SVD) [18] using neural networks applied to the clusters of different songs and musical features. However, as the number of vehicle owners increases, the recommendation failed to account for the contextual factors surrounding a vehicle fixing situation.

In the case of this study, the researchers used the collaborative algorithm in recommending service providers online for vehicle fixing. The basic concept of collaborative filtering in vehicle fixing recommender is that two or more vehicle owners sharing some similar vehicle problem in one area tend to get inclined towards a similar service provider or mechanic from some other area too. Collaborative filtering (CF) and its variants rank among the recommendation algorithms most frequently utilized [19] to be applied this time in terms of vehicle fixing. In such a scenario, the most rational approach is to identify vehicle owners with similar vehicle problems, analyze their preferences and choice, and subsequently recommend the same service provider to the new users.

This outlines the creation and implementation of an online vehicle fixing recommender system, aimed at matching users with specific service providers based on their criteria or preferences, and concurrently facilitating service providers to advertise their skills or shops. [20]. An online web-based application or website will handle all activities, including searching for recommended service providers, advertising the service provider's skills or shop, and facilitating other transactions. The application or website features a registration page for account creation and a login page for accessing services and functionalities. It also provides a dashboard and manage request page for handling customers' requests, a list of service providers page for searching recommended providers, and a bookmark request status page. These interfaces serve as the main points of interaction for the users.

This paper centers on the design and development of an online vehicle fixing recommender system using user-based collaborative filtering, with the primary goals of recommending a list of service providers to customers, promoting the skills and/or shops of mechanics, and ultimately enhancing business opportunities. To enable the system to recommend a list of service providers, customers are required to input their location, desired service(s), and vehicle information, and set preferences regarding cost, ratings, distance, and the number of requests. This process eliminates the need for traditional laborious methods. To advertise their skills and/or shop, service providers are required to furnish

information about their services offered and associated costs, the geographical distance of their working location or shop, service coverage, and lastly, their performance ratings based on previous customer feedback collected within the system. By adhering to these requirements, service providers can attract a larger customer base and enhance their business prospects.

This study focused on addressing the following concerns and issues:

1. How Online Vehicle Fixing Recommender System using the User-based Collaborative Algorithm be developed through the following Iterative Processes:
    1.1 Data Gathering;
    1.2 Requirements Specification;
    1.3 Planning
    1.4 Designing;
    1.5 Coding;
    1.6 Testing?

2. How Online Vehicle Fixing Recommender System using the User-based Collaborative Algorithm be evaluated by the users through the following system attributes:
    2.1 Efficiency
    2.2 Reliability;
    2.3 Availability;
    2.4 Security; and
    2.5 User-friendly?

2. RESEARCH DESIGN

2.1 Process Model

The study adopted a case study design method, employing the Iterative Process Model [21] to develop the Online Vehicle Fixing Recommender System. This model starts with initial specifications and system development, which are then iteratively refined and repeated until the required specifications are fulfilled, proceeding to the next set of specifications and repeating the process until the system is fully completed.

2.2 User-based Collaborative Filtering Algorithm

The algorithm used in the design and development of the study considers an active user as the vehicle owner who at a particular time experienced a vehicle problem and to whom the recommendation is aimed. The collaborative filtering engine first looks for similar users, that is users who share the active users' rating patterns.

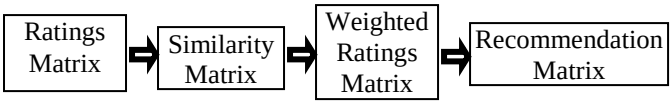

Figure 1: User-based Collaborative Filtering Algorithm

Figure 1 shows the algorithmic flow at which the User-based Collaborative Filtering was employed in a Vehicle Fixing Recommender System.

2.2.1 Ratings Matrix

This shows the ratings of the vehicle owners to their service providers or mechanics after the vehicle fixing which serves as the aggregated dataset to be utilized for recommendation to the active user.

2.2.2 Similarity Matrix

This shows how similar the active user is to the other users or experienced vehicle owners who have availed of some of the recommended services online for vehicle fixing. This can be done through several different statistical and vectorial techniques such as distance or similarity measurements including Euclidean Distance, Pearson Correlation, Cosine Similarity, and so on. Regardless of what similarity measurement is used, their numbers represent similarity weights or proximity of the active user to other users in the dataset.

2.2.3 Weighted Rating Matrix

This shows the calculated possible opinion of the active user to the possible service providers or mechanics available. This is achieved by multiplying the similarity weights by the user ratings. It incorporates the behavior of other users and gives more weight to the ratings of those users who are more similar to the active user.

2.2.4 Recommendation Matrix

This shows the aggregation of the weighted rates with normalization of the weighted rating values as one user might have rated several service providers that differ in quantity from the other users. The result is the potential rating that is used to rank the service providers or mechanics for providing recommendations to the active user.

