Smart Bike Sharing and Rental Management Service

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***Abstract*—As smart cities are on the rise and the demand for smooth job and internship opportunities increases, career advancement is now a necessity facilitated by digital platforms. This project introduces Career Connect – An Interactive Job and Internship Platform, a web application to fill the gap between recruiters and job seekers. Developed on React.js, HTML, CSS, and SQL for backend support, the website enables recruiters to list job vacancies while making it easy for applicants to search, filter, and apply for jobs. It includes secure login sites, a user-friendly interface, and dynamic features like job listing management, live application tracking, and user profile personalization. With the use of technology to automate the recruitment process, this system hopes to promote employment accessibility, increase candidate-employer interaction, and respond to the growing need for a centralized, easy-to-use career hub.**

Keywords—flask, HTML, CSS, JavaScript, RFID, Jinja2, LSTM, MySQL

I.Introduction

With the fast growth of urbanization and increasing demand for green mobility options, bike-sharing schemes have emerged as a crucial part of contemporary city transportation systems. But the majority of current platforms are dependent on company-owned fleets, excluding participation from those who possess private bikes and would like to offer them for rent. The Smart Bike Sharing and Rental Management System fills this void by providing an online platform that links individual bike owners with users in need of flexible, cost-effective, and environmentally friendly transport. This project is developed with the Flask framework, HTML, CSS, and JavaScript for an interactive front-end and Python driving the back-end functionality. It has two different user roles—providers who are able to list their bikes with major details, and users who are able to search available bikes by choosing their location. The system provides a secure and organized experience for both parties, providing a user-friendly interface, profile management, and easy navigation between features.

Through the facilitation of bike rentals in local communities, the system facilitates sharing on a localized basis, optimum use of resources, and environmental transport. Besides empowering citizens to generate income from underutilized assets, it also furthers sustainability and wiser city dwelling at a higher level.

II. Ease of Use

The emergence of shared mobility solutions, particularly bike-sharing schemes, has revolutionized urban transport worldwide in the last few years. Major urban issues such as air pollution, traffic congestion, and the need for more eco-friendly transportation are all supposed to be taken care of by these services. To enhance RFID-based bike rental systems, a web services-based framework was proposed. To provide efficient bike tracking, inventory control, and secure transactions, their work focused on utilizing RFID technology to streamline the rental process. The system demonstrated potential to enhance the operational efficiency and scalability of bike-sharing systems by integrating web services with RFID, setting the basis for the technology advancements in the intelligent bike-sharing systems of the present time [1].

A deep learning method was utilized to forecast the availability of bicycles at bike stations within short-time intervals. Following a comparison among different predictive models, the paper established Bidirectional Long Short-Term Memory (Bi-LSTM) networks as being most suitable in forecasting bicycle availability between 15 and 60 minutes ahead of time. The study also pointed to the importance of weather and temporal patterns in affecting bike demand, and how such contextual information can improve prediction accuracy if used. All these findings play a role in enhancing operational effectiveness and user experience in urban bike-sharing systems [2]. A low-cost bike-sharing system was established using Near Field Communication (NFC) technology and digital displays to enable easy bike rental. LCD-based user interfaces for user registration, bike rental, and returning the bikes, along with NFC-smartcards for authentication and payment, make up the system. The envisioned design assures better security, scalability, and cost-effectiveness, thus offering a suitable solution for smart cities. Functional testing verified the efficiency of the system, demonstrating its potential for extensive deployment in urban transport networks [3]. Investigating the interplay between environmental sustainability, social media engagement, and bike-sharing schemes. They highlighted the importance of social media websites in advocating for bike-sharing schemes, influencing user behavior, and promoting sustainable urban mobility practices [4].