Furthermore, the study employs a survey design to gather precise data. It utilizes survey questionnaires to assess the validity of the system functionality concerning its characteristics. A survey design represents a type of research design and a descriptive research method used to collect data from system stakeholders through reports, questionnaires, or interviews.

3. RESULTS AND DISCUSSION

In the realm of software development, a process model aims to mitigate project risks through meticulous planning, ensuring that the software not only meets customer expectations during production but also continues to do so beyond that stage. It lays out a sequence of steps that break down the software development process into manageable tasks, which can be assigned, completed, and measured.

3.1 Design and Development of the Online Vehicle Fixing Recommender System using a User-based Collaborative Algorithm

The project underwent design and development based on the Iterative Process Model, encompassing distinct phases, each of which is detailed and discussed in the subsequent sections.

3.1.1 Data Gathering

The initial phase of the project involves data gathering. The researchers give paramount importance to collecting data from different service provider users, including staff, mechanicians, and managers. To achieve this, the researchers designed and developed a survey tailored to the service provider users' needs. Concurrently, they identified the essential activities and devised a schedule for the system's development.

In this phase, the researchers engage in comprehensive data-gathering activities. They collect information about the challenges and requirements faced by the service providers and their customers. Furthermore, the researchers prepare a proposal, organize group discussions, conduct extensive research, and convene meetings. Additionally, a user interface (UI) prototype is developed to facilitate user interaction during the data-gathering process for the service providers.

3.1.2 Requirements Specification

The second phase of the project involves requirements specification. The researchers meticulously documented the specifications of the system to be developed. In this phase, they diligently identified, specified, and defined the system's comprehensive requirements.

During this phase, several modifications were made based on consultations with the technical experts and other stakeholders. Most of these changes were effectively implemented during regular consultations between the researchers and possible actors of the system.

3.1.2.1 Scope

The researchers stipulated that the scope of the system as the basis of the software development has been defined:

- A top-up or reload of the module for the administrator.
- Three primary users: Admin, Service Provider, and Customer.
- A recommender (Service & provider) module to recommend services to the customer.
- A book appointment module for booking an appointment.
- A manage book appointment requests module for managing customers' request
- A log history module for the list of records of all the transactions, past services, and ratings

3.1.2.2 Product Functions

The system has three users in which, the two primary users: the service provider and the customer as the vehicle owner, and the administrator. Each user has different user interfaces and performs distinct functions on the system. The service provider and customer communicate with each other during the transaction process.

3.1.3 Planning

In the third phase of the project, the researchers embark on the planning stage. This involves estimating and summarizing the project, identifying the deliverables, and allocating schedules, work activities, and resources. The final roles and responsibilities are assigned, and the budget is allocated. Additionally, the researchers specify the tools, methods, and techniques to be utilized in the system's development. The process concludes with consultation and validation with the technical consultants to ensure a comprehensive plan.

3.1.4 Designing

During the designing phase of the project, the researchers hold meetings, create diagrams, and develop the system's design. They actively consult with and seek feedback from the technical consultants and stakeholders during this stage. As a result of the consultations and feedback, various modifications are made to the diagrams to ensure alignment with the project's objectives and requirements.

3.1.4.1 Activity Diagram

An activity diagram serves to depict the sequential actions or flow of control within the system. It provides a model of the system utilizing fundamental components, such as actions, decision nodes, control flows, start nodes, and end nodes. These elements collectively help visualize the dynamic behavior and interactions within the system's processes.

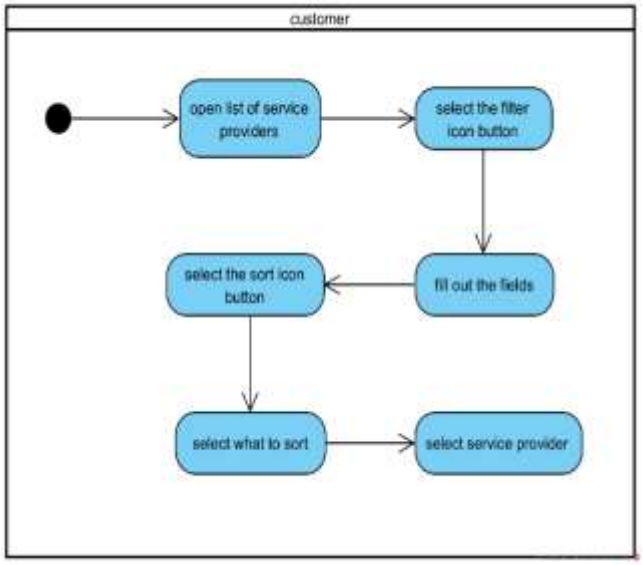

Figure 2: Highlighted Activity of the System

Figure 2 shows the flow or control of the activity in the system's focus, recommending a service provider to a customer as a vehicle owner.