Applying machine learning methods to enhance the effectiveness of bike-sharing schemes. To maximize the availability of bikes and ensure demand-supply equilibrium at multiple locations, their study utilized predictive models. This data-driven approach illustrated how machine learning can improve the operational management and user experience of urban bike-sharing networks [5]. A strategic solution for RFID technology deployment in bike rental systems was examined to enhance automation, efficiency, and integration in multiple rental sites. The research described a business model framework that focuses on the accuracy of real-time data, streamlined rental processes, and networked information systems. With the employment of Ultra High Frequency (UHF) RFID tags, the system improves bike tracking and authentication and overcomes operational challenges such as tag collisions and environmental interference. This strategy allows for hassle-free bike hire and return, with interoperability across various rental outlets through web services [6]. A Hierarchical Consistency Prediction (HCP) model is introduced to enhance bike-sharing system efficiency by accurately forecasting bike returns and rentals throughout a city. The model incorporates an Adaptive Transition Constraint (AdaTC) clustering algorithm to partition stations for enhancing prediction accuracy, a Similarity-based Gaussian Process Regressor (SGPR) to predict demand on various scales (stations, clusters, city level), and a General Least Square (GLS) method for improving predictions. Moreover, a Transition-based Inference (TINF) approach estimates the demand for bike returns based on rental forecasts. The research proves that this method improves prediction accuracy, allowing for improved bike repositioning and service quality in urban mobility networks [07]. Optimizing mobile applications for car hire services with focus on improving operations effectiveness and enhancing user experience. Their work accentuates the importance of integrating live data and simplified user interfaces into optimizing the hiring process [8]. Data-balancing solution designed to enhance system maintenance and quality of service (QoS) for bike-sharing operations. The approach optimizes the distribution of bikes between stations through real-time data and predictive analysis, minimizing service disruptions and optimizing maintenance schedules.

This dual focus on operation efficiency and service quality sets the benchmark for future smart bike-sharing systems that seek to find a balance between customer demand and system viability [9]. An introduction of a public bike-sharing system that is operated through smartphones, with an emphasis on promoting healthy lifestyles through bicycling in addition to its ecological benefits. The system offers a more sustainable and user-oriented urban transport alternative by monitoring users' behavior and optimizing bike allocation through smartphone sensors and cloud technologies [10]. The sharing economy point of view toward planning and management of a campus bike rental system. The answer employs cell phone applications and cloud computing-based systems to simplify the rental of bicycles while allowing for location tracking and real-time status updates. Their work establishes the foundation for similar applications to be used in urban environments as they point towards the importance of efficiency in terms of resources and optimizing user experiences to increase campus bike-sharing programs' uptake [11]. Applying genetic algorithms to optimize system performance and resource utilization. Research illustrates how algorithmic models can enhance the overall efficiency of stationless bike-sharing systems by solving operational challenges such as bike redistribution and user demand forecasting [12]. A systematic approach to realizing an Internet of Things network-based smart bicycle sharing system. Their research illustrates how sensors, GPS devices, and cloud-based infrastructure can be deployed to provide real-time monitoring of bicycles, enhancing the efficiency and usability of systems [13].

Using a mechanism design methodology to provide valuable insights on how supply and demand are managed in mobility service networks. The authors propose a dynamic pricing and incentive approach for optimal vehicle allocation, emphasizing the need for finding the right balance between user demand and resources available in shared mobility networks. This approach is particularly relevant to intelligent bike-sharing systems, as user satisfaction and system effectiveness hinge on instantaneous coordination of bike availability and demand [14]. To ensure optimal bike availability and rental experiences, smart bike-sharing systems studied user behavior. They enhanced the efficiency of operations and customer satisfaction for public bike rental systems by providing information on customer preference and rental patterns through the utilization of real-time data and network-based solutions [15]. The innovation of different smart bike-sharing technologies is an indication of the ongoing evolution of urban mobility solutions. From RFID automation and deep learning-based forecasting to IoT-based tracking and NFC-enabled rental systems, these technologies play a role in enhancing efficiency, security, and user experience. With the use of intelligent frameworks, predictive analytics, and digital payment solutions, bike-sharing systems are transforming to cater to increasing demand for convenient and sustainable transportation. The convergence of these technologies is the building block for future solutions, making shared mobility a real and scalable proposition for cities of the future.

III. Methodology

The **Smart Bike Sharing and Rental Management System** development was guided by a systematic, user-focused methodology to provide an effortless, secure, and scalable experience for bike providers and users alike. The approach combines conventional web development with smart data-driven features to provide usability, functionality, and extensibility.

1. **Requirement Analysis and Planning:**

The project started with the collection of requirements for two primary user roles—providers and renters. Providers required registration, bike management, and booking monitoring capabilities, whereas users required browsing, renting, and reviewing bike features. Other requirements were to incorporate secure login functionality, spam protection through CAPTCHA, and a modular design to enable future feature enhancements like predictive analytics and real-time booking management.

2. Back-End Development Using Flask and Python:

The back-end was coded with the Flask framework, business logic and route management being done using Python. Some of the major features were:

- Individual route handling for provider and user functionality (registration, login, listing, booking, etc.).
- Session handling for safe access and state tracking of users.
- MySQL integration for database-like structured data, managing entities like users, providers, bikes, rentals, and reviews.
- Logic for checks to prevent conflicts between rental dates was added in terms of SQL queries to prevent the double booking of bikes.

3. Front-end Development With HTML, CSS, JavaScript, and Jinja2:

Front-end development was intended to be simplistic and intuitive in design:

- HTML offered structural construction, CSS allowed for responsive style, and JavaScript provided interactivity.

- Templating through Jinja2 allowed for the rendering of dynamic data, allowing fluid communication between UI and server.
- Separate dashboards for providers and users were introduced to improve usability and role-based navigation.

4. User and Provider Registration with Secure Authentication:

- Sign-up forms specific to each type of user were created:
- Providers provided extra fields like city and address to facilitate location-based bike filtering.
- Passwords were hashed with MD5 encryption, and CAPTCHA verification was included to deter automated sign-ups.
- Session-based login was implemented to ensure security and individualized access.

5. Bike Management and Provider Dashboard:

Providers are able to:

- Create new bikes with detailed information such as model name, registration number, daily rents, manufacture date, and picture.
- Modify or remove their advertisements at any given time.
- Display all rental operations including their bikes, renter information, and rental duration.
- Modify their user profiles or close their account.

6. Bike Browsing and Rental via User Portal:

Users are able to:

- Search for bicycles by choosing a city, which sorts listings according to provider location.
- See detailed details for every bicycle, such as images, features, and availability.
- Go ahead and book a bicycle for a given date range. The system verifies booking conflicts with SQL logic and computes rental fees based on days.
- See and manage their rental history in a special dashboard.

7. Predictive Insights Using LSTM (Long Short-Term Memory Model):

To make the user experience richer and assist with intelligent decision-making:

- A pre-trained LSTM model was embedded to forecast potential rental price directions from available pricing data.
- The model output is displayed along with search results, providing users with further insight into price expectations.
- This adds a layer of smart analytics, improving the intelligence of the platform without detracting from usability.

8. Review and Feedback System:

Users can:

- Provide star ratings and text-based reviews for rented bikes.
- See others' reviews, assisting in building trust and transparency within the system.
- Every review is traceable to verified user accounts, which ensures honest feedback.

9. Testing, Deployment, and Evaluation:

The site was subjected to:

- Unit testing for separate modules like login, booking, and search functionality.
- Integration testing to confirm seamless interaction among user interfaces, back-end functionality, and database operations.
- The final application was deployed on a web server with scalability, performance, and security in mind.

IV. Implementation

To ensure a seamless experience for both bike providers and renters, the Smart Bike Sharing and Rental Management System uses front-end, back-end, and database elements on a modular and scalable architecture. The project makes use of Flask for the back end, **HTML/CSS/JavaScrip**t with **Jinja** templates for the front end, and **MySQL** (in place of SQLite) for storing structured data. Implementation was done in the following major stages:

1. Environment Setup:

Development environment was set up with critical Python libraries and packages:

- **Flask** as the web framework of choice
- **Flask-WTF** for form handling
- **Flask-Login** for authentication and session handling
- **MySQL** Connector / **PyMySQL** for interacting with the database
- Virtual environments to handle dependencies and keep development separated from the system Python environment.

2. Database Design:

The MySQL database contains several relational tables:

- **users**: Holds user details such as name, email, mobile number, and password hashes.
- **providers**: Stores the provider information like name, email, mobile number, address, city, and password.
- **bike**: Stores bike listings with attributes like model name, registration number, daily charge, manufacture date, description, image path, and provider ID (foreign key).
- **rent**: Stores rental records with user email, provider ID, bike ID, start and end dates, and total charges.
- **review**: Stores feedback submitted by users like ratings, messages, and references to bike IDs.

3. Provider and User Authentication:

Independent registration and login modules were established for:

- **Providers**: Have to input name, email, mobile number, address, city, password, and fill out CAPTCHA verification.
- **Users**: Input name, email, mobile number, password, and CAPTCHA entry.

Passwords are encrypted with **MD5 encryption** prior to storage. State of login is saved securely using Flask sessions. CAPTCHA keeps the platform safe from automated spam registrations.