3.1.4.2 Vehicle Fixing Recommender Interface

Figure 3: Interface that recommends the service provider

Figure 3 shows the rating, distance, and location of the recommended service provider or mechanic according to the vehicle problem of the vehicle owner.

3.1.5 Coding

The fifth phase of the project involves coding, during which the researcher translates the system specifications derived from the requirements documentation into a functional system. The development process follows a modular approach, as outlined in the documentation. For the back end, the researcher utilizes a PHP framework, specifically Codeigniter4, and MySQL as the database. On the front end, HTML, Bootstrap, CSS, and JavaScript are employed for coding. Throughout this phase, several changes are made to the developed modules based on suggestions and recommendations received during consultations with the researcher's adviser. Each module of the system is continuously refined to ensure its effectiveness and alignment with project objectives.

3.1.5.1 Technical Specification

The components of the Web-based Vehicle Fixing Recommender System, employing a User-based Collaborative Algorithm, can be categorized as follows: Website, Hardware, Administrator, and end-users.

The Website encompasses both service providers and their customers, and it serves as the interface for interaction with the system, including the Administrator's access. The system was constructed by developers using a range of web-based software components.

3.1.6 Testing

Once the system development is complete, the researchers proceed with specifying testing on a module-by-module basis. They meticulously document the functionality of the entire system, along with the individual modules for service providers and customers. Each functionality of the modules is assessed and rated based on remarks as either pass or fail, ensuring a comprehensive evaluation of the system's performance and reliability.

The service provider module contains the following functionality that was tested with their corresponding remarks:

- Updating the account details – Passed
- Managing the offered services, requests, serviceable vehicles, and locations – Passed
- Managing the customer's book appointment request – Passed
- Working on the accepted customer request – Passed

The customer module contains the following functionality that was tested with their corresponding remarks:

- Updating the account – Passed
- Searching for a service provider – Passed
- Booking an appointment request – Passed
- Paying the amount to the service provider – Passed
- Rating the service provider – Passed
- Canceling the book appointment request – Passed

The functionalities that were tested of the system that the users shared are the following with their corresponding remarks:

- Registration – Passed
- Login – Passed
- SMS Authentication – Passed

3.2 System Attributes Evaluation of the Online Vehicle Fixing Recommender System using a User-based Collaborative Algorithm

Users' Evaluation of the Online Vehicle Fixing Recommender System using a User-based Collaborative Filtering Algorithm

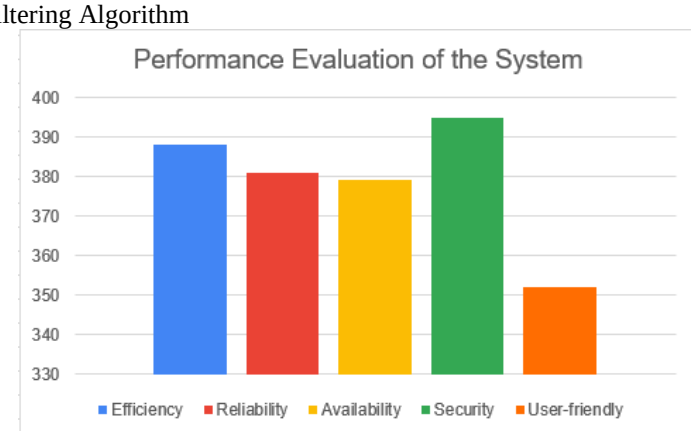

Figure 4: System Attributes Result

Figure 4 shows that the researchers ensure that the expected software system attributes add value to the users' experience.

● Efficiency – rank second to the highest rating which signifies that the vehicle fixing recommender creates a significant satisfaction to the users.
● Reliability – reliable even on the minimum Internet speed
● Availability – available on devices, Android, iOS, and PCs (Personal Computers)
● Security – stores basic information and details, and passwords were hashed
● User-friendly – rank last which could mean that the users were not too familiar with the system's navigation menu.

4. CONCLUSION

Based on the ratings provided, it appears that the software being evaluated has a high level of quality in terms of functionality, reliability, usability, efficiency, maintainability, and portability. However, it's important to note that these ratings are based on a limited sample size of 33 participants and may not be representative of the entire user population. Further evaluations and user testing may be needed to fully assess the software's quality and identify areas for improvement.

Based on the results of the survey, it may be recommended to focus on improving the functional completeness and functional correctness of the product or system. It is also important to consider the time behavior, resource utilization, and capacity to ensure that the product or system can meet the requirements. Furthermore, attention should be given to the co-existence and interoperability characteristics to ensure that the product or system can work well with other products, systems, or components. Finally, the user interface aesthetics, accessibility, and learnability characteristics should also be improved to enhance the overall user experience.

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