4. Provider Dashboard and Bicycle Management:

After logging in, providers are taken to a customized dashboard where they can:

- **Add Bike:** Enter model name, registration number, charges, manufacture date, description, and upload a bike image. Image paths are saved in the database, and files are stored in the server directory.
- **Edit Listing:** Modify any bike information with pre-filled form data.
- **Delete Listing:** Delete a bike from the system and remove its image file.
- **View Rentals:** View all bookings for their bikes, including user contact information and rental dates.
- **Manage Profile:** Edit personal details or remove their account if necessary.

5. User Dashboard and Bike Rental Workflow:

After logging in, users can:

- Search for Bikes by City: Choose a city from a dropdown. A back-end query retrieves matching bikes listed by providers in that city.
- View Listings: View available bikes, including photos, specifications, and rental fees.
- Rent a Bike: Choose dates for rental, see total amounts, and accept the booking. Overlapping

bookings are avoided by SQL date conflict checks before confirmation.

- View Rental History: View all previous and existing bookings from their own dashboard.
- Manage Profile: Change name and mobile number without leaving the profile page.

6. Review and Feedback System:

Users can provide:

- Ratings (1-5 stars) and written feedback for every bike hired by them.
- Submitted reviews are saved in the review table and associated with the bike and user.
- These reviews can be seen by other users when searching for bikes, providing transparency and trustworthiness to the system.

7. Integrating Predictive Analytics (LSTM Model):

To offer smart insights, the platform incorporates an **LSTM (Long Short-Term Memory) pre-trained neural network**:

- When users search for bikes, the system makes future rental fees forecasts based on past price history.
- This is done through an already trained lstm_model.h5 and a MinMaxScaler, both of which were previously preprocessed on historical rental data.
- Forecasted values are presented on the sidebar of bike listings to enable informed decisions by users.

8. CAPTCHA Integration:

Dynamically generated CAPTCHA images are displayed for both user and provider registration. This is utilized as a security measure to block bot form submissions, allowing only genuine users to access the system.

9. Front-End Development:

The front-end was created utilizing

- **HTML** for layout structure
- **CSS** for styling and responsive design
- **JavaScript** for client-side interactivity
- **Jinja2 templating** to incorporate dynamic back-end content into HTML views

Different interfaces were created for users and providers so that navigation would be easy, role-specific workflows could be achieved, and everything would be clear.

10. Image Upload and File Handling:

Providers can upload images while listing bikes:

- File uploads are securely managed through Flask's **request.files**.
- Uploaded images are stored in the server's **/static/bike/ directory**.
- Paths to images are fetched and rendered dynamically on listing pages for users.

11. Testing and Debugging:

The system was thoroughly tested:

- **Unit testing** was conducted for every function (registration, login, listing, search, booking, etc.).
- **Integration testing** ensured all the components collaborated nicely.
- Flask's internal debugger and tools such as **Postman** were employed to perform **API endpoint** and **HTTP** route testing.
- Popular edge cases (e.g., overlapping bookings, blank fields, invalid input) were tested extensively.

V. RESULT

Smart Bike Sharing and Rental Management System was successfully deployed as an operational web-based application, providing a smooth interaction experience for users as well as bike providers. Usability, responsiveness, and modularity of the platform were assessed through various stages of testing. User and provider dashboards were tested for navigation and usability, and successful registration, login, and session management were confirmed through unit testing. Providers could list, edit, and delete bikes effectively, with uploaded photos saved and displayed correctly.

Users could search for bikes by city, view listings with estimated rental charge information, and complete bookings. The system calculated rental charges accurately from chosen date ranges and avoided overlapping bookings by efficient SQL conflict checks. This promoted fairness and accuracy in the rental process and minimized booking errors substantially.

The incorporation of the LSTM-based forecasting model improved the intelligence of the system by providing users with future price trends, thereby enhancing decision-making at the time of rentals. The user rating and review system also helped in transparency, enabling new users to gauge the quality and reliability of listings. During testing, the platform ran stably across various devices and browsers, with prompt page loads and bug-free navigation. The responsive front-end design made access available for both desktop and mobile interfaces. Security components like password hashing and CAPTCHA validation worked correctly, protecting data integrity as well as preventing spam.

In total, the system satisfied all the functional and non-functional requirements and showed great potential for real-world use, community adoption, and future development with features such as payment integration and mobile support.

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